Application of seismic systems to pin-point the location of the drill-bit in real time

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Presentation

- Introduction
- Project concept
- Results and discussion

Introduction

Drilling

- Perhaps the most important operation in mining.
- Accurate drilling reduces the mining cost .
  - Makes it possible to increase the mining scale.
  - Reduces dilution, overbreak, damage and ore losses.
  - Improves fragmentation and reduces disturbances.
  - Reduces specific drilling and charging.

Gellivare Hard Rock Research (GHRR)

- Initiated in year 2002 the project ”Guided drilling with coil tube – a possible step change in production drilling”.
- An essential part of that project was determining the location of the drill bit.
- A number of alternative measurement methods were explored.
- Seismic technique were opted.

GHRR project

- Completed in year 2005.
- Important contribution was brought by LTU (signal analysis – adaptive blind deconvolution).
- Conclusions
  - Seismic methods feasible.
  - Many problems remained to be resolved.

Feasibility study

- Carried out by Vibrometric OY.
- Conclusions
  - Seismic methods might be viable.
  - Accuracy probably less than the required ± 0.1 m for a 40-50 m long borehole.
  - Possibly uneven seismic velocity distribution throughout the rock mass.

Project concept

Continuation project

- Started in 2006.
- Managed by RTC (Rock Tech Centre).
- LKAB and SKB as present sponsors. (SKB = Swedish Nuclear Fuel and Waste Management)

Four phases in the project

1. In-depth feasibility study and pre-planning of a new field test.
2. Further analysis of data recorded in the former GHRR project.
3. New field test at the LKAB Kiruna mine.
4. Evaluation and recommendation for further actions.
    - A related effort could be launched at this point aimed at selecting technology for actively steering the drill bit using real-time positioning information.

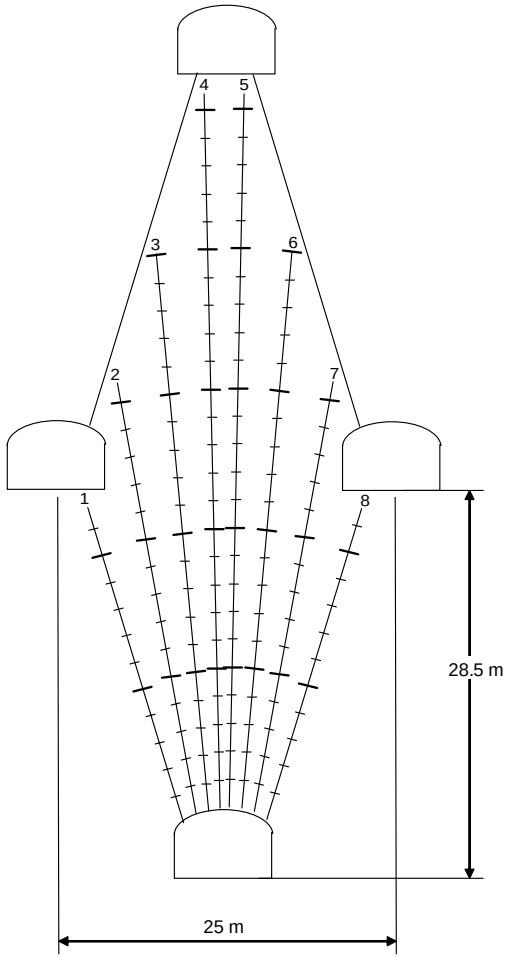
Objectives

- Develop and test seismic techniques able to pin-point the location of the drill-bit with high accuracy.
- Demonstrate real time localization.
- Build-up a 3D seismic velocity distribution image.

To date

- Phase 1 and 2 are completed.
- Preliminary activities started for phase 3 – the field test.
  - A large number of sensors will be used.
  - On line drilled depth recording.
  - Zero time measurement.
  - A number of holes will be drilled through the upper level enabling conventional surveying of end-point coordinates.

