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The Aid of Geophysics in Mineral Exploration in India

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OVER 3/4ths of a million square miles of India, covered under barren superficial deposits of great thickness, the usual orthodox geological methods of survey and prospecting for economic minerals, ores, coal, oil, etc., are inapplicable. This is because over this vast extent of the surface, the geological formations consist only of a mantle of minerally barren recent and sub-recent alluvial silts of the Indus-Ganges river systems, their deltas, the sands of deserts and, for an immense stretch of the country, of equally barren lava—flows of an ancient gigantic volcanic eruption.

2. With the knowledge placed at our disposal by the geological sciences we cannot fathom this thick surface mantle, hundreds, if not thousands of feet in thickness, and find out what underlies it. There is a probability that part of this rock-blanket conceals extensions of geological formations which are known to be the parent rocks or carriers of our gold, iron and manganese ores, coal measures, and minerals like mica, diamond, beryl, etc. But there is no means of ascertaining the exact underground depth, location and extent of these possible mineral-bearing rocks.

3. The new science of geophysics with its delicate electrical, magnetic and gravitational instruments has, within the last few years, brought about a revolution in the technique of exploring sub-surface rocks and their structure and constitution. On the principle that these delicately adjusted mechanisms are able to detect and measure any inhomogeneity or discontinuity in underground rock-bodies (and the presence of economically useful mineral deposits invariably cause in the surrounding rocks inhomogeneity in their density, electrical or magnetic conditions), some far-reaching and important discoveries have been made in the last 10 years. With the help of these instruments geologists have succeeded in locating workable petroleum reservoirs at 10 to 15 thousand feet depth, metallic lodes and ore bodies, salt deposits, prolific water-bearing strata, coal seams as well as in detecting and mapping geological structures, such as rock-folds and faults at critical points, which often serve as guides in the locating of mineral accumulations.

4. The development of geophysical technique in investigation of the earth beneath the surface received great stimulus through the exigencies of the last World War. Air-borne magnetometers successfully detected many enemy submarines. Soon after, this principle was used for detecting sub-surface geological structures carrying concentrations of metals such as iron, chromium, manganese and nickel. During the war seismic and sonic methods were developed to locate the position of German guns. Instruments were devised to measure the time taken for sound-waves or minor earth-tremors from the guns to travel to distant points. The same principle was applied to seismic prospecting of underground mineral masses or rock structures. The principle is based on a study of the elastic sound-waves or earthquake-waves (both are essentially similar in nature) generated by a blast of explosives at a small depth in the ground. From the measurement of times of arrival of the waves at specified centres it is possible to infer the nature of the rocks through which the waves have passed and the depth of the geological inhomogeneity, which is the chief point to be investigated. The most striking discoveries of new oilfields of great richness in recent years have been made by seismic probing of sub-surface structures.

5. Measurement of varying elect ic potential an1 currents generated by spontaneous polarisation of metallic and mineral bodies buried underground, or the electric resistivity of rocks in a mining field, is the basis of electrical prospecting. The use of electrical geophysical instruments has resulted in some outstanding discoveries in Canada of gold-fields, large nickel deposits and segregations of sulphidic ores of copper and other metals.

6. Researches on gravitational methods of measuring anomalies of density in the ground, invariably caused by the presence of entombed minerals and ores of specific gravity different from that of the country rocks, have evolved to extremely delicate physical instruments—the Torsion Balance and the Gravimeter. These are so perfected that they are able to measure differences of underground density amounting to only 1/10th of a millionth part of the value of gravity. When all topographic and relative altitude corrections are applied, the readings on a modern Gravimeter can be accurate to 1/10th of a *milligal*. These instruments are portable and a number of readings can be taken in a field of several hundred square miles in the course of a working day. The Torsion Balance is very effective in measuring the horizontal gradient of gravity from place to place.

7. Recently, small portable instruments are designed (the gamma-ray Geiger-Muller Counters) for the search of radioactive minerals which have sprung into great strategic prominence in the atomic energy age that has dawned since the use of atomic weapons in 1945. These Counters can be used on any bare rock-face, quarry, mine, or tunnel with immediate audible or visible indications if any uranium, thorium or possibly beryllium, is present in the rocks in invisible microscopic amounts.

8. One further use of geophysical science, though only of indirect utility in the mining field, is in the radioactive dating of rock systems. in determining the age of the earth, the duration of time represented by the successive periods of earth history, the age of sediments accumulating on ocean and lake beds, etc.

9. Although the new instrumental technique has placed in the geologists' hands a valuable means of exploration, the use of the technique is attended with certain limitations and numerous precautions are needed in accurate interpreting of the data and indices obtained in their working. They need a sound judgment and trained powers of observation and deduction in resolving of the masses of intricate scale readings.

10. Application of geophysics in the realm of meteorological phenomena is fairly well-established in India, and the India Meteorological Department has a fine record of observations of atmospheric physics, earth-electricity, magnetic and seismologic phenomena. But the use of geophysics as an aid to exploration of minerals in India is very recent. The Geological Survey of India has, since 1946, a geophysical branch in operation which is slowly building up a trained personnel for field investigation of several interesting geological problems, besides locating of mineral deposits, such as manganese-ore, coal, underground water sources, etc. The Burmah Oil Co. of India has during the last 15 years surveyed geophysically several thousand square miles of alluvium-covered ground in search of petroleum. The Mysore Geological Department have located some auriferous quartz veins, pyrites and graphite deposits, etc. One can foresee important results flowing from extensive employment of geophysics in a country of the size and geological constitution of India.