

Use of Electrical Logs in Subsurface Studies in Indiana

GEORGE V. COHEE,¹ Indianapolis

Electrical logging of wells has been used to obtain subsurface data by the Oil Industry for several years. In each log two types of electrical diagrams are obtained, the self potential, which gives a record of the self potential generated naturally in a drill hole and the resistivity

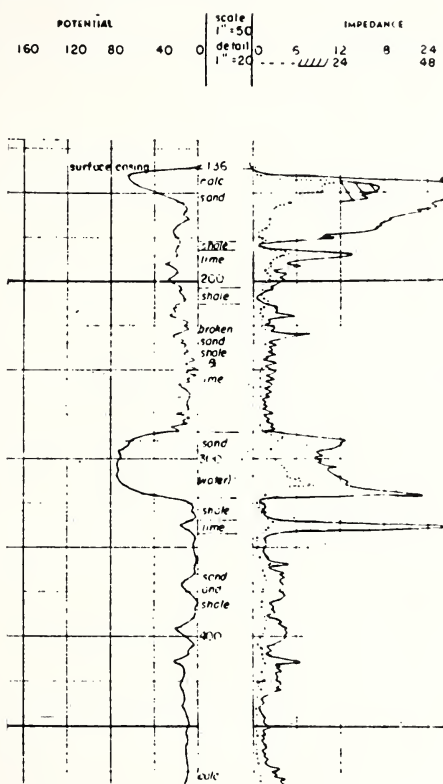


Fig. 1. Electrical log showing self potential and resistivity curves.

diagrams which are the result of the difference in potential registered by two electrodes from an electrical current conducted into the ground.

Self potential is the result of electro-filtration and electro-osmosis.² Electro-filtration is caused by the passage of the fluid from the hole into

¹ Assistant State Geologist, Division of Geology, Dept. of Conservation.

² Electrical Well Logging by the Houston Geological Society Study Group. Bull. Amer. Assn. Petrol. Geologists Vol. 23, No. 9, p. 1288.

a porous substratum or if the formation pressure is higher than the hydrostatic pressure of the fluid in the hole, the passage of the fluid into the hole. The latter condition rarely occurs. Electro-osmosis occurs when the drilling fluid comes in contact with the fluid in the formation. If the salinity of the water in the sand is higher than that of the drilling mud the current enters the formation. If the salinity of the drilling fluid is greater than that of the formation, the current enters the hole. The former case is the normal condition. Since these conditions can occur only where porous strata are penetrated the self potential diagram (Fig. 1) is indicative of the porosity of the formation.

The electrical resistivity of rocks varies considerably due to the physical character and water content (Fig. 1). The contained water may be connate, or fresh or salt water which is free to circulate. In addition to water, the pore spaces may contain oil or gas, which are non-conductors, and show high resistivity. Formations carrying salt water show low resistivity. High resistivity in permeable formations may be due to fresh water, sulphur water and oil and gas. Non-permeable formations, such as limestone, coal and well-cemented sandstone, show high resistivity.

Therefore, from the electrical log of a well we are able to determine the lithologic character of the formations penetrated, the character of the fluid content of the porous strata and we also have an index to the porosity of the formation. The electric log affords an accurate measurement of the depth to various key horizons used in contour maps of subsurface formations. Also, a number of distinctive coal horizons can be determined and correlated by use of electric logs. Although the coal beds are generally too thin to show up prominently on the electric logs, the beds immediately above and below the coal are indicated well enough to correlate the sequence of strata.

An electrical log cross-section in the New Harmony field, Illinois (Fig. 2), which connects with the Griffin field in Indiana, shows the characteristic lithology of the Chester formations in that area. Log No. 7, of the cross-section, is a sample study adjusted to the electric log of the well. Note the high resistivity and low potential of the limestone beds and the high potential and low resistivity as shown by the Tar Springs sandstone which carries salt water in that area. The Aux Vases sandstone shows fairly high self potential and low resistivity which would normally be interpreted as a water sand. Investigations have shown that, due to the large amount of calcium carbonate, cement and connate water, the resistivity curve indicates salt water, whereas actually the formation contains much oil.

Many local problems which develop in the use of electric logs are overcome when they are checked with an occasional sample study in the area. A sandstone near the surface which carries fresh water will probably appear to be limestone as there is little or no self potential developed and the fresh water will give a high resistivity reading. A well-cemented, hard, tight sandstone may appear to be limestone. Also, it is often difficult to determine the presence of oil or gas in limestone and particularly in dolomite.

Electrical logging has been employed recently in water well drilling where further information regarding the thickness and porosity of the aquifer is desired. The Illinois Geological Survey has conducted experiments in electrical logging of water wells and their results have been highly favorable, particularly so in old wells where no records have been kept.³ The Missouri Geological Survey plans to use electrical logging in

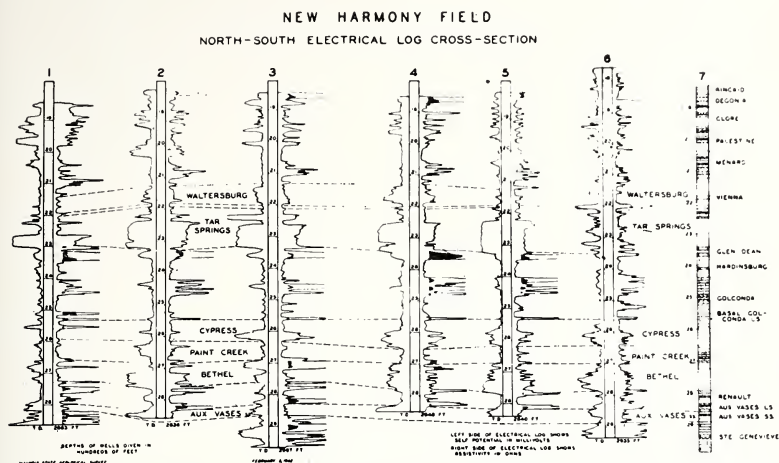


Fig. 2. North-South electrical log cross-section in the New Harmony field.

water wells, particularly in the Cretaceous and Tertiary sands of south-eastern Missouri and in the dolomite section in the water wells in the Ozark Region.⁴ In the Dolomite wells they want to determine the zones of porosity which might be acidized to increase the flow of water.

Electrical logs have been run on approximately 500 oil and gas test wells in Indiana, practically all of which are in the southwestern part of the State. The Indiana Geological Survey has received copies of many of the logs and it is contacting the operators in an effort to get all of the logs that have been run, as they will be of great assistance to the Survey in subsurface studies in the State.

³ Carl A. Bays—personal communication.

⁴ H. S. McQueen—personal communication.