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Application of fault seal Analysis, Buselli field, Onshore Nile Delta, Egypt

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ABSTRACT: Buselli study area showed some hydrocarbon in Pliocene interval. The pre-Miocene target proved the water wet probably due to trap configuration risk. To decrease the exploration risk associated with pre Miocene succession, a complete static model dedicated to fault seal analysis as the faults may control the hydrocarbon accumulations and compartment architectures. In this report detailed fault analysis could help in reducing the hydrocarbon uncertainty. Understanding of the sedimentary architecture and clay content is a key for cross fault juxtaposition analysis. Evaluation of SGR and ESGR is considered to be the most reliable method to predict the amount of clay in fault zones. The juxtapositions discrete facies property allows for the identification of key windows such as sand: sand windows or critical reservoir overlap areas. The proposed method aims to predict fault zone properties and to capture the influence of unresolved fault zone structure in sandstone/shale sequences using different algorithms which will help to increase the chance of success for Buselli field.

KEYWORDS: Fault seal, sealing capacity, Abu Madi, Nile Delta, trapping mechanism, prospect.

I. INTRODUCTION

Buselli field is located onshore Nile Delta about 20 km east of Abu Qir gas field (Fig.1) and some 6 km south of Rosetta town. Buselli well was drilled by Phillips Oil Company in 1970 with total depth 2693.5 m at Qawasim Formation. At that time it did not represent any economic value. The Buselli structure is a Tertiary structure of lower Pliocene and middle Miocene. The lower Pliocene Structure is a four way dip closure while the Miocene one is a dependent faults closure. The well objective was to test similar structure and stratigraphy in nearby productive Abu Qir gas field. The first target was Abu Madi reservoir which was considered to be well developed north of the Hinge line zone. Also by drilling Buselli well some information will be gained between the wells to the south and to the north and east (Abu Qir and IEOC wells).

The well tested gas bearing sand in Kafr El Sheikh Formation as a good secondary target while the first target Abu Madi sand proved to be dry. The natural gas was produced from Buselli well at 5300 ft. probably it originated in Kafr El Sheikh Shale; (strong background reading of methane in mud seems to indicate that shale of the northern delta wells (Abu Qir-1x and Buselli -1x) have a good source potential. The pressures indicated that gas was probably produced from sand lens rather than blanket sand, and the closure may be a result of uncertain east west fault.

Figure 1: Satellite image showing Buselli wells

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GEOLOGICAL SETTING

The Nile delta plays a key role in tectonic evolution of eastern Mediterranean and Levant basin. It lies on the northern margin with the African plate which extends from the subduction zone adjacent to the Cretan and Cyprus arcs to the red sea, where it is rifted apart from the Arabian plate. (EGPC, 1984). Structure and deposition are controlled since Eocene time by vertical movement associated with gradual sinking of the Mediterranean basin and opening of red sea rift. In addition, the faulting northern coast to Cyrenaica was probably coincident with opening of Gulf of Suez.

An ancestral Nile delta broke into the present delta region in middle –late Miocene. However deltaic progrdation started in late Pliocene and developed in the Pleistocene. The area of greater Nile delta can be divided from south to north into four structural sedimentary provinces (Sestini, 1989); the South Delta Province, the North Delta Province, the Nile Cone and the Levant Platform.

The main feature in delta area is the faulted flexure zone or the hinge line zone (Fig.2), which tectonically affects pre Miocene formations and extends East -West across the middle onshore part area producing step faults Its age was dated back to a Jurassic crustal break and about 30-40 km width, representing the boundary between a southern stable platform and a northern subsided basin

