CANADIAN WELL LOGGING SOCIETY

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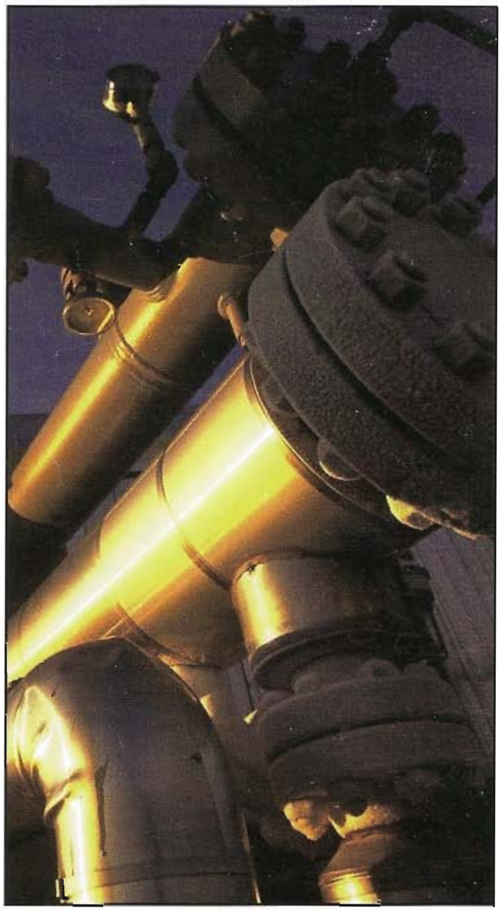
President's Remarks

As the newly elected President I would like to address what I believe to be the reason a technical society exists. From these remarks you should be able to interpret the direction which I believe the C.W.L.S. should be moving, and if you disagree or have parallel thoughts, please, by all means communicate with me.

When I first heard about the society I joined thinking the C.W.L.S. was an education and industry communications vehicle. A society where people involved in the petrophysical fields could learn and grow from each other to advance our industry and socialize at the same time. For years the only communications to the membership was the Calgary monthly meeting notice, a complimentary copy of the J.C.P.T. (which isn't that bad), and the C.W.L.S. journal once a year with a few technical articles in it. If you did not attend and socialize at monthly meetings the communication was basically one way, with zero value as a petrophysical knowledge communications vehicle.

In order for the C.W.L.S. to be of value to service anyone or anything, there needs to be two way communication of thoughts and ideas. For you to gain value from the membership you must communicate with the membership. This new quarterly technical newsletter will be one on many opportunities to communicate your thoughts and idea's to others. "in situ" is a communications vehicle for you, use it !

If you interpreted these remarks like you interpret logs, you will see pay in communications.



Glen Gray
President,
CWLS

Methodology of Shaly Sand Interpretation

Kenneth Heslop, OAKROCK Ltd.

Shaly sands, as the name infers, are sands with a shale component. These shales are a very significant component of shaly sand reservoirs. Increased volumes of shale decrease the effective reservoir capacity. At the same time, the conductive shales reduce the formation resistivity, and, if not corrected for, the hydrocarbon volume calculated. A major task for the petrophysicist is to determine the effects of shale upon porosity, permeability and fluid saturations.

Consider a reservoir continuum from clean sand to pure clay. Such a continuum is illustrated in Figure 1. Moving from left (clean sand) to right (pure clay) the clay volume is increased until all of the available pore space has been filled. Up to this point the reservoir is grain supported. Moving further to the right, the addition of clay displaces sand grains. The formation is now mud supported with sand grains as inclusions. The boundary between grain supported and mud supported rock is the sand/shale boundary.

The gamma ray log is the most common shale volume indicator. This log responds to the changes in natural gamma radiation emitted by the formation. In shaly sands the level of gamma radiation emitted is generally a function of clay volume only. The gamma ray log does not measure the volume of silts or other inclusions within the shales. Although the gamma ray log is often the best shale indicator available, it is not definitive in identifying the sand-shale boundary by itself.

