# A "PASSIVE" COAL EXPLORATION METHOD

AS PRESENTED
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## 1.0 INTRODUCTION

We have come so far with exploration methods in the last 100 years. Cable-tool drilling was an economical breakthrough over exploratory shafts and drifts. Rotary drilling using water or "drilling mud" was of great benefit to the exploration budget. Portable air compressor packages opened other drilling doors. In recent decade's geophysical logging, bit designs, and geophysical surveys have assumed their special place in exploration. All of these methods still have their place in today's exploration programs. But we have always wished for a "little black box" capable of outlining mineral deposits.

Such a "black box" can be added to these previously mentioned exploration techniques. A passive geophysical instrument called the Petro-Sonde is marketed by Geophysics International of Dallas, Texas. What makes this instrument unique is the small size and portability. The instrument's usefulness has been successfully demonstrated in the fields of coal, oil &gas, hydrology, metallic and non-metallic minerals. This presentation specifically addresses the instrument's application to coal.

## 2.0 THE SYSTEM

### 2.1 PRINCIPLE

The Petro-Sonde is a passive geophysical instrument that detects and allows the operator to analyze the electrical field at the earth's surface. The re-radiated field detected by the Petro-Sonde has its origin in the interaction of solar radiation and the earth's ionosphere. Electrical pulses penetrating the earth are "re-radiated" to the earth's surface by planes of contrasting conductivity in the subsurface. The audible signal generated by the Petro-Sonde reveals the relative differences in electrical characteristics of the target lithologic interval. Lithological composition can then be inferred, and their depths and thicknesses measured. Qualitative information is produced in a form similar to conventional resistivity logs.

### 2.2 EQUIPMENT

The Petro-Sonde instrument is a small, portable, self-contained instrument less than 15 pounds in weight. The outside dimensions are 13" x 8" x 4", perfect for a medium sized carrying case or backpack. The major components include a rechargeable power system, an electrical sensor or antenna, frequency filtration equipment for depth control, and an audio system for data collection.

The electrical sensor is used to detect the re-radiated electrical fields. The filtration equipment selects different frequency bands which correspond to specific depth intervals. This filtration is controlled through the use of both a large scale and fine scale calibration verniers. Each signal collected by the sensor from a selected depth is transduced into an audible signal. The signals are received by the operator through a set of headphones and further tuned using a gain control for sound amplification and a balance control for bass-treble balancing.

Instrument operators are degree geologists employed by Geophysics International. These geologists undergo an intensive training period averaging 120 days. After an office based orientation with the equipment, the trainee geologist accompanies an experienced operator into actual job situations. Some of the operators become specialists by area, by type of mineral deposit or both.

## 3.0 THE FIELD SURVEY

### 3.1 CALIBRATION

Calibration is very important to the success of the Petro-Sonde survey. Our survey designs are typically 3 to 7 days in length. One additional day is utilized to calibrate the instrument to the lithologic interval or intervals to be surveyed. This is accomplished by calibrating the instrument on one or more drill sites having good geophysical logs and/or core records. Our operator is given a selected interval or intervals to "read". No other information is given to our operator until his readings and his subsequent field log are completed. This field log is then compared to the drill log record and our operator can then calibrate his instrument and his ear to the same interval. This calibration technique should be carried through as many drill sites as possible during the first day.

Subsequent calibrations continue throughout the field survey. The usual procedure is to reca1ibra.te and check the instrument 3 times a day: morning, noon and at the end of the field day. These calibrations are made on drill sites having previous calibration records. This allows a statistical record to be created and maintained through the survey period.

### 3.2 FIELD READINGS

Once calibration has been completed, the field readings begin. Selection of an appropriate reading station grid is dependent on the type of problem to be resolved. A staggered grid method with stations placed every 3 to 5 acres appers to be the most versatile in terms of stratigraphic control. Grid station locations are surveyed and pre-staked or the locations are staked as the field readings progress and surveyed later. Dependent on the topographic relief, vegetation cover and map quality, surveyed locations may not be necessary.

Unlike drill holes, Petro-Sonde readings are very selective about a stratigraphic interval. Most properties having drill data have developed structure maps on the seams of interest. Using these structure maps and a topographic map, projecting the depth to the seam or seams of interest is easy. A 100 foot reading interval surrounding each horizon of interest appears to work best for developing stratigraphic control.

### 3.3 LIMITATIONS

As with any exploration technique the Petro-Sonde system has certain limitations. Most of these limitations relate to weather conditions. Precipitation events such as rain, drizzle

and snow "short circuit" all readings. Other atmospheric events such as approaching weather fronts and afternoon thunderheads also disrupt the accuracy of the signal. Even the soils, saturated from snow melt or rain, will not allow accurate readings.

