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Spontaneous Potential Profile of a Given Area of Interest & Its Analysis.

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Abstract:-Basically spontaneous-potential, which is synonymous with self-potential method in geophysics refers to an electrical surveying method used for looking at electrical anomalies in the ground electrical resistivity responses of the spontaneous potential (SP) of a two porous pot electrodes with different altitudes and spacing was carried out. The aim of the investigation was to obtain characteristic signatures that may be diagnostic of similar geological targets. The method of investigation involved the burial of the porous pot electrode at different angles of inclination in sand with solution of $CuSo_4$ at equal spacing. Measurements were then taken across the conductor and the obtained data were used to generate graphs. The results indicate that, on the one hand, SP profiles delineate the electrical resistivity giving the location, information on the magnitude and direction of inclination, and quantitative estimation of the depth of burial. It is primarily used in mineral exploration and basic knowledge for oil&gas presence. Streaming-potential, on the other hand, is caused by a fluid-typically water with dissolved minerals (an electrolyte)—moving in the ground or other fluids as hydrocarbons which causes a change in voltage. This change is detected when a reading is taken.
Keywords – *Spontaneous Potential, Electrical Resistivity, SP-profile, porous pot electrodes.*

I. INTRODUCTION

The self-potential method was the first electrical method used for mineral exploration and is still used therein. In fact, it was used to find raw materials in the industrial revolution, making it extremely valuable back in the day. For those interested in mineral exploration, it’s worth noting that detecting a large negative anomaly isn’t necessarily indicative of an ore body—it could also be graphite. One is clearly more valuable than the other, though graphite can still be a great find.

Self-potential is also used in the oil industry. Oil companies lower geophysical sondes into their boreholes to measure a number of parameters: resistivity, self-potential, temperature, radiation, and more. Self-potential is used in boreholes to find porous zones, which is where the oil can exist. Like vertical electrical sounding, it’s safe to say that the self-potential method is used less today—and there are a few reasons for this. First, other geophysical methods (like resistivity imaging) are taking over the market. Second, most ore bodies that are close enough to the surface to be detected by SP have already been discovered—so those interested in mineral exploration have to look deeper. This is more difficult with the SP method.

The main purpose of this study is to learn about the application of self-potential geophysical technique for electrical conductivity to produce self potential. The basic background of this technique is similar to the classical correction process use in electrical prospection. The self-potential data are collected on a square grid in archaeological prospection. In this case, the desired anomaly is affected by many undesired polarization problems due to the shift of non-polarizing electrodes along the survey line. Thus, the known correction techniques are not sufficient to eliminate these undesired effects.

II. BASIC CONCEPT OF SELF POTENTIAL GEOPHYSICAL SURVEY

By measuring electrical potential difference between pairs of electrodes that contact the surface of the earth (or water, in water covered area) at a number of survey stations in the area of interest is the way self-potential survey is carried out. Self-potential method measure naturally occurring electrical potential in the earth. One source of these self-potentials is the “streaming potential” (or electro kinetic potential) which from the flow of fluid (e.g. ground water) through a porous medium. The stations may be along profiles or spaced so as to obtain a real coverage. One station is selected as a base station and all potentials are referenced to that point. The base station should be located at a point removed from expected anomalous activity. Potential measurements are made by contacting the earth with non-polarizing electrodes. These electrodes often called as “porous pots,” are designed so as not to create any spurious chemical potential upon contact with the ground.

Measurements are made by connecting a high impedance voltmeter between two electrodes, usually the base station and a roving electrode.

Self-potential interpretation can range from a simple qualitative inspection of the plotted self potential profiles to complex computer modeling involving subtle interactions between temperature electrochemical reactions and earth geometry. Data are plotted as profiles or, if the data provides sufficient areal coverage, as contour plot. All else being equal, the anomaly location corresponds to the maximum earth potential.

There are several sources of self potential variations which may act as noise or interference when mapping streaming potentials for hydrocarbon investigations. These includes : buried metal, temperature variations, soil property variations, electrochemical variations topographic effects and telluric naturally occurring time varying electric potentials caused by distant thunder storms and ionosphere disturbance.

2.2 Role of geophysics In Hydro-Carbon Prospecting

Geophysics plays a critical role in the oil and gas industry. Geophysical data are used by exploration and production personnel to ascertain the presence, nature and size of subsurface rock layers and reservoirs contained therein. This discipline encompasses the physics of the planet, especially its electrical, gravitational and magnetic fields, and the propagation of seismic waves within it. Terms in this field include acoustic, magnetic and zero-phase. All definitions have been reviewed by geophysicists, and many are accompanied by high-quality photographs or illustrations

Naturally occurring (static) electrical potential in the Earth. Spontaneous potentials are usually caused by charge separation in clay or other minerals, by the presence of a semi permeable interface impeding the diffusion of ions through the pore space of rocks, or by natural flow of a conducting fluid (salty water) through the rocks. Variations in SP can be measured in the field and in wellbores to determine variations of ionic concentration in pore fluids of rocks.