It is common practice to use the maximum gamma-ray response (figure 2) as the shale point. However, it is known that shales can vary greatly in their composition. It is therefore more accurate to identify the gamma-ray response at the sand-shale boundary. Several log combinations may be used to determine the sand-shale boundary. Experience has shown that the neutron,

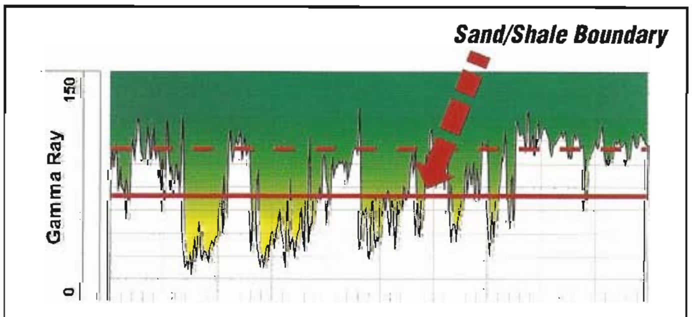


figure 2

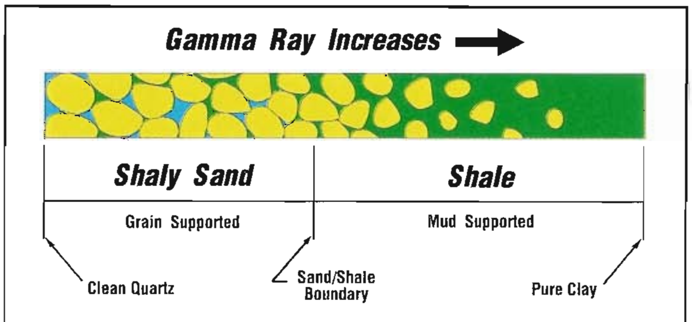


figure 1

density and resistivity logs used in combination with the gamma ray log are best suited for this purpose.

Each porosity log responds to shales and shaly sands in a different manner. A cross-plot technique is used to determine the porosity log responses for each shaly sand formation. Incorporated into this technique is an understanding of the physical principles behind the porosity log measurements.

The neutron log is measuring the hydrogen population of the formation. Therefore it records a nearly constant response through sands (Figure 3) and increases in shales. Since the population of hydrogen is nearly the same in water, oil, and wet clay, the neutron log cannot distinguish between them.

In the shale portion of the shaly sand the quartz fraction is not in grain to grain contact and the clays form the matrix. Hydrogen population is therefore no longer controlled by the pore distribution. The neutron log then measures increased hydrogen as the clay volume increases.

As a sand becomes increasingly more shaly (Figure 4) fluids in the intergranular pore spaces are displaced by clay, and the bulk density increases as the gamma ray level increases. When the intergranular pore space is filled with a heavy mineral forming a cement, the density increases but the gamma ray response is constant. In a shale, however, the bulk density remains nearly constant since an increase in the clay volume displaces quartz which has a similar density.

The combined responses of the neutron and density logs clearly distinguish between sands and shales. On a cross-plot of neutron versus density (See Figure 5) three points can be defined: the Quartz Point which is at 0% porosity on a neutron sandstone scale, and the quartz grain density (which is usually taken to be 2.65 gm/cc); the Water Point defined by the neutron and density

