GEOLOGY AND ITS RELATION TO THE CHEMISTRY TEACHER*

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Introduction.—By the use of rocks, minerals, and ores in class room discussion the students will have a better understanding of the elements and compounds used in the laboratory. This unites laboratory practice with the occurrence of raw materials in nature and their economic importance and will dramatize the otherwise prosaic concept of materials found on the laboratory shelf as purchased from chemical supply houses. A knowledge of the geographic distribution and extensive economic use of rocks, minerals and ores will not only be of interest to the students but will aid greatly in the interpretation of current affairs of world wide importance. Local collecting by students quickly develops initiative and interest. Certain specimens are available in almost every community in the State and these which can not be found locally may be obtained from the State Geological Survey and various mineral supply houses.

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Geology, like Chemistry, has an interesting history. Leonardo da Vinci of the fifteenth century, Florentine painter, sculptor, architect and naturalist wrote on "The Earth and the Sea." In this article he gave his ideas concerning the nature of fossils, ideas which were revolutionary in his day. During this same period Agricola (George Bauer) a Saxon physician and professor of Chemistry, whose *De re metallica* was the basis for all later metallurgy, wrote "The Structure of the Earth and the Forces which Change the Earth." It included discussions of the origin of minerals, underground waters, and the construction and destruction of mountains.

Geology is the history of the earth and its inhabitants. It treats of the rocks and minerals and of the agencies and processes which have made them. The field of geology has many subdivisions. Astronomic Geology deals with the outer relations of the earth. Petrology is the study of rocks; Structural Geology deals with the arrangement of the rocks in the earth's crust. Dynamic Geology deals with the forces involved in geologic processes, such as the formation of mountains, volcanic action and sea level changes. Physiographic Geology treats of the face of the earth or topographic form and changes that take place on the earth's surface. Paleontology is the study of plant and animal fossils in the rocks, which are the remains or traces of the flora and fauna of the past. Historical Geology traces the succession of events in the earth's history recorded in the rocks formed through the ages and in the fossils they contain. Economic Geology is concerned with the industrial applications of geologic knowledge. Mining and Petroleum Geology are important subdivisions in this field. Economic Geology is of particular interest to the Chemistry teacher since it treats of the occurrence, utilization and mining methods of rocks and minerals of economic value.

Nature is the great chemist. All the processes of nature involve chemical changes which are indeed the processes of our existence. The chemist observes and studies nature's methods to discover means by which he can change her products, create new substances, and adapt natural materials to the uses of man.

Nature brought the atoms of elements and molecules of compounds together and they acted as they do now in the chemical laboratory. The great mass of the earth's crust is composed of chemically combined substances. Here and there in the crust of the earth were left few elements. Among these we find gold, silver, copper, platinum and the diamond.[2]

We do not have a full understanding about the earth on which we live and from which we derive the materials essen-

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[2] Morrison, A. Cressy, Man in a Chemical World, (1937) Charles Scribner's Sons, N. Y.

tial for life. We tend to accept as commonplace the works of nature because they are so familiar. The product of nature's work is about us everywhere if we only pause to see it. No doubt at some time or other all of us have had the curiosity to wonder what some rock, mineral or ore might be. We have wanted to know of what it was composed, how it was formed, and perhaps whether or not it had economic importance.

While teaching chemistry at University High School, Urbana, Illinois, some years ago, under the direction of Mr. W. E. Harnish, we found that students show keen interest in mineral and ore specimens used in class room discussion. When a certain element or compound was to be discussed, hand specimens of minerals, ores and rocks in which this element or compound occurred were available for inspection by the students. The mode of occurrence, geographic distribution, value, mining methods and historical background were among the topics discussed. It was noted that many students are familiar with some rocks and minerals and are eager to learn more about their chemical constitution, physical properties and uses in industry. Some students brought specimens from home which either they or immediate members of their families had collected in their own community or in various travels.