Electrical resistivity at the surface of the earth to measure the physical properties of the subsurface, along with the anomalies in those properties. It is most often used to detect or infer the presence and position of economically useful geological deposits, such as ore minerals; fossil fuel and other hydrocarbons; geothermal reservoirs; and groundwater reservoirs.

Exploration geophysics can be used to directly detect the target style of mineralization, via measuring its physical properties directly. For example, one may measure the density contrasts between the dense iron ore and the lighter silicate host rock, or one may measure the electrical conductivity contrast between conductive sulfide minerals and the resistive silicate host rock.

2.3 Spontaneous Potential

Spontaneous potential (SP), also called self potential, is a naturally occurring electric potential difference in the Earth, measured by an electrode relative to a fixed reference electrode. Spontaneous potentials are often measured down boreholes for formation evaluation in the oil and gas industry, and they can also be measured along the Earth's surface for mineral exploration or groundwater investigation. The phenomenon and its application to geology was first recognized by Conrad Schlumberger, Marcel Schlumberger, and E.G. Leonardo in 1931, and the first published examples were from Romanian oil fields. Spontaneous potential is a good indicator of water salinity. To understand how the SP can be used to find R_w a little should be known about the origin of the SP.

Two $CuSo_4$ solution of different concentration are separated by a permeable membrane, then ions from the more concentration solution will tends to migrate into lesser concentration. Hydrocarbon saturation may reduce SP measurements only water-bearing sands should be used for determining the result.

Self-potential geophysical surveys meaures the potential difference produced by small, naturally produced currents beneath the earth's surface, between any two points on the ground. The self potential method is passive , non intrusive and does not require the application of an external electric current

2.4 Uses

Electrodes can be placed on the ground surface to map relative changes in the SP value (in mill volts, or mV), typically with the goal of identifying the path of groundwater flow in the subsurface, presence of any ores or seepage from an earthen dam. A voltmeter measures the voltage between a fixed liquid-junction electrode and a mobile one (rover), which is moved along a dam face or over an area of investigation to collect multiple readings. Anomalies observed may indicate groundwater movement or seepage. SP can be affected by several factors that complicate the interpretation. Beside petrochemical component, SP is also affected by electro kinetic potential and bimetallism. Besides, SP is also affected by the following factors:

- Bed thickness (*h*); Since SP is a measurement of electrical potential produced by current in the mud, its amplitude approaches the SSP value only when the resistance to current due to formation and adjacent beds is negligible compared with that of the mud. This condition is met only in thick bed. In thin beds, the SP is proportionally reduced.

- True resistivity (R_t) of permeable bed; As R_t/R_m increases, the SP deflection decreases, and the bed boundaries are less sharply defined. Presence of hydrocarbons also attenuates SP.
- Resistivity of invaded zone (R_{xo}) and mud resistivity (R_m); SP increases with increase of R_{xo}/R_m
- Diameter of invasion (d_i); SP decreases as invasion deepens
- Ratio of mud filtrate to formation water salinities: R_{mf}/R_w
- Neighboring shale resistivity (R_s); SP increases with increase of R_s/R_m
- Hole diameter (d_h); With increasing hole size, the value of SP is reduced

2.5 Electrical Resistivity

Survey usually involves walking with the instrument along closely spaced parallel traverses, taking readings at regular intervals. In most cases, the area to be surveyed is staked into a series of square or rectangular survey "grids" (terminology can vary). With the corners of the grids as known reference points, the instrument operator uses tapes or marked ropes as a guide when collecting data. In this way, positioning error can be kept to within a few centimeters for high-resolution mapping. Early surveys recorded readings by hand, but computer controlled data logging and storage are now the norm. Electrical resistance meters can be thought of as similar to the Ohmmeters used to test electrical circuits. Archaeological features can be mapped when they are of higher or lower resistivity than their surroundings. A stone foundation might impede the flow of electricity, while the organic deposits within a midden might conduct electricity more easily than surrounding soils. Although generally used in archaeology for plan view mapping, resistance methods also have a limited ability to discriminate depth and create vertical profiles (see Electrical resistivity tomography). Further applications include the measurement of the electrical resistivity of concrete to determinate the corrosion potential in concrete structures.

