A Combined Seismic Tomographic and Reflection Imaging Across the Red Lake Greenstone Belt Using LITHOPROBE Line 2B

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The Red Lake greenstone belt comprises Mesoarchean basaltic and komatiitic lavas with ages of approximately 2925 Ma to 2940 Ma and younger bimodal rhyolite-andesite volcanics with ages of 2730 to 2750 Ma. As part of the LITHOPROBE Western Superior transect, crustal seismic reflection profile 2B was shot north to south through the region, employing a 4 vibrator source array and a 963-channel symmetric split spread with a maximum offset of 12 km. The long offset recording of first arrivals permits their tomographic inversion for subsurface velocity structure. Unfortunately the quite crooked nature of the acquisition profile results in numerous artifacts when 2-D methods are employed. We have therefore used a 3-D subsurface grid model with dimension of 48×87×1.5 km. We employed a cell size of 50 m in the velocity model for forward modeling of travel times using a finite-difference solution to the Eikonal equation, and 100 m for the regularized inversion. We processed the hard-rock reflection data using a customized processing sequence, including crooked line geometry assignment, careful refraction statics, surface-constant deconvolution and dip moveout to obtain an interpretable stacked reflection profile. The velocity model from the tomographic inversion was then superimposed into the reflection profile to help to constrain the depth extent of the main lithologies and shallow faults absent on the reflection profile. Interpretation of velocity model and reflection profile was based on results from laboratory measurements of seismic velocities and densities in hard-rock regions. The velocity model indicates that localized high velocity anomalies of around 6500 m/s, relative to typical background values of 5800 m/s, correspond to the mafic volcanic rocks within the Red Lake greenstone belt. The velocity model also indicates depressed velocities of approximately 5500 m/s within the Sidney Lake fault zone and even lower velocity of 5000 m/s in the meta-sedimentary rocks to the south of Red Lake area. The lower velocity of around 5500 m/s in the northern limit of the Red Lake greenstone belt correlates approximately with a major southeast-dipping extensional shear zone, which was clearly identified on the reflection profile, extending into the lower crust placing the greenstone rocks in its hanging wall. Although the depth of penetration of first arrival ray-paths is rarely greater than 800 m, the velocity model is of value in correlating the reflection image, which shows other sequences of south-dipping reflections that approach the surface, with the mapped geology.

References

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Figures Enclosed:

