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Study of Water Migration Pattern and Identification of Un-swept Area in Basement Field in a Major Oil Field of NE India

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Abstract

This paper discusses the water migration pattern during production from Fractured Basement. The analysis suggests presence of possible un-drained areas which need to be probed for hydrocarbon presence. Notwithstanding with the inadequacy of seismic and image log data, this study is based solely on the long production history and reservoir behaviour of wells drilled to basement in the field. Well production data have been analysed through different diagnostic plots, to decipher the preferential migration pathways for hydrocarbon and to detect the possible source of excessive water production. In general watering out of wells appears to be more controlled by depth of penetration in basement, based on field life cycle, rather than only on structural position of basement. In conclusion, it has been found that certain up dip areas are still left with un-swept oil, based on the water cut movement. Possibility of drilling few horizontal wells within this band would be worth for monetizing the un-drained hydrocarbon.

Introduction

The area under study is located in the north eastern part of India (Fig.1). Commercial oil production was established in the Pre-Cambrian fractured granitic reservoir of this field way back in 1981. Out of 54 wells drilled in this field till date, 42 wells have been drilled to basement. 17 of these wells have flowed oil in commercial quantities, while 13 wells have indicated hydrocarbon in basement during testing or drilling, and 12 wells were water bearing or did not become active. The peak oil production rate of 250m^3/d was achieved in the year 1988-89 but flow of oil gradually ceased in 2012 due to high water cut from active bottom water. Basement testing and production details of the wells are shown in Fig. 2.

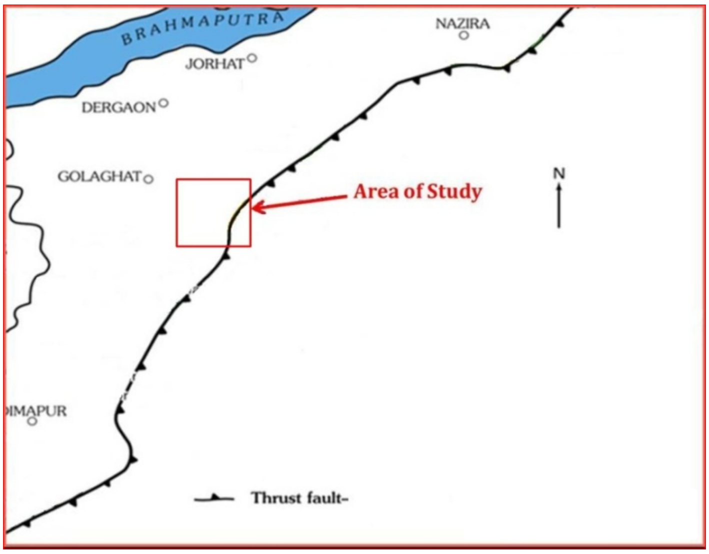

Fig. 1: Area of study

The overall field performance has been evaluated by analysing the trend of liquid production over time. Study of oil and water production rates over time clearly shows that water cut has got a typical jump which is a classical signature of basement production with an active water support.

Experimental Details/Methodology

This field has a long production history spanning around 30 years starting in the year 1981. Oil continued to be produced till March 2012. Performance of the field is shown in Fig. 3. Based on geological fault position the field is divided into 4 blocks. Analysis of water movement in the field has

