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The Influence of Reverse-Reactivated Normal Faults on Fault Damage Zone Characteristics in Sandstones: A Case Study at Castle Cove, Otway Basin

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ABSTRACT

Basin inversion is one of the most significant modes of compressional intraplate deformation and has fundamental implications for the prospectivity of petroleum producing basins. Inversion is mainly accommodated by the contractional reactivation and reversal of pre-existing extensional faults. Whilst there have been many previous studies of the large scale geometrical characteristics of fault reactivation during basin inversion, there is little data on the properties of damage zones associated with these faults. We present results from a detailed structural investigation of a well exposed fault system within the Otway Basin at Castle Cove, southeast Australia. Castle Cove provides excellent exposures of the Lower Cretaceous Eumeralla Formation, which is a moderately porous (up to 12%) fine-grained volcanogenic sandstone. The Castle Cove Fault is a 30 km long, NE–SW striking fault. The fault originated as a listric normal fault during the late Cretaceous and was reverse-reactivated during NW–SE mid-Eocene to Recent compression. We assess the influence of the fault displacement history on damage zone characteristics by undertaking detailed structural mapping (88 m2 total) and collecting structural data for 973 fractures. Of these fractures, 56% were filled with siderite, 33% had no visible fill and 11% were filled with calcite. Within 25 m of the fault 16 fractures/m were recorded, however more than 25 m the spatial density of fractures decreased to 8 fractures/m. A total of 11 fracture sets were identified, with six sets recording pervasive structural events. Two sets record NW–SE strike-slip and NE–SW to NW–SE compression and these sets may have formed prior to, or during, tilting of the strata during mid-Cretaceous compression. Two sets record NE–SW and NW–SE extension and this has been attributed to renewed rifting and normal faulting in the late Cretaceous. Lastly, two sets record NE–SW and N–S compression, attributed to fault rotation during reversal of the fault in the mid-Eocene to Recent. The remaining sets are minor and interpreted to record overpressure or local stresses unrelated to regional tectonics. Considering the extent of mid-Eocene to Recent compression, there are surprisingly small number of fractures recording NW–SE compression. This study highlights the need to conduct careful reconstruction of the structural histories of faults that experienced complex reactivation histories when attempting to define off-fault fluid flow properties.