7-1976

Minerals and Gemstones of Nebraska: A Handbook for Students and Collectors

Roger K. Pabian

University of Nebraska - Lincoln, rpabian1@unl.edu

Allan Cook

University of Nebraska - Lincoln

Follow this and additional works at: http://digitalcommons.unl.edu/conservationsurvey

Part of the Natural Resources and Conservation Commons


http://digitalcommons.unl.edu/conservationsurvey/2

This Article is brought to you for free and open access by the Natural Resources, School of at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Conservation and Survey Division by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.
The Conservation and Survey Division of the University is the agency designated by statute to investigate and interpret the geologically related resources of the state, to make available to the public the results of these investigations, and to assist in the development and conservation of these resources.

The Division is authorized to enter into agreements with federal agencies to engage in cooperative surveys and investigations in the state. Publications of the Division and the cooperating agencies are available from the Conservation and Survey Division, University of Nebraska, Lincoln 68508.

Publications and price lists are furnished upon request.
THE MINERALS AND GEMSTONES
OF NEBRASKA

A Handbook for Students and Collectors

BY
ROGER K. PABIAN

ILLUSTRATED BY
ALAN R. COOK

PUBLISHED BY THE UNIVERSITY OF NEBRASKA
CONSERVATION AND SURVEY DIVISION, LINCOLN
The cuff links (left and right) and tie tack (center) make up the set of men's blue chalcedony jewelry that was presented to Norbert T. Tiemann, then Governor of Nebraska, upon signing L. B. 251, 77th session, Nebraska State Legislature, March 1, 1967, which named blue chalcedony the Nebraska State Gemstone.

A specimen of blue chalcedony showing the banded and plume portions of the stone.
PREFACE

In recent years the earth sciences have become an important part of the curricula of many school systems. In the past, pupils were given only a smattering of geology, paleontology, mineralogy, etc. to help them to better understand the world around them. Recent emphasis on the earth sciences has created a demand from teachers and students for geologic information in the area in which they live. In response to this demand in Nebraska, Educational Circular No. 1, “Record in Rock,” was prepared. The need for a similar publication on the minerals and gemstones of Nebraska was also recognized. In addition to the educational emphasis on earth sciences, rock collecting has grown to be one of the nation’s most popular hobbies. In Nebraska, at least one school now offers a class to teach the fundamentals of building a rock collection as a hobby. This publication is intended to help answer the many questions of students and hobbyists, including the many out-of-state visitors who collect and vacation in Nebraska, and to encourage the growing interest in the earth and its environment.

The writer is grateful for the help and cooperation of a number of persons. In addition to assistance given by the staff members of the University of Nebraska State Museum, Conservation and Survey Division, and Departments of Geology and Botany (all of the University of Nebraska), the following have contributed material, time, talent, and knowledge toward the completion of this publication: John Hufford, Omaha; Bruce and Clark Morgan, Valley; Howard and Harvey Kenfield, Ogallala; James Marburger, Humboldt; Thurman Stevenson, Cordova; former Governor of Nebraska Norbert Tiemann, Ralph Ulrich, George McGinnis, John Lewis, and Gene Eno, Lincoln; Charlie Bass, Jay Em, Wyoming; and Professor William Walker, Washington University, St. Louis, Missouri.
TABLE OF CONTENTS

<p>| Introduction ........................................................................... 1 | Goethite ........................................................................... 29 |
| What Are Minerals? What Are Rocks? What Are Gemstones? .......... 1 | Gold ................................................................................ 29 |
| What is Mineralogy? ................................................................ 1 | Gypsum ......................................................................... 30 |
| What Can Minerals Tell Us? ..................................................... 2 | Halite ............................................................................. 31 |
| Minerals and Geologic Time .................................................... 3 | Halotrichite ..................................................................... 31 |
| Minerals as Environmental Indicators ........................................ 6 | Hematite ......................................................................... 31 |
| Minerals as Resources ............................................................. 7 | Jade ................................................................................ 31 |
| Where are Minerals Found? ...................................................... 7 | Limestone ....................................................................... 31 |
| Collecting Courtesy ................................................................ 10 | Limonite ......................................................................... 31 |
| Tools for Collecting Minerals .................................................. 10 | Magnetite ........................................................................ 40 |
| Care of Tools .......................................................................... 12 | Marcasite ....................................................................... 40 |
| Tips on Collecting Minerals ..................................................... 12 | Melanterite ...................................................................... 41 |
| Safety Rules ............................................................................ 12 | Meteorites ...................................................................... 41 |
| Preparation of Specimens ....................................................... 14 | Mica ............................................................................... 43 |
| Mineral Identification ............................................................... 16 | Muscovite ....................................................................... 43 |
| Physical Properties .................................................................. 16 | Opal ............................................................................... 43 |
| Cleavage ................................................................................ 16 | Onyx .............................................................................. 43 |
| Hardness ................................................................................. 17 | Orthoclase, Plagioclase ....................................................... 43 |
| Luster ................................................................................... 17 | Pyrite ............................................................................ 43 |
| Streak .................................................................................. 17 | Pyrulosite ...................................................................... 44 |
| Specific Gravity ....................................................................... 17 | Pyroxene ....................................................................... 45 |
| Form .................................................................................... 17 | Quartz ........................................................................... 45 |
| Color .................................................................................... 18 | Sabugalite ...................................................................... 45 |
| Tenacity ................................................................................ 19 | Sand Crystal .................................................................. 45 |
| Fluorescence ......................................................................... 19 | Selenite .......................................................................... 45 |
| Chemical Properties ................................................................ 19 | Septarians .................................................................... 45 |
| Chemical Composition ............................................................. 19 | Siderite ......................................................................... 46 |
| Taste .................................................................................... 19 | Sphalerite ...................................................................... 46 |
| Chemical Tests ....................................................................... 19 | Sulfur ............................................................................ 46 |
| Crystallography ..................................................................... 19 | Turquoise ...................................................................... 47 |
| Common Nebraska Minerals .................................................... 20 | Uranium Minerals ............................................................. 47 |
| Amphibole ............................................................................. 21 | Vivianite ....................................................................... 47 |
| Ankerite ............................................................................... 21 | Gem and Ornamental Stones from Nebraska ......................... 47 |
| Aragonite ............................................................................. 21 | Type I. Gem and Ornamental Stones Indigenous to Nebraska .... 50 |
| Autunite ............................................................................... 23 | Type II. Gem and Ornamental Stones Transported into Nebraska by Streams Originating in Adjacent Western States .... 50 |
| Barite .................................................................................. 23 | Type III. Gem and Ornamental Stones Having Been Transported into Nebraska from Northern Sources by Glaciers .......... 53 |
| Bauxite ............................................................................... 24 | Common Nebraska Gemstones ............................................ 53 |
| Biotite ............................................................................... 25 | Agate, Type II Occurrences ................................................. 54 |
| Calcite ............................................................................... 25 | Fortification or “Fairburn” Agates ....................................... 54 |
| Carnotite ............................................................................. 26 | Prairie Agates ................................................................. 57 |
| Celestite ............................................................................. 26 | Moss Agates ................................................................. 57 |
| Chalcedony .......................................................................... 27 | Agate, Type III Occurrences ................................................. 57 |
| Chalcopyrite ........................................................................ 27 | Lake Superior Agates ....................................................... 57 |
| Chalk .................................................................................. 27 | Moss Agates ................................................................. 58 |
| Chert ................................................................................... 27 | Chalcedony, Type I Occurrences ......................................... 58 |
| Chlorite ............................................................................... 27 | Vein Chalcedony and Blue Chalcedony .................................. 58 |
| Coal .................................................................................... 27 | Chalcedony, Type II Occurrences ......................................... 59 |
| Copper ............................................................................... 27 | Lard Agate ................................................................. 59 |
| Dolomite ............................................................................. 29 | |</p>
<table>
<thead>
<tr>
<th></th>
<th>Page</th>
<th></th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chert, Type I Occurrences</td>
<td>................................</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>Pennsylvanian, Permian,</td>
<td>................................</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>and Cretaceous Chert</td>
<td>................................</td>
<td>................................</td>
<td>59</td>
</tr>
<tr>
<td>Chert, Type III Occurrences</td>
<td>................................</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous Chert</td>
<td>................................</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Coral, Type I Occurrences</td>
<td>................................</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Horn Coral</td>
<td>................................</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Coral, Type II Occurrences</td>
<td>................................</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Colonial Coral</td>
<td>................................</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Coral, Type III Occurrences</td>
<td>................................</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Horn and Colonial Coral</td>
<td>................................</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Feldspar, Type II Occurrences</td>
<td>................................</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Labradorite, Moonstone</td>
<td>................................</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Garnet, Type II Occurrences</td>
<td>................................</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Hematite</td>
<td>................................</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Ivory</td>
<td>................................</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Jade, Type II Occurrences</td>
<td>................................</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Nephrite</td>
<td>................................</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Jade, Type III Occurrences</td>
<td>................................</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Nephrite</td>
<td>................................</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Jasper, Type II Occurrences</td>
<td>................................</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Nephrite</td>
<td>................................</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Onyx, Type I Occurrences</td>
<td>................................</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>Opal, Type I Occurrences</td>
<td>................................</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>Pearl and Mother-of-Pearl</td>
<td>................................</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Petrified Wood and Plants, Type I Occurrences</td>
<td>................................</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Black Wood</td>
<td>................................</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Opalized Wood</td>
<td>................................</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Petrified Wood and Plants, Type II Occurrences</td>
<td>................................</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Cycladophytes</td>
<td>................................</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Tempskya Ferns</td>
<td>................................</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Petrified Wood and Plants, Type III Occurrences</td>
<td>................................</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Quartz, Type II Occurrences</td>
<td>................................</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Quartz, Type III Occurrences</td>
<td>................................</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Topaz</td>
<td>................................</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>Unakite</td>
<td>................................</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous Heavy Minerals</td>
<td>................................</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>Selected References</td>
<td>................................</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>Appendix I</td>
<td>................................</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Appendix II</td>
<td>................................</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>Glossary</td>
<td>................................</td>
<td>79</td>
<td></td>
</tr>
</tbody>
</table>
THE MINERALS AND GEMSTONES OF NEBRASKA

INTRODUCTION

Mineral and gem collecting, in one form or another, is a favorite pastime, or hobby, of several million Americans. As with other hobbies, collectors have varying goals and methods. Some want to learn about the minerals and gemstones that occur in the area where they live. Others collect minerals and gemstones only for their natural beauty, never attempting to discover any of their secrets. Still others collect minerals and gemstones and use them to aid in deciphering the natural history of the earth—the ultimate goal of the geological sciences.

Some collectors are systematic, arranging their collections in a series of mineral suites, in much the same way that a stamp or coin collector arranges his material. Other collectors try to acquire a single specimen of as many different minerals as possible, or perhaps many different specimens of the same mineral. Still other collectors strive to obtain a collection of a basic group, or family, such as the carbonate minerals or the copper minerals. Some may prefer to collect only micromounts, which are very small, perfectly-formed crystals that must be viewed under high magnification. And then there are collectors who are interested only in semiprecious or precious gemstones and minerals that can be cut, polished, or faceted to show their beauty.

Minerals and gems have fascinated man since prehistoric times, and he has attached value to these naturally occurring substances for a variety of reasons. Stone artifacts have been found in association with the oldest human remains. Early man used shaped stone tools to cut softer materials, such as animal hides and wood, long before he knew how to smelt and shape metals. The first metals used by man were very likely native copper masses that were eroded from basaltic rock.

Early man collected certain stones for their beauty and rarity and adorned himself with some of them. Stones such as marble and verd antique were used for decorating buildings. Attractive stones are still used in modern jewelry, as accent objects in interior decoration, and for decorative and functional design in our structures.

Man has imputed magical properties and spirits (both good and evil) to certain stones, for casting spells or for protection. The wearing of birthstones is an example of the persistence of some of these ideas. We may read about the famous race driver who credits his victories to his “lucky agate.” Medicinal properties have been attributed to some stones. For example, powdered sapphire was used as a cure for gout. Because of the chemical properties of the stones, some of these unusual uses may have been effective. Orientals believed that the smooth surface of a jade touchstone provided a tranquilizing effect. These jade touchstones are now called “tranquiliths.”

The purpose of this publication is to familiarize the reader with the occurrences of minerals and gemstones in Nebraska. Although this publication was designed with the student in mind, it may be useful to the amateur collector or rock hound.

WHAT ARE MINERALS?
WHAT ARE ROCKS?
WHAT ARE GEMSTONES?

The terms mineral and rock are often used interchangeably, but this usage is not geologically correct. A mineral is a naturally occurring, homogeneous, inorganic substance having characteristic physical properties and a definite chemical composition. Although the chemical composition of a mineral may vary, this variation takes place within well-defined limits. Most minerals have a definite crystal structure; if the same chemical compound occurs in several different crystal habits, each form is usually a separate mineral. Just as minerals consist of certain groups of elements, rocks are composed of certain groups of minerals. A rock may consist of a single mineral, such as quartz sandstone, or of several different minerals, such as granite, which usually consists of quartz, feldspar, and mica. Most of the rocks in the earth’s crust may be described in terms of about 25 common rock-forming minerals, many of which are described in the text. Gemstones are usually colorful, durable, naturally-occurring substances that can take a high polish. Many minerals (e.g., quartz) can be of gem grade. Not all gem materials, however, are minerals (e.g., ivory). This group of materials is discussed in more detail in another section of this report.

WHAT IS MINERALOGY?

The science of mineralogy deals with those inorganic substances which, as rock masses or mineral deposits, make up the basic materials of the earth. Mineralogy has several branches, each applying a different and somewhat specialized point of view. Crystallography is the study of crystal structure, especially of minerals. Physical mineralogy is the study of physical properties of minerals, such as cleavage, hardness, and streak. Chemical mineralogy is the study of chemistry, as applied to the compositions of minerals. Mineral occurrences is the study of modes of occurrences of minerals and mineral associations. Descriptive mineralogy is a study leading to the identification and classification of minerals based upon their crystallography, physical and chemical mineralogy, occurrence, and other details. This paper is intended to provide a descriptive mineralogy for Nebraska.
WHAT CAN MINERALS TELL US?

Collecting minerals is an enjoyable pastime whether one does it for a livelihood or merely as a hobby. Each collecting trip should be thought of as a visit to the remote past; to some ancient, now dry, seaway; to a long-obiterated mountain range; or to the gravel deposits of a former stream. This book will help the student identify some of these former landscapes and environments.

The earth is about five billion years old. The fossil record of the first 90 percent of the earth’s history is scant. Fossils are common only in rocks deposited in the last ten percent of the earth’s history. Therefore, the events during most of the earth’s history must be determined by analyzing the minerals that formed in these ancient rocks. For example, the orientation of the long axes of quartz crystals told geologists (Sutton and Watson, 1951) of an early mountain-building episode in the highlands of Scotland, and indicated the trend of the ancient mountain range. This was possible because the long axes of some mineral crystals are arranged perpendicular to the mountain-building forces (text-fig. 1).
MINERALS AND GEOLOGIC TIME

The geologic-time column (text-fig. 2) is based on the evidence provided by fossils. Recognition of every geological period, from Cambrian through Quaternary, is based, for the main part, on the type of organisms present in rocks formed during these periods. Rocks of like ages contain similar assemblages of these fossils. However, rocks of like ages do not contain similar assemblages of minerals. For example, quartz and pyrite are abundant in recently formed rocks; they are also abundant in ancient Precambrian rocks. Individual minerals did not appear in a certain order during geologic time. However, minerals still play a very important part in the development of a geologic time column.

Basically, there are two irreversible processes in the march of geologic time—organic evolution and radioactive decay. (See Teichert, 1958, p. 99-120.) Paleontology, the study of fossils, provides evidence for determining the sequence of events from the Cambrian Period through the Quaternary Period. This type of evidence can indicate whether an event is older or younger than some other event. Radioactive decay, however, gives “absolute dates” expressed in years for a geologic event. These interpretations determine how many years ago each event occurred.

Several methods have been developed which give us these “absolute dates” for our geologic time column. By measuring the ratio of potassium to argon in micas and feldspars, it is possible to fix a date when these minerals crystallized. This is possible because radioactive potassium$^{40}$ decomposes to form the inert gas argon$^{40}$ at a known rate. Thus, it can be determined how long it would take for radioactive decay to form the measured amounts of each element. Similar interpretations can be derived from other radioactive elements.

A second method of dating rocks involves the use of fission tracks. These tracks are disturbed areas in crystals resulting from bombardment by alpha particles. Alpha particles result from fission of uranium$^{238}$. When these sub-atomic particles strike atoms in a crystal (text-fig. 3), especially a feldspar or a mica, the result is much the same as a bullet striking a piece of wood; that is, the atomic arrangement of the crystal is disturbed. By preparing a very thin slice of rock and then etching it in hydrofluoric acid or
<table>
<thead>
<tr>
<th>AGE</th>
<th>GEOLOGIC TIME UNITS</th>
<th>ROCK TYPES</th>
<th>MINERAL RESOURCES AND PRODUCTS</th>
<th>TYPICAL FOSSILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>?</td>
<td>PRECAMBRIAN</td>
<td>Subsurface only. Granite, other igneous rocks, and metamorphic rocks.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>600</td>
<td>CAMBRIAN</td>
<td>Subsurface only. Dolomite, sandstone.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>ORDOVICAN</td>
<td>Subsurface only. Dolomite, sandstone, shale.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>440</td>
<td>SILURIAN</td>
<td>Subsurface only. Dolomite.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>DEVONIAN</td>
<td>Subsurface only. Dolomite, gray shale.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>310</td>
<td>PENNSYLVANIAN</td>
<td>Limestone, shale, sandstone, coal.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>280</td>
<td>MISSISSIPPIAN</td>
<td>Subsurface only. Limestone, dolomite.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>225</td>
<td>PERMIAN</td>
<td>Shale, limestone, dolomite, gypsum, anhydrite, sandstone, siltstone, chert.</td>
<td>Water, agricultural lime, oil, road rock, riprap.</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>TRIASSIC</td>
<td>Subsurface only. Sandstones and shales.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>180</td>
<td>JURASSIC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>135</td>
<td>CRETAKEOUS</td>
<td>Chalk, chalky shale, dark shale, varicolored clay, sandstone, conglomerate</td>
<td>Water, oil &amp; gas, cement, brick, agricultural lime, &amp; other construction materials.</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>TERTIARY</td>
<td>Sandstone, siltstone, clay, gravel, marl, volcanic ash.</td>
<td>Agricultural soil, water, sand &amp; gravel, volcanic ash.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>CENOZOIC (RECENT LIFE)</td>
<td>Glacial till, silt, clay, sand, gravel, volcanic ash.</td>
<td></td>
<td>MAMMOTH</td>
</tr>
<tr>
<td>1</td>
<td>PRECAMBRIAN</td>
<td>Subsurface only. Granite, other igneous rocks, and metamorphic rocks.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>LATE PRECAMBRIAN</td>
<td>Subsurface only. Granite, other igneous rocks, and metamorphic rocks.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>PENNSYLVANIAN</td>
<td>Limestone, shale, sandstone, coal.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>MISSISSIPPIAN</td>
<td>Subsurface only. Limestone, dolomite.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>CRETAKEOUS</td>
<td>Chalk, chalky shale, dark shale, varicolored clay, sandstone, conglomerate</td>
<td>Water, oil &amp; gas, cement, brick, agricultural lime, &amp; other construction materials.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>TERTIARY</td>
<td>Sandstone, siltstone, clay, gravel, marl, volcanic ash.</td>
<td>Agricultural soil, water, sand &amp; gravel, volcanic ash.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>CENOZOIC (RECENT LIFE)</td>
<td>Glacial till, silt, clay, sand, gravel, volcanic ash.</td>
<td></td>
<td>MAMMOTH</td>
</tr>
</tbody>
</table>
Text-Figure 3. Fission tracks. A, An alpha particle emitted by spontaneous breakdown of uranium 238 approaches a stable portion of a mineral crystal where atoms of various elements are bonded together. B, The alpha particle strikes the crystal and disrupts the molecular arrangements. C. Photomicrograph of fission tracks in a zircon crystal. Each fission track is about 10⁻⁶ centimeters in length.
sodium hydroxide solution, it is possible to observe the fission tracks, or the disturbed areas in the crystal, under magnification as low as 80-power. The fission tracks are counted and this value is placed in a mathematical formula, the solution to which provides a number that can be converted to an "absolute date." Fission-track dating is possible because uranium decomposes at a known rate and in a given time a known amount of U\(^{238}\) can provide only a given number of alpha particles to produce tracks.

**MINERALS AS ENVIRONMENTAL INDICATORS**

Paleontologists are able to determine ancient environments by using fossil organisms. Not all rock is fossiliferous, however, and in such cases determination of environment often can be made by studying the minerals present.

Some minerals are formed in place and remain unaltered from the time of their formation. Other minerals are formed in place and are later altered to, or completely replaced by, a new mineral. Some minerals are formed in one place and then transported by streams, ocean currents, or winds to another place where they may remain unchanged or may be completely altered or replaced. These and other possibilities must be considered before interpretations are made.

*Geochemistry* is the science dealing with the distribution of elements in space and time. Some minerals indicate the chemical factors present in ancient environments.

In fresh or sea water chemically precipitated sulfide minerals, such as pyrite, marcasite, and sphalerite, can form only in oxygen-deficient, reducing environments. Oxide minerals, as limonite, hematite, and goethite, can form only in oxygen-rich, oxidizing environments. For example, oxide minerals that have the crystal form of a sulfide mineral (e.g., a limonite pyritohedron) indicate that the original mineral was a sulfide that has been oxidized. Chert may be a primary precipitated deposit, in which case its presence is either a function of the pH (hydrogen ion content) of the ocean or it may be secondary and its presence may be a function of weathering phenomena such as the development of a soil.

