THE LOCATION OF MINERAL FIELDS
by
GEOPHYSICAL METHODS

The rapid progress that has been made in recent years in the art of mineral prospecting by scientific methods is not generally known. In local newspapers brief reference has been made from time to time to the application of geophysical methods to ore finding and the location of oil and coal fields, but the great importance of the advancement in these aids to industry has not been impressed on the minds of all who are interested in the practical side of mining ventures.

Unscientific methods, wasteful of time and money which have been, are, and in a minor degree perhaps always will be, squandered in the pursuit of fantastic hopes and fixed ill-founded ideas are gradually but surely being displaced by the use of modern methods of exploration. The great saving in organized drilling, not to mention the early stages of exploratory work and "wild-cat" ventures, will be immediately obvious when it is realised that the whereabouts of ore-bodies can be predetermined skilfully and accurately. Moreover, it is possible to determine with some degree of accuracy the nature of the commercial minerals and their proportion of the ore-body.

While practical geological investigations up to the present time have been confined to ocular observations and deductions therefrom with chemical and other aids, it is the purpose of geophysical surveys to determine and place on record certain of the physical properties of subterranean rocks by means of suitable instruments and thus to amplify the geological survey. Geological knowledge concerning country not opened by bores and pits is based almost entirely upon observations at surface, whereas geophysical investigations supply information more particularly about the deeper formations.

Geological investigations relate chiefly to the analytical survey of the mineralogy, petrology, palaeontology and stratigraphy of areas.

From evidence based on such surveys estimates are formed of the nature of the formations, but except where opened at surface an estimate of value or an indication of value cannot be made. The geophysical methods on the contrary are applied in the opposite direction, commencing with a non-analytical diagnosis of the nature of the deeper formations and continuing by employing a combination of the various methods and thus narrowing the diagnosis down to the localisation of the deposit: a synthetic operation. Geological work should be supplemented by geophysical investigation one is complementary to the other.

The great advantage to be gained by the use of instruments designed for the purpose is that no extra-ordinary expenditure is necessary. The operations are performed at surface by specially trained officers equipped with all the appliances that make up the combined outfit.

As to methods of operation a number of instruments

have been designed for the purpose of determining specific physical properties of the rock formations as a whole and of the variations due to the presence of invading bodies, such as ore lodes. Upon one or more of the following physical conditions the various methods are based (Krahmann):

(1) Specific gravity, density or gravitation, and their total changes:

(2) Magnetism in horizontal and vertical directions and its intensity:

(3)Electric earth currents or static electric properties as they appear, for instance, in the outcrop of many lodes:

(4) Radio activity such as observed in large faults and in certain deposits.

(5) Geo-thermic properties occurring as irregularities in the increase of temperature towards the centre of the earth:

(while these properties can be ascertained by suitable instruments to be permanently present under the earth and observable at a distance, it is necessary in order to establish the following not less important properties to produce artificially a particular condition by suitable means. These measurable properties thus brought about are:

(6) Conductivity or resistance to artificially produced electric currents and their electric fields.

(7) Permeability or reflectivity in regard to artificially produced electric waves.

(8) Conductivity or reflectivity in regard to artificially produced acoustic or seismic waves:

In practice the following four methods have proved of greatest satisfaction:

1. Measurements of density, specific gravity or gravitation;

2. Magnetic measurements;

3. Examination of electric conductivity and resistance;

4. Seismic measurements of the propagation of electric waves.

Investigations carried out by the electro-magnetic conductivity method depend upon the difference in the resistances offered by the various minerals and rocks in the earth to the passage of an artificially produced electric current forced through the earth.