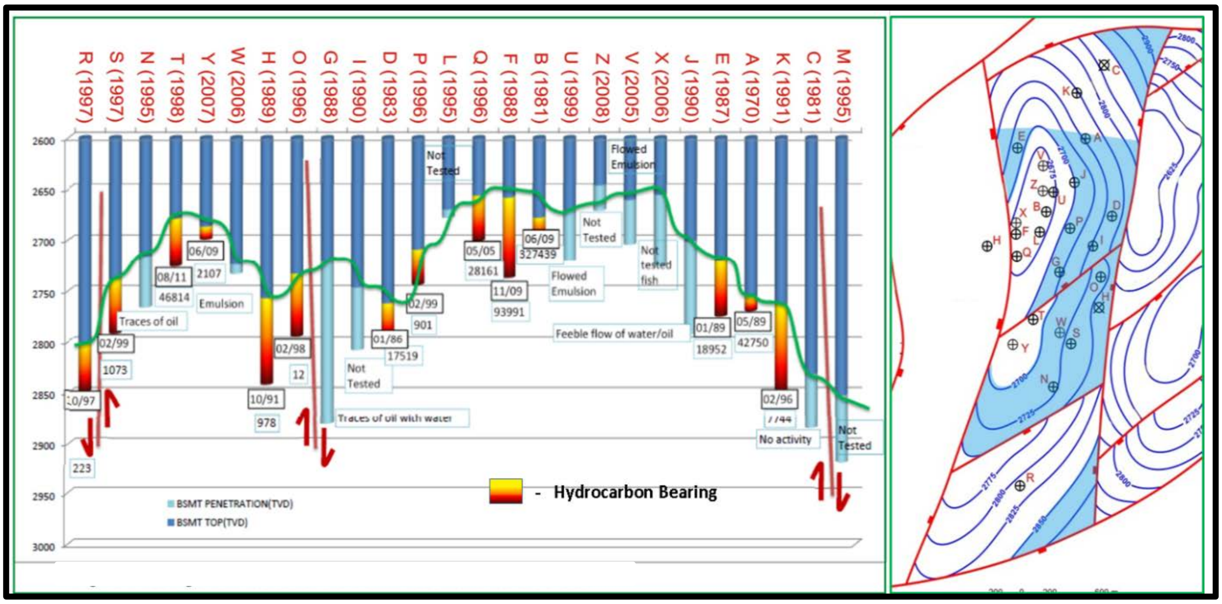

Fig. 2: Testing and production details in Basement/Basal Clastics

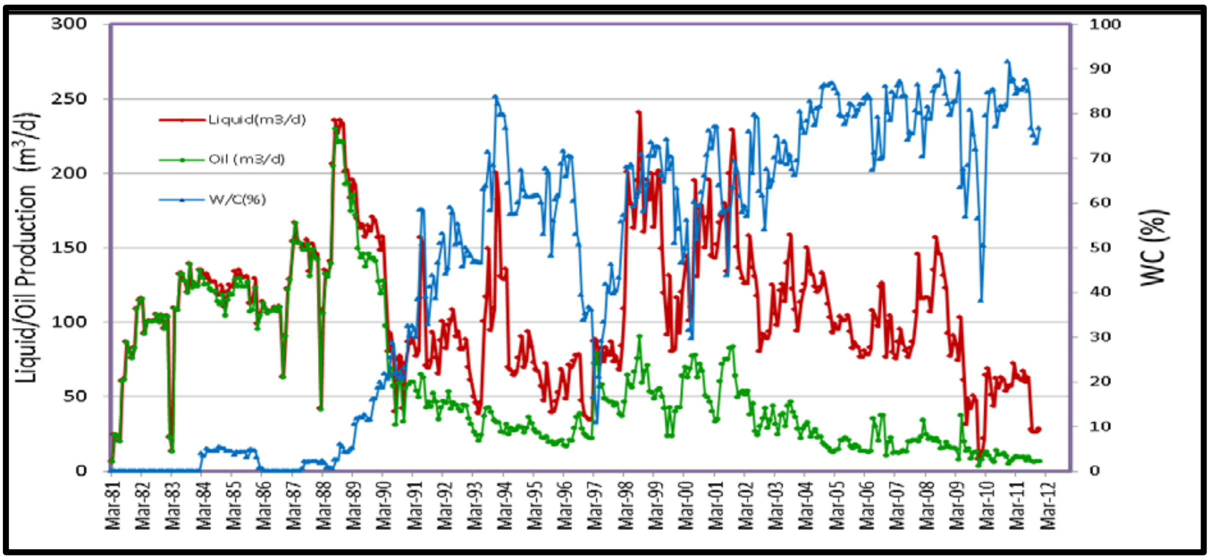

Fig. 3: Performance curve of Basement production of the field

been carried out with the available water cut and reservoir data. Water cut in wells started as early as 1984. The water movement has exhibited a uniform pattern across the blocks. Water loading appears to be from the faults and on the flanks. The sequential water cut occurrence has been represented graphically, along with map view visualization of zones of preferential water flooding in Figures 4 to 6.

