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The logs vis-à-vis production characteristics of TS2 paysand of Lakwa Field, India

Ashok Kumar*, [1]Yogesh Chandra and Shri Pati Das,
Well Logging Services, ONGC, Vadodara,[1]ONGC, Mumbai

Summary

TS2, the largest and most extensive paysand of Lakwa Field, is highly permeable except its shaly silty top portion which is less permeable and fining upward. The lower highly permeable portion and the less permeable top silty portion have distinct log and production characteristics even though they are part of the same reservoir. While the highly permeable lower portion produces with high influx and generally high water cut, the less permeable top silty portion gives low influx and generally negligible water cut. The overlying subsidiary of TS2, designated as TS2S, is also less permeable and has production characteristics similar to TS2 top silty portion. A good correlation is observed between the logs and the production data for the main TS2, its silty top portion and subsidiary sand. The changes in the production performance after layer or zone transfer are in accordance with the log characteristics. An understanding of log-production relationship as expounded for TS2 reservoir in this paper is helpful in optimization of workover jobs and better exploitation of reservoirs.

Introduction

Lakwa is one of the largest fields of Upper Assam, India. It is an anticlinal structure divided by faults into several blocks. Lakwa Field has multiple paysands which have been producing for four decades, and now penetrated by hundreds of wells. TS2 is the largest and most extensive paysand of Lakwa Field. It is one of the six paysands, second from top, of Tipam Formation of Miocene age. The Tipam sands are deposited in a braided channel environment. The total thickness of TS2 sand is about 180m and the initial maximum pay thickness is about 80m. TS2 paysand is characterized by 23-26% porosity and 300-500md permeability and an oil water contact, and it has strong bottom water drive with 245 kg/cm^2 initial reservoir pressure. It is developed in all blocks of Lakwa Field.

Voluminous well data, logs and production data have been generated in Lakwa Field over the years. In a comprehensive study carried out for knowing the current status and for augmenting the production of different paysands of Lakwa Field, all the data were integrated and analyzed, and, during the process, interesting relationships among various data sets were observed and found very useful for deciding actions in respect of sick and non flowing wells. (Chandra et al., 2006 and 2007). The correspondence between the logs and production data of TS2 paysand is the subject matter of the present paper, and it has been explained with the help of logs and production data of different wells of the field.

Log characteristics of TS2

A full set of logs including NMR log against TS2 paysand in one of the wells, say well A of Lakwa Field is shown in Figure 1. The logs, especially the conventional porosity logs (3rd Track) and NMR log (4th to 6th Tracks) show massive nature of TS2 pay sand except its top portion which is silty and shaly showing fining upward character- a characteristic of channel sands. The free fluid porosity and permeability of the main paysand are about 16% and 300 md respectively while those of the top portion are much less and upwardly decreasing. Conversely, the bound water is much more against the top portion than the main cleaner sand. This is usual since finer grains with larger surface area have more bound water and lesser permeability than coarser grains. TS2 top portion has lesser resistivity than the lower main sand because of shaliness and larger bound water. Overlying TS2 sand is a subsidiary sand of TS2 designated TS2S. The

Well Logging Services, ONGC, India, e-mail: kumarashok56@rediffmail.com

NMR response against the subsidiary sand TS2S is not reliable due to borehole washout, but other logs show it even less porous than TS2 top portion.

The resistivity of the TS2 main paysand is about 20 Ωm without any break. By seeing the nature of the resistivity log, one is left wondering whether TS2 is really oil bearing or water bearing. As a matter of fact, the sand appears to be more water bearing than oil bearing. For clear understanding, logs of the present well A are compared with the logs of its nearby adjacent wells B and C in a common 2314-2400m tvdmsl depth interval (Figure 2). The first track shows SP, GR and sonic whichever available and second track shows resistivity logs. For each well, the corresponding log scales are uniform. Well B (1968) being the oldest well represents the reservoir in its original condition with initial OWC at 2389m msl and resistivity as high as 80 Ωm. (The production from Lakwa Field started in 1968.) This well ceased due to high water cut in 2005 after 259K MT cumulative oil production. Well C (1982) shows slight rise in OWC and decrease in resistivity, and it also ceased due to high water cut in 2003 after a cumulative oil production of 79K MT. Well A (2001) was not tested in TS2 as it was completed in a deeper paysand. At the time well A was drilled in 2001, its adjacent wells B and C were flowing with high water cut from TS2, and soon afterwards ceased due to high water cut completely. They could not be revived in TS2 despite water shut off jobs. It shows that TS2 in this particular area was depleted and flooded with water by the time well A was drilled. It explains low and monotonous resistivity against TS2 paysand in well A. The resistivity of TS2 below OWC (100 % water saturation) is 20Ωm, the same as that of TS2 paysand in well A. It shows that there was very small, almost negligible residual oil left in main TS2 paysand in well A. The small residual may be the result of very good permeability of TS2 main paysand and strong bottom water drive. The same, however, cannot be said about top portion of TS2 where, due to shaliness and finer grain size, the permeability and resistivity are low, and oil may be masked by low resistivity. The field experience shows that in well A, TS2 top portion might be oil bearing, and the subsidiary sand TS2S may also be oil bearing.

