Seismic and Mineral Exploration

- Time for a new relationship

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Quickfire session
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Hon. Martin Fergusons's challenge to the "Searching the Deep Earth" Think Tank

"Deep earth exploration is the next frontier and it is a frontier that we must conquer if we are to continue to reap the economic benefits of our natural mineral wealth"

Conquering the new frontier!

- Detect point locations of contacts and structures
- Resolution of conventional minerals geophysics degrades rapidly with depth
- Each hole tests a small area and provides limited context for further exploration
- 3 holes in 3 months
- ≈ $300K per km

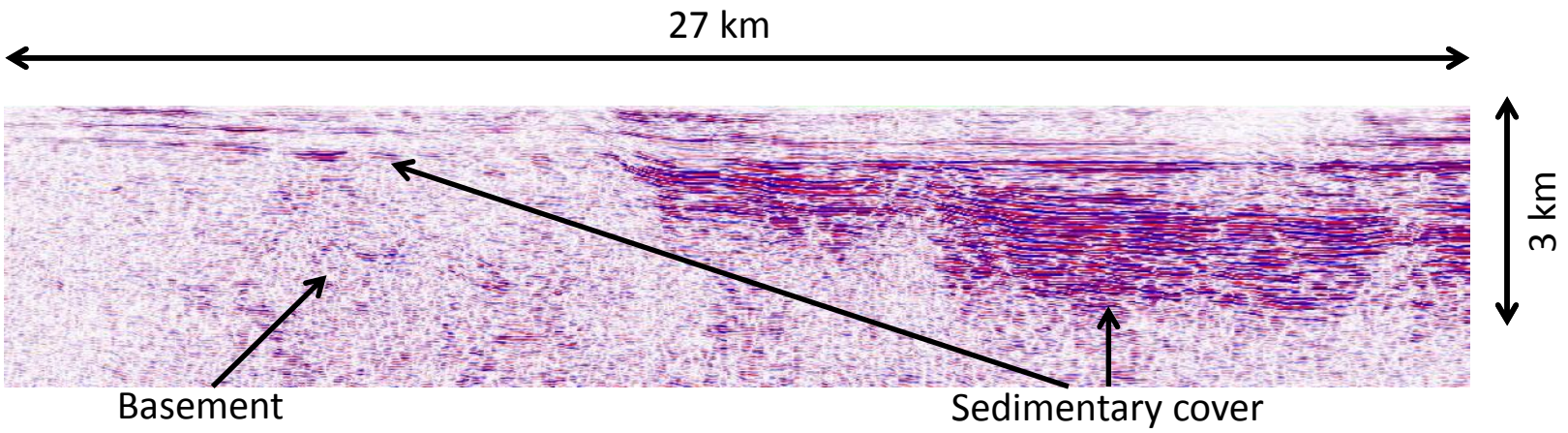
- Map contacts and structures in 3D
- Resolution is maintained at depth
- Each 3D seismic survey screens multiple km^3 and provides framework for subsequent exploration
- 10km^2 acquired and processed data in 3 months
- ≈$150K/$km^2$ (0→2km^+)
- Cost effective!

HiSeis

Seismic Reflection – Depth of Cover

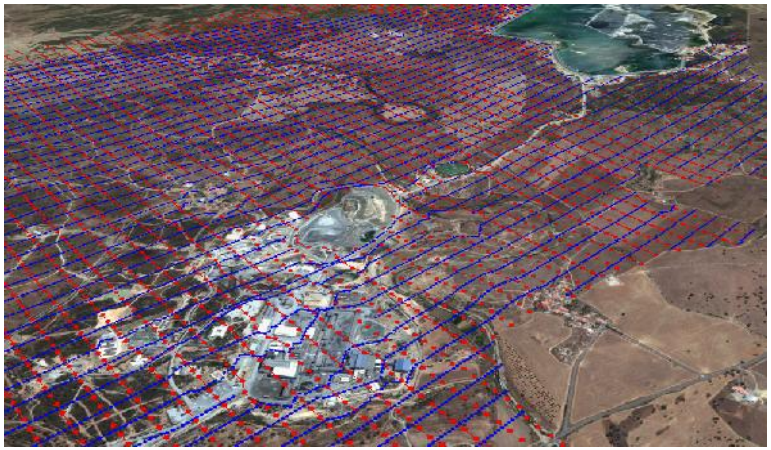
Key attributes:

- **Resolution - Resolution of the order of 10m, maintained as a function of depth**
- **Depth range - Can map cover thickness from 10s of metres to >1km**
- **Broad applicability - Works in wide range of environments**
- **Customisable – eg LiteSeis to map cover and basement structure ~ $3500/km**



