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Salt Deformation and Associated Traps, Officer Basin, Western Australia

The Officer Basin (Fig. 1) is the third largest onshore basin in Australia. The portion of the basin within the state of Western Australia, referred to as the western Officer Basin, covers an area of 310 000 km^2 and contains a Neoproterozoic and Cambrian sedimentary section more than 6 km thick.

The western Officer Basin has a complex structural history, beginning in the Neoproterozoic and continuing into the Paleozoic, with multiple phases of salt mobilization. Its present-day structural and stratigraphic patterns are dominated by salt deformation and associated features. This study focuses on better understanding of the salt deformation and its role in the basin's structural history and formation of hydrocarbon traps. Reprocessing of approximately 4300 km of early 1980s 2D seismic data yielded enhanced imaging of the salt structures and the sub-salt sequence, leading to improved understanding of the halokinetic evolution and the petroleum potential of the basin.

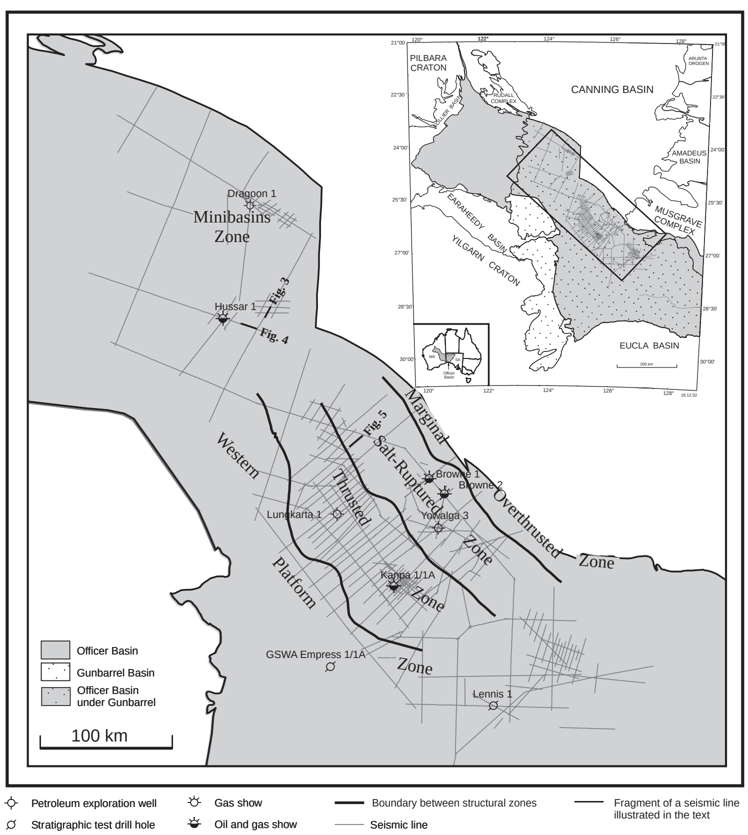

Fig. 1. Location map, Officer Basin,Western Australia. The zoomed in map shows the study area and the structural subdivision (modified after Carlsen et al., 2003).

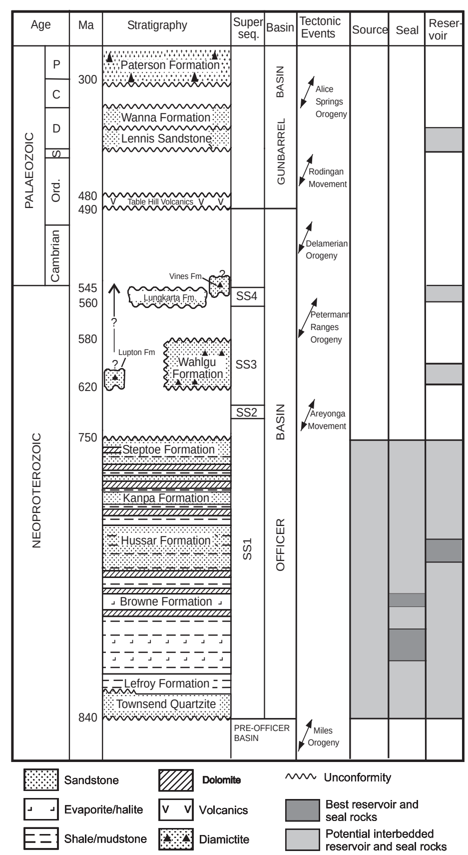

Fig. 2. Generalised stratigraphy and major tectonic events, Officer Basin, Western Australia

