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Stratigraphic entrapment confirmation by Fault seal analysis, Elastic Inversion and Seismic Attribute, Rawat basin, Sudan

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Abstract

The Rawat basin is part of the elongated White Nile rift system, which is composed of a series of half-graben structures. This area mainly develops the Neogene, palegene and cretaceous formations. The inter-bedded clastic lacstrine sequence of Cretaceous formation is the main component (source-reservoir) of the petroleum system in Rawat basin. The oil discovery is found in the topmost of cretaceous layer.

The present day complex structural geometries and stratigraphic architectural features, of Rawat clastic sedimentary basin, evolved as a result of sequential periodic tectonic events and local tectonic pluses, as a consequences of; extensional, compressional and transtensional tectonic forcing, that were revolved during the history of the basin formation.

A basinal well in Rawat Central sub basin oil field discovered in 2011. Was observed the oil column is greater than available in structural trap and the faults throw is small to make lateral sealing.

In order to assess and delineate the oil entrapment and to understand the trapping mechanism of this field we marriage between fault seal analysis, elastic inversion and seismic attributes

First and second order Fault seal analysis applied to the basinal well Structure as routine work. Considering the hydrocarbon accumulations in the Rawat Basin rely either totally or partially faults dependence. Therefore, it has become necessary to evaluate fault seal capacity in order reduce exploration risk. The results of fault seal analysis confirm that the hydrocarbon column shown on drilled structure cannot be supported by the fault seal only.

Seismic attributes and inversion are the main tools to explore and develop unconventional traps. We found that inversion is favorable way for the lithology discrimination, especially in this central sub-basin for it clears Acoustic Impedance separation in the reservoir zones.

These approaches allow more precise descriptions of this Oil field. We come out by good understanding of the hydrocarbon distribution in Rawat central sub-basin, and the lateral barrier for oil to be trap is combining between structure and stratigraphic trap.

Introduction

The Rawat Basin lies in the northern part of Block 7 in the Republic of Sudan, around 350 km south of Khartoum City **(Fig-1).** It is a Late Cretaceous to Tertiary rift basin and forms the northern extension of the elongated White Nile rift system, which includes the prolific oil province of the Melut Basin. The sedimentary infill of the basin is dominated by fluvial and lacustrine sandstones, mudstones and local tuffs of Upper Cretaceous to Quaternary in age. Distribution of facies is likely to have been controlled by pulses of fault-controlled subsidence followed by more prolonged episodes of thermal subsidence