Rock, mineral and ore are commonplace terms used in every day life, and the geologic definition of each is as follows: A mineral is a natural inorganic substance which has a homogeneous structure, definite chemical composition, and physical properties, and usually a definite crystal form. Rocks are composed of minerals in a state of mechanical mixture, some rocks are almost made up of a single mineral, as for instance a very pure limestone which is largely calcite. The term ore means a natural mineral substance from which some metal may be profitably extracted, and its value is determined not only by its content of metal, but also by the cost of working and transportation.

As an example of what minerals might be used in classroom work when the compounds of sulphur are to be discussed the following common ones are suggested: Argentite, Ag_2S, which occurs as an ore in the Comstock lode in Nevada; Galena, PbS, the most important ore of lead which is found in Illinois as well as many other states; Chalcocite, Cu_2S, an important ore of copper, Chalcopyrite, CuFeS, another important ore of copper; Sphalerite ZnS, a zinc ore; Cinnabar, HgS, an ore of mercury; Pyrite, FeS_2, and Marcasite, FeS_2, which are very common in sedimentary and igneous rocks. Marcasite is particularly abundant in the coal deposits in Illinois. It is of interest to note that marcasite, which has the same chemical composition as pyrite, is usually found in coal deposits rather than pyrite because it is formed under acid conditions. An abundance of humic acid was present in the swamps of the Coal Age when our coal deposits in Illinois were formed. Likewise minerals occurring as oxides, carbonates, and silicates could be grouped in their respective classes for discussion.

In addition to studying the specimens in the classroom the geographic distribution of the mineral, ore or rock was brought out. For example it was mentioned that the principal deposits of cinnabar are in Spain near Cordova where it has been mined for hundreds of years. Cinnabar is also found in the Coast Ranges of California. A mineral of more local interest is Galena, lead sulphide. It occurs in many countries throughout the world and important deposits in this country are found in Missouri and in northwestern and extreme southern Illinois.

The history of exploration for, and mining of ores, is of particular interest to the students; for example, the history of the first mining of lead deposits in northwestern Illinois. The date of the earliest use of the lead deposits of the upper Mississippi region is unknown. Some of the oldest mines had been worked by the Indians before the advent of Europeans. Nicolas Perrot, an Indian trader and French commandant in the West in 1690, was probably the first white man actually to see the Indian mines. The Indians loaded the ore at the bottom of an inclined shaft into deerskin bags and dragged it to the surface by means of long thongs of hide. This work was performed almost entirely by old men and squaws. At the surface the ore was heaped on a pile of logs. The fire was set in the evening and in the morning shapeless pieces of lead would be found. The mines were later operated by the French, Spanish, and English prior to American control in 1816.[3]

The economic importance of ores and materials occurring in nature was included in the classroom discussions. These products of nature have long governed the destiny of nations and supplemental information regarding them greatly adds to the students' interest. In our present era of world changes and conflicts, minerals and ores play an immensely important part. Many of these have been cut off from world markets, and it is difficult for some countries to obtain supplies sufficient for their needs. Tungsten from China was largely cut off from the outside world by the conflict with Japan. The Swedish iron ores are now unavailable to England. Germany has a shortage of copper and tin and is forced to substitute aluminum wherever possible. The United States fears that if Japan takes over the Dutch East Indies its own major supply of tin will be cut off.

Of greatest importance to a nation involved in war today is an adequate supply of petroleum. Should Germany's supply be stopped the war would soon end as that country produced only 4,557,000 barrels of oil in 1939 but consumed 54,000,000 during the same period. The United States, which has the world's greatest supply of crude oil, produced one and one quarter billion barrels in 1939. Illinois produced seven and one half per cent of this amount. As a result of the discovery of new pools in this State and the tapping of deeper productive formations, it is estimated that Illinois' production for 1940 will be 150 million barrels of crude oil. The economic importance of this industry in our own State is reflected in many communities in southern Illinois. This newly acquired wealth has made that part of our State much more prosperous.

