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Quantitative analysis for compaction trend and basin reconstruction of the Perth Basin, Australia: Limitations, uncertainties and requirements

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This study quantifies compaction trends of Jurassic-Quaternary sedimentary units in the Perth Basin, and applies the trends to reconstruct the sedimentation and subsidence history with 2D and 3D models. BasinVis 2.0, a MATLAB-based program, as well as MATLAB 3D surface plotting functions, 'Symbolic Math' and 'Curve Fitting' toolboxes are used to analyze well data. The data were collected from fourteen industry wells and IODP Site U1459 in a study area (200x70 km2) on an offshore part of the basin, which were arranged for four successive stratigraphic units; Cattamarra, Cadda, Yarragadee, and post-breakup sequences. The Perth Basin is a large north-south elongated sedimentary basin extending offshore and onshore along the rifted continental margin of southwestern Australia. It is a relatively under-explored region, despite being an established hydrocarbon producing basin. The basin has developed by multiple episodes of rifting, drifting and breakup of Greater Indian, Australian and Antarctic plates since the Permian. The basin consists of faulted structures, which are filled by Late Paleozoic to Cenozoic sedimentary rocks and sediments. After deltaic-fluvial and shallow marine deposition until early Cretaceous time, carbonate sedimentation has prevailed in the basin, which is related to the post-rift subsidence and the long-term northward drift of the Australian plate.

High-resolution porosity data of Site U1459 and well Houtman-1 were examined to estimate best fitting compaction trends with linear, single- and two-term exponential equations. In the compaction trend plot of Site U1459 (post-breakup Cenozoic carbonates), the linear and single-term exponential trends are relatively alike, while the two-term exponential trend has abrupt change near seafloor due to highly varying porosity. The compaction trends at well Houtman-1 (Jurassic sandstones) are alike in the estimated interval, however initial porosities are quite low and different. In the compilation plot of the two wells, the two-term exponential trend presents better the porosity distribution, by adopting a trend change as estimation overfitting, by the lithologic transition from carbonates to sandstones. The abrupt trend change suggests that the multiple piece-wise compaction trend is suitable for the Perth Basin. The compaction trends are used to quantify the sedimentation profile and subsidence curves at Site U1459. 2D and 3D models of unit thickness, sedimentation rate and subsidence of the study area are reconstructed by applying the exponential trend to the stratigraphic data of industry wells. The models are visualized using the Ordinary Kriging spatial interpolation. The results allow us to compare

differences between compacted (present) and decompacted (original) units through depth and age. The compaction trend has an impact on thickness restoration as well as subsidence analysis. The differences become larger with increasing depth due to the rising compaction effect during burial. Other factors can deviate the compaction trend further through age. This phenomenon highlights the fact that the restoration of largely compacted (usually deeper or older) layers is crucial to reconstruct sedimentation systems and basin evolution. This has often been underestimated in academic and industry fields. This study suggests that researchers apply the appropriate compaction trend estimated from on-site data for basin reconstruction and modelling.

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