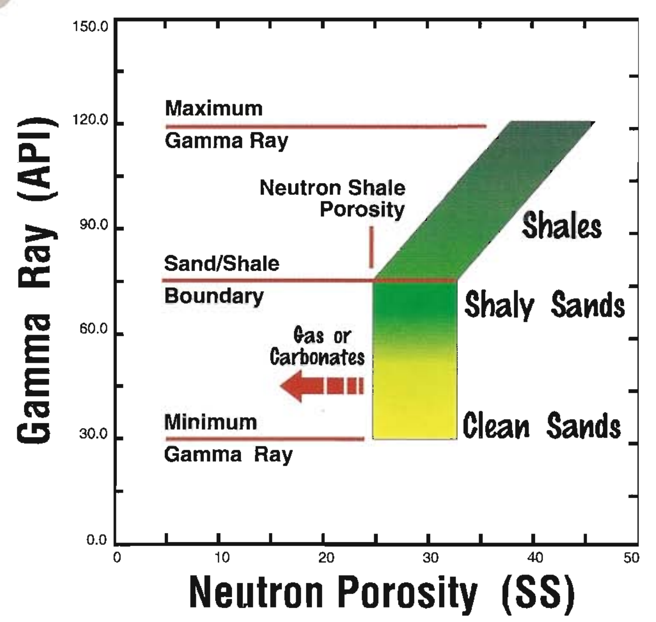


figure 3

responses to formation water (typically 100% porosity and 1.0 gm/cc); and the Shale Point determined by the neutron and density shale responses selected from the previous cross-plots. The Clean Sand Line connects the Quartz Point and the Water Point. The Shale Line joins the Quartz Point and passes through the Shale Point. The typical shaly sand response will be a lobe of data vertically between the Shale Point and the Clean Sand Line, with the cleanest sands obviously nearer to the Clean Sand Line. The effect of gas or rough borehole will be to shift

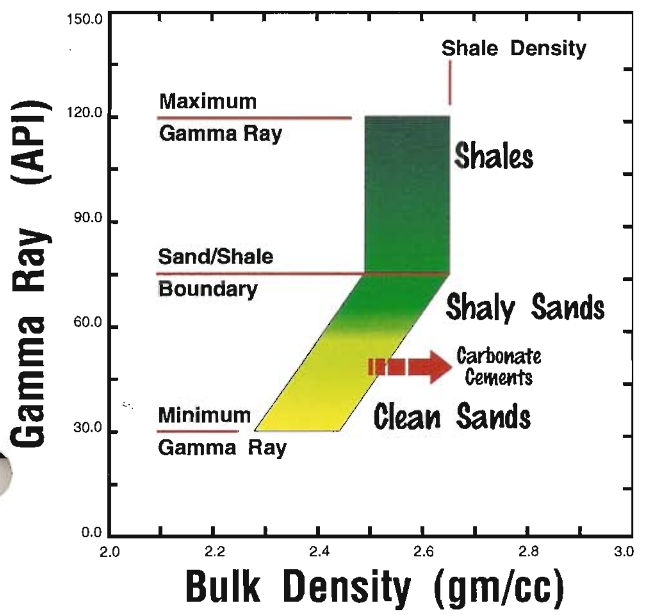


figure 4

the data across the Clean Sand Line. Cementation will tend to shift the data to the left on the cross-plot. Shale data will form a lobe of data along the Shale Line to the right of the Shale Point.

Understanding the neutron and density responses, and their relationships as seen on the neutron / density cross-plot, is very helpful in cases where the sands are partially radioactive. In such cases the correct sand/shale boundary responses can be determined from this cross-plot alone. Therefore, correct shale volumes can be determined even when the gamma ray log has been significantly effected by radioactivity.

The acoustic transit time in sands and shales are often similar. See Figure 6. Therefore, it can be difficult to distinguish between the sand response and the shale response on the acoustic log. For this reason it is not possible to apply a model similar to that used for the neutron and density logs to the shale response characteristics of the acoustic log.

