NATURAL SCIENCE IN ARCHAEOLOGY

George (Rip) Rapp

# Archaeo-mineralogy

Springer

Natural Science in Archaeology

George Rapp

# Archaeomineralogy

Second edition

Springer

Prof. Dr. George Rapp
University of Minnesota
Department of Geological Sciences
Duluth MN 55812-2496
USA
grapp@d.umn.edu

ISBN: 978-3-540-78593-4 e-ISBN: 978-3-540-78594-1

DOI 10.1007/978-3-540-78594-1

Library of Congress Control Number: 2008937806

Natural Science in Archaeology ISSN: 1613-9712



*Cover design:* Bauer, Thomas

Printed on acid-free paper

9 8 7 6 5 4 3 2 1

springer.com

# Preface and Reader's Guide

With major limitations, the planned scope of this book is a systematic look at the mineral and rock materials that have been used from prehistoric times through the seventeenth century CE. The author has used the end of the seventeenth century as a stopping point because the expansion of the world economy and scientific knowledge at that time would have led this book to become two volumes. [The notation used for dates throughout is BCE (Before the Common Era), CE (dating to our Common Era) and BP (Before the Present) to avoid any religious connotations.]

"Archaeomineralogy" may seem like a small and arcane niche in the scholarly world. However, it turned out to be very difficult to limit the number of references cited from the large universe of publications. In preparing this volume it became obvious that the number of germane articles and books lies somewhere between 5000 and 10,000. Those publications used and referenced constitute only a small fraction of the literature. Although there are over 800 references, and almost as many additions were consulted but not used, the sheer immensity of the literature precluded comprehensive coverage. Hence, the references in this volume are in no way exhaustive.

Consideration of the use of specific ores grades imperceptibly into production technology and other aspects of archaeometallurgy. Consideration of metal ore and lithic sources leads imperceptibly into provenance studies and consideration of the color of gems can lead directly into gemology. It has been difficult at times to draw the line and stay on course to keep the content of this volume to a manageable size.

The author has taught geoarchaeology approximately a dozen times, spanning nearly 30 years at three universities, so his gathering of material and references dates back this far and even farther. He has made notes on lithologic compositions of artifacts in excavation storehouses, in museum displays, and non-display collections, particularly in Greece, Turkey, Cyprus, Israel, Jordan, Egypt, Tunisia, North America, and China. Many of these found their way into lecture notes and into this book. The reader can assume that when a reference is not given, the items are from the author's 34 years of experience in the field.

The coverage and references are often extensive but never exhaustive. In addition, there are many language and geographic gaps. This is in part because of lack of published research and also because neither the author nor his two research

assistants read Far Eastern languages, particularly Chinese and Japanese. However, most relevant publications from India are in English. This book will not usually cover secondary mineral products such as patinas on archaeological artifacts. For patinas, the reader is referred to a series of three annotated bibliographies in Art and Archaeology Technical Abstracts (e.g., Volume 6, #4, 1967; Volume 7, #1, 1968; and Volume 7, #2, 1968). Many rocks and minerals of necessity are discussed under more than one topic heading. Repeating standard information each time would be inefficient. Therefore, readers are directed to the extensive mineral and rock species index to see all references to a specific rock or mineral.

This book is written for a broad group of scholars and students. Foremost would be those archaeologists (practicing and in training) who deal regularly with rock and mineral artifacts. Geoarchaeologists, diverse geoscientists, historians, conservationists, and anthropologists should find this book helpful. The diversity of this group presents a challenge. Many geoarchaeologists have at least the equivalent of a Bachelor of Science in geology. Few historians would have any background in geology. I ask your indulgence if some sections seem "elementary"; others might find these sections critical for their understanding. Behavioral archaeologists sometimes ask why a given group had certain preferences for this or that raw material. Mineral science can address only those materials that could have provided a higher quality product for human use. Many cultural preferences may well be unrelated to anything that can be measured scientifically.

I have had more than 30 years of experience identifying the **lithology** of materials excavated in Greece, Turkey, Cyprus, Israel, Egypt, Tunisia, China, and North America. The word "lithology" appears in boldface type because all the scientific nomenclature in this book that is not in common use or defined in the text appears in boldface when used for the first time and then defined in the Glossary.

