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BOREHOLE RADAR FOR EXPLORATION IN AUSTRALIA

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Introduction

- Borehole Radar (BHR) provides high detailed continuous ore body and structural delineation information.
- Borehole Radar has been delineating ore bodies for mine planning for over 10 years.

- Improvements in technology over the last 2 years now enables borehole radar to be deployed on the drill allowing quick and easy surveying underground.

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History

- The GeoMole BHR was developed out of the University of Sydney
- Early trials in Australia in the 90s
- Trial efforts moved to South Africa and Canada
  - Diamond, Platinum and Gold Reefs
- In the last few years more effort has been made to implement the technology in Australia
  - Nickel and Gold

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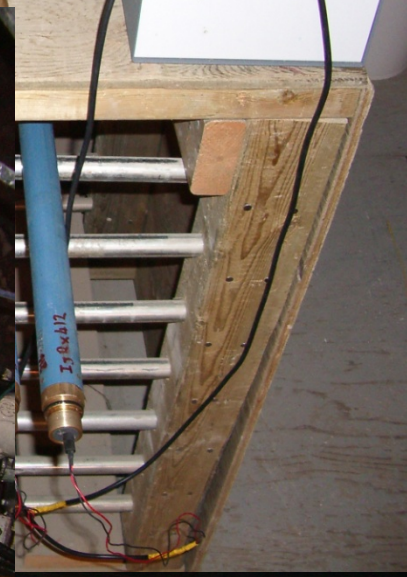
GeoMole
Charge Box



The Advantage of using BHR

- BHR can provide a quantum leap forward in geological mapping by providing off-hole information:
  - the continuity of features logged in the core
    - Lithology contacts
    - Faulting or shear zones
    - jointing
  - Map off-hole features
    e.g. Image additional ore lenses or potential structural targets

EXPLORATION AND IN-MINE APPPLICATIONS

- BHR has a proven capacity to improve confidence in the geological model.

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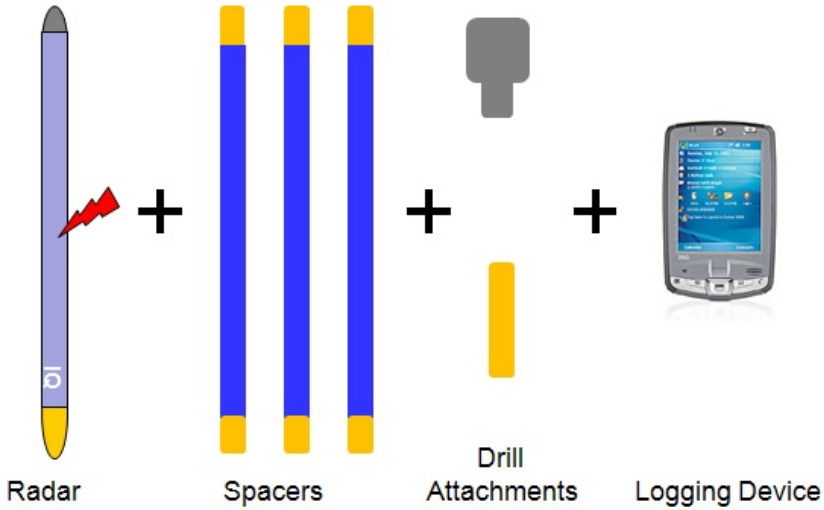
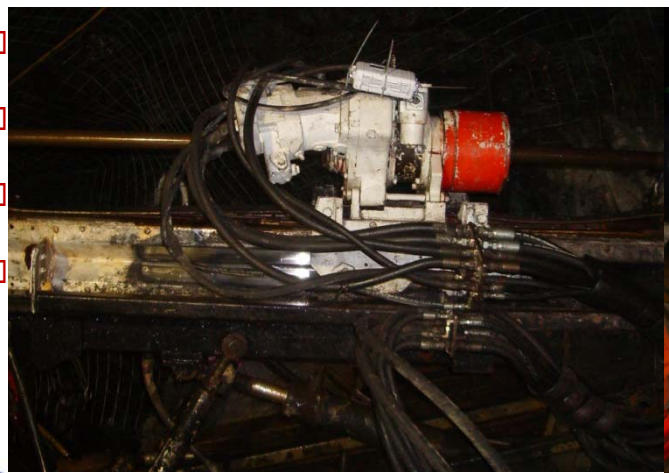
What is Borehole Radar?



- GeoMole unique technology:
- Single-stick radar only 1. 6m long.
- All data stored onboard.
- No wire-line cables or bulky winches.
- Sciewin purpose built interpretation delling software.
- penetration around 40m- o the rock.
- solution images – 1m y.
- apability > 2km



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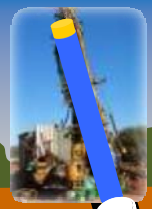
What is Borehole Radar?



The borehole radar system can be deployed by winch or on the drill rods similar to a gyro survey

Data is acquired continuously as the rods are pulled and the radar ascends the drillhole

Signal is sent radially outwards into the surrounding rock

The radar images the rock surrounding the drillhole.

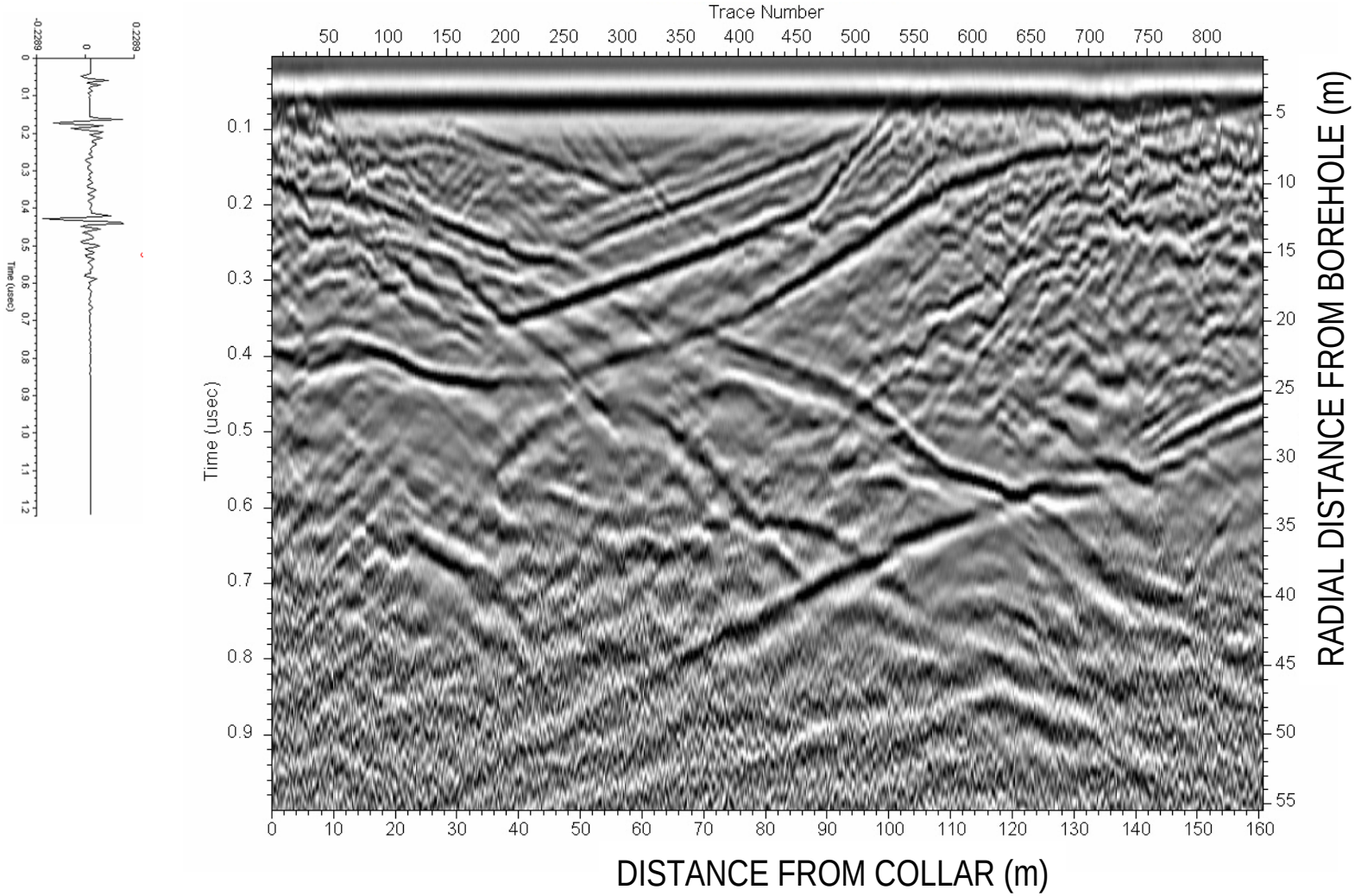
The radar is not directional, Neighboring drillholes and knowledge of stratigraphy aids interpretation.

