Physical Properties and Seismic Imaging of Massive Sulphides

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ABSTRACT

Laboratory studies conducted by the Geological Survey of Canada show that the acoustic impedances of massive sulphides can be predicted from the physical properties (Vp, density) and modal abundances of common sulphide minerals using simple mixing relations. Most sulphides have significantly higher impedances than silicate rocks, implying that seismic reflection techniques can be used directly for base metals exploration, provided the deposits meet the geometric constraints required for detection. To test this concept, the GSC has conducted a series of 1, 2 and 3D seismic experiments with industry to image known ore bodies in central and eastern Canada. In one of the most recent tests, conducted at the Halfmile Lake Cu-Zn deposit in the Noranda Bathurst camp, laboratory measurements on representative samples of ore and country rock demonstrated that the ores should make strong reflectors at the site, while velocity and density logging confirmed that these reflectors should persist at formation scales. These predictions have been dramatically confirmed by the detection of strong reflections from the deposit using vertical seismic profiling (VSP) and 2D multichannel seismic (MCS) imaging techniques.

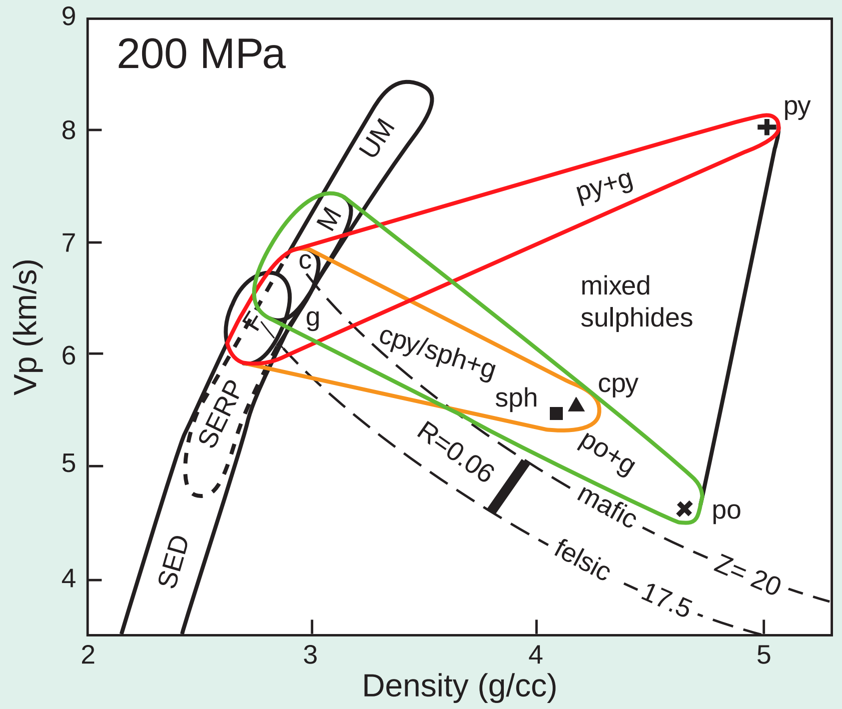

FIG.1. Velocity (Vp)-density fields for common sulphide ores and silicate host rocks at 200 MPa. Ores: py, pyrite; cpy, chalcopyrite; sph, sphalerite; po, pyrrhotite. Silicate rocks along Nafe-Drake curve: SED, sediments; SERP, serpentinite; F, felsic; M, mafic; UM, ultramafic; g, gange. c=carbonate. Dashed lines represent lines of constant acoustic impedance (Z) for felsic and mafic rocks. Bar shows minimum impedance contrast required to give a strong reflection (R=0.06).

