Self-similarity of intrasalt thrust faults: Lessons from offshore Levant Basin and the Dead Sea

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1. INTRODUCTION

The Levant Basin in the eastern Mediterranean Sea developed during rifting episodes occurring from Permian to the Early Jurassic (Netzeband et al. 2006; Gardosh et al. 2010), and has been a deep-water basin with a passive continental margin at least since the Cretaceous (Gardosh et al. 2008). Thick sequences of halite and interbedded shale were deposited during the infamous Mesozoic Salt Crisis (c. 160–53 Ma). Salt-rich passive continental margins facilitate complex deformation of both the mobile (stringers) and rigid (basin) units (Netzeband et al. 2006; Gardosh et al. 2010), and has been a deep-water basin with a passive continental margin at least since the Cretaceous (Gardosh et al. 2008). The eastern Mediterranean Sea is bounded by the Cretaceous-Paleogene (66–53 Ma) extensional tectonics and the Mesozoic–Cenozoic (53–2 Ma) compressional tectonics. All seismic data are displayed with a normal SEG polarity, where a downward increase in acoustic impedance corresponds to a positive (red) reflection. Multiple seismic attributes have been used in this work and are summarized in Figure 3.

2. METHODS

This study utilizes a pre-stack zero-phase, depth migrated 3D seismic reflection survey showing the seismic dataset utilized in this study. Seismic analysis and interpretation of the approach used in this study. Fold Characterization • Structural plots Figure 2 (above): Depth map to Top Salt in the study area. The dominant thrust zones and their seismic sections, name diagram and dip plot in the zone are indicated. Figure 3: Schematic illustration of the approach used in this study. 3. RESULTS

3.1. DIFFERENT THRUST SYSTEMS

The work demonstrates three different thrust fault types, where the dominant one being N-S oriented and the other two N-S and NW-SEE trend faults, respectively. However, only the N-S and NW-SEE oriented deformational features are believed to be syn-Messinian structures; the NW-SEE trending thrusting was likely initiated at a later stage. This is best visualized in seismic sections (Figure 4) and on depth- and dip illumination maps (Figure 5). At lower stratigraphic levels, the dominant intrasalt thrusts are assumed to evolve from the NW-SEE trend axis in the seismic package 4 (MC1) to a NW-SEE trend in the seismic package 4 (MC2) and on the Top Salt (TS) reflector. The extensional NW-SEE faulting in MC1 induces NW to NW-SEE bending in Mc2 and on the TS reflector. Although the MC2 package and the TS surface are folded similarly, they are not conformably deformed. The MC2 is much more deformed by folding and faulting than the underlying elastic surface indicating that some salt deformation occurred before the Early-Messinian event. An important observation that the smaller scaled N-S structural elements have a general vergence to the west, while the dominant NW-SEE trending deformation is verging to the NE. This is indicative of a polyphase deformation history, and cannot easily be explained simply by a rotation of the deformational trend.

3.2. DETAILED INTERPRETATIONS

3.3. FAULT PROPAGATION

The N-S oriented west-verging fault train is believed to be fore thrusts, indicating a westwards transportation direction. An alternative interpretation is that they represent an important basin-bounding fault, but as no significant steepening of older master thrusts occurs, we see this as unlikely. The NW-SEE oriented thrusts exhibit a striking similarity to the thrust systems described by Alsp et al. (2017b). Even though the thrusts show a general vergence to the NE, a considerable number of faults display an opposite verging trend. This can be explained by the ‘downslope-directed underthrust model’ as presented by Alsp et al. (2017b). The presence of a basal detachment, steepening of back thrusts and hanging wall checkbook supports this model. We propose that the presence of older Messinian faults act as buttresses and encourage the development of piggyback sequences within the evaporites.

4. CONCLUSIONS

We propose a polyphase deformation model for the intrasalt strata in the Levant Basin. Two distinct syn-Messinian sets of contractual faulting affects the salt sequence. The N-S oriented thrust faults exhibit a westwards transport direction, while the NE-SV oriented thrust fault set is associated with syn-salt deformation. The polyphase deformation model for this area is supported by the presence of a basal detachment, steepening of back thrusts and hanging wall checkbook. We propose that the presence of older Messinian faults act as buttresses and encourage the development of piggyback sequences within the evaporites.

REFERENCES


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