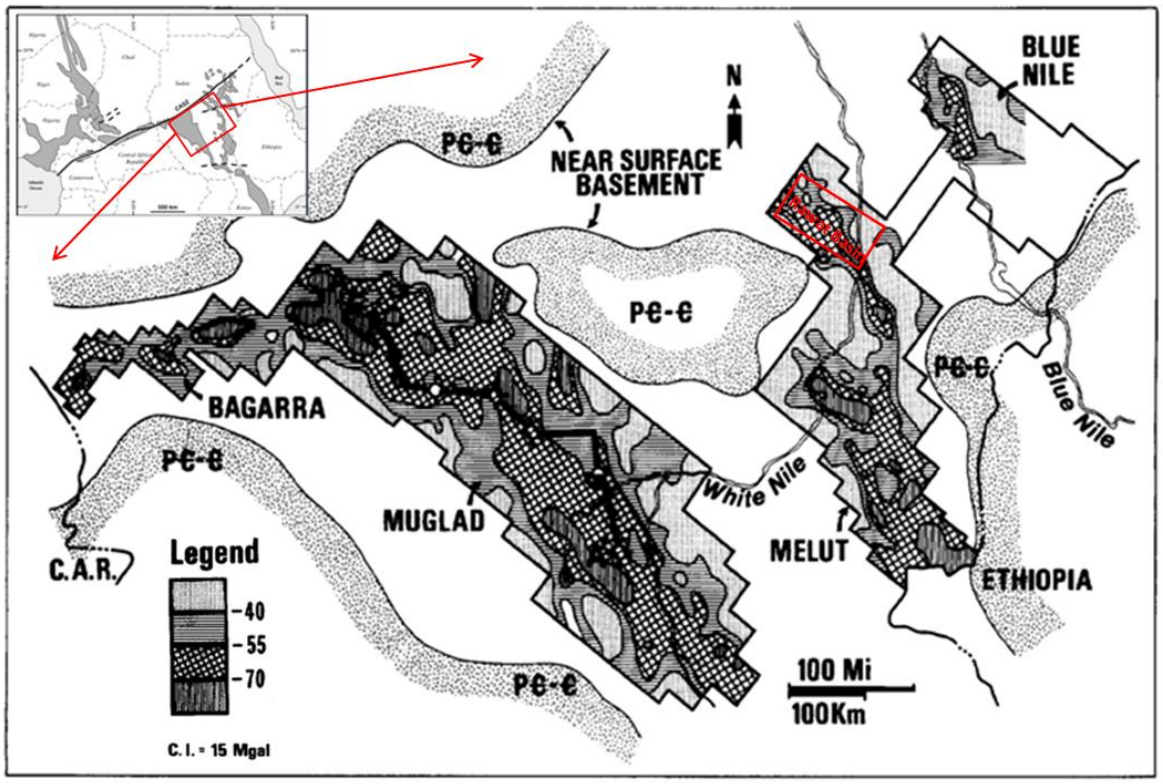

Fig.1 show the location of the study area, Rawat basin, the shading represents the gravity anomalies as per legend

Structurally, the area is dominated by dip-slip normal faults. The three rifting phases resulted in a long complex history of horst and graben development and the formation of a highly complicated fault system. The predominant fault orientation is parallel or sub parallel to the strike of the primary grabens and basin margins. These longitudinal faults mainly strike (NW-SE). Few major transverse faults may occur but cannot be evidenced only by seismic. The fault pattern exhibits a great variety in displacement, geometry and growth history. Along the basin flanks the faults clearly involve basement. However, in the trough areas many faults appear to sole into the fine-grained early rift sequence

The Rawat basin can be structurally subdivided in 5 sub-basins: the Eastern sub-basin, the Central sub-basin, the Western sub-basin, the Northern sub-basin and the Southern sub-basin. The shoulders of the rift basin run parallel to the basin and are made of basement highs only covered by Late Tertiary deposition

The main goals of this Study are to develop an integrated understanding of the Cretaceous reservoir and its impact on the distribution of oil within the Rawat sub-basin

Three wells discover oil in the Rawat central sub-basin; one of which was drill base on interpretation of the 2D seismic data as structure traps consequently they appraise it, accordingly they acquire 3D seismic data and drill the third well.

The third well was designed as pure conversion structure proposal. In a Hanging wall of thin skin synthetic fault, the thrown of it is around 70m fig-2.the maximum closure area is 0.6 km^2 .the results of this well Surprised the exploration department expectations, with the oil column discover never can be preserved in this structure.

The total depth of the studied well is 2985m, 310m of oil shows column was described in the mudlog, 6DSTs were perforated and the results of which are oil with moderate production rate 169p/d and good crude oil quality (27-31 API).

Methodology

Fault seal analysis, seismic inversion and attribute have been selected to be implementing in this trap confirmation and delineation.

To evaluate the fault seal capacity of the Abasinal well, Structure Framework was build in Trap Tester software. The reservoir zones were defined in the well. The zones isochors were map in the fault and the attribute of fault geometry and shale smear calculated.