Final interpretation is produced.

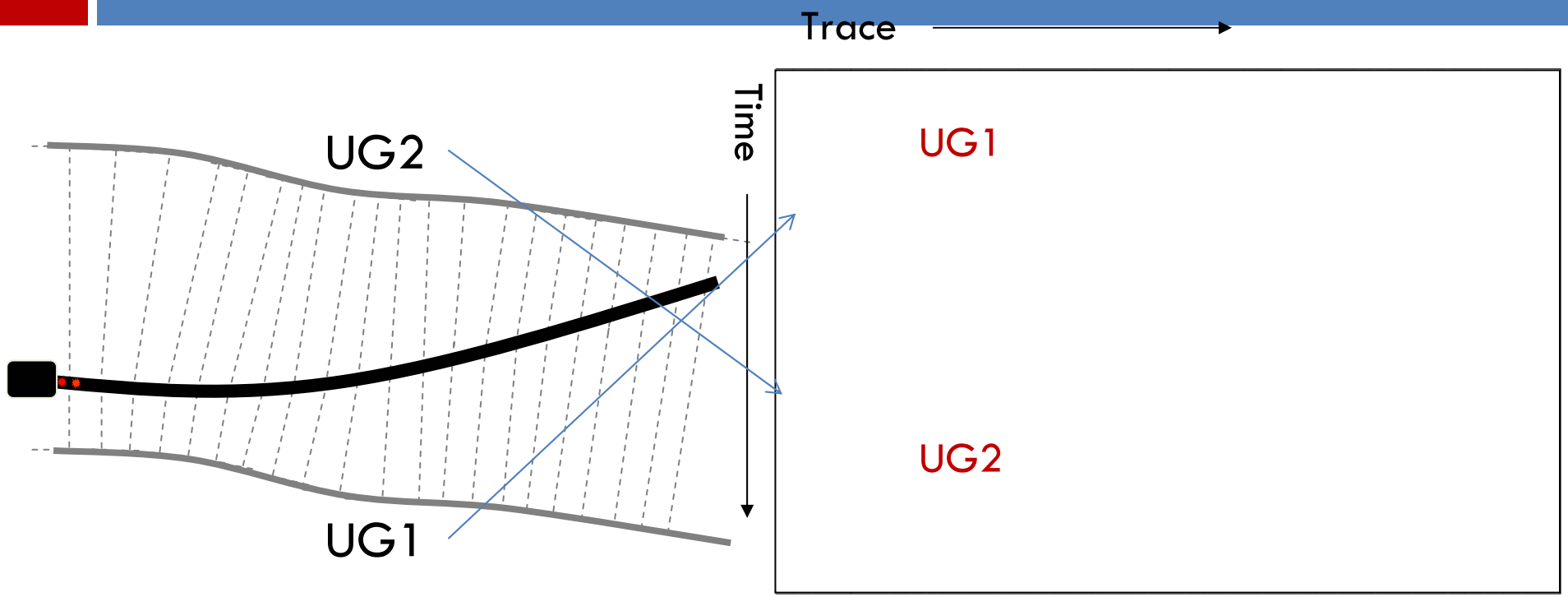
BHR TIME-SECTION

The borehole radar time-section or radargram (right) is made up of series of traces (left). Data quality can be improved through processing. Data can be converted to real space through migration.

Reflections in the data are caused by dielectric changes at lithology contacts and structures.



How does BHR Reflection work?



Borehole radar is non-directional. This means that we cannot tell which direction a reflection has come from. However GeoMole have developed procedures to overcome this.
These procedures include but are not limited to forward modeling techniques that take into consideration the curvature of the drillhole or the use of multiple neighboring drillholes.

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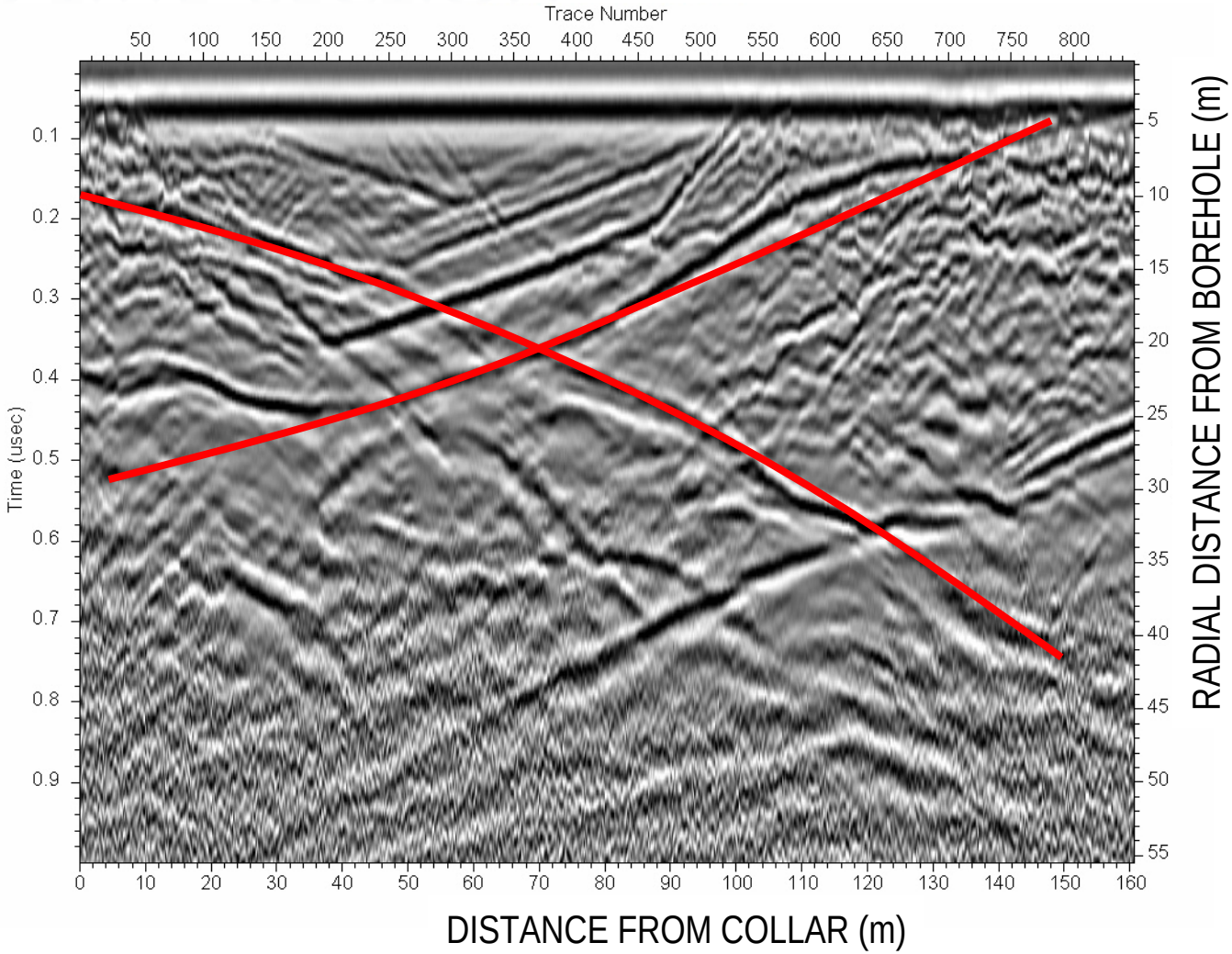
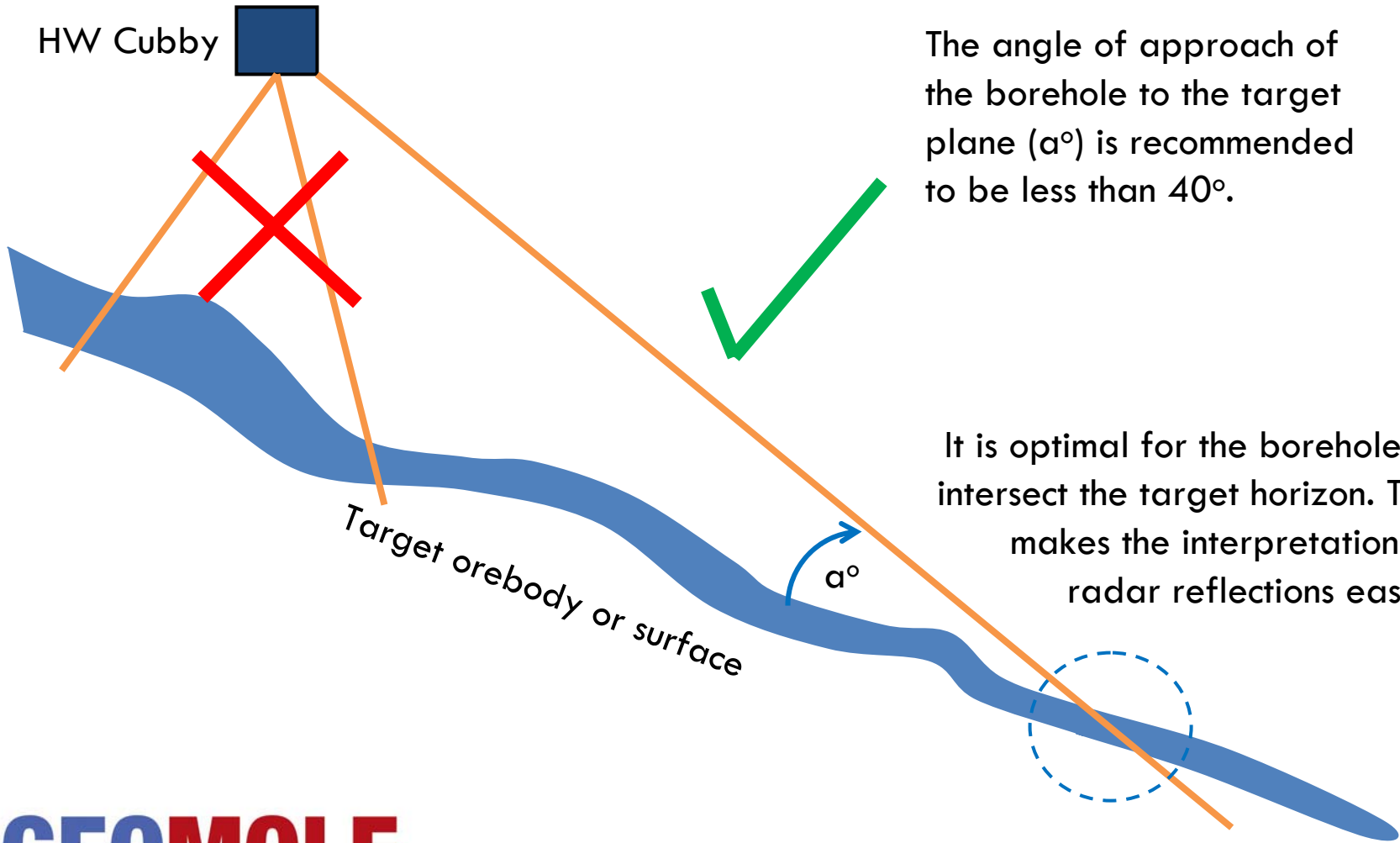
BHR TIME-SECTION