Logs versus production behavior

From the above discussion, we find that from production point of view, the highly permeable TS2 main sand is likely to produce at high flow rate and be prone to water cut whereas the less permeable top silty portion will have low flow rate and less water cut. We shall now consider production history of three wells X, Y and Z to examine if there is any correlation between the production behavior and the log characteristics of TS2 and TS2S. For each well, its logs and performance plot are given together (Figures 3, 4 & 5). The well performance plot shows variation of total liquid flow rate Q_l and oil flow rate Q_o with time. The difference between Q_l and Q_o curves is the water cut. For each well, the perforation interval(s) and the corresponding production performance are marked with flags and bars of the same colour, and the type of lift i.e. self, ESP or GLV are also indicated on the performance plot.

Well-X: The well has given 465K MT cumulative oil production (N_p) from TS2. In this particular well, the lower cleaner portion of TS2 paysand is thicker than its top silty portion (Figure 3). The well was drilled in 1969, and it started its production in Sep'70 on self flow from the interval 2455-2470m, and continued on self flow till it ceased due to high water cut in Jan'90. During the Feb'90 workover, interval 2474-2475m was perforated and cement retainer (CR) was set at 2472m followed by block cementation (BC). The interval 2455-2470m was reperforated, and the well was activated and put on ESP. As shown by the production plot, this job resulted in reduction in total liquid Q_l but the water cut still remained high. During the next Sep'98 workover, the existing perforations were cement squeezed, interval 2455-2460m opened, and the well was put on GLV. This, however, again failed to reduce the water cut, and the well again ceased due to 100% water. In the next Oct'01 workover, the existing perforations were cement squeezed, interval 2456-2459m perforated, polymer job carried out followed by cement squeeze, and the shallower layer 2435-2440m in the top silty portion was opened. After the layer transfer in the top silty portion, total liquid rate reduced and the water cut also reduced as can be seen from the production plot.

Well-Y: This well has given 245K MT cumulative oil production from TS2. In this well, the top silty portion of TS2 paysand is thicker than its lower cleaner portion (Figure 4). The subsidiary sand TS2S is also present. The well was drilled in 1964, and it started production in Jul'68 on self flow from the lower cleaner sand interval 2477-2483m but ceased in Jul'77 after 40% water cut. Then, during the work over in 1979, additional intervals 2467-2469m and 2471-2473m were perforated, and the well was completed on ESP. The well flowed with high water cut. In the next workover in 1982, interval 2488-2490m was perforated, cement retainer was set at 2485m followed by block cementation and reperforation (2471-2473m), and the well was completed on ESP again. However, the water cut still remained high as shown in the production plot. In the next Aug'85 workover, the layer 2477-2483m against the cleaner sand was isolated by cement squeeze, and additional intervals 2455-2457m and 2461-2465m in the top silty portion were opened. After isolation of the lower cleaner sand, the water cut became negligible.