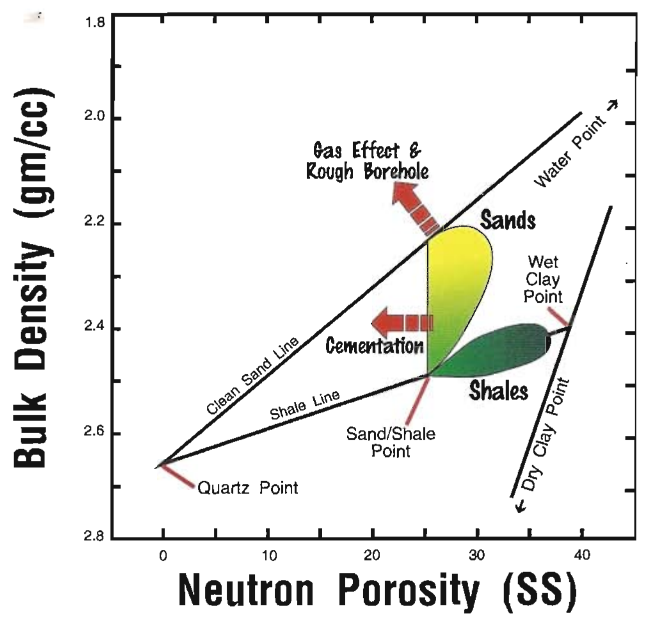


figure 5

The resistivity response for shales of common depositional environment are generally constant. It is quite common to observe shales with varying clay contents, as identified by the gamma ray log, which have a constant resistivity response as seen in Figure 7. Shales are a clay matrix with quartz and other minerals as inclusions. These inclusions are much more resistive than the clay matrix. Based upon the electrical theory for parallel circuits it can be concluded that these high resistivity