Some minerals, such as mica, feldspar, amphibole, and pyroxene, are restricted mainly to plutonic and metamorphic rocks. Other minerals, as barite, gypsum, and celestite, are restricted mainly to sedimentary rocks. The presence of igneous or metamorphic minerals in sedimentary rocks indicates that the minerals were reworked from an igneous or metamorphic source area. Some minerals, as quartz, may form in nearly any type of environment, but even quartz has high- and low-temperature forms.

*Paleotemperatures*, or ancient temperatures, can sometimes be determined from minerals. Calcite and aragonite are two forms of calcium carbonate. Aragonite forms in warmer water than does calcite. By determining the amounts of oxygen isotopes O\(^{16}\) and O\(^{18}\) in the shells of fossil belemnites (squid-like animals) it was deduced that an individual animal that lived during Jurassic time (about 100 million years ago) lived in warm waters.
years ago) lived in water that was warmer in its youth than old age, and died in the spring at an age of about 4 years, and that the mean temperature of the sea in which it lived was 17.6° C., with a seasonal temperature variation of 6° C. (Urey et al., 1951).

Paleomagnetism, the study of the location of magnetic poles, is determined by studying magnetic minerals and their orientation. The axes of crystals of iron-rich minerals show a preferred orientation with respect to the earth's magnetic poles. Paleomagnetism has been used to demonstrate polar reversals, determine rates of sedimentary deposition, and correlate sedimentary deposits of like ages.

MINERALS AS RESOURCES

Minerals are commonly thought of as lovely crystals to be seen in museum galleries. Though these beautiful specimens are truly minerals, they represent only an infinitesimal fraction of all minerals of the earth. The possession, control, and exploitation of mineral resources by single nations and groups of nations have had a profound effect upon the history of the world.

Man is faced with the problem of depleting mineral resources because of increased civil and industrial demands for mineral products. High-grade ores are being used up at a rapid rate—lower grade ores are also being utilized extensively. Conservation practices must be applied to the use of mineral resources before even the low-grade ores are depleted. Written history presents ample record of fallen civilizations who did not use their mineral wealth wisely.

History shows that the Persian rulers squandered their most precious mineral—gold—almost solely for ornaments and trinkets. When the Greeks conquered Persia they wisely used the captured gold to develop and expand naval and shipping fleets. Thus, the Greeks, by using Persia's wealth to promote commerce and industry, came to rule the Mediterranean.

Prior to the industrial revolution, and the increase in population and rise in living standards that accompanied it, precious metals such as gold and silver, rather than base metals such as iron and aluminum, drastically influenced the economies of world powers. Demands for base metals were modest enough that local supplies and what could be obtained by trading were sufficient to meet the needs of world powers. Modern demands for these base metals are ever increasing and, as a consequence, geologists throughout the world must constantly search for ore deposits. We must remember that the supply is finite and that even modern technology cannot create new mineral resources.

WHERE ARE MINERALS FOUND?

All the deposits from which minerals have been collected in Nebraska are of sedimentary origin. The rocks that contain them are marine sediments of Pennsylvanian, Permian, or Cretaceous age and terrestrial sediments of Tertiary and Quaternary ages. Their distribution at the surface is shown by text-figure 4, a geologic bedrock map of Nebraska. Fortunately for collectors, some of the terrestrial deposits include abundant fragments of plutonic, volcanic, and metamorphic rocks transported into the state by streams draining mountainous areas to the west and by glaciers moving from the north and east.
GEOLOGIC BEDROCK MAP OF NEBRASKA

Cross Section Along Southern Nebraska Border

Legend:
- TERTIARY:
  - Ogallala
  - Hemingford-Arikaree
  - White River
  - Fox Hills
  - Pierre
  - Niobrara
- CRETACEOUS:
  - Carlile
  - Greenhorn-Greneros
  - Dakota
- JURASSIC
- PERMIAN
- PENNSYLVIANIAN
- MISSISSIPPIAN
- DEVONIAN
- SILURIAN
- ORDOVICIAN
- CAMBRIAN
- PRECAMBRIAN

Scale in Miles

University of Nebraska
Conservation & Survey Division
Nebraska Geological Survey
1969
Generally speaking, most mineral specimens are collected from natural exposures or from artificial exposures such as road cuts and quarries. Most gemstones and cutting materials are collected from alluvial gravels along stream valleys or from glacial deposits in the eastern part of the state. The widespread “mantle” deposits of dune sand, loess (wind-blown silt), and glacial debris greatly limit the areas in which mineral specimens are easily found.

Minerals can be collected wherever there are exposures, either natural or man-made, of mineral-bearing strata. Some rocks, such as limestones and gray shales, are commonly very rich in desirable mineral specimens while other rocks, such as red and green shales and some sandstones, contain little of interest to the collector.

Abandoned rock quarries, road cuts, and natural exposures along streams usually are good sites for mineral collecting. Piles of shales, which have weathered to the degree that the small particles of silts and clays have been washed or blown away, have residues of large particles, many of which are desirable minerals, on the surface. Weathered limestone slabs may also yield residual mineral crystals on the upper surfaces.

Some of the better collecting localities in Nebraska are located along the major drainages such as the Missouri, Platte, Niobrara, Republican, Blue, and Nemaha Rivers and their tributaries. Because of the downcutting action of these streams, there is little overburden or cover on the bedrock. Many of these natural exposures have been deepened by quarries, highway cuts, or railroad cuts.

Many well-known sites for mineral collecting are in quarries and road cuts which occur on either side of the Platte River valley from Ashland, Saunders County, to Plattsmouth, Cass County; and along the Missouri River valley from near Fort Calhoun, Washington County, to near Nebraska City, Otoe County. Collectors come from many states to obtain specimens from these areas and some well-known mineral occurrences have been described from the outcrops.

Good exposures of Pennsylvanian and Permian rocks are found along the valley of the North Fork of the Nemaha River and its tributaries at Tecumseh and Elk Creek, Johnson County; Table Rock, Pawnee County; and Humboldt, Richardson County. Many interesting and attractive minerals can be found in this area.

Permian rocks are exposed along Salt Creek valley near Roca, Lancaster County; and the Little Nemaha River near Bennet, Lancaster County, and Palmyra, Douglas, and Burr, Otoe County. Permian Limestone is quarried at Douglas.

Cretaceous rocks are exposed along the Niobrara River eastward from approximately the east border

Breaking large rocks may be hard work requiring considerable time.
of Cherry County to the Missouri River, and southeastward down the Missouri River to near Blair, Washington County. Some of these exposures contain interesting minerals.

Cretaceous rocks are also exposed along the entire length of the Republican River valley in Nebraska and many exposures containing mineral specimens are located in this area. Both Permian and Cretaceous rocks are exposed along the Big Blue River and its tributaries in the lower part of the basin, and Cretaceous rocks are found along the Little Blue River.

Cretaceous and Tertiary rocks are well-exposed in the Chadron Dome area north of Hay Springs, Sheridan County, and Chadron, Dawes County.

Tertiary (Oligocene and Miocene) rocks are exposed in northwestern Nebraska along the Pine Ridge escarpment. Pliocene rocks are exposed along the North Platte valley from the Wyoming-Nebraska border eastward to Lake McConaughy, along Lodgepole Creek valley, and along the South Platte River valley from the Colorado-Nebraska border eastward to Sutherland, Lincoln County.

**COLLECTING COURTESY**

If one plans to collect minerals on private property, it is necessary to obtain permission from the land owner or quarry operator. This creates a feeling of goodwill and collecting is much more enjoyable if one feels welcome.

There are several rules that must be obeyed once permission to collect is obtained. *Leave the gates as found:* opened gates are to be left opened—closed gates are to be left closed. *Never cut wires* to get through a fence. *Never litter the area* with lunch sacks, paper wrappers, or beverage containers. Not only is this litter unsightly but it creates a feeling of ill will on the part of the property owner; furthermore, broken bottles or rusted metal cans create a hazard to livestock and future collectors. *Never molest animals,* either wild or domestic ones. *Do not allow the family pet to run loose*—many city dogs chase poultry and livestock. *Be sure to thank the owner.* Show the owner some of the specimens that have been collected to satisfy his natural curiosity about what you are seeking. If you collect gemstones, return the property owner’s favor with a piece of hand-made jewelry cut from a stone collected on his property.

**TOOLS FOR COLLECTING MINERALS**

Proper tools are essential for mineral collecting; without them, a trip to even the most productive sites may be fruitless. A geologist’s rock hammer, shown in text-figure 5, is a *must.* A brick mason’s hammer or a light sledge also can be used. Suitable hammers can be obtained from hardware stores, rock shops, or scientific supply houses. A carpenter’s hammer is made from a much softer metal than a rock hammer and may be unsafe.

Gads and cold chisels are much better than ripping chisels for cutting rock. Several gads or chisels, each a different size, are essential tools. They should be kept well-dressed and sharp. The burr which ham-
Text-Figure 6. A dull, poorly-dressed, unsafe chisel (above) compared to a sharp, well-dressed chisel (below).

Topographic maps may save the collector many hours of looking and help increase his yield.
mering causes to form on the end of the gad or chisel (text-fig. 6) should be removed as rapidly as it forms. Otherwise, the burr may fly off when struck with a hammer and cause serious injury. A flying burr may have the mass and velocity of a 22-caliber slug and can deeply penetrate flesh. A dull gad or chisel cuts slowly and is unlikely to stay in the groove; such instability can cause the tool to slip and damage the mineral specimen. A detailed description of collecting tools is given in Sinkankas (1970, p. 38-78).

**CARE OF TOOLS**

If the collecting site is in an active rock quarry or gravel pit, it is absolutely necessary that all hammers, gads, chisels, and other metal tools be accounted for at all times. Such tools can cause considerable damage to quarry machinery if they should happen to become lodged in it. For this reason, tools not being used should be kept in their containers and away from machinery.

A knapsack is useful for carrying both tools and specimens. Moreover, it leaves both hands free when moving about on a rock exposure, allowing for better balance and easier collecting.

Tissue, paper towels, and newspapers are useful for wrapping minerals. Soft paper is best for wrapping small or fragile specimens, whereas newspapers are more suitable for large specimens. Paper should not be allowed to scatter over the collecting area as this is both unsightly and unpopular with property owners.

A small magnifying glass is useful but not absolutely essential. As rock particles are likely to damage the lens, a low-priced, second quality glass is better for field use than an expensive one. Furthermore, small tools are easily lost in the field and, obviously, it is much cheaper to replace a low-priced tool. For detailed study of minerals, an expensive, first-quality glass is preferable, both for seeing detail and for ease to the eyes.

Pencil and paper are essential for recording information as to where, when, and how each mineral was collected. Such information should be placed with each specimen. Materials collected from several different levels in the same location, or from the same level at several different locations should also be kept separate and so marked. Minerals lose much of their value if not accompanied by appropriate identifications.

Small boxes and sacks are useful as containers for small specimens. Small boxes can be obtained from gift shops, stationery counters in department stores, rock shops, or from any of the established scientific supply houses.

Maps are useful not only for locating oneself in the field but also for recording collecting sites. Excellent topographic maps of Nebraska are available from private vendors and the state or federal Geological Surveys. Many quarries and outcrops are indicated on these maps and the user, therefore, has a few locations “given” to him. A topographic map is shown in text-figure 7. These maps present a detailed picture of the landscape by means of brown contour lines, and they denote water in blue and major highways in red; some also show stands of trees in green and farm houses, churches, and schools in black. County maps showing roads, drainage courses, water bodies, man-made structures, and building-material locations are available from the State Department of Roads. These maps are cheaper than topographic maps but are less useful to collectors, although the sites of many active pits and quarries are located on them.

**TIPS ON COLLECTING MINERALS**

When collecting on gently sloping or flat rock surfaces, it is wise to sit or kneel. Knee pads help relieve the discomfort of kneeling. Small areas should be examined carefully with eyes about 16 inches from the surface. As many of the crystals are small—less than 1 inch in diameter—they are likely to be overlooked if viewed from a standing position. Good finds that more casual collectors have overlooked may be yours for being careful.

Minerals are sometimes more clearly visible if the rock surface is wet. Thus, it may be profitable to collect during or right after a rain. If, however, the rock surface is dry, it can be wetted easily by using an insect-spray gun loaded with water. As water is used up quickly, an ample supply should be taken on expeditions during dry weather. It should be noted, however, that some rocks, especially limestone, may become more elastic when they are wet and may not break easily when hit with a hammer.

If the mineral being collected is imbedded in rock, it generally can be cut out by using a hammer and chisel. First, an adhesive bandage should be placed over the mineral. Then a trough a little deeper than the specimen should be cut around it, as shown in text-figure 8. Striking at the base of the pillar thus formed, in the direction of the mineral, will dislodge the specimen.

**SAFETY RULES**

No collecting guide is complete without a few pointers on safety. Serious accidents not only ruin the fun of a field trip but may result in lifelong crippling of the victim and lead to good collecting localities being closed down to later collectors.

Plan to go with another person; if you must go alone, notify someone where you are going and when you expect to return. Keep your tools clean, dressed, and sharp. Don’t throw tools—someone may happen to be within hitting range. Wear plastic safety goggles
TEXT FIGURE 7. A section of a topographic map (Garland, Nebraska, Quadrangle) showing elevations, drainage, vegetation, roads, and other man-made structures.
when hammering on rocks and chisels. Do not climb to any place from which getting down will be hazardous. Ordinarily, it is much easier to climb than to descend. In addition, some special rules should be observed when visiting quarries, as follows:

1. *Always obtain permission to collect.* Even though the quarry operator may have given you permission to enter his property without first visiting him, be sure to let him know. It is to your advantage that the quarry people know where you will be so they will not “shoot” (detonate explosives) and will be on the lookout for you when dumping overburden from large trucks.

2. *Never pull loose wires in rock quarries.* These may be connected to explosives which did not go off during the regular blasting operations. The friction resulting from pulling a wire may generate sufficient heat to detonate the charge. Hapless collectors have lost life or limb from this type of accident.

3. *Never climb on the rock faces in a quarry.* The minerals you seek will almost always be in the rejected rocks on the dump piles. This is where you are expected to be. If rock faces have been severely shattered by blasting, kicking loose a keystone may bring several tons of rock down on the members of the collecting party.

4. *Never swim in quarries.* Although the water holes are inviting, the water is usually quite deep and abrupt dropoffs are not uncommon. The water in rock quarries usually has fewer dissolved solids and considerably less buoyancy than water in swimming pools. Therefore, this rule applies also to accomplished swimmers. Also, do not fish without the quarry operator’s permission as the water may have been stocked privately.

5. *Keep off the machinery.*

Remember that violation of any of the above rules may lead to your being asked not to return, and may lead to the localities being closed to other collectors.

**PREPARATION OF SPECIMENS**

Minerals are rarely found in the clean condition in which they are displayed in museums. To prepare a mineral specimen for display, all dirt and excess matrix must be removed from it.

If a mineral occurs in a water-soluble matrix, it may need only to be washed and scrubbed gently with a soft-bristled brush. Removal of harder matrix may require use of a scouring agent, such as a household cleanser. A brush with brass bristles, of the type used for cleaning suede shoes, is helpful provided the hardness of the specimen is greater than 3 (see p. 17).

Hard or insoluble matrix generally can be cut away with a hobbyist’s knife, which may be purchased at any hobby store, or some other type of sharp, stiff-bladed tool. A small hone is needed to keep the tools sharp.
TEXT-Figure 9. Cleavage in minerals. The preferred directions of breakage in some common materials. 

A, Mica, a single cleavage; 
B, feldspar, two cleavages at 90 degrees; 
C, amphibole, two cleavages at 60 degrees; 
D, galena, three cleavages at 90 degrees; 
E, calcite, three cleavages at 75 degrees; 
F, fluorite, 4 cleavages.
Sharp; dull tools cut slowly and may slip, damaging the mineral or injuring the collector. Excess material should be scraped away from the mineral; gouging with a tool is likely to damage the mineral or injure the preparator.

Most minerals are not acid-soluble; therefore, acid may be used selectively as a cleaning agent. Calcite, however, is highly soluble in acid.

Lacquers or sprays should not be used because, with time, they are likely to turn yellow and crack, presenting an unsightly appearance. Even worse, they may cause a chemical reaction that can damage the mineral.

MINERAL IDENTIFICATION

Students and mineral collectors, regardless of their special interests, should learn to identify as many minerals as possible. The more minerals one can identify, the easier and more accurate one's future determinations become. There are a number of simple tests that yield useful criteria for mineral identification. These tests are effective because each mineral has distinct physical properties, a characteristic chemical composition, and a characteristic crystal structure.

PHYSICAL PROPERTIES

Important physical properties include: cleavage, hardness, luster, streak, specific gravity, form, color, tenacity, and fluorescence. Determination of these properties is, therefore, useful for identification of minerals.

Cleavage

Cleavage is the preferred direction in which a mineral splits when it is struck a sharp blow. If the mineral consistently splits with smooth, flat surfaces, it is said to have perfect cleavage. If the surfaces are less than perfect, the cleavage may be described as good, fair, or poor. Cleavage is also described in terms of the number of directions in which it occurs. Mica has a single cleavage plane (text-fig. 9A). Feldspar and pyroxene cleave perfectly in two directions at 90 degrees (text-fig. 9B, C). Amphibole cleaves perfectly in two directions at 60 degrees (text-fig. 9C).
Galena (cubic) and calcite (rhombohedral) cleave perfectly in three directions: galena at 90 degrees and calcite at 75 degrees (text-fig. 9D, E). Fluorite (octahedral) cleaves perfectly in four or six directions (text-fig. 9F). Cleavage is directly related to chemical bonding that exists between atoms. The cleavage is best developed where bonding is weakest. Mica is a sheet silicate and its weakest bonds occur in planes, which accounts for the single cleavage. Amphiboles are chain silicates with zones of weakness between oxygen atoms in Si₄O₁₁ silicate chains. Quartz is composed of silicon ions bonded to oxygen ions; there are no weak bonds, all of them being of almost the same strength. For this reason, quartz breaks with a conchoidal fracture (text-fig. 26B) rather than a cleavage.

**Hardness**

Hardness is simply the measure of resistance a mineral has to being scratched. A scale of hardnesses known as the “Mohs” scale is used. This scale is based on ten arbitrary levels of hardness, each of which is defined by a particular mineral. Talc, number 1 on the scale, is the softest; diamond, number 10 on the scale, is the hardest. The Mohs scale is as follows:

1. Talc—very easily scratched with a fingernail, feels greasy
2. Gypsum—scratched with a fingernail, does not feel greasy
3. Calcite—scratches a fingernail but can be scratched with a penny
4. Fluorite—scratches a penny, easily scratched with a knife
5. Apatite—barely scratches a knife, does not scratch most glass
6. Orthoclase—scratches glass but with some difficulty
7. Quartz—scratches glass easily, scratches orthoclase
8. Topaz—scratches quartz
9. Corundum—scratches topaz
10. Diamond—scratches corundum

Specimens of the minerals ranging in hardness from 1 to 9 may be obtained from mineral dealers for a small fee. A hardness set is useful for purposes of comparison but is not essential.

When a test for hardness is made, the surface that has been scratched should be wiped clean. Thus, any lines of powdered mineral, which might be mistaken for actual scratches, will be removed. Such lines of powdered mineral appear when the mineral used for the test is softer than the mineral being tested. Hardnesses of 7 or greater are more difficult to determine as there are fewer minerals or man-made substances with which comparisons can be made. As experience is gained, hardnesses above 6 can be estimated quite accurately by the ease with which the mineral scratches glass. For example, orthoclase barely scratches glass even when considerable pressure is applied, whereas corundum and diamond inflict deep scratches in glass with relatively little pressure.

Minerals may be altered by reaction with oxygen or water in the air, resulting in the specimen becoming coated with a mineral which is either harder or softer than the mineral to be identified. For this reason, scratch tests should always be made on a fresh surface.

**Luster**

The manner in which light is reflected from the surface of a mineral is referred to as the luster. If similar to that shown by broken glass, the luster is termed vitreous (as quartz). Adamantine luster is a particularly brilliant luster that is exhibited by sphalerite and diamond. Other, more common terms describing luster are: metallic (pyrite), earthy (limonite), waxy (agate), resinous (sphalerite), and greasy (quartz).

**Streak**

Streak is the mark made when a mineral is rubbed across a streak plate (an unglazed piece of porcelain). Hematite, whether earthy or highly metallic, always has a red streak. Goethite has a yellow-brown streak. Sphalerite has a yellow streak and smells like rotten eggs (hydrogen sulfide) when it is rubbed briskly across the streak plate.

**Specific Gravity**

Specific gravity is the weight of a mineral sample compared to the weight of an equal volume of water at standard pressure and temperature. Gold has a specific gravity of 19.3; that is, 1 cc. (cubic centimeter) of water weighs 1 g. (gram); 1 cc. of gold weighs 19.3 g. Pyrite has a specific gravity of 5.0, barite 4.2, calcite 2.6, quartz 2.6. With experience, one can estimate the specific gravity of a mineral fairly accurately from its “heft.”

**Form**

The term *form* has two entirely different meanings when used to describe a mineral. *Crystal form* indicates which type of faces occurs on a crystal. Since each mineral has a distinct crystalline structure, only certain kinds of crystal forms are possible. Pyrite frequently crystallizes in the form of a cube or a pyritohedron (text-fig. 25), sphalerite crystallizes in the form of a tetrahedron (text-fig. 30), and barite in the form of a diamond (text-fig. 13).

Form is also used to describe the general external appearance of a mineral, often with respect to the
Rattlesnakes are a potential hazard to collectors in Nebraska.

shape of some commonly known object. Some of the more common structures or forms found in minerals include: fibrous, as tightly packed strands (gypsum, text-fig. 22E); radial, as fine crystals pointing outward from a central point (gypsum, text-fig. 22D); botryoidal, or lumpy as a head of cauliflower (goethite, text-fig. 21); stalactitic, like icicles or cave formations; pisolitic, or pea-shaped (bauxite, text-fig. 14); and dendritic, or branching (pyrolusite, text-fig. 26).

Form is a useful criterion for mineral identification. For example, goethite is commonly botryoidal and bauxite is commonly pisolitic.

