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Composite Log Triplets Offer an Effective Way of Ascertaining Status of Pay Sands in a Brown Field

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Summary

The hydrocarbon producing pay zones undergo changes such as increase in water saturation and rise in free water level with time. In an old brown field where closely spaced wells drilled in different periods are available, changes in reservoir properties can be monitored at no extra cost with the help of already acquired open hole logs and production performance of the wells. This is systemized by making composite log triplets of three closely spaced old, intermediate and new wells. For nearby wells, change in oil saturation is represented by change in formation resistivity. So, a comparison of resistivity of nearby old, intermediate and new wells along with production data gives valuable information about the extent of depletion, water rise, bypassed oil and status of the pay sand. This is illustrated with examples from Lakwa field.

Introduction

The hydrocarbon producing pay zones experience changes in reservoir properties such as fluid saturations, free water level and reservoir pressure etc with time. These changes can be very prominent in the old brown fields, and knowledge of their current status is mandatory for important decisions like drilling of infill wells, work over of non-flowing or sick wells and well abandonment. Generally, the current oil/water saturation and oil/gas water contact of a pay zone in a cased hole are ascertained with the help of wireline tools like RST (Reservoir Saturation Tool) based on induced gamma ray spectroscopy and CHFR (Cased Hole Formation Resistivity) based on resistivity measurement behind casing.

Recently, the authors were entrusted a study for revival of sick and non-flowing wells of Lakwa which is one of the oldest fields of Upper Assam, India with multiple pay sands under production for four decades (Chandra, Y. and Kumar, A., 2006; Chandra, Y., Kumar, A. and Jamkhindikar, A., 2007). The study required to know the current status of the pay sands, based on which work over plan for revival of wells could be made. All geological, production and log data were integrated for the study. However, the cased hole saturation logs GST/RST and CHFR were available for very few wells only. This constraint was overcome by devising a substitute method which relies on comparison of open hole log responses of new, old and intermediate nearby wells (to be referred to as composite log triplets) along with production data. The method is described next followed by illustrations and examples.

Method

Triplets of old, intermediate and new nearby wells are selected. In an old field like Lakwa, closely spaced nearby wells drilled under different periods are easily available. For each well triplet, composite open hole logs of the selected wells in the same tvdmsl interval covering the pay sand of interest are prepared with uniform scales and put together. Such log triplets are useful not only for usual well to well subsurface correlation, but also for knowing the changes in fluid contents of the reservoir that have taken place during the course of production. This is so because logs of old well give resistivity of virgin reservoir and hence, initial oil saturation whereas logs of intermediate and recent wells give depleted oil saturation. Recalling basic theory of log interpretation, oil saturation is a function of formation water salinity, porosity, formation resistivity and petrophysical parameters a, m and n. For closely spaced wells drilled under different periods, all the above parameters except formation resistivity can be treated as constant letting resistivity represent oil saturation. Thus, a comparison of resistivity of nearby old, intermediate and new wells along with production data gives valuable information about the extent of depletion, water rise, bypassed oil and status of the pay sand as a whole. This is illustrated with three examples of Lakwa field.

Example-1

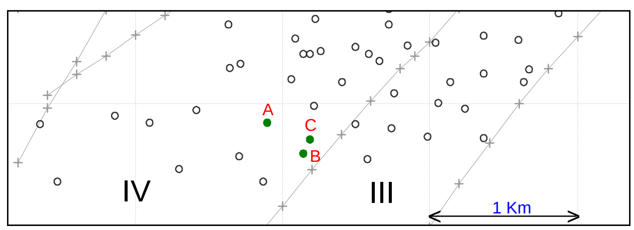
Figure 1 shows an example of composite log triplet for TS1 pay sand of Lakwa field. Well A, drilled in 1971, shows Oil Shale Contact (OSC) at 2311m msl depth and maximum resistivity of about 30 Ωm. This well started production from TS1 in Apr'74 @ 50 m^3 /d oil with negligible water cut, and ceased in Nov'95 due to low influx and high water cut with a cumulative oil production (Np) of 2,53,000 tons. Well B, drilled in 1985, falls in the gas cap area with Gas Oil Contact (GOC) at 2278m msl and OSC at 2290m msl depth.