The idea for this volume came from the Series Editor, Günther Wagner. In amassing and organizing the data I had the devoted and critical assistance of two of my Ph.D. students, Doris Stoessel and Edith Dunn. Russell Rothe assisted with all of the figures. The photos in this book were taken by Russell Rothe or by the author. Elaine Nissen did the stippled drawings. Nancy Nelson reviewed and improved many chapters. Although portions of this book are based on more than 30 years of the author's direct experience carrying out geoarchaeology, archaeomineralogy, and archaeometallurgy, most of what is presented herein is from the literature. Hence, the often excellent primary work, as well as the many thoughtful summaries by others, must be acknowledged as the essential basis of whatever value resides in this book. The author exercised his, perhaps idiosyncratic, judgment concerning both truth and relevance, and is thus alone responsible for any errors of fact or judgment.

Duluth, Minnesota, *George (Rip) Rapp*
January 2001

# Preface to the Second Edition

First, read the Preface and Reader's Guide to the First Edition. That 'guide' is useful for understanding the focus and context of what is covered in this book. Although we can never be sure that a mineral or gem name used by Theophastus, Pliny, Albertus Magnus, and Agricola refer to the same material, this new edition attempts to untangle some of the confusion in the names used in antiquity. This is done where discussing individual minerals, rocks, and gems, not in a separate section. Overall, the reference to consult for mineral names is de Fourestier 'Glossary of Mineral Synonyms' (1999). The modern rules for naming, redefining, renaming, or discrediting a mineral species can be found in Nickel and Grice (1998). This article also has a list of references concerning the nomenclature of mineral species and mineral groups.

The First Edition [2002] focused on regions where I had been engaged in geoarchaeologic and archaeomineralogic research since 1967. This Second Edition expands the geographical coverage, especially to Eastern Europe – for help with this I acknowledge Ruslan Kostov. There is more on China, where I have been working since 1990, and on Western Europe.

Chapter 1 has been expanded to include additional information from ancient and medieval authors and a deeper look at the development of mineralogy and gemmology from earliest times through the heightened interest in rocks, minerals, and fossils in the sixteenth century. For some reason what I wrote on Agricola did not make it into the First Edition. This has been corrected.

Chapter 2 is little changed from the First Edition except for corrections to Table 2.2 and a couple of additions to the text. This chapter includes a theoretical background for mineral properties, especially color, which was fundamental in early classifications. However, many readers may want to skip this material.

Chapter 3 sets out the classification of rocks and their salient properties. There is some overlap in the coverage of rock materials in this chapter with Chap. 6, which covers carved stone, and with Chap. 11, which discusses building and monumental stone structures. There is some degree of arbitrariness concerning in which chapter important uses are noted, e.g., examples of rock sculptures are discussed in both Chaps. 6 and 11.

Chapters 4 through 9 have been expanded to include new earth materials as well as additional information on minerals, rocks, and gems uncovered since the First Edition. Although Chap. 10 is in some ways the place for discussion of materials that do not fit readily elsewhere these materials have played a major role in the lifeways of humans as technological progress has expanded the utilization of natural resources. Finally, in Chap. 11 more information is presented on those earth materials suited for the construction of mega structures.

The References have been expanded to approximately 1000. A new section, entitled Bibliography, supplements References by calling attention to important source materials not referenced in the text.

This Second Edition has been enhanced by five new drawings by Elaine Nissen. Again, carefully editing by Nancy Nelson has improved both the text and the organization of the book. Carol Kubeczko edited the photos that became six new figures. Lucy Wilson provided Fig. 2.1. I owe each of these talented women my gratitude. The Preface to the First Edition should have noted that Doris Stoessel was exceptionally helpful because she read four modern and three or four ancient languages and that Edith Dunn supplied the Arabic. Of course, I alone remain responsible for all errors in fact or judgment.

Tucson, Arizona, *George (Rip) Rapp*
August 2008

# Contents

# List of Figures

# Chapter 1
# Introduction and History

## 1.1 Prologue

What is archaeomineralogy? The term has been used at least once before (Mitchell 1985), but this volume, now in an updated and expanded Second Edition, is the first modern publication to lay down a scholarly basis and the systematics for this subdiscipline. Students sometimes call an introductory archaeology course "stones and bones". Archaeomineralogy covers the stones component of this phrase. Of course, archaeology consists of a great deal more than just stones and bones. Contemporary archaeology is based on stratigraphy, geomorphology, chronometry, anthropology, and a host of other disciplines in addition to those devoted to stones and bones (Rapp and Hill 2006).