Below (UG1)

Above (UG2)



Drillhole Orientation is important



The angle of approach of the borehole to the target plane (a°) is recommended to be less than 40°.

It is optimal for the borehole to intersect the target horizon. This makes the interpretation of radar reflections easier

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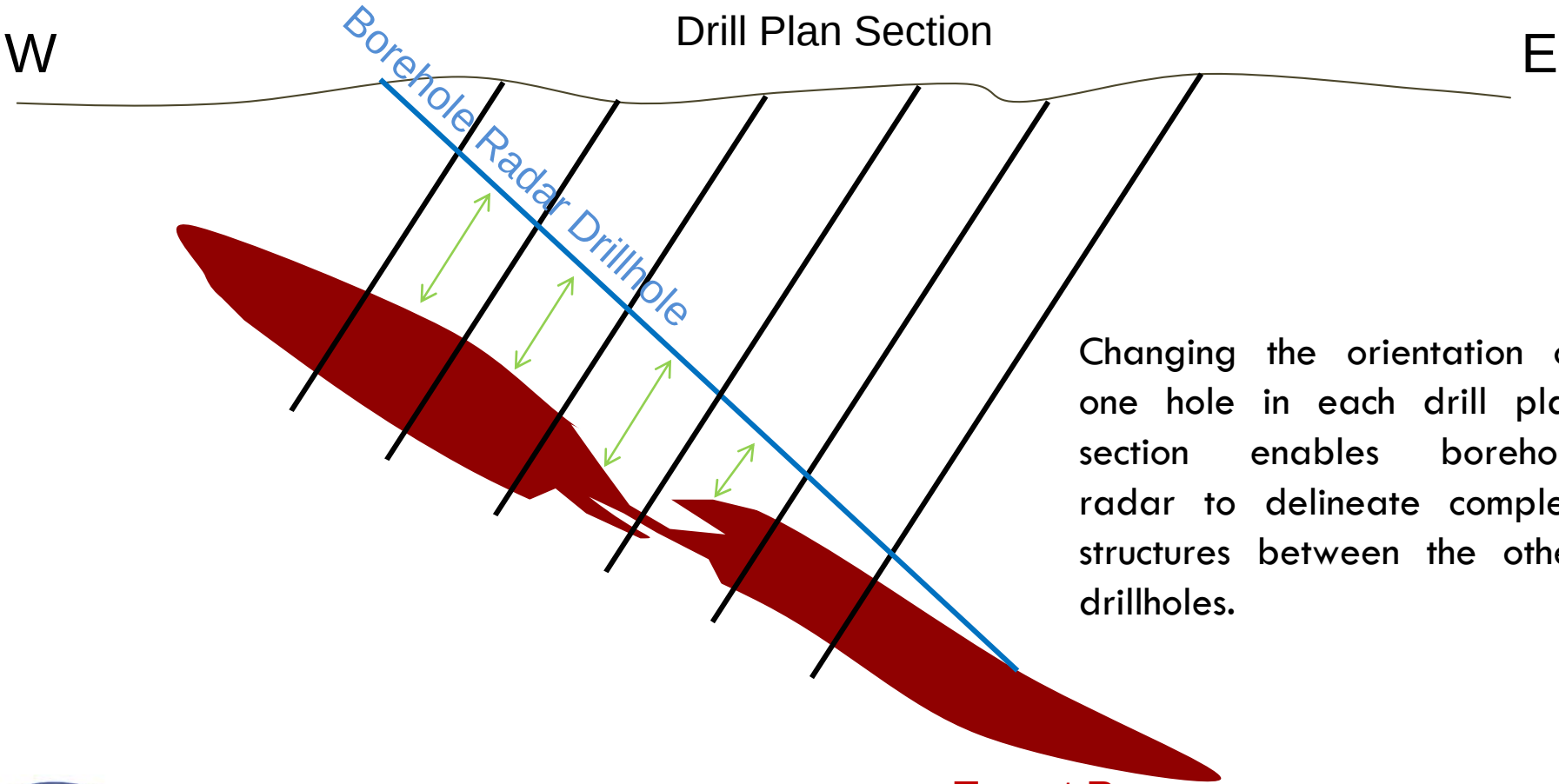
Drillhole Planning



Changing the orientation of one hole in each drill plan section enables borehole radar to delineate complex structures between the other drillholes.

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BHR for Nickel Delineation

- Map lithology contacts
- Map structure
- Detect massive sulphide through amplitude analysis

Exploration

- Continuously map the contact along exploration boreholes
- Improved drillhole design eg. wedge design

In-mine

- Better delineate the orebody directly ahead while mining
- Map bas-bas pinch outs
- Map remote pods of nickel in the hanging wall

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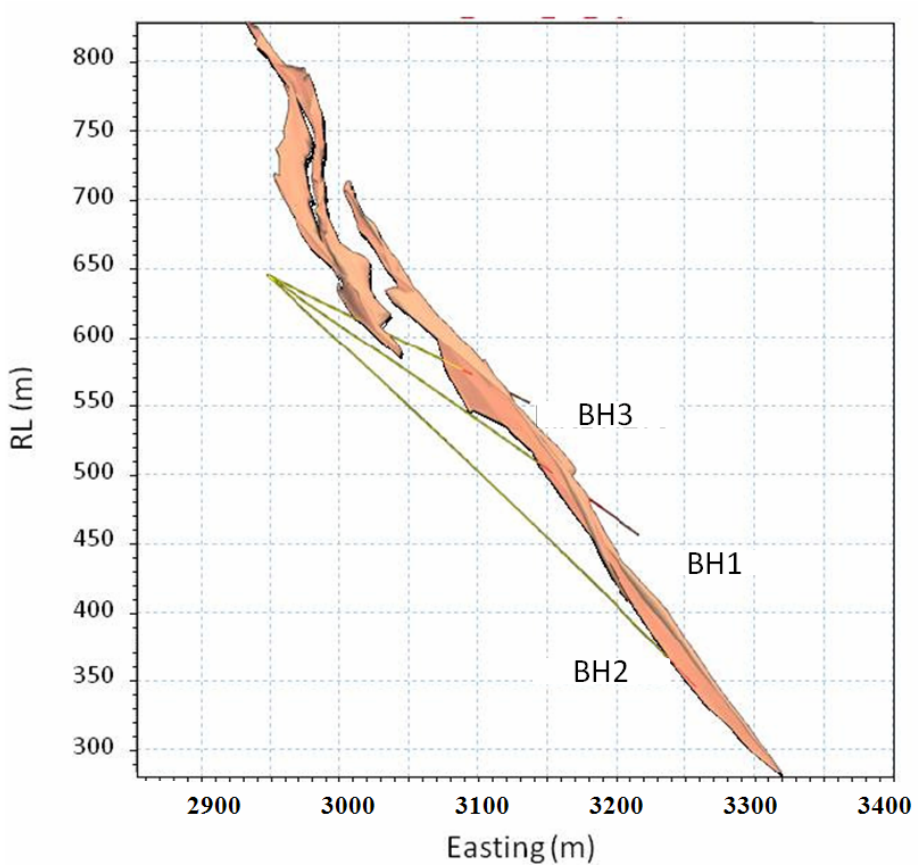
BHR in the Kambalda Style NiS..