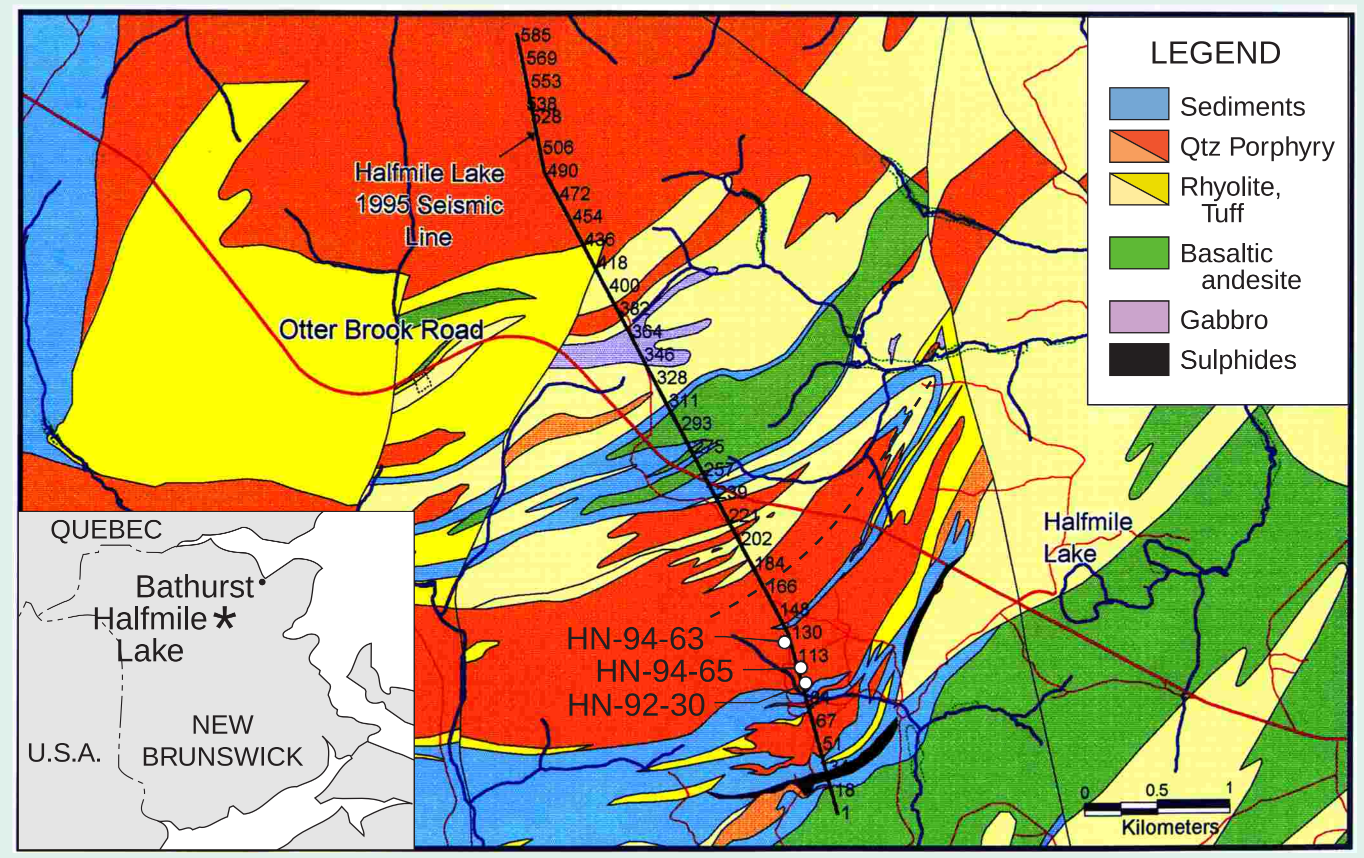

FIG. 2. Geology map of Halfmile Lake deposit showing location of 2D seismic line presented in Figure 7. Geologic cross-section shown in Figure 3 extends from stations 1-166 (10-1660 m along line). Geophysical logging was conducted in holes HN 94-63 (Figure 5) and HN 94-65. Offset VSP shown in Figure 6 was conducted in hole HN 92-30. Inset shows regional setting of Halfmile Lake deposit. Dashed arrow shows axis and plunge of F1 antiform.