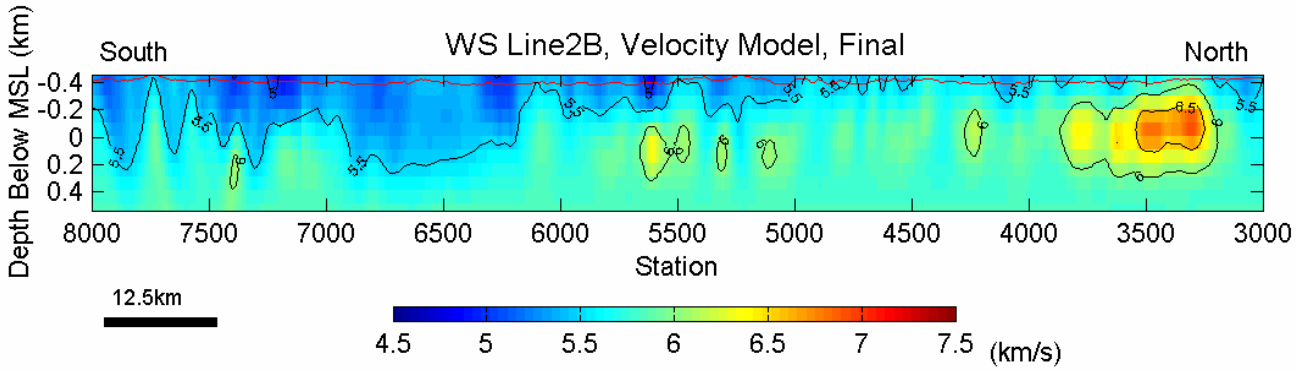

Figure 1 The final velocity model vertically sliced along the crooked line

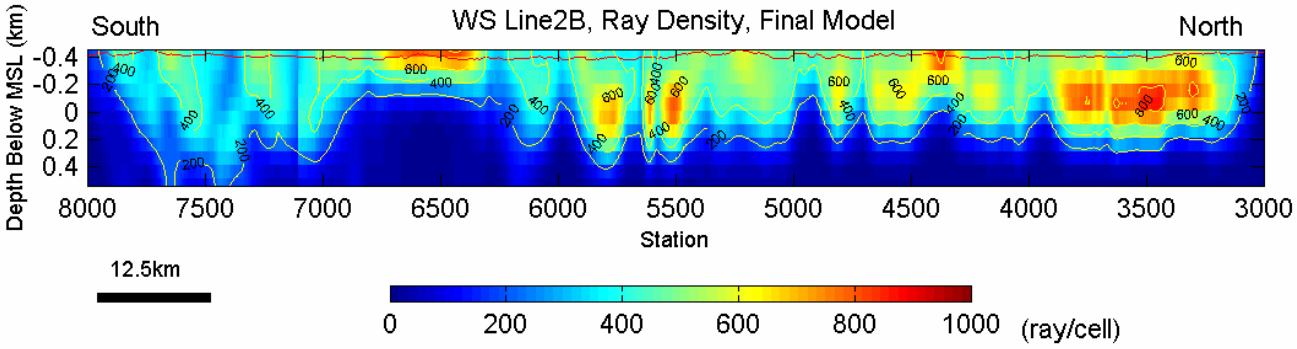

Figure 2 Ray coverage density for the final model vertically sliced along the crooked line