Seismic Attributes Analysis has been performed using the Petrel and Geoframe software. The IESX was use to interpret the 3D seismic data and petrel for Attributes generation

Simultaneous inversion of partial angle stack to obtain the compression (Ip) and shear (Is) Impedance was done by Haomsson Ressul software. The key point of this methodology is the estimation of the seismic wavelet. In this case a different a wavelet for each angle stack was derived matching the seismic amplitudes with trace modelled by Akil&Richards equation.

three different-angle stack data cubes which are respectively near angle stack data cube (4°-14°), medium angle stack data cube (14°-24°) and far angle stack data cube (24°-34°) were used for elastic inversion, only one well in the study area has the S-wave interval travel time curve, so the S-wave acoustic curve of this well used to validate the other Wells.

Results and Discussion

Computation of Shale Gouge Ratio (SGR) over the fault surfaces, in combination with juxtaposition diagrams, was used to estimate the sealing potential of the A basinal Well fault.

Fault seal analysis is performed for the trapping fault provided positive results regarding the sealing capacity of the fault in term of reservoir seal juxtaposition and amount of shale gauge ration. SGR is greater than 35% at depth shallow than 2300 m, while at depth from 2300m to 2985 the SGR less than 20% (Fig -3).

There is no debate in top seal because the presence of the high shale contain in the upper formation. The shale parentage in this formation is more than 70%.

The availability of good to fair 3D seismic data provided opportunity to carry out different type of qualitative and quantitative seismic analysis, to have more insight into reservoir geometry and properties. Different attribute and classified seismic maps and volume were generated from the Rawat 3D seismic volume (Fig-4).

Attributes maps derived anomalous feature which observed in mostly all maps indicating better reservoir quality, fig-4 is an example of extracted value attribute.

We can see that the inversion results match well with the measured well data, so the inversion results are reliable (Fig-5).