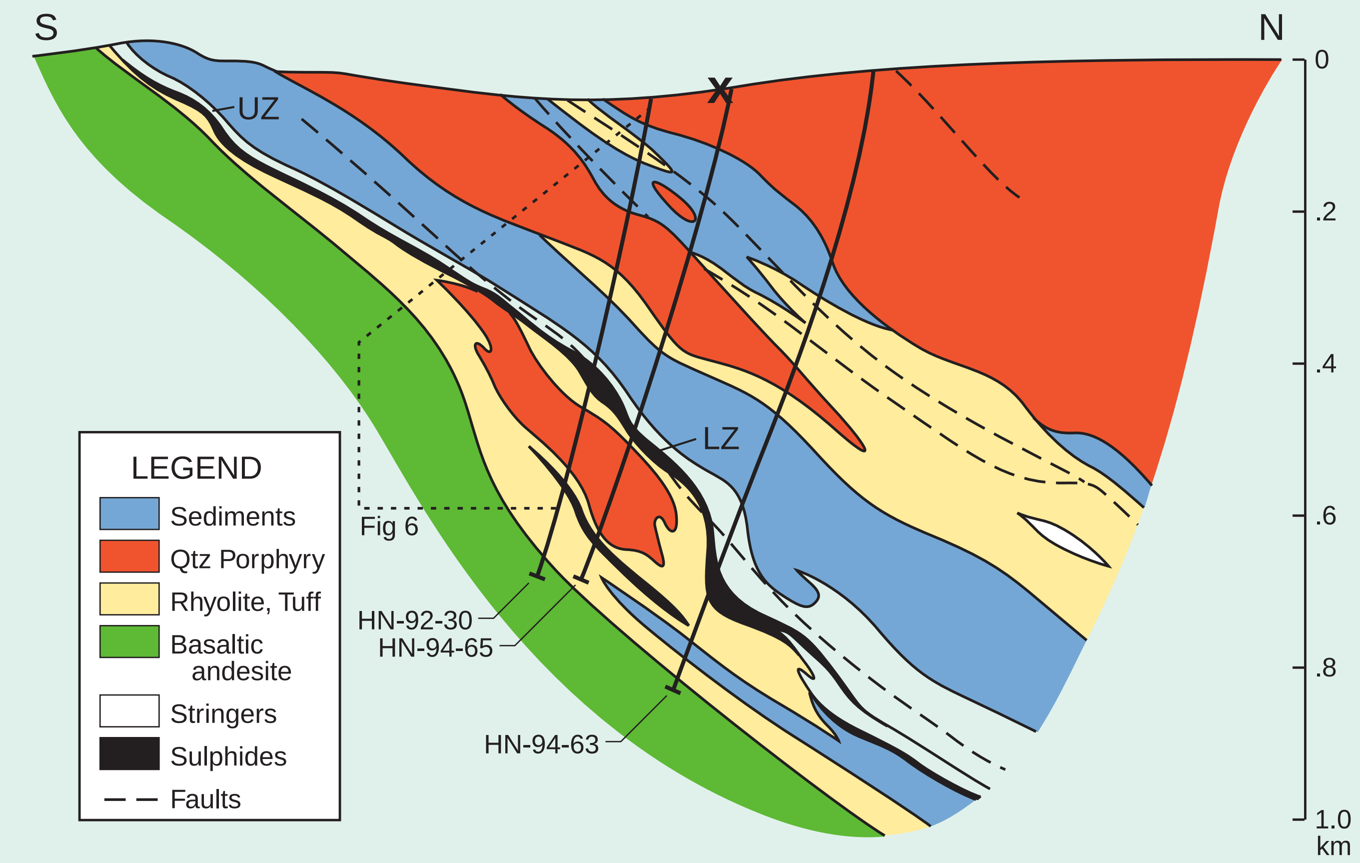

FIG. 3. Simplified geologic cross-section through Halfmile Lake deposit based on drilling results projected onto seismic line between stations 1-166. UZ, Upper Zone; LZ, Lower Zone. VSP survey (Figure 6) was conducted in hole HN 92-30 (shots at X) and logging was conducted in holes 94-63 and 94-65. No vertical exaggeration.

