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Wide-angle seismic imaging of a Mesoproterozoic anorthosite complex: The Nain Plutonic Suite in Labrador, Canada

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Abstract. The Mesoproterozoic Nain Plutonic Suite (NPS) of Labrador (Canada), one of the largest anorogenic plutonic terranes, was studied by a refraction/wide-angle seismic experiment. Four ocean bottom seismometers and 18 land stations were deployed along a 330-km profile and recorded air gun shots from the easternmost 160 km with the NPS located in the center of the line at the suture of the Nain and Churchill Provinces. *P* and *S* wave velocity models were developed by forward modeling of travel times and amplitudes. Upper and middle crustal *P* wave velocities outside and beneath the NPS range from 5.9 to 6.5 km/s, lower crustal *P* wave velocities range from 6.55 to 7.0 km/s. Within the anorthositic rocks, velocities are as high as 6.8 km/s, and reflections define the base of the NPS to be 8 km deep in the SE Churchill Province and 11 km in the Nain Province, a variation that may be the result of lateral density changes within the country rocks or the anorthosites. The total crustal thickness is 39 km west of the NPS but is only 32-34 km beneath the NPS, some 5 km less than Nain Province crust distal from the NPS. The inferred crustal thinning is possibly related to anatexis of the lowermost crust by a thermal plume that generated the plutonism. The Poisson's ratios are 0.275 within the anorthosite plutons, 0.27 in the upper and middle crust, and 0.285 in the lower crust. These values are some 0.03 higher than in the Archean Nain crust distal to the NPS, indicating a higher plagioclase content at all crustal levels as result of the plutonism. We postulate that a crustal root, similar to the root observed farther north in the Torngat Orogen, was completely removed by anatexis and the silicic and basic magmas probably ascended to midcrustal levels along preexisting zones of weakness at the Nain-Churchill boundary.

1. Introduction

The Nain Plutonic Suite (NPS) in Labrador (northeastern Canada) comprises a diverse assemblage of 1350-1290 Ma anorogenic igneous rocks collectively referred to as an anorthosite-mangerite-charnockite-granite (AMCG) suite or complex [*Emslie*, 1978; *Emslie et al.*, 1994]. The anorthositic part of the NPS is among the largest areas of such rocks in the world. Large volumes of anorthosite within continental crustal plutonic settings such as the NPS are generally thought to result from the accumulation of plagioclase associated with mantle-driven magmatic processes, but the actual mechanism of formation, the tectonic setting, and the apparent limiting of such rocks to the Proterozoic are still matters of much debate [*Emslie*, 1978; *Ashwal*, 1993; *Emslie et al.*, 1994; *Longhi et al.*, 1999].

Seismic studies of large anorthosite terranes are few [e.g., *Musacchio et al.*, 1997; *Martignole and Calvert*, 1996]. Lithoprobe's Eastern Canadian Shield Onshore-Offshore Transect (ECSOOT) offered an opportunity to conduct a refraction/wide-angle reflection (R/WAR) seismic profile across the Nain Plutonic Suite, covering the central part of the NPS and its enveloping rocks (Figures 1 and 2). The objectives of the survey were (1) to determine the structure and characteristics of the Archean Nain Province crust and the Archean to Paleoproterozoic Churchill Province crust that bounds the NPS, (2) to examine the circa 1860 Ma continental collisional suture (Torngat Orogen) that welds together the Nain and Churchill provinces, and (3) to evaluate the setting and characteristics of the NPS in relation to its position as a suture-stitching anorogenic batholith emplaced some 500 Myr after terminal collision between the Nain and Churchill Provinces. *P* wave velocities and Poisson's ratios derived from the data gathered during the survey are used to determine the internal characteristics of the metamorphic and igneous rocks in the Nain transect and allow us to advance a reasonable geological picture of the crust in this part of Labrador.

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2. Geological Setting

The Nain Plutonic Suite straddles the boundary zone between the Archean and Early Proterozoic SE Churchill Province and the Archean Nain Province (Figure 1). These two crustal blocks were sutured during development of the Torngat Orogen, the thermotectonics associated with the continental collision lasting from 1.86 to 1.74 Ga [*Bertrand et al.*, 1993; *Scott and Machado*, 1995]. The orogen is