2.5.1 Mechanism

Two electrodes are placed in the ground a couple meters apart, with one electric wire running from each electrode to the instrument. When the user takes a reading, the instrument reads the voltage difference between the two electrodes and stores the value in its memory. It's worth noting that in many electrical geophysical methods, the electrodes used are metal stakes. Metal stakes can be used when performing a self-potential survey but non-polarizable electrodes—also called "porous pots"—are recommended. The reason is that when a metal stake comes into contact with moisture in the ground a weak voltage is created, which disturbs the measurements. Using non-polarizable electrodes when performing SP measurements is the way to avoid such disturbances. Porous pots got their name as they originated as unglazed ceramic pots with a porous bottom. To be used as electrodes for the self-potential method, the pots were filled with a saturated copper sulfate solution and solid copper sulfate crystals. A copper rod was then placed through the lid and into the solution in the pot, and an electrode wire was attached from the copper rod to the instrument. This works as an electrode for SP because the metal from the copper rod doesn't come in contact with the ions in the electrolytic ground moisture —instead, it stays in contact with the copper sulfate solution which has the same copper ions as the rod is made of.

2.5.2 Study Area

The study area is LORD'S Institute of Engineering and Technology (LIET), is located on latitude 17.3187° N and longitude 78.3586° E .It is near to Sy.No.32, Himayat Sagar and surrounded by hilly areas; it is in the vicinity of TSPA. Telugu is the Local Language here. Total population of Himayatsagar is 2458 .Males are 1227 and Females are 1,231 living in 492 Houses. Total area of Himayatsagar is 278 hectares. The geology of himayat sagar region consists of igneous and sedimentary structures. The area is composed of intense process of laterisation as of the rocks went through chemical weathering.

2.5.3 Methodology

The electrical geophysical methods are used to determine the electrical resistivity of the earth's subsurface. Thus, electrical methods are employed for those applications in which knowledge of resistivity or the resistivity distribution will solve or shed light on the problem at hand. The resolution, depth, and areal extent of investigation are functions of the particular electrical method employed. Once resistivity data have been acquired, the resistivity distribution of the subsurface can be interpreted in terms of soil characteristics and/or rock type and geological structure. Resistivity data are usually integrated with other geophysical results and with surface and subsurface geological data to arrive at an interpretation.

Electrical methods can be broadly classified into two groups: those using a controlled (human-generated) energy source and those using naturally occurring electrical or electromagnetic energy as a source. The controlled source methods are most commonly used for shallow investigations, from characterizing sacrificial materials to investigating resistivity down to depths as great as 1 to 2 km, although greater depths of investigation are possible with some techniques and under some conditions. The natural source methods are applicable from depths of tens of meters to great depths well beyond those of interest to hydrocarbon development.

Possible applications of electrical methods for the development geologist range from the investigation of soil contaminants and the monitoring of enhanced oil recovery (EOR) projects to reservoir delineation and the evaluation of geological stratigraphy and structure. The application of electrical methods has been primarily confined to the onshore environment. The offshore use of some techniques is possible, particularly for permafrost delineation and shallow marine geotechnical investigations

III. EQUIPMENT USED

Fig.1 Electrical Resistivity sp- Meter

Electrical Resistivity measurement is a versatile tool in process control. The measurement is simple, fast and most advanced sensors require only a little maintenance. The measured conductivity reading can be used to make various assumptions on what is happening in the process. In some cases it is possible to develop a model to calculate concentration of the liquid. Concentration of pure liquids can be calculated when the conductivity and temperature is measured. The preset curves for various acids and bases are commercially available. For example it is possible to measure the concentration of high purity hydrofluoric acid using conductivity based concentration measurement. Benefit of conductivity and temperature based concentration measurement is the superior speed of inline measurement compared to on-line analyzer.

The method starts with two electrodes: one at the starting point (point zero) and the other at whatever spacing you've determined (we'll say 10 meters). A reading is taken here. You then move each electrode in steps: The electrode at 10 meters moves to 20 meters, and the electrode at point zero moves out 10 meters, and so on.

The benefit is that even if you measure 1,000 meters, you only need a 10-meter wire between the two electrodes. The issue is that you get an error with each reading. So when you sum all of the gradient measurements up, it adds to the error. This tends to hide any small anomalies.

IV. EXPERIMENTAL

$CuSo_4$ is added to the porous pot electrodes, thereafter these electrodes are placed below the sub surface up to a little depth distance of 5m are taken between fixed electrode and resistivity meter and resistivity meter to the mobile electrode.

4.1 Addition of $CuSo_4$

- Crystals of copper sulphate are taken and are kept for dissolving in H_2O overnight.

