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Better interpretation through better data handling

Harrison T. Brundage Exploration Editor, WORLD OIL

Industry is improving its use of known exploration techniques; radical new methods are few. Search for geological significance of geophysical data spurs interpretation efforts

RECENT ADVANCES in exploration methods have developed mainly from better, more thoroughly integrated use of geological and geophysical information.

Radical new exploration tools, insofar as is generally known, have not appeared during the past year. There are also relatively few radically new interpretive techniques. Many of the more important recent exploration progress is found in better use of available data, hence there is much stress here on better data handling.

In effect, exploration personnel are working harder to utilize known methods and data better. More sophisticated instrumentation has but one real purpose applied to oil-finding —to enhance interpretive methods. Instruments are *not* being designed to provide a substitute for interpretation.

Looking ahead, there is great potential for further advances in interpretation which cannot be predicted until there is more experience with geological and geophysical data handling and processing systems now in preliminary stages of use.

NEW ONSHORE TECHNIQUES

Infrared color photogeology. Research is under way to utilize infrared's advantages over more conventional color photogeologic interpretation.

Infrared energy can be used to detect and measure properties of terrain materials as functions of heat release, rather than first surface solar reflection as in the case of visible spectrum aerial photography. Such heat release evidently can be directly related to lithology and porosity.

Vegetation changes often show more distinctly on infrared than in the more representative green; and subtle tonal changes may be seen on infrared photography, though invisible on green or black-and-white. Such vegetation changes are often related to proximity and nature of bedrock, and to jointing and fracture patterns.

Downhole television's exploration potential is beginning to be evaluated with workable equipment.[1] So far, the main effort has been to view (literally) conditions causing drilling and production problems in shallow clear-water drilled development wells.

Most of the strictly geological uses and possible adaptations mentioned in the cited literature[1] have not yet been employed. The 120° F bottom hole temperature limitation for continuous operation remains an obstacle to full utilization for exploration purposes.

A subsurface interpretive method based largely on SP characteristics of electrical logs has become popular in the U.S. Rocky Mountain region. Briefly stated, higher SP values reflect higher salinities and may indicate proximity to oil fields, whereas lower SP values may denote a flushed sand of little or no oil potential. Such methods have become further refined since originally described in an American Petroleum Institute paper in 1958.[2] A likely limitation to such methods is the association of many oil and gas fields with brackish and fresh water sediments.[3]

Geophysical interpretation. Seismic data recorded on magnetic tape continue to enjoy greater versatility for interpretation and presentation. An advantage of magnetic tape lies in ability of interpreters to correct some errors which might be found later. That is, if some seismic energy were filtered out as "noise" but later were found to have some value, additional playback and reinterpretation are readily available.

A limitation on old seismic records now being converted to magnetic tape is that, prior to the advent of tape, some filtering was done in the field which now is conducted through processing in the office. Previously, seismic energy filtered out in field recording was of course eliminated forever.

Among various new seismic interpretation techniques, a new wide-band filtering process[4] allows preservation of events with dips in a given range with no alteration over a wide frequency band. The technique seeks to separate steeply dipping events, to separate primaries and multiples, or to sort noise by velocity in a noise analysis. This is a velocity filtering method, as contrasted to filtering based on time and depth. It is reported to be effective in dip determination in some areas where high seismic noise levels have been a problem.

Another new development is a seismic dip vector plotter, adjustable on different horizons. This equipment is designed to provide information on correlative events of a specific quality only, or on combinations of good, fair, poor and/or questionable ties. It can be keyed to known subsurface geology so that, if desired, regional dip may be ignored, and areas of interpreted anomalous dip only are registered and observed.

Gravity interpretation is being improved rapidly, as greater effort is being made to determine its geological significance. Considerable current emphasis is on anomalous gravity conditions within the sedimentary section above basement.

A relatively simple concept, evidently little utilized until recently, is being used to good advantage. Specific gravities of well cuttings and cores are being determined by weighing them. Such data, when logged, sometimes provide some good long-distance correlations not otherwise evident; and allow accurate calibration of density well logs. Such information greatly aids consideration of gravity effects of the sedimentary section above basement.[5]

More attention is being paid to gravity anomalies in the sedimentary section which may *not* affect oil accumulation in any way whatsoever. The gravity method has suffered in the past from *very negative* results of drilling anomalies without regard to their probable cause. For instance, anhydrite's specific gravity is listed at 2.89 to 2.98, whereas gypsum's is 2.32.[6] A mass of anhydrite might locally be hydrated to gypsum. Either can serve as an effective cap rock in oil country. And such a facies change might cause a gravity anomaly.

The airborne gravity meter has been enhanced.[7] Evidently, with improved instrumentation, it has satisfactory resolution to provide an adequate determinant of regional gravity patterns.

A new onshore seismic shock source device under development is the air piston. Originally developed for metal extrusion, the air piston may provide efficient, vertically-directed impact, to join the growing family of seismic impulse sources.

