Deep Crustal Structure and Plate Tectonic Development of the Canadian Appalachians: Insights From Marine Deep Seismic Reflection Profiling

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Approximately 1600 km of marine deep seismic reflection data, gathered northeast of Newfoundland in 1984 and within the Gulf of St. Lawrence and Cabot Strait in 1986, have provided remarkable insights into the deep crustal structure underlying the familiar tectonostratigraphic zones of the Canadian Appalachians. These new data, coupled with recent geologic interpretations, encourage a re-examination of simple models of the plate tectonic evolution of the orogen.

The seismic data, which sample the crust and upper mantle to depths of the order of 50 to 60 km, demonstrate the existence of at least three discrete, lower crustal blocks which underlie the five well-known tectonostratigraphic zones. The western block is the North American craton that formed the western margin of the Iapetus Ocean; it underlies the Anticosti basin, the Humber Zone, and the western portion of the Dunnage Zone. The central block, inferred to be the eastern margin of the Iapetus Ocean, underlies the eastern portion of the Dunnage Zone and the Gander Zone. The eastern block underlies the Avalon Zone and possibly the Meguma Zone. The zone boundaries defined on the surface are not underlain by analogous mid- to lower crustal structures, except in the case of the boundary between the Avalon and Gander zones (represented by the Dover and Hermitage Bay strike-slip faults in Newfoundland). Rather, the data suggest that much of the orogen is allochthonous with respect to the lower crust.

These observed and inferred upper crustal to lower crustal relationships are remarkably consistent from one seismic line to another, over along-strike distances of up to 500 km. This internal consistency enables us to interpolate between lines and to infer the three-dimensional configurations of the lower crustal blocks, based on isolated, two-dimensional seismic observations. For example, these data strongly support long-standing suspicions that the ancient, Iapetan rifted-margin of the North American craton is mimicked by the St. Lawrence promontory and the Quebec reentrant of the Appalachian orogen.

By treating the lower crustal blocks as semi-rigid "plates," we can palinspastically restore their relative motion along selected major fault systems. Specifically, we examine the implications of restoring motion on major Carboniferous faults which were linked through the Magdalen Basin, and on a major hypothesized fault zone, believed to have been active primarily during the Acadian orogeny, which lies orthogonal to the regional trend of the Appalachians and separates Cape Breton Island from the mainland. These reconstructions also have important implications for the emplacement of the Meguma Zone.