Color

Although color can be a useful guide for identification, it is the most variable and misleading physical property of minerals. Some minerals, such as calcite and barite, occur in nearly every color, whereas epidote, for example, is almost always a pistachio green. Color must be used with great caution as a means of mineral identification.
Tenacity

Tenacity is the resistance that a mineral offers to breaking, crushing, bending, or tearing. Although most minerals are brittle—that is, they can be crushed readily into a fine powder—a few have other types of tenacity. Definitions of various types of tenacity, each with an example, are given below:

- **Brittle**—breaks or powders easily when struck with a hammer (quartz)
- **Ductile**—can be drawn into thin strands of wire (gold)
- **Elastic**—thin layers can be bent without breaking the mineral and, when released, return to their original shape (mica)
- **Flexible**—thin layers may be bent without breaking but do not return to their original shape (asbestos)
- **Malleable**—may be hammered into thin sheets (gold)
- **Sectile**—may be cut into thin shavings (gypsum)
- **Tough**—very hard to break into pieces or crush into a powder (jade)

Fluorescence

Fluorescence occurs if a mineral is irradiated with light of invisible wavelengths (ultra-violet, infra-red, etc.), and the disturbances created in the atomic and sub-atomic particles of the crystal convert this light to a visible wavelength. A fluorescent mineral appears to "glow in the dark." **Phosphorescence** occurs if a mineral continues to fluoresce in the dark several moments after the source of invisible light is removed.

CHEMICAL PROPERTIES

Chemical Composition

The chemical composition of a mineral may vary within limits. Olivine is a simple example. This mineral is an iron-magnesium silicate whose formula may be written (Fe,Mg)2SiO4. The iron and magnesium symbols enclosed in parentheses mean that iron or magnesium may occupy the cation site in the olivine structure. If all of the cation sites are occupied by magnesium, the mineral is forsterite; if all the cation sites are occupied by iron, the mineral is fayalite. If both magnesium and iron occur in the cation sites, the mineral is olivine.

Taste

Water-soluble minerals have characteristic tastes. Halite (sodium chloride) tastes like table salt, which it is. Melanterite (ferrous sulfate) has a sweetish, astringent or metallic taste. Minerals of the alum group generally have a sour taste and cause one's lips to pucker. Sylvite (potassium chloride) has a lasting, bitter taste. Some clay minerals have a mildewy taste and adhere to the lips or tongue.

Chemical tests

Most chemical tests require extensive laboratory equipment and considerable experience in order to be effective for mineral identification. However, one simple chemical test is commonly used: calcite effervesces (fizzes) freely when treated with dilute hydrochloric acid. If hydrochloric acid is not available, household vinegar may be used instead with a similar effect (a powdered sample effervesces freely in household vinegar).

CRYSTALLOGRAPHY

A crystal is the regular polyhedral form assumed by an element or compound when it passes from a liquid or gaseous state to a solid state. A crystal is characterized by a definite, internal molecular structure which is expressed by its external form. Although a great variety of crystal forms is possible, all forms may be classified into six large groups, each of which is called a crystal system.

Each crystal system is characterized by a particular relationship of crystallographic axes, a line of symmetry expressing the relationships of the crystal faces and the center of the crystal. The relationships between crystallographic axes and crystal faces for the six systems is illustrated in figure 10.

- **Isometric system** (text-fig. 10A)—crystals having three axes, all of which are of equal length and are perpendicular to each other.
- **Tetragonal system** (text-fig. 10B)—crystals having three axes, two of equal length, one unequal, all intersecting at right angles.
- **Hexagonal system** (text-fig. 10C)—crystals having four axes, three of equal length intersecting at angles of 120 degrees, and a fourth, unequal axis perpendicular to the three equal axes at their point of intersection.
- **Orthorhombic system** (text-fig. 10D)—crystals having three unequal axes, all of which are perpendicular to each other.
- **Monoclinic system** (text-fig. 10E)—crystals having three unequal axes, two of which are perpendicular, and the third inclined to the other two.
- **Triclinic system** (text fig. 10F)—crystals having three unequal axes, all inclined to each other.

Pseudomorphs, or false forms, result when a crystal in a rock is dissolved and the void left behind retains the form of the crystal. If this void is then filled by another mineral, a pseudomorph results. A pseudomorph may also result when a mineral is altered or replaced, as when pyrite alters to limonite, or when marcasite is replaced by gypsum.
Some minerals have no crystalline structure; these are called amorphous (without form) minerals. Opal is probably the most common example. Some minerals occur as seemingly amorphous masses but are actually composed of very small crystals which can be seen only with magnification. Such cryptocrystalline minerals include agate and chalcedony.

**COMMON NEBRASKA MINERALS**

Since minerals are not restricted to rocks of any particular age or to any particular geographic location, each mineral variety is treated alphabetically in the section that follows. Their modes and places of occurrence are discussed in the text. Physical properties are listed for each mineral and the following abbreviations are used: streak, Str.; hardness, H; specific gravity, G; and chemical composition, Comp. Luster is indicated as metallic, nonmetallic, earthy, etc., but the word luster is omitted. Crystal systems are given the following abbreviations: isometric, Isom; hexagonal, Hex; tetragonal, Tetr; hexagonal-rhomboidal, Rhomb; orthorhombic, Ortho; monoclinic, Mono; triclinic, Tri; and cryptocrystalline, Crypto.

Following is a short résumé of the common mineral occurrences in Nebraska of interest to collectors. Also included are some sediments (e.g., chalk), sedimentary structures (e.g., geodes), and meteorites. There are probably many other minerals and many new occurrences of minerals already known in the state that could be added to the list. This list will certainly grow as collectors report new finds.

Keep in mind that many of the locations noted are on private property and that it is essential to obtain permission to collect. DESCRIPTION OF LOCATIONS IN THIS BOOKLET IN NO WAY IMPLIES THAT IT IS PERMISSIBLE TO COLLECT THERE WITHOUT THE OWNER'S PERMISSION.

The illustrations accompanying the text are designed to familiarize the reader with the characteristics which are important for proper identification of minerals and gemstones. In most cases the minerals or gemstones were illustrated from actual specimens. When good specimens were not available, the illustrations were modified after specimens shown in plates and figures of one or more of the references listed in the Selected Bibliography.

Don't become discouraged if your first field trip fails to yield an abundance of minerals or gemstones. Each geologic setting requires a special "bag of tricks" to find minerals. It is important for the reader to realize that the material described in the text has been collected by several hundred persons over a period of about 100 years. Thus, one should not expect to find the described material in large quantities.

Throughout the remainder of the text reference will be made to named geologic beds. The collector...
Failure to obtain permission to collect on private property may result in one being ejected by the owner.

will be more successful if he familiarizes himself with local geology. Information can be obtained from geologic maps and reports, study of collections on display at the University of Nebraska State Museum, and by consulting the Conservation and Survey Division in Nebraska Hall, University of Nebraska. For additional source material, the reader is encouraged to consult references in the Selected Bibliography.

Many of the unfamiliar terms used in this publication are explained in the Glossary.

**Amphibole**

Cleavage: 2 at 56°; Ortho-Mono; H 5-6; G 3.3; Comp. Complex silicate of Na, Ca, Mg, Fe, Al.

Amphibole occurs as dark-green to black, elongate crystals in plutonic and metamorphic rocks. In Nebraska, plutonic and metamorphic rocks occur as boulders, cobbles, and pebbles in glacial tills and river gravels. Amphibole differs from pyroxene whose crystals are of similar colors but whose crystal habit is short and stubby. See text-figure 11.

*See also* Jade, in Gemstone section.

**Ankerite**

Cleavages 3 at 75°; Rhomb; H 3.5; G 2.9-3.1; Comp. CaCO₃ (Mg, Fe, Mn)CO₃.

Ankerite has been collected from septarian concretions (p. 45, text-fig. 28) occurring in the Cretaceous Carlile Shale of the Chadron Dome area, north of Hay Springs, Sheridan County. It looks much like calcite (p. 25) but is gray with a brownish coating.

**Aragonite**

Cleavages 3, 2 at 63°; Ortho (Pseudo-Hexagonal); H 3.5; G 2.9; Comp. CaCO₃.

The most common occurrences of aragonite in Nebraska are in the Pennsylvanian and Permian rocks of Cass, Sarpy, Otoe, and Gage Counties. Aragonite generally occurs as a fibrous crust lining fracture planes, especially in thick limestones. It appears to have been precipitated from calcium carbonate-saturated waters that periodically flow through fracture systems in limestones. Some aragonite has formed recently since it is sometimes found encasing cocoons of recent caterpillars. Typically, it is layered and is
honey-colored or light brown. The layered aragonite is commonly referred to as “cave onyx” or “Mexican onyx” and is frequently used as a gemstone or ornamental stone (p. 64).

Rather large quantities of layered aragonite have been collected from the Pennsylvanian Plattsmouth and Ervine Creek Limestones exposed in quarries near Plattsmouth, Cass County. Aragonite also occurs in the Permian Aspinwall Limestone near Dunbar, Otoe County, and at the abandoned Aspinwall ferry-boat moorings near the old St. Deroin townsite in southeastern Nemaha County.

“Hairy” aragonite crystals occur as fuzzy coatings on calcite and quartz crystals lining vugs and geodes in the Permian Fort Riley Limestone, exposed in the abandoned Gage County quarry near Wymore. The material fluoresces a bright yellow to yellow green under ultra violet light; it is also quite phosphorescent.

Aragonite undoubtedly occurs in many places in southeastern Nebraska other than those already mentioned. Aragonite also has been reported from the Cretaceous Carlile Shale near Bloomington, Franklin County (text-fig. 12).

See also Onyx, in Gemstone section.
Autunite

Good basal cleavage; lemon-yellow streak; Ortho.; H 2-2.5; G 3.1; Ca(UO₂)₂(PO₄)₁₀·12H₂O.

Autunite occurs as fracture coatings and as granular aggregates dispersed in clays in the Oligocene Brule Formation near Chadron, Dawes County. It is lemon yellow to yellow green and very brightly fluorescent. Autunite also occurs as globular grains on the surfaces of veins of gypsum that are partially replaced by chalcedony.

Barite

Cleavages 3, 2 alike, 1 different; Ortho; H 3; G 4.5; platy composition BaSO₄.

Barite is one of the most sought after and prized minerals occurring in Nebraska. It is fairly common, and attractive specimens showing many different
Crystal forms and colors can be obtained quite easily. Furthermore, many of the known localities from which barite is collected are easily accessible.

Yellow and white, tabular and prismatic barite crystals have been collected from vugs in a zone near the top of the Pennsylvanian Argentine Limestone near Louisville, Cass County (text-fig. 13A). The crystals are usually quite large and are associated with calcite and gypsum.

Pennsylvanian rocks exposed in the King Hill quarry and in the abandoned quarry at the Snyderville railroad siding, both in Cass County, contain gray, green, and white, tabular barite crystals.

Blue barite occurring on calcite crystals lining vugs in the Pennsylvanian Beil Limestone has been collected from the north end of Queen Hill quarry near Plattsmouth, Cass County.

Some of the finest barite crystals collectible anywhere are found in vugs and geodes occurring in the upper part of the Florence Limestone and the lower part of the Fort Riley Limestone (both Permian), which are exposed in several quarries in the vicinity of Holmesville and Wyom, Gage County (pl. I, fig. 15). Barite may be present as an accessory mineral covering calcite or quartz, or it may be the only mineral in a vug. In either case, the barite generally occurs as radiating tufts of needle-like crystals or as tabular, wedge-shaped crystals. Orange, yellow, blue, green, white, and colorless barite have been found in this locality. The vugs that contain barite occur in a massive, heavy limestone which can be broken only with relatively heavy tools. The barite-containing vugs are not uniformly distributed through the limestone, some zones being richer than others and some zones lacking barite entirely. All barite from Holmesville fluoresces yellow green under shortwave ultraviolet light, except for the white, tabular crystals which are not fluorescent.

Barite from the abandoned quarries near Wyom occurs as colorless or blue, tabular crystals (pl. II, figs. 1, 2) that are also fluorescent. However, the fluorescent colors of the barite are often masked by fluorescent calcite in the small vugs.

Small, diamond-shaped, prismatic barite crystals, popularly referred to as “Odell diamonds” (pl. I, fig. 8; text-fig. 13B) occur in shales in the Cretaceous Dakota Group west of the village of Odell, Gage County. These crystals are generally white or pink, and many show phantom growths. They are not usually fluorescent.

Barite has been collected from fractures in concretionary materials from the Cretaceous Dakota Group at the old Burnham (now Yankee Hill) brick yard near Lincoln, Lancaster County. This barite is of particular interest since the crystals are pseudomorph replacements of marcasite.

Barite pseudomorphs after marcasite concretions are found in the Cretaceous Carlile Shale in Franklin County; these are referred to as “barite dollars.” The crystals radiate from the center of the concretion, as in the original marcasite.

Blue, bladed crystals of barite occur along fault planes in the Cretaceous Niobrara Chalk in Harlan County at the Harlan County reservoir. These crystals are often enclosed in calcite or in vugs within calcite-filled veins. There appear to have been two generations of barite, the first consisting of tabular, light-blue crystals and the second of light-blue rosettes. First-generation barite crystals frequently have been damaged by fault movement; second-generation barite appears to have crystallized on the fault planes.

Blue, fibrous barite is found at one of the borrow pits from which material was excavated during construction of the Harlan County dam. This, too, occurs in the Niobrara Chalk. Harlan County barite may or may not be fluorescent.

Blue, tabular and fibrous barite is found in the Pliocene rocks near the village of Lisco, Garden County. There are many known occurrences of barite in Nebraska and it is possible that exceptional crystals remain to be found. Some colorless barite crystals have been collected from unidentified, post-Cretaceous rocks exposed near Crofton, Knox County (pl. I, fig. 9).

Bauxite

Clay-like pisolitic; G. 2.5 hydrated Aluminum Oxide; Al₂O₃·2H₂O.

Bauxite is a hydrated oxide of aluminum resulting from intense weathering of granitic or basaltic rocks. No bauxite is native to the state although it is found
here in small quantities in the glaciated portions of eastern Nebraska. Bauxite was formed at some of the exposures of Precambrian rocks on the Canadian Shield and was transported to Nebraska by Pleistocene glaciers. It is easy to recognize as it consists of pea-sized, reddish pellets (pisolites) in a tan or brown matrix (text-fig. 14). It can be collected from exposures of glacial till.

Biotite—See Mica

Calcite

3 Cleavages at 75°; Rhom.; H-3, G 2.7; doubly refracting; Calcium Carbonate, CaCO₃.

With the exception of clay minerals, calcite is perhaps the most common mineral to be found in the sedimentary rocks of Nebraska. Calcite takes many different forms and colors and specimens are instructional and attractive additions to any mineral collection.

The Winterset Limestone, exposed in several quarries near Papillion, Sarpy County, contains numerous calcite-filled vugs. The crystals are usually distorted and only large, rhombohedral cleavages are collectible.

Calcite has been collected from several quarries near Louisville, Cass County. Several dozen very large plates of calcite were collected from a joint plane in the Stanton Formation. These were accompanied by metallic accessory minerals such as pyrite and marcasite. Pennsylvanian rocks near Louisville and Weeping Water frequently contain isolated vugs filled with either rhombohedral or scalenohedral calcite crystals (text-fig. 15A, B, C).

Excellent colorless and yellow calcite crystals have been collected from the Beil and Plattsmouth Limestones, exposed in several quarries near Plattsmouth and Weeping Water, Cass County (pl. I, fig. 11). These crystals occur in vugs in massive limestones, and heavy tools and equipment are required to collect them successfully. Calcite also occurs in voids left by the shells of fossil organisms and in burrows made by ancient sea dwellers. Accessory minerals include pyrite, marcasite, and sphalerite.

Calcite that fluoresces yellow has been collected from geodes occurring in the Permian Hughes Creek Shale along several creeks near Brock and Johnson, Nemaha County, and in the Eskridge Shale exposed in road cuts near Humboldt, Richardson County. Fluorescent calcite also occurs as a lining of fractures in the Hughes Creek Shale exposed near Salem, Richardson County.

Massive pink and orange calcite has been collected in the vicinity of Bennet, Lancaster County, from several seams in the Permian Johnson Shale. It is not common and is sometimes erroneously referred to as "red celestite."

Highly fluorescent calcite has been collected in Nebraska from the Permian Roca Shale near Douglas and Burr, Otoe County. The calcite occurs in geodes which can be dug from the creek bank with small tools. It fluoresces either green or yellow green under ultraviolet light. Some is so active that it fluoresces under an ordinary household fluorescent lamp. This material is also phosphorescent and glows for several seconds after the ultraviolet or fluorescent light has been removed.

Some excellent specimens of calcite have been collected from the Permian Fort Riley and Florence Limestones near Holmesville, Wymore, and Blue Springs, Gage County (pl. I, fig. 1). Many different crystal forms are assumed by this calcite. Most of the calcite from this area is colorless, but some orange, iridescent, and green calcite has been collected. The calcite occurs in siliceous geodes in which calcite is usually the most common mineral. Some calcite from Wymore is both fluorescent and phosphorescent. That

Text-Figure 15. Common forms of calcite crystals. A, A scalenohedron; B, a rhombohedron; C, a scalenohedron modified by a rhombohedron.
from Holmesville is not. Heavy tools are needed to collect from these sites, all of which are presently in active quarries.

Calcite is found in Cretaceous rocks throughout much of the state. Greenhorn Limestone contains some calcite in vugs in natural exposures at Milford, Seward County; and in quarries at Garland, Seward County; Fairbury, Jefferson County; and Hebron, Thayer County. Calcite shells of the clam Inoceramus are fluorescent, glowing a red-orange under ultraviolet light. These fossils are collectible at almost any exposure of Greenhorn Limestone.

Choice calcite scalenohedrons (text-fig. 15A) have been collected from the Carlile shale which is exposed about 20 miles north of Chadron, Dawes County, and Hay Springs, Sheridan County. These crystals occur in large septarians that can be broken only with heavy tools and strenuous effort.

In Harlan County, some excellent calcite crystals have been collected from the Niobrara chalk which is exposed along fault planes. In the area of the Harlan County Reservoir the collecting sites are not accessible during moderate- to high-water stages.

Sand crystals (pl. I, fig. 10) form when calcite crystallizes in loose sand. Sand grains are entrapped within the framework of the crystal. The visual impression is that the sand is crystallized rather than the calcite. Sand crystals occur in the Oligocene Chadron Formation in the northwestern panhandle near Orella, Sioux County, and Chadron and Crawford, Dawes County. Generally, the crystal form is a combined acute and obtuse rhombohedron. These crystals are usually found lying on weathered surfaces of sandstone outcrops and are commonly referred to as "Cretaceous quartzite," although they are of Oligocene age or younger.

The abundant and diverse geographic and stratigraphic occurrences of calcite in Nebraska show how common this mineral is. The possible occurrences of calcite in Nebraska are far too numerous to mention and many new collecting localities for this mineral will no doubt be discovered.

Calcite provides a classic example of a phenomenon called double refraction. The index of refraction is the ratio of the velocity of light traveling through air to the velocity of light traveling through some other medium (e.g., a mineral). This change in velocity is accompanied by a corresponding change in direction of the light ray. A mineral may have one, two, or three indices of refraction. Calcite has two indices of refraction and breaks a single ray of light into two rays (double refraction) and yields a double image of whatever is observed through it (see text-fig. 16).

Carnotite

Powdery; Ortho; K₂(UO₂)₂(VO₃)₂.1-3H₂O.

Carnotite is a yellow, powdery, fluorescent mineral. It has been noted as irregular veins and pore fillings in gypsum crystals. Carnotite also may occur within cleavage cracks in gypsum. It has been found in gypsum in the Oligocene Brule Formation near Chadron, Dawes County.

Celestite

Cleavages 3, 2 alike, 1 different; Ortho; H 3; G 4; often white or bluish; SrSO₄.

Celestite has a somewhat restricted geographic occurrence in Nebraska but is usually rather abundant when found. The Permian Fort Riley and Florence Limestones, exposed near Wymore, have yielded considerable amounts of blue celestite, popularly referred to as "blues" (pl. II, fig. 3; text-fig. 17). The celestite occurs in vugs in massive limestone and reasonably heavy tools are needed to collect it. Acicular crystals are found along Squaw Creek, near Wymore, Gage County.

TEXT-Figure 16. Refraction and double refraction. A, When a light ray passes through a crystal face, the velocity of light changes and the direction of the ray changes. B, A ray of light passing through a cleavage rhomb of calcite is split into two rays, forming a double image.
Large, tabular, blue and colorless celestite crystals have been collected from the Cretaceous Carlile Shale near Hay Springs. They occur in septarians; heavy tools are needed to remove them.

Small septarians (p. 45) containing minute, colorless, acicular celestite crystals have been reported from Loup River gravels at Fullerton, Nance County.

Chalcedony

Conchoidal fracture; Hex (Crypto); H 7; G 2.6; often layered or banded; Comp. Silicate.

Several interesting, if not unique, forms of chalcedony are found in the Oligocene Chadron Formation in northwestern Nebraska. Chalcedony frequently occurs along fault and joint planes, and in many areas it is seen standing vertically several feet above the natural ground level. These occurrences have been referred to as "chalcedony dikes" and are restricted to the Chadron Formation.

Hollow nodules (pl. I, fig. 13) are sometimes lined with stalactitic chalcedony, calcite, gypsum, or quartz. Much of the chalcedony is layered and forms banded agate.

Chalcedony rosettes (pl. I, fig. 12, text-fig. 18A) are found near Orella, Sioux County. These result from the replacement of gypsum by chalcedony through groundwater action. Massive forms of chalcedony also replace gypsum and the chalcedony frequently assumes the perfect cleavage of the gypsum (text-fig. 18B). A very unusual type of geode was collected near Orella. Its shell is a chalcedony-replaced gypsum crystal (pl. I, fig. 3; text-fig. 18C) and its hollow is lined with calcite or gypsum. Stalactitic chalcedony also occurs near Orella.