OFFSHORE EXPLORATION

Many of the methods just discussed have offshore application also, though others (e.g., photogeology) generally do not.

Shipborne gravity surveys are of greater interest, for reasons stated in the corresponding World Oil feature last year.[8] Satisfactory shipborne reconnaissance gravity survey methods are evidently being developed.

Offshore seismic methods, particularly those employing non-conventional shock sources, are evolving rapidly. The practice of utilizing gas guns only partially submerged,[9] which provided penetration to about [illegible]00 feet, has been replaced by a more efficient gun which operates totally submerged and provides about 10,000 feet of penetration.

Another adaptation is a "sled," housing the gun(s) and towed from a survey boat.

More attention is being given to minimizing noise in hydrophones caused by their motion in the water. A mechanism has been devised to spool out the cable in 3-second intervals, compensating ship movement and currents, so that the hydrophones are essentially motionless during these periods (which are coordinated with the shots).

Another technique, developed in Cook Inlet, and applicable to other such strong tidal current waterways as the Magellan Strait,[10] is to shoot while drifting backward in a 10-knot tide. Improved navigation gear helps make such "backward" shooting feasible. Analogous problems were discussed in detail in the cited literature.[11]

Like so many other proven exploration tools, the offshore "sparker"[12] is being further improved. Penetration capability, formerly about 1,000 feet, is being about doubled. An improved spark source is under development.

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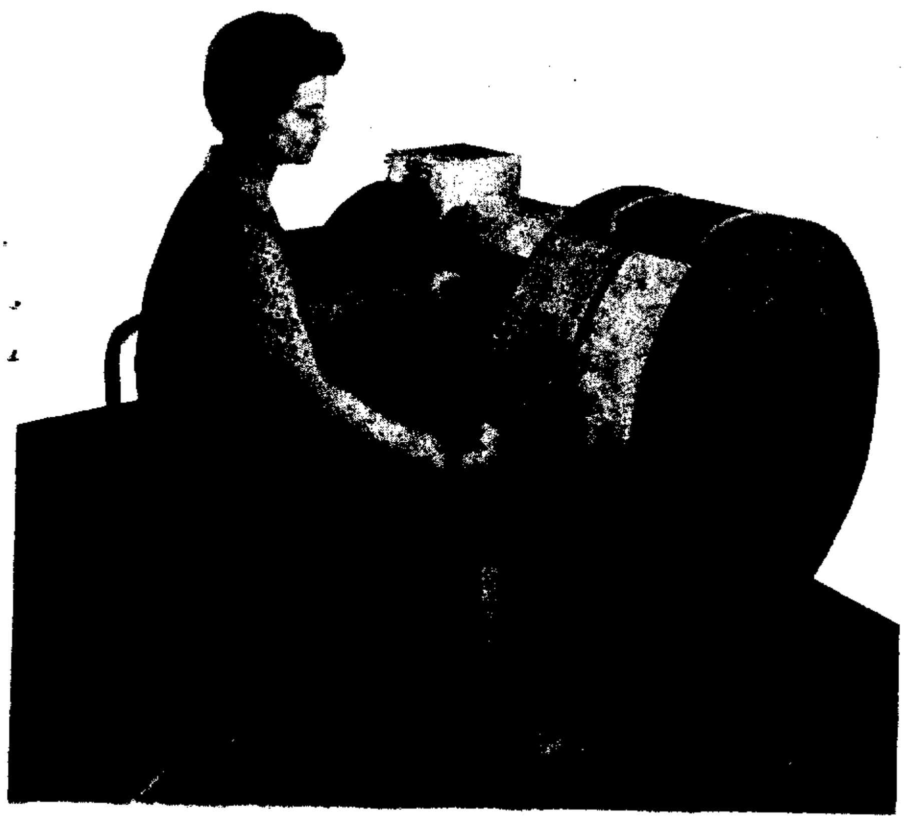

FIG. 1—Transcribing equipment in use. High proficiency may be obtained after a short period of training by personnel with no previous experience in geophysical work.

How to convert old records onto magnetic tape

Transcribed seismic records may be adaptable to new data-handling techniques

Frank A. Rotramel, Chief Engineer, Electrodynamic Instrument Corp., Houston

REINTERPRETATION, VIA MODERN METHODS, of geophysical records from surveys conducted before the advent of magnetic tape is now possible through the use of recently developed specialized equipment.

Most exploration personnel agree that there is much new oil and gas to be found through proper use of old, "in-house" data. But practical utilization of such data may constitute a problem, often because old information may have been recorded in a manner which renders it unwieldy or unsuitable to application through modern techniques.

Application of new interpretive techniques to older geophysical records is possible by converting the form of the older data to magnetic tape recordings by an instrument called a transcorder.

Several years of experience have been obtained in the use of magnetic tape in oil exploration. Many advantages of magnetic recording have been utilized in the development of improved data-handling techniques. Magnetic tape provides a permanent record of field information that can be replayed and processed; for example, different filtering methods can be applied. These tape records allow the use of automatic correction devices, thereby saving valuable time in the computations for step-out, weathering, elevation and datum plane.

