TEXTE UND STUDIEN

ZUR WISSENSCHAFTSGESCHICHTE

AHMAD Y. AL-HASSAN

Studies in al-Kimya'

Critical Issues in Latin and Arabic Alchemy and Chemistry

OLMS

Ahmad Y. al-Hassan
Studies in al-Kimya'

Texte und Studien zur Wissenschaftsgeschichte

Band 4

Ahmad Y. al-Hassan

Studies in al-Kimya'

2009
Georg Olms Verlag
Hildesheim · Zürich · New York

Ahmad Y. al-Hassan

Studies in al-Kimya'

Critical Issues in Latin and Arabic Alchemy and Chemistry

2009
Georg Olms Verlag
Hildesheim · Zürich · New York

*

Die Deutsche Bibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über *http://dnb.ddb.de* abrufbar.

Die Deutsche Bibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at *http://dnb.ddb.de*.

ISO 9706

www.olms.de

Printed in Germany
Satz: Martin Noble Editorial / AESOP, Oxford, UK
Umschlagentwurf: Inga Günther, 31171 Nordstemmen
Gedruckt auf säurefreiem und alterungsbeständigem Papier
Herstellung: Strauss GmbH, 69509 Mörlenbach
ISBN 978-3-487-14273-9

To Laila, my wife
who supported me with devotion and endurance
throughout our journey together

Contents

Preface and Acknowledgements

I review in the Introduction the contents of this book and the conclusion attained in discussing each critical issue in the history of alchemy and industrial chem.-istry. My interest in doing research into these critical issues was triggered by a question about the origin of Damascus steel. I was then a graduate student at University College London. I was visiting an exhibition and while contemp-lating one of the exhibits, a stranger asked me, 'Do you know what this is? It is a sword made from Damascus steel. You young people should revive you're herit-age.' He knew from where I came.

I shall not tell a long story here, but that incident resulted in a series of concrete actions in Syria in response to the challenge posed by that stranger in London. One of the last actions was to create the Institute for the History of Arabic Science at the University of Aleppo.

I have chosen to do my research on the critical issues in the history of science and technology in general. I call a 'critical issue' any case in the history of science and technology where the historical facts are written without concrete evidence, and are based mainly on conjecture and on nationalistic feelings. To correct these historical errors it was mandatory that we should go back to the original sources. I decided to study the original Arabic manuscripts and to com-pare the Arabic texts with the Latin works whether they are in Latin or in their vernacular translations.

For this purpose I amassed a great number of copies of manuscript from the international manuscript libraries, such as the B.N. de France in Paris, the BL of London, the Wellcome Institute of London, the Chester Beatty Library in Dublin, the Leiden University, the Staatsbibliothek of Berlin, Gotha Manuscript Library, the various Turkish libraries such as the Süleymaniye Library in Istanbul, Dar al-Kutub of Cairo, the Alexandria Library, the National Library of Medicine (NLM) in Bethesda, USA, and the Institute of Oriental Manuscripts at St Petersburgh. I express my gratitude to the staff in these libraries for the invaluable service that I have received.

I should single out those who presented me with some valuable manuscripts and express my thanks to them. Professor Fuat Sezgin from Frankfurt, provided me with a CD copy of the two Arabic manuscripts about the dialogue between Prince Khalid ibn Yazid and the Hermit Maryanus. Professor A.T. Grigorian from Moscow presented me with the Arabic military manuscript of St. Petersburgh. Dr Yusuf Zaidan from Alexandria presented me with a CD copy of Kitab al-khawass al-kabir, and Mr Mahmud Amin al-'Alim from Cairo sent me a copy of Kitab sunduq a-hikma.

Some of the chapters this book were published in learned journals. I express my thanks to Cambridge University Press the publisher of *Arabic Sciences and Philosophy* and to Professor Roshdi Rashed the editor of the journal for their consent to publish 'The Arabic Original of *Liber de compositione alchimiae*' that was published in Volume 14(02): pp. 213–31, (2004); and the article 'An Eighth Century Arabic Treatise on The Colouring of Glass', published in Vol. 19(01): pp. 121–56 (2009).

My thanks also are due to Professor Mustafa Mawaldi, Dean of the Institute for the History of Arabic Science and editor of the *Journal for the History of Arabic Science* for his permission to publish the article 'Iron and Steel Technology in Medieval Arabic Sources', published in Vol. 2, No. 1, pp. 31–43 (1978), and also the article on 'The Arabic Origin of the Summa and other Geber Works', due to be published in Vol. 15 (2009).

I thank also Professor Alexander Keller the editor if ICON, the journal of ICOHTEC (International Committee for the History of Technology), for his permission to publish the article: "Gunpowder Composition for Rockets and Cannon in Arabic Military Treatises in the 13th and 14th Centuries" that was published in ICON, Vol. 9, pp. 1-30, (2003).

Several scholars gave me valuable help while I was working on this research, and I would like to thank two in particular. The founder of the Alchemy Website Adam McLean of Glasgow was of great help in explaining and elucidating some Latin texts. Professor Ana Maria Alfonso-Goldfarb of Brazil and her team read and gave valuable advice on the essay about the Arabic Origin of the Summa.

Special thanks are due to Georg Olms Verlag and to Dr Peter Guyot, Lektorat, in particular. Dr Guyot gave a positive response when I first wrote to him, and he conducted the initial contacts with promptness and with courtesy. I had always held Georg Olms in high esteem for the high quality of their academic publications, and I therefore chose to put this book in their hands. I cannot thank in this limited space all those who were of help to me, but I should thank Mr Martin Noble of Oxford, UK (www.copyedit.co.uk) who copy-edited the manuscript and who was patient in meeting my demands.

Mr Ayman Gabarin, who established the website www.history-science-technology.com and who maintains it and keeps it running, deserves my thanks and gratitude. I publish on this site the results of my research; and it is now one of the main sources online for academic research into Arabic-Islamic science and technology and the critical issues in Latin and Arabic alchemy and chemistry.

Ahmad Y. al-Hassan
Saint Laurent du Var
June 2009

Introduction

This volume is not a traditional history of alchemy, nor is it another book on the history of industrial chemistry. Moreover, unlike usual histories, it is devoted to the discussion of some important critical issues in the history of Arabic and Latin alchemy and industrial chemistry.

History of science and technology is not an exact science; and it is marred every so often by nationalistic feelings and by the political encounter between cultures. Western historians wrote this science largely and overwhelmingly, and due to the absence of research in developing countries, there was no role in the past for scholars of those countries. In addition, whenever a scholar from a developing country voices a valid criticism, Western scholars consider it as apologetic or defensive.

The history of Arabic and Islamic science and technology was on the whole lucky because there were some trustworthy Western historians who rendered a great service in writing this history during the 19th and 20th centuries.

In addition, in the last few decades scholars of Arabic or Islamic origin gained prominence in Western universities and excelled in their research into the history of Arabic-Islamic science. Recently also the study of the history of Arabic and Islamic science in Arabic and Islamic universities had started and special institutes were established. Moreover, with the constant discovery of new Arabic manuscripts and with editing and publishing them, the history of Arabic and Islamic science is being corrected and rewritten again; albeit at a slow pace.

Research into the Arabic–Islamic exact sciences, in particular, is currently quite active, and the results of research cannot usually be contested. Numerous scholars, some of whom are imminent, are devoting their research activities to this branch of science more than to any other domain.

The story is different when we look at the history of Arabic alchemy and chemistry. There is at present a scarcity in scholars with a mastery of Arabic, who are qualified to do research in this field. Moreover, for the last seven decades no serious work on Arabic alchemy and chemistry has appeared, with the exception of a few edited texts.

On the other hand, in the last decades of the 19th century and the first half of the 20th, some historians took a serious interest in Arabic alchemy and chemistry. Some of these like Henry E. Stapleton and Eric J. Holmyard were largely trustworthy and reliable; but others, like Marcelin Berthelot and

Julius Ruska, were generally biased. Berthelot and Ruska had their own motives, and they based their preconceived judgements on mere conjecture. Unfortunately, those speculations were accepted uncritically in the West. First, these two historians were of immense authority, and they presented their conjectures in the garb of scholarship. Their ideas were accepted since they played on the Eurocentric sentiments of the educated Western individual. In addition, and more importantly, there was no possibility for any academic to check the trustworthiness of those conjectures. It was not feasible for any scholar who usually lacked knowledge of Arabic, and even Latin, to waste his time and efforts in an endeavour that lacked any kind of incentive or support.

The motive behind those conjectures was to divorce Latin alchemy from its Arabic roots, and since they remained unchallenged, the present history of alchemy and chemistry in the West in the early period is built mostly on feeble and defective foundations.

Our purpose in this work is to discuss some critical issues in this history. We shall not disprove conjectures by counter conjectures; otherwise, our work will be worthless and doomed. On the contrary, our presentation in this whole volume is based on our research into original sources, mainly Arabic manuscripts.

We present here the results of three decades of research into Arabic manuscripts. And although some of the results of this research were presented at international conferences and were published in learned journals and on the internet, it has now become necessary to put them together and make them accessible to the academic community in a convenient form.

This book has ten chapters; one of these is a review of Arabic alchemy and another a review of Arabic industrial chemistry; the remaining chapters deal with eight important critical issues.

The first critical issue is that of the dialogue between Prince Khalid ibn Yazid and Maryanus the hermit. This dialogue was the first Arabic alchemical treatise to be translated into Latin by Robert of Chester in 1144 under the title of *Liber de compositione alchimiae*. It heralded the start of Arabic alchemy in the West. Yet Julius Ruska had the unabashed spirit to cast doubts on Khalid, Maryanus, and Robert of Chester. He conjectured that this whole dialogue is an imaginative story and that a Latin monk had written the Latin treatise in the 13th to 14th century. Ruska wrote for this purpose his book *Arabische Alchemisten*, of which volume one is devoted to his conjecture about Khalid and Maryanus. This work is considered by many to be one of Ruska's masterpieces.

We have discovered the Arabic original of the dialogue and have found that the Arabic text corresponds to an amazing degree with the Latin treatise.

Thus, one main conjecture of Ruska was demolished and his honest scholarship became questionable.

The second critical issue is that of the Geber problem. Western alchemy started with the translation of Arabic works in the 12th and 13th centuries. In the 13th century, several treatises appeared in the West carrying the Latin name of Jabir ibn Hayyan (Geber). The most important among them was the *Summa perfectionis*. In 1893 Berthelot came out with the conjecture that the Geber works were not written by Jabir but by Latin authors.

In 1935, Ruska came out with another conjecture when he claimed that a treatise called *De investigatione perfectionis* of Geber was not written by Jabir, and a Latin who was also the author of the *Summa* wrote that part of it.

In 1986, William R. Newman adopted Ruska's conjecture and built his whole work on it. Newman made up a complicated hypothetical assumption that an unknown Paul of Taranto was the author of the *Summa*; and further, he attributed to this unheard of character the conception of the corpuscular theory that was much publicised by Newman, and the mercury alone theory. However, these two so-called theories are in fact old concepts in Arabic alchemy as is conclusively shown in Chapter 3.

These conjectures of Berthelot, Ruska and Newman are marring the early history of Latin alchemy. We were able to refute all these speculations by evidence based on extensive research into Arabic manuscripts. We proved that the entire *Summa* is based on Arabic alchemy, and that the conjectures of Berthelot, Ruska and Newman about pseudo Latin authors for Geber works are unfounded.

The remaining six critical issues relate to Arabic industrial chemistry. Two of them are on books of recipes, one on potassium nitrate and nitric acid, one on explosive gunpowder and cannon, one on alcohol and one on Damascus steel.

There appeared in the West before the introduction of Arabic alchemy in the 12th century, four books of practical recipes related to industrial chemistry. The earliest two go back to the 9th century and two are from the eleventh. One is the *Mappae Clavicula* and one is the book of Theophilus. Western historians considered them to be the only sources on the chemical technology of medieval Europe and without parallel in Arabic literature.

These judgments are caused by lack of knowledge of the Arabic treatises on alchemy and chemistry and by the erroneous notion that Jabir ibn Hayyan was an allegoric alchemist.

However, contrary to these assumptions, there are numerous Jabirian treatises on practical alchemy and chemistry. One book of recipes is *Kitab al durra al-maknuna* on the colouring of glass and the making of artificial pearls, and it contains a large number of recipes. There is also *Kitab al-khawass al-kabir* which contains dozens of recipes on industrial chemistry.

In comparing the contents of *Kitab al-durra* and *Kitab al-khawass* with the four Latin books of recipes, we found that none of them matches Jabir's recipes in their novelty and detail. These two works of Jabir, which are discussed in this volume, confirm that Arabic literature has more mature books of recipes than the four early Latin treatises and they dissipate the false notion that was painted by Berthelot and reinforced by his followers, about Jabir as a vague allegoric alchemist.

Another critical issue is that of the first knowledge of saltpetre and nitric acid. Berthelot, followed by others, assumed that Arabic works did not know these two chemicals, and that they were first known in Europe at the end of the 13th century.

This wrong assumption is also caused by ignorance of Arabic works. Potassium nitrate was known in Arabic alchemy since its earliest stages, and was identified under different names. Indeed, saltpetre was even recognised since the ancient civilisations of Mesopotamia.

Recipes for nitric acid and aqua regia before the 13th century are also given in different works of Jabir, al-Razi and in Ta'widh al-Hakim.

Another critical historical issue is that of the first formulation of explosive gunpowder. It is known that the first recipes of gunpowder were formulated in China. However, the powder was weak and non-explosive, suitable only for fireworks.

Claims were made that Berthold Schwartz, a legendary German monk, or Friar Roger Bacon, the famous medieval English scientist, were the inventors of explosive gunpowder. A century ago Colonel H.W.L. Hime published his own assumptions about this matter, and later in 1956, David Ayalon published his assumptions about *Firearms in the Mamluk Kingdom*. These are only two of the many authors of various nationalities and of different motives who delved into this subject. Our research here proves that the legends and conjectures about this question are without foundation.

In Arab lands, recipes for explosive gunpowder suitable for cannon are given in al-Rammah's treatise of the 13th century, and in other contemporary military and alchemical treatises. We find in these military treatises also the description of the first cannon in history. This was a portable one, which was used against the Mongols in the battle of 'Ayn Jalut in 1260 for frightening the horses of Mongol cavalry.

The ideal gunpowder composition contains 75 per cent saltpetre, besides sulphur and charcoal. Arabic recipes gave the same ideal composition. In Europe and China, the explosive mixture started to appear in

the second half of the 14th century, and the first cannon were used in the battle of Crecy in 1346.

The discovery of alcohol is another disputed area. It is assumed in Western literature that the earliest reference to the distillation of wine occurred in a text from Salerno around 1100 CE, although the technology of distillation was transferred to Salerno with the translation of Arabic works.

Islamic chemists knew the distillation of wine and the properties of alcohol from the 8th century. The prohibition of wine in Islam did not mean that wine was not produced and consumed.

The flammable property of alcohol from wine bottles was known from Jabir's time, and Al-Kindi, al-Zahrawi and al-Farabi mentioned the distillation of wine.

Alcohol was called *khamr musa'ad* (distilled wine), and the current word for distilled wine is *'araq* which means sweat, an indication of a distilled liquid. In early Arabic poetry of the early Abbasid Caliphate, distilled wine or strong alcoholic drinks were served. They were not denoted by a special name and were just another variety of wines.

Wine was distilled in Sharish (Jerez) in al-Andalus. It is believed that distilled spirits were produced there and that sherry (from Sharish) was known since the Arab days.

The final critical issue in this work is that of Damascus steel, which was renowned in the West for its superior qualities, and European steel-makers sought to find its secret. Britain in the 19th century imported 'wootz' steel from India. Therefore, historians thought that Damascus was only a trading centre and steel was not produced there.

Research into Arabic literature has revealed that Damascus steel was made from local iron ores near Damascus. There were also other Islamic areas producing iron and steel from local ores.

Jabir, al-Kindi and al-Biruni wrote about steel in detail. According to them Damascus steel is composed of *narmahan* which is soft iron, and of *daus* which is cast iron, and this is the reason behind the *firind* (pattern) in swords. This composition as reported by Arab scientists is in conformity with modern interpretation. Al-Jildaki, in commenting on Jabir's *Book of Iron*, describes how cast iron and steel were produced on an industrial scale.

The question of Damascus steel was the starting point in my interest in the critical issues, and it was an impetus for me to establish the Institute for the History of Arabic Science at the University of Aleppo in 1976, and *the Journal for the History of Arabic Science* at the same time.

In conclusion, this work is a manifest proof that history of science and technology in the Middle Ages cannot be written in isolation from a thorough search into Arabic sources. To base this history on Latin sources only will result in gross errors as we can see from reviewing the critical issues in this work.

The best reception for this work is to be reviewed by qualified and fair scholars who can help in pointing out where I have erred; and if I have sometimes used candid language in discussing some of the critical issues, I hope that I may be excused.

1 Arabic Alchemy: ʿIlm al-Sanʿa (Science of the Art)

INTRODUCTION

The Art of alchemy *(ʿIlm al-Sanʿa),* as we shall discuss here, is a theoretical and a practical science which is aimed at the transmutation of metallic bodies such as iron, copper and lead into silver and gold by using chemical preparations and with the help of the elixir. On the other hand, practical industrial chemistry is concerned with the production of industrial products by using chemical processes and this will be the subject of Chapter 4. Our discussion here does not deal with the occult, mystical or spiritual aspects of alchemy.

THE ORIGIN OF THE WORD ALCHEMY

The Arabic word *al-kimya'* is composed of the article *al* (the) and *kimya'* (chemistry). This word reached the West with the translation movement, which took place in the 12th century. The Arabic form *al-kimya'* is the origin of the word alchemy, which is used to denote the science of alchemy, which preceded modern chemistry. *Kimya'* without the article *al* is the origin of the word chemistry. In Arabic the word *al-kimya'* means both alchemy and chemistry, Some contemporary Arab writers try to differentiate between alchemy and chemistry by using the word *al-khimya'* الخيمياء to denote alchemy.

The word *khemeia* occurred for the first time in a decree issued by the Roman Emperor Diocletian (*c.* 245–*c.* 312), to burn all Egyptian books of *khemeia* that deal with alchemy and the manufacture of gold and silver.

This word is most probably derived from the name of Egypt. Plutarch (*c.* 46–127) mentions in a treatise written about 100 CE that Egypt is called Khemia because of the colour of its black soil. Some think that the word is of Greek origin, and others think that it is of Chinese.[1]

Although this branch of science was called *al-kimya'* in Arabic, yet it was also called also the Science of the Art *ʿilm al-san'a* علم الصنعة and the practitioner of this Art was called *sahib al-san'a*, and alchemists were called *hukama'* or philosophers.

1. For the origin of the word alchemy see Leicester, 1956, p. 45.

ALCHEMY AND CHEMISTRY IN ANCIENT CIVILISATIONS

Chemical knowledge started with the ancient civilisations of Mesopotamia and Egypt since the fourth millennium BCE. Metallic bodies such as gold, silver, copper and iron were used from an early date for various purposes. The technique of mining the ores, extracting the metals, alloying and forming them was mastered quite early. The industries of glassmaking, glazing, dying, tanning, oils and fats extraction, detergents and perfumes were also developed.

Several kinds of raw materials that were used in the chemical industries were known. Among these were alums, various kinds of salts and nitrates.[2] This indicates that chemical knowledge was known since the rise of ancient civilisations. It was, however, an empirical knowledge and alchemy and chemistry were not yet developed into sciences.

It is well established that the beginnings of science in general started in Mesopotamia and Egypt, and from thence they were transferred into Greece. It is useful therefore to investigate the beginnings of chemistry in these two ancient civilisations since this may reveal to us the origin of several theoretical concepts in both alchemy and chemistry.

The Babylonians believed that the universe originated from water. They noticed also that the universe contains opposite elements. Thus there is day and night; light and darkness; male and female; hot and cold; wet and dry. There is also the good and the evil, and in general, there is for every feature an opposite one. It is also possible to divide matter into two opposite elements, and from these two opposite elements, everything can be generated.

The Babylonians were keen observers of the stars; and from their early history, they believed that the gods are in control of the planets. They also believed that the sun, moon and other planets have influence on what happens on earth. This was the beginning of astrology. The influence of the planets involves metals; thus, the sun influences gold, and the moon influences silver, and the other planets control the remaining metals. This linkage between the planets and metals was the biggest contribution of the Babylonians to alchemy or the Art.

2. Levey, 1959, pp. 128 & 152 says that potassium nitrate was known in Ancient Mesopotamia. Forbes in *Studies in Ancient Technology*, III, p. 188, also says that saltpetre was known and used in ancient Mesopotamia. It was obtained as an efflorescence of the soil in certain places where organic matter decayed. It was collected and treated to obtain the crystals of saltpetre. It seems that this ancient practice in these pre-Islamic lands continued into Islamic times.

Greek philosophers who were thinking about the nature of matter, and whose theories were based in part on the Babylonian concepts, inherited the principle of the two opposites.

Aristotle was one of the latter Greek philosophers who benefited from those who preceded him and believed in the existence of four principal properties, which are composed of two opposites: hot and cold, wet and dry. If we combine a pair of these opposites, we obtain four main elements: fire (from hot and dry); earth (from dry and cold); water (from cold and wet) and air (from wet and hot). This theory of Aristotle prevailed until the middle of the 17th century and it exerted a great influence on the possibility of transmuting one element into another.

ALCHEMY AND CHEMISTRY BEFORE ISLAM

Most historians of science believe that the science of alchemy and chemistry started and developed principally in the Nile Valley, and that it was practised in Syria, Mesopotamia and Persia.

Stapleton advanced the idea that the origin of alchemy is to be traced to Syria (especially Harran), Mesopotamia and Persia, rather than Egypt. He suggested that Syrian refugees from the Persian invasion had carried their ideology and technique into Egypt and practised alchemy there using the Greek language; and this is how Egyptian alchemy had originated according to him.[3]

Alchemy became a prominent science in Alexandria in the early years of the CE. The language of culture in Egypt was Greek and most alchemical treatises that were translated into Arabic were from Greek, yet it was Egyptian alchemy and it will be misleading to describe it otherwise.

The majority of the inhabitants of Alexandria and the other cities in Egypt were Egyptians, with small communities of Syrians and Greeks. The Egyptian industrial skills in metallurgy, dying and glass-making were combined with the Syrian, Babylonian and Greek philosophical contemplations in formulating the science of alchemy. It is of great significance to know that the most important Greek alchemical treatises were found in Upper Egypt and that Zosimus was a native of Akhmim in that part of Egypt.[4] During the first centuries CE there existed in Egypt several Gnostic groups, and philosophy degenerated unto Hermetic spiritualism and beliefs in magic and hidden powers.

3. Multhauf, 1966, p. 115; Stapleton, 1953–56, reproduced by Fuat Sezgin, *Chemistry Texts and Studies* Vol. II (*Natural Sciences in Islam*. 56), Frankfurt, 2001.
4. Akhmim, which was called Panopolis in Greek, is 700 km south of Alexandria.

We find in the writings of early Arabic alchemists many quotations attributed to pre-Islamic persons and there are several Arabic alchemical treatises attributed to them. These works were the subject of research by historians of science who concluded that most of these works were attributed to pseudo authors.

These pseudo authors included Hermes, Iflatun (Plato), Aristo (Aristotle), Pythagoras, Agathodaimon, Ostanes, Hiraql (Heraklius, Byzantine emperor, 610–41), Cleopatra, Mary, Zosimos, Isis, Krates, Markos, Jamasp, Furfuriyus and many others. They came from Egypt, Syria, Mesopotamia, Persia, Greece and Asia Minor.

Sezgin gave a list of the Arabic treatises attributed to each of these pseudo authors. It is probable that these works were written before Islam and were translated into Arabic from Greek or Syriac. Stapleton,[5] Sezgin and others are of this opinion. Other historians are of the opinion that these works were written by pseudo-Arabic authors after Islam. However, whether these pseudo-alchemical works are pre-Islamic or Islamic, they are a chief source for Arabic alchemy.

Most of the Greek and Syriac originals of these works are lost and very scanty fragments have survived. Of these fragments is a Greek text attributed to the Hellenized Egyptian alchemist Bolos of Mende. (Mende is now called Tall al-Rab'a in the Egyptian Delta.) The treatise is called *Physica et mystica* ('Natural and Mystical Things'), a kind of recipe book for dyeing and colouring, but principally for the making of gold and silver. Other alchemical texts, mostly recipes written on papyrus and going back to 300 CE were found in a cemetery in Luxor in Upper Egypt.[6] These papyri are distributed between Leiden and Stockholm. However, the most important alchemical extant texts are those attributed to the Egyptian alchemist Zosimus, a native of Akhmim in Upper Egypt who probably lived between 350 and 420 CE. Zosimus had compiled the works preceding him and he mentions the names of several pseudo authors such as Hermes, Ostanes and Mary.

Because of the scarcity of Greek texts and the abundance of Arabic ones, the main sources for the study of pre-Islamic alchemy are Arabic. Again, since most Western historians of science are not familiar with Arabic, the serious study of pre-Islamic alchemy remains deficient.

5. Stapleton, 1953–56, p. 1
6. Luxor is the site of the ancient Egyptian city of Thebes.

The works attributed to Hermes are one important source for Arabic alchemy, and his name became linked to it. His fame reached the Latin West after the translation of the Arabic works attributed to him. He is called in Arabic "Hermes al-Muthallath bi al-Hikma" which means Hermes the thrice endowed with Philosophy. *Hikma* or philosophy indicates here the great Art of alchemy. Latin name Trismegistus is a translation from Arabic.

One of the important texts attributed to Hermes is the *Tabula Smaragdina* that was translated into Latin from Arabic in the twelfth century. Apollonius of Tyana gave this very short text of few sentences at the end of his book *The Secret of Creation*. Jabir Ibn Hayyan cited this text also in one or more of his works. The short text of *Tabula Smaragdina* occupied a prominent place in the alchemical literature of the Latin West.

About Hermes Trismegistus (of the Triple Wisdom) Arabic sources say that the first Hermes was the Prophet Idris (the Biblical Enoch) who preceded the Flood and built the pyramids of Egypt. Hermes the second was from Babylon, he lived in Mesopotamia after the Flood, and he had given life to sciences. Hermes the third lived in Egypt after the Flood and he developed several sciences and crafts. These three personalities of Hermes combined are the source of alchemy, astronomy, astrology, philosophy and the remaining sciences.[7] Balinas, or Apollonius of Tyana [8] helped in spreading the alchemy of Hermes in his book *Sirr al-Khaliqa* (The Secret of Creation).

Most historians of science and chemistry believe that the alchemy of India and China did not exert any significant influence on the development of alchemy and chemistry in the western half of the ancient world. They believe that chemistry and alchemy, like other sciences, started in ancient Babylonia and Egypt, and they continued their historical development within the western half of the ancient world until the rise of modern science.[9]

7. Plessner, *EI*, on CD.
8. Tyana is a town in Kilikya in Asia Minor on the borders with Syria.
9. See e.g. Multhauf, 1966, p. 15; Stapleton, 1953–56, p. 38.

THE BEGINNINGS OF ARABIC ALCHEMY AND KHALID IBN YAZID

Khalid Ibn Yazid was the first Arab to work on alchemy or *'ilm al saná* (Science of the Art). His exact birthday is not accurately known, but we know that when his brother Mu'awiya Ibn Yazid had died in 64/683, Khalid was not able to become a caliph because of his young age. Some historians estimated the year of his death to be 84/703 or 90/708. But Stapleton determined his year of death at 102/720 on the basis of some Arabic manuscripts.

According to Ibn al-Nadim, Khalid summoned from Egypt a number of Greek scholars[10] who were well versed in Arabic and commissioned them to translate works on the Art of alchemy into Arabic.[11]

Khalid learnt the Art of alchemy under Maryanus, an ascetic hermit living in the mountains of Jerusalem who was either an Egyptian or a Syrian, and a follower of the Melkite Church, which was loyal to the Byzantine Emperors. Maryanus was in turn a pupil of Istfan (Stephanus) of Alexandria.[12]

The treatise *Liber de compositione alchimiae* "رسالة مريانس الراهب الحكيم للامير خالد بن يزيد", whose Arabic original became known recently, gives an account of the encounter between Khalid and Maryanus and the dialogue which took place between them.[13]

Arabic sources that were close in time to Khalid reported his interest in alchemy, and Jabir Ibn Hayyan reported in *Kitab al-rahib* how Khalid summoned Maryanus. Al-Jahiz (*c.* 776–868) reported in *Kitab al-bayan wa al-tabyin* that Khalid Ibn Yazid was an orator and poet, eloquent, comprehensive, of sound judgment and extremely well-mannered, and the first (in Islam) to order the translation of works on astronomy, medicine and alchemy.

Khalid occupies a high standing among Arabic alchemists, and most Arabic works on alchemy give citations from his writings and poems on *'ilm al san'a* (the Art). He occupies also the same high standing in Latin alchemy. Ruska raised doubts about Khalid's work in alchemy. However, Sezgin refuted Ruska's assumptions based on original Arabic sources.

10. These are Egyptians or Syrians who were followers of the Melkite Byzantine Greek Church.
11. Ibn al-Nadim, n.d., p. 352.
12. Jabir Ibn Hayyan, 1936, p. 529.
13. Al-Hassan, 2004.

Our recent discovery of the Arabic original of *Liber de compositione alchimiae* had proved conclusively that Ruska's speculations were groundless.[14] I will discuss this discovery in Chapter 2.

ARABIC ALCHEMISTS AFTER KHALID

After Khalid, more translations of alchemical works emerged in Arabic, and many Arabic alchemists appeared. We shall mention only some of the most eminent ones according to the chronology of their appearance.

Ja'far al-Sadiq

Abu 'Abd Allah Ja'far al-Sadiq Ibn Muhammad Ibn 'Ali Zayn al-'Abidin, (d. 148/765) was the sixth Shi`i Imam, and was the coach of Jabir Ibn Hayyan. Jabir referred to him in many of his works. There are several alchemical treatises attributed to him. It is not certain whether Ja'far had written them or they were collected or edited by his disciples,[15] but they form an important part of Arabic alchemical literature.

Jabir Ibn Hayyan

The greatest Arabic alchemist and chemist, and the most celebrated, East and West, until the rise of modern chemistry, Abu Musa Jabir Ibn Hayyan al-Sufi, also called al-Azdi, al-Kufi, al-Tusi, was born in about 103/ 721 in Tus, Khurasan, when his father was residing there, and died in 200/815 in Kufa. Jabir is from the Arab tribe of Azd, and Kufa was his principal residence. He is known as al-Sufi because he was a follower of one of the Sufi orders.

After the death of his father, Jabir was sent to Arabia where he became a pupil of Harbi al-Himyari, according to what Jabir had mentioned in some of his works. He studied the Qur'an, mathematics and other sciences, in addition to the Himyaric language. Jabir mentions also that he studied alchemy under a monk (rahib), who was a pupil of Maryanus, the tutor of Khalid Ibn Yazid.

We do not know much about the early life of Jabir; but we know that he was an alchemist at the court of the Caliph Harun al-Rashid. He was an intimate friend and a disciple of Ja'far al-Sadiq the sixth shi'ite Imam. We

14. Ibid. See Ruska, 1924.
15. Muhammad Yahya Al-Hashimi had written a book about Ja'far al-Sadiq in which he refuted the assumptions about Ja'far in Ruska's book: *Arabische Alchemisten. II. Ga'far Al-sâdiq, der sechste Imâm* (1924), that was reprinted by Fuat Sezgin in *Natural Sciences in Islam*, 59, Frankfurt, 2001.

find in many of Jabir's works expressions of his deep love and respect to Ja'far where he refers to him always as *sayyidi*, 'my master'.

Jabir had a close relationship with the Barmakids, the ministers of the Abbaside caliphs. Ja'far al-Barmaki, the minister, introduced Jabir to the Caliph Harun al-Rashid, for whom Jabir composed a treatise on alchemy. After the misfortune of the Barmakids in 187/803 Jabir resided in Kufa in seclusion until he died. It is reported that a copy of *Kitab al-rahma* was found under his pillow when he died.

Eric John Holmyard, the historian of chemistry, is credited with investigating the historical identity of Jabir, in elucidating his high standing and in indicating his contribution to developing alchemy into an experimental science. Holmyard considered that Jabir's importance in the history of chemistry is equal to that of Boyle and Lavoisier.[16]

Ibn al-Nadim in his *Fihrist* gave a list of Jabir's works. He relied on two of the three catalogues prepared by Jabir himself for his works. One of these catalogues listed all Jabir's works, while the other gave only his works on alchemy. Ibn al-Nadim says that he selected from the two catalogues those books which he had actually seen or which were testified for him by trusted scientists.

The number of books attributed to Jabir is great. Paul Kraus gave a detailed account of those works, which he was able to investigate whether extant, or not. Later, Sezgin added to Kraus's list a number of newly discovered titles.

The fame of Jabir is due mainly to his works on alchemy, but he also wrote on industrial chemistry, as we shall see in Chapters 5 and 6, as well as medicine, physics, mathematics, philosophy and all branches of sciences that were known at this time.

Kraus and Ruska investigated the works attributed to Jabir, and they believed that Jabir wrote some of them, while the remainder were written by others and were attributed to him. They thought that the complete Jabirian corpus was written between the 2nd/8th, and the 4th/10th centuries.[17]

It seems that the most important works of Jabir are the following:

16. Holmyard, Eric John, 'Jabir Ibn Hayan', *Proc. of the Royal Society of Medicine*, Section History of Medicine, vol. 16, 1923, pp. 46–57, reproduced by Fuat Sezgin, in *Jabir Ibn Hayyan, Texts and Studies*. Vol. I (*Natural Sciences in Islam*. 69), Frankfurt, 2002. In the same volume see also Holmyard's article: 'The identity of Geber' (1923).
17. A good discussion about Jabir and the assumptions of Kraus and Ruska is given by Sezgin, 1971, and he refuted them.

1. The collection of the *One Hundred and Twelve Books*. There are some extant books from this collection, but the majority of titles are still missing.
2. The *Book of Seventy*.[18] Several of the articles in this book were translated into Latin and they are known as the *Septuaginta*.[19] The Arabic original was missing until the first two decades of the 20th century.
3. The collection of the *Balance Books*, consisting of 144 treatises of which few are extant.
4. The collection of the *Corrections Books*, consisting of ten treatises about the works of ancient authors and of some contemporary ones including Jabir himself. One treatise only has survived (*Musahhahat Iflatun*), and we know about some others through citations by various authors.
5. *The Great Book of Properties* (*Kitab al-Khawass al-Kabir*).

This list does not represent all of Jabir's important works. Most of the extant works are not studied and are still in manuscript form; the greater part is still missing and some more titles may be found.

There are at least seven Latin treatises that carry the name of Geber (Jabir's Latin name) for which the Arabic originals are not yet identified. This gave some western historians of alchemy and chemistry the occasion to ascribe them to pseudo Latin authors. We have discussed this question in Chapter 3.

Dhu al-Nun

Dhu al-Nun, Abu al-Fayd Thuban Ibn Ibrahim al-Misri (d. 246/861) was a Sufi mystic from Egypt, and a master of asceticism and self-discipline. He was one of the earliest Sufis and influenced its development; and was involved in medicine, alchemy and magic. As a mystical alchemist, he was much quoted by Ibn Umayl and several later alchemists. Ibn al-Nadim listed some of his works. Stapleton discovered eight of his alchemical treatises.

Abu Bakr al-Razi

Al-Razi was the greatest Arabic alchemist after Jabir. He was also one of the greatest physicians in Islam and was an accomplished philosopher. He is known as Rhases in Latin and like Jabir (Geber), he influenced greatly the

18. Jabir Ibn Hayyan, 1986.
19. Berthelot, 1906.

development of Latin alchemy. His influence on the development of Latin medicine was immense.

Abu Bakr Muhammad Ibn Zakariyya al-Razi was born in Rayy in present Iran about 251/865 and died in 313/925. He received his education in Rayy, and later directed his attention to medicine and excelled in it.

In his earlier years, before turning to medicine, he devoted his attention to alchemy, gaining prominence in it, and wrote several important works. Al-Razi was renowned for his brief practical recipes and descriptions of materials and apparatus. His writings are of experimental nature and are considered as an important step in the direction of modern chemistry.

There are thirteen known Arabic treatises on alchemy for al-Razi, some of which are extant, and nine treatises in Latin. Among the renowned extant Arabic treatises are *Kitab al-asrar*, *Kitab sirr al-asrar*[20] and *Kitab al-madkhal al-ta'limi*.[21] One of the missing treatises is *Kitab ithbat al-san'a wa al-radd 'ala man ankaraha* (a book on proving the Art and a refutation of those who deny it).

Ibn Wahshiyya

Ibn Wahshiyya is Abu Bakr Ahmad Ibn 'Ali Ibn Qays Ibn Wahshiyya. He lived in the 3rd/9th century, and was active in alchemy, astrology and agriculture, among other things.

The most important of his works is undoubtedly *K. al-filaha al-nabatiyya* on agriculture as it was practised in Mesopotamia before Islam. About eight treatises on alchemy are attributed to him, the most prominent of which is *Kitab al-usul al-kabir*, also known as *Usul al-hikma*.

Ibn Umayl

Ibn Umayl was one of the foremost allegorical, philosophical and spiritual alchemists. His works are of interest in the analytical psychology of Carl Jung.[22]

Abu 'Abd Allah Muhammad Ibn Umayl al-Tamimi lived in Egypt in the first half of the 4th/10th century. One of his Latin names is Senior Zadith filius Hamuel. He wrote several treatises and poems on alchemy. The most important of his poems is *Risalat al-shams ila al-hilal* (The message of the sun to the crescent),[23] which was translated into Latin under the title *Epistola solis ad lunam*. This poem was explained by the author himself in his treatise *Kitab al- ma' al-waraqi wa al-ard al-najmiyya* (The Silvery Water and the Starry Earth), which is known in Latin as *Tabula Chemica*.

Abu Maslama al-Majriti

Abu Maslama Muhammad Ibn Ibrahim Ibn 'Abd al-Da'im al-Majriti was from Majrit (Madrid) in Muslim Spain. He lived in the first half of the 5th/11th century. He is not the same person as Abu al-Qasim Maslama Ibn Ahmad al-Majriti, the mathematician, who died in 398/1008. The confusion arose because of the similarities in their names.[24]

Abu Maslama wrote several works on alchemy and magic. His most important work on alchemy is *Kitab rutbat al-hakim wa madkhal al-ta'lim* (The Rank of the Sage and the Introduction to Learning). This work gives accurate information on the purification of gold and silver, and describes several accurate chemical operations.[25]

The second important book of Abu Maslama is *Ghayat al-hakim* (The Goal of the Sage), which is a work on magic and one of the most important books ever written on astrological magic. It was translated into Spanish and then into Latin. The Latin treatise carries the title *Picatrix* and occupies a unique place in the Latin literature on magic.

Al-Tughra'i

Mu'ayyid al- Din Abu Isma'il al-Husayn Ibn 'Ali al-Tughra'i was a great poet and an accomplished alchemist. He entered the service of Saljuqids at the time of Malik Shah and went on to become chief secretary under that ruler's son, Muhammad I. He was the second most senior official in the civil administration of the Saljuqid Empire. During a struggle for power among the Saljuqid princes, he was executed in 516/1122, unjustly according to historians.

As an alchemist, al-Tughra'i was a prolific writer. One of his most interesting works appears to be *Kitab Haqa'iq al-istishhad* (The Truths of Citations), a response to Ibn Sina's refutation of alchemy. Another important work is *Kitab mafatih al-rahma* (The Keys of Mercy).

Al-Jildaki held great esteem for al-Tughra'i and considered him to be next to Jabir only as an alchemist. He always referred to him as the Martyr.

20. These two books were published in Tehran. See bibliography.
21. Stapleton *et al.* 1927.
22. Jung, 1952; Von Franz, 1981.
23. H.E. Stapleton; M.H. Husein: Report on the Mâ' al-Waraqî (1932); and H.E. Stapleton; M.H. Husein: Three Arabic treatises on alchemy by Muhammad Ibn Umail, (1933). Both reprinted by Fuat Sezgin in *Ibn Umayl (fl. c. 912). Texts and Studies* (*Natural Sciences in Islam.* 75), Frankfurt, 2002.
24. Sezgin, 1971, p. 295.
25. Holmyard. 1990, pp. 101–2.

Ibn Arfa' Ra's

Abu al-Hasan 'Ali Ibn Musa al-Jayyani al-Andalusi, better known as Ibn Arfa' Ra's, lived in Fas and died there in 593/1197. He was an allegorical alchemist like Khalid Ibn Yazid, Ibn Umayl and al-Tughra'i, and became renowned because of his eloquent alchemical poem, *shudhur al-dhahab* (nuggets of gold), which is composed of 1460 verses in *rajaz* form which covered all letters of the alphabet. Ibn Arfa' Ra's wrote a treatise in which he explained his poem. Others also wrote treatises in its explanation including al-Jildaki.

Abu al-Qasim al-'Iraqi

Abu al-Qasim Ahmad Ibn Muhammad al-'Iraqi al- Simawi lived in the middle of the 7th/13th century. One of his most important works is *Kitab al-'ilm al-muktasab fi zira'at al dhahab* (Book of Knowledge Acquired Concerning the Cultivation of Gold) which was edited, translated and published by Eric John Holmyard.

Al-Jildaki

'Izz al-Din Aydamir Ibn 'Ali al-Jildaki had lived in both Cairo and Damascus, and died in Cairo in 743/1342. He is considered one of the prominent Arab alchemists. His importance, however, is due to his most extensive volumes of explanations and commentaries on the works of those alchemists who preceded him such as Jabir, Ibn Umayl, Ibn Arfa' Ra's, al-Tughra'i, Dhu al-Nun, Abu al-Qasim al-'Iraqi and others. He quoted extensively from the works of his predecessors both pre-Islamic and Arab. It is possible to write a complete history of Arabic alchemy by studying his works alone.

Al-Jildaki says that he spent seventeen years in studying all works on alchemy before embarking on writing his books, and during this period, he visited several Islamic countries and met the most prominent alchemists there.

Al-Jildaki's works give us very important information on some of those earlier Arabic alchemical works whose originals were lost. He wrote no less than twenty-five books some of which are in several voluminous tomes: *Kitab nihayat al talab*, which is one of his most important works, was studied in a PhD thesis.[26] However, the majority of his other works have not yet been investigated.

26. Taslimi, M., PhD Thesis University of London, 1954 (written at University College London, under Holmyard).

LATER ALCHEMISTS

Interest in alchemy continued in Islamic lands until later centuries. Limitations of space do not allow us to give a due account of later activities. One of the most important alchemists after al-Jildaki was 'Ali Bek al-Izniqi (from Izniq in Anatolia) who was known as 'Ali Chelebi or al-Mu'allif al Jadid (the New Author). He lived in the 9th/15th century and left important works that can be quite useful in any study of Arabic alchemy.

One of the later alchemists who also left serious works was Hasan Agha Sirdar who was from Jirja in Upper Egypt and lived in the 11th/17th century.

THE DEBATE ABOUT THE VALIDITY OF THE ART

The debate about the validity of al-San'a (the Art) and the possibility of the transmutation of base metals into gold started from the beginning of Arabic alchemy. Among the great Islamic scientists and philosophers who denied the possibility of transmutation were al-Kindi, Hunayn Ibn Ishaq, al-Biruni, Ibn Sina, Ibn Khaldun and several others. It seems that the debate was acute before and at the time of Jabir Ibn Hayyan. This prompted Jabir to write a treatise in defense of the Art under the title: *Al-Burhān wa ithbāt al-san'a* (The Proof and the Verification of the Art). Al-Kindi wrote a treatise against the Art with the title: *Ibtal da'wa al mudda'in san'at al-dhahab wa al-fidda min ghayr ma'adiniha* (refutation of the claim of those who allege that gold and silver can be made from other than their minerals). Al- Jildaki gave a detailed account of this debate in *Kitab nihayat al-talab*. There is a fuller discussion of this debate in Chapter 3.

THE THEORY OF ARABIC ALCHEMY

Most people dismiss alchemy as the false Art of transmuting base metals, such as tin and lead, into silver and gold. This view may be contrasted with the notion of some modern historians of science and chemistry who assert that alchemy was never anything different from chemistry and that it was essentially the chemistry of the Middle Ages.[27]

According to alchemical theory, all forms of matter are one in origin; and are transmutable. These views bear a close resemblance to those of modern physical science. Indeed modern science has shown the possibility

27. Read, 1995.

of bringing about many transmutations of elements. Nuclear experiments have successfully transmuted lead into gold, albeit at great cost.

The sulphur–mercury theory was the basis upon which the alchemy of Jabir was based. This theory appears to be a derivative of the Aristotelian theory that matter was composed of the four elements of earth, air, fire, and water.

Balinas, and Jabir after him believed that, under the influence of the planets, metals were formed in the bowels of the earth by the union of sulphur (which would provide the hot and dry natures) and mercury (providing the cold and moist).[28] This theory, which was adopted and generalised by Jabir, and which appears to have been unknown before Balinas, is generally considered as one of Jabir's principal contributions to alchemical thought.

The reasons for the existence of different kinds of metal are that the sulphur and mercury are not always pure, and that they do not always unite in the same proportion. If they are perfectly pure, and if they combine in the most complete natural equilibrium, then the product is the perfect metal, namely gold. Defects in purity and, particularly in proportion, result in the formation of silver, lead, tin, iron, or copper; but since these inferior metals are essentially composed of the same constituents as gold, the accidents of combination may be rectified by suitable treatment. Such treatment, according to Jabir, is to be carried out by means of elixirs.

This concept that the metals are composed of mercury and sulphur was generally accepted by later generations of alchemists and chemists and remained a part of alchemy and chemistry even into the 18th century. The idea of the presence of an inflammable principle, sulphur, in metals and indeed in almost all bodies, is the ancestor of the notion of phlogiston.

The sulphur-mercury theory is related to the two exhalations concept of Aristotle. One of these vapours, given off by the earth under the influence of the sun, was hot and fiery, dry and gaseous, the other moist, cool and aqueous. The former generated the idea of the sulphur component, the latter that of mercury. The two exhalations concept and its relationship to the sulphur-mercury theory is elaborated in several Arabic treatises such as those of Balinas, Jabir (including the Latin work *Summa Perfectionis*), Ikhwan al-Safa, Ibn Sina, al-Tughra'i, al-Jildaki and others.

It is of interest to give one Arabic text outlining the theory of alchemy. Appendix 2 is an edited text based on Holmyard's translation of *al-'Iraqi's Kitab al-'ilm al-muktasab fi zira'at al dhahab* (*Book of Knowledge Acquired Concerning the Cultivation of Gold*).

28. See Chapter 3 in the present volume for a detailed discussion.

APPENDIX 1 PROCESSES IN ALCHEMICAL AND CHEMICAL PRACTICE

Al-Razi's entire scheme of work did not differ from that of Jabir and other Arab alchemists and it is summarised as follows:[29]

1. Cleansing and purification of the substances is performed by means of (a) distillation, decantation or filtration (Taqtir): (b) the use of the descensory (Istinzal): (c) assation (or roasting – Tashwiyah) ; (d) coction (or digestion – Tabkh) ; (e) amalgamation ; (f) lavation ; (g) sublimation ; and (h) calcination; the last-named being used only in the case of metals and stones. Calcination included rusting; and another process – allied apparently to both calcination and lavation – was Taswil (a word which may be translated as lixiviation).
2. Having freed the crude materials from their impurities, the next step was to reduce them to an easily fusible condition. This was done by a process known as ceration (Tashmi), which resulted in a product which readily melted, without any evolution of fumes, when dropped on a heated metal plate.
3. The next step was to bring the cerated products to a further state of disintegration by the process of solution (Hall).
4. Solutions of different substances, suitably chosen in proportion to the amount of Body, Soul and Spirit they were supposed to possess, were brought together by the process of combination (Tamzij). Sometimes, however, admixture of solutions was replaced by trituration with various liquids, followed by either assation or ceration but al-Razi expressly mentions .that combination of solutions is the best.
5. Finally the combined solutions underwent the process of coagulation (`Aqd), the product that resulted being the elixir. This was a substance of which a small quantity, when projected (tarh) on a larger quantity of baser metal, was believed to be capable of converting it (by a process analogous to fermentation) into silver, or if silver was used, of converting it into gold.

29. Al-Razi, 1964.

APPENDIX 2 THE THEORY OF ALCHEMY ACCORDING TO AL-'IRAQI

1 Metallic Minerals Are One Species

Know, may GOD have mercy on thee that the materials used in the Art of Chemistry are of one species essentially. They are called the metallic minerals and subdivided into six sorts varying in form and in properties, but not immutable, as are individual animals and plants.

They are gold, silver, copper, iron, lead and tin. Each of them is marked off from the others by accidental distinguishing properties, and it should be possible to effect the necessary removal of these properties, the specific nature remaining constant.

We say and maintain that two species of natural things which differ radically and essentially cannot be changed and converted one into the other by the Art as, for example, man and the horse. However, these six bodies can be mutually converted.

It is possible (for example) for a part of the lead to be changed into silver. In the same way silver may be converted into gold. But if silver differed from gold in species it would not be possible to convert it into it, just as it is impossible to convert a horse into the human species by the Art, because they differ radically and essentially.

These six metallic forms are all of one species, distinguished from one another only by differentiating accidental qualities; their extreme limit is reached when they become gold. Now that which is free from any accidental quality is gold, while what possesses these becomes either silver or the two leads if it has the quality of coldness, or copper or iron if it has the quality of hotness. And these six forms of a single species are similar merely to health and fever in man. When the fever is treated so that it departs and the man returns to freedom from disease, he regains the most perfect state of health.

2 Removing the Accidental Qualities

Know, may GOD, the Most Exalted, have mercy on thee that we began by saying that these six forms are all gold by species, and gold is their limit. Now that which is composed in the right proportion quantitatively, and in agreement therewith, in the right proportion qualitatively, and whose nature has reached its highest point, has become gold; while that in which the qualitative (composition) is varied comes forth from the ore in the state of imperfection.

But the quantitative (composition) of these six individuals does not vary; for this composition in them depends upon moistness and dryness, whereas the qualitative composition depends upon hotness and coldness.

Now the moistness and dryness of which minerals are composed are nothing but watery steam and earthy smoke, and if compounded together in right proportion, they give rise to these six metallic substances. However, if the dryness, that is, the smoke, is in too great proportion, then are formed brittle stones such as the marcasites, magnesia, tutias, and the stones related to the mineral substances from kuhl and zarnikh, etc. If the moistness, that is the steam, is in too great proportion, mercury and nothing else will result. This occurs only in particular districts of the earth in places that are very near to equilibrium, that is, equilibrium of climate.

Hence, it has been established that the quantitative composition of these six metallic substances is constant. Understand this, therefore, and know that the cause of the existence of gold is nothing but the equilibrium of the hotness and coldness, and that the reason why the rest of the six substances fall short of being gold is excess either of hotness or of coldness.

When scientists considered these six ductile mineral substances and found them to be of one species, part imperfect and part perfect, and when they found imperfect ones in the ores of the perfect, they knew that the difference between them was only qualitative. They found that the accidental qualities which marked off one from another were only distinguishing unessential qualities which could be removed by means of a proper remedy.

And they said: One of the two following things is necessary: (a) that we remove the accidental properties of these five substances by the fire; or (b) that we make a compound which if projected upon them will perfect in them that which is imperfect, and remove from them what is in excess of equilibrium or falls short thereof.

Now if we use fire alone, it must be either violent or gentle; and the time of each of these fires must be either long or short.

When silver is placed in a light fire, no success is acquired by a short action, but a long period is necessary – even to years: a thing which human nature makes difficult.

So there is no benefit at all to the silver neither by a long action nor by a short one. A long action is difficult, and life is too short for it. Also, a short action does not succeed. Moreover, when silver is placed in a violent fire, if the time is shorter than necessary there is no success. While, if time is long, it is certainly tinctured in the fire and is strengthened, but only after removal of the greater part, and so small a part is left that it was not worth transmuting it into gold on account of the loss incurred and the outlay required. Thus, there is no advantage in converting silver into gold by fire alone.

[The author gives then the same argument for copper, iron and the two leads.]

When this made itself clear to scientists, necessity drove them to make a compound from a single drug, or from drugs either differing in species, or differing in form, but nevertheless included in a single species essentially, though not relatively. And they made two Elixirs, one of them for whiteness and the other for redness, fusible, miscible, soluble, permeating, stable and assimilable. For if there be no fusion there can be no mixing, and if there be no mixing there can be no assimilation, and if there be no assimilation there can be no solution, and if there be no solution there can be no permeation, and if there be no permeation there can be no stability in the fire. And if one of these qualities is lacking the combination is ruined, and if the combination is ruined then the Art is vain.

It is necessary that one of the Elixirs should be hot and red, in order that it may remove the quality of coldness and may tincture the substance with its colour, red; and the second cold and white, to remove the quality of hotness and to tincture the substance with its colour, white. Therefore, upon whatever of these (metallic) forms the elixir is projected, it dissolves in it with effervescence, and will be an aid to the fire in shortening the operation. It will be such a substance that it removes the accidental qualities, and at the same time preserves the (metallic) form and the equilibrium of its moistness with its dryness.

Now to whatever of these (metallic) forms is cold, is added the hot Elixir, and it heats it and tinctures it red; while to those which are hot with a heat in excess of equilibrium is added the white Elixir, and it cools them and tinctures them white, and gives equilibrium to their constitution which was disordered.

For that which renders necessary the heating of these (metallic) forms in the refining fire is only the qualitative variation; thus there occur among them the soft and the hard, the heavy, and the light.

As for silver, the Elixir of Redness when projected upon it fixes it not by its heaviness but by its stability and ready fusibility and by protecting it from the fire. Thus the fire is able to accelerate the action, completes the maturing of the silver, fixes it, and tinctures it, and it becomes gold when the lightness and whiteness have disappeared from it. For the whiteness in silver is the necessary consequence of the coldness and small degree of maturing, and when the cause disappears there disappears with it the effect. Understand that, therefore, for it is one of the foundations of this Art, and the

Sages one and all were very jealous of it even with their sons, and more so with the rest of men.

As for the two leads, that which prevents them from being silver is only their coldness, which is in excess of that of silver. Their constitution is rendered imperfect by the paucity of their hotness and maturing.

And since it is known that the Elixir of Whiteness is hotter than the two leads, in the same way that the hotness of silver is greater than that of the two leads, then the Elixir of Whiteness may be projected upon the two leads. It will increase them in hotness and cohesion until it transforms them into the just proportion of silver and its hotness, which falls short of gold and goes beyond the two leads.

Thus, the Elixir of silver is not excessively cold, and the Elixir of gold is not excessively hot.

The two coppers, as far as concerns their relationship to gold and silver, are hotter and drier than the latter. Now things will strengthen their like and weaken their opposite, so that if the Elixir of Redness is projected upon the two coppers, it increases them in heat and dryness, and converts them into powders from which no advantage whatever can be gained. It is therefore necessary that the Elixir of silver should first be projected upon them, to moisten them and cool them and convert them into silver: if the Elixir of gold is then projected upon them it will convert them into gold, after their transformation into silver. So understand that and think thereon.

These bodies change at first only into the form of silver, and then into gold; and this follows uniformity of specific nature, for what is right for any one of all these forms is right for the others, since they are all varieties of the metallic mineral.

When the Elixir is projected upon mercury it coagulates it not to a hard mineral but to an elixir in the form of powder, such that when it is projected upon a mineral form of an imperfect degree it makes it reach perfection of the species.

Understand, therefore, the hidden things of the secrets of this Art, and thou wilt attain to a high degree, if GOD, the Most Exalted, will.

And Know, may GOD the Exalted have mercy upon thee that I intended, in composing this prologue in two sections, only to guide aright him who looketh into this book of mine. For every Art must have given materials upon which it is based, and we found that materials of this Art are these six substances, – nay, five rather, since gold, even if it is of their number, is perfect, and the Art of Chemistry was founded only to raise the remaining substances to its level. I have treated the whole matter thoroughly, in order that the reader may easily enter their town, speak their language, know their Art, and copy their royal and philosophical procedure. And from

GOD – may He be exalted and magnified – I ask aid and guidance and right direction to the Path, by His grace and munificence. Verily, He is powerful over whatsoever He willeth.

BIBLIOGRAPHY

Berthelot, M. (1893) *La Chimie au Moyen Age*, vols I, II and III, Paris.

Berthelot, M. (1906) *Archeologie et Histoire de Sciences*, pp. 310–63.

Forbes, R.J. (1955) *Studies in Ancient Technology*, vol. III, p. 188.

Halleux, Robert (1996) 'The reception of Arabic alchemy in the West', *Encyclopedia of the History of Arabic Science: Volume III*, ed. Roshdi Rashed and Regis Morelon, Routledge, pp. 886–902.

Hashimi, Muhammad Yahya (1958) *Al-Imam Ja'far al-Sadiq mulhim al-kimya''*, Aleppo.

Al-Hassan, Ahmad Y. *et al.* (2002) *Science and Technology in Islam,* Vol. 4, Part 2, of the multivolume work on *The Different Aspects of Islamic Culture*, UNESCO.

Al-Hassan. Ahmad Y. (2004) 'The Arabic Original of *Liber de compositione alchimiae* – The Epistle of Maryanus, the Hermit and Philosopher, to Prince Khalid Ibn Yazid', *Arabic Sciences and Philosophy*, 14: 213–31 Cambridge University Press.

Holmyard, Eric J. (1990) *Alchemy*, Dover.

Holmyard, Eric J. (1923) 'Jabir Ibn Hayan', *Proc. of the Royal Society of Medicine*, Section History of Medicine vol. 16.

Ibn al-Nadim (no date) *Kitab al-fihrist*, Arabic edition, Cairo.

Al-'Iraqi (1923) *Kitab al-'ilm al-muktasab fi zira'at al-dhahab*, *Book of Knowledge Acquired Concerning the Cultivation of Gold*. Edited with a translation and introduction by E.J. Holmyard, reprinted by Fuat Sezgin, Vol. VII (*Natural Sciences in Islam*. 61), Frankfurt, 2001.

Jabir Ibn Hayyan (1936) *Kitab al-Rahib, Mukhtarat Jabir Ibn Hayyan*, edited by Paul Kraus, Cairo, p. 529.

Jabir Ibn Hayyan (1986) *Kitab al-sab'in*, reproduced by offset, Fuat Sezgin, Frankfurt.

Al-Jildaki (n.d.) *Nihayat al-talab fi sharh al-muktasab*, MS Berlin 4184.

Jung, C.G. (1952) *Psychologie und Alchemie*, Zurich.

Kraus, P. (1934, 1942), *Jabir Ibn Hayyan, Contribution à l'histoire des idées scientifiques dans l'Islam*, Vol. I; Le corpus des écrits Jabiriens, Kairo 1934; Vol. II, Jabir et la science grecque, Kairo, 1942.

Leicester, Henry M. (1956) *The Historical Background of Chemistry*, New York.

Levey, Martin (1959) *Chemistry and Chemical Technology in Ancient Mesopotamia*, Elsevier.

Multhauf, Robert (1966) *The Origins of Chemistry*, London.

Plessner, M. (n.d.) 'Hirmis', in *Encyclopaedia of Islam* (*EI*), New Edition, Brill, on CD-ROM.

Al-Razi (1964) *Kitab al-asrar* and *Kitab sirr al-asrar*, edited by Muhammad Taqi Danishpazhuh, Tehran, 1343.

Read, John (1995) *From Alchemy to Chemistry*, Dover.

Rulandus, Martinus (1612) *A Lexicon of Alchemy*, translated by A.E. Waite, London, 1964. Reproduced by Kessinger, USA.

Ruska, Julius (1924) *Arabische Alchemisten*. I. *Châlid Ibn Jazîd Ibn Mu'âwija.* Reprinted by Fuat Sezgin, *Natural Sciences in Islam*, 59, Frankfurt, 2001.

Sezgin (1971) *Alchemie-Chemie-Botanik-Agrikultur bis ca 430 H.* [*Geschichte des arabischen Schrifttums*, vol. IV] (Leiden: E.J. Brill). Also: the Arabic edition, translated by 'Abd al-Allah Hijazi, King Sa'ud University, 1986.

Siggel, Alfred (1950) Arabisch-Deutsches Worterbuch der Stoffe, Berlin .

Stapleton. H.E. (1953–56) 'The Antiquity of Alchemy', *Ambix*, vol.5, pp. 1–43.

Stapleton, H.E., Azo, R.F. & Husain, M.H. (1927) 'Chemistry in Iraq and Persia in the tenth century A.D.', *Asiatic Society of Bengal Mem.*, Vol. 8, pp. 315–418.

Stillman, John Maxson (1960) *The Story of Alchemy and Early Chemistry*, Dover.

Al-Tughra'i (1982) *Haqa'q al-istishhad*, Baghdad.

Ullmann, Manfred (1972) *Die Natur und Geheimwissenschaften im Islam*, Leiden.

Von Franz, Marie Louise (1981) *Alchemy*, Inner City Books.

2 The Arabic Original of *Liber de compositione alchimiae*

رسالة مريانس الراهب الحكيم للامير خالد بن يزيد

The Epistle of Maryanus, the Hermit and Philosopher, to Prince Khalid ibn Yazid

Liber de compositione alchimiae or *The Book of the Composition of Alchemy* is believed to have been the first book on alchemy that was translated from Arabic into Latin. The translator was the Englishman Robert of Chester who was one of the earliest translators to flock to Spain to learn Arabic and to translate some of the Arabic works. He completed his translation on 11 February 1144.

With the translation of this book, Europe was acquainted with alchemy for the first time. Thus, Robert writes in his preface to the translation, 'Since what Alchymia is, and what its composition is, your Latin world does not yet know, I will explain in the present book.'[1]

Alchemy remained something rather new to Europe until more than a century later. Thus in 1267 Roger Bacon writes in his *Opus tertium* (explaining to the pope the rightful role of the sciences in the university curriculum and the interdependence of all disciplines):

> But there is another science which is about the generation of things from the elements, and from all inanimate things, of which we have nothing in the books of Aristotle; nor do natural philosophers know of these things, nor the whole Latin crowd of Latin writers. And since this science is not known to the generality of students, it necessarily follows that they are ignorant of all natural things that follow there from … And this science is called *theoretical alchemy*, which theorizes about all inanimate things and about the generation of things from the elements.[2]

Liber de compositione alchimiae acquired a prominent place in the Latin alchemical literature. The names of Maryanus (Morienus)[3] and Khalid

1. McLean, Adam, *The Book of the Composition of Alchemy*, Glasgow, 2002. p. 5.
2. Roger Bacon, quoted by John Maxson Stillman, *The Story of Alchemy and Early Chemistry*, Dover, 1960. pp. 262–3.
3. Although we do not know much about the life of Maryanus from reliable sources, yet we can paint a reasonably good picture of him. From the text of the dialogue's treatise, we learn that Maryanus was a hermit living in the mountains near Jerusalem. We also learn that he was a follower of Melkite Christianity. His dialogue with Prince Khalid was conducted in Arabic, which implies that he was an Arabic-speaking monk. We learn also that the encounter between Maryanus and Khalid took place in Damascus. From these facts and from the

(Calid) became well known to all alchemists in Europe. Their importance in alchemy matched that of al-Razi (Rhazes), Ibn Sina (Avicenna) and Jabir (Geber).

A large number of Latin manuscripts have survived. These were classified into several categories.[4] Five contain the original Latin text that was not altered by later editors. Two of these unedited manuscripts go back to the 13th century. They are the Glasgow Hunterian Library MS 253, 46r–53v, and the Paris Bibliothèque Nationale MS Lat. 7156, 197r–201v. They include the story, as told by Ghalib the *mawla* (client) of Khalid, which relates how Khalid and Maryanus (Morienus) came to meet each other. This is followed by the dialogue between the two.

All the other numerous Latin manuscripts contain a revised dialogue. Some contain a preface by Robert of Chester, and some have an additional speech by Morienus. The various parts were printed for the first time in 1559 in Paris. The printed edition contains the preface of Robert of Chester, the speech of Morienus, the revised account of Ghalib, and the revised dialogue. The Latin title translates as: 'Booklet of Morienus Romanus, of old the Hermit of Jerusalem, on the Transfiguration of the Metals and the Whole of the Ancient Philosophers' Occult Arts, Never Before Published'.[5] The same publisher issued a second edition in 1564. The text of the Paris editions was printed in 1572 in a larger collection of alchemical texts published in Basel.[6] The Latin printed edition was translated into English, German and French.

The first English translation was done in the 17th century and is contained in a manuscript in the British Library, MS Sloane 3697. This is a translation of the Paris Latin edition of 1564. This translation was first

---

following account, we may assume that Maryanus was living near the Monastery of Mar Saba.

At that same time in history, St John of Damascus (675–*c*. 749) was a high official in the court of the Umayyads in Damascus. He was a Damascene from a Syrian family, and carried the family's Arabic name of Mansur. His father before him was also a high official in the service of the Umayyads. St John was a Melkite and he retired, probably in 726, to the monastery of Mar Saba near Jerusalem, Palestine. The ecclesial heirs of St John were also Arabic-speaking Melkites such as Theodore Abu Qurra, who wrote in Arabic. The Melkite Church was the first Near Eaastern church to adopt Arabic as its official language in about the 8th century. (For more information on Christianity in the early Muslim Empire see the numerous works of Sidney H. Griffith.)

4. Stavenhagen, Lee, *A Testament of Alchemy*, The University Press of New England, Hanover, New Hampshire, 1974, pp. 53–4, and Appendix I.

5. Morieni Romani, Quondam Eremitae Hierosolymitani, de transfiguratione metallorum et occulta, summaque antiquorum philosophorum medicina, Libellus, nusquam hactenus in lucem editus. Paris, apud Gulielmum Guillard, in via Iacobaea, sub diuae Barbarae signo. 1559.

6. Pernam, Petrus (ed.), Auriferae artis, quam chemia vocant, antiquissimi authores, sive Turba Philosophorum, Basilea, 1572, 2 vols.

published by Holmyard in 1925 in its 17th-century English.[7] Adam McLean published a recent edition in current English in 2002.[8]

In 1974, Lee Stavenhagen who published the Latin text on opposite pages to his translation undertook an English translation based on the oldest unrevised Latin manuscripts.[9]

As is customary with most historians of alchemy of the 19th and 20th centuries, such as Berthelot and Ruska, doubts were cast on the old established knowledge about the Latin translations of Arabic works. Thus the Latin works of Jabir were considered by Berthelot to be authored by a Latin Pseudo-Geber. The Morienus-Khalid dialogue did not escape a similar kind of judgment. Ruska who was a master in the art of considering most works to be written by pseudo authors, cast doubts about Robert of Chester's translation and on Khalid, Maryanus and their dialogue, and he came out with the conclusion that the whole Latin work was a compilation by an Italian Christian cleric possibly as late as the 14th century. Other scholars followed Ruska in this assumption.[10]

The curious thing is that Ruska knew about the existence of several citations in Arabic alchemical literature extracted from the Maryanus–Khalid dialogue, but this did not deter him from coming out with his conclusion. The Italian compiler, he assumed, should have known Arabic and he had interpolated some Arabic citations. Ruska did not know yet about the existence of the complete Arabic texts. This stresses again the fact that historians of science, however eminent and scholarly they appear to be, should not come up with sweeping conclusions based on the limited Arabic sources available to them.

Although Stavenhagen was also sceptical about Robert of Chester and his Latin translation, yet he became convinced that the work was 'certainly a translation from Arabic'. He arrived at his conclusion after he saw Holmyard's translation of *The Book of Knowledge Acquired Concerning the Cultivation of Gold* العلم المكتسب في زراعة الذهب of Abu al-Qasim al-`Iraqi.[11] This is in addition to the mention of Maryanus and Khalid in the

---

7. Holmyard, Eric, 'A Romance of Chemistry', a series of articles that appeared in *Chemistry and Industry*, Part I, Jan. 23, 1925, pp. 75–7; Part II, Jan. 30, pp. 106–8; part III, March 13, 1925, pp. 272–6; Part IV, 20 March 1925, pp. 300–1; Part V (printed IV by error), 27 March 1925, pp. 327–8. In this series of articles Holmyard published the full text of the 17th-century English translation of Ye Booke of Alchimye (Sloane MS. 3697).

8. McLean, op. cit.

9. Stavenhagen, op. cit.

10. McLean, op. cit. p. 3; .Ruska, Julius, *Arabische Alchemisten*, Wiesbaden, reprint, 1967, p. 48.

11. Abu 'l-qasim Muhammad Ibn Ahmad Al-'Iraqi, *Kitab al-'ilm al- muktasab fi zira'at adh-dhahab; Book of Knowledge Acquired Concerning the Cultivation of Gold*; the Arabic text edited with a translation by E. J. Holmyard. Paris: Geuthner, 1923.

commentary of Ibn Umayl on the *Book of the Silvery Water and Starry Earth* كتاب الماء الورقي والارض النجمية.[12] Stavenhagen did not know about the existence of the complete Arabic manuscripts of the Maryanus-Khalid dialogue.

There is no doubt about Khalid's place in the history of the Umayyad Caliphate. Ruska and others doubted whether he has engaged himself in alchemy. Sezgin gave enough historical evidence testifying that Khalid did actually work on this science.[13]

Jabir in *Kitab al-Rahib* reported on Khalid's relationship with Maryanus,[14] and citations from the dialogue were given by most succeeding Arab alchemists.

We have in the text of the dialogue itself strong evidence regarding the authenticity of the meeting between the two men. One is the mention of the words *mawla* and *mawali*. The *mawali* were non-Arab Muslim freemen. The system existed only during the Umayyad period, namely in the early period of the Arab rule in Syria, where Khalid lived. The *mawali* were assimilated during the Umayyad period and when the Abbasid caliphate arose, there was no distinction between Arab and non-Arab Muslims, and the word *mawla* ceased to be used.[15] This is one indication that the story of the dialogue was written during the Umayyad period.

There is also clear evidence of the correctness of the dates. Maryanus says that he became a hermit four years after the death of Hiraql (Heraclius), namely in 645. When he met Khalid he was a very old man according to Ghalib's story. We can assume that he was in his eighties and that he was in his thirties when he decided to become a hermit. This indicates that the meeting took place in the last decade of the 7th century or probably at the beginning of the eighth, when Khalid was an adult in his thirties. The historical dates are plausible and are in conformity with each other.

A further indication is apparent in the name of Maryanus itself. This name is written as Marianus in non-Arabic Western literature until modern times. This name was common among the followers of the Melkite church in Syria and Egypt that was loyal to the Byzantine emperors. The name was ancient Roman, well known to the Latins. If a pseudo-Latin writer had compiled the dialogue as was suggested by Ruska, he could not be ignorant of the name Marianos so as to deform it into Morienus, as he has done with all the Arabic names. On the other hand, the Arabic writer wrote the correct

12. Stapleton and Husain, Three Arabic Treatises on Alchemy by Muhammad Bin Umail, Arabic texts edited by M. Turab, *Asiatic Society of Bengal.* Calcutta, 1933, pp. 54, 84.
13. Sezgin, Fuat, *Geschichte des arabischen Schrifftums,* Vol. IV, Brill, 1971, pp. 120–5.
14. *Mukhtarat Jabir ibn Hayyan*, ed. Paul Kraus, Cairo, 1935, p. 529.
15. About the mawali see article MAWLA in EI, New Edition.

name as it was pronounced and written throughout the centuries until modern times.

Similarly several Arabic terms for substances were deformed when they were translated into Latin, again testifying to the Arabic origin of the Latin text.

The language of the Arabic text contains several Islamic expressions influenced by the language of the Qur'an. These same expressions were translated faithfully into Latin and consequently into English as can be seen by examining the texts that are presented here.

We can cite other examples testifying to the Arabic origin of the dialogue. It is doubtful that a Latin writer could have composed a text with such historical authenticity and full of so many Arabic terms and Islamic expressions.

Maryanus was a Melkite[16] as is attested by his title *Rumi* and by his allegiance to the Byzantine Emperor Hiraql (Heraclius). The word *Rumi* here describes a follower of this faith. The Melkite church is also known as *Rum Catholic* in Arabic. He was either a native of Palestine or Egypt. Melkites are usually the people of Syria, Palestine and Egypt who remained faithful to the Council of Chalcedon (451) when the greater part turned Monophysite. The word means *imperialist* and the root of the name is Semitic from *malka* in Syriac for king (*malik* in Arabic).

After the Arab conquests of the Near East in the 7th century, the native Christians of the various Christian churches were the main vehicle through which the various sciences and philosophy were translated from Greek, Syriac, Coptic and Persian into Arabic. Followers of the Melkite Church were among the first to adopt Arabic in their liturgy, earlier than the Coptic and the Maronite Churches. They were among the earliest translators of the sciences into Arabic.[17] Amongst the earliest Melkites to write in Arabic was Theodore Abu Qurra (740–820),[18] who refers to himself as a disciple of John of Damascus (d. 749), and al-Bitriq who lived during the caliphate of al-Mansur (754–775). Arabic was already in use as a language in Christian

16. Melkite: pertaining to the Greek Catholic Church. The expressions 'Room Katuleek' and 'Rumi Kathuliki' both literally mean 'Roman Catholic'. In these titles, Rome refers not to the City of Rome in Italy, but to the city of Constantinople. Constantinople was called the New Rome.
17. George Khoury, The Arabic Christian Literature, an article on the internet at http://www.al-bushra.org/arbhrtg/arbxtn0I.htm See also: Samir Khalil Samir, 'The Earliest Arabic Apology for Christianity (*c.* 750)', in Samir Khalil Samir and Jorgen S. Nielsen (eds.), *Christian Arabic Apologetics during the Abbasid Period (750–1258)* (Leiden: E.J. Brill, 1994), pp. 57–114.
18. See article Abu Qurra in *EI,* New Edition.

churches at the beginning of the 8th century:[19] The use of Islamic terms, as is used in the Maryanus-Khalid dialogue, was common among followers of the Christian churches when they started writing in Arabic. One of the Arabic Christian manuscripts from the 8th century contains so many Qur'anic expressions that the reader of this manuscript would think he was reading an Islamic text.[20] Maryanus lived in this period when Arabic was in use by Christian intellectuals and thus he was able to express himself freely in Arabic in his dialogue with Khalid. This also confirms the report of Ibn al-Nadim who mentions that Khalid ibn Yazid summoned a group of Greek philosophers who were versed in Arabic from Egypt and ordered them to translate books on *san`a* from Greek and Coptic into Arabic.[21] Greek philosophers in this case mean native scholars from Egypt who remained Christians.

In 1971, Sezgin published Vol IV of *Geschichte des arabischen Schrifftums*. It indicated the existence of complete Arabic manuscripts of the Maryanus Khalid dialogue.[22] Similarly in 1972 Manfred Ullman's *Die Natur und Geheimwissenshaften im Islam* was published, also giving similar information about the complete manuscripts.[23] Both furnished information about other Arabic works that gave citations from the dialogue.

Thus the question of the Arabic origin of the dialogue was settled. It was deemed necessary, however, to edit the Arabic text, to translate it into English and correlate it with the English translation of the Latin text.

The present chapter aims at this. The writer had sought to obtain copies of the two known Arabic manuscripts from the libraries of Istanbul, and he was fortunate to receive help.[24] These are Fatih 3227 (ff. 8b–18b) and Şehit Ali Pasha 1749 (ff. 61a–74b). The writer was also able to secure copies of several Arabic manuscripts that gave citations from the Maryanus-Khalid dialogue. The appendix gives a list of the Arabic sources available for this study, and a list of the manuscripts that were not available. It is believed that more Arabic sources may appear in future.

---

19. Rachid Haddad, 'La phonétique de l'arabe chrétien vers 700' in: Pierre Canivet and Jean-Paul Rey-Coquais (eds), *La Syrie de Byzance à l'Islam,* VII e–VIII e siècles (Damascus: Institut Français de Damas, 1992), pp. 159–64.
20. MS. Sinai Arabic 154, see Mark N. Swanson, 'Beyond Prooftexting: Approaches to the Qur'an in Some Early Arabic Christian Apologies', *The Muslim World* 88 (1998): 308–11.
21. Ibn al-Nadim, *Al-Fihrist*, Cairo, n.d., p. 352.
22. Sezgin, op. cit., pp. 111 and 126, and the Arabic updated version, Jeddah, 1986, pp. 163 and 188.
23. Ullmann, Manfred, *Die Natur und Geheimwissenshaften im Islam,* Leiden, 1972, pp. 192–3.
24. Professor Fuat Sezgin sent me copies on CD-ROM which was an invaluable help in editing the Arabic text. IRCICA in Istanbul sent another copy on microfilm.

The Arabic texts of Fatih and Şehit Ali Pasha are similar to each other with minor differences. The largest citation occurs in *Kitab al-shawahid fi al-Hajar al-wahid*, in BL MS add 23418. It was found that the text in this MS has been revised so that it deviates to some extent from that in Fatih and Şehit Ali Pasha.

The texts in Fatih and Şehit were compared with the two English translations mentioned earlier. It was found that the translation of Stavenhagen corresponds very well with the Arabic text of Fatih and Şehit. This result seems understandable because Stavenhagen opted to translate the oldest unrevised Latin text, whereas the 17th-century English translation published by Holmyard and McLean is based on the revised Latin text printed in Paris in 1564.

The English translation of Stavehagen and the Arabic text start with Ghalib's account and contain the dialogue. The Speech of Morienus is not part of the Arabic text nor of the earliest unrevised Latin text translated by Stavenhagen.

The last few pages of the English translation of the Latin text are not found in the Fatih and Şehit manuscripts. Investigation will continue to find the possible Arabic texts that correspond with these last few pages.

The account or prologue of Ghalib is reproduced in this article in Arabic followed by our English translation of this text, and then follows Stavenhagen's English translation of the Latin text. This will enable the reader to examine the correlation between the Arabic wording and the English translation of the Latin text. The important deviations between the Arabic and Latin text are indicated. The footnotes indicate some of the distortions of the Arabic names. There must have been errors in the Latin translation due to some ambiguity in the Arabic text or to the lack of understanding it. There is also sometimes a purposeful editing while the translator was undertaking his work. These will become apparent to the reader.

رسالة مريانس الراهب الحكيم للامير خالد بن يزيد

The Epistle of Maryanus, the Hermit and Philosopher,
to Prince Khalid ibn Yazid.
[A Testament of Alchemy][25]

***

بسم الله الرحمن الرحيم

In the name of God the merciful and compassionate

[In the name of the Lord, holy and compassionate[26]]

---

25. Stavenhagen's English translation of the Latin text follows our translation of the Arabic text, and is placed between square brackets.

[This is the story of how Khalid ibn Yazid ibn Mu'awiyya[27] came into possession of the spiritual riches handed down from Stephanos of Alexandria to Morienus, the aged recluse, as is written in the book of Ghalib, bondsman of Yazid ibn Mu'awiyya.

Now Ghalib was Yazid's faithful servant,[28] entrusted with all his master's possessions, and in time, it is said, became faithful servant likewise to Yazid's son Khalid.] [29]

***

قال غالب (مولى) خالد بن يزيد بن معاوية كان سبب وصول خالد إلى الصنعة الكريمة انه خرج ذات يوم متنزها إلى دير< برّان> بدمشق [30] وكان مغرما بالصنعة كلفا بها لا يوثر عليها شيئا وكان لا يفتر عن البحث فيها والتجربة <بها> والسؤال عما يعرض له فيها رجاء أن يصل إليها .

Ghalib the *Mawla* of Khalid ibn Yazid ibn Mu`awiya said that the reason behind Khalid's accomplishment of the noble art (*al-san`a al-karima*) is that he went one day on a picnic to Dayr Barran in Damascus. He was fond of the art (*al-san`a*), fascinated by it so that he would not give preference to anything else. He was constantly searching and experimenting with it and enquiring about what might come his way, hoping that he may arrive at it.

[Ghalib relates as follows how Khalid ibn Yazid ibn Mu'awiyya sought out Morienus the Greek,[31] who lived as a recluse in the mountains of Jerusalem. One day, Khalid went abroad to a place called Dirmanam.[32] He was assiduous in his quest for the Major Work,[33] continually enquiring after all those he assumed to be privy to this operation.]

---

26. This is a translation of the Muslim verse that precedes the start of any text. بسم الله الرحمن الرحيمThe word Lord is the ecclesiastic expression for God.
27. The names of Khalid, Yazid and Mu`awiya were distorted in the various Latin manuscripts. See Lee Stavenhagen, p. 2, notes 1 and 2.
28. Ghalib was a mawla and not a servant.
29. This is a short introduction to the Latin text.
30. Dayr Burran is most probably Dayr Murran in Damascus. It was on the lower slopes of Jabal Qasyun, overlooking the orchards of the Ghuta. It was a large monastery, and around it was built a village and, one presumes, a residence in which the caliphs could both entertain themselves and keep watch over their capital. Dayr Murran often figured in poems of the time. The Caliph Yazid I (father of Khalid) was staying there sometimes. Other caliphs and their representatives visited or lived there on various occasions (Soudrel, *E.I.* under Dayr Murran). Khalid, according to this text, used to stay sometimes at Dayr Murran as well.
31. Rumi here denotes a person from the Rum Catholic Church.
32. Dirmanam is a distortion of Dayr Murran; see note above.
33. The Major Work is al-san`a in Arabic الصنعة In the later Latin revised versions the word Magistery was used.

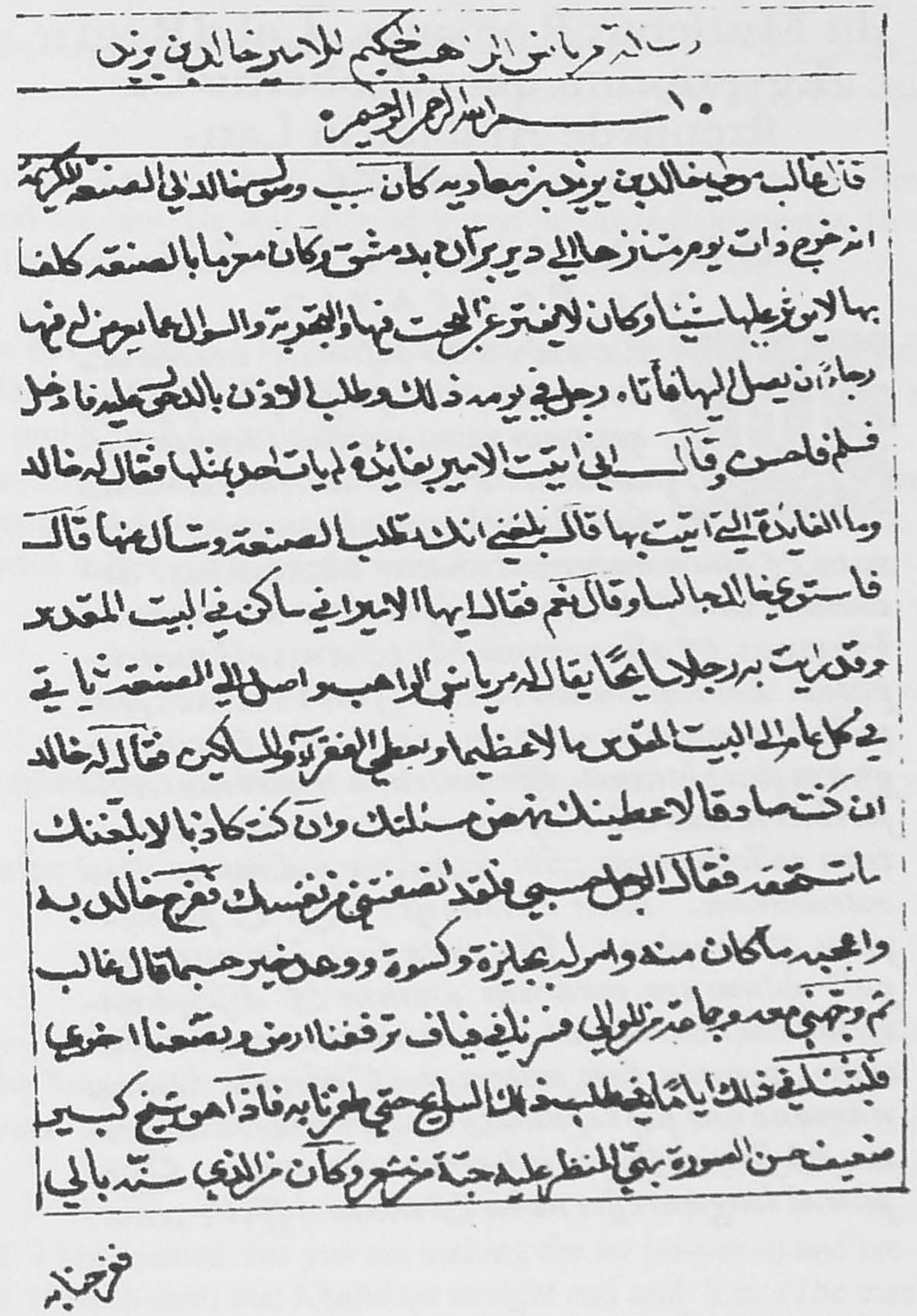
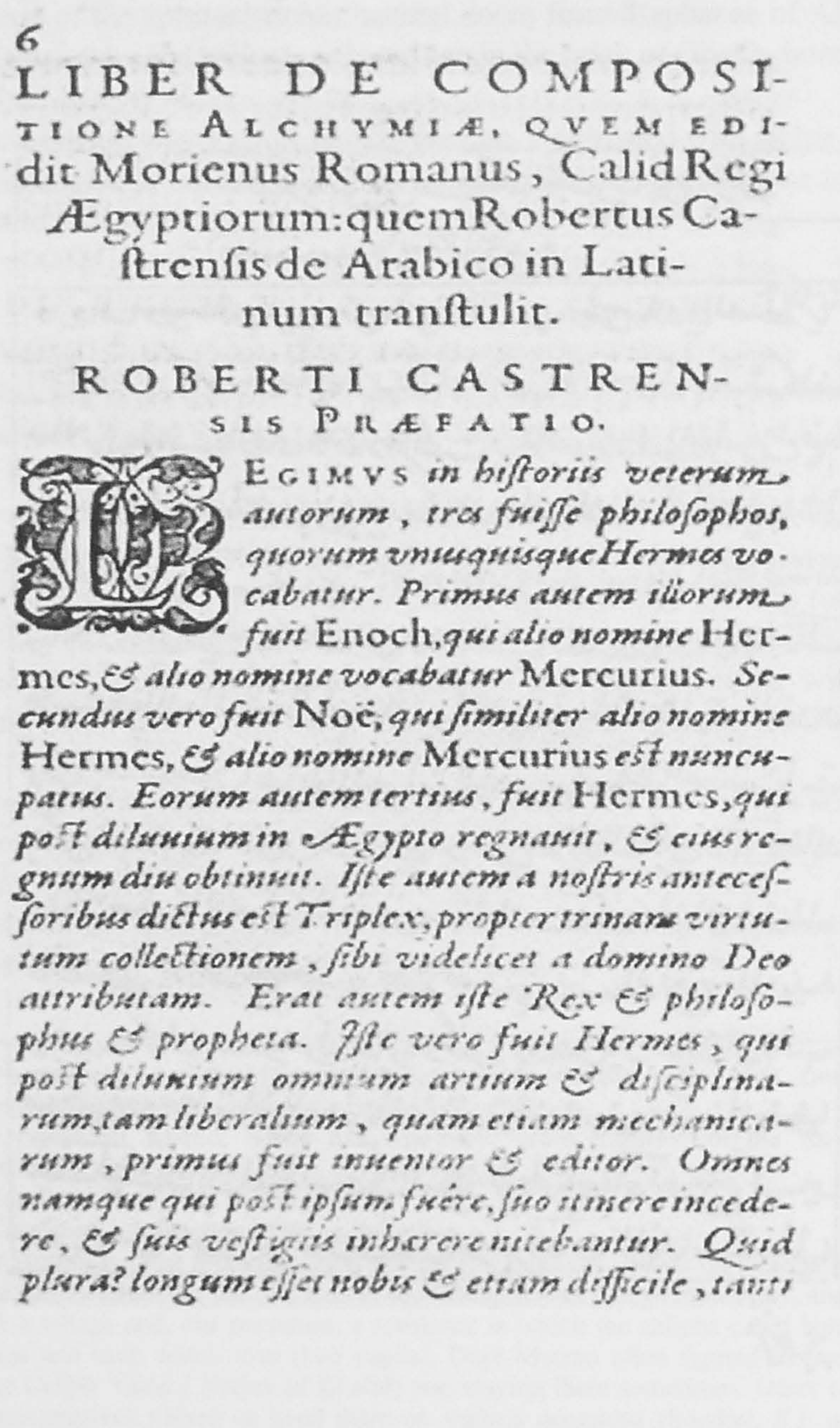


Figure 2.1 The Epistle of Maryanus, the Hermit and Philosopher, to Prince Khalid ibn Yazid, MS Fatih 3227 (ff. 8b–18b) the Arabic text of the dialogue.


6
LIBER DE COMPOSITIONE ALCHYMIÆ, QVEM EDIDIT Morienus Romanus, Calid Regi Ægyptiorum: quem Robertus Castrensis de Arabico in Latinum transtulit.

ROBERTI CASTRENSIS PRÆFATIO.

Egimus in historiis veterum autorum, tres fuisse philosophos, quorum vnusquisque Hermes vocabatur. Primus autem illorum fuit Enoch, *qui alio nomine* Hermes, *& alio nomine vocabatur* Mercurius. *Secundus vero fuit* Noë, *qui similiter alio nomine* Hermes, *& alio nomine* Mercurius *est nuncupatus. Eorum autem tertius, fuit* Hermes, *qui post diluuium in Ægypto regnauit, & eius regnum diu obtinuit. Iste autem a nostris antecessoribus dictus est Triplex, propter trinam virtutum collectionem, sibi videlicet a domino Deo attributam. Erat autem iste Rex & philosophus & propheta. Iste vero fuit Hermes, qui post diluuium omnium artium & disciplinarum, tam liberalium, quam etiam mechanicarum, primus fuit inuentor & editor. Omnes namque qui post ipsum fuére, suo itinere incedere, & suis vestigiis inhærere nitebantur. Quid plura? longum esset nobis & etiam difficile, tanti*

Figure 2.2 *Liber de compositione alchimiae*, the Latin text of the Maryanus-Khalid dialogue.

***

فأتاه رجل في يومه ذلك وطلب الإذن بالدخول عليه فادخل فسلم فأحسن وقال إني أتيت الأمير بفايدة لم يأت احد بمثلها .

On that day, a man came to him and asked for permission to be allowed to enter and see him. He was allowed in and he saluted eloquently. He said: I brought to the *Amir* a benefit that nobody else had matched.

[and on this occasion a certain man came to him and desired to speak with him. Hearing of this, Khalid bade the man come before him. He saluted Khalid, and Khalid returned his greeting.

The fellow then spoke thus to Khalid: 'I dwell in the mountains of Jerusalem, and I have come to you, O King,[34] with delightful news. Never has anyone before me given any king such cause to rejoice.']

***

فقال له خالد وما الفايدة التي أتيت بها ؟

Khalid asked him: and what is the benefit that you have brought with you?

['And what is this news?' asked Khalid.]

***

قال بلغني انك تطلب الصنعة وتسال عنها . قال فاستوى خالد جالسا ، وقال : نعم . فقال : أيها الأمير إني ساكن في البيت المقدس وقد رأيت به رجلا سايحا يقال له مريانس الراهب واصل إلى الصنعة يأتي في كل عام إلى البيت المقدس <ويهب> مالا عظيما ويعطي الفقراء والمساكين .

He said: I had learned that you are seeking the art (*al-san`a*) and are asking about it. (Ghalib said) that Khalid sat straight and said: Yes. (The man) said: O *Amir*, I live in Jerusalem (*al-Bayt al Muqaddas*) and I saw in it an ascetic called Maryanus (Marianus) al-Rahib (the Hermit). Who has attained the Art

34. Khalid was not a king because he did not become a caliph after his father Yazid. In the Arabic text he is called amir or prince.

(*san`a*). He comes every year to Jerusalem (*al-Bayt al-Muqaddas*) and donates a huge amount of money and gives the poor and the needy.

[He replied: 'I have heard many say that it is you who continually seek after the operation which the philosophers call the Major Work. I will bring you to the knowledge of it through a certain Romaean, who lives as a recluse in the mountains of Jerusalem, but whose dwelling place I well know. He sends large amounts of gold to Jerusalem every year.']

***

فقال له خالد إن كنت صادقا لأعطينك نهض مسألتك وان كنت كاذبا لأبلغنك ما تستحقه.

Then Khalid said to him: If you are telling the truth I shall give you what you will ask for, but if you have lied then you will receive what you deserve.

[Khalid said to him: 'If I find that you have told the truth, I will reward you with whatever you may ask. But if you have lied, you may expect the worst.']

***

فقال الرجل حسبي فلقد أنصفتني من نفسك .

The man said: I am content with this since you have treated me with justice.

['Well,' the fellow replied, 'so be it.']

***

ففرح خالد به وأعجبه ما كان منه وأمر له بجائزة وكسوة < ووعده> خيرا حسبما قال غالب.

Khalid rejoiced and was pleased with what the man had said. He ordered for him a reward and raiment and he promised him good, according to Ghalib.

[Then Khalid rejoiced greatly and commanded that the man be rewarded with gifts and raiment and much else, as he had promised him.]

***

ثم وجهني معه وجماعة من الموالي

Then he asked me to accompany him with a group of *mawali*.

[And the king commanded me along with many other of his servants to go with him.]

***

فسرنا في فياف ترفعنا ارض وتضعنا أخرى فلبثنا في ذلك أياما في طلب ذلك السايح حتى ظفرنا به فإذا هو شيخ كبير ضعيف حسن الصورة بهي المنظر عليه جبة من شعر < وكأن جلده سنة بالية >[35]

We travelled in realms rising up with some terrains and descending with others. We stayed thus for several days in search of that ascetic until we located him. We found that he was an old man, weak, of good appearance and elegant countenance, wearing a woollen robe and his skin showed as if it was worn.

[And so we set out. After wasting much time going from one place to another, in hopes of chancing upon the recluse, we did indeed find him. He was tall of stature, though aged, and although lean, so noble of countenance and visage that he was a marvel to behold. Yet he wore a hair shirt, the marks of which were borne on his skin.]

***

ففرحنا به ورفقنا به وداريناه حتى قدمنا به خالد فأدخلناه عليه ففرح به فرحا شديدا ما رأيناه على مثل ذلك الفرح قط .

We rejoiced at finding him and we treated him kindly and persuaded him until we arrived and brought him to Khalid who was greatly delighted to see him. We have never seen Khalid so pleased at anything before.

[We rejoiced to have found him and spoke kindly to him, at last persuading him with sweet words to relent, and brought him with us back to our own country, there presenting him to King Khalid. Never before had we seen the king so pleased by anything.]

***

35. The word سنة has several meanings. It can mean picture or face. The general meaning is that Maryanus had a wrinkled skin due to his old age.

ثم التفت إلي وسألني عن مسيرنا في البيداء والرجعة فأخبرته بأمرنا من أوله إلى أخره.

Then he turned towards me and asked me about our journey in the country and our return and I related to him what happened with us from the beginning till the end.

[At last he turned to me and asked what had befallen us in going and coming, and told him the story from beginning to end.]

***

ثم اقبل على الشيخ فقال له ما اسمك ؟ قال : مريانس الرومي

Then he turned to the old man and asked him: what is your name?
He answered: Maryanus al-Rumi.

[Then the king regarded the aged man we had brought and wished to know by what name he was called. The elder replied, 'I am called Morienus the Greek.']

***

فقال : منذ كم صرت في هذه الحال ؟

Then Khalid asked: Since when have you been in this state?