The extent of water flooding in the field during year 1988 is shown in Fig 4. In year 1988 there were seven wells drilled in the structure and production of wells started in year 1981 whereas first water cut recorded was 20% in year 1984 in well D. First flooding in Block B occurred in well D in year 1988; this well penetrated the depth of 2796m. It can be inferred that during year 1988 water level was at 2796m. Till the year 1988 no well was drilled in Block of N and R.

Fig. 5 depicts water level distribution in year 2006. The production data of field shows that though the water level was continuously rising in the field, no well ceased with 100% WC, till year 2006. During these six years i.e. 2001-2006 wells were producing with more than 70% water cut. In year 2006 water flooding occurred in well Q, which penetrated the depth of 2700m, i.e. there was 37m water level rise in Block B in there 6 years. In Block N, after well S no well was flooded till year 2005, but in year 2006 a well was drilled, in this Block which penetrated the depth of 2733m, which showed oil/oil emulsion in combined testing. This well did not produce oil in commercial quantities. Hence for year 2006, the probable rise of water level can be considered to the depth of 2733m in Block N.

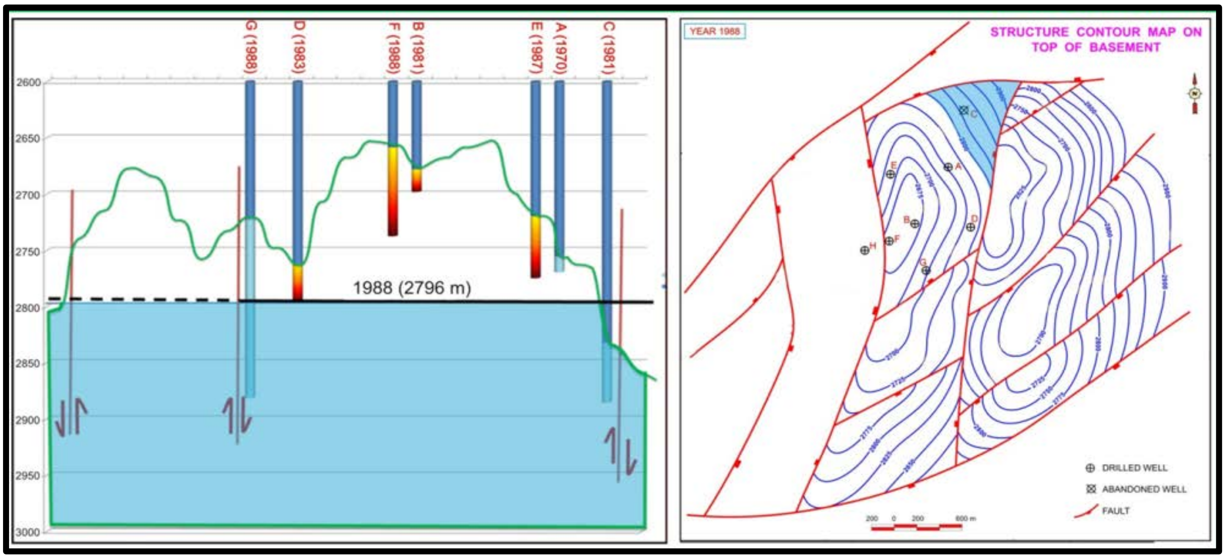

Fig. 4: Extent of water flooding in year 1988

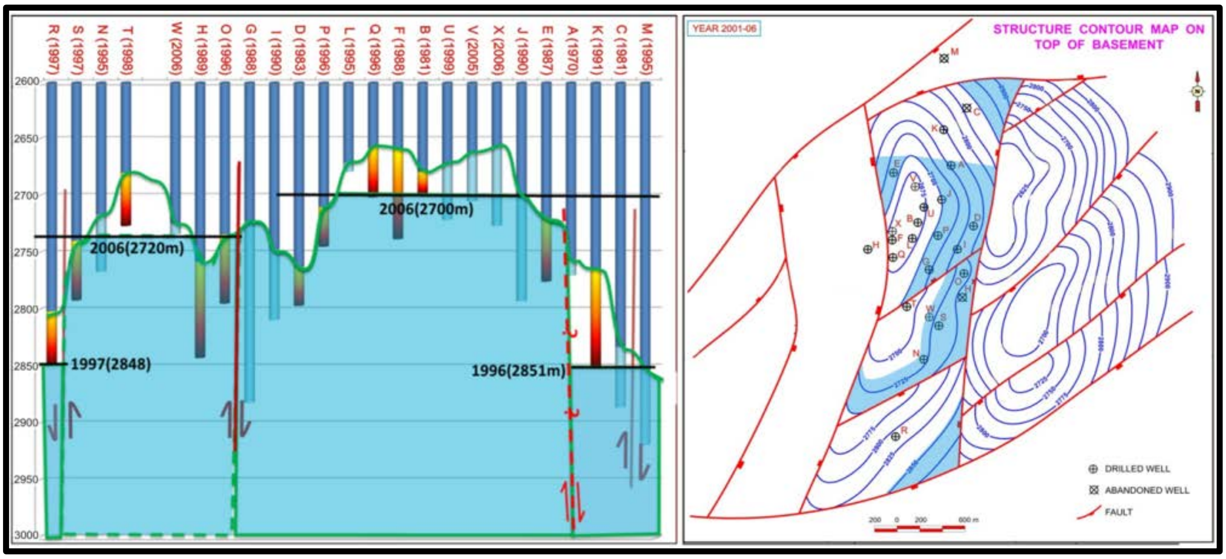

Fig. 5: Extent of water flooding during the years 2001-06

Figure 6 depicts the inferred present water level of the field. The last production from this field was from well T, in year 2012, which was drilled at the crestal part of the Block N and was the most

