Oblique and Orthogonal Rifting in the East African Lakes: Analogs to the South Atlantic Pre-salt Basins

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Ancient tectonic lakes such as those of the East African Rift host thick sequences of organic-rich hydrocarbon source rocks, and in some basins also contain extensive oil and gas reservoirs. The Great Lakes of the East African rift are the most extensive modern depositional analog for the pre-salt basins of the South Atlantic Ocean, and studies of these tectonically active basins are useful for understanding hydrocarbon systems within deeply buried Cretaceous sequences. New seismic reflection data are presented from Lake Albert at the northern end of the western branch of the East African Rift, and contrasted with legacy seismic data from the southern part of the East African Rift System. Lake Albert experiences approximately orthogonal extension, whereas northern Lake Malawi, at the southern end of the western branch, undergoes oblique rifting. By comparing two basins experiencing similar strain rates along a common plate boundary, and rifting lithosphere of comparable thickness and rheology, it is shown that extension direction and lithosphere structural heterogeneity pre-determine the regional rift segment geometry, drainage system development, and patterns of sediment infilling. The contrasting extensional framework produces radically differing subsidence patterns and drainage networks. Oblique extension leads to severe sediment underfilling of asymmetric basins and the development of the world's deepest and longest-lived lakes. Orthogonal rifting produces isolated, symmetrical structural segments, leading to sediment overfilling of the basins, and shallow lakes, especially later in the history of the basins. This late, shallow lake stage of extension and infilling leads to the increased likelihood of repeated desiccation events; this shallow lake environment has profound implications for evolving faunal assemblages and the sedimentary facies geometries in the basins.