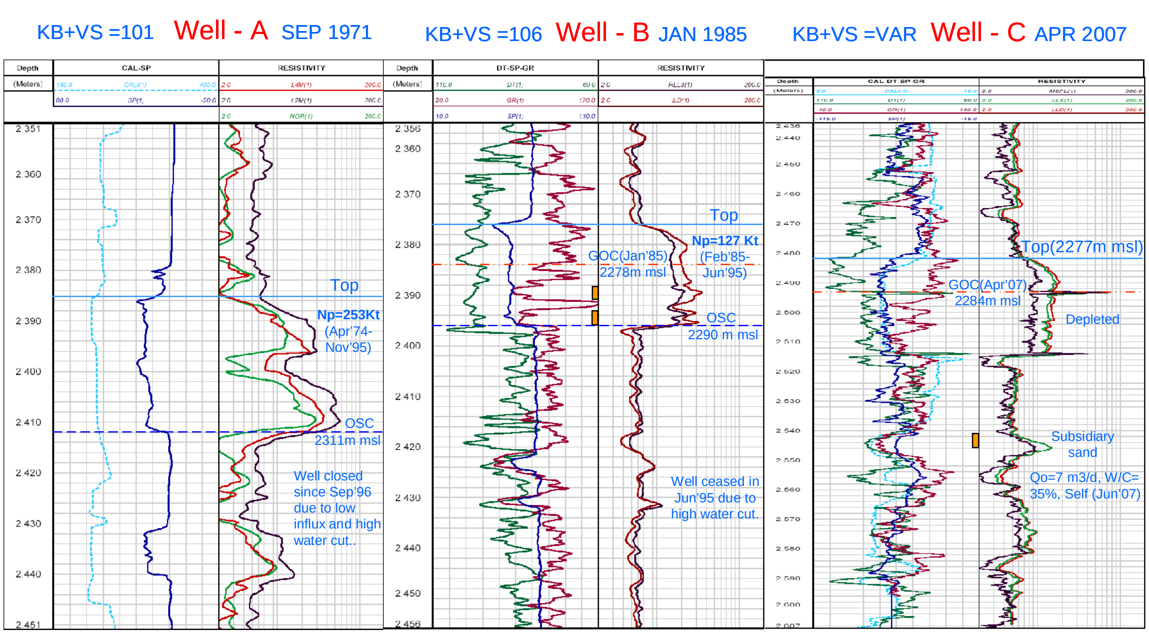
This well, completed in lower portion of the sand (below GOC), produced 1,27,000 tons oil before it ceased in Jan'95 due to high water cut. Thus, both the wells A and B ceased production in 1995 indicating depletion of the pay sand in the adjoining area. Well C, drilled in 2007, shows GOC at 2284m msl indicating expansion of the gas cap. The top gas bearing portion shows same resistivity 20 Ωm as the corresponding portion of well B. However, the resistivity of the lower portion below GOC has fallen from 25 to 13 Ωm indicating increase in water saturation. As a result, well was not completed in main TS1 sand but in a lower subsidiary sand from where it is producing oil @ $7m^3/d$ with 35% water cut on gas lift. Well A, though structurally down, produced much more than wells B and C since it was drilled and completed in early stage of the reservoir than wells B and C.

Example-2

Figure 2 shows an example of composite log triplet of Lakwa TS2 pay sand having active bottom water drive mechanism. The logs of well P, drilled in 1968, show the initial Oil Water Contact (OWC) at 2387m msl depth, and resistivity as high as 90 Ωm. Well Q, drilled in 1986, has OWC at 2360m indicating 27m rise from its initial level. Some residual oil is left below OWC. Above OWC, resistivity has fallen to about 55 Ωm indicating decrease in oil saturation. Well R, drilled in 2001, shows further rise in OWC and fall in resistivity. The water cut of this well increased from nil to 92% indicating even further rise in OWC and further depletion of the pay sand.

Figure 1- Composite Log Triplet of nearby wells A, B and C against TS1 pay sand (2250 -2350m tvdmsl) of Lakwa field, Block IV. Recently drilled well C shows gas cap expension and depletion of the pay sand. Though structurally down, well A gave more oil production as it was drilled and completed at an early stage than wells B and C.