In order to obtain some idea as to the values involved in the measurements of electric resistance, it may be mentioned that the specific resistance of one cubic centimetre is for -

Silver	0000001437 Ohms
Chemically pure water	9400 "
Ordinary glass	2500000
Sulphur	3,430,000000000000

That conveys an idea of the relative values of substances and indicates the way by which the composition of subterranean formations may be diagnosed and in some cases determined with a fair degree of accuracy The theoretical principle is set out by Khramann as follows: if by means of two or more earth contacts used as electrodes, a fairly strong electric current is passed into and through the earth, then this current in perfectly homogeneous ground (of perfectly even conductivity) will follow underground a course which when plotted has some similarity to that of the magnetic field, The lines of electro-magnetic force passing between one electrode and another flow not only in the horizontal plane but they take the same form in the vertical plane or in any sloping plane. From this it will be seen that in the presence of particularly good or bad conductors underground the normal electro-magnetic force - diagram would be deformed in such a manner as to show that the electric current would endeavour to avoid dielectric bodies and be attracted by good conductors. From the appearance of these deformations, their concentration, intensity and position in relation to the electrodes and the electro-magnetic field as a whole, deductions can be made concerning the particularly good or bad conductivity of bodies underground which are thus revealed.

Another method is by plotting, instead of the lines of force lines of equal potential i.e. lines connecting all points having equal electro-magnetic potential (iso-potential lines) between which therefore no current flows. These lines are always perpendicular to the lines of force and accordingly show the same characteristics transposed at an angle of 90 degrees. From this it will be seen that the equi-potential lines of any non-homogeneous sub-soil will show deformations corresponding to those indicated by the lines of force but transposed by 90 degrees, If thus in any area examined the equi-potential lines are found to be divergent, then this means that the same fall in potential will take place over a greater distance and therefore that the electro-magnetic resistance is relatively less. Vice-versa, a convergence of equi-potential lines indicates a considerable reduction in conductivity, or which amounts to the same thing, increased resistance at this point.

The apparatus hitherto found to be the best for these investigations is that known as the "Elbof".

Other well known methods are the Nathorst, Lundberg, Sundberg Schlamberger and the Dawson (Australian), the Sundberg of late coming into prominence and replacing the Nathorst and Lundberg.

The best objects for survey by electro-magnetic line of force method are those where the mineral is either of good conductivity or where it has good insulating properties. The two extremes are, on the one hand oil and gas deposits, and on the other hand, ore-bodies. The possibility of locating other useful minerals, especially non-metallic minerals, depends usually more upon the surrounding geological formation on the spot than upon their electric properties, and can only be decided on for each individual case. Besides locating deposits it is possible to locate faults, intrusions and other structural breaks. The principal

advantage of the electro-magnetic induction (Elbof) method as compared with other geophysical methods arises from the fact of the direct influence of the deposits themselves.

The depth penetration of the Elbof method is stated to be 5,000 feet as against 1,000 by the Sundberg apparatus. A thorough survey of one square mile occupies five weeks.

The Mines Department of Tasmania has been inquiring into the several processes during the past three years, and of the Elbof process in particular since 1925. Late last year the Director of Mines witnessed a demonstration of the Dawson process in Victoria. The time is fast approaching when a staff of geophysicists will become an integral part of the Geological Survey. The initial cost will be relatively high, but in the opinion of the writer, would be returned many hundred fold as a result of stimulus to mining and discoveries of great economic value. The main objective would be the location of 'blind' lodes not outcropping at surface perhaps covered with lava flows or glacial debris, and the survey of known lodes to get an indication of their value at depth.

It would not be possible to excite the interest of all engaged in mining ventures if a great deal had not already been accomplished, and if the principles upon which these processes are based had not been scientifically and thoroughly investigated and proved sound. It is not necessary today to cite specific cases in support of this important aid to exploration suffice it to state that in almost all European States, America, Africa, Dutch East Indies and other countries these plants are in successful operation, and are being added to as requirements demand.

A company has been formed in the United States of America with a capital of $500,000 to handle the business of geophysical exploration in that country. The latest American contracts of the Elbof Company are with Gulf Production Company in Houston, Humble Oil Company in Houston, the Texas Oil Company and the Texas Sulphur Company.

Similar results have been obtained in Sweden as vouched for by the Director of the Geological Survey of Sweden in a certificate dated 9th October 1925.

This is in truth the most important post-war development in mining science.

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