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3D imaging and modeling of upper mantle reflections associated with Paleoproterozoic subduction in NW Canada

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Vibroseis near-vertical incidence (NVI) and explosion wide-angle (WA) seismic data, recorded as part of LITHOPROBE studies in the Northwest Territories of Canada, show remarkable reflections from within the upper mantle. The reflections are interpreted as delineating a Paleoproterozoic subduction zone associated with the ca. 1.84 Ga convergence of the Fort Simpson terrane with the Hottah terrane, two components of the Wopmay orogen. On the NVI data in the west, a parallel pair of reflectors at ∼9 and 11 s two-way traveltime dip eastward from the Moho (∼33 km) over a distance of ∼60 km to times of 14 and 17 s. They can be correlated with a similar pair of reflectors that reach times of 21 and 23 s about 80 km further downdip. The reflectors have been interpreted as the top and bottom of a slab of subducted oceanic crust preserved since the collision. Fifty kilometers eastward, another pair of reflectors is observed at 20 and 22 s. They extend continuously further east at about the same times for ∼100 km before dipping shallowly to times of 25 and 28 s (depths of 85-100 km). In the original interpretation of these data, the sub-horizontal reflections represented a different feature and were not considered part of the dipping slab. Interestingly, they become sub-horizontal about where the road along which they were recorded veers from an E-W direction to almost N-S. Do the sub-horizontal reflectors represent the same slab as the dipping ones? If so, does the slab continue to dip or does it flatten? By taking advantage of the crooked line acquisition geometry, the NVI and WA reflection datasets are analyzed using 3-D procedures. These include application of 3-D forward ray-tracing procedures, a 3-D forward modeling algorithm that generates synthetic seismograms by computing the elastic wavefield at any point in the medium using the Kirchhoff integral formula, and a 3-D finite-difference traveltime inversion

algorithm that generates a 3-D surface consistent with picked traveltimes. Our results demonstrate that the subhorizontal reflectors could represent the same slab as the shallower, dipping ones. The apparent flattening of the slab can be explained as an artifact of projecting a 3-D geometry onto a 2-D cross-section. Thus, we interpret that the reflections along 350 km of profile image a subducted plate which dips eastward from Moho levels to depths of $\sim$90 km and has been preserved for 1.8 Ga.