Well-Z: This well has production from both TS2 and TS2S (Figure 5). TS2S, the subsidiary sand of TS2, is present only in selected wells with no definite pattern, and it is probably of lenticular nature. The cumulative oil production of the well is 125K MT from TS2, and 20K MT from TS2S. In this well, the lower cleaner portion of TS2 paysand is dominant compared with the top silty portion which is relatively very thin and was not opened during upward layer transfer. The well, drilled in 1985, shows 20m rise of OWC in TS2 paysand. It started production in May'86 from TS2 (2480-2498m) on self but ceased in May'89 after 40% water cut. Then GLVs were installed and well flowed with high water cut. In Aug'2000, the existing perforations were cement squeezed; interval 2489-2492 perforated for polymer job/ cement squeeze, and the upper layer 2481-2485m was opened. However, in spite of the water shut off job and upward layer transfer, the water cut remained high. Then, during Oct'01 workover, TS2 was isolated by bridge plug, and well was transferred to TS2S (2463-2466.5m). The zone transfer to TS2S resulted in low influx and nil water cut.

All the above cases show that a good correspondence exists between the log characteristics and the production performance of TS2 and TS2S paysands. The changes in the production performance after layer or zone transfer are in accordance with the log characteristics. As expected from the log character, the high permeable lower portion of TS2 paysand gives high influx and high water cut while its less permeable top portion and subsidiary produces less influx and negligible water cut.

Conclusions

The highly permeable TS2 paysand has a less permeable and fining upward shaly silty top. The difference in the lithological character of the lower and top portions is reflected in their production behavior as illustrated by the well examples. While the highly permeable lower portion flows with high influx and high water cut, the less permeable silty top portion gives less influx and negligible water cut even though both are part of the same reservoir. The fine grained top silty portion prevents encroachment of water. Because of inherent difference in character, the lower and top portions have to be produced separately as has been the practice- the wells have been transferred to the upper layers successively after the lower layers started high water cut, and the high water cut became uncontrollable even with water shut off jobs. The subsidiary sand being silty and less permeable also produces with less influx and very less water cut. The production behaviors of the lower and top portions of TS2 paysand, and of subsidiary sand are in tandem with their log characteristics. The above understanding will be helpful in better exploitation of TS2 reservoir and optimization of workovers. Similar log-production relationships need to be worked out for other reservoirs.

Reference

Chandra, Y. and Kumar, A., 2006, Study of Lakwa Field, Blocks I and II for revival of sick and non flowing wells, Assam Asset, ONGC Nazira Unpublished report.