[And Khalid asked: 'How long is it now that you have dwelt as a recluse in these mountains?']

***

قال : بعد موت هرقل بأربع سنين .

He replied: Four years after the death of Hiraql.

[He replied: 'I began my retreat four years after the death of King Herakleios.'[36]]

***

فقال خالد اجلس يا مريانس فقعد وشرف مجلسه وأعجبه ما رأى من سمته[37] وأدبه.

36. The Arabic name is Hiraql. This name was distorted in Latin as was the case with all other names.

37. السمت: هيئة أهل الخير (لصحاح في اللغة)

Then Khalid said: Sit down Maryanus. He sat down and was given a seat of honour. Khalid was pleased by his noble appearance and politeness.

[Then the king bade Morienus be seated, and himself arose to give Morienus a place of honour beside him, much pleased with his reserve, modesty, and elegance.]

***

ثم قال : يا مريانس لو كنت في كنيسة أو دير كان أرفق بك.

Then he said: O Maryanus, would it not have been kinder to you if you were in a church or a monastery?

[The king said to him: 'O Morienus, recluse though you be, would it not be better that you live in the congregation of others, rather than alone in the mountains?']

***

فقال : أصلح الله الأمير . ا لخير إلى الله وبيده يفعل ما يشاء ، قد صدقت ، الراحة في ذلك أكثر والنصب في السياحة اشد واتعب وإنما يحصد الزارع ما زرع وأرجو أن تكون الخيرة فيما أنا فيه إن شاء الله تعالى وانه لا يدرك الإنسان الراحة إلا بكثرة التعب.

He said: May God guide the Prince. Good is from God and it is in his hand to do what he wills. You are right, rest in that is more and wandering causes more fatigue and tiredness; but a farmer reaps what he sows, and I hope that good will result from what I am in, if God wills. Man will not achieve rest except by much toil.

[He said: "Perhaps, O king. But the virtues I look for are in God and in his hand, who will do as he will. And while I grant that, as you have said, life might be easier for me than in the mountains, still only he who sows shall reap, and he must reap that which he has sown. Now I trust that I have gained some little virtue of my own. A man cannot attain repose except through labours of the spirit."]

***

فقال خالد لو كان هذا من صدر مؤمن . ثم قال : يا مريانس بلغني عنك فضل ودين فأحببت أن أراك فأرسلت إليك .

Then Khalid said: Had this been said from the heart of a believer. Then he said: O Maryanus I heard that you are a virtuous and a devout person, therefore I desired to see you and I have sent after you.

[Then the king said: 'These things are true, if said from the heart by one believing in God. O Morienus, I am pleased that you continue in your faith. I wished to see you and therefore sent for you.']

***

فقال له مريانس : ما أنا بعجب وفي الناس مثلي كثير والموت ل كل راصد وهو اشد على الأجساد <من ذنوبها> وما بعد الموت أطول واقطع وأعظم والله المستعان.

Maryanus said to him: I am not unique. Moreover, among people there are many like me. Death is awaiting each; it is harder on bodies than their sins, and what follows death is longer, harder and greater. And God is our aid.

[Morienus said to him: 'You need not marvel at one such as me, a mere son of the race of Adam. At best, I might only be somewhat comelier, except that the passage of time has altered me. There are many like me among men. And at the end is cruel death, than which no punishment is worse; yet a harsher punishment awaits the spirit after death. But the almighty Creator be our aid.']

***

فقال خالد اللهم أعناعليه فانه داهية على كبر سنه.[38]

Khalid said: God help us in dealing with him because he is a cunning man despite his old age.

[The king replied: 'Thus God may confound man, who is only scorned the more, the more he is advanced in age.']

***

ثم أمر خالد أن اذهب<به> ناحية بالقصر وان أتيه برجل نصراني من الشيوخ العلماء ي ؤ نسه ويحدثه ليسكن إليه ففعلت ذلك.

38. The Latin translator edited this Arabic sentence.

Then Khalid commanded that I take him to a part of the palace and to bring to him a Christian man from among the elder scientists to entertain him and talk to him, so that he can feel at home with him, which I did.

[Then the king commanded me to conduct Morienus to a dwelling near the royal palace and to fetch one of the Christian elders who might speak with him and comfort him with sweet words, and thus set his heart at peace. I did so.]

***

وكان خالد يأتيه في كل يوم مرتين فيجلس إليه ويحادثه ويسأله عن الأمم والزمان وسير الملوك وأحاديث اليونانيين وهو يخبره بعجايب القوم وحكمهم وأمو ر هم لم يسمع خالد بمثلها فوقع منه موقعا عظيما لم يقع منه احد قط قبل ذلك إلى بعض الأنام.

Khalid used to visit him twice a day to sit and chat with him asking him about the various nations, past days, biography of kings and the stories of the Greeks (the Byzantines). He told him about the wonders of the people, their rule and their affairs, things that Khalid had never heard before. This caused Maryanus to occupy a high place in the esteem of Khalid, more than anybody has ever occupied before.

[and the king made it his custom to come twice every day to Morienus, sitting down with him and speaking with him, but asking him nothing concerning his magistery. The king often stayed long, and Morienus confided greatly in him. Khalid enquired repeatedly about the customs both royal and common of the Greeks, and about their times and histories. Never at a loss for a reply, Morienus retold the marvels of their deeds and discoursed expertly on their sciences, matters such as the king had never before heard. Not anyone before had ever held such a firm place in the king's affection as Morienus soon came to hold.]

***

فقال له خالد : يا مريانس : إني طلبت الصنعة حينا وبحثت عن أمرها وتعبت فيها فلم أجد أحدا يخبرني عنها ولا يدلني عليها فأسالك أن تسبب لي من أمرها وعلاجها سببا ولك علي ما تسال مع ردك إلي موضعك الذي كنت فيه ، ولا باس عليك مني.

Then Khalid said to him: O Maryanus, I have pursued the Art (*al-san`a*) for some time and searched about it and laboured in it but I did not find anybody who can give me information or guide me to it. And I ask you to enable me to know it and learn its treatment and you will have whatever you request, and in addition you will be returned to your original place; and you do not have to be afraid from me.

[Eventually Khalid addressed him: 'O Morienus, know that I have long sought the Superior Work, but found none to counsel me in this matter. Therefore, I earnestly request that you prepare for me some portion of your magistery. You shall have from me then whatever you may ask, and I will see to it that you return to your own land, God willing. Nor need you thenceforth have any fear of me.']

***

فقال له مريانس : قد علمت انك لم ترسل إلي إلا لحاجة منك إلي ، وأما قولك أيها الأمير لا باس علي منك فقد بلغت مبلغا ليس ينبغي لمثلي بعده أن يخاف إلا من الله ، وقد أوليتني ما أنت أهله ورأيت من رفقك وشفقتك وإحسانك ورأفتك ومحبتك ما لا ينبغي لمثلي أن يكتم شيئا مما تطلبه <مع> ما أرى من ذكاء فطنتك وفهمك وجميل مذهبك وطلبك ، فالله المحمود

Maryanus said to him: I knew that you did not send after me unless you had a need for me. As to what you said, O Prince, that I do not have to be afraid from you, I have reached the stage at which no body like me should be afraid except from God. You have bestowed on me what is befitting for you, and I have seen of your kindness, your sympathy, your benevolence, your mercy and your love such that a person like me should not hide anything of what you require. Added to this what I see of your intelligence, your comprehension and the nobility of your faith and your pursuit. Praise God.

[Morienus said to him: 'O king, may God enrich you. Now I understand that you have sent for me only out of great need. But I disregard the kind assurance you added, namely that I should not fear you, inasmuch as I have no need to fear anyone save God alone. You have approached me as an equal in spirit, and now I see by your affection, excellence, and discrimination that one such as I should have no reason to keep from you anything of that which you seek, for you are indeed a man of good intentions as well as deeds and most virtuous. Very well, you have attained to your initiation and instruction simply and with the greatest ease. May the Creator be praised!']

***

فتبسم خالد عند ذلك وقال من لم ينفع به الرفق اضر به الخرق والعجلة من الشيطان .

At this Khalid smiled and said: A person with whom compassion is not effective will be harmed by crudeness. Haste is an act of Satan.

[At this, King Khalid smiled, and then said: 'The crudeness of haste ensnares any man, unless he be ruled by patience. I am of the house of Mu'awiyya, and there is no strength save in great God most high.']

***

قال مريانس أنا أبين لك ولا حول ولا قوة إلا بالله ألعلي العظيم ، أصلحك الله ، أنصت للحكمة تعرف المطلوب وتفهمه وتعلمه وتفكر في مداخله ومخارجه لتقف عليه إن شاء الله تعالى . إن هذا الأمر الذي طلبته ليس يقدرعليه احد بالشدة ولا يظفر به احد <بالعنف> ولا يصل إليه من عالم إلا بالرفق والتودد والمحبة الصادقة . أول ذلك انه رزق من الله تعالى يسوقه إلى من يشاء من خلقه بالقدرة البالغة حتى يسبب له <تعلم> ذلك ويكشف له عن مستوره وهو من أعظم مواهب الله تعالى يعلمه من أحب من خلقه وعباده والدالين عليه الخاضعين له.

Maryanus said: I shall explain to you, and there is neither might nor power but in God, the most high the supreme. May God guide you to the better. Listen to this science (*hikma*) and you will know what is needed and understand it and learn it and will contemplate its inside and outside traits so that you will become acquainted to it if God, glory to him, wills.

This matter that you have requested cannot be attained by any one by force and cannot be gained by violence and can only be acquired from a scientist by kindness, affection and true love. First it is a fortune from God, glory to him. He delivers it to whom he chooses from among his creatures by supreme power. He causes him to learn it and discloses to him its secrets; and this is one of the gifts of God, the high. He teaches it to whom he loves from among his creatures and his subjects and to those who are his guides and are submitting to him.

[Morienus then said: 'O king, may God enrich you. Now attend to the examination of this operation, and you will know it well and understand. Consider it thoroughly from beginning to end, and you will know all things that pertain to it, God willing. No one will be able to perform or accomplish this thing which you have so long sought or attain it by means of any knowledge unless it be through affection and gentle humility, a perfect and true love. For this is something which God gives into the sure keeping of his elected servants until such time as he may prepare one to whom it may be handed on from among his secrets. Thus it is only the gift of God, who chooses among his humble and obedient servants those to whom he reveals it.']

***

فقال خالد:< أجل لا حيلة إلا بالتوفيق من الله عز وجل>.

Khalid then said there is no course of action except by guidance from God, the most powerful and dignified.

[Khalid said to him: 'Surely we know that nothing can be done without the help and guidance of God, most high and eternal.']

***

ثم قال خالد اجلس يا غالب واكتب ما يدور بيني وبينه.

Then Khalid said: Sit down, O Ghalib, and write what will take place between him and me.

[Then King Khalid said to me: 'O Ghalib, quickly now, sit down and write all that we have said.']

***

قال مريانس : اعلم يا خالد[39] أن الله تعالى خلق العباد ضعفا من ضعف لا يؤخرون ما قدم ولا يقدمون ما أخر ولا يعلمون إلا ما علمهم الله ولا يدركون إلا ما أعطاهم الله ولا ينالون إلا ما جعلهم إليه السبيل بقدرته ، وجعل من اختص من خلقه يطلبون علم هذه الموهبة التي تخرج صاحبها من نصب الدنيا وتوصله إلى ملك الآخرة ونعيمها ، فلم يزالوا يتوارثون علمها واحد فواحد حتى درس العلم وذهب أهله وعدم المعلمون ، فكان مما وجد في الكتب الصادقة والباقية كتب الأولياء والحكماء التي كتبها من كان قبلنا وأورثوها من أعقابهم من أراد الله أ ن يبلغ هذه الصنعة التي وصفوها بالإكثار والأباطيل ، وان كانوا أكثروا وسموا الأشياء بغير أسمائها ووصفوها بالرموز وإنهم لا محالة قد بينوها وأوضحوها واخبروا عنها بالصنعة والأمثال والتعريض وحاولوا دفع السفهاء عنها ومنع الظلمة منها بعقول زكية وأقاويل صادقة فحيروا ذوي الفهم واهلكوا من لا رأي له ، وأشاروا لأهل العلم والفهم وأوضحوا وبينوا ، وعلى العاقل طلب العلم فلا يقصر عنه ولكن يكون رجاؤه في الله واليه رغبته أن يلهمه مراشد أموره كلها وأن يرزقه الفهم الناقد والتدبير الجميل والتأويل الصحيح وحسن التأليف من غير زيغ.

39. The Arabic text makes Maryanus call Khalid by his name without any formality, whereas in the Latin text Morienus is addressing Khalid as 'O, King'.

Maryanus said: Know, O Khalid, that God, the high, has created his servants weak from weakness.[40] They cannot hold back what he had advanced and they cannot advance what he had held back. They cannot know anything except what God reveals to them, and they cannot understand except what God gives them, and they cannot get except what he has opened a way to it by his power. He made those whom he has chosen from among his creatures seek the knowledge of this mental gift that takes out its possessor from the hard toil of this world and lead him to the riches of future life and its delights. They continued transmitting its knowledge by inheritance from one to the other until the science was eradicated and its people had gone and the teachers could no longer be found. From those genuine books that had remained there are the books of the holy men and philosophers that were written by our predecessors and were left as inheritance to those successors whom God has willed to attain this Art that was described to be too elaborate and to be full of falsehoods. If they have said too much and called things by other than their true names and described them by symbols yet without doubt they have explained them, clarified them, and informed about them by the art and by examples and allusions. They tried to keep away the fools and to prevent darkness by intelligent minds and true sayings and so they perplexed men of comprehension and reduced to nothing those who have no belief. They signalled to men of science and comprehension, clarified, and explained. The wise should seek science and should not fall short of it. Let him put his hope in God and desire from him that he enthuses in him true guidance in all his affairs, and to bestow on him critical understanding, good handling, correct interpretation and excellent compiling without deviation.

[Thereupon Morienus continued: 'Almighty God in his power created powerless servants who can neither undo what he has done nor advance what he holds back, nor can they even know anything except what he reveals to them or accomplish anything except what he grants to them. Nor are they able even to possess anything except by the strength that same God has conferred upon them, nor even govern their own spirits except insofar and so long as he has ordained for them. And from among his servants, he chose to select certain ones to seek after the knowledge he had established that rescues him who masters it from the wretchedness of this world and assures him riches to come, God willing. While those so chosen used to hand down this knowledge to their own heirs, it was at last lost and its masters dispossessed of it when none could be found any more who knew it. But of the books which set forth the matter correctly there remained a few by the

40. الله الذي خلقكم من ضعف (سورة الروم الاية 54)

ancient seers who went before us. They left their knowledge as a legacy to their successors, whom God had chosen to become adepts according to the methods that had been explained truthfully and forthrightly by their predecessors. The ancients, however, did not refer to the matters pertaining to this science by their proper names, speaking instead, as we truly know, in circumlocutions, in order to confute fools in their evil intentions. This they did by formulating their convictions and true sayings always in parables, so that only those of great wisdom and resource would be able to uncover their true meaning. Since the ancients thus disguised this knowledge, those who would learn it must understand their maxims. Nor may they draw back from this, but must fix their faith in God and persist to the end that he bring them to this knowledge, improve; their estate, and give them direct, unerring access to the methods of the science.]

***

قال خالد قلت يا مريانس فأحسنت ووعظت فأبلغت ونصحت فأرحت وليس ببعيد في ذلك إذا كان مثلك في علمه وسنه ومعرفته ورأيه ، قد وعد أن يستتم ذلك منه ، فاشرح لي ما سألتك عنه وأوضحه لي إيضاحا بينا استغني عن شغل فكري وإعماله في هذا الشئ ، أمن شئ واحد هو أو من أشياء شتى .[41]

Khalid said: O Maryanus, you have spoken and excelled, and you preached and your message was well received, and gave advice that caused relief, and it is not unfitting if somebody like you with his scholarship, his age, his knowledge and his judgment has promised to bring this into completion. Explain to me what I am enquiring about and clarify it to me in an unambiguous description that saves me from occupying my mind and exerting it in this question. Is it from one thing or from several?

[King Khalid then said: 'Now well taught and well spoken, O Morienus, nor do I hold these precepts strange, coming as they do from a teacher of such wisdom and years as yourself, who is willing that I should learn this science. Therefore explain to me clearly that which I ask of you, sparing me needless labour over this matter which I seek from you. Tell me whether this operation is accomplished only by a single principle or by several.']

41. This is the first question of the Morienus-Khalid dialogue.

APPENDIX: ARABIC TEXTS OF THE MARYANUS – KHALID DIALOGUE

I Available

a *Complete manuscripts*

1. MS Fatih 3227 (ff. 8b–18b).
2. Şehit Ali Pasha 1749 (ff. 61a–74b).

b Large citations

3. Brıtısh Lıbrary MS add 23418, *al-Shawahid fi al-hajar al-wahid* (ff. 123a–125b).

c *Fragments*

4. al-`Iraqi al-Simawi, *al-`ilm al-muktasab*, BL MS add 24016 (ff. 27, 28, 48).
5. al-Jildaki, Nihayat al-talab II, Berlin, MS 4184 (fo. 183).
6. Manuscript of Abdallah Yurki Hallaq, Aleppo (p. 180).
7. NLM (National Library of Medicine), MS A-70 (ff. 53b–57b).

II Existing but not available at the time of writing this chapter

8. Khanji, Cairo, according to Kraus, *Jabir*, vol. I, p. 182. Sezgin, p. 126 (seems to be a complete one).
9. Haidarabad, Asafiya, according to Stapleton. See Sezgin, p. 111.
10. Tehran, Khaniqah-i- Ni'matallah 145 (a fragment, 18b) Sezgin, p. 126.
11. Leningrad University, MS Or. 1192, Sezgin, p. 126.
12. *as-Sifr al-mubajjal,* see Siggel Katal. Gotha p. 65; see Ullman, p. 193, note 2.
13. al-Iraqi al-Simawi, *K. al-Aqalim al-sab`a,* see Siggel Katal. Gotha p. 25; see Ullman, p. 193, note 2.
14. Chester Beatty MS 5002 (fo. 55a). see Ullman's Catalog, p. 172.
15. Personal Collection; see Kraus I, p. 187.

3 The Arabic Origin of the *Summa* and Geber Latin Works: A Refutation of Berthelot, Ruska and Newman Based on Arabic Sources

ABSTRACT

This chapter presents a reassessment of the Geber Problem based on research into the extant Arabic works of Jābir ibn Hayyān and other Arabic works that incorporated his ideas. Part 1 discusses the hypotheses of Marcelin Berthelot that heralded the problem and texts from the *Summa* and Arabic sources are compared, and thus the Arabic identity of the *Summa* is confirmed.

Part 2 refutes the assumptions of Julius Ruska about a Latin author for part of the *Liber Geberis De Investigatione Perfectionis Magisterii* of the Riccardiana manuscript, and for the *Summa.* It follows that all the assumptions of William Newman that he built on Ruska's speculations, about a previously unknown compiler called Paul of Taranto as the author of the *Summa* are baseless.

INTRODUCTION

'Geber' was the name ascribed to the author of a series of alchemical treatises, which began to appear in the Latin West in the middle of the thirteenth century. These treatises included the *Summa Perfectionis Magesterii*; *De Investigatione Perfectionis*;[1] *De Inventione Veritatis; Liber Fornacum* and *Testamentum*, which were usually printed together between the fifteenth and seventeenth centuries. These were known until the nineteenth century to be translations of works originally written in Arabic by Jābir ibn Hayyān.[2] His name, in the Latin form 'Geber', became widely

---

1. This short treatise is not the *Liber Geberis De Investigatione Perfectionis Magisterii* of the Riccardiana manuscript that is the subject of our discussion in Part 2.
2. The exact dates of the appearance of the Geber Latin works are a matter of speculation. The first assumptions regarding the *Summa* and the four treatises which accompany it were made by Marcelin Berthelot, *La Chimie au Moyen Âge* (Paris: Imprimerie Nationale, 1893), vol. 1, 343–4; Ernst Darmstaedter speculated about the *Liber Claritatis*, 'Liber claritatis totius alkimicae artis, Bologna Cod. lat. 164 (153)' (later: dem arabischen Alchemisten Geber zugeschrieben, or: als deren Autor 'Geber' genannt wird), (Roma: Archeion, 1925–1928), reprinted by Fuat Sezgin, *Natural Sciences in Islam* (Frankfurt: 2001), vol. 71, pp. 325–482. Robert Multhauf gave a review with a discussion of the available information, *The Origins of Chemistry* (London: Oldbourne, 1966), pp. 167–75. William R. Newman, in his PhD thesis

celebrated. The *Summa* was so successful that, according to George Sarton, it became the main chemical textbook in medieval Europe,[3] and its author was called 'the father and founder of chemistry' by some Western historians.[4]

Nobody had challenged this attribution to Jabir until the end of the nineteenth century. In 1893, Marcelin Berthelot claimed in his work *La Chimie au Moyen Âge* that these treatises had been written by Latin authors who would have used Jābir's name in order to facilitate the diffusion of their own works. Berthelot was a noted scientist and a public figure, and as a high official, he was most influential in France.[5] He 7outlined his reason in writing his history of chemistry in the introduction to Volume 3. He said that it is necessary that 'we radically change the current ideas about the chemical knowledge of the Arabs, and on the influence exerted by this knowledge on the civilization and science of the West'.[6]

However, several eminent historians of chemistry and alchemy raised serious objections to Berthelot's assumptions. The earliest appeared in 1905 by Henry E. Stapleton,[7] while Eric Holmyard raised the largest and most consistent objections in a series of papers published between 1922 and 1928.[8] James R. Partington sided with Holmyard,[9] whereas Lynn Thorndike would further question Berthelot's accuracy and judgments.[10]

Despite those refutations of Berthelot, in 1935 Julius Ruska attributed the authorship of a part of *Liber Geberis De Investigatione Perfectionis*

(Harvard University, 1986), vol. 1, pp. 118–21, discussed both Berthelot's assumptions and Multhauf's analysis and gave his own interpretation.
3. George Sarton, *Introduction to the History of Science* (Baltimore: Williams & Wilkins for the Carnegie Institution of Washington, 1931), 2, 1043.
4. Ferdinand Hoefer, *Histoire de la Chimie* (Paris: Didot, 1866), vol. 1, 327, 329, 340; Eric John Holmyard, 'An Essay on Jābir ibn Hayyān', in *Studien zur Geschichte der Chemie*, Festgabe Edmund O. v. Lippmann, ed. Julius Ruska (Berlin: Springer, 1927), pp. 28–37.
5. Berthelot was Minister of Public Instruction, and Minister of Foreign Affairs (*The Nation*, 21 March 1907), He was also a member for life of the Senate (*The Nation*, 23 December 1901).
6. Berthelot, op. cit., vol. III, p. 6. See also p. 16.
7 Henry E. Stapleton & Rizkallah F. Azo, 'Alchemical Equipment in the Eleventh c. A.D', *Memoirs of the Asiatic Society of Bengal*, (Calcutta: 1905), 1, 47–70; reprinted by Fuat Sezgin, *Natural Sciences in Islam* (Frankfurt: 2001), vol. 61, *Chemistry and Alchemy*, *Texts and Studies*, VII, 1–25.
8. Most of Holmyard's papers are reprinted in Fuat Sezgin's series, *Natural Sciences in Islam*, in the three volumes on *Jābir ibn Hayyān*, (Frankfurt: 2002), 69, 70 and 71 and in vol. 55, *Chemistry, Texts and Studies* (Frankfurt: 2001) 1, 131.
9. James R. Partington, 'The Identity of Geber', *Nature*, 111 (1923) , 219–20.
10. Lynn Thorndike, *History of Magic and Experimental Science* (New York: Columbia University Press, 1923), vol. 2. 471–2; (1934), vol. 3, 40–1, 46, 64, 179, 355.

Magisterii of the Riccardiana manuscript[11] to a Latin author,[12] who would also be the author of the *Summa*. In 1986, William Newman adopted Ruska's assumptions and attributed the *Summa* to a previously unknown writer by the name of Paul of Taranto.[13]

In this way, although the 'Geber Problem' is more than one century old, and in spite of the definitive judgments by Holmyard and other scholars, the assumptions of Berthelot, Ruska and Newman are still adopted uncritically by Western historians of alchemy.

We have dealt with some of Berthelot's assumptions elsewhere and they will not be repeated here;[14] thus in Part 1 of the present chapter we make a brief summary of our refutation of these assumptions, and continue with a discussion of the remaining ones.

In Part 2, we dispute Ruska's speculations in his study of the *DIP* and his unfounded assumption that a Latin author wrote part of it. We shall also discuss William Newman's assumptions which he had built on Ruska's speculations, and which culminated in his conjecture that an unknown compiler called Paul of Taranto was the author of the *Summa*.

In this way, we hope to contribute in bringing to light the deliberate errors on which the early history of Latin alchemy is built.

PART 1 REFUTATION OF MARCELIN BERTHELOT'S ASSUMPTIONS

Berthelot's main claims for Latin authors of Geber's works are summarised in the following assumptions:[15]

1. The treatises carrying Jābir's name were written by Latin authors, who attributed their work to Jābir due to his high standing in the West.
2. There are no Arabic originals for these same works.
3. The style in the Arabic works by Jābir is vague and allegoric.

11. Henceforward to be mentioned as *DIP*. This treatise is a long one and it is not the short treatise of the same name that is usually printed with the *Summa*.
12. Julius Ruska, 'Übersetzung und Bearbeitungen von al- Rāzī's Buch Geheimnis der Geheimnisse' (1935), reprinted by Fuat Sezgin, *Natural Sciences inIslam* , vol. 74, Al- Rāzī, II, 261–347.
13. William R. Newman, *The Summa Perfectionis of Pseudo-Geber: A Critical Edition, Translation and Study* (Leiden: Brill, 1991).
14. Ibid.
15. The assumptions of Berthelot are dispersed in the various chapters of his three volumes, especially in vols 1 and 3, but Chapter X of volume 1 (pp. 336–50) embody his main hypotheses

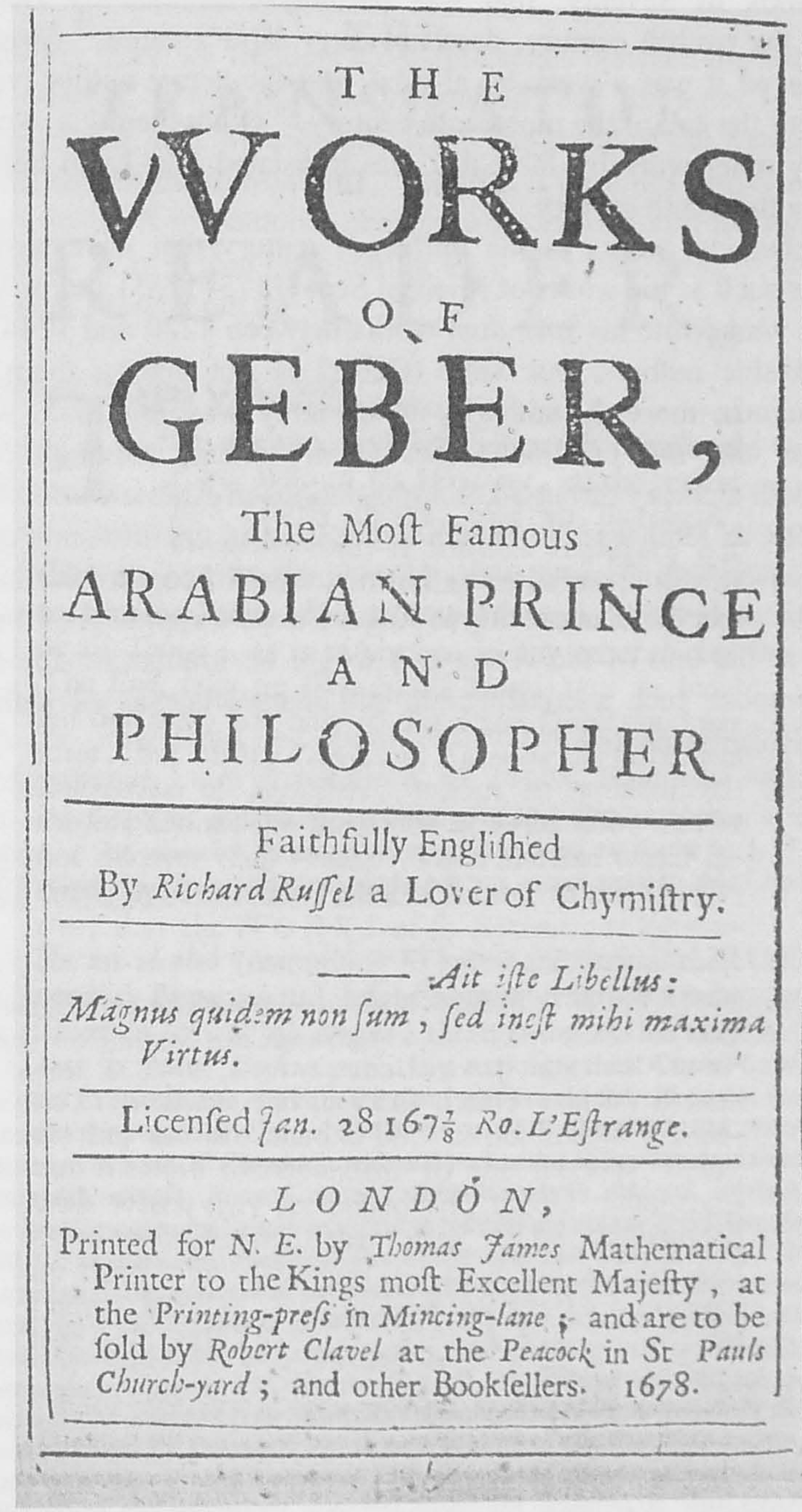
4. The style of the *Summa* recalls the style of the Schoolmen.
5. The *Summa* is devoid of Muslim expressions, which are extravagant in the Arabic texts of Jābir.
6. The *Summa* contains an account of the arguments against transmutation, which is not existent in Arabic works.
7. The Arabic works of Jābir do not contain practical recipes for the preparation of materials.
8. The minor Latin works bearing Geber's name mention more modern materials, such as saltpeter, as well as the preparation of nitric acid, which are absent in the Arabic works of Jābir.
9. The Arabic works do not mention the sulphur-mercury theory of the generation of metals, nor the three principles in metals – sulphur, arsenic and mercury.

We shall now discuss these assumptions in the same order:

1 Jābir's Hypothetical High Standing in the West

Before the translation of Arabic works into Latin, alchemy was unknown in the West. Robert of Chester finished in 1144 the first translation from Arabic of a book on alchemy – *Liber de Compositione Alchimiae*. In the preface he states, 'Since what Alchymia is, and what its composition is, your Latin world does not yet know, I will explain in this present book.'[16] Between this and 1300, some major Arabic alchemical works were translated into Latin. These included *Tabula Smaragdina*, *Turba Philosophorum*, *The Secret of Creation* of Bālīnās, *De Perfecto Magisterio*, attributed to Aristotle, *De Aluminibus et Salibus* and the *Liber lumen luminum* by al-Rāzī, parts of *Kitāb al Sab'īn* (The Book of Seventy) by Jābir,[17] and possibly *De anima in arte alchimiae* attributed to Ibn Sīnā (Avicenna).[18]

16. Eric J. Holmyard, *Makers of Chemistry* (Oxford: Clarendon Press, 1931), 86. See also: Ahmad Y. Al-Hassan, "The Arabic Original of *Liber De Compositione Alchemiae*, The Epistle of Maryānus, the Hermit and Philosopher, to Prince Khālid ibn Yazīd', *Arabic Sciences and Philosophy*, 14 (2004): 213–31; see also Lee Stavenhagen, *Liber de Compositione Alchimiae*, '*A Testament of Alchemy*' (Hanover, New Hampshire: The University Press of New England,1974), 51–2.
17. Multhauf, *Origins of Chemistry*, 167. See also: Robert Halleux, 'The reception of Arabic alchemy in the West', in *Encyclopedia of the History of Arabic Science*, ed. Roshdi Rashed (London: Routledge, 1996), vol. 3, 886–902.
18. Multhauf, *Origins*, 160–1.


THE
WORKS
OF
GEBER,
The Most Famous
ARABIAN PRINCE
AND
PHILOSOPHER
Faithfully Englished
By *Richard Russel* a Lover of Chymistry.

——— *Ait iste Libellus:*
Magnus quidem non sum, sed inest mihi maxima Virtus.

Licensed *Jan.* 28 1677/8 *Ro. L'Estrange.*

LONDON,
Printed for N. E. by *Thomas James* Mathematical Printer to the Kings most Excellent Majesty, at the *Printing-press* in *Mincing-lane*; and are to be sold by *Robert Clavel* at the *Peacock* in St *Pauls Church-yard*; and other Booksellers. 1678.

Figure 3.1 The English translation of the Geber works by Richard Russell was published in 1678.

The 'Book of Seventy' that was partially translated by Gerard of Cremona in the twelfth century, does not carry Jābir's name.[19] Most Latin authors believed it was a work by al-Rāzī, and the actual author remained unknown until the end of the nineteenth century.[20] Other than this, we do not know of any other work by Jābir that was translated into Latin before the middle of the thirteenth century.

The alchemical works of the thirteenth century that were written by Latin authors such as the works of Michael Scot (1175–1233) and of Vincent de Beauvais who wrote his *speculum* works between 1220 and 1244, quote numerous Arabic authors, but Jābir (Geber) is not among them.[21] For Albertus Magnus, the only authority in alchemy was Ibn Sīnā, whereas Roger Bacon did not mention Geber (Jābir) either, although he was acquainted with alchemy through Latin translations of Arabic works.[22]

Therefore, as Jābir was not known in the West in the thirteenth century, there is no reason to suppose that any Latin author would attribute his work to him. On the other hand, according to Roger Bacon's appraisal of the status of alchemy at the end of the century, it would be impossible for a Latin writer to compose such a considerable and mature corpus of alchemical knowledge. Roger remarked:

> But there is another science which is about the generation of things from the elements [...], of which we have nothing in the books of Aristotle; nor do natural philosophers know of these things, nor the whole Latin crowd of Latin writers.[23]

19. Gerard of Cremona, 'A List of Translations Made from Arabic into Latin in the Twelfth C', translated from Latin and annotated by Michael McVaugh, in *A Source Book in Medieval Science*, ed. Edward Grant (Cambridge: Harvard University Press, 1974), 38, item 65.
20. It is important to remark that the existing Latin manuscripts of *Liber de LXX* do not carry the name of Geber. MS. BN Latin 7156 at the Bibliothéque Nationale of Paris carries the name of an unknown person called Johannis. (The title of this MS is *Liber de Septuaginta Jo, translatus a Magistro Renaldo Cremonensi, de Lapide animali.*) Hoefer did not include *Septuaginta* among Geber's works, but listed it as an anonymous Latin work, Hoefer, *Histoire de la Chimie,* 327–40, 433. We find also in MS *cod. speciale* conserved at the Biblioteca Comunale, Palermo, and also in MS 1400 (II), conserved at Cambridge University, Trinity College, that *Liber septuagenta* (*Liber de LXX*) is attributed to al-Rāzī. See Paul Kraus, *Jābir ibn Hayyān*, (Hildesheim: Georg Olms, 1989), 42 [reprint]. In some other manuscripts the author is anonymous: BL MS Arundel 164; Yale University MS Mellon 2; Ferguson MS 39; Ferguson MS. 49; Florence, Biblioteca Nazionale MS. Palat. 887; Modena, Biblioteca Estense MS. Latin 357.
21. On Michael Scot, see Multhauf, *Origins of Chemistry*,168–70, and also Charles H. Haskins, 'The "Alchemy" Ascribed to Michael Scot', *Isis,* 10 (1928): 350–9. On Vincent de Beauvais, see Multhauf, *Origins of Chemistry* 168.
22. Multhauf says: 'The two eminent Latins did not know Geber'. Multhauf, *Origins of Chemistry,* 175; see also p. 171.
23. Roger Bacon, *Opus Tertium* [1266–1268], chapter 12. citation given in English translation by John M. Stillman, *The Story of Alchemy* and *Early Chemistry* (New York: Dover, 1960),

Translator of Liber fornacum

Furthermore, there are frequent cross-references between the *Summa* and the *Liber fornacum*. It was possible to establish that the latter is a translation form the Arabic, and we currently know the name of the translator and the place and date of the translation.[24] This fact is of utmost importance and it is sufficient in itself to demolish the assumptions of Latin authors for Jabir's Latin works. It is indeed bewildering as to why historians of chemistry and science kept silent about it.

2 Lack of Arabic Originals

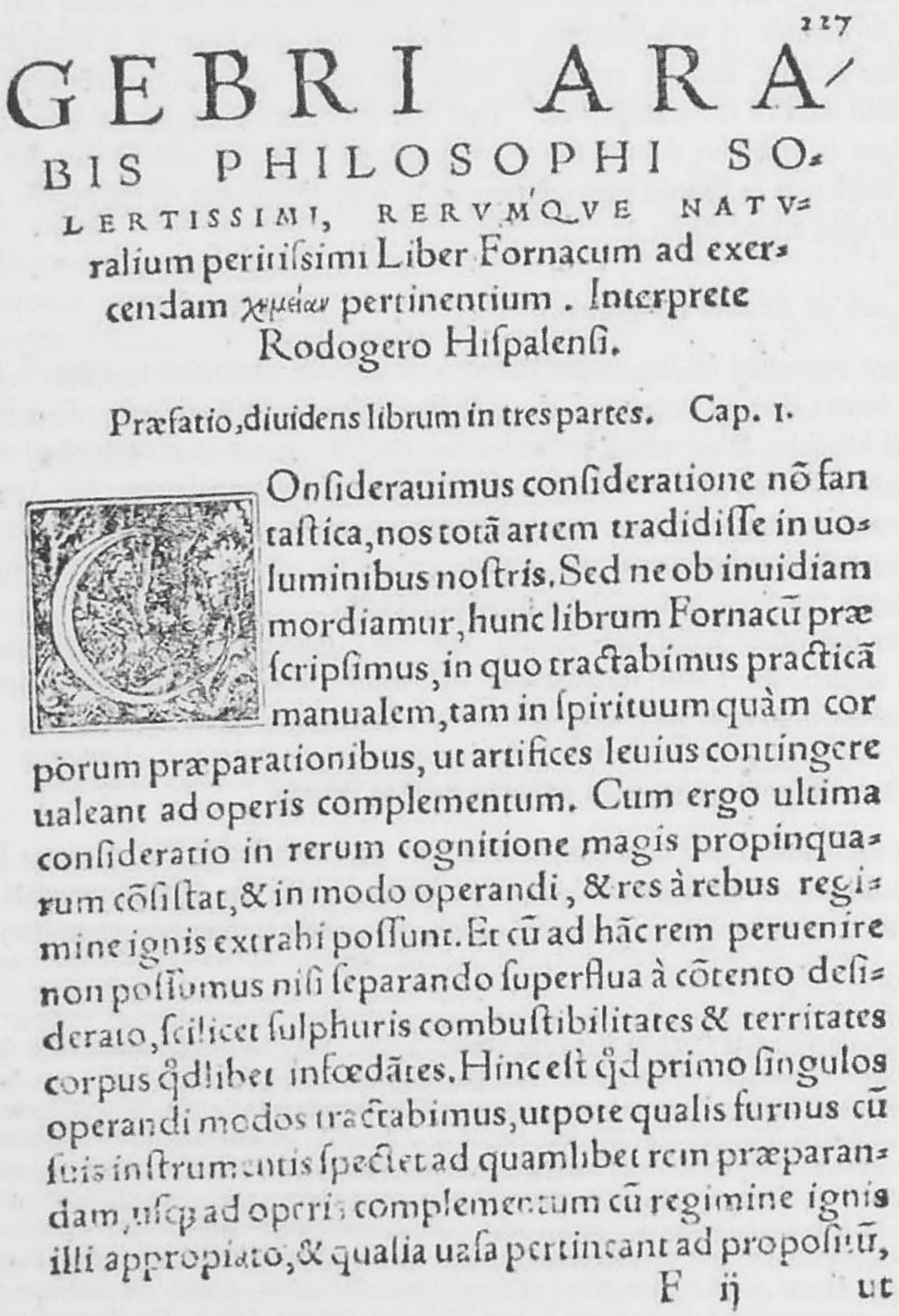
We have surveyed all the extant dated Arabic MSS attributed to Jābir.[25] The oldest ones (2%) do not date back earlier than the twelfth century. This is to say, all MSS by Jābir which preceded the twelfth century have perished and, among them, most probably also the ones used by translators. All Arabic MSS were written on paper that deteriorates with the passage of time and the factors of the environment, and not on parchment, that was the only writing material in the West before the advent of printing.

On the other hand, we should remember that the Arabic originals of many significant Latin translations of Arabic scientific and philosophic works were also lost, surviving exclusively in Latin or Hebrew.[26]

3 The Allegorical Style of Jābir's Arabic Works

Jābir's alchemical and chemical works may be classified in two groups. The first includes writings on the Art of alchemy, while the second consists of numerous treatises on practical alchemy and industrial chemistry.[27]

262–5; also quoted in A.C. Crombie, *Augustine to Galileo*, The History of Science, A.D. 400–1650, Harvard University Press, Cambridge, Massachusetts, 1953, pp. 36–7.
24. Ernst Darmstaedter, 'Geber Handschriften' (1924), reprinted in Sezgin, *Natural Sciences,* vol. 71, *Jābir ibn Hayyān*, III, 299-300. See also: Ahmad Y. Al-Hassan, 'The Translator of *Liber fornacum:* Additional Significant Information', www.history-science- technology.com.
25. Ahmad Y. Al-Hassan, 'Jābir's Surviving Works, www.history-science-technology.com.
26. Beside Geber's Latin works, many other Arabic works exist only in Latin or Hebrew. Some examples in alchemy are: Nine works of al- Rāzī on alchemy in Latin, see Fuat Sezgin, *Geschichte des Arabischen Schrifftums* (Leiden: Brill, 1971), vol. 4, 282; *De anima in arte alchimiae* attributed to Avicenna, see Robert Multhauf, *Origins*, 160–1; *The Secret Book of Artephius,* see Halleux, 'The Recepton', 892. There are also many important Latin works in other disciplines whose Arabic originals were lost such as in mathematics, astronomy, philosophy astrology and medicine, such as works for Al-Khwārizmī; Ibn Rushd; Ishāq al-Isrā'īlī,; Mashā'allāh; Abū 'Alī al-Khayyāt and many others.
27. Al-Hassan, Berthelot's Motives in Choosing the Wrong Arabic Alchemical Treatises and the Extant Arabic Works of Jabir on Theoretical and Practical Alchemy and Chemistry, www.history-science-technology.com.


227

GEBRI ARABIS PHILOSOPHI SOLERTISSIMI, RERVMQVE NATVRALIUM peritissimi Liber Fornacum ad exercendam χυμέιαν pertinentium. Interprete Rodogero Hispalensi.

Præfatio, diuidens librum in tres partes. Cap. I.

Onsiderauimus consideratione nõ fantastica, nos totã artem tradidisse in uoluminibus nostris. Sed ne ob inuidiam mordiamur, hunc librum Fornacũ præscripsimus, in quo tractabimus practicã manualem, tam in spirituum quàm corporum præparationibus, ut artifices leuius contingere ualeant ad operis complementum. Cum ergo ultima consideratio in rerum cognitione magis propinquarum cõsistat, & in modo operandi, & res à rebus regimine ignis extrahi possunt. Et cũ ad hãc rem peruenire non possumus nisi separando superflua à cõtento desiderato, scilicet sulphuris combustibilitates & territates corpus q̃dlibet infœdãtes. Hinc est q̃d primo singulos operandi modos tractabimus, utpote qualis furnus cũ suis instrumentis spectet ad quamlibet rem præparandam, usq; ad operis complementum cũ regimine ignis illi appropiato, & qualia uasa pertineant ad propositũ,

F ij ut

Figure 3.2 The first page of liber fornacum of Geber in which the name of the translator is given.

Berthelot selected for his analysis works belonging exclusively to the first group. This was already noticed by Holmyard: '[Berthelot] deliberately wanted to underrate Jābir [...], the choice of Jābir's works made by Berthelot is entirely misleading.'[28]

4 The Style of the *Summa* Recalls that of the Schoolmen

Jābir was a philosopher and according to *al-Fihrist*,[29] he wrote numerous works on philosophy. More recently, Paul Kraus was able to list 23 titles for Jabir on philosophy, among which several deal with logic.[30] In several works of Jābir, there are arguments where he describes two opposite points of view and employs logic to arrive at a right conclusion.[31] Thus, Jābir was well versed in the tools later employed by the Schoolmen.[32]

5 Muslim Expressions

According to Holmyard, 'It is here that Berthelot's ignorance of Arabic led him astray. As a matter of fact, the *Summa* is full of Arabic phrases and turns of speech, and so are the other Latin works.'[33]

Our study of the *Summa* confirms Holmyard's assertion.[34] Indeed, it retained several Islamic expressions of praise to God, mostly of Qur'anic origin. Furthermore, there are also well known Arabic sayings. For instance in *De Investigatione*, "Contraries set near each other are the more manifest" وبضدها تتميز الاشياء; "Haste is from the Devil's side" العجلة من الشيطان.[35]

28. Eric J. Holmyard, 'A Critical Examination of Berthelot's Work upon Arabic Chemistry', *Isis*, 6 (1924), 479–99.
29. *The Fihrist of al-Nadim*, edited and translated by Bayard Dodge (New York: Columbia University Press, 1970), 2, 862.
30. Kraus, *Jābir ibn Hayyān*, 1, 161–6.
31. *Kitāb al Khawāss al-Kabīr* (The Great Book of Properties) contains several chapters of this kind. MS Or 4041, British Library, chapters (*maqālāt*) 2; 5; 15; 17; 25; 63–70.
32. In the 12th and 13th centuries, the works of Arab philosophers, notably Ibn Sīnā (Avicenna), al-Fārābī and Ibn Rushd (Averroes) were translated into Latin. These works included commentaries on Aristotle. Medieval scholars, known as Schoolmen, used the logical procedures of Aristotle available to them to defend the dogmas of Christianity. Five centuries before the Schoolmen in the West, Muslim thinkers used logic to defend Muslim dogma and the *Mutakallimūn* of Islam were the predecessors of the Christian Schoolmen. See Harry A. Wolfson, 'The Twice-Revealed Averroes', *Speculum*, 36 (3, 1961): 373–92; see also T.J. De Boer, *History of Philosophy in Islam*, translated by Edward R. Jones (London: Luzac, 1903) 43.
33. Eric J. Holmyard, 'The Identity of Geber', reprinted in Sezgin, *Natural Sciences*, vol. 69, *Jābir, Texts and Studies*, 1, 66–7.
34. Al-Hassan, Arabic Expressions in the *Summa* and the *Investigation*, www.history-science-technology.com.
35. *The Alchemical Works of Geber*, translated in 1678 by Richard Russell, introduction by E.J. Holmyard, Reproduced by Samuel Weiser (Maine: Weiser, 1994), 4, 17.

6 Arguments for and Against Transmutation

Debates regarding the validity of *al-Sanʿa* (The Art) and the possibility of the transmutation of base metals into gold began with the inception of Arabic alchemy itself.[36] Throughout Jābir's works, references are found to the need to defend the Art against those who denied it. Jābir systematically warned his readers to be aware of them and gave instructions on how to confront them.[37] More specifically, he wrote two treatises devoted to the subject: *Al-Burhān wa ithbāt al-Sanʿa* (The Proof and the Verification of the Art)[38] and *Kitāb al-thiqa bi sihhat al-'ilm* (The Book of Confidence in the Truth of Science).[39]

After Jābir, the debate continued unabated. Al-Jāhiz (*c.*781–868) was not convinced of the validity of the Art[40] and al-Kindī (*c.* 801–873) wrote *Kitāb ibtāl da'wā al-muddaʿīn sanʿat al-dhahab wa al fidda min ghayr ma'ādinihā* (A Refutation of Those Who Pretend to be Able to Win Gold and Silver Otherwise than from Ore).[41] His contemporary, Hunayn ibn Ishāq (808–873) was also opposed to alchemy.[42] Their attacks were challenged by al- Rāzī (865–925) in his book *Kitāb ithbāt al- Sanʿa wa al-radd 'alā munkirīhā* (Book of Confirmation of the Art and Refutation of Those Who Deny it).[43] The debate continued well into the fourteenth century.[44]

---

36. References to those who denied the Art are found in the dialogue between Maryānus and Khālid ibn Yazīd, Al-Hassan, 'The Arabic Original of *Liber De Compositione Alchemiae*', 213–31. See Chapter 2.

37. See e.g. NLM MS A33, *Kitāb al-malāghim al-awwal* (The First Book of Amalgams), folio 9b; *Kitāb al-tadābīr al- saghīr* (The Small Book of Processes) fo. 92a; and *Kitāb al-usūl* (The Book of Fundamentals), ff, 64a–70b.

38. Kraus, *Jābir ibn Hayyān,* 1, item No. 85. *Al-Fihrist,* ed. G. Flugel (Leipzig: Rodiger and Muller, 1872), item no. 70. Kraus' numbers of the *Fihrist* items follow Flugel's edition.

39. Kraus, *Jābir ibn Hayyān,* 1 , item no. 236, *Fihrist*, Flugel, No. 229. Stapleton *et al.* mentioned a third work by Jābir, *Kitāb naqd 'alā al-falāsifa* (Book of Refutation of the Philosophers). H.E. Stapleton, R.F. Azo & M.H. Husain, 'Chemistry in Iraq and Persia in the Tenth Century A.D.', reprinted in Sezgin, *Natural Sciences*, vol. 73, *Muhammad ibn Zakariyā ar- Rāzī. Texts and Studies*, 1, 9–114.

40. Al- Jāhiz, *K. al- Hayawān*, ed. A. Harun (Cairo: Al-Babi al-Halabi, 1950), 3, 374 ff.

41. *Al-Fihrist*, ed. Bayard Dodge (New York: Columbia University Press, 1970), vol. II, 626.

42. Al- Jildakī, *Nihāyat al- talab,* Sifr 1, Berlin manuscript no. 4184 (Landberg 350a); fo. 16a.

43. Stapleton *et al*, 'Chemistry in Iraq', 54; 112.

44. On the defendants side, among others: *Al- Fārābī* (d. 950), E. Wiedemann, 'Zur Alchemie bei den Araben', *Journal für praktische Chemie,* N.F. 76 (1907), 65–87, 105–23, on 82 and on 115–22; see also 'Farabi'nin Simyanin luzumu hakkindaki risalesi' ed, Ayadin Sayili (1951), reproduced in Sezgin, *Natural Sciences*, 60, *Chemistry and Alchemy,* VI, 45–59; *Al-Hamdānī* (d. 945), *Kitāb al-Jawharatayn,* ed. C.Toll (Uppsala: Studia Semitica Upsaliensia, 1968), ch. 36; *Al- Tughrā'ī* (d. 1211), *Kitāb Haqā'iq al-istishhād,* ed. Faraj Razzuq (Baghdad: 1982); *al- Jildakī* (d. 1342), *Nihāyat al- talab*, Sifr I, Berlin MS No. 4184 (Landberg 350a), f. 16a ff. On the opponents' side: *Abū Hayyān al-Tawh īdī* (*c.* 930–1023), see M. Ullmann, Article 'Al-*kīmiyā*', *Encyclopedia of Islam* (*EI*), New Edition; *Ibn Sīnā* (*c.* 980–1037), E.J. Holmyard. and D.C. Mandeville, *Avicennae de congelatione et coagulatione lapidum* (Paris:

7 Recipes for the Preparation of Materials

Berthelot assumed that Jabir's works are devoid of recipes for the preparation of materials. A survey of 59 MSS by Jābir on practical alchemy shows the description of large umbers of recipes.[45] There is a whole treatise of recipes which is *Kitāb al-durra al-maknūna* (The Book of the Hidden Pearl),[46] which contains dozens of recipes on the colouring of glass, the manufacture of artificial pearls and improving their colour, and several other industrial products. We devoted to this treatise Chapter 6 in the present volume.[47] Also, *Kitāb al- Khawāss al kabīr* (The Great Book of Properties),[48] contains many chemical and industrial chemical *recipes.*[49] Some are on the manufacture and annealing of steel,[50] the desalination of sea and brackish water by ultra filtration,[51] the manufacture of zunjufr (cinnabar),[52] the colouring of glass,[53] and the manufacture of pearls.[54] Several recipes are on cosmetics (removing unwanted hair,[55] dying of hair into yellow gold[56] and dying the hands of maidens with various colours),[57] on varnishes and paints including waterproofing,[58] making inks of various colours,[59] and several other industrial products. We have discussed in Chapter 5 these industrial recipes of *Kitab al-khawass* in detail. The other books of Jābir contain also many recipes for the preparation of most of the

---

Paul Geuthner, 1927), reproduced in Sezgin, *Natural Sciences,* vol. 60, *Chemistry and Alchemy,* VI, 147–240, on 194–5 (English) and on 239 (Arabic) ; *Ibn Hazm al-Andalusī* (994–1064), *Ibn Taymiyya* (1263–1328) and *Ibn Qayyim al-Jawaziyya* (d. 1349), see Ullmann, 'Al-*kīmiyā*', *EI.*; see also J.W. Livingstone, 'Ibn Qayyim al-Jawziyyah: A Fourteenth-Century Defence against Astrological Divination and Alchemical Transmutation', *Journal of the American Oriental Society* (*JAOS*) 91(1971): 96–103; *Ibn Khaldūn* (1332–1406), see G.C. Anawati, 'La Refutation de l'Alchimie par Ibn Khaldun', in *Mélanges d'Islamologie dédiés à la mémoire du A. Abel par ses collègues, ses élèves et ses amis*, Leiden 1974, 6–17.

45. These 59 MSS are listed in the appendix to our article "The Extant Arabic Works of Jābir on Theoretical and Practical Alchemy and Chemistry'. www.history-science-technology.com.

46. B.N. MS Arabe 6915.

47. Ahmad Y. al-Hassan, 'The Colouring of Glass, Lustre Glass and Gemstones, *Kitāb al-durra al-maknūna* (The Book of the Hidden Pearl) of Jābir ibn Hayyan', *Arabic Sciences and Philosophy*, vol. 19, number 1, March 2009, CUP. See Chapter 6.

48. British Library, MS Or 4041; Alexandria Library, MS Alexandria Municipality 5204.

49. Ahmad Y. al-Hassan, 'Industrial Chemistry in *Kitāb al- Khawāss al-kabīr* of Jābir ibn Hayyan', *Journal for the History of Arabic Science,* vol. 14, Aleppo, 2008. See Chapter 5.

50. BL MS, article (*maqala*) 16, fo. 32b.

51. BL MS, article (*maqala*) 4, fo. 10b.

52. BL MS, article (*maqala*) 36, fo. 68a.

53. BL MS, articles (*maqalat*) , 28, ff. 53a, 28, fo. 54b, and 35, fo. 66a.

54. BL MS, article (*maqala*), 24, fo. 46a.

55. BL MS, article (*maqala*) 28, fo. 46b.

56. BL MS, article (*maqala*) 59, fo. 85b.

57. BL MS, articles (*maqalat*), 28, ff. 53b, 60, 60a, 60b.

58. BL MS, articles (*maqalat*) 29, ff. 55a, 56b; 30 57a; 31, 59a.

59. BL MS, article (*maqala*) 29, ff. 56a; 31, 61a.

chemical materials that were known, which include for example the making of salt of alkali (*milh al-qilī*),[60] the refining of tin (*rasās qal'ī*)[61] of iron[62] and the other metals.

8 Modern Materials

The large number of recipes described in Jabir's MSS mention all materials known to alchemists and chemists until the end of the Middle Ages. We have dealt with Berthelot's assertion that saltpeter and nitric acid were first known after the thirteenth century in Chapter 7.[63] There, we have shown that saltpeter was known under various names since the beginnings of Arabic alchemy and chemistry, while several recipes for nitric acid are given in Jābir's Arabic works as well as in other Arabic treatises before the thirteenth century.

9 Theories of Alchemy in the *Summa* and in Arabic Works

Contrary to Berthelot's views, the sulphur-mercury theory and the theory of three principles of metals – sulphur, arsenic, and mercury – arrived in the Latin West via Arabic translations. The sulphur-mercury theory was basic to Arabic alchemy. We shall discuss both theories as they were expounded in Arabic works and compare them with the texts of the *Summa*, together with other theories of Arabic alchemy.

(a) *The Two Exhalations Theory*

In Arabic alchemy, smoke (*dukhān*) and vapour (*bukhār*) were considered to be the origin of metals and stones and were equated to sulphur and mercury.[64] Although the smoke-vapour notion had started with Aristotle,[65]

60. Jābir, *Kitāb sundūq al- hikma,* Dar al-Kutub al-Misriyya, Cairo, MS Tabī'yyāt 303, ff. 66b–67a.
61. Jābir, *Kitāb al- Khawāss al- Kabīr,* MS Or 4041, maqāla 36, ff. 67b–68a.
62. Jābir, *Al-Jumal al-'ishrūn*, MS Huseyin Celebi, 743/5, maqāla 13, p. 489.
63. Ahmad Y. Al-Hassan, 'Potassium Nitrate in Arabic and Latin Sources', Proceedings *of the XXI International Congress for the History of Science,* Mexico City, 2001. See Chapter 7.
64. While this chapter was being written a paper appeared on exhalations theory by John A. Norris, 'The Mineral Exhalation Theory of Metallogenesis in Pre-Modern Mineral Science'. *Ambix*, 53 (1, 2006): 43–65. Our essay here concentrates on the exhalation theory in Arabic literature, and in the *Summa*. It takes into consideration only the exact text of the *Summa,* without any interpretations not stated in the text itself. It may be added that the text of Ikhwān al-Safā' says the following about sulphur: 'Those airy oily parts, with the earthy parts that were picked up by them, will become combustible sulphur through the cooking by heat and with passage of a long time.'
وتصير تلك الاجزاء الهوائية الدهنية وما يتعلق بها من الاجزاء الترابية بطبخ الحرارة لها بطول الزمان كبريتا محترقا.

the full account of their role in the generation of metals and the relation to the sulphur-mercury theory was first given in Bālīnās' *Kitāb sirr al khalīqah* (Book of the Secret of Creation) or *Kitāb al-'ilal* (The Book of Causes).[66] According to Paul Kraus, Jābir drew heavily from this source in his own works, including the two exhalations theory and the sulphur-mercury theory.[67]

Hugh of Santalla, who stayed in Tarazona from 1145 to 1151, translated Bālīnās' *Book of the Secret of Creation* into Latin in the twelfth century. We compared the chapter dealing with the generation of metals in Françoise Hudry's edition of Hugo of Santalla's Latin translation with the corresponding chapter in Ursula Weisser's edition of *Kitab sirr al khalīqah*,[68] and found them to be similar (Appendix 1). From this, it is evident that the two exhalations theory of the generation of metals and the sulphur-mercury theory were available in Latin since the middle of the

Rasā'il Ikhwān al-Safā' wa khillān al-wafā (Epistles of the Brethren of Purity and Loyal Friends), (Beirut: Dar Sadir, 2004), vol. II, 106. Section Two, on natural sciences, contains 17 epistles (*rasā'il*); epistle (*risāla*) number 5 is on 'How Minerals are Formed'.
65. Aristotle, *Meteorologica*, trans. E. W. Webster (Oxford: Clarendon Press, 1968), III 6, 378a 15 ff. For the text of Aristotle's exhalations concept, see also F. Sherwood Taylor, *The Alchemists* (London: Heinemann, 1951) reproduced by Kessinger Publishing Company, Montana, USA , n.d. , 12–13.
66. Bālīnās, *K. Sirr al-Khalīqa*, ed. Ursula Weiser (Aleppo: Institute for the History of Arabic Science, 1979), 243–79. The complete theory is developed in Bālīnās' *Kitāb sirr al-khalīqa*; *Rasā'il Ikhwān al-Safā;* al- Majrītī's *Rutabat al- hakīm*; al- Tughrā'ī' s *Mafātīh al- hikma*; al-'Irāqī's *Kitāb al-muktasab* ; al- Jildakī's *Nihāyat al-talab* and several other later works. See: Bālīnās; *Ikhwān al-Safā;* Al- Majrītī, MS BN arabe 2612, ff. 39a–40a; Al- Tughrā'ī, *Kitāb mafātīh al-rahma wa masābīh al- hikma*, Wellcome MS OR 21, ff. 36a–36b and 44b–46a; J.E. Holmyard: *Kitâb al-'ilm al-muktasab fi zirā'at adh-dhahab* by Abū 'l-Qāsim Muh. b. Ahmad al-'Irāqī (1923), reproduced in Sezgin, *Natural Sciences,* vol. 61, *Chemistry and Alchemy,* VII, 125–6; Al-Jildakī, *K. nihāyat al-talab,* MS Berlin 4184, folios. 29a–29b. Although there are small variations among these accounts in the details, they are all quite similar. For this reason, in this essay we follow al- Jildakī's account.
67. Kraus, *Jābir ibn Hayyān*, 2, 280–3.
68. The paper of F. Nau, 'Une Ancienne Traduction Latine du Bélinous Arabe (Apollonius de Tyane) Faite par Hugo Sanctelliensis…' (1907); reproduced in Sezgin, *Natural Sciences in Islam,* 60, vol. II, 289–96; was useful in our study since it gave a list of all the folios of Hugo of Santalla's ms. dealing with the generation of metals. Pinella Travaglia's study (*Una cosmologia ermetica, Il Kitab sirr al-Haliqa/De secretis naturae,* Naples, 2001) on the other hand gave selections only from both *Kitāb sirr al- khalīqah* and from Hugo of Santalla's Latin translation. His selections from the Arabic and Latin texts did not enable us to compare the generation of metals in both languages. We had therefore to study the original Arabic work and the original Latin translation and do the comparison. We used Ursula Weisser's Arabic edition of *Kitāb Sirr al- khalīqah* (Aleppo, 1979) and Françoise's Hudry's Latin edition of Hugh of Santalls's translation; '*Le De secretis nature du Ps. Apollonius de Tyane*, traduction latine par Hughes de Santalla du *Kitāb sirr al-khalīqa*', Chrysopoeia, 6, 1–154 (Paris, 1997–99).

twelfth century and not at the end of the thirteenth century, as Berthelot had claimed.

Vincent of Beauvais was acquainted with these theories. Lynn Thorndike asserts that in *Speculum Doctrinale*, Beauvais stated that:

> everything has an occult quality opposed to its natural one; that four spirits, mercury, sulphur, arsenic and sal ammoniac, and six metals, gold, silver, copper, tin, lead and iron are generated in the bowels of the earth; and that the metals are generated by mercury and sulphur.[69]

For this reason, Thorndike did not accept Berthelot's assertion that these basic theories of alchemy were not known in the West until the *Summa* had appeared at the end of the thirteenth century. Although Thorndike did not question the authenticity of Beauvais' statement, he was not sure about his source.[70] Now, however, it is conceivable to assume that Beauvais had based his statement on Hugo of Santalla's Latin translation of the *Book of the Secret of Creation*.[71]

Comparison of the Exhalation Theory in Arabic Alchemy and the Summa

The Arabic text for the exhalation theory and the text of the *Summa*, are reproduced in Appendix 2. An attentive reading of the Arabic and the *Summa* accounts shows them to be remarkably similar. Both assert that the metallic bodies cannot be generated from mercury and sulphur in their natural form (*Summa*) or in their coagulated form (Arabic). Both argue that natural sulphur and mercury cannot be found together in the same mine, but that each one is to be located in its own separate mine. For this reason, they should be used in the form of an earthy substance (*Summa*) or non-coagulated form (Arabic). Metallic bodies are thus formed from a double fume (*Summa*) or from vapour and smoke (Arabic).

This close resemblance of the *Summa's* text to the Arabic one refutes Newman's assumption that 'the theory probably occurred first in the *TP*, from whence it was transferred to the *Summa*'.[72] Indeed the *TP*'s account itself is also taken from an Arabic origin.[73]

69. Thorndike, *History of Magic*, 2, 471–2.
70. Ibid.
71. The source for Beauvais was not known, and since he was acquainted with the sulphur-mercury theory and the generation of metals in the bowels of the earth, and since this information was based on Bālīnās which was translated into Latin, it is conceivable that Beauvais might have used the available translation.
72. Newman, *Thesis*, 1, 169.
73. For the *TP*'s account of the two-exhalation theory, see Newman, Thesis, vol. IV, Part II, p. 58–60.

It is obvious, therefore, that the account in the *Summa* for the exhalation theory is an Arabic one. This leads us to two corollaries, one regarding the corpuscular theory, and the other regarding the mercury alone theory.

(b) *The 'Corpuscular Theory'*

Newman gave an assumed 'corpuscular theory' great publicity, and it was the main theme of at least one academic conference, the proceedings of which were lavishly published by Brill of Leiden.[74] Newman thought that this theory was first propounded in the *Summa* and that it was a theory of Paul of Taranto.[75] However, this so-called 'corpuscular theory' in the *Summa* is nothing but the same two exhalations theory already discussed. Nonetheless, it is worthy to remind that Bālīnās in his *Book of the Secret of Creation*, which was one of the basic sources for Jābirian alchemy, and the basis of the sulphur-mercury theory, had elaborated this Aristotelian concept.

To give special prominence to the alleged singularity of this theory, Newman chose the word *corpuscle* to translate the Latin *pars*, instead of *part* as Russell had done.[76] Nevertheless, the words 'pars', 'part' and 'corpuscle' are translations of the same Arabic word *juz'*.

Newman also attached particular significance to the degree of 'packing' of the 'parts' of a metal; as such 'packing' affected its weight and its proximity to perfection.[77] This same 'packing' (*talzīz* or *tarzīz*) of the 'parts' (*ajzā'*, singular: *juz'*) of a metallic body occurs frequently in Arabic alchemy within the context of the two exhalations theory. We present below a small selection from Arabic texts in order to show how Newman's 'corpuscular theory' is an old concept in Arabic alchemy.

Bālīnās

- On gold: 'And it became heavy "*razīn*" because its parts entered into each other.'[78]
- On mercury: 'It is heavy in weight and its parts entered into each other.'[79]

74. An example is Christopher Lüthy, John E. Murdoch and William R. Newman, editors, *Late Medieval and Early Modern Corpuscular Matter Theories* (Leiden: Brill, 2001). This work was reviewed and criticized severely by Gad Freudenthal in *Journal of the History of Philosophy* 41.2 (2003) 273–4.
75. Newman, *Thesis*, 1, 288–340.
76. Newman, *Summa*, 154–5.
77. Newman, *Summa*, 154.
78. Bālīnās, *Kitāb sirr al- khalīqa*, 258–9.
79. Bālīnās, *Kitāb sirr al- khalīqa*, 237.

JĀBIR

- On gold: 'Its parts entered into each other in an intermingling that cannot be separated and it works with them all.'[80]

- On silver: 'To become gold, silver needs two things: the packing of its parts (*tarzīz)* and tinting.'[81]

AL- JILDAKĪ

- On metallic bodies in general: 'A condition for the removal of ailment from a metallic body is that its parts should be packed so that it acquires weightiness instead of lightness.'[82]

(c) *The 'Mercury Alone' Theory*

The emphasis on mercury, rather than sulphur, is based on old knowledge in Arabic alchemy. From a single sentence in the *Summa*, Newman assumed that this idea would have begun in the thirteenth to fourteenth century. This sentence reads: 'And if you can perfect by *Argentvive* only you will be the *Searcher* out of a most precious Perfection; and of the *Perfection* of that which overcomes the *Work of Nature*.'[83]

This sentence appears in the *Summa's* chapter on the nature of Venus or copper. The full paragraph reads:

> Hence it is manifest that those *Bodies* are of greater *Perfection* which contain more of *Argentvive*; but what contain less, of less *Perfection*. Therefore study in all your *Works* that *Argentvive* may excel in the *Commixtion*. And if you can perfect by *Argentvive* only you will be the *Searcher* out of a most precious *Perfection*; and of *Perfection* of that which overcomes the *Work of Nature*. For you may cleanse it most inwardly to which *Mundification Nature* cannot reach. But the *Probation* of this *viz*. that those *Bodies* which contain a greater *Quantity* of *Argentvive* are of greater *Perfection* is their easie *Reception* of *Argentvive*. For We see *Bodies* of *Perfection* amicably to embrace *Argentvive*.

This text is recommending mercury '*if you can*'. However, in the *Summa* itself there are recipes prescribing other ingredients besides mercury. For instance, one recipe is for the solar medicine of the third order that transmutes silver into gold; here sulphur is the essential ingredient.[84]

80. Quoted by al- Tughrā'ī, *K. Mafātīh al- rahma,* from *Kitāb al-dhahab* (Book of Gold) of Jābir, fo. 65a.
81. Jābir, *Kitāb al- usūl*, NLM MS A33, fo. 62b.
82. Al- Jildakī, *Nihāyat al- talab*, Berlin MS 4184 (Landberg 350b), vol. I (sifr 1) fo. 30b.
83. Russell's translation, *The Alchemical Works,* 137; Newman, *Summa*, 206, and his translation, 731.
84. Russell, *The Alchemical Works,* 177–8.

The importance of mercury as the matter of metals was repeatedly stated in the Arabic alchemical literature and it recurred in the *Summa* and in the works of the fourteenth-century Latin alchemists, and it is in conformity with the sulphur-mercury theory.[85] Concerning the Arabic sources, the examples below will suffice:

BĀLĪNĀS

> 'I say that the origin of all melting bodies is mercury. Mercury is the origin of melting bodies and it is the first one among them and they were formed from it.'[86]

JĀBIR

> 'Mercury is the origin of melting bodies and it is their material and first object, like the sperm for animals or the seed for plants.'[87]

Jābir's comparison of mercury to sperm was repeated by Arnold of Villanova[88] and John Dustin but does not occur in the *Summa*.[89]

(d) *The Sulphur-Mercury Theory and the Composition of Metals*

Berthelot assumed that the Arabic works of Jābir did not mention the sulphur-mercury theory. Later, Newman assumed that a text in the *TP* on the differences in the constitution of metals is unique and is one of two main proofs for the relationship between the *TP* and the *Summa*. However, the account for differences in the composition of metals is part of the sulphur-mercury theory and is an essential concept in Arabic alchemy. Indeed, it is the basis on which the whole idea of transmutation is built. Gold was the perfect metal, followed by silver. The four remaining metals – copper, iron,

85. 'Quicksilver alone is the perfection of metals, and it contains its sulphur inherent in itself', Lynn Thorndike, *A History of Magic and Experimental Science*, 3 (New York: Columbia University Press, 1953), 58.
86. Bālīnās, *Kitāb sirr al- khalīqa* , 243
87. Jābir, *sharh Kitāb al- rahma*, Jarullah MS 1641 f. 10a. Indeed, Jābir devoted the three treatises of *Kitāb al- malāghim* (Book of Amalgams) mainly to the preparation of the elixir from mercury, which had to be purified before it could be used. NLM MS A33, *Kitāb al-malāghim, al-awwal* (the first) ff. 2a–10b, *al-thānī* (the second) ff. 11b–27a, and *al-thālith* (the third), ff. 28a–36b.
88. Thorndike, *History of Magic*, 3, 70.
89. Thorndike, *History of Magic,* 3, 97. It is significant to mention that in one work by Dustin, *Desiderbile Desiderium*, the name 'Jeber' in contrast to the more familiar 'Geber' is mentioned three times, and according to Thorndike, 'An interesting feature of the two [main] works [of Dustin] is their frequent citation of Geber or Jeber, whose influence upon Dustin's doctrine in these issues seems great and openly acknowledged.' Thorndike, *History of Magic*, 3, 70) Thus, it seems possible that Dustin was consulting a work of Jābir other than the *Summa*.

tin and lead – were defective. The aim of alchemy was, precisely, to treat the defective metals in order to be brought back to the ideal composition of gold. Arabic alchemy texts give accounts of the differences among the metals in one form or another.[90] The first account is found in the *Book of the Secret of Creation* of Bālīnās. Several other accounts are present in Jābir's works as well as in the works of other alchemists.

In the case of gold, the texts quoted below agree that mercury is its main constituent, while sulphur should be pure and non-combustible. Regarding other metals, the accounts by Jābir and the *Summa* are quite similar, with insignificant variations. Newman acknowledged that this part of alchemy was common knowledge in the thirteenth century. Nevertheless, he also believed that the *Summa* and the *TP* contained unique information regarding the fixedness (non-volatility) and the indication of the amounts.[91] A close look at the Arabic sources reveals that such information was not unique.

Jābir

'Mercury is the origin of metals; it is their matter and their principal constituent.'[92]

Further he says:

> And we shall say also that all metallic bodies in their essences are mercury that was set (coagulated) by means of the sulphur of the mine that has risen to it with the vapours of the earth. Moreover, they (i.e. the bodies) have differed because of the differences in their properties; and their properties differed because of the differences in their sulphurs. The differences in their sulphurs are caused by the differences in their earths and in their positions in relation to the heat that reaches them from the sun as it oscillates in its orbit. And the finest of those sulphurs, the purest and the most temperate was the golden sulphur and for this reason mercury was coagulated with it firmly and temperately; and because of this temperance it resisted fire and it stood firm and fire was not able to burn it in the same way as it burns other bodies.[93]

Ibn Sīnā

> If the mercury be pure, and if it be commingled with and solidified by the virtue of white sulphur which neither induces combustion nor is impure, but on the

90. One of the best explanations for the defects of the four metals, iron, copper, tin and lead is to be found in al-'Irāqī's treatise; see E.J. Holmyard: *Kitāb al-'ilm al-muktasab,* 124–30. It elaborates on the differences among the metals. See Chapter 1, Appendix 2.
91. Newman, *Thesis*, vol. 1, 81–4.
92. *Kitāb sharh kitāb al-rahma*, Jarullah MS 1641, fo. 10a.
93. E.J. Holmyard, *K. al-īdāh*, in *The Arabic Works of* Jābir *ibn Hayyān, edited with translations into English and critical notes,* (1928), reproduced in Sezgin, *Natural Sciences,* 69, *Jābir Ibn Hayyān, Texts and Studies*, I, 54.

> contrary is more excellent than that prepared by the adepts, then the product is silver. If the sulphur besides being pure is even better than that just described, and whiter, and if in addition it possesses a tinctorial, fiery, subtle and non-combustive virtue, in short if it is superior to that which the adepts can prepare, it will solidify the mercury into gold.[94]

Ikhwān al- Safa

> If mercury was pure and if sulphur was free from impurities and if their parts are comingled, and if their quantities were at the appropriate ratio, then *ibrīz* gold will be formed after a very lengthy period of time.[95]

Summa

> Therefore, 'tis now clear from the precedent, that if clean, fixed, red, and clear sulphur fall upon the pure substance of argentvive (being it self not excelling, but of small quantity, and excelled) of it is created pure gold.[96]

To conclude, it is clear that the constitution of metals according to the sulphur-mercury theory is the same in the *Summa* as it is in Arabic alchemy, from which it was derived.

(e) *The Theory of the Three Principles: Mercury, Sulphur and Arsenic*

One of Berthelot's main hypotheses was that the theory of the three natural principles was not mentioned in the Arabic works. Newman stated similar views. This theory and the inclusion of arsenic as the third principle was Newman's second main argument to establish the *TP* as the source of the *Summa*:

> Let us now point out that the inclusion of arsenic among the metallic principles is not easily extracted from the Arabic sources that our texts may have used.

He then concludes that

> The *Summa* and the *TP* share the unusual theory that arsenic must be included among the metallic principles: this further substantiates our view that dependence – let us now say a direct dependence – exists between the two texts.[97]

Nevertheless, the three principles – mercury, sulphur and arsenic – are

94. Eric J. Holmyard and Desmond C. Mandeville, *Avicennae De congelatione et conglutinatione*, 147–240.
95. *Rasā'il Ikhwān al-Safā'*, 2, 106.
96. Russell, *The Alchemical Works*, 132.
97. Newman, *Thesis*, vol. 1, 86.

always grouped together in Arabic alchemical texts whenever spirits are discussed. This naturally also applies to Jābir.[98] Arsenic was a major spirit, like sulphur, and there is extensive literature on its preparation and use in chemical operations.[99] Thus, the conclusions of Berthelot and Newman must have been based on a lack of familiarity with Arabic sources and a very limited number of available Latin texts translated from Arabic. None knew Arabic; Berthelot relied on few texts of Jābir of the allegorical category translated for him, and Newman relied on a very small number of available Latin translations.

JĀBIR

> And one of its principles is arsenic which has preparation, work and precious tincture; this is in addition to the high quality of this principle and its nobility.[100]

Further, he says:

> We have to believe also that sulphur is one of the spirits and it is necessary for the gold work; and arsenic is one of them and it is necessary for the silver work; and if arsenic is used in the gold work it will be deficient, and if sulphur is used in the silver work it will be deficient.[101]

SUMMA

> It now remains that we at present speak of arsenick. We say it is of a subtile matter, and like to sulphur; therefore, it needs not be otherwise defined than sulphur. But it is diversified from sulphur in this, viz. because it is easily a tincture of whiteness, but of redness most difficultly: and sulphur, of whiteness most difficultly: but of redness easily.[102]

(f) *The Three Orders of Medicines*

In the *Book of Seventy* of Jābir, the concept of the three orders of medicines is mentioned in numerous chapters. The *Summa* contains complete texts describing this concept that correspond to the texts of the *Book of Seventy.*[103]

---

98. Among Jābir's numerous works that discuss spirits (mercury, sulphur and arsenic) are: *Kitāb al- riyād*, Bodleian, MS Marsh 70, ff. 5a, 6a, 6b and 8a; *Kitāb al-usūl,* BL MS Add 23418 fo. 145a; *Kitāb al- Khawāss al- Kabīr*, maqāla 66, Alexandria Municipality, MS 5204, fo. 143b; *Kitāb ustuquss al-uss al-awwal*, in E.J. Holmyard, *The Arabic Works of Jābir ibn Hayyān* (1928), reproduced by Sezgin, 229.
99. Jābir, *Kitāb al-khālis al-mubārak*, NLM, MS A 33, ff. 250a–250b.
100. *Kitāb al-Jumal al-□'ishrīn*, MS Huseyin Celebi, 521.
101. *Kitāb tadbīr al-arkān*, in *L'élaboration de l'élixir suprème*, *Jābir ibn Hayyān*, ed. Pierre Lory (Damas Institut Français de Damas 1988), 142.
102. Russell, *The Alchemical Works*, 61.
103. Russell, *The Alchemical Works*, pp. 161, 195.

Further, numerous chapters in the *Summa* are based on this concept also.[104] We have discussed this topic elsewhere.[105]

Unique Jābir Traits in the Summa

Besides the discussions given above of Berthelot's assumptions, we would like to close Part I of this chapter by showing three unique traits of Jābir's writing, which distinguish his Arabic works. These same distinguishing features exit again in the *Summa* and the other Geber Latin works.

(a) *'Our Volumes'*

Jābir wrote scores of books and treatises, for which he compiled three *fihrists* (indices). These are listed in the *Fihrist* of Ibn al-Nadīm. More recently, Paul Kraus devoted one full volume to catalogue the works of Jābir.[106] Within these contexts, it is not surprising to find Jābir continually referring to his numerous other volumes or books. This referral became a characteristic feature of his style.[107]

In each of the four Latin tracts, Geber also speaks of his 'other volumes'.[108] He declares that the *Summa* is the sum of what he had written in his 'other volumes'.[109] Certainly, those 'other volumes' cannot possibly be the minor texts traditionally linked to the *Summa*. As we shall see below, Julius Ruska, followed by William R. Newman, assumed that the Riccardiana *DIP* was a source for the *Summa*. Ruska based his assumption on a single paragraph in the *DIP* which refers to the author's other volumes.[110]

We conclude from all this that the expression 'our volumes' does not apply to any of the above few Latin works. The expression 'our volumes',

---

104. The *Summa,* Russell's translation, Second Part of the Second Book, chapters X–XX, pp. 161–77.
105. See www.history-science-technology.com where we gave the English texts from Russell's translation and compared them with our English translation of the corresponding Arabic texts.
106. Kraus, *Jābir ibn Hayyān*, 1.
107. *Kitāb al-manfa`a* or the Book of Benefit in *L'élaboration de l'élixir suprème*, ed Lory,153; *Kitāb ustuquss al-uss al-thalith*, in E.J. Holmyard, *The Arabic Works of Jābir ibn Hayyān*, reproduced by Sezgin, 101; *Kitāb al-muntakhab min Kitāb al-Ittihād*, NLM MS A 33, ff. 121a, 145b; *Kitāb al-sirr al-maknūn*, NLM MS A 33, fo. 175a; *Kitāb al- Khawāss al-Kabīr*, British Library MS Or 4041, ff. 33a, 47a, 87b, 88a.
108. Russell, *The Alchemical Works*, *De investigatione* 18, 19; *Summa,* 23, 24; *De inventione*, 201, 214, 221; *Liber fornacum*, 227, 229, 240, 253, 254.
109. Russell, *The Alchemical Works*, 23.
110. Julius Ruska, 'Übersetzung' (we shall use in this paper the page numbers of Ruska's original paper), 78.

repeated in each of the Geber works, points out to an author who had written a large number of works on alchemy. Such an author cannot possibly be a pseudo-Geber, as we do not know of any thirteenth-century Latin author who wrote so extensively on alchemy. Nor do we know of any Arabic or of any pre-Arabic author. The only known author who had composed scores of treatises and books on alchemy was Jābir, and his style is reflected also in the Latin works.

(b) *The Principle of the Dispersion of Science*

Paul Kraus affirms that one of the most characteristic traits in Jābir's works is his continual declaration of not having exposed the full truth in one place only, but that he had distributed the alchemical knowledge throughout his countless treatises.[111] He constantly advises the student of the Art to collect and study his books. The Latin works of Geber also exhibit this same trait.

JĀBIR

> Understand that we have compiled in this art many books in numerous topics and arranged them in different ways. Some were related to others and some were complete in themselves [...]. Each complete book is adequate on its own. As to those books that are related, each one needs the other, and no person can benefit by using them unless he gets hold of a complete collection (and) read them all and learn their purposes.[112]

GEBER

> We declare that we have not treated of our *science with* a continued series of discourse, but have dispersed it in diverse *chapters*. And this was done; because, if it had been delivered in a continued *series* of *speech,* the just *man,* as well as him that is evil, might have usurped it unworthily. Therefore we have concealed it in places, where we more openly speak; yet not under an *enigma,* but in a plain discourse to the *Artist.*[113]

(c) *Jābir's Books of 'Sums'*

It is not rare to find similar declarations in Jābir's Arabic works, and in the *Summa*. The opening paragraph of the *Summa* is similar to the corresponding one in his *Book of Seventy*. Jābir distinguished between his larger and smaller books and in the preface to the former, sometimes he states that a larger book is a sum of the knowledge dispersed in the smaller ones.

111. Kraus, *Jābir ibn Hayyān*, vol 1, XXVII–XXX.
112. Lory, *L'élaboration de l'élixir supreme, Kitāb al-manfa'a*, 153–4.
113. Russell, *The Alchemical Works*, 196.

JĀBIR

> Since there appeared many books of ours on this Art that is called *hikma* (philosophy) which has no limit and is the ultimate of philosophy, it became unavoidable that we should put down a book that explains our previous abbreviated words. Consequently, we are explaining one word of a certain art [in the previous abbreviated treatises] by a hundred words of the same art [in this volume]. So that this volume [*Book of Seventy*] contains what was in our former and our later books.[114]

Further, he says

> We have written before this book of ours several books dealing with such fundamentals like these, and all are dispersed. We have made this book of ours like the *sum* of those fundamentals, and arranged it in twenty parts.[115]

SUMMA

> Our whole Science of chymistry, which, with a divers compilation, out of the books of the ancients, we have abbreviated in our volumes, we here reduce into one *Sum*. And what in other books written by us is diminished, that we have sufficiently made up, in the writing of this book of ours, and supplied the defect of them very briefly. And what was absconded by us in one part, which we have made manifest in the same part, in this our volume; that the compleatment of so excellent and noble a part of philosophy, may be apparent[116]

PART 2 JULIUS RUSKA'S HYPOTHESIS ABOUT THE RICCARDIANA *LIBER GEBERIS DE INVESTIGATIONE PERFECTIONIS* AND THE ASSUMPTION OF NEWMAN ABOUT PAUL OF TARANTO AS THE AUTHOR OF THE *SUMMA*

Ruska's and Newman's Assumptions

The following chart is a reworked copy of the one that William Newman had drawn to summarise his assumptions regarding a pseudo author of the *Summa perfectionis*.[117] We shall also use it here to summarise the assumptions of both Ruska and Newman.

114. *Book of Seventy*, article 1, *al-lāhūt* 'Divinity', Lory, *L'élaboration de l'élixir supreme*, 8.
115. Jābir, *Kitāb al-riyād*, MS. Marsh 70, fo. 2b.
116. Russell, *The Alchemical Works*, 23.
117. William Newman, *The Summa Perfectionis*, 65.

In 1925, Ernst Darmstaedter discovered a codex in the Riccardiana Library of Florence (MS 933), containing Latin MSS devoted to Arabic alchemy. He affirmed that it corresponded to the end of the thirteenth century and it included 'the oldest MS of the *Summa Perfectionis* of Geber that I know, but among other things, the *Liber Geberis de Investigatione Perfectionis*'.[118] In this chapter we shall designate the Riccardiana *de Investigatione Perfectionis* as *DIP* (no. 5 in the diagram, Figure 3.3).

In that period, Julius Ruska was deeply involved in his study of al-Rāzī, and in 1935 he wrote an extensive paper in which he assumed that this newly discovered *DIP* (no. 5) is a reworking of *Liber Secretorum Bubacaris* of the BN of Paris[119] (no. 3). He declared that the attribution of the *DIP* to Geber was erroneous: 'only one example of the thoughtlessness with which ignorant writers and scribes put arbitrary names to alchemical treatises'.[120]

He therefore decided to include the *DIP* in his study of the Latin works of al- Rāzī.[121] Ruska even suggested further that the last part of the *DIP* had been written by a late Latin author (no. 4) who would have also been the author of the *Summa* (no. 6).[122] He considered that *Liber Secretorum Bubacaris* (no. 3) was a reworking of *Liber Ebu Baccar er Raisy* of Palermo (no. 2), which was a translation of *Kitāb al-asrār* of al- Rāzī (no. 1).

In 1986, William R. Newman adopted all Ruska's assumptions and based his voluminous work on them; his main goal was to search for the unidentified Latin author that was imagined by Ruska. For this purpose, he conceived a maze of bewildering assumptions with an abundance of Latin citations to conclude that a previously unknown Paul of Taranto, a compiler of a treatise with the title of Theorica and practica (no. 4), was the author of both the Riccardiana *DIP* (no. 5) and the *Summa*[123] (no. 6).

We shall prove in this part of the chapter that all the assumptions of Ruska and Newman are untenable and without foundation. And since the Riccardiana *DIP* is pivotal in Ruska's and Newman's assumptions, the analysis and discussion of this treatise will be a major component in this chapter. To do this we shall discuss all their assumptions as illustrated in Figure 3.3, under the following main headings:

118. Ernst Darmstaedter, 'Liber Misericordiae Geber. Eine lateinische Übersetzung des grösseren *Kitâb al rahma*'. (1925), Republished by Fuat Sezgin in *Natural Sciences in Islam*, 71, *Jābir ibn Hayyān, Texts and Studies*, III, 181.
119. We shall refer to this MS henceforth as *Bubacaris*.
120. Ruska, Julius, 'Übersetzug', 86.
121. Ruska, 'Übersetzung', 26.
122. Ruska, 'Übersetzung', 53.
123. Newman, *Thesis*, vol. 1, 96–7.

- *The Latin MSS of Kitāb al-Asrār of al- Rāzī:* We shall prove here that the Palermo MS (*Liber Ebu Baccar er Raisy* – no. 2) is not related to the Paris MS (*Liber Secretorum de Voce Bubacaris* – no. 3).
- *Ruska's Assumption that the Riccardiana DIP is an Edition of Liber Secretorum De Voce Bubacaris* : We shall prove here that the *DIP* (no. 5) is not an edition of the Bubacaris (no. 3).
- *Attribution to a Latin Author:* We discuss here why Ruska's assumption of the attribution of part of the *DIP* and of the *Summa* to a Latin author (no. 4) is unsubstantiated.
- *The Jābirian Paragraph of the DIP on which Ruska and Newman Based their Hypothesis of a Latin Author of the Summa*: We prove here that the single paragraph on which Ruska had based his conjecture about a Latin author is simply a translation of one of Jabir's recognisable statements. This fact alone disproves the whole hypothesis of Ruska and Newman about the imaginary Latin author (no. 4).
- *Arabic and Islamic Expressions in the DIP*: We go a step further here to prove that the *DIP* as a whole is rich in Arabic and Islamic religious and non-religious expressions, including the part that Ruska had assumed to be written by a Latin author.
- *Arabic Technical Terms in the DIP:* We continue our proof that the *DIP*, including the part that Ruska had assumed to be written by a Latin author, is rich in Arabic technical terms that are not part of the usual terms that a Latin author will use in his writing.
- *Jābir as the Likely Main Author of the DIP:* We prove here that Jabir is most probably the author of the major part of the *DIP*, contrary to Ruska's assumptions. Our proofs are supported by the fact that the *DIP* refers to Jabir's *Libro quietis* (*Kitāb al- rāha*), and we discuss this book in some detail.
- *Further Examples from Newman's Assumptions*: After we have proved that the whole structure shown in Newman's diagram is imaginary, we give few further examples from Newman's assumptions to demonstrate how they are without any foundation.
- *The TP as a Compilation*: we end this chapter by giving further examples to illustrate that the *TP* of Paul of Taranto is a mere compilation from translations of Arabic alchemy. This excludes any possibility for it to be a source for the *DIP* or the *Summa* as was assumed by Newman (4, 5 and 6 in Figure 3.3).

This list of topics should guide the reader in selecting what topic is of interest to him or her. If reading the whole paper is not possible we advice the reader to read: 'The Jābirian Paragraph of the *DIP* on which Ruska and

Newman based their Hypothesis of a Latin Author of the *Summa*'. This is a short text but of great significance.

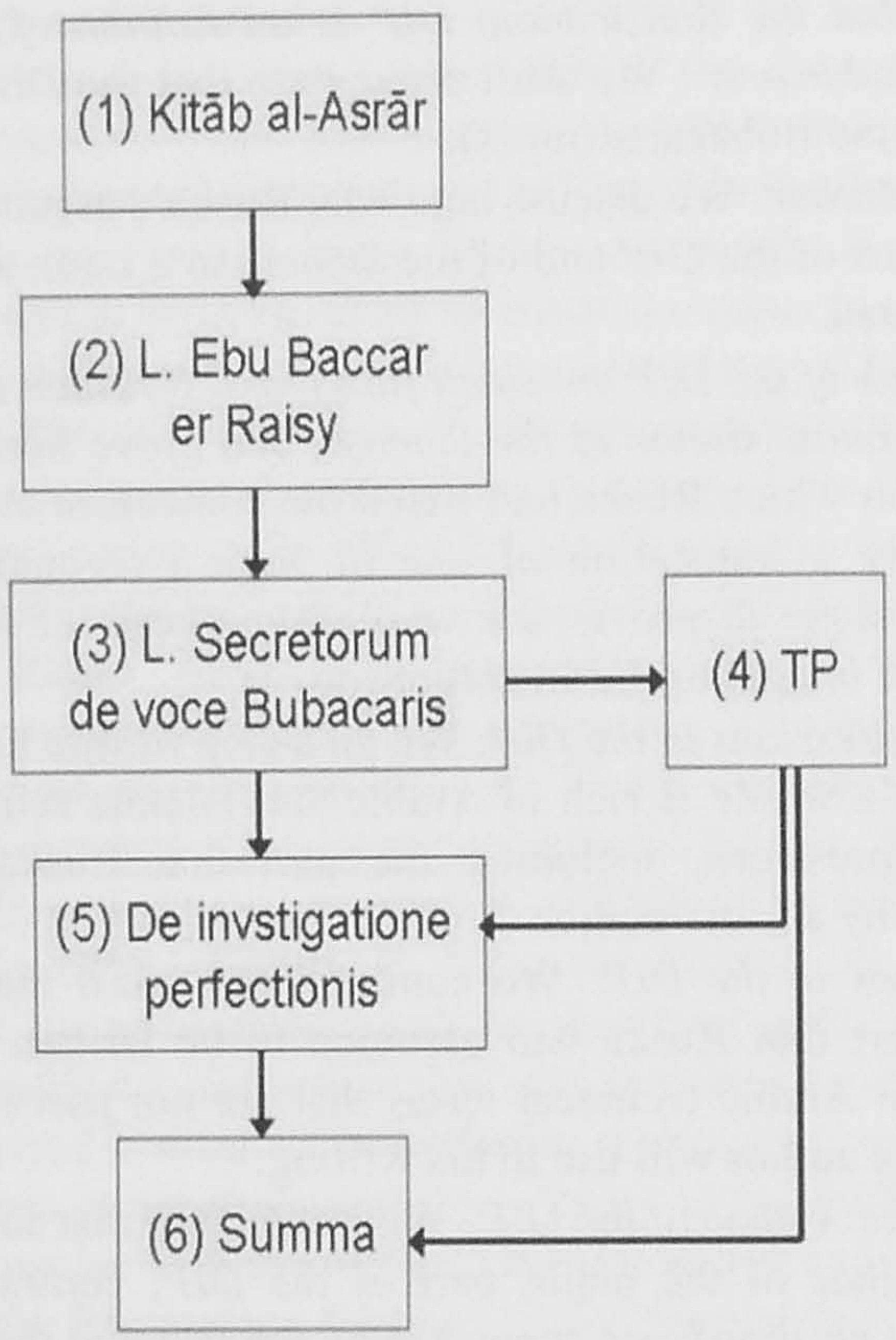


Figure 3.3 The assumptions of Ruska and Newman.

Ruska assumed that an unknown Latin author (4) wrote part of the *DIP* (5) and that he also wrote the *Summa* (6). Newman based all his work on Ruska's assumptions and imagined that the unknown Latin pseudo author is called Paul of Taranto who wrote a treatise TP (4), the *DIP* (5) and the *Summa* (6).

The Latin MSS of Kitāb al-Asrār of al- Rāzī

We all know that *Kitāb al- asrār* (Book of Secrets) of al- Rāzī[124] is a practical treatise on alchemy, devoid of theory. In the first two parts, it

124. Henceforward to be mentioned as *KA*.

gives a classification of substances and a description of alchemical apparatus, and in the third and largest part, practical recipes. This work remained little known in the West throughout the centuries and the number of available Latin MSS is small.[125] Ruska examined six of them: (1) BN 6514; BN 7156, both from the thirteenth century; (2) Oxford Bodleian Digby 119, fourteenth century; (3) Cambridge Trinity College 1120, fifteenth century; (4) B.L. Sloane 1754, fourteenth century; (5) Palermo Codex Speciale 19, fourteenth century.[126]

As the title of 'book of secrets' on various subjects was very common, and in order to distinguish one from the other, the name of an author was customarily attached to the title. In this way, the first four copies, listed above, carried the name of 'Bubacar', while the latter two – Sloane and Palermo – carried a distorted name of al- Rāzī.[127]

The importance of *Kitab al-asrar* (*KA*) lies in its first two parts, on substances and apparatus, which in fact constitute a very small fraction of the whole work; and they were frequently quoted by compilers. On the other hand, the third part, on recipes, although it constitutes the major part, seems not to have been cited in its entirety. This is, probably, because a vast number of recipes, from both Arabic and Latin sources, were available to compilers[128] This is the reason why the Latin versions of *KA* differ in the content and arrangement of the third part.