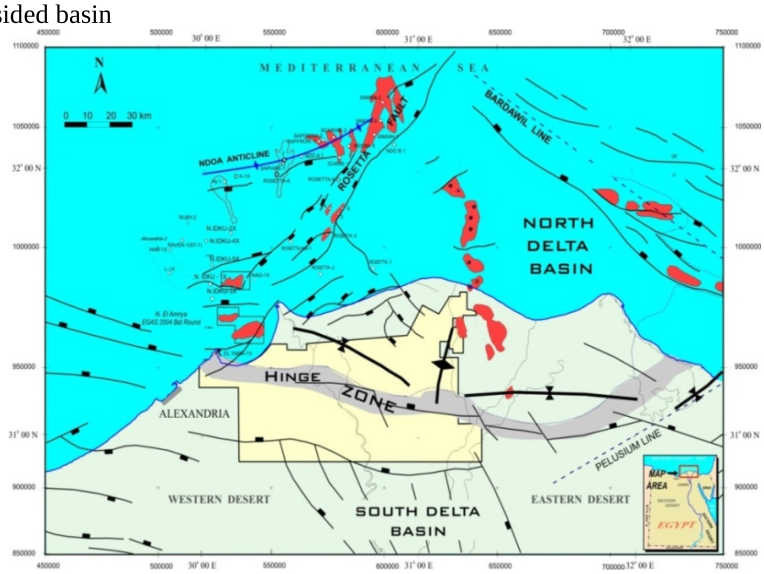

Fig. 2: Main structure elements on Nile Delta (after RWE Dea)

. The hinge zone has played a dominant role in the stratigraphic and tectonic evolution of the Nile Delta (Said, 1981; Herms and Wary, 1990). North of hinge zone Cretaceous-Middle Eocene carbonate platform drops to the north with facies changes between platform and slope carbonates that form the westward continuation of the Jurassic-Cretaceous hinge zone of the north Sinai and Palestine (EGPC, 1994).To the north of the hinge zone there is the dominant positive structures Abu Madi anticline which appear to correspond to paleo-relief on the Messinian unconformity surface.

DISCUSSION

The Pre Pliocene static model is used as input back ground to conduct detailed fault seal analysis and this will be a subject of evaluation in this work. New technique of fault seal analysis (RDR) is used to reduce the uncertainty and risk in faulted reservoirs area using different source of data like seismic data, structure input, and Facies and petrophysical property distribution to predict the fluid flow across the fault.

The Main faults bounded the Buselli field and having clear impact on fluid flow across the fault, and trap mechanism (Fig. 3) are:

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Southern Bound Fault NW-SE) direction

Northern Bound Fault (E-W) direction,

Eastern Bound Fault (NE-SW) direction,

These faults (Fig.3) will be evaluated and define the seal capacity and structure configuration. The seismic section running S-N direction along the area passing through Buselli well define the main structure elements and faults bound the study area .

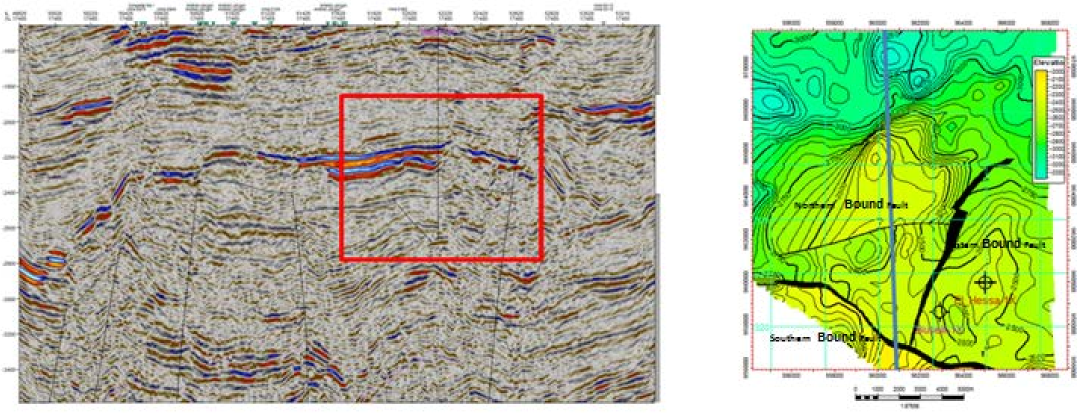

Fig.3: seismic line & Structure map of top 6.8 SB with main bounding faults

prior to the fault seal ,a suite of geometric analysis functions has been implemented that allows the testing of the relationships between geocellular grids and fault input data in addition to seismic horizons, these analyses allow for the rapid clean-up of input data to help streamline the geocellular modelling processes .