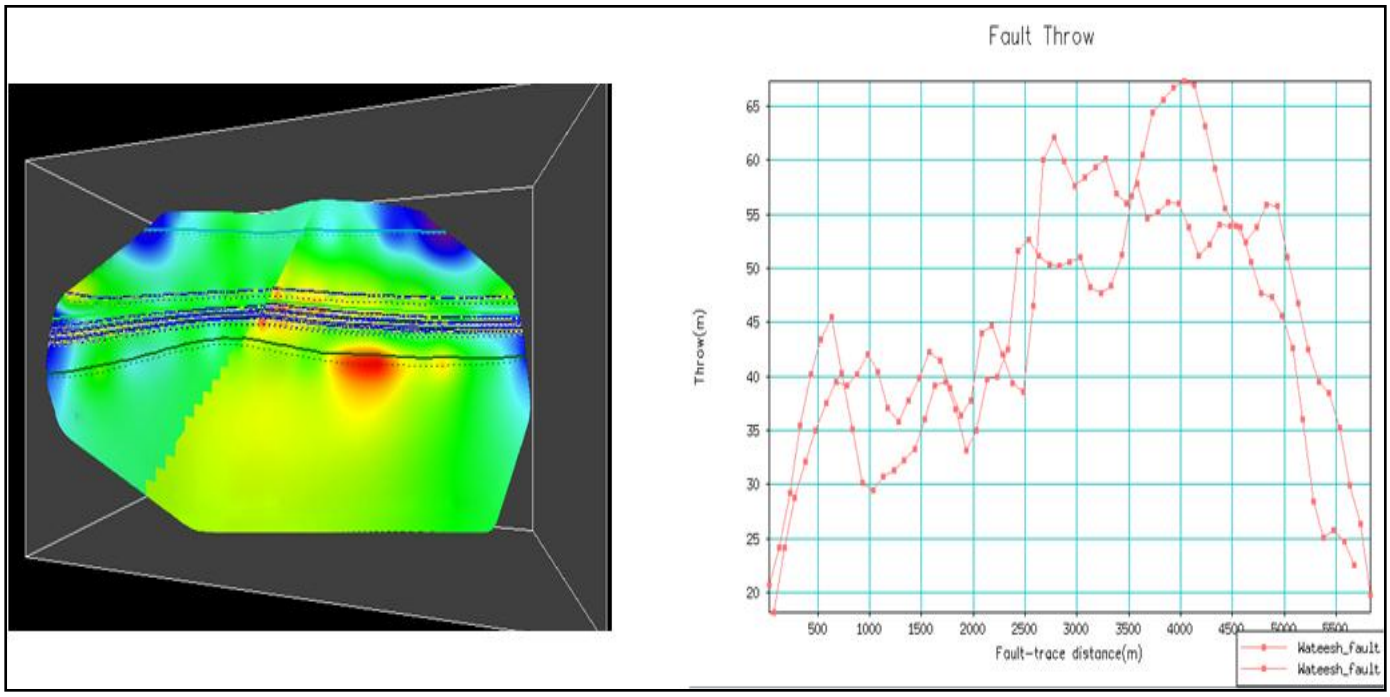

Fig.2 the fault thrown variability along the a basinal well fault plan

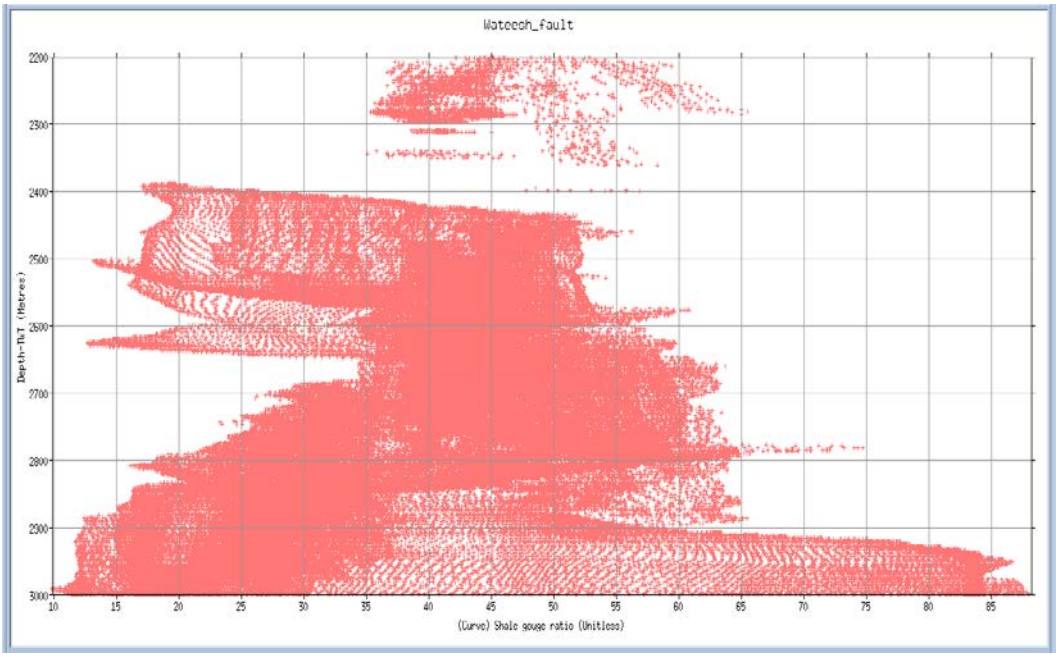

Fig.3 cross plot of the Gauge ratio versus the depth, in the reservoir level (depth greater than 2300m) the SGR is more than 35%.