- Three boreholes
- Imaging target is the ultramafic-basalt prospective contact
- Aim to determine the geometry of the NiS ore body



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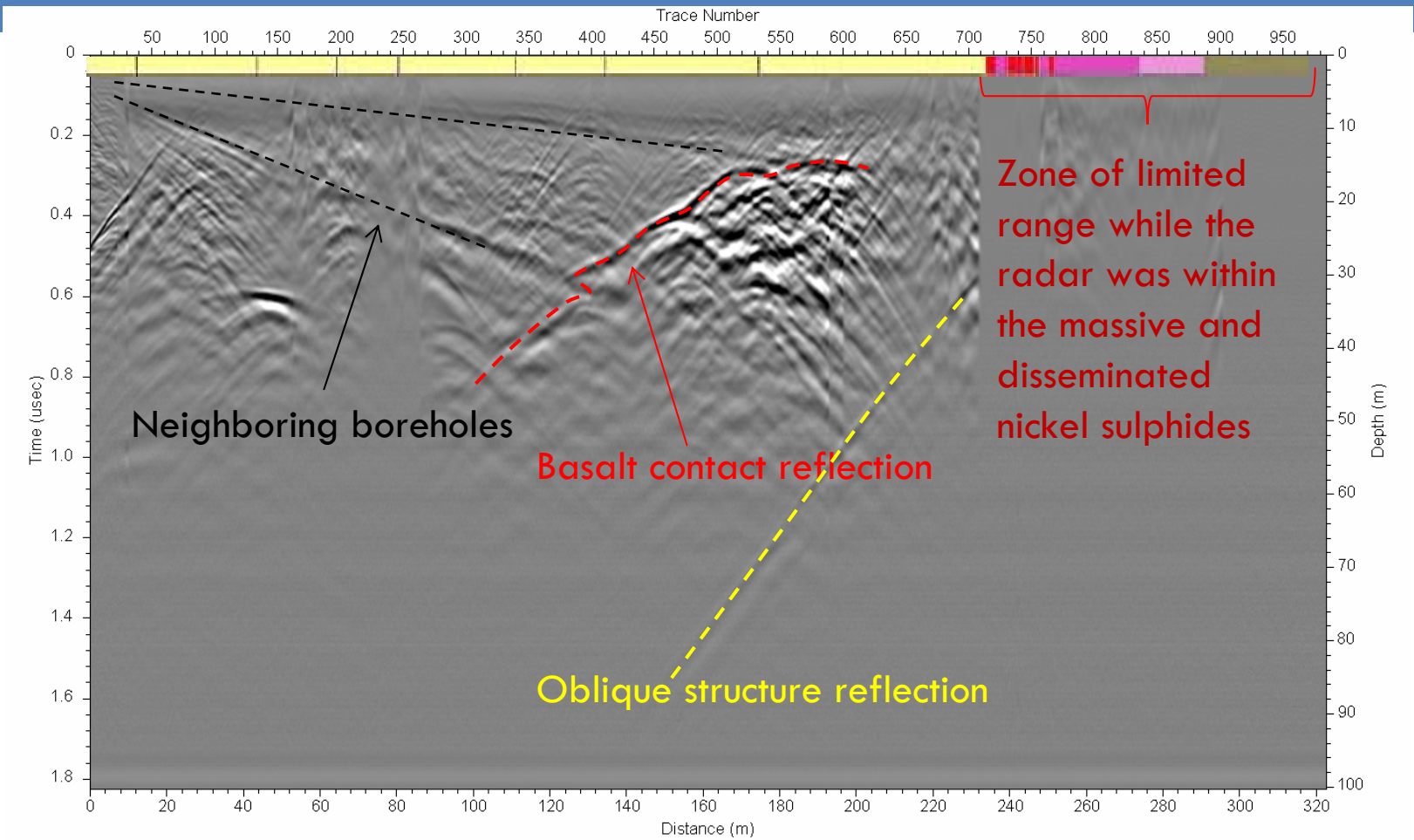
The Borehole Radar Data…



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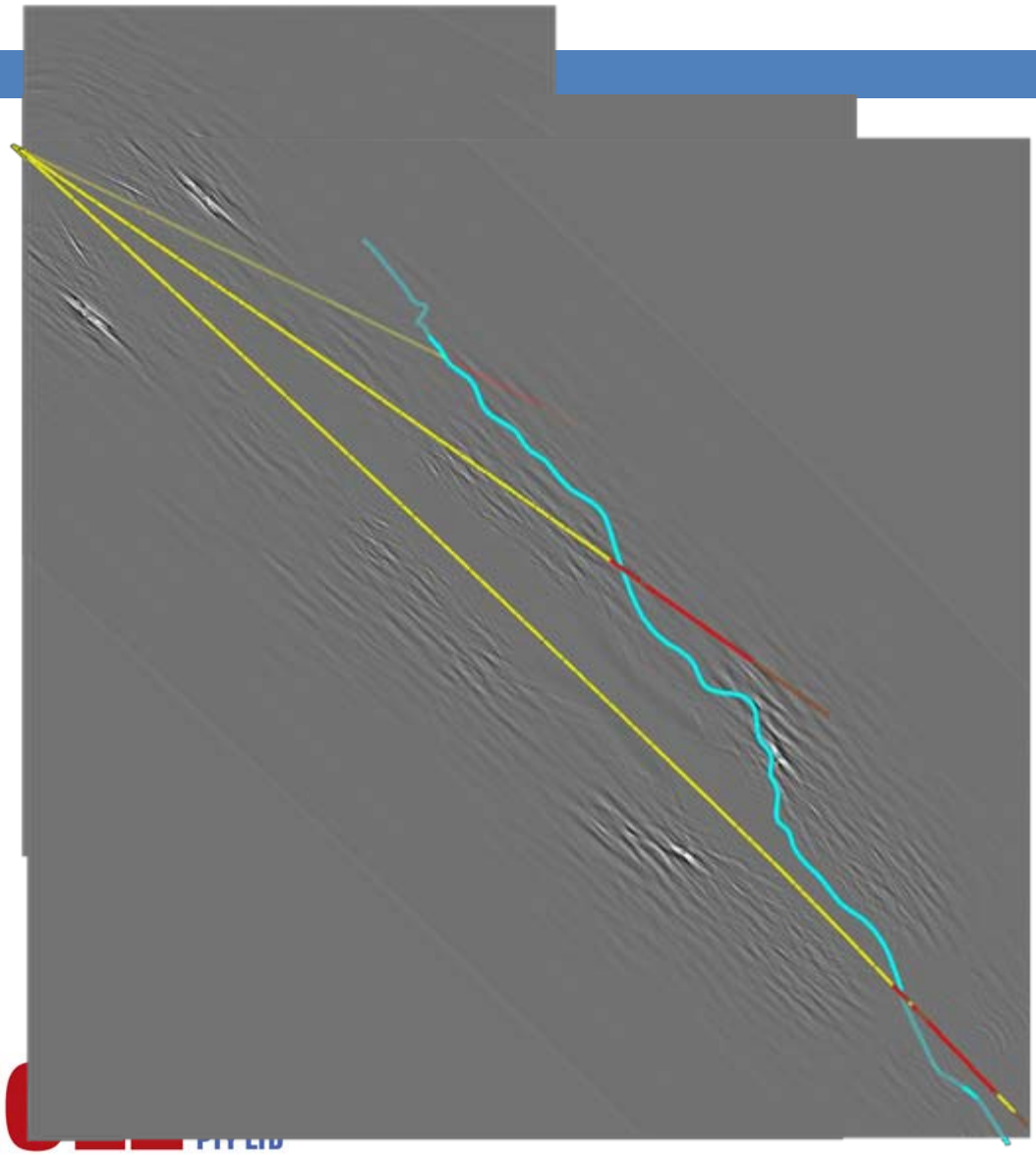
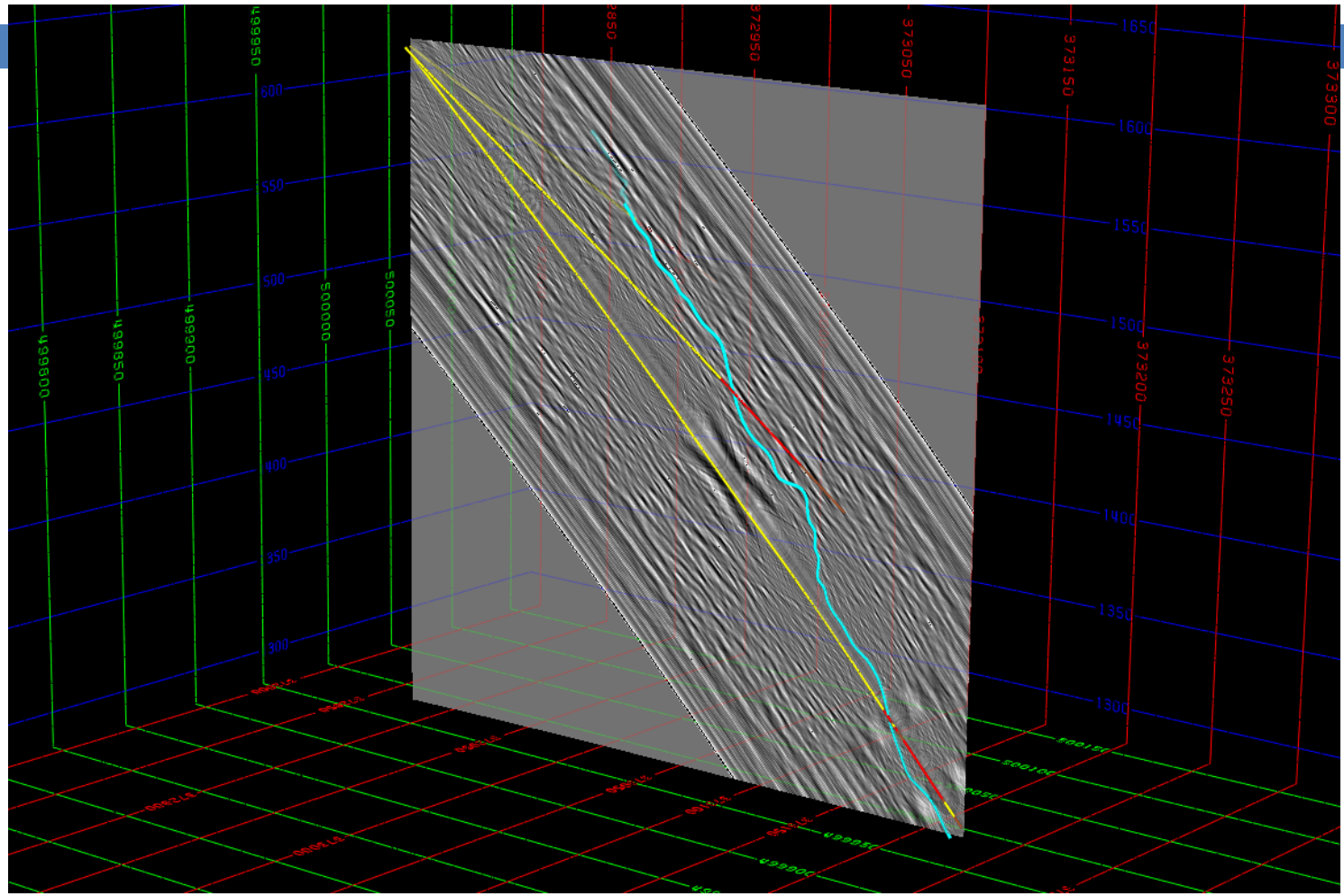
The Data in 3D space…