What about the thousands of records made on photographic paper before magnetic tape recording equipment became available? The areas covered by these records often are no less interesting because they were surveyed before 1950. New data-handling techniques applied to these records can frequently indicate new prospects.

In many cases, new velocity information, change in lease status, or some other development makes reshooting economically justifiable. Some seismic prospects have been reshot onto magnetic tape when old paper records were available. If new transcribing techniques could have been applied to the old paper records quickly and easily in the office, much of the expense of reshooting, at from $500 to $1,000 per mile, might have been saved.

One way to enable the application of new techniques to old paper records is to transcribe the paper records onto magnetic tape. These tapes could then utilize office playback systems now almost universally available. These systems are designed to save time in the routine application of data-handling methods to seismic information.

The device for converting old paper records to magnetic tape, described herein, provides for paper records with time scales of from 7 to 13 inches per second (not necessarily constant). Paper records may be of any width up to 16 inches. Tape to which the records are transcribed may be any of those most popular in seismic work.

Records of the styles in use before the advent of tape can be transcribed at a cost to the owner of the originals of about 15 cents per trace foot. For 3-second records, this amounts to approximately $10 per record. For spreads used before 1950, the cost would amount to about $50 per mile. Transcording costs are obviously less than reshooting costs.

How equipment is used. In the process of transcribing a record to tape, the transcorder operator places the paper record on a large drum and a new magnetic tape on the tape drum. Then the operator selects datum and sets a control to establish tape-time zero. He then calibrates with a simple procedure so that tape-time is slaved to record-time, and calibrates the magnetic head circuit

FIG. 2—More direct view of transcorder shows drum speed control (dial visible immediately to right of and below operator's chin).

for amplitude displacement on an average paper-record trace. The operator then proceeds with transcription by starting the paper drum at a comfortable speed and causing a small spot of light to follow the excursions of the galvanometer trace. This is done by turning a knob back and forth which causes the spot of light to move accordingly. The control is positive enough that a new operator soon gains a "feel" for the operation. An average operator can complete the transcription of a 24-trace, 3-second record in about 1½ hours.

Facilities are provided for changing the speed at which the paper record is moved, for stopping and starting as desired by the operator and for making a monitor record in ink showing how the taped record compares with the original paper record. All components of the machine, such as light spot, magnetic recording head and monitor pen may be positioned accurately and easily.

Timing marks may be recorded on the tape from timing lines on the paper record. This part of the operation is automatic once it is started.

The transcorder may be built with one or two magnetic tape drums; with or without provisions for transcribing from one tape drum to the other. The instrument is thus adaptable to varying modes of use.

Results obtained. This device has been in use for about three years; hence many aspects concerning its manufacture and use have been determined. One surprising aspect is the high proficiency which may be obtained after a short period of training by a transcorder operator having little or no previous experience in geophysical work. Largely due to this experience, the speed of transcription has exceeded original expectations.

The degree of accuracy to be expected of the unit was a critical matter from the inception of the instrument's design. The original proposal was for a rather inexact machine, with the thought that if the new technique showed good potential, standard re-examination procedures would be activated and the transcorder would have served its purpose. In practice, the transcorder records compared most favorably with the original records. There have been continual improvements to the first models to increase accuracy.

It is pertinent to note that the making of a monitor paper record (showing how the operator followed the original) is considered unnecessary shortly after the machine is put into use.

The control used by the operator to follow the trace has been improved several times. The height of this control above the floor has been changed, based on experience gained. The transcorder is available either in unit form, or in two parts—the paper drum and tape drum being mounted separately.

Organization for efficient use. Users of these machines have found that organization of the flow of records to the transcorder operator is of importance in keeping transcribing time down. For example, calibration can often be made for several records, merely spot-checking each subsequent one, if these records were made together originally. The more fully the operator can maintain a routine, the shorter will be the transcribing time. Amount of trace overlap, frequency of the signals and individual operator co-ordination also have been cited as affecting the speed of operation. Set-up time can vary, depending on the quality of the old records.

Limitations and cost. Improvements are continuing toward more accurate transcription. Currently, an accuracy of plus or minus 5 milliseconds is easily obtainable, with plus or minus 2 milliseconds possible with increased care by the operator. Distortion is on the order of 2 percent at 100 percent modulation level. Noise is -36 decibels below the 100 percent level. The follower mechanism is arranged for a maximum excursion of two inches on the old paper record.

The transcribed tape is direct-recorded, one trace at a time, on standard 7.5 or 3.6 inch-per-second tape. Plans are underway to adapt the unit to direct digital recording on half-inch magnetic tape. ■

About the Author

Frank A. Rotramel is chief engineer, Electrodynamic Instrument Corporation, Houston. A native of Texas, he received his B.S. degree in electrical engineering from Rice University in 1950. Rotramel was engaged in design of well-logging instruments before coming to EIC in 1958. Since then he has been concerned with the design of custom seismic instrumentation.