Chalcedony tends to have many inclusions. Goethite crystals have been observed in the hollows of nodules. Some chalcedony is quite muddy and encases a portion of the bedrock in which it formed. These inclusions frequently produce a desirable subject for lapidaries (see Gemstones). Most chalcedony from the Chadron Formation is fluorescent.

Numerous specimens of chalcedony of undetermined origin can be collected from gravels in all of Nebraska’s major drainageways and in most exposures of glacial till.

See also Chalcedony, in Gemstone section.

Chalcopyrite

Cleavage indistinct; Tetr; Str. black. H=3.5, G 4.2; CuFeS

Sparse occurrences of brassy yellow and iridescent chalcopyrite have been reported from mineralized vugs in the King Hill quarry near Plattsmouth, Cass County, and from the Fort Riley Limestone near Holmesville, Gage County.

Chalk

Chalk is a white to gray, loosely-cemented limestone that may be as much as 99 percent pure calcium carbonate. It consists largely of the calcareous remains of minute fossil organisms such as foraminifera and coccoliths and calcite of unknown origin.

Chalk is common in the upper Cretaceous Niobrara formation. Large exposures of chalk can be seen near Niobrara, Knox County; Franklin, Franklin County; Alma, Harlan County; and Chadron, Dawes County.

Chert—See Gemstone section

Chlorite

Cleavage 1 perfect; Mono; H 2.5; G. 2.7; complex, hydrated magnesium silicate.

Chlorite is a light blue-green, flaky mineral which occurs mainly in metamorphic rocks that have been transported into Nebraska by streams or glacial activity.

Coal

Coal is a sediment formed by the accumulation and decomposition of plants. Since it is composed mostly of organic material, coal is not properly classified as a mineral. Coal is found as thin layers or seams in Pennsylvanian, Permian, and Cretaceous Dakota rocks in southeastern Nebraska. It more commonly occurs in the Dakota, however, as carbonized logs. Many minerals are associated with coal deposits, including gypsum, halotrichite, marcasite, melanterite, pyrite, and sphalerite.
TEXT-Figure 18. Chalcedony. A, Chalcedony rosette; B, chalcedony replacing gypsum; C, a chalcedony pseudomorph after gypsum containing calcite crystals (X1). All specimens collected from the Oligocene Chadron Formation exposed near Crawford, Dawes County.
Copper

Malleable; H=2.5; G 8.9.

Rare occurrences of native metallic copper have been noted from the Permian Florence Limestone at Holmesville, Gage County, where it occurs as minute inclusions in black chert.

Dolomite

Cleavage I perfect; Rhomb; H=3.5-4; G 2.8-3.0; CaMg(CO₃)₂.

Although dolomite is abundant in the subsurface rocks of Nebraska, no crystals had been recorded from the surface until collectors turned up samples of this mineral in vugs in the Kereford Limestone exposed in several quarries near Plattsmouth, Cass County. The crystals (text-fig. 19) are small, white, curved rhombohedrons, and are associated with calcite, sphalerite, marcasite, and gypsum. Although dolomite is widely disseminated throughout the Kereford Limestone, it is not abundant. Massive dolomite has been reported from the Bonner Springs Shale near Louisville, Cass County.

Epidote

Cleavage I perfect; Mono; H 6.5; G 3.4; Complex silicate of Ca, Al, Fe.

Epidote occurs as an alteration product of feldspar. Its occurrences are restricted to granitic rocks which originated in plutonic and metamorphic rocks outside of Nebraska and have been transported into the state by stream or glacial activity. Epidote is easily distinguished by its pistachio-green color.

See Unakite, in Gemstone section.

Feldspar

Two perfect cleavages at 90°; H 6; G 2.6; KAl(Si₃O₈) (Orthoclase); NaAlSi₃O₈-CaAl₂Si₂O₈ (Plagioclase).

Feldspar originated in plutonic and metamorphic rocks in areas outside of Nebraska. It has been transported into the state by streams and glaciers. Orthoclase feldspar is commonly pink and gives a pink color to many river gravels. Orthoclase is distinguished from plagioclase by the lack of striations along cleavage planes (text-fig. 20). Plagioclase feldspar is commonly white and is striated (text-fig. 20) due to twinning of crystals along cleavage planes.

Fluorite

Cleavage 4 at 70°, perfect; isom; H=4; G 3.2; CaF₂.

Fluorite sometimes occurs as a purplish coating on quartz crystals lining geodes which are found in the Fort Riley Limestone at the abandoned Gage County quarry near Wymore. Fluorite is also associated with the celestite crystals which have been collected from the Squaw Creek section at Wymore. Fluorite from these localities has erroneously been called amethyst.

Geodes

Geodes are hollow, globular, sedimentary structures which are commonly an inch or two in diameter and are found most frequently in limestones and shales. Although geodes as large as three feet in diameter are known to occur elsewhere, specimens from Nebraska are small. They have a hollow interior and are lined with crystals which project inward. They have a thick outer shell and show evidence of growth.

Goethite

Cleavage, 1 perfect; Ortho; Streak, yellow-brown; H=5; G 4.4; HFeO₂.

Goethite is a hydrated iron oxide which frequently occurs in the Cretaceous Dakota Group. It is usually dark brown or black and is botryoidal (text-fig. 21), stalactitic, or fibrous in appearance. Specimens have been collected from near Ashland, Saunders County; Lincoln, Lancaster County; Pleasant Dale, Seward County; Beatrice, Gage County; and Fairbury, Jefferson County. Goethite occurs in most exposures of Dakota Group Sandstones. It also occurs in chalcedony geodes found in the Oligocene Chadron Formation near Crawford, Dawes County (p. 27).

Gold

Malleable; Isom; H=2.5; G 18 (19.3); Au.

Nuggets of gold are occasionally found in Platte River gravels and in some of the glacial deposits of southeastern Nebraska. All of the gold found in Nebraska has been transported here; none is native. There were "gold rushes" at Milford and Pleasant Dale, Seward County; Crete, Saline County; Humph-
TEXT-Figure 20. Feldspars. Though all feldspars are characterized by two perfect cleavages at 90 degrees, orthoclase, A, can be differentiated from plagioclase, B, which is highly striated.

Gypsum

Cleavage, 1 perfect; Mono; H 2; G 2.5; CaSO₄·2H₂O.

Gypsum, or selenite, is a rather common mineral having several noteworthy occurrences in Nebraska. It is commonly associated with dark shales and is usually very easy to collect. Much of it can simply be picked up from the surface.

Gypsum, typically, has many different crystal habits and occurs in a large variety of forms. Single crystals, fishtail twin, penetration twin, and radial aggregates of crystals are commonly found (text-fig. 22A-D).

Balls of gypsum replacing marcasite and fibrous, bedded gypsum (text-fig. 22E) are also common.

Small gypsum crystals in association with marcasite are found in road cuts south of Humboldt, Richardson County. Gypsum rosettes, about one inch in diameter, have been reported from Pennsylvanian and Permian rocks in Richardson County. Gypsum crystals have been reported from a stream-side outcrop of Permian rocks between Douglas and Burr in Otoe County.

Gypsum crystals have been collected from the Cretaceous Niobrara Chalk and Pierre Shale from exposures along the Republican River in Franklin and Harlan Counties. Gypsum, as large crystals and sheets of crystals up to several feet long, is frequently found in the Pierre Shale of northwestern Nebraska. Gypsum crystals are common in shales in the Dakota Group exposed near Newcastle, Dixon County (pl. I, fig. 4). Fishtail (pl. I, fig. 5; text-fig. 22), and penetration twins (text-fig. 22B) are common in Pierre Shale gypsum occurrences.
TEXT-Figure 21. Botryoidal goethite collected from the Cretaceous Dakota Formation exposed near Ashland, Saunders County (X1).

Gypsum rosettes (text-fig. 18A) which are partially to fully replaced by chalcedony (pl. 1, fig. 12) are found in the Oligocene Chadron Formation. Many of the rosettes of chalcedony, when broken open, contain unplaced, crystalline, yellow gypsum, which fluoresces orange under ultraviolet light.

Chalcedony pseudomorphs after gypsum crystals (text-fig. 22E) have also been collected from the Chadron Formation near Orella, Sioux County. These have the same outline as the monoclinic gypsum crystal but are hollow and lined with calcite crystals. No trace of the original gypsum is retained except the shape of the crystal.

Gypsum is a rather common mineral in Nebraska and is easily collected by simple surface-gathering techniques. It is not profitable to dig gypsum crystals as they are quite soft and easily damaged. Autunite, carnotite, halotrichite, melanterite, and sabugalite are often found with gypsum in Nebraska.

Halotrichite

Hydrated iron aluminum sulfate, FeSO₄·Al₄(SO₄)₂·24 H₂O.

Halotrichite is a yellow, encrusting mineral which frequently occurs in dark shales or coal. It results from the breakdown of gypsum or pyrite. Its appearance is either as a yellow, powdery or silky coating, or as a yellow, mohair-like crust on the surface of the matrix.

Halotrichite has been found in a coal in the Pennsylvanian Severy Shale near Dubois, Pawnee County; the Pony Creek Shale near Brownville, Nemaha County; shales of the Dakota Group near Denton, Lancaster County; and in the Graneros Shale near Valparaiso, Saunders County.

Hematite

Nearly cubic parting; Rhomb; H 5½-6½; G 5.26; red streak; Comp. Fe₂O₃.

Hematite is a rather heavy, black to metallic gray mineral commonly found in glacial deposits in southeastern Nebraska. It probably originated in the Mesabi Range, an iron-producing area in Minnesota.

See Hematite, in Gemstone section.

Jade—See Gemstone section.

Limestone

Limestone is a rock consisting of at least 50 percent calcite, the remainder being largely silt or clay particles, land-derived debris, fecal pellets, and algal remains. Unlike chalk, it is well-cemented.

Limestones of Pennsylvanian and Permian age are exposed throughout much of southeastern Nebraska (text-fig. 4). The extensive limestone deposits are the basis of a large road-aggregate, agricultural-lime, and Portland-cement industry.

Limonite

Earthy, Amorphous; H 5-5½; G 3.6-4; 2Fe₂O₃·3H₂O.

Limonite is a yellow-brown to dark-brown hydrated iron oxide that has no crystal structure. It is usually stalactitic or botryoidal and occurs under the same conditions and at the same localities as goethite and Marcasite.

Limonite nodules are found in sandstones of the Cretaceous Dakota Group in Lancaster, Saunders, Sarpy, Cass, Gage, and Jefferson Counties. Limonite is also found at the unconformable contact between the Pierre Shale and Chadron Formation in northwestern Nebraska.

Limonite pseudomorphs after pyrite crystals are found in many Pennsylvanian Limestones near Weeping Water and Louisville, Cass County.
EXPLANATION OF PLATE I

1, Calcite geode in pyrite shell, near Holmesville, Gage County. 2, Pyrite-coated, quartz geode, near Holmesville, Gage County. 3, Chalcedony (outside) replacing gypsum (inside), near Orella, Sioux County. 4, Gypsum rossette, near Newcastle, Dixon County. 5, Gypsum, fishtail twins, near Chadron, Dawes County. 6, Marcasite, near Plattsmouth, Cass County. 7, Pyrite cubes modified by octahedron, near Plattsmouth, Cass County. 8, Prismatic barite crystals, near Odell, Gage County. 9, Barite-lined geode, near Crofton, Knox County. 10, Calcite “sand crystals” near Chadron, Dawes County. 11, Calcite scalenohedron penetrating a rhombohedron, near Plattsmouth, Cass County. 12, Chalcedony rossette, pseudomorph after gypsum, near Orella, Sioux County. 13, quartz-lined, chalcedony geode, near Orella, Sioux County. 14, Quartz geode, near Odell, Gage County. 15, Tabular barite, near Holmesville, Gage County. 16, Sphalerite, near Plattsmouth, Cass County. 17, Common opal, near Kimball, Kimball County.
EXPLANATION OF PLATE II

1. Barite (blue) on calcite (yellow) and calcite (white), near Wymore, Gage County. 2. Barite (blue) on calcite, near Wymore. 3. Celestite, near Wymore. 4. Onyx sphere, near Plattsmouth, Cass County. 5. Fortification agate, near Harrison, Sioux County. 6. Blue chalcedony with gypsum inclusions, near Chadron, Dawes County.
EXPLANATION OF PLATE III

1, Silicified wood, Ogallala, Keith County. 2, Silicified wood, Chappell, Deuel County. 3, 4, Chalcedony, Chadron, Dawes County. 5-9, Lake Superior agates: 5, Brock, Johnson County; 6, Palmyra, Otoe County; 7, Lorton, Otoe County; 8, Johnson, Nemaha County; 9, Valparaiso, Saunders County. 10, Moss agate, Fremont, Dodge County. 11, Fortification agate, Orella, Sioux County.
Explanatory of Plate IV

Cabochons, jewelry, and faceted material from Nebraska. 1, 2, Chalcedony: 1, a solid stone with no backing, Orella, Sioux County; 2, a doublet with a layer of chalcedony over a blackened layer of chert, Orella. 3-6, Lake Superior agates: 3, Douglas, Otoe County; 4, Tecumseh, Johnson County; 5, Agnew, Lancaster County; 6, lady's ring, Fremont, Dodge County. 7, 8, Fortification agates: 7, a lady's pendant, Orella; 8, a cabochon, near Toadstool Park, Sioux County. 9, Silicified wood, Sutherland, Lincoln County. 10, Jasper, Chadron, Dawes County. 11, Faceted quartz, 31.97 carats, Chappell, Deuel County. 12, Opalized wood, O'Neill, Holt County. 13, A lady's pendant containing yellow-brown wood from near Ogallala, Keith County, and black wood from near Crawford, Dawes County. 14, Silicified wood, Chappell. 15, Lake Superior agate, Tecumseh, Johnson County. 16, Nephrite (jade) in a lady's pendant, Bridgeport, Morrill County. 17, Jasper, near Elk Creek, Johnson County. 18, Jasper, near Cozad, Dawson County. 19, A man's bola slide using mother-of-pearl (white), Platte River, near Ashland, Saunders County; onyx (tan), near Plattsmouth, Cass County; and black wood, near Crawford, Dawes County. 20, Ivory, near Lexington, Dawson County. 21, 22, Chert, near Cook, Johnson County. 23, Agate, near Humboldt, Richardson County. 24, Jasper, near Brock, Nemaha County. 25, Silicified wood, near Paxton, Keith County. 26, Opalized wood, near Ewing, Holt County. 27, Prairie agate, near Orella, Sioux County. 28, Moss agate, near Lincoln, Lancaster County. 29, Jasper, near Ogallala, Keith County. 30, Moss agate, near Ogallala. 31, Jasper, near Ogallala. 32, Silicified wood, near Roscoe, Keith County. 33, Silicified wood, near Fremont, Dodge County. 34, Silicified wood, near Brule, Keith County. All specimens actual size.
TEXT-Figure 22. Common forms of gypsum found in Nebraska. A, Normal crystal, side view left, front view center, and perspective view right; B, a penetration twin; C, a fishtail twin; D, radial gypsum crystals collected from the Cretaceous Carlile Shale exposed near Butte, Boyd County; E, fibrous gypsum collected from the Cretaceous Pierre Shale exposed near Crawford, Dawes County. (All figures XI).

Magnetite
Octahedral parting; Isom; H. 5.5-6.5; G 5.2; metallic; Fe₃O₄.

Magnetite, or magnetic iron ore, is one of the more common minerals to be found in Nebraska. It is most easily recognized by its magnetic properties. It usually occurs in deposits of sand and gravel and is easily separated from the nonmagnetic minerals by means of a small magnet. All magnetite has been transported into Nebraska, none being native to the state. Magnetite is not known to occur in commercially workable deposits in Nebraska.

Marcasite
Cleavage, 1 distinct; Ortho; black streak; H 6-6.5; G 4.9; FeS₂; frequently smells rotten.

Marcasite is an iron sulfide which is common throughout much of Nebraska. Typically, it is a dull, brassy-yellow mineral occurring as nodules or bladed crystals in black or dark-colored shales (text-fig. 23). Marcasite is found in many Pennsylvanian and Permian black shales, especially in Cass, Otoe, Nemaha, Lancaster, Gage, Richardson, Johnson, and Pawnee Counties. Marcasite replacements of invertebrate fos-
Marcasite concretions, many of which are partially to almost completely replaced by barite, are found in exposures of the Cretaceous Carlile Shale in Franklin County. These concretions have been called “marcasite dollars” and “barite dollars”.

Caution! Marcasite is quite unstable. It can decompose, leaving sulfuric acid as a product. It should never be carried in the pockets and should be housed in a mineral collection with care as the acid may eat holes in containers.

Halotrichite and melanterite often occur as powdery scales on decomposed marcasite.

Melanterite

Mono; H 2; G 1.9; water soluble; FeSO₄·7H₂O.

Melanterite occurs under the same conditions as marcasite, pyrite, and halotrichite. It usually appears as a white, powdery crust on dark shale. It occurs as a decomposition product of pyrite or marcasite. Melanterite has an astringent taste. Collecting localities are essentially the same as those given for pyrite or marcasite.

Meteorites

Meteorites are probably fragments of disaggregated asteroids which have fallen upon the surface of the earth. A meteorite is not a mineral but is an aggregate of minerals which are found rarely, if ever, on earth. Many meteorites have been found in Nebraska. Only a few, however, have been observed to fall. Meteorites generally consist of a nickel-iron alloy and a crystalline silicate, usually olivine or pyroxene, or a mixture of these components. Meteorites are basically divisible into three groups, as follows:

1. Siderites, or iron meteorites (average 98% metal)
2. Siderolites, or stone-iron meteorites (average 50% metal, 50% silicate)
3. Aerolites, or stone meteorites

Siderites, siderolites, and aerolites have all been found in Nebraska.

On February 18, 1948, farmers near Beaver City, Furnas County, observed a meteor falling to the earth. Later that year, the meteorite, which weighed 2360 pounds, was recovered by a field team from the University of Nebraska State Museum. It is, to date, the largest recovered meteorite to have been seen falling. An aerolite weighing 43 pounds was found near Arcadia, Valley County, in 1937. Other aerolites have been found near Broken Bow, Custer County (1937, 15 pounds); near Dix, Kimball County (1938, 3 pounds); Whitman, Grant County (1937, ½ pound); and near Glen, Sioux County (1933, ½ pound). The Glen meteorite was recovered the same day its falling was witnessed, August 8, 1933.
TEXT-Figure 24. Meteors and meteorites. A, Most large meteors falling in Nebraska did so in the distant past and were probably witnessed only by Plains Indians; B, a polished cross-section of a meteorite showing Widmanstätten figures, low nickel kamacite bounded by high nickel taenite (Xl).
A six-pound siderolite was found near Cody, Cherry County, in 1939; it is believed to be the meteorite whose falling was witnessed in 1936.

Siderites have been found near Lincoln, Lancaster County (1903, 29 pounds); near Heartwell, Kearney County (1931, 21 pounds); and near Ogallala, Keith County (1918, 6 pounds).

Meteorites are more easily recognized when they are found in the dunes of the Sand Hills or in loess (windblown silt) deposits as they are usually quite large compared to the surrounding material and appear to have a rusty or burnished surface. If they are mixed with glacial or river gravels they can be recognized only with great difficulty. In the latter case, a stone must usually be analyzed (chemically and structurally) to determine whether or not it is a meteorite, which means that at least a small part of the specimen must be destroyed. Meteorites are illustrated in text-figure 24.

**Mica**

Cleavage, 1 perfect; Mono, H 2-4 G 3; complex silicates of K, Al, Mg.

Mica is a soft, shiny mineral that can usually be peeled apart into thin flakes with the fingernails (text-fig. 9A).

The occurrence of mica minerals in Nebraska is restricted to volcanic, plutonic, and metamorphic rocks which originated outside of Nebraska and have been transported into the state by glacial or stream action. Two types of mica—biotite and muscovite—are common.

Biotite is a dark-colored, iron-rich mica which often has a brassy appearance when seen in rocks. Muscovite is a colorless, transparent, potassium-rich mica. It has a silvery appearance and is similar to biotite in its physical properties. It is popularly called “isinglass.”

**Muscovite—See Mica.**

**Opal**

Conchoidal fracture; Amorphous; H 6; G 2; SiO₂·nH₂O.

Opal (pl. I, fig. 17) is one of the more easily collected minerals of Nebraska. It is usually restricted to Tertiary deposits of north-central, northwestern, and southwestern Nebraska. Opal is easily identified by its conchoidal fracture and low specific gravity. It often has dendritic inclusions of manganese dioxide (pyrolusite). It tends to occur as fillings between bedding planes or in faults or joints. Some opal is found as a replacement of wood or other plant materials. Most of Nebraska’s opal is fluorescent, the colors ranging from a pastel to a bright green. Some opal has been mined commercially at Angora, Morrill County. (See also Gemstone section).

**Onyx—See Aragonite, in Gemstone section.**

**Orthoclase, Plagioclase—See Feldspar.**

**Pyrite**

Indistinct; brassy yellow; Isom; H 6; G 5; FeS₂.

Pyrite, or “fool’s gold,” is a rather commonly found mineral in Nebraska. It frequently occurs as nearly perfect crystals in dark shales of the Pennsylvanian and Permian rocks of southeastern Nebraska.

Pyrite is an iron sulfide that differs from marcasite in crystal structure. Pyrite usually has a more metallic luster and is somewhat harder than marcasite.

Some exceptional cubic and octahedral crystals (pl. I, fig. 7; text-fig. 25A, B) of pyrite have been collected from the Canville Lime- stone and Wea Shale from the quarries at Fort Calhoun, Washington County. The long axes of these crystals may measure up to one-half inch. The crystals frequently require cleaning before their colors are apparent.

Cubic crystals of pyrite have also been collected from the Argentine, Stoner, Cass, Plattsmouth, Beil, and Ervine Creek Limestones of Pennsylvanian age from quarries in Sarpy and Cass Counties. Pyrite is not acid-soluble and the specimens can be freed from the matrix by dissolving the limestone in dilute hydrochloric acid.