Now that topics of interest to students concerning specimens used in classroom discussion have been touched upon briefly one may wonder how to obtain them and which to use. The first thing to do is to become familiar with the local industries which utilize the natural resources. Mines and quarries of our industrial minerals are to be found throughout the State: fluorspar mines for example, in Hardin County, southern Illinois, yield beautiful specimens of fluorite, calcite, galena, sphalerite, barite, and limonite. The limestone quarries yield specimens of calcite, dolomite, crystal-filled geodes and a variety of interesting minerals besides the stone itself. At coal mines one may obtain various rocks and minerals associated with coal deposits. Gravel pits offer the opportunities for the collection of many different kinds of rocks. Almost pure silica sand is quarried near Utica, Illinois; tripoli, a white powdery form of silica is quarried in Alexander and Union counties; Fuller's earth, a filtering and bleaching clay of especial importance to the petroleum industry, is mined in Pulaski County. Other materials of importance to industry, such as clays, shales, molding sand, gravel, flux stone, wool rock and others, are also available in Illinois in inexhaustible amounts.

As a suggestion to increase the students' personal interest in rocks and minerals, special projects might be started whereby each student would see how many different specimens he could collect in his own community. As many of these as possible should be identified by the student without the assistance of the instructor. Each student should be responsible for his own exhibit which would develop originality in arrangement of specimens according to industrial uses as well as chemical composition.

Minerals, rocks, and fossils common to Illinois may be obtained from the Illinois State Geological Survey, Urbana, Illinois. Study units are mounted for wall cabinet display and duplicate sets of loose specimens for class handling and study are available for $1.50 each. A study manual accompanies each set. The Geological Survey also conducts Earth History field conferences providing authoritative information on geology, geologic history, physiography and resources of local areas through the State. Also lectures on geology of Illnois or specific local areas, mineral resources, geologic history will be made upon request. The Survey also offers an identification service free of charge of rock, mineral and fossil material. Address all inquiries or requests to Don L. Carroll who is in charge of the Educational Extension Services of the

[3] Geology and Geography of the Galena and Elizabeth Quadrangles, Trowbridge, A. C., Shaw, E. W., Shockel, B. H., Illinois State Geological Survey Bulletin No. 26, (1916) pages 179-184.

Illinois State Geological Survey, Urbana, Illinois.

In addition to the rocks and minerals common to Illinois, it would be desirable to obtain specimens not found in our State for use in the chemistry classroom. These may be obtained from various mineral supply houses for little cost. It would be desirable to have reference books on rocks and minerals which the students could use. These would also serve as means of identification of specimens they would collect. A book was recently published by McGraw-Hill Book Company, "Getting Acquainted with Minerals," which retails for $2.50. It includes the following topics: What equipment is needed, how to collect minerals, where to find minerals, how to buy minerals, how to examine and test minerals, facts about crystals, descriptions of minerals and rocks, and the identification of minerals. Such a book would be a valuable addition to any chemistry library.

The following is a list of rocks and minerals suggested for use in the Chemistry classroom, also a list of reference books which might be used, and the name of a well known company from which a complete supply of rock, mineral and ore specimens can be obtained.