The four '*Bubacaris*' MSS have complete Latin translations of the first two parts. In 1927, Stapleton *et al.* published an English translation of the

125. This work was never printed.
138. Ruska, 'Übersetzung', 1–26. See also: Dorothea Waley Singer (DWS), *Catalogue of Latin and vernacular alchemical manuscripts in Great Britain and Ireland: Dating from before the XVI century*, Brussels,1928. Singer had listed 22 MSS for *Lumens Luminus* in England against three only for the *Secretorum* of Rhazes. (under item 113 for *Lumens Luminus* and item 116 for *Secretorum*).
127. Bubacar is a corruption of Abu Bakr which is part of al-Razi's name. This work remained unknown to historians of chemistry, like K.C. Schmieder in *Die Geschichte der Alchimie,* (Halle: 1832); Hermann Kopp in *Geschicte der Chemie* (Branschweig: 1843–1847); Ferdinand Hoefer took notice of the Bubacaris MSS at the B.N. but did not realise that 'Bubacar' was al- Rāzī. (Ferdinand Hoefer, *Histoire de la chimie,* 357). According to Julius Ruska, in his paper, 'Übersetzung', 4, Moritz Steinschneider realized that 'Bubacar' was al-Rāzī. Berthelot gave a brief description of the Bubacaris B.N. MSS. (Berthelot, *La Chimie au Moyen Age*, I, 306.)
128. We have mentioned above that we have collected for the present research a large number of the works of Jābir on practical alchemy and chemistry. This is in addition to other works for other Arabic alchemists and chemists. In Latin translations the works available to compilers include *Liber sacerdotum* of Arabic recipes by an anonymous compiler (Berthelot, *La Chimie au Moyen Age*, 1, 179–228; see also Dorothea Waley Singer (DWS), *Catalogue*, item 499); Darmstaedter, *Liber claritatis*; and *Artis chemicae principes Avicenne, atque Geber*, Bale (Basel), Pietro Perna, 1572).

first two parts of *KA*, together with extracts from the third.[129] An important feature of this translation is that it used both an Arabic MS and a *Bubacaris* MS (BN 6514), finding small differences between both.

In 1935, Ruska published a study on the Latin translations and reworkings of *KA*, and two years later, a German translation including all three parts.[130] However, he mistook *KA* that he had translated for a different work of al-Rāzī, which is *Kitāb sirr al-asrār* (The Book of the Secret of Secrets).[131]

While he described briefly the Bubacar MSS in his 1935 study, he gave excerpts from the Sloane and Palermo MSS.[132] The translation of the Sloane MS was made by a Syrian priest in Antioch and retains more Arabic words than the others retain.[133] Ruska did not give excerpts from the Palermo MS, but reproduced a listing published by Isodoro Carini,[134] establishing his evaluation of this MS on Carini's headings of the recipes. Although a closer look at Carini's list shows that this MS is probably not a complete translation, Ruska concluded not only that it was, but that the others were reworkings of it.

Moreover, we can differentiate the six Latin MSS reported by Ruska into three types. The four *Bubacaris* manuscripts correspond to one type, while the Sloane and Palermo MSS are second and third types. The differences among all three types are noteworthy, thus the possibility of any one being a reworking of another seems remote.

We draw attention here also to a discrepancy in the historical dates of the six MSS. We do not know for sure which MSS preceded the other. If we consider the dates reported in Ruska's paper, we notice that the Palermo MS goes back to the fourteenth century, whereas the Bubacaris Paris MS goes back to the thirteenth. Based on these dates, the Palermo MS cannot be the source for the Bubacaris MS. This uncertainty about the dates of the MSS

129. H.E. Stapleton, R.F. Azo, & M. Hidayat Husain, 'Chemistry in Iraq', 317–417.
130. Julius Ruska: *Al- Rāzī 's Buch Geheimnis der Geheimnisse. Mit Einleitung und Erläuterungen in deutscher Übersetzung*. (1937), reprinted by Fuat Sezgin, *Natural Sciences in Islam*, 74, *Al- Rāzī*, II, 2002, 1–260 (Sezgin page numbers).
131. Al- Rāzī's *Kitāb sirr al- asrār* is a smaller treatise of recipes, without neither classification of materials, nor description of equipment and was not translated into Latin. It was published, along with a Russian translation, by U.I. Karimov, Tashkent, 1957. The text has also been published in facsimile by Muhammad Taqi Danish-Pazuh, together with *Kitāb al- asrār*, Tehran, 1964. In this study, we consulted the Danish Pazuh edition and the copy in NLM MS A 33.
132. Julius Ruska, 'Übersetzung', 10–26.
133. The introduction to this Latin version of al-Rāzī follows the Islamic way of invoking God's mercy on the translator.
134. Ruska, 'Übersetzung', Palermo Codex, 10–16.

precludes the assumed relationship between them as hypothesised by Ruska in the Figure 3.3.

Ruska's Assumption that The Riccardiana *DIP* is an Edition of *Liber Secretorum De Voce Bubacaris*

The *DIP* is an extensive treatise,[135] written on 24 folios, comprising 45,200 words, which are compiled from different sources. However, besides the initial few pages dealing with substances and equipment,[136] Ruska could not find any Rāzian Latin texts matching the *DIP*. Moreover, his analysis showed that the share of the Rāzian Latin texts amounted only to about 13 per cent of the full MS.[137] For this reason, he had to resort to the Arabic *KA*.

However, if Ruska wanted to prove that the *DIP* was a new edition of the *Bubacaris*, the Arabic text of the *KA* was not the right place to search. And, if he was searching for the real sources of the *DIP*, he should not have limited himself to the Arabic *KA*, but should have surveyed the numerous extant works on Arabic alchemy, particularly Jābir's, since after all, the *DIP* does carry his Latin name.

However, since Ruska limited himself to *KA*, he had no other options but to compromise. Thus, sometimes he writes that the *DIP* text corresponds *on the whole* (*im ganzen*) to *KA*, while at other times he says that it is a rough approximation (*annähernd*).[138] If he had adhered to proper comparison rules, the share of materials taken from *KA* would diminish considerably. To illustrate: upon finding a difficulty in comparing the Arabic *KA* with the *DIP*, he explains:

135. The Riccardiana *DIP* was edited and published by Newman in vol. 3, Part 2, of his PhD thesis. Ruska published also extensive parts of the MS in his paper. Wherever there were differences, we used Ruska's version because we are discussing his paper. The folio numbers cited correspond to Newman's edition.
136. There are obvious differences between the first few folios of the *DIP* and the first folios of *Bubacaris* which indicate that these first folios of the *DIP* are not based and are not reworking from the *Bubacaris*. We give two examples only of the differences between the *DIP* and the *Bubacaris*: The *DIP* says that boraces are six including 'borax arabie'. In the Arabic text this is *bauraq al gharb* or *al-gharab*. الغرب . The translator read this word as the 'Arab العرب' with the letter *'ayn* ع ' instead of *ghayn* غ (a common error); so the word became 'arabie'. In the *Bubacaris* the word is carde and in another version it is carbe.

Another example is the Arabic word *kharsīnī.* Al-Rāzī listed seven metals. One of them is *khārsīnī*. The *DIP* says that bodies are seven including 'karesin'. The word 'karesin' stands for *khārsīnī*. It is nearer to the Arabic original than the word 'catesim' of *Bubacaris*.
137. Ruska, 'Übersetzung'. 26–33. Word count was based on Ruska's detailed analysis of the *DIP* contents under the heading 'Allgemeine Übersicht'.
138. Ruska, 'Übersetzung', 27; 31.

The *'DIP' text* corresponds *on the whole* (*im ganzen*) to the first prescript in *KA*'s chapter on the 'egg', however at the end it has a strong infringement or intrusion. The end seems to have been taken from a third source.[139]

Toiling in this way, to find in the Arabic *KA* similarities to the *DIP*, Ruska was able to add a further 27 per cent to the share of Rāzian sources in the *DIP*, raising the total to about 40 per cent. But the remaining 60 per cent still had to be attributed.

Attribution to a Latin Author

As mentioned above, Ruska could not find in the Latin *Bubacaris* and the Arabic *KA* similarities justifying the hypothesis that the *DIP* was a reworking of the Latin *Liber Secretorum Bubacaris*.[140] Thus, he had to admit that the compiler had have recourse to other sources. Therefore, he ventured to attribute the last part of the *DIP* to a Latin pseudo-author.

To substantiate his hypothesis, Ruska focused on the *DIP* section dealing with alums and salts (ff. 21r–24r), which corresponds to the last paragraphs of Part IX and the full Part X, to conclude:

What distinguishes these pieces from the largest part of the preceding compilations is obviously only due to their mature late Latin formulation. Here we do not have to deal with translations of Arabic writings, but with original Latin texts, which follow in their content older models of the translation literature. In their style, however, they are quite Latin and do not reveal the spirit of the Arabic language.[141]

However, in the first place, here Ruska made an assumption without presenting any evidence. Moreover, the description of the style of the text as 'mature late Latin' is inaccurate. The copy of the *DIP* under analysis was transcribed in the last decades of the thirteenth century but the actual translation and compilation were obviously made before. We still have to keep in mind the state of knowledge on alchemy in the Latin West by the middle of the thirteenth century, as portrayed by Roger Bacon.[142]

The Latin literary style as a criterion to decide on the origin of this part of the *DIP* is not justifiable. We must remember that a translation may be literal or edited. In the latter case, a translator has his own understanding of a text, and then writes it in another style. Thus, for instance, the translators of Toledo in the twelfth century used the literal – word-by-word – style, but in

139. Ruska, 'Übersetzung', 31, Vorschrift was translated here as prescript.
140. Throughout this essay we use the word *Bubacaris* to denote *Liber Secretorum Bubacaris*.
141. Ruska, 'Übersetzung', 64.
142. See above, Part 1.

the course of the thirteenth century, the translators became more knowledgeable and some began to edit their translations.[143] The expression 'reworking' is often used to denote the editing of a translated text. Nevertheless, we cannot consider an editor or a reworker as the author of a text.

Finally, another genre is compilations that is taken from several sources, as is the case of the *DIP*. Compilers may perform some editing. The work may carry the name of the compiler, and when it includes material from an important author, it may bear his name. In the latter case, we have examples from both Arabic and Latin texts. *Kitāb Sundūq al-hikma* (Chest of Wisdom) is a compilation of chemical and alchemical recipes[144] and is ascribed to Jābir. The *Liber claritatis*, which is a compilation of chemical recipes translated from Arabic, is ascribed to Geber in the same way as the *DIP* which is also ascribed to Geber.[145] Another example is the *Artis Chemicae Principes* or *De anima in arte alchemia* which is a compilation of Arabic chemical and alchemical recipes attributed to Avicenna (Ibn Sīnā).[146] These three Latin compilations of Arabic alchemy and chemistry (including the *DIP*) appeared in the thirteenth century at about the same period.

Actually, Ruska based his hypothesis of a Latin author on a single paragraph in the *DIP*, which is a *Jābirian* one, as will now be shown.

The Jābirian Paragraph of the *DIP* on which Ruska and Newman Based their Hypothesis of a Latin Author of the *Summa*

Ruska based his hypothesis of a Latin author for part of the *DIP*, and moreover that this same author would have written the *Summa*, on the following paragraph:[147]

De quorum nominibus, naturis et operationibus hic dispersa in diversis voluminibus posuimus capitula, et induimus opiniones diversas. Alibi tamen cum Deo summam omnium, quae sparsim tradidimus, aggregabimus cum veritate probationis in summa una sermone brevi, in qua quidquid nostra volumina utile seu superfluum continent aut diminutum, hic per illam ibique per haec sanae mentis et diligentis indagationis artifex absque errore reperiet et perveniet ad desideratum perfectae artis actum et expectatum laboris effectum. Et nos non

143. Charles S.F. Burnett, 'Literal translation and intelligent adaptation amongst the Arabic-Latin translators of the first half of the twelfth C', in *La diffusione delle scienze islamiche nel Medio Evo Europeo*, ed. Biancamaria Scarcia Amoretti (Rome, 1987), 9–28.
144. Cairo, MS Tabī'yyāt 303.
145. Ernst Darmstaedter, 'Liber claritatis totius alkimicae artis, Bologna Cod. lat. 164 (153)', (1925–1928).
146. *Artis chemicae principes Avicenne, atque Geber*, Bale (Basel): Pietro Perna, 1572), 157.
147. Ruska, 'Übersetzung',78; Newman, *Thesis*, 3, part 2, 247–8. I express my gratitude to Adam McLean and Lou Gilberto for their assistance in the translation of this Latin paragraph.

collegimus ob aliud multa ex antiquorum dictis et in voluminibus nostris ea multiplicavimus, nisi ut ex illis eliceremus secretum eorum, et vitaremus errores, et ex eorum coniecturis nostri roboraremus perscrutationem sermonis via brevi et veritate perfecta, ad quam faciente glorioso et sublimi Deo, licet cum longi vigilia studii et magni laboris instantia usque quaquam pervenimus, et earn totam in libro qui Summa intitulabitur, non sub illorum scribemus aenigmate vel figuris, neque ita lucido trademus sermone, quin illum accidat necessario insipientes latere eosque subire errorem. Sed traditionum omnium assumentes arcanum ex his, quae perquisivimus, vidimus atque palpavimus. et certificati sumus cum experientia vera, tali sermone volente Deo explicabimus. Quod si se ad ea bonae mentis artifex exercitaverit, se totum [aut saltem partem] artis excelsae fructum Dei dono adinvenisse laetabitur.

In this paragraph, the author makes three important declarations:

1. He refers to his 'various volumes' (*diversis voluminibus*).
2. He has dispersed alchemical knowledge in these volumes.
3. Therefore, he will write a 'sum book' (*summa*).

This is a Jabir's paragraph and we have already cited similar ones at the end of Part 1 under the heading, 'Jābir's Books of Sums' when we discussed the 'Unique Jābir Traits'.

We have shown that Jābir was the only author who had written numerous volumes throughout which he had dispersed knowledge and who wrote 'sums' of this scattered knowledge.

Also in this same paragraph, the author employs four Islamic expressions of praise to God: 'cum Deo', 'glorioso et sublimi Deo', 'volente Deo' and 'Dei dono'.[148] As we have also discussed above, Geber's works included this kind of Islamic expression. Moreover, Geber was acknowledged among the Latin alchemists up to the seventeenth century as the author that most characteristically praised God, this being a sign of the Arabic origin of these works.[149]

This paragraph is therefore, a translation from an Arabic *Jābirian* text. It ought to be very alarming for historians of science to realise that the whole hypothesis of Julius Ruska is based on his false interpretation of this single paragraph, and also to realise that the whole intricate structure of William R. Newman in his voluminous work concerning a pseudo Paul of Taranto, and

148. Some of these expressions are also familiar ones in Latin, but their recurrent use in the same text is characteristic of Islamic writings. Cum Deo means with God or under command of God; volente Deo, God willing, if God wills; Dei dono, by the grace of God. All are equivalent to the Muslim Qur'anic expression *'inshā'a Allāh* or *inshāllah*. Glorioso et sublimi Deo, the Glorious and High God is also a Qur'anic expression.

149. See e.g. Thomas Vaughan, *Aula Lucis, or The House of Light*. Adam McLean, *The Alchemical Web Site*, http://www.alchemywebsite.com/aula_lucis.html.

his imagined role in the history of Latin alchemy, is built on Julius Ruska's false understanding of just one *Jābirian* paragraph.

Arabic and Islamic Expressions in the *DIP*

The *DIP* as a whole, including the section selected by Ruska as a Latin original text, is rich in Arabic and Islamic expressions. The assumption that they were insertions by the author in order to imitate the Arabic style needs sound substantiation. It seems infinitely more probable that, inversely, they are an intrinsic part of the fabric of the *DIP*.

Latin translators used to purge the Arabic texts from conspicuously Muslim expressions, like the name of the Prophet and other explicit Islamic religious idioms.[150] However, there are some Islamic expressions that can be applied to any religious belief, especially those that praise or glorify God. These expressions were sometimes kept in the translations.[151]

Among the many Islamic expressions, one sentence reads: 'Benedictus igitur sit gloriosus et sublimis Deus qui nihil fecit regimine carens', which means, 'Therefore be blessed the glorious and sublime God, who made nothing which lacks order.'[152]

150. Arabic treatises start with the Qur'anic verse '*In the name of God, most Gracious, most Compassionate*'. This is sometimes followed by various forms of the prayer: 'Blessings and Peace upon our Master Muhammad, his Family, and his Companions'. The Latin translators were usually monks and it was natural for them to delete such Islamic expressions. One example is that Hugh of Santalla removed the Qur'anic verse '*In the name of God, most Gracious, most Compassionate*' in his translation of *Kitāb sirr al- khalīqah* of Bālīnās, (Nau, p. 102). Another typical case is that *Kitāb al-rahma* of Jābir was translated into Latin probably in the 13th century. It was translated into French at the end of the 19th century by Berthelot-Houdas. The Latin translation has the starting Qur'anic verse removed while the French translation of Berthelot-Houdas had kept it. In addition, the Latin translation had the concluding prayer for Muhammad the Prophet removed, while the French translation had kept it. Darmstaedter who published the Latin translation says in his very last footnote that the final sentence with the name of Muhammad is missing here. 'The Latin translation was surely intended for Christian readers'. 'Der Schlußsatz mit der Nennung MOHAMMEDS fehlt hier. Die lateinische Übersetzung war sicher für christliche Leser bestimmt.' (Berthelot, *La Chimie au Moyen Age*, 3, 163–90; Darmstaedter, 'Liber Misericordiae Geber', original pp. 183, 197, 'Sezgin pp. 309, 323'). Besides this voluntary censorship, there was official church censorship during the Middle Ages which culminated in the establishment of the Inquisition, (There is a vast literature on the subject. See for example the article: 'Censorship of Books' in the *Catholic Encyclopedia*, online.)

151. See e.g. Lee Stavenhagen, *Liber de Compositione Alchimiae*, '*A Testament of Alchemy*'. (Hanover, New Hampsire: The University Press of New England, 1974); *The Secret Book of Artephius*, published by Adam McLean, *The Alchemy Web Site*, http://www.alchemywebsite.com/artephiu.html.

152. Ruska, 'Übersetzung', 76.

This sentence is similar to one or two verses in the *Qu'rān*.[153] The *DIP* also includes 56 short Islamic religious expressions, such as 'cum deo', 'cum deo volente', and the like, distributed throughout its 24 folios – 10 of which appear in the section selected by Ruska as being written by a Latin author.[154] In the Arabic alchemical literature, these kinds of expressions tend to occur at the end of recipes and they are translations of the Arabic '*inshā'allāh*' (if God wills) and its other Arabic forms. The frequency of their use varied from one author to the other, but they occur in all of them. This is a typical Muslim phrase, derived from the *Qu'rān*. Its use is mandatory and is deeply rooted in Islamic culture.[155]

The non-religious expression 'scias hoc' appears 31 times – 12 of them in the section selected by Ruska. It means 'know this', 'understand this' and it is typical in Arabic texts whenever the author wanted to stress the importance of an idea or a prescription.[156] The phrase 'et est de secretis' occurs several times in the *DIP*, also being a typical expression in Arabic alchemy.[157]

A quantitative analysis also serves to underscore the difference between Jābir's and al- Rāzī's texts. In the latter's Arabic printed edition of *KA*,[158] the expression 'if God wills' occurs only 4 times, while 'know this' occurs 7 times throughout its 116 pages. This is in overt contrast to Jābir's Arabic texts. In his *al-malāghim* books – devoted to the practical alchemy of amalgams,[159] between folios 2a and 36a there are 48 expressions of 'if God wills' and 17 of 'know this'.

God references by Latin authors

We have surveyed several alchemical treatises written by Latin authors and other works translated from Arabic from the twelfth century on, looking for the word 'God' and others signifying 'God', together with their

153. There are few Qur'anic verses that resemble this text. One occurs in a verse describing men who contemplate the wonders of creation in the heavens and the earth. These men will praise God saying: 'Our Lord, Glory be to Thee, you have not created all this as lacking order.' ربنا ما خلقت هذا باطلا سبحانك. In contemplating the wonders of Heavens and Earth the word باطلا means the opposite of order (The *Qur'ān*, Al 'Imran, Sura 3, verse 191).
154. It may be objected that the expression 'cum deo volente' is also known in Latin; however, it could not be found in alchemical treatises by Latin authors.
155. Sūrat Al Kahf (18):24: 'And never say of anything "I shall do such and such thing tomorrow", except (with the saying): "If God wills" And remember your Lord when you forget.' This verse shows that it is mandatory for a Muslim to say *'inshā'a Allāh*.
156. See our reference below to *Kitāb al- malāghim* of Jābir where the expression 'understand this' is repeated throughout the text.
157. Ruska, 'Übersetzung', 69.
158. Al- Rāzī, *Kitāb al- asrār*.
159. NLM MS A 33 (*Majmū' Nafīs*), ff. 2a–36a.

qualifications.[160] We found that Latin writers did not use the qualities attributed to God by Muslim alchemists. That is to say, it is possible to distinguish a Latin author from an Islamic one through the occurrences of the word 'God'.

Latin authors had a particularly Christian style in their references to God. For instance, Arnald of Villanova, in *Chymicall Treatise*, mentions the word 'God' devoid of the Islamic attributes. In this work, the term 'Holy Ghost' appears more times than 'God' while the latter is defined as 'I say that the Father, Son and Holy Ghost are one, yet three.'[161] Furthermore, 'The Word was a Spirit, and that Word the Spirit was with God, that is with himselfe, and God was that word, he himself was the Spirit', based on John 1:1. Thus, in this treatise we find a clear Christian tone, completely different from the Islamic.

In the *Book of Quintessence*, by John of Rupescissa (d. 1365), the author begins his essay 'in the name of the Holy Trinity', in opposition to the Qu'ranic verse which opens an Arabic work like the *Liber de Compositione Alchimiae*. God is designated several times as 'our Lord God'; the name 'Jesus Christ' is used, and in no instance do references to God include the Islamic attributes.[162]

We quote one more example. In *New Pearl of Great Price*, written by Peter Bonus in the fourteenth century and edited by Janus Lacinius in the sixteenth, we find once again the same Christian style of references to God (without the Islamic attributes), besides the expressions: 'Christ', 'Jesus Christ, the Son of God', 'our Saviour Jesus Christ' and 'our Lord Jesus Christ'.[163]

Arabic Technical Terms in the *DIP*

Many technical terms clearly betray the Arabic origin of the *DIP*. One instance is the units of weight. Latin translations of Arabic alchemical works generally used the 'libra', a translation of the Arabic word *ratl*. One *ratl* was usually equivalent to about 468 grams, although this value had regional variations.[164] The Roman libra or pound was used throughout Europe, and

160. The surveyed Arabic treatises and Latin works of Arabic origin and the Latin works written by Christian authors are given within the text of this article and in the footnotes.
161. *A Chymicall Treatise of the Ancient and Highly Illuminated Philosopher, Devine and Physitian Arnoldus de Nova Villa*, published by Adam McLean, *The Alchemy Web Site*, http://www.alchemywebsite.com/arnaldus_treatise.html.
162. John of Rupescissa, *The Book of Quintessence*, Glasgow, 2002.
163. Peter Bonus of Ferrara, *The New Pearl of Great Price*. Reprinted by Kessinger Publishing Company, Montana, USA, n.d.
164. E. Ashtor, Article *'Mawāzīn'*, in *Encyclopedia of Islam* (EI), New Edition.

was divided into 12 ounces (about 329 grams).[165] However, many European merchants in the Middle Ages preferred to use a larger pound of 16 ounces (about 457 grams).[166] As in the case of the *ratl*, there were many standards simultaneously in use. For example, a fifteenth-century Venetian *libbra grossa*, was equivalent to about 476 grams.[167] Thus, the libra and the *ratl* are nearly equivalent. Still the *DIP* compiler (or translator) used the Arabic *ratl*. The word *rotulum* and its variants occur 55 times in the text.[168]

Arabic texts also use the *dirham*, which is equivalent to about 3.6 grams.[169] In the *DIP*, the *dirham* is translated as drachma, and occurs 54 times.[170] In Spain, the drachma was a unit of mass in apothecaries, and it was equivalent to about 3.6 grams and in European countries in general it varied between 3.3 and 4 grams.[171] However, the drachma is not used in Latin alchemical works.

'Ocab' corresponds to the Arabic *'uqāb*, meaning eagle. This word is much used in Arabic alchemical works as a pseudonym of *nushādir* (sal-ammoniac). The word 'ocab' appears 101 times in the *DIP*,[172] while in other Latin translations or works written by Latin authors, the term employed was *sal ammoniacum*. There are many other terms in the *DIP* that kept closeness to their Arabic origin. A few examples are presented in Appendix 3.

Jābir as the Main Author of the *DIP*

If we accept Ruska's assumption that the Rāzīan contribution to the *DIP* amounts to 40 per cent of the whole treatise, we are left with 60 per cent that need to be accounted for. We have demonstrated that the pivotal paragraph that Ruska imagined was written by a Latin author is a translation from Jābir and that the whole section which Ruska tried to assign to a Latin author is an Arabic translated text. Therefore, we are left with one choice only which means that Jābir is the main author of the *DIP*. Let us elaborate.

165 'Libra', in *Encyclopedia Britannica Online*.
166. A Dictionary of Units of Measurement, published online by Russ Rowlett and the University of North Carolina at Chapel Hill. www.unc.edu/~rowlett/units/.
167. Giorgio di Lorenzo Chiarini, *Libro che tracta di mercatantie et usanze de paesi.* (Florence: 1481).
168. *DIP* MS f. 1v, 2v, 3r, 4v, 5r, 8r, 8v, 9r, 9v, 10r, 10v, 12r, 12v, 13r, 13v, 14r, 16r, 18r, 18v, 19r. It occurred up to 8 times in some folios.
169. G.C. Miles, article *'Dirham', EI.*.
170. *DIP* MS f. 2v, 3r, 3v, 4v, 5r, 8r, 8v, 9r, 9v, 10r, 10v, 12r, 12v, 13r, 13v, 14r, 16r, 18r, 18v, 19r. It occurred up to 6 times in some folios.
171. Wikipedia, article 'Apothecaries' system' See also: 'Units & Systems of Units' at www.sizes.com/units/drachma.htm.
172. *DIP* MS 5r, 8r, 9v, 10r, 11r, 11v, 12r, 12v, 13r, 13v, 14r, 14v, 15v, 16r, 16v, 18r. It occurred up to 20 times in some folios.

The dominant figure in Arabic alchemy was Jābir ibn Hayyān. Many alchemical works bear his name, as was pointed out above. On the other hand, al- Rāzī wrote a much smaller number of treatises, the most renowned of which is *KA*.[173] For Arabic writers on alchemy, Jābir was the main authority. They quoted him systematically more often than al- Rāzī. For example, al- Jildakī's *Nihāyat al- talab* – a commentary to al-'Irāqi's treatise on the cultivation of gold –[174] mentions only one work by al- Rāzī 10 times, whereas Jābir is mentioned 194 times and 42 works are cited.[175]

This same huge disparity is found in the literature of Arabic alchemy and is not difficult to explain. Al- Rāzī had an interest in alchemy in his youth, for a period of about ten years, to devote himself later to medicine. On the other hand, Jābir devoted his long life – 90 years, according to al-Jildakī – mainly to alchemy.

We would like to mention here that Jābir was the main source for al-Rāzī. This was demonstrated in detail by Stapleton. [176] Earlier, Abū Maslama al- Majrīṭī (d. 1008) had shown in his book *Rutbat al- hakīm* that al- Rāzī did not discuss any topic that was not discussed earlier by his 'teacher' Jābir,[177] and that Jābir had revealed facts that remained obscure to his 'student' al- Rāzī.[178] Another noted alchemist, al-Tughrā'ī (d. 1121), claimed in his book *Mafātīh al-rahma*, that most of al- Rāzī's twelve books were copied.[179] In recent times, Ruska acknowledged that the twelve books of al- Rāzī are influenced by the teachings of Jābir.[180]

Thus, it cannot surprise us that a vast disparity is reflected in the alchemical works that were translated into Latin. The translators had a much larger choice from Jābir's works on both practical and mystical alchemy than from al- Rāzī's works. This helps to explain the existence of several Geber Latin works.

Therefore, the compiler of the Riccardiana *DIP* would have had two main Arabic sources: the lesser would be al- Rāzī, and the main one was Jābir.

173. Fuat Sezgin, *Geschichte des Arabischen Schrifttums*, vol. 4 (Leiden: Brill, 1971), 279–82.
174. Translated and edited by Eric J. Holmyard, *Kitāb al-'ilm al-muktasab*.
175. This statistics is based on the index made by M. Teslimi as a part of his 1954 Ph. D. thesis on *Kitāb Nihāyat al- talab*, at London University, under the supervision of Eric J. Holmyard.
176. Stapleton, Azo, & Husain, 'Chemistry in Iraq', 335–8.
177. Al- Majrīṭī, *Kitāb rutbat al- hakīm*, BN arabe 2612, fo. 27a.
178. Al- Majrīṭī, *Kitāb rutbat al- hakīm*, fo. 27b.
179. Al- Tughrā'ī, *K. Mafātīh al- rahma*, fo. 7b.
180. Ruska, *Islam*, vol. 22, 1935, He says on p. 292, 'Ich muß mich mit der Feststellung begnügen, daß die 'Zwölf Bücher' ar- Rāzī 's offenbar weit enger mit den Lehren Jābir's zusammenhängen, als man nach dem Inhalt des *K. sirr al- asrār* anzunehmen geneigt wäre.'

Libro quietis (*Kitāb al- rāha*)

A further argument for Jābir is found in a paragraph in folio 6r of the *DIP*:

> Diximus superius in libro quietis utilia et non utilia, ubi diximus congelationes spirituum et coniunctiones corporum, et subtiliter diximus in operatione supradicti libri.

Here the author states that he had talked above, in the '*libro quietis*' (*Kitāb al-rāha*), of the congelation of spirits, the union of bodies and their preparations.[181]

Ruska had noticed this paragraph, but he was not able to find any mention of the *libro quietis* or the *Kitāb al- rāha*, neither in *Bubacaris*, nor in *KA*. Thus, he concluded that it must have referred to a different unknown source.[182] However, as al- Rāzī's *Kitāb al-rāha* is not a book on alchemy,[183] the *libro quietis* mentioned in the *DIP* must be *Kitāb al- rāha* of Jābir. This work by Jābir is missing, but we have significant information about it from al- Tughrā'ī and al- Jildakī.[184]

The importance of *Kitāb al- rāha* may be appraised from the following statement in al- Jildakī's *Nihāyat al- talab*:

> And since to us was revealed everything concerned with this science we devoted this our book and *K. ghāyat al-surūr* and *K. al-shams al munīr* and *K. al-taqrīb fī asrār al-tarkīb* and *K. sharh k. al- rāha* of Jābir (Explanation of the Book of Rest) to important, useful and comprehensive practical discourses, which if mastered by the seeker of knowledge would enable him to grasp all the principles and doctrines of the Art.[185]

From the paragraph in the *DIP*, we learn that the *libro quietis* discusses the '*coniunctiones corporum*', that is, the union of bodies or their alloying. From al- Tughrā'ī , we learn that *Kitāb al- rāha* deals with the union (*tazwij'*) of bodies. The word '*tazwij*' literally means intimate union and, in an

181. The *Liber Quietis* is also mentioned in a Spanish MS of the *DIP*. On f. 61r begins: 'secunde partis de coniunctione corporum', a marginal note in f. 61v states that the text contains a reference to *Liber Quietis*, José María Millás Vallicrosa, *Las traducciones orientales en los manuscritos de la Biblioteca Catedral de Toledo* (Madrid 1942), MS 96-35 (Zelada), No 10031 de la Biblioteca Nacional.
182. Ruska, 'Übersetzung', 55.
183. This book has two titles, the alternative one is *Kitāb al-tartīb*. See Stapleton, Azo, & Husain, "Chemistry in Iraq", 361 (Sezgin p. 55).
184. Al- Tughrā'ī quoted from it in two of his books, *Kitāb Mafātīh al rahma wa masābīh al-hikma,* and *Kitāb tarākīb al anwār;* see Kraus, *Jābir ibn Hayyān,* 1, 120–1. Al- Jildakī devoted a whole book, also missing, under the title *Kitāb sharh Kitāb al- rāha*, to explain it; see Teslimi, *Thesis,* 302; 494. He also quoted from it in two of his books, *Kitāb al-wādih fī fakk al-ramz* and *Kitāb al-taqrīb*.
185. Quoted and translated by M. Teslimi, PhD Thesis, 494.

alchemical sense, mixing or alloying. In other words, '*tazwij*' and '*coniunctiones*' convey similar meanings. Al- Tughrā'ī would also quote extensively from Bālīnās and Jābir. An instance of a long quotation taken from *Kitāb al- rāha* is the following:

> And Bālīnās was speaking in this chapter about the method of mixing and the union of the thin (rarefied) with the dense (thick). And his meanings are similar to what Jābir had said in *Kitāb al- rāha*, although the approaches are different; but the scientist perceives with God's light and understands the relative relationship. Jābir ibn Hayyān said that no whiteness can take place, or redness, without the spirits and the spirits of bodies. And there is no way of differentiating and of bringing out the gentle spirit of the body except by the spirits of the spirits, This is because the spirits of bodies yearn for the spirits of spirits and seek them since all of them are spiritual and aeriform. Therefore if they are subjected to the heat of fire they fly and evaporate. So if the spirits are mixed with the spirits of bodies they cling to each other by an adherence that cannot separate.[186]

At the end of this long citation, Al- Tughrā'ī comments, 'If Jābir in his book, which nobody has surpassed us in compiling, had given only this chapter it would have been sufficient, because it contains most of the principles that are needed in this Art.'[187]

Recapitulation: Bringing to an End Ruska's and Newman's Assumptions

We have discussed in detail why the *DIP* cannot be considered as a reworking of the *Bubacaris*, why it was entirely compiled from sources of Arabic alchemy, mainly from Jābir, why the pivotal paragraph on which Ruska had based his hypothesis is translated from Jābir, and why no part of the *DIP* was written by a Latin author.

Having refuted Ruska's speculations and since Newman had built his work on Ruska's hypothesis (see the diagram), it follows that all Newman's assumptions are without foundation.

With this conclusion, it is irrelevant to discuss the arguments given by Newman on the interdependence of the *Bubacaris*, the *TP*, the *DIP* and the *Summa*. There is no need for this any more. Nevertheless, we shall give few examples.

Further Examples from Newman's Assumptions

We have given ample evidence of the Arabic identity of the *Summa* and the *DIP* and shown that the corpuscular theory and the mercury alone theory are

186. Al- Tughrā'ī, *Kitāb Mafātīh al rahma wa masābīh al-hikma,*, MS Wellcome Or 21 ff. 52a–52b.
187. Al- Tughrā'ī, *Kitāb Mafātīh al rahma wa masābīh al-hikma,*, f. 52b.

of Arabic origin and were not the invention of the pseudo Paul of Taranto. We also showed at the end of Part 1 that all alchemical theories in the Latin language came with the translation of Arabic works in the twelfth and thirteenth centuries. Nevertheless we shall give now further samples of the kind of assumptions that Newman used in his work.

The Bubacaris and the Summa

Newman would suggest that the *Bubacaris* was a source for the *Summa*.[188] He had studied the two Latin translations of Arabic works available to him – Geber's *L. Misericordiae* and *De Re Tecta* by pseudo-Avicenna – and since he could not find in them anything comparable to the *Summa*, he concluded that it must have had the *Bubacaris* as a source.[189]

This hypothesis would be *a priori* unlikely as these are very different works: the *Bubacaris* is a practical treatise, including very little theory, while the *Summa* is a theoretical work, with a minor content of practical alchemy. Thus, any potential similarities would be too fragile a ground to establish a dependence of either of them on the other. However, it is worth reviewing one of the instances (about ceration) which Newman chose to base his assumption.

Ceration

This instance was deemed by Newman to be unique and would not occur in any other alchemical texts except the *Summa* and the *Bubacaris*.[190] It concerns the materials that ought to be used as agents of ceration. He did not find such information in the two Arabic Latin translations that were available to him.

According to Newman, *Bubacaris* is using sulphur and arsenic in ceration, whereas the *Summa* is using mercury, sulphur and arsenic. He says that the author of the *Summa* has 'divined' the reason why the *Bubacaris* had used sulphur and arsenic only, so he added mercury.[191]

188. Newman used MS BN 6514 for comparing the *Bubacaris* treatise with the *Summa*.
189. Newman, *Thesis*, 1, 149.
190. Newman, *Thesis*, 1,150–1.
191. The real reason why *Bubacaris* did not include mercury lies in the fact that the third part (the recipes part), according to Ruska, is not an exact translation from *Kitāb al- asrār* but is a re-working, (Ruska, 'Übersetzung', 16–18). The Arabic *KA* gives the ceration reagents as spirits (mercury, sulphur and arsenic), salts and boraces, *Bubacaris* gives them as sulphur, arsenic, salts and boraces.

Newman thinks that this alchemical knowledge is quite unique to the *Summa*, but its 'underpinning' is found only in *Bubacaris* and he concludes that the *Summa* had used *Bubacaris* as a source[192]

Summa

> Putaverunt ideo aliqui cerationem debere ex oleis, liquidis, et aqueis fieri: sed erroneum est illud a principiis huius magisterii semotum penitus, et ex manifestis nature operibus reprobatum. Naturam enim non videmus in ipsis corporibus metallicis humiditatem cito terminabilem ad illorum fusionis et mollificationis necessitates posuisse ... In nullis autem robus melius et possibilius et propinquius hec humiditas cerativa invenitur qualm in his – videlicet sulphure et arsenico propinque – propinquius autem in argento vivo et melius.[193]

The *Summa* here is advocating the use of spirits only (sulphur, arsenic and mercury) for ceration and is opposing the use of oils, liquids and waters.[194]

Bubacaris

> Inceratio corporum sapientissimi philosophi cum sulheribus(!) et auripigmentis puris facere preceperunt quia commiscentur cum corporibus si coniunguntur et si cum ipsis fuerint. Elargant enim ea et diasol[v]unt et faciunt currere (pro currere cod. legit cinerem). Et secundum quod multi dixerunt corpora incerantur cum salibus aut boracis et non intellexerunt quod pertinet incerationi et de salibus. Non est tamen inceratio nisi fuerit cum eis aut sulfur aut auripigmentum preparatum.[195]

Bubacaris here is recommending using sulphur, arsenic, salts and boraces.[196] This range of materials is not the same as the one in the *Summa*.

Jābir

Jābir discusses ceration in numerous books. We give here a selection only:

- *Kitāb al-rahma al-kabīr* (The Great Book of Mercy)[197] and *Kitāb sharh Kitāb al- rahma* (The Book of Explanation of the Book of Mercy)[198]: Jābir advocates the use of mercury, sulphur, arsenic and sal-ammoniac.

192. Newman, *Thesis*, 1,150.
193. Newman, *Thesis*, 1,150.
194. Russell, *The Alchemical Works*, 119.
195. *Bubacaris*, BN. MS 6514, fo. 107vb; Newman, *Thesis*, 1, 150.
196. Newman, *Thesis*, 1,150.
197. *Kitāb al- rahma al- Kabīr*, BN MS arabe 2606, ff. 148b–149a.
198. *Kitāb sharh Kitāb al- rahma* , Jarullah MS No 1641, fo. 23a.

- *Kitāb musahhahat iflātūn* (The Book of *iflātūn*'s Corrections):[199] mercury, sal-ammoniac and sharp waters.
- *Kitāb al- usūl* (Book of Principles):[200] sal-ammoniac solution.
- *Kitāb tadbīr al-arkān wa al- usūl* (The Book of Treatment of Bases and Principles):[201] sal-ammoniac solution.
- *Kitāb al-tajrīd* (The Book of Abstraction):[202] sal-ammoniac solution.
- *Kitāb al-riyād* (The Book of Gardens):[203] water of eggs' white with sal-ammoniac, borax and tinkār; also the fat of the horns of deer.

Comparing the Latin with the Arabic texts on ceration

Jābir's materials for ceration are: spirits (mercury, sulphur and arsenic), salts (mainly sal-ammoniac), borax, tinkār, sharp waters, water of the white of eggs and fat or oil from the horns of deer. These materials include all the reagents given in the *Summa* and the *Bubacaris*.

Let us remember that ceration is a basic step in a series of operations of Arabic alchemy, each one leading to the other, in order to obtain the elixir for metals such as gold. It begins by calcination, followed by ceration, solution and coagulation.

From the above comparison we conclude that the *Summa* and *Bubacaris* are not dependent on each other and that their ultimate sources are Arabic.

The TP and the DIP

Newman had assumed that the *DIP* is based to some extent on the *TP* of Paul of Taranto, since some formulations are similar in both MSS. However, the fraction of such similar formulations is very small relative to the full contents of the *DIP*, representing a mere 3.3 per cent.[204] Thus, they cannot be taken as an argument for the dependence of the *DIP* on the *TP*, nor for Paul of Taranto as the author of the *DIP*.

This similarity is due to one of two causes: either the *TP* used the *DIP* as one of its sources, or both compilers used the same source. In addition to the very small fraction of similarities, we noticed that the compiler of the *TP* had cut down parts of some formulations and removed the typical Arabic Islamic expressions. The hypothesis that the Latin compiler of the *DIP* had purposefully introduced such Arabic and Islamic expressions is untenable.

199. *Kitāb musahhahat iflātūn,* BN MS arabe 6915 fo. 89 b.
200. *Kitāb al- usūl* , NLM MS A 33, ff. 48b, 49a.
201. *Kitāb tadbīr al-arkān wa al- usūl*, in *L'élaboration de l'élixir suprème*, 144.
202. *Kitāb al-tajrīd*, in E.J.Holmyard, *The Arabic Works of Jābir ibn Hayyān*, 138–9.
203. *Kitāb al- riyād*, Bodleian MS Marsh 70 fo. 40a.
204. The *DIP* contains about 45108 words, while the recipes in question total 1490 words.

Inter-dependence of the *TP* and the *Summa*

Under the title 'The *Theorica et Practica* and its relationship to the *Summa*' Newman gave two main arguments to prove the inter-dependence of the *Summa* and the *TP*. One was about the composition of metals on the basis of the sulphur mercury theory, and the second was in connection with arsenic as one of the principles. These two assumptions were discussed above in Part 1. (See 'The Sulphur- Mercury Theory and the Composition of Metals' and 'The Theory of the Three Principles: Mercury, Sulphur and Arsenic', where we compared the *Summa* with the Arabic sources.) We proved there that this alchemical knowledge in both the *Summa* and the *TP* is a basic one in Arabic alchemy. The restriction of the search to a few Latin sources is the cause of this flawed hypothesis.

Differences between the TP and the Summa

Newman went further, and in order to prove that the *Summa* could not have been the source of the *TP*, he paid special attention to the differences between both texts. However, in this way, what he did prove, indeed, was their lack of similarity.[205]

The differences between the *TP* and the *Summa* are indisputable and there is no need to prove them. However, it is inconsistent to infer from the differences that the *Summa* is based on the *TP*. On the other hand, our discussion in Part 1 above clearly shows that all the chemical theories in the *Summa* are based on Jābirian alchemy.

The *TP* as a Compilation: Additional Examples

It is not our aim to give in this chapter a thorough discussion of the *TP*. Its character as a compilation is stated in its colophon, which says that it was '*compiled*' by Paul of Taranto.[206]

The theoretical part of the *TP* begins with a short article on 'what things and what kind of things this art takes as materials'. The text gives several cover names (decknamen) for metals and their calxes. This reminds us of the tradition of Arabic texts.[207] Moreover, in one page only we can find several

205. The differences between the *TP* and the *Summa* occupied 50 pages of Newman's *Thesis*, 1, pp. 121–70.
206. Newman's translation, *Thesis*, 4, Part 2, 175.
207. See for example: *Kitāb sundūq al- hikma*, attributed to Jābir, Cairo, MS Tabī'iyyāt 303, ff. 25a–29a; The *Karshūnī* manuscript, items 46–66, Berthelot, *La Chimie au Moyen Âge*, 2, 157–61; *Kitāb al-aqālīm al-sab'a* (Book of the Seven Regions) by Abū al- Qāsim al-'Irāqī, Gotha MS 1261, ff. 16b, 17b–19a; *Kitāb al-kanz fī fakk al-ramz* (The Treasure Book in Revealing Decknamen), anonymous author, Berlin MS 4191, ff. 49b–59b. A good survey of

Arabic terms mentioned in a distorted form such as, e.g. 'sodebeb' (*dhahab*, gold); 'alkal' (*al-kuhl, stibnite*); 'anec' (*anūk*, tin); 'kasdir' (*qasdīr*, tin); 'sericon' (*zarīqūn*, or *sarīqūn*, lead oxide); 'usurub' (*usrub*, lead); saffron of iron is a translation of *za'farān al- hadīd.*[208]

In the second article, dealing with the four principles (or spirits), mercury has alternative distorted Arabic names, such as 'azot', 'azet' and 'zambac', from *zi'baq*. It is also called 'servus fugitivus', which is the literal translation of the Arabic pseudonym of mercury, *al-'abd al-ābiq* (the fugitive slave). Among the names of sulphur we find the Arabic *kibrit*. Arsenic is mentioned by its Arabic name 'zernech' from *zarnīkh*. Sal-ammoniac is called "almizedir" and "nischader", from *nushādir*, and 'capocab' from *'uqāb* (eagle).[209]

The second part of the *Practica* contains practical procedures and recipes easily identifiable as taken from translated Arabic works. We have examined the items and recipes that fall between folios 39V and 45R.[210] There are 28 items from which 19 were identified by Newman to have been 'rewritten' by the author of the *TP* from Latin translations of Arabic sources.[211] These recipes are found in the original Arabic works also.[212]

Sal Alkali

An article under the heading 'how sal alkali should be made', describes how sal alkali, to make glass, is to be prepared from a herb. Newman remarks that

> this is the only recipe for sal alkali which I have found in an alchemical text that describes the preliminary roasting necessary for the production of potash. It probably reflects the author's own experience.[213]

Arabic works on decknamen is that of Alfred Siggel, *Decknamen in der arabischen alchemistischen Literatur* (Berlin: Akademie-Verlag, 1951).

208. Newman, *Thesis*, 4, Part 2, 13–14.

209. Newman, *Thesis*, 4, Part 2, 14–15.

210. Newman, *Thesis*, 4, Part 2, 114–34.

211. These are: *Bubacaris*, MS BN 6514, ff. 102ra-rb; *De aluminibus et salibus* of pseudo-Rhazes, ed. Steele, pp. 15, 16, 18; *De Perfecto Magisterio*, of pseudo-Aristotle, BCC 1, 646A and 642B; *Lumen Luminum* attributed to Michael Scot, ed. J. Wood Brown, in The *Life and Legend of Michael Scot* (Edinburgh: 1897), 247.

212. The Arabic sources that we have examined and which contain most of these recipes are: *Kitāb al- asrār* of al- Rāzī,. 2-7; *Kitāb sundūq al- hikma* (Book of the Chest of Wisdom) attributed to Jābir but is also a collection derived from other sources, ff. 57b, 66b, and the last two folios without numbers; *Kitāb al-muntakhab min Kitāb al-ittihād* (Book of Selections from the Book of Union) of Jābir, NLM MS A33, fo. 128b; The *Karshūnī* MS, Berthelot, *La Chimie au Moyen Âge*, 2, items 30 and 31, 149.

213. Newman, *Thesis*, 4, Part 2, 124.

During the Middle Ages, and until the discovery of a manufacturing process for alkali, the chief source for this material for glass-making in Italy was an alkali imported from Syria, known as *polverine*, *rochetta* or *allume catina*. It is the ashes of a shrub called *ushnān*, which grows in the Syrian Desert, and belongs to the salsola soda family. The Venetians had established strong connections to Syrian glass making since the thirteenth century.[214] *Allume catina* became, thus, the most important single ingredient in the Venetian glass manufacture, establishing a regular and plentiful supply from their cotton trade with Syria in the fourteenth century. The 'use of Levantine ashes was mandatory for Venetians glass-makers',[215] ensuring the superiority of their glass for centuries.[216]

Therefore, the shrub in question did not grow then in Italy, and the compiler of the *TP* would not have been able to have a personal experience in this respect. Most probably, the recipe was compiled from an Arabic source. The description in the *TP* is found in Arabic and Persian texts on alchemy and on glazes and ceramics.

According to one such treatise, potash (qalī or qili) was prepared by specialists (*qallā'*). They worked on the edge of the desert and were renowned for the high quality of their product. The *Salsola* plants were collected while they were still not completely dry, and then burned in a slow smouldering fire, in a pit about one metre wide and two metres deep. The ashes were then calcined into blocks of ten pounds each.[217]

Both al- Rāzī, in *KA*, and Jābir, in *Kitāb sundūq al-hikma*, give recipes to prepare the salt of *al- qalī* or *al-qili* from this same material.[218]

EPILOGUE

The 'Geber Problem' started with Berthelot in 1893. We have summarised most of his assumptions. In the 1920s, Holmyard gave substantial evidence against Berthelot's hypotheses.

In 1935, Ruska removed the name of Geber from the Riccardiana *DIP* and considered it a reworking of the *Bubacaris*, with a part written by a Latin author, who would have also been the author of the *Summa*.

214. Aziz S Atiya, *Crusade, Commerce and Culture* (Bloomington: Indiana University Press, 1962), 238–9.

215. Turner, Guy, "Allume Catina and the Aesthetics of Venetian Cristallo', 115.

216. Yousef Barkoudah and Julian Henderson, 'Plant Ashes from Syria and the Manufacture of Ancient Glass. Ethnographic and Scientific Aspects', *Journal of Glass Studies*, 48, (2006), 279-320; Guy Turner, 'Allume Catina and the Aesthetics of Venetian Cristallo", *Journal of Design History*, 12, (1999); 112-122.

217. J.W. Allan, 'Abū'l- Qāsim's Treatise on Ceramics', *Iran*, 11 (1973): 111–20.

218. *KA*, 6–7; *Kitāb sundūq al-hikmah*, ff. 66b–67a.

In 1986, Newman based his work on Ruska's conjecture, and attributed both *DIP* and *Summa* to Paul of Taranto.

Following Holmyard, once again we have disproved Berthelot's hypotheses. Moreover, on comparing Arabic texts with the *Summa*, we were able to show that the *Summa* is based in its entirety on Arabic alchemy.

We gave in Part 2 substantial evidence which proves that the compiler of the *DIP* could not have been the author of any portion of it, and that it is rather a compilation from Latin translations of Arabic alchemy. The *Liber Secretorum Bubacaris*, or rather a different translation of al- Rāzī's *Kitāb al-asrār,* is only a minor source, whereas the major one is most probably Jābir (Geber). Therefore, the *DIP* is not a new edition of the *Bubacaris*, as Ruska had claimed. It also follows that the attribution of the *DIP* to Geber was not due to the scribe's ignorance, but it was purposefully ascribed by the compiler, the only person who knew what sources he had employed.

Ruska had based his hypotheses regarding a Latin author of the *Summa* on a paragraph in the *DIP* that he assumed was written by a Latin author. We have proved that this paragraph is of Arabic origin and that it is a familiar one in Jābir's works.

Newman had built his work on Ruska's speculations, and since we have refuted these, it follows that all Newman's assumptions about Paul of Taranto are unsubstantiated.

Finally, this essay as a whole gives ample evidence to prove that the hypotheses of Berthelot, Ruska and Newman are unfounded. The *Summa* is either a compilation from Arabic sources, mainly Jābir, or a complete translation of a missing Arabic treatise.

If this research is to serve a useful purpose, it should help to cast serious doubts on the reliability of the existing history of early Latin alchemy as written by Berthelot, Ruska and Newman who tried to divorce Latin alchemy from its Arabic origins. This history cannot be written with fairness and impartiality without a thorough research into Arabic sources.

APPENDIX 1: THE GENERATION OF METALS IN *KITĀB SIRR AL- KHALĪQAH*[219] AND IN THE LATIN TRANSLATION OF HUGH DE SANTALLA (*DE SECRETIS NATURE*) [220]

Description	*Sirr page no.*	*De secretis folio no.*	*Hudry page no*	*Notes*
Generation of the seven metals	227	10v	65	
Lead	328	10v	65	*Lead is heavy because its parts entered into each other
Tin	229	11r	66	
Iron	231	11r	66	
Gold	233	11r	66	
Copper	234	11r	67	
Mercury	236	11r	67	
Silver	238	11v	68	
Prologue	243	11v	69	
Cause of mercury	243	11v	69	* Mercury is the origin of all metals. * Two exhalations theory
Prologue	245	12r	70	
How each metal was formed from mercury and sulphur	246	12r	71	* how sulphur was embedded inside mercury * Some metals became defective. * Sulphur mercury theory
How lead was formed	249	12r	71	
How tin was formed	251	12r	72	
How iron was formed	253	12v	72	

219. Ursula Weisser, *Kitāb sirr al- khalīqah*, Aleppo, 1979.
220. Françoise Hudry, *De secretis nature*, Paris and Milan, 1997–1999. This is an édition of MS BNF lat. 13951.

Description	*Sirr page no.*	*De secretis folio no.*	*Hudry page no*	*Notes*
How gold was formed	257	12v	73	* Gold is heavy because its parts entered into each other
How copper was formed	260	12v	74	
How mercury was formed	263	13r	75	* Mercury is the origin of all metals. * Two exhalations theory
How silver was formed	264	13r	75	
Summary	266	13r	75	
Cause of sulphur	269	13v	76	

7

APPENDIX 2: THE EXHALATION THEORY IN ARABIC AND IN THE *SUMMA*

Exhalation Theory in Arabic Alchemy

Know that fusible metallic bodies originate from sulphur and mercury before mercury was yet fully coagulated as mercury and before sulphur was fully coagulated as sulphur. Because if they were fully coagulated when they are used as constituents then malleable bodies (that are extendable under the hammer) would not have been formed from them; especially that sulphur is originated in an earth different from that in which mercury is originated. Fusible bodies do not, in fact, originate from these coagulated sulphurs, nor from that quivering mercury. Mineral bodies originate only from the vapour and the smoke, and from un-coagulated mercury and un-coagulated sulphur, or, to tell the truth, metallic bodies originate from nothing but the water (*mā'*) and the oil (*duhn*). In the hollows of the earth the gentle heat causes the water to ascend to the top, carrying the oil (*duhn*) inside it. There, because of proximity to coldness, it cools down and descends (again), tumbling and breaking on each other till it reaches its bottom place. Here again the natural heat cooks it; and it constantly moves up and down, part of it tumbling over the other until it gradually becomes more and more sticky (like the gum of a tree), more hard and thick, and it continuous thus until it is completed as a fusible malleable body. Thus it had progressed from the vapour and smoky state to the gummy state and the vapour and smoke continue to contact it and descend upon it acting as if it is nourishment, with the heat of the mine cooking it. The slightly coagulated body acts in the beginning as a ferment. It gradually grows and hardens little by little from the viscous gummy state to a doughy state then to the state of a body molten in fire, then it coagulates into an actual mineral body, which would become gold if the earth from which vapour and smoke emanated has been pure and if there has been a moderate heat. And with pure earth and deficient heat, silver is produced. We have thus given a great proof for all those philosophers who have preceded us.[221]

The Exhalation Theory in the Summa[222]

But others say otherwise, that *argentvive* in its *nature* was not the *principle*, but altered, and converted into its *earth*, and *sulphur* likewise altered and changed into *earth*. Whence they say, that in the intention of nature, the principle was other, than a foetent spirit, and fugitive spirit. And the reason, that moved them hereunto, was this, viz. because, in the silver mines, or in the mines of other metals, they found not any thing that is argentvive in its nature, or any thing that is sulphur likewise; but they found each of them separated in its proper mine, in its own nature. And they also affirm this for another reason, viz because there is no transition (as they say) from contrary to contrary, unless by a middle disposition. Therefore, seeing it so is, they are compelled to confess and believe that there is no transition (or passing) from the softness of argentvive, to the hardness of any metal, unless by a disposition, which is between the hardness and softness of them. but in the mines they find not any thing, in which this middle disposition

221. *K. nihāyat al-talab*, MS Berlin, 4184, ff. 29a–29b.
222. We are still preserving the English of Russell.

may be salved; therefore they are compelled hence to believe, that argentvive and sulphur, in their nature, are not the principles according to the intention of nature: but another thing, which follows from the alteration of their essences, in the root of nature, into an earthy substance. And this is the way, by which each of them is turned into an earthy nature; and from these two earthy natures, a most thin fume is resolved, by heat multiplied in the bowels of the earth; and this duplicate fume is the immediate matter of metals.

This fume, when it shall be decocted by the temperate heat of the mine, is converted into the nature of a certain earth; therefore it receives a certain fixation, which afterward the water (flowing through the bowels of the minera, and spongiosity of the earth) dissolves, and is uniformly united to it, with a natural and firm union. Therefore, so opining, they thus said, that the water flowing through the passages of the earth, finds a substance dissolvible from the substance of the earth in the bowels thereof, and dissolves the same, and is uniformly with it united, until the substance also of the earth in the mines is dissolved, and the flowing dissolving water and it become one with natural union. And to such a mixtion come all the elements, according to a due natural proportion, and are mixed through their least parts, until they make an uniform mixtion. And this mixtion, by successive decoction in the mine, is thickened, hardened, and made a metal. And indeed, these men, although they be nigh the truth, yet they do not conjecture the very truth.[223]

223. Russell, *The Alchemical Works,* 57–8.

APPENDIX 3: SOME FURTHER TECHNICAL TERMS OF ARABIC ORIGIN IN THE *DIP*

DIP	*Arabic*	*English or Latin*
Alcofol[224]	*al-kuhl*	Stibnite
Alenbiccum[225]	*al-inbīq*	Alembic
Amar[226]	*ahmar*	(red)
Anzarut[227] plant which contains gummy matter; used in Arabic medicine and in alchemy; it grows in Arabia and Ethiopia	*anzarūt* or *'anzarūt*	Sarcocolla
Baurac[228]	*Bauraq*	Borax
Borrile[229]	*Billawr*	(crystal glass)
Caley, kaley[230]	*(al)qalī*[231]	Alkali
Canina, cannine[232]	*Qannīna*	(glass bottle)
Edaus[233]	*al-daus* or *el-daus*	(one of the components of iron and steel)
Exir[234]	*(al)ixīr*[235]	Elixir
Fauled[236]	*fūlādh*	(steel)
Flore murorum antiquorum[237]	salt of old walls (saltpeter)	This description is not known to Latin alchemists
Inderami[238]	*Andarānī*	Crystal clear salt

224. *DIP* MS, fo. 21r.
225. Julius Ruska, 'Übersetzung', 47–8; 70–1.
226. Julius Ruska, 'Übersetzung', 65.
227. *DIP* MS, ff. 5v, 6r,11v.
228. *DIP* MS, ff. 12r, 12v, 13r.
229. Julius Ruska, 'Übersetzung', 68.
230. *DIP* MS, ff. 10r, 12v, 13r, 13v, 14r, 14v, 17r.
231. It should be noted that the article *al* is not a part of the word *qalī*. The *DIP* translation is the correct form, while the current Latin *alkali* considered 'al' as being a part of the word.
232. Julius Ruska, 'Übersetzung', 48; 49; 83.
233. *DIP* MS, ff. 1r, 9v, 13r.
234. *DIP* MS, ff. 5r, 11v, 12r, 14r, 16r, 18r, 18v, 23r.
235. See the note above on *al- qalī*. Here also the root word is *iksir*, and *al* is the article. The *DIP* translation is the correct form, while the current Latin *elixir* considered *'el'* as part of the word.
236. *DIP* MS, ff. 18r, 19v, 20r; Julius Ruska, 'Übersetzung', 66.
237. Julius Ruska, 'Übersetzung', 73–4. On the name of this compound see our article, 'Potassium Nitrate in Arabic and Latin Sources' (2001).
238. Julius Ruska, 'Übersetzung',73; *DIP* MS, fo. 22v.

DIP	Arabic	English or Latin
Insula Hispaniae[239]	*Jazīrat al-Andalus,* i.e. the Island of al-Andalus. Arabic authors referred to al-Andalus as an island.	Spain
Merdesenge[240]	*Murdasanj, martac*	(litharge, lead oxide)
Obrizum, obrizo[241]	*Ibrīz* - The best quality of gold is *dhahab ibrīz*	Gold. This designation is peculiar to Arabic alchemy
Porta[242]	*bāb*, means also a chapter in a book or a division of a text or formulation	(door)
Serrapinum[243]	*sharāb*	(syrup)
Tannura[244]	*Tannūr*	Athanor

239. Julius Ruska, 'Übersetzung', 70.
240. *DIP* MS, ff. 5v, 8v.
241. *DIP* MS, ff. 3v, 12v, 13v, 18r, 18v, 19r.
242. Frequently used in *DIP* MS.
243. Julius Ruska, 'Übersetzung', 67.
244. *DIP* MS, ff. 2v, 18r.

4 Arabic Industrial Chemistry

INTRODUCTION

The origins of chemical technology lie in the ancient civilisations of the Near East. In Egypt, Syria and Mesopotamia, there appeared three to four thousand years BCE several industries such as the metallurgical ones including gold, silver, copper, bronze and iron. Other industries included glass, dyes, oils and fats, perfumery, tanning, medical drugs, and the utilisation of such basic materials as nitrates, alum, soda, salt and gypsum.[1]

The metallurgical artisans in Egypt were speculating on the causes of the physical facts that they observed, and they attempted to imitate true gold and silver as much as possible. This was one reason behind the rise of alchemy and the start of alchemical writings.[2]

The Arab conquests and the spread of Islam in the Near East and Iran did not disrupt the economy of these countries. The traditional local industries were given a new impetus with the flourishing Islamic civilisation and the increased demand for more products.

Similarly, almost the whole corpus of pre-Islamic knowledge in philosophy and science was translated into Arabic. Works on alchemy were among the earliest to be translated, and thus Arabic alchemy had an early start.

Arabic chemical industries, which were based on the skills of artisans, were enriched by the multitude of Arabic treatises on practical alchemy and on specific chemical industries. Scientists and technicians who were experienced in their specialties wrote these treatises. Some of these treatises had survived but the majority did not, although we know the titles and the names of authors of some of them.[3]

SOURCES OF ARABIC INDUSTRIAL CHEMISTRY

1 Works on Practical Alchemy

The main sources for Arabic industrial chemistry are the books on practical alchemy. Jabir ibn Hayyan (d. *c.* 815) described in his numerous books a

1. Levey, Martin, *Chemistry and Chemical Technology in Ancient Mesopotamia.*
2. Holmyard, E.J., *Alchemy*, p.19 ff.
3. Ibn al-Nadim, *Al-Fihrist*, See for example p. 454 for books on perfumes, and on cookery, and pp. 511 ff on alchemy.

great number of materials and processes.[4] Among his works which give descriptions of procedures and equipment, and contain many practical recipes, are *Kitab al-sab'in* (the Book of Seventy), *Kitab al-riyad* (The Book of Gardens), *Kitab al-khalis al-mubarak* (The Blessed Pure Book). They also include *Kitab al-usul* (The Book of Fundamentals), *Kitab al-jumal al-'ishrin* (The Book of Twenty Clauses), the three books on amalgams, *Kitab musahhahat iflatun* (The Book of Iflatun Corrections), *Kitab al-khawass al-kabir*[5] (The Great Book of Properties), and many others. There are also chemical compilations attributed to Jabir such as *Kitab sunduq al-hikma* (The Book of the Chest of Wisdom). Jabir also wrote non-alchemical books of recipes such as *Kitab al-durra al-maknuna* on the different methods of colouring glass and other industrial products.

Al-Razi, who considered Jabir as his teacher,[6] left works that also exerted a great influence. His most important extant alchemical works are *Kitab al-asrar* (The Book of Secrets) and *Kitab sirr al-asrar* (The Book of the Secret of Secrets). The main contribution of al-Razi is his summarising of chemical substances, and his description of chemical laboratory equipment. He also gave detailed descriptions of the main chemical processes with a large number of recipes (see Chapter 1).

We gave in Chapter 1 the names of the other outstanding Arab alchemists whose works are also rich in descriptions of chemical materials and equipment and in giving practical chemical recipes.

Works on Arabic alchemy were translated into Latin in the 12th century and later and Latin alchemy became acquainted with chemical materials, equipment and processes through these translations. These Latin works of Arabic alchemy included several works from Jabir (Geber), al-Razi, and several other Arabic alchemists (see Chapter 3).

2 Works that Deal with Specific Industrial Subjects

There were other Islamic scientists who were not classified as alchemists but who wrote important works on chemical subjects, especially on chemical technology. We give below brief notes on the more prominent ones, mainly those who preceded the 14th century:

Al-Kindi (d. *c.* 260/873) wrote numerous treatises on industrial chemistry. Among these is *Kitab Kimiya' al-'Itr wa al-tas'idat* (Book of the Chemistry of Perfume and Distillations) which contains numerous recipes of fragrant

4. Holmyard, op cit, p. 81.
5. British Library MS Or 4041 and Alexandria Municipality MS .5204
6. The relationship between Jabir and al-Razi is described in part II of Chapter 3.

oils, aromatic waters and distillations. He left also important treatises on the metallurgy of steel and the various kinds of swords and their treatment, on luster-painted glass, on jewels, the adulteration of foods and other topics in chemical technology.

Al-Hamdani (died either in 335/945 or 360/970), wrote *Kitab al-jawharatayn al-'atiqatayn* (on the metallurgy of gold and silver), which is an invaluable work.

Al-Biruni (died probably in 442/1050), wrote *Kitab al-jamahir fi ma'rifat al-jawahir* which deals with precious stones and the metallurgy of metals.

Al-Tamimi (end of 4th/10th century), wrote *Kitab jayb al-'arus wa rayhan al nufus* on perfumes, and another work *al-Murshid ila jawahir al-aghdhiya wa qiwa al-mufradat min al-adwiya*, which is an encyclopaedic work mainly on nutrition and simples with very useful industrial chemical information.

Al-Mu'izz Ibn Badis (ruled between 407/1016 and 454/1062), has an important treatise that is attributed to him,[7] *'Umdat al kuttab and 'uddat dhawi al-albab* on the manufacture of inks and paper.

Al-Tifashi (died 651/1253) is better well-known for his lapidary work *Kitab azhar al-afkar fi jawahir al ahjar* in which he describes 25 precious stones.

Al-Muzaffar Ibn Rasul (ruled in Yemen from 638/1249 until 695/1295), left a book on industrial arts carrying the title of *Al-Mukhtara' fi funun min al-suna'* (Inventions from the Various Industrial Arts), which contains descriptions of several chemical industries such as soap making.

Al-Jawbari (died 630/1232), is well known for his book *Kitab al-mukhtar fi kashf al-asrar wa hatk al-astar*, in which he warns the public against trickery of all kinds such as practices used by perfumers, alchemists, jewellers and armourers.

Al-Iskandari (presented his book to King al-Kamil who reigned between 615/1218 and 636/1238). This is *Kitab al-hiyal al-babiliyya li al-khizana al-kamiliyya* that discusses fakery and counter-fakery. Some of these trickeries depend on principles of chemistry and physics and other scientific principles.

7. Attributed also to Yusuf ibn Abd Allah al-Zujaji (d. 1024 CE).

It also deals with inks, paints, removing of ink writing and the colouring of paper.

Al-Kamili wrote in 630/1232 a practical handbook on the extraction, purification and assaying of gold. This is *Kashf al-asrar al-'ilmiyya bi dar al-darb al-misriyya* (Revealing the Scientific Secrets in the Egyptian Mint Authority).

Abu al-Qasim al-Qashani wrote in the year 700/1300 a work in Persian with the title *Jawahir al-'ra'is wa atayib al-nafa'is.* The book deals with precious stones and minerals, perfumes and ceramics.

Hasan Al-Rammah (d. 638/1294) left several military treatises, including *kitab al-furusiyya wa al-manasib al-harbiyya* which describes the first method for the purification of potassium nitrate. It also gives scores of recipes for explosive gunpowder for use in rockets, military devices and fireworks. It describes military weapons utilising gunpowder, and discusses the distillation of several materials.

3 Works that Do Not Deal with Specific Industries

Books on Cosmography: Useful information on various chemical technological subjects is found in works on cosmography such as those of al-Qazwini (d. 682/1283) and Shams al-Din al-Dimashqi (d.728/1327).

Books of Geographers: The books of Islamic geographers such as al-Maqdisi (wrote in 375/985), al-Istakhri (fl. *c.* 339/950), Ibn Hawqal (fl. *c.* 332–67/943–77), and others contain important information on the products of chemical technology.

Books on Agriculture: Works on *al-filaha,* such as that of Ibn al-'Awwam (fl. towards the end of the 6th/12th century), contain useful industrial information such as the distillation of rose water.

Encyclopaedic Works: such as *Mafatih al-'ulum* of Abu Bakr al-Kuwarizmi (fl. *c.* 366/976), the works of al-Mas'udi (d. *c.* 346/957), al-Nuwayri (d. 733/1332) and al-Qalqashandi (d. 821/1416) are rich sources on chemical industries. Anthologies of interesting knowledge such as that of al-Tha'alibi (d. 430/1038) and al-Ibshihi (d. 850/1446) are among the important sources, and similarly are books on philology such as *al-Mukhassas* of Ibn Sida (d. 458-9/1065–6).

Works on Medicine and Materia Medica: The Arabic books of medicine and materia medica are full of useful information. Works on materia medica include the books of al-Kindi, al-Biruni, Ibn al-Baytar, (d. 646/1248), Abu Mansur Muwaffaq, al-Antaki and numerous others. Medical works include *Kitab al-tasrif* of al-Zahrawi, al-*Qanun* of Ibn Sina (d. 428/1037), *al-Hawi* of al-Razi and many others.

4 Arabic Industrial Chemistry in Latin

The translation movement in the West took place in the 12th century and later. That was an era in which translations and adaptations of Arabic scientific, medical and technological works took place and continued to appear until the time of printing in the 15th century and beyond.[8] Many of the works were alchemical or have a strong alchemical touch. The technological works that appeared in the West during this period were a product of contacts with the Arabic world [9]

The *liber sacerdotum* is a decidedly typical product of the early Latin works of Arabic origin. It contains over 200 technical recipes, which were collected by an Arabic writer from various sources, and the collection was translated into Latin in the first part of the 13th century. The text is full of badly transliterated Arabic and some corrupt Greek terms that have passed through Arabic. It contains a small dictionary of Arabic-Latin metallurgical and chemical terms.[10]

In this same period, there appeared the *Liber ignium* (*c.* 1250) which is ascribed to an uncertain author called Marcus Graecus. Some historians thought that he was a Byzantine, but it is generally established now that this work was translated from Arabic and Marcus was a fictitious name. The book is full of Arabic terms and some of its recipes appear in other Arabic treatises.[11]

These two works are typical of the Arabic works that are extant in Latin and their Arabic originals were lost. This has led some historians of science[12] to attribute the authorship of such works to Latin writers irrespective of their Arabic origin.

8. See Sherwood Taylor in his article on 'Pre-Scientific Industrial Chemistry', in *A History of Technology*, volume II.
9. Taylor, F. Sherwood, *The Alchemists, Founders of Modern Chemistry*.
10. Berthelot believed that this work is a translation from Arabic (*La Chimie au Moyen Age*, Vol. I, 179).
11. About Liber Ignium see Foley, Vernard and Keith Perry, 'In defense of Liber igneum, Arab alchemy, Roger Bacon, and the introduction of gunpowder'.
12. Ruska is well known for his attributing several Arabic works especially of Jabir (Geber) in Latin, to pseudo Latin authors. One example is elaborated in Chapter 2 and another in Chapter 3 of this work.

Technology Transfer to the West

We have dealt with the transfer of Arabic industrial chemistry in a paper, which is not included in this book.[13]

SOME CHEMICAL INDUSTRIES

In Chapter 1 we gave a list of processes from al-Razi's *Kitab al-asrar*,[14] from the Karshuni manuscript[15] and from *Mafatih al-`Ulum.*[16] We shall give in the following pages a brief survey of very few basic chemical materials and of some chemical industries.

1 Acids, Alkalis and Some Basic Chemicals

Mineral acids were products of the distillation of alum, vitriol, sal ammoniac, common salt, and potassium nitrate, in various combinations. The books of Jabir, al-Razi and other Islamic alchemists have numerous recipes for the distillation of these substances. Sharp waters or dissolving waters were produced in the laboratory, and stored for later use.

Some Basic Chemicals

Before we discuss mineral acids, it is useful to acquaint ourselves with the main materials that were used. The lack of adequate chemical science did not enable the chemist or technician to characterise and evaluate the available materials. The identification depended on experience and observation. This created sometimes ambiguity in the proper labelling. Materials that had similar general properties were given the same name. Thus, *natrun* in Arabic and *nitrum* in Latin meant both sodium carbonate and potassium nitrate.

Natrun: Because of the importance of this material in the history of science, *natrun* (as potassium nitrate), deserves a special treatment, and we have dealt with it extensively in Chapter 7.

13. Al-Hassan, 'Transfer of Islamic Technology to the West', *Cultural, Contacts.*
14. Stapleton, H.E., Azo, R.F. & Husain, M.H.
15. The Karshuni MS was published by Berthelot in volume II of *La Chimie au Moyen Age.* Duval translated the Arabic text that is written in Syriac script (the Karshuni), into French. The Syriac script was converted into Arabic script in Aleppo by the Rev. Al-Khurfasqfus Barsum Yusuf Ayyub and is still in manuscript form.
16. Al-Kuwarismi, *Mafatih al-'Ulum.*

Zaj is vitriol. The term is a generic one for sulfates. Al-Razi mentioned seven kinds of *zajat* including, *qalqadis, qalqatar, qalqand* and *al-Suri* (the Syrian).

Shabb: *Shubub* (sing. *Shabb*) or alums are classified among the *zajat* by al-Razi. This is because alums are sulphates also. They are hydrated double salts, usually consisting of aluminium sulphate, water of hydration, and the sulphate of another element such as potassium, ($KAl(SO_4)_2 12H_2O$.) The best alum was *al-shabb al-yamani* (Yemeni alum).

Nushadir or sal-ammoniak was classified among the spirits, together with mercury, sulphur and arsenic (*zarnikh*). It can be a natural mineral or manufactured. The quality that was used in chemical processes is white similar to salt but sharp with burning taste. *Nushadir* is ammonium chloride (NH_4Cl) which has the property that it will sublimate at a relatively low temperature. Either *nushadir* or salt, which is sodium chloride, were used interchangeably in chemical processes to obtain mineral acids.

Mineral Acids

Nitric acid: The question of when nitric acid was first known is a critical issue in the history of science. Therefore, we have devoted Chapter 7 to it along with potassium nitrate. We shall deal briefly here with the remaining acids.

Sulphuric acid: In *Kitab al-asrar* of al-Razi we find references to the water of distilled alum which was used in the various processes.[17] In the Arabic Karshuni manuscript, we have three recipes for this acid. One of them runs as follows: '*The water of vitriol and sulphur which is used to irrigate the drugs*: yellow vitriol three parts, yellow sulphur one part, grind them and distil them in the manner of rose-water.'[18]

In the treatise *Risalat Ja'far al-Sadiq fi 'ilm al-san'a*, we read the following recipe: 'Then distil green vitriol in a cucurbit and alembic, using medium fire; take what you obtain from the distillate, and you will find it clear with a greenish tint.'[19]

17. Al-Razi, *Kitab al-Asrar*, pp. 38, 66; H.F. Stapleton, R.F. Azo, and H. Husain, Chemistry in Iraq, p. 393.
18. M. Berthelot, and Duval, *La Chimie au Moyen Age*, vol. II, pp. 61–104. The cited acid recipe is on p. 90.
19. Ruska, Julius, *Arabische Alchemisten. II. Ga'far Al-Sâdiq, der sechste Imâm*, includes the text of *Kitâb fi 'ilm as-sinâ'at*, Arabic text, folio 5b. See also, R.J. Forbes, *Short History of the Art of Distillation*, p. 32.

This description, which is a preparation of sulphuric acid from vitriol, may be of a later date than that of Ja'far al-Sadiq, but it is earlier than the 13th century. We find also references to the distillation of vitriol in other Arabic alchemical treatises.

Hydrochloric acid: This was called water of salt or spirit of salt (*ruh al-milh*). Al-Razi in *Kitab al-asrar,* gives the following recipe for a dissolving sharp water:

> Take equal parts of sweet salt, bitter salt, tabarzad salt, andarani salt, salt of *al-qili*, and salt of urine. After adding an equal weight of good crystalline sal ammoniac, dissolve by moisture, and distil (the mixture). These will distil over (to give) a strong water which cleaves stone instantly.[20]

Islamic chemists practised the distillation of bricks early. This produces an impure hydrochloric acid. One description was given by al-Zahrawi (d. 404/1013) in his book *al-tasrif* (*Liber Servitoris*), another by Masawayh al-Mardini (Mesue the Younger, d. 406/1015) who lived in Baghdad.[21]

The oil of bricks continued to be produced throughout later centuries and we find frequent recipes in the Arabic military treatises of the 13th century.[22]

Silicic acid: Abu Mansur Muwaffaq was acquainted with Silicic Acid, which he obtained from the bamboo.[23]

Organic Acids

Vinegar was used in large quantities. It was distilled to give acetic acid, and this acid was also produced by the dry distillation of wood. Acetic acid [CH_3COOH], is known also as ethanoic acid.

Alkalis

The term alkali was originally applied to the ashes of burned sodium- or potassium-bearing plants, from which the oxides of sodium and potassium could be leached. Alkalis were in great demand for the manufacture of glass, glazes, soap and other industries.

20. Al-Razi, *Kitab al-Asrar*, p. 77; see also Stapleton, Azo and Husain, p. 333.
21. Needham, Joseph, *Science and Civilization in China*, vol. V pt. 3, pp. 237–238; also Multhauf, pp. 207–8, and *EI*, Article *Aqrabadhin* by B. Lewin.
22. Al-Rammah, *Kitab al- furusiyya,* p. 126.
23. Holmyard, *Makers of Chemistry*, p. 68.

Al-qili was obtained from the fused ashes of a low woody shrub in Syria called *ushnan*. Its botanical name is Salsola Soda. Chemically it is about 80 per cent potassium carbonate with some 29 per cent sodium carbonate. The concentrated *al-qili* was called by Jabir and al-Razi *milh al-qili* (salt of alkali).[24]

The ashes of oak and other trees were also utilised, and the concentrated ashes were called salt of ashes, *milh al-ramad.*[25] The ratio of potassium to sodium carbonates varied greatly with the kind of plants and trees. Al-Razi described methods of refining and concentrating both *milh al- qili* (salt of alkali) and *milh al- ramad* (salt of ashes).

Abu Mansur Muwaffaq was the first to make a clear distinction between sodium carbonate (soda) and potassium carbonate (potash), which are similar in so many respects.[26]

Lime was quite abundant. It was used in soap making, as a building material, and for military purposes as an ingredient in military fires. It is produced by burning stones or marble, and when slaked with water it was called *nura*.

Caustic Soda or sodium hydroxide was not produced on a commercial scale, but was produced in the laboratory, and in *Kitab al-asrar* of al-Razi we find a recipe for this material.[27]

2 Alcohol

Islamic chemists knew the distillation of wine and the properties of alcohol. The prohibition of wine in Islam did not mean that wine was not produced and consumed or that the alchemists did not subject it to their distillation processes.[28] As to the lack of a cooling device for efficient condensation, Jabir described a technique to solve this problem in his distillation of mineral acids.[29] The same method also applies in the condensation of other vapours. Alcohol and the distillation of wine is one of the critical issues in the history of science and therefore we have devoted Chapter 9 to it.

24. Al-Razi, p. 3; C. Singer *et al*., *A History of Technology*, vol. II, p. 354.
25. Al-Razi, p. 3.
26. Holmyard, *Alchemy*, p. 90.
27. Al-Razi *Kitab al-Asrar*, p.108; Stapleton, Azo and Husain, p. 391.
28. Wine was used in medicines as well as a drink.
29. Jabir ibn Hayyan, *Kitab al-jumal*, ff. 532–4.

3 The Perfume ('itr) Industry[30]

Perfumes were in great demand in the flourishing civilisation of Islam. There were many Arabic technical treatises that gave details of this industry.[31] Among the existing ones, the most prominent is the *Book of Perfume Chemistry and Distillations* of al-Kindi. In this book, al-Kindi gives 107 recipes. A more detailed exposition of the perfumes industry is written by al-Nuwairi in his encyclopaedic work, *Nihayat at al-Arab.*[32] Al-Nuwairi mentions his sources and gives us a good review of the literature on the subject. He quoted extensively from al-Tamimi who wrote *Kitab jayb al-'arus wa rayhan al nufus*. Ibn Al Jazzar (AD 898–980) wrote a treatise dealing with perfumes.[33] 'Umar Ibn Al-'Adim (d. 660/1262) wrote a guide on cooking and making perfumes (*tib*).[34]

Perfumes are obtained by the blending of fragrant materials in certain proportions. The word *'attar,* from *'itr* (perfume), denoted the perfumer who blends the ingredients of a perfume. From this came the word *attar* in English that means a fragrant essential oil.[35]

The materials used are either of plant or animal origin. Essential oils and waters from flowers and aromatic plants are obtained by distillation. Animal pleasant odoriferous materials include *misk* (musk) and *'anbar* (ambergris)

According to some historians of perfumes, the Arabs became for several centuries the perfumers of the world.[36] It is reported that among the many presents of Harun al-Rashid to Charlemagne were several types of perfumes.[37] Forbes says that only with the coming of the golden age of Arab culture was a technique developed for the distillation of essential oils.

30. Existing sources on perfumes: There were many Arabic technical treatises that give details of this industry; Al-Kindi wrote *Kitab kimya' al 'itr wa al-tas'idat* (*Book of Perfume Chemistry and Distillations*), or '*Kitab al-taraffuq fi al-'itr'*. In this book al-Kindi gives 107 recipes; al-Tamimi, *Kitab jayb al-'arus wa rayhan al nufus* which was a main source for al-Nuwairi; Ibn al-Jazzar, A *Treatise on the Arts of Medicine and Perfume*; Abu al-Qasim al-Qashani discusses perfumes in his book *Jawahir al-'ara'is wa atayib al-nafa'is*; Al-Nuwairi in his encyclopaedic work, *Nihayat al-Arab* gives a detailed exposition of the perfumes industry. He mentions his sources and gives us a good review of the literature on the subject; 'Umar Ibn Al-'Adim wrote a guide on cooking and making perfumes (*tib*); Shams al-Din Al-Dimashqi gave details on the distillation of rosewater in Damascus.

31. Al-Fihrist listed nine until his time, p. 454.

32. Al-Nuwairi, vol. 12, pp. 1 ff.

33. Ibn al-Jazzar's treatise was published in Tunis (see bibliography).

34. Ibn al-'Adim, *al-Wusla ila al-habib fi wasf al-tayyibat wa al-tib.*

35. Merriam-Webster's Collegiate Dictionary.

36. Trueman, *The Romantic Story of Scent*, p. 83.

37. Einhard, Notker the Stammerer, p. 184, n. 39.

> By distilling their favourite flower, the rose, the Arabs succeeded in extracting from it a perfume that is still a favourite all over the world – rose water. Rose water came to Europe at the time of the Crusades.[38]

According to Arab geographers, rosewater was distilled in Jur, and in other towns in Fars. The rosewater of Jur was the best quality and it was exported to all countries of the old world including the *Rum* (Byzantium), *Rumia* (Rome) and the lands of *Ifranja* (France and Western Europe), India and China.[39] Sabur was famous for its essential oils, and ten varieties were produced including violets, lotus, narcissus, lilies and other flowers. No other place surpassed the quality of its essential oils except Kufa that produced the best *khiri* (carnation) and *banafsaj* (violets). Damascus became renowned in the production of rosewater later and it was exported. Essential oils were also produced in al-Andalus and other Islamic countries.

In the manufacture of perfumes, both old and new methods were applied. In the old method, the scent of the roses or flowers was captured by oil such as the *hall* (sesame oil). In the new method, the manufacture of essential oils and perfumes was carried out by distillation.

Currently, essential oils are distilled with water added to the flowers in a vessel that is heated by direct fire. Water vapour and volatile oil are condensed together. In a modification to this, the plant material is suspended on a grid above the water level, and steam rises from under the grid. The volatiles with water vapour are condensed and the oil is separated.

In the Arabic method of the past, no water is added to the plant material, and no direct steam touches the flowers. Heating is done from the outside. This method can be considered as a dry distillation one. Here the condensed liquid is primarily essential oil together with the condensed moisture from the fresh plants. Any limited amount of water is separated.

The wet method denotes heating the cucurbit from the outside by steam coming from a water bath and not by direct heating (Figure 4.1 and Figure 9.2, Chapter 9).

Essential oils were also produced in Al-Andalus. Ibn al-'Awwam who lived in Seville (end of 12th century) gives in *Kitab al-filaha*, a description quoted from al-Zahrawi of an industrial installation for rosewater and other essential oils, containing 16 or 25 cucurbits. He describes the equipment for the wet and the dry methods.

In the 13th century, Damascus had a thriving rosewater industry. This is described by Shams al-Din al-Dimashqi (d. 727/1327) in *Nukhbat al-Dahr*. He describes two industrial installations, one using the wet method and the

38. Trueman, *The Romantic Story of Scent*, pp. 83–4.

39. Ibn Hawqal, pp. 260–1.

other the dry. Figure 4.1 from al- Dimashqi is for an installation using the wet method.

Ghaliya: Among the liquid perfumes, the *ghaliya* was the highest in quality. Al-Kindi gives in his book on *'itr* fourteen formulations for *ghaliya*. Al-Nuwairi gives a description of seven, that were formulated for Caliphs, kings and the upper classes. Each carries the name of the Caliph or dignitary to whom it was formulated. He gives the names of the *'attar* or *'attara* (the lady perfumer) who formulated the perfume. Al-Zahrawi gave also formulations for *ghaliya*.

Nadd: the *nadd* occupied among the dry perfumes the same high esteem that the *ghaliya* occupied among liquid perfumes. In both, the *misk* and *'anbar* are the main ingredients. The *nadd* is made in the form of bars, sticks or powders. It was also incorporated in candles. It was put in perforated boxes or in cloths; and was carried on the person or placed between clothes or furniture.[40] Perfumed candles emitted their perfumes as long as they were burning.

Al -Tamimi gave the formulations of many kinds of *nadd*.[41] One is *al-nadd al-Musta'ini* which was made for the Abbasid Caliph Al-Musta'in bi-Allah:

Misk was the most valued ingredient in the formulation of Arabic perfumes. It came from Tibet and China from a gland in a sac under the skin of a deer's abdomen.

*'Anbar (*Ambergris*)* is a substance of sweet smell similar to musk. It was also highly valued as a perfume. It is found floating on the water in tropical seas, or on shores. It is probably a secretion of the gall bladder of the sperm whale in whose intestines it is found.

'ud (Aloe wood) is a fragrant wood of a tree that grew in abundance in the mountains of Assam.

Sandal (Sandalwood) is of Indian origin. The yellow has the best pleasant scent. It is used in wood form or as oil.[42]

40. Al-Antaki p. 302.
41. al-Nuwairi, p. 60.
42. Nuwairi on Sandal p. 39 ff.

Figure 4.1 Installation in Damascus for the distillation of rosewater by the wet method from the cosmography of al-Dimashqi, 13th century.

4 Petroleum Products

Petroleum was also refined and utilised. Crude oil was produced in Iraq from oil seepage on the eastern bank of the Tigris. Arab travellers reported that it was produced in large quantities and was exported.[43] It was also produced in Khuzistan[44] and in Sinai in Egypt.[45]

43. *Rihlat ibn Jubayr*, p. 209. Ibn Sa'id al-Maghribi, *Kitab al-Jughrafiya*, p. 158.
44. Shams al-Din Al-Dimashqi, p. 119.
45. Ibn Sa'id, p. 130.

The oilfields of Baku were developed on a large scale since the early days of the Arab Empire. Al-Mas'udi visited the fields in 302/915 and reported that merchant vessels sailed to Baku to carry loads of white *naft*.[46] Marco Polo visited the oilfields two centuries later and said that hundred shiploads might be taken from it at one time.[47] He remarked that:

'this oil is not good to use with food, but it is good to burn. People come from vast distances to fetch it, for in all countries round about they have no other oil.'[48]

Distillation of crude oil or *naft* is described in several Arabic chemical and military treatises such as in *Kitab al-asrar* of al-Razi.[49] Several fractions were obtained. The first fractions were highly flammable and precautions were given for their distillation, storage and use. Sometimes the distillation continued until heavy distillates, which do not catch fire quickly, were produced. Crude *naft* and its distillates were used for military fires.

The very light fractions were used as solvents and were mixed with the resins to prepare waterproof varnishes. A further use was in medicine, and the white fractions of *naft* were considered as drugs for some ailments.[50]

5 Soap[51]

Arab geographers frequently mention places where soap was made: Aleppo, Balis on the Euphrates, Sarmin, Damascus, Nablus, Balkh, Tirmidh, Arrajan and Bust. Ordinary and coloured perfumed toilet soap was made and exported from Syria.[52]

In Antiquity, though mixtures containing soap were known and used in Mesopotamia, soap as such was unknown.[53] The classical world did not have better detergents, and bran, pumice-stone, natrun, vegetable alkali and the like were used.[54] Later on, Pliny described a pomade kind of soap invented by the Gauls. It was recommended for washing the body to treat certain illnesses. By 800 CE, soap from animal fats was produced in Europe which

46. Al-Mas'udi, 'Ali ibn al-Husain ibn 'Ali, *Muruj al-dhahab*, p. 208.
47. Marco Polo, *The Travels*, p. 48.
48. Marco Polo, p. 48.
49. Al-Razi, *Kitab al-Asrar*, p. 109.
50. *Tadhkirat Dawud al-Antaki*, p. 304.
51. Al-Muzaffar Ibn Rasul described soap-making in *Al-Mukhtara' fi funun min al-suna'*; Dawud al-Antaki, gave also a description of soap-making in his *Tadhkira*.
52. *Rihlat ibn Battuta*, p. 67; Shams al-Din Al-Dimashqi, pp. 67, 200. Al-maqdisi, p. 180, *Tadhkirat Dawud al-Antaki*, p. 203.
53. Forbes, *Studies in Ancient Technology*, vol. III, p. 187.
54. Forbes, op. cit., pp. 187–8.

had a very unpleasant smell.[55] However, hard toilet soap with a pleasant smell from Islamic lands started to arrive.

In Islamic territories, soap-making was an established industry. Recipes for soap-making are found in alchemical treatises such as those of al-Razi. Soap results from the interaction of fatty oils and fats with alkali. In Syria, where soap-making was a thriving industry, olive oil was used together with *al-qili* and lime. A detailed description of a soap-making process on an industrial scale is given by Al-Muzaffar ibn Rasul, and in *al-Tadhkira* of al-Antaki.

6 Glass[56] and Artificial Gemstones[57]

Glassmaking originated in the Near East, probably first in Mesopotamia. It was a thriving industry in Egypt, Syria and Mesopotamia. Some important innovations took place before Islam, and the most important one in the whole history of this industry was glass blowing, the discovery of which is credited to Syrian glass workers.[58]

Under Islam, the glass industry witnessed a revival. The old centres flourished and new ones were established. The remarkable sumptuous Islamic glass treasures, which are distributed among museums throughout the world, bear witness to the high artistic and technological level of Islamic glass.[59]

Most Islamic glass was of the soda-lime-silica type.[60] Islamic writers do not mention lime in the manufacture of glass and they speak usually of glass being made from sand and *milh al qili* or the salt of the ashes of oak and other woody plants. Lime came with the sand in the form of seashells.

Transparent colourless glass was highly valued and this was produced either by selecting raw materials of high purity or by adding an oxidising

55. Singer *et al.*, pp. 355–6.
56. Existing sources on glass: Jabir ibn Hayyan wrote *Kitab al-durra al-maknuna* on coloured glass, lustre glass, dyeing of stones and pearls. This is a unique treatise in dealing with lustre-painted glass; Al-Biruni, in *Kitab al-jamahir* has chapters on billaur, glass, enamel and *adhrak* (a precious artificial jewel).; Al-Karshuni manuscript devoted sections for coloured glass and glass-making furnaces.
57. Available sources on gemstones: Jabir *Kitab al-durra al-maknuna*; Jabir, Kitab *al-khawass al-kabir*;; Al-Biruni, *Kitab al-jamahir*; Al-Tifashi, *Kitab azhar al-afkar fi jawahir al ahjar*; Ibn al-Akfani, *Nukhab ad-dakha'ir fi ahwal al-jawahir*.
58. Singer *et al.*, p. 337.
59. All books on Islamic art, especially those devoted to the history of glass, give descriptions of such treasures. Some are: *Islamic Art*, by D.T. Rice, London, 1979; and *The Art and Architecture of Islam: 650–1250*, by R. Ettinghausen and O. Grabar,. *Glass of the Sultans*, Stefano Carboni and David Whitehouse; *The Arts of Fire*, ed. Catherine Hess.
60. Compare: Singer *et al.*, p. 329.

substance. *Maghnesia* (manganese dioxide, pyrolusite) was used to oxidise the iron and improve the colour of the glass. Thus, it is reported that certain kinds of glass were so white as scarcely to be distinguished from crystal.[61] Other substances, like lead compounds, for improving the quality of glass were also added.

The cut glass that was made at Samarra in the 3rd/9th century is considered peerless in its quality. Colourless crystal-type glass was made and glass engraving was a specialty of glassworkers under the Abbasids. Bowls, bottles and ewers of remarkable sumptuousness were decorated with forms of running animals and plant scrolls.

An important Islamic innovation was the invention of lustre painting in Syria during the Umayyad period. This consisted of painting with a pigment containing silver which, when fired in an atmosphere without oxygen, produced a thin metallic film on the glass varying in colour from pale yellow to brown.[62] Some glass was made with sumptuous polychrome effects; the technical secrets of these are not yet understood. Other innovations in Egypt included gilding techniques.

The most important achievement in decorating glassware was the art of enamelling of colourless and coloured glass. It is thought that after the fall of the Fatimid dynasty in Egypt in 567/1171 some glassworkers immigrated to Syria where they laid the foundation of the Syrian art of enameled and gilt glass.[63] The earliest phase of this art seems to have taken place in Raqqa in Syria where thick enamels were used. Later, two groups of Syrian glass evolved. One is characterised by the use of thick, jewel-like enamels and is connected with Aleppo; the other, notable for its exquisitely painted figural decoration, is attributed to Damascus. These two types of glass represent one of the highlights in the history of the art.[64]

From a peak of excellence at the beginning of the 14th century, a decline took place after the sacking of the chief Syrian cities by Timur. Damascus fell in 803/1400 and the glass-workers of that city were taken to Samarqand.[65]

As was the case with the transfer of science to the West, the art and techniques of glass-working were transferred also. The first phase of

61. Jabir mentioned the uses of manganese dioxide in glass making, see Holmyard, *Alchemy*, p. 79; Magnesia as an ingredient is mentioned by most Arabic authors, e.g. Shams al-Din al-Dimashqi, p. 59; al-Mas'udi, vol. I, pp. 403–4; al-Antaki, p. 161.

