Synchronous Development of Squeezed Diapirs, Thrust Welds and Reverse Faults: Learnings from Field Examples in the Flinders Ranges and Application to Prolific Basins Such as the Gulf of Mexico

Oskar Vidal Royo[1], Mark G. Rowan[2], Oriol Ferrer[3]

[1]Terractiva Consulting SL
[2]Rowan Consulting Inc.
[3]Universitat de Barcelona

Abstract

The rheological nature of salt makes it a very effective seal in either hydrocarbon reservoirs and CO2 storage sites. The study of salt structures has consequently experienced a recent uprise, the characterisation of their geometry in three dimensions becoming indispensable for successful E&P assessments. The complexity of salt structures formation and growth, however, challenges the common geometric principles that typically inform about the sedimentation and deformation of geological bodies. Due to salt and overlying stratigraphic units deformation complexity, good 3D visualization skills are required, along with an integrated understanding at both regional and prospect/site scales.

The interactions between salt diapirs, thrust welds and thrusts in contractional belts are poorly understood due to, first, the inability of seismic data to distinguish between thrusts and welds or resolve associated sub- resolution deformation, and second, the paucity of good field examples. The Warraweena area in the Northern Flinders Ranges of South Australia contains examples of Neoproterozoic to Early Cambrian squeezed diapirs linked by steep reverse faults formed during the Delamerian Orogeny. Benefiting from good field exposures, we use geological mapping, cross-section construction and conceptual structural models to assess the three- dimensional geometry and evolution of the structures, the lateral transition from diapirs to linking faults and the variability of associated meso-and small-scale deformation.

Three discrete diapirs consist of narrow outcrops of Callanna Group megabreccia (Willouran in age) up to 5-km long. Their diapiric origin is confirmed by local development of caprock, steepening of flanking strata in composite halokinetic sequences and reworked diapir and roof debris in adjacent strata. The surrounding rocks display only background levels of small-scale deformation. In contrast, the linking faults show no evidence of precursor diapirism, have fault-related anticlines up to 100s of m in wavelength in their hanging walls, and an associated increase in small-scale deformation (i.e. millimetre to metre scale folds, fractures and shear fabrics). The transitions from diapirs to faults occur within less than 200 m as short thrust welds at the diapir terminations.

The exposed structures are analogous to those found on the subsurface of prolific salt basins such as the Gulf of Mexico and the South Atlantic conjugate margins. The results of this work can aid geoscientists evaluating three- way traps against squeezed diapirs, welds or faults, and can help them to predict the style and abundance of both halokinetic and small-scale structures that are below seismic resolution.