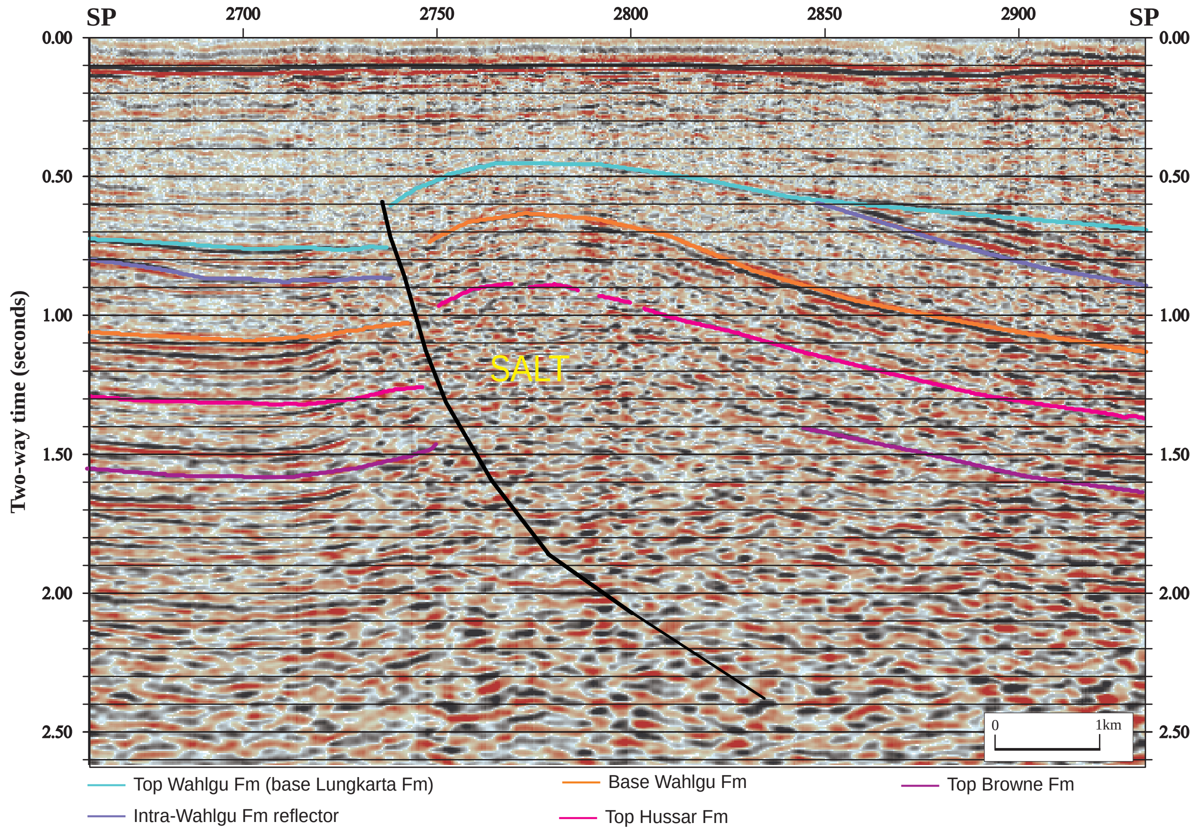

Fig. 3. Seismic line N83-011, showing a salt-lubricated thrust and associated drag rollover and salt-nucleated anticlinal feature. For line location see Figure 1.

The sedimentary succession of the western Officer Basin contains clastics, evaporites and carbonates, in part glacigene, that were deposited in three supersequences (Walter et al., 1995). Regional unconformities are associated with major uplift events in the basin during the Areyonga Movement, the Petermann Ranges Orogeny, and the Delamerian Orogeny (Apak and Moors 2000; Apak et al, 2002), and define the supersequence boundaries (Fig. 2).

A thick, basin-wide, halite-dominated sequence is present low in the succession, within the Browne Formation, which also contains mudstone, argillaceous siltstone, dolomite, and sandstone. Minor evaporites are observed in the overlaying Hussar, Kanpa and Steptoe Formations. These are a succession of alternating sandstone, dolomite, shale and evaporates, deposited in restricted shallow-marine shelf, shoreface and possibly lagoonal environments.

Compressional processes, associated with deformation of the adjacent Mesoproterozoic igneous-metamorphic Musgrave Complex, triggered multi-phase mobilization of the thick halite-dominated sequence. Significant salt redistribution resulted in thickness variations in the overlying section and a variety of salt-related features. Thin-skinned low-angle thrusts were lubricated by the salt, producing ramp anticlines and salt-nucleated structures. Contractional structures formed at this time were rapidly modified by halokinetic uplift. The latter continued and resulted in diapiric ridging and variety of salt emplacement features. Some ridges extend more than 100 km laterally and vertical piercement ranges from tens of meters to more than 1500 m, with several outcropping diapirs.