To hazard a definition: archaeomineralogy is the study of the minerals and rocks used by ancient societies over space and time, as implements, ornaments, building materials, and raw materials for metals, ceramics, and other processed products. Archaeomineralogy also attempts to date, source, or otherwise characterize artifacts made from earth materials. Unlike geoarchaeology, archaeomineralogy is not yet a recognized subdiscipline. Practitioners of archaeomineralogy are mostly either (1) geoarchaeologists who specialize in geology and have a strong background in mineralogy or petrology (the study of the origin of rocks) or (2) historians of science.

In organizing the information in this book there were two competing options: (1) to do it in encyclopedic fashion, listing each mineral and rock type by name, then describing their uses in antiquity, or (2) to organize the content around specific uses of rocks and minerals such as for lithics, ornaments, pigments, or building materials. I chose the latter, both to make it more readable and to lead the reader sideways into related topics. The encyclopedic form has been utilized in the two editions of *Encyclopedia of Minerals* (Roberts et al. 1974, 1990) that I co-authored, but the projected audiences for this current volume – archaeologists, geoscientists, and historians interested in the historical aspects of rock and mineral use – would be predominantly topic rather than species-name oriented.

Many systematic mineralogy books can be consulted for information on minerals. Roberts et al. (1990) includes all mineral species identified up to the time of publication. There are many books containing systematic descriptions of rocks that

G. Rapp, *Archaeomineralogy*, 2nd ed., Natural Science in Archaeology,
DOI 10.1007/978-3-540-78594-1_1, © Springer-Verlag Berlin Heidelberg 2009

would aid those interested in archaeomineralogy. Recent examples would be Blatt et al. 2006 or Raymond 2002. In his excellent and wide-ranging book on the birth and development of the geologic sciences, F. Adams (1938) weaves the evolution of ideas on mineral and rock classifications into the broader human view of the nature of the earth and of earth materials. By the sixteenth century the interest of practical men in the role of "fossilia" [fossils, minerals, and rocks] in pharmacy and in mining, accompanied by the long and slow shift from a dependency on classical authorities to one based on observation and experimentation, led to the accumulation of new knowledge concerning the nature of minerals and metals. Conrad Gesner (1516–1565) constructed a mineral classification based on the complexity of the crystal forms of minerals. When this new knowledge was expanded by the introduction of chemical analysis we had the basis for modern mineralogy.

## 1.2 Organization of the Book

First, readers are advised to go back and read the Preface and Reader's Guide, which offers valuable background information. This volume is organized more or less by the function that the mineral or rock material played in the various ancient contexts. One downside to this approach is that some minerals and rocks are covered in more than one chapter. Within limits, the same information on properties is not repeated, and the index lists all pages where a mineral or rock is discussed.

The literature of archaeomineralogy is huge, especially if one considers the abundant descriptions of mineral and rock artifacts found in many thousands of excavation reports. This volume has hundreds of references to the easily-obtained literature from more than a dozen countries but is not comprehensive in the sense that Lucas (1989) was comprehensive in his review of the mineral and rock materials utilized by the ancient Egyptians or Morey (1983) was in his exposition of the materials used in ancient Mesopotamia. Readers outside North America might not be familiar with the names, chronologies, and geographies of North American prehistoric cultures. As a reference for these items, the author would suggest *Archaeology of Prehistoric North America: an Encyclopedia* (Gibbon 1998).

As far as possible, examples are provided for the most significant ancient uses of rocks and minerals for the various purposes covered in this volume. These examples are somewhat skewed toward those geographic areas where the author has carried out research (Greece, Turkey, Cyprus, Israel, Egypt, Tunisia, and China, as well as North America) but this Second Edition has extended the coverage. Citing the hundreds or even thousands of archaeological references worldwide to the use of chert for lithics or marble for monuments would be impractical, so the examples needed to be selective.

Readers interested primarily in individual minerals, rocks, or related compounds should begin with the index of rock and mineral names. The diversity of uses of many rocks and minerals required that many materials be considered in more than one of the topical chapters. When a mineral or rock is discussed in more than one chapter, the index lists all mentions of a rock or mineral species.