Migrated data can be imported into Geological modeling and mine planning packages like GoCAD and Surpac.



The Data in 3D space…



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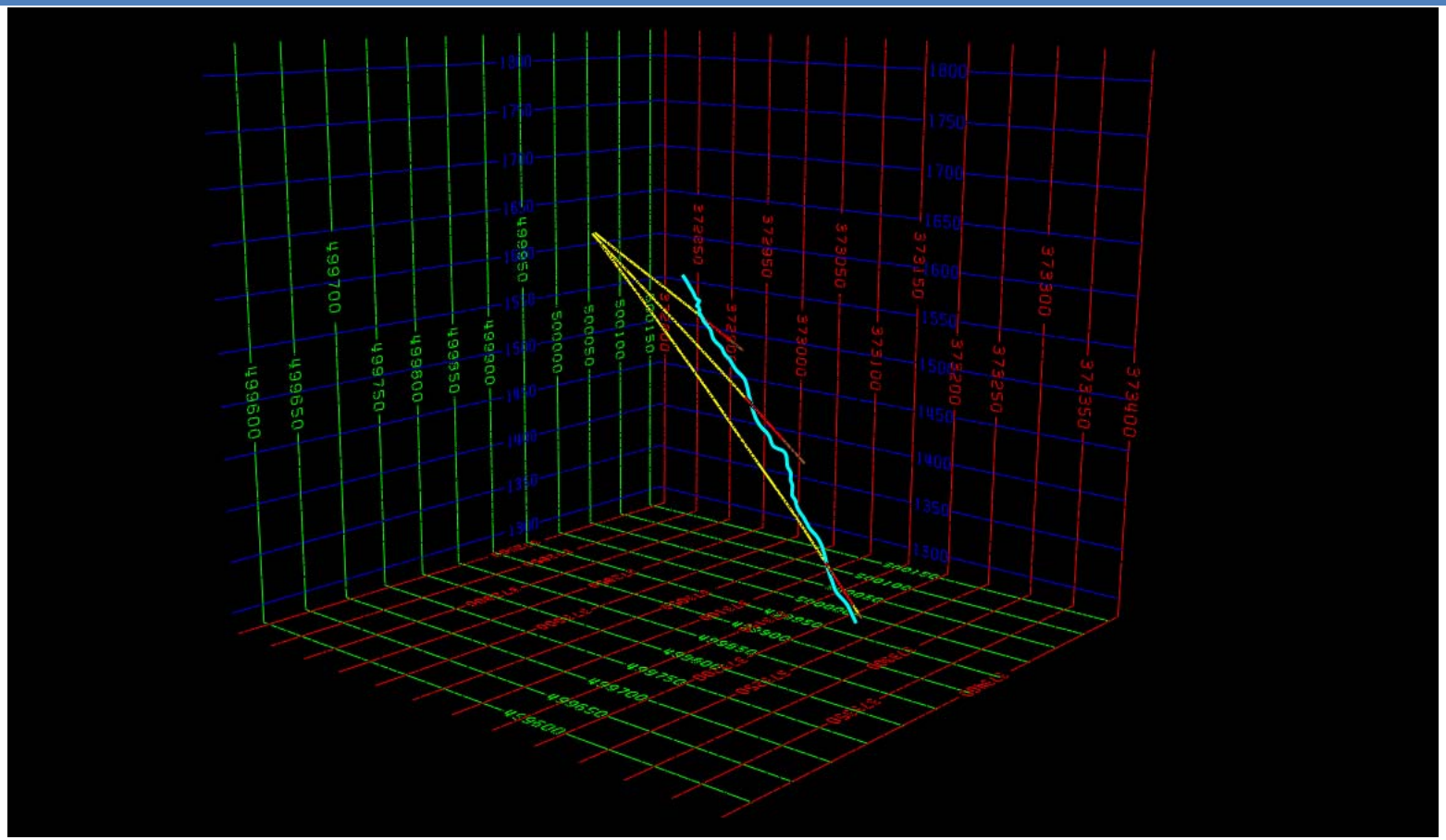
The Borehole Radar results…