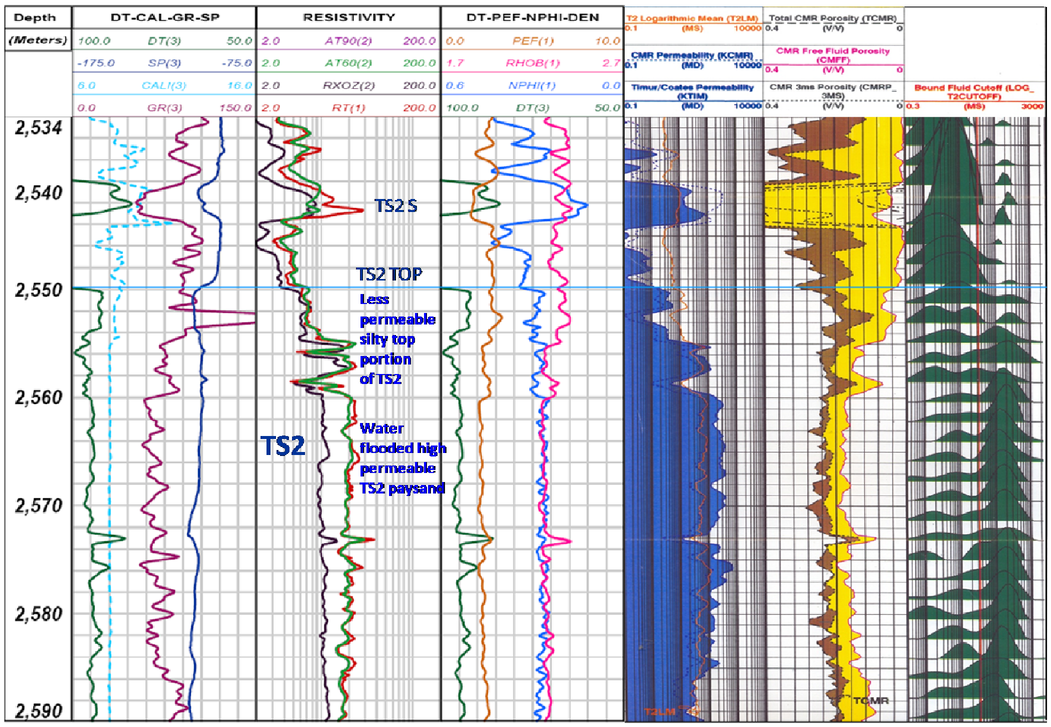


Figure 1. Composite log suite near TS2 top in Well-A, Lakwa Field. TS2 paysand is clean, massive with high permeability but its fining upward top portion is shaly, silty and less permeable associated with large bound water causing decrease in the resistivity. In this well, TS2 paysand is water flooded as shown in Figure 2 below. However, TS2 silty top portion, in spite of low resistivity, might be oil bearing as it resists water encroachment. TS2S, the subsidiary sand of TS2 is less porous than TS2 paysand.

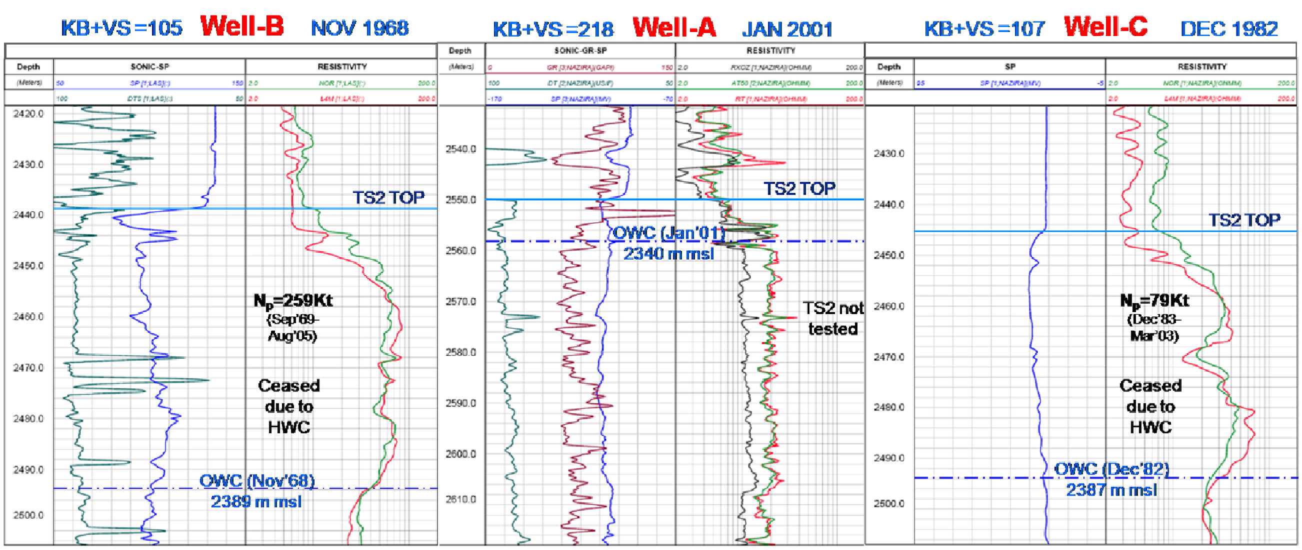
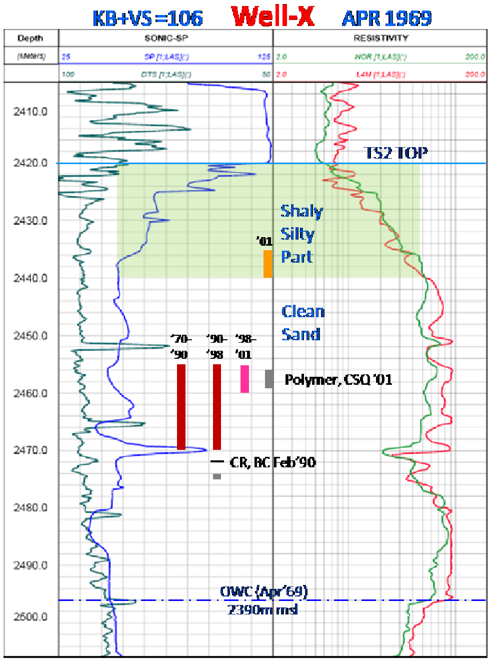


Figure 2. Comparison of logs of well A with logs of its adjacent older wells B and C shows TS2 to be water flooded in that area at the time well A was drilled. This is supported by production data as both the wells B and C ceased due to high water cut soon after A was drilled and could not be revived even after water shut off job. The well spacing is about 300 to 400m.