- Method of Mixing

Copper sulphate and Water are mixed well and shaken for 10 min in closed container and is kept for 24hrs for saturation at 28^oC.

Fig.2 Apparatus of spontaneous potential of electrical resistivity

V. PROCEDURE

1. Take the required apparatus which includes porous pot electrodes, Electrical Resistivity meter, Conductive wires, Connecting wires, Copper sulfate and water solution, a hammer and an axe.
2. Firstly dig a hole on land to a depth which can accommodate the fixed porous pot electrode. After the digging is completed adjust the electrode within the dug only the upper brim of the pot electrode should be above the ground.
3. Now the fixed electrode is connected to the electrical resistivity meter through the connecting wires.
4. Now again taking 5m distance from the resistivity meter we have to dig a hole on land and adjust the mobile porous pot electrode in it, thus mobile electrode is also connected to the resistivity meter.
5. Both the porous pot electrodes should be handled with care and should be filled with the solution of copper sulfate and H_2O.
6. Now switch 'ON' the switches of the meter. Thus the digital screen displays the Spontaneous potential profile of the taken area of interest and its analysis.
7. 10 reading of each 4 traverse is to be taken and the distance between each traverse should be 25m.

VI. RESULT AND DISCUSSION

Table 6.1, 6.2, 6.3 and 6.4 shows the observed potential and investigation dept obtained from the investigation points 1, 2, 3 and 4 respectively, Which shows the spontaneous electrical resistivity of the ground by change in the observed potential with its change in electrode spacing which gives an idea regarding the presence of ores, hydrocarbons or ground water by change in self-potential for each new spacing.

Table 6.1 Data Collected In Investigation Point 1

Sr/no	Electrode spacing(M)	Observed SP potential (mV)
1.	5m	345
2.	10m	-371
3.	15m	382
4.	20m	-383
5.	25m	386
6.	30m	85
7.	35m	-75
8.	40m	91
9.	45m	119
10.	50m	-130

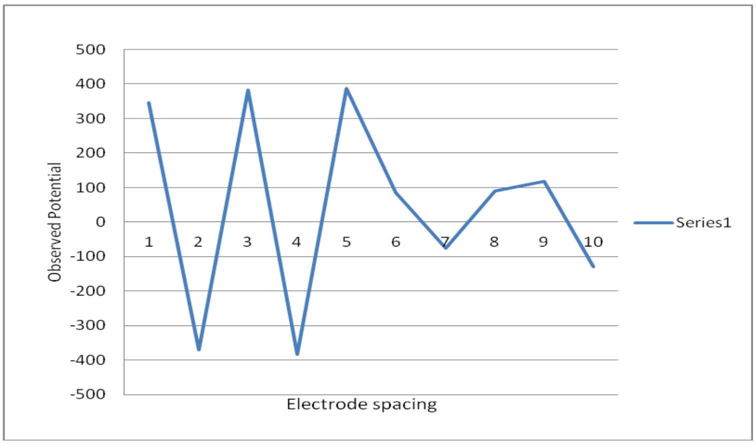

Figure 6.1 Graph of Investigation Point 1

Table 6.2 Data Collected In Investigation Point 2

Sr/no	**Electrode Spacing (M)**	**Observed SP Potential (mV)**
1.	5m	312
2.	10m	320
3.	15m	-352
4.	20m	290
5.	25m	-300
6.	30m	285
7.	35m	-259
8.	40m	250
9.	45m	290
10	50m	300

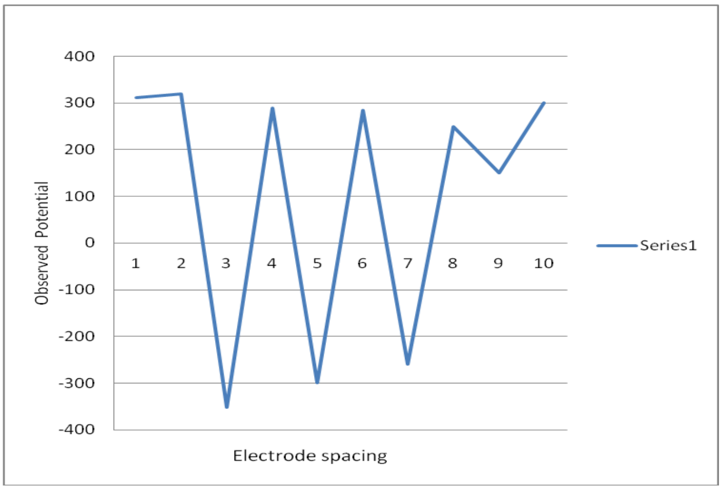

Figure 6.2 Graph of Investigation Point 2

Table 6.3 Data Collected In Investigation Point 3

Sr/no	**Electrode Spacing (M)**	**Observed SP Potential(mV)**
1.	5m	-275
2.	10m	282
3.	15m	295
4.	20m	-300
5.	25m	298
6.	30m	-270
7.	35m	-220

