Geophysics in the Training of a Geologist

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The realization that geophysical methods might be of service in prospecting for ore bodies and likely areas for petroleum accumulation aroused extensive interest on the part of the mining and oil fraternity twenty or more years ago.

The continued increasing demands of modern civilization upon natural resources made it imperative to increase output and to develop new sources of supply. The evident and most likely areas of mineral wealth were either depleted or were being depleted by active mining. This left, as always, the less probable areas for future prospecting and development.

It will be granted that successful prospecting in the beginning was more luck than science. An increasing appreciation of geological control in ore deposition developed, in the old time prospector, a rule of thumb method which was fruitful when applied to exposed ledges. The recognition of the value of gossan, like the variability in the occurrence of gold leading to the prospector's statement that 'gold is where you find it,' is a well-known example. Continued prospecting under these crude beginnings resulted in the discovery of many famous mines. Drake's first oil well drilled in 1859 at Titusville, Pennsylvania, was, as history records, the first application of the anticlinal theory.

The increasing number of producing mines and oil wells served to create, after a time, a desire or what might be termed a need for more raw materials. Since the average rate of depletion of a mine is taken to be fifteen years and an oil field much less, it soon became apparent that to fill this growing demand new areas should anticipate their depletion. From this necessity arose the economic geologist. He brought to the aid of the mining industry an accumulation of knowledge of ore deposition, previous exploration, development, and production. By correlation, both geographical and geological, other areas were indicated as being economically favorable for reconnaissance. Mining engineers and others made possible the extraction of ore at greater depth and by decreasing cost of production made lower grade deposits available to industry.

The rate of discovery has not kept pace with the rate of consumption. Except for petroleum no major source of mineral has been found since 1850, with the exception of the copper in Africa and the lately discovered iron ores of India. No discovery of major value has been found in North America since 1910. The future looks to Asia and Africa for supplies, but it should not be held as patent that all other areas have been completely worked out since we have concerned ourselves to date only with surface or shallow indications. By the law of averages, mineral wealth should lie in the crust in equal or greater abundance than outcrops imply. Since economic or what may be termed applied geology has been of value in this connection, the profession should make use of any and all branches of science that will aid in this continued search for raw materials.

One of the latest and most promising is the science of geophysics. The science itself is not new; it is only an application of much that has been known for ages.

The use of lodestone, credited to the Chinese, dates back at least 3000 years B. C. The discovery of the laws of magnetic attraction and repulsion, the use of a pivoted needle by mariners, Columbus' discovery of the declination of the compass from the true north, and Gilbert's published *De Magnete* in 1600, which remained without addition until the nineteenth century, is a short history of magnetic phenomena. Modern geophysics has made much use of magnetic methods in prospecting.

Cavendish's experiments, using a crude torsion balance in determining the mean density of the earth, were made in 1798. It was not until the 1880's that Baron Von Eötvös devised a modification using the Cavendish principle and used it in the determination of local variations in gravity caused by rock masses. This principle is used in the modern torsion balance. From its use we have arrived at a conclusion as to the constitution of the earth's interior, and it has played its part in solution of the problem of isostasy.

The first basic statements, dealing with the question of transmission of earthquake waves, were made by Robert Mallet, an Irish engineer, about 1850. He was antedated by Reverend John Mitchell, who in 1760 stated that believed earthquake shocks travelled in a series of waves through the associated rocks. Mallet also suggested that an artificial earthquake could be created by explosions in the ground from which it should be possible to measure velocities of wave transmission. Our modern seismic methods are not so modern after all. Researches along this line have also given more information as to the condition and constitution of the earth's interior, which may be of only academic interest; yet the science and techniques are made use of daily in prospecting for underground information not only for oil but for other purposes.

Electricity and magnetism are closely related in the mind of the physicist; but in geophysics the property of current travel, the development of natural electric currents within the earth (sometimes called the natural battery action), and transmission of radio waves and distortion are separated from pure magnetic properties. Many electrical properties have been determined for rock masses. Delineation of faults, contact zones, the outlining of ore bodies in mineralized areas, and many other applications have given an insight into deeply covered ore zones.

Geologists should be made familiar with the various physical laws noted in the foregoing and their application to modern prospecting. Too few schools at present recognize that such should be part and parcel of geological training. It is not necessary that we train our men as geophysicists since that has become a specialized field, but we should train them in the basic principles on which the science of geophysics is built. The current argument as to whether or not the new science should be taught by the department of geology or the department of physics should not concern us at the present. That is more pertinent in the training of the specialist as to whether he major in physics and minor in geology or major in geology and minor in physics.

If it be granted that geophysics has a bearing on economic geology, should not our graduates be given some foundation in geophysical principles? This will require, no doubt, a more specialized course in physics specifically designed for this purpose, advanced courses in mathematics beyond the calculus, and a knowledge of mechanics, followed by a general geophysics course. In answer to the question, which is no doubt in the minds of some, as to where we are to find the time in an already crowded curriculum, my answer is—we should evaluate our curriculum—throw out outmoded courses, prune to the bone, and let our graduates be modern in concept and training.