62. A detailed discussion of lustre painted glass is in Chapter 6.

63. Ettinghausen and Grabar, p. 373.

64. Op. cit., p. 374.

65. On the history of Islamic glass see also the article 'Glass, History of' by R.J. Charleston, in *The New Encyclopedia Brittanica*, Macropaedia, vol. 8, 1981, pp. 183–4. Also: *Glass of the Sultans*, op. cit. and *The Arts of Fire*, op. cit.

technology transfer took place in the 5th/11th century when Egyptian artisans founded two glass factories at Corinth in Greece. Here they introduced contemporary techniques of glass manufacture, but the factories were destroyed during the Norman conquest of Corinth in CE 1147 and the workers emigrated westwards to contribute to the revival of Western glassmaking.[66] Technology transfer took place again after the Mongol conquest of the 13th century CE, which drove large numbers of Syrian glass-workers from Damascus and Aleppo to glassmaking centres in the West.[67]

A third and a unique method of technology transfer, which reminds us of modern technology transfer, is a treaty that was drawn up in June 1277 CE between Bohemond VII, the titular prince of Antioch, and the Dodge of Venice. It was through this treaty that the secrets of Syrian glass making were brought to Venice. Raw materials as well as Syrian Arab artisans were sent from Syria. The techniques of Islamic glassmaking formed the foundations upon which Venice established its famous glass industry.[68]

Artificial Gemstones

The imitation of mineral gemstones was always of interest to chemists and artisans since the pre-Islamic civilisations. During Islam, we started to see a real interest by eminent scientists such as Jabir ibn Hayyan, al-Kindi, al-Razi and al-Biruni, who wrote treatises or gave recipes in their works. This interest continued until later centuries.

There are two methods to obtain artificial gemstones; one was to cast the colouring materials with the ingredients of glass and the second is by diffusing colour to glass stones. Jabir described both methods in *Kitab al-durra al-maknuna* (see Chapter 6) and in *Kitab al-khawass al-kabir* (see Chapter 5). Al-Razi gave several recipes in *Kitab al-asrar*. Al-Biruni gave in *Kitab al-jamahir* a recipe for an artificial high valued jewel called adhrak that is obtained by casting.

Among the much later works is one for Muhammad ibn Muhammad Iflatun al-Bustami who lived in the 17th century and who wrote *Jawahir al-funun wa al-sana'i' fi ghar'ib al-'ulum wa al-bada'i'* (Jewels of Arts and Artisan Works in the Unique and Wonderful Sciences). This work deals mainly with the manufacture of artificial jewels. Our list here is not complete as there are other later treatises on this subject.

66. Singer *et al.*, p. 328.

67. R.W. Douglas and S. Frank, *A History of Glassmaking*, p. 6.

68. Sarton, vol. II, pt. II, p. 1040.

7 Ceramics[69]

The glazed and painted ceramics that are exhibited in world museums reveal the splendours of the glorious Islamic art of pottery. Egypt, Syria, Mesopotamia and Persia had a continuous history in this art before Islam, but under Islam, a revival took place, and the art spread throughout the Islamic World reaching Muslim Spain and then the West.

Glazes are a kind of glass and are applied both to the inside and outside of pottery, either to render it impervious to water or for decoration. Two main kinds were applied, an alkaline glaze and a lead glaze. Normally lead glazes are transparent and colourless but can be given colour by the addition of metal oxides. If tin oxide is added to lead, a white opaque glaze is obtained. Al-Biruni gave a chapter in *al-Jamahir* for enamels and gave the recipe for lead and tin glazes.[70]

In classifying Islamic ceramics, historians of art discuss each locality independently. The main sites of early Islamic pottery that are known are Samarra in Iraq, Raqqa and Damascus in Syria, Rayy in Persia and al-Fustat in Egypt.

One of the earliest types is the Jabri. This was made in Persia in the early days of Islam (7th century CE), and the bulk of it was produced between the tenth and thirteenth centuries CE. The Jabri uses earthenware that is coated with a white slip of liquid clay and covered by a transparent lead glaze. Decoration was affected by cutting a design through the slip coating exposing thus the red ware below. The colour of the lead glaze was varied by washes of green and purplish brown derived from copper and manganese respectively.

Another type is the Sgraffito that was popular in all Islamic pottery centres. The body of the ware was first covered with a white slip and the design executed by cutting through the slip with a thin point, thus producing a kind of line drawing. Then the ware is covered with a thin yellow lead glaze, which, when fired, left a dark tone above the exposed body and a pale above the slip. Splashes of coloured glazes are then added in green, manganese or yellow. The most important of all Raqqa wares was one with a sandy white body and a decoration in black, blue or bluish-purple painted under the glaze. Sometimes a thin sgraffito design was associated with the painted decoration.

69. Sources on ceramics: Abu al-Qasim al-Qashani wrote in the year 700/1300 an important work in Persian with the title *Jawahir al-'ra'is wa atayib al-nafa'is*. The last chapter is on ceramics. This chapter became a classic document on the technology of ceramics.

70. al-Biruni, *al-Jamahir*, pp. 224–7.

Lustre painting is considered by historians of art as the chief Islamic contribution to ceramic decoration. The pottery found in Samarra proves that lustre painting was fully developed in the 9th century CE in Iraq. The white body of the ware was covered with a thin coat of transparent glaze and then fired. On this glazed surface the designs were painted in metallic glazes and the ware was re-fired at a low temperature. This process deposits a film of metal on the surface of the ware, in golden brown, greenish or red colours, and if the film is thin such as to allow the light to penetrate it, it glows with beautiful rainbow reflections. It is believed that the Islamic lustres of Iraq, Syria, Egypt, Persia and Spain were a form of gilding, though their decorative effect was much more beautiful than gilding has ever been.

Tin glazing was an important development. Tin oxide was added to lead to render the glaze opaque. This tin glaze was decorated in cobalt blue, green and sometimes manganese brown or yellow. This type was found in Samarra, was also produced in Persia and it reached Spain and then Italy. The golden pottery of Granada was tin-enamelled earthenware painted in metallic colours derived from silver and copper.

One important class is the *minai* (enamel) ware that was produced in Persia. Like lustre, this is a luxury ware. It is polychrome painted. In the *Minai* the bodies, which were of white consistency, were painted in pale blue, green or purple under the glaze and fired. Black outlines and details of the designs were then added in verifiable colours which were of great variety. The colours were then set by a second firing. The painting was in delicate miniature-like technique.[71]

As early as the 12th century the superior artistic pottery of Islamic countries had already attracted the notice of Europeans as an article of luxury for the wealthy. It is reported that Arab potters were brought into Italy, France and Burgundy to introduce the practice of their art, while Italian potters certainly penetrated into the workshops of Muslim Spain and elsewhere and gathered new ideas.[72]

Valencian tin-glazed wares, a legacy of the Andalusian wares, were exported to Italy, with Majorcan trading ships and were called maiolica (majolica). The Italian potters extended the name to the tin-glazed pottery which they made in imitation of the Valencian and the Andalusian wares. Another example is the Sgraffito ware. This technique was derived from the Islamic East through the Byzantine medium. It attained artistic importance in Italy towards the end of the 15th century and was made in Bologna until the seventeenth.

71. A good survey of Islamic pottery is found in the two books by A. Lane: *Early Islamic Pottery*, and *Later Islamic Pottery*. Also in Caiger-Smith, Alan, *Lustre Pottery*.

72. See T. Glick, *Islamic and Christian Spain in the Early Middle Ages*, pp. 238–41.

8 Pigments and Inks[73]

Pigments

Pigments are colouring matter that impart colour without penetrating far below the surface. They are normally applied as either inks or washes suspended in water, or as oil paints. Islamic artists and artisans used pigments in many applications in inks, oil, paints, glazes, lustres, enamels and other purposes.

There are Arabic treatises on inks and paints; one of the earliest is *'Umdat al-kuttab* (*Handbook of Scribes and the Tool of the Wise*), in which Ibn Badis (398–453/1007–61) gives details of coloured inks as well as paints and lacquers. Besides these specialised treatises, we find in alchemical works such as *Kitab al-asrar* (The Book of Secrets) of al-Razi a wealth of information on colouring materials.

Black pigments come from carbon, which was produced either from the smoky flame of oils and waxes, such as lamp-black, or from charcoal. White pigments came mainly from white lead (*isfidaj*), though bone-white was sometimes mixed with it. Red pigments were mainly made from cinnabar (*zunjufr*) the red or crystalline form of mercuric sulphide and from red lead (*isrinj*). Sometimes red arsenic was mentioned in ink formulations. Another red pigment was the lac, which was taken from dark red resinous incrustation deposited on certain trees by the lac insect. Another source was madder (*fuwwa*) and *baqqam* (Brazil wood). Blue pigments were obtained from lapis lazuli (*lazaward*) and from indigo. Azurite (a form of copper carbonate) was used frequently. Green pigments were derived from the basic copper acetate verdigris (*zinjar*), and from mineral malachite (*dahnaj*), a basic carbonate of copper. It is also obtained by mixing other varieties of pigments. Yellow pigments were made mostly from yellow arsenic or orpiment (arsenic tri-sulphide). Masticote (monoxide of lead) was also used, as also saffron, which was employed with other pigments.

In preparing a paint the pigments have to be brought to the requisite fineness by grinding them first in a mortar, then by rubbing them on a flat stone mortar (*sallaya*) using a stone roller (*fihr*). Water-based pigments required a binding medium. Gum Arabic was mostly used, though glues (especially fish glue) and glair (a preparation made of white of egg) was employed.

73. Main existing sources on inks: A considerable number of recipes for ink have survived from medieval times; many devised by scribes for their personal use and improved for their purpose by trial and error. Jabir ibn Hayyan, *Kitab al-khawass al-kabir*; Ibn Badis, *Umdat al kuttab and 'uddat dhawi al-albab* discusses the manufacture of inks, especially in Chapters 2–10.

Inks

On the subject of inks we have several treatises with a large number of recipes. The handbook of Ibn Badis mentioned above is one of them. Besides black inks there were inks of various colours: golden, silver, red, yellow, green, blue, and white. In any of the treatises related to the subject, we find several recipes for each colour.

A typical black ink would be composed of gall nuts, ferrous sulphate and gum Arabic. Another typical black ink is composed of the soot of oil. The soot is roasted until the smell of oil disappears. Jabir ibn Hayyan gave in *Kitab al-Khawass al kabir* several ink recipes based on soot, and he described its preparation (see Chapter 5). Ibn Badis gave also several recipes for the preparation of carbon from various seeds and vegetable materials.

9 Dyes[74]

The high level of the Islamic textile industry, and the eminence Islamic chemists, were two factors behind the importance of dyeing. There was a degree of specialisation in this industry. This was due, on the one hand, to the enormous variety of colours, and to the great skill and experience required in using the many natural and industrial dyes available. Colourful fabrics were used by both men and women and their tastes were to be satisfied. To meet these demands, the dyers had to specialise according to the colouring matter used by them. Thus, we find specialists in crimson, saffron, sumac, purple, vermilion, or indigo, etc.

Like many industries, the quality of dyeing was controlled by the *muhtasib*. In one manual, there is a warning against fraud of dyers, such as the substitution of henna for madder. When dyed with henna, red silk lost its colour and brightness if placed in the sun.[75]

Red dyes were the most important. Madder (*fuwwa*) is the most ancient source of red colour. This plant grows in the Mediterranean area, and the red dye extracted from it is called alizarin in modern nomenclature, a word derived probably from Arabic. Another red dye is Kermes (*qirmiz*). This is an insect-based dye. There were several insects that were parasitic on various plants. The words *crimson* and *carmine* are derived from the Arabic word *qirmiz*. A third important red was brazil wood or sappanwood (*baqqam*). However, the *muhtasib* must prevent the dyers from dyeing red

74. Existing sources on dyes: Jabir ibn Hayyan: *Kitab al-khawass al-kabir*, Al-Dimashqi, Abu al-Fadl Ja'far, *al-Ishara ila mahsin al-tijara*, Cairo, p. 211.

75. Ibn al-Ukhuwwa, *Ma'alim al-qurba fi ahkam al-hisba*, pp. 141–2 (Arabic text).

with this dye for it does not last.[76] A fourth source was henna (*Lawsonia inermis*). Here also, we have seen that the *muhtasib* warned against its use. A fifth source was lac (*lakk*).

Blue dye came from an indigo plant (*nil*). Indigo was an excellent dye and had a fast colour. In Arabic treatises, we find information on its growing and on the extraction of indigotin, the chemical compound responsible for the blue colour. The Arabic word *nil* or *al-nil* is the origin for the Portuguese word anil and the English aniline.

Yellow dye came from a variety of materials; important among them were Safflower (*'usfur*) and Saffron (*za'faran*). The English words for these dyes are derived from Arabic. Other sources were turmeric (*kurkum*).

Green dyes were obtained by dyeing with blue and yellow. Although there were some green vegetable dyes, they were not satisfactory.

Purple dyes were derived from a number of species of shellfish. Tyre and Sidon in Syria were famous for their purple dyes, and the fabrics dyed in purple commanded very high prices. The technique of purple dyeing from shellfish was carried on in Syria until a century ago.

Black dyes were obtained by boiling the fabric first in a solution of galls and then in a solution of ferrous sulphate. Alternatively, a black could be obtained by superimposing two or more dark colours.[77]

10 Metallurgical operations[78]

Gold

Gold in the mines occurs in three forms; it can be found in nuggets, with gold-bearing rocks, or with gold-bearing alluvium. Both al-Biruni and al-Hamdani explain in detail the methods of extracting gold from its ores. Gold-bearing rocks are crushed and pulverised. Al-Biruni wrote:

> Gold may be united with stone as if it is cast with it, so that it needs pounding. Rotary mills (*tawahin*) can pulverise it, but pounding it by *mashajin* (trip hammers) is more correct and is a much more refined treatment. The *mashajin* are

76. R.B. Serjeant, *Islamic Textiles*, pp. 206–7.

77. On dyes used in Islamic textiles, the following works are useful: Serjeant, *Islamic Textiles*; H. Wulff, *Traditional Crafts of Persia*; A. Siggel, *Arabische-Deutsches Worterbuch*; Al-Dimashqi, *al-Ishara ila mahasin al-tijara*, p. 211; R.J. Forbes, *Studies in Ancient Technology*, vol. IV.

78. Extant sources on metallurgy: Jabir ibn Hayyan, *Kitab al-khawass al-kabir*, Al-Kindi, a treatise on the kinds of iron and swords, the good ones and their provenance; Al-Kindi, A treatise to Ahmad ibn al- Mu'tasim bi Allah about what is thrown on iron and swords so that their edges do not get damaged and do not become blunt; Al-Hamdani, *Kitab al-Jawharatayn al-'Atiqatayn* on the metallurgy of silver and gold; Al-Biruni, *al-Jamahir fi ma'rifat al-jawahir*.

> stones fitted to axles which are installed on running water for pounding, as is the case in the pounding of flax for paper in Samarqand.[79]

This important statement indicates that water-driven trip hammers were used for crushing gold-bearing rocks before the 3rd/10th century. In the West, the lighter stamp mills were used around 885/1480, and the heavy stamp mills driven by water-power for pounding auriferous rocks were used at least as early as 1519, five centuries later.

The gold-bearing alluvium was washed in troughs of wood divided by partitions. Al-Hamdani gives the details of this operation. The particles of gold are deposited at the end of the trough.

The very fine particles of gold from both the pounded rock and the alluvial are recovered by amalgamation. The crude residues of gold particles are mixed with mercury, which dissolves the gold and leaves the other minerals. The mercury is squeezed through a leather or canvas bag, leaving the gold that it amalgamated with it in a compact mass. This amalgam is roasted until the quicksilver is driven off.

Al-Biruni gives an interesting method for collecting alluvial gold from a flowing river. He writes:

> There are places in which they dig small pits under the water, which flows over them. They fill the pits with mercury and leave it for a while. Then they come back after the mercury has become gold.[80]

The nugget of gold left after roasting was further purified by melting the gold in a process called *ta'riq*. On melting, any impurities in the gold come to the surface in the form of scum.[81]

Gold occurs mixed naturally with silver, and gold is subjected to a second purification process-*cementation*, to remove the silver. This process is called *tabkh* or *tas'id*. According to al-Hamdani thin plates of gold were interleaved with the cementation compound, known as the *dawa'*. This consisted of a mixture of vitriol, salt, and ground brick. The whole was then strongly heated. The mixture evolved the vapours of sulphuric and hydrochloric acids. These did not attack gold but converted the surface silver and copper into chlorides that could be scraped off. Cementing could be done more than once if the gold was to be made really pure.[82]

Nitric acid was used in the separation or parting of gold from silver, the silver dissolving and the gold remaining. Aqua regia was used to separate

79. Biruni, pp. 233–4.

80. Al- Biruni, p. 236.

81. Al-Hamdani, pp. 155, 165.

82. Al-Hamdani, op. cit., pp. 165 ff.

silver from gold. The gold dissolves to a soluble chloride, while silver is attacked and it precipitates as an insoluble chloride. Gold is easily recovered by the evaporation of the liquid and beating the residue, while silver is obtained by smelting the chloride with an alkali. Nitric acid is suitable for separating small quantities of gold from silver and aqua regia for separating small quantities of silver from gold.

Silver

In one chapter of his book, al-Hamdani describes how to extract silver out of its ores. Silver is associated with lead in the form of galena, *al-kuhl al-ithmid*, or lead sulphide. After being mined, they were crushed and roasted in a special furnace equipped with double bellows, using layers of firewood, and the lead runs out through an outlet in the rear of the furnace into a tank. If lead in the silver ore is not significant, lead is introduced artificially, because it has an affinity for silver, and when it is fused with it, it acts as a solvent and extracts it from its union with baser metals. The lead was then placed in a dish and put back into a furnace. It was covered with layers of wood, and subjected to blasts of air from bellows until lead was reduced into litharge. The silver ingot remains and could be removed.

At the end of the chapter on the extraction of silver out of its ores, al-Hamdani concludes that when the silver ores are very rich it is possible to extract half a *ratl* of silver from one *ratl* of ore. The amount of silver that can be extracted form lead ores varied from mine to mine.

In another chapter, al-Hamdani describes how to purify or refine silver from its impurities. In one method that was used in Yemen, crushed burnt bones and charcoal are used in a furnace. The bones absorb the lead and the impurities leaving pure silver. Outside Yemen, crushed salt and bricks, together with charcoal, are used.

Copper

There are two main classes of copper ores, the carbonates-oxides (such as cuprite, malachite and azurite), and the sulphides (such as chalcopyrites and chalcocites). The smelting or both types of ores was practised from ancient times. The carbonate ores were easy to smelt: they were just burnt in a charcoal fire, but were not abundant in nature. The sulphides were always the main source of copper, but were difficult to treat. They were first roasted to remove the bulk of the sulphur, and then the roasted ore was mixed with charcoal and fed into a high cupola or blast furnace. The first copper obtained was of poor quality and still contained much sulphur. Therefore, it was smelted again to purify it further. Then it was subjected to refining by

oxidation to remove the remaining sulphur, and then to refining by reduction to reduce the remaining cuprous oxide into metal. Some or all of these steps were undertaken.

In Muslim Spain, however, an interesting discovery took place in that the sulphide ores on exposure to air in the presence of water, became oxidised to form soluble sulphates. 'The Moors then found that if water containing copper sulphate is allowed to run over iron, pure copper is deposited and the iron dissolved.' As iron was cheap and abundant in Spain, this discovery yielded an efficient method of recovering copper from sulphide ore. In essence this 'precipitation' method is still used today.[83]

Zinc and Brass

Zinc was not known as a distinct metal in early Islamic metallurgy. Sometime before the 16th century *ruh al-tutiya* or zinc, had become recognised as a metal and was alloyed with copper to form brass. It is reported that metallurgists in India seem to have isolated zinc as early as the 13th century,[84] and it replaced *kharsini* and mercury as the seventh metal. When Abu-l-Fadl 'Allami (958/1551–1001/1602) wrote *A'in-i Akbari* in the 10th/16th century, zinc was already known and several compositions for brass using zinc were given.[85] It was not until 1720 that the smelting of zinc was started in Europe.[86]

Before zinc was known, brass was made by treating copper with zinc oxide (*tutiya*). Brass (*shabah*) was known before Islam, and zinc oxide was produced from its ores at an early date. Al-Hamdani (9th century CE) mentioned the treatment of molten copper with *al-iqlimiya* (calamine). Al-Razi also mentioned that brass (*shabah*) is not an elemental metal like copper and iron but is a compounded metal. Similarly Al-Biruni in *al-Jamahir* gave a chapter on brass under the title, 'Description of *shabah* (brass) which is manufactured and mixed by *san'a* (the Art)'.

Al-Biuni stated that when *tutiya* (zinc oxide) is mixed with copper, it does not unite (chemically) with it and is not transformed into copper. Although al-Razi and Al-Biruni did not mention metallic zinc, yet they considered brass as an alloy. Al-Biruni noticed also the change in the specific gravity between copper and red brass and gave exact values for both

Al-Biruni described the production of zinc oxide (*tutiya*) from its ore.

83. Singer, p. 11.
84. *EB*, article Zinc.
85. Abu-l-Fadl 'Allami,' *Ain-i-Akbari*.
86. Derry and Williams, p. 142.

> The ore is put in a furnace in which there are objects like baked pottery pegs. The fire is lit under the furnace floor. The *tutiya* rises and attaches itself to the pegs and covers them like a wrapping, so that the pegs become looking as though they have scales on them.[87]

Earlier, Al-Maqdisi (4th/10th century) described the manufacture of *tutiya* in Kirman. Still later, in the 13th century, Marco Polo described also its manufacture.[88]

Before metallic zinc was produced, all brass was prepared by a cementation process. A high temperature (about 1300 °C) is needed to reduce calamine to zinc with charcoal, and since this is above the boiling point of the metal, its vapour distils off and, under ordinary circumstances, it re-oxidises and condenses as zinc oxide. If, however, copper is heated in a mixture of powdered zinc ore and charcoal, a proportion of the zinc formed in the vicinity of the copper will diffuse into it and form a coating of brass. This was the old cementation process, in principle similar to the manufacture of steel by diffusion of carbon.[89]

Lead, Tin, Bronze and Other Copper Alloys

Lead (*usrub, al-rasas al-usrub*), was abundant and it was found associated with silver. The main ore of lead is galena (*al-kuhl al-ithmid*), lead sulphide. Lead can be obtained from it by heating it with charcoal, with some access to air. Al-Hamdani describes the furnace. It was provided with an outlet and a tank at the back, with one or two pairs of bellows; two men worked each bellow. The bellows were separated from the furnace by a wall in order to protect the men from being exposed to the lead vapours coming out of the furnace. The lead ore was laid in layers inside the furnace, alternating with firewood, and the furnace was then fired and kept going by operating the bellows day and night. The outlet was then opened and the molten lead runs into the tank.

Tin (*al-rasas al-qal'i, qasdir*) was produced from two sources, the main one was from the Malaysian peninsula, from a place called Kalah; hence the name *qal'i* for the metal. The other source was from England through Spain and the other Mediterranean ports. The most important use for tin was for making bronze, and for tinning copper or bronze cooking pots, and for mirrors.

87. Al-Biruni, p. 263.
88. Al-Maqdisi, p. 470; Marco Polo, p. 69.
89. Forbes in Singer, p. 54.

Bronze is an alloy of tin and copper. It was used by the ancient civilisations before iron. Its use was so widespread that archaeologists gave the name 'Bronze Age' to the 2000 years that preceded the use of iron.

High tin bronze was called by al-Biruni *asfidhruy* which means in Persian white copper; it is also called *sufr*, and is best cast or forged at red heat. These high tin bronzes contain between 20 and 30 per cent tin, and were used for vessels, weapons and mirrors.[90]

Another copper alloy was *batruy*. This was a mixture of copper and lead (*usrub*), and was used for mortars, casseroles and cauldrons.[91] However, the most common alloy in use was a quaternary alloy of copper, tin, zinc and lead. This alloy was used for cast objects such as mortars.

Mercury

Mercury occurs generally as cinnabar (mercury sulphide ore). Very rarely it can be found as native mercury. The two main sources of mercury were from Spain and from Transoxiana. The mine Almaden (from the Arabic word for mine: *al-ma'dan*) was the most famous Spanish mine.

Al-Biruni and al-Hamdani described the method of extracting mercury from its ore. Al-Biruni says:

> It is produced from red stones which are heated in the oven until they are disintegrated and mercury rolls from the outlet. Others pound the stones and distil them in distillation type equipment in the form of cucurbit and alembic; mercury is collected in the receiver.

Iron and steel

Damascus steel is important in the history of metallurgy. The origin and secret of Damascus steel and the cause of the *firind* (pattern) on swords is one of the critical questions in the history of science, therefore we devoted Chapter 10 to this subject.

90. Al-Biruni, pp. 264–6.
91. Ibid.

11 Military Fires[92] and Gunpowder[93]

Military fires were first developed by the ancient civilisations of the Near East and Persia. The materials used were petroleum (*naft*), and mixtures of liquid pitch, resin, sulphur, and other inflammable materials.[94]

From the early days of the Arab Empire, Arab armies and navies employed military fires. It is reported that the ships built in Alexandria in 716 CE for the Umayyad's siege of Constantinople were equipped with fire-spouting engines.[95]

During the War of Seven Years (55/674–61/680), new fire, the so-called Greek fire, was used for the first time by the Byzantines. About the year 54/673 a Syrian architect called Kallinikus of Heliopolis (Baalbek) in Syria, defected to Byzantium. This was less than forty years after the establishment of the Arab Government in Syria, and just before Constantinople was besieged by the Arabs. It seems that Kallinikus had brought with him the secret of a new fire, which helped the Byzantines defend themselves. This new fire differed from all the previous ones since it contained some secret ingredient. The Crusaders called it Greek fire, though the Byzantines themselves never called it Greek.[96]

The inheritance by the Arabs of the technical skills of pre-Islamic civilisations, together with their mastery of the art of distillation, and their control of the petroleum and mineral resources, enabled them to develop their own secret military fires that were used in most of their military operations. The military fire, called *naft,* was a regular weapon in Muslim armies, and the word *naft* came to denote the whole mixture or the entire ingredients of the fire, whether it was an incendiary mixture or a gunpowder mixture. In the Crusades, the Europeans fighting in Syria and Egypt

92. Sources on military fires: The furusiyya treatises of the 12th century are a good source on Islamic military fires that preceded gunpowder. These are two notable examples; Murda ibn 'Ali al-Tarsusi (12th century), wrote a treatise, supposedly, for Salah al-Din (Saladin). It contains several recipes for incendiary military fires. Another military treatise, *Al-Hiyal fi-l-hurub wa fath al mada'in wa hifdh al durub* of uncertain author (that was attributed to Ibn Mankali by two printed editions) discusses military fires on a large scale. See Ibn Mankali in bibliography.

93. Sources on gunpowder: Hasan Al-Rammah's book, *Al-furusiyyah wa al-manasib al-harbiyyah* contains 71 gunpowder recipes for flying fires, rockets and fireworks. It is the first book that gives explosive mixtures for gunpowder, and the first one to give a description of the purification process of potassium nitrate.; The Karshuni manuscript gives gunpowder recipes either preceding al Rammah, or contemporary with him. Several other Arabic military treatises are full of recipes for gunpowder.

94. J.R. Partington, *A History of Greek Fire and Gunpowder*, p. 28.

95. P. Hitti, *History of the Arabs*, p. 203.

96. About Kallinikus and the Byzantine fires see Hitti, p. 202; M. Mercier, *Le Feu Gregois*, p. 202.

encountered the use of the Muslim *naft* (which they called Greek fire) on a large scale, and it inspired great terror.

Modern historians tried to discover the precise compositions of these fires. They agree that, in addition to the incendiary materials mentioned above, the *naft* mixture contained a secret ingredient, which made it particularly effective. From examining the archaeological and historical evidence, some have come to believe that the secret ingredient was saltpetre.[97] However, some suggested that the secret lay in the use of distilled fractions of petroleum. It seems that both opinions are correct. Distilled fractions were important ingredients, but saltpetre came to be used gradually as a major ingredient, and when the *naft* developed into gunpowder, i.e. a mixture of saltpetre, sulphur and charcoal, it replaced all other mixtures.[98]

Up to the 13th century the petroleum fractions were a principal ingredient, but as the percentage of saltpetre increased, the *naft* troops in the 13th century dealt mainly with gunpowder. Liquid *naft* was applied by means of what was known as *Zarraqa, naffata* or siphon. This was a bronze piston pump from whose nozzle a jet of burning liquid was projected.

From the *furusiyya* treatises of the 12th century, we can have a good idea about Islamic military fires that preceded gunpowder. One of these is the treatise of Murda ibn 'Ali al-Tarsusi (12th century), which was written, supposedly, for Salah al-Din (Saladin). It contains several recipes for incendiary military fires.[99] Another military treatise that discusses military fires on a large scale is entitled *Treatise on Stratagems, Wars, the Capture of Towns, and the Defense of Passes.*[100]

Gunpowder and Cannon

This subject is one the critical questions in the history of science and therefore we have devoted Chapter 8 to it and have also devoted Chapter 7 to a discussion of potassium nitrate as mentioned earlier.

97. Mercier, *Le Feu Gregois.*

98. Ibid., pp. 13–16.

99. Al-Tarsusi, Ali ibn Murda, *Tabsirat arbab al albab, etc.*

100. *Al-Hiyal fi-l-hurub wa fath al mada'in wa hifdh al durub*, ms. Ahmet III, Serai No. 3469, Istanbul, ff. 127a–181b, Author uncertain. Several other manuscripts exist in Istanbul, Leiden, and Ribat. This work has been edited and published twice, see bibliography.

12 Paper[101]

When paper was first manufactured by the Arabs in Samarqand in 751 CE it was not made from the bark of mulberry trees as was the case with Chinese paper. This material was not available in Samarqand, and the Arabs employed flax fibres, hemp and linen rags instead. According to Dard Hunter the Arabs at Samarqand, therefore, must be given the credit for the fabrication of the first linen paper.[102]

Microscopic examination by Wiesner and Karabacek of old Arabic Paper (dating from about the 4th/10th century) had shown that the paper examined was composed almost entirely of linen.[103] Other tests have shown that the paper was composed chiefly of flax fibres and hemp. Ibn al-Nadim (325/936–385/995) wrote that the paper of Khurasan was made from linen (*kittan*).[104] Al-Biruni (d. 440/1048) in *Al-Jamahir* mentioned that paper in Samarqand was made of hemp (*qinnab*). In *'Umdat al-Kuttab* of Ibn-Badis it is mentioned that white hempen cords of excellent qualities were exported from Syria for paper-making. In Jativa in Al-Andalus paper was made from flax fibres and hemp. Summarising all available information, we can say that Arabic paper was made chiefly from flax fibres, hemp, linen rags and worn out hempen cordage. Some secondary materials were added such as cotton waste, esparto grass, straw, rice husks, and waste paper.[105] A typical method of manufacturing paper on a small scale from flax fibres is described in *'Umdat al Kuttab* of Ibn Badis.

According to Dard Hunter, 'in the development of papermaking by the Arabs a trip hammer was put to use'.[106] Further, we know from *Kitab al-jamahir* of al-Biruni that these trip hammers (*mashajin*) were driven by water wheels.[107]

Water-wheels in paper making were mentioned by several sources and the Arabic expression of paper-making *raha* (paper-mill) is frequent. It was thought that the water-wheel in paper-mills was first used by the Arabs in Jativa in 546/1151, but it is now evident that the first use of water-wheels in paper-making preceded this date by few centuries.

---

101. Sources on paper: Ibn Badis wrote a treatise, '*Umdat al-kuttab,* in which he describes the manufacture of paper.
102. Dard Hunter, p. 156.
103. op. cit., p. 156.
104. *Al-Fihrist*, English translation, vol. 1, p. 39.
105. Ibn al-Nadim, *al-Fihrist*, Cairo, pp. 37–8; al-Biruni, *Kitab al-Jamahir fi Ma'rifat al-Jawahir*, pp. 233–4; Ibn Badis, *Kitab 'Umdat al-Kuttab wa 'Uddat dhawi al-Albab*, ms. Cairo, ff. 55–85; D. Hunter, *Papermaking Through Eighteen Centuries*.
106. Dard Hunter, p. 157.
107. Al-Biruni, *Al-Jamahir*, p. 234.

An important Islamic development in the paper-making industry was the invention of a bamboo mould from which the wet sheet of paper was placed to drain, and could be removed while still moist. Hunter says that this constituted 'the first real step in paper-making, as it enabled the artisan to form sheets continually upon the same mould. In other words, this invention changed paper-making from a craft into an industry.'

Hunter adds that 'even the most modern paper-machine employs precisely the same principles'.[108]

Arab paper-makers used wheat starch for sizing paper so that its surface is rendered more suitable for writing with ink, but the use of starch took place also in China in the same period.[109].

Figure 4.2 **Arabic paper from the 8th to 10th centuries.**

---

108. Dard Hunter, p. 186 ff.
109. Dard Hunter, pp. 141, 156–7, 186, 190.

Qualities of paper

Kinds of paper differed in thickness, toughness, polish, colour and flexibility. Heavy white paper, which is durable, was preferred.

The size of a full sheet differed between the various countries. The width of a full sheet ranged between one to one and a half dhira'. Smaller sizes were standardised to 2/3, 1/2, 1/3, 1/4 and 1/6 of full sheet. Each occasion and each category of people had its size in official correspondence. One sheet is called *farkha* or *talha*. A *kaffa* or *dast* (*dasht*) makes 25 sheets, and a *rizma* is five *kaffa* or 125 sheets. The words ream in English, *reime* in old French, *rame* in modern French, and *resma* in Spanish came from the Arabic word *rizma*. Smilar words are used in several other European languages. The number of sheets in a ream was normally 480 or 500 sheets.

Red paper was made in Syria and in al-Andalus and was assigned to some court uses. Paper was made in other shades and colours. Syrian paper mills also produced lightweight correspondence paper that was attached to carrier-pigeons. Some of this paper was almost transparent. Kraft paper for wrapping goods was produced, similarly some qualities of thick (strengthened) paper. Paper was used also in some trades like clothing and shoemaking, and some disposable dishes were made.[110]

13 Leather and Bookbinding

Leather

Leather was produced since the dawn of history and is mentioned in the recorded history of every human culture. Egyptian carvings from 3000 BCE depict leather dressers at work. The British Museum contains leather articles like shoes, sandals and other products of the twenty-first dynasty and earlier. The Sumerians possessed a developed tanning technology.

The major tanning operations have come down from the earliest times as a slow empirical development. The Islamic civilisation inherited the skills of the Near East and during several centuries tanning technology flourished and Muslim artisans contributed in developing this art. From Islamic artisans the expertise of leather-making began to reach Europe. The Arabs in Spain introduced a great variety of leathers to the West. Morocco and Cordoba leathers became widely known throughout Europe for their fine quality and fine colours. Through this technology transfer, the tanning industry was already established in Europe in the 15th century. However, the basic tanning technology remained unchanged, and until the end of the 19th

110. Al-Qalqashandi, vol. II, pp. 476–7; Ibn Badis, op. cit; al-Iskandari, *al-Hiyal al-Babiliyya li al-Khizana al-Kamiliyya*, ms. no C528; Milli Kutuphane, Ankara, ff. 104–5.

century, the only notable change in leather production was the introduction of power-driven machinery. The first change in 2000 years in tanning technology was the use of chrome salt at the end of the 19th century.

After the necessary preparatory operations, skins are ready for the chemical conversion to leather, known as tanning (*dibagha*).[111] By the 4th/10th century, Islamic tanners had improved the manufacture of leather into well-established techniques that remained without change until the end of the 19th century. Three basic tanning processes were in use: (a) the vegetable process, (b) the mineral (alum) process or towing, and (c) the oil process. These processes were used singly or in combination.

In Spain, the Arabs introduced an important development in tanning technology, namely the manufacture of Cordovan leather (cordwain).[112] This resulted in a leather of unique character and was famed all over Europe. The Cordovan leather involved different methods of preparation, among them tanning with sumac and tawing with alum. Chamoising was an important oil-oxidation process, and this term was early applied to the dressing of any leather in which oil predominated. Robert Forbes suggests that the word 'chamois' is derived from the Arabic word *shahm* meaning fat.[113]

Bookbinding

After the rise of the paper industry, Arabic manuscripts were produced in great quantities. All these were preserved by bookbinding with leather. Bookbinding therefore became an important craft in Islamic civilisation. Several treatises were written on this subject. These include *'Umdat al-kuttab* of Ibn Badis (d. 497/1103), *Subh al-a'sha* of al-Qalqashandi (d. 821/1418); and the treatise of al-Sufyani who wrote in 1029/1619. A study of these gives us an insight into the Islamic bookbinding techniques.

Bookbinding was a respected craft, and was practised by learned men. The geographer al-Maqdisi (4th/10th century), was also a bookbinder and was proud to practise his craft on his journeys. Ibn al-Nadim in *al-Fihrist* mentions a number of some scholars who were bookbinders.[114]

Gold tooling reached Western Europe in the 16th century from Islamic bookbinders. Other decorating techniques are described in Arabic literature

111. See Al-Hassan and Hill, *Islamic Technology* for the details of the tanning process.

112. From Old Spanish *cordovano, cordován*, cordovan leather, Merriam-Webster Dictionary.

113. On the technology of leather the following sources are useful: Ibn Badis, op. cit; Ibn al-Ukhuwwa, op. cit., p. 149; Singer, op. cit., pp. 146–74; Wulff, op. cit., pp. 230–2.

114. *Al-Fihrist*, p. 20, English text, p. 18.

on bookbinding, and many fine examples of the Islamic art of bookbinding exist in many of the world museums.[115]

14 The Sugar Industry

We find information on sugar-cane cultivation in Islam in books on agriculture and in various other Arabic sources. *Nihayat al arab fi funun al-adab* by al-Nuwairi, contains a particularly detailed and good description of the sugar refining process.[116]

It was said that the best quality of sugar came from Egypt and Syria; with Syria being renowned not only for its products but also for its export trade. Waterpower was used. Recent discoveries have revealed the existence of 32 water-driven sugar mills in the Jordan Valley. Similarly, wind-driven and animal-driven crushing mills were in use.

Until the end of the 14th century, the technological level of the sugar industry in Syria and Egypt was high. Syrian specialists were renowned and taught their methods in Cyprus until the second half of the 15th century. Some of Cyprus sugar products were offered as 'Damascus sugar made in Cyprus' *domaschini di Cipri.*[117] The technology of sugar refining was also transferred from Islam to China. According to Marco Polo Egyptian technicians were called to China where they taught people how to refine sugar using wood ash.[118]

The West became acquainted with the industry only during the Crusades, when the Franks occupied the Syrian coast.

Sugar-cane plantations spread to North Africa and then to Spain and Sicily. From Spain sugar-cane plantations were established in the 1400s in Madeira, the Canary Islands, and St Thomas. The Islamic technology of sugar-cane processing and sugar refining were established there. In 1493 Columbus carried sugar cane cuts from the Canaries to Santa Domingo, and by the mid 1500s its manufacture had spread over the greater part of tropical America.

115. al-Sufyani, *Sina'at Tasfir al-Kutub*, see Martin Levey; Ibn Badis in Marin Levey also; Wulff, pp. 236–8.

116. Al-Nuwairi on sugar: al-Nuwairi remarked that the use of heavy ploughs *(maharith kibar)* was necessary before the sugar-cane could be planted. This remark is important in the history of medieval technology since it was assumed that the use of heavy ploughs was an innovation of medieval Western Europe only (see Lynn White's assumptions in his book).

117. Ashtor, *A Social and Economic History of the Near East*, p. 105.

118. Marco Polo, pp. 232–3.

15 Vegetable Oils

Edible vegetable oils were always an important part of the diet. These included olive oil and oils from sesame, cottonseed, poppy seed, and other similar substances. However, some oils such as linseed oil and castor oil, were used only for industrial purposes. Olive oil was the most valued, so that the olive tree was highly esteemed in Islamic culture, being praised in the *Qur'an.* Due to the tree's very long life and the value of its fruit, it was always considered as important an asset as the land on which it grew. Olive trees were always widely cultivated in the Islamic Mediterranean lands especially in Syria, Tunisia, al-Maghrib and al-Andalus.

In the accounts of Muslim geographers, there is much information about the centres of olive oil production. In Syria *(bilad al-Sham),* Nablus was always famous for its olive oil, which was exported to other Muslim countries, particularly Egypt. In Tunisia, production was permanently at a high level. Al-Maqdisi reported that at Banunash in the district of Rusfa, situated in the heart of the olive-tree forests of the Tunisian Sahel, there were 360 olive oil presses.[119]

The extraction of oils from cottonseeds, almonds, apricot kernels, sesame, castor and other oily seeds and plants is described in various sources such as in the treatises of Jabir ibn Hayyan, al-Kindi, al-Nuwairi and Hasan al-Rammah. Methods of producing olive oil were developed mainly in Syria, the home of the olive tree since ancient times. Arabic sources give details of a variety of techniques as well as information about the different qualities of oil that were produced.

The principal method was summarised by Dawud al-Antaki, who explained how the olives were first crushed, then soaked in hot water and pressed. It was a method that lasted until modern times and the introduction of more efficient presses.

Olives were crushed in a mill with vertical millstones. Design details varied but usually there were two cylindrical stones fixed on the same horizontal axle, which was itself fixed in the middle to a pivoted vertical axle.

From this first crushing high-quality oil was obtained, though there was still oil to be extracted. The pulp was often soaked in hot water before being subjected to a second pressing, this time using a beam or tackle and weight press, or a screw press. Such secondary pressing could be done in a number of stages by raising the pressure between one crushing and the next; indeed, a third stage was frequently used. The oil from later pressings was of lower quality than that from the first, so three qualities of oil were usually

119. Al-Maqdisi, p. 227.

produced. In addition, the liquid that separated out from the pulp was stored in settling vats; later the water could be drawn off, leaving low grade oil behind; this too was collected.

According to al-Antaki, oil was obtained from sesame by first soaking the seeds in water and then removing the skins. The peeled seeds were next roasted, ground and kneaded, then soaked in hot water. However, the oil could also be obtained by pressing.

Oils from other seeds, whether for edible purposes or for industrial uses, were obtained by almost the same procedure as that adopted for olive oil.

Adulteration of Foods and Quality Control

Adulteration was bound to occur, especially with important commodities, and this explains why the office of *al-muhtasib* was concerned with controlling the ingredients of foods.

A very interesting essay attributed to al-Kindi was on making foods from materials other than their normal ingredients (*fi sun' at'ima min ghayr 'anasiriha*).[120] He described meat dishes without meat, meatless sausages, and omelets without eggs and so on. And al-Jawbari in *Al-Mukhtar* fi *kashf al asrar (on the Revelation of Secrets)* devotes one chapter to 'revealing the secrets of those who make foods', declaring that these people had innumerable tricks and left no food without some adulteration. He described for example methods of making artificial honey, artificial *samn* (cooked butter), artificial vinegar, and even a way of manufacturing artificial milk. These two authors were not alone; since there are other similar Arabic sources that give adulteration recipes.

BIBLIOGRAPHY

Abu Mansur Muwaffaq, b. 'Ali Harawi, *Kitab al-abnia 'an haaqāiq al-adwia*, MS Vienna, Österreichischen Nationalbibliothek Codex Vindobonensis A. F. 340, facs. ed. by F. R. Seligmann, Vienna, 1859; facs. ed. with a tr. of the introduction and comments of Seligmann's ed. by C. H. Talbot as *Das Buch der Grundlagen über die wahre Beschaffenheit der Heilmittel*, Graz, 1972. Was edited and published by A. Bahmanyar and H. Mahbubi Ardakani, *Ketab al-abnia 'an haqa'iq al-adwiya* , Tehran, 1346 Š./1967. Translated by Abdul-Chaliq Achundow as "Die Pharmakologischen Grundsätze (*Liber Fundamentorum Pharmacologiae*) des Abu Mansur Muwaffaq bin Ali Harawi,", Halle, 1893.

Abu-l-Fadl 'Allami,'*Ain-i-Akbari*, translators: H. Blochmann (Vol. I) and H.S. Jarrett (Vols II–III) 1868–94, reissued, 1948, B.I. Series: Combined edition. 3 vols in one.

120. Al-Fihrist, p. 379.

Allan, J.W., 'Abu'l Qasim's Treatise on Ceramics', *Iran*, xi, 1973, 111–20.

Antaki, al-, *Tadhkirat Dawud al-Antaki*, Cairo, 1359 H.

Ashtor, E., *A Social and Economic History of the Near East in the Middle Ages*. London, Collins (1984).

Berthelot and Duval, *La Chimie au Moyen Age*, vol. II, Paris, 1893. Duval translated the Arabic text that is written in Syriac script (the Karshuni).

Biruni,al-, *Al- Jamahir fi ma'rifat al-jawahir*, ed. Krankof, Haydar Abad, 1936.

Bosch, K.G., *Islamic Bookbinding, 12th–17th Centuries*, PhD Dissertation, University of Chicago, 1922.

Bustami, al-, Muhammad ibn Muhammad Iflatun, *Jawahir al-funun wa al-sana'I' fi gharib al-'ulum wa al-bada'i'* (Jewels of Arts and Artisan Works in the Unique and Wonderful Sciences), Gotha MS.

Caiger-Smith, Alan, *Lustre Pottery*, New Amsterdam, 1985.

Carboni Stefano and David Whitehouse, *Glass of the Sultans*, Yale University Press, 2001.

Charieston, R.J., 'Glass, History of', in *The New Encyclopedia Brittanica*, Macropaedia, vol. 8.

Derry, T.K. and Trevor I. Williams, *A Short History of Technology*, Oxford, University Press, 1960.

Dimashqi, Shams al-Din, Muhammad ibn abi Talib al-Ansari, *Nukhbat al-dahr fi 'aja'ib al-barr wa al-bahr* , ed. M. A. F. Mehren, Leipzig, 1923.

Al-Dimashqi, Abu al-Fadl Ja'far, *al-Ishara ila mahsin al-tijara*, Cairo, 1318/1900; an edition was published by Bushra al-Shurbaji, Cairo, 1977.

Douglas, R.W. and S. Frank, *A History of Glassmaking*, Oxfordshire, 1972.

Einhard, Notker the Stammerer, *Two Lives of Charlemagne*, trans. with intro. by Lewis Thorpe, Penguin, 1969.

EI, Article *Aqrabadhin* by B. Lewin.

Ettinghausen, R., and O. Grabar *The Art and Architecture of Islam: 650–1250*, Penguin, London, 1991.

Forbes, R.J., *Studies in Ancient Technology*, vol. III, 1955.

Forbes, R.J., *Studies in Ancient Technology*, vol. IV, Leiden, 1964

Forbes, R.J. *Short History of the Art of Distillation*, Leiden, 1948.

Glick, T. *Islamic and Christian Spain in the Early Middle Ages*, Princeton, 1979.

Hamdani, *Kitab al-jawharatayn al-'atiqatayn al-ma'iyytayn al-safra' wa al-bayda'. Die beiden Edelmettalle Gold und Silber*, Einleitung, arabischer Text und Ubersetzung von Christopher Toll, Uppsala 1968.

Al-Hassan, Ahmad Y., 'Chemical Technology', in *Storia della scienza*, vol. III: *La civiltà islamica*, Enciclopedia Italiana, Rome, 2002.

Al-Hassan, Ahmad Y. and Donald R., Hill, *Islamic Technology, an Illustrated History*, CUP and UNESCO, 1986.

Al-Hassan, Ahmad Y. *et al.*, *Science and Technology in Islam*, Vol. 4, Part 2, of the multivolume work on *The Different Aspects of Islamic Culture*, UNESCO, 2002.

Al-Hassan, Ahmad Y. Transfer of Islamic Technology to the West *Cultural Contacts in Building a Universal Civilization: Islamic Contributions*, E. Ihsanoglu (ed.), IRCICA, Istanbul, 2005, pp. 183–223.

Hess, Catherine (ed.), *The Arts of Fire*, J. Paul Getty Museum, Los Angeles, 2004.

Hitti, Philip, *History of the Arabs*, 10th edition, Macmillan, 1991.

Holmyard, Eric J., *Makers of Chemistry*, Oxford at the Clarendon Press, 1931.
Holmyard, Eric J., *Alchemy*, Dover, 1990.
Hunter, Dard, *Papermaking through Eighteen Centuries*, New York, 1971.
Ibn al-'Adim, 'Umar, *al-Wusla ila al-habib fi wasf al-tayyibat wa al-tib*, ed. S. Mahjub and D. al-Khatib, Aleppo, 1988.
Ibn al-Akfani, Muhammad Ibn-Ibrahim Ibn Sa'id al-Ansari as-Sinjari, *Nukhab al-dhakha'ir fi ahwal al-jawahir*, ed. Anastas Mari al-Karmali, first printed, Cairo, 1939, reproduced, Beirut, Dar Sadir [*c*. 1980].
Ibn al-'Awwam, *Kitab al-filaha, Le livre de l'agriculture d'Ibn-al-Awam*, interpr. Clément-Mullet. Lutetiae: Franck, 1864–1867. 3 vol. Arabic edition with Spanish translation, Madrid, 1802.
Ibn Badis, al-Mu`izz, *`Umdat al-kuttab wa `uddat dhawi al-albab*, Martin Levey, 'Medieval Arabic bookmaking and its relation to early chemistry and pharmacology', in *Transactions of the American Philosophical Society*, New Series, Vol. 52, Part 4, 1962. Philadelphia.
Ibn Hawqal, Abū l-Qāsim Muhammad b. 'Alī al-Nāsībī, *Kitab surat al-ard* [Picture of the Earth] also known as *Kitab al-masalik wa-al-mamalik*. , ed. De Goeje,. Brill 1873, second edition 1938. Reprinted in Baghdad and Beirut.
Ibn al-Jazzar, Abu Ja'far Ahmad, *Kitab fi funun al-tibb wa-al-'itr* (A Book on the Arts of Medicine and Perfume), ed. Al-Radi al-Jazi and Faruq al-'Asali, Tunis, 2007. See also Rachid Chemli, International Phyto-Aromatic conference, March 2000, Nice. Chemli gave a list of the contents of Ibn al-Jazzar's treatise.
Ibn Jubayr, *Rihlat ibn Jubayr*, Beirut, 1964.
Ibn Mankali, *Al-Hiyal fi-l-hurub wa fath al mada'in wa hifdh al durub*, (*Treatise on Stratagems, Wars, the Capture of Towns, and the Defense of Passes*), ms. Ahmet III, Serai No. 3469, Istanbul, author uncertain. Several other manuscripts exist in Istanbul, Leiden, and Ribat. This work has been edited and published twice, one edition by Sulayman al-Rahili, Saudi Arabia, 1997, and anther by Nabil Ahmad, Cairo, 2000.
Ibn al-Nadim, *Kitab al-fihrist*, Arabic edition, Cairo, no date.
Ibn al-Nadim, *The Fihrist of al-Nadim*, edited and translated by Bayard Dodge (New York: Columbia University Press, 1970).
Ibn Rasul, King Al- Muzaffar, *Al-mukhtara' fi funun min al- suna'* (*Inventions from the Various Industrial Arts*), ed. Muhammad 'Ali Salhiyya, Kuwait, 1998.
Ibn Sa'id al-Maghribi, *Kitab al-Jughrafiya*, ed. by I. al-'Arabi, Beirut, 1970.
Ibn Sidah, abu al-hasan 'Ali b. Isma'il, *Kitab al-mukhassas*. 17 parts in 7 volumes. Cairo, al-matba'a al-kubra al-amiriyya (1316) 1898.
Ibn al-Ukhuwwa, Muhammad ibn Muhammad ibn Ahmad, *Ma'alim al-qurba fi ahkam al-hisba*, ed. R. Levy, Cambridge, 1938.
Iskandari, *Kitab al-hiyal al-babiliyya li al-khizana al-kamiliyya*, ms. no C528; Milli Kutuphane, Ankara.
Jabir ibn Hayyan, *Kitab al-durra al-maknuna* (see Chapter 6).
Jabir ibn Hayyan, *Kitab al-jumal al-'ishrin*, MS Bursa Husain Celebi, Istanbul, No. 15.
Jabir ibn Hayyan, *Kitab al-khawass al-kabir* (see Chapter 5).
Jabir ibn Hayyan, *Kitab al-sab'in*.
Ja'far al-Sadiq, *Risalat Ja'far al-Sadiq fi 'ilm al-san'a* , see Julius Ruska below.
Jawbari,al-, *Al-Mukhtar fi kashf al-asrar*, Damascus, 1302/1884.

Kamili, Manṣūr ibn Ba'rah al-Dhahabī, *Kitāb kashf al-asrār al-'ilmiyyah bi dār al-ḍarb al-Misriyyah*, edited by Abd al-Rahman Fahmi, Cairo, 1966.
Karshuni manuscript, see Berthelot and Duval.
Kindi, al-, *Early Arabic Pharmacology*; ed. Martin Levey (1973), E.J. Brill; Leiden.
Kindi, al-, *Kitab kimiya' al-'itr*, ed. Grabers, Leipzig, 1948.
Kindi,al-, *Risalah fi anwa' al suyuf wa al-hadid* (Treatise on Various Kinds of Swords and Iron). It was published under: *Medieval Islamic Swords and Swordmaking: Kindi's Treatise 'On Swords and Their Kinds'*, ed., transl. and commentary by Robert G. Hoyland and Brian Gilmour, Gibb Memorial Trust, 2006; the same treatise was edited by Abdul Rahman Zaki, *Majallat Kulliyat al-Adab*, vol. 14, Cairo, 1952.
Kindi, al-, *Riasala ila Ahmad ibn al-Mu'tasim bi Allah fi ma yutrah 'ala al hadid wa al-suyuf hatta la tatathallam wa la takill* (on what Drugs are Applied to Iron and Swords so that they cannot become Broken at the Edges or Become Blunt). This treatise was published under the title: *Risalat al Kindi fi 'amal al-suyuf* (on the manufacturing of swords), ed. and annotated by Faysal Dabdub, Baghdad, 1962.
Kuwarizmi, al-, Muhammad ibn Ahmad al-Khuwarizmi, *Mafatih al-'Ulum* (Key to the sciences), ed. Nuha Najjar, Beirut, 1993.
Lane, Arthur, *Early Islamic Pottery: Mesopotamia, Egypt and Persia*, London, 1947.
Lane, Arthur, *Later Islamic Pottery: Persia, Syria, Egypt, Turkey* (revised ed.), London, 1971.
Levey, Martin, *Chemistry and Chemical Technology in Ancient Mesopotamia*, Elsevier, 1959.
Levey, M., Mediaeval Arabic bookmaking and its relation to early chemistry and pharmacology, in *Transactions of the American Philosophical Society*, Philadelphia 1962. See al- Sufyani below.
Liber ignium, see Foley, Vernard and Keith Perry. In defense of 'Liber igneum: Arab alchemy, Roger Bacon, and the introduction of gunpowder into the West', *J Hist Arabic Sci.* 3 1979, 200–18.
Al-Maqdisi, *Ahsan al-Taqasim fi ma`rifat al-aqalim*, ed. De Goeje, Brill, Leiden, 1906, offset reproduction by Qasim al-Rajab, Baghdad, n.d.
Marco Polo, *The Travels*, trans. by R. Latham, Penguin, London, 1958.
Mas'udi, al-, 'Ali ibn al-Husain ibn 'Ali, *Muruj al-dhahab wa ma'adin al-jawhar*, vol. I, ed. by Y.A. Daghir, Beirut, 1965.
Mercier, M. *Le Feu Gregois*, Paris, 1952.
Multhauf, Robert P., *The Origins of Chemistry*, London: Oldbourne, 1966.
Needham, Joseph, *Science and Civilization in China*, vol. V pt. 3, CUP, 1974.
Nuwayri, Al-, Shihāb al-Dīn Ahmad b. 'Abd al-Wahhāb, *Nihayat Al-Arab Fi Funun Al-Adab*, Cairo, 1998.
J.R. Partington, *A History of Greek Fire and Gunpowder*, London, 1960.
Marco Polo, *The Travels*, trans. by R. Latham, Penguin, London, 1958.
Qalqashandi, al-, Shihab al-Din abu 'l-Abbas Ahmad ibn 'Ali ibn Ahmad Abd Allah, *Subh al-a'sha*, in 14 volumes, Cairo: Dar al-Kutub al-Misriyyah, 1922.
Qashani, see Allan.

Rammah, al-, *Al-Furusiyya wa al-manasib al-harbiyya,* edited and annotated by Ahmad Y. al-Hassan, Aleppo, 2001.
Razi, al-, *Kitab al-asrar,* and *Kitab sirr al-asrar,* ed. Muhammad Taqi Danishpazhuh, Tehran, 1343 (1964).
Rice, D.T., *Islamic Art*, London, 1979.
Ruska, Julius, *Arabische Alchemisten.* II. *Ja'far Al-Sâdiq, der sechste Imâm.* [Includes the text of Kitâb fî 'ilm as-sinâ'a wa-l-hajar al-mukarram, Gotha A. 1292 (Haleb 338)], Heidelberg (1924).
Sarton, George, *Introduction to the History of Science*, Baltimore, 1931, vol. II, pt. II.
Serjeant, R.B., *Islamic Textiles*, Beirut, 1972.
Siggel, A., *Arabische-Deutsches Worterbuch der Stoffe*, Berlin, 1950.
Singer, Charles, *et al.*, *A History of Technology*, vol. II, Oxford, 1956.
Stapleton, H.E., Azo, R.F. & Husain, M.H., Chemistry in Iraq and Persia in the Tenth Century AD, *Mem. Asia Soc., Bengal*, vol. III, No. 6, 1927.
al-Sufyani, *Sina'at Tasfir al-Kutub*. See M. Levey: Mediaeval Arabic bookmaking and its relation to early chemistry and pharmacology, in *Transactions of the American Philosophical Society*, Philadelphia 1962; and also: Es-Sofiani (Abou el-'Abbas Ahmed). *Art de la reliure et de la dorure. (Sina'at tasfir al-kutub wa hall ad-dahab)*, ed. P. Ricard, Paris, Paul Geuthner, 1925.
Tamimi, al-, *Kitab jayb al-'arus wa rayhan al nufus*l, Kitabkhanah-i-Majlis-i-Shuray-i-Milli, MS no.2294, Tehran.
Al-Tarsusi'Ali ibn Murda, *Tabsirat arbab al albab, etc.*, part of which was edited and translated by C. Cahen, 'Un Traite d'Armurerie Composé Pour Saladin', in *Bulletin d'études orientales*, 12 (1947–8). A copy was published in Beirut under the title *Mawsu'at al-asliha al-qadima*, ed. Carin Sadir, Beirut, 1998.
Taylor, F. Sherwood, *The Alchemists, Founders of Modern Chemistry*, Schuman, New York. 1949. Reissued Heinemann, London, 1951.
Taylor, F. Sherwood, in his article on 'Pre-Scientific Industrial Chemistry', in *A History of Technology*, volume II, edited by Charles Singer *et al.*, Oxford, 1956.
Tifashi, al-, *Kitab azhar al-afkar fi jawahir al-ahjar*, ed. Muhammad Yusuf Hasan and Muhammad Basyuni, Cairo, 1977. A translation into English (with many errors) was published under the title:*Arab Roots of Gemology: Ahmad Ibn Yusuf Al Tifaschi's Best Thoughts on the Best of Stones*. Translator Samar Najm abul Huda, Maryland, 1997.
Trueman, John, *The Romantic Story of Scent*, Doubleday, NY, 1975.
White, Lynn Townsend, Jr., *Medieval Technology and Social Change* (Oxford: University Press, 1962).
Wulff, *Traditional Crafts of Persia*, Cambridge, Mass., 1966.
Zahrawi, Abu al-Qasim Khalaf ibn al-Abbas al-, *Al-Tasrif liman 'ajiza 'an al-ta'lif*, facsimile copy of MS Bashir Agha 502, Istanbul, Fuat Sezgin, Frankfurt, 1986. See also: *Albucasis; On Surgery and Instruments*; edition of the Arabic text with English translation and commentary, by Spink, M.S and Lewis, G.L.; London, 1973.

5 Industrial Chemistry in Kitab al-Khawass al-Kabir (The Great Book of Properties) of Jabir ibn Hayyan

ABSTRACT

Kitab al-Khawass al-Kabir (the Great Book of Properties) of Jabir ibn Hayyan is one of his major works. It consists of 71 chapters (*maqalat*) on diverse subjects and 70 per cent of these are chemical, industrial chemical or alchemical. Popular accounts of Jabir's inventions originated mainly from this book. However, no text from *Kitab al-Khawass al-Kabir* was ever edited or published. In this chapter, all texts of industrial chemical recipes are edited and translated into English, based on two manuscripts: British Library MS Or 4041 and Alexandria Municipality MS 5204.[1]

This chapter discusses *Kitab al-Khawass al-Kabir* and analyses the industrial recipes. Then we give the translated text of the recipes followed by a glossary of the main materials. With this chapter and with Chapter 6 on Jabir's *Kitab al-Durra al-Maknuna* which deals with coloured and lustre-painted glass, Jabir's standing as a chemist and an industrial chemist is confirmed, and the old notions about Jabir being only an allegoric or spiritual alchemist are disproved.

INTRODUCTION

The picture that Berthelot and others have painted of Jabir ibn Hayyan until now depicts him as an allegoric and spiritual alchemist who was involved in the Art of alchemy (*'ilm al-san'a*) that deals with transmutation and that his writings in this Art were vague and incomprehensible. This picture is the core of what is known as the Geber Problem that was instigated by Marcelin Berthelot in 1893 and continued throughout the twentieth century. We have dealt with this problem in Chapter 3.

Actually, Jabir was also a practical chemist whose works are rich in outlining chemical processes, in giving recipes for producing materials, and in the description of laboratory equipment.

In addition to Jabir's work on the Art or *'ilm al san'a*, he was involved in industrial chemistry. Some popular books on Arabic and Islamic

---

1. The Arabic texts of these recipes had been published in the *Journal for the History of Arabic Science*, Aleppo, vol. 14, 2008.

civilisation enumerate Jabir's achievements in this field. The circulating information is based on what some historians had written in the first decades of the twentieth century, but until now we have not had concrete evidence to substantiate this circulating information. In the absence of a proof to such claims, the tendency is that of disbelief. Jabir's achievements in industrial chemistry are dispersed in his numerous works and no effort was made to collect them and to publish their contents.

One of Jabir's important works is *Kitab al-khawass al-kabir* (The Great Book of Properties). It is a large book consisting of 71 chapters (*maqalat*), dealing with a variety of topics among which are recipes on industrial chemistry.

We have investigated this work and we realised that it would be quite important to publish the recipes on industrial chemical products. These recipes, in addition to those of *Kitab al-durra al-maknuna*, will acquaint us with Jabir the industrial chemist and with his achievements in this field.

In editing the recipes of industrial chemistry we have used two manuscripts for *Kitab al-Khawass al-kabir*; one is the British Library MS Or 4041, and the second is the Alexandria Library MS 5204 (of the Municipality of Alexandria). Paul Kraus considered the first to be an excellent one; but we have found that the Alexandria MS was also quite reliable. The correspondence between the two MSS was satisfactory, but there were some words and phrases in both of them which remained ambiguous. Both were descended from earlier copies: the BL MS was written in the 8th century of Hijra and the Alexandria MS was written in the tenth.

KITAB AL-KHAWASS AL-KABIR: (THE GREAT BOOK OF PROPERTIES)

The science of properties (*'ilm al-khawass*) is listed in the classifications of sciences in Arabic literature. It has few definitions, one of which is that it deals with the properties of things that are well known but whose causes are hidden. We know for example that a magnet attracts iron but we do not know the reason behind this property. In regard to the properties of things as given in *Kitab al-Khawass* of Jabir and in other similar works, some causes seem reasonable and some are not.

Properties are classified into several types. There are properties of amicable numbers, minerals, plants and animals. Several authors after Jabir wrote on the science of properties. These include Muhammad ibn Zakariyya

al-Razi,[2] al-Simawi al-'Iraqi[3] and Aydamir al-Jildaki.[4] *Kitab al-khawass al-kabir* discusses the properties of minerals, plants and animals whether beneficial or harmful and discusses the uses of these properties in industrial chemical recipes and in the treatment of illnesses and in other useful applications.

The book mentions some strange properties that seem unreasonable, but were common at the time of Jabir. These represent a small part of the contents. They were apparently inherited from pre-Islamic civilisations and became part of the popular heritage.

Out of the 71 chapters, Jabir devoted 20 to philosophical discourses dealing with the science of the balance (*'ilm al-mizan*) in alchemy. There are 10 chapters giving practical alchemical recipes that elucidate the *Book of Seventy*. There are 12 chapters on elixir and its benefits including the healing ones; 8 chapters are on industrial chemical recipes. Thus, the total chemical and alchemical chapters are 50. Of the remaining chapters 13 contain medical and protective recipes, some of which are strange depending on talismanic properties; these include recipes to protect from bugs, insects and vermin. Two chapters deal with the breeding of pigeons, and one deals with pistachios and walnuts. Four chapters contain interesting chemical and strange recipes. Thus, with the introductory chapter the total comes to 71.

From this brief survey, we conclude that the chemical and alchemical content of *Kitab al-khawass al-kabir* exceeds 70 per cent, with 18 per cent dealing with medical healing and protective recipes, some of which are talismanic and strange. The recipes with odd properties, some of which are alchemical, do not exceed 6 per cent of all chapters.

PART 1 DISCUSSION OF THE RECIPES

Forty industrial recipes are edited in Part 2 of this chapter, which can be grouped into the following categories: (1) water desalination; (2) the manufacture and annealing of steel, and hardening it; (3) the colouring of glass; (4) artificial pearl; (5) cosmetics; (6) varnishes, paints and waterproofing; (7) inks; (8) miscellaneous industrial products.

2. Al-Razi, *Kitab al-mufid al-khass fi 'ilm al-khawass*, a facsimile copy published in Tehran by Kitabkhana Markazi, 2008.
3. Al-Simawi al-'Iraqi, *'Uyun al-haqa'iq wa idah al-tara'iq*, Gotha Ms 1274.
4. Al-Jildaki, *Kitab kanz al-ikhtisas fi 'ilm al-khawass*, BN MS arabe 2340.

1 Water Desalination

Jabir says that sea water, the water of the Tigris River, rain water or distilled salt water can be filtered ten times in something that is thick and closely knitted so that its *jawhar* (its essence) and its purity is obtained.

The concept of desalination by using membranes is a modern one that was first known in the last decades of the 19th and 20th centuries Desalination is now performed by reverse osmosis or ultra filtration. Jabir's recipe of the desalination of seawater by using a closely knit and thick membrane to obtain pure (potable) water is akin to this modern technology.

2 Making and Annealing of Steel, and Hardening It

We have two recipes discussing steel. One is for making steel from its components and of annealing it, and one for hardening it.

(a) *Making of Steel and Annealing It*

Jabir says:

> How do we explain the fact that if we take soft iron '*narmahan*' and throw on it the *daus* it is converted into steel? And if we heat steel several times and quench it in *du'* which is sour milk; it is converted back into *narmahan* as it was before?

In this short text we find two important metallurgical facts, the first is about the composition of steel from *narmahan* and *daus*, and the second is about the annealing of steel.

What Jabir had said about the composition of steel is repeated by both al-Kindi and al-Biruni. Al-Biruni gives in his book *al-Jamahir* a definition of the two components of steel (which give rise to the *firind* or pattern in Damascus steels). He presents also a very interesting interpretation of the cause behind the formation of the *firind* . It is due, in his opinion, to the incomplete mixing of two components of steel in the crucible: soft iron (*narmahan*) and its water (*daus*). Al-Biruni's interpretation of the cause of the *firind* or pattern in Damascus steel is reminiscent of the modern interpretation of historians of metallurgy who were studying the secret of Damascus steel. We have devoted Chapter 10 to a fuller discussion of this subject.

(b) *Annealing of Steel*

The process of heating steel several times and cooling it denotes the annealing or softening of steel, which is a common metallurgical process.

There are different methods used currently for the heating and cooling of steel in annealing. For cooling, some liquids contain certain kinds of salts. Jabir used sour milk, and it seems probable that this liquid had an effect similar to present-day solutions. The speed of cooling is not indicated. Although the word *itfa'* is translated into quenching, yet Jabir in this case uses the word to indicate the cooling of the heated steel.

Making a Saw and a Knife that Can Cut Glass and Hard Stones

This is a recipe for steel hardening. The '*siqaya* سقاية' means quenching steel in a liquid.[5] This term is still used in Arabic. A saw or a steel blade is heated and then quenched in a liquid for hardening. At present, the quenching medium can be water, oil or a liquid of a special formulation, some of which are proprietary. The liquid formulation of Jabir is a complex one, and it should have been effective at the time. Arabic sources discuss the *siqaya* of iron and various formulations are given. Al-Jildaki in his book *Kanz al-ikhtisas* gave Jabir's recipe without change.

3 Colouring of Glass

Jabir wrote a complete book devoted mainly to the colouring of glass and making artificial pearls. This is *Kitab al-durra al-maknuna* to which we have devoted Chapter 6. In *Kitab al-durra*, Jabir gave recipes for three methods of the colouring of glass. One is to cast the ingredients including the colouring materials together and thus obtain the cast coloured glass. The second is to prepare the colouring ingredients into a paste and to apply it by brush to the surface of the glass vessel then introduce it into the oven. This method is called *talwih* or staining of glass. The third method is to bury the piece of glass inside a bed composed of the colouring materials and heat the whole. Colour is imparted or diffused into the surface of the piece of glass by this method.

Jabir gave in *Kitab al-khawass* one example from each of the three methods. In colouring by casting, he gave a prescription to obtain a precious artificial jewel called *adrak*. The ingredients are *bijadhi*, rock crystal, cornelium, Syrian glass, rubies, red emery, natron, red lead and the filings of gold. These are cast together as prescribed and the result is the *adrak* precious jewel.

The second recipe deals with the colouring of glass by *talwih* or by staining. Details of this method are given in Chapter 6 on *Kitab al-durra*, and need not be repeated here. In this recipe Jabir is describing how to stain

5. Dozy under سقاية الحديد

bottles of glass in the colour of silver. He uses silver burnt with yellow arsenic. This is pulverised in wine vinegar, painted on the surface of the bottle, and then introduced into the furnace. Gold filings can be used to obtain a rose like colour matching rubies.

The third recipe for the colouring of glass deals with imparting colour to a piece of rock crystal. In this recipe pine gum, dragon's blood, *balsan*, and Syrian pitch are mixed and pulverised and made into a paste. The rock crystal stone is heated and then wrapped up inside the paste. It is left inside the paste for three hours. Red colour is imparted to the stone. We have explained in Chapter 6 on *Kitab al-durra* that this method of diffusing colour is considered now as modern technique and patents are granted on some versions of it.

4 Artificial Pearls

The recipe in *Kitab al-khawass* on making artificial pearl is similar to the recipes of *Kitab al-durra*. We give a brief note on this subject in Chapter 6.

5 Cosmetics' Recipes

Arab authors used the term '*zina*', literally beautifying, to discuss cosmetic recipes. These recipes take care of removing unwanted hair, dying hair, dying the palm of the hand with various colours, the use of perfumes, improving the smell of mouth and armpits and all similar beautifying procedures. The recipes include also medical ones for removing deformations of skin and hair.

Beautifying procedures go back to the ancient civilisations of Egypt and Babylon and to other pre-Islamic civilisations.[6] It is possible that some recipes continued in circulation in the Near East, and it is probable that Jabir had chosen some recipes that seemed unique and deserve to be included in his book on the science of properties. His recipes on beautifying include one to remove unwanted hair, two recipes for dying the colour of hair into golden, and ten recipes for dying hands with various colours.

Arab physicians who came after Jabir had devoted chapters in their medical works to the subject of '*zina*'. It seems that the first to devote chapters on this subject after Jabir, was Abu al-Qasim al-Zahrawi (936–1013) from al-Andalus. He wrote his medical encyclopaedia *'al-Tasrif liman 'ajiza 'an al-ta'lif* at the end of the 10th century. It consists of 30 discourses (*maqalat*) and the 19th discourse deals with *al-zina*. This discourse has 20

6. R.J. Forbes, 'Cosmetics and Perfumes in Antiquity'. *Studies in Ancient Technology*, vol. III. Chapter 1 (Leiden: Brill, 1955), 1–50.

chapters; the first 10 chapters deal with perfumes and the second 10 discuss beautifying procedures including care of hair, skin, teeth, voice, genitals, and other parts of the body.[7] A little later in the east, Abu 'Ali ibn Sina (980–1037) wrote *al-Qanun fi al-tibb*.[8] This is also a medical encyclopaedia of immense importance. In Book Four of al-*Qanun,* Ibn Sina devoted four discourses for al-zina. The first discourse discusses hair and dandruff, the second discusses the colour of skin, the third discusses skin diseases and its remedies, and the fourth discusses the medicines used in al-*zina* for other parts of the body.

Parts of al-Zahrawi's work and the *Qanun* of ibn Sina were translated into Latin and they continued in use during several centuries in Western universities. These Latin translations had acquainted the West with the *al-zina* recipes.

Other medical works as well as works on medical formularies (*aqrabadhinat*) and on simple drugs contain recipes of *al-zina*. The *Aqrabadhin* of Qalanisi for example contains a chapter on *al-zina* that has more than 85 recipes.[9]

Later books on the science of properties have recipes on *al-zina*. One of these *is Kitab 'uyun al-haqa'iq wa 'idah al-tara'iq* of Abu al-Qasim Ahmad ibn Muhammad al-Simawi al-'Iraqi who wrote his book in 1261 during the reign of al-Sultan al-Dhahir Baybars and it contains a chapter on dyes for hair and the hands.[10] Another work on the science of properties is *Kitab kanz al- ikhtisas fi 'ilm al-khawass* of al-Jildaki (d. 1342) which discusses *al-zina* such as removing unwanted hair and dyes for hair and skin.[11] Books on *'ilm al-bah* (the science of sexual relations) contain recipes on *al-zina* for both women and men, one of these is *Kitab ruju' al-shaikh* of ibn Kamal Pasha who devoted a chapter to the colouring of the hands and nails of women.[12]

Even books on exposing cheating practices discuss such topics. We find in al-Jawbari's book *Kitab al-mukhtar fi kashf al-asrar* a chapter on revealing the practices of those who change the colour of horses and another on the practices of those who dye the skin of human beings.[13]

7. Sami Khalaf Hamarneh, 'The First Known Independent Treatise on Cosmetology in Spain', *Bulletin of the History of Medicine*, 39 (1965), 309–25.
8. Ibn Sina, *Al-Qanun fi al-tibb*, Bulaq Press, Cairo, 1294 H (1877 CE); reproduced by Dar Sadir, Beirut.
9. *Aqrabadhin al-Qalanisi,* edited and annotated by Muhammad Zuhair al-Baba, IHAS, University of Aleppo, 1983.
10. Al-Simawi al-;Iraqi, *'Uyun*, op. cit.
11. Al-Jildaki, *Kanz*, op. cit.
12. *Kitab ruju' al-shaykh ila sibah fi al-quwwati 'ala al-bah,* attributed to ibn Kamal Pasha, Bulaq, Cairo, 1309 H.
13. al-Jawbari, *Kitab al-mukhtar fi kashf al-asrar,* Damascus, 1302/1884.

(a) *Removing Body Hair*

Some of Jabir's recipes depend as we have pointed out on inherited tradition and on practice. It is rather difficult to find complete correspondence between the various recipes of Arabic works. In the recipe, which Jabir gave for hair removal, he is using the gall bladder of a wild porcupine, the head of a bat and the milk of a female dog. This recipe seems strange. However, if we look at Ibn Sina's recipes, we find a recipe that prevents the growth of hair using a fat in which a porcupine has been cooked. Another recipe uses the blood of a bat, its brain and its liver. Al-Qalanisi gives a recipe similar to that of ibn Sina where a fat in which a porcupine is cooked will prevent the growth of hair. The blood of a bat is used in frequently cited recipes, thus ibn al-Baytar mentions that the blood of a bat will prevent the growth of hair under the armpits and in the boys' pubic hair.

(b) *Dyeing Hair Yellow Gold*

Jabir says that to dye hair to become of yellow gold colour is unusual; therefore, he gave two recipes for it. He did not give recipes for dyeing hair into black colour because it is common. If we look into medical works and books of properties, we find that almost all the recipes are concerned with dyeing hair into black colour. However, we find that ibn Sina is also devoting some recipes for dying hair into blond colour.[14]

Jabir's first recipe uses vitriol and turmeric roots. Although some vitriols will impart red colour, yet it is the turmeric which imparts the yellow colour. The second recipe employs yellow golden marqashisha (marcasite) and yellow zarnikh (arsenic), both will impart the yellow golden colour.

(c) *Dyeing Skin with Golden Colour*

There are three recipes for the dyeing of hands and nails with golden colour. In the first one henna and red arsenic are used. In the second, *qalqant* (one the vitriols, probably copper sulphate) and iron filings which are converted into red iron oxide. This is similar to a recipe given *in Kitab ruju' al-shaikh* of ibn Kamal Pasha.[15]

In the third one, Jabir is using qasab nabti (nabti reed) the distillate of which comes out red like blood. Ibn Sina gave in the *Qanun* a similar recipe for turning hair into gold blond colour. Also al-Simawi al-'Iraqi gave a similar recipe in book *'Uyun al-haqa'iq wa idah al-tara'iq*.

---

14. Ibn Sina, *Al-Qanun*, op. cit., vol. 3, p. 274.
15. *Kitab ruju' al-shaykh*, op. cit., chapter 7.

(d) *Dyeing Skin with other Colours*

Jabir gave six recipes for dyeing the hands with other colours beside the golden one. These are silver, red, green, peacock, saffron and turquoise colours.

In Arabic works that discuss colours, the basic ones are four: red, yellow, white and black. Red was obtained from zunjufr (cinnabar) as a principal colouring material, yellow was obtained from yellow arsenic, and black was obtained from Indian indigo and white from isfidaj (ceruse).

It is possible to obtain the various other colours from two or more pigments. We shall look into the pigments used by Jabir so that we can analyse his recipes without dealing with the other secondary ingredients such as gum Arabic.

For the silver colour, the principal materials are tin isfidaj (ceruse), lead isfidaj (ceruse) and camphor.[16] These ingredients are also found in later works that gave recipes for dyeing skin.[17]

For red, Jabir used beside zunjufr (cinnabar), red baqqam (sappan-wood or brazilwood), red vitriol, dragon's blood, red roses, henna and saffron.

For peacock, Jabir used Persian vitriol, qalqadis, iron rust, henna and zunjufr (cinnabar).

Saffron colour means yellow saffron, red saffron or a colour in between. From the unclear text, we understand that this colour is composed from henna and from a combination of the above colouring materials.

The last colour is the turquoise. The colouring materials are zinjar (verdigris or cuprum aceticum), yellow zarnikh (arsenic), indigo, qalqant and saffron.

6 Varnishes, Waterproofing and Paints

This group constitutes an important part of the industrial recipes totalling twelve. Varnish is a thin transparent protective shining coating used mainly for finishing wood surfaces; or other surfaces as well. It is composed from a resin and a quick drying oil. A varnish is usually colourless and it is applied over coloured paints for protection.

The most important resin is the sandarus (sandarac), and the quick drying oils include linseed[18] oil, castor oil and chestnut oil.

---

16. Camphor is a waxy, white or transparent solid with a strong, aromatic odour.
17. Al-Simawi al-'Iraq, op. cit., 48a; and *Kitab ruju' al-shaykh*, op. cit.
18. The word linseed or linseeds is sometimes written without the word oil. Most probably the intention is linseed oil in all cases.

Jabir labelled several recipes in this category as Chinese. We shall see below that this name does mean that these recipes are of Chinese origin.

We like to point out here that the Arabic terms used in these recipes can cause some ambiguity. The varnish is called *duhn*, which in modern Arabic means grease or oil. Paint is called also *duhn*, and castor oil is *duhn* and similarly linseed oil. The word *duhn* includes all these materials, but the reader will soon be able to understand what material is involved in each recipe.

Waterproofing

We can say that in general varnish coating protects surfaces from getting wet. However, Jabir specified three recipes to be suitable for waterproofing cloths and other surfaces. One of these carries the heading: 'A duhn which if applied as a coating on cloths and armour will protect them from getting wet with water.' Here Jabir is using varnish materials, which are sandarus (sandarac), castor oil and chestnut oil, and then he adds mastic (mustaka).

Jabir took the second waterproofing recipe from al-Fadl ibn Yahya ibn Barmak, and it is for waterproofing cloth especially silk. The main ingredients are sandarus (sandarac), chestnut oil, ban oil and mastic (mustaka). Jabir says that this varnish will protect a person from drowning when he crosses water, if he wears a garment coated with it, and tightens it at the neck, the hands and feet and fills it with air. It protects also from rain.

Using Iron Filings in Paints

Jabir used iron filings in five recipes for coatings. We could not find in the early Western books of recipes any mention of iron filings in varnishes or paints until the 19th century and we still find patents issued since the 20th century for paints incorporating iron filings.

In a paint incorporating iron filings,[19] Jabir is using qalifonia (rosin), mustaka (mastic), butm (turpentine tree) resin, Iraqi pitch, chestnut, linseed oil and iron filings. If iron, copper and other surfaces are smeared with this paint it adheres to them and it can hardly be peeled off. Another kind of paint is composed of a mixture of sandarus (sandarac), qalifonia (rosin), dragon's blood, mustaka (mastic), linseed oil and needles' filings.

7 Inks

Jabir gave four recipes for ink, two for black, one for red and one for gold. Black ink is usually made from lampblack or from galls and iron sulphate.

21. Article 29, 55b.

Jabir gave recipes for the lampblack ink only. In literature after Jabir there appeared several treatises devoted to writing materials, which discussed inks in more detail.

In one of the recipes for black ink, lampblack is made from the charcoal of the *ghada* or pine trees. A paste is made from this lampblack and fish glue. Discs are made from the paste, which are threaded for use when needed. Discs are pulverised when used. For paints, more fish glue is added and for ink, liquid gum is added.

In the second black ink recipe, a lampblack from the butter of cow's milk is used. It can be made also from the oils of khiri (lavender or wallflower), ban (ben oil tree) or banafsaj (violets). Such an ink will be suitable for the dyeing of hair and beards.

Red ink is made from the isfidaj (ceruse) of lead and qalqant. These are heated overnight in a glassmaking furnace, then pulverised and liquid gum is added.

For the gold colour ink,[20] Jabir is using the same ingredients that are used in one of the recipes for dyeing hair into yellow gold, namely bauraq, the yolk of eggs and yellow gold marqashisha (marcasite). After washing the ingredients in vinegar several times, they are pulverised and dissolved in the ushnan (Salsola Soda) water. The drug will have a colour that surpasses gold. It is suitable for writing on paper or on cloth without the need for gum or glue.

8 Diverse Industrial Products

There are five recipes for miscellaneous products, for cinnabar (zunjufr), black glue, making cooking pots from recycled materials, making whips from ropes and making saddles.

Making Zunjufr (Cinnabar)

Cinnabar (mercuric sulfide)[21] results from the union of sulphur and mercury by the method described by Jabir. It is a basic material for red colour. Until recently, historians of technology thought that the first recipe for obtaining manufactured cinnabar appeared in the Latin book of recipes *Compositiones variae* or Compositiones Ad Tigenda Musiva that exists in the Lucca Library in Italy and dated at the end of the 8th or the early 9th century. However, Jabir's recipe in *Kitab al-khawass al-kabir* has now corrected this

20. Article 60, 85a.
21. HgS.

assumption (see Chapter 6 for more details about the early Latin books of recipes).

Black Glue

This is a recipe for cheese glue. A recipe for this glue is also found in *Kitab al-durra al-maknuna*.

In the *Mappae Clavicula* we find faint allusions to this glue without recipes.[22] In about 1100 CE, Theophilus gave a recipe in his book *On Divers Arts*.[23] In addition, Cinnino Cinnini in the 15th century gave a recipe in his book *The Craftsman Handbook*.[24]

Recycling of Stoneware Debris

This is a simple recipe in its composition but of great significance. Recycling is now of great importance in our modern world. The recycling of glass debris is an ancient concept and of metals filings, but to recycle debris of stoneware is quite unique.

This recipe was transmitted to later Arabic works on the science of properties such as al-Jildaki's *Kitab kanz al-'Ikhtisas fi 'ilm al-khawass*; but we could not find anything similar in the Latin books of recipes.

Making Whips from Ropes

Whips were used since ancient civilisations for a multitude of uses. It was used as a weapon for defence and attack, for punishment, and in controlling horses in riding or in driving. Its use has not stopped until now.

Whips are made either from leather or from ropes, especially hemp. Jabir is describing here a whip that he designed on the request of a contemporary ruler who complained to him from the splintering of whips. The recipe gives a whip that solves the problem.

This recipe and others confirm that Jabir was a practical person and that he was an engineer. The catalogue of his books indicates that he wrote on various engineering subjects.

---

22. Smith, Cyril Stanley, and John Hawthorne, *'Mappae Clavicula*, A little key to the world of medieval techniques,' *The American Philosophical Society*, New Series – volume 64, part 4, 1974, Philadelphia.
23. Theophilus, *On Divers Arts*, translated by John G. Hawthorne and Cyril Stanley Smith, Dover, New York, 1979, p. 26.
24. Cennino Cennini, *The Craftsman's Handbook*: 'Il Libro dell' Arte', translated by Daniel V. Thompson, Jr. New York: Dover, 1933.

Making of a Saddle

This simple recipe was of importance when saddles were a main product and were in demand. However, Jabir's description of the colouring of wood and of polishing it is of importance irrespective of saddle making.

Sources of Recipes

The recipes on industrial chemistry that we discuss here represent the technology that was in current use in the 8th century at the time of the Abbasid Caliph Harun al-Rashid and Jabir ibn Hayyan. These recipes were either inherited or newly developed. For recipes that were not developed by Jabir, he alluded sometimes to their sources, and that he collected some of them. He says for example that he took a waterproofing recipe from Al-Fadl ibn Yahya ibn Barmak who also took it from a manuscript of unknown author, since the first pages and the last ones were missing. Moreover, when Jabir describes the manufacture of the *adrak* gemstone, he says that he took it from a valuable manuscript. In both of these two recipes Jabir says that he tested them.

Jabir mentions that he tested other recipes. Thus in describing the dyeing of belts, he says that he tested the recipe, 'I tested it and found it extraordinary.' In describing a paint he says that the recipe 'was described to us, so we tested it and found it correct and perfect'.

Other recipes were devised and developed on the example of the transmitted ones. About these, Jabir says:

> A scientist should contemplate these origins, because if he were a scientist, then he can develop something similar. All sciences are based on each other and on analogy, and every rational science is based on what preceded it.

About the Name 'Chinese' for Some Recipes

During the early Abbasid Caliphate, commerce with China was flourishing, and technology transfer from China happened through direct contacts, as was the case with the paper industry. There was no translation movement from Chinese at that early period.

Some Chinese products were appreciated, as was the case with ceramic tableware. Arab artisans were able through experimentation to imitate Chinese ceramics using local raw materials without any knowledge of Chinese recipes. Islamic ceramic products acquired the description 'Chinese' although neither the recipes nor the products were Chinese. Until now, a tray is called in Arabic '*siniyyah*' or 'Chinese' even if it is made from metal.

Among the recipes of *Kitab al-khawass al-kabir* the word Chinese is used in the names of some varnishes and inks. Moreover, as in the case of porcelain, these recipes did not come from China. They are Arabic recipes for local products. The word Chinese is a description for the product. Julius Ruska says about them: 'we cannot say that these recipes are Chinese. They are probably of Greek, Syriac or Persian origin.'[25] Paul Kraus says also: 'Jabir discusses in chapters 28–31 some dyes that are imitations of Chinese. But the details of these recipes represent the technology of the local artisans who were contemporary to Jabir.'[26] We add here that these are simple recipes for local varnishes or paints, and their technology was a local one earlier than the period of trade with China.

Joseph Needham in his monumental work in which he enumerated Chinese achievements cited the recipes of *Kitab al-khawass al-kabir* as part of Chinese achievements. However, Needham should have relied on Chinese sources and not on Arabic ones because as we have just explained the word Chinese here does not mean that these recipes were of Chinese origin.[27]

Jabir used Arabic manuscripts when he compiled some recipes. Moreover, if these recipes were of Greek, Syriac or Persian origin as Ruska has maintained, they represent the technology of the same lands that became Islamic. In addition, if we accept his assumption, then the original books of recipes were translated into Arabic during the Umayyad period. The other possibility is that these Arabic recipes which Jabir had compiled were composed during the Umayyad period on the basis of existing local technology.

Jabir's Recipes are Detailed

There is a sharp contrast between the recipes of Jabir in *Kitab al-khawass al-kabir* and in *Kitab al-durra al-maknuna* on the one hand and the recipes of *Mappae Clavicula* and the early Latin books of recipes on the other. We can see this, from examining Jabir's recipes and comparing them with the Latin ones. The Latin recipes are very concise, not exceeding few words sometimes while Jabir's recipes are detailed. Jabir, moreover, is interacting with the reader as if he is speaking to them.

A Note about the Method of Editing

In editing the Arabic recipes, we used only two manuscripts. The first is the British Library MS OR 4041, and the second is the Alexandria Municipality

25. Ruska, see bibliography.
26. Kraus, see bibliography
27. Needham. See bibliography.

MS 5204, which is now among the manuscripts' holdings of Alexandria Library. The first one is the oldest among the existing MSS of *Kitab al-khawass al-kabir* and is the finest one according to Paul Kraus. However, although Kraus had praised it highly, yet it has its defects with frequent lacunas and some text errors. In our editing of the recipes, we found missing folios and in this case the MS of the Alexandria Library was of extreme value. It was also useful in correcting some errors.

In order to arrive at the best possible text, we have adopted the BL MS as the main one, and used the Alexandria MS for the missing folios in the BL MS. We have also selected the correct text from the Alexandria MS where the BL text seemed inaccurate. The adopted texts from the Alexandria MS are written inside angle brackets, <...>. Even with the utilising of both MSS, some ambiguous words or phrases remained and are indicated in the footnotes.

PART 2 EDITED TEXTS OF THE RECIPES

The recipes that are given here are those that were differentiated as purely industrial. There are, however, numerous other recipes in *Kitab al-khawass* that are of industrial importance, which are part of the alchemical chapters. Such recipes require a further study for distinguishing them as we have done here.

Excerpt from the Fourth Maqala: Water desalination [10 b][28]

And from this also is that water should be from sea water or Tigris water or from rain water or distilled salt water or others which we have well compiled in *Kitab al-tajmi'* (The Book of Compilations). It should be filtered ten times in something that is thick and closely knit so that its essence and its clear filtrate come out.

Excerpt from the Sixteenth Maqala: Converting Iron into Steel [32b][29]

We ask also about the khawass (properties) and their existence in the world: How do we explain the fact that if we take soft iron '*narmahan*' and throw on it the *daus*, it is converted into steel? And if we heat steel several times and quench it in *du'* which is sour milk; it is converted back into *narmahan* as it was before?

28. This is missing in Alexandria MS. Square brackets give the folio numbers of the BL MS.
29. 50b in Alexandria MS.

Excerpt from the Twenty-Fourth Maqala: Making Artificial Pearls [46a–46b]

Take some pearls, put them in a bottle, and pour citron juice on them. Then throw on them lead isfidaj (ceruse), and then cover the top of the bottle with a fitting plate of the same size. Then hang the bottle in the sun for the whole day, and if it is during hot weather it will be better, that is in the heat of summer. The next day open the bottle, pour out the water, and pour in new water. Then pour it out in the third day and pour in new water again. Do this for three days. If some of the pearls did not dissolve and become like thick sour milk, then pour in more of the citron water. Then take them out after they are dissolved and put them in cups and pour out the water from them. Then wash them with pure sweet water until you do not find in the water any of the citron sourness when you taste it. They should never be touched with hand. Put them in a place free from dust and earth until they are dry. Then put them in a bottle and cover it, and keep them until you need them.

Afterwards, take mercury and pulverise it with an equal weight of qalqandis and half its weight of andarani salt. Pulverise them until mercury cannot be detected, then take a little from it and spread it on your hand and if you notice any glittering continue pulverising until shining disappears. Then sublime it twice, kindling fire under it, using thick and large firewood, for three hours at mild fire and three hours with intense fire. Lute the mouth of the jug (*kuz)* and leave for the next day, and shelve it. If you want to mix them (i.e. the dissolved pearls with the mercury mixture), take from the dissolved pearls four mithqals, and from mercury six mithqals and mix them together and knead them with egg white inside a smooth glass vessel with a raised rim in which you can knead. Then pulverise the mixture with a glass pestle on a marble or a glass tray without pressing hard until it becomes like mumiya (pitch). Then take it out little by little, using a white silk without touching it by hand, and put it in a glass tray. Then roll it until it is <spherical>, and so that if you take it by hand it does not stick. Then pierce it with a pig's hair and put it back on the tray until it becomes firm, and when it dries well put back the hair and roll it as before; and then you will take it pure white as hard as a pebble that cannot be broken if you strike it. Put it now in a small box lined with carded cotton and leave it for ten days if it is summer, and twenty days if it is winter, so that it becomes well dried. If you want to know if it has dried well or not, put it in the glass tray in which you have rolled it, and if its sound is clear like the ring of a small bell then it has dried, otherwise put it back in the small box until it dries well. Then

polish it with the jewellers polishing tool. Rub it with polishing tool until it shines. If it does not shine, return it to the small box so that it dries up well.

If you want to irrigate it and if it has no sound,[30] then take a fish and slit its belly and remove what is inside. Take the bubble of the fish, pierce it and wash it with warm water and borax, or do not wash, then put the pearl inside it. Make a strong thread knot between each two pearls. Put it inside the fish and tie its belly. Kindle fire inside a tannur until it becomes good white. Remove the ashes and the fire and place the fish on a brick in the middle of the tannur. Lute the top of the tannur so that no smoke can go out. Leave it for three hours. Open and take the pearl out. If you find that it had any fat, wash it with warm water and soap. Know that mercury gives weight to the pearl; it tightens it and solidifies it.

This recipe is one of the masterpieces, and the cores of the heart. May God be pleased with my Master; he used to say: O Jabir, these are the cores of the heart, and if you look into our books, you should collect them and what may be added to them of their arts. Let peace be on you (wa al-salam).

Twenty-Eighth Maqala: From *Kitab al-Khawass al-kabir* of Abi Musa Jabir ibn Hayyan al-Sufi al-Azdi

In the name of God, Most Gracious, Most Merciful.

He (Jabir) said: We gave enough evidences to illustrate that al-khawass is a singular science. We shall now mention some of the precious works which are a complement to these maqalat, in which we give pleasant anecdotes of works in which the learner will find delight and joy and complete benefit if he likes to work on them in addition to knowledge, if God wills.

Dyeing a Crystal Gemstone

I shall mention something nice from dyeing.

<The method is> to take two mithqals from the gum of pine tree, the same amount from dragon's blood, half a mithqal from balsan and half a mithqal from Syrian pitch. These are well pulverised and kneaded with half a mithqal of cow's murrar (centaurea aegyptiaca). You can add more of the murrar (centaurea aegyptiaca) if needed since pulverisation will dry up most of its wetness if the pulverisation attains the high quality indicated by us. Take a crystal gemstone, put it in a crucible, and heat it very well. When the gemstone becomes hot and the crucible is red due to heat, take out the stone and wrap it with that drug and leave it inside it for three hours, then uncover

30. The Arabic text says (وما زمر به), which is not quite clear. This is what we think it means.

it. If you are not satisfied with its colour, wrap it again until it comes out red. By my obligation to my master, God's blessings are on him, if the operator was skilful he will get the intense red colour from the first time. This <recipe> is one of the great secrets and precious benefits. If we compose these ingredients in a different manner, we shall get a similar result; however, the advantage of the weights given here is to obtain the result that we have indicated, but these recipes will be universal.

Removing Hair from the Body

We say to them also, what about if we take the whole gall bladder of a wild porcupine and pulverise it with the head of a bat until it becomes thick, and then mix the whole with the milk of a female dog, and finely pulverise them until the mixture becomes like honey? If we coat the body several times with it, it removes the hair from the body and no hair will come back at all. In this <recipe> is a great and useful knowledge and with it there will be no need for practices that harm the body. This <recipe> is useful also for persons of cold humor because in addition of removing the hair, it benefits the body greatly.[53b]... If using drugs causes these effects then everything in this world has a property. I wonder therefore why we keep considering khawass as a science if it is found in most things.