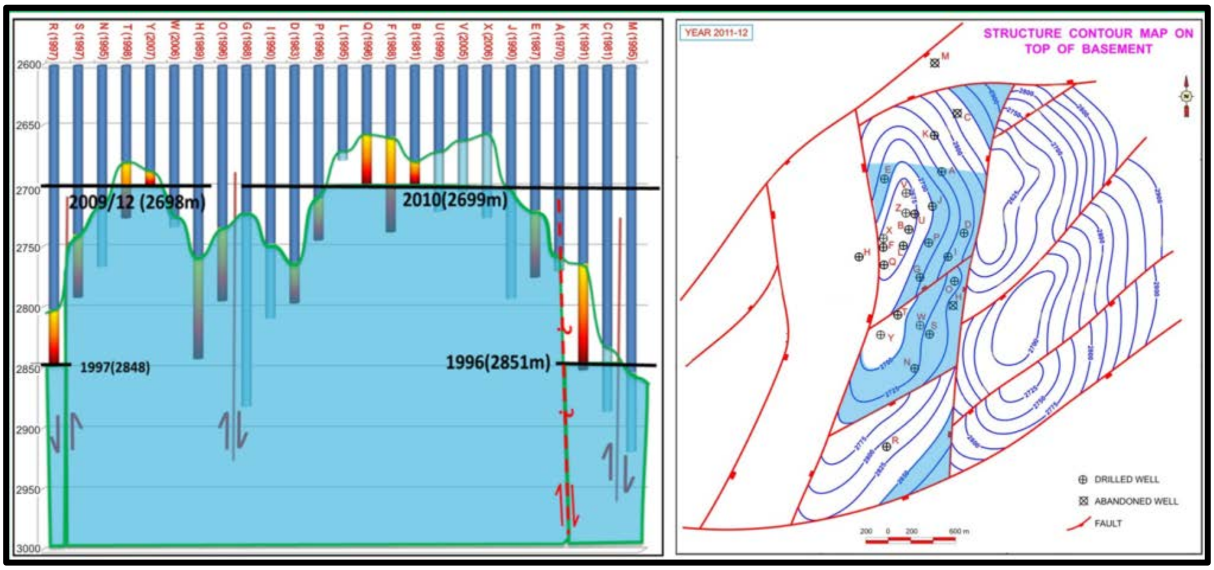

Fig. 6: Extent of water flooding during the years 2011-12

consistent well of this block. In this block well Y has the shallowest penetration depth i.e. 2698m and ceased in 2009. Hence for block of N shallowest water flooding data is from the well Y i.e. 2698m. Above this depth the block of 37 is still unexplored. In Block B the last well ceased was B in year 2010, this well was drilled to the depth of 2699m. Above this current water level position is still unexplored.

The study shows that the water front movement took place at different rate in different fault blocks. The initial variation is probably the result of differential withdrawal of hydrocarbon from different blocks at different rates. However the final equalization establishes that there is a common active water support for all the blocks as corroborated by Static Pressure. However there are a couple of cases wherein occurrence of hydrocarbon at deeper levels in younger wells has been noticed, which is an enigma.

Well wise analysis of production data has also been carried out by generating pie diagrams of oil and water productions in the wells of block N, B & R. Well wise pie diagrams of production data for year 1988, 2006 and 2012 depicted in Fig. 7 to 9. These diagrams clearly show the water loading pattern in the production behaviour of individual well. A scrutiny of the figures 4, 5 and 6 reveals that the active water top in different blocks have moved up at different rates because of two factors i.e. differential withdrawal rate and the disposition of fractures and faults. However, the effects of the fractures and the fault disposition could not be studied in detail in the absence of FMI and DSI data.

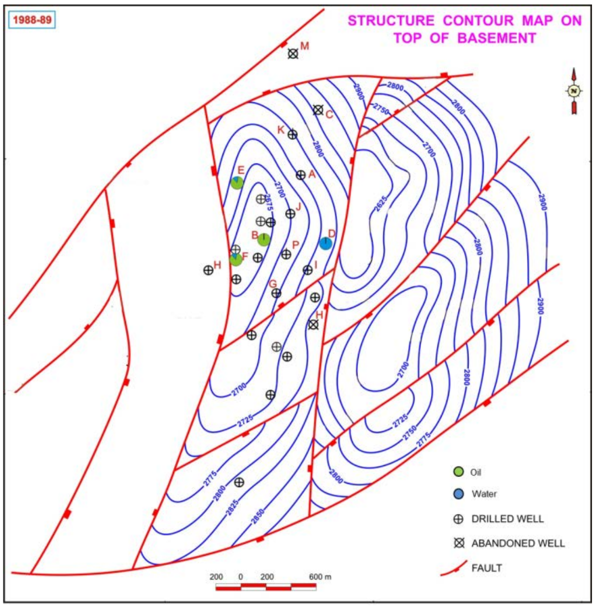

Fig. 7: Well wise oil/water production ratios: year 1988

Results and Discussion

The reservoir in this field is fractured granitic basement. These reservoirs are quite different from conventional type of reservoirs, and the fractured Basement has almost zero matrix porosity while its fractures have high permeability. In these reservoirs, production of hydrocarbons occurs only through interconnected fracture network.

