

Thermal Maturity of the Early Mesozoic Richmond and Fundy Basins, in the Context of Newark and Taylorsville Basin Thermal Histories, Eastern USA and Canada

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Previous vitrinite reflectance and thermal history studies (Malinconico, 2002, 2010) of the eastern USA early Mesozoic Taylorsville (VA/MD) and Newark (NY/NJ/PA) continental rift basins have shown that basement conductive heat flow in these basins has been modified by basin-scale advective fluid flow, pathways of which vary among basins based on distribution of permeable fluvial versus impermeable lacustrine facies. The basal basin heat flow is hypothesized to be a relict of position relative to the Alleghanian orogenic metamorphic/ thermal axis, which was also the locus of post-orogenic collapse. In the Taylorsville basin, an overfilled-lake-basin type according to Carroll and Bohacs (1999), and located along the Alleghanian thermal axis, the syn-rift background geotherm was $\sim 45\text{-}55^\circ\text{C}/\text{km}$. Basin-scale groundwater flow through extensive fluvial strata and driven by gravity-driven meteoric water downwelling at the western border fault resulted in lower syn-rift geothermal gradients in the western basin ($40^\circ\text{C}/\text{km}$) than in the eastern basin ($\sim 55^\circ\text{C}/\text{km}$). The Newark basin, generally a balanced-fill lake-type basin and west of the Alleghanian metamorphic axis, had a calculated syn-rift background gradient of $\sim 25^\circ\text{C}/\text{km}$. Syn-rift steady-state groundwater flow confined to basal fluvial strata, again gravity-driven by border-fault meteoric downwelling, conductively heated overlying low-permeability lacustrine formations to $\sim 35^\circ\text{C}/\text{km}$. Both basins experienced post-rift, pre-coastal-plain structural inversion and erosion.

The Richmond basin is located ~ 15 km southwest of the Taylorsville basin along strike with the Taylorsville western border fault. The exposed strata are Triassic, and form a structural syncline. The pattern of new surface vitrinite reflectance data indicates that synclinal deformation was post-rift (post-thermal maximum), consistent with inversion processes affecting other basins. Reflectance data was also measured on cuttings from two deep industry wells in the center of the basin: Cornell Oil Bailey #1 and Horner #1. Vitrinite reflectance of 1.7% was reached at ~ 6600 ft (2000 m) in Bailey and ~ 6000 ft (1800 m) in Horner. Calculated geotherms of $\geq 45^\circ\text{C}/\text{km}$ are consistent with the Richmond basin's similar tectonic position and facies association as the Taylorsville basin.

The Fundy basin of Nova Scotia and New Brunswick (NB) is primarily an underfilled-lake-type basin with a paucity of confirmed organic-rich sediments. Sparse industry maturity data (from the Canada-Nova Scotia Offshore Petroleum Board) is available for the Irving Chevron et al. Cape Spencer #1 well in the Bay of Fundy, 5 km south of the NB coast and

Headlands fault (Wade et al., 1996), which is part of the border fault system that also separates the basement Avalon and Meguma terranes. The downhole industry vitrinite reflectance data suggest a syn-rift geothermal gradient of $\sim 20^{\circ}\text{C}/\text{km}$, reasonable for cooling of a background gradient of $25^{\circ}\text{C}/\text{km}$ by meteoric downwelling processes similar to other rift basins. The Fundy basin, like the Newark basin, is located off-axis of late Paleozoic metamorphism. New surface reflectance data from isolated rider-block exposures of Triassic (Carnian) Wolfville Formation in the highly-faulted Avalonian footwall, coastal NB, at Melvin Beach (0.83% Ro) and 30 km northeast at Martin Head (0.28% Ro) indicate both variable syn-rift burial depth and post-rift exhumation.