Dyeing the Back and the Palm of the Hand

We also need to mention from these practical prescriptions few things that help us to be acquainted to many ambiguities in industry and especially to properties. If you wish to dye the back of the hand and the palm with various colours, take a qirtas (sheet of paper) and stick it to the hand; it should be in the shape of the palm of the hand, and white in colour. Pack it with the various dyes, which I shall describe to you. If you like, make it a tree, a palm tree or any illustration you like. Make the fingers as roots, with the origin black, the spadix silver in colour, the branches deep red, the fruit gold, the leaves turquoise, and the twigs parrot colour, which is green and sky colour, some of the fruits peacock colour, and some henna colour. If you do this, your work will come out well.

GOLD COLOUR INGREDIENTS

The first colour, which we shall discuss, is the gold. Take two mithqals of za'faran (saffron), half a mithqal of 'anzarut (gum of astragalus), one daniq of gold ziryab (burned gold), three mithqals of red zarnikh (arsenic), one quarter of a mithqal zarawand (birthwort), one mithqal wars (memecylon) which are the red roots, half a mithqal of the gall bladder of the shabbut

(carp). Further, take one mithqal gum Arabic, one mithqal mustaka (mastic), one mithqal seeds of iklil al-malik (sweet clover), in another recipe flowers of iklil al-malik, one mithqal sandarus (sandarac), two mithqals garlic juice, ten mithqals henna of the best quality available. If you collect these, pulverise each individually and knead it with the garlic juice and with the moist cow's murrar (centaurea aegyptiaca), and treat it as we have described. Paint with it with a feather or with a hairbrush or with a spindle having a cotton swab at its end; take care not to touch it with your hand. If you paint with this and leave it, it will assume the colour and you can use it for everything. I swear by my master, it is extraordinary. Wa al-salam (let peace be upon you).

SILVER COLOUR INGREDIENTS

As for the ingredients of silver colour and how to make them, take three mithqals of tin isfidaj (ceruse), two mithqals of jiss (gypsum), one mithqal of dry pigeon droppings, one mithqal of bitter almond kernel. Further. take half a mithqal from olive seed kernel, two mithqals from white chestnut kernel, one mithqal from gum Arabic, one qirat of kafur (camphor), one dirham of lead isfidaj (ceruse). Pulverise each ingredient individually, knead with egg white and good vinegar, and coat the fingers with it. All colouring should be uniform. Use it as you did in the first chapter and it will be extraordinary. Wa al-salam (let peace be upon you).

RED COLOUR

We need to speak about red colour. [54a]. Take from qalqand one dirham, from red baqqam (sappan-wood or brazilwood) one dirham, red vitriol one dirham, fuwwa (madder) and dragon's blood one mithqal from each, zunjufr (cinnabar) and red roses one dirham, good Zabadani henna five mithqals, pure za'faran (saffron) half a dirham, mustaka (mastic) one mithqal. Pulverise each individually, mix them, and knead them with 'unnab (jujube) juice or with egg yolk and paint whichever fingers you desire and leave it overnight so that that the colour is imparted, then wash it. This will be the best red colour. You should take care to follow the recipe exactly in order to obtain the perfect results as we have described, if God wills.

GREEN COLOUR INGREDIENTS

As for the parrot green colour, take twenty dirhams from good henna, two mithqals nura (slaked lime). Three mithqals mardasang (litharge), one mithqal zaj (vitriol), one mithqal gum Arabic or kathira (tragacanth) and thirty mithqals good Chinese lazaward. Pulverise and knead with wine vinegar and egg white. Dye with it and it comes out green by God's help.

A scientist should contemplate these fundamentals. He can if he is a scientist, devise similar recipes using the examples given here; this is because all sciences are based on each other. Every rational science is built on a previous one; therefore build your work according to this, especially because these examples are among the choicest of properties. So learn them. and follow their example and you will follow the right path as you like, if God wills.

PEACOCK COLOUR INGREDIENTS

We ought to mention after this the ingredients of the peacock colour as we have promised at the beginning of this book. Take one mithqal of Yemeni alum, two mithqals of Persian zaj (vitriol), two mithqals of qalqadis, three mithqals from khabath al-hadid (dross of iron), five mithqals of sour pomegranate rinds, ten mithqals of henna, one mithqal of zunjufr (cinnabar). Pulverise each individually, then mix them together and knead them with a boy's urine. Make it very fine by extended pulverisation. Paint the fingers or other areas that are to be coloured with it and it will come out a peacock colour of the best kinds. Work accordingly and it will come out by the power of God as we have described; and do not deviate from what we have prescribed.

SAFFRON COLOUR[31]

As for saffron dye, the hand that is to be coloured with it is dyed with henna in the usual way; mix it with these colours and let it be in its middle and it will become as required. It was thus prescribed by philosophers, and it will appear brilliant saffron red. If it is mixed with these colours it will make it rich and shining, better than if it is alone. Know this, and if you realise that you should work accordingly, you will have acquired a good knowledge.

TURQUOISE COLOUR INGREDIENTS

The turquoise colour is one of the main colours and one of their best. [54b] Take from the water of zinjar (verdigris) five mithqals, from yellow zarnikh (arsenic) one mithqal, from indigo one mithqal, from qalqand two mithqals, from gum Arabic two mithqals, and from pure za'faran (saffron) two grains to one qirat , and from the back of sea crab two mithqals. Grind and knead

31. The original text is not very clear.

with vinegar. Paint with it the palm of the hand and leave it to set and it comes out a good turquoise.

These practices can be in the sheet of paper, which you have fixed on the hand and fingers. Think well in executing the picture and the decorations that you desire. The more precise these are, and if the branches are entwined, and the decorations are turned upon each other, the better it is and the more bright. Do this since it is, by God, one of the strange and valuable things and it is one of the great benefits that philosophers were avaricious about it. This is the end of what we shall discuss in this subject.

A Jewel Called Adrak

We want to speak now about what we believe is correct and which deserves to be added to these chapters (abwab) in this specific treatise. Philosophers have a jewel known as adrak. It is extraordinary and precious and it matches yaqut (corundum) in hardness, beauty and nobility. It is, by my master, one of the most precious treasures which if one cannot get anything else, I mean than this jewel, he needs not have with it any other. By my master, let God's blessings be upon him, this recipe which I give in my present book is one of the most precious, noblest, superior, clearer and one of the greatest in value; and I have worked according to it. Operate according to it if you like and leave other works; and by my master, you will achieve with it what you desire out from operations and riches because it is almost greater in importance, esteem and value than yaqut (corundum). Jewellers know this and they desire it greatly more than yaqut..

The method of work is this: Take from bijadi (tourmaline) one ratl, from clear rock crystal one ratl, from good 'aqiq (cornelian) half a ratl, from Syrian glass half a ratl, from white yaqut (corundum) one uqiyya and from red sunbadhaj (emery) half uqiyya. Pound all after you heat them and immerse them in water and salt to purify them. Throw on them half a ratl natron, three uqiyyas of isrinj (red lead), one ratl of gold filings that are pulverised with sal ammoniac until they become <soft> like marrow.

Pulverise first the jewels,[32] and send them for casting with some natron, tincar and borax. They will come out in two ingots, one solid and one porous on the top. Throw away the porous since it is iqlimiya (calamine). Take the <solid> ingot and pulverise it very well until it becomes like powder, and wash it with water and salt, then sweeten it with fresh water. Throw on it the rest ingredients and pulverise very well until the ingredients are mixed together and all their parts are intermingled. [55a]. Put them in a luted pot and cover it with a cover having a hole in which you can insert a large

32. He means the gems and glass materials of the first group of ingredients.

needle. Verify that the joint is secure. Kindle a fire with thick firewood and *ghada* (haloxylon persicum) charcoal until they whirl. Have with you a long large needle with a slight bend at its end. You will know the degree of melting of the jewels with that iron rod. You have to keep testing it, and when you know that it has melted and that it whirls quite well, intensify the fire and after three hours from its whirling, take out a little from the molten jewel at the end of the iron and put it in a white trough until it cools down. If it looks black or if it has turbidity, do not consider it and return it to fire and increase the fuel for one more hour, and test it continuously until all of it comes out a red jewel like shaqa'iq (anemone) with a shade of yellow. When you see it like this, it will be better than yaqut (corundum), and it has matured. Stop the fuel and leave it to cool down. Make out of it whatever gemstones you desire. If you like to pour it before it cools down, then use impervious clay and form it in whatever shapes you like, and pour it <in the moulds> as we have mentioned in *Kitab al-durra al-maknuna* and you will get what you like, if God wills.

This is the end of the twenty-eighth maqala of *al-Khawass*, praise be to God. It is followed by the twenty-ninth maqala of *al-Khawass al-kabir* of Jabir, God's mercy be upon him.

The Twenty-Ninth Maqala

In the name of God, Most Gracious, Most Merciful. I begin with God's name and His help. Sufficient to me is God alone. Praise be to God, the One and Only One, God the Eternal, Absolute. He has taken neither a wife nor a son, and there is none Like unto Him. Far He is high above what the pagans and men who are futile say, Exalted and Great. God's blessing and peace be upon Muhammad the Prophet and all his family.

If the wise contemplates our books,[33] he will find that they all contain knowledge about dyes either for jewels or something similar. These are found in three kinds only. We have discussed in the previous maqala some dyes for animal's skins and some for jewels; these are not peculiar properties for drugs and balances. I shall discuss now in this maqala some of the dyes for animal's skins and some dyes for clothes according to what I have found. The paint known as the Chinese is something that I did not see correct, as it should be except with one or two. <I shall mention> some of clothes dyes within the limits of this maqala. We shall mention also some of the paints for weapons and other things so that neither water nor dust will reach them with the passage of time. We shall start with the base for all these sciences, which deserve to be presented before others; and this is according to our plan in all

33. He means the present chapters.

the sciences that we have discussed before in completely or in part in our present books, if God wills.

A Varnish for the Waterproofing of Clothes and Weapons

We start these recipes with a varnish that prevents water and dust from reaching clothes and weapons so they remain unaffected.

Take from fresh castor <seeds> any quantity you like, and peel the outer shells gently until they become clean. Rub them on a flat stone mortar (sallaya) until they become like ointment, even softer; Put the paste in a stoneware pot that is particularly clean from fat, and a new pot is better. Pour on it clear water as much as you like, and boil it vigorously. The oil will rise to the top. Skim it as it comes up little by little until you take all the oil, pure and thin. Take from this oil three parts and from chestnut oil one part. Peel the outer shell of chestnut and the thin skin also. Extract the oil, clarify it once or twice, and keep it in a bottle. Place the bottle on hot ashes or cold water and test it. Use the best quality oil and get it clarified and clear like a teardrop. Preserve it and store it in clean bottles. Mix the castor oil with the chestnut oil, taking three parts from the first and one part from the second. When they are mixed, put the mixture in a bottle and place it on a gentle fire. Take good quality white sandarus (sandarac), peel it with a knife, bruise it and take from its extract half the amount of the mixture of the two oils. Take from mustaka (mastic) that is peeled on fire half the amount of the sandarus (sandarac). Put the bruised mustaka (mastic) in a bottle and place it on fire and it will melt and be dissolved. Let the castor oil and the chestnut oil be hot and throw on them the mustaka (mastic) and it will melt with them, and then take the bottle containing the oils and the mustaka (mastic) while it is warm and pour the contents on the sandarus (sandarac); it will melt instantly, and this is its secret. Then introduce a reed into the mixture and take a sample. Put the sample on a glass. If the sample drops down and solidifies, lift the mixture from the fire. If it does not solidify, leave it on fire until it dissolves, and so that when it drops on the glass it solidifies. Paint clothes and weapons and other things with this varnish and it is, by my master, God's blessings be upon him, one of the noblest works.

A Chinese Varnish for Belts and Girdles

We describe after this the Chinese varnish for belts, girdles, belts for animals, for weapons' sheaths and similar items; according to the best method that I have practised, tested and made use of. I have found it marvellous in every shade, if God wills.

Take from good quality and pure sandarus (sandarac) whatever quantity you desire and clip it into the size of lentils. Put it in a bottle and bury it in dung until it dissolves. When dissolved, take from it one part, from the oil of maiwizaj (delphinium staphisagra) one part and from linseed oil one part. Take linseeds, husk them as you do in sesame husking, then pound them, and extract their oil. Combine all the oils and cook them on a gentle fire for an extended period. Take care that they do not catch fire because fire will burn them and consume them. Take from anbat gum (gum of turpentine tree) one part, pulverise it very well and throw it on the oils so that they are all mixed together. Put down the varnish and filter it. Take the filtrate and put it in a bottle, and close its mouth to prevent any earth from falling into it.

Choose a day with silent wind and without dust and take the belts of girdles and bridles or whatever you want, and strain a belt between two firm pegs. Take out some of the varnish using a reed or a stick and dribble one drop on every shibr (span of the hand) so that you know that you have distributed it sufficiently all over. Leave it in the sun until it melts. When it has melted use a coarse canvas or a rag and polish the belt continuously until it shines and improves so that you can see your face in it. It is, by my master, God's blessings be on him, one of the precious works in this application.

In addition, since we have discussed this varnish, there is no harm if we discuss a recipe for Chinese paint, which is one of the peculiar works in these things. If you start doing a thing, you should make it perfect, the better in quality and the most preferred so that it is distinguished. Because if you do something that is common, and is made by everybody, then you do not have any advantage over the others, except on those who cannot make it. Unless of course if what you have made and in which you are equal with the others, has only one way of doing it, in which case you are excused.

A Chinese Paint Recipe

Take one uqiyya of qalifunia (rosin) which is ratanj (resin), one uqiyya of mustaka (mastic), one uqiyya of butm (turpentine tree) gum, one uqiyya of Iraqi zift (pitch), the kernels of ten chestnuts, six awaqi (uqiyyas) of linseed oil and three awaqi of Indian iron filings. Cook in a copper utensil, having no traces of lead, until it gets thick. Then filter the paint using a cloth of close texture, then smear with it iron, copper and whatever you like and they will accept it. It is marvellous and can hardly be removed from the utensils. This is one the secrets of their knowledge, so work accordingly and you will get something better. It is one of their good basics in these works. Wa al-salm (peace be upon you).

Recipe for Black Chinese Glue

Take old cheese and cut it as thin as possible. Then add salt to it in addition to its original saltiness. Place it on a sallaya (stone mortar) and compress it by stones, using numerous ones and let them be heavy as much as you can. Put it in the hottest sun such as in June, July or August and similar, until you see all or most the fat of the cheese coming out and until fat stops seeping out. After this, wash it very well to get rid of its salt. Then put it in the sun, if you find fat in it, return it under the sun with salt and pressing by heavy stones and rinsing afterwards, until it is fat free, if God wills, Wa al-salam (peace upon you.)

Then take it and pulverise it finely like dust. When it reaches this condition, take a part from it and a part from good quality white fish glue. Dissolve the fish glue in some water and when it dissolves throw on it the pulverised cheese and one quarter of pulverised Indian ink. When all are mixed you can coat with it whatever you desire. If you perform this manufacture do it in a hot bath (hammam), because if it gets dry it will never dissolve even if you kindle under it all the firewood in this world, and do not leave the hammam until you finish making it because if it is contaminated with dust it is spoilt. We have discussed something similar when we described the making of glass jems and Chinese clay in *Kitab al-durra al-maknuna*, so work according to this <recipe> because it one of the marvellous manufactures. We have said that you should not leave the hammam until your work is completed because if it becomes dry it will never coalesce to each other and will be spoiled. Also, if it is wet and if dust enters its sides and edges it is spoiled and will never coalesce, so know these basics in all these chapters and you will achieve [56a] what you desire, if God wills.

Moreover, since we have discussed these manufactures, we say that one of the superior among them is the making of the Chinese saddles, because it has strength, lightness and hardness which are necessary for much movement, in addition to its beauty. Such a manufacture may have to follow the preceding ones. We seek God's help in all matters.

Description of How to Make Saddles and other Chinese items of Cadi (Catechu) Colour[34]

Take the wood that you want to use and carve it to the extent that you desire and rub it down vigorously with barley. After you have soaked henna leaves,

34. Cadi is catechu or cutch, extract from the heartwood of *Acacia catechu*, a leguminous tree of the pulse family, native to India and Myanmar. Catechu is a fast brown dye used for various shades of brown and olive, including the familiar khaki, and in tanning.

rub it with henna water five times and dry it. After it is dried, rub it with baqqam (sappan-wood) water. To make baqqam (sappan-wood) water, take baqqam (sappan-wood) and bruise it and throw it in a pot without any fat in it and cook it until its colour comes out yellow in water. Leave it to settle then filter it and throw in it three dirhams of ground Syrian alum. Then rub your article with baqqam (sappan-wood) water until it takes its colour and the dye is fixed in it and its colour is clear. When it reaches this stage you will like it since it is one of the best handicrafts. When it reaches this stage take a rag and moisten it and pour nura (slaked lime) on it and rub your article with the rag and nura (slaked lime) until you are satisfied with its colour as it becomes warm with the intensity of rubbing; and it come out red as if it is fire in its beauty and colour. Then polish it and varnish it with any of the varnishes of your liking, either from the above or by any other varnish of your choice and it will come as you like if God wills.

Since we have finished these recipes, we need to mention the making of the ink that we require in the above works. This is the Indian and the Chinese and it is suitable for everything and is one of the best handicrafts in itself, so follow it and you will see something marvellous.

Description of Indian and Chinese ink

Put a pot on a brazier of ghada charcoal. If you do not want to use charcoal you can use pinewood, as oily as possible since some of it is so oily that its fat will drip because of its richness. Then set it aflame and place on top of it a vessel that covers it completely. When it burns, no smoke will be wasted because it rises into the vessel. Take all the smoke and put it in a mortar and pour on it a quantity of fish glue sufficient to combine it. Pound it strongly for one good hour until the smoke and the glue are very well mixed. Then moisten your hand with water and take it out of the mortar and knead it with your hand very strongly until it extends like *natif* (a sweetmeat paste). You should know that this operation on it is similar to the ceration of elixirs, and the better it is mixed and the more resilient it is made the more you will achieve your purpose. When it reaches its end by kneading and it becomes like ointment, pinch it into discs and thread them, leaving spaces between the discs so that they will not stick together, then dry them in the shade and do not make an error.

If you want [56b] to coat with it anything like saddles or vessels or anything else, pound the <discs> and add fish glue to them to the consistency needed and coat with it what you like. If you want to write with it throw it after pounding in gum water and write. The gum used is that of pears' trees only, but glue is better. Work accordingly and you will find what you like, and it is one of the secrets in these sciences.

If you like to make ink using another method, then work according to this <following> recipe because it is wonderful and is of great benefit in its art and it has a good characteristic.

Description of Another Ink

Put cow's ghee in a vessel and overturn on top of it another vessel. Kindle fire under the vessel containing the ghee. You can use instead of the ghee other fats such as those of the khiri (lavender or wallflower), the ban (ben tree oil), banafsaj (violets) or anything similar, and then it can be used as a dye for beards, hair and the like. Continue kindling fire until the whole ghee or fat is converted into smoke adhering to the upper vessel. Then do with this smoke as you have done with the previous ink. You may have to know that the previous ink is known as the Chinese ink, while this one is known to those who deal with it as the Indian, so know them and use them as you wish, wa al-salam (peace on you).

Now, since we have discussed these things and niceties we need to mention a paint that cannot be penetrated by water and cannot be dissolved by it and cannot harm it even if it had remained on it a long time. We shall now start in this if God the Exalted wills.

Description of Paints that Cannot Be Dissolved by Water

This recipe for paint with which you treat silk so that water cannot reach it is taken from al-Fadl ibn Yahya ibn Barmak. I have used it and asked him if it is from his own composition, and he said no, but I have found it in an old dismembered book with other <recipes> and I tested them all and found them to be correct. The <title> of the book was not found at the beginning or at the end and it could not be recognised.

To make this paint take any cloth you like, but if it is silk it will be better. And if you want it to be white then let it be cotton cloth. If you like, you can dye it to your liking using patterns of your choice and let the dyes be with good gum Arabic. Then take from clear white sandarus (sandarac) that resembles billaur (crystal) and which is rich in its fat one mann, from chestnut fat one mann, from mustaka (mastic) three manns and from raw ban fat (ben tree oil) three manns. Take the cooking pot and place it on a hearth that does not allow fire to escape from its sides from anywhere around it, and kindle underneath it a gentle fire and keep stirring with an iron rod until all the sandarus (sandarac) inside it has melted.

When it has melted quite well throw on it the mustaka (mastic) keeping the fire as it is. When the mustaka (mastic) has melted also, throw on it gently the chestnut fat, sending it little by little and stirring it slowly while keeping the fire. When it boils take a little <sample> by a thin iron [57a] and drop it on your nail, and if it solidifies like billaur (crystal) or gum or anything similar then throw on it the fat of ban (ben tree oil) until it boils again. If it is not clear as we have indicated, then keep feeding the fire with fuel and let it be gentle and for a longer time until it fulfils its sign. Then try it on your nail <and throw the fat of ban and try it again on your nail>[35] and if you find that it will adhere to the cloth then it has matured and it will not be difficult for you to find this out.

When it reaches this condition bring it down from over the fire and leave it to cool and use it in whatever you like and it will achieve what we have mentioned. Coat with it any type of cloth and it will prevent drowning in water and will protect against rain especially for travels. A person can wear a garment from this cloth and fastens tightly the buttonholes. In addition he fastens the sleeves and at the legs, and if the garment has no tail so that it is a shirt at the top and trousers at the bottom, and if he fills it with air and wades into water he will not drown, wa al-salam (peace on you).

This is the end of twenty-ninth maqala of *al-Khawass al-kabir* of Jabir God's mercy be on him.

The Thirtieth Maqala: From *Kitab al-Khawass al-kabir* of Abi Musa Jabir ibn Hayyan al-Sufi may God be Pleased with Him

In the Name of God, the Most Gracious the Most Merciful.

We said in the previous maqala that we shall complete in this one what we have started there and after that we shall discuss [57b] other sciences. I say that I have started in the previous maqala describing dyes for belts, clothes, wood and other things. In this one, I shall continue discussing the same topics to complete what I have started, if God wills. I have described to you how to make a varnish that will prevent water from reaching cloth and I shall start by describing here a paint that will prevent water from reaching cloth, iron and wood, and it will be good and perfect, and we seek God's help in all matters.

35. This sentence seems to be a repetition by the scribe.

Making a Chinese Paint for Coating Cloth, Iron and Wood and other Things like Belts and all Devices

Take white, clear and good sandarus (sandarac). Peel the upper skin until its white appears. Then pound it and sieve it with a sinews[36] sieve or a hair sieve, which should not be of narrow holes. Take one part from it and two parts from the pure oil of chestnut. I think that chestnut oil should be of the quality that is used in all things including confectionery. Combine them and place them in a clean stone cooking pot having no traces of fat or grease, or in a luted clean Syrian copper pot, and if the quantity is little put it in a luted cup.

Now place it on charcoal, and if it is in a pot then place it on a hearth of the type used for pots. Shield it so that fire will not rise from its sides, and kindle underneath it a gentle fire until the sandarus (sandarac) melts. Insert a rod into it for stirring, then test it between two fingers and if you find it elastic then increase the fuel until it becomes soft between your fingers like oil and does not stretch. Take it out from above the fire and use it in whatever you like such as cloth, wood, belts and other objects.

If you want it to be yellow, black, red or of any other dyeing colour, then dye the cloth in the colour of your choice and paint it with this varnish then expose it to the sun and it will dry in one day. The place should be immune from dust as much as possible because dust will spoil it and destroy it. Choose a place with grass or a watercourse, and it will be wonderful if God the Exalted wills.

One can make from Tibetan wood an article or saddles or whatever other objects, so that they come out similar to what is brought from Tibet and its areas. If the workmanship is to be precise, then let him grind the dyes of his liking such as isrinj (red lead), zinjar (verdigris), lazaward or any similar dyes, separately with this varnish and grind as thoroughly as possible because grinding is the secret of good dyeing.

The varnish here is the one that we have described earlier. Moreover, if the materials are too much for it, then take the gum [58a] of anbat (gum of turpentine tree) and linseed (oil), one part seeds' oil and two parts gum. Start with the gum, and put it in the pot and kindle fire underneath until it melts and foams and then settles. When it has settled, pour the seeds' oils on it and stir a little until they are mixed then bring it down. This is the varnish of gum that is used by saddlers.

Take this varnish and grind the pigments with it. Then coat with it wood and skins applying one dye after the other. When one dye is applied it is left to dry and then another dye is painted on top until all colours are finished.

36. منخل عقب, according to Lane عقب are the sinews or tendons.

Then it is dried and carved with an iron with whatever patterns one desires. The patterns are coloured with hair, then coated with the white Chinese varnish that we have described, then it is dried. All the dyed colours of the carving will be seen.

I have seen this varnish being applied to a polished mirror, which accepted dyeing and you could see the face in it, and it could not be harmed by water or dew or anything related to its functioning. If it is coated, overturn on top of it a glass cover and leave it in the sun for drying. When it has dried, it will come out as we have described. As to the carvings in the dyes let it be yellow under the red and green above rose and the like from every colour as it is done in books. Know this and work accordingly and you see what you like of this and it is wonderful, wa al-salam (peace on you).

You can if you like add to the white varnish one or two pieces of mustaka (mastic) or more or less. This will speed up its drying. But this is not good for coating because it will form grains, hence it is better not to add mustaka (mastic) and it will be easier to apply and smoother, wa al-salam (peace on you).

Since we came to the end of this chapter let us describe some varnish for stones because it is one of the wonderful things. Here we shall say:

Making Chinese Varnish Especially for Marble and Brass

Take large pieces of good quality mustaka (mastic) and purify them. The method of purifying is to take a sample at the end a large needle, and put it close to the fire, and when it melts, squeeze it taking what comes out and throwing the rest. Then take from white ratinj (resin) the same quantity as mustaka (mastic) and put it in a clean pot or in a luted jug, and kindle underneath a gentle fire until it melts and solidifies in your hand. Then take it out, put it aside and clean the jug.

Then take from the oil of banafsaj (violets) a quantity equal to the sum of the weight of both, or you can take sesame oil or chestnut oil, and put it in a pot and throw on it the mustaka (mastic) and the ratinj (resin). Kindle a gentle fire underneath so that it will not burn. When it thickens and becomes like honey, take it out next morning and put it in a bottle of wide head.

If you want to paint it on brass, use the linseed oil instead of banafsaj (violet) oil together with the oil of shahdanaj (cannabis sativa), one part of each, then polish the brass and wipe it and paint it two or three times and dry it in the sun until it becomes dry and transparent. Thus, it will not rust, its colour will not change, and it will be without smell. If you want to paint with it a tray, take the naphta smoke and knead it with the water of trotters, and

then the oil of hawwara (white wheat flower)[37] and use it. It is wonderful; wa al- salam (peace on you).

This is what we have promised to describe, and we need now to devote one of these Chinese paints to iron and let it be golden since there is much profit in these crafts.

Description of a Chinese Golden Paint for Iron

Take one ratl from old linseeds and one quarter of a ratl from qalifonia (rosin), that is ratinj (resin). Pulverise the ratinj and put it in a pot with a bundle of iron filings. Kindle underneath it a mild fire, taking care that it will not catch fire, until it thickens. If you want to know if it had matured, dip a reed in it and if you see hat it adheres to the reed like thick honey then it had matured and store it until you need it.

If you want to coat with it brass or iron, the first thing to be aware of is that you should not paint in a windy day to avoid dust, because dust is the blight of all elastic things and of elixirs. If you want to paint with it then melt it on fire. The fire should be quiet without smoke or ashes. When it dries, paint again twice or thrice until it comes out to your liking, if God wills.

Now, since we have completed describing these manufactures we need to describe other paints. The former golden paint was especially from the people of Basra; while the similar one that we shall describe presently is from the work of Hamdan philosophers. It is one of the curious things, so work according to it and you will find out what you like if God the Exalted wills.

Description of Chinese Paint for Gilded Iron

Take five dirhams of ratinj (resin), five dirhams sandarus (sandarac), three dirhams dam al-akhawayn (dragon's blood) and five dirhams mustaka (mastic). Pound them all and throw them on the oil of old seeds, and throw on them a bundle of the filings of needles, using a thin rag. Put all in an iron pot. Kindle a gentle fire underneath until it boils violently and paint with it a thin coat, then approach it to fire taking care that no ashes stick to it. Then coat it again and approach fire taking care against dust and ashes. If you want to approach fireplace on top of it stones or iron; and place the painted object on top, so that it is heated without being exposed to ashes or dust. If you want to paint a pole or something similar in length make the fire and then let it be quiet and insert the pole, and if you want to paint a thing with gold, polish it first very well so that gold will adhere to it, if God wills.

37. Hawwara is white wheat flower according to Siggel. Probably wheat germ oil is intended.

Because we have discussed these paints and works, let us describe here the basic paints starting with the white one, leaving the rest to the second part of this discourse and this will be the end of our descriptions of these things if God the Exalted wills.

Describing White Chinese Varnish that is the Basic One

Take from good quality anbat (turpentine tree) gum any amount you like. Filter it from the sediment, and when it is filtered put it on a flat stone or ceramic and place it on hot ashes or gentle fire until it gets rid of its humidity and adhesiveness and becomes pliant under your hand. Then put it in a pot and throw into it thirty dirhams of mustaka (mastic) and two ratls of chestnut oil. Then kindle underneath it a gentle fire from the morning until mid-day. Then bring it down and store it until you need it. Then varnish with it whatever you like and it will be wonderful, if God the Exalted wills.

The Thirty-First Maqala: From *Kitab al-Khawass al-Kabir* of Abi Musa Jabir ibn Hayyan al-Sufi

In the Name of God, the Most Gracious, the Most Merciful.

We have promised in the previous maqala that it will be the last one to deal with these crafts. But we found that there are more crafts that were not covered, so we have added this maqala to enable the reader to be in no need for any further crafts and so that he will be in no need for guidance.

We say, God protect you, that the artisan who will make these things, and everything that he will make, should be clean and with good manual skill. To acquire manual skill one should be patient in the job that he practices. Moreover, if he does not get what he desires he should be patient until he corrects himself and get the desired result. If one follows this recommendation, he will not require a teacher, even in the science of music, which can rarely be learned except under the guidance of a teacher, and when this science is acquired then the student can teach it wherever he likes after he performs it correctly.

Because we have started this discourse, we need to complete the description of the remaining paints so that the learner of this craft will have what he needs, and in these descriptions, we rely on God's help.

At the end of the thirtieth maqala, we described the manufacture of the white Chinese paint. We need now to describe the manufacture of the black Chinese paint and other things of this same art as additions. Thus, the learner will have wide knowledge in these crafts and so he can achieve what he desires if God the Magnificent wills.

Making Black Chinese Paint

Take whatever quantity you like from the oil of old seeds (linseeds) which is used for polishing saddles, and take from marzanjush (sweet marjoram), sunbul (spikenard), myrtle (الآس) and ifranjmashk (sweet basil) one <splinter> of each and one nut from buwa nuts (nutmeg). Pour water on top to immerse and boil them in a pot very well so that the water will acquire the sweet smell of the fragrant plants. Then filter the scented water leaving the plants and pour the water on linseed oil, and cook it very well until the water is gone and the oil remains with the good smell of the aromatic plants and without the smell of the linseed oil.

Then take from the linseed oil one ratl, from iron dross (khabath al hadid) half a ratl, and from iron filings half a ratl and cook in a gentle fire in a new pot and take care that fire does not enter from above. Keep the fire from morning until noon then leave it to cool down, then filter it with linen cloth while it is slightly warm, then store it and use it in whatever purpose you like, and it will be wonderful, if God wills.

We need now to describe other paints as extra items only

A Chinese Paint

One of these is a Chinese paint that was described to us. We tested it and we found it to be proper and of top quality. Take from resin (ratinj) one part, from iron filings one part and from linseed three parts. Put the linseeds in a container or an iron ladle and throw on it the filings and the resin until they are thickened with light fire from underneath. When it becomes like wax (mum) remove it from fire. If you like to make it paint, put it in a luted cucurbit (round still flask), and cover it with an alembic and distil it, and it will come out red. This is one of alchemists' proofs that they have red distillates for their elixirs.

If this distillate comes out red, it does not mean that it succeeds only with red colour. This is not the case. If you want to make an article that is to be coated with this paint then make the paint and dye it with any colour of your choice and then paint the article yellow, green, black, white, blue, rose and any other colour, and it will never peel off.

If you want to coat with it a cloth, then do so and it will match the best works in quality, and it is one of the secrets in these crafts. If you work with it, you will reach what you desire in painted works, saddles, ornaments and other objects. A philosopher should be able to answer all questions that are presented to him in the best manner and in the most intricate details, since a philosopher should comprehend all existing sciences or as much as possible of them and he should be able judge the rest by analogy, peace be upon you, wa al-salam.

We need also to follow this with another Chinese paint and this will be our last discussion of paints in these books if God the Magnificent wills.

Description of a Chinese Paint

Take ten istars[38] of sandarus (sandarac) and pound it very well then sieve it in a fine hair sieve. Put it in a cooking pot and kindle for it a gentle fire and it will dissolve. Once it has dissolved pour on it fifteen istars of good quality old linseeds and continue the gentle fire until the sandarus (sandarac) and the linseeds are mixed. [60a] If you want to know if they are mixed or not, take a reed and take a drop and touch it with your finger. If you find it to be viscous then it has reached its end, If it still like oil you will know that it has not, so continue until it reaches its end; and when this is done store it until you need it. Use it in any application you like and it will be wonderful, wa al-salam (peace on you).

We need now to mention a nice red dye for women, that came across us, in the colour of gold, which is easy to make, and it should be practised after one becomes well versed in these crafts.

This is one of the good recipes and of top quality and we have tried it and found it as described. If one follows in all dyes the procedure described in this one, then he can as well produce all colours of dyes. This is one of the better recipes so work according to it.

Description of a Nice Golden Dye

Take two parts of qalqant and one part of iron filings. Then pour on them the best quality wine vinegar until they are immersed. Foam will rise on top similar to fish scales.

Take this foam and dry it in the shade then pulverise it and knead it with ghasl (marshmallow) water that was distilled with a cucurbit and alembic, then ferment it slightly as you ferment henna. Then dye with it the [the hand] of the maid for one or more hours, as required, then wash her hand and the dye will become after washing as if it is gold but purer in its beauty and brightness. This is all that we need from these prescriptions, so work according to them and you will achieve your purpose by the power of God the Magnificent.

A king of our times, complained to me about the splintering of whips, their lack of beauty, and high cost. Even with these, they do not perform as

38. Istar is about 4.5 mithqal or 6.4 dirham, which amounts to 20 grams.

required. He asked me to design a whip that meets his desire. For this, I had developed this prescription, which is for one of the unique devices.

Description of Rope Whips

Take hemp the thickness of a finger and cut from it the length of two cubits (dhira'). Throw it in a pot containing fish glue and boil it until the glue penetrates it. When it had absorbed the glue take it out, put it between two pegs and twist it, and stretch it like the bowstring. When it is dry, cut it to the length of the desired whip.

Then take the loose end and weave it lengthwise and width wise so that it has warp and weft Rub (the glue) over it smoothly, softly and evenly and the more you do this the more beautiful and perfect it will become.

Then take a hem of a good coarse cloth and sew it on it then paint it with any of the preceding paints. If you like it black then smear it with the smoke of naft and then varnish it, or you can choose any colour, and it will not change, like cotton cloth which is one of the best long-lasting textiles, and peace be on you, wa al-salam.

Because we have discussed these things, let us mention something that matches big and rare industries. What we shall describe will be of a general benefit and much usefulness. Such recipes occur in these notes by error and they contain secrets and wisdom, and if people are distracted by them they will neglect their livelihood and their usual activities, peace be on you, wa al-salam.

This one is of stoneware making out of everything, and this prescription matches in its virtue the important prescriptions when need arises. It is of benefit for artisans. It is one of the great secrets especially in stonework, so work according to it and reveal its secret and you will achieve what you like if God the Magnificent wills.

Making Stoneware and Everything from Broken Stones

Take five parts from the broken fragments of stoneware and one part from murdasanj (litharge), and if this not available take isrinj (red lead) in its place. Take kathira (tragacanth) and soak it in water until it swells, and when it has swollen put it in a linen rag and squeeze it until the extract comes out leaving the shells, sticks and other impurities inside the rag.

Then moisten the stoneware fragments with the kathira (tragacanth) water, and make from them whatever wares you like, and dry them. When they are dry, place them in a tannur until they are baked into pottery or solidify like stone and become like the original stoneware.

Moreover, in this manner you can treat anything made from stones and from things that cannot burn in fire. Follow the same procedure and you will obtain objects similar to the original. The usefulness of this chapter is great, because if you find the fragments of an object you will be able to restore the original through this prescription and this procedure. It has a great, magnificent and noble secret in it if you have noticed, because it teaches you the basis of all fermentations, and there is in it the best guide for what you may need in these crafts.

So work according to it, and by my master, God's blessings be on him, I have rendered you a great service with these crafts which are unique in science, if you have realised. So search for them and work accordingly and you will find wonderful things.

In this also is a gradual training for you towards more difficult works, so listen to what I am telling you, and infer by analogy and this will be a great insight for you in deducing sciences.

I shall mention now some unique products and will describe precious, great and noble water that has two benefits, one is that it will distil red in colour, and the second is that it will be used in dyes. This is a unique product.

Description of a Wonderful Golden Dye

Take new nabti reeds and cut them into pieces each four fingers long, then put them in a glass cucurbit and overturn on it the alembic and make a tight joint in between. Kindle fire underneath until its water is distilled and a water red as blood will come out. Then knead the henna with it and when it has matured and after one hour had elapsed, it will come out in the unmatched colour of gold. Moreover, one may imagine that the palm of a woman's hand is painted with a gold paint.

Then work accordingly in your applications and examine it and you will find in it, by my master, God's blessings be on him, many benefits of great usefulness, and if there is only the red distillate this is in itself one of the wonders.

For at the beginning a small quantity of white distillate comes out, and then a red distillate and it is an amazing thing so know it and use it. Some people were doubtful about it and said that this is the dye and because it is plentiful, water will be mixed with it and both will come out red.

Moreover, I think, and God is wiser and more informed, that the true thing is what these people had said. So know this and apply it and it is one of the more important sciences, if God the Magnificent wills.

Description of a Nice Red Ink

This recipe is the last one in these maqalat, and the end of our maqalat also. Therefore, work on it because it is good and unique and it contains useful things for anyone who applies it, searched and tried it.

Take eight mithqals from lead isfidsj (ceruse), and four mithqals from qalqant, and put them in a bottle smeared securely with clay and tight at its head.

When it is dry, put it in the upper glassmakers' furnace for one night and take it out in the morning. Break the bottle, remove what is inside and pulverise it quite well, then moisten it with gum water and write with it whatever you like and it will be wonderful, wa al-salam.

Let this be the last discussion in this art and the end of the maqala. Moreover, we come to the exposition that we have previously promised if God the Magnificent wills.

Excerpt from the Thirty-Sixth Maqala [68a]: Solidifying Mercury into Red Colour <Making Cinnabar>

Take a round glass cup and pour a quantity of mercury into it. Then take a Syrian jar and put at its bottom a quantity of pulverised yellow sulpur. Then place the cup on the sulphur and let it surround the cup up to its rim.

Then place it in a tannur, after it has been used for baking bread, and cover the mouth of the jar securely. Then take it out and it will be found as a solid stone, red like blood of the best colour. Use it whenever you need red mercury (cinnabar).

This mercury is called the zunjufr (cinnabar) of philosophers. It is also called the exterior dye, the start of the interior dye and the contrary dye; and it is called the strong dye, the achiever of tasks and other similar descriptions. Use it in any of the mentioned tasks and for similar things, if God the Magnificent wills.

The Forty-Second Maqala: From *Kitab al-Khawass al-Kabir* of Abi Musa Jabir ibn Hayyan al-Sufi

Making a Saw and a Knife that Cut Glass, Horns and all Stones

In the Name of God, the Most Gracious the Most Merciful.

Praise be to God, the first without a beginning and the last without an end, the capable of doing anything without an example or support. Let Him be exalted to great highness.

Because we have discussed until now in these maqalat, in the various doctrines, sufficient subjects in the sciences and crafts, we need now to mention something from the properties of the inner philosophical sciences that are difficult. We shall bring the best that we can in these maqalat and end with this one to go into discussing the functioning of the balance as we have promised you, if God the Magnificent wills.

The first thing is to describe making a saw and a knife that can cut glass, horns and all hard and soft stones as easily as they can cut wood and reeds, and will pass through them with ease without stopping.

Philosophers attributed these recipes to talismans as they should be. They are talismans in reality. Every talisman pertains to a property since it is fast in action [73b] on its own, wa al-salam.

The method to make these tools is to take the mushroom, which is called the mushroom of the snake, which kills anyone who eats it. This mushroom according to dependable experts and to specialists in agriculture, is grown only in the dung of donkeys. The best procedure is to grow mushrooms under olive trees and to fertilise them with donkey's dung. The mushroom that results will quickly kill anyone who eats it and is much more harmful than the bish (aconitum ferox Wall), because of its singular property. When the crop has grown, take from it the amount required, and take the juice of the mountainous karnab (wild mustard). It comes from various places but the mountainous one is the best for this application. Take also moist Persian ushnan (Salsola Soda) juice, 'awsaj (lycium arabicum) juice, old wine tartar, I mean the wine should be old since it is better, zabad al-bahr (pumice), dhararih (Spanish fly) and the juice of moist banj (henbane) tree.

Pulverise the dry ingredients and mix them with the waters. Put them in a bottle and seal its head and bury it in the dung for fourteen days renewing the dung every three days, and the contents will dissolve into clear blond thick water, which will be a poison for iron, and will rip everything and dissolve it. It is also a poison so avoid it because it is quick acting and kills, wa al-salam.

Then make the saw that you desire or the knife to any size. Let the teeth of the saw be very small like the teeth of a turtle or smaller, and the knife can be with one edge or two edges, and make its blade as thin as possible because this will be better and quicker in action, if God the Magnificent wills.

If you finished with this and made it according to our description, take a felt and soak it in old urine for three days then remove it from the urine and dry it in the shade, then irrigate it with that water.

Then heat the saw or the knife and quench it with this water in the same manner used by ironsmiths in quenching swords. When it is quenched and

becomes cool, wrap it very well in rags and safeguard it from dust as much as you can, because dust is the plague of everything, wa al-salam.

If you want to work with it then do so as is the case with all tools in their different applications and when you are finished wrap it again with the rag and take care not to leave it exposed otherwise the heat treatment will be lost.[39] It will cut marble, by my master, as easily as a knife cuts watermelons and similar things. It will also cut every stone and no iron at all can affect it. It will, by my master, cut emery and large stones which brass-makers use for hammering. So use it when the need arises for similar applications, if God wills. It can cut through diamonds as sharp knifes cut through meat and faster.

This is what the philosophers had indicated, and I see that the juice of wild qatha al himar (ecballium elaterium rich) can be added. Also the juice of the habb tree (sweet clover), the juice of marzion (daphne mezereum), the water of la'iya (euphorbia triaculeata forsk) and the poison water that is used in elixirs, or the juice of rayhan (basil) alone or the juice of the hanzal (bitter apple) tree. It will, by my master, cut everything,[40] so work accordingly, wa al-salam.

It is not in our power to give more than one prescription in this maqala, and so let this be the end of it.

The Fifty-Ninth Maqala: From *Kitab al-Khawass al-Kabir* of Abi Musa Jabir ibn Hayyan al-Sufi [85b]

Dyeing Hair Yellow in the Colour of Gold

In the Name of God the Most Gracious the Most Merciful, praise be to God the Alert, the Subtly Kind, the Pardoner, who has no equal.

It is not forbidden or abnormal to dye hair in black, red or green colours, or to dye black, red and green hair into white colour, but it is strange to dye the hair yellow in the colour of gold. It is, by God, one of the big wonders. I will give on example that can be followed by anyone who has no experience in these matters.

The recipe for this is to take from good quality Cypriot qalqant one part and a half, one part shahira (vitriol), one part Syrian zaj (suri vitriol) and one part red qalqatar. Combine them in good pulverisation and knead all with the eggs' yolk.

Put them in a luted kuz (mug), seal the mouth and roast for one night in a strong fire in the glassmakers' oven or that of the potters. Then take it out

39. Here comes a phrase, that is vague.
40. We omitted here a vague phrase.

and leave it to cool down. Take it out from the kuz (mug) and pulverise it with the juice of kurrath (leak) and seal the head and roast it in fire another night, then take it out in the morning and leave it to cool down. When it is cold take it out and pulverise it and store it for your future need.

If you want to dye with it, take an old wine of good quality, with nice smell and clear. Take the roots of kurkum (turmeric), pulverise them with the wine and make them like little balls. Let the weight of the kurkum roots be half an uqiyya.

Then take an uqiyya from that prepared drug and knead it with the wine that contains the kurkum. Wash the head beforehand with natron only and let it not be contaminated afterwards with grease or anything, then apply this dye. Then leave it one night and in the morning it will all be soft. Wipe the hair with a cloth and then coat it with pure ban oil (ben oil) and it will come out the colour of smooth ibriz gold that will not change for six months. Keep it, use it, take it as an example for all other sciences because it is amazing, and so use it in all applications that come your way. It will not change with passage of years and so what may be adduced from it in all sciences, if God the Magnificent wills.

Another Similar Prescription

Take Armenian bauraq (borax) and pulverise it with the yolk of eggs for three days, and whenever the yolk dries irrigate it from the water of the Armenian bauraq (borax).

Then take pure yellow gold marqashisha (marcasite) and pound it into coarse grains. Pour it into a glass container and pour on it filtered vinegar or utruj (citron) juice covering it by two fingers above. Then stir it three times daily and when the vinegar becomes black pour it out and replace it until the vinegar does not change in colour and does not become black. If you see it like this, take it out and pulverise it with first drug in qarasia (prune) juice for three days. Then dry it and roast in a luted ceramic kuz (mug) in a strong fire and take out in the morning and protect it from dust, which is the plague of all works, and from dew also. When you want to use it take from it two parts and from yellow zarnich (arsenic) one part. Pulverise the zarnich in water until it becomes liquid. Pulverise all in eggs white and some za'faran (saffron), and murrar al-baqar (centaurea aegyptiaca) with za'faran (saffron). Then coat with it what you like and use it and you will see it ibriz gold. We added to it that that it be coated with the Indian paint of the Art, which is the same as the Chinese paint of sandarus (sandarac) and linseeds, if God the Magnificent wills. This is the end.

The Sixtieth Maqala: From *Kitab al-Khawass al-Kabir* of Abi Musa Jabir ibn Hayyan al-Sufi al-Azdi

Writing on Paper in the Colour of Gold

In the Name of God, the Most Gracious the Most Merciful. Praise be to God the forbearing, The Ever Returning, the Generous, the Bestower.

The writing on paper in the colour of gold by artifice may dispense with the pasting of gold on it. It will be better, brighter, softer, and more durable over years than gold.

Gold is pasted on these things with the water of ashaq (ammoniacum). It will change place, carry the gold and peel it off. The method of making this is to follow the procedure of the fifty-ninth article until you reach the stage when the colour of the vinegar remains white. I mean that in which the golden marqashisha (marcasite) is soaked and if the black colour is gone and the vinegar becomes white you will not need the marqashisha (marcasite), then bring out the drugs and roast them. Take them out, pulverise them, and dissolve them in five fingers of the juice of moist ushnan (Salsola Soda) which is called the ushnan of zatha.

You will see that your prepared drug will become upon contacting this ushnan (Salsola Soda) better in colour than ibriz gold. So write with it upon whatever you like: a writing book, paper, a cloth or anything like this and it will come out ibriz gold without glue or gum

In addition, you will need this in most similar works. The nobility of this prescription is more than can be described, because, o, my brother, you will know the virtue of what we have mentioned if you approach people dealing with this same application and practiced the recipe in which they excel. Moreover, if you achieve several times their accomplishment with less cost and labour than what they have, and in less time, then you will appreciate our favour to you and to all people. We ask God to reward us for this and to bless us with more knowledge in the sciences; he is generous and liberal and fulfils what he desires, wa al-salam.

APPENDIX: GLOSSARY OF SELECTED TERMS

Description	الاسم بالعربية
Utrujj, utrunj. Citrus medica Risso; citrus limonum risso; English: citron	الاترج
Adrak or adhrak; A precious jewel made by casting glass	ادرك
Ifrinjmishk; Ocinum basilicum, sweet basil	افرنجمشك
Iklil al-malik; Melilotus officinalis, Yellow Sweet Clover	اكليل الملك
Ban; Moringa arabica. (Siggel p. 19). Its oil is called ben oil or behen oil.	بان
Bijadhi; according to al-Biruni, *bijadhi* is one of hyacinth-like stones.	بجاذي ، بيجاذي
Old linseeds	بزر عتيق
Baqqam; Caesalpinia sappan (Dozy I, 104, Siggel p.21)	بقم
Buqqam; Datura, known as Devil's trumpet, metel, downy thorn-apple	بقم
Balsan, Commiphora opobalsamum, known as Balm of Gilead.	بلسان
Billaur; rock cristall	بلّور
Banj; hyoscyamus niger L.	بنج
Bish, aconitum ferox Wall	بيش
Jauz buwa; Myristica fragrans Houtt, nutmeg.	جوز بوا
Hummad al- utruj, Citron juice	حماض الاترج
Hummad; rumex acetosa L.; common sorrel	حماض
Hanzal, Citrullus colocynthis. Colocynth, Bitter apple	حنظل
Dukhan al-naft, The soot of naphtha.	دخان النفط

Description	الاسم بالعربية
Dam al-akhawayn, Dracaena Cinnabari dragon's blood	دم الاخوين
Duhn al-hawwara; Probably wheat germ oil	دهن الحوارى
Duhn al-khiri. Oil of matthiola	دهن الخيري
Duhn al-ban; ben oil.	دهن بان
Daus, cast iron, or cementite, one constituent of steel.	دوص
Du' or dugh, is makhid; buttermilk	دوغ
Dhararih, cantharis vesicatoria, littavesicatoria, Spanish fly.	ذراريح
Ratinaj; resin	راتنج
Zabd al-bahr;, pumice	زبد البحر
Zarawand; aristolochia longa, birthwort	زراوند
Ziryab, scorched or intensely roasted.	زرياب
Zunjufr; cinnabar	زنجفر
Sunbul, valeriana celtica; spikenard, or nardin.	سنبل
Sunbadhaj; emery.	سنباذج،
Sandarus; sandarac. sandaraca	سندروس
Shajarat al habb; probably iklil al-malik; mellilotus officinalis; sweet clover.	شجرة الحب
Shahira; vitriol.	شحيرة
Simgh al-butm; gum of pistacia terebinthus L. (Siggel, p. 20), Turpentine Tree.	صمغ البطم
'aqiq; cornelian.	عقيق
'unnab; Zizyphus sativa Gaertn ; Jujube	عناب
'anzarut or anzarut; Astragalus sarcocolla Dymock	عنزروت
'awsaj; lysium shawi.	عوسج

Description	الاسم بالعربية
Ghada or Ghadda, Haloxylon persicum	غضا
Farrash; Ceruse of lead	فراش
Futr al-hayyah; fungus of the snake, poisonous fungus	فطر الحية
Fuwwa, rubia tinctorum L; madder.	فوة
Qiththa' al- himar; ecballium elaterium rich.	قثا الحمار
Qarasiya; prunus cerasia; prunes.	قراسيا
Qulfuniya; colophony. Rosin	قلفونيا
Kafur; cinnamomum camphora nees; camphor	كافور
Kathira, tragacanth; astragalus gummifera lab	كثيرا
Kurrath; allium porrum, leek.	كراث
Kurkum; curcuma longa, turmeric.	كركم
La'iya; euphorbia triaculeata forsk	لاعية
Ma' al-kawari'; or akari'; water of trotters.	ما الاكارع
Mazaryun; daphne mezereum	مازريون
Murrar; centaurea aegyptiaca del.	مرار البقر
Mararat al – Shabbut; gall bladder of shabbut (carp) fish.	مرارة الشبوط
Mardasanj; litharge.	مرداسنج
Marzanjush; origanum majorana L.; Sweet Marjoram	مرزنجوش
Maiwizaj ; delphinium staphisagra; Lice-Bane	ميويزج
Mastaka; pistacia lentiscus; Evergreen pistache ; mastic.	مصطكى
Manthur; cheiranthus cheiri L; Wallflower	منثور
Mumiya'; asphalt	موميا

Description	الاسم بالعربية
Narmahan; soft or wrought iron.	نرماهن
Nil; indigofera tinctoria; true indigo	نيل
Wars; memecylon tinctoria willd; dye plant.	ورس
Yaqut; corundum, ruby	ياقوت

ADDITIONAL BIBLIOGRAPHY

See also the footnotes.

Ibn al-Baytar, *Al-jami' li mufradat a;-adwiya wa al-aghdhiya*, Beirut, 1992, two volumes.

Berthelot, M: *La Chimie Au Moyen Age*. Paris: 1893, vol. I, pp. 336–50.

Al'Biruni,*Kitab al'saydana fi al'tibb,* ed, Abbas Ziryab, Tehran, 1991.

Dozy, *Supplement aux dictionnaires arabes* (Leiden, 1877–1881, 2 vols), reproduced by Librairie du Liban, Beirut; 1968.

Kraus, Paul, *Mukhtarat rsaàil Jabir ibn Hayyan*, Cairo, 1935.

Kraus, Paul. *Jâbir ibn Hayyân: Contributions à l'Histoire des Ideés Scientifiques dans l'Islam* 1: *Le Corpus des Écrits Jâbiriens. Mémoires de l'Institut d'Égypte* 44, 1 (1943). Reproduced by Georg Olms, 1989.

Kraus, op. cit. Vol 2, pp. 78–9.

Needham, Joseph, *Science and Civilization in China*, Vol. 5, Chemistry and Chemical Technology, Part 4, CUP, 1980, pp. 451–2.

Newman, W.R. *The Summa Perfectionis of Pseudo-Geber*, Brill, 1991, pp. 57–60.

Ruska, J.: Chinesisch-arabische technische Rezepte aus der Zeit der Karolinger. (1931) *Chemiker Zeitung*, reproduced by Fuat Sezgin in (*Natural Sciences in Islam*. 62), *Chemistry and Aclhemy. Texts and Studies* Vol. VIII. 2002.

Sezgin, Fuat. *Geschichte des arabischen Schrifttums*, Band IV. Leiden: E. J. Brill, 1971.

Siggel, A: *Arabisch-deutsches Wörterbuch der Stoffe aus den drei Naturreichen* (1950), Reproduced by Fuat Sezgin Sezgin in (*Natural Sciences in Islam*. 63), *Chemistry and Alchemy. Texts and Studies* Vol. IX. 2002.

6 An Eighth-Century Arabic Book of Recipes on the Colouring of Glass, the Manufacturing of Pearls and Other Industrial Products: *Kitāb Al-Durra Al-Maknūna* (The Book of the Hidden Pearl) of Jābir ibn Hayyān (c. 721– c. 815)

Jābir ibn Hayyān wrote in the 8th century a unique treatise of technical recipes dealing with the manufacture of coloured glass, making lustre-painted glass (stained glass), colouring gemstones, purifying of pearls and making artificial ones and other useful objects.[1]

This chapter is composed of two parts. Part 1 discusses briefly Islamic glass industry during Jābir's time and the origin of lustre (stained) glass. It reviews the colouring of glass in Arabic literature and in pre-Islamic times and in Latin early books of recipes. This is followed by a description of the manuscript of *K. al-durra* and how it relates to the present knowledge about Islamic lustre (stained) glass. This part ends with a note on *lāzaward* as cobalt blue in the colouring of glass. In Part 2, we give selected recipes from *Kitāb al-durra al-maknūna.*

PART 1 ISLAMIC GLASS INDUSTRY AT THE TIME OF JĀBIR

When Jābir was writing his treatise on the colouring of glass in the 8th century, there were in Iraq, Syria, Egypt and Iran thriving glass industries. Glass originated in this area since ancient times but it flourished and great innovations were introduced after the advent of Islam. Some glass industries were established during the Islamic period such as those of Raqqa, Basra, Kūfa, Baghdād, Sāmarra and Fustāt.

Our knowledge about Islamic glass is based partially on Arabic literature; but we are indebted to the archaeological excavations that were undertaken at several sites like al-Raqqa, Qasr al- Hayr al-Sharqī, Sāmarra, Fustāt, Nisapūr, Palestine, several other locations in the Near East, Europe and in the Far East.[2] Furthermore, world museums hold great treasures of

1. See Chapter 1 for a biography of Jabir.
2. Carboni, Stefano, Archaeological Excavations of Islamic Glass, in *Glass of the Sultans*, Stefano Carboni and David Whitehouse, Yale University Press, 2001, pp. 14–24. More recent

Islamic glass and they contributed considerably to our knowledge through the special exhibits that are organised from time to time and the published catalogues that include valuable studies by glass specialists.[3]

Glass-making was a mass production industry and large glass factories were discovered by recent excavations in Syria and Palestine, in Iraq, Iran and Egypt.[4]

We are not discussing in this chapter the production of ordinary glass and shall limit ourselves to the production of coloured and lustre painted (stained) glass that are the main themes in *Kitāb al-durra*. However, we may mention in passing that at the time of Jabir and later, clear glass of great purity was produced according to al-Biruni,[5] who always quotes Arab poets in illustrating his statements.[6]

Origin of Lustre Painted or Stained Glass

Lustre-painting, which is characteristic of Islamic glass and pottery, is a metallic sheen applied on the surfaces of glass or pottery objects. Its origin has been the subject of discussion amongst historians, the suggested centres being, Syria, Iraq, Egypt or Iran.

According to the latest reported archaeological finds, the earliest existing examples of lustre glass were of Syrian origin during the Umayyad period.(660–750).[7] Numerous Umayyad glass lustre fragments have been found at Qasr al-Hayr al-Sharqi[8] that was built in (728–9) by the Umayyad Caliph Hisham ibn Abd al-Malik, who ruled between 723 and 742. In

excavations in Qasr al-Hayr al-Sharqi in Syria. were conducted by a team led by D. Genequand as indicated below.

3. A recent example is the exhibit that was arranged in 2001 by the Metropolitan Museum of Art of New York, the Corning Museum of Glass and the Benaki Museum, Athens. *Glass of the Sultans* is a catalogue of that exhibition.
4. Some of these excavations were reported by Carboni in *Glass of the Sultans*, op. cit. Also Sarah Jennings, reported in *Glass News* (of the Association for the History of Glass,AHG), Number 1, June 2003, her discovery of amazing large tank furnaces from Tyre, Lebanon, thought to date from the 10th–12th centuries. Vast quantities of glass were melted from raw materials in furnaces of capacities of up to 37 tonnes.
5. Al-Biruni, *Kitab al- Jamahir*, pp. 222–3.
6. Al-Buhturi (820–897), the celebrated Arab poet, said describing a glass containing wine: 'Its colour hides the glass as if it is standing in it without a container.'
يخفي الزجاجة لونها فكأنها في الكأس قائمة بغير إناء
7. Ashmolian, Abbasid Ceramics, Revolution or Evolution? The Development of a True Islamic Style in Ceramics. A Web-Based Teaching Course on Islamic Ceramics.
8. Genequand, D., with contribution by M. O'Hea, 'Qasr al-Hayr al-Sharqi: une ville neuve des débuts de l'Islam dans la steppe syrienne', *Archéologie Suisse,* 29.2006.3: 22–9.

addition, the glass found at the ancient site of Pella[9] in Jordan included Umayyad lustre-painted and gilded fragments.[10]

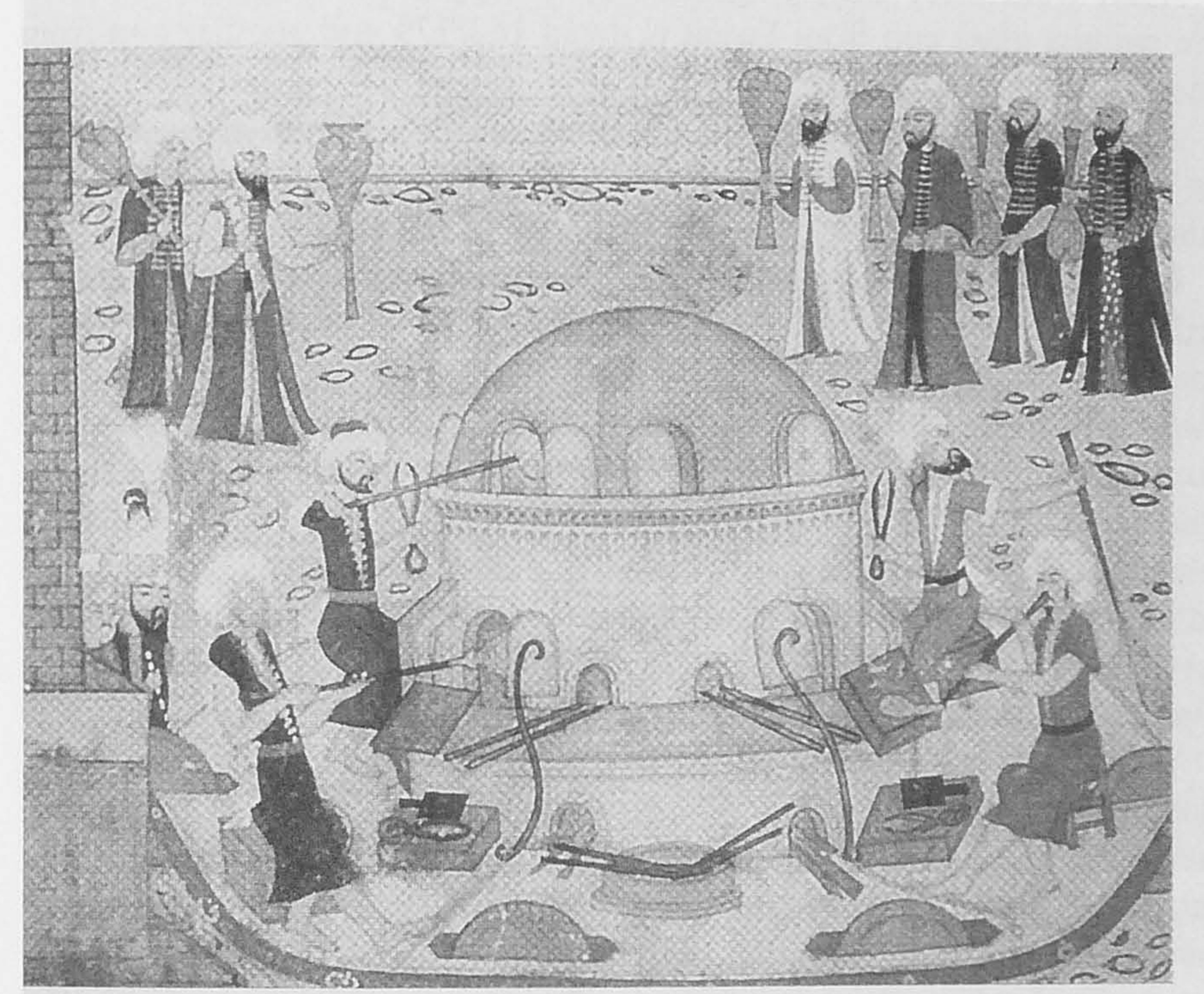


Figure 6.1 Glass furnace in working order from *Mourad III surnamesi, 1582.*

Since luster glass was used in Qasr al-Hayr al-Sharqi, it is reasonable to assume that the technique of lustre painting was developed in Syria at an earlier date in the same century or even before. This assumption seems reasonable because Jabir, who was writing in the second half of that century, gave a large number of recipes for this art, some of which may have been formulated by him and some may have been compiled from previous

9. Pella is set in a fold of the hills that rise from the Jordan Valley 78 km north of Amman, It is known in Arabic as *Tabaqat Fahl*; and is one of the most ancient sites in Jordan and a favourite of archaeologists being exceptionally rich in antiquities. After the 7th century Arab conquest, Pella continued as an Umayyad city for just over 100 years, and some superb pottery remains have been found here. But like so many places in Jordan, the city was destroyed by the terrible earthquake of AD 747. The site continued to be occupied during the Abbasid and Mamluk periods, but it was now a much smaller and more rural community.
10. Margaret O'Hea: 'Umayyad to Fatimid Glass: find at Pella', *Historians of Islamic Art Newsletter* ; Volume XIII, Spring 2003.

practice. The accumulation of such a large number of mature recipes requires several decades of industrial experience.

Apart from these early fragments of Umayyad lustre glass, an extant lustre painted glass cup from Fustat is dated 163/779 and another cup from Damascus is dated 170/786.[11]

After the rise of the Abbasid Caliphate in 750, Syrian glass-workers may have been encouraged to migrate to Iraq[12] and lustre glass was produced in Basra, Kufa and Samarra in the 8th and 9th centuries.

In 1942 Ettinghausen published information about two glass lustre sherds, one from the Princeton Art Museum and the other from the Islamic Museum in Cairo, the latter of which was inscribed with the *nisba* (family name) 'al-Basri'.[13] He argued that this inscription was likely to refer to the maker, and he dated the sherds to the 9th century. A third glass lustre sherd, in the Freer Gallery, is reported to have come from Basra. This clearly implies that there was a glass lustre manufacturing industry at Basra, which is also known from the historical sources. According to Ya'qubi, Basran glassworkers were among the artisans brought to work on Samarra by the Caliph al-Mu'tasim (833–842).

We do not have until now lustre glass objects or sherds from Kufa, although there are the remains of lustre pottery. It is assumed by several writers that lustre glass is the origin of lustre pottery;[14] and that the first painters of lustre pottery inherited some of their techniques from glassworkers, and may actually have been glass-painters as well.[15] This seems natural, since the manufacture of pottery and glass uses similar materials, and the two industries have been usually established at the same sites. In addition, we can assume that since lustre pottery was produced in Kufa, then lustre glass should have been produced there as well. Jabir, who mentions the glass of al-Kufa in *Kitab al-*.durra, confirms this.

Lustre glass was also produced in Samarra. There are existing lustre glass objects from Samarra in world museums.[16] The windows on the inside of the magnificent private houses of Samarra were filled with many-coloured

11. Scanlon, George T. and Ralph Pinder-Wilson, *Fustat Glass of the Early Islamic Period*, London, 2001, p. 210.
12. Ashmolean; Abbasid Ceramics, op. cit.
13. Ettinghausen, Richard, 'An Early Islamic Glass-Making Center', *Record of the Museum of Historic Art*, Princeton University, Vol. 1, No. 2 (Autumn, 1942), pp. 4–7.
14. Caiger-Smith, Alan, *Lustre Pottery*, New Amsterdam, ,p. 10.
15. Craiger –Smith, op. cit., p. 17.
16. *Glass of the Sultans*, op. cit., pp. 201, 215.

glass disks of 8–19 inches in diameter, or with smaller pieces of stained glass set in a framework of stucco.[17]

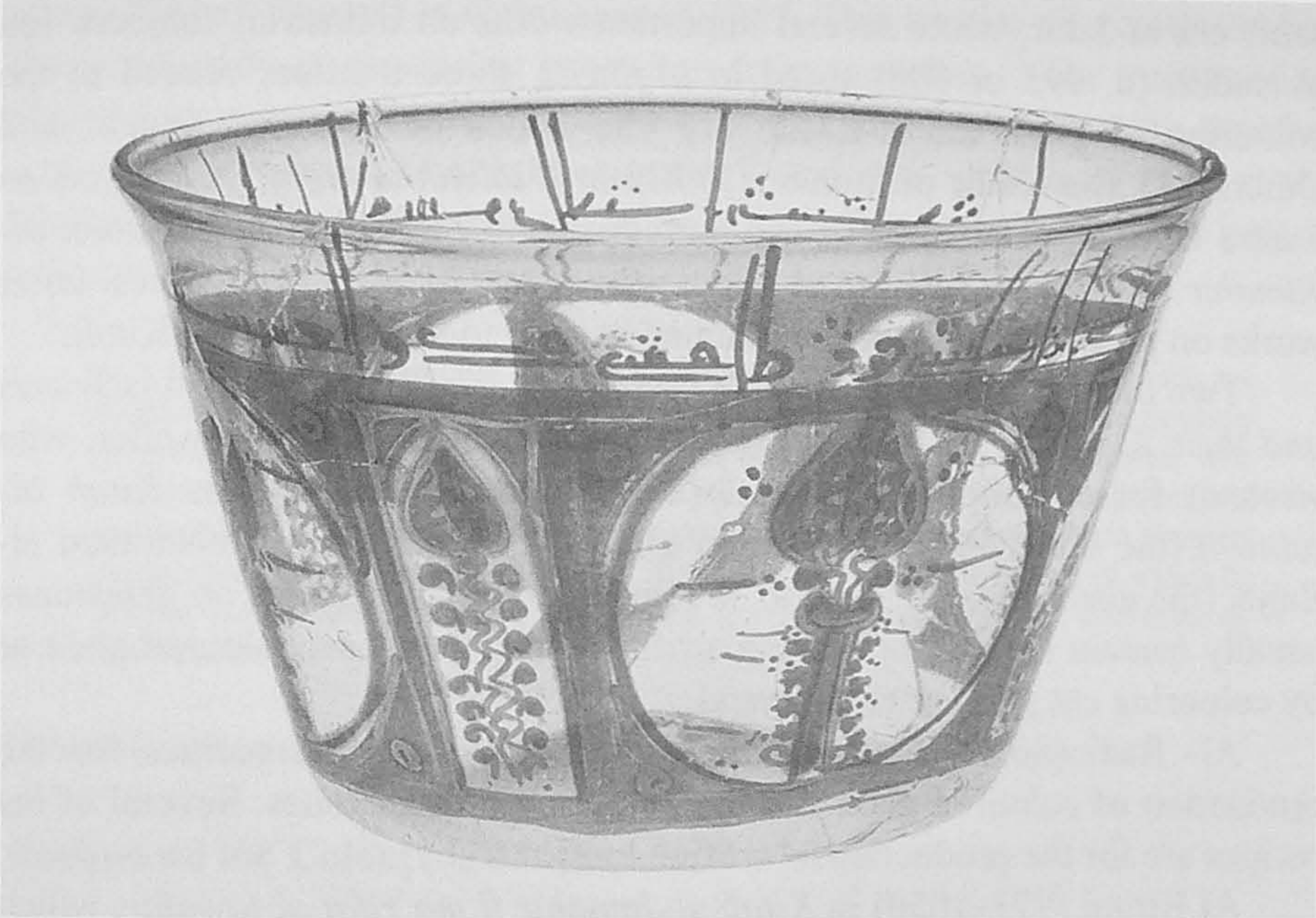


Figure 6.2 Bluish colourless glass, late 10th to early 11th century with yellow and brown copper and silver lustre painting.

The Colouring of Glass in Arabic Literature

Arabic literature on the colouring of glass is not yet investigated. Therefore, our review here is an introductory one and is not exhaustive. We shall limit ourselves to the end of the thirteenth century, which is the same period in which the major Latin books of recipes had appeared.

We know at least two existing works for Jabir in which there are recipes on the colouring of glass. One is *Kitab al-durra al-maknuna* and the second is *Kitab al-khawass al-kabir*.[18] Al-Biruni mentions a third book for Jabir called *Kitab al-nukhab* in which there are recipes for producing gemstones from cast coloured glass.[19] A careful search in Jabir's works may reveal

17. Diamond, M.S., Samarra the Ephemeral, *The Metropolitan Museum of Art Bulletin*, Vol. 23, No. 3. (Mar, 1928), pp. 85–90.
18. Jabir ibn Hayyan, *Kitab al-khawass al-kabir*. See bibliography. See Chapter 5 on this subject.
19. Al-Biruni, *Kitab al-Jamahir*, p. 227.

some more recipes. However, the present known works, especially *Kitab al-durra*, are without equal.

Al-Kindi (801–873), the great Arab philosopher, who lived about the same era as Jabir, wrote several important works on industrial subjects. Ibn al-Nadim (d. 995 or 998) listed in *al-fihrist,* three treatises related to the colouring of glass for al-Kindi: (1) The Kinds of Precious Jewels, and Others; (2) The Kinds of Stones; (3) *Risala fi talwih al-zujaj* (A Treatise on Lustre Glass).[20] These works did not survive but al-Biruni in his book *al-Jamahir* refers quite often to al-Kindi who is one of his main sources. Later works on precious stones also continued to refer to the works of al-Kindi.[21]

Two other works on glass were listed in *al-fihrist*, one of them is *Jewels and their Kinds* by Muhammad ibn Shadhan al-Jawhari, 'the Jeweller, who wrote it for al-Caliph al-Mu'tadid (857–902), and the other is *Kitab al-talawih* (the book on lustre 'stained glass'), by Yahya ibn Muhammad al-Zajjaj (the glass-maker).[22] It is to be remembered that treatises on gemstones usually contain recipes for making artificial ones from cast coloured glass or by colouring cut glass or rock crystal.

Al- Razi (865–925) in *Kitab al-asrar* gives several recipes for the production of coloured glass and the colouring of gemstones. Several of his recipes are for the production of artificial *yaqut* (ruby).[23]

Al Biruni (973–1050) in *Kitab al-Jamahir fi ma'rifat al-jawahir*, which deals with precious stones and metals, devoted one chapter to glass, one to *mina* (enamel), and one to a manufactured precious stone called *adhrak*.[24] This same adrak is described in both *Kitab al-durra* and *Kitab al-khawass* of Jabir.

The Karshuni manuscript (written in Arabic with Syriac script), was compiled between the 9th and 11th centuries according to Berthelot and Duval.[25] It contains several recipes for producing coloured glass and description of glass furnaces.[26]

20. *Al-Fihrist,* English translation, vol. 2, p. 625. Arabic edition, Cairo, p. 378.
21. Such as Ibn al-Akfani (d.1248) in his book *Kitab nukhab al-dhakha'ir fi ahwal al jawahir*, ed. Rev. Anstas Mari al-Kirmilli al-Baghdadi, Cairo, 1939.
22. *Al-Fihrist*, English translation, vol. 2, p. 743. Arabic edition, Cairo, p. 455.
23. Al- Razi, *Kitab al-asrar*, Arabic edition, edited by Taghi Danechpajouh, Tehran, 1964, pp. 95–9. 102–3, 105–6, 114.
24. Al-Biruni, *K. al-Jamahir*, pp. 227–8.
25. Berthelot, M. and R. Duval, *La Chimie au Moyen Age*, vol. 2, Paris, 1893. . The Karshuni MS was published in Syriac script, with a translation into French by Duval. The Karshuni Arabic text was converted into Arabic script in Aleppo by the Rev. Father Barsum on the request of the author of the present volume. The Arabic text in Arabic script is still in MS form.
26. Karshuni MS, Berthelot and Duval, op. cit., pp. 194–7.

In the 13th century, we have two treatises having recipes on coloured glass. One is for al-Tifashi and the other is for al-Marrakishi. Al-Tifashi (1184–1253) wrote *Kitab azhar al-afkar fi jawahir al-ahjar* (Best Thoughts on the Best of Stones) in Cairo around 1243. This treatise on gemstones has one recipe only on producing gemstones from cast glass.[27] The treatise of al-Marrakishi was not known until now. It was discovered recently together with *Kitab al-durra* in one manuscript,[28] and was written in 1252 at the Nizamiyya School in Baghdad. The opening statement of the treatise runs as follows:

> Al- Marrakishi, Muhammad ibn Maymun ibn 'Umran al-Himyari, says: These are chapters (*abwab*) about the casting of *billawr* (crystal), glass and *fayruzaj* (turquoise) based on the know-how of brother Hibat Allah ibn Shirwan who communicated them to me in his own words; and afterwards we got together and applied them in practice and the results came as he had explained. These chapters explain also the causes of this art and its truth, its fires and structures of which he did not keep a secret and did not conceal any thing; so understand this from al-Marrakishi.

In addition to this statement, the MS has some chapters on pearls.

Recipes on the Colouring of Glass before Islam

The earliest recipes for glass were from Mesopotamia and go back to the 17th century BCE. They were found at Tall 'Umar on the Tigris, and were translated into English. They show a well-established tradition in glass making. The recipes give compositions of glazes.[29]

More elaborate recipes for coloured glass, are given in the Assyrian Cuneiform Tablets from Nineveh from the Library of Assurbanipal (668–626 BCE). These tablets were translated into English[30] and German. Despite the difficulty and the uncertainty in translating the texts of the tablets, it is believed that glass of various colours was produced and the recipes included metallic oxides among other ingredients.

The tradition of making coloured glass in Mesopotamia, Syria, Egypt and the Near East as a whole continued throughout the later centuries and

27. Al- Tifashi's book on gemstones was translated into English by Samar Najm Abul Huda, *Arab Roots of Gemotology*, London, 1998. The translation has many inaccuracies. The recipe on an artificial gemstone is on pp. 150 and 231.
28. B.N. MS Arabe 6915, folios 24b–33a.
29. Forbes, R.J. *Studies in Ancient Technology*, Brill, vol. v, 1966, pp. 133–4.
30. Thompson, R. Campbell, *On the Chemistry of the Ancient Assyrians*, London, 1925. A more recent translation is given by A. Leo Oppenheim, Robert H. Brill, Dan Barag and Axel Von Saldern, *Glass and Glass Making in Ancient Mesopotamia: An Edition of the Cuneiform Texts Which Contain Instructions for Glassmakers*, The Corning Museum of Glass, 1970.

there are obviously similarities between the inherited recipes. Jabir as a chemist gave advanced and clear quantitative recipes. He had utilised the practical inherited knowledge, but he was evidently not acquainted with any recipes from the buried Assyrian cuneiform tablets that preceded him by about fourteen centuries.

The other important pre-Islamic recipes, beside the Assyrian tablets, were those of the Egyptian papyri of the 4th century CE. However, the papyri of both Leyden and Stockholm are devoid of any recipes for the production of coloured glass.[31]

The Stockholm papyrus contains recipes that deal with the imitating of gemstones. The first step in the manufacture of imitation was to treat the stone in such a way as to roughen it and to make its surface porous. Caley who translated the papyrus says:

> After corroding the stone, some kind of a dyeing material was then applied. Vegetable dyes and mineral substances were employed in dyeing. These latter fall into two classes, the inorganic and the organic substances. Copper salts, for example, were usually applied to form imitation emeralds from the base, while alkanet was used for red stones.[32]

On this basis Caley assumed that: 'the manufacture of coloured glass was not a developed art at the time of this collection'.[33]

One part of *Kitab al-durra* is devoted to the colouring of gemstones. Jabir gives much more advanced recipes in which colouring by diffusion is employed, He provides details of this technique and describes the ovens that are used for this purpose.

As in the case of the cuneiform tablets, these papyri recipes were buried in a tomb in Thebes of Upper Egypt and they could not have been possibly a literary source for Jabir who relied of course on the inherited skills of the area where he lived.

The Colouring of Glass in the Latin Books of Recipes

There appeared in the West before the introduction of Arabic alchemy in the 12th century four books of practical recipes related to industrial chemistry.[34]

31. Caley, E.R. 'The Stockholm Papyrus: An English Translation with Brief Notes', *Journal of Chemical Education* IV:8 : (1926), 979–1002.
32. Caley, op. cit., p. 1000.
33. Caley, op. cit., p. 1001.
34. Sherwood Taylor in his article on 'Pre-Scientific Industrial Chemistry', in *A History of Technology*, vol. 2, edited by Charles Singer *et al*., Oxford, 1956, p. 351, listed a fifth MS to which he referred to it as 'craftsman's manuscript written in Catalonia about 1130'. This MS has been edited by M. Burnham. 'Recipes from Codes Matritensis A. 16.' Palaeographic

These were acclaimed by some Western historians of chemistry and technology as 'sources of information on the chemical technology of medieval Europe which are without parallel in Byzantium or Islam'.[35] The earliest is the text known as *Compositiones ad tingenda* (Recipes for Colouring), the manuscript of which goes back to the end of the eighth or the beginning of the 9th century.

The *Compositiones* has in it eight recipes for the manufacture of coloured glass. These are very concise and rudimentary. For blood red, it says: 'Put 3 oz. of cinnabar to a pound of glass and cook it for 2 days.' For the milky colour it says: 'Put 3 oz. of tin to a pound of glass and cook it for 2 days.' For a red colour it says: 'To a pound of glass, 2 oz. of copper calcine.'[36] R.P. Johnson discusses the sources of the *Compositiones* in a monograph.[37] He has shown that there is an Arabic influence in the book. Certain of its terms for dyestuffs are Arabic or Persian, such as *luza* which is the Arabic for almond, lulax from lilac, and lazure from *lazaward*, whence comes the word 'azure'. There is also the word siricum (a kind of minium) which most probably came from the Arabic *sariqun*.[38] Overall, these recipes are collected from various sources originating in Syria, Mesopotamia, Egypt and Byzantium.

Another book of recipes is the *Mappae clavicula*, 'Key to painting',[39] which was first compiled in about the 9th century. It contains most of the recipes of the *Compositiones* including the eight recipes for coloured glass. Three more concise recipes for coloured glass were added. Adelard of Bath (*c*. 1080–*c*. 1152) had edited the 12th-century version of the Mappae and he introduced into it several Arabic recipes.[40]

edition. University of Cincinnati Studies, second series, Vol. 8. University Press, Cincinnati. 1912.
35. Multhauf, Robert, *The Origins of Chemistry*, London, 1966, p. 154.
36. Burnham, John M., *A Classical Technology*, Edited, from Codex Lucensis, 490, Boston, 1920, pp. 82–3. Also Hjalmar Hedfords, *Compositiones Ad Tingenda Musiva*, edited and translated into German, Uppsala, 1932, pp. 82–5.
37. Johnson, Rozelle Parker, *Compositiones Variae from Codex 490, Bibliotheca Capitolare, Lucca*, The University of Illinois Press, 1939, pp. 82–4.
38. See Part 2 of this chapter.
39. Smith, Cyril Stanley, and John Hawthorne, '*Mappae Clavicula*, A little key to the world of medieval techniques,' *The American Philosophical Society*, New Series – volume 64, part 4, 1974, Philadelphia.
40. Berthelot, M., *La Chemie au Moyen Age*, vol. 1, Paris, 1893, p. 60. The Arabic influence was noted by Phillipps. Cyril Stanley Smith and Hawthorne, op. cit., remark on p. 6 of their edition of the M.C. that 'Phillipps could equally well have argued that the author was from the Middle East, for many Arabic terms appear in chapters 195 to 201'. See also Charles Burnett and Louise Cochrane, 'Adelard and the Mappae clavicula' in Charles Burnett, ed., *Adelard of Bath: An English Scientist and Arabist of the Early Twelfth Century*, Warburg Institute Surveys and Texts, 14., London: Warburg Institute, 1987, pp. 29–32;

A third book of recipes is The *Schedula diversarum artium*, 'Notes on Various Arts', of Theophilus that was put together in Germany between 1110 and 1140. This book is considered the most advanced among the Latin books of recipes. Part 2 of this treatise deals with glass. However, the recipes for coloured glass do not have added metallic oxides. Hawthorne and Stanley Smith who edited and translated the book into English say:

> Theophilus describes a relatively large plant for making glass in the form of windows, vessels, mosaic tesserae, and glazes. The chemistry of the process is again rather lightly treated. To obtain glass of different color for windows, he evidently depended on the incidental presence of manganese in the beech wood ashes and iron in the sand and refractories that were used, for there is no suggestion of any added metallic oxides or other coloring matter, except in compounding the pigment to be applied superficially on painted windows.[41]

The *De coloribus et artibus Romanorum* of Eeraclius is a craftsman's handbook of about the same date as Theophilus, or a little later where there are few concise recipes for making red, green, yellow and purple glass. Copper or brass filings are used.

Stained glass is the popular general name applied in Europe for the glass used in the making of coloured church windows.[42] The Corning Museum of Glass defines stained glass as:

> the generic name for decorative windows made of pieces of coloured glass fitted into cames and set in iron frames. Strictly speaking, the term is inaccurate because, in addition to glass coloured by staining,[43] glaziers used, and continue to use, glass coloured throughout by metallic oxide, glass coloured by flashing, and glass decorated with enamel.[44]

In the four Latin manuscripts discussed above, lustre-painted glass was not described. Theophilus and Eraclius described a vitrified or an enamel painting that is quite different from lustre.[45] The one prescription given by Theophilus for a vitrified paint does not contain lead oxide that is needed as a flux for the enamel. It consists of burnt copper, green glass and blue glass only.[46] The enamel had to be melted onto the glass body so that it would soften at a temperature lower than that required to soften the body of the

41. Hawthorne, John G. and Cyril Stanley Smith, *Theophilus on Divers Arts*, Dover, 1979, pp. xxxi–xxxii.
42. Merriam-Webster's Dictionary.
43. i.e. lustre-painting.
44. Corning Museum of Glass: *A Pocket Dictionary of Terms Commonly Used to Describe Glass and Glassmaking*, Revised Edition. Online.
45. Merrifield, Mary P., *Original Treatises on the Arts of Painting*, 2 volumes, Dover, 1967, vol 1, p. lxxxiii.
46. Hawthorne and Cyril Smith, *Theophilus*, op. cit., Book II, Chapter 19, p. 63.

object and a lead compound is necessary. The Islamic prescriptions for enamels given by Jabir in *Kitab al-durra*, and by al-Biruni in *Kitab al-jamahir* have lead oxide fluxes added to the colorants. One enamel prescription from Jabir is given in Part 2 of this chapter.

Proper stained glass, which is lustre painted, first appeared in Europe in about the 11th century. It was applied on flat glass for church windows. It is likely that Venetian immigrant glass workers, who settled in Limoges in France, introduced the art of staining (or lustre). This was a great development. The new radical process consisted in painting with metallic pigments that were fused into the glass, the painting being thus made as durable as the glass itself. One of the first churches to use the new method was the Church of St Denis at Paris in the 12th century. Its picture windows were so successful that stained glass thereafter became an essential constituent of every religious building.[47]

Silver was first employed in staining church glass windows more than five centuries after this technique was applied in Syria and Egypt. The earliest known example is in the Norman church of Le Mesnil Villeman (a village in the Manche, north of France) and is dated 1313. By the 1320s silver stain was widely used, and the technique has been continuously employed since then. It survives today in modern stained-glass windows and art glass, in which yellow stains are still based on colloidal silver, sometimes accompanied by copper.[48]

When we come to the end of the twelfth or beginning of the 13th century, we enter the period of translations of Arabic alchemical and technological works. These translations continued to appear until the time of printing in the 15th century, and beyond. The *liber sacerdotum* is a typical product of the translation movement from Arabic. It contains over 200 technical recipes. These were collected by an Arabic compiler, and the collection was translated into Latin in the first part of the 13th century. The text is full of transliterated Arabic words, such as *kibrit asphar* for yellow sulphur, with some corrupt transliterations. It contains a little dictionary of Arabic-Latin chemical terms. Berthelot found that there are similarities in some of its recipes with those of the *Book of Seventy* of Jabir. The treatise contains recipes that deal with similar topics as the *Mappae Clavicula* and the other Latin treatises on recipes but the details are different and there is no correspondence between this treatise and the above four treatises.[49] The *liber sacerdotum* contains several recipes for colouring and painting on glass.[50]

47. *Catholic Encyclopedia* (1913), Stained Glass, by several editors, online.
48. Brill, in *Glass of the Sultans*, op. cit., p. 35.
49. Berthelot, *La Chemie*, vol : 1; op. cit., pp. 180–2.
50. Berthelot, op. cit.

This important Latin treatise of Arabic chemistry has not been translated from Latin and its recipes on the colouring of glass deserve a special attention.

From this survey, it is evident that the recipes for producing coloured glass in the four early Latin recipe treatises are extremely concise and very few, and the art of lustre-painted (stained) glass was not mentioned in any of them. The colouring of gemstones by diffusion was also not mentioned. Neri's book of 1662 discussed in detail the production of coloured glass and enamels but it did not consider lustre-painted glass nor colouring of stones by diffusion.[51] It is reported, that copper and silver lustre technique occurs in a 15th-century manuscript of recipes, now at Munich, but no details are known about it [52]

The Manuscript of *Kitab al-Durra al-Maknuna*

This is a unique treatise. It is number 36 in the *Fihrist*[53] of Ibn al-Nadim, number 45 in Kraus's catalogue, and number 39 among the *One Hundred and Twelve Books* of Jabir.

In *maqala* (article) 2 8 of *Kitab al-khawass al-kabir* Jabir gives recipes of technical chemistry. In describing in detail a gemstone called *adrak* that rivals corundum in its hardness, he concludes this recipe by saying:

'and pour it in it, as we have mentioned in *Kitab al-durra al-maknuna*, and you will get what you like if God wills'.[54]

وافرغه فيه كما ذكرنا في كتاب الدرة المكنونة يجيك ما تحب ان شاء الله

In *maqala* 29 which deals also with technical chemistry Jabir says:

> And we have mentioned something similar in our discussion of glass and its working, and Chinese ceramics in *Kitab al-durra al-maknuna*, so work according to it because it is one of the miracles in practical industries.[55]

وقد ذكرنا مثل ذلك في الزجاج واعماله والغضار الصيني في كتاب الدرة المكنونة فاعمل به فانه من العجائب في الاعمال.

51. Neri, Antonio, *The Art of Glass,* translated by Christpher Merrett, ed. Michael Cable, Sheffield, 2004.
52. Pope, E.M. in *A History of Technology*, op. cit., p. 304.
53. This is according to the Cairo edition, and it is number 35 in the edition of Gustav Flügel. Leipzig, 1871–2.
54. See Chapter 5.
55. Alexandria Library, MS Alexandria Municipality 5204, fo. 93b; Br. Museum, MS OR 4041, fo. 55b.

In *maqala* 68 Jabir also says:

> If the waters were sharp, then use pharaonic glass the manufacturing of which was discussed in our book *al-durra al-maknuna* which is among the *One Hundred and Twelve Books*. Know this since it has no allegories and no superfluities.[56]

فان كانت المياه حادة فمن الزجاج الفرعوني الذي ذكرنا عمله في كتابنا المسمى بالدرة المكنونة من جملة الكتب المائة والاثنى عشر فاعلم ذلك فانه لا رمز فيه ولا زيادة والسلام.

Apart from these references, no complete manuscript of this treatise was known to exist when Kraus compiled his catalogue in the forties of the last century.[57] Nevertheless, while we were searching for Jabir's manuscripts in the Bibliotheque Nationale of France, this treatise was unexpectedly found in BN MS Arabe 6915 which was acquired by BN at a relatively recent date, having been listed only in 1987.[58]

This collection (*majmu'a*) includes several valuable treatises that were copied and edited by Muhammad ibn Maymun ibn 'Umran al-Marrakishi when he was residing at al-Madrasa al-Nizamiyyah in Baghdad in 650/1252. The treatises in this collection are: *K. al-durra al-maknuna* of Jabir (ff. 1a–24b); a treatise on making coloured glass and gemstones composed by al-Marrakishi as disclosed to him by an artisan experienced in this craft (24b-33a); *K. musahhahat Iflaton* of Jabir which is the major treatise in the collection and occupies about half of the folios (33a–91a); *K. sina'at al-tibb al-nabawi* which is a practical treatise ascribed to Jabir containing alchemical, medical, talismanic and curious recipes (92a–108b). Then after a short recipe ascribed to Jabir for the preparation of salt (108b–109a), there follows *Hirz al-Hakim* the Fatimid Caliph (109a–123b). The collection ends with an alchemical treatise which al-Marrakishi ascribes to his mother (123b–133a).

Contents of *Kitab al-Durra al-Maknuna*

Jabir says at the start of *K. al-durra* that he did not deal with this art (the colouring of glass and related topics) in his other books because he devoted to it this book, which he called *al-durra al-maknuna, which* alone contains this science.

56. Alexandria Library, MS Alexandria Municipality 5204, fo. 151a.
57. The text in Br. Lib. Add 7722, treatise number 11, purported to be part of *K. al-durra al-maknuna*, is on theoretical alchemy and is unrelated to technical chemistry.
58. *Catalogue des Manscrits Arabes*, index no. 6836–7214, compiled by Yvette Sauvan *et al.*

أمّا بعد فانّا لم نذكر في جملة كتبنا هذا الفن لأنا أفردنا له كتابنا هذا وسميناه الدرة المكنونة فجعلنا هذا العلم فيه دون ساير كتبنا.

The treatise can be divided into four main themes. The first is on the manufacture of coloured glass by casting. The second is on lustre painting of glass (stained glass). The third is on the colouring of gemstones by diffusion with descriptions of two ovens for this purpose. The fourth is concerned with the manufacture and treatment of pearls and gives recipes for glues and other materials.

Assessment of *Kitab Al-Durra Al-Maknuna*

Arabic Chemistry and the Colouring of Glass

Some modern scholars supposed that there should have been a relationship between the methods of glass colouring and Arabic chemistry. Some had expressed an interest in knowing whether the chemistry of Jabir ibn Hayyan had any bearing on the development of lustre painting.[59] This interest arose from the fact that lustre glass was being produced at the same time when Jabir was active. He was the chemist of the Caliph Harun al-Rashid who made al-Raqqa his second capital and during whose reign the glass industry was established in that city.

In one of his papers, Henderson suggested that Jabir ibn Hayyan must have exercised some influence on the constituents of glass in al-Raqqa in his capacity as the chemist of the Caliph while he was residing there.[60]

Alan Caiger-Smith wrote a chapter on alchemy in its relationship to lustre-painting. He drew attention to the similarity in materials used by alchemists and lustre-makers.[61]

The relationship between Jabir and industrial practice is clearly indicated by him in *Kitab al-khawass al-kabir* in which Jabir gave a multitude of recipes on industrial chemistry. In several of these recipes, Jabir indicated that he had tried some of the recipes for himself and proved their truth.[62]

59. When the present writer discovered *Kitab al-durra* he was keen to know whether the recipes in this treatise correspond with the current knowledge about colouring glass. He communicated with Prof. Julian Henderson who was also interested in Jabir ibn Hayyan. Henderson sent the author a complete set of published papers about his excavations and findings in Raqqa.
60. Henderson, Julian, 'Radical Changes in Islamic Glass Technology', *Archeometry*, 46, 3 (2004), p. 461.
61. Caiger-Smith, *Lustre Pottery*, op. cit. pp. 186–96.
62. See Chapter 5.

Other Arabic scientists like al-Kindi and al-Biruni were also stressing the importance of checking industrial formulations with the practice of technicians of their times.

Al-Biruni discussed the relationship between the chemist and the artisan in the colouring of glass. After discussing the various colours that arise from metallic oxides, he says:

> They have many methods and disclosures on the composition of basic glass and the quantities of the colouring materials; but none of these can be considered right except by observing the work of the distinguished artisans and by actually getting involved in the work and practicing it by doing experiments on the compositions. Glass, enamel and ceramics are close to each other and they have common techniques in pigments and in the methods of colouring.[63]

We may mention again that al-Marrakishi wrote a treatise on the colouring of glass based on the verbal narration of an artisan and both of them tested the recipes together afterwards.

Islamic Lustre Painted Glass According to Contemporary Scholarship

Chemical analyses of a group of luster-ware glass fragments in the Corning Museum of Glass confirmed that the stained surfaces contained silver and copper.[64] Brill, who conducted the tests, says:

> We now believe, from our analyses, that the indispensable ingredients for staining the glasses were a silver compound, a copper compound, a reducing agent, and a vehicle with a thickening agent.