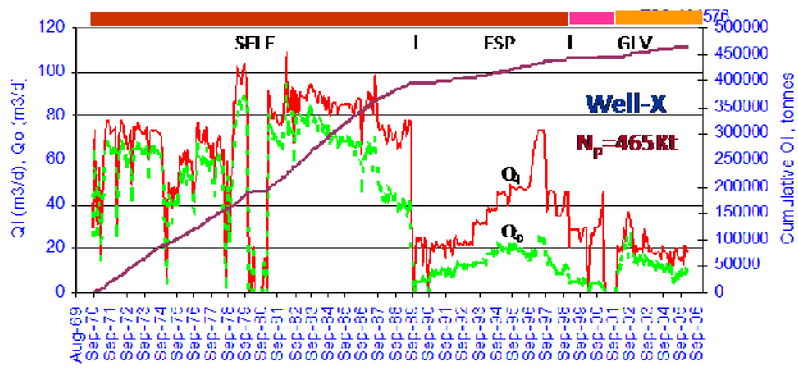
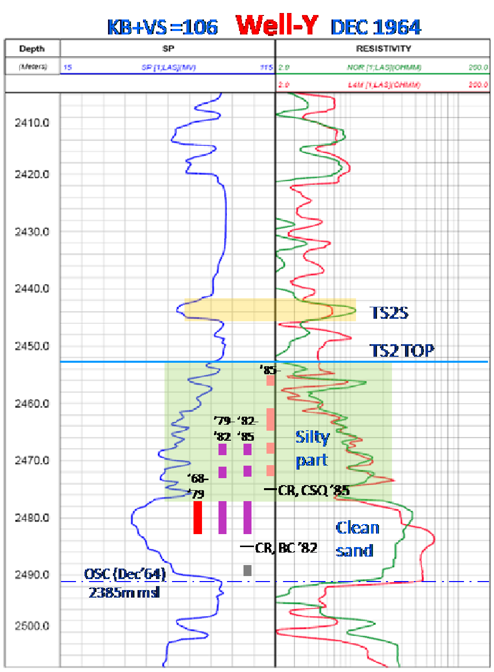


Figure 3. Logs vis-à-vis production performance of TS2 in Well-X. In this well, the lower high permeable portion of TS2 paysand is thicker than its shaly-silty top portion. During different spans of time, the corresponding perforation interval(s) and the production performance are indicated by flags/bars of the same colour. The type of lift is also mentioned in the production performance plot. A good correspondence is observed between the log character and the production behavior. The high permeable TS2 paysand produces with high flow rates and is prone to high water cut whereas its less permeable fine grained top portion produces with low flow rate and very less water cut.



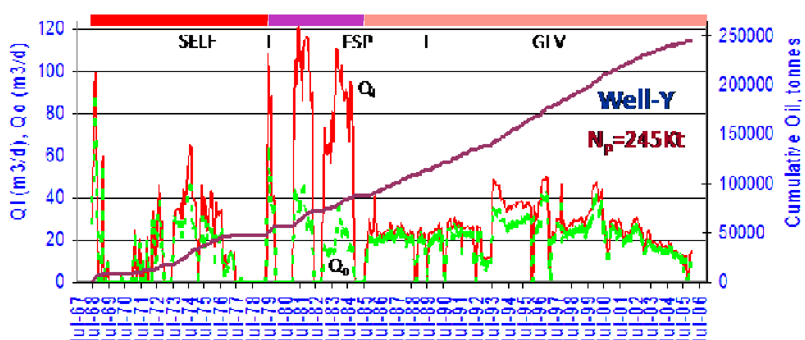


Figure 4. Logs vis-à-vis production performance of TS2 in Well-Y. In this well, the shaly-silty top portion of TS2 paysand is thicker than its lower high permeable portion. There is a good correspondence between the log character and the production behavior. Whereas the high permeable TS2 paysand produces with high flow rates and generally high water cut, the less permeable fine grained top portion flows with low influx and negligible water cut. After the lower clean sand is isolated during '85 workover, the water cut is drastically reduced.