Sources of rock and mineral raw materials are a vital aspect of their utilization and their archaeological context. However, the rapidly expanding field of **provenance** studies precludes this aspect from being a major component of this book. Obsidian sourcing alone is more than a "book length" subject. Specific sources are given when appropriate; for example the Afghan source of lapis lazuli. Most rock and mineral sources in ancient times were local or regional. Another ancillary area is ancient mining. There is a brief section in Chap. 3, but for coverage of this field see Shepherd (1993).

Readers should be aware of three significant aspects of mineral names. First, in ancient times mineral identification was frequently haphazard, often relying on color alone. Second, the name given to many mineral species has changed over time. Third, even today, the same mineral may have a variety of names and synonyms. The spellings used in this volume are English, although occasionally the German spelling is used if more appropriate. This volume uses American spellings rather than British, for example, sulfur rather than sulphur.

One example of the problem with names is the various forms of hyacinth (hyacinte, hyacithe, hyacinthine, hyazinthos, hyacynthus, and similar variations). These names have been applied to zircon, spinel, vesuvianite, corundum, quartz, beryl, and garnet (de Fourestier 1999). Another example concerns the large number of names and hyphenated names based on the name opal. There are 40 listed in de Fourestier (1999). One value of the de Fourestier volume is that it gives synonyms and spellings in a number of western languages. Four volumes can aid in working through these problems with names: (1) the *Glossary of Mineral Synonyms* (de Fourestier 1999), (2) *Encyclopedia of Mineral Names* (Blackburn and Dennen 1997), (3) *Glossary of Obsolete Mineral Names* (Bayliss 2000), and (4) *Encyclopedia of Minerals* (Roberts et al. 1990). The volume by Roberts et al. presents data on mode of formation and major localities as well as the basic physical and chemical properties of all minerals.

It has been my experience that, although there are more than a thousand names given to various rock types, sorting out what rocks were exploited in antiquity is somewhat easier than for minerals. Perhaps the best guide to rock names is the *Glossary of Geology* (Neuendorf et al. 2005). That volume presents historical definitions and obsolete variations in names and meanings.

Because of the nature of the material, each chapter is structured somewhat differently. In some chapters, an Introduction incorporates a short guide to general bibliographic items that present extensive reviews of specific materials, geographic regions, or chronological periods. Many rocks and minerals were exploited for multiple purposes or products. Therefore, these appear under each of the product topics. To review everything on a given rock or mineral, please refer to the extensive index. The topics covered in most chapters are organized along obvious lines with a few rock and mineral resources or their products falling into miscellaneous categories.

We begin with an overview of the information found in the most relevant works of ancient writers in various parts of the world. For readers with a significant interest in the historical development of archaeomineralogy I strongly recommend spending considerable time with the three books that were paradigm changing:

Theophrastus's *On Stones*, Pliny's *Natural History*, and Agricola's *De Natura Fossilium* (sometimes referred to as *Textbook of Mineralogy*). Theophrastus was the first significant figure in archaeomineralogy. I have a copy of the only modern translation [in English] of *On Stones*, that of Caley and Richards (1956), which also includes the Greek text, an introduction, and a commentary. Pliny's *Natural History* was written as 37 "books". Minerals and gemstones are treated in books 33–37. I have the Loeb Classical Library edition in 10 volumes, edited by Goold (1938 and reprinted numerous times). Agricola's *De Natura Fossilium*, translated by Bandy and Bandy from the first Latin edition (1546) was published in 1955 as Special Paper 63 by The Geological Society of America. I have the Dover reprint published in 1964. In this chapter I have introduced each of these authors but most of the references to their ideas and works concerning minerals, gems, and rocks are distributed throughout this book where appropriate rather than with this introductory material.

All the scientific nomenclature in this book that is not in common use or defined in the text appears in boldface when used for the first time and are defined in the Glossary.

## 1.3 The Ancient Authors

Evidence for ancient utilization of minerals and rocks is available in several contexts. Cuneiform texts from Mesopotamia and Assyria and papyri from Egypt cite the use of minerals as medical treatment or drugs, building materials and embellishments on buildings, and as artifacts. In some cases topographic information is given, particularly when a mineral or a rock is a trade item. Pictorial representations also suggest how minerals and rocks were utilized or manufactured. Other information is gleaned from examination of an artifact itself. Increasing attention to archaeomineralogic research will rapidly expand our knowledge in this twenty-first century CE.