Five structural zones are distinguished in the central western Officer Basin (Fig. 1), based mainly on seismic data: the Marginal Overthrusted, Salt-ruptured, Thrusted, Western Platform and Salt-dominated Minibasins Zones (Carlsen et al., 2003). These reflect the influence of the orogenic processes within the Paterson Orogen and the Musgrave Complex, the salt mobilisation associated with these processes, and the style of the halokinetic structures produced. These zones can not be mapped in the northwestern and southeastern portions of the western Officer Basin, where

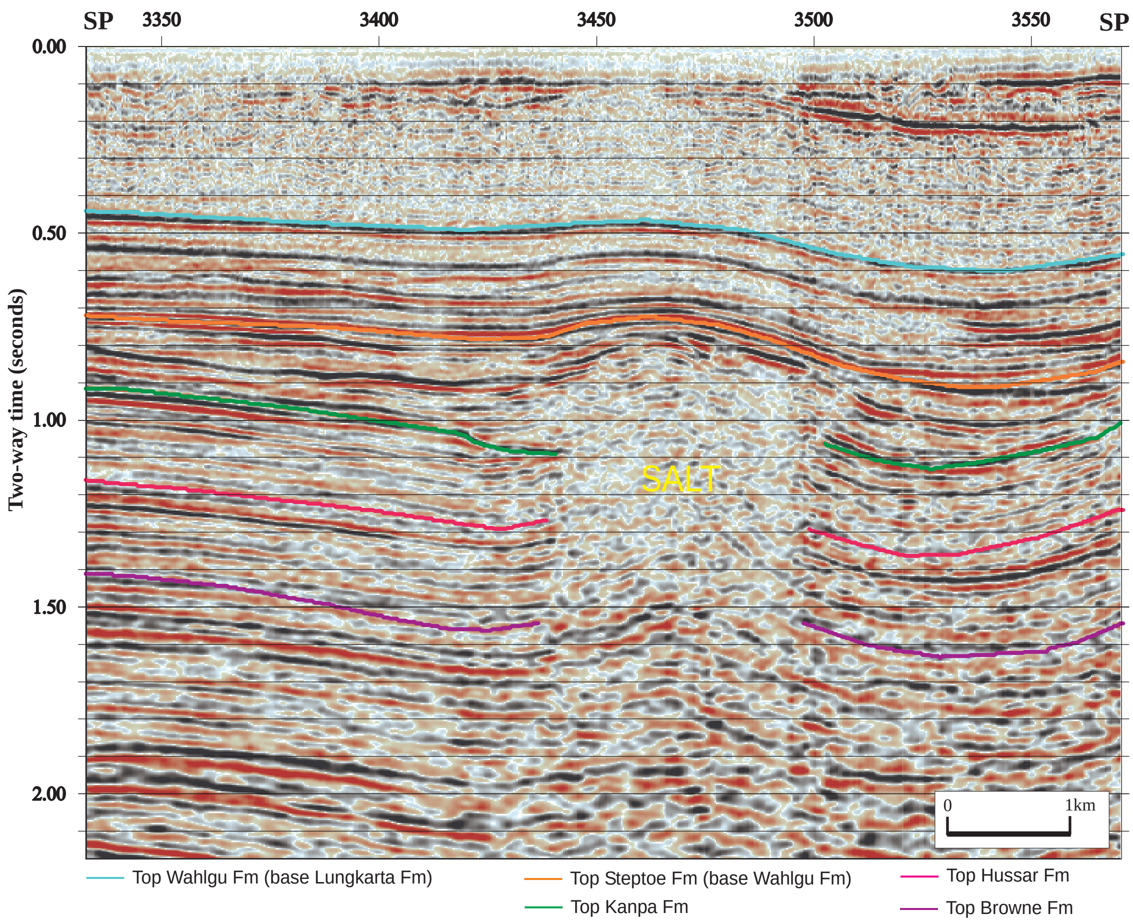

Fig. 4. Seismic line N83-006, illustrating a salt diapir and related trap styles. Hussar Formation sandstones and Steptoe Formation carbonates and clastics of enhanced porosity are the potential reservoirs. For line location see Figure 1.

there are little or no seismic data. The Marginal Overthrusted Zone is identified as transitional between the orogen and the Officer Basin; the Salt-ruptured Zone is characterised by intense salt piercement into the overlying strata; the Thrusted Zone is characterised by thin-skinned, low-amplitude thrusts and reverse faults, lubricated by the salt within the Browne Formation; the Western Platform Zone is a relatively stable area, least affected by halokinetic deformation; and the Salt-dominated Minibasins Zone is developed in the north-northwestern (Gibson) area of the western Officer Basin, where salt withdrawal has provided accommodation space for restricted depositional basins, and extensive salt-cored structures form salt stocks and walls.

