Workshop paper: H07

Quantification of Depositional and Diagenetic Geobody Geometries for Reservoir Modelling, Hammam Fauran Fault Block, Sinai Peninsula, Egypt

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SUMMARY

Outcrop data has traditionally been used to constrain conceptual models during subsurface reservoir characterisation and geocellular modeling, but published data of depositional and diagenetic geobodies in carbonate systems is lacking. Furthermore, few studies address how these diagenetic bodies, which often cross-cut sedimentary bedding, can be captured in reservoir models, even though diagenetic modification is likely to impart a significant influence on flow behaviour. This paper presents a case study from the differentially dolomitised pre-rift Eocene Thebes Formation on the Sinai Peninsula. It documents the size of depositional and diagenetic geobodies and demonstrates how these data have been incorporated into a 3D geocellular model. The results can be used as input parameters or templates for reservoirs in which fault/fracture controlled dolomite bodies have been described, whilst the workflow could have broader applications to other carbonate reservoirs.

Introduction and Study Area

Outcrop data has traditionally been used to constrain conceptual models during subsurface reservoir characterisation and geocellular modelling. In carbonate systems, these data have been largely qualitative and focused upon the sedimentological framework. Recently, quantitative depositional geobody data has been published[1-3], improving the representation of geological heterogeneity in reservoir models. The volume, shape, size and connectivity of flow-controlling bodies in carbonate systems is also strongly controlled by post-depositional modification, however, and therefore reservoir models also require a quantitative description of diagenetic and structural body geometry. Data of this sort can only be obtained through detailed, multiscale field, petrographical and geochemical, and published examples are rare. Furthermore, representation of the resultant geobodies in reservoir models can require integration of multiple geostatistical tools.

The Hammam Faraun Fault (HFF) block is located on the western Sinai Peninsula and offers exceptional pseudo-3D exposure of the pre-rift, Eocene Thebes Formation. The lower part of this 500m thick succession of remobilised, slope, and basinal carbonates is differentially dolomitised and well exposed in the footwall of the westward-dipping HFF (Fig. 1). The HFF is located immediately offshore of the study area and exhibits approximately 5km of throw[4]. A modern day hot spring occurs adjacent to the HFF, pumping freshwater with a temperature of approximately 70^{o}C.

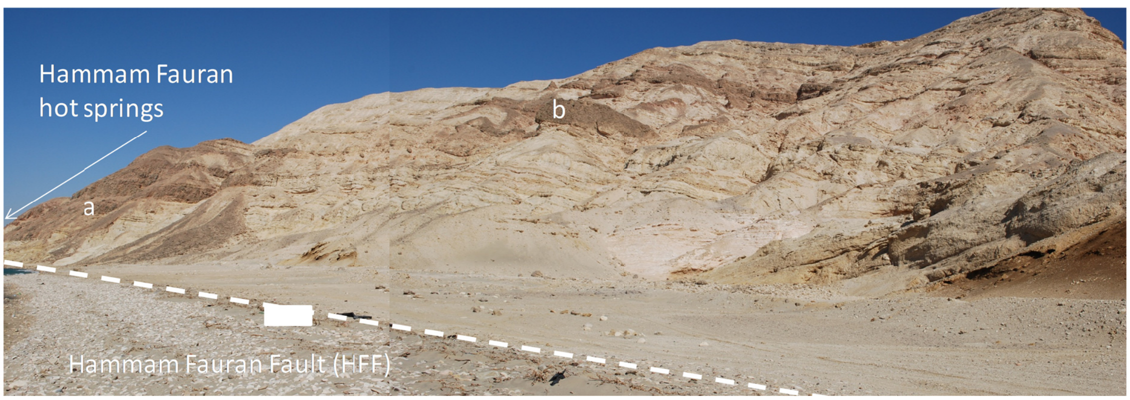

Figure 1 *Hammam Fauran Fault Block, Sinai Peninsula showing massive dolomite (a) and stratabound dolomite (b) within remobilised sediments of the lower Thebes Formation.*

Sedimentological framework and geobody dimensions

The lower Thebes Formation comprises matrix-supported conglomerates and skeletal grainstones, some of which are slumped, and embedded in bedded nummulite and planktonic foraminiferal wackestones and packstones. The presence of matrix-supported conglomerates and slumped deposits suggests sediment remobilisation and slope instability on the distally steepened margin of a shallow water carbonate platform. The matrix –supported conglomeratic beds are interpreted as debris flows and show a low width to thickness ratio (<300m long and $\leq$ 20m thick). In contrast, skeletal grainstone beds, interpreted as high density grainflows or turbidity currents, are up to 1000m in length but <10m thick. In the upper Thebes Formation, highly bioturbated planktonic foraminferal wackestones are interbedded with foraminiferal algal grainstone beds that are up to 1000m long and 1-12m thick. Localised channels are 3-5m thick and 8-15m wide and host skeletal packstone.

