JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 104, NO. B4, PAGES 7463–7480, APRIL 10, 1999

Wide-angle seismic transect across the Torngat Orogen, northern Labrador: Evidence for a Proterozoic crustal root

Thomas Funck and Keith E. Louden

Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada

Abstract. A refraction/wide-angle reflection seismic transect across the Labrador peninsula covers the Core Zone of the SE Churchill Province, the Paleoproterozoic Torngat Orogen, and the Archean Nain Province including a portion of the Labrador continental margin. An airgun array was used as source, and 11 ocean-bottom seismometers and 16 land stations recorded the shots. Forward modeling of travel times and amplitudes reveals a deep asymmetric crustal root beneath the Torngat Orogen, with a crustal thickness of >49 km and with *P*-wave velocities of 6.9-7.0 km/s. The geometry of the velocity model and the root can be best explained by either westward dipping subduction or westward underthrusting of the Nain crust. Gravity modeling suggests a correlation of the crustal root with a gravity low that extends ~100 km in an E-W direction and ~200 km from north to south. The preservation of the crustal root is attributed to the lack of postorogenic heating and ductile reworking consistent with the lack of abundant postcollisional magmatism in the SE Churchill Province. A discontinuity possibly cutting through the entire crust is interpreted as a zone of major transcurrent shearing associated with the main phase of deformation. West of the Torngat Orogen, the crustal thickness in the Core Zone of the Churchill Province varies between 35 and 38 km (*P*-wave velocities of 5.8-7.0 km/s). East of the orogen, the crystalline crust in the Nain Province is ~38 km thick (velocities from 5.8 to 6.9 km/s) but thins to 9 km in the shelf area of the Labrador margin, where it is covered with up to 8 km of sediments. No high-velocity zone was found beneath the thinned continental crust at the margin.

1. Introduction

The geology in the northeastern Canadian shield (Figure 1) studied by the Lithoprobe Eastern Canadian Shield Onshore-Offshore Transect (ECSOOT) is characterized by a block of mainly Archean crust (Core Zone), which was trapped during the oblique convergence of the Archean Superior and Nain provinces [*Wardle and Van Kranendonk*, 1996]. The Proterozoic New Quebec Orogen sutures the Superior Province and the Core Zone to the west, while the Torngat Orogen sutures the Core Zone with the Nain Province to the east. The refraction/wide-angle seismic (R/WAR) transect across the Torngat Orogen was designed to address several questions associated with the development and structure of that orogen.

One major question is the crustal thickness beneath the Torngat Orogen. Seismic studies in associated Proterozoic orogens (e.g., the Trans-Hudson Orogen [*Lucas et al.*, 1993] and in the Baltic shield [*BABEL Working Group*, 1990]) reveal crustal roots, although such features are regarded as rather unusual for early Proterozoic orogens [*Wilson*, 1966]. The maintenance of the Torngat mountains as a relatively high mountain range (the peaks exceed 1700 m) over 1.8 Gyr and an associated Bouguer gravity low led to the idea that a crustal root might be preserved beneath the orogen. However, a reflection seismic survey across the northern Torngat Orogen [*Hall et al.*, 1995] did not show evidence for a crustal root. Our experiment is a transect across the southern Torngat Orogen designed to cross the gravity low and the mountain range to obtain a more definitive answer to the issue of a possible crustal root.

Previous geological studies and geodynamic models for the Torngat Orogen (e.g., the summaries by *Wardle and Van Kranendonk* [1996] and *Rivers et al.* [1996]) suggest a different evolution for the northern and southern Torngat Orogen. While eastward dipping subduction is well established in the north, there are different models for the south. It is fairly certain that early subduction in the southern Torngats was to the east, but there are several possibilities for its later development, including continued eastward subduction, double subduction, and flip of subduction direction [*Wardle and Van Kranendonk*, 1996]. The velocity model along the transect was not expected to give a final answer to these different geological models but instead to provide constraints for assessing crustal geometries predicted by the individual models.

Finally, there is surface evidence that transcurrent shearing is a major feature of the later stages of the Torngat Orogen. So far, it is unknown whether these shear zones sole within the crust or extend down to the mantle. A previous wide-angle seismic velocity model in the Nain Province [*Funck and Louden*, 1998] found evidence that a surface fault (Handy fault) is associated with a velocity contrast that cuts through

Paper number 1999JB900010.
0148-0227/99/1999JB900010$09.00