Brill further states that the paste is painted onto the surface of the object, which was then re-fired at a moderate temperature. During the re-firing, the silver migrates through the surface into the body of the glass. Upon becoming reduced chemically to minute colloidal particles of metallic silver, it imparts a permanent stain just beneath the surface. The colour of the resulting stain depends primarily on the amount of silver present and the extent to which the chemical reduction had proceeded. It could range from a lemon yellow to strong amber. Evidently, the presence of copper shifts the colour further toward the amber shades.[65]

The above results reported by Brill, correspond with the recipes of Jabir in which the most important material in the recipes for painted lustre is copper and its compounds. It occurs in about 90 per cent of the recipes, and

63. Al-Biruni, *al-Jamahir*, op. cit., p. 225.
64. Brill, *Glass of the Sultans*, p. 34.
65. Brill, op. cit.

burnt silver is most prevalent also and it occurs in about 73 per cent of the recipes. This correspondence between the recipes of Jabir and modern analysis is so important that it merits further research.

Colouring of Gemstones by Diffusion

The colouring of artificial stones by diffusion was not mentioned in any medieval work as far as we know. This is rather a modern concept. It is applied currently for the enhancement of the colours of gemstones. The conventional diffusion treatment was based on using rather high temperatures, but recently patents were granted for diffusing colour at lower temperatures. One such patent is US patent number 7033640, 'Method of colouring gemstones', issued in April 2006. In summary, the patent calls for colouring cut gemstones by introducing metals or metal oxides into the surface of the stone by means of heat treatment. During the heat treatment, the gemstones are laid on a solid plate and the metals or metal oxides form a substantial constituent of the plate. The process described by Jabir in Part 2 of this chapter has the main elements outlined in this patent.

Artificial Pearls

Jabir gave a recipe for making artificial pears in *Kitab al-khawass al-kabir*, in addition to the recipes in *Kitab al-durra*. This note is about artificial pearls in *Kitab al-durra* and in non-Arabic literature.

The Stockholm papyrus that goes back to the 4th century CE describes a primitive recipe for making artificial pearl by coating stone grains with a paste aimed at imitating the colour of pearl. However, in Jabir's recipes actual small pearls are dissolved in citron juice and mixed with special ingredients to make a paste. Pearls are formed from this paste by rolling and then drying and polishing.

Several Arab scientists after Jabir discussed pearl. One of the best accounts is given by al-Biruni in *Kitab al-jamahir*, where he gives recipes for making artificial pearls and improving their colour.

In the Latin books of recipes preceding the 15th century we do not find recipes on making artificial pearl. The Bologna MS that was written in the middle of the 15th century gives a recipe similar to Jabir's recipes in which pearl is dissolved in citron juice to make artificial pearl. About the same period, between 1480 and 1488, Leonardo da Vinci gave a recipe similar to those of Jabir in which small pearls are dissolved in citron juice.

This similarity between the recipes of the Bologna MS and the Leonardo da Vinci's recipe on the one hand and the recipes of Jabir on the other hand raises the question on whether the recipes of *Kitab al-durra* and *Kitab al-khawass* found their way to Europe during the Renaissance. George Saliba had discussed this question in detail and he proved that during the Renaissance Arabic manuscripts were studied without the need for them to be translated.[66]

Lazaward (*Lajvard*) and Zaffer

Cobalt oxide was used for blue colour in lustre glass during the Umayyad Caliphate and the early times of the Abbasid Caliphate and the later centuries.[67] The Arabic word *lazaward*, Persian *lajvard* was used to denote this pigment. The word indicates also 'lapis lazuli', which is a stone with one of the longest traditions of being considered a gem. The ultramarine pigment from this rock, cannot be used for glaze or for producing lustre-painted glass because of its lower temperature resistance, therefore the word *lazaward* (Arabic) or *lajvard* (Persian) when used for lustre pigment must mean cobalt ore.[68] At lower temperatures, ultramarine pigment can be used in colouring.

The mines for cobalt ore were on the south of Kashan in Persia. The ore was processed and used in the Islamic Near East and was exported to China and to Europe. Towards the end of the 19th century, it was still processed in the same traditional way. Schindler (the German-born British engineer who had spent nearly thirty years in Persia and was director of mines there), visited the mines in the village Kamsar, 19 miles to the south of Kashan, and he described the mining operation. The earthy cobalt contains about 5 per cent of metal. It is collected and washed with water, and the heavy sediment is made into cakes. The cakes, under the name of lajverd i Kashi, are exported.

The ore is reduced in the following way: ten parts by weight of the earth or ore (in cakes), five of potash, five of borax, are pounded together to a fine powder, and then made into a paste with concentrated grape juice (*shireh*), and formed into small balls or cakes. The balls are then put with pounded quartz into a *sufar* (earthen pot with wide opening) and exposed to heat in a furnace for sixteen hours. The metal gained in this way amounts to about one twentieth of the weight of the cobalt cakes employed. To use the cobalt for colouring pottery it is ground into fine powder with an equal quantity of quartz.[69]

---

66. George Saliba, *Islamic Science and the Making of the European Renaissance*, MIT Press, 2007, Chapter 6, pp. 210–32.
67. Hess, Catherine. 'Brilliant Achievement: The Journey of Islamic Glass and Ceramics to Renaissance Italy', in *the Arts of Fire*, ed. Catherine Hess, J. Paul Getty Museum, Los Angeles, 2004, pp. 1–33.
68. Allan J.W. 'Abu'l-Qasim's Treatise on Ceramics', *Iran* 11 (1973) pp. 111–20.
69. Allan, op. cit.

Although cobalt blue was known in Islam for many centuries, it was not used in Italy until early in the 15th century. It was imported as the impure oxide, zaffre, from Syria through Venice and known as *colore damaschino* (Damascus pigment). Since it was dutiable in many ports, there was considerable smuggling.[70]

During the Yuan Dynasty (1271–1368), and the early period of Ming (1368–1644), the crude cobalt oxide was imported from Persia and was known as hui hui ching or 'Mohammedan Blue' which has always been greatly admired.[71]

Chemists and alchemists did not know the chemical composition of numerous materials before the age of modern chemistry. The word *natrun*, for example, was used to denote either potassium nitrate or sodium carbonate. The same applies to the word *lazaward* or *lajvard*. It could mean either lapis lazuli or crude cobalt oxide. The common quality here is the blue colour only. In Western literature, the word zaffer was used to denote this pigment. The etymology of the word indicates most probably an Arabic origin.[72] This seems probable since this material was imported from Arabic lands.

The real composition of *lazaward* (*lajvard*) or zaffer remained unknown until about 1739 when Georg Brandt of Sweden, who was studying the blue colour of glass, discovered that the colour was due to a new element, cobalt.

In *Kitab al-durra al maknuna*, *lazaward*, indicating cobalt oxide pigment, occurred in more than twenty recipes, mostly for producing lustre glass.

Western literature of technical recipes dealing with paints and the staining of glass did not refer to cobalt blue until after the 15th century. This applies to the *Compositiones Ad Tingenda Musiva*,[73] the *Mappae Clavicula*[74] and the *Schedula diversarum artium* of Theophilus.[75] The word zaffer was used extensively in Neri's *The Art of Glass* in 1612.[76] This is about eight centuries after *Kitab al-durra al-maknuna*.

70. Saliba, George, 'The World of Islam and Renaissance Science and Technology' , in *The Arts of Fire*, ed. Catherine Hess, J. Paul Getty Museum, Los Angeles, 2004, p. 57. Saliba is quoting from Pope, E.M. 'Ceramics, Medieval' in *A History of Technology*, ed. Charles Singer *et al.* Vol. 2, Oxford. 1954–58, pp. 284–310.
71. Article 'Pottery, Ming dynasty (1368–1644)' in *Britannica online*.
72. Webster's Dictionary (1913 Edition).
73. *Compositiones Ad Tingenda Musiva*, op. cit.
74. *Mappae Clavicula,* op. cit.
75. *Schedula diversarum artium* of Theophilus, op. cit.
76. *The Art of Glass*, op. cit.

Conclusion

It seems that *Kitab al-durra al-maknuna* of Jabir ibn Hayyan is the only treatise of its kind that discusses extensively lustre-painted or stained glass.[77] It is also the only treatise that deals with cast coloured glass in a detailed manner until the 17th century. It also describes a method of colouring gemstones that is the forerunner of the modern colouring by surface diffusion. The known Latin books of recipes do not discuss lustre painted (stained) glass or pottery. Such lustre wares began to be produced in north Italy about 1300. Similarly, the recipes for cast coloured glass in Latin literature until the 17th century are very few and concise. Colouring of gemstones by surface diffusion was not yet known.

Recent analysis of Islamic lustre painted (stained) glass and pottery had proved that the main ingredients for staining were silver and copper. This analysis corresponds with the recipes of Jabir ibn Hayyan in *Kitab al-durra al-maknuna*.

The discovery of this book of industrial chemical recipes dissipates the wrong notion of some historians that Jabir was only an alchemist whose writings were vague and allegoric. It also disproves the prevailing assumption of some historians of science that the Latin books of technical recipes that appeared in the West before the 12th century had no parallels in Arabic literature.[78] In fact, there is no parallel to *Kitab al-durra* in practical chemical recipes in any language.

PART 2 SELECTED RECIPES FROM *KITAB AL- DURRA AL-MAKNUNA*

1 The Manufacture of Cast Coloured Glass

There are about 51 original recipes for producing coloured glass in addition to about 12 recipes inserted by al-Marrakishi. The typical procedure is to prepare a batch composed of clear or pharaonic glass [79] and the colouring

77. We know nothing about the Munich MS of the 15th century that is reported to contain recipes on lustre-painted glass using copper and silver.
78. Multhauf, Robert, op. cit.
79. Pharaonic glass is a very high quality lead glass. The name 'pharaonic' does not mean that this glass is ancient Egyptian. It indicates the quality only. The high quality of this glass is apparent from literary sources. In describing the luxury of a Baramki wazir, al-Asma'i says, when he visited his palace, that he saw a tray on top of which was a jug of pharaonic glass. The Caliph al-Ma'mun presented to the Ka'ba in Mecca a becher (*jam*) of pharaonic glass with an opening of one *shibr* (span) and on the middle of its side is the image of a lion in front of which is a man kneeling on his knees holding a bow and arrow and pointing the arrow

materials. The ingredients are ground finely and put in a luted pot which is placed inside a glass furnace until the contents are melted.

Materials Used

The following materials are arranged according to their descending frequency in the 51 recipes:

- Glass, and the like, 49 (*billaur* 'rock crystal', 1; glass, 31; glass, pharaoanic, 5; pebbles '*hasa*', 8; rock crystal '*maha*', 2; sand, Egyptian for glass, 1; cornelian stone '*aqiq*', 1)
- Copper compounds, 35 (dross of brass '*barani*',[80] 4; copper filings,1; copper, burnt, 5; calcified copper (*halqus*), 3; copper scales '*rusakhtaj*', 11; verdigris '*zinjar*', 7; malachite '*dahnaj*', 4)
- Lead compounds, 26 (red lead '*isrinj*', 16; litharge '*martak*', 6; lead '*usrub*', 1; lead '*usrub*' filings, 1; lead 'usrub', burnt, 2)
- Iron compounds, 20 (steel, scales, 2; iron, saffron, 4; iron, filings, 3; hematite '*sadhanj*', 7; marcasite, 3; green copperas 'qalqant' , 1)
- Magnesia,[81] 18
- Alkali, 9 (alkali, 7; alkali, salt, 2)
- Natrun, 8
- Tin compounds, 6 (tin '*anuk*' foil, 1; tin filings, 2; tin, burnt, 1; tin, ceruse '*isfidhaj*', 1; tin, killed, 1)
- Dragon's blood,[82] 4
- Orpiment (*zarnikh asfar*), 4

towards the lion. Al-Biruni in *al-jamahir*, p. 93, says that al-Kindi described diamond as to be similar to Pharaonic glass. Dawud al-Antaki in *al-tadhkira*, op. cit., p. 161 gave a recipe for making pharaonic glass that includes burnt silver. We may speculate and compare pharaonic glass to the modern best quality lead glass like crystal.

80. *Barani* according to al-Marrakishi is the dross of brass when it is melted.

81. Magnesia here is the mineral of manganese oxide. It is not the present-day magnesia (Siggel). Ibn al-Baytar, *al- Jami' li mufradat al-adwiya wa al-aghdhiya*, vol 3. Beirut, 1992, p. 452; al-Dimashqi, *Kitab nukhbat al dahr*, ed. Mehren, Leibzig, 1923, pp. 80–1; and Dawud al Antaki, *al-Tadhkira*, Cairo, 1359 H, p. 296; all these described magnesia as the material used to help in melting sand and in purifying glass. In the analysis of Islamic glass, Brill remarked in *Glass of the Sultans*, op. cit., p. 29, that Islamic glasses generally do contain manganese, usually 0.5–1.5 per cent Mn O. He remarks that this amount indicates a deliberate addition to decolourise the glass and offset the greenish tints produced by iron impurities. This observation is confirmed by the large number of recipes in *Kitab al-durra* in which magnesia is added to the ingredients.

82. Dragon's blood is called *dam a-akhawayn* (blood of the two brothers) or *qatir*. The word qatir قطير comes from the Arabic name of the island Suqutra, which is the source of dragon's blood, The word Suqutra breaks down into *Suq*, which means market or emporium, and *qutra* which is a vulgar form of dragon's blood (*qatir*). see Serge D. Elie, University of Sussex, *Yemen Update* 44 (2002).

- Cobalt blue (*lazaward*),[83] 3
- Tutia, green, 3
- Realgar (*zarnikh ahmar*), 3
- Borax, 2
- *Iqlimiya*, gold,[84] 2
- Red clay (*mughra*), 2
- Cinnabar (*qinbar*[85] and *zunjufr*), 2
- Salt, 2
- Talc, 2
- Vitriol (*zaj*), 2
- Eggs' shells, 1
- Curcuma roots, 1
- Marble, 1
- Mercury, 1
- Oil dregs (*'akar*), 1
- Sal – ammoniac, water of, 1
- Silver, burnt,1
- Sulphur, 1
- *Tincar*, 1

Selected Recipes for Producing Coloured Glass

We have assigned tentative numbers to Jabir's recipes. These numbers are used below for convenience.

RECIPE 1, FO. 1A: A TWIN-FACED GLASS, ONE FACE RED AND ONE FACE GREEN, WHICH IS PLEASANT

Take four dirhams of red lead (*isrinj*), one dirham of dragon's blood (*dam al-akhawayn*), one dirham of curcuma roots, one dirham of copper

83. *Lazaward* means either lapis lazuli or cobalt blue. In glass colouring it mostly means cobalt blue. See Part 1. Depending on the temperature reached in melting it could mean also lapis lazuli at lower temperatures.

84. Al-Biruni in *Kitab al-saydana* (article 370, p. 236) defines the dross of silver (*khabath al-fidda*) as *iqlimiya*. Musa ibn Maimun (Maimonides) defines *iqlimiya* as the scoria of the metal in fusion. (Martin Levey , 'Medieval Arabic Bookbinding and its Relation to Early Chemistry and Pharmacology', *Transactions of the American Philosophical Society*, New Series, vol. 52, no. 4, 1962, p. 36, note 256). *Iqlimiya* according to Dawud al-Antaki in his *Tadhkira* is the dross that floats on top of a molten metal. The *iqlimiya* that is often mentioned in Arabic pharmacological and medical texts is that of silver and of gold, there is also the *iqlimiya* of brass and copper. *Iqlimiya* is sometimes translated as cadmia (Latin for calamine) but this is not always correct, since cadmia is defined, as an oxide of zinc (tutty) which collects on the sides of furnaces where copper or brass was smelted, and zinc sublimed.

85. It is interesting to note here that the Greek word for cinnabar is kinnabari.

hammerscale (*rusakhtaj*),[86] and one dirham of red marcasite. Grind them all and throw them on one ratl of glass. Put these in an earthenware pot and place it in the glassmaker's furnace. Use the same procedure in the other recipes that I am discussing. (Al-Marrakishi, the editor, adds that the pot should be luted.)

RECIPE 2, FO. 1A: RED WITH A NAVY BLUE HUE

One hundred dirhams glass, copper burnt with fire (*nuhas muharraq*) fifteen dirhams, tin ten dirhams, cobalt blue (*lazaward*) one dirham. Melt if God wills.

RECIPE 3, FO. 1A: ANOTHER GREEN

Burnt copper three dirhams, dragon's blood (*dam al-akhawayn*) one dirham, red lead three dirhams. These are thrown on one ratl of glass and melted, if God wills.

RECIPE 4, FO. 1B: YELLOW WITH A GREEN HUE

One hundred dirhams of pharaonic glass, throw on them twenty dirhams of tin filings, and five dirhams of copper burnt three times. Grind the burnt copper finely, mix it with the tin filings, throw the whole on the glass, and melt them.

RECIPE 5, FO. 1B: ANOTHER YELLOW WITH A PURPLE (*FARFIRI*) HUE

Take one hundred dirhams[87] of pharaonic glass. Add to it thirty dirhams of burnt lead and six dirhams of verdigris (*zinjar*) borax, (which is copper burnt with sal-ammoniac according to al-Marrakishi). Melt the ingredients.

RECIPE 8, FO. 1B: ROSE PHARAONIC GLASS

Throw two parts of male magnesia on every one hundred parts of glass. When melted, it will show red streaks. This is nice and rare.

RECIPE 10, FO. 1B: ANOTHER YELLOW WITH GOOD YELLOWNESS

Throw on every one hundred dirhams of glass twenty dirhams of clarified litharge extract (*martak*). Melt as I have indicated.

86. Mainly copper oxide
87. One dirham is about 3.12 grams.

RECIPE 12, FO. 2A: A MORE INTENSE YELLOW THAT IS NOBLER AND MORE FIRE-ENDURING

Throw on one hundred dirhams of glass twenty dirhams of tin burned with orpiment (yellow *zarnikh*) only. Melt it and it will come exceptional.

RECIPE 18, FO. 2B: EMERALD-LIKE GREEN GLASS

Take a good quality Kufic green glass, or if possible a clear pharaonic glass. Pulverise it and sieve it through a fine mesh sieve, or through a silk cloth. Take a dish (of clay or porcelain) and put in it two dirhams of *rusakhtaj* (copper scales) and one dirham of green tutia (zinc oxide), pulverise both and mix them. Take from the pulverised glass 120 dirhams and mix well the whole together. Take a cup of Damascus pottery <and put the mixture in it>.

Take from good red natrun two parts and from *al-qili* (alkali) one part and with a total weight equal to that of the glass, namely 120 dirhams, and put them in a glass vessel. Pour water and submerge these under four fingers of water. Stir slowly until the materials are dissolved. Leave the solution to settle and becomes clear like tears. Take gently some of the solution and irrigate with it the glass mixture that you intend to tint. Then introduce the glass with its ingredients into the glassmakers' furnace and melt them. Take precautions against dust and smoke at the finishing and it will come out an emerald equal to the real one.

The secret of melting is to choose a good and pure Damascus earthenware cup. Put in it the pulverised glass with its pigments already mixed. The pulverised glass mixture will fill two-thirds of the cup. Then irrigate it with the *al-qili* (alkali) and the natrun solution. If you desire to make it like a paste, then irrigate it daily and put it on a gentle fire until you consume the whole solution. When it becomes rather dry then introduce it into the furnace while it contains some humidity and set on the fire until it is melted. To test if it has melted introduce an iron rod and dip it in the cup. A small sample will show at its end. When it cools and if you do not see in the sample any cloudiness and if it is clear and the green colour is even then the melting is complete, otherwise you will increase the fire until the sample comes out as described. When this is done make out of the melted glass whatever you need. The firing of the furnace will take two days and one night.

RECIPE 19, FO. 3A: PRODUCING *ABU QALMUN* WITH UNIQUE IRIDESCENT COLOURS

Take marcasite, magnesia, hematite (*sadhanj*), iron saffron (*za'faran al hadid*), malachite (*dahnaj*), tutia, iron scales, and dross of brass (*barani*) in equal parts. Pound them and sieve them, then pulverise them with the vinegar of aged wine that contains fifteen dirhams from each of sieved borax and sieved alkali. Dry the pigments and throw ten dirhams of them on each one hundred dirhams of Damascus glass. The pulverised glass with pigments should be put in a luted earthenware pot and placed in a glassmaker's furnace. Light a very strong fire and you will obtain *abu qalmun* that keeps changing colours.

RECIPE 21, FO. 3B: WHITE LIKE IVORY

You will pound glass into a very fine powder as *kuhl* (eye powder). Take ten parts of talc extract (*talq mahloub*) for every one hundred parts of glass and pulverise it with the glass so that they are mixed together. Put the mixture in a Damascus earthenware pot (*qidr shamiyyah*). Place the pot in the grand furnace (*atun a'zam*), for two days and two nights. Withdraw a sample, and if it looks undispersed, continue the fire until noon and shut the door of the furnace to prevent wind from entering. Take it out when it has cooled and you will find it as we have described, if God wills.

RECIPE 33, FO. 4B: SEMI-TRANSPARENT *ADRAK*[88] OF INDIGO (*NILAJI*), GREEN AND RED COLOURS

Take one part of dragon's blood and one part of iron saffron (*za'faran al-hadid*), add to each *uqiyya*[89] of them two dirhams of good green copperas (*qalqant*) and two dirhams of iron saffron (*za'faran al-hadid*) that falls from under the hammer and one dirham of malachite (*dahnaj*), three dirhams of litharge (*martak*) and two dirhams of pure gold *iqlimiya*. Pulverise all in sharp wine vinegar until the whole are mixed together. Roast the mixture in a luted mug with a handle (*kuz*)) with a closed top in a *tannur* in which it is heated for one day and one night. Pulverise with vinegar one day and one night until it is dry. Then return it for roasting. Repeat this until its redness becomes intense. It reaches this condition after three roastings. Take from this, three dirhams and from hematite (*sadhanj*) one dirham and pulverise well. Throw from this one dirham on one ratl[90] of good pharaonic glass that can be better if it is old. Melt and stir until the drug (pigments) is thoroughly mixed. Keep the fire until the sample of the iron rod comes out semi-transparent red.

If you desire the redness intensity of the glass to be like gold, place the earthenware pot on a deck (*dukkan*) in a *tannur* half full of fire. The *tannur*

88. Al-Biruni, *Kitab al- Jamahir*, edited by S. Krenkow, Haydarabad Deccan in 1355/1936. In the chapter on *adhrak* he writes: '*Adhrak* is a noble stone, among those that are from the moulded stones of the Alexandrians. It is ancient and beautiful, and pleasing, and in delicacy equals the ruby.'

89. One *uqiyya* is about 37.5 grams.

90. One ratl is about 450 grams.

will be the same size as the pot and it will be one span (*shibr*)[91] high above its top. There will be one hole cut in the *tannur* opposite the pot for fuel and another hole opposite the top of the pot from behind the *tannur*, and it will be luted with clay or bricks. The two holes at the two sides of the pot will be to monitor the firing and will be for smoke and for kindling the fire. Close the hole at the back of the *tannur* and kindle the fire using either reeds (*qasab*), or wood, which is better, until midday. If you started early in the day keep watching the glass. If it turns like water take the bundle of drug and overturn it over the molten glass and stir by an iron rod shaped like a hook extending from the top of the pot to your hand. Continue stirring intensely until you know that the drug and the glass are mixed thoroughly. Take a <sample> at the end of the iron rod, and if you see in it two different colours continue feeding the fire with fuel, and if you see it evenly mixed continue with little fuel until you realise that it reached its end and became like water, then stop the fuel.

The deck will be one span higher than the bottom of the *tannur* and its diameter will be the same as that of the pot. You will get a beautiful indigo-coloured *adrak* from which you will make whatever you desire, if God wills.

RECIPE 35, FO. 5B: TO MAKE WHITE AND RED ENAMEL (MINA)

Take one part of pulverised white pebbles (*hasa*), one part of red lead (*sirinj*), and one part of natrun. Combine, cook, and it will come out white. If you want the enamel red, you will take one part of the filings of steel and imbibe it with dissolved sal-ammoniac. Leave it in a damp place for several days and then take it out and you will find it a disc as hard as stone. Pulverise it with wine vinegar on a flat stone mortar (*sallaya*). Take magnesia and treat it as you have done with iron except for the putrefaction (*ta'fin*). Take one part from the magnesia and one part from the iron and pulverise them all and put them in a bottle (*qarura*), luted very well, and place it in a brickmaking furnace. Take it out when it flows. Then return it to the brick furnace two or three times. This serves as an elixir. Take now from the white enamel (mina) whatever you want and throw on each one hundred dirhams of mina two dirhams from the elixir and it will come out in the colour of the pomegranates grains (*habb al-rumman*).

RECIPE 38, FO. 6A: MAKING JEWEL (*JAWHAR*)

Take from rock crystal (*maha*) or from Damascus glass one ratl. Throw on it five dirhams of hematite (*sadhanj*), two dirhams and a half *rusakht* (copper

91. The *shibr* is the span of the hand, from the thumb to the little finger. One *shibr* equals approx. 7 inches or 17.78 cm.

scales), two dirhams of good magnesia and one and a half dirhams of *tincar*. If you like its colour tinted yellow and red introduce to it good quality iron saffron (*za'faran al-hadid*). If you do not want it yellowish but you want it of the *bijadhi*[92] colour then do not introduce iron saffron (*za'faran al-hadid*) but keep it as we have described. Put it in a mug (*kuz*) luted from the inside with the clay of Upper Egypt (*tin Sa'idi*) to prevent it from sticking. Put on the head of the mug (*kuz*) a rag with a hole in it. Place the mug with a handle (*kuz*) in a self-blowing furnace (*nafikh nafsihi*)[93] and put a large quantity of charcoal. When you know that it has melted, insert in the hole an iron rod and if the water on the iron rod is clear then it has reached its end and then lift it from the fire and cool it. Break the mug (*kuz*) and you will obtain one jewel (*jawhara*) from which you can make whatever you wish.

RECIPE 44, FO. 6B: GLASS WITH BLUE *LAZAWARD* COLOUR

Take two parts of red *zarnikh* (realgar) and yellow *zarnikh* (orpiment), one quarter part of vitriol (*zaj*) of kirman, and the same from the pure Egyptian sand from which glass is made. Pound each alone and sieve. Irrigate with vinegar after you mix them together. Put the drugs in a very well luted earthenware vessel (*fukhkhara*), keeping the drugs humid with the vinegar in a similar consistency as that of the *sawiq*.[94] Close the *fukhkhara* with a rag and lute it. Fill the *tannur* with wood and dung (*sarjin*) until the height of one *dhira'* (cubit).[95] Bury the *fukhkhara* in it. Cover the head of the *tannnur* and lute it. Take out the mug (*kuz*) the next day and take out the (glass) from the mug (*kuz*) and you will find it as you like, if God wills.

RECIPE 46, FO. 7B: MAKING RUBY (*YAQUT AHMAR*) WITHOUT EQUAL

Take one hundred dirhams of cornelian stone (*'aqiq*), two hundred dirhams of rock crystal (*billaur*) and twenty-five dirhams of magnesia. Heat each one alone and throw it in sour vinegar. Pound and cook with sour vinegar to

92. According to al-Biruni op. cit., *bijadhi* is one of hyacinth-like stones. He says that Al-Kindi and Nasr hold the ruby variety of it as comparable to gold. *Bijadhi* with its rubicundity has a glitter of violet (p. 88).

93. It is a tannur supported at the bottom on three legs. It has perforated walls and bottom and is provided with a deck made of clay on which fire is made. The drug is put in a luted mug with a handle (kuz) and the tannur is placed in a location in which wind is blowing (*Mafatih al-'ulum*).

_نافخ نفسه: تنور يكون له أسفل على ثلاث قوائم مثقب الحيطان والقرار وله دكان من طين يوقد ويوضع عليه الدواء في كوز مطين في موضع تصفقه الريح.

94. A food made of pounded wheat and barley.

السويق طعام مدقوق بالقمح والشعير

95. In Abbasid times, a dhira' (cubit) measured only some 48.25 cm.

which *al-qili* (alkali) has been added. Cook very well for half a day until it becomes dry and roasted. Throw it in cold water and wash it with water and salt until its water and *jawhar* become clear. Put it in a luted pot (*qidr*) with one hundred dirhams of natrun, twenty-five dirhams of *al-qili* (alkali) salt, forty dirhams of Armenian borax and ten dirhams of coarse salt (*milh jarish*). Light up fire on it in the furnace two days and two nights or one day and one night. If it melts take it out when it cools and throw on it *iqlimia*. Take out the melted ingot (*nuqra*) and pulverise it with sixty dirhams of red lead (*isrinj*), five dirhams of cinnabar (*zanjufr*), two dirhams of realgar (red *zarnikh*) pulverised in vinegar, five dirhams of magnesia, five dirhams of copper scales (*rusakht*),and ten dirhams of pulverised blood stone which is *sadhan*. Mix and put in a luted pot (*qidr*) and place in a furnace. Blow on it continuously until it melts and becomes mature. The sign of its maturity is that you put out one carat (*qirat*)[96] of it on a clear surface until it cools. If you see it clear red with plenty of water that is the water of ruby (*yaqut*) then it has matured. If it has turbidity then blow on it until it matures.

RECIPE 47, FO. 8A: IF YOU WANT IT CLEAR GREEN

Pulverise with it after you take it out from the furnace (*atun*) sixty dirhams of verdigris (*zinjar*), five dirhams of copper scales (*rusakht*), five dirhams magnesia, two dirhams red lead (*isrinj*) and five dirhams malachite (*dahnaj*).

RECIPE 48, FO. 8A: IF YOU WANT IT VIOLET (*BANAFSAJI*)

Pulverise with it twenty-five dirhams of verdigris (*zinjar*), five dirhams of hematite (*sadhanj*), ten dirhams of red lead (*isrinj*), ten dirhams of orpiment (yellow *zarnikh*) pulverised with egg yolk, five dirhams of copper scales (*rusakhtaj*) and five of magnesia. This will come out violet sapphire

RECIPE 49, FO. 8A: YELLOW SAPPHIRE

Pulverise with it thirty dirhams of orpiment (yellow *zarnikh*) pulverised with eggs' yolk and vinegar, ten dirhams of red lead (*isrinj*), three dirhams of copper scales (*rusakht*), three dirhams of magnesia, two dirhams *murdasanj* which is litharge (*martak*) and five cobalt blue (*lazaward*). This will come out yellow sapphire (*yaqut asfar*).

RECIPE 50, FO. 8A: IF YOU WANT IT *TAWUSI* (PEACOCK CLOURED) WHICH IS THE CLEAR AND STRANGE COLOUR

Throw with it thirty dirhams of verdigris (*zinjar*), five dirhams of hematite (*sadhanj*), five dirhams of red lead (*isrinj*), three dirhams of malachite

96. Qirat is about one carat. A qirat is about 198 milligrams, and a carat is 200 milligrams.

(*dahnaj*), five dirhams of orpiment (yellow *zarnikh*) pulverised with eggs' yolk, one dirham of *rusakhtaj* (copper scales) and two dirhams of magnesia. This will come out a *tawusi* if God wills.

2 Al-Talawih:[97] Lustre-painted (stained) Glass

The treatise contains 118 recipes for *talawih* (lustre painted or stained glass), in addition to nine recipes inserted by al-Marrakishi, the editor. The following list of materials of Jabir's treatise is arranged by the frequency of the materials in the recipes. The most prominent material is copper and its compounds. It occurs in about 90 per cent of the recipes. Burnt silver is most prevalent also, and it occurs in about 73 per cent of the recipes. Iron occurs in about 42 per cent. Vitriols (sulfates of metals, such as ferrous sulfate, zinc sulfate, or copper sulphate) occur in about 58 per cent. Cinnabar (*zunjufr*) occurs in about 38 per cent. The list shows the other important materials with the frequency of each.

In a typical process, metallic ingredients, mainly burnt silver, burnt copper or copper compounds, iron and its compounds and cobalt blue, plus other materials such as cinnabar, magnesia, realgar, orpiment, sulphur, and vitriol, are pulverised individually in vinegar or citron juice and mixed together. Glass articles such as cups are painted and decorated with the colouring mixture from the inside or outside or from both sides, and are then introduced into the smoke chamber in the oven. When the cups become black, they are withdrawn and allowed to cool. Then they are washed until the colour appears. By introducing them again into the fire, the colour intensifies and changes. Sometimes they are introduced into the fire once again and the colour becomes brighter.

Materials Used for Lustre Painting: Frequency in 118 recipes

- Copper, 107 (red, burnt with sulphur, burnt with sulphur and arsenic, burnt with arsenic and sal-ammoniac, brass '*shabah*' scales, verdigris '*zinjar*', copper scales '*rusakhtaj*', calcified copper; malachite '*dahnaj*')
- Silver, burnt, 86
- Vitriol '*zaj*', 69 (Qalqant, qalqatar, qalqadis , suri , green vitriol, yellow vitriol, vitriol '*shahira* ')
- Iron, 49 (scales '*tubal*', saffron, filings, burnt with sulphur, roasted with sal-ammoniac and alum; marcasite; hematite '*sadhanj* ')
- Cinnabar, 46 (*zunjufr, qinbar, sanjfar*)

97. Talawih is the process of exposing a painted glass article to fire inside the glassmakers' furnace.

- Magnesia, 31
- Arsenic, 30 (*zarnikh*), (red, yellow)
- Sulphur, 22 (yellow, white, black, *qassari*)
- Lead, 21 (ceruse '*isfidaj*';[98] litharge (*martak*); *Isrinj*)
- Cobalt oxide, 18 (*lazaward*)
- Alum, 14 (Yamani, Egyptian)
- Tutia, 12
- Sal-ammoniac, 8
- *Iqlimiya*, 8 (gold, copper)
- Tin, calcined, 3

Selected Recipes of Talawih *(Lustre-painted or Stained Glass)*

RECIPE 1, FO. 8B: COLOURING BOTTLES INTO PURPLE RED LUSTRE (*MULAWWAH*)

One part silver burnt with sulphur and arsenic. Silver is burnt thus for all these recipes. And one part golden marcasite, one part brittle magnesia, half part hematite (*sadhanj*), ten parts *iqlimiya* of copper, half part copper burnt with sulphur, one part qalqant, half part yellow sulphur, half of one tenth of green tutia, and two parts green vitriol (*zaj*) and Indian iron burnt with sulphur. Combine all these ingredients. Each one is pulverised with distilled wine vinegar and citron juice. Paint mature Damascus bottles with this and they will come out purple red, if God wills.

RECIPE 2, FO. 8B: RED LUSTRE (*MULAWWAH*) LIKE RUBY WHICH SPARKLES IN THE SUN IF IT IS FILLED WITH PURE WINE

One part burnt silver, one part yellow sulphur, one part Indian tutia, one part iron hammer scales (*tubal*), one part iron saffron (*za'faran al-hadid*), one part iron roasted with sal-ammoniac and alum, and four parts green vitriol (*zaj*). <or> take from each of these ingredients one quarter part and take from green vitriol one whole part. And according to the <first> manuscript take <also> six parts qalqant, one part hammer scales of brass, one part qalqatar and four parts brittle magnesia. Pulverise all with citron juice and paint the clear glass and introduce it into the fire and it will come out matchless transparent red.

98. Isfidaj is known to be white lead or ceruse of lead. It is here listed as ceruse of tin. Al-Biruni in *Kitab al-saydana fi al-tibb* says under item isfidaj that it is of two kinds that of lead and that of tin (item 55, p. 52). It is mentioned also in *Mediaeval Lore from Bartholomew Anglicus* by Robert Steele 'white colour that is called Ceruse is made of tin, as it is made of lead'.

RECIPE 4, FO. 9A: MAKING BLUE AND YELLOW; YELLOW FROM INSIDE AND BLUE FROM OUTSIDE, MATCHLESS, AND IS CALLED THE CAT'S EYE (*'AYN AL SANNUR*)[99]

One *daniq*[100] old malachite (*dahnaj*), and seven grains[101] copper scales (*rusakhtaj*) which is two qirats and one grain (*habba*), and one daniq of brass scales, and one daniq of iron saffron (*za'faran al- hadid*), and one daniq white sulphur, and four daniqs orpiment (yellow arsenic), and two daniqs burnt silver, and two daniqs green vitriol (*zaj*), and two daniqs sal-ammoniac (*nushadir*). Pulverise all with citron juice and paint the vessels with this mixture and introduce into the fire and it will come out as we have described.

RECIPE 6, FO. 9B: A COLOUR LIKE EMBROIDERY OF RED, GREEN, YELLOW AND FROM EVERY COLOUR

Take equal parts of burnt silver, realgar (red arsenic), marcasite, magnesia, *matitus* (which is *sadhanj* or hematite, according to al-Marrakishi), calcined tin, cinnabar (*qinbar*), qalqatar, cobalt oxide (*lazaward*), suri which is red mineral vitriol (*zaj*), and yellow vitriol. Pulverise in squill juice or onion juice. Paint with it and it will come out like embroidery.

RECIPE 7, FO. 9B: A COLOUR LIKE THAT OF A SOLID *LAZAWARD* STONE, PROVEN

Twelve parts silver, the same amount of iron scales (*tubal*) and one quarter of a part from cobalt oxide (*lazaward*). Pulverise all for one day with the water of leek and for one more day with vinegar; and paint with it.

RECIPE 10, FO. 10A: A TURQUOISE COLOUR

One dirham from each of marcasite and qalqatar. One and a half daniq from clear crystal, one daniq of cobalt oxide (*lazaward*), one and a half daniq of orpiment (yellow arsenic), four daniqs from red copper burnt with sulphur, one dirham and a daniq verdigris (*zinjar*), one dirham burnt silver. Use these as before.

RECIPE 21, FO. 10B: ANOTHER COLOUR, PISTACHIO

Verdigris (*zinjar*) and arsenic (*zarnikh*) one dirham of each, scales (*tubal*) of copper half a dirham, burnt silver half a dirham. Use them as before.

---

99. About 'ayn al-sannur, al Biruni writes in *al-Jamahir*, p. 228: 'Among the cast stones (masbukat), Al-Kindi mentioned a stone known 'ayn al-sinnawr (the cat's eye) and described it to be farfiri in colour 'red colour with a violet tint'.
100. A daniq is four carats, or 1/6 of dirham. It equals 0.525 grams.
101. Grain is habba or sha'ira (barley grain). It is equal to 0.049 grams.

RECIPE 26, FO. 10B: BUTTER COLOUR SIMILAR TO CHINESE CLAY

Vitriol (*zaj*) and cinnabar (*qinbar*), one dirham of each. Yemeni alum one dirham, salt one and a half daniq, silver burnt with white sulphur one dirham and three dirhams of lead ceruse (*isfidaj*). Pulverise all in distilled vinegar and work with it.

RECIPE 29, FO. 11A: ANOTHER PISTACHIO COLOUR

Take two dirhams of verdigris (*zinjar*), one dirham malachite (*dahnaj*), two daniqs cobalt oxide (*lazaward*), three dirhams realgar (red arsenic) and three dirhams burnt silver. Pulverise in the water of leek and work with it, if the Most High God wills.

RECIPE 33, FO. 11B: GOOD GOLD COLOUR, UNDERSTAND IT AND WORK ACCORDINGLY

Filings of *Rumi*[102] yellow copper two mithqals,[103] silver filings one quarter mithqal, *zunjufr* half mithqal, vitriol (*zaj*) one qirat, qalqadis two qirats, sal-ammoniac (*nushadir*) three qirats. Pulverise with vinegar and use it.

RECIPE 44, FO. 12A: AND ANOTHER *LAZAWARD* GOLDEN COLOUR

Take two qirats of burnt copper, magnesia four qirats, *zunjufr* and verdigris (*zinjar*) two qirats from each. Pulverise with vinegar and paint from inside and outside. What is painted from inside will come out *lazaward* blue and what is painted from outside will come out gold. Expose it to fire and let fire scorch it slightly. That is all.

RECIPE 45, FO. 12B: ANOTHER VIOLET COLOUR

Burnt copper four qirats, vitriol (*zaj*) and verdigris (*zinjar*) four qirats from each, and yellow sulphur three qirats. Pulverise in very sour vinegar (*khall thaqif*),[104] and use it.

RECIPE 46, FO. 12B: AND IF YOU WANT THE SKY COLOUR

Take two dirhams of burnt silver, magnesia six qirats, realgar (red arsenic) three qirats, qalqant four qirats, verdigris (*zinjar*) four qirats and vitriol (*zaj*) eight qirats. Pulverise in vinegar and use it.

---

102. Rumi means coming from the land of Rum or Anatolia. In the Abbasid era, the Rum was Byzantine.
103. The value of the mithqal varies between 3.6 and 4.68 grams.
104. In Arabic dictionaries, khall thaqif means very sour vinegar. الثقيف في اللغة الحاذق ومنه خل ثقيف أي شديد الحموضة

RECIPE 58, FO. 13B: AN OYSTER SHELL, RESEMBLING RUBY

Magnesia, qalqatar and verdigris (zinjar), one dirham from each. Marcasite and yellow sulphur two daniqs from each, cinnabar (*qinbar*) one daniq and a half, cobalt oxide (*lazaward*) one daniq and burnt silver one dirham. Pulverise in distilled vinegar or citron juice and expose to fire and it will come out like red ruby.

RECIPE 60, FO. 13B: A GREEN OYSTER SHELL RESEMBLING CORUNDUM

Cinnabar (*qinbar*) one quarter of a part, magnesia one part, qalqatar one part, verdigris (*zinjar*) one part, marcasite (*marqashisha*) half a part, cobalt oxide (*lazaward*) one sixth of a part, yellow sulphur one third of a part, *sadrat al-'aj* (*sandarus*[105] *al-'aj* according to al-Marrakishi) one part. They are worked with distilled vinegar or *hummad*[106] and then you illustrate with it on the inside of the cup (*qadah*) or on the outside. If you paint one side, the other side will look as corundum.

RECIPE 63, FO. 14A: GOLD LUSTRE (*MULAWWAH DHAHAB*)

One magnesia, two marcasite (*marqashisha*), one copper, three parts litharge (*martak*), two arsenic (*zarnikh*). They are worked with good vinegar and exposed to fire (*talwih*) and it comes out golden.

RECIPE 65, FO. 14A: ANOTHER GOLDEN LUSTRE (*MULAWWAH MUDHAHHAB*)

Seven tutia, four sal-ammoniac, two litharge (*martak*), one verdigris (*zinjar*), one half of a part vitriol (*shahira*), one part qalqant, one and a half part silver burnt with yellow sulphur. It is utilised and exposed to fire and it will come out golden.

RECIPE 66, FO. 14A: ANOTHER GOLDEN <LUSTRE>

Take four dirhams of yellow copper burnt with sulphur and arsenic together, two and a half <dirhams> golden marcasite (*marqashisha*), two and a half dirhams male magnesia, one and a half dirhams litharge (*martak*), three dirhams sal-ammoniac , one dirham verdigris (*zinjar*), one dirham qalqant, four dirhams silver burnt with sulphur. Work with vinegar and expose it to fire.

105. Sandarus is the resin of a tree. We could not find a reasonable interpretation for the resin (sandarus of 'aj 'ivory').

106. Hummad is rumex accetosa. Most of such plants contain oxalic acid and tannin. Jabir most probably means hummad al-utruj as in other recipes which is citron juice.

RECIPE 70, FO. 14B: AMAZING GOLDEN LUSTRE (*MULAWWAH MUDHAHHAB*)

Get as much as you can from the milk of red anemone (*shaqa'iq al-nu'man*), and as much qalqant, and the same *tincar*, and the same dorema ammoniacum[107] (*ushshaq*), that is one part from each. Pound and sieve through a silk cloth. Then take the unwashed water of leek (allium porrum. *kurrath*) after you leave it overnight, and mix with it this drug and the milk of red anemone (*shaqa'iq al-nu'man*). Combine all in a bottle in the bran of wheat for ten days and decorate the glass with it. [Al-Marrakishi, the editor, expresses here his admiration for this recipe which is used by the people of al-Maghrib and which he had verified with them.][108] Then you put on the decorations silver foil that has not been smoked and introduce into the smoke house for three hours and it will come out matchless gold. [Moreover, we have tried this.]

RECIPE 77, FO. 15A: AND ANOTHER GOLDEN

Ten parts burnt silver, twenty four parts cinnabar (*qinbar*), four parts vitriol (*shahira*), four parts qalqant. Pulverise with vinegar and paint pictures from inside and expose to fire and it will be gold from outside.

RECIPE 91, FO. 16A: SILVER LUSTRE

Take one uqiyya from each of Yemeni alum, Egyptian alum, and sal-ammoniac. Take one mithqal from ceruse (*isfidaj*), borax of goldsmiths, *tincar* and natron. Combine and pulverise with white vinegar for two hours; adorn with it and expose to fire.

RECIPE 100, FO. 17A: YELLOW LUSTRE, AND CORNELIAN GOLD

It comes out yellow but if fire is persisted, it comes out golden. One dirham of good quality *Rumi* brass burnt with sulphur, pulverise finely with water. One dirham of calcified copper (*halqus*), one quarter of a dirham from each of sal-ammoniac, orpiment (yellow arsenic), Iraqi red lead (*asriqun*) and yellow vitriol. Pulverise in strong vinegar. Illustrate with it from inside the cup (*qadah*). Introduce into the smoke chamber until it becomes black. When it is washed it comes yellow as the yolk of an egg. If you intensify the fire, it will come out as cornelian stone (*'aqiq*) and if you renew after this it becomes better. Understand this.

107. Ushshaq is the gum resin exuding from the flowering and fruiting stem of Dorema ammoniacum.

108. Al-Marrakishi, the editor, is inserting information and sometimes complete recipes. It is sometimes not easy to disentangle his insertions from the original text of Jabir.

RECIPE 106, FO. 18A: YELLOW *KHALUQI*[109] LUSTRE, LIKE SMOKE

Seven parts burnt copper, two orpiment (yellow arsenic) and one realgar (red arsenic). Pulverise with vinegar that contains two parts of vitriol (*shahira*). Expose to fire.

RECIPE 110, FO. 18A: YELLOW OYSTER SHELL FROM INSIDE

Seven parts copper, two parts vitriol (*zaj*), half a part orpiment (yellow arsenic). Work it in vinegar; expose it to smoke and fire. Take it out and wash it and its purity will be exposed. Introduce it into fire and it will come out *ibriz*[110] gold if God wills.

RECIPE 111, FO. 18A: YELLOW LUSTRE

One part from each of burnt copper and white marcasite (*marqashisha*), half a part from each of gold *iqlimiya*, verdigris (*zinjar*) of Hims[111] and hematite (*sadanj*). One part of silver burnt with sulphur and arsenic. Pulverise each individually in pure vinegar. Combine all using vinegar also. Draw pictures with it from inside and place in the smoke chamber until it becomes black. Take it out gently and when it cools down, wash it with a fibre sponge (*lif*) from inside and outside and it will come out yellow.

RECIPE 112, FO. 18A: GREEN LUSTRE

Three parts burnt silver, two parts and a half realgar (red arsenic), two parts verdigris (*zinjar*), one part magnesia, half a part cinnabar (*sinjufr*). You will burn silver in sulphur, pulverise in vinegar, and expose to fire.

3 The Colouring of Gemstones

In *Kitab al-durra al maknuna*, the recipes for the lustre painting of glass are followed by twelve recipes for the colouring of gemstones and by two descriptions of the oven (*tannur*) used for this purpose.

Materials Used and the Colouring Process

The following list gives the materials used in the twelve recipes, arranged in a descending order. The most prevalent material is copper and its compounds. This is followed by alkali, slaked lime, glass and red lead:

109. Al Qalqashandi in *Subh al a'sha* classifies the red colour into'innabi for intensive red, khamri (wine colour) if less intensive , and khaluqi for less intensive than khamri.
اللون الرابع الحمرة - إذا كان شديد الحمرة قيل عنابي فإن كان دون ذلك قيل خمري فإن كان دون ذلك قيل خلوقي
110. Ibriz: pure gold.
111. Hims is a town in Syria, on the road between Damascus and Aleppo.

- Copper (burnt, verdigris, copper scales), 9
- Slaked lime, 8
- Alkali, 7
- Glass, 7
- Lead, red (litharge), 6
- Sand, red, 3
- Cobalt oxide, 2
- Balsam of Mecca, 3
- Pitch, 2
- Borax, 1
- Dragon's blood, 1
- Silver, burnt, 1
- Iron, scales, 1
- Pebbles, white, 1
- Sulphur, yellow, 1
- Mastic, 1
- Rosin, 1
- Pistacia terebinthus, resin, 1
- Alum, Yemeni,1
- Vitriol, 1

In a typical process the ingredients, such as burnt copper, glass, alkali, slaked lime and a resin, are pulverised with vinegar or water. The stones are heated and buried in the mixture, or placed in boxes. If boxes are used, they are coated from the inside with the ingredients' paste. The stones are placed inside the boxes, and the lids are closed. The boxes are then exposed to the fire of the oven (*tannur*) overnight and the stones will come out coloured.

Selected Recipes of Gemstones Colouring

RECIPE 1, FO. 19A: SKY COLOUR

Two and a half mithqals of cobalt oxide (*lazaward*),[112] two mithqals balsam of Mecca (resin of commiphora gileadensis - *duhn al-balasan*[113]), half mithqal pitch (*qitran*), two mithqals pistacia terebinthus resin (*samgh al-*

112. Depending on the heating temperature, this can be also ultramarine pigment.
113. Duhn al- balasan is a resin and not oil. This was indicated by al-Biruni in *Kitab al-saydana*, p. 126, and in modern literature. The extract from the trees is known as Balsam of Mecca (or balsam of Gilead or balm of Gilead) and is a resinous gum of the tree Commiphora gileadensis (syn. Commiphora opobalsamum), native to southern Arabia and also naturalised, in ancient and again in modern times, in Palestine. The resin was valued in medicine and perfume. In Latin the resin was technically known as opobalsamum.

butm).[114] Pulverise all. Heat the stones and bury them in the mixture until they cool down.

RECIPE 4, FO. 19A: COLOURING ROCK CRYSTAL (*BILLAUR*) RED

<Four> mithqals dragon's blood, one mithqal mastic, one mithqal rosin, one mithqal pitch, one mithqal balsam of Mecca (resin of commiphora gileadensis; *duhn al-balasan*). Pulverise the drugs and knead with pitch and balsam of Mecca. Heat the stones and bury them in the mixture. Leave them until they cool down.

RECIPE 5, FO. 19A: DYEING OF BEADS SKY OR TURQUOISE COLOUR

Ten dirhams glass, five dirhams slaked lime (*nura*), three dirhams litharge (*martak*), two dirhams burnt copper. These are pulverised in alkali water and the boxes and the gemstones are coated with the paste and are placed in fire overnight, and they come out as we have mentioned.

RECIPE 7, FO. 19B: ANOTHER COLOURING

One part glass, one and a half parts slaked lime (*nura*), one part alkali, half a part burnt copper, a small amount of litharge (*martak*), and a small amount of red lead (*isrinj*). Some people throw into it verdigris (*zinjar*) and cobalt oxide (*lazaward*)[115] and do with it as before.

RECIPE 9, FO. 19B: ANOTHER COLOURING

Ten dirhams sand, three glass, three burnt copper, two slaked lime (*nura*), one alkali, one verdigris (*zinjar*). Pulverise in vinegar and coat the boxes with the paste. Kindle fire on them, and afterwards let them cool down, and they will come out nice.

RECIPE 11, FO. 19B: COLOURING STONES ALSO

Ten dirhams from each of vitriol (*zaj*) and slaked lime (*nura*), four dirhams alkali, three dirhams burnt copper. Pulverise in vinegar and coat the boxes and the lids with the paste from the inside.

RECIPE 12, FO. 19B: PREPARING THE STONES BEFORE DYEING SO THAT THEY CAN ACCEPT THE COLOUR

One part glass, and one part borax, slaked lime (*nura*) and Yemeni alum (*shabb yamani*). Put the ingredients in a pot together with the stones. Pour on

114. Butm is Pistacia terebinthus which is a native of the eastern Mediterranean countries, It is tapped for turpentine A resin from the trunk is used as a vegetable and as a chewing gum.
115. Possibly also ultramarine pigment.

them vinegar until they are immersed by four fingers. Cook until noon, and if the vinegar is diminished, add more. Then cool down the gemstones and place them in the boxes that contain the colouring drugs.

Description of the oven (tannur) for the boxes

Jabir, may God bless him, said in this respect: Build a structure similar to an oven (*tannur*), one dhira' by one dhira' with a height of one dhira' also. Make for it a *banij*[116] with a trough all around. The door of the fire-grate is below the *banij*. Mount another oven (*tannur*) above the *banij* and let it be centred evenly, and make for it a flat tray with partitions (*ahjiza*). In the upper oven (*tannur*), are shelves (in one level) and under each shelf is a <supporting > column made of clay with its lower end resting on the *banij*. The number of shelves is equal to the number of the boxes, either three or four. Between the shelves are spaces to allow the flames of fire to pass between the boxes, ascend over them from all sides, and alternate over them. The lower oven (*tannur*) has <holes >[117] for the escape of smoke. Make your work according to the example;[118] and this is the end, *wa al-salam*.[119]

4 Artificial Pearls, Purifying of Pearls and Other Industrial Recipes

After the recipes on the colouring of glass, there follows the last part of the treatise which contains eight recipes for the purifying of pearls, three recipes for artificial pearls, three recipes for the manufacture of glue from cheese, mastic gum and castor oil extraction. The treatise ends with a recipe to utilise the bones of animals such as cattle and camels for producing an artificial material that can be moulded into different shapes and is light, tough and unbreakable.[120]

Artificial Pearls

RECIPE 13, FO. 22B: TO MAKE PEARLS

Take small pearls and crush them. Wash them with water and salt. Pour on them distilled rumex juice (hummad) in a clean vessel and <protect> them from dust <while warm>and whenever the rumex juice <hummad>

116. Banij: could not be found in the available dictionaries. From the text, we understand that it is the upper part of the tannur with a trough all around.
117. The text saye kuri كوري which is tashif (alteration by the copyist).
118. From this we assume that the original MS contained an illustration.
119. Wa al-salam means 'and peace on you'. This is used at the end of a statement.
120. It is to be noted that all the recto folios of the manuscript were not photographed in their entirety. The right edge of the recto folio is partly hidden so that some words are not reproduced.

diminishes top it up until the pearls become like dough. Then take white sea-shells and calcine them until they become like gypsum. Then take, according to your need, <washed> mercury sublimated with vitriol (zaj) and salt three times and then with salt alone between two cups until you see it like snow. Take from each one part and knead in a cup. Before this, cover your finger with a <piece> of thick cloth (qatifa) impervious to water and let it be of silk. Let the amount of rumex juice (hummad) be little if you need it. Wash your hands clean and put in your balm white and clean <cloth?>. Take from the paste an amount as much as you want, small or large, and put in its middle a thick <hair> then roll it on a silk cloth inside a cup (jam). Cover it with another. When it becomes dry, knead for it dry hyoscyamus niger (banj) white and pure, and put it in its middle like a hazelnut. Take the dough of a loaf and put inside it what you have kneaded. Lay on it another loaf and put the double loaves on the deck of the oven (tannur), and cover its head. If you know that it had been well cooked (ripened) take it out. If it is not what you like, you can follow one of two methods. One method is to bury it again inside the loaves, and put the loaves back on the deck of the oven. The second is to place it inside dough and feed it to a chicken. Lock up the chicken for two or three days, slay it and take the pearl from its gizzard. Another way is to put it inside a fish and roast it, which is better than <feeding it> to the chicken; and this is the end, wa al-salam.

Purifying of Pearls that were Discoloured from the Sea or from Grease

RECIPE 2, FO. 20A: PURIFYING YELLOW PEARLS WHOSE YELLOWNESS WAS CAUSED BY THE SEA

Take the amniotic fluid, the liquid that cushions the foetus in the womb of a pregnant sheep, and put it in a bottle. Hang the pearls in this liquid for seven or nine days. Take out the pearls every three days, examine them, and return them to the liquid until you reach the required purity (al-Marrakishi says here that if the liquid becomes weak; change it). When the pearls are cleaned and purified, put them in fresh water for five days and change the water daily, and they will come out purified.

RECIPE 3, FO. 20B: ANOTHER CHAPTER ON PURIFYING YELLOW PEARLS WHOSE YELLOWNESS IS CAUSED BY SEA, IT IS INTENSELY YELLOW AND IS CALLED SUKKARI (SUGAR-LIKE)

Take one part white marcasite, and one part sal-ammoniac. Pulverise and combine them in a luted green earthen jug (barniyya). Place on it an alembic (anbiq) and kindle on it the fire of charcoal. Take the distillate and put it in a bottle. Hang the pearls in it for three hours, and take them out every hour and suck them with your mouth strongly. Then immerse them in cold water for two or three days and they will come out as you like, if God, the Glorious, wills.

RECIPE 4, FO. 20B: ANOTHER CHAPTER ON PURIFYING YELLOW PEARLS

Wash them softly in water and ashes and insert in the hole of a pearl a needle and dip it once in the milk of giant milkweed (*'ushar*),[121] and take it out quickly so that it does not melt. Then wipe it softly and dip it in dog's milk for one hour and it will come out as pure as when it came out from its shell.

RECIPE 5, FO. 20B: ANOTHER CHAPTER ON PURIFYING YELLOW PEARL

Take the shells of eggs and calcine them. Knead them in dog's milk and make them into two discs. Put the pearl between the two discs and leave it for three days. Take it out and you will find it purer than its original colour and clearer and better if God, the Glorious, wills.

Cheese Glue

RECIPE 9, FO. 22A: DESCRIPTION OF CHEESE GLUE FOR ALL DUTIES

Take old cheese that is free from fat in any amount of your liking. Cut it with a knife as thin as possible. Put it in a pot, one layer cheese and one layer salt. Immerse it for a short time with water, then take it out and wash it well with fresh water. Pour water over it and put it on a gentle fire. Be careful that water is not diminished. If it is diminished, replenish it until midday, until you know that it is fat free. Pour out water from it, and take out the quantity that you need. This is the same as with purified fish glue.

Put it in a luted glass vessel, and boil it in fat-free whey (dawgh دوغ) which is to be filtered before it is poured on the glue. When the glue is dissolved in it <pour it> on a flat stone mortar (sallaya) and pulverise it till you are satisfied by its coarseness or fineness. Use it for whatever purpose you want. Know that this glue does not dissolve at all after its first application. It glues any noble stone, gypsum (qass),[122] clay, rock crystal, or glass. Wash the vessel which contains the glue before it sets, since if it sets it cannot be removed, and any object that is glued with it cannot be separated unless broken.

121. Ushshar عشر is giant milkweed, or *Calotropis procera*.
122. قص also means gypsum.

Making a Light and Tough Material from Bones

RECIPE 15, FO. 24A: UTILISING BONES AND MAKING VESSELS FROM THEM IN ANY <SHAPE> YOU WANT AND THE MATERIAL WILL BE AS PLIABLE AS LEAD

Take Lychnis githago (yabruh sanami)[123] rumi one hundred dirhams, sal-ammoniac one hundred dirhams, <tincar> one hundred dirhams and asafoetida (haltit mintin) ten dirhams. Pulverise them and pour them over four ratls of wine vinegar. Place the whole over fire until half the <liquid> is gone. Take the bones of <sheep>, cows, or camels. Choose the <bones > that have marrow, <meat> and sinews. Break the bones and cook them in the vinegar of old wine in a pot until they dry up, then dry them in the sun and pulverise them and sieve them through a close textured sieve. Weigh a quantity and throw it into a luted earthenware vessel. Pour on it the cooked batch of vinegar and drugs. Put the <whole> in the furnace (kur) and blow on the fire of charcoal or wood until it melts. The vinegar will dry out and the <bones> will melt like lead. If it melts and flows, take fifty dirhams of verdigris (zinjar) and five dirhams of copper scales (rusakht) and five dirhams tutia. Pulverise them and feed them to the flowing <bone mixture>, and let <the whole> flow smoothly. Then pour the molten material into any vessel, I mean into any mould you choose, and it will come out as pliant as lead, green, without smell, and unbreakable even if you try to break it. Its greatest secret is in the high-quality of its melting. It is light having no <heavy > weight. It cannot sink at all. If you make from it mail-and-plate armours (jawasin), helmets (bid) and shields (daraq), they cannot be cut by iron, and this is the end, wa al-salam.

The reason for choosing marrow bones is that they are moister, and the more moist the bones are the stronger will be the material . The cause of this is that the <bones> are cold and dry originally. If their dryness is too much their interior will be tender and they will easily be broken because of this. If moisture flows in them, which is the marrow, this moisture will be in equilibrium with dryness and with coldness if the material becomes slightly warm the dryness will depend in its entirety on that moisture which is inherent and latent in it and which hardens it and makes it <resistant to breakage>. When fire touches its moisture, it becomes malleable. This is because fire introduces dryness and dryness is thus augmented. This necessarily prompts moisture to come into action and thus melting takes place quickly; if God, the Glorious, wills. We shall discuss the manufacture of this <material> and its different kinds in a special book devoted to it, if God the Glorious, wills, and this is the end, wa al-salam.

123. Yabruh sanami:is lychnis githago.

May God send his blessings and peace on *sayyidina* (our master) Muhammad.

This is the end of *Kitab al-durra al-maknuna*.

APPENDIX ARABIC-ENGLISH GLOSSARY OF MATERIALS USED IN PEARL MAKING, PEARL PURIFYING, GLUES AND BONES UTILISATION

'Ajin	عجين	Dough
'Izam	عظام	Bones
Ushnan farisi	أشنان فارسي	Salsola cali. Persian
Basal abyad	بصل ابيض	White onions
Billaur	بللور	Rock crystal
Dawgh	دوغ	Whey
Duhn al-akari'	دهن الاكارع	Fat of trotters
Duhn al-khirwa'	دهن الخروع	Oil of castor
Duhn al-mustaka, Luban al-mustaka	دهن المصطكى لبان المصطكى	Mastic
Ghira al-jubn	غرا الجبن	Cheese glue
Haltit mintin	حلتيت منتن	Asafoetida
Hummad al-utruj	حماض الاترج	Citron juice
Jubn 'atiq	جبن عتيق	Old cheese
Kafur	كافور	Camphor
Khall	خل	Vinegar
Khamir	خمير	Leaven
Laban al-'ushshar	لبن العشر	Milk of giant milkweed
Laban al-kalba	لبن الكلبة	Dog's milk
Laban al-tin	لبن التين	Fig's milk
Laban halib	لبن حليب	Milk
Lulu	لولو	Pearls
Ma' rahm al- shat	ماء رحم الشاة	Amniotic fluid from the womb of a sheep
Mahlab muqashshar	محلب مقشر	Peeled mahlab seeds
Marqashisha	مرقشيشا	Marcasite
Milh andarani	ملح اندراني	Andarani salt
Natrun	نطرون	Natron
Nura	نورة	Slaked lime
Nushadir	نوشادر	Sal-ammoniac
Qili	قلي	Alkali

Qishr al-bayd	قشر البيض	Eggs shells
Ramad	رماد	Ashes
Rusakht	روسخت	Copper scales
Sabun	صابون	Soap
Sadaf bahri	صدف بحري	Sea shells
Shabb yamani	شب يماني	Yemeni alum
Sham'	شمع	Wax
Simsim muqashshar	سمسم مقشر	Peeled sesame
Talq	طلق	Talc
Thum	ثوم	Garlic
Tutia	توتيا	Tutia
Yabruh sanami	يبروح صنمي	Lychnis githago
Zaj	زاج	Vitriol
Zi'baq	زئبق	Mercury
Zinjar	زنجار	Verdigris

BIBLIOGRAPHY

See footnotes for a comprehensive literature.

Al Biruni, *al-Jamahir fi ma'rifat al-jawahir* , ed. F. Krenkow, Hyderabad, 1936.

Al-Biruni, *Kitab al-saydana fi al-tibb*, ed. 'Abbas Zayrab, Iran University Press, Tehran, 1991.

Dozy, R. *Supplément aux Dictionnaires Arabes.* Reprinted by Librarie du Liban, Beirut, 1968.

Elie, Serge D. *A Historical Genealogy of Socotra as an Object of Mythical Speculation, Scientific Research & Development Experiment*, University of Sussex, Yemen Update 44 (2002).

Ibn al-Nadim, *al-fihrist,* Gustav Flügel. Leipzig, 1871–2; Cairo edition, 1348 (1929-30). *Al-Fihrist* was translated into English by Bayard Dodge, *The Fihrist of al-Nadim*, in two volumes, Columbia University Press, 1970.

Jabir ibn Hayyan, *Kitab al-khawass al-kabir,* MS Alexandria Municipality 5204.

Jabir ibn Hayyan, *Kitab al-khawass al-kabir* , Br. Museum, MS OR 4041.

Al- Khuwarizmi, *Mafatih al-'ulum*, Cairo, 1342 (1923).

Kraus, Paul, *Jabir ibn Hayyan. Contribution à l'histoire des idées scientifiques dans d'Islam*. Vol. 1: *Les corpus des écrits Jabiriens*, Cairo: 1943 , reprinted by Fuat Sezgin, Natural Sciences in Islam. 67, Frankfurt, 2002.

Lane, Edward William, *An Arabic-English Lexicon*, Reprinted by Libraire du Liban, Beirut, 1997.

Siggel, A. *Arabisch-deutsches Wörterbuch der Stoffe*, Berlin, 1950.

Steele, Robert, *Mediaeval Lore from Bartholomew*, online.

7 Potassium Nitrate and Nitric Acid in Arabic and Latin Sources

INTRODUCTION

This chapter discusses the various names that were given to potassium nitrate in Arabic, and the equivalent words that were used in Latin. In investigating this subject, the following question was posed: what were the names of potassium nitrate in Arabic before the word *barud* became common? Because the term *barud* was applied in Arabic to potassium nitrate in the 13th century, some historians of science and technology assumed that familiarity with potassium nitrate in Arabic chemistry and alchemy dates from the 13th century only.[1]

Potassium nitrate is a resource that was always available in natural deposits. Its existence could not have passed unnoticed as in the case of other materials found in nature. It should have been utilised to meet the various needs of societies across history. Hence, its applications as a viable substance, as a medicine, as a raw material for industry or in warfare in some form or another, were readily discernable.

The difficulty arose in labelling this and other compounds long before the establishment of the science of chemistry. For example, in the Arabic language, minerals found in nature, including potassium nitrate, were collectively designated under nebulous and all encompassing categories such as salts, boraces, alums or stones, among other misnomers. The difficulty is compounded when different ancient authors classify a certain material under different categories; hence, the same material shows up with different labels.

1. Partington, J.R., *A History of Greek Fire and Gunpowder*, W. Heffer & Sons, Cambridge, 1960, reprinted by John Hopkins University, 1999. In various places, Partington gives in his book sweeping questionable statements. These are some examples: on p. 22 he says, 'The first definite mention of saltpetre in an Arabic work is that in Ibn al-Baytar (d. 1248).' On the same page he translates the Latin sentence '*sal anatron id est sal nitri*' by assuming that the word sal anatron is soda, reversing thus the real meaning of the sentence. On p. 304 he says, 'bauraq meaning soda', which is also incorrect.

The general notion that saltpetre was not known until the 13th century in Arabic alchemy and chemistry is reflected in other works on the history of chemistry. Thus R. Multhauf in *The Origins of Chemistry, London*, 1966, says on p. 27, 'Saltpetre, which does not appear to have been known either to Arabic or European chemists prior to the thirteenth century A.D., is found by Levey in the Nippur medical tablet of about 1100 B.C.' This is curious, since the use of saltpetre is acknowledged to have taken place in ancient Babylon while in Latin chemistry it is claimed to have been known only in the 13th century AD.

Furthermore, treatises that were derived from different sources used to label identical materials differently in the same collated work.[2]

The insignificance of the names that are given to potassium nitrate was explained expressively in *The Natural History of Nitre* of W. Clark (1670) where he says:

> *Nitrum*, (nitron in Greek) or *Nitre*, is also called *Sal-nitri*, or *salt-nitre*, from its likeness to salt, and Sal-petrae, or Salt-petre, from its shooting on walls, and is also called by other various and aenigmatical names, It is no matter by what name it is called, so we agree about the thing.[3]

The same author describes the confusion that was still existing in his time (1670) in differentiating similar materials:

> The experienced Druggist shall not more accurately discover a sophisticated Drug from a real, than our *Nitrarian* may distinguish between *Nitre* and *salt*, *Allum* or *Vitriol*, which are so like one to another, and may be mistaken by a superficial observer.[4]

BORACES AND NATRUN IN ARABIC AND LATIN

We should not be confused in the maze of discussions that took place about what the word *nitrum* indicated at the time of Pliny and before. [5] We know from Arabic and Latin literature of the medieval period that the word *natrun* or *nitrun* in Arabic and *nitrum, nitro or nitri* in Latin used to be applied to a group of salts, like potassium nitrate or sodium carbonate, that are characterised by general similarities[6]. The development of the use of both the Arabic word *natrun* and its Latin equivalents went in a parallel path throughout the following centuries.

The word *natrun* in Arabic has been applied down to the advent of the 20th century, to denote potassium nitrate more than sodium carbonate as will be apparent from this chapter. It did not become restricted to denote sodium carbonate until recently, following the later restrictive usage of the word natron in European languages to denote sodium carbonate. However, as late as 1902 an article in *al-Mashriq* about minerals in the Ottoman Empire gave

2. Such as in the Karshuni manuscript. See below.
3. Clark, W., *Natural History of Nitre*, London, 1670, pp. 1–2.
4. Clark, op. cit. p. 7.
5. This discussion was taking place in the 17th century and it continued until recently. Clark, op. cit., pp. 12–15 discusses this question and concludes that potassium nitrate was known under the word *nitrum* since the time of Pliny and before. See also p. 36 of the same work.
6. Singer, C. *et al.*, *A History of Technology*, vol. 2, Oxford, 1957, pp. 370–1.

the following statement: 'the salt of *barud* or *natrun* is classified among the boraces, and it is mined extensively in Qunya'.[7]

In the early stages of Latin alchemy in the 12th and 13th centuries when Arabic alchemy was being introduced into Europe, the word nitrum or sal nitrum in Latin was used to denote the Arabic word *natrun* when Arabic works were translated into Latin. Moreover, as in Arabic, the word in Latin could then mean more than one kind of nitrum. So both the Arabic *natrun* and the Latin nitrum could refer to potassium nitrate, among other things.

A search for the word *natron* as sodium carbonate in European alchemical literature prior to the 17th century revealed the absence of this word. The etymology of natron in the English language indicates that it was introduced in 1684 only.[8]

Edelard of Bath (d. AD 1150), considered to be one of the most prominent scientific individuals in the Latin west, was among the first translators of Arabic manuscripts into Latin. He mastered the Arabic language during his stay in Syria, and then travelled to Spain, where he edited or rewrote *Mappae Clavicula*, in which he utilised recipes consisting of words having Arabic roots. Edelard states that *Nitrum est sal qui nascitur in terra fiet in laminas in tempore cavatur*, which is a description that applies to Potassium nitrate.[9]

Michael Scot (1180?–1236?) was translating from Arabic in Toledo in 1217, and after 1227 was court astrologer and philosopher to Frederick II at Palermo. In the Cambridge manuscript of *De Alkimia*, attributed to Scot, three kinds of nitrum are given.

> Sal nitrum de puncta is said to come from India, and Alexandria. It is tested by putting it on burning coals, and if it does not decrepitate or make a noise it is good. There is also a foliated Sal nitrum somewhat long and thick with a taste something like vinegar when touched with the tongue and not salty, and it makes a flame over a fire. It is mentioned in some books; it is the best for making mercury malleable, and changes copper into the best gold. It is found in Spain and is exported from Aleppo. A third kind is nitrum depilatum, from Hungary and Barbary. It cleans dried pork.[10]

7. Yasu'i, Louis Sheikho, article on mineral mines in the Ottoman Empire (in Arabic), *Al-Mashriq*, vol. v, issue number 17, 1902, p. 775.
8. See The Oxford Shorter English Dictionary, and the Merriam-Webster Collegiate Dictionary, under natron.
9. Partington, op. cit., p. 303.
10. Partington, p. 88. For the Latin text see Wood Brown, *An Enquiry into the Life and Legend of Michael Scot*, Edinburgh, 1897, p. 247. See also S. H. Thomson, The Texts of Michael Scot's *Ars Alchemie*, *Osiris*, 1935, vol. 5, pp. 523–59, the three kinds of nitre are given on p. 535.

Partington says: 'There is little doubt that the salnitrum foliatum is saltpetre.'[11]

The foliated sal nitrum as described by Michael Scot has been described at earlier dates by several Arabic authors. In the *Canon* (*Al Qanun*) of Ibn Sina (d. 428/1036) we find under article *natrun*: 'It is the Armenian *bauraq* and was discussed in the chapter of the letter b.'[12] Then under article *bauraq* we read: 'It can be burnt on top of live fire on a porcelain. The best kind is the Armenian, the light, the foliated, the brittle, the spongy, the white, the rosy and the *farfiri*.'[13]

Al Biruni (973–1048) in *Kitab al-saydana fi al-tibb* in article *bauraq* says: 'in Greek it is *aphinatrun*[14] and in Syriac it is *nitra*'.[15] 'The best quality is the Armenian that is light and foliated, having leaves. It crumbles easily with a *farfiri* colour; it resembles foam and has a burning taste.'[16] In the same article, al-Biruni says that the foam of *natrun* is said to be the Armenian *bauraq*.

Ibn al-Baytar gives similar statements. When discussing *bauraq he says:*

> as to that which is called *aphruntun*[17] which means foam of *natrun* it is alleged by some people to be the Armenian *bauraq*, the best quality of which is very light with leaves and crumbles easily; it resembles *farfir* in colour; and is like foam and has a burning taste.[18]

In the *Lexicon of Alchemy* of Martinus Rulandus that appeared in AD 1612, Armenian *bauraq* was defined as saltpetre.[19] In the same *Lexicon*, aphronitrum is defined as froth of saltpetre or wall-salt.[20] In Lemery's *Cours de Chymie*,[21] it is stated that saltpetre was called aphronitrum by the ancients.

11. Partington, op. cit., p. 88.
12. Ibn Sina, *Al-Qanun fi al-tibb*, vol. 1, Bulaq edition, 1877, offset printings in Baghdad and Beirut, p. 376.
13. Ibn Sina, p. 267.
14. Obviously this is aphronitrum.
15. Duval translated *nitra* into saltpetre, see below Berthelot and Duval.
16. Al -Biruni, *Kitab al-saydana fi al-tibb*, ed. Abbas Zaryab, Tehran, 1371, pp. 606–7.
17. Obviously this is aphronitrum.
18. Ibn al-Baytar, `Abdullah b. Ahmad al-Andalusi, *Al-Jami` li Mufradat al-Adwiya wa al-Aghdhiya*, vol. 1, Beirut, p. 125.
19. Martinus Rulandus, *A Lexicon of Alchemy*, translated by A.E. Waite, reprinted by Kessinger Publishing Company, original Latin edition appeared in 1612, p. 70, item, Baurac.
20. Rulandus, op. cit., p. 32.
21. *Cours de chymie* contenant la manière de faire les opérations qui sont en usage dans la médecine par une méthode facile, avec des raisonnements sur chaque opérations ... par Nicolas Lemery, Paris, Ed. Baron, Théodore, d'Houry, fils, Paris, 1757, pp. 1689.

In '*De Compositione Alchemiae*' or '*De Re Metallica*',[22] which is the text of the dialogue between Maryanus (Morienus) and Khalid ibn Yazid (see below) the Latin text says:[23] '*Sal annatron id est sal nitri.*' The 17th-century English translation of this sentence says: 'with *salt Annatron, that* is with *salt peter*'; the translator substituted *sal nitri* for *salt peter*.[24] The use of the word *saltpetre* instead of *sal nitri* was a later development adopted by the *moderns* according to Biringuccio (d. *c.* 1539).[25] The word anatron has entered the English language dictionaries. Although not much in use, it can denote either native carbonate of soda, i.e. natron, or saltpeter.[26]

The following definitions from the *Lexicon of Alchemy* of Rulandus illustrate the relationship between the Arabic words *natrun* and *bauraq* and their Latin equivalents:

> Nataron or Natron – i.e. Nitre.[27]
> Nitrum – Nitre[28]
> Nitrum, Baurach, Rock Salt, Saltpetre, Nitre.[29] Nitre is manufactured in several ways – in stables, ancient dormitories, in rocks, cellars, walls, and other such places, as well as in old and disused sand-pits.
> Sal Nitri[30] – Saltpetre, smelted out of earth which has been drenched in urine – for example, such earth as forms the floors of stables.

In *Al-Madkhal al-ta`limi* (Instructive Introduction) and in *Kitab al-Asrar* (The Book of Secrets), Abu Bakr Muhammad Ibn Zakariyya al-Razi (Rhazes) (d. AD 925) mentions that Goldsmiths' Borax is white and is similar to *al-sabkha (al-shiha)*[31] *which is found at the feet of walls.*[32] The

22. Holmyard, 'A Romance of Chemistry', a series of articles that appeared in *Chemistry and Industry*, Part I, 23 Jan. 1925, pp. 75–7; Part II, 30 Jan, pp. 106–8; part III, 13 March 1925, pp. 272–6; Part IV, 20 March 1925, pp. 300–1; Part V (printed IV by error), 27 March 1925, pp. 327–8. In this series of articles, Holmyard published the full text of the 17th-century English translation of *Ye Booke of Allchimye*, (Sloane MS. 3697), see also Lynn Thorndike, *A History of Magic and Experimental Science*, vol. 2, Columbia University Press, Fourth Printing, 1947, p. 215. Lee Stavenhagen, *A Testament of Alchemy*, The University Press of New England, 1974. Adam McLean published the English translation of Sloane MS. 3697 after modernising its English, see below.
23. Morienus, in Manget, *Bibliotheca Chemica Curiosa*, Geneva, 1702, I, p. 514
24. The *Book of the Composition of Alchemy*, edited by Adam McLean, Glasgow, 2002, p. 22.
25. Biringuccio, Vannoccio, *Pirotechnia*, translated by Cyril S. Smith and Martha T. Gnudi, New York, 1959, p. 111.
26. Webster's Revised Unabridged Dictionary, Version published 1913.
27. Rulandus, p. 238.
28. Rulandus, p. 240.
29. Rulandus, pp. 238–9.
30. Rulandus, p. 283.
31. This word occurred as *al-sabkha* and as *al-shiha* in the various texts.
32. Al-Razi, Abu Bakr Muhammad b. Zakariyya b. Yahya, *Kitab al-Asrar wa Sirr al Asrar*, ed. Muhammad Taqi Danishpazhuh, Tehran, 1343 (1964), p. 6.

same description appears in the Karshuni manuscript (written in Arabic with Syriac script), which belongs to the period 9th to 11th century according to Berthelot and Duval.[33] Duval translated *al-shiha which is found at the feet of walls* as saltpeter.[34]

The Karshuni manuscript also classifies *natrun* under the salts. It says that:

> *Salt consists of seven varieties, namely,* (1) salt for food, (2) salt of goldsmiths, (3) *Andarani* salt, (4) naphtha and *natrun* salt, (5) Khurasani salt, (6) Indian salt, and (7) *natrun* which is the *nitra* salt.

It is obvious that the two kinds of *natrun* listed here, namely, in items (4) and (7) denote two different kinds of salts, one of which, the Syriac word *nitra salt*, denotes potassium nitrate. Duval translated *nitra salt* as *sel de nitre.*[35]

Liber Lumen Luminum (Light of Lights), of al-Razi that exists in Latin and which is devoted mainly to salts and alums, was translated by Gerard of Cremona.[36] Lacinius published extracts from this work. The salts mentioned in this extract are: salt armoniac; sal gemme; saltpetre, common salt and salt alchali.[37]

USE OF NATRUN AS A FLUX IN METALLURGY

Potassium nitrate was used since the early days of alchemy and until later centuries as a fluxing material in the roasting of ores and the melting of metals. This becomes evident from a study of medieval and renaissance books on metallurgy and alchemy. From *De Re Matallica* of Agricola (d. 1555), from *Pirotechnia* of Biringuccio (d. *c.* 1539) and from the *Treatise on Ores and Assaying* of Lazarus Ercker (d. 1593), we learn that saltpetre was

33. Berthelot, M. and R. Duval, *La Chimie au Moyen Age*, vol. 2, Paris, 1893. p. XII. The Karshuni MS was published in Syriac script, with a translation into French by Duval. The Karshuni Arabic text was converted into Arabic script in Aleppo by the Rev. Father Barsum on the request of the author of the present work. The Arabic text in Arabic script is still in MS form.

34. Berthelot and Duval, 1893, p. 145.

35. Berthelot and Duval, p. 163. See also the text above, where it was mentioned that al-Biruni correlated between the words *bauraq*, aphronitrum with the Syriac word *nitra*.

36. McVaugh, Michael, A List of Translations Made From Arabic into Latin in the Twelfth Century – Gerard of Cremona (1114–1187), Chapter 7 in *A Source Book in Medieval Science*, edited by Edward Grant, Harvard University Press, 1974, pp. 35–8. Thorndike (vol. 1, p. 670) thought that it might have been translated by Michael Scot.

37. Peter Bonus of Ferrara, *The New Pearl of Great Price*, reprinted by Kessinger, Montana, USA, The extracts made by Laciniius from the Lights of Lights by Rhasis, are given on pp. 363–88; for salts see pp. 367–70.

an important fluxing material in the melting and smelting operations of metals.[38]

In assaying copper ores Agricola writes:

> If, however, it is less rich, a stony lump results, with which the copper is intermixed; this lump is again roasted, crushed, and, after adding stones which easily melt and saltpetre, it is again melted in another crucible, and there settles in the bottom of the crucible a button of pure copper.[39]

In assaying iron ore, Agricola says that the ore is burned, crushed, washed and dried. Then a magnet is laid over the concentrates and the iron particles are colleted in a crucible. 'These particles are heated in the crucible with saltpetre until they melt, and an iron button is melted out of them.'[40]

In Ercker's book the use of saltpetre as a fluxing material is mentioned in several places. In describing a flux for brittle silver we read:

> silver may also be made malleable by a flux that purifies metals greatly. Take sal alkali, saltpetry salt,[41] crude argol,[42] and saltpetre, of each as much as the other, calcine them, then dissolve the mixture in warm water, pass it through a piece of felt, let it coagulate, and the flux will be ready.[43]

The book describes the flux for use in assaying copper ores.

> Take two parts of argol and one part of saltpetre, grind them separately, and then mix them. Put the mixture in unglazed pot and then toss in a piece of glowing charcoal. This will start a fire in the pot; let it burn until it stops by itself. When the pot has cooled, the flux is ready. Take it out of the pot, remove the charcoal, and, after grinding it, store the flux in some warm spot; thus it will keep.[44]

38. *De Re Metallica*, by Georgius Agricola, Translated by Herbert Hoover and Lou Hoover, Dover, New York, 1950; *Pirotechnia*, by Vannoccio Biringuccio, op. cit. (for references to saltpetre as a fluxing material in *Pirotechnia* see pp. 136, 194, 296, 213); The *Treatise on Ores and Assaying* by Lazarus Ercker was translated from the German Edition of 1580 by Anneliese Grunhaldt and Cyril Stanley Smith, The University of Chicago Press, 1951.

39. Agricola, p. 245. It must be noted that Agricola used the word *halnitrum* i.e. *sal nitrum* and not saltpetre. The translators (Hoover and Hoover), substituted the word saltpetre for halnitrum. The words nitrum or sal nitrum or sal nitri, etc. were replaced by saltpetre by several translators and publishers starting with the appearance of book printing in the 15th and 16th centuries. This was unfortunate because this substitution had made it extremely difficult to know the exact terms used by the original authors. It made it also difficult to know the history of the development in the use of the different terms.

40. Agricola, op. cit., p. 247.

41. Ercker defines this as an incrustation on saltpetre vats capable of being refined to give a table salt, p. 34, pp. 307–8.

42. Crude tartar.

43. Erckert, op. cit., p. 81.

44. Erckert, op. cit., p. 207.

The practice of using potassium nitrate as a fluxing material continued in Latin alchemy until later centuries. Newton (last quarter of 17th century) in his alchemical treatises gave details of processes in which he used nitre or saltpeter as a fluxing material. In his treatise *The Key* (*Clavis*),[45] he describes the preparation of the antimony metal by heating antimony sulphide with iron and with nitre as a flux:

- Make the regulus by casting in nitre bit by bit; cast in between three and four ounces of nitre so that the matter may flow.
- Little nails may be used and especially the ends of those broken from horse-shoes. Let the fire be strong so that the matter may flow [like water], which is easily done. When it flows, cast in a spoonful of nitre, and when that nitre has been destroyed by the fire, cast in another. Continue that process until you have cast in three or four ounces.
- Beat the regulus and add to it two, or at most 2½, ounces of nitre. Grind the regulus and the nitre together completely and melt again.

Newton recommends grinding the regulus a third and a fourth time adding nitre each time. Then he says:

> In the last three fusions the regulus must be beaten, and ground and mixed with nitre. Some cast the nitre into the crucible, but this is not recommended. You will see that the regulus mixed with nitre in this way flows easily with it.[46]

It is interesting to know that Nicolas Lemery in his *Cours de Chymie*, published in 1675, i.e. at the same time when Newton was writing his treatises, gave a chapter in his book on 'Regule d'Antimoine avec le Mars', in which he describes a procedure similar to that of Newton.[47]

In the 17th century, the nomenclature was not the same as it is now. The name antimony was applied by Newton to the stibnite ore (*ithmid* in Arabic), while the term *regulus* or *regulus of antimony* indicated the antimony metal.

Let us now give citations from the earlier Arabic and Latin treatises on Alchemy. One of the earliest treatises on alchemy to be translated from Arabic into Latin was the dialogue that took place between Maryanus (Morienus) and Khalid ibn Yazid (d. *c.* 90/708). Robert of Chester (Robertus Castrensis) finished translating it on 11 February 1144. This work is entitled *De Compositione Alchemiae* or *De Re Metallica.*[48]

45. Keynes MS18. The Latin text and English translation were given in *The Foundations of Newton's* Alchemy, by B.J.T. Dobbs, CUP, 1975, pp. 251–5.
46. Dobbs, op. cit., p. 254.
47. Lemery, Nicolas, *Cours de Chymie*, Paris, 1675, pp. 182–4.
48. For Holmyard's articles giving text of 17th-century English translation see note above. McLean published this same translation, see above.

Holmyard published a 17th-century English translation of the Latin text of *De Compositione Alchemiae* from a manuscript preserved in the British Museum (Sloane MS. 3697). In this translation we read:[49]

> for ye wisemen have thus said of this: Now we have taken away ye blackness, and have fixed ye whiteness with *salt Anatron*, yt. is, with *salt peter*, and *almizader*[50] whose Complexion is Could and drye [...] first there is blackness, then followeth whiteness with salt Anatron.

The use of *natrun* together with *salammoniac* (*nushadir*) in the preparation of metals, such as whitening as mentioned above, was a common practice in Arabic alchemy.

In his work, *The Book of Seventy (Kitab al-Sab`in)*, and in the *Book of Twenty Articles* (Kitab *Al-Jumal al-`ishrin*), Jabir ibn Hayyan (d. *c.* 815) gave a number of chemical recipes in which he uses *al-natrun* as a flux for melting. Here are examples:

In *Kitab al Naqd* on iron (Mars) that is book 34 of the *Book of Seventy*, we read about the *istinzal* of iron (purification by melting in a descendary apparatus). Iron is first roasted with yellow arsenic (*zarnikh asfar*) several times. Then 'it is crushed and mixed with one third of its weight of *natrun* and kneaded with oil and melted, and it will descend as white as silver'.[51]

Gerard of Cremona (1114–1187) translated the *Book of Seventy* into Latin. The corresponding Latin text to the Arabic one reads in part: 'Deinde tere ipsum cum triplo sui de nitro. Et sperge cum oleo et distilla *Argentum* liquefactende.'[52] Thus in the 12th-century translation of Jabir's work the word *natrun* was translated as *nitro*.

A similar process is given in *maqala* thirteen of the *Book of Twenty Articles* (Kitab *Al-Jumal al-`ishrin*):[53]

> As for iron, take one *ratl* from it and throw on it one *ratl* of yellow *zarnikh* (arsenic). Roast it in a hard fire after it was made into filings. Take it out after one night and throw on it half a *ratl* of *yellow zarnikh* then return it to roasting. Do this twice. Take it out and throw on it one *ratl* of *red zarnikh* and roast for the

49. ye = the; yt.= that.
50. Al-mizader = Al-nushadir (ammonium chloride) according to Holmyard.
51. Jabir ibn Hayyan, *Kitab al-sab`in*, a facsimile edition produced by the Institute for the History of Arabic -Islamic Science, Frankfurt, edited by Fuat Sezgin, 1986, from MS Huseyin Chelebi 743, Bursa, Turkey, p. 205 The text can be read as three times.
52. The Latin translation of the *Book of Seventy* by Gerard of Cremona was published by M. Berthelot on the basis of BN manuscript number 7156; in *Archeologie et histoire des sciences*, Paris, 1906, reprint 1968, p. 347. Sections of the Latin text from Berthelot's book were quoted by Stapleton, H.E., Azo, R.F. & Husain, M.H. Chemistry in `Iraq and Persia in the tenth century A.D., *Asiatic Society of Bengal Mem.*, Vol 8, 1927, pp. 315–418.
53. *Kitab Al Jumal al-`ishrin*, MS Huseyin Chelebi 743, Bursa, Turkey, p. 489, Maqala 13.

third time, Then take it out and purify its blackness by the descendory process. The descendory process is done by grinding with it one quarter of its weight of *natrun*, knead it with little oil and place it in *but-bar-but* and cover it ... You descend it several times until it descends white and pure, better than silver in whiteness.

In *Liber Sacerdotum,* which is a medieval Latin translation of an Arabic work, we find a similar process: '*De preparando ferro quoddam secretum*'. The text that follows resembles that of Jabir in the *Book of Seventy* and in the *Book of Twenty Articles*. Here also, the corresponding Latin word to *natrun* is given as *nitro*.[54]

We find a similar description for the treatment of iron in Chapter XIV of Jabir's (Geber) Latin work *De Inventione Veritatis.*[55] Russell's English translation of the Latin text runs thus:

Prepare *Mars* thus: Grind one pound of the Filings thereof, with half a pound of Arsnick sublimed. Imbibe the Mixture with the Water of Salt-peter, and Salt-Alkali, reiterating this Imbibition thrice; then make it flow with violent Fire, and you will have your iron white.[56]

This description of the treatment of iron in *De Inventione Veritatis* is analogous to the text in the *Book of Seventy* and the *Book of Twenty Articles*, and the corresponding Latin word for *natrun* is *salis petrae* (*salt-peter*).[57]

In *Kitab al-Layla* on copper (Venus) which is book 36 of the *Book of Seventy* it is mentioned that in one treatment method, burnt copper or *rusakhtaj (copper scale)* is taken. It is heated and quenched in good pure oil, then heated and quenched many times. Then 'it is crushed, placed in *but-bar-but* (descendary vessel) and melted with *natrun* or other softening material and it will descend like gold'.[58]

54. Stapleton *et al.,* p. 355. The Latin text '*De preparando quoddam ferro secretum*.' is reproduced from Berthelot (Berthelot, *La Chimie*, I. p. 198, quoting from Biblio. Nat. Ms. lat. No. 6514).
55. *The Alchemical Works of Geber*, translated into English by Richard Russell in 1678, Introduction by E.J. Holmyard, reprinted by Samuel Weiser, 1994, p. 215.
56. Russell's translation, op. cit.
57. Stapleton *et al.* cited the Latin text of the Preparation of Mars where the word salt petrae occurs. And since Stapleton noticed the proximity of the Latin text to the Arabic texts of Jabir and Al-Razi he thought that the Latin translation of the Arabic word *natrun* into *salt petrae* was incorrect. Stapleton, among some others, held the fixed idea that the Arabic word *natrun* is not *salt petrae*. In the same footnote he says that an unknown mediaeval Latin writer published *De Inventione Veritatis* under the name of Geber. We notice here a clear contradiction: Stapleton says on the one hand that the word *natrun* was translated [from Arabic] into *salt petrae* wrongly, and at the same time he ascribes *De Inventione Veritatis* to an unknown Latin writer.
58. Jabir, *Kitab al-sab`in,* op. cit., p. 196.

In *Kitab al-Ghasl* on lavation of bodies and souls and which is book 61 of the *Book of Seventy* we read about the treatment of copper. Take one hundred *dirhams* of copper, forty *dirhams* of *zarnikh* (arsenic) and ten *dirhams* of sulphur and grind,

then beat *al-zuhra* (venus) into thin discs like *dirhams*, place it in a small pot and roast it and copper will become easy to crush. Crush it in a golden mortar and pan it off with water then throw on it salt and grind it and wash it. Then take it and grind it with *natrun* and oil, melt it and it will descend like silver in colour.[59]

In the Latin translation of *Kitab al-Ghasl* of the *Book of Seventy* by Gerard of Cremona the last sentence of the '*Ablutio Veneris* ' says: 'Tere ipsum cum nitro et oleo et fac ipsum descendere in botum barbotum. Et descendet colore Argenti.'[60]

In *De Inventione Veritatis* (Chapter XV) of Jabir (Geber), one description of the treatment of copper (Venus) reads thus:

Venus thus calcined, grind, 1 *lib.* of it with four *Ounces* of *Arsnick* sublimed, and imbibe the *Mixture* three or four times with the *Water of Lithargiry*,[61] and reduce the whole with *Salt-Peter*, and *Oyl of Tartar;* and you will find the Body of Venus white and splendid, fit for receiving the Medicine.[62]

This description of the treatment of copper (Venus) in *De Inventione Veritatis* is analogous to the two descriptions quoted from the *Book of Seventy*. Again, the corresponding Latin word for *natrun* is *nitro* and *salis petrae* (*salt-peter* in the English translation).

Jabir's (Geber's) Latin *De Inventione Veritatis* appeared in the latter part of the 13th century. It was thought until now that similar processes, in which saltpetre was used, never appeared before in Arabic. This gave rise to the doubtful conclusion by some historians of science that Geber was not the Arabic Jabir, and that saltpetre was known for the first time in the 13th century in the Latin West when the Geber's Latin works first appeared (see Chapter 3).

Al-Razi gave another analogous description for the treatment of iron in *Al-Madkhal al-Ta`limi*:

Take filings of iron, as much as you want, and having thrown on them one quarter their weight of powdered red *zarnikh*, stir (the mixture up). Then put it in a bag (*surrah*), and after luting it with good clay, place it in a hot *tannur* (oven).

59. Jabir, *Kitab al-sab`in*, op. cit., p. 329.
60. Berthelot, M. *Archeologie et histoire des sciences*, op. cit., p. 359.
61. Lithargiry = litharge, lead monoxide.
62. Russell, op. cit., p. 215.

Afterwards take it out, and weigh it. Then throw upon it one-sixth of its weight of *natrun*, and add olive oil to the mixture.

In al-Razi's other works, *Kitab al- Asrar*, and *Kitab sirr al-asrar*, we find numerous other recipes describing the treatment and preparation of iron, and copper in which *natrun* is used.[63]

We find the same practice also in al-Razi's *Liber Lumen Luminum (Light of Lights)*, where it is mentioned: 'Take equal amounts of *salt armoniac*, *saltpetre*, and *borax*; pound together, dissolve in a little wine, and let it dry. This will render the silver malleable.'[64]

A similar description for the treatment of iron occurs in the *Arabic Karshuni* manuscript. It says that after treating the iron filings with red and yellow arsenic take it out when it becomes cold; wash it with water and salt. When it is dried, mix it with one-sixth its weight of *natrun* kneaded with oil. Then it is melted and subjected to the process of *istinzal* in *the but-bar-but.*[65]

More similar citations can be given illustrating the use of *natrun* as a fluxing agent in early Arabic Alchemy.[66] This practice continued in later centuries as well, and we find numerous similar recipes in the works of Al-Jildaki and later alchemists.[67]

While discussing the use of potassium nitrate as a fluxing agent for metals, it may be relevant to mention here the use of this material in the refining of gold. Al-Hamdani (*c.* 251/865–313/925) in his book *Kitab al-Jawharatayn al-`Atiqatayn* describes a refining cementation process for gold called *ta`riq* (sweating). *Ta`riq*, he says, is a slight cooking which removes impurities and makes gold more malleable under the hammer. The usual drugs used are white vitriol or alum, salt, and yellow bricks, all ground. He says:

63. al-Razi, *K. al-asrar wa sirr al-asrar*, op. cit., p. 135 and several other pages.

