This paper focuses on the use of cross-borehole electric methods in ore body delineation. A BRT (Borehole Resistivity Tomography) test survey has been conducted to map massive sulfide zones between boreholes up to 130 m apart. The boreholes need to be water filled, so that the electrode array couples to the rock formation. We have established a multi-step procedure for data acquisition, processing and interpretation. Between boreholes, we have successfully imaged the massive sulfide mineralization in a very resistive host. We have demonstrated that the equipment is easy to deploy in water filled boreholes and we conclude that single borehole Vertical Resistivity Profiling (VRP) data can detect conductive zones within a 30 m range around the borehole and it also provides an independent estimate of bulk (4 - 100 m) resistivity for calibration / interpretation of other EM datasets. The cross-borehole tomography data can map conductive zones between boreholes up to 130 m apart. We did not test the larger offset during the present experiments.

**Abstract**

This paper focuses on the use of cross-borehole electric methods in ore body delineation. A BRT (Borehole Resistivity Tomography) test survey has been conducted to map massive sulfide zones between boreholes up to 130 m apart. The boreholes need to be water filled, so that the electrode array couples to the rock formation. We have established a multi-step procedure for data acquisition, processing and interpretation. Between boreholes, we have successfully imaged the massive sulfide mineralization in a very resistive host. We have demonstrated that the equipment is easy to deploy in water filled boreholes and we conclude that single borehole Vertical Resistivity Profiling (VRP) data can detect conductive zones within a 30 m range around the borehole and it also provides an independent estimate of bulk (4 - 100 m) resistivity for calibration / interpretation of other EM datasets. The cross-borehole tomography data can map conductive zones between boreholes up to 130 m apart. We did not test the larger offset during the present experiments.

**Vertical Resistivity Profiling (VRP)**

From the electrode array in a single borehole, we perform Vertical Resistivity Profiling (VRP), in which the current and potential electrode array are located at the same surface. The measured voltage is converted to apparent resistivity through a geometry factor which takes into account the earth-air interface. The apparent resistivity pseudo-section is created by assigning the apparent resistivity at AB/2 from the borehole. The VRP data is nearly be collected within half an hour. This data provides bulk 4-m to intra-resistivity measurements for the calibration / interpretation of other EM data sets. Furthermore, the VRP data is so informative about the resistivity structures in the vicinity of the borehole. In the following figure, we show VRP data characteristics for two different situations:

(A) Borehole intersects sulfide zone: From the apparent resistivity pseudo-section, we can clearly identify that the sulfide zone has an apparent resistivity of less than 50 ohm.m. The zone is located between the depths of 40 and 50 m and its lateral extension is more than 30 m. There is a weak conductor at the depth of 25 m. This zone is not in contact with the borehole.

(B) Borehole passes a sulfide zone at a distance: The VRP apparent resistivity pseudo-section shows that there is a conductive zone at the depth of 60-70 m. This zone is about 30 m away from the borehole.

**Cross Borehole Resistivity Tomography (BRT)**

We construct the BRT model by applying the following steps: (1) use VRP pseudo section to build a starting model at the two borehole locations; (2) perform inversion on VRP data only (use the starting model to constrain the inversion, no smoothness stabilization applied); (3) build a starting model between two boreholes using the two resistivity by inversion models derived from VRP data; (4) constrain the near borehole resistivity and let the tomography inversion adjust the resistivity in the surrounding region; and finally (5) fine tune the tomography inversion model with geological / petrophysical constraints (where available). Two BRT models from two survey locations are shown below with borehole traces.

**Cross Borehole Electric Current Mapping: A Quality Control Tool**

When a constant injection voltage is applied between electrodes A and B across the two boreholes, the electric current flowing between A and B depends on the contact resistance of the electrodes A and B and the rock formation resistance between A and B. If the borehole is water filled, we can assume the contact resistance is uniform. Thus the electric current from A to B maps the rock formation resistance between points A and B. The injection current between A and B is low enough that the assumption of a single conductive zone between the two boreholes is valid. The borehole separation is 68 m. The second example shows a case where one borehole intersects the massive sulfide ore body while the other is away from the sulfide. The public wants to build a long electric current is observed for electrodes within certain depth range. For the borehole passing the ore at a distance, the ore zone is visible from the injected electric current.

**Conclusions about the Geoserve Survey**

- Detect conductive zones in the vicinity of a borehole
- Provide independent estimate of bulk (4 - 100 m) resistivity data for calibration / interpretation of other EM datasets
- Map conductive zones between boreholes (tested up to 180 m apart)
- Works for weak and strong conductivity contrasts
- Very easy field operation procedures

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