MINERALS

Group	Mineral Name	Chemical Composition	Use
1. Native Elements	Graphite	C	Industrial
	Sulphur	S	Industrial
	Copper	Cu	Industrial
	Silver	Ag	Industry and Arts
	Gold	Au	Industry and Arts
2. Oxides	Hematite	Fe_2O_3	Ore of Iron
	Limonite	$FeO(OH)$	Ore of Iron
	Magnetite	Fe_3O_4	Ore of Iron
	Ilmenite	$FeTiO_3$	Ore of Titanium
	Chromite	$FeCr_2O_4$	Ore of Chromium
	Cassiterite	SnO_2	Ore of Tin
	Franklinite	$(FeMnZn)\ (FeMn)_2O_4$	Ore of Zinc
	Pyrolusite	MnO_2	Ore of Manganese
	Bauxite	$Al_2O_3\ 2H_2O$	Ore of Aluminum
	Cuprite	Cu_2O	Ore of Copper
	Zincite	ZnO	Ore of Zinc
	Quartz	SiO_2	Industrial
	Corundum	Al_2O_3	Industrial
3. Sulphides	Argentite	Ag_2S	Ore of Silver
	Galena	PbS	Ore of Lead
	Sphalterite	ZnS	Ore of Zinc
	Cinnabar	HgS	Ore of Mercury
	Chalcocite	CuS	Ore of Copper
	Pyrite	FeS_2	Ore of Sulphur
	Marcasite	FeS_2	Ore of Sulphur
	Pyrrhotite	$Fe_{11}S_{12}$	Ore of Sulphur
	Pentlandite	$(FeNi)S$	Ore of Nickel
	Chalcopyrite	$CuFeS_2$	Ore of Copper
	Bornite	Cu_3FeS_3	Ore of Copper
	Stannite	Cu_2FeSnS_4	Ore of Tin
	Stibnite	Sb_2S_3	Ore of Antimony
4. Carbonates	Siderite	$FeCO_3$	Ore of Iron
	Malachite	$(CuOH)_2CO_3$	Ore of Copper
	Azurite	$Cu(OH)_2\ 2(CuCO_3)$	Ore of Copper
	Cerussite	$PbCO_3$	Ore of Lead
	Smithsonite	$ZnCO_3$	Ore of Zinc
	Calcite	$CaCO_3$	Industrial
	Dolomite	$(CaMg)CO_3$	Industrial
	Magnesite	$MgCO_3$	Industrial
	Rhodochrosite	$MnCO_3$	Ore of Manganese
	Witherite	$BaCO_3$	Industrial
5. Sulphates	Barite	$BaSO_4$	Industrial
	Gypsum	$CaSO_4.2H_2O$	Industrial
	Celestite	$SrSO_4$	Industrial
6. Chlorides	Halite	$NaCl$	Industrial
	Sylvite	KCl	Industrial
	Cerargyrite	$AgCl$	Ore of Silver
7. Fluorides	Fluorite	CaF_2	Industrial
	Cryolite	Na_3AlF_6	Ore of Aluminum
8. Nitrates	Soda Niter	$NaNO_3$	Industrial
	Borax	$Na_2B_4O_7.10H_2O$	Industrial
9. Silicates	Willemite	Zn_2SiO_4	Ore of Zinc
	Calamine	$Zn_2SiO_4.H_2O$	Ore of Zinc
	Kaolinite	$H_4Al_2Si_2O_9$	Industrial
	Talc	$H_2Mg_3(SiO_3)_4$	Industrial
	Muscovite (Mica)	$H_2KAl_3(SiO_4)_3$	Industrial
	Othoclase (Feldspar)	$KAlSi_3O_8$	Industrial

COMMON ROCKS USED BOTH IN INDUSTRY AND AS THE SOURCE OF VARIOUS ECONOMIC MINERALS

1. Igneous rocks (those which have cooled from a molten state)

	Intrusive (Within the earth)	*Extrusive* (Volcanic)
A. *Acid Rocks* (Rich in silica or alkalies)	Granite Pegmatite Syenite	Rhyolite Trachyte Obsidian Pumice Tuff
B. *Intermediate Rocks*	Diorite	Andesite
C. *Basic Rocks* (Less silica or alkalies than in the acid rocks; iron, magnesium and calcium content much greater)	Gabbro	Basalt
D. *Ultrabasic Rocks* (Made up mostly of iron and magnesium minerals)	Peridotite	Limburgite

2. Sedimentary Rocks (Rocks classified as to mode of deposition)

A. *Mechanical*	B. *Chemical precipitates*	C. *Organic accumulations*
Shale	Travertine	Limestone
Sandstone	Gypsum	Marl
Conglomerate	Rock Salt	Peat
	Chert	Coal
	Agate	
	Onyx	

3. Metamorphic Rocks (Rocks which were originally igneous or sedimentary that have been altered in place without decomposition or disintegration).
   A. *Original rock of sedimentary origin:* Quartzite, Slate, Marble, Anthracite.
   B. *Original rock of igneous* (or sedimentary) *origin:* Gneiss, Schist, Serpentine.

REFERENCES

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Field Book of Common Rock and Minerals—Loomis, F. B. Putnam Sons, New York, New York.

The Mineralogist—Published monthly by the Mineralogist Publishing Company, Portland, Oregon.

Rocks and Minerals—Published monthly, Peekskill, New York.

Mineral Supply House: Ward's Natural Science Establishment, Inc., Rochester, N. Y.

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