The salt deformation in the basin provides structural features capable of trapping hydrocarbons. The prospective geometries are attributed to drape structures with a potential for multiple pay, thrust-related anticlinal features, combined traps at diapirs' flanks and enhanced porosity traps.

Large- and small-scale thin-skinned thrusts lubricated by the salt within Browne Formation, and intersecting younger strata, produced drag rollover structures and salt-nucleated anticlinal features (Fig. 3). Such traps are prospective particularly with the presence of the Hussar Formation reservoir facies at the crest of the structures. Drape folding in the suprasalt section is common and creates four-way dip closures above the salt diapirs and turtle structures, with a possibility of multiple pay. Traps associated with enhanced porosity are found both above diapirs or in the distal limb of the rim synclines due to truncated updip away from the diapir. Leaching of soluble components such as halite, anhydrite, and carbonate from the sandstone and carbonate, and development of karst within carbonates may create

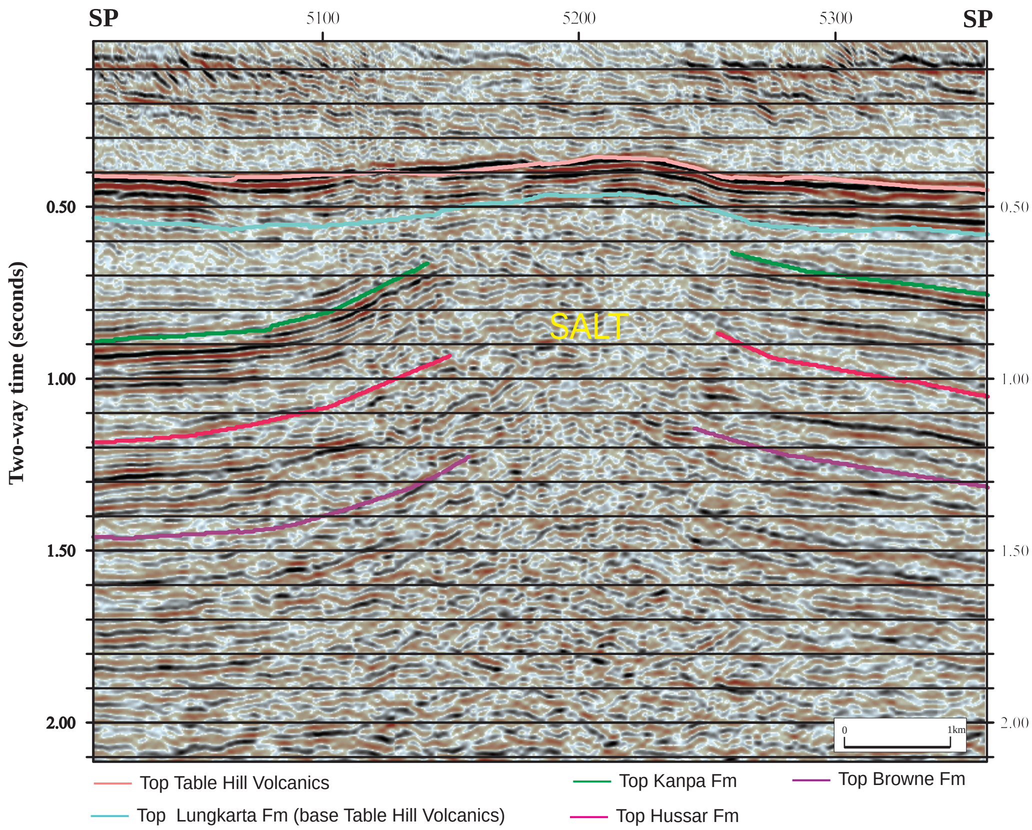

Fig. 5. Seismic line T82-055, illustrating a salt diapir and possible trap styles in the Salt Ruptured Zone. Hussar Formation is considered the major reservoir. For line location see Figure 1.

extensive secondary porosity, particularly in the Steptoe Formation (Fig. 4). In the rim synclines pinchout traps exist due to sediments thinning away from the diapir. On both flanks of diapirs, prospective geometries are related to structural traps beneath overhangs or to upturn of sediments by the diapir, providing salt wall abutment traps (Fig. 5). Most of the salt-related traps were available before the main phases of petroleum expulsion and could form interesting targets for future oil and gas exploration.

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