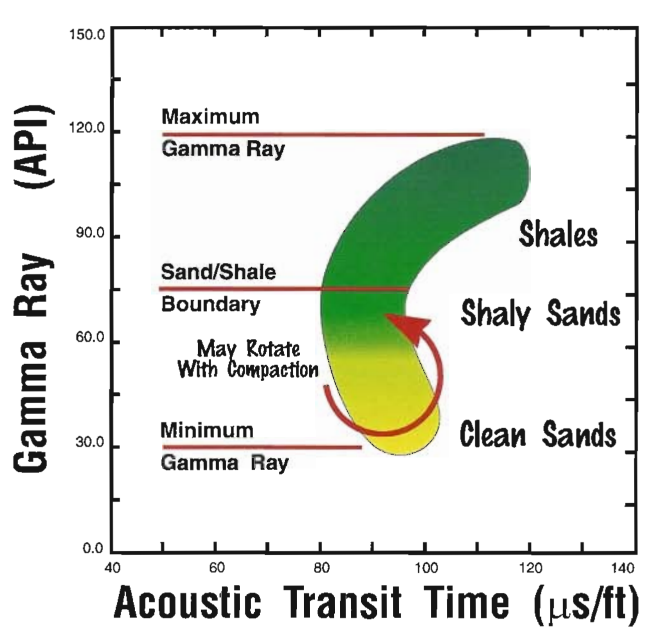


figure 6

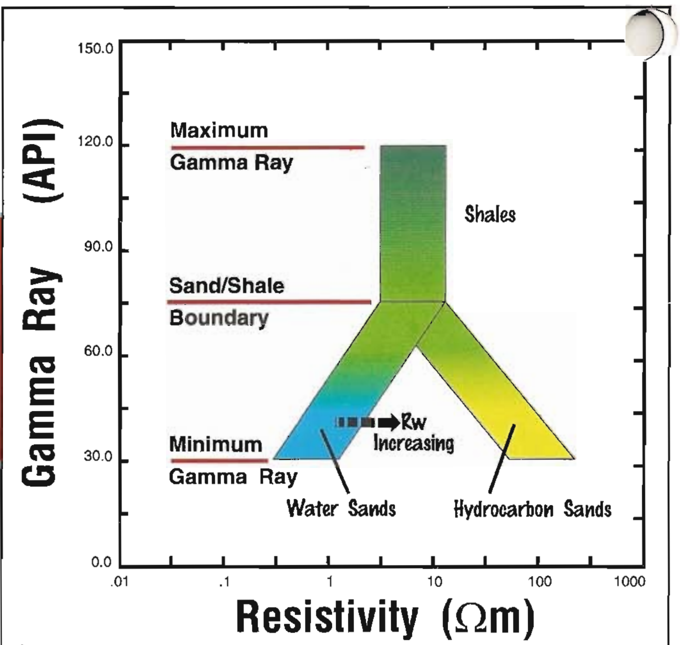


figure 7

inclusions will have very little effect upon the total resistivity of the shale. Variations in the volumes of these inclusions will also have little effect upon the resistivity.

Understanding and comparing the responses from a suite of logs allows the petrophysicist to built a shaly sand model that correctly determines the shale content and the effective porosity. An example of the results obtained using the model described here is shown in figure-8.