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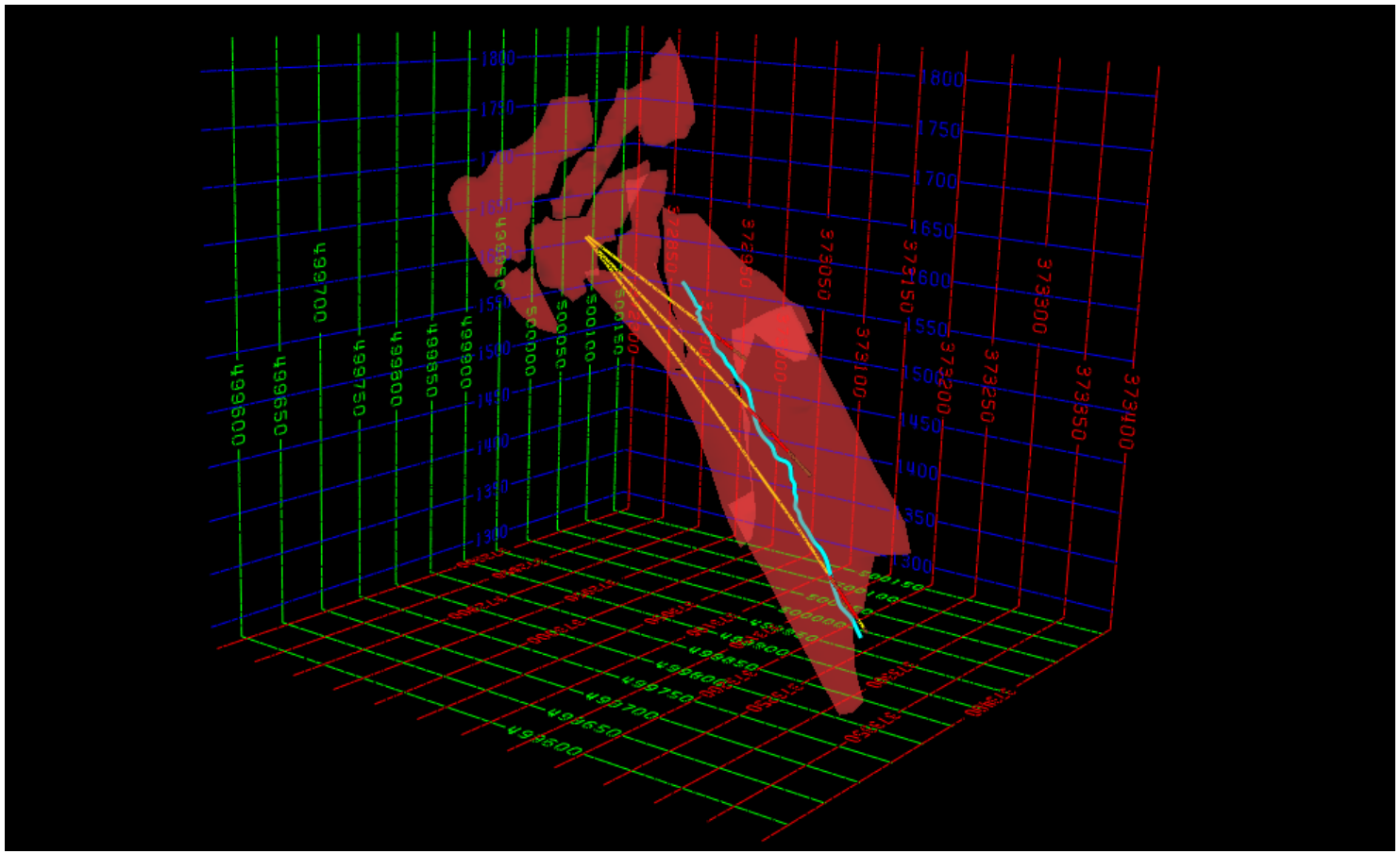
Compared to the ore body model from drilling alone.



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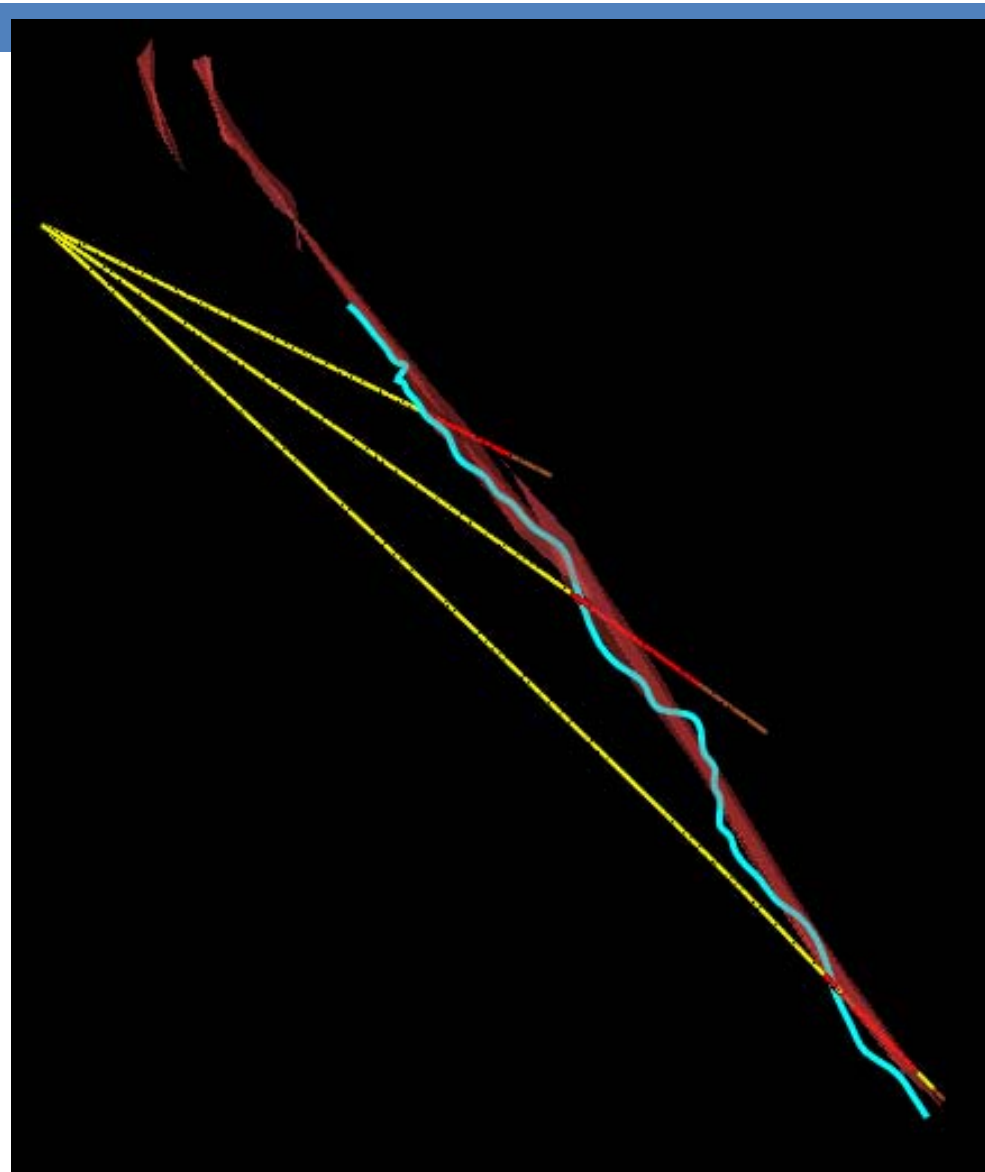
Compared to the ore body model from drilling alone.

- BHR provides detail between the drilling.
- Straight lines vs. knowing what the contact is actually doing.



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Nickel Exploration Example

- Exploration down-dip from current mine in long inclined holes with wedges
- Difficult to drill into contact because of the angle of drilling
- Need to know how far away you are from the contact as you drill
- Need to target nickel channels with wedge drilling