In ancient Assyria, the following minerals and metals were prescribed as drugs: white and black sulfur, iron sulfate, arsenic, yellow realgar (probably orpiment), black saltpeter, antimony, iron oxide, iron sulfide, magnetite, mercury, alum, bitumen, naphtha, and lime (Marks and Beatty 1975). In ancient Egypt doctors knew of the antacid properties of limestone (which is still in use today). To absorb water or toxins from the stomach they used kaolin, also still in use today. They also knew that antimony was effective against flukes. Precious and semiprecious stones also were used in medicinal preparations. These were diamond, ruby, sapphire, emerald, jade, jadeite, peridot, lizardite, topaz, garnet, rock-crystal, aquamarine, lapis lazuli, tourmaline, moonstone, and chrysoberyl. Pearl, coral, and shell also were similarly employed.

In the Western world we have rooted much of our scientific nomenclature in Greek and Latin (and sometimes Arabic). Chinese science developed independently, and they acquired their stock of scientific words early. We know the earliest forms of Chinese characters from the oracle bones of Anyang (Late Shang – circa 1100 BCE) [where I have worked since 1997] and from the Shang and Zhou (1100 to 256

BCE) inscriptions on bronze vessels. Needham (1956, pp. 220–230) presents an extensive table of the ideographic etymologies of important works in early Chinese scientific thinking.

Both the Greeks and Romans used mineral drugs extensively, as is attested by the numerous citations in the works of classical authors. Pliny's *Natural History* and Dioscorides's *De Materia Medica* are the foremost sources for mineral remedies in the ancient world. The latter source presents the first description of the extraction of mercury. The Arabic writers who translated the Greek and Latin sources carried on this tradition, adding their own observations and commentaries. In turn, the Arabic sources and the earlier classical writers were utilized through the Middle Ages for pharmacopoeia.

In addition to the magical and amuletic qualities of many minerals and gemstones, Pliny's list of minerals used as drugs is extensive. Eye diseases were thought to be cured by stibnite, lodestone, powdered marble, scale of iron, sulfur, marcasite, pumice, copper byproducts, and red ochre. The latter was also employed for dysentery and vomiting. Ash of biotite mica was used as a remedy for leprosy, bronchitis, and tuberculosis. Bismuth, calamine, and sulfur were used to cure the latter disease as well as skin diseases and typhoid. Orpiment was prescribed for bronchitis. Realgar when mixed with turpentine was considered a cure for asthma. Alum was prescribed as an antiperspirant, to alleviate mouth ulcers, and as a remedy for scabies. Caustic soda was used in liniments. Lead and its byproducts were used in various medical prescriptions to remove scars, as an emollient plaster, for dysentery or constipation, and were added to other mineral compounds. Powdered marble and pumice were used as tooth powders. Decomposing marcasite was used to cure toothaches and to fill cavities.

Medieval mineralogy was little advanced from Pliny. Rocks, minerals, and gems were considered valuable because of reputed medicinal and magical properties. For essentially all ancient writers, the most important property was color. However, color is of no great value in mineral classification, because many species occur in a variety of colors. Ancient writers commonly believed that different colored varieties of the same mineral were different species and, conversely, classed several different minerals into one species based on color. Until the fifteenth century CE, minerals were always listed alphabetically as the only organizing characteristic. In 1546, Agricola published his *De Natura Fossilium*, which had the first classification of minerals based on physical properties: color, weight, transparency, luster, taste, odor, shape, and texture. However, he made no distinction between individual mineral species and some rocks with more than one mineral present. It is interesting to note that Medieval scholars, believing that the essence of a substance was in its name, developed from this the discipline of etymology.

The alchemists discovered the oxides of numerous metals, and physicians adopted some of these in their practice of medicine. Arsenic was introduced in this manner, and both phosphorus and lead were used as poisons. Mercury was employed to treat syphilis. Sulfur was widely used internally as an agent for purification and externally for dressing wounds. The discovery of sulfuric acid is credited to the eighth century Arabian alchemist Jabir ibn Hayyan. Sulfuric acid was