Shaly Sand Interpretation of Basal Quartz Formation

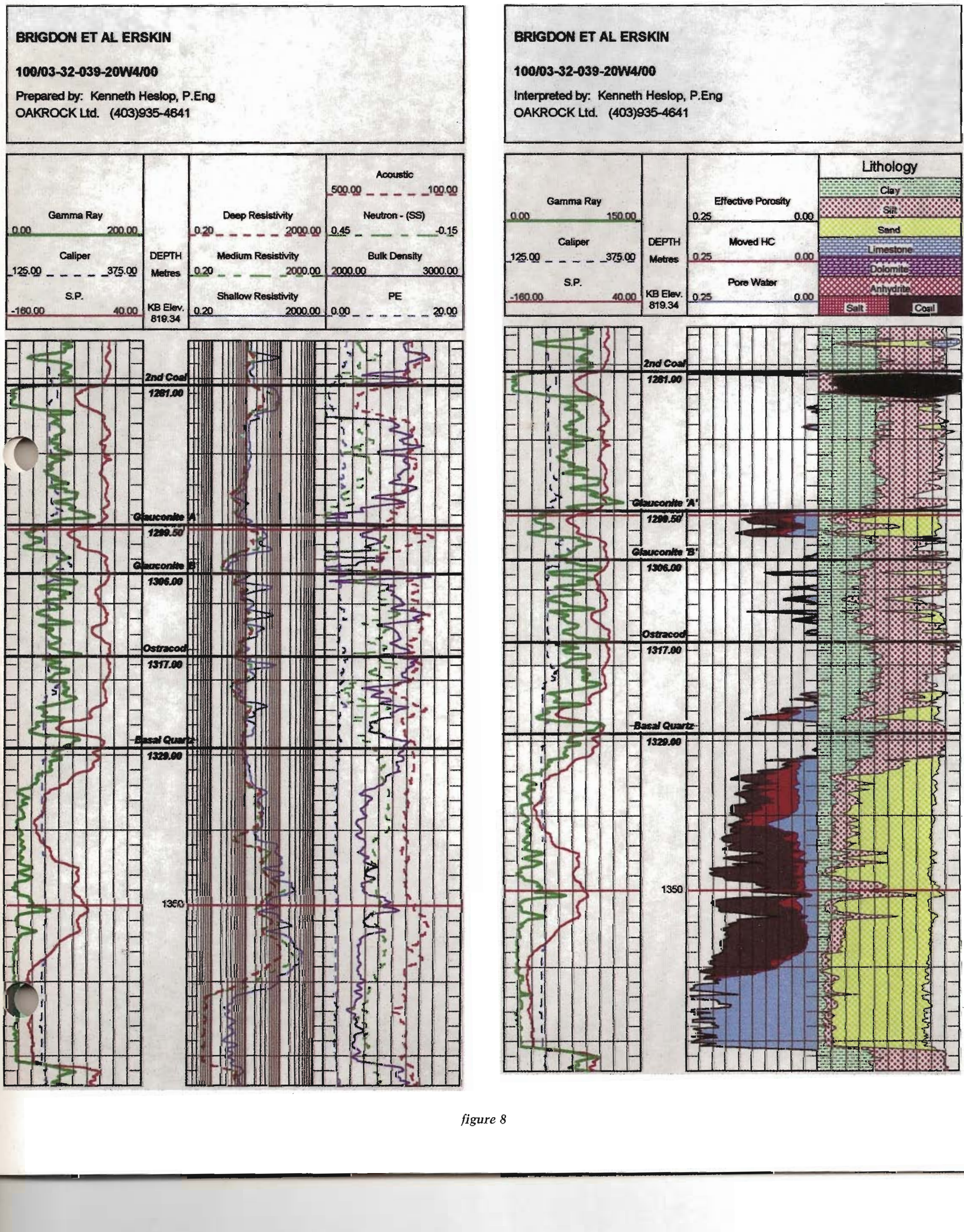


figure 8

Enhanced Formation Evaluation in Horizontal Wells, Using Residual Oil From Drill Cuttings

Rigel Energy Corporation / Howard Pitts / Core Laboratories / Marci Mills / Ken Simpson

Formation Evaluation of Horizontal Wells in the Williston Basin presently consists of viewing wellsite lithology logs(based on well cuttings). These logs, along with the estimated rock type, include estimated porosity (rate of penetration), hydrocarbon shows (staining/mud log total gas), and well-bore trajectory. Wireline logs are seldom run in horizontal wells due to cost and interpretational problems. Two powerful techniques, **Relative Hydrocarbon Fluorescence (RHF) and Thermal Extraction Chromatography (TEC)** now enhance the drilling information used in problem solving (high water cuts and lack of productivity). This combination of data can be routinely used to estimate matrix quality (i.e. permeability).

A plot of quantitatively measured fluorescence (RHF), derived from a solvent extraction process (N-Heptane) on the well cuttings, versus horizontal well depth - provides a profile of fluorescence intensity (residual oil in the matrix) along the horizontal section of the well-bore (figure 1). An accurate concentration value from the fluorescence reading is possible using reference crude oil from the well location. This standardization of fluorescence data also allows well to well comparisons.

Variations in the RHF profile form the basis for more detailed chromatographic analysis (TEC), to determine oil or water signatures on a few select samples. The TEC analysis involves heating the cuttings to 300 degrees celcius, with the extracted residual hydrocarbons passed through a chromatograph to provide diagnostic hydrocarbon signatures, which helps calibrate the RHF measurement. Numerous operators, such as Rigel, are routinely following this procedure in their formation evaluation process.

Examples of three wells (figure 2) are illustrated as follows: -Well A - Good Producer (60 m3 OPID) with a minimal watercut (2 m3 WPID); Well B - Intermediate Producer with intervals of varying rock quality (producing with high water cuts); and Well C - Poor Well with little potential.

This new development in formation evaluation of horizontal wells integrates all available data. These include the wellsite lithology Logs(rock type, rate of penetration, hydrocarbon shows), and well-bore trajectory information. Using data from offset vertical wells, and relating core derived RHF profile/TEC data to the log suite, provides increased confidence in applying this new technique. This correlation of downhole logs to laboratory measurements, provides the explorationist with two analogs not previously available; the RHF profile to the wireline gamma ray/spontaneous potential, and the TEC response to wireline resistivity. ■

