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3-D seismic modelling in the Flin Flon mining camp, Canada

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A comprehensive seismic survey for VMS ore exploration was recently conducted in the Flin Flon mining camp (Trans-Hudson Orogen, Canada). The seismic project comprised a total of 75 km of high-resolution 2-D profiles and a 14 km2 3-D survey. Processing of the vertical-component data for P-wave reflections reveals prominent reflectivity associated with contacts between the metasedimentary and mafic volcanic rocks, as well as moderately dipping reflectivity within the polydeformed volcanic rocks including the main rhyolite horizon which hosts the VMS deposits. However, complex volcanic stratigraphy of the Flin Flon mining camp makes the interpretation of the 3-D seismic data especially challenging. Toward providing further constraints on the interpretation of seismic data, we have performed 3-D seismic forward modelling on a detailed geological model constructed for the camp, both in stack and prestack (i.e,. simulating the complete 3-D survey) mode. A 3-D geological model of the Flin Flon mining camp was created based on an extensive set of drillholes, surface geology, interpretation of the 2-D seismic profiles and predictive modelling. The original model was generalized into six lithofacies and the elastic rock properties were assigned based on the rock property measurements on core samples. 3-D forward seismic modelling implemented the phase-screen method, which allows the calculation of an approximate (narrow angle) but fast solution to the elastic wave equation in complex 3-D media. To simulate the 3D stack volume, initial simulations were conducted by using the "exploding reflector" mode (plane-wave simulation) both for the whole model and for the ore lenses only. Ultimately, the prestack data simulations were performed, by calculating the individual shot-gathers using the real survey 3-D geometry. A total number of 934 shot points were simulated, each recording 23 lines. Data were binned using the same bin parameters as the original 3-D survey (25 m inline bin size and 12.5 m crossline bin size) and processed in a similar manner up to DMO and post-stack migration phase.

Comparison of the "exploding reflector" simulation performed for the original model and for the ore bodies only with the processed 3-D DMO volume suggests that the lack of a clear ore body response in the real data (namely the diffraction patterns) can be mainly attributed to the wave interference arising from the complex volcanic stratigraphy. Alternatively, it could be due to the fact that the most of the ore lenses included in the 3-D model have been already mined out. However, the mined out ore was back-filled with material that should still produce a significant acoustic impedance contrast with the host rock. In fact, a close examination of the results of modelling and the real data suggests that the bright dipping reflectors in the 3-D DMO volume correspond to the down-dip diffracted energy of the ore bodies. As our model includes the known ore bodies, we can use predicted seismic data in combination with the 3-D seismic survey for direct ore targeting.