Pyrite replacements of fossils are frequently associated with black shales in Lancaster, Johnson, Pawnee, Otoe, Cass, and Sarpy Counties. These fossils include many of the common Pennsylvanian and Permian invertebrates. Frequently the pyritized fossils are in concretions and their presence is only revealed when the calcareous material is leached away with acid.

Pyrite is found as small crystals coating larger crystals of either quartz or calcite in the Fort Riley and Florence Limestones at Holmesville, Gage County. The specimens are spectacular and are quite rare.

Pyrite has been collected from the Cretaceous Dakota Group near Lincoln as crystals lining fractures in concretions of limonite.

Pyrite has been collected from the Niobrara Chalk at the Harlan County Reservoir, where it generally occurs as large nodules. Here pyrite occurs disseminated throughout calcite crystals.

Pyrite is one of the more easily found minerals of Nebraska but its occurrence is usually related to the
TEXT-Figure 25. Forms of pyrite commonly found in Nebraska. A, a cube; B, an octahedron; C, a pyritohedron; D, a cube A modified by a pyritohedron C; E, pyritohedron C modified by an octahedron B.

older Pennsylvanian-Permian and Cretaceous rocks of the state. Halotrichite and melanterite often occur as powdery scales on decomposed pyrite.

**Pyrolusite**

Dendritic; Tet; H 1-2; G 4.8; MnO₂.

Pyrolusite is common in many of the rocks and gravels of Nebraska. It often occurs as black, dendritic stains or large black spots on limestones of all ages. Frequently it stains gravels black, as evidenced by some of the Pleistocene terrace gravels in Harlan County and some of the glacial gravels in Saunders and Lancaster Counties.

In Cheyenne County, pyrolusite occurs in Pliocene rocks as radiating nodules which are about one inch in diameter.

TEXT-Figure 26. Dendrites of pyrolusite in common opal (XI).
Pyrolusite may form the “moss” in agate or the dendrites in dendritic opal (text-fig. 26).

Pyroxene

2 perfect cleavages at 90°; stubby crystals; mono or ortho;
H 6; G 3.3; complex silicate of Fe, Mg, Ca, Al.

Pyroxene occurs in plutonic, volcanic, and metamorphic rocks and that found in Nebraska is restricted to rocks that occur in glacial tills and river gravels. Pyroxene occurs as dark-green to black crystals. Pyroxene (text-fig. 11B) can be differentiated readily from amphibole; the former occurs as short, stubby crystals, while the latter occurs as elongated, lath-like crystals.

Quartz

Conchoidal fracture; massive; rhomb.; H 7; G 2.7; SiO₂.

Quartz (text-fig. 27) and quartz minerals are found in abundance in Nebraska. The sands and gravels in Nebraska consist of considerable amounts of water-worn quartz (text-fig. 27B) and quartz minerals, much of which is suitable for gemstones. Quartz minerals make up the bulk of semi-precious and ornamental stones found in Nebraska; these are treated in detail in the section dealing with gemstones.

Crystals of milky and white quartz occur in the Permian Winfield, Fort Riley, and Florence Formations and have been collected from several quarries and natural exposures near Holmesville, Wymore, and Odell, Gage County. These quartz crystals occur in geodes (pl. I, figs. 2, 14). The clear crystals occur in higher parts of the exposed section, whereas white crystals are collected from the lower parts of the exposed section.

Amethyst is a purple quartz whose coloring is due to the presence of a small amount of iron or titanium. Amethyst has been collected from the abandoned Gage County quarry near Wymore, where it occurs as small, light-purple, rhombohedral crystals, rarely a half-inch long, lining vugs and geodes in the Permian Fort Riley Limestone. Many of these crystals are suitable for micromounts. Amethyst is also found in small quantities in many of the river and glacial gravels of Nebraska.

Small, double-terminated amethyst crystals have been collected from the Permian Odell Shale near Odell.

Aventurine is quartz that has a green color due to minute inclusions of chlorite. It has been reported from both gravel pits and terrace gravels in the Bayard area, Morrill County.

Finely disseminated crystals of fluorite on quartz, which occur in the Permian Florence Limestone along Squaw Creek near Wymore, have been mistakenly identified as amethyst.

See Fluorite; see also Agate, Amethyst, Chalcedony, Chert, Flint, Jasper, and Quartz, in Gemstone section.

Sabugalite

\[\text{Al} \,(\text{UO}_2)_4\,(\text{PO}_4)_{10}\cdot 16\text{H}_2\text{O} \].

Sabugalite is a nearly colorless mineral with a yellow-green fluorescence. Without this fluorescence, it would be difficult to discern. Sabugalite occurs in carbonaceous gypsum in the same manner as does carnottite (p. 26). It has been reported from the Oligocene Chadron Formation exposed near Crawford, Dawes County.

Sand Crystal—See Calcite.

Selenite—See Gypsum.

Septarians

Septarians (text-fig. 28) are not minerals; they are a type of concretion which occurs in shales as a result of the dehydration and shrinking of a gel of aluminum hydroxide. Shrinkage causes the precipitated
mass to form cracks from the inside outward, leaving a large number of open fissures in which minerals may crystallize. Calcite and barite are two of the minerals most commonly found in septarians.

Septarians are especially common in the Cretaceous Blue Hill member of the Carlile Shale. Many huge septarians, some weighing several tons, have been collected from the area about twenty miles north of Hay Springs.

Minerals occurring in septarians are treated under each mineral heading.

*See also* Ankerite, Barite, Celestite.

**Siderite**

3 perfect cleavages at 70°; often in pellets; Rhomb.; H 4; G 3.9; FeCO₃.

Siderite is an iron carbonate that is reported to occur in shales and sandstones of the Cretaceous Dakota Group. The mineral occurs as tiny brown pellets, popularly called "Fuson Pellets" (text-fig. 29).

**Sphalerite**

6 perfect cleavages; adamantine; Isom; H 3.5; G 4; ZnS.

Sphalerite is a sulfide of zinc. Only three occurrences of this mineral have been noted in Nebraska.

It has been collected from the Kereford Limestone at the Queen Hill quarry near Plattsmouth, Cass County (pl. 1, fig. 16; text-fig. 30). Field evidence indicates that it is disseminated throughout a zone about one foot thick from about 2 to 3 feet above the base of the formation. The tetrahedral crystals are often found in vugs, associated with calcite and gypsum. Loose crystals may be collected by dissolving the limestone in acetic acid.

Sphalerite-replaced invertebrate fossils have been found in concretions containing pyrite fossils from the Severy Shale near Du Bois, Pawnee County. These may be obtained by dissolving the concretions in acetic acid.

Small, deep-red to black, tetrahedral crystals about 1/16 to 1/4 inch in diameter have been collected from the Permian Florence Formation at a quarry about two miles north of Holmesville, Gage County.

**Sulfur**

Yellow; powdery; mono; H 1.5; G 3.2; S.

In Nebraska, sulfur usually occurs in association with melanterite and halotrichite, the decomposition products of marcasite. Sulfur forms a yellowish crust on black shales and is distinguishable from melan-
terite (melanterite is white; sulfur is yellow) and halo-
trichite (halotrichite is water-soluble; sulfur is not).

Some sulfur is occasionally found in the Cretaceous
Dakota Group in a shale exposure on Middle Creek,
about two miles southwest of Pleasant Dale, Seward
County.

**Turquoise**

Turquoise has been reported (erroneously) to occur
in Brown County, in association with tusks of fossil
elephants. The material reported as turquoise was
probably vivianite, which often stains fossil bones a
light-blue color.

*See Vivianite.*

**Uranium minerals**

*See Autunite, Carnotite, Sabugalite.*

**Vivianite**

Blue; Mon; H 1.5-2; G 2.6; Fe₂(PO₄)₂·8H₂O.

Vivianite is a hydrated phosphate of iron that fre-
quently occurs as an alteration product of the calcium
phosphate of bones of fossil mammals found in the
Pliocene and Pleistocene rocks of Nebraska.

Vivianite is, typically, a dark-blue mineral. Finely
disseminated crystals of vivianite impart a bluish
color to the fossilized bones of some mammals. This
material is sometimes called "bone turquoise."

**GEM AND ORNAMENTAL STONES
FROM NEBRASKA**

**INTRODUCTION**

Nebraska is well known for its natural resources;
particularly its abundant water supply, fertile soils,
and wide-open spaces, including the unique Sand
Hills region. Less well known are the widespread
occurrence and relative abundance of gem and orna-
mental stones—an exotic resource more commonly
associated with mountainous areas. These unusual
stones may be collected by anyone who casually picks
up a colorful stone from a hillside, a quarry, or gravel
pit, or from the gravel piled alongside the many miles
of gravelled roads.

A wide enough variety of material can be found in
Nebraska to satisfy the needs of practically every level
of collector. Although good gem material is scarce
in Nebraska, as it is in most other places, it occurs
in sufficient quantities so that rarely will a knowledge-
able collector go home empty-handed. Many good
localities in Nebraska are near modern, hard-surfaced
roads and can be reached without need of a special
vehicle such as a jeep or four-wheel-drive truck.
Most of Nebraska is not so rough topographically that
only the young and nimble can traverse it. Indeed,
many elderly people find gem collecting in Nebraska
an enjoyable pastime within their physical capabil-
ities.
In Nebraska gem collecting is pursued by people of all ages and in all walks of life.

Much of Nebraska is mantled by gravels transported into the state by streams and glaciers that eroded such distant localities as Wyoming and Ontario. These streams and glaciers transported material that originated in a wide variety of parent rocks, ranging from sedimentary rocks originally formed in environments of low temperatures and pressures, to plutonic and regionally metamorphosed rocks, originally formed in environments of extremely high temperatures and pressures. This variety of sources is reflected in the abundance and diversity of gem and ornamental stones—agate, jade, topaz, and jasper, to mention only a few found in Nebraska.

Basically, there are three types of occurrences of gem and ornamental stones in Nebraska (text-fig. 31). These are:

Type I Gem and ornamental stones formed in place in Nebraska.

Type II Gem and ornamental stones transported into Nebraska by streams originating in adjacent western states.

Type III Gem and ornamental stones transported into Nebraska by glaciers originating in the northern and northeastern part of the continent.

By recognizing these types of occurrences, it is possible to develop a system for identifying and classifying gem and ornamental stones from Nebraska and to develop techniques for successful field collecting. Knowledge of the natural history of gems and ornamental stone is as important to the lapidary as it is to the geologist.

Generally speaking, a stone that forms under the low temperatures and pressures present during the deposition of sedimentary rocks must be cut and polished under conditions of low temperature and pressure (e.g., opal). A gemstone that originated under conditions of high temperatures and pressure associated with regional metamorphism or igneous activity can usually tolerate much more stress without suffering damage. Minerals that formed in similar environments tend to have many common cutting and polishing properties. There are, of course, exceptions to the above generalizations.

Knowledge of the natural history of gemstones is also important to the field collector. Gemstone occurrences are seldom random. Most gemstones in Nebraska are closely related to the type or age of deposit in which they occur. For example, Lake Superior agates tend to be most highly concentrated in the
Text-Figure 31. Types of occurrences of gem and ornamental stones in Nebraska. In addition to gem and ornamental stones that have formed in place in Nebraska (Type I occurrences), material has been transported into the state by streams from the west (Type II occurrences) and by glaciers from the north and northeast (Type III occurrences).
Pleistocene Cedar Bluffs Till, a glacial deposit. Therefore, a knowledge of the stone's history may be worth many hours of field work.

It is possible to devise a Nebraska gemstone-area map (text-fig. 32). In each of the areas shown in text-figure 32 the gemstone suite is distinct. For example, the gemstones found in area 1 (White River and Hat Creek basins) differ markedly from the gemstones found in area 5a (the South Platte River basin). The explanation is as follows: The White River and Hat Creek drain the Front Range of east-central Wyoming, whereas the South Platte River drains an area in north-central Colorado. More precisely, the gemstone suite in any area reflects the rock types found in the various drainage basins. In eastern Nebraska the gemstone areas have been modified by Pleistocene glacial deposition (text-fig. 33). The gemstone areas of Nebraska are, for the main part, delineated by the major drainage basins in the state.

**TYPE I**

Gem and Ornamental Stones Indigenous to Nebraska

The gem and ornamental stones of this type that are found in beds exposed at the surface in Nebraska have formed under conditions of low temperature and pressure. These stones occur in Tertiary and older sedimentary rocks, the oldest such stones being agate and chert occurring in Pennsylvanian rocks in southeastern Nebraska. Other stones of this type include blue chalcedony and onyx. Occasionally, opalized wood can be found in deposits as geologically recent as Pleistocene.

**TYPE II**

Gem and Ornamental Stones Transported into Nebraska by Streams Originating in Adjacent Western States

Gem and ornamental stones of this type found in Nebraska originally were formed in much older rocks. They were eventually reworked by streams into the younger Tertiary and Pleistocene rocks in which they are now found. The abundance and diversity of stones of this type reflect not only the wide range in age of the source rocks (Precambrian through Tertiary) but also the broad geographic area and the many different geological conditions under which these stones were formed. Western source areas for Type II stones, which are now found in stream deposits of Tertiary and Pleistocene age, include the Front Range of Colorado and Wyoming, the Hartville uplift of Wyoming, and the Black Hills of South Dakota. During the Tertiary these source areas were uplifted and eroded. Streams eroding these rising mountain ranges carried massive loads of sand and gravel into the geographic area now called the Great Plains. Many of these cobbles and pebbles were gem and...
TEXT-FIGURE 33. Separate advances of glaciers (A) transported many different gemstones into Nebraska, depositing them in the glacial debris below and at the edges of the ice sheet. As the ice cap melts (B) the glacial deposits are subjected to weathering and erosion. The removal of fine particles from the glacial deposits forms a concentrate of large particles on the weathered surface. Some of these large particles are gemstones.

ornamental stones destined to adorn man who had not yet arrived in ancient Nebraska.

In Pleistocene time there was renewed mountain-building activity in adjacent states to the west of Nebraska (text-fig. 34). On the Great Plains this was accompanied by fracturing of bedrock and gentle tilting of the land surface. This crustal warping took place along established, deep-seated zones of weakness. These events changed the gradients of streams flowing into Nebraska, resulting in greater loads of sand and gravel being transported into the state.

These structural events were accompanied by several glaciations (text-fig. 33), the ice of which flowed into and covered the easternmost portion of Nebraska. Associated with the above structural and glacial events were harsh climatic changes, violent winter and summer storms, and periods of extreme droughts and extreme precipitation. These periods of extreme climatic conditions alternated with long, relatively stable climatic periods, during which extensive soil development took place. The combination of crustal movement and adjustment, the blocking of eastward-flowing streams by glaciers, and climatic change had a profound effect on the streams of Nebraska. Stream gradients and stream courses were changed; stream valleys were deepened, widened, and filled; and ancient major streams were captured by tributaries of other streams. The deposits laid down by these ancient streams form terraces, which, ideally, are flat, broad benches along the sides of the valleys of the present streams. However, terraces along modern streams may be so modified by erosion that they can be recognized only by careful field work and map study. On the other hand, terraces or a combination

TEXT-FIGURE 34. Mountain-building events in adjacent western states, A, have caused considerable down cutting by streams, B, and, consequently, the transportation and deposition of extensive gravel deposits in Nebraska.

51
of them may be so extensive that they constitute a terrace plain that is many miles wide and may extend for miles.

Being able to recognize terraces and terrace plains can be of considerable help to the collector for this enables him to search for gravels in the hills about the present streams. Since terraces are difficult to correlate over great distances, this concept is useful only locally, but it will enable the collector to determine the most likely areas in which to prospect. Topographic and soils maps are very useful to the collector in the field in assisting him to recognize patterns of terrace occurrences and, hence, collecting sites.

Typical examples of type II material often found in terrace deposits are fortification agate or “Fairburn” agate, prairie agate, and silicified wood.

**TYPE III**

*Gem and Ornamental Stones Having Been Transported into Nebraska from Northern Sources by Glaciers*

The third major group of gemstones to be found in Nebraska are those gemstones that formed in plutonic, metamorphic, and sedimentary rocks in such areas as Minnesota and in Ontario and Manitoba in Canada, and were subsequently transported into Nebraska by Pleistocene glaciers. There is an abundance and diversity of gemstones in the glaciated portion of eastern Nebraska, reflecting these varied northern sources. The distribution in Nebraska of those glacial deposits that are commonly called till is shown in text-figure 35.

When collecting gemstones in glacial tills, there are several things to remember: (1) At any one place more than one till may be exposed, but the vertical sequence is commonly incomplete. (2) Thicknesses of tills vary within short distances; a section of till several tens of feet in thickness in one spot may thin rapidly or be entirely absent at a distance of only a few hundred yards. (3) Although silts, clays, sands, and gravels are the dominant particles in tills, pebbles, cobbles, and boulders are usually present also. When finer grained materials are removed by erosion, a concentration of these cobbles and boulders is left behind as a thin layer. Many good specimens can be found in these “lag concentrates.”

Outwash is a concentration of sand and gravel that has been removed from a glacier by stream activity and redeposited elsewhere. It differs from till inasmuch as its average particle size is larger, it is better sorted, and it is stratified. Outwash deposits are frequently good collecting areas. Topographic and soils maps provide clues to outwash materials of the glaciated areas.

Typical type III gemstones include Lake Superior agate, jasper, and faceting-grade quartz.

**Things to Remember**

There are several generalizations one must keep in mind when collecting and studying the gemstones of Nebraska:

1. Type I occurrences may be in any area. Type I occurrences at the surface in Nebraska range in age from Pennsylvanian to Pleistocene.

2. Type II gemstone occurrences are most abundant to the west of the areas covered by glacial deposits. These gemstone occurrences are controlled directly by the type of rock within the drainage system. Type II gemstones are found in stratigraphic horizons ranging in age from Oligocene to Pleistocene. However, the stones in Type II occurrences come from rocks that may be as old as Precambrian.

3. Locally, the terrace concept (p. 51) may be a useful collecting aid. It can best be applied by using topographic maps (p. 12) since each terrace usually forms a topographic element that can easily be delineated on maps.

4. Where major drainages join, the gem suites of two or more areas become intermingled. For example, the area 6 (Middle Platte) gemstone suite is a mixture of materials from area 5 (North Platte) and area 5a (South Platte). Where the streams have eroded into glacial deposits, Type II and Type III occurrences may become mixed.

5. Type III gemstone occurrences are associated with the glaciated portion of eastern Nebraska. The gemstone suites are reflective of the rocks in the source areas through which the glaciers eroded. Each major advance of the glaciers is characterized by a somewhat different gemstone suite.

6. The optical properties of a mineral are the factors which usually determine its suitability as a gemstone. Pleasing colors (p. 18), high indices of refraction (p. 26), and bright lusters (p. 17) are among the properties which contribute to the beauty of a stone. The most critical non-optical property of a mineral which influences its use as a gemstone is hardness (p. 17). A non-mineralogical factor is rarity. Cleavage (p. 16) does not restrict, and may even enhance, a stone's use as a gem. Both diamond and topaz are used as gemstones and both exhibit perfect cleavages.

**COMMON NEBRASKA GEMSTONES**

The variety of gemstones in Nebraska is large. Those that are more common or more highly prized by collectors are listed alphabetically in the following section. Each variety has been subdivided according to its type of occurrence (I, II, or III). In many instances specific occurrences are given. The popular names and some of the obvious physical characteristics are listed. Cutting and polishing properties and techniques are also given.
**Agate**

**Type II Occurrences**

**Fortification or “Fairburn” Agates**

Plate II, fig. 5; Plate III, fig. 11; Plate IV, figs. 7, 8; text-fig. 36.

The “fortification” or “Fairburn” agate is perhaps the most popular stone that has been transported to Nebraska from a western source. These colorful agates are usually found in the stream-deposited, basal conglomerates of the Oligocene Chadron Formation in northern Sioux and Dawes and northwestern Sheridan Counties. They are found in lesser quantities in other channel deposits within the Chadron Formation. These agates were originally named for the town of Fairburn, South Dakota, where the first specimens were collected and described.

In recent years many midwestern agate collectors have reserved the name “Fairburn” for agates collected at Fairburn, South Dakota. This is because the “type Fairburns” are known to be derived from a single source area, the Black Hills. Agates similar to Fairburn agates found in Nebraska and Wyoming have been derived from several sources—the Front Range, the Hartville Uplift, and possibly the Black Hills. Fortification agate has been used to describe the agates from Nebraska and Wyoming. Inasmuch as fortification agates and Fairburn agates originated in widely separate source areas, the distinction is recognized here, even though their geologic history may be similar in all other respects.

The fortification agates found in Nebraska originated chiefly in sedimentary rocks (limestones and shales) in the Wendover, Meek, and Hayden Groups of Pennsylvanian age in the Hartville Uplift and the Front Range of Wyoming. Some may have originated in the Black Hills, but this appears to have been a minor source. These Pennsylvanian sediments were uplifted and eroded during the late Cretaceous and early Tertiary mountain-building period, the Laramide Orogeny. By Oligocene time, the first great floods of continental type sediments were being deposited in the great plains. Fortification agates were among the rocks transported into Nebraska with this great influx of gravels.* A later influx of Pleistocene and Pleistocene gravels along the North Platte River also contained fortification agates. The agates transported to Nebraska in the Oligocene are restricted to the White River Group (see text-fig. 4 and area 1, text-fig. 32). The fortification agates transported to Nebraska in Pliocene and Pleistocene times are restricted to areas 6, 7 and 7a, text-fig. 32).

Fortification agates occurring in Platte River gravels are the same as those occurring in the Oligocene gravels. They have been collected from near Orella and Harrison, Sioux County, and Chadron and Whitney, Dawes County. They also have been collected from Pleistocene terrace gravels near Mitchell and Henry, Scotts Bluff County, and Bridgeport, Morrill County. They have been found in gravel pits near North Platte, Lincoln County; Gothenburg and Lexington, Dawson County; Kearney, Buffalo County; Wood River and Grand Island, Hall County; Central City, Merrick County; and Fremont, Dodge County, to mention a few localities.