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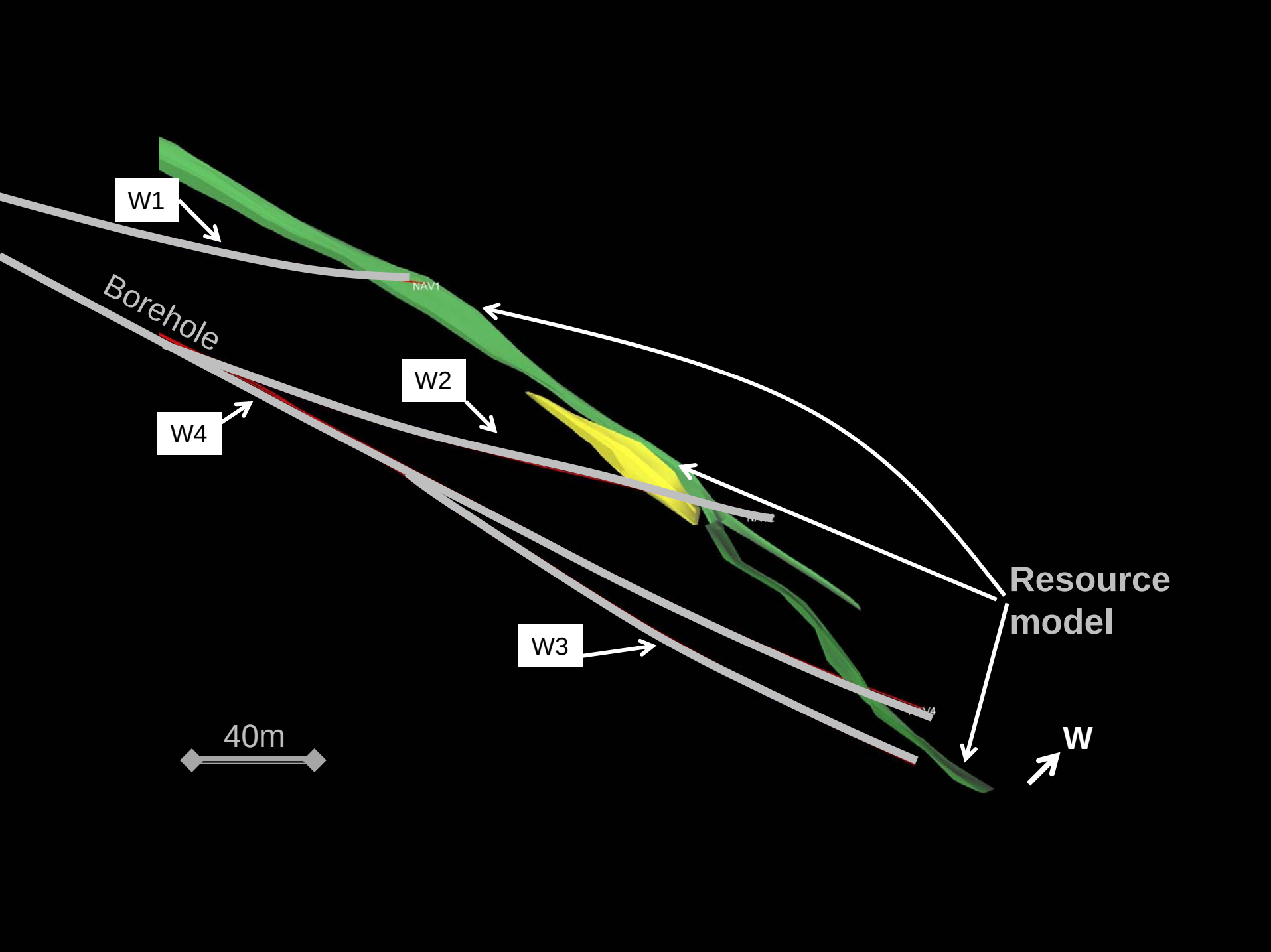
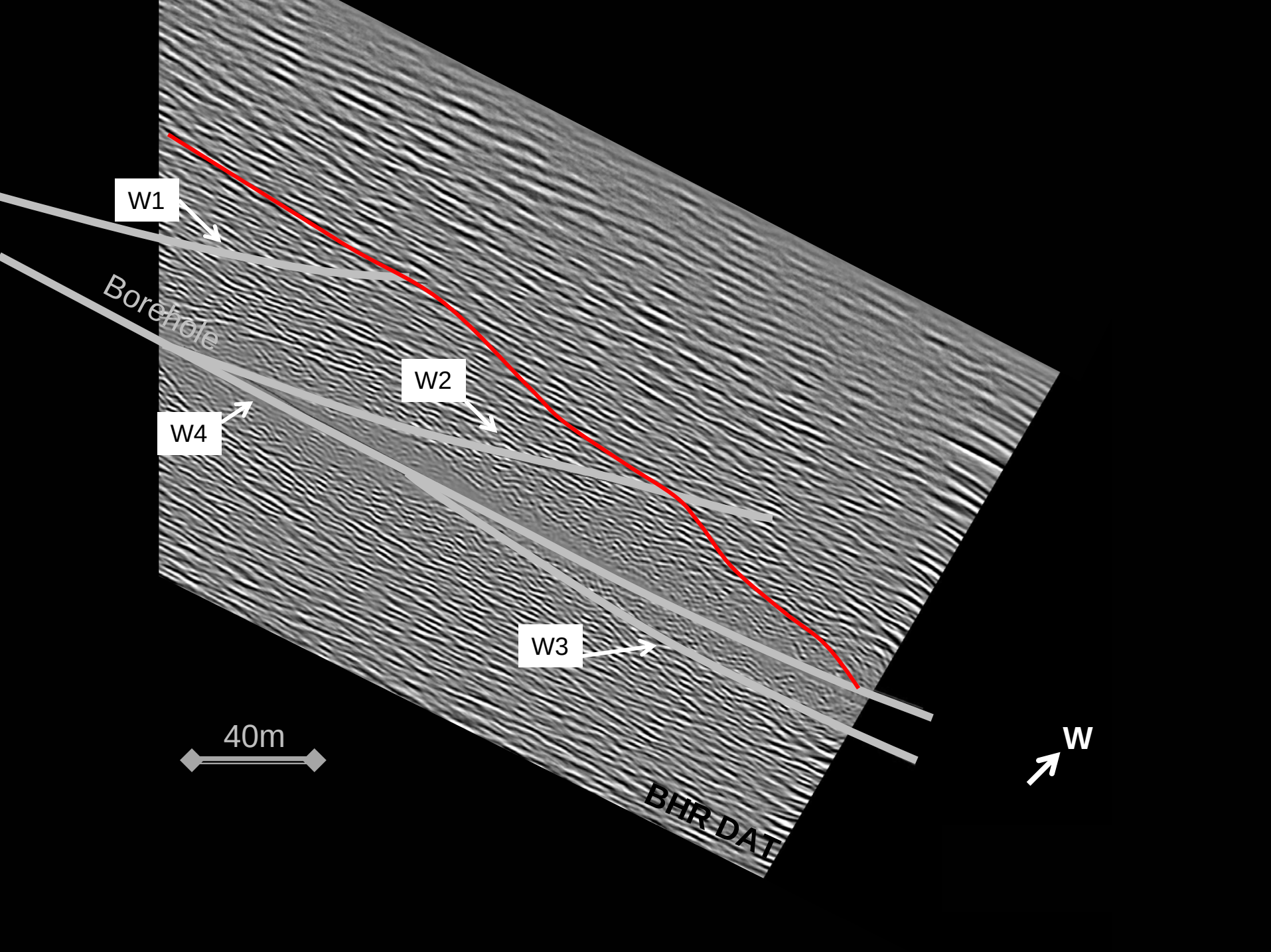
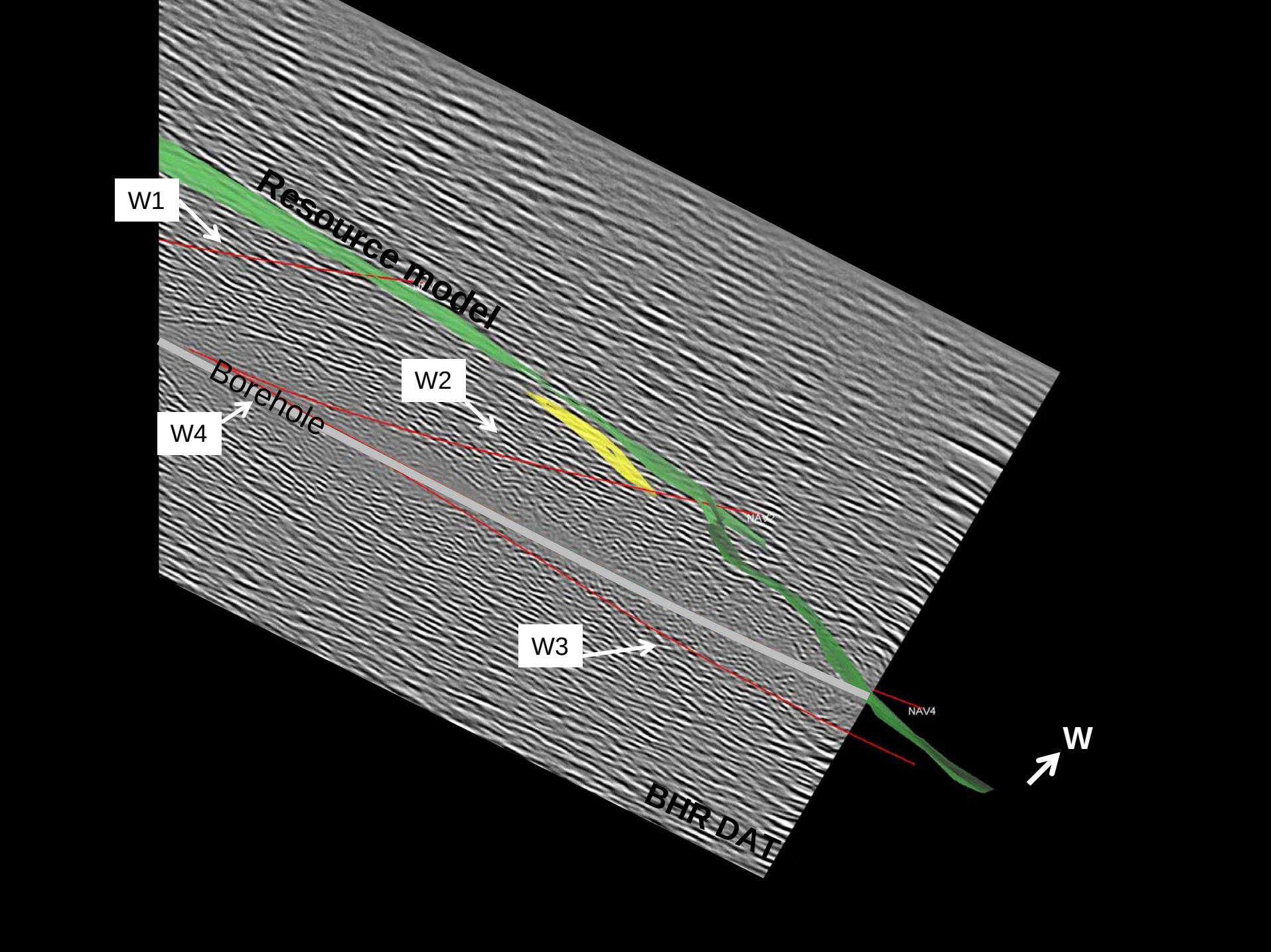