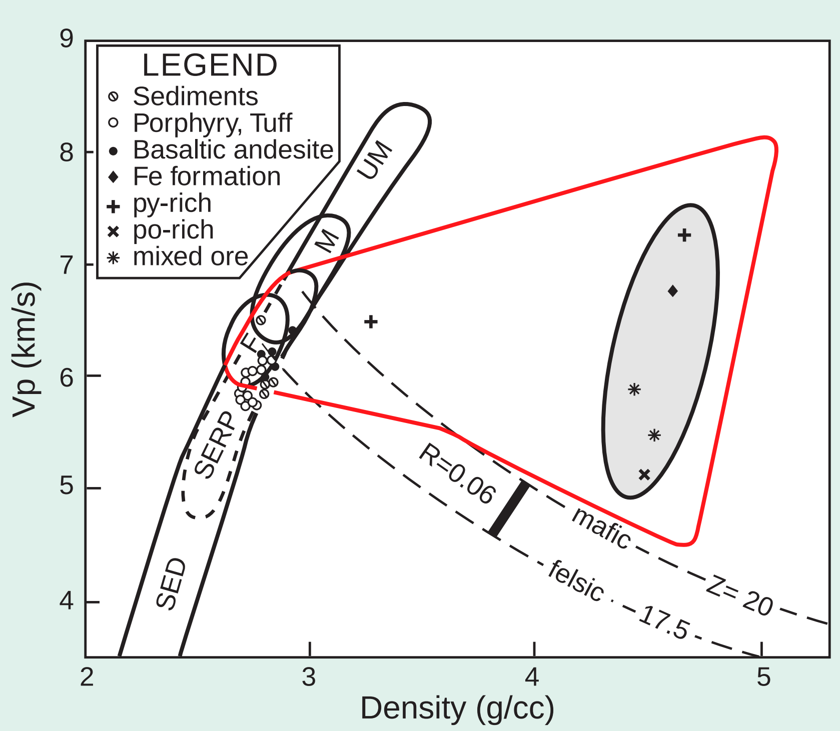

FIG. 4. Average compressional wave velocity (Vp) at 200 MPa versus density for ore and host rock samples from the Halfmile Lake deposit superimposed on velocity-density fields for sulphides and silicate rocks shown in Figure 1. Also shown are lines of constant acoustic impedance for mafic rocks (Z=20) and felsic rocks (17.5). Impedances of Halfmile Lake ores (ellipse) are much greater than those of their silicate hosts.