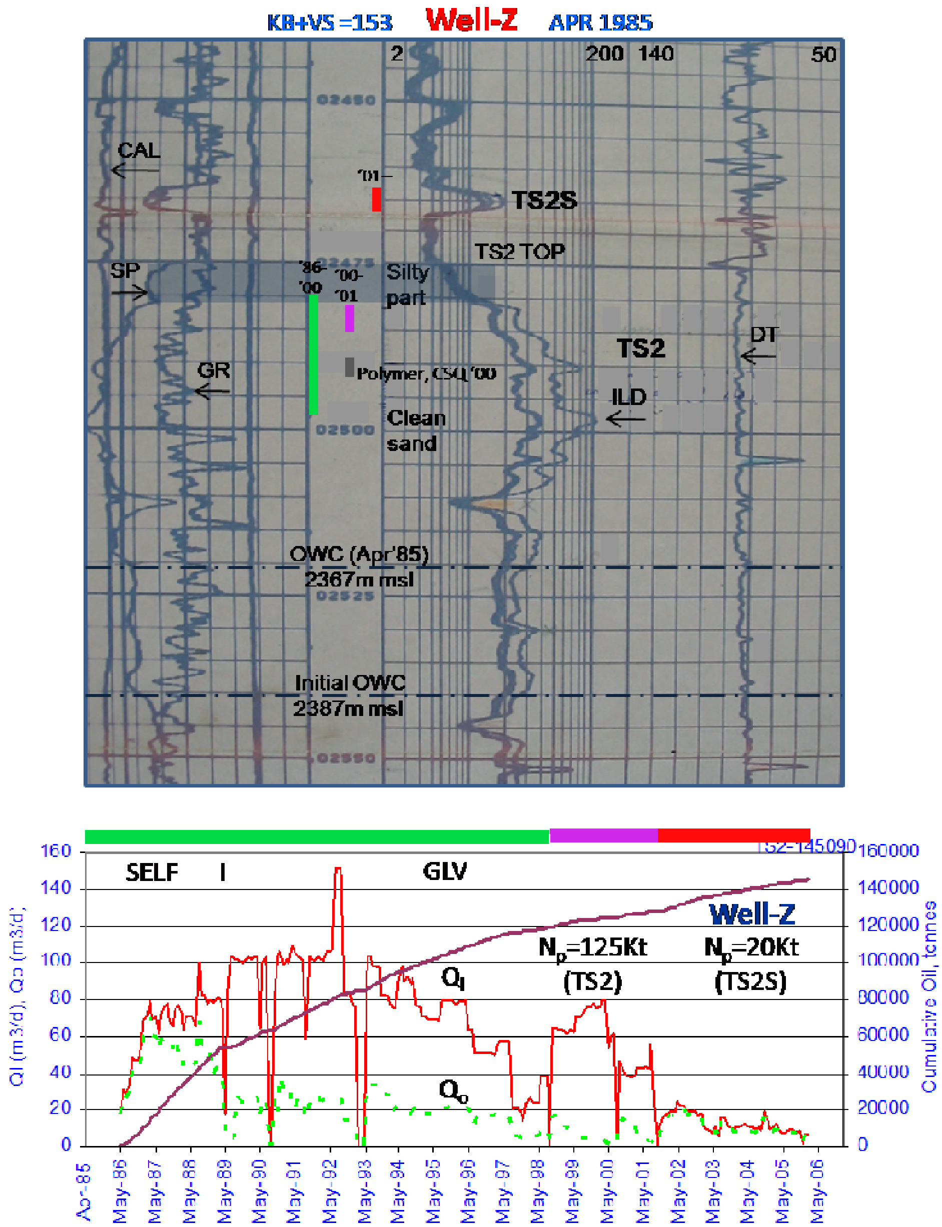


Figure 5. Logs vis-à-vis production performance of TS2 and TS2S in Well-Z. The logs show 20m rise in OWC from the initial OWC in TS2. The shaly silty top portion is thin and was skipped during upward layer transfer. The high permeable TS2 paysand produced with high flow rates and high water cut. The less porous-permeable subsidiary sand TS2S produced with less influx and nil water cut. Thus, there is a good harmony between the logs and the production data.