Eugene J. Hall

English For Careers

The Language of Mining and Metallurgy in English

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FOREWORD

This book is one of a series called *English for Careers*, intended to introduce students of English to the language of a number of professional and vocational areas. The careers covered are those in which English is widely used throughout the world, such as air travel, computer programming, international commerce or, in the case of this book, mining and metallurgy.

The series serves a dual purpose: to give the English student an introduction in English to a specific occupation and to improve his or her overall use of this language. In this book the duties, problems, and rewards of different aspects of mining and metallurgy are discussed, as well as some of its history, background, and future.

From the vantage point of language learning, these books are intended for students at the high intermediate or advanced levels who are acquainted with most of the structural patterns of English. The principal goals of the learner should be mastering specific vocabulary, using normal patterns, and improving his or her ability to communicate effectively in English, especially in the particular career area.

This book meets these needs. Each lesson begins with a glossary in which specific words and terms are defined and discussed. There follows a vocabulary practice section in which questions and answers guide the reader to use these terms. Then the terms are used again in context. Each section is followed by topics for discussion which give the language student an opportunity to use ideas, special terms, general vocabulary, and structural patterns. The lesson ends with comprehensive vocabulary review and conversational and writing practice. The index of special terms at the end of the book makes it easy to find definitions of the specialized vocabulary for reference.

Much successful language learning comes from interest and experience that is not fully conscious. In offering this book, it is hoped that the English student's identity with mining and metallurgy will enhance his or her ability to communicate easily in this language.

EUGENE J. HALL
Washington, D.C.

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UNIT ONE
MINERALS, METALS, AND MINING

Special Terms

Mineral: A naturally occurring, inorganic substance, usually crystalline, with relatively definite chemical composition and physical characteristics. Although coal in its rock like form is originally organic, it is sometimes classified as a mineral.

Metal: Any one of a group of chemical elements with similar properties. Metals are usually shiny, malleable (able to be hammered into sheets), and ductile (able to be pulled out into long, thin shapes). They all conduct heat and electricity and can replace hydrogen in certain compounds. Iron, copper, gold, silver, and aluminum are common metals.

Crystal: A solid substance with a symmetrical, repetitive arrangement of surfaces. Quartz, a compound frequently found in rock and sand, has a *crystalline structure*, like a diamond.

Rock: Hard material on the outer crust of the earth consisting of one or more minerals. There are three kinds of rock: igneous (a familiar example is granite), sedimentary (a familiar example is limestone), and metamorphic (a familiar example is marble).

Mining: The process of extracting minerals from the earth. A *mine* is the place where this process takes place.

Quarrying: The process of excavating rock to obtain stone usually used for building purposes. A *quarry* is the place where the process is carried on.

Compound: A chemical state in which two or more elements are joined together. Quartz is a compound of one particle or atom of silicon and two of oxygen; its chemical name is silicon dioxide.

Ore: A mineral compound that contains a metal or some other element that can be extracted for profit.

Alloy: A mixture rather than a compound of two or more metals. Familiar alloys are *bronze* (copper and tin), *brass* (copper and zinc), and *steel* (iron and carbon).

Concentration: The process of separating metal from rock in an ore.

Refining: Removing impurities from metal that has been concentrated from its ore. The entire process of extraction, concentration, and purification is often referred to as refining.

Smelting: A process for extracting or refining metal that involves heating until the metal melts.

Cassiterite: The mineral form in which tin usually occurs.

Outcrop: A rock formation exposed on the surface of the earth.

Shaft: A vertical opening into the earth. *Shaft mining* is underground mining.

Vein or Seam: A mineral deposit between layers of rock under the ground. Vein usually refers to a metallic ore and seam to coal.

Meteorite: A mineral mass that has entered the earth from space; it often consists of iron or iron and nickel.

Charcoal: A nearly pure form of carbon obtained by the partial burning of wood; it burns at high heat.

Cast Iron: A form of iron that contains a relatively high percentage of carbon.

Wrought Iron: A form of iron with a lower percentage of carbon than cast iron; it is more malleable and ductile than cast iron.

