Log Before You Drill

By Philip Goldstone

DALLAS-When one reviews the history of geophysics over the last 50 years, there is the impression of simple ideas becoming complex. Seismic began with a simple energy source and recording system that allowed a geophysicist (often called a computer in those days) to work with a geologist in the field, and together map an area. Today we are mostly specialists producing data in different formats that only another specialist with similar training can understand.

All methods of exploration today playa roll in finding new sources of energy. What I am proposing is a greater effort toward integrating appropriate methods to maximize the chance of finding oil or gas while doing it in a cost-effective manner. We need new and better technologies that will give the industry more useful information for less cost and present it in a manner that is understandable to all explorationists.

One recurring theme of independents is the difficulty in raising capital for drilling. Prospects need to be presented in a manner that potential investors can evaluate. The best prospect may not be drilled if the facts presented to investors are incomplete or incomprehensible. It is therefore important to use an exploration method which will clearly convey your best judgment about a particular prospect.

The Petro-Sonde Method

The primary energy source for the Petro-Sonde method is the sun. Low velocity proton streams emit from the sun and travel into space. Some of this energy reaches the Earth's outer atmosphere where it strikes and distorts the Earth's outer magnetic field. This action creates electromagnetic waves which pass through the ionosphere where an energy enhancement takes place and the waves take on their pulse characteristics. These pulses strike the surface at a rate of 10-14 per second. At the surface, the electrical portion of the pulse is canceled and most of the magnetic energy is lost. A small portion of the magnetic energy will penetrate the air ground interface, recreating the
electrical field in the Earth.

The magnetic pulse travels vertically through the earth until it reaches a change in conductivity caused by change in lithology or fluids. At the conductivity interface an electrical current is induced and an electromagnetic pulse is created containing wave lengths of thousands of feet and frequencies which range from zero to 2,000 hertz depending on the depth of occurrence. The typical frequency response at 3,000 feet will be around 10 hertz. The frequency response will vary at depth according to the average conductivity as measured from the surface to the rock or fluid interface.

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A new electromagnetic pulse (a local electromagnetic field for each interface) is created and radiates to the surface where the electrical portion of the pulse combines with the electrical field beneath the air-ground interface, causing a doubling of the field strength at a particular frequency within a bandwidth of frequencies which are possible at each depth. The extremely long wave lengths allow for the imaging of any subsurface point with negligible energy loss.

The Petro-Sonde instrument selects different frequency bands by employing a high cut linear filter which allows the Petro-Sonde geologist to dial the instrument (tune the filter) to any specified depth. The geologist will then slowly dial through a range of depths listening for changes in degrees of pitch (zero-low-medium-high frequency responses) which will tell him he has crossed a rock or reservoir boundary. Although actual frequency responses in the earth are very low, the Petro Sonde accentuates the changes caused by a material change (change in electrical properties of each strata) and places them in the audible range for interpretation.

The Petro-Sonde Alone

The Petro-Sonde method gives the oilman three important pieces of information. The depth of formation, the thickness of formation, and an indication whether the formation contains hydrocarbons. The latter is accomplished by a signature recognition of the detected signal because of the unique wave pattern created when the wave passes through a fluid or chemical precipitate zone. For example, oil, saltwater, fresh water, gasses associated with chemical precipitates, coal and certain minerals all have recognizable and repeatable patterns which can be used to determine their presence or absence in a formation.

Depending on the zones of interest, the extent of the survey will depend on the area being surveyed and the subsurface geology to be defined. If the operator wants to know the extent of a blanket sand and knows the depth within 200 feet, a grid can be constructed using wide spacing (600-1,000 feet between readings) with each reading taking less than 30 minutes.

On the other hand, in an area where there are unconformities, meandering sand channels, large fault displacements and rapidly changing stratigraphy, closely spaced readings (200300 feet) will need to be taken to resolve the finer detail. When displacements can be plus or minus 200 feet from the last drilled location, then a minimum of a 500-foot interval needs to be read to be certain of detecting the faulted horizons.

The time spent on a Petro-Sonde survey will depend on the interval read at each station, the geology of the area and the subsurface complexity, coupled with the detail requested.

As a ru le, the number of stations read on a lease should return the amount of information needed to make an intelli
gent decision on which location has the best chance of making the most successful well. If a structure or iso
pach is called for, then a grid pattern will be needed. An offset between two producing wells may only need one or two survey lines between the two producing wells and a cross section.

The first thing the Petro-Sonde geol

agist will do when arriving on location is to calibrate the instrument. This is done by taking a reading next to a producing well, producing a Petro-Sonde log in the field and determining how many feet error there is between the well log and the Petro-Sonde log.

A compensation adjustment is then made to the Petro-Sonde instrument, bringing it in line with local conditions. This is a good juncture to introduce adjacent field and wildcat situations. Calibration is essential for correct depth readings (plus or minus five feet of true depth is the maximum error once calibrated). Uncalibrated or infrequent calibration can give us a maximum error of 25 feet. Because the Petro-Sonde method determines thickness of beds by detecting changes in average conductivity from the surface to the bed, determining thickness of beds never varies more than a couple feet of true thickness regardless of the circumstances.

Error in a wildcat situation is introduced by a lack of familiarity with what actually lies below the ground and what the readings mean. Still, if used properly, the Petro-Sonde method can be used in all situations.

What the Petro-Sonde geologist does in the field is create a hand drawn graph showing all the lithology breaks in a predetermined interval, and note at which zones oil, gas or water has been detected. The field notes are expressed to Geophysics International's home office in Dallas where a computer generated log is created. The Petro-Sonde log is in standard log format and scale, and can be used in conjunction with well logs or correlated with other Petro-Sonde logs to create geologic maps that define both the structure and stratigraphy of an area. Oil, gas or water can be superimposed on the maps, allowing the geologist to make sense out of the subsurface conditions.

Because the principles on which the Petro-Sonde is based are similar to the principle of the dual induction log, we can see an exceptionally good correlation between the two. We like to say that every time the Petro-Sonde is used it is like having a dual induction log reading done without having to first drill a well. The operator can have 10 or 15 of these done a day for a fraction of the cost of drilling a well.

In Conjunction With Other Methods

The best use of the Petro-Sonde method is in pin-pointing the optimum location for drilling. If the area of interest, both on the ground and beneath the earth can be narrowed to one area and depth interval, then the PetroSonde, with its ultra high resolution and depth pinpointing abilities, can determine the exact ground location, depth and thickness of pay. In many cases seismic can give us an idea of structure but is poor at determining the thickness of strata at the deeper depths.

Since the Petro-Sonde technology is primarily based on differentiating conductivity changes, we can resolve a three-foot bed at 10,000 feet given a large enough conductivity contrast (change in lithology) between the layers. Seismic works well in locating areas of interest for the Petro-Sonde to follow and do the detailed work.

Large scale reconnaissance methods; satellite, magnetic, gravity, and geochemical, all serve to give us anomalies which allow the client to narrow the area of interest and either bring in the Petro-Sonde directly or use seismic to further reduce the area to one which will be most cost effective for the client.

Coming In August

Insight into areas of research and development of improved drilling fluids to meet the challenge of today's exploration needs, plus the development of non-toxic, environmentally safe muds are featured in *The American Oil & Gas Reporter's* annual report on drilling fluids.