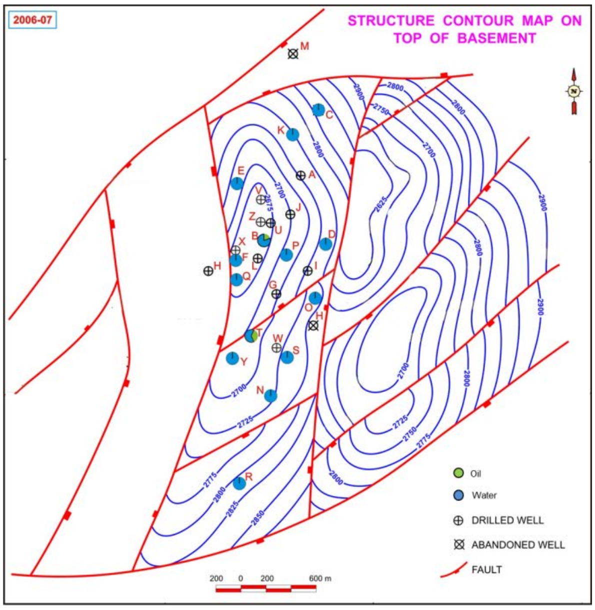

Fig. 8: Well wise oil/water production ratios: year 2006-07

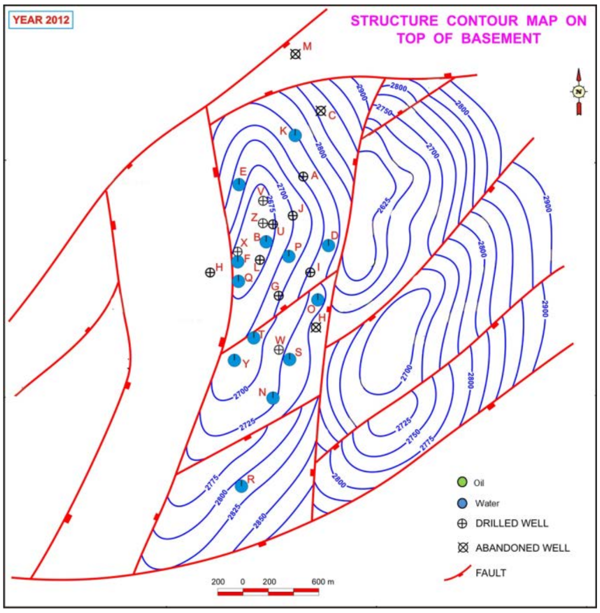

Fig. 9: Well wise oil/water production ratios: year 2012

The high degree of reservoir heterogeneity and the complexity of the paths of hydrocarbon and other fluids created by fractures require us to characterize fractured reservoirs accurately to make use of assistance from fractures and their inhibition in hydrocarbon production so as to achieve ultimate recovery. However, the high degree of reservoir heterogeneity and the complexity of the paths of hydrocarbon and other fluids created by fractures require us to characterize fractured reservoirs accurately to make use of assistance from fractures and their inhibition in hydrocarbon production so as to achieve ultimate recovery.

In case of present field much of the data required for analysis of fractured reservoir are absent. But two of the very important data are present and they are production and pressure data. The absence of any PLT data makes us to assume the production zone. The analysis of production from individual wells does indicate presence of fractured reservoir. However when block level analysis is carried out; the reservoir is like any high porosity permeability reservoir. Production behaviour of Basement wells has been studied in order to analyse the watering out pattern of wells through time; and in turn to bring areas with un-drained hydrocarbon potential in Basement. This study suggests that water loading in entire structure was from flanks of the structure through faults.

It is inferred that, oil accumulation in the basement is controlled not only by fractures but also by structural disposition. Whenever a well has penetrated below a certain level (~2850m) all fractures is water bearing and the aquifer has flooded the troughs in the vicinity of good producers.

Conclusions

The analysis of watering out pattern of producing wells can serve as an important tool to understand the hydrocarbon movement. In the instant study, an area, with possible un-swept hydrocarbon has emerged (Fig. 10). A NS geological section through the un swept areas is shown in Fig. 11. Monetization of this hydrocarbon can be achieved by drilling high inclined wells in this crestal part of such areas. The overall understanding of spatial disposition of fractures can be improved by acquiring special logs like FMI, Shear Sonic and ECS in the basement section.