FAULT THROW AND DISPLACEMENT

Throw is calculated as the vertical horizon offset between the hanging wall and the footwall sides of the fault for the different horizons displacement is calculated down the fault surface and takes account of the variation in the fault surface form calculations are carried out down average fault dip unless a slip vector is defined.

Fault throw and displacement calculated (Fig.4) and provides a rapid means of understanding the significance of faults in a grid. Fault throw and displacement are also very useful for static model quality check .By investigating the throw on the Buselli main bounding faults shows ,

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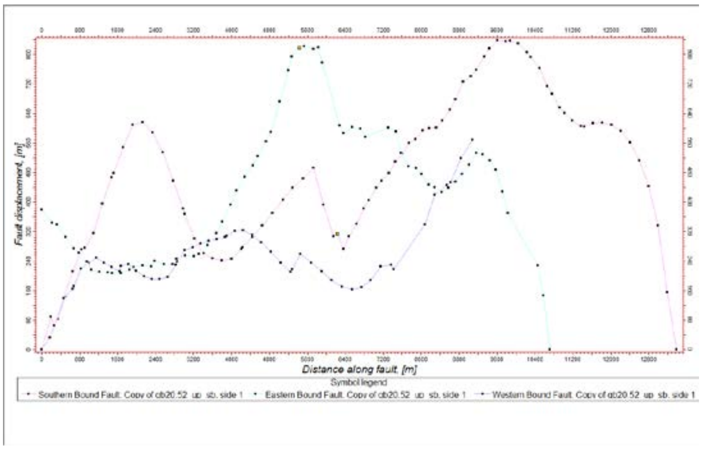

Fig.4: Fault displacement cross plot for Buselli main faults

. The fault throw along the southern main bounding fault ranges from 80-800 m which is properly will juxtaposed top of 20.52 SB against shaly formation, and could be juxtaposed sealed Fault. Length – displacement relationship: as a QC for fault interpretation (Fig.5).The southern fault about 1200 m length and fault displacement around 800 m which is located in a reliable fault throw interpretation between length and displacement. The eastern fault displacement is about 8 km and fault length range from ~80 – 500 which is also within the expected range.

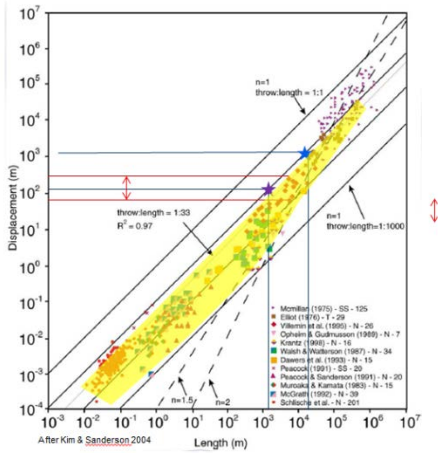

Fig.5: Fault length/displacement relationship for Buselli fields

(After Kim & Sanderson) 2004

FAULT DIP AND DIP DIRECTION

The aim of this operation is to analyze and compute the amount of dip and dip direction of fault faces (Fig.6) along the faults in geocellular grid. Faults within grids that contain at least 2 horizons can be analysed for dip and dip direction. The dip of a fault can often highlight problems with its generation.it was illustrated in the below figure on top of 6.98 SB structure map with main bounding faults, the amount of dip was calculated and extracted along the fault using RDR software and the range of the dip angle for the bounding fault around 57 degree, while Eastern bound fault around 37 degree

