PRESSURE-DECAY PROFILE PERMEAMETER

By

Dan Fargo
Core Laboratories, Inc.

In today's exploration climate, geologists and reservoir engineers face the challenge of producing hydrocarbons from complex, heterogeneous reservoirs. An understanding of permeability variations in such formations is necessary for optimum completion and production decisions.

Core Laboratories' Pressure-Decay Profile Permeameter (PDPK^{tm}) provides a precise method for rapidly determining core permeability and heterogeneity. These data can be used to cost-effectively identify and quantify thin, highly permeable beds, permeability barriers, and depositional/diagenetic features.

The PDPK data are usually measured from slabbed cores that have been cleaned and dried, although unslabbed cores can also be measured. The measurements can be adjusted to meet your specified sampling intervals (e.g., per centimeter, per bed) by changing the grid pattern, and a detailed permeability profile of the core can be created. The ability of the PDPK system to rapidly and accurately measure a large number of data points improves the statistical validity of these data, thus providing a more reliable permeability characterization of your reservoir. The results can be presented in tabular or digital form as well as in log or contour map format.

Profile permeabilities allow reservoir engineers to make rapid completion and production decisions. Specific tasks expedited by the PDPK data include:

- Optimizing the design of completion programs
- Determining the location and spacing of perforations
- Maximizing sweep efficiency in reservoirs

In addition, the PDPK system provides a cost-effective way to measure permeabilities of archived cores, thus facilitating the re-evaluation of previously drilled wells. The sampling density of profile permeability measurements make them ideally suited for calibrating wireline log-derived "permeability" indices.

Using PDPK data with other core and log data, a detailed signature of a facies can be built, allowing permeability predictions to be confidently extended to uncored zones. Furthermore, pressure-decay profile permeability data permit geologists, for the first time, to quantify depositional features and diagenetic alteration for enhanced reservoir modeling and simulation.

A NOTE ON THE FLUID LEVEL TRAPS IN THE SAN JOAQUIN VALLEY

By

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Traps with adequate caprock (anticlines), and with adequate updip seals (fault and stratigraphic traps) have been sufficiently treated in the literature, but the fluid level trap without an updip seal has seldom been mentioned. Yet the fluid level trap is important in that giant oil fields such as the Kern River field (½ billion bbls.) are trapped by this method. Also, this type of trap is responsible for the early discovery of oil in the San Joaquin Valley.

The fluid level is the plane of zero hydrostatic pressure. This is called the potentiometric surface or the water table where the valuable impurity oil is not present. The fluid level forms a trap because the oil cannot migrate beyond the plane of zero hydrostatic pressure, in the same way the oil won't come out of a well when it reaches the same potentiometric surface. It has to be pumped.

When the fluid surface is several hundred feet deep in a sand that is connected with the surface, there is very little evaporation. When the horizontal distance down low dipping sand beds is considered, the distance is thousands of feet. With highly porous and permeable sands little capillary pressure is involved. The San Joaquin Valley has had an increasingly arid climate since the ice age, thereby lowering the fluid level. If there had been a more humid climate an accumulation like the Athabaska Tar Sands would have been formed instead of the Kern River Field.

In other words, a caprock or updip seal is not necessary unless the oil is under some pressure. In the latter case, as the pressure increases, the caprock or seal has to be increasingly stronger and more impermeable. Therefore the adequacy of caprocks or seals changes due to deeper burial and higher pressures. Thus, under no pressure, even highly permeable sand can form an adequate seal. As the pressure increases, first a sand or silt of low permeability, then an impermeable shale or fault gouge is necessary. Also the lower the gravity of the oil, the more pressure it takes to migrate.

Where the fluid level comes to the surface, as in some river valleys, there are oil springs (seeps) or water springs, depending on the top fluid present. There are also springs that come up from fluid under pressure though an impeded channel, often a fault plane ("artesian" springs). In other words, the seal is not quite sufficient for the pressure. These springs can also be either oil or water, depending on the top fluid. Where the oil is not removed when reaching the surface, tar seals or pits will be formed.

In producing fields with fluid level traps, the fluid level can become irregular due to the withdrawal of vast amounts of fluid in one area and not another. Irregular stratigraphy then causes irregular re-entry of the water and oil to re-establish the former fluid surface. In the same way, changes can occur in the geometry of the trap due to cutting of a river channel deeper or increasing aridity lowering the potentiometric surface, etc.

Recent fluid level traps are limited to shallow depths, depending on what the potentiometric surface or water table is in that area. Also, they are for the most part limited to the borders of the basin or eroded uplifts within the basin where the oil bearing sands are exposed to the surface. The fluid level trap has low gravity oil with no gas cap. They are often in recent Plio-Pleistocene formations such as at the Kern River field and South Belridge Tulare pool, but they can be in older formations where the trap has been altered from some other kind of trap to the fluid level trap by erosion such as the Coalinga field.

If the anticlines, fault traps, unconformity, and stratigraphic traps are above the potentiometric surface, the effective trap is the fluid level. The oil will be down-dip from the highest portion of the trap, as for example the oil will be on the flanks of the anticline, where the crest is barren.

Because of the widespread drilling for water in the valley, probably few of this type of trap remain. However, in the Temblor Hills there are probably traps of this type in the Point of Rocks and other sands still not found. The potentiometric surface will be below the deepest valleys, therefore some of the anticlines and other structures in the Temblor Hills that have been drilled on the crest of the structure may not be adequately tested because of the low potentiometric surface. The west side of the Sacramento Valley is another place where there are numerous oil and gas seeps (springs) yet little has been found.