Slag: Impurities separated from a metal during the smelting process.

Steel: An alloy of iron and carbon, with a carbon content of up to 1.7 percent; it is hard, tough, and easily worked.

Quenching: Plunging a hot metal into cold water, or other liquid, to harden it.

Coke: A product of coal from which gases have been removed by heating; it burns at very high heat.

Crucible Process: An eighteenth-century steelmaking process involving melting the metal at very high temperatures in clay vessels known as *crucibles*.

Bessemer Process: A nineteenth-century steelmaking process in which a blast of air is blown through the molten (red-hot and liquid) metal in a vessel called a *converter*.

Electrolysis or Electrolytic Process: A method of reducing ores or refining metals by passing an electric current through a liquid mixture or solution.

Vocabulary Practice

1. What is a *mineral*?
2. What is a *metal*? List its properties.
3. What is a *crystal*? Give examples of substances with *crystalline structures*.
4. List the three kinds of *rock*.
5. What is *mining*? Where does it take place?
6. What is *quarrying*? Where is it done?
7. What is a *compound*? Give examples of common compounds.
8. What does the term *ore* mean?
9. How does an *alloy* differ from a *compound*? What are some familiar alloys?
10. What does *concentration* do?
11. What is *refining*? What does the term often include?
12. What is *smelting*?
13. What comes from *cassiterite*?

14. What is an *outcrop*?

15. What is a *shaft*? What does *shaft mining* refer to?

16. What is the difference between *veins* and *seams*?

17. Describe a *meteorite.*

18. What is the difference between *cast iron* and *wrought iron*? How does *steel* differ from both of them?

19. What does *slag* consist of?

20. What does *quenching* mean?

21. What is *coke*? Does it burn at a high or low temperature?

22. What is the *crucible process*?

23. What is the *Bessemer process*?

24. What is the *electrolytic process*?

Minerals, Metals, and Mining

Dominance over our environment depends to a large extent on our ability to utilize materials that occur in nature. *Minerals* and *metals* are among the most important of these materials. Minerals are inorganic substances—not animal or vegetable matter—that occur in nature, usually in the form of *crystals*. *Rocks*, stones, and grains of sand are composed of minerals, a term usually extended to include coal, although it comes from decayed vegetable matter that has solidified into a rocklike form under pressure and heat over millions of years. Metals are chemical elements, the basic substances from which all matter is formed. Among the most common metals are iron, copper, and aluminum, but there are many others, some familiar to all and some known only to scientists. All metals have certain similar properties: most are shiny, malleable (capable of being hammered into thin sheets), and ductile (capable of being pulled out into rods or wire); they conduct heat and electricity and replace hydrogen in acids to form salts.

Evidence of human use of minerals long precedes written records. Ancient people began to shape tools and weapons from stones; they learned how to shape utensils from wet clay which was hardened by firing. This early phase of development is called the Stone Age because the use of stone implements was of primary technological importance. From the Stone Age, humanity progressed to the Bronze Age and the Iron Age as those metals in turn came into primary use.

The first evidence we have of *mining* comes from the Stone Age. Mining is the process of extracting minerals or metals from the earth. We have archeological evidence of pits where prehistoric people searched for flint, a mineral that contains crystals of quartz. It was valuable because it could be chipped into sharp points for use as arrowheads, and because it could strike a spark to light a fire. Flints are still used for that purpose in modern cigarette lighters!

Another activity that began with the Stone Age was *quarrying*, the process of excavating rock to obtain stones useful for building purposes. Such colossal monuments as Stonehenge in England, the pyramids in Egypt, and the temples of Mexico and Peru, give some idea of the amount of skill and labor that was developed for quarrying. Some stones in the pyramids weigh as much as 14,500 kilograms. They were cut to shape in the quarries, transported to the building site, and lifted into place. In some ancient quarries, the rock was first weakened by fire and then cut into shape with the available tools.

