Delineation of VMS ore lenses from Flin Flon, MB, Canada using vertical seismic profiles and 3D finite difference modeling*

Corresponding author: Dave Melanson, Carleton University, dave.melanson@carleton.ca

Co-authors:
Don White, Geological Survey of Canada, Don.White@NRCAN-RNCAN.gc.ca
Claire Samson, Carleton University, Claire.Samson@carleton.ca
Gilles Bellefleur, Geological Survey of Canada, Gilles.Bellefleur@NRCAN-RNCAN.gc.ca
Ernst Schetselaar, Geological Survey of Canada, Ernst.Schetselaar@NRCAN-RNCAN.gc.ca

One of the main drivers of recent geophysical research in mineral exploration is the desire to investigate and define targets at greater depths. Seismic methods, including vertical seismic profiling (VSP), currently provide a means of achieving this goal. In October 2006, three-component VSP data using dynamite and Vibroseis sources were acquired in three deviated wells in the Flin Flon mining camp as part of a larger 3D seismic survey. The Flin Flon mining camp is located in northern Manitoba, Canada within the Amisk collage of the 1.92-1.83 Ga Flin Flon-Glenennie complex, which was obducted during the collisional stages of the Trans-Hudson orogeny. The VSP data appear to have an observable reflection response from the 85.5 Mt Flin Flon-Callinan-777 VMS ore system. This system comprises pyrrhotite, chalcopyrite and sphalerite-rich ore lenses that are hosted within altered rhyolites of the Millrock member, which in turn lies between mafic volcanic and volcaniclastic rocks of the footwall and hanging wall. This region has been subjected to greenschist metamorphic facies and several deformation events. Boundaries between rock units and the massive sulfide ore provide strong contrasts in acoustic impedance from which seismic reflections will originate.

The Flin Flon mining camp has been extensively mapped, drilled, mined and targeted by geophysical surveys for decades, leading to a wealth of multidisciplinary geoscience data. From these data, several voxel models were constructed, which can be used in 3D finite difference-modeled simulations of the VSP surveys. The voxel models are populated with elastic rock properties that have been determined from physical rock properties measured using in-situ sonic logs and laboratory measurements on core samples from the boreholes used for VSPs in this study. The number of distinct geological units used in the 3D voxel model was increased incrementally to determine the effects on seismic response of major rock units and massive sulfide ore. The outputs of this simulation method were synthetic VSP shot-gathers, which capture the particle velocity at receiver stations. In addition, the simulated propagation and scattering of the seismic wavefields can be visualized in 2D and 3D using the output from the simulations taken at sequential time steps. These synthetic shot-gathers were found to be directly comparable to the VSP field data. By integrating the modeled results into the interpretation process, we were able to identify and characterize the response from the mine horizon and from the massive sulfide ore in the VSP field data.