figure 2

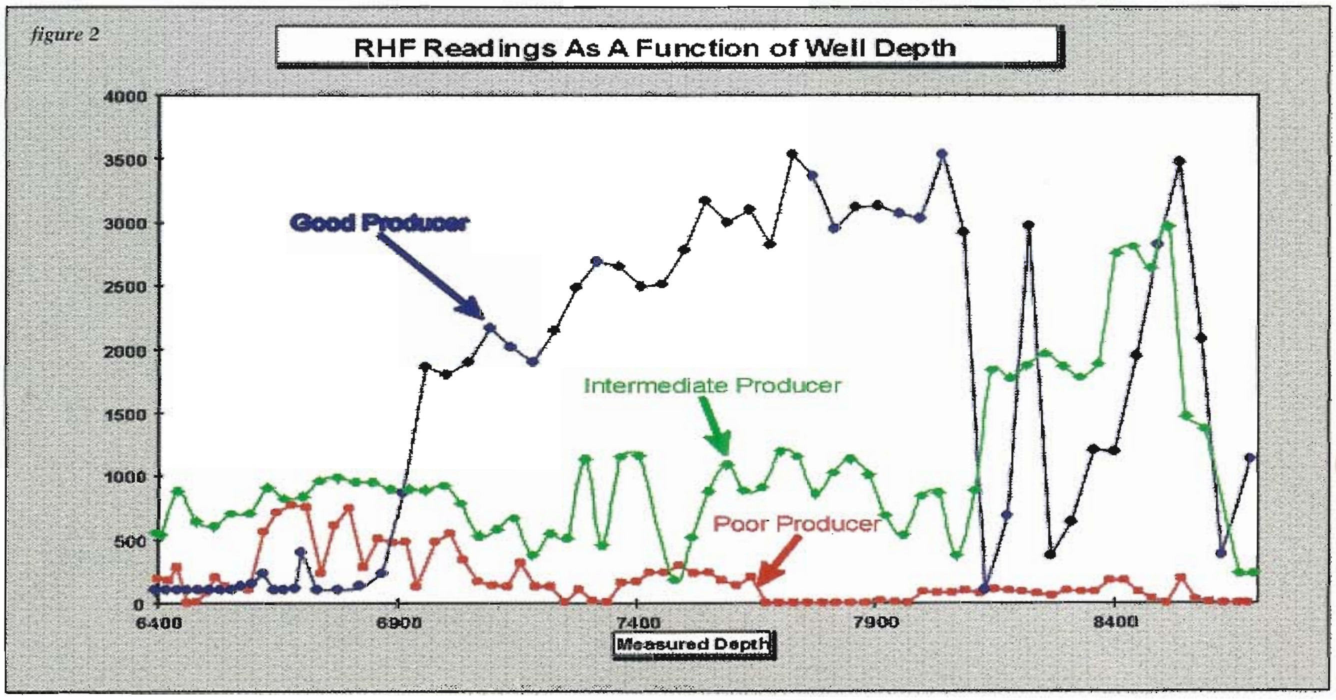
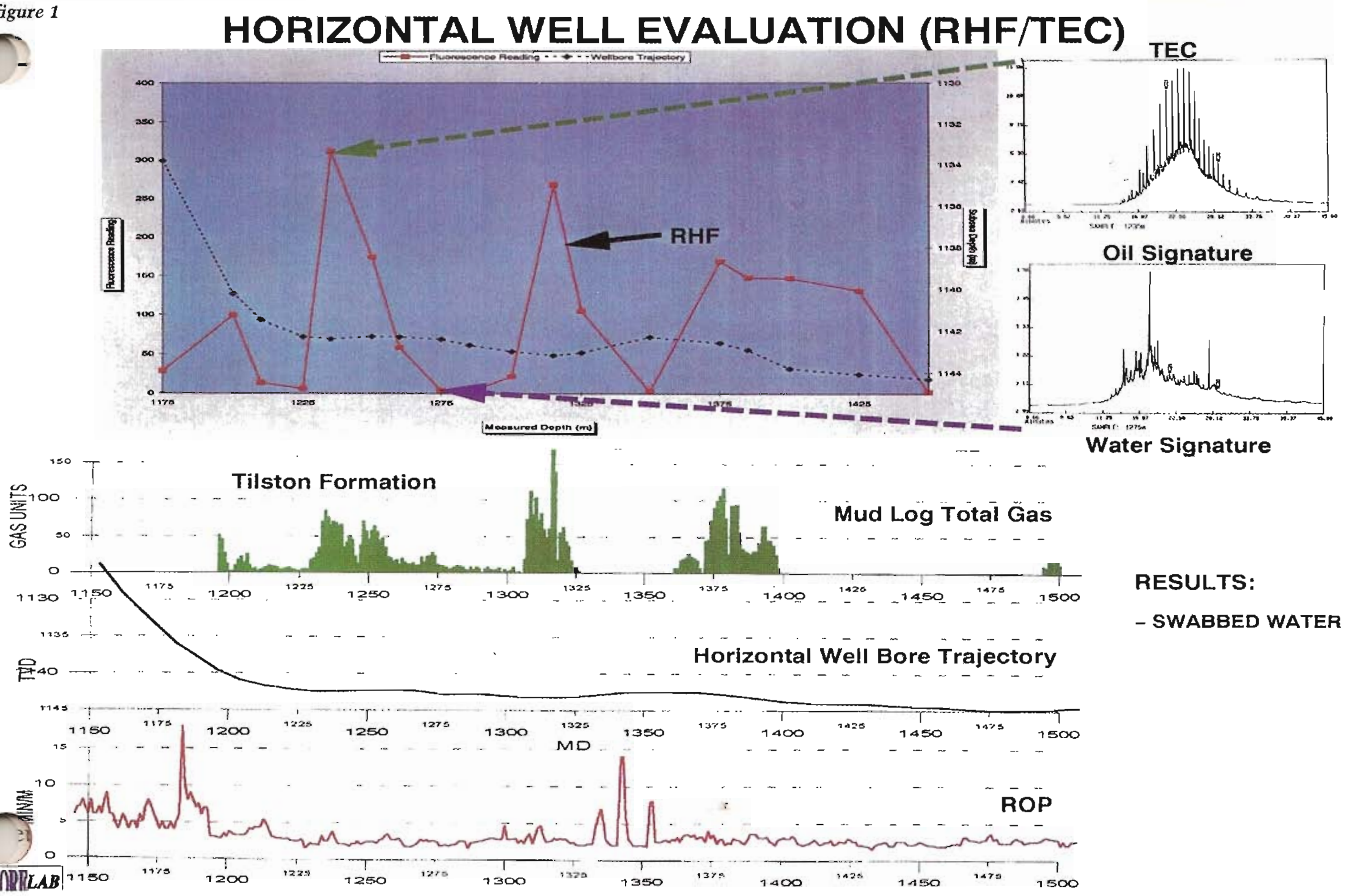