Besides the recent fluid level traps, possibly there are ancient fluid level traps that have now been converted into other kinds of traps. The unconformity traps such as at Midway-Sunset, may have been ancient fluid level traps. As the formation was up-lifted, the potentiometric surface dropped; when it was to the present position of the unconformity, the oil and the potentiometric surface was several hundred feet below the subcrop. If higher subcrops existed they would have been flushed. When this again sank, the potentiometric surface was at or only slightly above the subcrop and with slow sinking and rapid sedimentation, such as in the Pliocene, the formation of the overlying seal kept up with the pressure increase. These deposits have low gravity oil.

Sometimes the oil is sealed in place by expansion of clays or cementation down-dip from the subcrop or unconformity before it is re-covered with sediments. In this case, the oil is higher gravity.

In summary, there are three types of traps: 1) structural, 2) stratigraphic, and 3) hydrostatic. Of the hydrostatic traps, the fluid level trap has been important in the San Joaquin Valley, accounting for the early discovery of oil and giant oil fields. The fluid level trap does not need an updip seal, but the lower the potentiometric surface and the dip of the sands is, the more the oil accumulation is protected. Without hydrostatic pressure, oil cannot migrate. The oil is generally low gravity. The fluid level trap has generally been formed where no trap down-dip has been able to withstand the increasing pressures. Many of the unconformity traps on the west side of the San Joaquin Valley may be ancient fluid level traps. The Temblor Hills may not have been adequately explored for this type of trap.

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APPENDIX

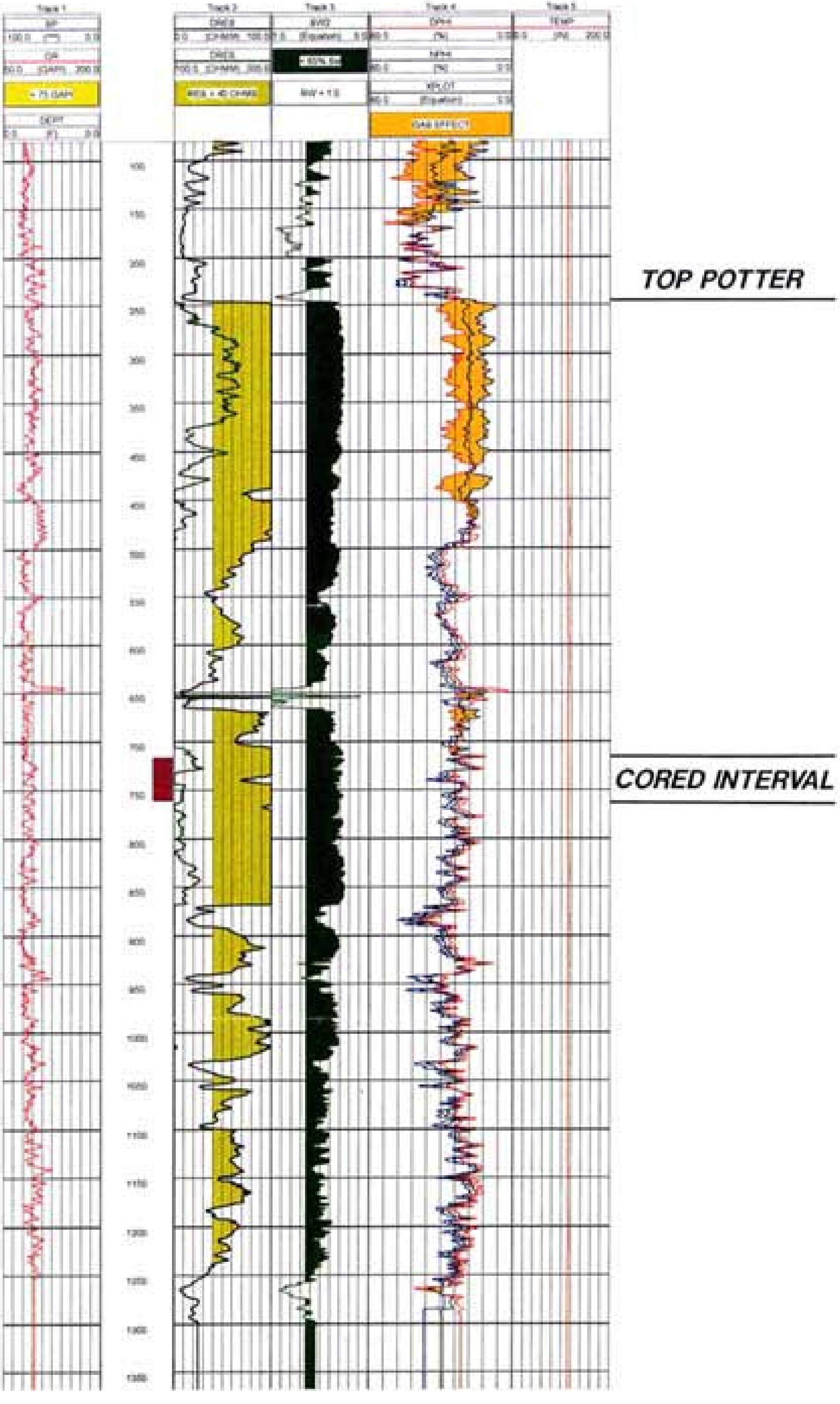
Composite Electric Logs for Santa Fe Energy Resources, Inc., Well No. 371.

Composite Electric Logs for Santa Fe Energy Resources, Inc., Well No. 232-8.

SANTA FE ENERGY RESOURCES

MIDWAY - SUNSET FIELD, Well 371-21 31/22

California Well Sample Repository
Open House
March 11-12, 1994



SANTA FE ENERGY RESOURCES

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MIDWAY - SUNSET FIELD, Well 232-8 32/23

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