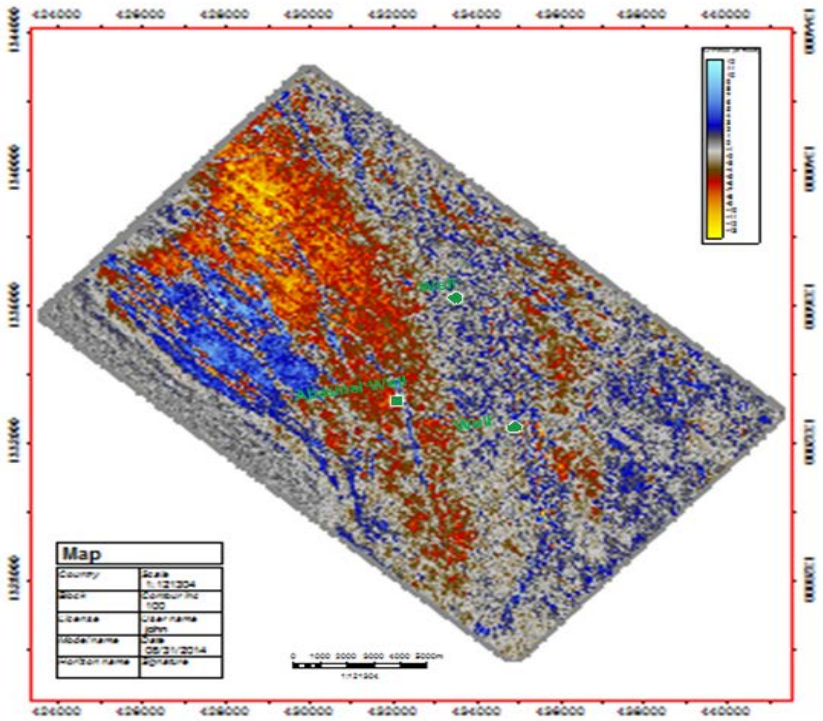

Fig.4 extracted value of amplitude among the oil reservoir, the high elongated value represent the oil sand distribution.

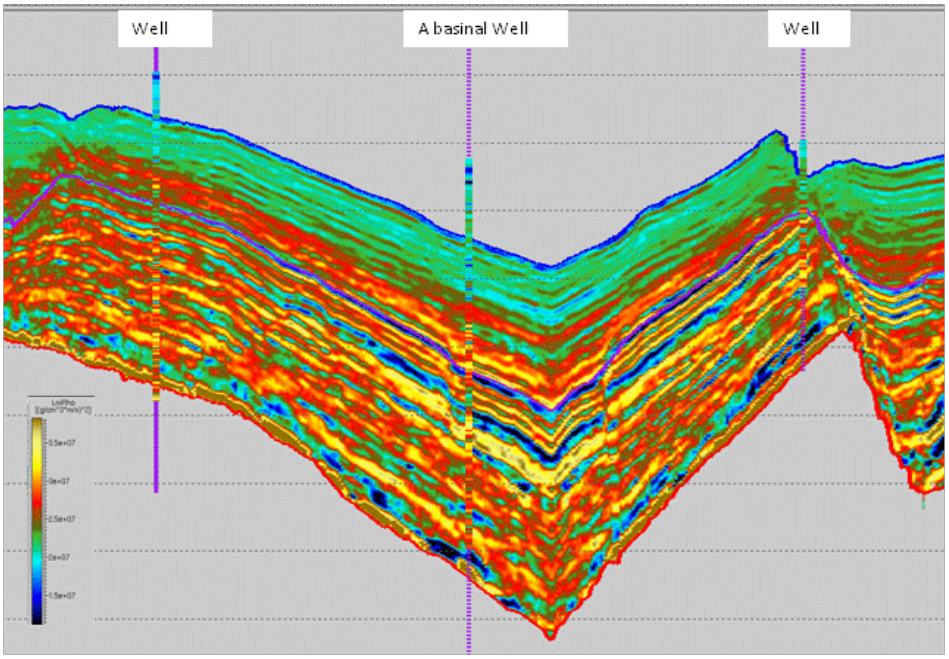

Fig.5 LMu/Ro section examining the well and the elastic inversion result matching

Conclusions

Hence oil is expected to trap stratigraphically in the study area, The clearly observed features of the targeted reservoirs in the seismic data eastward of A basinal well location is further prove the assumption of stratigraphically trapped hydrocarbon in this area.

The elastic inversion result gives better image and solid evidence for the stratigraphy entrapment.

The SGR more than 20% most-likely could have good seal.

Combining with the Attributes, siesimic inversion and fault seal analysis on structure tap is an initial characteristic for each well proposal in the central Rawat sub-basin

References

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