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Paleobathymetry from 3-D flexural backstripping: Implementation and application to NW Australia and Liberia passive margins

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Understanding paleobathymetry is important to hydrocarbon explorationists, as it impacts depositional environments, reservoir quality, source rock preservation, hydrocarbon migration pathways, and paleo-stress. At long wavelengths (basin scale), bathymetry is controlled predominantly by isostatic compensation of vertical loads, which include sediment, water and spatial and temporal variations in the thickness and temperature of the crust and lithospheric mantle. Roberts, et al. (2003) present a workflow to account for these loads and derive paleobathymetry by 3-D flexural backstripping. However, to our knowledge, commercially packaged software for flexural backstripping is limited to two dimensions, and 3-D software is limited to Airy isostasy, which does not account for the elastic stiffness of the earth's crust and may, as a result, produce local error of 1km or more.

We have developed a 3-D backstripping application that incorporates flexural isostasy, and is implemented in a workflow modeled after Roberts, et al. (2003). The application restores the isostatic components of basin geometry and bathymetry, and may account for the effects of sediment loading (isostasy & compaction), and rift-related subsidence (post- and syn-rift effects of homogeneous or depth-dependent pure-shear stretching models. Effects of dynamic topography, if quantifiable, may be prescribed as a bulk shift after backstripping. Implemented as a plug-in to Gocad, the application is accessible to a broad audience of geoscientists.

The flexural isostasy implementation accounts for basin geometry and spatially heterogeneous layer thickness by discretizing each layer as a series of cylindrical loads of varying density and thickness at the nodes of a square grid. The isostatic effect of a single cylindrical load is provided by Brotchie & Silvester (1969) and the effect of multiple loads may be summed linearly. An iterative approach for calculating local water depth accounts for variations in eustatic sea level, allows for emergent topography, and overcomes potential pitfalls associated with the analytical solution for a "filled" basin.

We review the numerical implementation of flexural backstripping, and discuss implications, as well as limitations, of paleobathymetric maps for source rock preservation and reservoir presence in two diverse passive margin settings: offshore Liberia and the Northwest Shelf of Australia.