Only a few metals exist in nature in a pure form; among them are gold, silver, and copper. When they are commercially extracted, most metals are found as parts of chemical *compounds* in minerals called *ores*. Gold, silver, and copper were being worked by the end of the Stone Age, essentially for ornamental rather than practical purposes. The discovery of bronze, probably by accident, was the real beginning of the age of metals. Bronze is an *alloy* of copper and tin, harder and more suitable for weapons and tools than either metal alone. An alloy often has properties that the single metal lacks—hardness, as in the case of bronze in contrast to cop-

Courtesy Society of Mining Engineers of AIME

The quarries of today look much the same as they did in the Stone Age—only the tools have changed.

per, or the ability to resist rusting, as in the case of stainless steel in contrast to iron.

The use of bronze led to advances in both metallurgy and mining. While pure copper exists in nature, it must be recovered from its ores in most cases. Techniques were developed very early for extracting or reducing, known as *concentrating*, the metal from the ore and for *refining* or purifying it. The principal method was *smelting*, which involves melting the ore at high heat so that the metal is separated from other substances in the ore. Tin most commonly occurs in an ore called *cassiterite* which was mined during ancient times in the south of England and in Spain. The principal source of copper ore was the island of Cyprus—indeed the name of the island comes from the Greek word for copper. Ancient bronze implements have recently been discovered in Thailand which, with its neighboring Malaysia, is still an important source of tin.

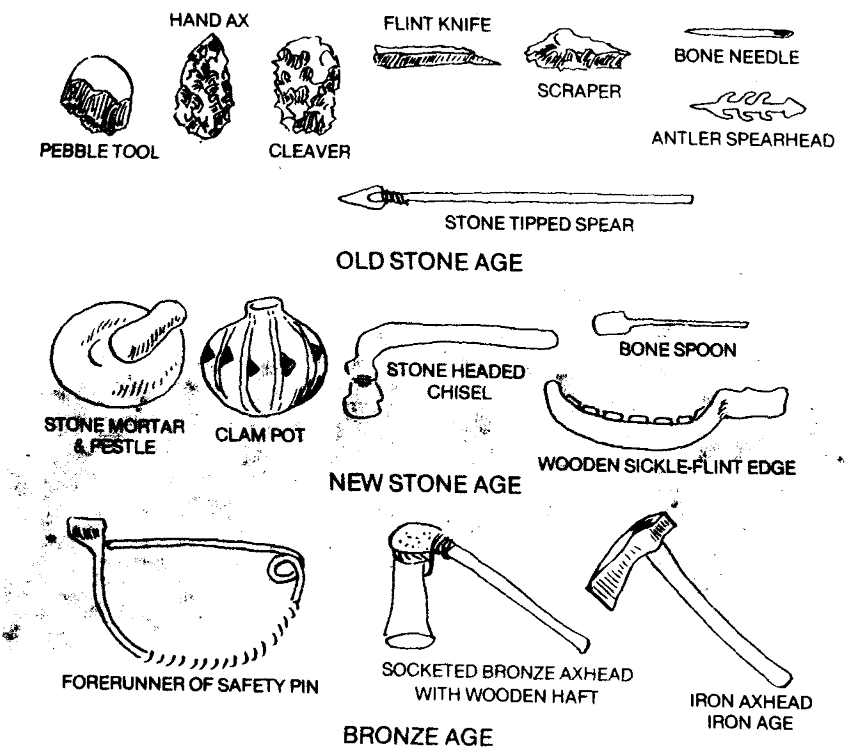
Ancient mines first developed around *outcrops* where the ores were exposed on the surface of the earth. When these were exhausted, it became necessary to dig *shafts* or tunnels underground

Courtesy American Mining Congress

A geologist examines an outcrop to determine the quality of its ore.

to follow the *veins* of ore—layers of the valuable mineral between deposits of commercially worthless rock.

The advances in mining, refining, and metalworking that developed with the use of bronze prepared the way for the utilization of iron. Pure iron exists in a few scattered places in the world in *meteorites*, masses of minerals that have fallen to earth from space. Most iron exists in several different kinds of ore from which the metal itself must be extracted. The technology of smelting was applied to extracting and refining iron. Originally *charcoal* was the fuel used for this process. Charcoal is a nearly pure form of carbon derived from the partial burning of wood; it burns at a high heat. Implements made of iron came into use a thousand years before the beginning of the Christian era in Europe and Asia.