64. Peter Bonus, op. cit., p. 368. As mentioned above, the *Liber luminis luminum* attributed to al-Razi was translated from Arabic by Gerard of Cremona. (See McVaugh, op. cit., p. 38). A treatise of a similar title is attributed to Michael Scot (see Thorndike, op. cit., vol. 2, p. 308). It was printed by Brown in 1897 as part of a work on Michael Scot. However, Thorndike presumed that it is the same as the *Lumen luminum* ascribed to Rasis in BN 6517. In MS Riccardian 118, ff. 35v–37v the following text appears: 'Incipit *liber luminis luminum* translatus a magistro michaele scoot philosopho', implying that Michael Scot was not the author (Thorndike, vol. 2, p. 308).

65. The Karshuni MS. Item 33, see Berthelot and Duval, op. cit..

66. As in the treatise of Salim al-Harrani *Kitab al-Shawahid fi al-hajar al-wahid* British Library ADD 23418, fo. 124b. Salim was a contemporary of al-Ma'mun and was in charge of Bayt al-Hikma. About Salim, see Sezgin, F., *Geschichte des Arabischen Schrifttums*, vol. IV , Brill, 1971, p. 272.

67. See for example British Library MS ADD 22756, fo. 114b, where we find a description of the use of *natrun* in the melting of iron filings.

The *ta`riq* may not affect the gold, either because of its nature, the inadequacy of fuel or because of the burning of the drug and the fineness of raw gold, so that the gold bars become dry. Then the gold refiners will heat the bars, and bury them either in the *salt of earth which is found at the feet of walls* (*milah al turab alladhi yakun fi usul al hitan*),[68] or in salt and vitriol.

From the above citations, we conclude that both in Latin and Arabic alchemical literature down to the 17th century, potassium nitrate were used as a fluxing agent in the smelting, melting and the refining operations of some metals. The Arabic words *natrun* and *al-milh alladhi yakun fi usul al-hitan* (wall salt), and the Latin words *nitrum* (nitre) and *salis petrae* (saltpetre) indicated potassium nitrate in these operations.

NATRUN IN THE PREPARATION OF NITRIC ACID AND AQUA REGIA

Having established that the Arabic *natrun* and the Latin *nitrum* denoted frequently potassium nitrate in Arabic and Latin alchemy, we can look into some recipes involving the production of nitric acid and aqua regia before the 13th century.

We have already mentioned the *Liber Luminis luminum*,[69] that is usually attributed to al-Razi, and which was published in a book on the life and legend of Michael Scot (d. 1235), on the assumption that it was one of Scot's works. The text gives a recipe for the preparation of nitric acid or aqua regia, by distilling a mixture of *sal nitrum*, sal ammoniac and vitriol. The Latin text runs thus:

M. cum sossile et nitro salso ana in aqua resolutis ac coagulatis es ad naturam lune reduxi. R. vitrioli romani Libra 1. salis nitri lihra 1 . salis armoniaci 3 . 3 . hec omnia comisce in unum terendo et pone in curcubita cum alembico et quod distillaverit serva et pone cum m. crudo ita quod in 3 aque fundatur super mediam libram m. in una ampulla et pone in cineribus bene clausam et da lentum ignem per unam diem et postea invenies m. in aquam purissmam.[70]

Adam McLean contributed the following translation:[71]

68. Al-Hamdani, al-Hasan ibn Ahmad, *Kitab al-Jawharatayn al-`atiqatayn min al-safra' wa al-bayda'*, Arabic text edited and translated into German by Christopher Toll, Uppsala, 1968; San`a' Arabic edition, 1985. p. 132.

69. See the footnote above on *Liber Luminis luminum*.

70. Brown, G. Wood, op. cit., pp.. 266 and 268.

71. See the Alchemy Web Site http://www.levity.com/alchemy/home.html for the archives of the Alchemy Academy Discussion Group moderated by Adam McLean.

> This text indicates that 'M' (usually a contraction for mercury in alchemical texts) must first be purified by being placed with 'sossile' and spirit of Nitre. ['Sossile' I do not recognise]. Then you perform a recipe, grinding together 1 pound of vitriol with 1 pound of nitre and 3 pounds of sal ammoniac, which you then heat in a flask and distill off a water. Then you are to place the purified 'M' (mercury) from your first stage and place this in a flask with three more parts of this acid distillate. The flask should be well sealed and heated gently for a day. After this, you should find mercury in this most pure water.[72]

On this recipe Adam McLean comments that 'this will produce a rather potent acid, indeed a mixture of nitric and hydrochloric acids – that is aqua regia – possibly with some sulphuric acid also as an impurity'.

Partington also says that this recipe gives apparently nitric acid or aqua regia.[73]

There are Arabic texts using the word *natrun* in the preparation of nitric acid and aqua regia that date from before the 13th century. One of these recipes describes the solution of sulphur with acids, and is given in *kitab al-mumarasa* (the book of practice) that forms book 65 of the *Book of Seventy* by Jabir ibn Hayyan (d. *c.* 815). The ingredients in the recipe are rice vinegar, yellow arsenic (*zarnikh asfar*), *natrun*, alkali salt, live *nura* (unslaked lime), eggshells, and purified salammoniac. The process, which involves distillation, produces aqua regia that is strong enough to put the sulphur into solution.[74]

Holmyard in commenting about the recipe for nitric acid in Geber's *De inventione veritatis (Invention of Verity),* says: 'The preparation of nitric acid, which is given in chapter xxiii, I have recently come across in a Cairo manuscript (the Royal Library) of a work ascribed to Jabir.'[75]

Holmyard says that the manuscript in question is *The Chest of Wisdom* (*Sunduq al-Hikma*) in Cairo.[76] The writer of this book was able to obtain a copy of this manuscript.[77] It is a collection of treatises that carry the title: *Sunduq al-Hikma*. The first treatise is *Sunduq al-Hikma* proper and is ascribed to Jabir. The style of writing raises some doubt about this. One of the treatises in the collection carry the tile *Kitab al-iqtisad al-hadi ila al-*

72. Adam McLean comments on the action of the resulting acid on mercury as follows: We should expect some of the mercury to have dissolved in the acid. Although mercury is not attacked by hydrochloric acid it will readily dissolve in Nitric acid. I am not quite sure if aqua regia , which is not merely a mixture of the two acids but has a special chemical structure, will readily dissolve Mercury.
73. Partington, op. cit., p. 87.
74. Jabir ibn Hayyan, *Kitab al-Sab`in*, op. cit., pp. 341–3.
75. Holmyard , in *Science Progress*, vol. 19, Jan. 1925, pp. 425–6.
76. Holmyard , *Alchemy*, Dover edition, p. 8; *Sunduq al-Hikma* is MS. 303, Dar al Kutub, Cairo, ff. 1b–24b (see Sezgin GAS, vol. iv, p. 265).
77. Courtesy of Mr Mahmud Amin al-`Alim, Cairo.

rashad which gives recipes attributed to Muhammad ibn Zakariyya al-Razi The recipes start at folio 56b and end on folio 69a. Between these, we read on folio 62a the following recipe:

> Take the water of eggs, [of] one hundred eggs, and one quarter of one *ratl* from salammoniac (*nushadir*), and two *qaflas*[78] of *natrun,* and *Yamani* alum (*shabb*) two qaflas. Bury this [mixture] in dung for seven days then take it out and distil it twice using the *qar`* (cucurbit) and *ambiq*. This distilled water is suitable for *zarnikh*, sulphur and mercury.

In an Arabic treatise, *Ta`widh al-îakim*, published in part by Ruska,[79] we read a description of the preparation of aqua regia which is called *al-ma' al-ilahi* (the divine water) or *ma' al-hayat* (the water of life). This treatise gives the recipes that were allegedly practised by al-Hakim (d. 411/1021) following the recipes that were used by Al Mu`izz (d. 365/975).[80] The recipes are traced back to Ja`far al-Sadiq (d. 148/765) in the works ascribed to him.[81] Ruska raised doubts about the date of authorship. He gave two dates between which he thinks that the *Ta`widh* was written; these are 1021 CE and the date of copying the manuscript in *Shawwal* 682 (early 1283). This last date is improbable as it is extremely unlikely that the scribe who copied several alchemical treatises in one collection should be considered as their author.

The ingredients are *natrun*, alum, the viriol of Cyprus, and sal ammoniac. The recipe starts with a description of the preparation of *natrun* water by solution:

> Dissolve one hundred *mithqals* of *natrun* by any solution method you choose; but the solution in wetness is the quickest.[82] Pound the *natrun* and put it in a porcelain pot (*kuz*) having holes in its bottom. Place the perforated pot over a China cup. Stretch on the top of the China cup a wet linen cloth. You should have wetted the *natrun* with a little fresh water so that it will adhere to the perforated pot. Place the cup and the pot in the wetness well. The *natrun* that will be dissolved by the wetness of the well will trickle into the cup through the holes of the pot.
>
> *Description of the wetness well*: Dig in the ground a well two *dhira`* (ells) in depth, wide at the bottom and narrow at the top. Put sand at the bottom. Fill the

78. *Qafla* is a measure of weight. In the Arabic dictionaries we read: *dirham qafla*. Qafla is a coin of one *dirham*.
79. Julius Ruska, *Arabische Alchimisten*, reprint in 1967 of the original work of 1924, pp. 115–16.
80. Al-Hakim (386-411/996-1021), sixth Fatimid caliph; Al-Mu`izz (341-65/953-75), the fourth Fatimid caliph.
81. Sezgin op. cit., Vol IV, pp. 293–4.
82. Solution in wetness is a standard method that was described by al-Razi in *K. al-asrar*, op. cit. p. 80. Solution of salts was a step preceding distillation for producing acids, p. 77.

well with water and leave it until the water saturates the sand and the soil of the well so that the sand becomes like mud. The well should be in a location immune from winds and not exposed to direct sun. Immerse the cup and the pot in the sand. Place at the top of the well a porcelain plate or closure and on top of that spread plenty of sand. The *natrun* will dissolve in two weeks or it may dissolve in ten days and it will descend in solution to the lower cup.

Weigh from this [*natrun* water] one hundred *dirhams*, and throw in it ten *dirhams* of alum, ten of salammoniac (*nushadir*) and five *dirhams* of *qalqatar* which is *zaj* (vitriol) available in Damascus, yellow in colour which has veins if broken. It is used by dyers in Syria and is imported from the island of Cyprus. After you throw the mixture in the *natrun* water leave the whole for two days and two nights and distil in a cucurbit (*qar'*) and alembic (*inbiq*). Take what is distilled and it will be clear and white as tears.

The above recipes for the preparation of nitric acid and aqua regia are similar to the Latin ones in *De inventione veritatis (Invention of Verity)* of Jabir (Geber). In Chap XXIII on solutive waters we read the following:

First R of Vitriol of Cyprus. Lib. 1 of Salt-peter, lib. ff. and of Jamenous Allum one fourth part; extract the water with Redness of the Alembick (for it is very solutive) and use it before alleadged Chapters. This is also made much more acute, if in it you shall dissolve a fourth part of Salammoniac, because that dissolves Gold, Sulphur, and Silver.[83]

Further we read:

Our other Philosophical Cerative Water, is this: R Oil distilled from the Whites of Eggs, grind it with half so much of Salt-peter, and of Salammoniac, equal parts, and it will be very good.[84]

The Latin recipe of *Liber Luminis luminum*, and the various Arabic recipes that were cited, all of them antedate the appearance of Jabir's (Geber's) *De inventione veritatis* in Latin at the end of the 13th century in which the recipe for nitric acid was given. In addition, contrary to the common belief that was prevalent until now, it is evident that Geber's Latin recipes of the 13th century were not the first ones to describe the preparation of nitric acid (see Chapter 3).

THE DIFFERENT ARABIC NAMES FOR POTASSIUM NITRATE

Al-Shiha that is Found at the Feet of Walls or *Milh al-ha'it* (Wall Salt)

83. Russell, *The Alchemical Works of Geber*, op. cit., p. 223.
84. Russell, op. cit., p. 224.

We have mentioned above, in discussing the classifications of al-Razi and the Karshuni MS, that *Al-Shiha that is found at the feet of walls* denoted potassium nitrate.

When discussing the refining of gold, we mentioned also that al-Hamdani who was contemporary with al-Razi used a similar expression: *milah al turab alladhi yakun fi usul al-hitan* (earth salt that is found at the feet of walls) to denote potassium nitrate.

According to al-Kutubi (about AD 1311) in his work *ma la ysa`u al-ʿabiba jahluhu* (what a physician cannot afford to ignore), *barud* or potassium nitrate was called *milh al-ha'it* (salt of wall) by the common people of Iraq. 'It is the salt that creeps on old walls, and they collect it.'[85]

The term *milh al ha'it* (salt of the wall) was listed in the Karshuni manuscript among the artificial or prepared salts, since it was to be collected and treated. The seven artificial are:

1-The *al-qili* (alkali) salt; 2- The *nura* (lime) salt; 3- The *bawl* (urine) salt; 4- al-*sha`r* (hair) salt; 5- The wood ashes salt, which is *sabarzaj*; 6- *milh al ha'it* (wall salt); 7- al-*tinkar* salt. All these salts are used for whitening; they clean the dirt and remove blackness, and are utilised in dissolving bodies and spirits. These are their actions.[86]

The practice used in Iraq in the 9th and 10th centuries for scraping *milh al-ha'it* (wall-salt or saltpetre) from walls was described in numerous works in Europe in much later centuries. These works describe the construction and operation of nitre beds and the scraping of saltpetre from walls built especially for the purpose of growing saltpetre.[87]

The Flowers of *Asyus* Stone, the Salt of *Asyus* Stone and the Salt of Stone

Ibn al-Baytar (d. 1248) defines *asyus* thus: 'Ancient physicians of Egypt call it China snow (*thalj al-Sin*), and it is known as *barud* by the common people and the physicians of al-Maghrib.'[88] Then he defines *barud* thus: 'It is the flowers of *asyus* stone.'[89] Further, *thalj sini* (Chinese snow) is defined as: 'It is *al-barud* that is known as the flowers of *asyus* stone.'[90] Also *hajar asyus*

85. Al-Kutubi, Yusuf ibn Isma'il, *ma la yasa'u al-tabiba jahluhu,* MS Ahmadiyya 1262, ff. 17b and 36b.
86. Berthelot and Duval, op. cit., the Karshuni manuscript, article 74, pp. 163–4.
87. Partington, op. cit., pp. 315 and 319.
88. Ibn al-Baytar, op. cit., vol. I, p. 41.
89. Ibn al-Baytar, op. cit., vol. I, p. 114.
90. Ibn al-Baytar, op. cit., vol. I, p. 206.

(stone of *asyus*) is defined as: 'It is *al-barud* ... and the people of Egypt know it as the snow of China.'[91]

As mentioned above, Al-Kutubi described potassium nitrate as the salt that creeps on old walls. In his definition of *barud* he says: '*barud* is the name that denotes the flower of *asyus*'.[92]

The extent to which the term *asyus* was prevalent in the Islamic lands is not clear. However, it seems that this terminology was used in certain regions. For instance, Dawud Al-Antaki (d. 1599), who was born in Antioch and lived part of his life in Anatolia, Damascus and Cairo, reported in his book *al- Tadhkira* under item *barud*, the following: 'it is called in our country (*`indana*), *ashush* and *milh sini* (Chinese salt)'.[93] It is apparent that *ashush* is a distortion of the term *asyus*. When he says 'in our country' he means in the region of Antioch in north-west Syria, where Al- Antaki had lived most of his life.

The expression *milh hajar asyus* (salt of *asyus* stone) becomes *milh al-hajar* (salt of stone) when dropping the word *asyus*. We actually find in some treatises that potassium nitrate or *barud* was described as *milh al-hijara* (salt of stones).[94] This is a synonym for the word *saltpetre* (salt of stone or salt of rock) in its different forms in Latin and Western languages.

Konrad Kyeser (d. *c.* 1405) used the word *assio* (*assionis*) for saltpetre in his book *Bellifortis*, which is a manuscript on warfare. In a recipe for nitric acid or aqua regia, he specifies distilling *Roman Vitriol* with *permisce Assionis* or with sal *armoniacum* (sal ammoniac) mixed with *permisce Assionis*.[95] The important aspect in *Bellifortis* is that the term '*Permisce Assionis*' is used in lieu of saltpetre or sal nitrum. Partington says that Keyeser gave illustrations of incendiary arrows and a rocket, apparently from an Arabic manuscript since the man in the illustration has Arabic dress.[96]

However, the use of the term *asyus* in Arabic or Assio or Asius in Latin, to denote potassium nitrate did not receive wide acceptance, either in Arabic or in Latin. A vague connection between *nitrum* and 'Asian rock or *Lapis Asius*' is expressed in the *Lexicon* of Rolandus when discussing *nitrum*:

---

91. Ibn al-Baytar, op. cit., vol. I, p. 264.
92. Al-Kutubi, op. cit.
93. Al-Antaki Dawud ibn `Umar, *Tadhkirat uli al-albab*, vol. 1, Cairo, 1356 H/1937 A.D., p. 62.
94. Anonymous, an Arabic military treatise containing, among other things, numerous formulations of gunpowder. MS Bashir Agha 411.
95. Partington, op. cit., p. 150. Partington quotes Romocki in this case. Von Romocki, *Geschichte der Explosivstiffe,* 1895, I, pp. 133–78.
96. Partington, pp. 147–8.

> There is also that Nitre which is called Spumous, and is Aphronitrum, Saltpetre, the spume of Nitre, and a true species of Nitre. It has affinities with the flower of the Asian rock or stone, referred to by Dioscorides.[97]

Barud

The results that were given above and which proved that potassium nitrate were known and were used in Arabic and Latin alchemy before the terms saltpetre and *barud* became common, diminish the importance of the dates that were considered by historians of science as landmarks in the history of chemistry. The date 1240 CE when Ibn al-Baytar mentioned the word *Barud*, and the date of the first appearance of Jabir's (Geber's) Latin work *De inventione veritatis* at the end of the 13th century, with a recipe for nitric acid, are no longer critical dates in the history of science as we were traditionally taught.

Although the date when the word *barud* first appeared is not so critical now, yet it is still of interest to study the history of the word. Until recently, Ibn al-Baytar was considered the first to mention the word *barud* in 1240. However, there are indications in the literature that the word was mentioned earlier.

Al-Jawbari, Abdul Rahim ibn `Umar al-Dimashqi, wrote *al-mukhtar fi kashf al-asrar wa hatk al-astar* in which he warned the general public against trickery in all forms. He says in his book that he met in Egypt in 617/1219–20 Shaykh Abdul Samad the skilled manjaniq maker. This indicates that Al-Jawbari probably wrote his book between 1220 and 1222 since he presented it to the last Artuqid ruler of Amid, al-Sultan Al-Mas`ud Rukn al-Din Mawdud (ruled 1222–1231), who was deposed by al-Malik al-Kamil (ruled 1218–1238), the Ayyubid Sultan. In *al-mukhtar* the word *barud* occurred at least four times as *barud thalji* (snow like *barud*) and *milh al barud* (salt of *barud*).[98]

We have already mentioned the Karshuni Arabic manuscript that was compiled between the 9th and 11th centuries according to Berthelot and Duval. If we accept these date limits then it antedates the work of Ibn al-Baytar. Moreover, even if we consider von Lippmann's doubts about the dates, the Karshuni manuscript was based on material that was long established in the area before the 13th century as we can infer also from Al-Jawbari's work. There are several recipes in the Karshuni manuscript that use the word *barud*. Here are two:

---

97. Rolandus, *Lexicon*, p. 239.
98. Al-Jawbari, Abdul Rahim ibn 'Umar al-Dimashqi, *al-mukhtar fi kashf al-asrar wa hatk al-astar*, Damascus, 1302/1884, pp. 22; 26; 118.

Item 174 - *For a violent fusion* – two parts pure alum; 2 burnt copper, two *barud*;[99] one black [vitriol];[100] two *tutiya*;[101] one honey; let the work be done in an enamelled glass ware (*zujaja khazafiyya*), [one adds] raisins and one [olive] oil; and begin work.

Item 175 – Alkali from wild rue (*harmal*); borax (*bauraq*) from alkali, sal ammoniac (*nushadir*) from *sawad*;[102] pure alum from its stony minerals; *barud* is taken from its sources; mercury is extracted from its red ores; the two stones of arsenic from metal ores [the two stones extracted from pyrites with a colour of fire are also employed].[103]

From Ibn al-Baytar, we learn that in North Africa the term *barud* was widespread among both the public and the physicians before he published his book in 1240. Since it requires a considerable length of time for a term to be adopted by the public, it may be concluded that the word *barud* was prevalent before 1240 by several decades; and one can safely assume that the word was used in al-Maghrib at least in the second half of the 12th century.

The same argument can be made from reading the front page of *Al-furusiyyah wa al-manasib al-harbiyya* (*The Book of Horsemanship and Weapons of War*) of Najm al-Din Hasan al-Rammah (d. 695/1295). This book was written between 1270 and 1280 and it was the first book in any language to discuss potassium nitrate and the use of *barud* in gunpowder and in military applications. The front page states that the book was written as:

instructions by the eminent master (*ustadh*) Najm al-Din Hasan Al-Rammah, as handed down to him by his father and his forefathers, the masters (*al-ustadhin*) in this art, and by those learned elders and masters from among their circles, may God be pleased with them all.[104]

It is unmistakable from this statement that Al-Rammah was not the inventor of all the recipes on *barud* and gunpowder but that he had inherited this knowledge from his father and forefathers, the masters in this art, and from the masters who befriended them. The detailed information and the elaborate designs recorded in his book support the statement in the front page that this

99. The word *barud* came in the Arabic text, but Duval translated *barud* into natron, [Berthelot and Duval, op. cit., p. 187], which means sodium carbonate in modern European languages. This is a gross error with no explanation.
100. The word vitriol was added in Duval's translation, p. 187. Words between square brackets are added by Duval to the French translation.
101. Translated as antimony by Duval.
102. Translated as soot (suie) by Duval.
103. Berthelot and Duval, op. cit., articles 174 and 175, p. 197. This is Duval's translation of an obscure Arabic text. The Arabic of these two items are rather poor.
104. Al-Rammah, Najm al-Din Hasan, *Al-Fur'siyya wa al-Manasib al-harbiyya*, edited with analytical introductory chapters by Ahmad Y. al-Hassan, Aleppo, 1998, p. 63.

knowledge was handed down to him from generations past. If we go back only to the generation his grandfather, as the first of his forefathers, then we end up at the end of the 12th century or the beginning of the thirteenth as the date when *barud* as an ingredients for gunpowder became prevalent in Syria where Al-Rammah was practising his military art.

Shura

In the Persian dictionary, *Burhan Qati`*, compiled in 1651 by Muhammad Al-Tabrizi the term *shura* in Persian is *barud.*[105] In modern Persian dictionaries *shura* is potassium nitrate. We find the word in Arabic alchemical treatises. In *Sunduq al-Hikma*, attributed to Jabir Hayyan, *shura* is listed among the pseudonyms that are given to the *Stone* (*al-Hajar*).[106] In distilling the Stone (*al-Hajar*), the distillates are called also by various pseudonyms *ma' shuri* (water of shura).

Shuraj

Shuraj is the older word for *shura*.[107] Dozy defined it as nitre.[108] In 869 CE, the rebellion of the Zanj slaves took place in Basra against the Abbasid Caliph. These slaves were employed in the *Shuraj* industry on the lower Euphrates. Some modern historians interpreted *Shuraj* as saltpetre.[109] The word for saltpetre in the late Sanskrit is *shoraka* which is taken from *Shuraj*.[110]

Suraj

Ibn al-Baytar gave a definition for *Suraj* and based his description of it on Dioscorides and Galen. It is a kind of foamy salt or flowers formed on rocks near the sea.[111]

105. Tabrizi, *Burhan Qati'*, edited by Muúammad Mu'in, Tehran, 1951, p. 216 and p. 1308.
106. *Sunduq al-hikma*, MS. Dar al-Kutub, Cairo 311, fo. 26b.
107. Colin, G. S. in *EI*, item Barud.
108. Dozy, R. *Supplement aux dictionnaires arabes*, vol. 1. Reprinted by Libraire du Liban, 1968, p. 801.
109. Hitti, Philip, *History of the Arabs*, Macmillan, 1970, p. 468; also R.A. Nicholson, *Literary History of the Arabs*, London, 1907, p. 273. Forbes in *Studies in Ancient Technology* (Brill, 1965, vol. 3, p. 188), says that saltpetre was known and was used in ancient Mesopotamia. It was obtained as an efflorescence of the soil in certain places where organic matter decayed. It was collected and treated to obtain the crystals of saltpetre. See also Martin Levey. It seems that this ancient practice in these lands continued into Islamic times.
110. Partington, op. cit., p. 215.
111. Ibn al-Baytar, op. cit., vol. 2, p. 56.

***Milh al-Dabbaghin* (tanners salt)**

Milh al-dabbaghinn (tanners salt) according to Ibn al-Baytar, is *suraj.*[112] Dozy also defined *milh al-dabbaghin* as nitre.[113]

***Shabb Yamani:* Misnomer for Potassium Nitrate**

Some physicians were not able to differentiate potassium nitrate from other chemicals. We have a case here where Ibn Bakhtawayh, the physician, in his book *Al-Muqaddimat* (composed in 420/1029), described the freezing of water at any season by using potassium nitrate, confusing it with *Shabb Yamani* (Yamani Alum). Ibn Abi Usaybi`a (1203–1270), gave this information in his book *Uyun al anba*. He says:

> He (i.e. Ibn Bakhtawayh) claimed that one takes one *ratl* of choice Yamani Alum, place it inside a new earthenware pot and grind it well into a fine powder; add to it six *ratls* of pure water; place the pot inside a *tannur* (oven) that is sealed with clay, until two thirds of the mixture evaporates. The remaining one third of the mixture will become thick. Place it inside a bottle and seal its aperture securely. If you desire to use it [to make ice], then get a new *thaljiyya* (vessel for making ice) in which you put pure water, Add to the pure water ten *mithqals* (ounces) of the already prepared alum water. Let it set for one hour; it will turn into ice.[114]

Von Kremer, and Fisher, confirmed independently that the *Shabb Yamani* in this case is in reality potassium nitrate, which has the property of lowering the temperature of water.[115] In the period during which Ibn-Bakhtawayh had lived, namely the 10th/11th century of our era, an author identified potassium nitrate by one of several labels, depending on what he thinks. It is of importance to note that as early as the 10th/11th century Ibn Bakhtawayh had described a process of purifying potassium nitrate by dissolving its basic components in water, and evaporating the excess water. A small amount was then taken from this concentrated substance and dissolved in the water that is to be cooled.

112. Ibn al-Baytar, vol. 2, p. 458.
113. Dozy, op. cit., vol. 2, p. 618, and vol. 1, p. 801.
114. Ibn Abi Usaybi`a ,*`Uyun al-anba' fi tabaqat al- atibba'*, ed. Nizar Rida, Beirut, 1965, p. 124.
115. Partington, pp. 311–12, and note 191, p. 335.

8 Gunpowder Composition for Rockets and Cannon in Arabic Military Treatises in the 13th and 14th Centuries

A GAP IN THE HISTORY OF GUNPOWDER AND CANNON

In some documented histories of warfare and weapons in the Middle Ages and the Renaissance there is a noticeable gap in the history of gunpowder and cannon in the 13th and 14th centuries. Some authors jump from China in the Far East to Europe in the far west with the slightest reference or no reference at all to the Arabic and Islamic lands that spanned the whole distance between east and west. In the 13th century, technology could hardly have been transferred between the two extremities of the old world unless it passed through the Arabic and Islamic medium and subjected to more developments.

It is not our purpose in this chapter to review the history of gunpowder and cannon in China and Europe. We shall revisit some Arabic sources that were known and repeatedly discussed since the middle of the 19th century, and shall add a few more manuscripts and sources that were not discussed before.[1] We shall analyse gunpowder composition for rockets and cannon as they are given in these manuscripts, and shall discuss briefly the development of cannon in the 13th and 14th centuries in the Mamluk Kingdom and in Muslim Spain. We conclude with a brief note about fireworks.

POTASSIUM NITRATE

In Chapter 7, we explained that Arabic alchemists knew potassium nitrate since the start of Arabic alchemy at the time of Khalid ibn Yazid (d. *c.* 709). It was known under various names, was used as a flux in metallurgical operations and for producing nitric acid and aqua regia. We find recipes for these uses in the works of Jabir ibn Hayyan (Geber, d. 815), Abu Bakr al-Razi (Rhazes, d. 932) and other alchemists.

Throughout the centuries, potassium nitrate in Arabic was known by a variety of names, and the most important of these was *natrun*. It was called also: *bauraq; al-shiha that is found at the feet of walls*; *milh al-ha'it* (wall

1. Renaud and Fave, 1848.

salt); flowers of *asyus* stone; salt of *asyus* stone; salt of stone; *shura*; *shuraj; suraj; milh al-dabbaghin* (tanners salt); *shabb Yamani* and lastly *barud*.

PURIFICATION OF POTASSIUM NITRATE

Before potassium nitrate can be used effectively in gunpowder, it should be purified. Two processes occur in Arabic literature:

1 The Process of Ibn Bakhtawayh (Early 11th Century)

Ibn Bakhtawayh, the physician, in his book *Al-Muqaddimat* (composed in 420/1029), described the freezing of water at any season by using potassium nitrate calling it *shabb* (alum) *Yamani* (see Chapter 7).

2 The Process of Hasan al-Rammah (13th Century)

Hasan al-Rammah describes in his book *al-furusiyya wa al-manasib al-harbiyya* (*The Book of Military Horsemanship and Ingenious War Devices*) [2] a complete process for the purification of potassium nitrate. This same process became a standard one in Arabic sources and we find it in various military treatises. It runs as follows:[3]

> Take from white, clean and bright (or fiery) *barud* (saltpetre) as much as you like and two new (earthen) jars. Put the saltpetre into one of them and add water to submerge it. Put the jar on a gentle fire until it gets warm. Skim off the scum that rises (and) throw it away. Make the fire stronger until the liquid becomes quite clear. Then pour the clear liquid into the other jar in such a way that no sediment or scum remain attached to it. Place this jar on a low fire until the contents begin to coagulate. Then take it off the fire and grind it finely.

The procedure is further continued using wood ashes, which would precipitate calcium and magnesium salts:

> Take dry willow wood, burn it, bury it (smother it) as is with the *harraq* (tinder). Take by weight two thirds of saltpetre and one third of ashes of wood, which has been carefully pulverised, and put the mixture into the jar, and if the jar is made from copper so much the better. Add a little quantity of water and apply heat until the ashes and saltpetre no longer adhere together. Beware of sparks.

In this method, calcium salts are removed by adding potassium carbonate in the form of wood ashes. Thus, calcium carbonates are precipitated and can

2. Al-Rammah's book.
3. Al-Rammah, p. 130.

be removed leaving the chemically equivalent amount of potassium nitrate in solution. Saltpetre is obtained from this solution by crystallisation.

The method of al-Rammah is the first in which wood ashes were used in the manufacture of saltpetre. Partington says that: 'the claim that Roger Bacon used wood ashes is based on an arbitrary manipulation of a text, and the first clear account of the process known to me is that of al-Hasan al-Rammah'.[4]

USE OF POTASSIUM NITRATE DURING THE CRUSADES

A subject that is still in its initial stages of investigation is the early use of potassium nitrate during the Crusades. There are advocates of the theory that potassium nitrate were used as a component of Greek fire whether Byzantine or Arabic.[5] We shall mention here a few cases that suggest the use of nitrate by the Arabs during the time of the Crusades.

1. In the year 564 H/1168 AD the *Firanja* (the Franks or the Crusaders) besieged al-Fustat (old Cairo). Shawar[6] decided to burn the city. Al-Maqrizi says that 20,000 pieces of *karaz shami* (ceramic Damascus grenades) full of incendiary materials were used. Al-Fustat continued burning for 54 days.[7] Mercier obtained several grenades from the site and their contents were analysed. The tests proved the existence of potassium nitrate.[8]

2. A military treatise that discusses military fires on a large scale is entitled *Treatise on Stratagems in Wars, the Capture of Towns, and the Defence of Passes* This gives a large number of Greek fire recipes. It describes Islamic military technology during the 12th century. In one recipe, *natrun* is one of the combustible ingredients.[9]

3. During the fifth Crusade that was directed against Egypt, Damietta was besieged in 1218 and the besieged used Greek fire extensively in their

4. Partington, p. 201.
5. Mercier, p. 9.
6. Shawar became minister in 559/1164. His treachery was serious, for he asked for the intervention of Amalric I to drive the forces of Shirkuh (his opponent) out of Egypt. The Franks besieged Fustat (Cairo), and Shawar became alarmed and was trying to negotiate the withdrawal of the Frankish troops. Being unable to defend Fustat, he had set the city on fire.
7. al-Maqrizi, p. 339.
8. Mercier, pp. 98–9, annex No. 1, p. 131.
9. *Al-Hiyal fi al-hurub*, p. 175 (published text of al-Rahili).

defences. Lalanne believes that the Arabic jars of fire contained potassium nitrate.[10]

4. The seventh Crusade was also directed against Egypt. Louis IX led a well-prepared invasion and occupied Damietta in 1249. By this time gunpowder was known in Syria and Egypt, and in the battle of al-Mansura in 1250, in which Louis IX was taken prisoner, the use of large pots full of gunpowder and other combustibles was the key in the victory of the Arab Army. Joinville who was an officer and an eyewitness of the battle described eloquently these projectiles and their effect on the Frankish army. His description left no doubt among some historians that he was describing projectiles containing gunpowder.[11] In their history of rockets, published on the internet, NASA says, 'the Arabs adopted the rocket into their own arms inventory and, during the Seventh Crusade, used them against the French Army of King Louis IX'.[12]

5. Gunpowder was used extensively in 1291 at the very end of the Crusades during the siege of Acre, in which the city capitulated. Western historians described the extensive mining of the city walls by gunpowder. A large number of manjaniqs (trebuchets) projected military fires containing gunpowder. In addition, archers threw huge amounts of arrows carrying gunpowder devices. Large numbers of Arab engineers participated in the siege.[13]

GUNPOWDER COMPOSITION OF AL-RAMMAH'S ROCKETS (1280 CE)

Al-Rammah (d. 695 AH/1295 CE) deals extensively in his book, *Kitab al-furusiyya,* with gunpowder and its uses. The estimated date of writing this book is between 1270 and 1280. The front page states that the book was written as:

> instructions by the eminent master Najm al-Din Hasan Al-Rammah, as handed down to him by his father and his forefathers, the masters in this art and by those contemporary elders and masters who befriended them, may God be pleased with them all.

10. Lallane, pp. 52–4.
11. Joinville, p. 216, see also Mercier, pp. 77–8.
12. http://science.ksc.nasa.gov/history/rocket-history.txt
13. The fall of Acre was described by several western historians. See Runciman, pp. 412 to 421.

It is unmistakable from this statement that Al-Rammah compiled the inherited knowledge. The large number of gunpowder recipes and the extensive types of weaponry using gunpowder indicate that this information cannot be the invention of a single person, and this supports the statement in the front page of his book. If we go back only to his grandfather's generation, as the first of his ancestors, then we end up at the end of the 12th century or the beginning of the 13th as the date when gunpowder became prevalent in Syria and Egypt.

The book contains 107 recipes for gunpowder.[14] There are 22 recipes for rockets (*tayyarat,* sing. *tayyar*). Among the remaining compositions, some are for military uses and some are for fireworks. The gunpowder composition of seventeen rockets is shown in Table 8.1. Five rockets are not included because their ingredients included other materials. We limited ourselves for the sake of comparison to the three main ingredients.

If we look at the table and the graph, we notice that most ratios fall around the median lines with few odd points only. The median value for potassium nitrate is 75 per cent. The minimum odd value is 68.57 per cent and the extreme odd one is 88.07.

Bert Hall reported that most authorities regard 75 per cent potassium nitrate, 10 per cent sulphur, and 15 per cent carbon to be the ideal recipe.[15] Al-Rammah's median composition for 17 rockets is 75 nitrate, 9.06 sulphur and 15.94 carbon which is almost identical with the reported ideal recipe.

Table 8.1 Gunpowder composition for 17 rockets from al-Rammah (1280 CE).

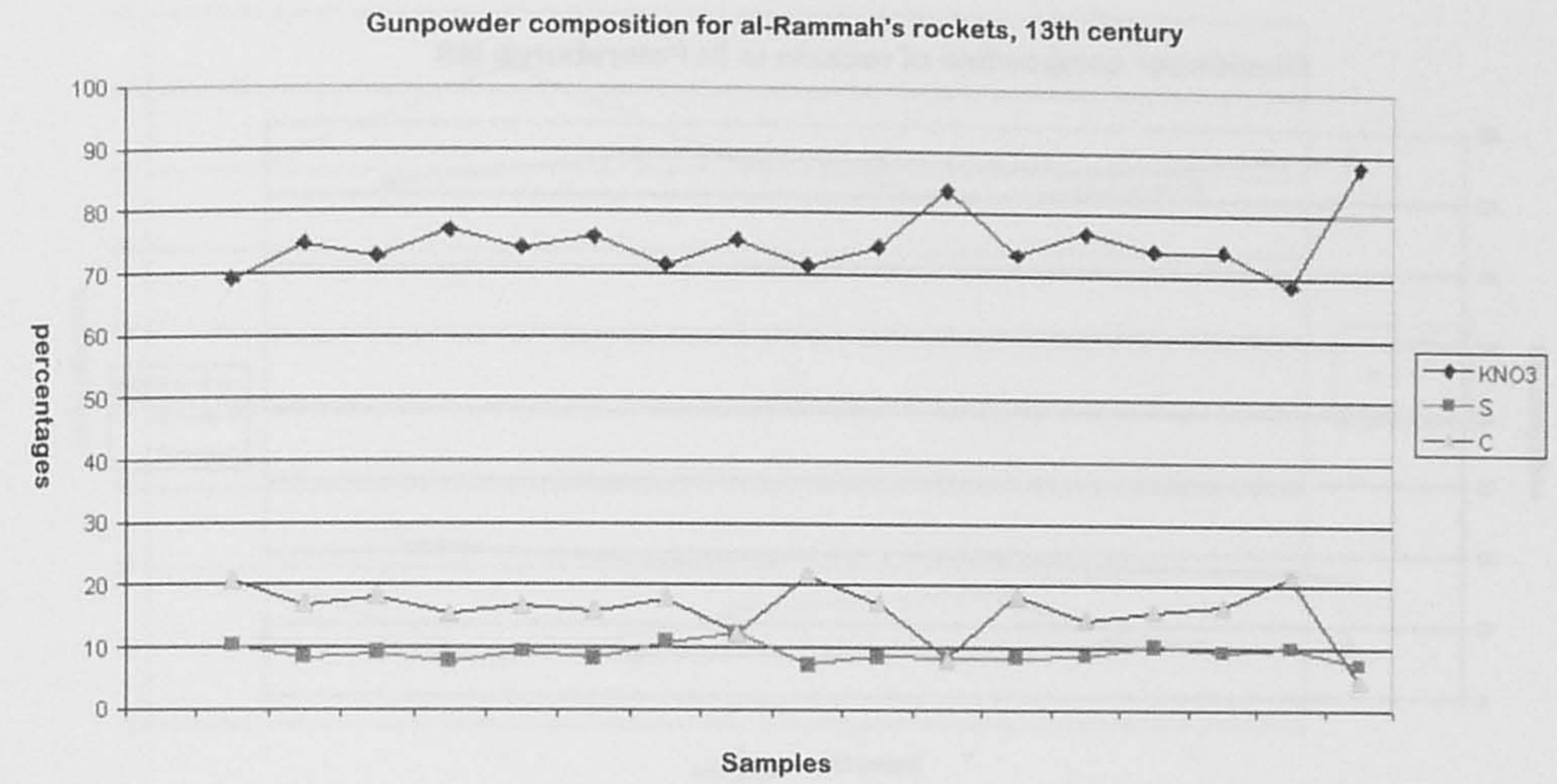
No.	*Description*	*KNO3*	*S*	*C*
18a	Tayyar (rocket)	10 69	1.5 10.33	3 20.67
19a	Tayyar (rocket)	10 74.77	1.125 8.41	3.25 16.82
21a	Tayyar (rocket)	10 76.92	1 7.70	2 15.38
22a	Tayyar (rocket)	10 74.07	1.25 9.26	2.25 16.67

14. Al-Rammah, pp. 70–7, and 131–7.
15. Hall, Bert, p. 67.

Table 8.1 (continued)

No.	*Description*	*KNO3*	*S*	*C*
23a	Tayyar (rocket)	10 75.95	1.083 8.23	2.083 15.82
25a	Tayyar (rocket)	10 71.43	1.5 10.71	2.5 17.86
26a	Tayyar mujarrab (tested rocket)	10 75.47	1.625 12.27	1.625 12.26
28a	Tayyar muqdah (roast rocket)	10 71.43	1 7.14	3 21.43
1b	Tayyar Majnun (mad rocket)- lifts I Dam. ratl + 7.5 uqiyya =2.13 kg	12 74.42	1.375 8.53	2.75 17.05
2b	Tayyar (rocket), lifts 1 Dam. Ratl = 1.85 kg	9 83.72	0.875 8.14	0.875 8.14
3b	Tayyar Tunsi (Tunisian rocket)	11 73.33	1.25 8.34	2.75 18.33
4b	Tayyar sakran (drunk rocket)	10 76.93	1.125 8.64	1.875 14.43
5b	Tayyar buruq (lightning rocket)	10 74.07	1.375 10.19	2.125 15.74
6b	White tayyar (rocket) without sparks	10 74.07	1.25 9.26	2.25 16.67
34b	Heavy tayyar (rocket) lifts 1.25 Dam. Ratl = 2.313 kg	12 68.57	1.75 10	3.75 21.43
36b	Tayyar (rocket) for arrows	12 88.07	1 7.34	0.625 4.59
	Average for 17 rockets	75	9.03	15.97

Notes: Series (a) are the main gunpowder formulations of al-Rammah. They are 65 in number and occur on pp. 70–7 of the published Arabic text. Series (b) are the second series of formulations. They are 42 in number and occur on pp. 131–7. First line is in dirhams and second line shows percentages.



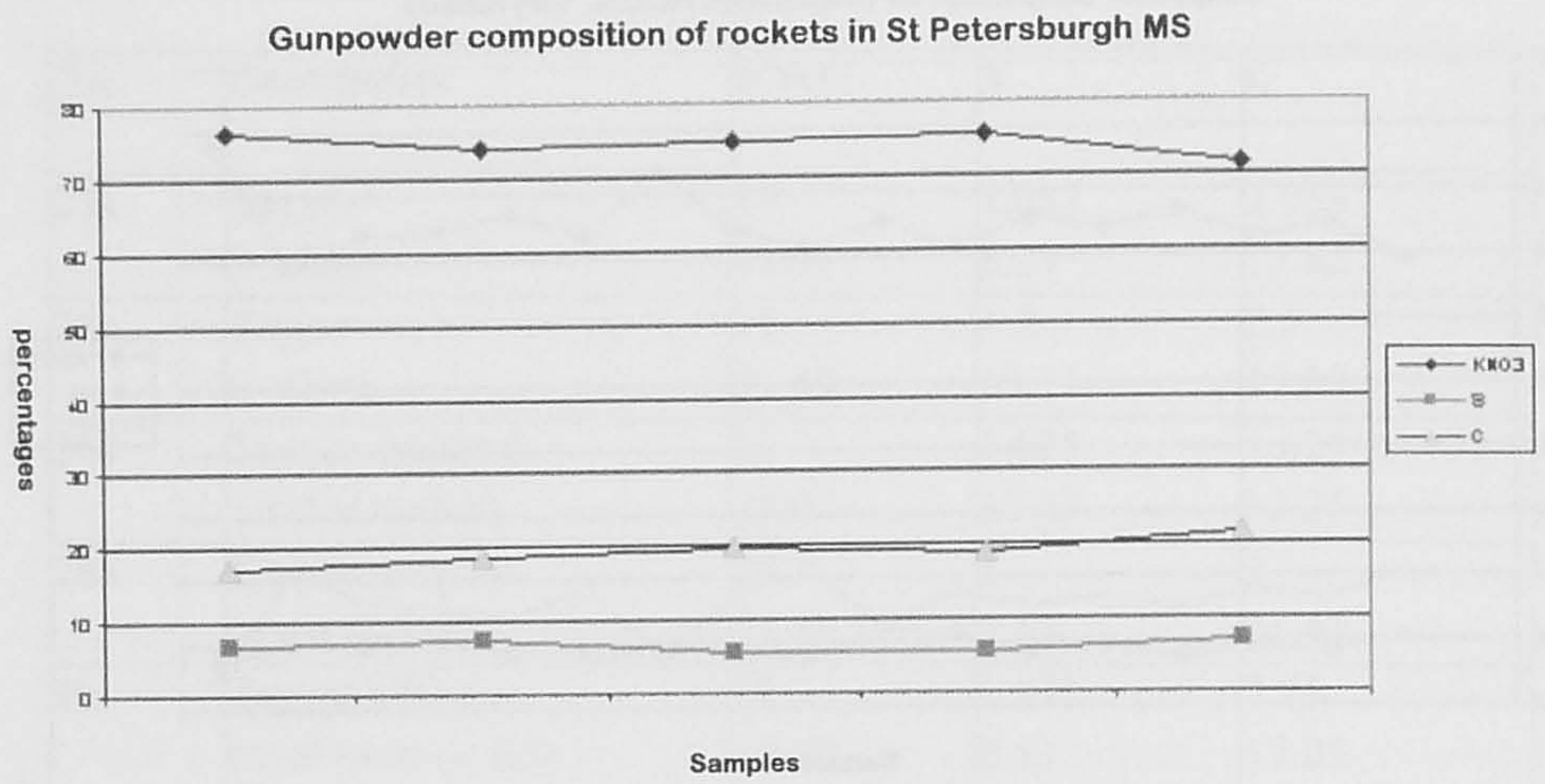
GUNPOWDER COMPOSITION FOR ROCKETS IN *FUNUN AL-NAFT* OF ST PETERSBURGH MS

We shall describe the St Petersburgh manuscript in more detail when we discuss cannon, below. There is a chapter in this manuscript under the title '*funun al-naft min al- jidd wa al-hazl*' (The art of gunpowder for serious work or for pleasure). It gives a list of gunpowder compositions for pleasure (fireworks) and for war including five compositions for rockets as shown in Table 8.2.[16]

Table 8.2 Rockets from St Petersburgh MS, early 14th century

	KNO3	S	C
	76.19	6.67	17.14
	74.07	7.14	18.52
	74.77	5.6	19.63
	75.47	5.66	18.87
	71.43	7.14	21.43
Average	74.38	6.5	19.12

16. St Petersbugh MS., *al-makhzun*, pp. 148, 149, 150.



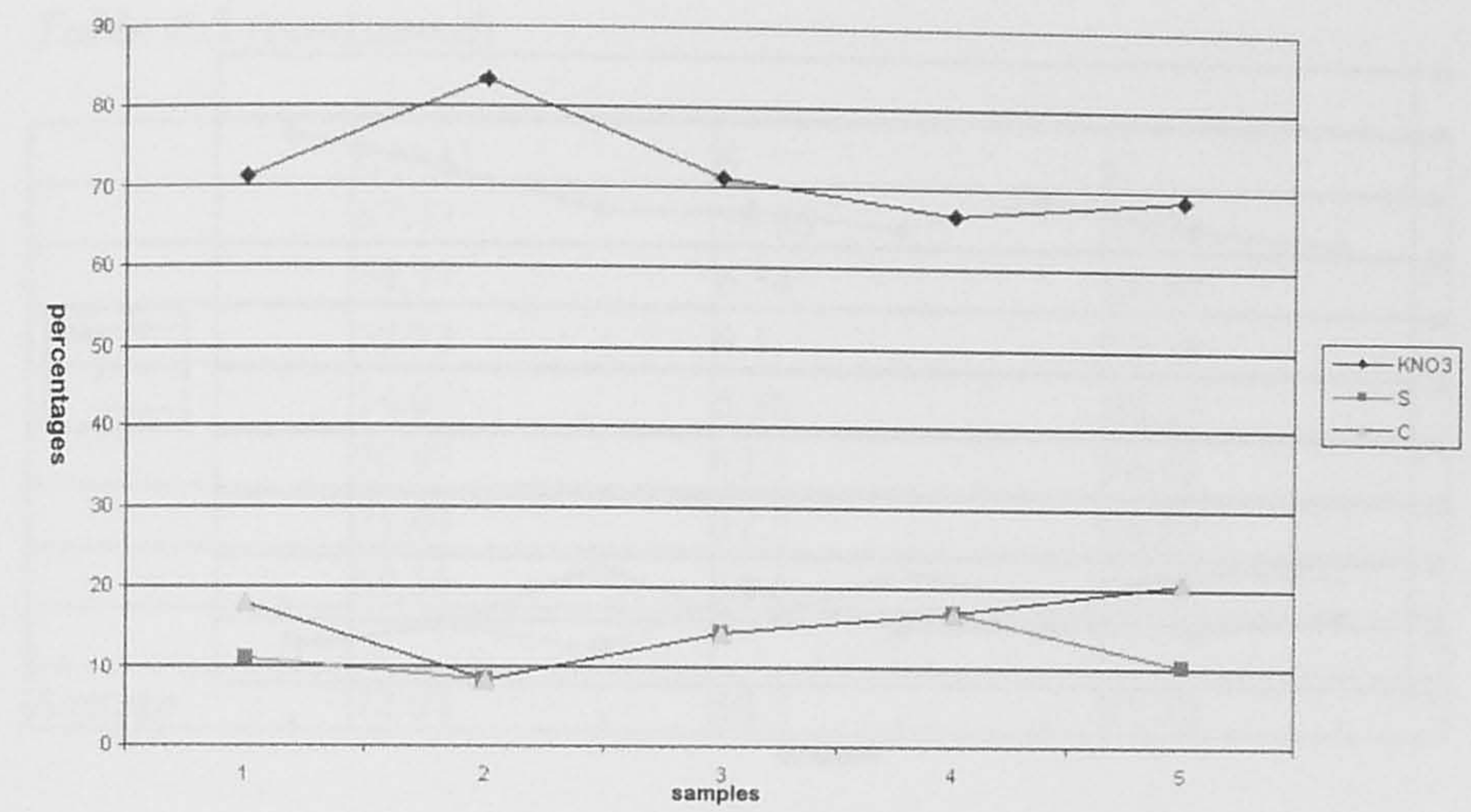
GUNPOWDER COMPOSITION IN AL-KARSHUNI MANUSCRIPT FOR MISCELLANEOUS MILITARY PURPOSES, 11TH CENTURY

The Karshuni manuscript (written in Arabic with Syriac script), which belongs to the period 9th to 11th century, according to Berthelot and Duval,[17] gives a few compositions of gunpowder. If we discount these early dates, then it is possible that these were later additions from the 13th century as was supposed by Lippmann. The following are the ones related to military uses.[18]

Table 8.3 Gunpowder composition in the Karshuni MS, 11th–12th century (possibly 13th-century additions).

	KNO3	S	C
	71.43	10.71	17.86
	83.33	8.33	8.34
	71.53	14.23	14.28
	66.67	16.66	16.67
	68.97	10.34	20.69
Average	72.37	12.06	15.57

17. Berthelot, and Duval, p XII,. The Karshuni MS was published in Syriac script, with a translation into French by Duval. The Karshuni Arabic text was converted into Arabic script in Aleppo by the Rev. Father Barsum on the request of the author of this work. The Arabic text in Arabic script is still in MS form.
18. Berthelot and Duval, p. 198.



Gunpowder composition in the Karshuni manuscript

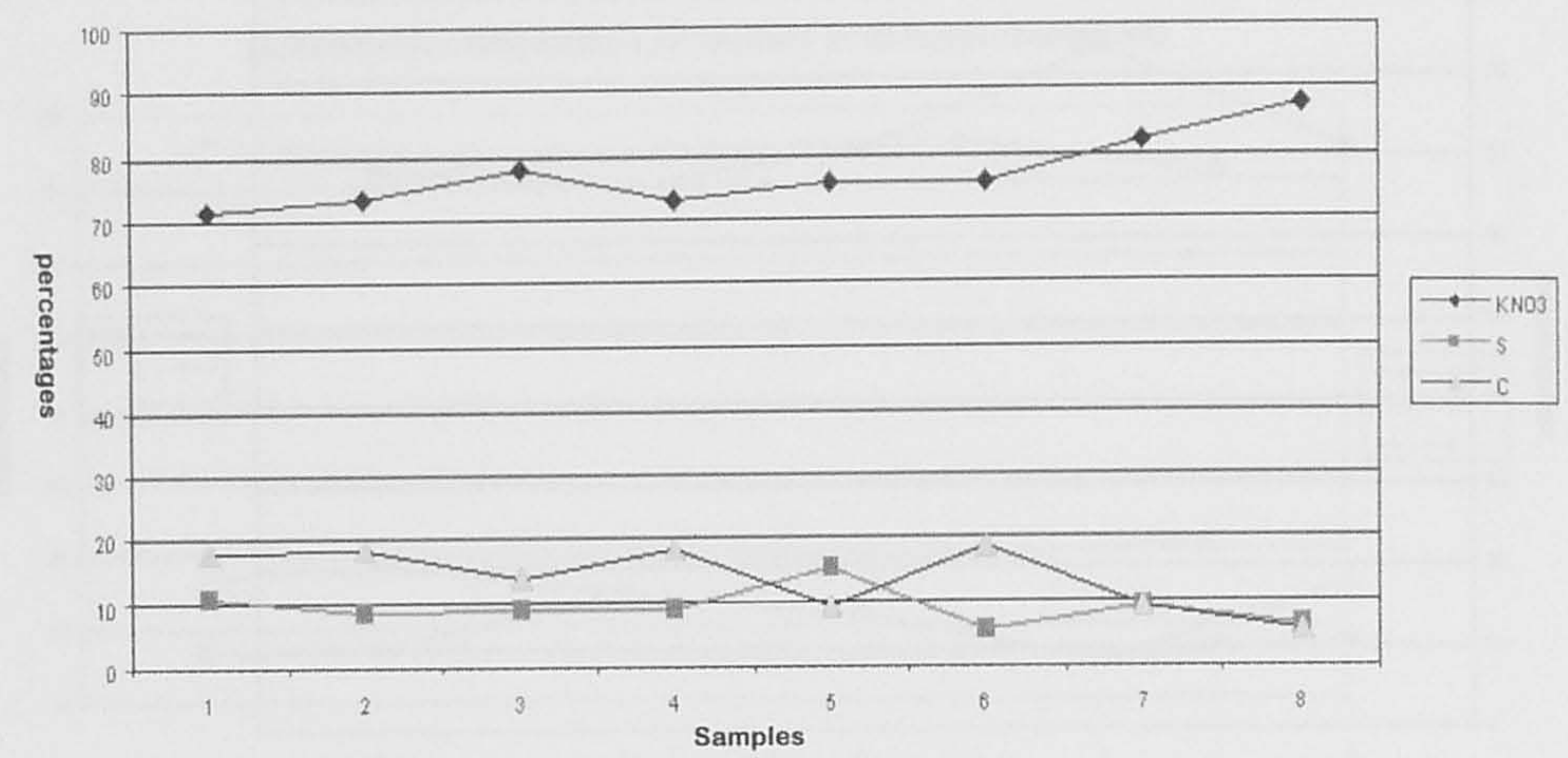
GUNPOWDER COMPOSITION IN BESHIR AGHA MANUSCRIPT FOR ROCKETS AND OTHER USES, 14TH CENTURY

This is a military treatise of unknown author and unknown date. From the text, we infer that it was written in the first half of the 14th century. The author says that the Franks are ignorant of the art of gunpowder and its uses and he warns in strong terms against revealing its secrets to them. This implies that the author was writing in the last days of the Crusades. The following are gunpowder recipes for rockets and other military uses:[19]

Table 8.4 Beshir Agha MS

	KNO3	S	C
	73.39	8.25	18.35
	77.67	8.73	13.6
	72.73	9.1	18.18
	75.47	15.1	9.43
	75.47	5.66	18.87
	81.63	9.18	9.18
	87.91	6.6	5.49
Average	76.96	9.17	13.87

19. Beshir Agha MS., fo. 23a.



Gunpowder composition in Beshir Agha MS

GUNPOWDER COMPOSITION OF ROCKETS FROM *`IYARAT AL-NAFT* MANUSCRIPT, 13TH–14TH CENTURIES

This manuscript contains a large number of gunpowder recipes, totalling about 239. Its title is *`Iyarat al-naft* (Formulae of Gunpowder). Its author is not known but the MS that we consulted was copied in 774/1372; the original should be much earlier. Al-Rammah's book was compiled in about 1270–80 and this one could be compiled on the first decades of the 14th century. It gives recipes for fireworks as well as for military purposes. We have selected all the rockets recipes that contain only the three main ingredients of gunpowder:[20]

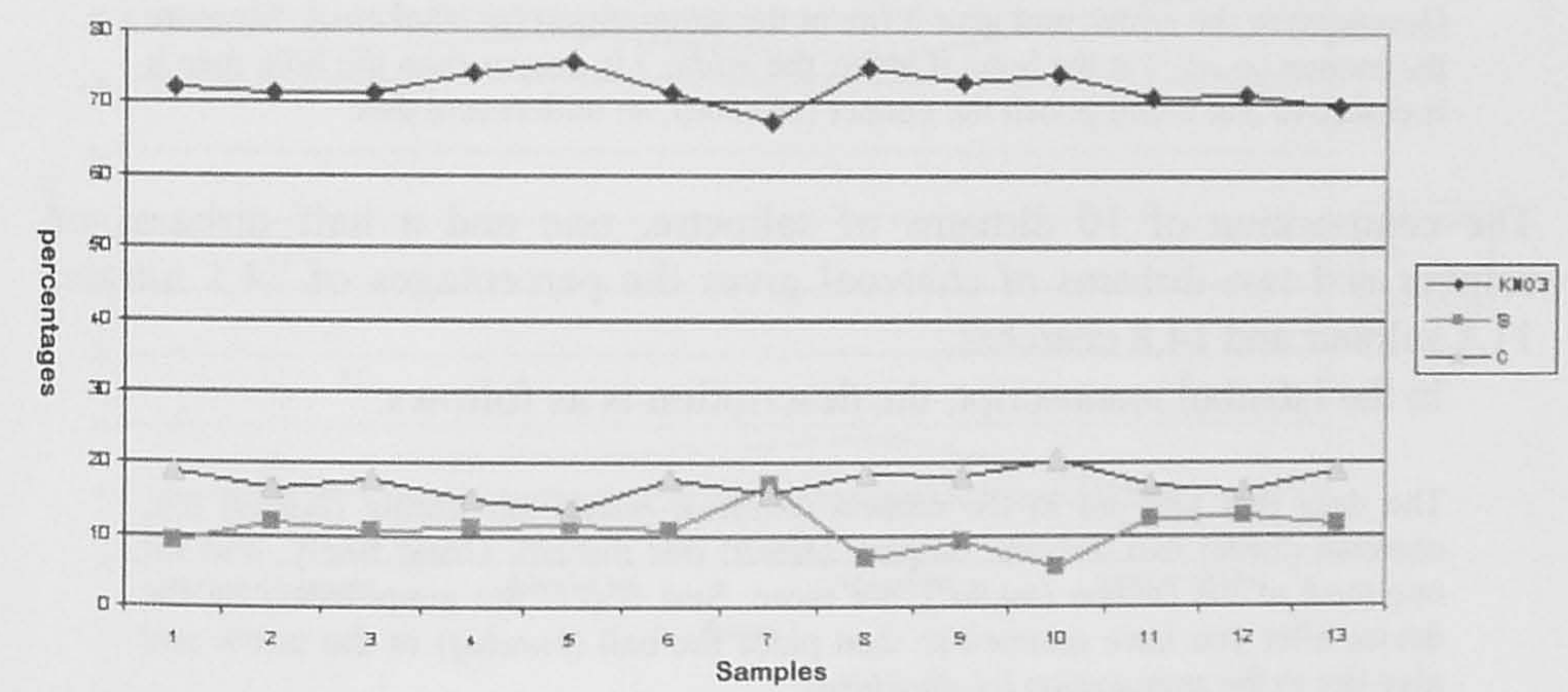
Table 8.5 Gunpowder composition for rockets from *Iyarat -naft* MS, 14th century

	KNO3	S	C
	72.07	9.06	18.92
	71.43	11.93	16.64
	71.43	10.71	17.86
	74.08	11.11	14.81
	75.47	11.32	13.21
	71.43	10.71	17.86

20. *"Iyarat al-naft* , pp. 84–132.

Table 8.5 (continued)

	KNO3	S	C
	67.47	16.86	15.71
	74.77	6.54	18.69
	72.72	9.1	18.18
	74.07	5.56	20.37
	70.97	12.1	16.93
	71.43	12.5	16.07
	69.56	11.6	18.84
Average	72.07	10.7	17.23



Gunpowder composition from 'iyarat al-naft MS

GUNPOWDER COMPOSITION FOR THE EARLIEST CANNON, 13TH/EARLY 14TH CENTURY

Four Arabic treatises describe or mention small portable cannon.[21] All these treatises report that cannon were used in the battle of `Ayn Jalut in Palestine in 1260 between the Arab Army and the Mongols, in which the latter were defeated. It was used once more against the Mongols in 1304. The purpose

21. These are: St Petersburgh MS, *al-makhzun jami` al-funun*; Paris Arabe 2826, *Kitab al-makhzun li arbab al-funun*; Paris Arabe 2824, *Kitab al-makhzun jami` al-funun*; and Istanbul Revan Koshku 1933.

of the early cannon and other gunpowder devices, as we shall see, was to frighten the enemy's horses and cavalry and cause disorder in their ranks. The St Petersburgh MS is the most renowned among the four manuscripts. Renaud and Fave attributed it to Shams al-Din Muhammad. The only known literary figure with this name at this period is Shams al-Din Muhammad al-Ansari al-Dimashqi (d. 1327) who like al-Rammah, was from Damascus, and both were contemporaries. Al-Dimashqi is well known for his cosmography in which he described the use of fireworks in Hama in central Syria.[22] In the St Petersburgh MS the cannon is described as follows:[23]

> Description of the drug (*dawa'*) that you put in the cannon (*midfa`*) – Its composition (*`iyaruhu*) is: potassium nitrate (*barud*) ten, charcoal (*fahm*) two *dirhams* and sulphur (*kibrit*) one and a half *dirhams*. Grind them finely and fill one third of the cannon (*midfa`*). Do not fill more otherwise it will split. Then let the wood turner make a wooden plug (*midfa`*)[24] of the same size as the mouth of the cannon (*midfa`*). Ram (the gunpowder) tightly and place on it the ball (*bunduqa*) or the arrow, and give it fire at the ammunition (*al-dhakhira*). Measure the cannon (*midfa`*) at the hole; if it (i.e. the *midfa`*) is deeper than the hole then it is defective and it will punch the gunner (*al-rami*), so understand this.

The composition of 10 dirhams of saltpetre, one and a half dirhams of sulphur and two dirhams of charcoal gives the percentages of 74.1 nitrate, 11.1 sulphur and 14.8 charcoal.

In the Istanbul manuscript, the description is as follows:[25]

> The drug that you put in the cannon (*midfa`*): potassium nitrate (*barud*) ten, charcoal (*fahm*) two *dirhams*, sulphur (*kibrit*) one dirham. Grind finely, and fill one third of the cannon (*midfa`*), not more. Seal it (i.e. the gunpowder) by the device after you have rammed it; then place the ball (*bunduq*) or the arrow and give fire to the ammunition (*al-dhakhira*).

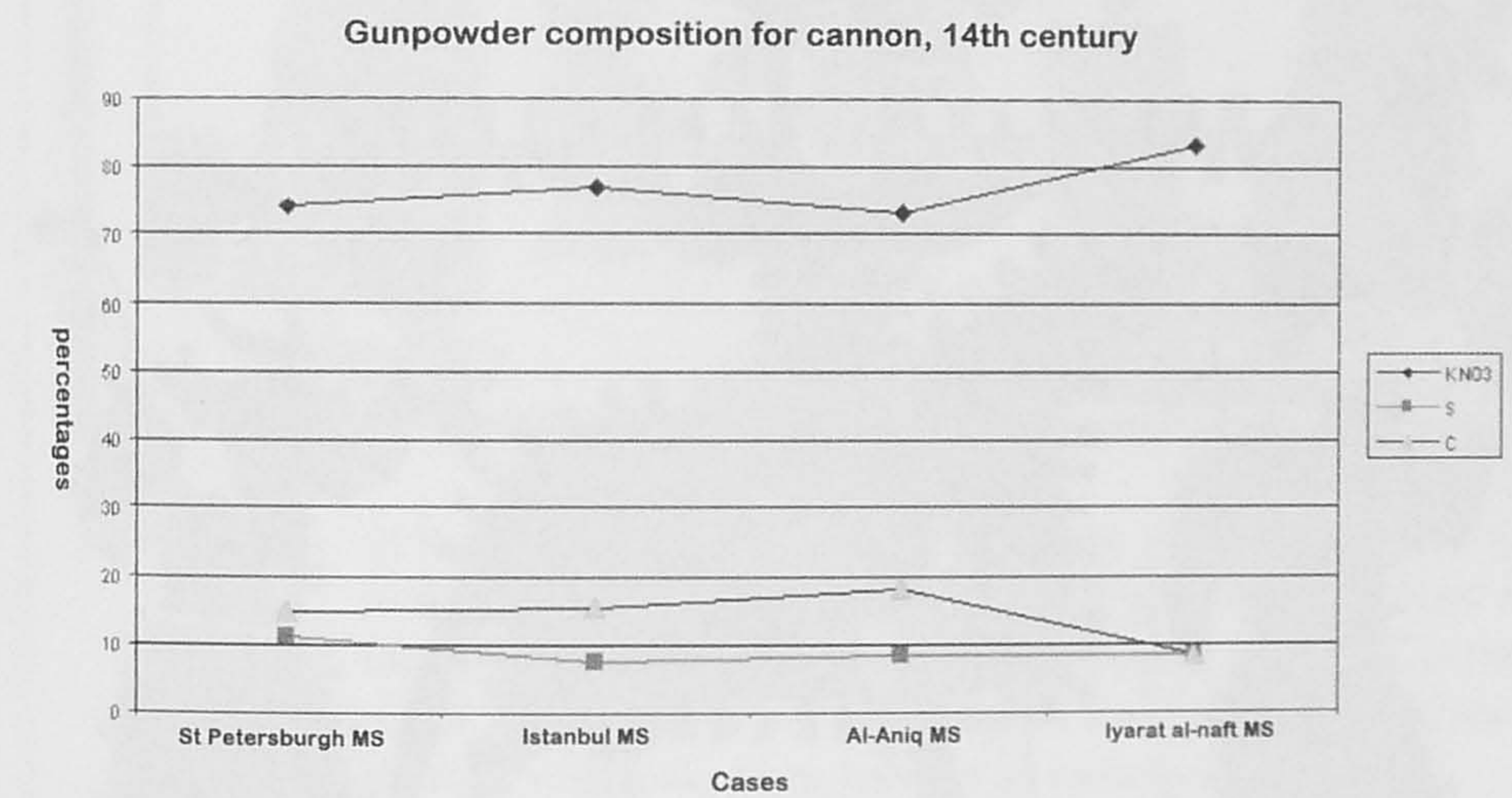
In these cannon, the percentages of gunpowder are 77 nitrate, 7.7 sulphur and 15.3 charcoal.

We have another gunpowder composition for cannon in *Kitab al-aniq*[26] and a fourth one in *Kitab `iyarat al-naft*. The four compositions are listed together as follows:

22. See under fireworks.
23. St Petersburgh MS., p. 160.
24. The word *midfa`* means the pusher or the device that pushes or propels. Here the whole gun is called *midfa`* and the plug that is placed inside at the top of the gunpowder is called also *midfa* since it pushes the ball or arrow when the explosion takes place.
25. MS Istanbul Revan Koshku 1933, fo. 71a.
26. *Al-Aniq*, pp. 196–7.

Table 8.6 Gunpowder composition for four cannon 14th century.

	KNO3	S	C	
St Petersburgh MS	74.1	11.1	14.8	
Istanbul MS	77	7.7	15.3	
Al-Aniq	73.4	8.26	18.34	
Iyarat al-naft MS	83.33	8.33	8.34	
Average	76.96	8.85	14.19	



TACTICS OF USING THE EARLY CANNON

The following text from St Petersburgh manuscript describes the use of the early cannon along with other gunpowder devices in battle tactics:

> The kings of old times did not engage in war except by stratagem. The Prophet said: war is trickery. This was the practice until the time of Halawun (Hulaku or Hulegu) when the people of Egypt used this trick and defeated the Tatars (Mongols). Horses (of the enemy) dare not face fire and the horse will run away with its rider. The way to do it is to choose a number of knights and furnish their lances from both ends with gunpowder (*barud*)[27]. The knight will wear a garment (*qarqal*) with its front face made of black thick woolen cloth (*balas*). It is strewn with balls of linen fiber (*mushaqq*) that have metal wires at their ends so that they are inserted into the garment and the helmet. The horse is also draped with thick woolen cloth (*balas*). His hands will be smeared with dissolved talc so

27. *Barud* here means gunpowder.

> that he is not burnt by fire. In front of them will be whatever they choose from foot soldiers furnished with sprinkler maces, crackers (*sawarikh*, explosive charges) and cannon (*madafi`*). They (the knights and the foot soldiers) will take their place in front of the army.[28]

More detailed description of the attire of the knight the horse and the foot soldiers, is given in the manuscript. There is a detailed description on how to train the horses to get them used to the loud explosive noise of the cannon and the gunpowder crackers. The method of conducting the attack to frighten the enemy's horses and causing them to run away is also described.

Figure 8.1 St Petersburgh MS, p. 159, illustration of the *faris* (knight) who frightens the horses of the enemy and the two foot soldiers accompanying him. On the right, the foot soldier is carrying a hand-held *midfa`* (cannon), and on the left the soldier is carrying a sprinkling club. The mounted knight carries a lance to which gunpowder cartridges are attached. The three men and the horse wear also fireproof clothing to which gunpowder cartridges are attached.

28. St Petersburgh MS, pp. 160–1.

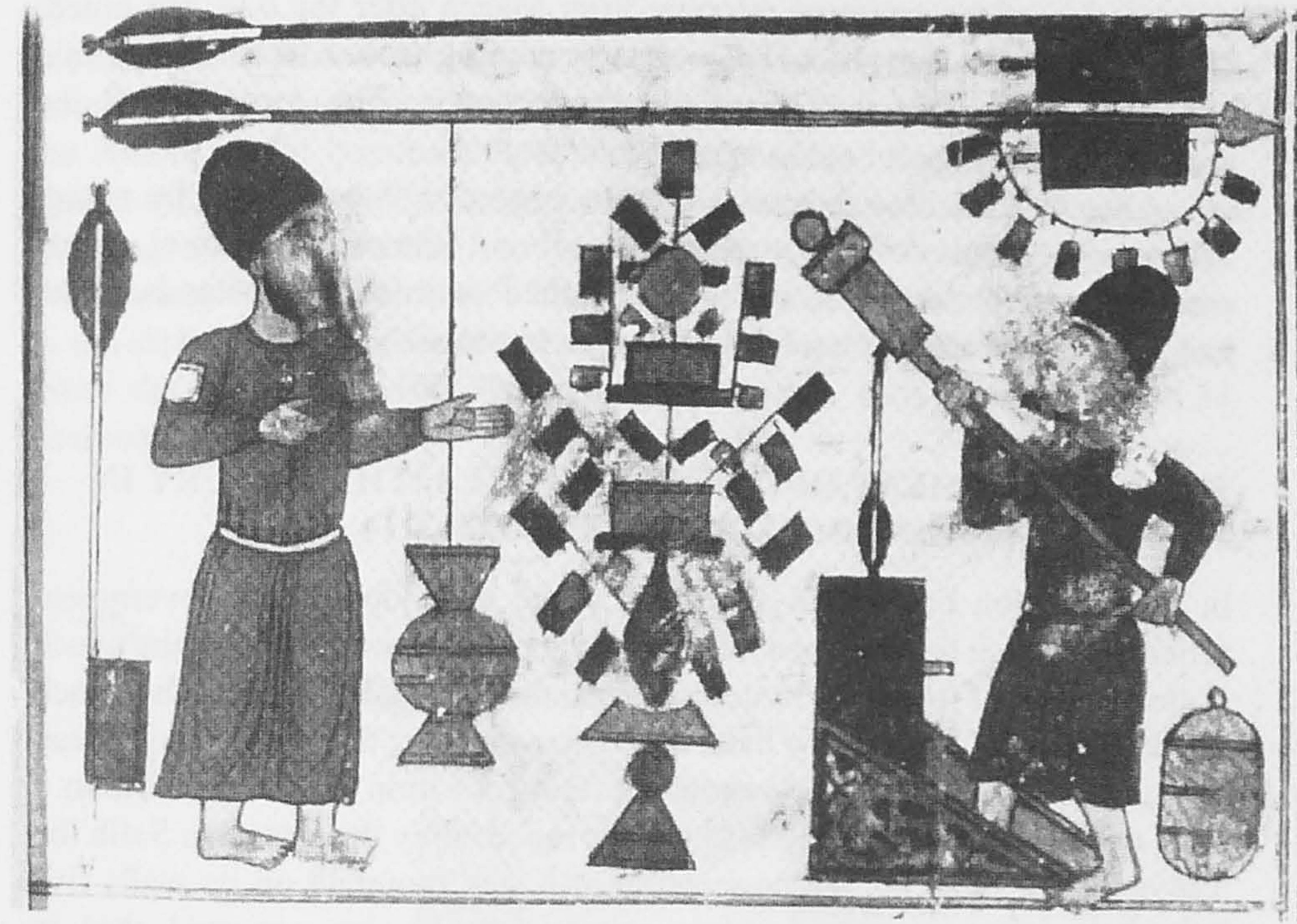


Figure 8.2 St Petersburgh MS, p. 156. On the left is an arrow propelled by a rocket attached to it. In the centre are gunpowder crackers and incendiary devices. On the right is a soldier holding a portable midfa` (cannon) attached to the end of a carrying stick. We see on the right what looks like a bomb or an incendiary jar.

This tactic of using the portable cannon continued throughout the century and was the precursor of portable firearms. Muhammad Ibn Mankali in one of his military treatises (written around 764–78/1362–70)[29] wrote:

> If the Franks who are facing us are cavalry then we shoot at them with incendiary arrows and cannon since their horses will be frightened away and when their mobilisation is in disarray then they will be chased.

The use of the portable cannon continued and was used in celebrations in addition to its use in warfare. The French traveller Bertrandon de la Brocquière visited the Holy Land in 1432 and wrote his book *Voyage d'Outremer*. When he was in Damascus, he saw the celebrations on

29. Ibn Mankali, p. 19.

the occasion of the return of pilgrims from Mecca after the *hajj*. He noted: 'The day after my arrival I saw the caravan coming from Mecca. It was said that there were more than three thousand camels. The lord and all the notables of the city went out to meet the caravan.'[30]

After he described the *mahmal*[31] that preceded the caravan, he noted: 'There were also at least thirty men around the *mahmal* camel, some carrying crossbows and others with unsheathed swords in their hands. Some had little cannon which they fired from time to time.'[32]

THE DEVELOPMENT OF CANNON IN THE 14TH CENTURY IN THE MAMLUK KINGDOM (SYRIA AND EGYPT)

In AD 1340, Ibn Fadl Allah al-`Umari wrote a handbook for government officials in which he described the main weapons that were used in the attack or the defence of towns.[33] He describes cannon that were used in the attack of walled cities. 'They throw balls that batter the tops of parapets and break the columns of arches.' The cannon developed within four decades into a siege engine along with the trebuchet. It is reported by the historian Salih ibn Yahya that in 743/1342 the besieged in al-Karak mounted on its walls five trebuchets (*manjaniqs*) and many cannon.[34] It is also reported that in 753/1352 the governor of Damascus fortified greatly the citadel by mounting on it gunpowder cannon (*al-makahil bi al-madafi`*).[35]

Al-Qalqashandi described in his encyclopaedia, *Subh al-a`sha,* the prevailing siege engines in 767/1365. About cannon he wrote:

> Among them (i.e. the siege engines) is the gunpowder cannon (*makahil al-barud*). These are the cannon (*madafi`*) that use gunpowder. They are of different types. Some of them throw huge arrows that can almost pierce stones. And some throw iron balls weighing from ten Egyptian *ratls* ( about 4.53 kg) up to more than one hundred (45.3 kg). I saw in Alexandria during the Ashrafiyya State, (of Sultan) Sha`ban ibn Husayn,[36] when Prince Salah al-Din ibn `Arram, God have mercy on him, was governor, I saw a cannon made of copper and lead and bound by iron ends. A huge heated iron ball was projected from it in the *maydan* (parade square or hippodrome), and it fell into the Silsila Sea outside Bab al-Bahr (Sea Gate), which is a faraway distance.[37]

30. Bertrandon de la Broquière, p. 56.
31. The *mahmal* is a richly decorated palanquin, perched on a camel, which was sent by sovereigns with their caravans of pilgrims to Mecca.
32. Bertrandon de la Broquière, p. 56.
33. `Umari, p. 208.
34. Ibn Yahya, p. 105.
35. Ibn Iyas, p. 167.
36. Ruled 764–78/1362–77.
37. al-Qalqashandi, pp. 144–5.

In this same period a military treatise called *al-Aniq fi al-manajiq* was written by Ibn Aranbugha al-Zaradkash. The author presented the book to the Atabik (chief commander of the army) Mankali Bugha al-Shamsi who was in office between 769/1367 and 774/1372. Figure 8.3 shows cannon for shooting arrows, mounted on an adjustable stand for pointing the gun at various angles of projection.[38] The gunpowder composition for these cannon is ten *dirhams* of potassium nitrate, 1.125 sulphur, and 2.5 charcoals. This gives the percentages of 73.4 potassium nitrate, 8.26 sulphur and 18.34 charcoals.

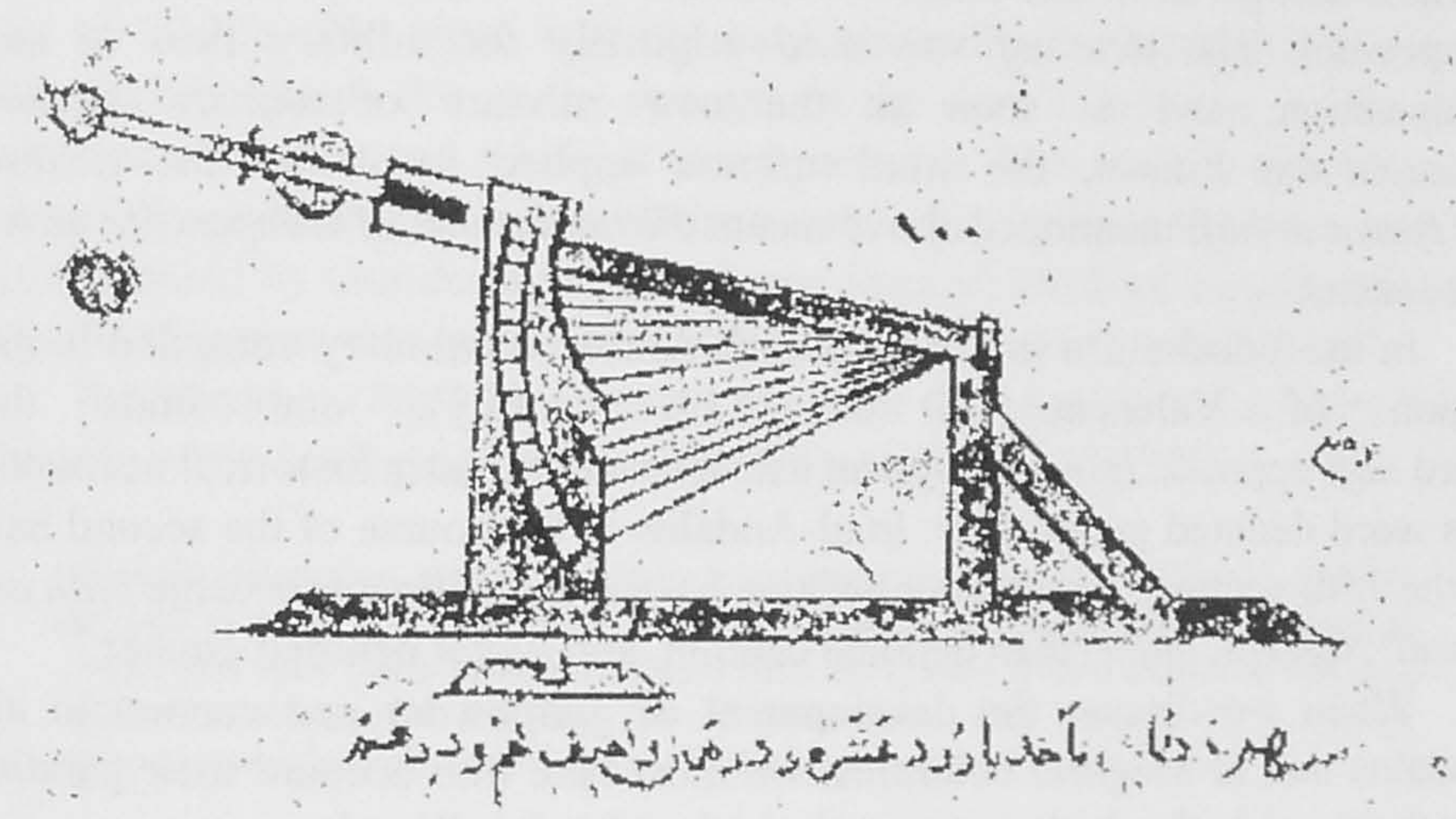


Figure 8.3 Adjustable midfa'.

DEVELOPMENT OF CANNON IN AL-ANDALUS AND AL-MAGHRIB IN THE 13TH AND 14TH CENTURIES[39]

We have no extant Arabic military treatises left to us from al-Andalus and al-Maghrib regarding gunpowder. Reports about the use of cannon by the Arabs in Spain are given in the works of Spanish and Arab historians who were closer to the times of the events or even have witnessed them. When they wrote their accounts, they did not have the same thinking that triggered

38. Ibn Aranbugha, p. 196.
39. This paper was delivered at Granada in June 2002 at the ICOTECH Symposium on the history of technology.

the debate among historians of gunpowder and firearms of the 19th and the first decades of the 20th centuries. The question about the first nation to formulate explosive gunpowder or to use cannon was irrelevant to them. In the last three decades of recent history, some scholars adopted a more balanced attitude and started to free themselves from the eurocentric way of looking at historical sources. In this brief survey, we shall present the primary reports about the main events without trying to confuse the reader with the disputations of the past two centuries.

Most of the argument arose when some historians tried to interpret the Arabic word *naft* to denote naphtha or a mixture of incendiary ingredients containing naphtha. A study of the titles of treatises dealing with gunpowder composition given in this chapter will make it clear that *naft* denoted in fact gunpowder. The term *naft* was used originally for military fires of any composition, and as soon as the new mixture of *saltpetre-sulphur-charcoal* was known, the word *naft* was applied to it. So the treatise of *`Iyarat al-naft* mentioned above means *Formulations of Gunpowder* as we have seen.

In the Vocabulista (a Latin-Spanish Arabic vocabulary compiled in the region of Valencia, in the 13th century), one finds the word *naft* opposite *Ignis* and *Ignem excutere*. In the later historical accounts, this word denoted gunpowder. In al-Andalus in the course of the second half of the 15th century, gunpowder became *barud*, and saltpetre became *milh al-barud*. *Naft* (pl. *anfat*) then denoted cannon, and *naffat* denoted gunner.[40]

When we discuss the development of gunpowder and cannon in al-Andalus and al-Maghrib countries, we must take into account their parallel development in the Arab east namely in the Mamluk Kingdom.

Another factor that is relevant to our study is the fact that potassium nitrate was abundant in Muslim Spain, and it was the only country in Europe having these natural deposits.[41] Richard Watson says in his *Chemical Essays*: 'The lands of Spain, says the author of its Natural History, if properly managed, would supply all Europe with saltpetre to the end of the world.'[42]

40. Dozy, vol. II, article *naft*, pp. 711–12.
41. Saltpetre was reported to be found in Spain by Michael Scot (Partington, p. 88). The article on Saltpetre in Encyclopaedia Britannica (2002) states that potassium nitrate forms in certain soils in Spain, Italy, Egypt, Iran, and India.
42. Watson, p. 322.

The Arabs are reported to have used rockets on the Iberian Peninsula in 1249; and in 1288 rockets attacked Valencia.[43] This report needs to be investigated further in order to determine the sources of information.

Peter, Bishop of Leon, reported the use of cannon by the Arabs while defending Seville in 646 AH / 1248 AD.[44] Ferdinand III harassed Seville increasingly and kept the town under siege for 17 months until it surrendered.[45] At this same time, in the Mamluk Kingdom, gunpowder was already in use in warfare during the Crusades, and if the devices used in Seville were not cannon, then they were most probably projectiles utilising gunpowder similar to those used by the Mamluks in the battle of al-Mansura in 1250 against Louis IX.

In 660/1262, King Alfonso X of Castile succeeded in conquering the city of Niebla. The siege was not easy either for the besiegers or for the Muslim inhabitants due to the strength of the town's defences, so the siege lasted nine months and a half. It is reported that Almohads in defending the city used machines that resembled cannon, which projected stones and fire accompanied by thundering noises. Some Spanish histories consider that this was the first time that gunpowder had been used in warfare in Spain.[46]

Ibn Khaldun (8th/14th century) says that the Marinid Sultan Abu Yusuf Ya`qub, when besieging the town of Sijilmasa in 672–3/1274:

> Brought into action against this town mangonels (majaniq) and ballistas (`arradat), as well as a *naft* engine (*hindam al-naft* i.e. gunpowder cannon) which discharged small iron balls (*hasa al-hadid*). These balls are ejected from a chamber (*khizana*) placed in front of a kindling fire of gunpowder. This happens by a strange property which attributes all actions to the power of the Creator.[47]

This precise information about the use of cannon came from a great historian. However, western historians of firearms in the 19th and the first part of the 20th centuries questioned the report of Ibn Khaldun. These historians were bound by preconceived certain historical dates for gunpowder and cannon that could not be changed even if they go to the extreme of discrediting a historian of the calibre of Ibn Khaldun. We have seen above that portable cannon were used by the Mamluks in 1260 in the battle of `Ayn Jalut. Indeed, we would advance the view that in the Maghrib and al-Andalus, where petroleum was not available whereas potassium

43. Fought, Stephen Oliver and John F.Guilmartin, Jr. Encyclopedia Britannica, article on 'rocket and missile system'.
44. Partington, p. 228, footnote 6 citing C.F. Temler.
45. *E.I (Encyclopaedia of Islam)* under Ishbiliya.
46. Enan, pp. 390–2 (see also the official history of Niebla on the internet:http://www.castillodeniebla.com/ingles/niebla_f.htm
47. Ibn Khaldun, p. 188.

nitrate was known to be abundant, cannon may have developed into a siege engine somewhat earlier than in the Islamic East. Moreover, the appearance of cannon at Sijilmasa as described by Ibn Khaldun was a natural development the truthfulness of which need not be doubted.

In the 14th century, the historic accounts regarding the use of cannon by the Moorish kings of Granada, in defensive as well as offensive operations had caused considerable debate among western historians in the nineteenth and the first decades of the 20th centuries. After reviewing the distrustful position of some military historians in Europe, Ada Bruhn de Hoffmeyer in her carefully focused survey, *Arms and Amour* in *Spain,* concludes that:

> The old theories about the Arabs and the Moors and their importance in regard to gunpowder and early artillery in the 14th century cannot be rejected – on the contrary! Alchemy and chemical experiments flourished among the Arabs in the Mediterranean world not least in *Moslem Andalusia,* and Saracen scientists and technicians were working at various courts of occidental Europe.
>
> The general opinion no doubt must be that gunpowder artillery was introduced rather early to Spain through the Arabs via the Moors of Maroc and from them to Moslem Andalusia. From the Hispano-Moors Christian Spain learned about gunpowder artillery. The routes probably passed via the *Granadine kingdom,* which at that time had very close contacts with the *sultan of Maroc in Fez,* from which place Granada got military help against the Christians. *Italy* is represented with the Genoese navy supporting Granadines and Moroccanes.[48]

The facts depend upon the correct translation of certain words from Arabic manuscripts. Hoffmeyer refers to the work of Kohler when she says:

> It is not impossible that G. Kohler in his work: *Die Entwicklung des Kriegswesens und der Kriegsführung,* Breslau 1887, was right in his suppositions that the Arabs rather early introduced not only gunpowder but even fire-arms to Spain, from whence they passed to Italy (coincidence with the documentation from Florence) and from Spain and Italy to France and Germany. (The routes from Hispano-Moorish Andalusia, passing through Murcia, the Levantine coasts of Spain, Aragon to Italy is nothing strange in the 14th century, when the Mediterranean was a 'Mar Aragones'.)[49]

The main incidents we are concerned with in the following account had taken place during the tenure of Sultan Abu al-Walid Isma`il ibn Nasr (713 AH / 1314 AD–725 AH / 1325 AD), the Nasrid king of Granada who waged a number of successful campaigns between the years 1324 and 1325. In 724/1324 he besieged the fort city of Huescar using cannon in his siege, of which Lisan al-Din ibn al-Khatib (1313–1374) who was a youth at the time, and who became later a minister in Granada, relates:

48. Hoffmeyer, pp. 216–17.
49. Hoffmeyer, p. 218.

> He headed towards the enemy territory and challenged the fort of Huescar that stands as a bone in the throat of Baza, which he besieged and attacked. He struck the arch of the invincible tower with a red-hot iron ball bombarded by the great engine that operates by *naft* (gunpowder).[50]

To celebrate the occasion, the scientist and poet, Abu Zakariyya Yahya ibn Hudhayl[51] whom Ibn al-Khatib highly praised, being his teacher, had composed a poem complementing the sultan for the conquest of Huescar:

> They thought that the thunder and the lightning had come down from the skies; whereas the thunder and lightning are all around them being created by man.
> These are things of wondrous shapes, sent high by Hermes[52] and engineered to demolish mountains when they hit.
> Yes, it is this world that always shows you miracles, since nature's innate powers are destined to appear.

Based on the reports of these eyewitnesses McJoynt concludes that: 'Granada must have been in the forefront of technical innovation in the world at this time. The new weapon was a success, for Huescar hastened to surrender.'[53]

Lomax concludes also that 'The capture of Huescar had seen the first use of gunpowder and cannon in European warfare.'[54]

After the conquest of Huescar, Sultan Isma`il waged a number of campaigns in which he captured a number of cities and forts including Baza and Martos in which he used cannon also.

In 732/1331 Sultan Muhammad IV laid siege to the city of Alicante, of which the Spanish historian Zurita (1512–1580) maintains that: 'When the Moorish king of Granada besieged Alicante he used a new machine that caused great terror. It threw iron balls with fire.'[55]

Hoffmeyer finds the report of Muslim gunpowder weapons at Alicante to be 'difficult to deny', given obvious awareness of such weapons at the time.

In a confrontation, known as the battle of Tarifa or the battle of Rio Salado in 1340, the Arabs lost heavily to the Castillian armies and their allies. The Spanish historian Conde relates that in the battle of Tarifa the Arabs had employed machines of thunder that launched iron balls propelled

50. Lisan al-Din ibn al-Khatib, vol. I, p. 231.
51. Maqqari, vol. III, p. 260.
52. The attribution of gunpowder to Hermes means that this invention is a chemical product.
53. Prescott, *The Art of War*, p. 92, footnote 188.
54. Lomax, p. 166.
55. Partington, p. 191 (Partington gave the Latin text of Zurita).

by *nafta*, causing extensive damage to the towers and the fortifications of the city.[56]

However, the main objective of the Spaniards was to occupy and hold on to the strategic port city of Algeciras (al-Jazira), situated next to the straight of Gibraltar. They had engaged the aid of their allies in Europe in a crusade against the Arabs, to which France and England were among respondents by sending army contingents. The siege of the city lasted twenty months, from 1342 to 1344, during which time the Arabs defended the city courageously, using cannon profusely and engaging the enemy in daring encounters.

The Spanish historian Juan de Mariana (1536–1623) described the use of gunpowder and cannons during the capture of Algeciras.[57] He states: 'The besieged did great harm among the Christians with iron bullets they shot. This is the first time we find any mention of gunpowder and ball in our histories.'

De Mariana also relates that the English Earl of Derby and Earl of Salisbury had both participated in this siege. Richard Watson[58] thinks that the two earls had conceivably transferred the knowledge about cannon and gunpowder and their use as effective firearms to England, and that the English adopted this new weapon and used it in the battle of Crecy in 1346. Furthermore, Prescott in his book *Ferdinand and Isabella*[59] emphasises that the Spaniards had adopted their knowledge of gunpowder from the Arabs of Granada who were familiar with its utilisation for a considerable time before their encounter with the Spanish in this siege. Ada Bruhn Hoffmeyer finds it 'fully trustworthy' that King Alfonso XI of Castile and the Muslims used 'gunpowder as propulsor for projectiles' at Algeciras in 1342.[60]

The use of gunpowder and cannon spread quickly in Spain. The Spanish kings at the initial stages enlisted the help of Moorish experts. Hoffmeyer says:

> The first *artillery-masters* on the Peninsula probably were Moors in Christian service. The king of Navarra had a Moor in his service in 1367 as 'maestro de las guarniciones de artilleria'. The Morisques of Tudela at that time had fame for their capacity in *reparaciones de artilleria*.[61]

56. Conde, vol. III, p. 254.
57. Mariana, part one, p. 264.
58. Watson, p. 331.
59. Prescott, *Ferdinand and Isabella*, vol. I, p. 148 note 34; pp. 401–2, text and note 46.
60. Hoffmeyer, p. 217.
61. Hoffmeyer, p. 220.

FIREWORKS: A BRIEF NOTE

The use of gunpowder in fireworks in festivities by the public in the Arab cities, took place at the same time as it was used for military purposes. This is evident from the titles of treatises giving the composition of gunpowder. The majority of recipes given in the 13th century by al-Rammah and in the Karshuni manuscript are for fireworks. Similarly, the gunpowder treatises of the 14th century deal mostly with fireworks. There are large numbers of recipes for fireworks. The names of the different kinds fireworks are varied to a large extent and this can be the subject of a separate study.