Fortification agates are distinctly banded. Red, yellow, and white are the most common colors; pink, black, and blue colors are quite rare. They may have several zones of banded agate alternating with zones of crystalline quartz. Crystal centers are common.

*Cutting and polishing fortification agates.* Because of their large size and excellent patterns, fortification agates are rarely cut into jewelry, other than utilization of small pieces or scraps left over from cutting cabinet specimens. Most frequently, they are ground down to make display specimens. Some agate collectors leave fortification agates uncut as they were found.

To prepare a cabinet specimen of fortification agates, one should first delineate the undesirable areas with a felt-tipped marking pen (text-fig. 36A) and then put the stone on a paper plate in an oven at about 225 degrees for several hours, until the stone is hot throughout. The stone should then be removed from the oven, immediately covered with epoxy 220 cement, and replaced in the hot oven until the epoxy sets (about 1 hour). After removing from the oven, allow several hours for the stone to cool. This process seals the minute fractures in the stone. Heat-sealing must be done before sawing or the coolant oil will seep into the fractures, thereby preventing an effective seal from taking place.

After the heat seal has been accomplished, remove as much excess matrix as possible from the agate with a diamond saw (text-fig. 36B). If any of the matrix must be ground away, grind it off with the edge of the diamond blade. Although this process is hard on diamond blades, it is still much cheaper than using *Similar agates (referred to as State Park and Tepee Canyon agates) occur in the Pennsylvanian-Permian section of the Black Hills in South Dakota and were reworked into Oligocene sediments flanking the Black Hills. Schultz and Stout (1955, p. 34) state that there exists lithologic evidence to show Black Hills sources for rocks in the Basal Chadron conglomerates of Nebraska but that no physiographic evidence exists to show a major north-south drainage from the Black Hills to Nebraska. Whether or not the agates from South Dakota became part of those occurring in Nebraska remains a moot question. It is popularly believed that the fortification agates that formed in the Black Hills were transported into Nebraska by glacial activity. This is not the case as the northwest panhandle was never glaciated in Pleistocene time. The agates occurring in the flanks of the Black Hills have a history similar to those occurring in the Oligocene of Nebraska, in every detail. Geologically speaking, fortification agate of Nebraska and Fairburn agate of South Dakota have the same history of origin and mode of transportation, both types coming to rest in the Oligocene conglomerates.
TEXT-Figure 36. Cutting and polishing a fortification agate. A, Before heat-sealing (p. 65), mark off the undesirable areas of the agate with a felt-tipped marking pen. B, After heat-sealing saw off the undesirable portions; the sawed-off portions may contain small patterns suitable for cabochons. C, Cut the stone to a semi-round by hand-feeding the rock in the diamond saw. D, Round off the stone on the grinding wheel. E, Sand and polish.
a grinding wheel. At this phase of cutting, the specimen should have a number of flat faces and subangular edges which may be rounded with the diamond saw blade (text-fig. 36C). Grinding (text-fig. 36D) can be done on a very well-dressed, soft-bonded grinding wheel turning at about 2,000 feet per minute. Grinding large specimens will cause the wheel to go out of round quickly. Therefore, extreme caution must be exercised or chipping of the stone may result. Fine grinding should be done on a 220-grit wheel turning at the same speed. Use plenty of water on both grinds.

Sanding should first be done with new, wet, 220-grit sandpaper turning at 1,200 to 1,500 feet per minute, followed by old 220-grit turning at the same speed. Repeat the above process with 400-grit sandpaper. A semi-polished stone should be the result.

The stone may be polished with tin or cerium oxide on a very wet, hard felt wheel turning at about 600 feet per minute.

Although it may appear that tumbling would produce the same result, this is not so. When fortification agates are tumbled, quartz crystals are chipped and broken out and do not polish with the same luster as the agate. In the sanding process, the quartz crystal areas cut and polish in the same manner as the banded agate. The highly polished quartz forms a "window" through which one can often see quartz crystals terminated against banded agate. This produces a very spectacular "foam" effect.

Fortification agates can be cut to produce two different effects (text-fig. 37): cutting through a nodule will produce a strongly banded pattern; cutting around the outer surface of the nodule will produce a window or eye effect consisting of a number of small, fortifed areas.

Text-Figure 37. Directions of cut related to banding of agates. A, The distance \(d\) between bands is shortest when the cut is made "perpendicular" to the bands. The distance increases to \(2d\) and \(4d\), etc. as the direction of the cut approaches being "parallel" to the bands. B, The type of pattern resulting when a cut is made "perpendicular" to the bands of an agate or "through" the nodule. C, The type of pattern resulting when a cut is made "parallel" to the bands or "around" the nodule. This produces the type of eye common to fortification agates. D, A cut both "through" and "around" a nodule showing the type of eye common to a Lake Superior Agate.
Prairie Agates

Plate IV, fig. 27.

The prairie agate was selected as the State Rock of Nebraska by the State Legislature in 1967 (L.B. 253). Typically, prairie agate is a layered chert that does not have the strong banding characteristic of fortification agate. In a mineralogical sense, prairie agate does not fall within the definition of agate. The colors of prairie agates range from brilliant reds and yellows to pastel shades of blue, tan, and gray. Prairie agates are found most frequently in areas 1, 6, 7, and 7a (text-fig. 32).

Prairie agates are very closely related to fortification agates in the place, mode, and time of origin and transportation into Nebraska. Prairie agates often occur with fortification agates in the Pennsylvanian and Permian limestones and shales in the Wyoming source area. Thus, prairie agates may be collected in the same localities as fortification agates.

Cutting and polishing prairie agates. Larger, more colorful prairie agates are usually used as display specimens, whereas smaller ones are frequently used in jewelry fabrication. Large specimens are usually sawed and polished on a flat surface because layering or banding is not compact enough to produce strong patterns by cutting around the stone.

Prairie agates are ideal for jewelry because they are cut with little waste and because they easily take a brilliant polish. They are brittle, however, and should be sliced into slabs of \( \frac{3}{10} \) or \( \frac{1}{2} \)-inch thick. Once the desired pattern is selected, the stone can be ground, sanded, and polished in the same manner as prescribed for fortification agates (p. 54). Prairie agates should always be ground on a very well-dressed wheel to prevent chipping.

Moss Agates

Plate III, fig. 10; Plate IV, fig. 30.

Moss agates are a form of agate that contains mineral inclusions. Pyrolusite, or pyrite, may produce a scenic pattern or a surrealist design within the stone. Dendritic (branching) patterns are formed by stains of manganese dioxide (pyrolusite). Inclusions consisting of a light-green or gray-green mineral may be chlorite.

Moss agates are found in the same stratigraphic horizons and locations as jasper. Jasper and moss agates found in Nebraska appear to have nearly identical histories. Moss agates occur in Pennsylvanian rocks in the Hartville Uplift in Wyoming, and appear to be closely related to fortification agates, prairie agates, and jasper that are found in Nebraska. Some moss agates also originated in very old, Precambrian rocks in the Hartville Uplift of Wyoming.

Cutting and polishing moss agates. Moss agates are used for both specimens and gemstones (Plate IV). Specimen-grade material usually consists of large pieces with mossy scenes that are too large to be used for jewelry. Jewelry stones are usually made from small moss agates or from larger moss agates that have only small moss-like inclusions.

Moss agates should be ground on a well-dressed, 100-grit wheel or on a diamond disk turning at about 2,000 feet per minute. Moss agates have a strong tendency to undercut because they contain many soft accessory minerals. Sanding should, therefore, be done with new, wet sandpaper. It is difficult to get a glossy, semi-polish on moss agate. Sanding should, therefore, be carried to at least the 600-grit paper, and finer, if possible. Polishing is best done with Linde-A (see glossary) on leather, although it is possible to obtain a high polish with stannic or cerium oxide on leather. Diamond powder also produces a high polish on moss agate.

Type III Occurrences

Lake Superior Agates

Plate III, figs. 5-9; Plate IV, figs. 3-6; text-fig. 37D.

Large varieties of agate are found in the glacial tills of eastern Nebraska, the best known variety being the type commonly called “Lake Superior agates” or simply “Lakers.” Lake Superior agates derive their name from the Lake Superior Till or Red Till of Minnesota to which they are stratigraphically restricted in the type area. These agates originated in Precambrian (Keweenawan) basalt flows, which are dated at about 1 billion years old. Lake Superior agates may, therefore, be one of the oldest known agates. They are generally very distinctly banded. Their colors are bright—red and white, brown and white, and gray and white being most common. Pastel colors are not too common, although occasionally a pink or yellow specimen is found.

Some Lake Superior agates have “eyes,” which are small, concentrically banded areas on the outer surface of the agate nodule. Eyes may be agate replacements of zeolite minerals, such as Thompsonite. The banding of eyes in Lake Superior agates is generally unrelated to the banding of the rest of the agate, although eyes may influence the course followed by subsequent bands (text-fig. 37D).

Lake Superior agates are widely distributed in the glaciated portion of eastern Nebraska. Present evidence indicates that they are restricted to, or at least most strongly concentrated in, the Cedar Bluffs Till, the till deposited during the second Kansan glaciation (text-fig. 35). Specimens of Lake Superior agates have been collected from near Winnebago, Thurston County; Norfolk, Madison County; West Point, Cuming County; Fremont, Dodge County; Touhy, Wahoo, Valparaiso, Prague, and Ashland, Saunders County; Garland and Pleasant Dale, Seward County; Agnew,
Davey, Lincoln, and Bennet, Lancaster County; Eagle, Weeping Water, and Union, Cass County; Omaha, Douglas County; Palmyra, Douglas, Burr, Syracuse, and Talmage, Otoe County; Brock and Auburn, Nemaha County; Holmesville and Wymore, Gage County; Crete and Wilber, Saline County; Cook, Tecumseh, and Elk Creek, Johnson County; Burchard, Table Rock, and Dubois, Pawnee County; and Humboldt, Dawson, and Salem, Richardson County.

Although Lake Superior agates are widely distributed in eastern Nebraska, they are not abundant—a day's collecting may yield a few small specimens and a year's collecting may yield a few larger specimens. The largest known specimen of Lake Superior agate collected in Nebraska weighs 5 1/2 pounds; however, many weigh 10 to 12 ounces.

There are some translucent, yellow, and colorless agate nodules occurring in the Cedar Bluffs Till along with Lake Superior agates. These are commonly called “honey agates.” By heating these colorless agates in the absence of air, brilliant colors are sometimes restored in the nodule. Thus, it would seem that some Lake Superior agates become bleached after lying in sunlight for several years.

Similar yellow and colorless agates are found in glacial tills in North and South Dakota and as far north as Manitoba Province in Canada, indicating that some of these agates originated in the very far north.

**Cutting and polishing Lake Superior agates.** Large Lake Superior agates are usually used for cabinet specimens. They may be ground in the same manner as prescribed for fortification agates (p. 54). Some collectors leave the large specimens of Lake Superior agates “as found” and never polish them. The direction of cut in a Lake Superior agate will determine the type of pattern that may be seen. A cut through the nodule produces a strongly banded pattern, whereas a cut around the nodule produces less emphasis on bands but shows eyes of two types. One type of eye simply results from a group of bands converging at the surface to produce a jagged outline (text-fig. 37C). A second type, previously discussed, is possibly a replaced zeolite mineral (pl. III, fig. 9; text-fig. 37D).

Small Lake Superior agates are commonly used in jewelry making. The stones have a remarkable potential for the development of matched sets—not too common a feature of most agates. It is important to remember that facing sides of two adjacent slabs produce the best matches.

Lake Superior agates are easily ground by almost any method. However, not only do they have a very strong tendency to undercut, but are also very heat-sensitive and fracture easily. Therefore, they should be sanded with new, very wet paper for all grits. Polishing is done easiest with stannic or cerium oxide on a leather wheel or disk turning at 400 to 600 feet per minute.

**Moss Agates**

Plate IV, figs. 23, 28.

Moss agates of undetermined origin are found in all of the glacial tills in Nebraska. Similar agates are found far to the north in tills in Saskatchewan, Manitoba, and Ontario, in Canada. These agates are very small, rarely being over an inch in diameter. In spite of their small size, many of them reveal exotic scenes. The inclusions appear to be of several minerals—probably marcasite, pyrolusite, and chlorite.

Some exceptionally fine moss agates have been recovered from glacial tills near Fremont, Dodge County; Valparaiso, Saunders County; Lincoln, Lancaster County; Pleasant Dale, Seward County; Palmyra and Dunbar, Otoe County; Table Rock, Pawnee County; Falls City, Richardson County; and Fairbury, Jefferson County.

**Cutting and polishing moss agates.** Moss agates found in glacial tills are used almost exclusively for jewelry, although a few have been used for cabinet specimens. For jewelry purposes, care should be exercised to select the most attractive pattern. Usually, stones will be small, with a maximum dimension of less than one inch.

Grinding can be done by any method. Moss agates found in glacial till have less tendency to undercut than moss agates found in river gravels; however, new, wet sandpaper is still preferable. Some stones acquire a high-gloss semipolish with old, dry sandpaper. Polishing is best done on wet, soft leather with stannic or cerium oxide turning at about 500 feet per minute.

**Chalcedony**

**Type I Occurrences**

**Vein Chalcedony and Blue Chalcedony**

Frontispiece; Plate II, fig. 6; Plate III, figs. 3, 4; Plate IV, figs. 1, 2.

Chalcedony is perhaps the best known of all of the ornamental stones to have formed in place in Nebraska. Chalcedony is found in the middle and upper parts of the Oligocene Chadron Formation in the northern parts of Dawes and Sioux Counties, near Chadron, Crawford, and Harrison. Apparently chalcedony has been deposited in faults and joints by cold, silica-rich groundwater. Often chalcedony appears to be lying on the ground in a “checkerboard” pattern which reflects the trend of the joint system in which the mineral was deposited. A good example of this phenomenon can be seen about five miles west of Orella, Sioux County. Much popular literature refers to the “chalcedony dikes” of Ne-
braska. It should be pointed out that these are not dikes in the true sense since dikes are related to extrusive igneous rocks.

Chalcedony is perhaps one of the most beautiful ornamental stones to originate in Nebraska. As part of the Nebraska Centennial activities, the 1967 State Legislature designated blue chalcedony the Nebraska State Gemstone. (See Frontispiece).

Nebraska chalcedony has both a banded portion and a plumed portion. The banded portion is generally restricted to the interiors of the nodules, whereas the plumed portion is generally restricted to the outer parts of the nodules. Chalcedony varies in color from area to area. Red-, blue-, yellow-, black-, and white-banded chalcedony have been observed. Plumes in chalcedony are generally white but yellow-brown, red, and black plumes may occur. An entire slab of chalcedony with both banded and plumed portions makes a highly attractive specimen. The richest colors of chalcedony are obtained by cutting it into very thick slices. It is often desirable to cut a nodule of chalcedony into halves in order to obtain the deepest, strongest colors.

Cutting and polishing chalcedony. Chalcedony should be slabbed with a sharp diamond saw running at a rim speed of 2,000 feet per minute. As the light-colored, plumed portions of chalcedony are quite porous and absorb fluids quickly, the coolant should be kept very clean. Immediately after it is removed from the saw, the freshly slabbed piece of chalcedony should be placed in hot, soapy water to remove the excess oil from the slab and from within the pores. Grinding should be done with a sharp, coarse, soft-bonded wheel turning at 2,500 to 3,000 feet per minute. Chalcedony should be wet-sanded with new, clean 200-, 400-, and 600-grit sandpaper turning at about 2,000 feet per minute. Large, flat specimens are best polished with tin or cerium oxide on a wet, hard, felt wheel moving at about 600 feet per minute. Cabochons can be polished best with tin or cerium oxide on wet, soft leather moving at about 400 to 600 feet per minute.

Cutting chalcedony cabochons is a somewhat different process. Because jewel stones are not especially desirable if they are thick or heavy, chalcedony is cut into thin slices, 1/16" to 1/4-inch thick. The side of the slab selected to be the reverse of the stone is then lapped smooth and this side is cemented with epoxy resin to a smooth slab of black, opaque material such as obsidian, Nebraska black wood (p. 65), blackened lard agate (p. 59), or blackened chert (p. 59). The gem is then cut from the selected pattern of the backed "doublet." Cabochons are usually cut from smaller pieces of chalcedony, whereas larger pieces of chalcedony are used for specimens. If colors and patterns are strong in a thin slab, it is not necessary to back the doublet with a black stone.

Although chalcedony is tough, rather than brittle like chert, it too formed under conditions of low temperature and pressure. Therefore, it must be kept cool during all operations to avoid cracking or undercutting.

Type II Occurrences

Lard Agate

Lard agate is a translucent chalcedony with grayish-white spots resembling lard. It is found in terrace gravels in areas 6a and 7 (text-fig. 32). Lard agate, as well as much chert and jasper, is totally unsuitable as a gemstone. This type of material can be used, however, as backing for some types of stones from which doublets are commonly produced (e.g., chalcedony, p. 58). Slabs of undesirable stone can be lapped smooth with silicon carbide grit. The smooth surface can be painted black, or any color the cutter desires, with a felt-tipped marking pen. Transparent or translucent stone, such as chalcedony, can be cemented to the painted slab with epoxy. This method is advantageous in that it does not require the use of black wood (p. 65) for a back-up stone. Thus, the supply of black wood is conserved and made available for other jewelry and specimen production.

Type I Occurrences

Pennsylvanian, Permian, and Cretaceous Chert

Chert occurs as nodules in many of the thick limestones of Pennsylvanian and Permian age in southeastern Nebraska. Most cherts are gray, gray-brown, brown, olive-brown, black, or white, although red, blue, green, and yellow chert is found occasionally. Many of these stones are of suitable shades for jewelry purposes. Often chert contains small areas of banded agate.

Chert is easily collected, especially from quarry dumps. Many limestone producers find cherty limestones unsuitable to sell as either road aggregate or agricultural lime. Thus, many of the limestone blocks in quarry dumps will contain abundant chert nodules. The nodules can be removed by splitting the limestone with a heavy sledgehammer.

"Rice agate" (text-fig. 38) is a dark-gray to black chert that contains abundant white shells of fusulinids, fossil protozoans resembling grains of rice. It most commonly occurs in the Plattsmouth Limestone near Weeping Water and Plattsmouth, Cass County. Similar material occurs in the Stoner Limestone near Louisville, Cass County. "Rice agate" can be found in small quantities in many of the other Pennsylvanian and Permian Limestones in southeastern Nebraska. It sometimes contains small patterns of banded agate.
Nance County. Jasper has also been collected from gravel pits near Norfolk in Madison County.

Brightly-hued jasper has been collected from the Big and Little Blue River basins (areas 9 and 9a, text-fig. 32). Jasper has been collected in abundance from pits at such localities as Ayr, Adams County, and Oak, Nuckolls County; from gravel bars and gravel pits near Hebron, Thayer County, and Fairbury and Steele City, Jefferson County. It has also been collected from gravel pits near Beaver Crossing, Seward County, and Crete and Wilber, Saline County.

Type III Occurrences

Several types of jasper are abundant in the glacial tills of Nebraska. Some of them are colored by inclusions of iron oxides and are similar to types found in the Minnesota iron ranges. It is likely, therefore, that much of this jasper originated in Minnesota, though some is of undetermined origin. Most of the jasper found in glacial tills is highly colorful, with reds, yellows, black, and greens being predominant. One type of jasper resembles the Mary Ellen Jasper (named for the Mary Ellen Mine) of Minnesota. This jasper is red or pink and contains red or white swirls of Precambrian fossil algae. Another common variety of jasper is deep red to purple and contains many small spots of metallic iron oxide. Usually, jasper is easily recognized in the field by its waxy luster that contrasts sharply with the dull lusters of most other rocks.

Jasper is commonly associated with Lake Superior agates, and is found in localities listed for them. In addition to these localities, jasper has been found in exposures of Nickerson Till near Fairbury, Jefferson County, and Odell and Beatrice, Gage County. Jasper also occurs in tills near Crofton, Knox County, and Hartington, Cedar County.

The extent of distribution of jasper and its full variation cannot be itemized because of its great abundance and diversity in Nebraska.

Cutting and polishing jasper. Most jasper found in Nebraska is of a dense, uniform color, although occasionally a few scenic pieces are found. For this reason, and because there is little waste material, jasper is used almost exclusively for jewelry making. Jasper may be cut and polished in the same manner as prescribed for prairie agate (p. 57).

Type III jasper, also used for jewelry making, can generally be handled in the same manner as prescribed for jasper from western sources. Probably because of its relationship to Precambrian iron formations, jasper from glacial tills generally contains more soft mineral inclusions than jasper from western sources and, therefore, tends toward undercutting. This can be remedied by using new sandpaper for all grits.

Onyx

Type I Occurrences

Plate II, fig. 4. Plate IV, fig. 19.

Onyx is a layered form of the mineral aragonite (p. 21). Gem-quality onyx has been collected from the Pennsylvanian Ervine Creek Limestone exposed at the Ace Hill (West Lake) quarry near Plattsmouth, Cass County.

Onyx, because it is porous, is highly absorbent to liquids. For this reason it should always be sawed and trimmed with clean oil. Grinding should be done wet on a fine grinder; polishing is accomplished with tin oxide on soft leather.

Opal

Type I Occurrences

Plate I, fig. 17.

Only a few pieces of precious opal have been discovered in Nebraska; common opal, however, is abundant. Perhaps the most extensive deposits of common opal in Nebraska are in rocks of the Pliocene Ogallala Group in Kimball, Cheyenne, Deuel, Harlan, Furnas, and Chase counties. Common opal also occurs in the upper part of the Miocene Harrison Formation. Most of Nebraska’s common opal is unsuitable for gem purposes, although occasionally a piece of gem quality is found. The most desirable common opal is pure white or clear and is dendritic.