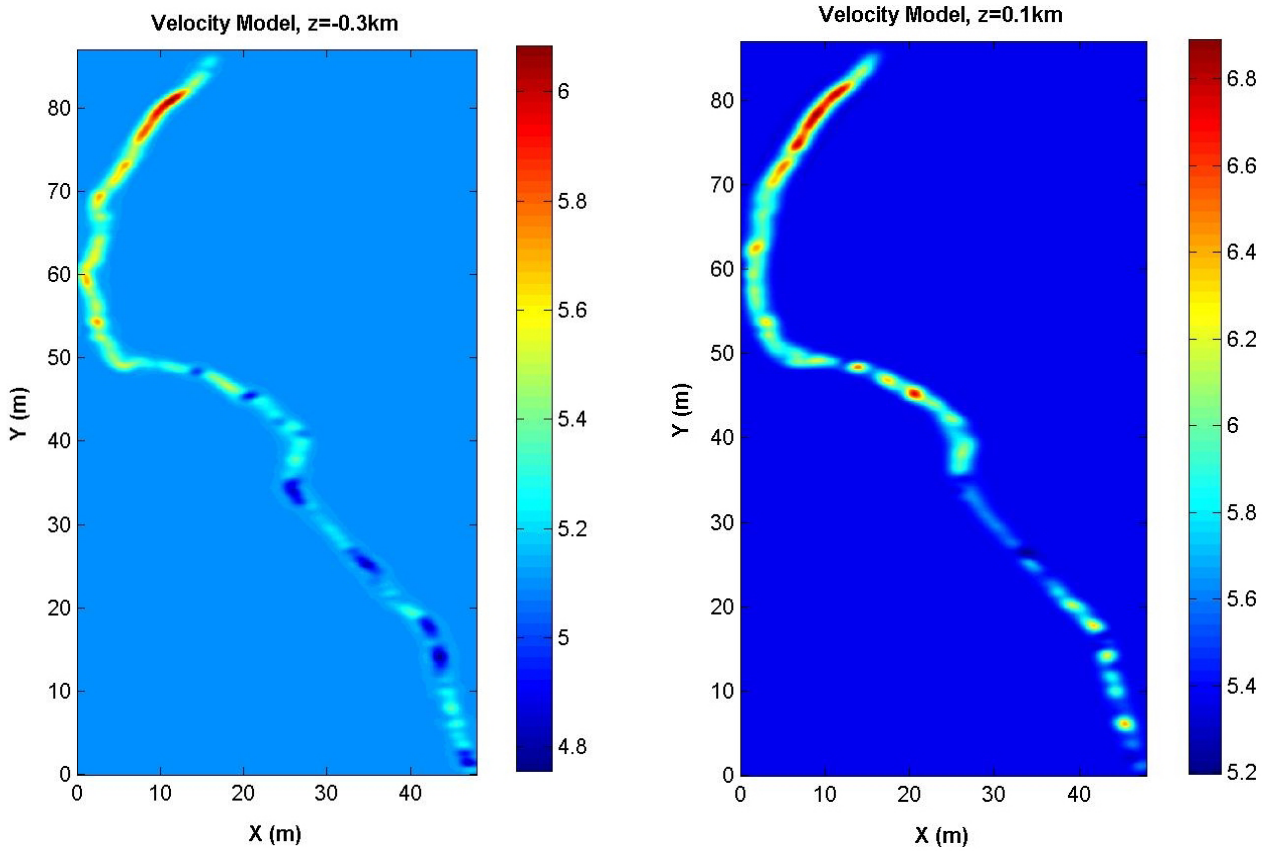

Figure 3 Horizontal slices of the final 3-D velocity model at depth of 300 m above MSL (left), and 100 m below MSL (right)

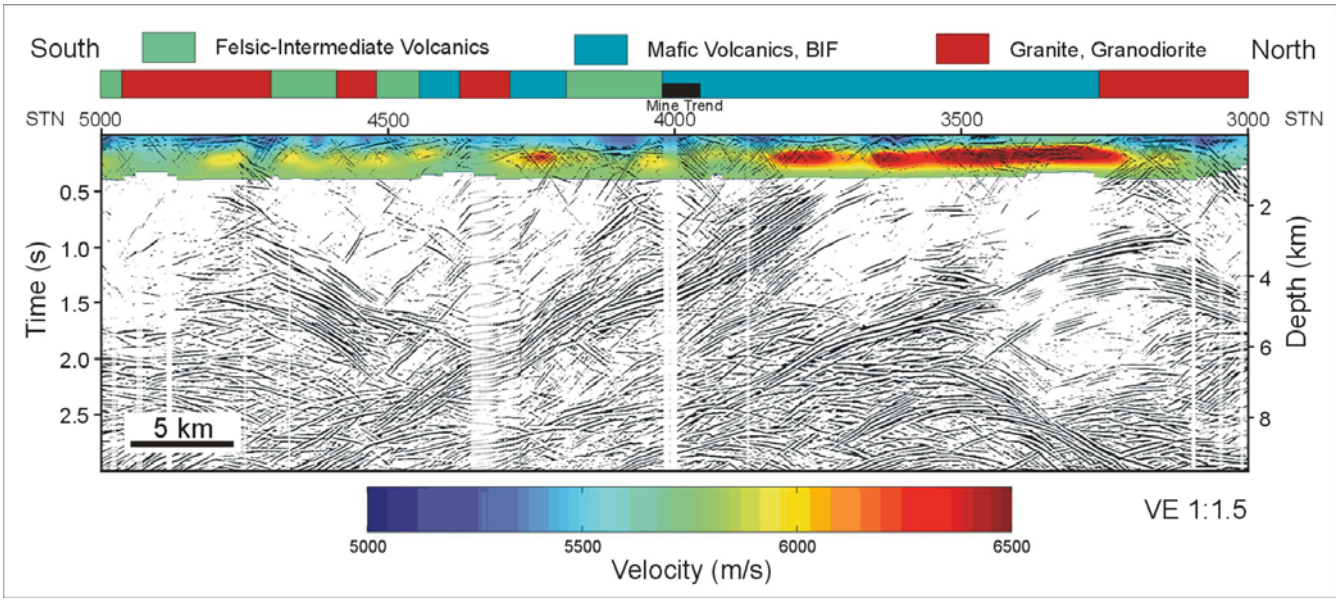

Figure 4 Combined interpretations of the tomographic image and the reflection profile