Diagenetic geobody characterisation

Two principal types of dolomite body are exposed:

- Statabound, fabric-selective bodies of laterally continuous dolomite that replaced skeletal grainstones and matrix-supported conglomerates. These dolomite bodies are up to 0.25-15m thick and 1-300m in length and extend for up to 2km away from the HFF.

- Pods of massive, fabric-destructive dolomite, up to 70m thick and 300m wide, bounded by fracture corridors that locally exhibit evidence of hydro-brecciation. These so-called massive dolomite bodies form adjacent to the HFF, are highly ferroan and cross-cut by multiple phases of mineralised fractures (dolomite, calcite, haematite, goethite, quartz, halite and anhydrite).

Stable isotope and rare earth element data suggest dolomitisation took place from modified seawater, and that fluid temperatures were lower during formation of the stratabound dolomite (60-90^{o}C) than the massive dolomite (>100^{o}C). A dominant fracture trend of NW-SE is recorded in the massive dolomite, with pervasive fracturing and formation of a chaotic breccia close to the fault core. Away from the HFF, faults, fracture corridors and fractures trend NW-SE, NE-SW and N-S

Reservoir modelling

A three-dimensional reservoir model of the Hammam Fauran fault was constructed using Schlumberger Petrel(c) software. The mapped base lower, base upper and top Thebes Formation surfaces were constructed to constrain the grid, which was bounded by the HFF to the west and the Thal Fault to the SE. Grid cell dimensions were 25 x 25m with a thickness of 3m. Sedimentological logs were placed as pseudo wells and used as the basis for the facies model. Slope and basinal deposits were modelled as background facies. The remobilised grainflow, debris flow and slumped geobodies were then modelled using object-based modelling with body dimensions constrained by the outcrop-derived geobody data (Fig. 2). The massive dolomite body was modelled using a distance from fault algorithm, and the stratabound dolomite modelled using facies-dependant distance from fault and probability functions.

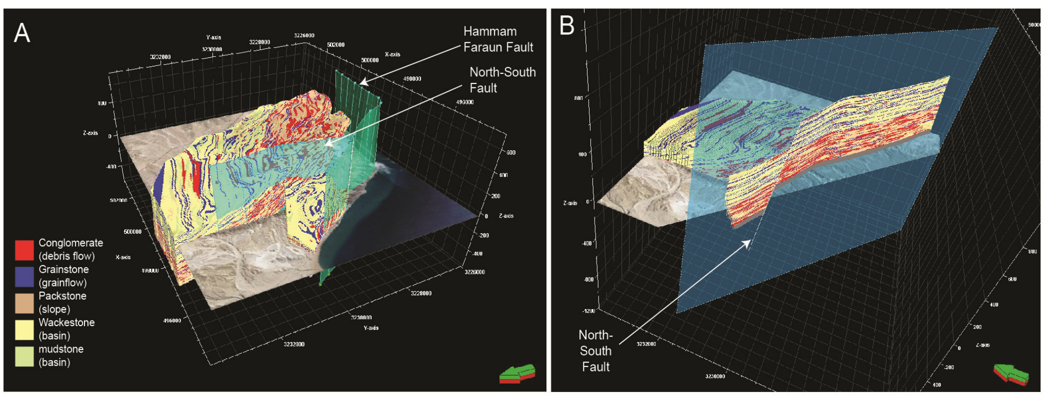

Figure 2*(A) Facies Model with faults. (B) general intersection through the model.*

Implications and Applications

This study has shown how multiscale sedimentological and diagenetic field data can be integrated into a 3D geocellular model, and how multiple geostatistical tools can be integrated to build a realistic 3D visualisation of the study area. The results of this study provide a template for subsurface reservoir models of fault/fracture controlled dolomite bodies, and can be taken forward for petrophysical modelling and simulation to test the impact of geobody properties and geometry on fluid flow.

References

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