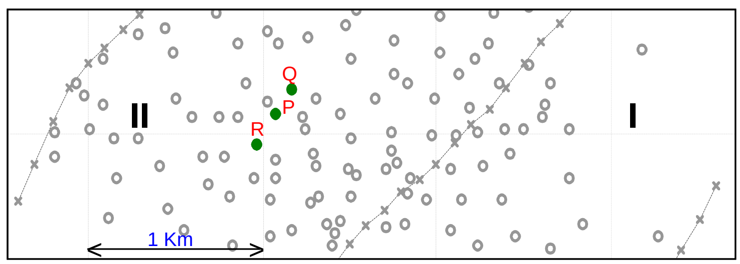




Example-3

Figure 3 shows an example of composite log triplet of Lakwa TS6 pay sand. Well X, drilled in 1965, shows initial OWC at 3113m msl and maximum resistivity of about 30Ωm. Well Y drilled in 1977 shows 7m rise in OWC but about the same resistivity as well X. Wells X and Y started production from TS6 in 1968 and 1977 respectively and both ceased in 1981 due to high water cut. The third well Z was drilled in 1995. The depletion in reservoir is reflected by decrease in resistivity of well Z. Though structurally higher, well Z produced water in initial testing. The example shows that TS6 in the adjoining area had depleted prior to well Z was drilled.

Figure 2- Composite Log Triplet of nearby wells R, P and Q against TS2 pay sand (2300-2400m tvdmsl) of Lakwa field, Block II. Wells Q and R drilled in 1986 and 2001 show 27m and 46m rise in oil water contact (OWC) respectively with respect to initial contact at 2387m msl in well P drilled in 1968.



