Modeling and simulation of a deeply penetrating low frequency subsurface radar system

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Background

- Radar subsurface imaging used for geophysical exploration
- Low frequency radar systems (1-5MHz) have been used for km range imaging: Mars, Antarctica
- Adrok Ltd. operates portable compact system (2.5 - 100MHz)
- Used for detecting minerals, oil/gas, water by remote sensing
- Exploration depth limited by absorption losses
- Data stacking increase signal to noise ratio
- How deep can we image through rock with such a system?

Aims

- Model radar system
- Model subsurface structures
- Numerically simulate experiments
- Use result as guide for experimental design and feasibility studies
- Select a specific rock type and target for this study

Methods

- Measure sensor output, noise level, sensitivity
- Measure physical properties of limestone in-situ
- FDTD/ray tracing numerical simulation (Maxwell in ground)
- Detect reflection time from wet layer
- CMP/WARR scan to build velocity model (semblance velocity spectrum)
- Vary target depth, rock roughness
- Vary stack (500-250,000), scan length (50-200m), line sampling (10-50)
- Test signal processing methods on synthetic data

Conclusion

Results indicate that with the modeled equipment a water layer (or other reflector) can be detected quickly at a depth of 350m through limestone by detecting the arrival time of the reflection using a correlation analysis of a scan and a phase based velocity spectrum analysis of a WARR scan over a 100m line sampled at 5m intervals. Small irregularities in dielectric of about 0.25 in the limestone are helpful for the interpretation but if these fluctuation become very large multiples interfere with dielectric (velocity) estimation. Under the constraint of a one day survey and limitations on the data acquisition rate, maximum exploration depth was estimated at 600m.

References