8.	40m	290
9.	45m	-320
10	50m	345

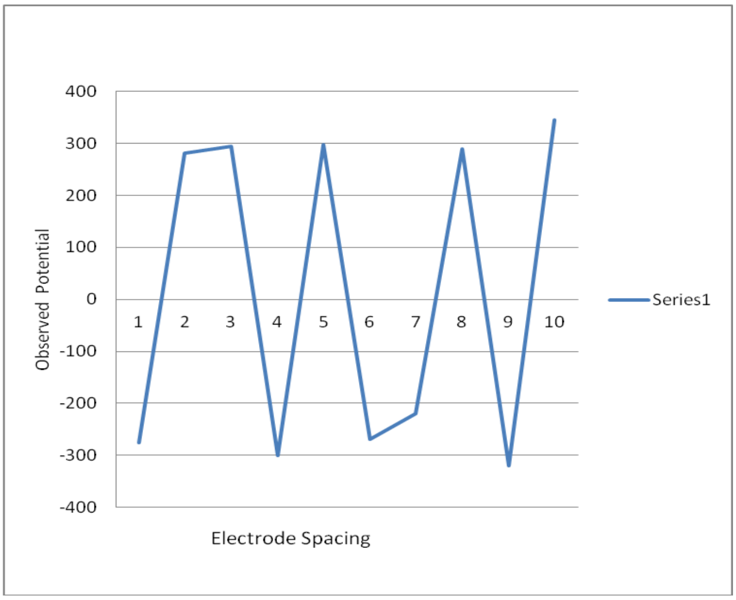

Figure 6.3 Graph of Investigation Point 3

Table 6.4 Data Collected In Investigation Point 4

Sr/no	**Electrode Spacing(M)**	**Observed SP Potential (mV)**
1.	5m	312
2.	10m	-340
3.	15m	262
4.	20m	300
5.	25m	345
6.	30m	-120
7.	35m	-130
8.	40m	300
9.	45m	382
10.	50m	380

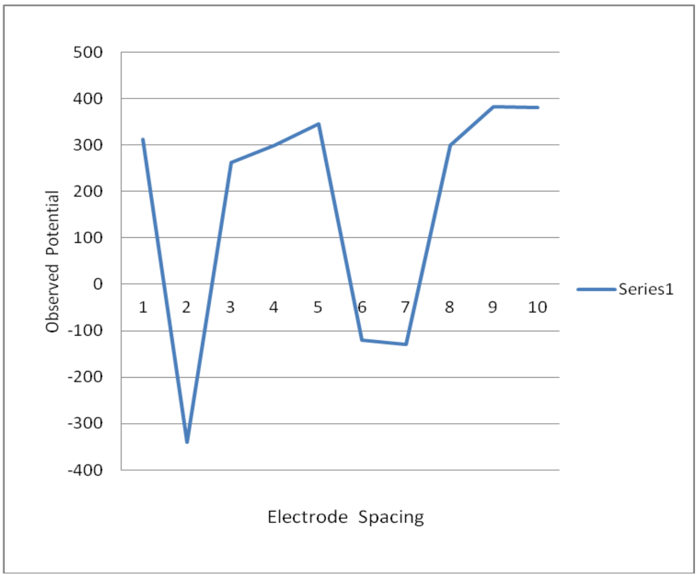

Figure 6.4 Graph of Investigation Point 4

VII. CONCLUSION

Self potential method of ground electrical resistivity is found to be very effective indicating the resistivity of ground water and ground ores movement with extremely low indication of oil&gas and along the area of investigation. Self potential method has the advantage of measuring a property of natural minerals, ores and ground water; that is what the electrical potential generated by its movement through the earth. The responses were recorded over the conductor buried at depth of 10-15 cm within sand in a porous pot electrode. The recorded data were presented in the form of graphs. The SP profiles delineate the conductor better giving the location, etc.Result obtained were within a limited area of experimental. Self potential has a property that it is related to underground ores, oil & gas and ground water. The above experiment of spontaneous potential about the basic ground resistivity for the initial knowledge of the land and its properties, which helps in stating its ability to produce different types of ores, ground water and oil& gas as this experiment provides basic information regarding resistivity, self-potential, temperature, radiation, and more.

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