

Borehole radar (BHR) is deployed in order to map the character of reflective features proximal to boreholes & mine infrastructure. A modelling workflow has been developed to effectively predict the morphology of reflectors within a radargram from simple geological scenarios. This study clearly demonstrates the applicability of this modelling workflow against field tests.

PROBLEM

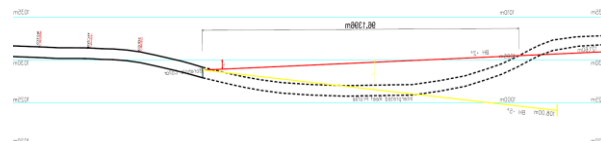
Borehole radar (BHR) data are often complex to interpret due to superposition of features originating from multiple reflectors in different orientations proximal to the borehole. This often leads to difficulty in the interpretation of the radargrams. Optimal placement of boreholes can significantly simplify the complexity of the eventual radargram image.

SOLUTION

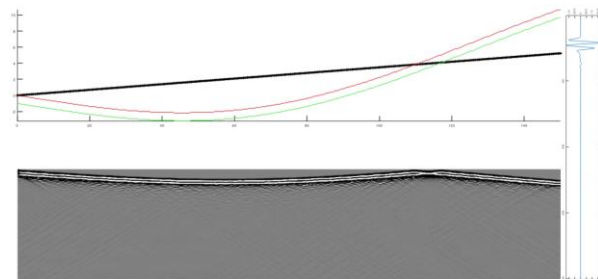
BHR is an electromagnetic technique used for imaging or detecting discontinuities in resistive hard rock formations. It is deployed through a borehole drilled near to subsurface complexity.

BHR reflections are normally caused by sharp changes in the electrical properties of the rock and can yield information on geological features such as lithology contacts, fractures, faults, voids, dykes, and ore body geometry.

Effective modelling of borehole radar reflectivity from simple geological scenarios significantly improves the ability to optimize the location of boreholes and further improves the interpretation process, enabling the development of realistic geological models from complex reflectivity data.



A simple geological scenario showing a planned borehole from within reef, trending upwards and across a local depression, with a targeted intersection point toward the end of the hole.



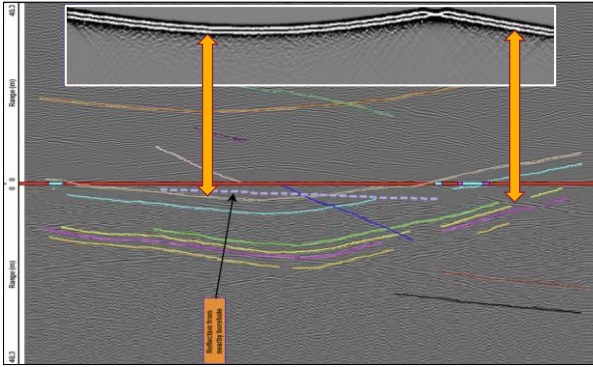
A simple model constructed from the geological scenario containing both contacts of the thin layer, intersected by the upward trending borehole. The derived radar gram illustrating both reflectors and the v-shaped complexity between 100m & 120m due to the borehole cross-cutting the reflective layer.

IMPACT

BHR successfully detected and imaged reef continuity, reef rolls and structures associated with brittle deformation. These results informed advanced mine design by reducing uncertainty around reef geometry and continuity before development entered higher-risk areas. The improved geological understanding supported safer, more continuous extraction by identifying zones where the reef was absent, displaced or significantly deflected. Forward modelling also provided a defensible basis for optimising borehole placement and distinguishing genuine geological reflectors from radargram complexity, increasing confidence in three-dimensional interpretation. Together, these outcomes can reduce avoidable development, limit exposure to unexpected ground conditions, focus follow-up drilling, and improve the quality and timeliness of mine-planning decisions.

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Vertical section illustrating interpretation of lithological contacts as well as brittle structures cross-cutting the lithological units. Comparison with the forward model indicates excellent agreement with the main reflectors which were identified in the geological scenario. With a-priori information on the predominant structural orientations one can confidently interpret in 3D.

TECHNOLOGY

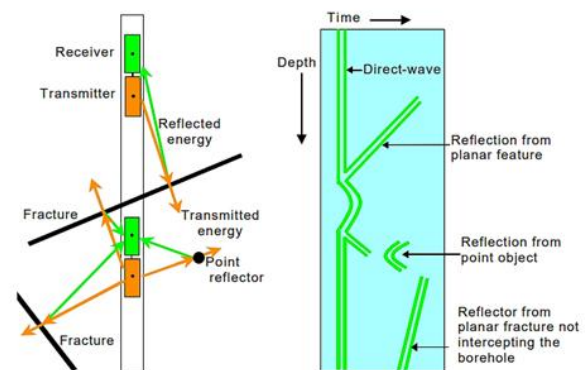
Borehole Radar (BHR) is a high-resolution electromagnetic reflection technique that images the rock volume beyond the borehole wall. A transmitter and receiver are moved along the borehole while short pulses are emitted into the formation. Contrasts in dielectric permittivity or electrical conductivity reflect energy to the receiver, revealing faults, fractures, lithological contacts, voids and mineralised boundaries, including off-hole features not intersected by drilling.

Successive traces form a two-dimensional radargram showing logging depth against reflected-wave travel time. Because an omnidirectional antenna receives energy from all azimuths, the result is a composite projection rather than a direct geological section. Planar contacts typically produce continuous curved or dipping events, while point targets, edges and folded or faulted structures may generate hyperbolic, intersecting or V-shaped responses.

Overlapping reflectors can therefore create substantial apparent complexity.

Forward modelling reduces this ambiguity by converting the borehole trajectory and simplified reflector geometry into a predicted radar response. Comparison with measured data tests alternative interpretations, distinguishes credible geological events from superposition effects and supports better borehole placement. Performance depends on target contrast, formation conductivity and water content, antenna frequency, borehole conditions, reflector orientation and distance. Integration with deviation data, geological logging, structural information and known intersections strengthens reliable three-dimensional interpretation.

In practice, reliable acquisition requires accurate depth control, stable tool movement and suitable borehole conditions. Consistent trace spacing and quality-control checks help identify noise, signal attenuation and depth mismatches before interpretation. These controls improve repeatability and ensure that modelled responses can be compared confidently with measured radar data.



Transmitter and receiver antenna arrangement for borehole radar reflection logging and the typical patterns from planar and point reflectors (Lane et al, 2001).