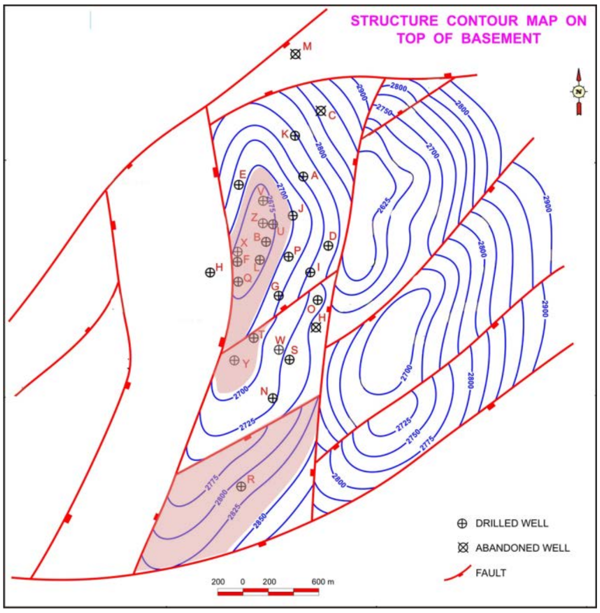

Fig. 10: Areas with un-drained hydrocarbon

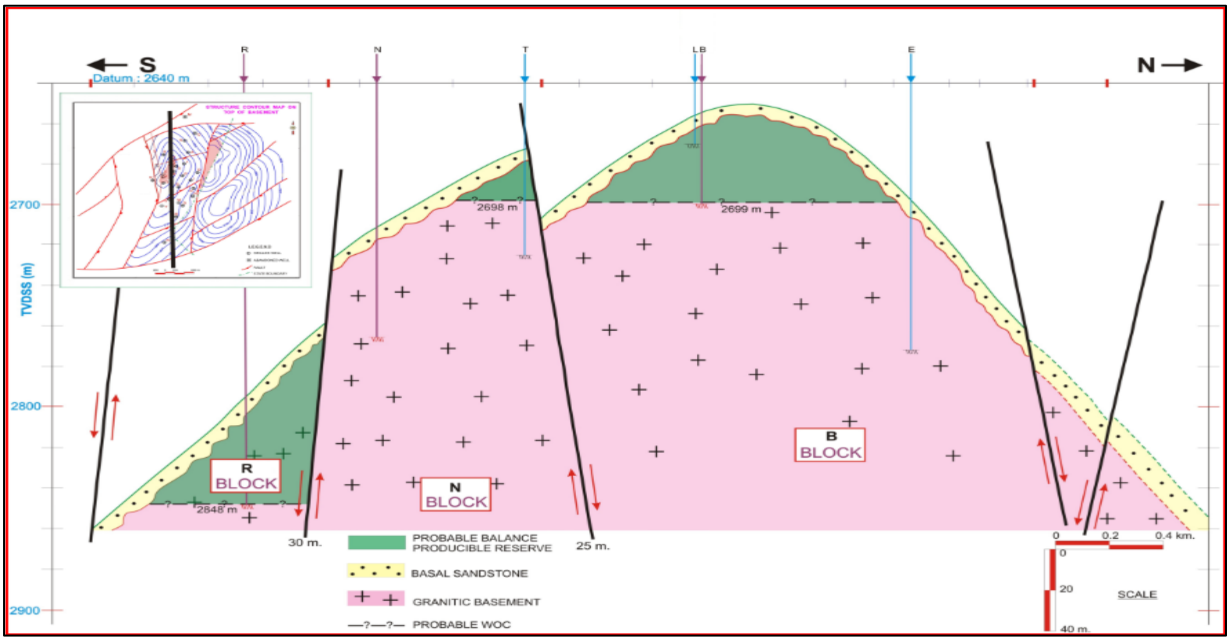

Fig. 11: NS cross section through un-drained area

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