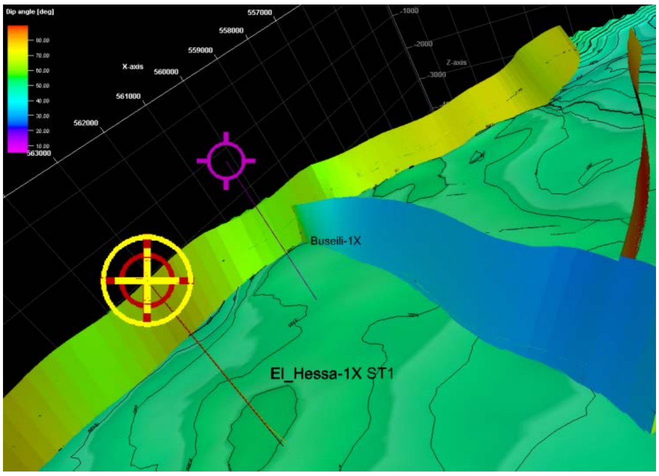

Fig.6: Calculated fault dip for the Buselli faults

Increasing down to 70 degree, while Eastern fault around 40 degree, in general there is no dip anomaly exist within the interpreted faults.

GRID PROPERTY EXTRACTIONS AGAINST THE FAULTS

Different properties were populated in a grid static model (Fig.7) and can be extracted along the faults, either on the up or downthrown side of the faults, in addition to cross-fault calculations to define the overlapping area. Cross-fault averages have computed to understanding and define high cross-fault permeability zones.

Understanding of the sedimentary architecture and clay content is consider key for juxtaposition analysis and often represents the largest uncertainty with defined Sand-shale cut-off for reservoir to non-reservoir zone. The juxtapositions of any discrete property, such as facies (Fig.7) this allows for the identification of key windows such as sand: sand windows or critical reservoir overlap areas.

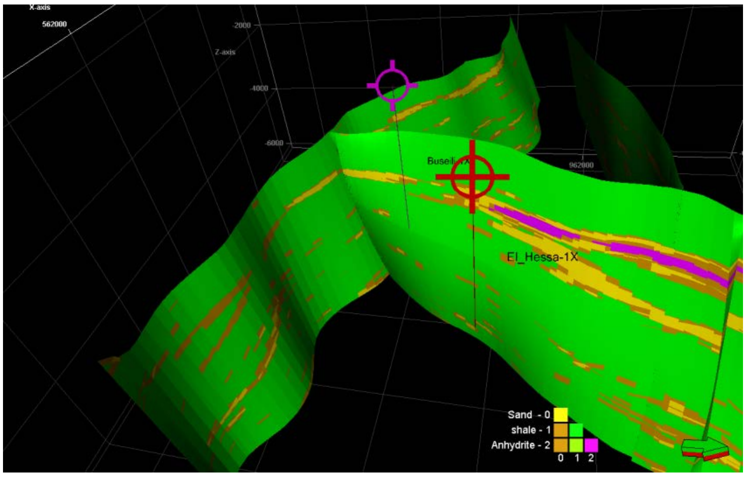

Fig.7: Discrete facies distributed along the fault plain.

This step is a first indication on sealing potentiality in Buselli field .By extracting the facies property along the fault, the northern bounding fault shows at upper part large res/res juxtaposition areas which need high SGR values are required in these areas for the fault to be sealing. While the eastern bounding fault shows minor res/res juxtaposition areas while anhydrite is considered as non-reservoirs. However, small res/res juxtaposition areas Northern fault has much high throw and large res/res juxtapositions are observed – low sealing potential.in general this will affect the smearing value of fault plan and hence the sealing capacity of the fault plain

SHALE GOUGE RATIO& EFFECTIVE SHALE GOUGE RATIO

The Shale Gouge Ratio (SGR) (Fig.8),, is an attempt to predict the proportion of shaly material in the Fault zone. It was defined in publications by Fristad et al. (1997), Yielding et al. (1997) and Freeman et al. (1998). At any point on the fault where the summation is over all units with thickness and clay content that have slipped past that point.

SGR $=\Sigma$ Vsh Δz) / t x100%

The assumption in this algorithm is that material is incorporated into the fault gouge in the same proportions as it occurs in the wall rocks in the slipped interval, based on that SGR can provide a direct estimate of the amount of shale of the fault zone as a result of the mechanical processes of faulting.

ESGR(Freeman,2009), is defined by the equation has developed by RDR, Where is the weighting factor applied to each individual unit.