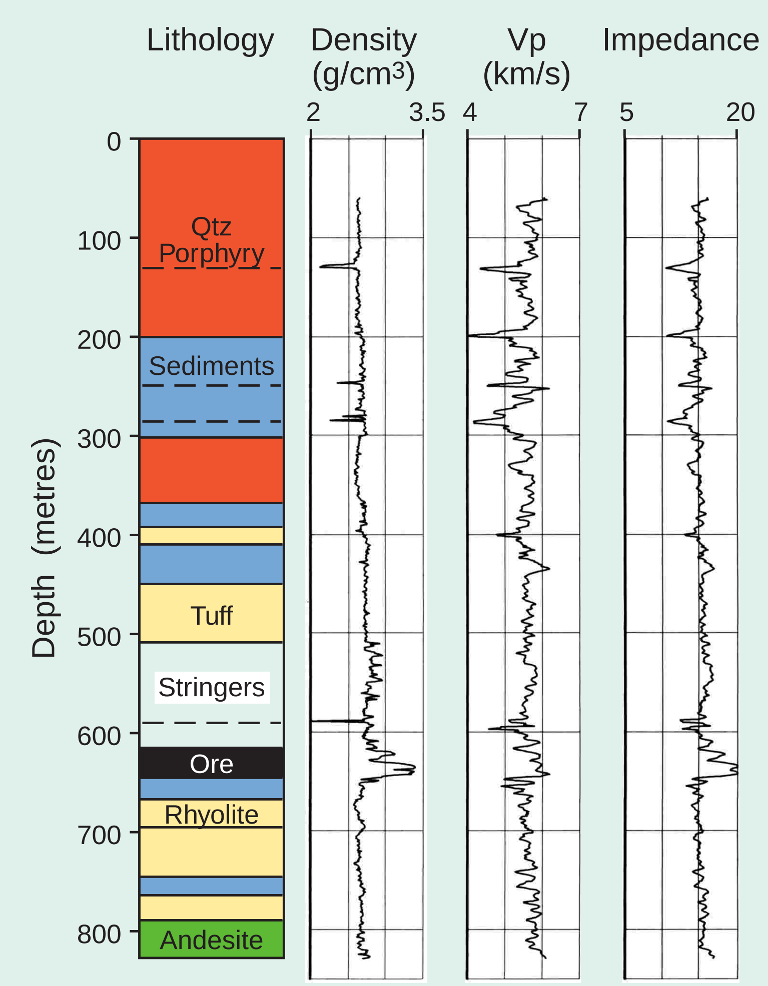

FIG. 5. Density, velocity (Vp) and calculated impedance versus depth in hole HN 94-63 from geophysical logging. Fault gouge in core indicated by dashed lines. Note high impedance of massive sulphides.

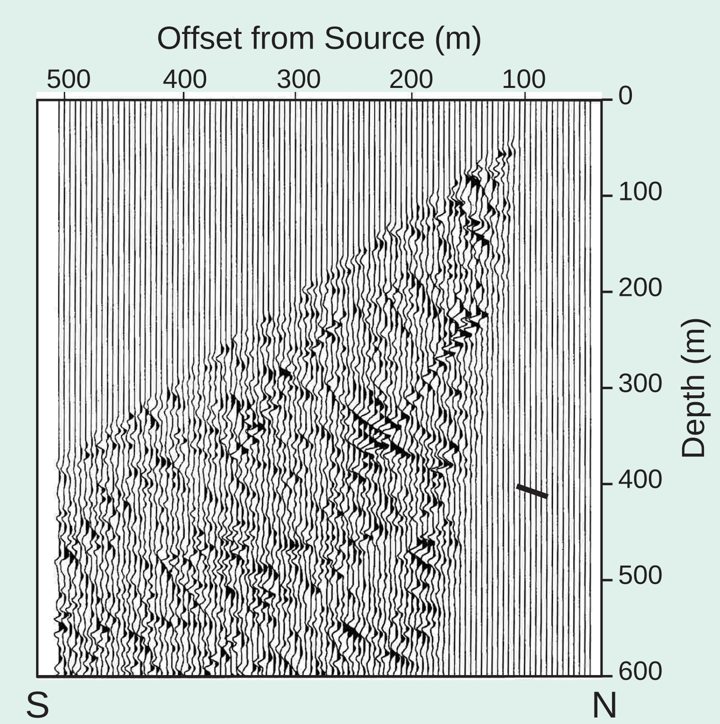

FIG. 6. CDP transform of VSP survey in borehole HN 92-30 showing reflection from Halfmile Lake deposit (arrow). X shows location of shots. Reflections are also observed from a thin sulphide layer between 550-600 m (see Figure 3).