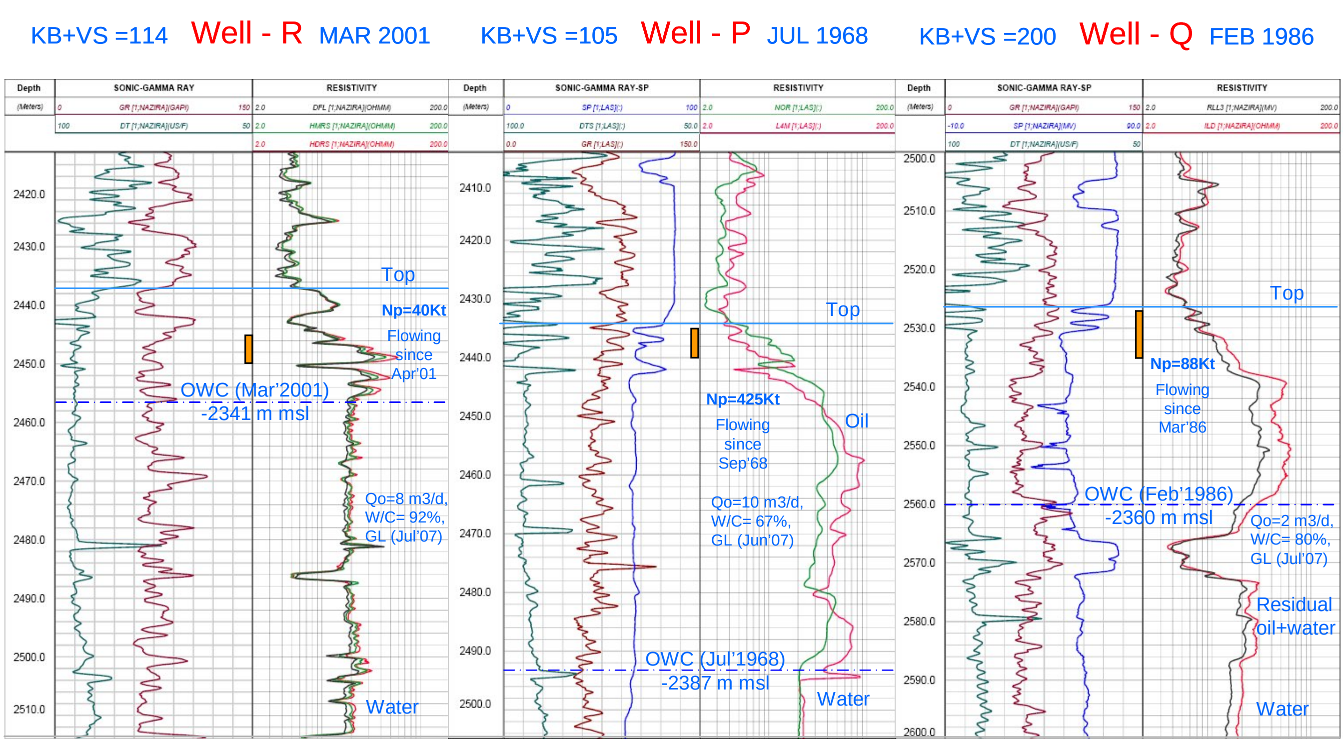
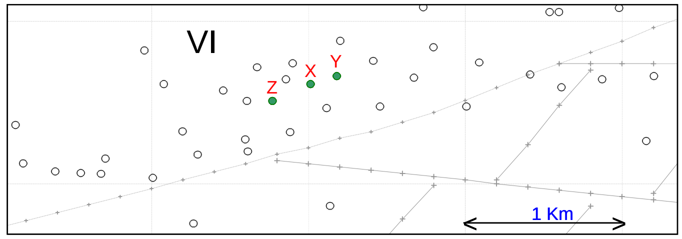
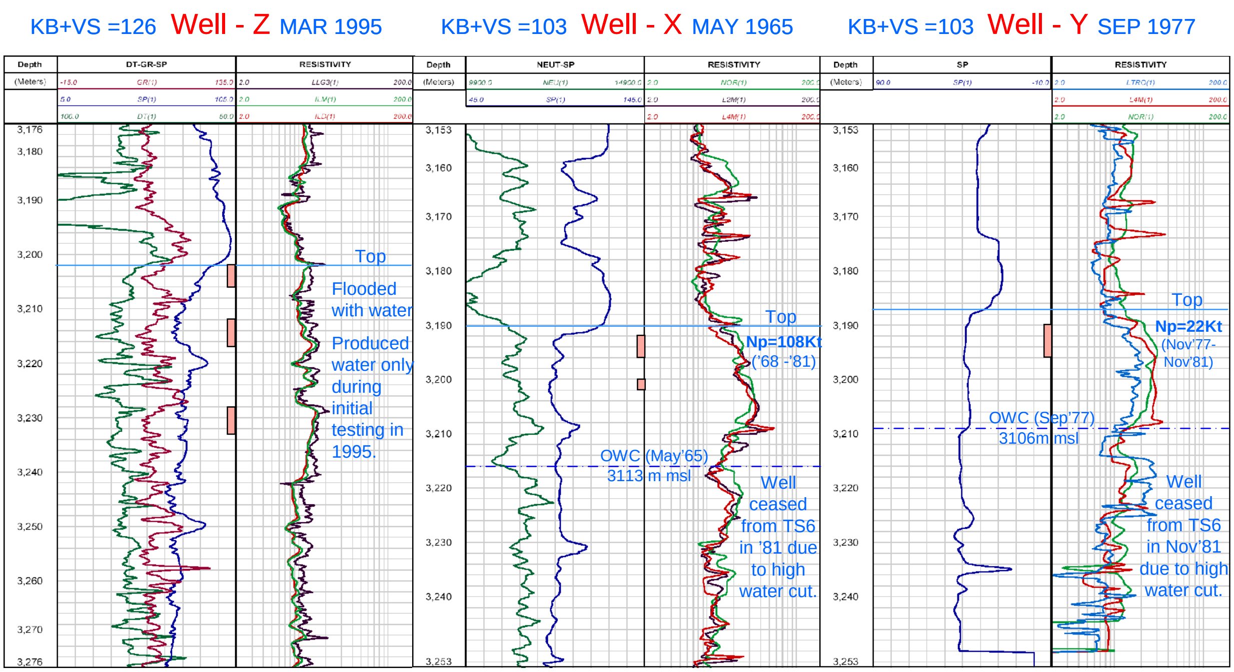


Figure 3- Composite Log Triplet of nearby wells Z, X and Y against TS6 pay sand (3050-3150m tvdmsl) of Lakwa field, Block VI. The pay sand had undergone depletion in the adjoining area prior to drilling of well Z in 1995 as is evident by fall in its resistivity. The sand produced water on testing in well Z.





Conclusions

The paper presents an effective way of looking into the history of producing pay sands and knowing their status with the help of composite log triplets and production data at no extra cost. The method has been extensively used and found to be very helpful in the analysis of Lakwa pay sands. The examples shown make it clear that, in addition to other parameters, oil saturation of a producing pay zone is also a function of time. The examples also show that wells structurally down but put on production in an early stage of a reservoir can produce more than wells located in the crust but put on production at a later stage.

References

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