Seismic Methods for Hard Rock Mineral Exploration

Ned Stolz
Group Leader - Continental Geology and Geophysics
Minerals and Natural Hazards Division
Why should we use seismic for hard rock mining exploration?
Seismic Basics

Wave equation

$$F = F_0 \cos \left( \omega \left( t - \frac{z}{v} \right) \right)$$

Force

Distance from Source

Sonic velocity

No loss of resolution with depth!

Reflection coefficient

$$RC = \frac{\nu_2 \rho_2 - \nu_1 \rho_1}{\nu_2 \rho_2 + \nu_1 \rho_1}$$

Plenty of contrast in hard rock!

Poisson’s ratio

$$\delta = \frac{\nu_p}{\nu_s}$$

Measure of rock strength!

Seismic can image the geological signatures of mineralising processes
A Deposition Model - Gold Orebody

- Fluids need drivers: heat, intrusions, and volcanism.
- Fluids need pathways: porosity, fractures, and brittle rocks.

Reduced fluid from mantle?
Rock Properties - Gold Deposit

- Felsic - basalt contrast
- Gold deposited in fracture zones caused by contrasts in rock strength
A Deposition Model – Nickel Orebody

• Distinctive stratigraphy and geometry

(After Williams, Whitford, Kepic, and Urosevic, 2012)
Rock Properties - Nickel Deposit

Kambalda Physical Properties

- UM = Ultramafic
- BsIt = Basalt
- Meta S = Metasediment
- Ni = Nickel ore

Seismic forward model for Ni orebody

- Nickel ore can be directly detected and mapped

(After Williams, Whitford, Kepic, and Urosevic, 2012)
Kambalda Nickel and Gold Field
Kambalda Nickel and Gold Field

Seismic data acquired by Mining Companies

Lake Lefroy

Kambalda Nickel and Gold Field

Seismic methods for hard rock mineral exploration; 34th IGC Brisbane

5km

2D seismic lines

3D seismic survey
Victory Gold Mine

Residual Gravity, Major faults, and Bismuth Geochemistry

Bismuth shows oxidised zones

Gravity lows interpreted as felsic intrusions

Bi anomalism denotes oxidised zones

Interpreted Felsic

Bismuth

< 0.1 ppm

> 0.2 ppm

(After Stolz and Lally, 2006)
Victory Seismic Line

Section View

Surface

10 km

3.5 km

(After Stolz, 2004)
Victory Gold Mine

Seismic line, Major Faults, and Bismuth Geochemistry

(Surface view)

Thrust Fault

Playa Fault

Victory Seismic Line

(After Stolz and Lally, 2006)

Felsic Intrusion

Bismuth Geochemistry

- < 0.1 ppm
- > 0.2 ppm

Perspective View

(Gold Fields)

Seismics for hard rock mineral exploration; 34th IGC Brisbane 13
Long - Victor Nickel Mine

3D Seismic Survey

(After Williams, Whitford, Kepic, and Urosevic, 2012)
Profiles from 3D Seismic Survey

Inlines 10 m apart

McLeay

Long South

(After Williams, Whitford, Kepic, and Urosevic, 2012)
Long - Victor Nickel Mine

Seismic “line” from 3D Seismic Survey

(After Williams, Whitford, Kepic, and Urosevic, 2012)
Long - Victor Nickel Mine

Time Slices from 3D Seismic Survey

(After Williams, Whitford, Kepic, and Urosevic, 2012)
Long - Victor Nickel Mine

Basalt contact and faults interpreted from 3D seismic data volume

(After Williams, Whitford, Kepic, and Urosevic, 2012)
Hard Rock Conclusions

• High resolution - low ambiguity method with no loss of resolution with depth

• Detects contrasts in sonic velocity, density and rock strength

• Images the geological signatures of mineralising processes
  – Fluid drivers
  – Fluid pathways
  – Deposition sites
  – Stratigraphy and geometry
  – High contrast ores

• 2D and 3D seismic provides high resolution data for detailed interpretation of lithology, structure and mineral alteration
References and Acknowledgements


Williams, P., Whitford, M., Kepic, A., and Urosevic, M., 2012, Recent experiences concerning the use of high definition seismic reflection applied to Komatiitic Nickel Deposits, Western Australia, 74th EAGE Conference & Exhibition, Copenhagen, Denmark, Extended Abstract.

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