Geophysics
International

The Electrotelluric Survey Method And Planning

The Geophysics International Electrotelluric Survey Method is an environmentally passive geophysical technology used to evaluate the presence and relative quantity of water bearing zones in the subsurface. Information is derived by measuring the effects that telluric currents have on the earth's electric field at the surface.

Telluric currents (earth currents) are naturally occurring electrical currents which flow within the earth. The flow of these electrical currents along a subsurface bedding plane induces an electromagnetic field at the bedding plane surface. (This occurs in much the same way that an electromagnetic field is induced around a man-made power line by the flow of an electrical current through the line.) The induced electromagnetic field at the bedding plane in turn radiates an electromagnetic wave back to the earth's surface where it is detected by a passive telluric receiver. The electromagnetic wave generated at the bedding plane contains specific information (e.g. thickness and relative porosity) about the adjacent rock layers from which it originated.

Modern Geophysics International electrotelluric technology differs from the older magnetotelluric methods which attempted to utilize the earth's magnetic field to analyze telluric currents. Today's technology has significantly improved depth and thin-bed resolution and is much less susceptible to cultural interference.

Survey Planning

Introduction

An important key to a successful and cost effective geophysical survey is careful and proper planning. While planning an electrotelluric (ET) geophysical survey the following need to be kept in mind:

A) An ET Log resembles a Downhole Log: The Electrotelluric Log (ET Log) for each survey station is graphed in a format very similar to a conventional downhole log. It can be used like a downhole log and is easily correlatable with nearby well logs and other ET Logs. The cumulative survey results could be compared to the data acquired from drilling and logging multiple wells for the purpose of mapping the depth, thickness and lateral extent of lithologic units.

B) During an ET Survey, Additional Survey Stations Can Be Recorded for Minimal Cost and Time Investment: For $10 and 20 min. per station, the client may record as many stations as he desires above and beyond the actual number of survey stations he wishes to have analyzed. This allows for a much greater degree of geologic control and flexibility during the analysis phase, as the geologist and the client review the stations being generated and control which stations to analyze next.

C) All Recordings Have Future Analysis Potential: Each recording contains all subsurface information from ground level to depths exceeding 20,000 feet. The client may chose at any time to analyze any vertical window at any station previously recorded and pays only for the amount of vertical footage analyzed.

Planning Parameters

Prior to conducting an ET survey, the flowing fundamental survey design parameters must be considered: 1) availability of support data, 2) the number and quality of accessible calibration wells, 3) size of vertical window to be used, 4) spacing needed between stations, 5) station array to be used, and 6) total number of stations required. Following is a description of the design parameters:

1) Availability of Support Data: Basic support data need to be available before an electrotelluric survey can be performed. Such data includes correlated and marked downhole logs for calibration wells, a U.S.G.S. topographic map (location map), and ground level values for all recording stations.

2) The Number and Quality of Accessible Calibration Wells: Calibration wells are used to model the electrotelluric signature of various lithologies, fluids, and reservoir porosity conditions. Calibration wells are also used to obtain depth correction values needed for the ET survey. The incorporation of relevant calibration wells into an electrotelluric survey is critical for accurate data interpretation. Ideally, calibration wells will be located as near as possible to the survey stations and will penetrate the target reservoir.

3) Size of Vertical Window to be Analyzed: The vertical interval (window) analyzed at each station should be large enough to allow for a confident identification and correlation of target horizon(s). Elements that influence the window size include 1) structural complexity, 2) position of marker beds and/or secondary objectives relative to the primary objective/reservoir, 3) area dip rate and direction, and 4) distance between survey stations. In some cases more than one vertical window will be assigned to evaluate the potential of a secondary objective. However, in most cases a 250 to 500 foot vertical window is sufficient to evaluate a primary objective.

Again, the raw signal recorded at each station contains within it lithology information from the surface to basement. Therefore, at any time during analysis, the depth of investigation or the size of the vertical window to be analyzed can be modified to obtain the needed information.

4) Spacing Needed Between Stations: The lateral distance between survey stations will be controlled by the geometry of the objective geological feature and the structural and stratigraphic complexity of the prospect area.

In general, survey station spacing is classified as either "reconnaissance" or "detailed". A reconnaissance survey is designed as a preliminary investigation of an area with: stations spaced 1/3 to 1/2 the anticipated width of the objective geological feature. A detailed survey should be performed after the reconnaissance work and will focus on a smaller area with shorter spacing between stations. Detailed surveys are used to acquire a greater degree of lateral resolution and to confirm a potential drill site location.

In unfaulted areas with low dip rates and uniform stratigraphy, data correlation will be relatively simple and the distance between survey stations can be large (1320 to 1980 Ft.) without compromising the accuracy of the correlations. However, in areas with complex lateral changes (e.g. faulting, high dip rate, nonuniform stratigraphy…etc.) data correlation will be more complex and closer spacing (330 to 660 Ft.) will be required.

5) Station Array to be Used: The specific station array used on a given electrotelluric survey is controlled mostly by the goal of the survey and the anticipated geometry of the objective geological feature. The station array may consist of a single drill site station with a few surrounding offset stations (drill site confirmation), one or more linear traverse lines, a grid pattern, a modified grid of selected locations (shotgun pattern), or a combination of pattern types.

A drill site confirmation array requires a minimal number of survey stations and is used mainly in development well applications. It consists of a drill site station surrounded by three or four close-in offset stations... The purpose of this array is to confirm the presence (or absence) and adjacent lateral extent of a prospective reservoir in a structurally controlled area.

A linear geological feature (e.g. offshore bar, cut and fill channel, up-dip pinchout, fault….etc.) requires one or more linear traverse lines oriented perpendicular to the anticipated axis of the linear geological feature.

A rounded or oval shaped geological feature (e.g. fluvial point bar, four-way closure….etc.) requires two linear traverse lines which are perpendicular to each other and intersect at the anticipated center/apex of the rounded geological feature.

If the orientation of the objective geological feature is uncertain or erratic, a grid pattern or Shotgun pattern can be used to resolve its preliminary geometry. A more focused approach may then follow the initial survey work.

To maintain a greater degree of correlation control, it is always best to incorporate calibration Welts into the station array. A sequence of step-out stations from a calibration well allows for more accurate point-to-point correlations. However, this will not be possible if the nearest calibration well is not within or immediately adjacent to the survey station array.

If a large lateral jump from calibration well to station array is necessary, it is recommended that a "reference station" is established in the middle of the objective geological feature. This reference station will have an expanded vertical window to allow for proper correlation with the calibration station and identification of the target horizons. Other stations are then offset from the reference station.

6) Total Number Of Stations Required: The number of stations required is directly related to the objective of the survey, the cost of the survey, the size of the area being surveyed, and the geological complexity of the area. An electrotelluric survey can readily be applied to evaluate one drill site location (drill site confirmation) or a 640 Ac. tract, i.e. needing as few as four work stations to as many as thirty stations plus. However, the "average survey" objective is to map a single prospective reservoir within a 60 to 120 Ac. area. Such a survey will require about 7 to 10 stations.