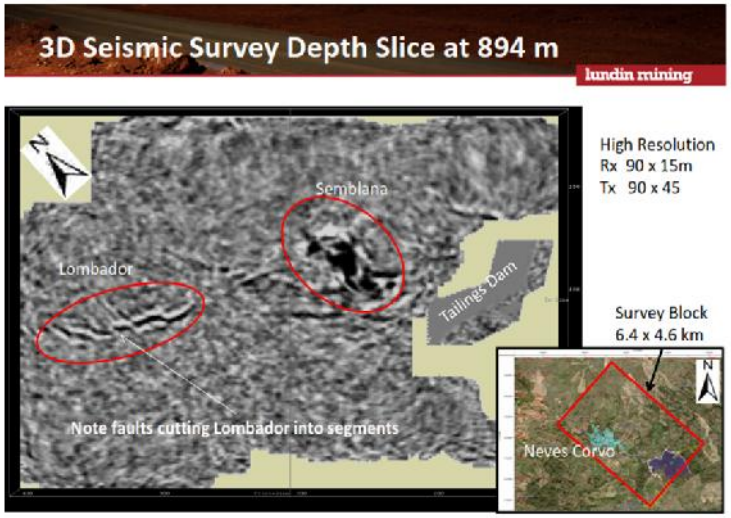
Geoscience Australia line GA_OD1 reprocessed by HiSeis

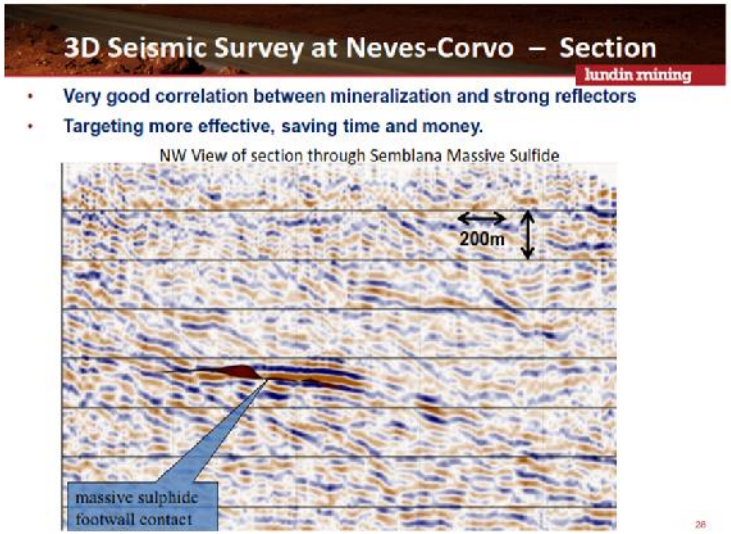
Seismic Reflection – Basement Geology



Key attributes:

- **Persistence** – Maps bedrock structure through cover and below mine infrastructure
- **Structures** – Tight spacing of measurements excellent for mapping structures
- **Direct detection** – Massive sulphides present strong seismic property contrasts to most host rocks





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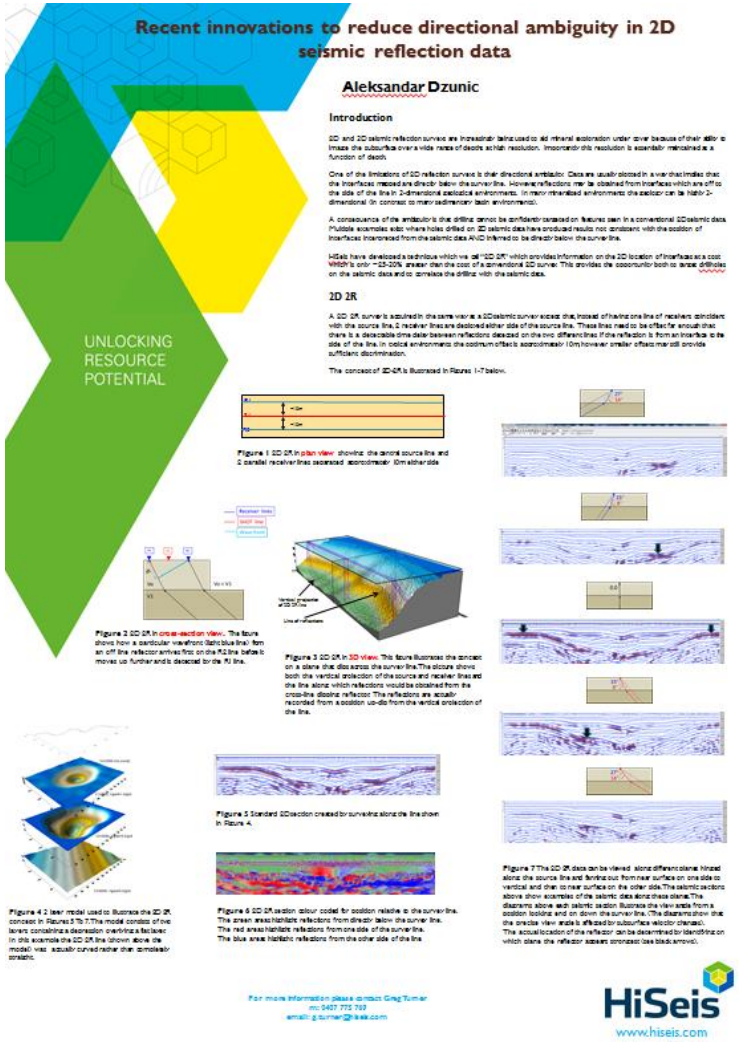
Seismic Reflection – Innovations