W1
Borehole
W2
W4
W3
Resource model
40m
W


W1
Borehole
W2
W4
W3
40m
W
BHR DAT


W1
Resource model
Borehole
W2
W4
NAV2
W3
NAV4
W
BHR DAT

BHR for Gold

- Map lithology contacts (qtz reef)
- Map structure (splays, intersections)
- Map massive pyrite zones

Exploration

- Continuously map the contact along exploration boreholes
- Improved drillhole design eg. wedge design

In-mine

- Better delineate the orebody directly ahead while mining
- Better place your stopes and development

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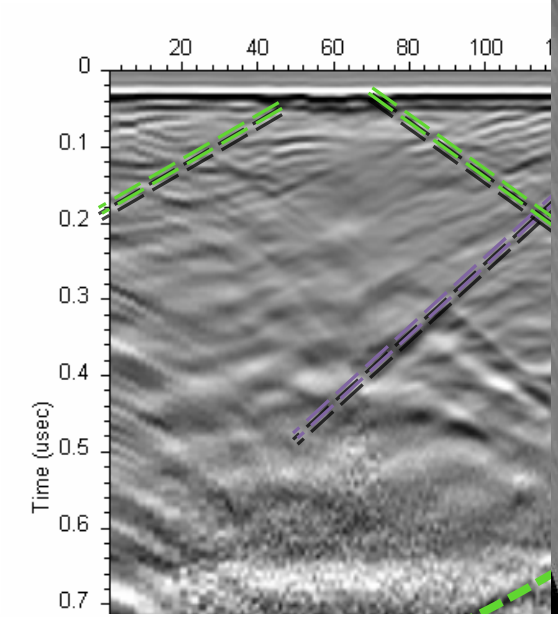
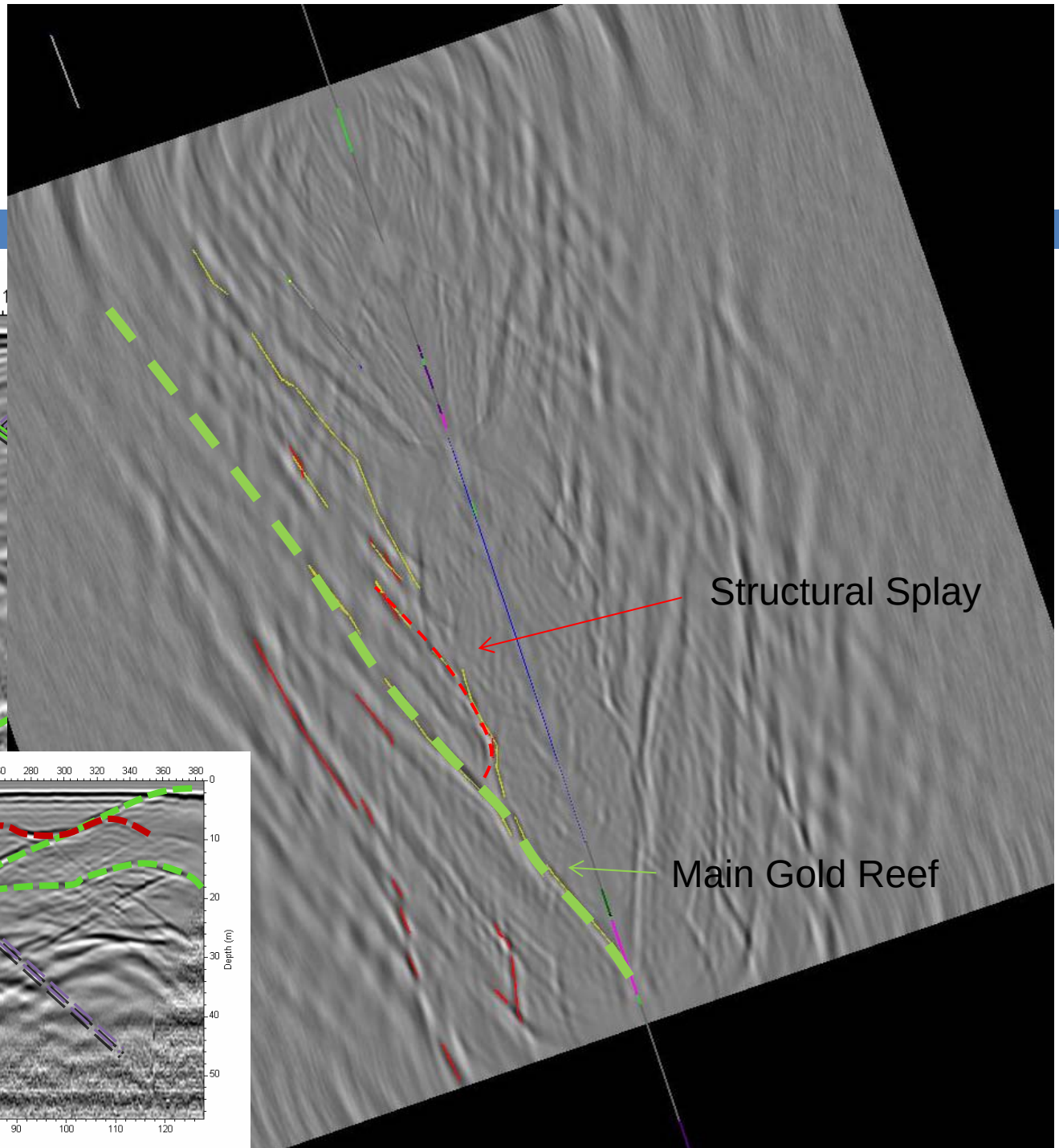
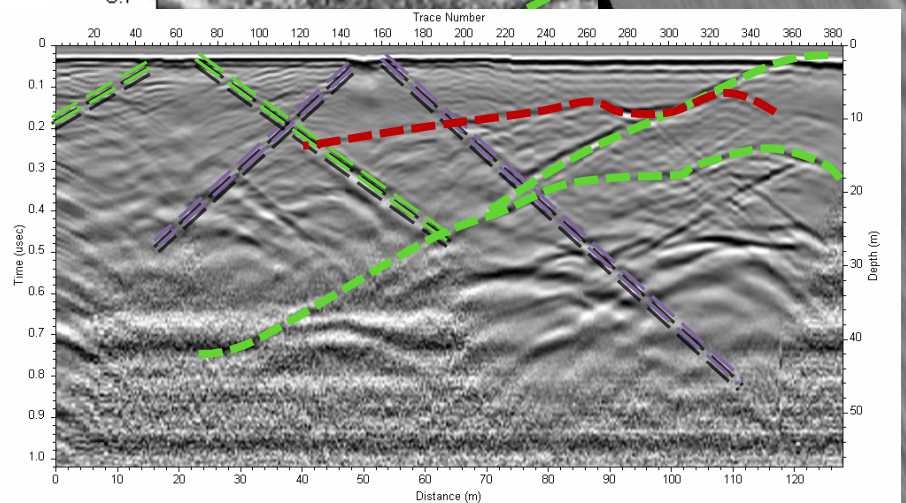

20
40
60
80
100
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Time (usec)


Structural Splay
Main Gold Reef


Trace Number
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Time (usec)
10
20
30
40
50
Depth (m)
0
10
20
30
40
50
60
70
80
90
100
110
120
Distance (m)

Conclusions

- Borehole radar has come along way in the last 10 years
  - Optic Fibre and Winch to drill deployed single stick radar
- Borehole radar is being successfully used in Canada and South Africa.
- Borehole radar is starting to be used in a more routine way in Australia for exploration and in-mine ore delineation.

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Conclusions cont

- Borehole radar can be used to assist with delineation of structure and lithology contacts for mineral exploration in Australia

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Acknowledgements

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  - Professor Iain Mason, Phil Manning, Steve Owens, Jonathan Hargreaves, Binzhong Zhou
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