Reports about the use of fireworks in Arab cities can be found in non-military treatises. Al-Dimashqi (d. 1327) who was contemporary with al-Rammah describes in his cosmography (written in the second half of the 13th century) the joint use of fireworks by the Muslims and Christians of Hama in central Syria on the eve of the birthday of Jesus.[62]

In a book on various trades and crafts, that was not noticed until recently, dating from the same period of al-Rammah and al-Dimashqi, we find a description of a gunpowder cracker and a gunpowder fireworks device. King al-Muzaffar Yusuf ibn `Umar ibn Rasul (d. 694/1294) of Yemen compiled this book. The title of the book is *al-Mukhtara` fi funun min al-suna`* (Inventions from the Various Industrial Arts). The description of the gunpowder cracker runs thus:

> Description of a *furqa`a* (cracker): fold a sheet of paper four or five folds on a mould. The mould is a rod that is turned to the thickness of a finger. Fold it very tightly, five or six plies. Take it off the mould. Seal its head very tightly, and fill it with *barud* and the charcoal of willow tree mixed together, and close its end very securely. If you want to give it fire, pierce the head with a small piercing iron and insert a fuse that has been twisted very well. Glue the fuse to the hole, give it fire and move away. It will crack and move with explosive noise.[63]

The use of fireworks by the Mamluk sultans in public celebrations in the 14th century and later is reported in the history books of that period.[64] Fireworks were called in these reports *harraqat al- naft* or *harraqat al-barud*.

When the French traveller Bertrandon de la Brocquière arrived in Beirut in 1432 the inhabitants were celebrating the *`Id*. He was surprised to see the fireworks for the first time. He says:

62. Dimashqi, p. 281.
63. Rasul, pp. 206–7.
64. Ibn Iyas, Vol. I, p. 179.

> The Moors held a celebration, which is, I understand, an old custom. It started at nightfall. There was a great crowd of people singing and shouting. The men of the castle shot off the cannon and those of the city shot some kind of fire very high and very far. It was bigger than the biggest lantern I have ever seen. They say that they use it sometimes on the sea, against enemies to burn the sails of a ship. It would easily burn a house or a town with straw roofs, it seems to me. In a cavalry engagement, it would terrify the horses. It is easy and cheap for someone who knows what they are doing.[65]

We infer from his story that fireworks were unknown in France at that time (in 1432). Brocquière says then that he was able, against a bribe, to learn the secret of these fires and he took the information with him to France.[66] The first recorded fireworks in England were at the wedding of Henry VII in 1486. They became very popular during the reign of Queen Elizabeth I.

The people of Granada and other cities in al-Andalus used fireworks in their celebrations,[67] as was the custom in the cities of Syria and Egypt.

BIBLIOGRAPHY

Arabic Manuscripts and References

Beshir Agha MS No. 441, Istanbul, *Risala fi jarr al-athqal wa ghayriha min al-`aja'ib*, unknown author.
رسالة في جر الاثقال وغيرها من العجائب

al-Dimashqi, Shams al-Din Muhammad al-Ansari, *Nukhbat al-dahr,* edited by Mehren, Leipzig, 1923.
نخبة الدهر في عجائب البر والبحر

Enan, Muhammad Abdulla, *al-athar al-andalusiyya al-baqiya*, Cairo, 1961.
الاثار الاندلسية الباقية

Al-Hiyal fi-al-hurub wa fath al mada'in wa hifz al durub, ms. Ahmet III, Serai No. 3469, Istanbul, author uncertain. Several other manuscripts of this treatise exist in Istanbul, Leiden, and Ribat. Sulayman al- Rahili, Saudi Arabia, published this MS in 1418/1997. He attributed it by error to Ibn Mankali.
الحيل في الحروب وفتح المدائن وحفظ الدروب

Ibn Abi Usaybi`a, *`Uyun al-Anba' fi tabaqat al atibba',* ed. Nizar Rida, Beirut, 1965.

65. op. cit., p. 23.
66. Galen R. Kline the translator of the *voyage* says that Bertrandon de la Brocquière went to the Holy Land as a spy for the purpose of spying out the possibilities of a new crusade to be led by the Duke of Burgundy. He describes de la Brocquière as a highly competent spy and a very observant tourist. He was keen to understand everything that came in his way. Atiya gave similar information about the mission of de la Brocquière, pp. 112–13.
67. Conde, vol. 3, p. 253.

عيون الانباء في طبقات الاطباء

Ibn Aranbugha al-Zaradkash, *al-aniq fi al-manajiq*, ed. Ihsan Hindi, Aleppo, 1985.
الانيق في المناجيق

Ibn Iyas, Muhammad ibn Ahmad, *al-mukhtar min bada'i` al-zuhur* ,vol. I, Cairo,1960.
المختار من بدائع الزهور

Ibn Khaldun, *Kitab al-`ibar* ..., vol. VII, Beirut, 1971.
كتاب العبر

Ibn al-Khatib, Lisan al-Din, *al-ihata fi akhbar ghirnata*, vol, I, Cairo, 1319/1901.
الاحاطة في اخبار غرناطة

Ibn Mankali, Muhammad, *al-adilla al-rasmiyya li al-ta`abi al-harbiyya*, Istabul, Aya Sophia MS 2875. It was edited by Mahmud Shith Khattab, and published by the Iraqi Academy, Baghdad, 1988.
الادلة الرسمية في التعابي الحربية

Ibn Yahya, Salih, *Tarikh Bayrut,* ed. Kamal Salibi, Beirut, 1969.
تاريخ بيروت

Istanbul MS. Revan Koshku 1933.
`iyarat al-naft* part of a collection of manuscripts (*majmu`a) under the title of *al-aniq*, Ahmet III 3469, Istanbul, pp. 94–132.
عيارات النفط

Al-Maqqari, Ahmad ibn Muhammad, *Nafh al-tib min ghusn al-andalus al-ratib*, Bulaq, 1279/1862
نفح الطيب من غصن الاندلس الرطيب

Al-Maqrizi, *Al-Mawa`iz wa al-`i`tibar*, vol. I, Cairo, n.d.
المواعظ والاعتبار

MS B,N Arabe 2826, *Kitab al-makhzun li arbab al-funun*
كتاب المخزون لارباب الفنون

MS B,N Arabe 2824, *Kitab al-makhzun jami` al-funun*
كتاب المخزون جامع الفنون

al-Qalqashandi, Ahmad ibn `Ali, *Subh al-a`sha*, vol. II, Cairo, 1963.
صبح الاعشى

Al-Rammah, Najm al-Din Hasan, *Al-Furusiyya wa al-manasib al-harbiyya*, edited with analytical introductory chapters by Ahmad Y. al-Hassan, Aleppo, 1998.
الفروسية والمناصب الحربية

Rasul, al-Malik al-Muzaffar Yusuf ibn `Umar ibn `Ali ibn , *al-mukhtara` fi funun min al-suna`*, ed. Muhammad Isa Salhiyyeh, Kuwait, 1989.
المخترع في فنون من الصنع

St Petersburgh MS. *Al-Makhzun jami` al-funun*, uncertain author.
المخزون جامع الفنون

al-`Umari ibn Fadl Allah, *al-Ta`rif bi al-mustalah al-sharif*, Cairo, 1312/1894.
التعريف بالمصطلح الشريف

Non-Arabic References

Atiya, Aziz S., *Crusade, Commerce and Culture,* Indiana University Press, 1962.
Berthelot, M. and R. Duval, *La Chimie au Moyen Age*, vol. II, Paris, 1893.
Conde J.A., *History of the Dominion of the Arabs in Spain,* translated by Mrs Jonathon Foster. 3 volumes, London, 1855.
Brocquière, Bertrandon de la, *[Le] voyage d'Outremer*, publ. et annote par Ch. Schefer, Paris: E. Leroux, 1892. Reproduced at Gallica web pages of Bibliothèque nationale de France, 2001. This book was translated into English by Galen R. Kline, New York, 1988.
Dozy, R., *Supplement aux dictionnares Arabes*, vol. II, reprinted by Libraire du Liban, 1968.
Hall, Bert S., *Weapons, Warfare in Renaissance Europe*, John Hopkins University Press, 1997.
Al-Hassan, Ahmad Y., Potassium Nitrate in Arabic and Latin Sources, paper presented to the XXI International Congress for the History of Science, Mexico City, 2001. See Chapter 7.
Joinville, *The Life of Saint Louis,* in Joinville and Villehardouin, *Chronicle of the Crusades,* Penguin, 1963.
Lalanne, L., *Recherches sur Ie feu gregeois et sur l'introduction de la poudre a canon en Europe;* Paris, 1845.
Lomax, Derek W., *The Reconquest of Spain*, London, 1978.
Mariana, Juan de, *Historia general de Espana,* 2 vols, Madrid, 1608, ii, 27; English tr. by Capt. John Stephens, *The General History of Spain,* 2 pts., London, 1699.
Mercier, Maurice, *Le Feu Gregois. Les Feu a Guerre depuis l'Antiquiti. La Poudre a Canon,* Paris, 1952.
Partington, J.R., *A History of Greek Fire and Gunpowder,* reprint by John Hopkins University Press,
Prescott, William H., *History of the Reign of Ferdinand and Isabella,* ed. John Foster Kirk, 3 volumes, Philadelphia, 1880.
Prescott, William H., *The Art of War in Spain – The Conquest of Granada*, edited by Albert D. McJoynt, London, 1995.
Reinaud, Joseph Toussaint and Ildephonse Fave, 'Du feu gregeois, des feux de guerre, et des origines de la poudre a canon chez les Arabes, les Persans et les Chinois,' in *J. Asiatique,* 1849, xiv, 257–327.
Runciman, Steven, *A History of the Crusades*, Vol. III, Penguin, 1978.
Watson, R., *Chemical Essays*, vol. I, London, 1787, 1999.

9 Alcohol and the Distillation of Wine in Arabic Sources from the 8th Century[1]

Islamic chemists knew the distillation of wine and the properties of alcohol from the 8th century. The prohibition of wine in Islam did not mean that wine was not produced or consumed or that Arab alchemists did not subject it to their distillation processes. Some historians of chemistry and technology[2] assumed that Arab chemists did not know the distillation of wine because these historians were not aware of the existence of Arabic texts to this effect.[3] The purpose of this chapter is to present some Arabic texts about the production of alcohol from wine, starting with the 8th century.

The first reference to the flammable vapours at the mouths of bottles containing boiling wine and salt occurred in *Kitab ikhraj ma fi al-quwwa ila al-fi`l* of Jabir ibn Hayyan (b. *c.* 103/721, d. *c.200/*815). He says:

> And fire which burns on the mouths of bottles due to boiled wine and salt, and similar things with nice characteristics which are thought to be of little use, these are of great significance in these sciences.[4] (see Appendix: Arabic Text 9.1)

This flammable property of alcohol (from distilled wine) was utilised extensively from Jabir's time and onwards and we find various descriptions of the alcohol-wine bottles in Arabic books of secrets and military treatises[5] (see Appendix: Arabic Texts 9.5, 9.6, 9.7 and 9.8).

---

1. This article embodies the latest research of the writer into this subject. It combines also the earlier results that first appeared in *Islamic Technology, an Illustrated History*, by al-Hassan and Hill, 1986, UNESCO and CUP.
2. Forbes; R.J. *A Short History of the Art of Distillation*, Brill, 1970, p. 87; Multhauf, Robert, *The Origins of Chemistry*, London, 1966, pp. 204–6.
3. Even in a recent work published in 2006, the author C. Anne Wilson in her book *Water of Life*, Prospect Books, U.K., 2006, p. 84, assumed that the Arabs did not know about the distillation of wine. She took her information from the outdated work of R.J. Forbes's *A Short History of Distillation*, Brill, 1948. She repeated the same error when she included on pp. 91–3 a very brief section on Arabs and Alchemy in which she did not mention anything about the distillation of wine by the Arabs. Here again, her sources were secondary and outdated. Anne Wilson is a non-academic author who has written books on foods and drinks including one on marmalade. Her book *Water of Life* is partly based on conjecture and lacks the quality of an academic work.
4. Jabir ibn Hayyan, *Kitab ikhraj ma fi al-quwwa ila al-fi`l*, in *Mukhtarat rasa'il Jabir ibn Hayyan*, ed. P. Kraus, Cairo, 1935, p. 76.
5. The writer came until now across four such alcohol wine bottles in four treatises. One is *Al-hiyal fi al-hurub*, which represents the technology prevailing around 1200; another is *al-hiyal al-babiliyya*, by al-Iskandari, first quarter of the 13th century; another is *Al-furusiyya wa al-*

Among the early chemists who mentioned the distillation of wine is al-Kindi (d. 260/873) in *Kitab al-Taraffuq fi al-'itr* (also known as *The Book of the chemistry of Perfume and Distillations*). He says after describing a distillation process: 'and so wine is distilled in wetness and it comes out like rosewater in colour'[6] (see Appendix: Arabic Text 9.2).

Al-Farabi (born *c.* 265/878, died *c.* 339/950) mentioned the addition of sulphur in the distillation of wine.[7]

Abu al-Qasim al-Zahrawi (d. 404/1013) also mentioned the distillation of wine when he was describing the distillation of vinegar from white grapes. He says: 'and similarly wine is distilled by any one who loves to do so'[8] (see Appendix: Arabic Text 9.3).

Ibn Badis (d. 453/1061) described how silver filings were pulverised with distilled wine to provide a means of writing with silver, which indicates that alcohol was collected as a product and was utilised in various ways. He says: 'take silver filings and grind them with distilled wine[9] for three days; then dry them and grind them again with distilled wine until they become like mud, then rinse them with water...'[10] (see Appendix: Arabic Text 9.4).

We find in the military treatises of the 14th century that old grape-wine became an important ingredient in the distillation processes for the production of military fires. One manuscript contains five such recipes, with warnings that such distillates can ignite easily and they should be stored in containers buried in sand[11] (see Appendix: Arabic Text 9.9).

In the early centuries of Islam distilled wine was not given a specific name. It was just one variety of wines. This is clear from the study of Arabic

---

manasib al-harbiyya, by Hasan al-Rammah, second half of the 13th century; and *MS Istambul-Beshir Agha No. 441*, probably the first half of the 14th century. Between Jabir's description, and the end of the 12th century this tradition of the wine and salt alcohol bottles continued uninterrupted and there are probably other accounts that will be revealed gradually.

6. Ya'qub ibn Ishaq Al-Kindi, *Kitab al-Taraffuq fial-`itr*, MS Topkapi Sarai, Istanbul, No. 62-1992, ff. 140–1; see also K. Garbers, *Kitab kimiya' al-'itr wa al-tas`idat*, Arabic text, and German trans., *Abhandlungen fur die Kunde des Morgenlandes*, Leipzig, 1948, p. 50 of Arabic text and p. 95 of German text. Reprinted by Fuat Sezgin, 2002 (Natural Sciences in Islam, 72).

7. *Liber Alpharabii*, BN MS. Lat. 7156, fo. 47v; Berthelot, M., *La Chemie Au Moyen Age*, Vol. I, Paris, 1976 (reprint of the 1893 edition). p. 143; Partington, J. R., *A History of Greek Fire and Gunpowder*, Heffer, Cambridge, 1960, p. 53 (reprinted by John Hopkins University Press, 1999).

8. Abu al-Qasim al-Zahrawi, *Kitab al-tasrif li man `ajiza 'an al-ta'liff*, maqala no. 28, Ms. 'Ali Amiri, Istanbul No 2854. A photocopy of the original folio was supplied through the courtesy of Prof. Sami K. Hamarneh.

9. خمر مصعّد

10. Ibn Badis, *Kitab `umdat al-kuttab wa `uddat dhawi al-albab*, MS of the Egyptian Public Library, ff. 73b 73a.

11. MS. Beshir Agha Istanbul, No. 441.

literary and scientific literature as we shall presently see. Some Arabic chemists such as Ibn Badis (11th century) called it خمر مصعّد (distilled wine). The same name was still in use in the 16th century when al-Antaki defined distilled wine خمر مصعّد as `*araqi* (see below).

As we have just mentioned, in early Arabic poetry distilled wine was one of several types of wine خمر and was not always denoted by a special name. The celebrated poet Abu Nuwas (died 198/813), who was a contemporary of Jabir ibn Hayyan, described wines in beautiful verses. When enjoying a drinking session with a friend he tasted three kinds of wine in succession. Each time he would ask the bartender (*khammar*) for a better (stronger) drink and the third time, he asked for a wine that 'has the colour of rain-water but is as hot inside the ribs as a burning firebrand'.[12]

في لون ماء الغيث إلا إنها بين الضلوع كواقد الجمر

An interesting name for wine was *ma' al-hayat* ماء الحياة (water of life) which is the same name as *aqua vitae* (water of life) that was given to distilled wine in the West when distillation was first transferred from the Arabs in the 13th and 14th centuries. An Arabic poet says: 'I am wandering how those who had pressed[13] it had passed away, whereas they have handed down to us *ma' al-hayat* (the water of life).'[14]

عجبت لعاصريها كيف ماتوا وقد تركوا لنا ماء الحياة

The current word for distilled wine in Arab Lands is `*araq* عرق which means sweat. The droplets of ascending wine vapours that condense on the sides of the cucurbit are similar to the drops of sweat. You find this word in Arabic alchemical treatises describing drops of condensing vapours during distillation. Jabir Ibn Hayyan in his *Kitab al-jumal al-`ishrin* (The Book of Twenty Articles) says in Article Thirteen: The material under discussion should be 'dried slightly after grinding so that its wetness is dehydrated and this is done to avoid the (formation) of `*araq* because if `*araq* is formed the quantity of the distillate will be smaller than if the `*araq* is not formed. Know this'.[15]

أن يجفف بعد السحق قليلا حتى ينشف ما فيه من نداوته وذلك فإنما يفعل ليومن عليه من العرق فإذا عرق كان المصاعد اقل مما لم يعرق فاعرف ذلك.

The etymology of `*araq* is of great interest in the history of alcohol. We have given evidence above about the existence of wine distillation since the 8th century. However, what was the common name for the distilled wine

---

12. Nuwayri, *Nihayat al-arab fi funun al-adab*, Cairo, n.d., Vol. 4, p. 98.

13. Wine is squeezed or pressed from grapes.

14. *One Thousand and One Night*, Vol. 4, Cairo, 1960, p. 390.

15. Jabir Ibn Hayyan, *Kitab al Jumal al-`ishrin*, MS Huseyin Chelebi 743, Bursa, Turkey, p. 487. Maqala 13.

among the public? This interesting topic has not yet been sufficiently investigated. In our search into literary sources we found in *Hikayat Abu al-Qasim al-Baghdadi* (written *c.* first half 5th/11th century) a mention of *`araq al-nabidh* عرق النبيذ (the `araq of wine).[16] Fakhr al-Din al-Razi (second half of 12th century AD) refers to distilled [wine] as *`araqi*.[17] Al-Nuwayri (d. 732/1331) mentions in his encyclopaedia that the taxes that were levied on *`araq* amounted to 10 per cent.[18] Al-Antaki (d. 1008/1599) mentions the *`araq* of sugar cane and of grapes. When discussing *khamr* (wine) he defines *`araqi* as a distilled wine that is useful in certain cases.[19]

Syria was particularly known for the production of wines and *`araq* which were produced in the numerous monasteries and convents of Syria, Iraq and Egypt.[20] Wine shops were plentiful in the main cities such as Baghdad, and were run by non-Muslims. They catered for all sectors of wine-loving persons including poets who left a rich poetry about wine خمريات.

Distilled spirits in Arabic-Islamic culture were not only obtained from the wine of grapes. They were distilled from the wine of dates especially in `Iraq where dates are abundant, and from sugar cane as was the case in Egypt. During the time of the Prophet when prohibition of alcoholic drinks in Islam was imposed, wines were made from grapes, raisins, dates, wheat, barley, corn (*dhura*), honey, and mare's milk. All these types were listed and discussed in the very early days of Islam.[21] Distilled spirits from some of these were produced as we have just seen.

In the 14th century alcohols were exported from the Arab lands of the Mediterranean to Europe. Pegolotti mentions alcohol and rosewater among the list of exported commodities (1310–1340).[22]

The question of cooling was given special attention in the history of alcohol. It must be mentioned that the introduction of the water cooled pipe between the alembic and the receiver in the 15th century in the West had no influence on the discovery of alcohol and of distilled spirits which had taken

16. Al-Azdi, *Hikayat Abi al-Qasim al-Baghdadi*, edited by Adam Mez, Heidelberg, 1902, (offset copy by Qasim al-Rajab, Baghdad), p. 125.
17. A MS at al Zahiriyya Library, Damascus, with the title: *Kitab fi al-san`a al-ilahiyya wa al-hikma al-rabbaniyya fi fada'l al-a`shab wa al-ashjar.* A script error is obvious since the word khall is written while it should be khamr. Araqi denotes distilled wine.
18. al-Nuwayri, op. cit., Vol. 8, p. 261.
19. Al-Antaki, Dawud, *al-Tadhkira*, Cairo, 1282 H, pp. 132–4.
20. Al- Shabushti, *Kitab al-Diyarat*.(The Book of Monasteries), ed. Gurguis Awwad, Baghdad, 1966.
21. See any book on *Hadith* (sayings of the Prophet).
22. Lopez, Robert S. and Irving W. Raymond, *Medieval Trade in the Mediterranean World*, Columbia University Press, 1990, p. 109.

place in the 8th century. Jabir ibn Hayyan described a cooling technique which can be applied to the distillation of alcohol.[23] In addition, we find in Arabic manuscripts instructions to make the alembic and the pipe leading to the receiver quite large with a large cooling surface (Figure 9.1). Fans were used to cool these surfaces.

Figure 9.1 From *Sharh Shudhur al-dhahab*, NLM, MS A 65, fo. 81a.

The alembic took also a conical shape with a trench along its rim. The condensed droplets would slide to the trench and thence to the pipe leading to the receiver (Figure 9.2). In the West this design became popular and it was known as rose-hat or 'rosenhut'.

This was followed by a further improvement whereby the alembic or still-head was surrounded by cooling water (Figure 9.3). This device was

23. Jabir Ibn Hayyan, *Kitab al-jumal al-`ishrin, Maqala No. 19*, MS. Bursa Husain Celebi, Istanbul No. 15, ff. 532–4.

known in the West as the Moor's Head. This name implies an Arabic origin. However, it is not clear at this stage where and when the Moor's Head was first applied since it was illustrated in both Arabic and European MSS of about the same period.

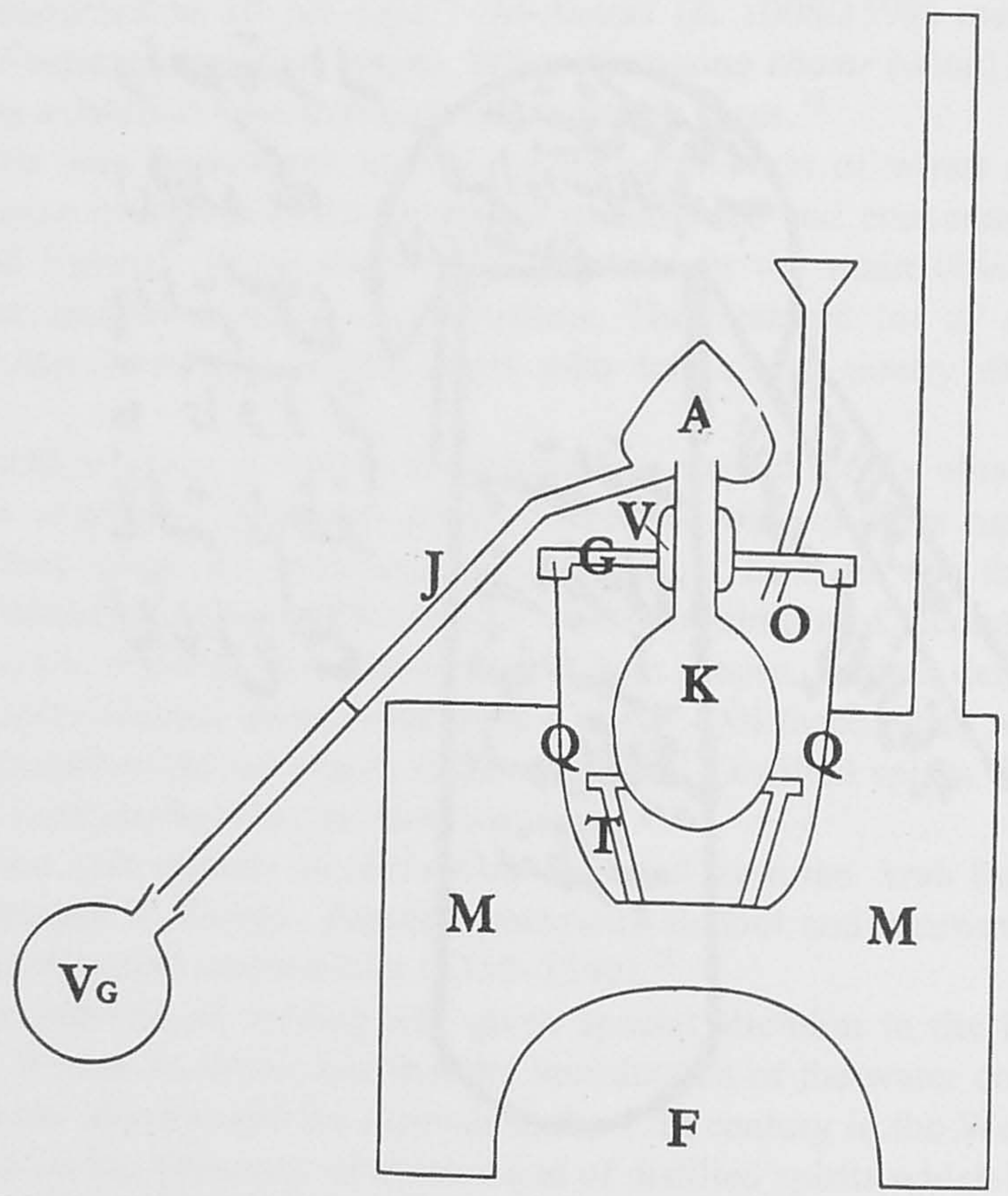


Figure 9.2 Wet distillation of al-Kindi, redrawn by Garbers from al-Kindi's book *Kimiya' al-'itr wa al-tas'idat* (*The Chemistry of Perfume and Distillations*).[24] The main parts are: M furnace or stove; Q earthenware; T supporting ring; at the bottom of the ware; K cucurbit; A conical shaped alembic; J long spout or pipe leading to the receiver; VG; F fireplace.

24. al-Kindî, op. cit.

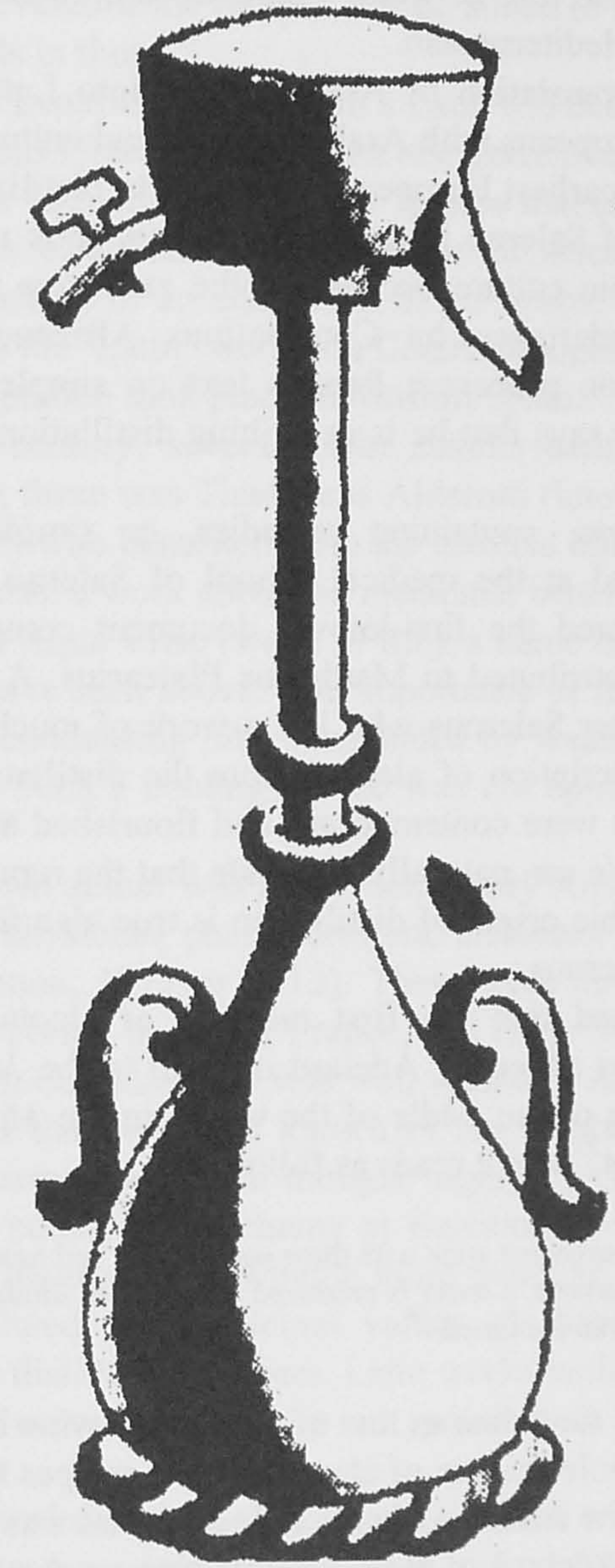


Figure 9.3 NLM MS A65, fo. 81b. Moor's Head

By the 14th century, the distillation of wine was transferred to the East and West and the word `*araq* in its various forms in the Latin alphabet (*arak, araka, araki, ariki, arrack, arack, raki, raque, racque, rac, rak, araka*) became widely used outside the Islamic lands of the Near East. The Mongols used the word arak for example in the 14th century. Mongol *araki* is first mentioned in a Chinese text in 1330.[25] The word spread to most lands of Asia and the eastern Mediterranean.

Because of the translation of Arabic works into Latin and the direct contact of learned Europeans with Arabic science and culture there appeared in Latin literature the earliest European references to distillation and alcohol. The medical school of Salerno in the south of Italy took up the distillation techniques from Arabic culture because of the extensive translations from Arabic that were undertaken by Constantinus Africanus (d. 1087). In describing a distillation process a famous text on simples, *Circa instans,* dated 1150 the author says that he is describing distillation 'as the Saracens make it'.[26]

The *Circa instans,* containing remedies, or simples, from Arabic sources, was compiled at the medical school of Salerno in the mid-12th century. It is considered the first-known document compiled by a Latin author and has been attributed to Matthaeus Platearius. A contemporary to Platearius was Magister Salernus who left a work of much less importance but which gave a description of alcohol from the distillation of wine. The authors of both works were contemporary and flourished around the middle of the 12th century. We can naturally conclude that the report given in *Circa instans* about the Arabic origin of distillation is true also for the description given by Magister Salernus.

It is also assumed that the first mention of alcohol occurred in a cryptogram which was added by Adelard of Bath to the *Mappae Clavicula* (*c.* 1130). The solving of the riddle of the words in the *Mappae* cipher was suggested by Berthelot[27] and it reads as follows:

> By mixing pure and strongest wine with three parts of salt and heating in a vessel customary for that purpose, a water is produced which when kindled is inflamed, (yet) leaves the material unburned.[28]

This description is the same one as that of the Arabic wine bottles mentioned above. As with the whole science of chemistry, the recipes for the distillation of wine were part of the Arabic alchemical legacy that was transmitted in its totality to the West. Adelard of Bath himself was an Arabist who lived in

25. Needham, Joseph, *Science and Civilization in China,* Vol. 5, CUP, 1980, p. 135 (Mongol *araki* had been first mentioned in the *Yin Shan Cheng Yao, c.* + 1330).
26. Hans Gerold Kugler an article on the internet http://www.world-spirits.com/de/worldspirits/Geschichte.htm
27. Multhauf, op. cit, p. 205, footnote 11.
28. Stillman, John Mazson, *The Story of Alchemy and Early Chemistry,* Dover, 1960, p. 189.

Arab lands and several of the recipes that he added to the *Mappae Clavicula* have Arabic words in them.[29]

A third early mention of alcohol in a Latin MS occurred in *Liber Ignium* attributed to Marcus Graecus. More than one description of the distillation of wine occurs in the later editions of *Liber Ignium* that are dated between 1250 and 1300. It was established by historians of science that this work is probably a translation, or an adaptation of an Arabic work of the time that made its way into the 'Latin' world via Constantinople. Others think that the translation or adaptation took place in Muslim Spain.

In the 13th century, several Latin authors mentioned distilled wine. Prominent among these was Thaddeaus Alderotti (known also as Thaddeaus Florentini d. 1303) who benefited from the medical knowledge of the School of Salerno. He wrote a work about the medicinal benefits of distilled wine in which he called it Aqua Vitae (water of life), a name that was used in Arabic literature as we have seen above. The importance of Aldoretti's work is that he used a coiled condensing tube surrounded by water between the alembic and the receiver. Such a cooling device was not applied in practice before the 15th century.[30]

A better known author was his contemporary Arnold of Villanova, who was a celebrated physician, pharmacist, and alchemist (b. between 1235 and 1240; d. near Genoa, 1312 or 1313). There were not a few towns named Villanova at that period in Spain, France, and Italy. Some identify his town with Villanueva in Catalonia. He was well versed in Arabic and Hebrew and comprehended all that was then known of the natural sciences, especially medicine and pharmacology. He thought highly of Galen and Rhazes and taught medicine, botany and alchemy at Barcelona, Montpellier, and Paris. He described the distillation of wine in more than one work and in his *Liber de Vinis* he outlined the medicinal values of distilled wine beside his description of the distillation process. Latin works multiplied about this topic in the following centuries and it is not possible in this limited space to enumerate them.

On the practical side the production of distilled wine during most of the 14th century was a monopoly of physicians and apothecaries because it was considered as a kind of medicine. This did not last long, however, and production of distilled wines was undertaken also by common people. We cannot go into the detailed development of the rise of the distilled spirits industry that arose in the following centuries. In this limited space, we

29. Berthelot, M., *Archeologie et Histoire des Sciences, Amsterdam,* 1968, p. 177.
30. http://www.zauser.at/schnaps/geschichte/geschichte2.shtm

mention only that most histories of distilled spirits acknowledge that the art of distillation of spirits is credited to the Arabs especially the Arabs of al-Andalus.[31] Jerez (Sharish), Malaga, Seville and other regions in al-Andalus were renowned for their wines. They were exported but the details of trade in wines are not fully documented.[32] In Cordoba, there was a state-operated market for wine in the Christian quarter during the time of al-Hakam I (796–823).[33] Wine was distilled in al-Andalus as we have seen above (see al-Zahrawi). It is thought that distilled spirits were produced in Jerez since the Arab days and that sherry in English and xérès in French are derived from Sharish the Arabic name for Jerez.[34]

---

31 Bert L. Vallee, Alcohol In the Western World: A History, first appeared in the June 1998 issue of Scientific American, and published on line at http://www.beekmanwine.com/prevtopy.htm,

32 Constable, Olivia Remie, *Trade and Traders in Muslim Spain*, CUP, 1994, p. 185.

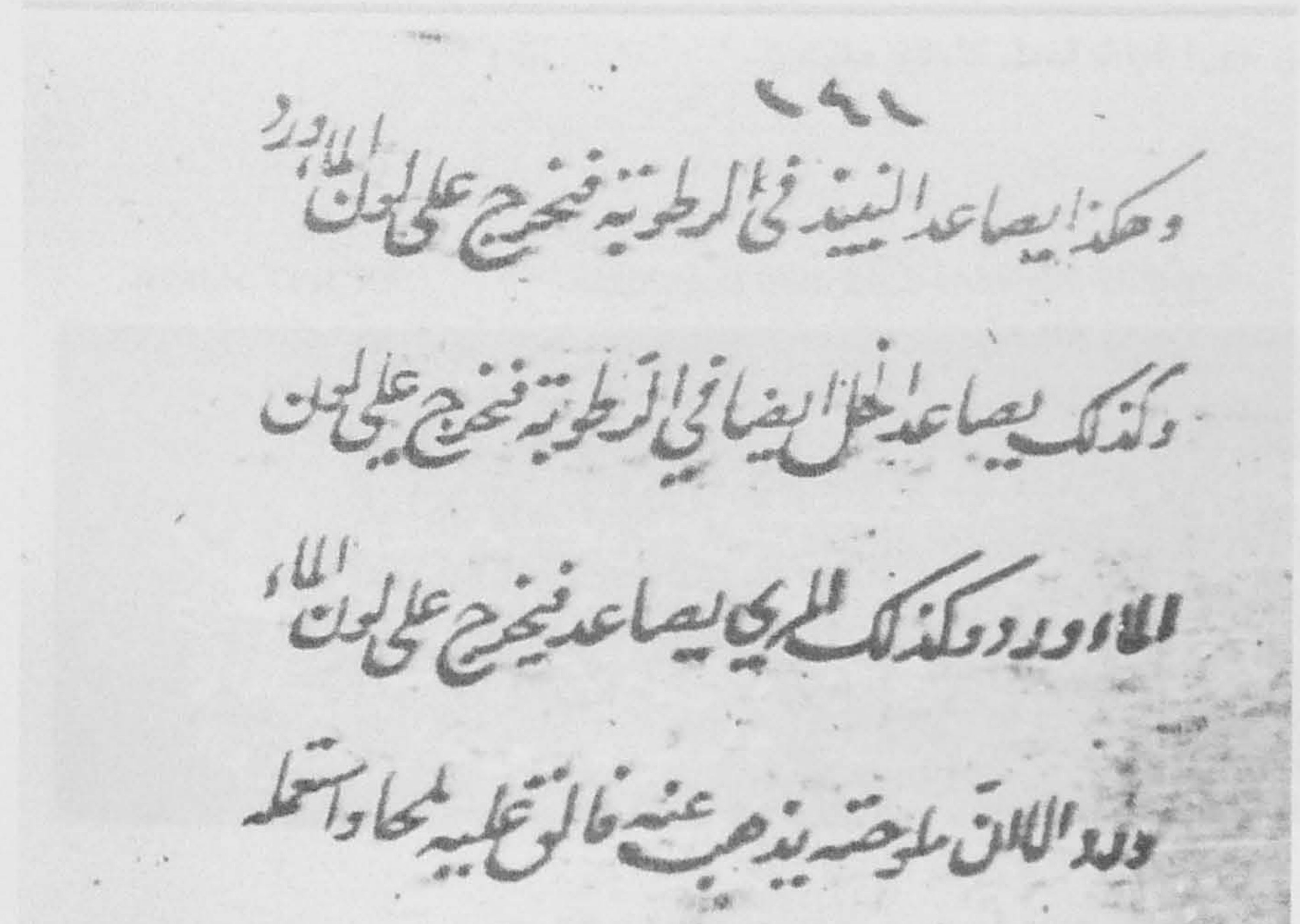
33 Glick, Thomas, *Islamic and Christian Spain in the Early Middle Ages*, Princeton University Press, 1979, p. 80.

34 http://home.online.no/~pernoll/D_Alcohol.html

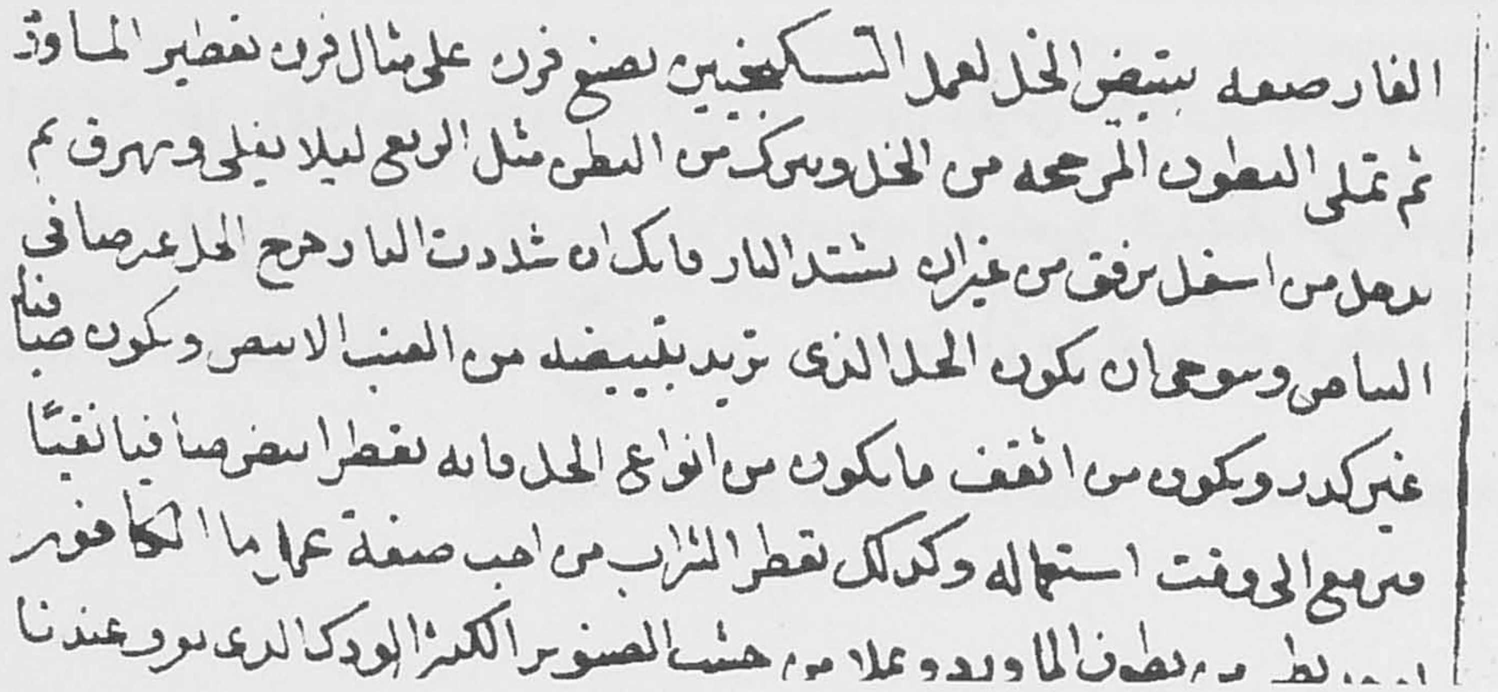
APPENDIX: IMAGES OF ARABIC TEXTS

على ذلك الحرير . والنار التى تشتعل فى رؤس القوارير بالنبيذ والملح
المغلى" وما أشبه ذلك من الأشياء فى الخواص" البديعة التى يُظن" أنّ
مقدار الفائدة فيها (٥٥) يسير . وهذه تدل" على شىء كثير فى هذه العلوم

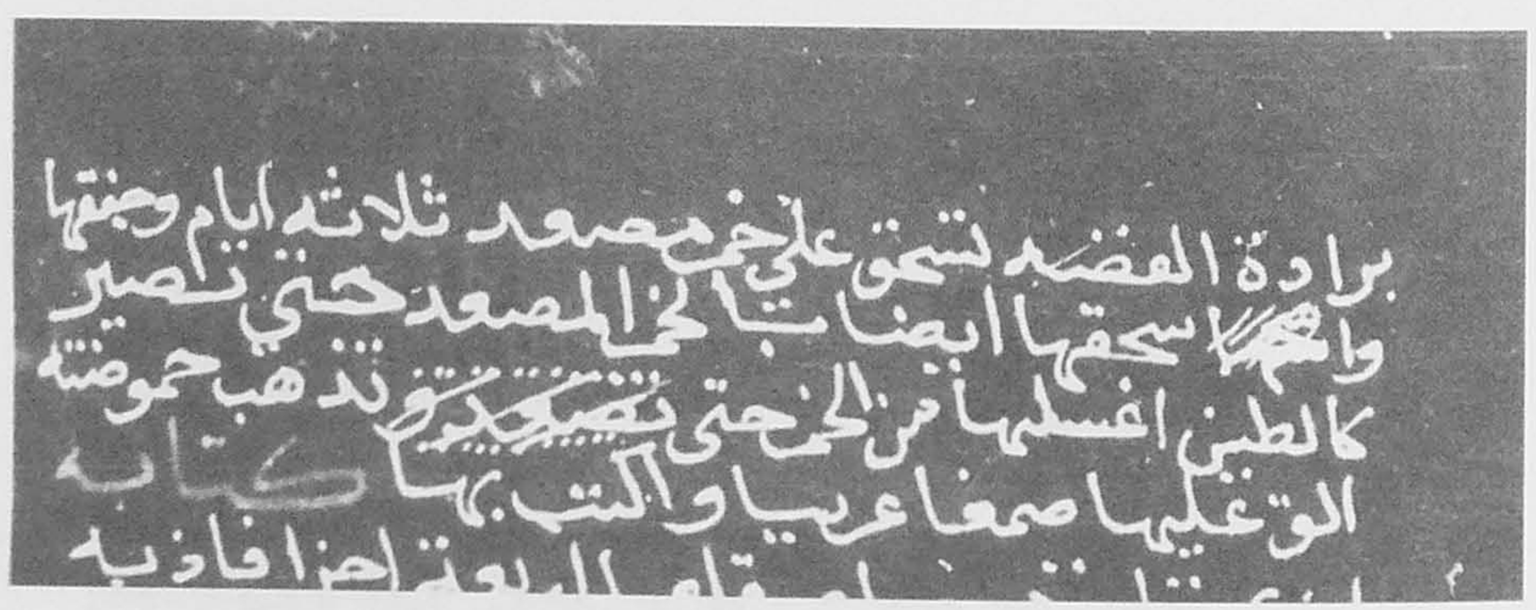
Arabic Text 9.1 Arabic text from Jabir ibn Hayyan.


وهكذا يصاعد النبيذ في الرطوبة فيخرج على لون الماورد
وكذلك يصاعد الخل ايضا في الرطوبة فيخرج على لون
الماورد وكذلك المري يصاعد فيخرج على لون الماء
[illegible]

Arabic Text 9.2 Arabic text from al-Kindi



Arabic Text 9.3 Arabic text from al-Zahrawi.



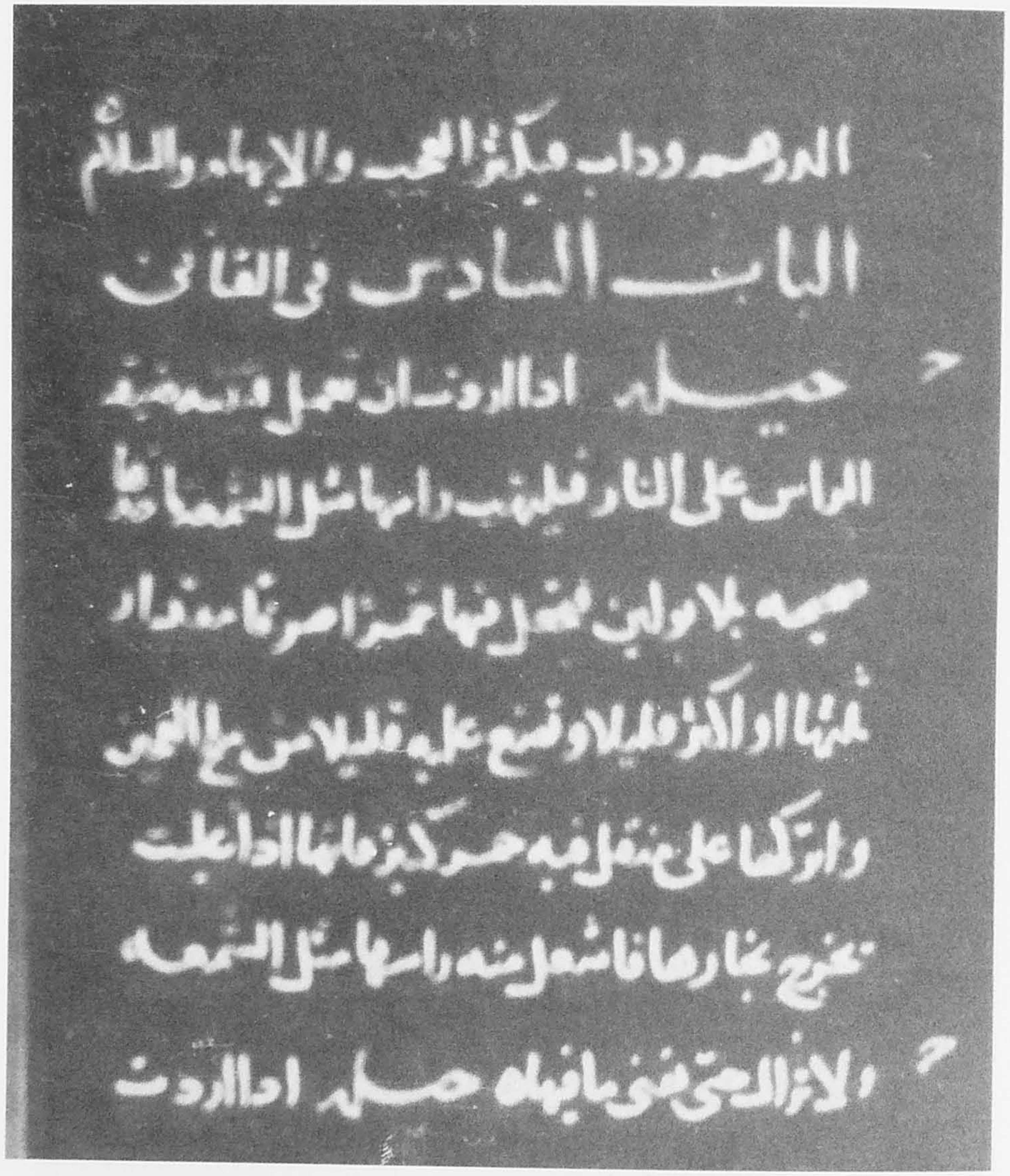
Arabic Text 9.4 Arabic text from Ibn Badis.

قارورة أخرى :

تأخذ خمراً صرفاً عتيقاً متيناً إن قدرت عليه، وخذ أيضاً جِيراً طرياً أول مايخرج من الطبخ، صيّر الجير في القارورة، ولايكون فيها قولين(٥) فتنكسُر ثم صُبّ عليه من الخمر مايغمره، ويكون خاثراً ليس بالرقيق جداً ولا بالغليظ، ويكون معك كبريت مَسْحوق، فإذا أردت اقتباس شيء من

النار، فَخُذ غصنَ آسٍ أَخضر وحَبَقاً أو بَقْلاً والكُراث أجود، فإن لم تجد شيئاً من الخُضَر فخذ عوداً أو خِرقةً أو بُرديّة فابلُلْها بالماء البارد نِعَماً(١)، ثم أخرجها فَنَشفْها من مائها، ثم انثرْ عليها من الكبريت المسحوق /٨٨/ ثم رُش عليها مِما في القارورة وَضَعه في الشمس، فإنه يُشعِلُ على المكان، أو تَغْمَسُهُ فيها، فإنه أجود، وأخبرني من عَمِل هذا الباب، قال القيت في الخمر جيراً فبات فعمل كأجود مايكون.

Arabic Text 9.5 Arabic text from kitab al-hiyal fi al- hurub.

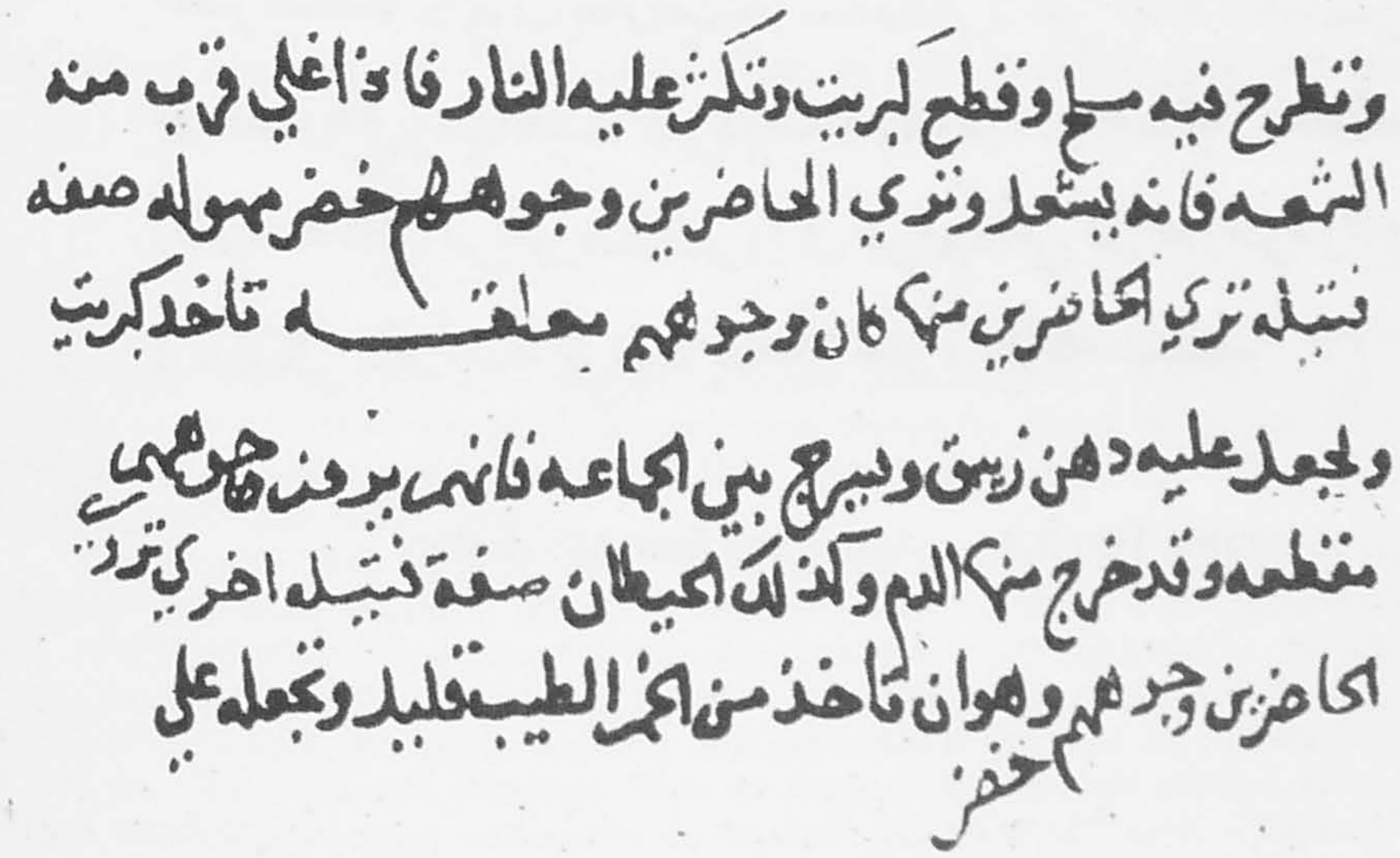

الدرهم وذاب [illegible] والاهليلج والسلام
الباب السادس في الفتائل
حيلة اذا اردت ان تعمل فتيلة
الراس على النار فليلتهب راسها مثل الشمعة [illegible]
صبه بلا [illegible] منها [illegible]
منها او اكثر قليلا وتنبع عليه قليلا من ملح [illegible]
واتركها على [illegible] فانها اذا غلت
تخرج بخارها فاشعل منه راسها مثل الشمعة
ولا تزال [illegible] حيلة اذا اردت

Arabic Text 9.6 Arabic text from al-hiyal al-Babiliyya.

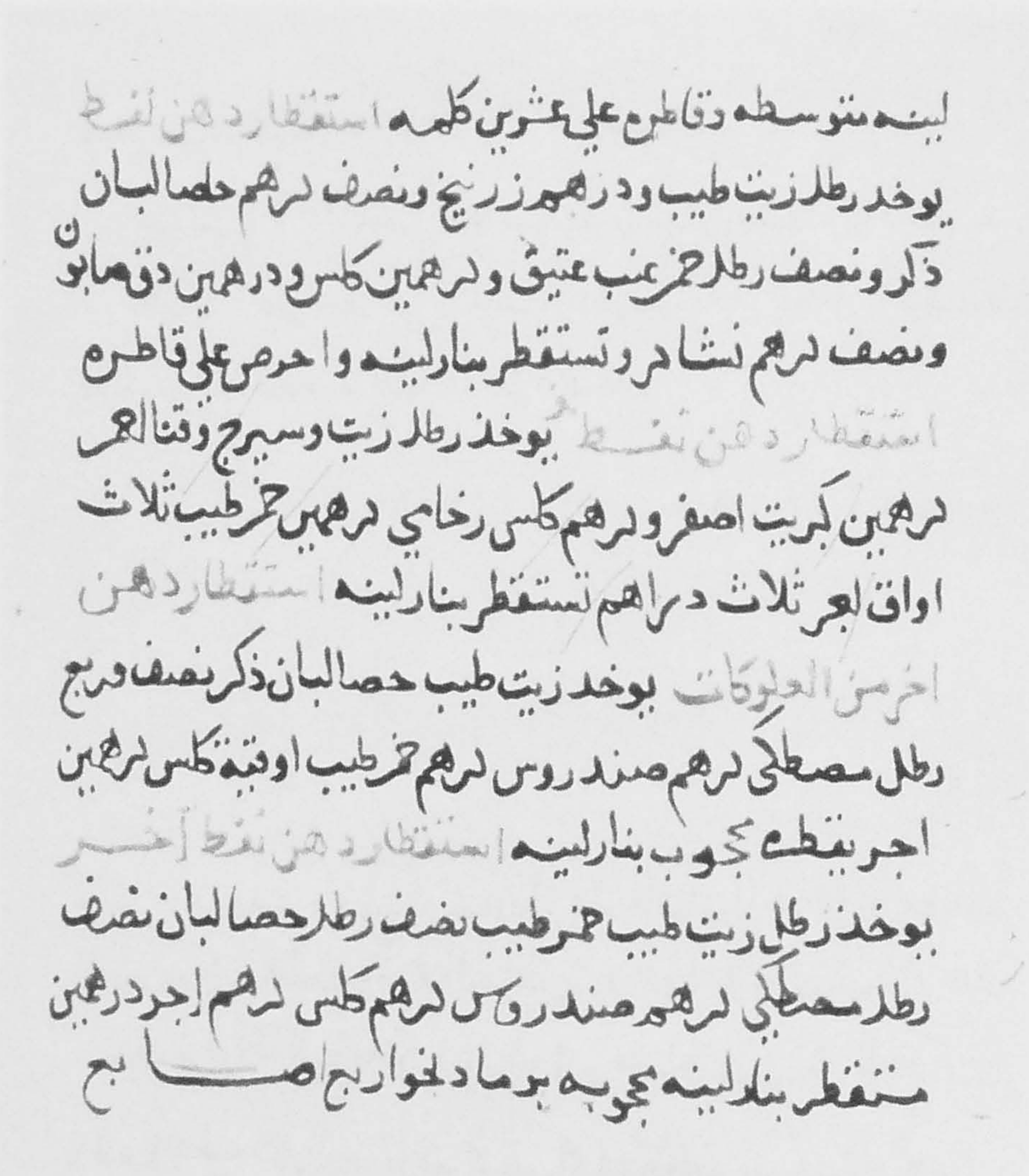
فتيلة على فم قنينة زجاج < تقد >[١] مثل الشمعة :

خذ قنينة * [٢] اعمل فيها نبيذ الى ربعها وارم فيها وزن درهم ملح < وحطها >[٣] على جمر حي فاذا غلت وطلع منها دخان فاجعل < منها >[٤] فتيلة وهي تقد عند فمها فانها تقد مثل الشمعة .

Arabic Text 9.7 Arabic text from al-Rammah.


وتطرح فيه ملح وقطع كبريت وتكز عليه النار فاذا غلي قرب منه
الشمعة فانه يشتعل وترى الحاضرين وجوههم خضر مهوله صفه
فتيله ترى الحاضرين منها كان وجوههم معلقة تاخذ كبريت
وتجعل عليه دهن زيبق وتسرج بين الجماعة فانهم يرون وجوههم
مقطعه وتدخرج منها الدم وكذلك الحيطان صفة فتيله اخرى ترى
الحاضرين وجوههم وهوان تاخذ من الخمر الطيب [illegible] وتجعله على
خضر

Arabic Text 9.8 Arabic text from MS Beshir Agha.



Arabic Text 9.9 Arabic text from MS Beshir.

10 Damascus Steel in Medieval Arabic Sources[1]

INTRODUCTION

The main purpose of this chapter is to make available to historians a selected number of passages from Arabic medieval literature (some of which were hitherto unpublished) which bear upon ferrous metallurgy. For each source, we present an English translation followed by the Arabic text.

We shall start with the composition of steel according to Jabir ibn Hayyan and al-Biruni. Then we discuss the reason behind the *firind* or the pattern in sword blades.[2] This is followed by a description of producing crucible steel in Damascus by the carburising of soft iron. Then we give a description of obtaining pig iron from ores, and of decarburising this high carbon iron to obtain steel. This is followed by a summary of al-Kindi's treatise on the kinds of swords and the centres of steel production in the eastern Islamic lands. The sections that follow trace the history of Damascus steel industry until the 19th century.[3]

COMPOSITION OF STEEL

The oldest description of the composition of steel is due to Jabir ibn Hayyan in *Kitab al-khawass al-kabir* as we have explained in Chapter 5. Jabir said

---

1. This chapter is an edited version of my article 'Iron and Steel Technology in Medieval Arabic Sources', *Journal for the History of Arabic Science*, Vol. 2, Number 1, May 1978, Aleppo, pp. 31-43. Since that date, the paper was frequently quoted and it had fulfilled its intended purpose. Our book (with Donald Hill), *Islamic Technology, an Illustrated History*, was quite useful also in this regard.

Recently, in 2006, 28 years after the publication of my paper, Hoyland and Gilmour published their book *Medieval Islamic Swords and Sword Making*, Gibb Memorial Series. They translated al-Kindi's treatise that was already summarised in this article, and they gave as an appendix Jabir and al-Jildaki's description of the production of pig iron and steel on an industrial scale, using my paper; and they also gave another appendix on al-Biruni's chapter on iron and steel that I also discussed. Thus my paper of 28 years ago which is given in this chapter presented the main information in Hoyland and Gilmour's book. I must mention, however, that the new book is a useful addition to the literature on Arabic-Islamic ferrous metallurgy.

2. *Firind* is the pattern that characterises Damascus steel swords.

3. These passages are based mainly on Ms. Ayasofya 4832, ff. 170–2. See also: `Abd al-Rahman Zakï, *al-Suyuf wa Ajnasuha'*, an edited Arabic text, *Faculty of Arts Journal*, vol. 14, part 2, Cairo, 1952; Hammer-Purgstall, Baron de, 'Sur les Lames des Orientaux', *Journal Asiatique, Ve Serie*, tome III, pp. 66–80, Paris, 1854.

that steel is composed from soft iron (narmahan) and daus. Al-Biruni gave the same formulation in more detail.[4] He says:

'As to (iron) which is made from *narmahan* and its water which flows before it when it gets rid (of its impurities), it is called *fuladh* فولاذ (steel).'

وأما المركب من النرماهن ومن مائه وهو الذي يسبقه الى الجريان عند التخليص فهو الفولاذ.

Al-Biruni elaborates on daus when he writes:

> *Narmahan* is divided into two types. One is (*narmahan*) itself, and the other is its water which flows from it when it is melted and extracted from stones, and it is called *daus* دوص, in Persian it is called *astah*, and in the area of Zabilstan, ru رو, because of its speed of flow and because it overtakes iron when it is flowing. It is solid, white, and tends to be silvery.

ثم ينقسم النرماهن الى ضربين أحدهما هو والاخر ماؤه السائل منه وقت الاذابة والتخليص من الحجارة ويسمى دوصا وبالفارسية استه وبنواحي زابلستان رو لسرعة خروجه وسبقه الحديد في الجريان. وهو صلب أبيض يضرب الى الفضية.

An iron that has a lower melting point that flows before soft iron and is hard, white and silvery is probably white cast iron. Thus, both Jabir and al-Biruni give the same formula for the composition of steel.

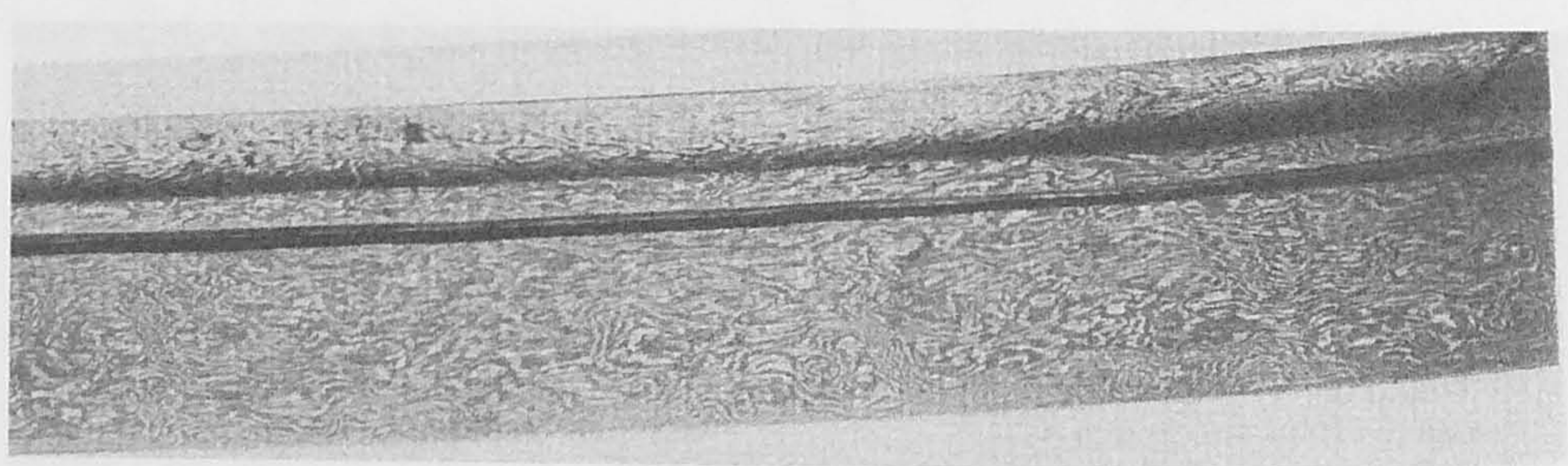


Figure 10.1 The pattern or *firind* on a sword.

4. Al-Biruni, *Kitab al-Jamahir fi ma'rifat al-jawahir* الجماهر في معرفة الجواهر (A Compendium of Mineralogy) written by the celebrated savant, Abu al-Rayhan al-Biruni (973–1048). Two main manuscripts were consulted. The first is Ms. Topkapi 2047 from Istanbul, and the other is Ms. Casiri 905 from the Escorial. Similarly, the book printed in Hyderabad was also consulted *(Kitab al-Jamahir,* edited by E. Krenkow, Hyderabad, 1936/37).

CAUSE OF THE *FIRIND* OR THE PATTERN ON BLADES

All Islamic swords that were made from Damascus steel or from steels of similar quality showed the peculiar pattern that was referred to in Arabic literature as *firind* or *'jawhar'* فرند ، جوهر.

From al-Kindi's treatise, we learn that the pattern or *firind* الفرند *or jawhar* الجوهر is found in all manufactured steels. According to him, swords made from natural steels (non-manufactured, *Shaburqan*) have no pattern or *'firind'*. When speaking about the *firind* of swords made from natural steel, al-Kindi states:

> 'These swords show no firind when treated with *tarh*[5] طرح or when treated otherwise, and all their iron is one colour.'

وهذه السيوف لا فرند لها في طرح ولا غيره وحديدها كله لون واحد

On the other hand, all swords that are made from manufactured steel show the *'firind'* in various degrees. Al-Kindi describes the *'firind'* or pattern of all types of manufactured steels and of swords produced in various localities in Islamic lands, and of Indian steel.

Al-Biruni in *al-jamahir* gives a very interesting interpretation of the cause behind the formation of the *firind* or pattern in steels. It is due, in his opinion, to the incomplete mixing of two components of steel in the crucible, namely soft iron *(narmahan)* and its water (daus دوص). He says:

> *'Fuladh* (steel) in its composition is of two types. In one type, all that is in the crucible, *narmahan* and its water is melted equally so that they become united in the mixing operation and no component can be differentiated or seen independently. Such steel is suitable for files and similar tools. (One may imagine that *shaburqan* is of such type and of a natural quality suited to hardening). In the second type, the degree of melting of the contents of the crucible varies, and thus the intermixing between both components is not complete, and the two components are *shifted* يتجاوز and thus each of their two colours (colour of their components) can be seen by the naked eye and it is called *firind*.'[6]

وحال الفولاذ في تركيبه على قسمين اما أن يذاب ما في البوطقة من النرماهن ومائه ذوبا سواء يتحدان به فلا يستبين أحدهما من الاخر ويستصلح للمبارد وأمثالها ، ومنه يسبق الى الوهم أن الشابورقان من هذا النوع وبصنعة طبيعية تقبل لها السقي؛ واما أن يخلف ذوب ما في البوطقة فلا يكمل الامتزاج بينهما بل يتجاوز اجزاؤهما فيرى كل جزء من لونيهما على حدة عيانا ويسمى فرندا.

5. *Tarh* referrs here to the drug (mixture of materials) that is used to treat the surfaces of swords to show their *firind* or pattern.
6. For the modern interpretation of the cause of the *firind* see Cyril S. Smith, *A History of Metallugraphy*, Chicago, 1960, pp. 14–24.

Al-Biruni's interpretation of the cause of the *firind* or pattern in Damascus steel is reminiscent of the modern interpretation of modern historians of metallurgy who were studying the secret of Damascus steel for the last two centuries.

A METHOD FOR MAKING CRUCIBLE STEEL IN DAMASCUS

Al-Biruni quotes a description of making crucible steel from a book written by a Damascene ironsmith called Mazyad ibn 'Ali. He says:

> Mazyad ibn 'Ali, the Damascene blacksmith, wrote a book describing swords that were specified in al-Kindi's treatise. He commenced by dealing with the steel composition and the construction of the furnace (*kur*), and with the construction and design of crucibles, the description of (the varieties) of clay and how to distinguish between them. Then he instructed that in each crucible five *ratls* of horseshoes and their nails should be placed, which are made of *narmahan*, as well as a weight of ten *dirhams* each of *rusukhtaj* روسختج, golden marcasite stone المرقشيشا الذهبي and brittle magnesia. They plaster the crucibles with clay and place them inside the furnace (*kur*). They are filled with charcoal and they (the crucibles) are blown upon with *rumi* bellows, each having two operators, until it (the iron) melts and whirls. Bundles صرر are added containing *ihlilaj* (myrobalan), pomegranate rinds, salt (used in) dough, and oyster shells أصداف اللؤلؤ ,(lit. pearl shells), in equal portions, and crushed, each bundle weighing forty *dirhams*. One (bundle) is thrown into each crucible; then it (the crucible) is blown upon violently for an hour. Next, they (the crucibles) are left to cool, and the eggs are taken from the crucibles.

ولمزد بن علي الحداد الدمشقي كتاب في وصف السيوف التي اشتملت رسالة الكندي على أوصافها. ابتدأ العمل بنصاب الفولاذ وصنعة الكور وعمل البواطق ورسومها وصنعة أطيانها ثم أمر أن يجعل في كل بوطقة خمسة أرطال من نعال الدواب ومساميرها المعمولة من النرماهن ومن كل واحد من الروسختج والمرقشيشا الذهباني والمغنيسا الهشة وزن عشرة دراهم ويطين البواطق وتودع الكور. تملأ فحما وينفخ عليها بالمنافخ الرومية كل منفاخ برجلين الى أن تذوب وتدور وقد أعد له صررا فيها اهليلج وقشر رمان وملح العجين وأصداف اللؤلؤ بالسوية مجرشة في كل صرة أربعين درهما يلقى في كل بوطقة واحدة. ثم ينفخ علها نفخا شديدا بلا رحمة ثم تترك حتى تبرد وتخرج البيضات عن البواطق.

THE PRODUCTION OF PIG IRON AND CAST STEEL ON AN INDUSTRIAL SCALE

We found that Ms. no. 4121 of the Chester Beatty Library, contains a part of *Kitab al-Hadid* (The Book of Iron) of Jabir ibn Hayyan, that is given in the course of a commentary by al-Jildaki (fl. *c.* 1339–42). The following text from this Ms. is of great significance for the history of metallurgy:

> 'Chapter: Learn, brother, that it is your comrades who found (from founding, melt metal يسكبون) iron in foundries (especially) made for that purpose after they have extracted it (the ore) from its mine as yellow earth intermingled with barely visible veins of iron. They place it in founding furnaces designed for smelting it. They install powerful bellows on all sides of them after having kneaded (يلتون) a little oil and alkali with the ore. Then they apply fire to it (the ore), together with cinders (الجمر) and wood. They blow upon it until it is molten, and its entire substance جسمه وجسده is rid of that earth. Next, they cause it to drop through holes like (those of) strainers, (made in) the furnaces أكوار so that the molten iron is separated, and is made into bars from that ore. Then they transport it to far lands and countries. People use it for making utilitarian things of which they have need.
>
> 'As for the steel workers, they take the iron bars and put them into founding-ovens مسابك which they have, suited to their objectives, in the steel works. They install firing equipment أكوار into them (the ovens) and blow fire upon it (the iron) for a long time until it becomes like gurgling water. They nourish it with glass, oil, and alkali until light appears from it in the fire and it is purified of much of its blackness by intensive founding, night and day. They keep watching while it whirls for indications until they are sure of its suitability, and its lamp emits light; thereupon, they pour it out through channels so that it comes out like running water. Then, they allow it to solidify in the shape of bars or in holes made of clay fashioned like large crucibles. They take out of them refined steel in the shape of ostrich eggs, and they make swords from it and helmets, lance heads, and all tools.' *See Appendix for facsimile of the MS folios.*

From these two descriptions, it seems safe to state that the first process describes the production of pig iron (or cast iron) from ores, and that the second one describes the production of cast steel by refining pig iron.

THE THREE METHODS OF STEEL PRODUCTION

From the above texts excerpted from Jabir ibn Hayyan, al-Biruni and al-Jildaki we learn that steel was produced by three methods:

Al-Biruni described the first method in which *narmahan* (soft iron) and *daus* (cast iron) were melted together in the crucible. The second method is by carburising *narmahan* (soft iron) in the crucible. Al-Biruni attributed this to Mazyad ibn 'Ali the Damascene ironsmith; and the third method is by the de-carburisation of pig or cast iron and refining it into steel as it is described in the commentary of al-Jildaki on Jabir ibn Hayyan's *Kitab al-hadid* (The Book of Iron).[7]

---

7. The three methods were outlined in our book *Islamic Technology, an Illustrated History*, al-Hassan and Hill, UNESCO and CUP, 1986. Recently, Hoyland and Gilmour (see above) gave an incorrect interpretation to the description of Jildaki of steel manufacture, although the text is obvious as can be realised.

THE ANNEALING AND HARDENING OF STEEL

Jabir ibn Hayyan gave in *Kitab al-khawass al kabir* one recipe for the annealing of steel and another for its hardening (see Chapter 5). Al-Kindi wrote also a treatise on the heat treatment of steels, other than the treatise that we shall summarise below. This carries the title of *A Treatise to Ahmad ibn al-Mu'tasim Billah on what Drugs are Applied to Iron and Swords so that they cannot become Broken at the Edges or Become Blunt* رسالة إلى أحمد بن المعتصم بالله فيما يطرح على الحديد والسيوف حتى لا تنتثلم ولا تكل.

Several treatises in Arabic give recipes on the annealing and heat treatment of steel. However, the discussion of these is outside the scope of this chapter.

AI-KINDI ON KINDS OF ISLAMIC SWORDS AND CENTERS OF STEEL PRODUCTION

Among the extant works of Abu Yusuf b. lshaq al-Kindi (fl. 850), the philosopher of the Arabs, is '*A Treatise (Addressed) to some of His Brethren Concerning Swords*' رسالة إلى بعض إخوانه في السيوف . The treatise contains much useful technological information. However, we shall be content in this chapter to give al-Kindi's classification of the various kinds of iron and steel from which swords were being made. We excerpted the passages below from this treatise.

Natural and Not-natural Iron

'Learn that iron from which swords are forged is divided into two primary or main divisions: natural (as mined) and not-natural (i. e. manufactured). Natural iron is divided into two divisions: *shaburqan* شابورقان and it is the male, hard iron which can be heat-treated قابل للسقي by its nature, and *narmahan,* which is the female soft iron which cannot be heat-treated by its nature. [Swords] can be forged from either of these two kinds or from both combined. Thus, all kinds of swords that are made of natural iron fall into three kinds: *shaburqani, narmahani,* and those made of a combination of both.'

اعلم أن الحديد الذي تطبع منه السيوف ينقسم قسمين أولين: إلى المعدني والذي ليس بمعدني، والمعدني ينقسم قسمين: إلى الشابورقان وهو المذكر الصلب القابل للسقي بطباعه، والى النرماهن وهو المؤنث الرخو الذي ليس بقابل للسقي بطباعه ، وقد يطبع من كل واحد من هذا الحديد مفردا ومنهما معا مركبين. فجميع أنواع السيوف المعدنية ثلاثة الشابورقانية والنرماهنية والمركبة منهما.

Not-natural or Manufactured Iron or Steel

'Iron which is not natural (i.e. manufactured) is steel or *fuladh* فولاذ. It means the refined or purified المصفى. It is made of natural iron by adding to it while smelting some (ingredients) for purifying it, and for decreasing its softness, until it becomes strong, flexible, susceptible to heat treatment, and until its *firind* فرند appears.'

فأما الحديد الذي ليس بمعدني فهو الفولاذ ومعناه المصفا ، ويصنع من المعدني بأن يلقى عليه في السبك شيء يصفيه ويشد رخاوته حتى يصير متينا لدنا يقبل السقي ويظهر فيه فرنده.

Three Main Qualities of Steel

'This steel is divided into three divisions: the antique العتيق, the modem المحدث, and the non-antique, non-modern. Swords may be forged from all these steels. Thus, there are three kinds of swords: the antique, the modern, and the non-antique, non-modern.'

وهذا الفولاذ ينقسم إلى ثلاثة أقسام إلى العتيق والمحدث والى لا عتيق ولا محدث وقد يطبع من هذه جميعا السيوف. فانواع السيوف الفولاذية ثلاثة: عتيق ومحدث ولا عتيق ولا محدث.

'Antique' Means Top Quality Steel

'Antique is not related to time (or age) but it indicates the noble or the generous qualities, as when it is said "an antique horse" meaning a noble horse (of good breed). That (sword) which has the noble qualities is "antique", no matter in which age it was forged. At the extreme end of the "antique" is its opposite in meaning, I mean that (sword) which is deprived of the qualities of the "antique". That is why it was given an opposite name, i.e. modern, even if was forged before the time of 'Ad. Those (swords) which have some qualities of the "antique", but which are deprived of some of its qualities, are the swords that exhibit some of the qualities of the "modern". Therefore, these swords are given a name in the middle between both, and they are classified as non-antique, non-modem even if they are forged in ancient or modern times. Sword-makers called some of these swords "non-antique", and called by some others "non-modern".'

ولم تذهب من عتقها إلى الزمان بل إنما تذهب من عتقها إلى الكرم كما يقال فرس عتيق يراد به كريم. فما لحقته خواص الكرم فهو عتيق في أي دهر طبع. والطرف الأبعد من العتيق هو ضده في المعنى أعني ما عدم خواص العتيق فلذلك سمي بضد اسمه أعني محدث وان كان قد طبع قبل زمن عاد. وأما الآخذة بعض خواص العتيق وحارمة بعض خواصه فهي التي وجد فيها بعض خواص المحدث فسميت أيضا باسم متوسط بين الاسمين فقيل ليس بعتيق ولا محدث وان كان متقدم الزمان أو حديثه؛ فاختص الصياقلة لها اسم لا عتيق في بعضها ولا محدث في بعضها.

Three Kinds of 'Antique' or Quality Swords

'The antique swords are divided into three kinds. The first and best in quality of all is the Yemenite; the second is the Qal`i قلعي and the third is the Indian.'

فالعتيق ينقسم ثلاثة أقسام أولها وأجودها اليماني ثم ثانيها القلعي ثم ثالثها الهندي.

Swords Forged from Imported Steel

Some swords were called *non-native* غير مولد. They were forged from imported steel. Some *Khurasani* swords for example were forged from steel imported from Sarandib; and this is the case in several other cities.

Swords Forged from Local Iron

'As for those native swords مولدة, they fall into five kinds. Of these are the *Khurasani,* the iron of which is produced and forged in Khurasan; the *Basriyya,* the iron of which is produced and forged at Basra; the *Damascene,* the iron of which is produced and forged at Damascus; and the *Egyptian,* which is forged in Egypt. Swords in this category may be forged in other places like those of Baghdad, of Kufa, and a few other places, but are not attributed to such places because of their scarcity. These are all the types of swords which are made from manufactured iron, I mean from steel.'

وأما المولدة فتنقسم خمسة أقسام. منها الخراسانية وهي ما عمل حديده وطبع بخراسان. ومنها البصرية وهي ما عمل حديده وطبع بالبصرة. ومنها الدمشقية وهي ما عمل حديده وطبع بدمشق قديما. ومنها المصرية وهي ما طبع بمصر. وقد يطبع في مواضع غير هذه كالبغدادية والكوفية وغير ذلك من المواضع القليلة ولا تنسب اليها لقلتها. فهذه جميع أنواع السيوف المذكورة من الحديد المعمول أعني الفولاذ.

IRON FOUNDRIES IN DAMASCUS IN THE 12TH AND 13TH CENTURIES

We find references to iron foundries in Damascus in medieval times in Arabic literature. Thus, in the book *Subh al-a`sha* (Cairo: Ministry of Culture) by al-Qalqashandi (d. 1418), when discussing government departments in Damascus during the *Ayyubid* dynasty (1171-1250), the following statement occurs (vol. 4, p. 18): 'There are several small departments such as the department of foundries شدّ المسابك for iron, copper, glass, and others.'

ومنها شدود صغار متعددة كشد المسابك من الحديد والنحاس والزجاج وغير ذلك.

Then (on p. 190), al-Qalqashandi speaks about departments of the civil service in Damascus and says:

Of these is the civil department of foundries نظر المسابك and the executive in charge of this department is the counterpart of the officer in charge of the military department of foundries شدّ المسابك who was mentioned above when dealing with military officers (men of the sword).

The *History of Damascus City* تاريخ مدينة دمشق (Damascus: Arab Academy of Science,1954) by Abu al-Qasim `Ali ibn al-Hasan, known as Ibn `Asakir (d.1177), mentions (vol. 2, p. 58) the sites of iron foundries in Damascus.

The Name 'Damascus Steel' is an old one and was used in Arabic Literature.

Zayn al-Din al-Dimashqi al-Jawbari (d. 1232) wrote his book *A Selective Book on Revealing Secrets* المختار في كشف الاسرار (Damascus, 1302 H) as a guidebook on how to discover cheating methods adopted by various trades and crafts. Chapter 8 is on 'revealing secrets of manufacturers of arms'. The following passage occurs (p. 61):

They have a prescription for a (good) cutting sword: Indian steel or Damascus steel is taken and a sword is made of these steels which is strong, thick in the middle and thin at the edges, with evenness such that no place is stronger than the other. Then, if it is heat-treated with the above-mentioned water, nothing can oppose it.

ولهم صفة سيف قاطع: يؤخذ فولاذ هندي أو دمشقي فيعمل منه سيف قوي الوسط رقيق الجوانب متساويا لا يكون موضع أقوى من موضع ثم يسقى من الماء المتقدم ذكره سابقا فانه لا يقف قدامه شيء .

The passage below also shows that the term 'Damascus steel' was current during the 14th century. The quotation is from a manual on quality control by Dia' al-Din Muhammad al-Qurashi, known as Ibn al- Uhkuwwa (d. 1329). The book is *Ma`alim al-qurba fi ahkam a*-hisba معالم القربة في أحكام الحسبة (ed. Reuben Levy, Cambridge, 1938; reproduced in Baghdad, Muthanna), p. 224:

An honest and trustworthy (individual) from among them (the artificers) is chosen (as inspector). He prevents (them) from mixing steel needles with those made of *armahan* (soft iron,) for, when sharpened, the latter may be confused as made from *Damascus steel.* Therefore, each quality should be separate from the other, and he should take an oath from the artisans to follow these regulations.

يعرف عليهم رجلا ثقة أمينا من أهل صناعتهم يمنعهم أن يخلطوا الإبر الفولاذية مع الارمهان لأنها إذا سنت جاز أن تختلط بالفولاذ الدمشقي بل يكون كل صنف منها على حدته ويحلف الصناع على ذلك.

IRON MINES IN THE LEBANON AND ANTI-LEBANON RANGES

Iron and steel foundries in Damascus were using the iron ore of the Lebanese mountains. The Geographer, Shams al-Din Abu `Abd Allah al-Maqdisi (also known as al-Muqaddasi, d. *c.* 1000), in *Ahsan al-taqasim* fi *ma`rifat al-aqalim* أحسن التقاسيم في معرفة الأقاليم (Leiden: Brill, 1906; reprinted Baghdad, Muthanna), p. 184, when speaking about *iqlim al-Sham* (i.e. Syria) states that there were iron mines in the mountains of Beirut.

وبه معدن الحديد في جبال بيروت.

In like manner, al-Idrisi (d. *c.* 1160) in *Nuzhat al-Mushtaq* fi *Ikhtiraq al-Afaq* نزهة المشتاق في اختراق الافاق (see Eilhard Wiedemann, *Aufsötze zur arabischen Wissenschaftsgeschichte,* vol. 1, p. 740) reports that iron ore in large quantities was being mined in the vicinity of Beirut and transported to all parts of Syria.

Ibn Battuta's famous travel account, *Rihlat Ibn Battuta* رحلة ابن بطوطة (Beirut, Sadir, 1964), contains a remark by the author (p. 62) to the effect that when he stopped over in Beirut in 1355, iron was being exported from there to Egypt:

ثم سرنا الى مدينة بيروت ... ويجلب منها الى ديار مصر الفواكه والحديد

Dawud Ibn `Umar al-Antaki (d. 1599) in his *Tadhkira* تذكرة داود الانطاكي (Cairo, n.d., p. 111) defines iron and describes the manufacture of steel from soft (female) iron in crucibles. He states that iron originates from *Sham* (Syria), Persia, and Venice.

ويتولد بالشام وفارس والبندقية

In the 18th century (between 1792 and 1798), the German traveller, U.I. Seetzen, in his *Reisen* (Berlin, 1854), Bd, 1, pp. 145, 188–91, reported that the ferrous industry in the Lebanese mountains was still flourishing. Operations involving mining, smelting, and the fabrication of steel implements were in full swing.

In the 19th century, W.M. Thomson, who lived in Syria, refers in his book *The Land and the Book* (London, 1886) to iron in the Lebanese mountains and to iron ore mining and smelting, which operations were still going on in about 1834.

In 1921, I.M. Toll wrote a paper on the *Mineral Resources of Syria (Engineering and Mining Journal,* vol. 112, 1921, p. 846) with a map showing the iron ore deposits. He describes the quality of iron ores and the locations of iron ore mining which was still going on in some localities. He states, however, that smelting of iron in the mountains of Lebanon ended in about 1870 due to scarcity of wood and fuel and the low price of imported iron.

CONCLUDING REMARKS

We have provided important information about the production of pig iron, cast iron, wrought iron and steel in Islamic lands; have discussed three methods for producing steel; and have given al-Biruni's explanation about the formation of the *firind* or pattern in sword blades.

We have also given a comprehensive summary of al-Kindi's treatise, which provided useful information on the kinds of Islamic swords and the centres for the production of iron and steel from local iron ores in the eastern lands of Islam.

We also reviewed the history of the steel industry in Damascus, Syria until the end of the 19th century, and reported on the iron mines in the Damascus region.

Although the myth about the role of Damascus as a trading centre only for wootz steel has now been dispelled, it is interesting to raise the question of how that myth came into being.

The answer seems to be as follows. As the Industrial Revolution got underway, European steel-makers sought to emulate the quality of Damascus blades.[8] At that time wootz steel was imported into Britain from India; and Syria and other Islamic lands were not known to be centres for steel production. Thus, the myth evolved that 'Damascus steel' was made from wootz steel and that Damascus was only a trading centre.

8. The literature on the European research into the secret of Damascus steel is considerable. The interested reader will find an account of much of it in Cyril S. Smith's A *History of Metallography* (Chicago: The University of Chicago Press, 1960).

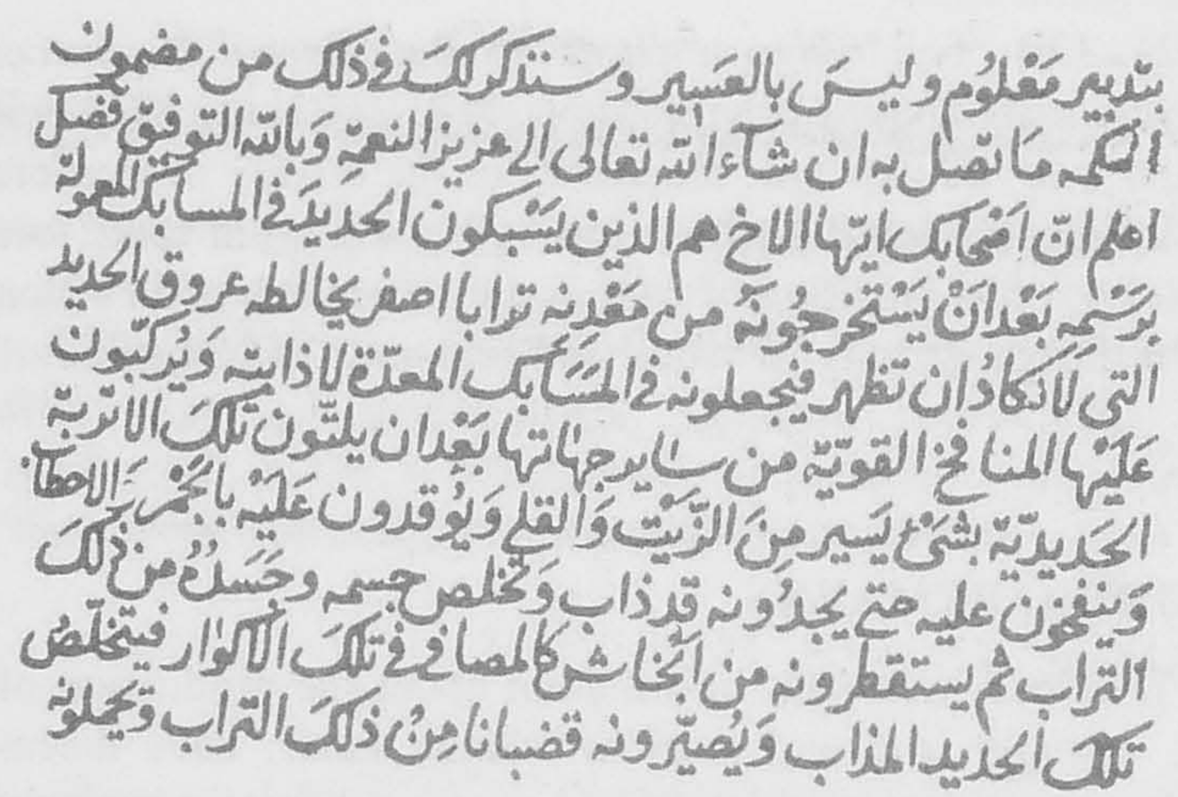


Figure 10.2 MS. Chester Beatty 4121, fo. 1v.

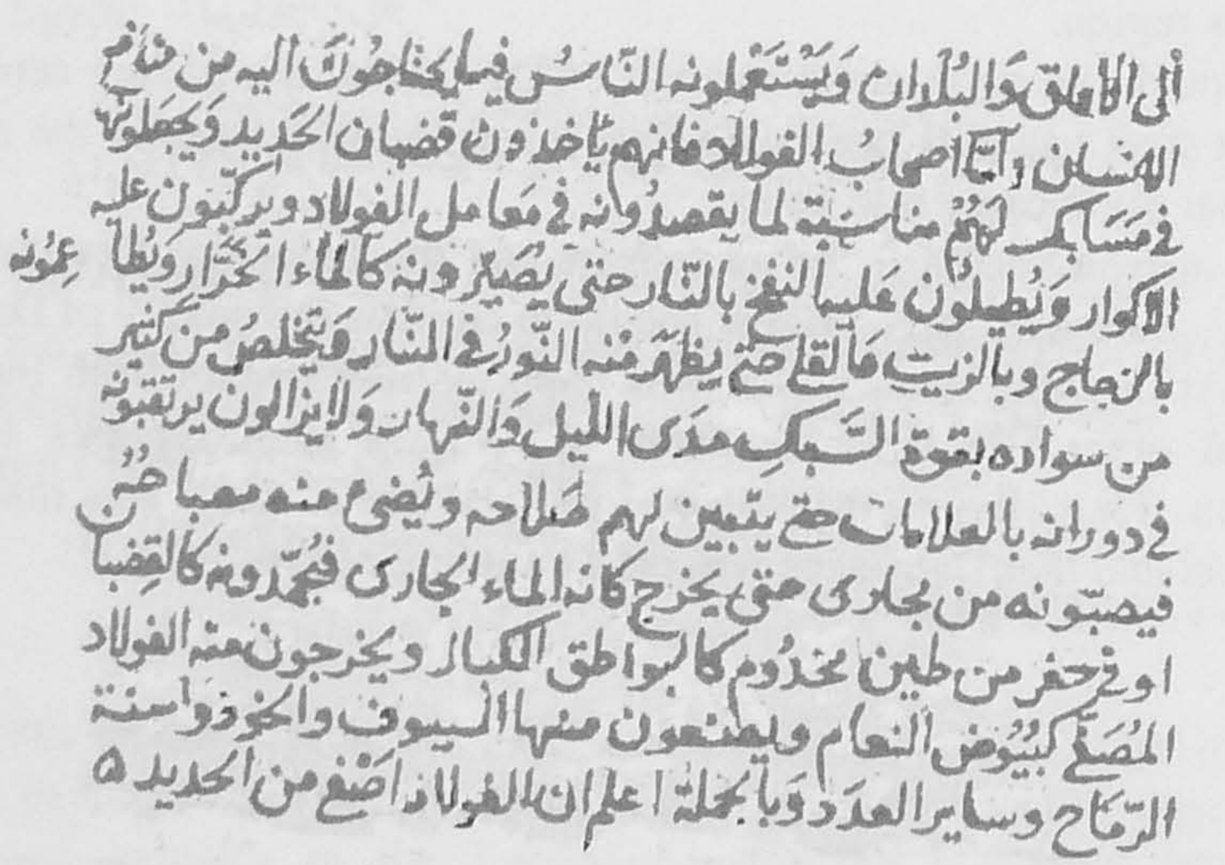


Figure 10.3 MS. Chester Beatty 4121, fo. 2r.

Index

AHMAD Y. AL-HASSAN | Studies in al-Kimya'

This book discusses eight critical issues in the history of Latin and Arabic alchemy and chemistry, which are currently accepted without concrete evidence, and are based mainly on conjecture. The essays in the book are based on extensive research into Arabic manuscripts and Latin literature.

The results of this research are challenging. They prove the Arabic origin of the *Summa Perfectionis* and the other Geber Latin works. Thus the prevailing conjectures about assumed Latin authors are refuted on the basis of ample evidence.

The book discusses the Arabic original of *Liber de compositione alchimiae* that was the first treatise on alchemy to appear in the West. It brings into light for the first time Jabir's book of recipes on the colouring of glass and his other chemical industrial recipes. An essay discusses potassium nitrate and nitric acid in Arabic and Latin sources. Both were known before the 13th century. Explosive gunpowder with the ideal formula and portable cannon were known in Arabic military treatises in the 13th century. The book gives an essay on the distillation of wine and alcohol since the eighth century. The final essay is on the composition of Damascus steel.

ISBN 978-3-487-14273-9