There are some geologic limitations on the instrument. Intense structural deformations such as steeply dipping strata and overturned strata cause some reflection problems. These problems translate into relatively inaccurate depth readings. Clean coal seams less than 3 to 3.5 feet are more difficult to read than the thicker coals. Multiple bands of high ash material within the coal seam effect reading accuracy. Complex inter bedding also forces the operator to spend more reading time sorting out the multiplicity of contacts. Massive deposits of sandstone, limestone, mudstone and coal are much easier to read.

## 4.0 INTERPRETATION

### 4.1 ACCURACY

Relative to a blind guess the Petro-Sonde system is an extremely accurate system, but how accurate are the system's projections relative to the actual deposit? In our surveys, the initial reading accuracy for a 4-5 foot coal seam was found to be within 15% of cool thicknesses measured at drill sites and in underground mine. As our operator gained more experience with the area, the standard of error was reduced to less than 10%. A footnote should be added at this point. The readings for one survey were consistently less than the physically measured coal thickness. Another survey found readings to be consistent with thicknesses measured underground.

Parting thicknesses within a given seam were found to be less accurate. I believe these readings could be resolved with additional calibration sites in the areas of these parting anomalies.

Depth to the coal seams as interpreted from the Petro-Sonde logs are generally within 10 feet of known coal elevations, as determined from drill hole and mine survey data. In one area, as stations approached an overthrust fault, the coal depth readings began deviating by 20 or 30 feet. This deviation was apparently due to the steep angle of the strata in the drag fold.

When assembled into a log form, the Petro-Sonde readings resemble a resistivity log. These logs are correlated with gamma or resistivity logs from the calibration drill sites.

### 4.2 STATISTICAL THICKNESS ADJUSTMENT

On every program we run a statistical analysis on the coal thickness readings from the Petro-Sonde logs. This analysis utilizes the repeated thickness data from the daily calibrations at the drill sites. From this analysis, a thickness adjustment factor for the coal seams is developed. These adjustment factors vary according to coal thickness category. Generally the greatest adjustment factors were noted where seams are less than 4 feet in thickness.

## 5.0 COSTS

### 5.1 PETRO-SONDE COSTS

Geophysics International has sent courtesy copies of their service charges. These charges are current for call-out services in the lower 48 states. The daily rate is $3400 for each 8 hours of service excluding the 1st day of calibration. Expense charges are $400 for the calibration day and $200 a day for every day after. These charges work out to approximately $500/station for a typical survey.

The field costs are usually a function of field conditions. Rough, heavily vegetated terrain accessible only by foot is more expensive to survey then gently rolling pastures.

### 5.2 SUPERVISORY COSTS

In addition to the Petro-Sonde field operator each of our project surveys is supervised by an on-site consultant. The consultant is responsible for supplying data for calibration, selecting station locations, mapping outcrops and interpreting Petro-Sonde data during the survey. Such supervision is invaluable by allowing the survey to be immediately directed as field logs are produced. The cost of this direct supervision is dependent on rates and the amount of expertise required.

## 6.0 RECOMMENDATIONS AND APPLICATIONS

### 6.1 GEOLOGIC LIMITS

All coal seams have geologic limitations. These can be faults, splits or other types of limits. we have found the Petro-Sonde survey to be very valuable for outlining many of these features. As we locate a geologic limit, we close our grid patterns to delineate the feature.

### 6.2 MINE WORKS

We have used the Petro-Sonde system to locate abandoned or current mining works. This can be of value where the accuracy of mine surveying or past mining extent is in question. Occasionally a drill hole must intercept a mine pillar or an opening in the mine. The Petro-Sonde instrument can be used to locate the drill site for the purpose intended.

### 6.3 ROUGH TERRAIN

The Petro-Sonde instruments can be conveyed by foot or vehicle. Station readings can be made without clearing a pad or a dozer path. Stations can be located on hill slopes, stream drainages, thick timber or any location accessible only by foot.

### 6.4 MINIMUM ENVIRONMENTAL DAMAGE

As you can imagine from the previous statements, environmental impact is minimal to non-existent with a Petro-Sonde survey. No permits or bonds are required to locate stations or collect non-destructive readings.

## 6.5 RAPID MOBILIZATION

Given conducive weather conditions and the availability of calibration sites, a Petro-Sonde survey can be moved into a project area very quickly.

## 7.0

## SUMMARY

In conclusion, we have found the Petro-Sonde survey to be a valuable asset to our exploration techniques. The survey in no way will replace good drilling information or detailed geologic mapping. Combined with these and other exploration methods it is a way for us to provide our clients with accurate reserve numbers in a timely manner. At this time I wish to thank Energy Fuels Coal, Inc. and Geophysics International for their advice and comments in the preparation of this paper.

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