Recent innovations to reduce directional ambiguity in 2D seismic reflection data

Aleksandar Dzunic

UNLOCKING RESOURCE POTENTIAL

Introduction

2D and 2D seismic reflection surveys are increasingly being used to aid mineral exploration under cover because of their ability to image the subsurface over a wide range of depths at high resolution. Importantly this resolution is essentially maintained as a function of depth.

One of the limitations of 2D reflection surveys is their directional ambiguity. Data are usually plotted in a way that implies that the interfaces imaged are directly below the survey line. However reflections may be obtained from interfaces which are off to the side of the line in 3-dimensional geological environments. In many mineralised environments the geology can be highly 3-dimensional (in contrast to many sedimentary basin environments).

A consequence of the ambiguity is that drillers cannot be confidently targeted on features seen in a conventional 2D seismic data. Multiple examples exist where holes drilled on 2D seismic data have produced results not consistent with the position of interfaces interpreted from the seismic data AND inferred to be directly below the survey line.

HiSeis have developed a technique which we call "2D 2R" which provides information on the 2D location of interfaces at a cost which is only ~25-30% greater than the cost of a conventional 2D survey. This provides the opportunity both to target drillholes on the seismic data and to correlate the drilling with the seismic data.

2D 2R

A 2D 2R survey is acquired in the same way as a 2D seismic survey except that, instead of having one line of receivers coincident with the source line, 2 receiver lines are deployed either side of the source line. These lines need to be offset far enough that there is a detectable time delay between reflections detected on the two different lines if the reflection is from an interface to the side of the line (in typical environments the minimum offset is approximately 10m however smaller offsets may still provide sufficient discrimination.

The concept of 2D-2R is illustrated in Figures 1-7 below.

Figure 1 2D 2R in plan view showing the central source line and 2 parallel receiver lines separated approximately 10m either side

Figure 2 2D 2R in cross-section view. The figure shows how a particular wavefront (light blue line) from an off line reflector arrives first on the R2 line before it moves up further and is detected by the R1 line.

Figure 3 2D 2R in 3D view. This figure illustrates the concept on a plane that dips across the survey line. The picture shows both the vertical projection of the source and receiver lines and the line along which reflections would be obtained from the cross-line dipping reflector. The reflections are actually recorded from a position up-dip from the vertical projection of the line.

Figure 4 2 layer model used to illustrate the 2D 2R concept in Figures 5 To 7. The model consists of one layer containing a depression overlying a flat layer. In this example the 2D 2R line (shown above the model) was actually curved rather than completely straight.

Figure 5 Standard 2D section created by surveying along the line shown in Figure 4.

Figure 6 2D 2R section colour coded for position relative to the survey line. The green areas highlight reflections from directly below the survey line. The red areas highlight reflections from one side of the survey line. The blue areas highlight reflections from the other side of the line.

Figure 7 The 2D 2R data can be viewed along different planes. Viewed along the source line and tilting out from near surface on one side to vertical and then to near surface on the other side. The seismic sections above show examples of the seismic data along these planes. The diagrams above each seismic section illustrate the view angle from a position looking end on down the survey line. (The diagrams show that the precise view angle is affected by subsurface velocity changes). The actual location of the reflector can be determined by identifying on which plane the reflector appears strongest (see black arrows).

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3D detection from 2D surveys

Come see our poster!