Opal has been mined commercially from Miocene rocks near Angora, Morrill County. This material is a colorless to transparent-green dendritic opal. Although the mine is now abandoned, reputedly it once furnished a large supply of the dendritic opal processed in the world’s gem cutting centers and is said to have offered strong competition to Australian sources of dendritic opal. The mine was shut down in 1964 and its entrance sealed because it served as a breeding ground for rattlesnakes. Greatly increased production costs have now made it impossible to operate the mine at a profit and its future is uncertain. Prior to its being closed, the mine was frequented by many amateur collectors and large amounts of opal were recovered. (See Mitchell, 1946, p. 115; and Sinkankas, 1959, p. 109).

Dendritic opal is often capped with clear quartz to add strength to the finished stone.

Fire opal, or precious opal, has been reported from only a few scattered localities in Nebraska (Arnold, Custer County; Bridgeport, Morrill County; and Beaver City, Furnas County).

Cutting and polishing opal. Although opal is relatively hard, its amorphous nature allows it to be cut easily. Opal is best slabbed with a very thin opal blade, a specially processed, very thin diamond blade...
Red, green, and brown chert occurs in exposures of the Cretaceous Niobrara Chalk near Beaver City, Furnas County. Indians often used this chert to make stone tools such as arrow heads and scrapers. The red and brown varieties are usually too grainy to be suitable for gem use. Green chert, commonly referred to as "green nodules," is less grainy and has been used for gem purposes. A very cherty, dendritic, nodular limestone is found in rocks that are probably of Tertiary age near Newcastle, Dixon County. Similar limestone has been reported from Cedar County. It looks almost like dendritic opal but effervesces when treated with dilute hydrochloric acid. This material can yield very fine cabochons.

### Type III Occurrences

**Miscellaneous Chert**

Plate IV, figs. 21, 22.

Chert from glacial tills appears to be closely related to jasper in time and mode of origin. The term *jasper* is commonly used for brightly colored microcrystalline quartz, and *chert* for the pastel-colored varieties. Also, the colored zones of jasper tend to be more sharply delineated and less transitional than those of chert. Rough, weathered nodules of chert usually have a white, chalky exterior that sticks to the tongue when moistened, whereas jasper does not develop this characteristic.

Chert in the glacial tills of Nebraska appears to have been derived from Paleozoic marine sedimentary rocks. Detailed studies should permit chert varieties to be traced to original sources in Minnesota, Iowa and elsewhere. Some of this chert can be traced to Pennsylvanian and Permian rocks in Nebraska. (See Corals, p. 60).

Chert generally has pastel colors; yellows, grays, blues, and pinks are most common. It is usually layered but the layering is not sharp, as in agate. However, the layering and color zones in chert often may produce scenic patterns.

**Cutting and polishing chert.** Chert from Type I occurrences forms under conditions of low temperature and pressure. It is brittle and chips easily. Chert should be slabbcd with a sharp diamond blade turning at about 2,000 feet per minute. Rough grinding should be done with a soft-bonded 80- or 120-grit, very well-dressed wheel or coarse diamond disk turning at the same speed. Fine grinding should be done with a 220-grit, soft-bonded wheel or a 260-grit diamond disk. Sanding should be done with wet, new 220-, 400-, and 600-grit sandpaper at a speed of 1,200 to 1,500 feet per minute. Polishing is easiest with stannic (tin) or cerium oxide on wet, soft leather turning from 400 to 600 feet per minute.

Dendritic, cherty limestone from Newcastle (p. 60) is best utilized in doublets. These are formed by capping thin, well-marked slabs with clear quartz. Chert from glacial tills is generally much less brittle than chert occurring in place. The reasons for this are not fully understood. Chert freshly quarried from limestone has been under considerable stress from the weight of overlying rocks. It may have been severely shattered by blasting operations in rock quarries. Freshly quarried chert effervesces in hydrochloric acid, indicating a high carbonate content. Chert that is free of flaws also would have been more able to withstand the abuses of glacial transportation. It is likely that a combination of all of the above factors makes freshly quarried chert more brittle than chert found in glacial tills.

The outer portions of chert nodules are often deeply weathered and the best material must be taken from the center of the nodule, thus accounting for a high percentage of waste. Slabs of less desirable chert may be painted black for use as back-up stones in doublets. Chert can be polished in the same manner as prescribed for jasper (p. 64).

**Coral**

**Type I Occurrences**

*Horn Coral*

Silicified coral (*Pseudozaphrentoides c.f. P. verticillatum*) has been collected from the Pennsylvanian Beil Limestone near Plattsmouth, Cass County. This coral is generally cream or white colored and some is suitable for cutting and polishing. Silicified coral is cut and polished in the same manner as prescribed for chert (p. 64).

Calcite replacements of *Pseudozaphrentoides sp.* occur in the Pennsylvanian Plattsmouth and Beil Limestones exposed near Plattsmouth and Weeping Water, Cass County. Although this coral can be polished and used for cabinet specimens, it is too soft for use in jewelry making. It can be polished in the same manner as prescribed for onyx (p. 64).
TEXT-FIGURE 39. Corals. A, Chaetetes milleporaceous Edwards and Haime; a colony center (X1) showing transverse (left, X20) and longitudinal (right, X20) cuts; B, Pseudosphrentoides c.f. P. verticillatum (Barbour); a transverse cut (left) and longitudinal cut (right) (X1).
Longitudinal cuts (text-fig. 39D) will produce three different types of patterns, depending on the position from which the cut was started. Transverse cuts (text-fig. 39C) produce a pattern of lines radiating from a central point.

**Type II Occurrences**

**Colonial Coral**
Silicified coral of the species *Chaetetes milleporaceus* Edwards and Haime (text-fig. 39A) is found in the Oligocene basal Chadron conglomerates. This coral originated in Pennsylvanian marine sedimentary rocks in the Hartville Uplift and Front Range of Wyoming. Red, pink, and gray are the most common colors.

**Cutting and polishing coral.** Coral can be cut and polished in the same manner as prescribed for prairie agate (p. 57). The direction of cut will produce different effects. A longitudinal cut (text-fig. 39A) through the coral will produce many fine, long lines, whereas a transverse cut (text-fig. 39A) will produce many fine, small dots.

**Type III Occurrences**

**Horn and Colonial Coral**
Chert replacements of Ordovician-, Silurian-, and Devonian-age corals have been found reworked into Pleistocene glacial tills that are exposed throughout much of eastern Nebraska. This coral is usually gray or white, and both solitary and colonial forms are known. It is usually quite solid and makes reasonably good cabochons which can be cut and polished in the same manner as prescribed for Type III chert (p. 60).

**Feldspar**

**Type II Occurrences**

**Labradorite, Moonstone**
An excellent specimen of labradorite was collected from the Two-Rivers Recreation Area near Venice, Dodge County (area 7a). A large specimen of moonstone was collected from a gravel pit near Ewing, Holt County (area 4). Labradorite and moonstone are typified by an iridescent sheen—the former is blue-green, the latter is white or milky. Labradorite has been collected from river gravels near Thedford, Thomas County (area 5). The material collected is in small fragments, some of which have the typical iridescent sheen. Labradorite has also been collected from terrace gravels near Broadwater, Morrill County (area 6). All of this feldspar probably originated in Wyoming. Future exploration may prove that gem feldspar is more common in Nebraska than previously thought.

**Cutting and polishing feldspar.** Feldspar cleaves very easily in two directions and grinding must, therefore, be done on a very well-dressed wheel. Cabochons can be polished easily with tin or cerium oxide on felt.

**Garnet**

**Type II Occurrences**

Dark-red to reddish-brown garnet has been reported from the basal conglomerates of the Oligocene Chadron Formation in the Hat Creek basin (area 1, text-fig. 32). Dark-red to reddish-brown garnet, probably of the almandine variety, has been reported from gravel pits in the middle Platte River basin (area 7, text-fig. 32).

Small garnets have been reported from the Pliocene Ogallala Group exposed near Ogallala, Keith County (area 6a) and near Sutherland, Lincoln County (area 6a). Small garnets have also been reported from the Ogallala Group near McCook, Red Willow County (area 8). Like feldspar, future exploration may prove garnet to be more common in Nebraska than previously thought.

**Hematite**

Hematite of gem quality has been found in the Cedar Bluffs Till near Davey, Lancaster County, and near Brock, Nemaha County. This material is an iron oxide that probably originated in the Mesabi Range of Minnesota.

Hematite is rarely cut and polished because it is very untidy to work with; its powder makes all liquids turn a deep-red color. Hematite from Nebraska polishes best on cloth buffs, by using cerium oxide.

**Ivory**

Ivory is an organic material, a modified dentine, composing the tusks of elephants and some other mammals, such as walruses. Fossil ivory is commonly reported from Nebraska, having been found in 82 of 93 counties. Ivory from mastodonts is found in the Pliocene Ogallala Group. Some notable mastodont finds have been near Valentine, Cherry County; Butte, Boyd County; and Red Cloud, Webster County. Ivory from mammoths has been found near North Platte, Lincoln County, and Crawford, Dawes County.

When a collector finds a tusk, he should not attempt to remove it lest he destroy important paleontological evidence; rather, he should notify the University of Nebraska State Museum of his find.

There is a sufficient quantity of small fragments of ivory to be found in river and terrace gravels to satisfy the needs of most gem cutters. These bits of ivory are usually suitable for cabochons (pl. IV, fig. 20) or carvings.
Ivory is very soft and cuts quickly, even on coarse sandpaper. Sanding is best done by hand, using new, clean, wet sandpaper. Polishing is done with tin oxide on very wet, hard leather turning at about 200 feet per minute.

**Jade**

**Type II Occurrences**

Several compact, tough varieties of amphibole and pyroxene are classified under the general term jade. All known jade from Nebraska is nephrite.

**Nephrite**

Small amounts of nephrite have been collected from terrace gravels and gravel pits in the North Platte River basin (area 6, text-fig. 32) and in the Middle and Lower Platte River basins (areas 7 and 7a, text-fig. 32). It originated in Precambrian metamorphic rocks in the Front Range in Wyoming. There are several claims in the Wyoming source area from which nephrite is now being mined.

Most nephrite found in Nebraska is black. Black nephrite has been found near Mitchell and Henry, Scotts Bluff County, and Ashland, Saunders County. The Ashland material may be a Type III occurrence. A small piece of light-green (apple-green) nephrite was found near Bayard, Morrill County.

**Cutting and polishing nephrite.** Nephrite is used almost exclusively for jewelry as it generally occurs in fragments that are too small for specimens. Nephrite grinds easily by almost any method. Sanding nephrite is difficult for it has a tendency to undercut. The texture of nephrite varies considerably from one piece of material to the next. Therefore, the technique used to get a glossy sanding job on one piece may fail on the next. The desired results may be produced by either wet- or dry-sanding. If one method fails, the cutter should try other methods until the desired effect is obtained. Generally, nephrite is easily polished with Linde-A on leather, but chromium oxide or stannic oxide may also produce a high, glossy polish.

**Type III Occurrences**

**Nephrite**

Nephrite has been found in the Cedar Bluffs Till in limited quantities near Nebraska City and Palmyra, Otoe County, and Humboldt, Richardson County. Nephrite may be more common in glacial deposits than present collections indicate. It is possible that much nephrite has not been recognized as such.

Many of the rocks occurring in the glacial tills are the same types of metamorphic rocks as those in which nephrite forms. Although nephrite, an amphibole, occurs in tills, it would be surprising to find jadeite, a pyroxene, in the tills of Nebraska as present evidence suggests that jadeite is restricted to post-Paleozoic (probably Jurassic or younger) metamorphic rocks. These rocks do not occur in the Canadian shield, whereas nephrite occurs even in Precambrian rocks. (See Turner and Verhoogen, 1960, p. 541–544).

Nephrite from northern sources cuts and polishes in the same manner as nephrite from western sources.

**Jasper**

**Type II Occurrences**

Plate IV, figs. 10, 18, 29, 31.

Jasper is perhaps Nebraska’s most common ornamental stone and many varieties occur throughout the state.

Jasper that is related to fortification agate and prairie agate in both time and mode of origin is found in terrace and stream gravels in areas 1, 5, 6, and 6a (text-fig. 32). Brilliant reds and yellows are the usual colors, although light blue or gray is not uncommon. Jasper differs from prairie agate by having a massive rather than a layered structure.

Beautiful jasper may be found in stream gravels in the South Platte River basin (area 6a, text-fig. 32). The colors are usually red, red and yellow, and yellow. One clear variety of agate with red plumes is found in this area. This agate strongly resembles a variety called “Pigeon Blood” which is collected in place in Colorado. Inasmuch as the Platte River drains that area, the Nebraska material probably is also Pigeon Blood agate. Jasper has been collected from terrace gravels near Chappell, Deuel County; from pits near Brule, Ogalalla, and Paxton, Keith County; and Sutherland and Hershey, Lincoln County.

Jasper commonly is found in gravels in the Republican River basin (area 8, text-fig. 32). This jasper differs markedly from jasper found in other basins. The Republican River drains a different area of Colorado than the South Platte and for this reason the jasper, as well as all other gemstones, differs strongly in the two areas. Republican River jasper usually is of pastel shades: pinks, yellows, tans, and olives are common colors. Some brilliant shades of jasper are also found in Republican River gravels but they are not as common as the pastels. Jasper has been collected from gravel pits and gravel bars near McCook, Red Willow County; Arapahoe, Furnas County; Republican City, Haxar County; and Franklin, Franklin County, to mention a few locations.

Jasper of unknown origin is abundant in gravels in the Niobrara, Loup, and Elkhorn River basins. Some jasper has been collected from gravel pits near Valentine, Cherry County; near Burwell, Garfield County; Thedford, Thomas County; and Fullerton,
of a small diameter. The blade should turn at the speed recommended by the manufacturer. Because of its very brittle nature, opal must be ground with a very well-dressed wheel. Opal can also be ground with very wet, 120- or 220-grit sandpaper, or with a 260-grit diamond disk. Opal is extremely sensitive to heat and sanding should be done by hand. Strips of wet or dry paper are suitable and only the 290- and 400-grits need be used. Opal sands quickly by hand. Polishing is done with tin or cerium oxide on a very wet, soft leather turning at about 400 feet per minute. Common opal may be used for back-up stones in doublets. (See Lard Agate, p. 59).

Pearl and Mother-of Pearl

Plate IV, fig. 19.

A few fresh-water pearls and abundant mother-of-pearl (nacre) have been found in clear, sandy streams in Nebraska. Pearls occur in the shells of several types of clams. Mother-of-pearl is the inner layer of a clam shell.

Mother-of-pearl is very soft and usually can be cut into the desired shape on a fine grinder or with coarse sandpaper. It has been used for inlay work. Inhaling the dust of some bivalve shells can cause illness; for this reason, mother-of-pearl should always be ground wet.

Petrified Wood and Plants

Type I Occurrences

Black Wood

Plate IV, fig. 19; text-fig. 40.

There are several very important occurrences of silicified wood of this type in Nebraska. The oldest occurrence is in sandy deposits in the middle part of the Oligocene Chadron Formation in northern Sioux and Dawes Counties. Fragments of jet-black wood are found there in abundance. Occasionally, a complete log or “round” is collected. Black wood is associated with fossil seeds of the walnut *Juglans siouxensis* (text-fig. 40A), which probably indicates that at least some of the wood is from walnut trees.

Although this wood is a very deep-black color, the grain can be exposed easily by soaking the slab in a full-strength solution of a commercial bleach (See text-fig. 40). The bleaching process may take place almost immediately or it may take several weeks, depending upon the type of wood. Usually, wood that has larger cells and, as a consequence, is more porous, bleaches more quickly. Bleaching should be done in a plastic or glass container, as bleach reacts with metal. The specimen should be completely submerged in the bleach to avoid an unsightly water line.

Text-Figure 40. A, A bleached section of black wood showing the grain (X1). B, A fossil walnut *Juglans siouxensis*, commonly associated with black wood (X5).

65
Large pieces of black wood, uncut and unpolished, are frequently used for specimens. Large polished slabs are also used for this purpose. Because of its intense black color, black wood is often used as the back-up stone for doublets (see Chalcedony).

Cutting and polishing black wood. Black wood should be sawed with a sharp blade turning at a rim speed of 2,500 to 3,000 feet per minute. Black wood contains abundant carbon which quickly causes the coolant oil in the saw to turn black. To avoid an unsightly black stain, oil used to saw black wood should not be used to saw light-colored, porous materials. The freshly sawed slices should be placed immediately in hot, soapy water to remove excess oil. Rough grinding should be done with a wet 100-grit, well-dressed grinding wheel or on a wet 100-grit diamond grinder turning at 2,000 feet per minute. Fine grinding should be done on a 220-grit silicon carbide wheel or a 260-grit diamond grinder turning at 2,000 feet per minute. Since black wood may be porous, it is often necessary to coat large slabs with a plastic resin before sanding. This operation usually can be omitted when polishing cabochons. If the slab is coated with plastic, allow about a half hour for the resin to seep into the pores, then wipe away the excess and allow the plastic to set. Sanding should be done with wet 120-, 220-, 320-, 400-, and 600-grit sandpaper turning at about 2,500 feet per minute. Polishing is best done with tin oxide on a very wet, hard felt wheel turning at about 500 feet per minute. If some of the pores of black wood take up tin oxide, this can be remedied by putting a coating of black shoe dye over the slab and wiping it clean, as the dye will color the polishing compound.

If specimens are polished on a vibrating-type lap, the manufacturer's recommendations should be followed.

Opalized Wood

Plate IV, figs. 12, 26; text-fig. 41.

Opalized wood occurs in the Pliocene Ogallala Group in several widely separated areas in Nebraska. Some very large logs, weighing several tons, have been reported from near Valentine, Cherry County, and near Ainsworth, Brown County. Such pieces are rare, however, and smaller fragments of opalized wood weighing from a few ounces up to several pounds are most common. Opalized wood occurs near Republican City, Harlan County, and Beaver City, Furnas County. Generally, opalized wood from Nebraska is black or brown. It may be bleached to expose the grain (see text-fig. 41; see also Black Wood). Opalized wood is not necessarily related to bedded, common opal; some bedded opal contains wood fragments and some does not. Opalized wood also occurs in gravel pits near Fremont in Dodge County and is of undetermined origin.

Cutting and polishing opalized wood. Opalized wood is very brittle and must be sawed with a very sharp diamond blade turning at a rim speed of about 3,000 feet per minute. Black opalized wood will cause the coolant oil to turn black (see cutting and polishing black wood). Opalized wood is usually too brittle to make suitable gems but if cut into slabs an inch or so thick, it is ideal for specimens. The freshly cut slabs should be soaked in warm, soapy water to remove excess oil. Lap the slab with 120-, 220-, 400-, and 600-grit sandpaper. Polish with tin or cerium oxide on a very wet, soft leather turning at 400 feet per minute. Use extreme caution to keep the slab wet and cool, as even the slightest overheating can cause opalized wood to chip, fracture, or burn.

Some lapidaries process opalized wood by lapping it with 120-, 220-, 400-, 600-, 1,000-, and, if possible, 1,200-grit only. The resulting specimen has a very smooth, nonglossy surface showing all of the detail of a polished section. Such surfaces have a very natural appearance which some wood collectors prefer to the polished sections.

Type II Occurrences

Plate III, figs. 1, 2; Plate IV, figs. 9, 13, 14, 25, 32, 33, 34.

Silicified wood of this type is among the more common gemstones to be found in Nebraska and occurs in
all areas (text-fig. 32). Petrified woods from each area originated in different sources and are, therefore, strikingly different.

Petrified wood is abundant in the basal conglomerates of the Oligocene Chadron Formation in area 1 (text-fig. 32). This wood is commonly found near Orella, Sioux County, and Whitney and Chadron, Dawes County. It probably originated in Cretaceous rocks of the Front Range in Wyoming. Although most of this wood has not been identified, it is associated with types of plant remains that have been both classified and dated (e.g., cycadophytes of Cretaceous age). Most of the wood in the basal Chadron conglomerates is an olive-brown color and is rarely used as specimens or gemstones. Occasionally, a colorful piece of wood, suitable for either gemstones or specimens, is found in the basal Chadron Formation.

Petrified wood is common in terrace gravels and in gravel pits in the North Platte River basin (area 6, text-fig. 32). This wood also originated in the Cretaceous strata of the Front Range in Wyoming. The wood found in the North Platte River basin is often light blue, red, brown, or yellow. It usually has well-preserved structure and is highly attractive and suitable for both specimens and gemstones. It has been collected in terrace gravels and gravel pits near Mitchell and Henry, Scotts Bluff County; Bayard and Bridgeport, Morrill County; and Lewellen, Garden County, to mention a few popular localities.

Brown-and-white petrified wood has been reported from the Niobrara River basin (area 2, text-fig. 32) from near Hay Springs and Rushville, Sheridan County. Wood of this color has also been collected from gravel bars and gravel pits along the Niobrara River near Valentine, Cherry County, and Verdigre, Knox County. This wood probably originated in the Pliocene Ogallala Group, reasonably close to the areas where it is now collected. Since it is now reworked in Pleistocene and Recent gravels, it is included in Type II gem occurrences.

Petrified wood of unknown affinities has been collected in the Elkhorn River basin (area 4, text-fig. 32). It has been found in gravel pits near Stuart, Atkinson, O'Neil, and Ewing, Holt County; Battle Creek and Norfolk, Madison County; Stanton, Stanton County; and West Point, Cuming County.

Petrified wood of undetermined origin is found in the gravel pits in the Loup River basin (area 5, text-fig. 32). This wood has been collected from gravel pits near Thedford, Thomas County; Burwell, Garfield County; Ord, Valley County; St. Paul, Howard County; Fullerton, Nance County; and Columbus, Platte County.

Petrified wood is also common in terrace gravels and gravel pits in the South Platte River basin (area 6a, text-fig. 32), and probably originated in Cretaceous-age strata in the Front Range in Colorado. Much of this wood is highly colorful—reds, yellows, whites, blues, and black in a clear matrix are a few of the colors found. Some of the wood has dendritic patterns. For example, fragments of small tree limbs similar to modern cottonwoods are found in the South Platte valley and terraces; these limbs are characterized by having a small “star” in the center (text-fig. 42). Palm wood, highly prized by collectors, occurs in the river and terrace gravels of area 6a and is typified by having large, tubular cells (text-fig. 43A). Palm root, typified by having large, eye-like cells (text-fig. 43B, C) is also highly prized. Wood from the South Platte River basin is found in terrace and pit gravels near Chappell, Deuel County; Ogallala and Paxton, Keith County; and Sutherland and Hershey, Lincoln County.