Human beings started toolmaking in the Old Stone Age. The discovery of bronze and the techniques for mining, refining, and metalworking that developed with its use, prepared the way for the utilization of iron.

By the end of the classical period of Rome, lead, mercury, zinc, and some other metals had been discovered, refined, and put to use. Zinc was mixed with copper in a gold-colored alloy called *brass*. Lead was cast into pipes still found in water systems that have survived from antiquity. The Romans learned that tin could be used for food containers, as it is in the modern tin cans found all over the world today.

Until the beginning of modern times the chief advances in metallurgy were in working with iron. In the smelting process some carbon from the charcoal mixes with the iron. The quantity of carbon separates the classes of iron with different properties. *Cast iron* contains a relatively high percentage of carbon; it is hard but brittle, not malleable or ductile. *Wrought iron* has a lower carbon content but contains some *slag* or impurities from the smelting process; it can be worked more easily than cast iron.

The most desirable form of iron is *steel*, which is an alloy of iron and carbon with a carbon content of up to 1.7 percent. Steel is very hard and tough and it can be worked into almost any shape. Steel was produced as early as 1000 B.C., but only in very small amounts and only in a few places. During the Middle Ages small quantities of steel were laboriously produced by heating and reheating the metal to reduce the carbon content, and by *quenching* or plunging the hot metal into cold water to harden it. Steel was reserved for precious finished products like the famous sword blades of Damascus and medieval Japan.

The principal fuel used to refine and work metals for many centuries was charcoal. One of the turning points in the history of metals and in technological history as a whole was the substitution of coal as a fuel. The fact that coal burned had been observed in the Western world, but it was in China that it was first used for fuel. Mining coal began in England near the end of the thirteenth century.

At first most coal was obtained from outcrops. As coal came into wider use underground *seams* or deposits of coal were mined by shafts. For many centuries the available technology did not permit mines to go very deeply into the earth. One problem was the inability to drain water from deep shafts; the first steam engines, developed in England at the end of the seventeenth and the beginning of the eighteenth centuries, were designed to solve this problem. The fortunate combination of supplies of iron ore, abundant

Because wrought iron can be worked more easily than cast iron, it has often been used for decoration. This gate, made in France in the sixteenth century, is a fine example of wrought iron workmanship.

coal, and people of inventive genius made England the first great industrial center of the modern world.

Coke is an industrial fuel derived by burning off gases contained in coal; it burns at a very high temperature. It was used as a fuel for the *crucible process* of making steel which came into use in England around the middle of the eighteenth century. *Crucibles* are clay containers in which metal can be melted at the very high degree of heat at which coke burns. The crucible process increased the amount of available steel but production on a large scale began with the *Bessemer process*, invented in the middle of the nineteenth century. In this process a blast of air is blown through the molten metal—metal that is red-hot and liquid—in a vessel called a *converter*. The blast of air removes impurities, including a large amount of carbon, to produce steel. The Bessemer process takes only a few minutes in contrast to much lengthier periods of time for other steel-producing processes.

There has been a steady advance in all phases of mining and metallurgy. Scientific knowledge has made it possible to develop new techniques and methods for finding valuable mineral deposits, for mining them, for processing them, and for creating new combinations with a multitude of new uses. Many previously unknown metals have been discovered and put to work; one dramatic case concerns aluminum. It was first isolated from its ores in 1825 but it remained a rare and expensive element in a pure form for almost a hundred years. It was not until 1889 that the *electrolytic process* for refining aluminum was patented. Since then, aluminum (aluminium in British usage) has become one of the most widely used metals in the industrial world, probably second only to steel. *Electrolysis* and other techniques and processes currently used in mining and metallurgy will be discussed in subsequent units of this book.

Discussion

1. What are minerals and metals and why are they important?

2. What were the first minerals put to use?

3. Name the principal stages of technological development.