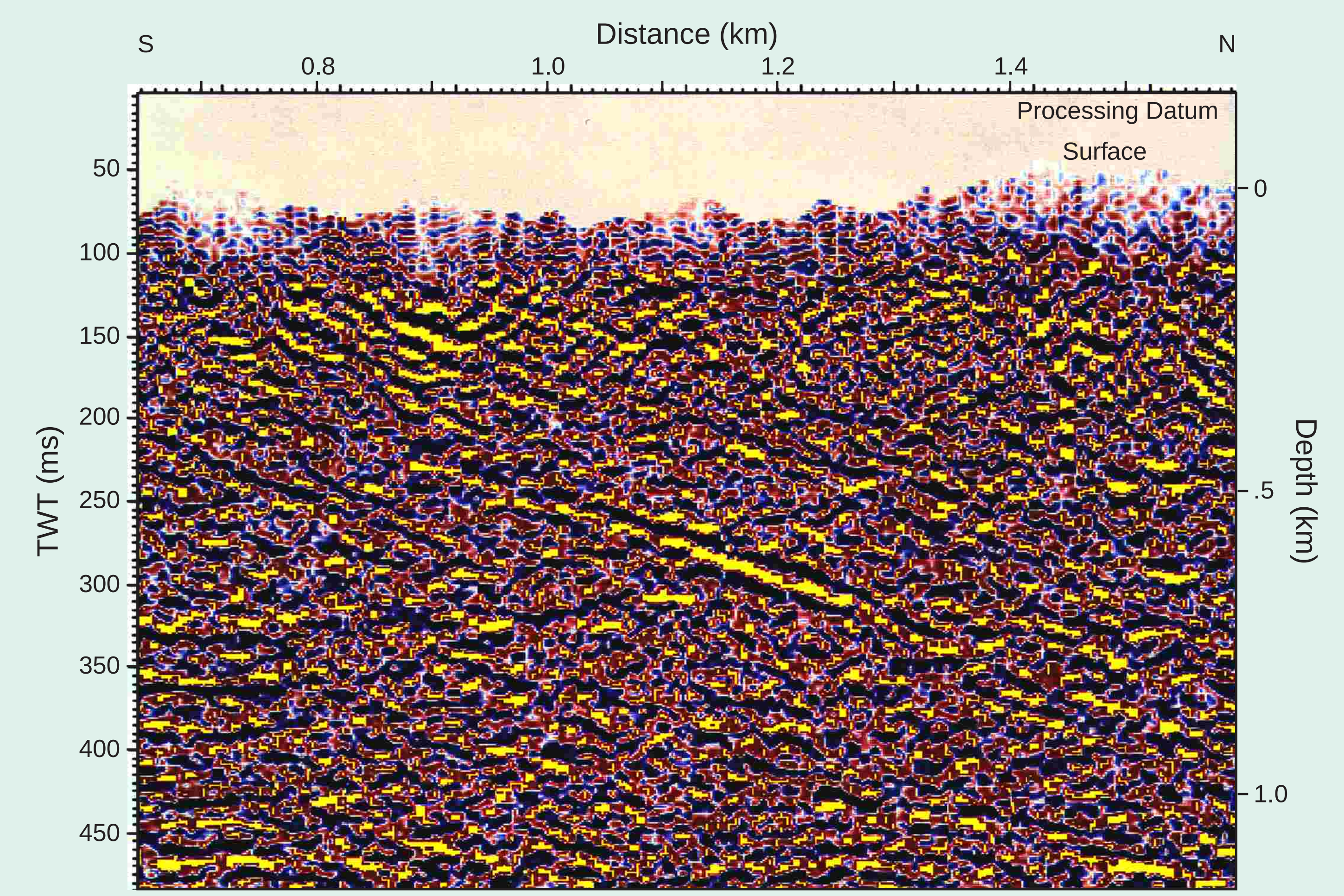

FIG. 7. Unmigrated 2D multichannel seismic image of the Halfmile Lake deposit. TWT, two-way travel time.

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