LITHOPROBE Crustal Seismic Reflection Profiling in Central Alberta: New Constraints on Tectonic Assembly and Basement-Cover Interaction

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The crystalline basement beneath the Western Canada Sedimentary Basin (WCSB) is composed of crustal domains recognized on the basis of aeromagnetic signatures and U-Pb zircon geochronology of recovered drill core. Based on analogies with the exposed shield, the mosaic of crustal domains is inferred to have formed during continental collision and accretionary events during the interval 1.78-2.0 Ga. In order to test the geometric implications of these models and to elucidate processes of continental growth, LITHOPROBE acquired more than 500 km of crustal scale (18 s) seismic reflection data along a transect extending from the Saskatchewan border at TWP 40 to Entwhistle, Alberta, crossing from the Archean Hearne Craton northwestwards into the Rae Province. From a petroleum perspective, the transect traverses a number of significant hydrocarbon production trends, such as the Rimbey-Meadowbrook reef chain.

Prominent reflections have been observed throughout the thickness of the crust (35-45 km) beneath the sedimentary section. Dipping reflection zones appear to sole into a reflective lower crust, the base of which is characterized by a dramatic loss in reflectivity (12 - 14 s) interpreted to be reflection Moho. The overall reflection geometry issuggestive of compressional deformation, and delineates two regions of crustal-scale thrust imbrication with opposing vergence. The vergence reversal coincides with a postulated suture zone within the Rimbey granite belt that is inferred to mark the boundary between the Rae and Hearne provinces. The eastern region is 300 km across strike and shows evidence for a west-northwest verging thrust belt and a corresponding increase in depth to the Moho and metamorphic grade into the inferred hinterland region. A prominent positive step in the gravity field in the western part of the transect is associated with the inferred suture zone and possibly a crust-penetrating shear zone that offsets the Moho, formed during late stages of a Rae-Hearne collision. Available geochronological constraints imply contemporaneity of crustal imbrication observed in the Alberta basement with that documented in the TransHudson Orogen to the east (1.78-1.81 Ga). This implies that a 1000 km wide tract of continental crust was undergoing shortening across strike during assembly of this part of the Canadian Shield.

Consistent acquisition and processing parameters, coupled with the unusual length and continuity of this dataset, provide a unique regional seismic perspective from which to evaluate the possible role of antecedent basement structures in Phanerozoic depositional and diagenetic processes. Three distinct styles of basement-cover interaction have been observed: sedimentary drape over paleotopographic highs on the basal unconformity, intersection of strong dipping reflectors (faults?) with the base of the sedimentary succession, and seismic sedimentary facies transitions that are spatially associated with basement domain boundaries. The latter is particularly evident beneath the Rimbey-Meadowbrook trend, where lower Paleozoic reflectors (pre Cooking Lake) exhibit an abrupt lateral change in amplitude and continuity that appears to coincide with a major basement suture zone.