figure 1


HORIZONTAL WELL EVALUATION (RHF/TEC)
TEC
RHF
Oil Signature
Water Signature
Measured Depth (m)
Tilston Formation
Mud Log Total Gas
GAS UNITS
RESULTS:
- SWABBED WATER
Horizontal Well Bore Trajectory
TVD
MD
ROP
CORELAB

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Publisher: iDEA MACHiNE iNC.
Layout and Design: iDEA MACHiNE iNC.
Chairman/Editor: Michael Cheng, Ian F. Smith
Advertising Manager: Taras Dziuba

Advertising inquiries should be directed to the Advertising Manager or the Publications Chairman care of the CWLS office.

Issue 2, April 1997
Published by the Canadian Well Logging Society
1600, 734 - 7th Ave S.W., Calgary, Alberta T2P 3P5

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1997 Calender of Events

SPWLA	Topical Conference "Improved Reservoir Evaluation with Log Modeling" South Padre Is., Texas	April 20-24
CSPG/SEPM	Joint Convention Calgary, Alberta	June 1-6
SPWLA	Annual Symposium Galveston, Texas	June 21-26
SEG	International Exposition and 66th Annual Meeting Denver, Colorado	November 10-15
SEG	Horizontal Well Technology Trade Show Calgary, Alberta	November 17-19

Printed in Canada