Typical full size ring at LKAB Kiruna



Results from phase 1 and 2

Location

- Different location methods tested.
- Velocity corrections necessary.
  (We can not assume a constant velocity especially not in a mining environment)

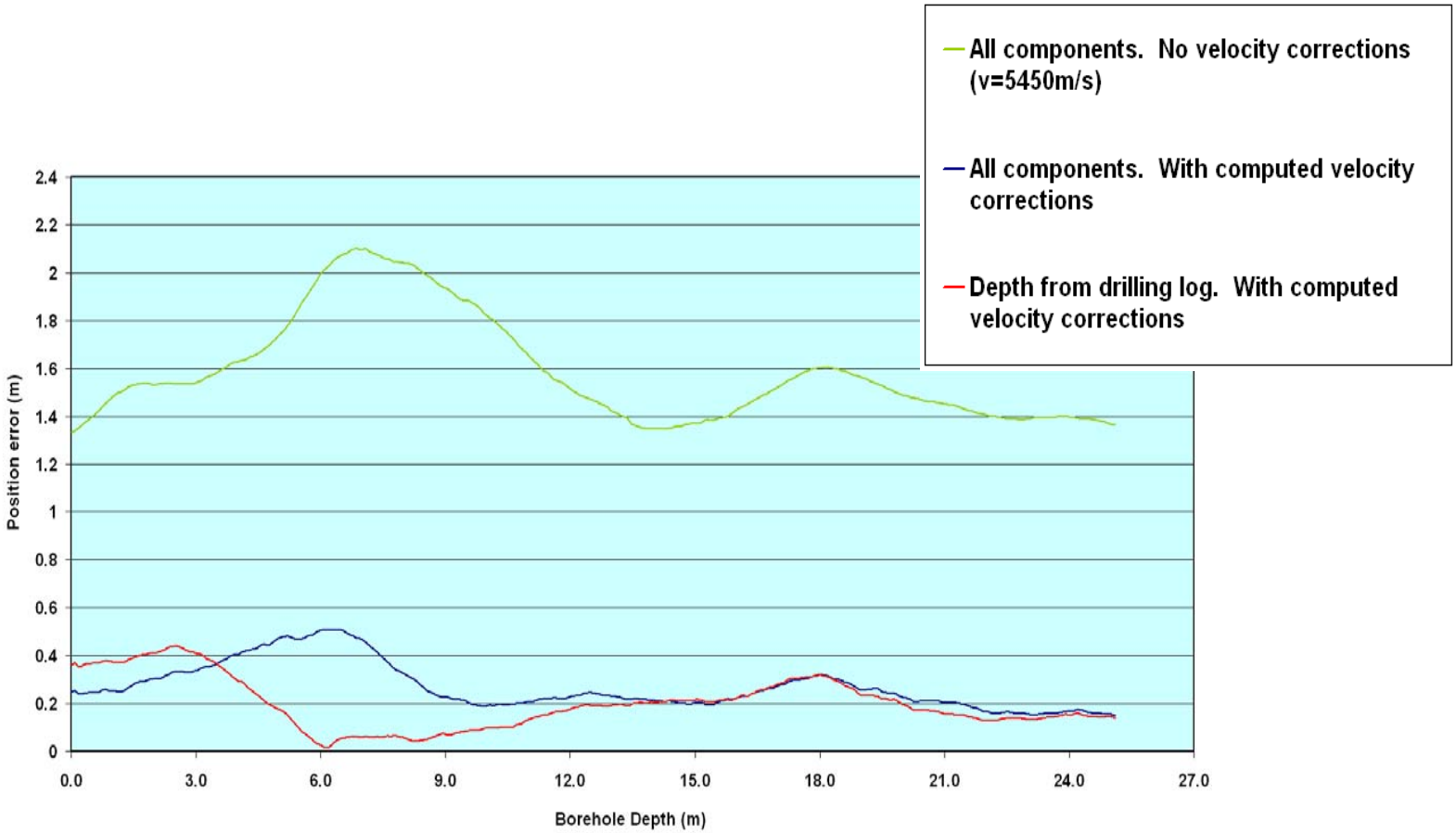
Conclusions from phase 1

- With the appropriate approach and receiver layout, errors can reach 0.1 m.

- Main concerns:
  - Accurate time picking.
  - Reliable velocity field evaluation.

Results from phase 2

Positioning errors. Removal of “spikes”. 4 m long borehole segments.



Conclusions from phase 2

- The localization error appears to be around 0.2 m except from two regions along the borehole. (Not exact results, we have assumed a completely straight borehole between the surveyed start- and end point)
- Knowledge about the drilled depth improves the localization.
- Knowledge about the zero time is useful for decoding the signals and also the localization.