Wood from the North Platte basin, (area 6, text-fig. 32) and the South Platte basin (area 6a) becomes intermingled in the Middle Platte basin (area 7). For this reason, petrified wood from the Middle Platte basin is both abundant and diversified. Wood is collected from gravel bars and gravel pits near Brady, Lincoln County; Gothenburg and Lexington, Dawson County; Kearney, Buffalo County; Wood River and Grand Island, Hall County; Central City, Merrick County; Columbus, Platte County; Fremont, Dodge County; and many other locations along the Platte River valley.

Petrified wood is abundant in gravel pits in the

---

**Text-Figure 42.** A complete limb section or “round” of wood of a species similar to modern cottonwood (X1). Note the stellate center ring.
Text-Figure 43. Palm wood and palm root. A, A complete section with a wedge-shaped segment removed to show the different patterns obtained from transverse and longitudinal cuts; B, C, palm root: B, a transverse section of root with a piece of trunk attached; C, a longitudinal section of root (all X1).
TEXT-Figure 44. Cycadophytes. A, Lateral view of a whole trunk (X1/5); B, polished surface of a trunk (X1/3); C, transverse section of a trunk (X1/2); and D, tangential section of a trunk (X1/2). Drawings modified after Wieland, 1906, 1916.
Republican River basin (area 8, text-fig. 32). Specimens have been collected from gravel pits on Stinking Water Creek near Imperial, Chase County, and Frenchman Creek near Hamlet, Hayes County. Petrified wood has also been found in gravel pits and gravel bars along the Republican River near Benkelman, Dundy County; Trenton and Culbertson, Hitchcock County; McCook, Red Willow County; Arapahoe, Furnas County; Oxford, Harlan County; Bloomington, Franklin County; and Guide Rock, Webster County.

Petrified wood of undetermined origin is also common in the Big Blue River basin (area 9, text-fig. 32) and Little Blue River basin (area 9a). It has been collected from gravel pits and gravel bars near Ayr, Adams County; Oak, Nuckolls County; Hebron, Thayer County; and Fairbury, Jefferson County. Gravel pits near Beaver Crossing, Seward County; Crete and Wilber, Saline County; and Wymore and Holmesville, Gage County, also yield petrified wood.

There is an abundance of varied and diverse fossil wood in Nebraska, and undoubtedly there are many other localities than those listed above.

Cutting and polishing petrified wood. Petrified wood is popular for both specimens and gems. Large, highly colorful pieces of wood are usually used as specimens, whereas small pieces are customarily used as jewelry stones. Pieces of wood of solid colors are ideally used for matched sets of stones.

The direction of cut will determine the pattern to be seen on petrified wood. A longitudinal cut will show the grain of the wood, whereas a transverse cut will show the annular rings. Annular rings are usually masked by the concentric deposition of silica; the large, wide bands one sees are formed by silica deposition, whereas annular rings are finer and quite sharp in detail. When sawing petrified wood, clean oil should be used with a sharpened blade turning at 2,000 feet per minute. Some wood is porous and absorbs oil, discoloring the specimen. The slabs should be soaked in soapy water to remove excess oil. Polishing can be completed in the same manner as prescribed for prairie agate.

Cycadophytes

Text-fig. 44.

Cycadophytes are commonly referred to as cycads. Cycadophytes that originated in Cretaceous rocks of Wyoming are found in the Oligocene basal Chadron conglomerates in the White River–Hat Creek basin (area 1, text-fig. 32). Specimens have been collected from natural exposures of basal Chadron conglomerates near Orella, Sioux County, and Whitney and Chadron, Dawes County. A small section of a cycadophyte was recovered from Pleistocene terrace gravels in Deuel County near Chappell, which is in the South Platte River basin (area 6a, text-fig. 32).

Cutting and polishing cycadophytes. Cycadophytes are typified by having diamond-shaped structures. The direction of cut will determine the type of pattern one sees in a cycadophyte (text-fig. 44). Cycadophytes can be polished in the same manner as prescribed for fortification agates (p. 54).

Tempskya Ferns

Text-fig. 45.

False stems of the Cretaceous fern genus Tempskya (text-fig. 45) are found in basal conglomerates of the Oligocene Chadron Formation in the White River–Hat Creek basin (area 1, text-fig. 32) near Orella, Sioux County, and Chadron, Dawes County. A false stem consists of hundreds of small stems deposited in a small area and then cemented together. Many small eye-like structures result. These bundles of small stems look like a large stem with large cells, such as palm wood (text-fig. 43).
Cutting and polishing *Tempskya* fern. Two distinct patterns can be produced, depending upon the direction in which *Tempskya* is cut (text-fig. 43). Longitudinal cuts will result in long, cell-like structures, whereas transverse cuts will show small "eyelets" of each *Tempskya* stalk. *Tempskya* can be polished in the same manner as prescribed for fortification agates.

**Type III Occurrences**

Petrified wood is common in all of the glacial tills in Nebraska. Little of it, however, is of a suitable color for gem use, as contrasted to the wood found in river and terrace gravels from western sources. Occasionally, a gem-quality piece of wood is found. Wood from the glacial tills cuts and polishes in the same manner as wood from terrace and river gravels.

A large piece of *Tempskya* fern, weighing ten pounds, was collected from a gravel pit on the Nemaha River (area 10) near Table Rock, Pawnee County.

Quartz

**Type II Occurrences**

Plate IV, fig. 11.

Quartz of faceting-grade has been collected from the South Platte River basin, the Middle Platte River basin, and the Lower Platte River basin (areas 6a, 7, and 7a, text-fig. 32). This quartz probably originated in Precambrian igneous rocks in the vicinity of Pikes Peak, Colorado, where similar quartz is now found in place.

A piece of tea-colored, smoky quartz, weighing 243 carats, was collected a mile south of Chappell, Deuel County. It yielded oval-brilliant-cut gems weighing 31.97 carats (pl. IV, fig. 11) and 18.50 carats, and two round-brilliant-cut gems weighing 5.30 carats and 3.65 carats.

A 28-carat, clear quartz crystal collected near Fremont, Dodge County, yielded round-brilliant-cut gems weighing 5.02 carats and 3.20 carats, and a 7-carat, clear quartz pebble, also collected near Fremont, yielded a 2.23-carat, square-cut gem. Although these occurrences at Fremont are believed to have originated from a western source, the crystals could have been derived from glacial till or outwash and thus be Type III occurrences.

An 8-carat pebble collected near Columbus, Platte County, produced a round-brilliant-cut gem weighing 1.57 carats, and a 5.5-carat pebble collected near Central City, Merrick County, produced an oval-brilliant gem weighing 1.52 carats.

Faceting-grade quartz also occurs in the Republican River basin (area 8, text-fig. 32) and this material, too, probably originated in the Precambrian rocks of the Front Range of Colorado. Some very good examples have been collected from gravel pits near Arapahoe, Furnas County, and Bloomington, Franklin County.

A small amount of faceting-grade quartz has been found in the Pleistocene gravels in the Little Blue River basin (area 9a, text-fig. 32). This material is of undetermined origin. Although a number of finished stones from these localities have been exhibited, no specific information on weights of rough pieces or finished pieces was recorded by the collectors.

**Type III Occurrences**

Faceting-grade quartz is not nearly as well known from the glacial deposits of eastern Nebraska as from the river gravels of western and central Nebraska. This may reflect a lack of prospecting rather than an absence of material.

Faceting-grade quartz has been found in the Cedar Bluffs Till near Table Rock, Pawnee County, and in the Nickerson Till near Steele City and Fairbury, Jefferson County. This quartz probably originated in Precambrian granitic rocks in Canada and Minnesota.

A piece of clear quartz weighing 5 carats was collected near Table Rock, Pawnee County; it yielded a 70-point, round-brilliant stone. A 112.5-carat piece of yellowish quartz and a 1,755-carat piece of smoky quartz were collected near Table Rock, Pawnee County. These pieces have not yet been cut.

A 19.5-carat piece of clear quartz was collected near Douglas, Otoe County; and a 35.2-carat piece of clear quartz was collected near Elk Creek, Johnson County. A large piece of rutilated quartz containing a few gem-quality areas was also found near Elk Creek.

A 1.5-carat quartz pebble was collected in the Nickerson Till exposed near Steele City, Jefferson County; it yielded a 34-point, round-brilliant stone. A similar piece of material from the same locality and weighing 4 carats was faceted into a 1.5-carat, round-brilliant gem.

Cutting and polishing quartz. Although quartz is abundant, little of it is suitable for use as either specimens or gemstones. Transparent quartz is used almost exclusively for gemstones; it often contains much undesirable material and rarely comes in large enough pieces to make attractive specimens. It is easy to determine whether or not a piece of quartz is of gem quality. Promising looking pieces of quartz should be cleaned and dipped in olive oil, which has nearly the same refractive index as quartz. Fractures, veils, impurities, and bubbles, which have refractive indices different from quartz, will show up very plainly. By this method, areas of gem-grade quartz can be found in large pieces of material which, for the main part, may not be of gem grade.

When faceting quartz, crown angles should be 40 to 50 degrees; pavillion angles should be 43 degrees.
The polishing direction should be changed frequently to avoid a rippled finish which is caused by twinning planes in the crystal.

**Topaz**

Clear and yellow topaz has been reported from one gravel pit in the Republican River valley (area 8, text-fig. 32) near Arapahoe, Furnas County. Although topaz has been observed in insufficient quantities in Nebraska to make any determinations of its origin, history, and polishing properties, it is worth noting. It is likely that further exploration will yield additional finds of topaz in Nebraska.

**Unakite**

Unakite is a mottled pink and green granite that forms when orthoclase is altered to epidote. It is named for the Unaka Mountains in West Virginia. Small quantities of unakite are found in the glacial tills of eastern Nebraska. Unakite is often used for gemstones.

**Cutting and polishing unakite.** Because of its crystalline nature, unakite should be sawed very slowly to prevent chipping and pitting of the rock. Grinding must be done with a very well-dressed wheel. Sanding must be done with new sandpaper. Because soft wheels, such as felt, will cause undercutting, polishing is best done with Linde-A on leather.

**MISCELLANEOUS HEAVY MINERALS**

A wide variety of heavy minerals (specific gravity greater than about 2.8) of types commonly used as gems is found as very fine to fine grains in many of the Tertiary and Pleistocene stream-deposited sands and gravels in Nebraska. Some important occurrences of heavy minerals in Nebraska have been noted in the fine fraction of western Nebraska sands (Hunter, 1955; Peckham, 1961). The kinds of minerals reported by these and other workers include: rutile, spodumene, sphene, tourmaline, apatite, zircon, and corundum.

In the laboratory, heavy minerals are separated from light minerals by the use of heavy liquids, such as bromoform, CHBr₃, (g 2.7). Bromoform is poured into a beaker and water poured on top, forming a layer of dense bromoform below and a layer of light water (g 1.0) above. The mixed mineral sample is poured into the beaker and the mixture is agitated. The light minerals (g less than 2.6) float on top of the bromoform, whereas the heavy minerals sink to the bottom. Bromoform is both toxic and expensive to prevent chipping and pitting of the rock. Grinding must be done with new sandpaper. Because soft wheels, such as felt, will cause undercutting, polishing is best done with Linde-A on leather.

SELECTED REFERENCES


Barbour, E. H., 1898, Chalcedony lime nuts (Archchicoria siouxensis) from the badlands of Nebraska: Nebraska Acad. Sci., proceedings of the Nebraska State Historical Soc., 2nd Series, v. 2, 3 p., 1 pl., 1 fig.

_____ , 1899, The barites of Nebraska and the badlands: Nebraska Acad. Sci., proceedings of the Nebraska State Historical Soc., 2nd Series, v. 2, 7 p., 3 pl. 5 figs.

_____ , 1898, Discovery of meteoric iron in Nebraska: Nebraska Acad. Sci., proceedings of the Nebraska State Historical Soc., v. 2, 5 p., 1 pl., 4 figs.


_____ 1971, Guidebook to the geology along portions of the lower Platte River valley and Weeping Water valley of eastern Nebraska: Nebraska Geol. Survey Bull., ser. 2, 38 p., illus.
Giacomini, A. (Mrs.), 1969, Flowers for the living: Lapidary Friends of the Pleistocene, Univ. of Nebraska, Lincoln.
Mendenhall, G. V., and Grafham, A. A., 1949, Minerals of the Harlan County Dam, Harlan County, Nebraska: University of Nebraska, Dept. of Geology, Unpublished Study, 23 p., 28 figs.
Mitchell, R. S., 1946, Bayard, Nebraska, quartz minerals: Rocks & Minerals, v. 21, no. 1, p. 29.
_____ 1950, A description of the quartz minerals found at Bayard, Nebraska: Rocks & Minerals, v. 25, nos. 1 and 2, p. 3-7, illus.
APPENDIX I

A brief review of gem-cutting equipment and methods is given below so that the reader will be able to apply additional meaning to the sections dealing with cutting and polishing properties of gems. Specific information is covered by Sinkankas (1962), Quick and Leiper (1959), and others. Interested readers can keep abreast of current developments in gem cutting by reading popular periodicals and publications (See Appendix II).

Saws

The diamond saw (text-fig. 46) is used to cut rough material into slabs and to trim away the portions of rock that will not be used as part of the gem. The diamond saw is equipped with a steel blade which is impregnated with diamond dust. The rock is held in a vise when slabs are being cut, but usually is held in the fingers when a slab is being trimmed. For lapidary purposes, the blade is generally cooled with an evaporating oil or mineral-seal oil.

Grinders

Cabochons and specimens are ground to shape with either a silicon carbide grindstone (text-fig. 47) or a diamond-impregnated disk or dish. Grinding wheels come in various degrees of coarseness (80, 100, 220, 400, .... grits). The lower the number, the coarser the grit. The stones must be kept cool while they are being ground. This is done by having a continuous flow of water run over the grinder.

Sandpapers

Either silicon carbide or diamond sandpaper is available, in types that can be used either wet or dry. Sandpaper comes in various grits and, as with grindstones, the lower the number, the coarser the grit. The gem cutter can use either a disk- or a drum-type sander and techniques are learned only through experience.

Sanding is a most difficult operation to master while learning to cut gems. An improperly sanded stone cannot be polished properly.

Polishing Wheels, Disks, and Polishing Compounds

Polishing wheels are generally made of either hard felt or hard or soft leather. Disks come in felt and leather, and, more recently, in plastics impregnated with polishing compounds. There is no universal polishing wheel. Some stones polish quickly with felt, whereas others cannot be polished at all with felt. The same holds true when polishing with leather or impregnated plastics.

The most popular polishing compounds are tin oxide, cerium oxide, chromium oxide, and Linde-A. Any of the above compounds may polish a stone quickly.

The skill of stone polishing is acquired through experience. There is no combination of wheel and compound that will work for all stones. Most gem-cutting manuals list the techniques that have produced successful results in both sanding and polishing. It is recommended that the cutter follow these techniques.

Rock Tumblers

Tumble polishers (text-fig. 48) can be built easily or can be purchased inexpensively. The tumbler consists of a water-tight barrel which rotates, causing the rocks to tumble, one over the other, in order to wear off sharp corners. The rocks are successively tumbled with coarse (80–120), medium (320–360), and fine (600–1000) grits mixed with water and are then tumbled in tin or cerium oxide and water. The entire operation requires about eight weeks. The stones and tumbler must be cleaned thoroughly after each operation to avoid contamination (by coarser grits) which will prevent polishing from being accomplished.

The above equipment and supplies can be purchased from any local lapidary supplier or may be ordered from one of many advertisers in the popular gem-cutters periodicals (See Appendix II).

Techniques for Shaping Stones

It is not difficult to learn to shape cabochons. The hard stones grind slowly and errors can usually be corrected before they become serious. First, mark the desired area with a brass or aluminum point (text-fig. 49A). Trim off the undesired portion (text-fig. 49B). Then, the trimmed blank cabochon is rounded off (text-fig. 48C) to the desired size and shape. Next, a bevel to prevent chipping (about 1/16”) is ground around the base of the stone. The third cut is made at about a 30-degree angle to the vertical (text-fig. 49D). A fourth cut at about 30-degrees to the first 30 degree cut is made (text-fig. 49E). The stone can then be rounded (text-fig. 49F). Once the stone is shaped, it must be sanded (p. 107) and polished (p. 107). Sinkankas (1962, p. 105–120) and Meader (in Giacomini, pp. 77–80) each give slightly different techniques for shaping cabochons, each technique producing slightly different profiles on finished stones. Either method is satisfactory.
Text-Figure 46. A typical diamond saw showing some of the important parts.

Text-Figure 47. An arbor fitted with grinding stone and sanding drum.
TEXT-Figure 48. A rock tumbler.
TEXT-Figure 49. The steps in cutting a cabochon: A, mark off the desired area; B, trim; C, put stone on a dop stick; D, cut bevel; E, make first cut at 27°; F, make second cut at 27° (this step may be omitted on thin stones); G, round off corners, sand and polish.

APPENDIX II

In addition to the many professional journals cited in the Selected References (p. 72), listed below are several nonprofessional publications available which deal with mineral collecting and gem cutting.

Earth Science
Box 550
Downers Grove, Ill. 60515

Gems and Minerals
P.O. Box 687
Mentone, Calif. 92359

Lapidary Journal
P.O. Box 2369
San Diego, Calif. 92112

Mineral Digest, Ltd.,
P.O. Box 341
Murray Hill Station, New York, N.Y. 10016

Mineralogical Record
P.O. Box 783
Bowie, Maryland 20715

Rocks and Minerals
Box 29
Peekskill, New York 10566

78
GLOSSARY

**Absolute date.** A statistical estimate of the true age of a mineral or rock in terms of years based on the rate of spontaneous decay of radioactive isotopes.

**Alpha particle** A positively charged, sub-atomic particle, a product of radioactive decay, similar to the nucleus of a helium atom, having 2 protons and 2 neutrons.

**Cabochoons** Unfaceted gems usually having oval shapes, although they may be round, square, heart-shaped, tear-drop shaped, or of many other shapes, but usually having a completely rounded surface (see pl. IV; text-fig. 49).

**Coal smut** An earthy coal layer at or near the earth's surface. Often contains minerals such as marcasite.

**Concretion** A nodular concretion of materials which develop by localized deposition from solution, usually around a nucleus.

**Crown** The upper part of a faceted gem.

**Crown angle** In faceted gems, the angle of the faceted crown of the stone measured with respect to the horizontal.

**Cut under** (see undercut)

**Doublet** A gem made up of two layers cemented together, either a thin layer of desirable material supported by more durable material, or a thin layer of desirable material capped with a protective layer of clear quartz.

**Dress, well dressed** The condition of a grinding wheel that has been smoothed and sharpened.

**Dry sand, dry sanding** Sanding without a coolant.

**Faceted stone** A gem with a faceted crown above and a faceted pavillion below, separated by a narrow girdle.

**Facets** Small, flat-cut surfaces on a gem, which produce a sparkling effect with transparent stones.

**Fault** A fracture in rock in which there is some displacement of opposite blocks (see text-fig. 34A). Fault planes are often mineralized.

**Girdle** A narrow band separating the crown and pavillion of a faceted gem.

**Igneous rocks** Rocks that formed from molten or partially molten material.

**In situ** A term describing material which is found in its place of origin.

**Isotope** Atoms of like elements that have slightly different atomic weights because their nuclei contain a differing number of neutrons; e.g., O\(^{16}\) with a nucleus containing 8 protons and 8 neutrons and O\(^{18}\) with a nucleus containing 8 protons and 10 neutrons are two isotopes of oxygen.

**Joint** A fracture in rock in which there is no displacement of opposite blocks. Joint planes are often mineralized.

**Lapidary** The art of cutting gemstones.

**Lapidary, lapidarist** One who cuts gemstones.

**Linde-A** A commercial polishing compound consisting of finely powdered aluminum oxide (corundum) H = 9.

**Matrix** The undesirable portions of rock containing mineral specimens or gemstones.

**Metamorphic rocks** Igneous or sedimentary rocks that have been changed in either texture or composition by external agents after their solidification. External agents may include heat, pressure, solutions, and introduction of new chemical constituents.

**Nodule** Bodies that occur as discrete masses within a larger formation.

**Orogeny** A mountain-building event.

**Oxidizing environment** An environment in which oxygen combines with other elements.

**Pavillion** The lower part of a faceted gem.

**Pavillion angle** In faceted gems, the angle of the pavillion facets measured with respect to the horizontal.

**Phantom** A smaller crystal of a mineral within a larger crystal of the same mineral.

**Plume** Feather-like inclusions, usually in agate or chalcedony, that often make desirable subjects for gems (see plate IV, fig. 1).

**Plutonic rocks** A general term applied to igneous rocks that have crystallized at great depth and usually have a granitoid texture.

**Polyhedral (polyhedron)** A solid form having many faces.

**Prism, prismatic** In crystallography, a crystal face that intersects two and only two crystallographic axes.

**Reducing environment** An environment in which oxygen is removed from compounds.

**Sedimentary rocks** Rocks formed by the accumulation of sediments in water or from the air. The sediment may consist of rock particles, remains or waste of animals and plants, inorganic chemical precipitate, or any combination of the above.
Till  Unsorted, unstratified glacial deposits consisting mainly of silt and clay but also containing sand, gravel, cobbles, and boulders.

Triplet  A gem of three layers; a desirable piece of material cemented between a more durable back-up stone and a layer of clear quartz.

Undercut, undercutting  An undesirable trait of some gems to sand (or polish) faster in some areas than others because of structural or mineralogical differences in the stone, producing a dull, rippled, or orange-peel surface.

Uplift  Mountain-building episodes; also, a mountain range, such as Black Hills Uplift.

Vug  A cavity in rock that may or may not contain minerals.

Wet sand, wet sanding  Sanding using a coolant.