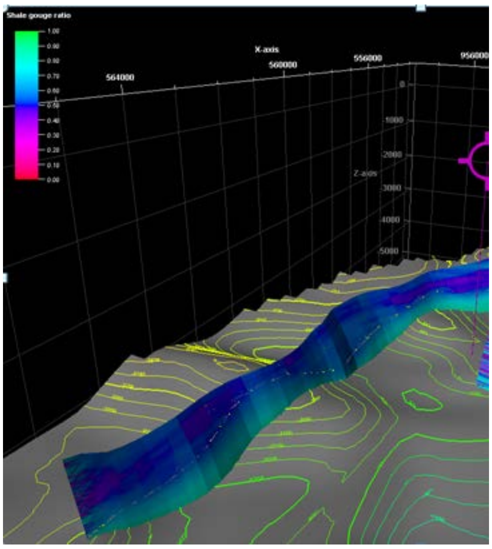

Fig. 8: SGR for clay predictions along the southern fault

A variety of clay mixing algorithms (SGR and ESGR) and clay smearing predictions were computed and combined on the faults. A clay distribution prediction for the faults is the common approach used to predict fault sealing capacity and fault permeability's.. the most upper part of the fault showing presence of Low SGR values indicate possible fault weak points with Rule of thumb when SGR more 25% its reflecting high likelihood of sealing behaviour and when SGR 15-25%: possibly sealing SGR < 15%: high likelihood of non-sealing faults.

the southern fault SGR appear to be of low value on the top part of the fault plain indicating high ability for leaking through the top most part of the fault take in consecration the high percentage of the sand related to shaly and muddy content .

FAULT SEAL CAPACITY

Hydrocarbon sealing capacity calculations (Fig.9) its define and map the sealing capacity distribution of the faults within a geocellular grid using an existing mapped clay content distribution and some form of defined V Shale to sealing capacity relationship.

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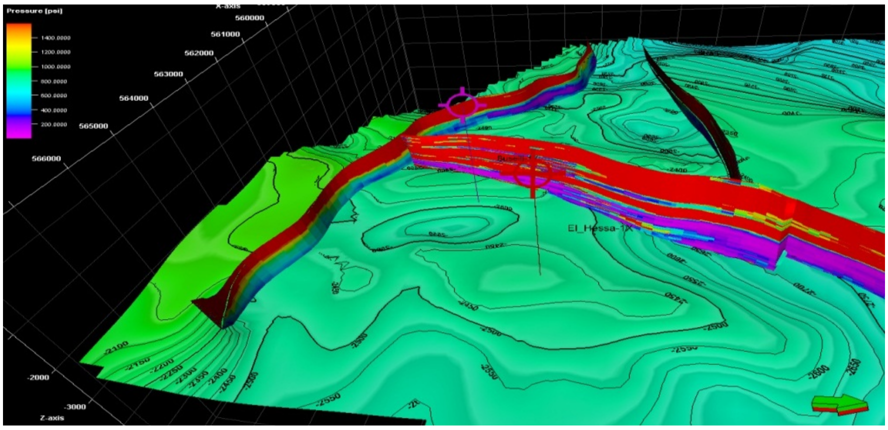

Fig.9: Threshold pressure distribution along the main bound faults.

The pressure regime surround the prospect and related to the thickness of hydrocarbon column can be maintain to 250 m of column height .the pressure variation along the fault plan lead to variation of hydrocarbon column along the fault . Which should not be constant along the fault and the variation of column height along the fault shows the important of define fault seal capacity. It is clear that the eastern bound fault is low pressure which gives hydrocarbon columns around 50 m.

CONCLUSION

Most probably the hydrocarbon migrate and accumulate in the area of the up thrown side from eastern fault further exploration in this up thrown book may be proved the concept lateral migration of the hydrocarbon throw the west fault. The area of Buselli -1 area seems to be in migration pathway of the hydrocarbon without successful trapping mechanism. The area of the up thrown side from eastern fault farther exploration in this up thrown book may be proved the conceptual lateral migration of the hydrocarbon throw the west fault This area on the top of 5.5 SB Abu Madi Formation was calculated t which can be good prospect in size in the future.

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