





Methods for measuring complex resistivity spectra of rock samples in the context of mineral exploration

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Introduction

Today critical raw materials such as Sn, W, In and rare earth metals are very important today for producing electronic equipment. In the past decades the exploration activities in Germany for mineral resources were low and, therefore, the research in this field as well. Nowadays efforts are undertaken to develop new technologies and exploration systems (e.g. using helicopter electromagnetics as in the project, where this work is involved in). Along with the geophysical exploration, it becomes important to know about petrology and the genesis of the expected mineral deposits. The knowledge about petrophysical characterization of the rocks involved is essential.

The main focus in the current research project is on antimonite deposits. For measuring petrophysical parameters such as density, conductivity (as a key parameter in exploration) and magnetic susceptibility, samples of antimonite and the surrounding material of the deposit are required. However, at least in Germany, in situ samples cannot be obtained anymore due to closed mining pits. Existing samples in rock collections are the only available source for sample material. The problem is that it is mostly not allowed to destroy or cut these samples so new approaches have to be developed to measure the complex resistivity. The following study demonstrates preliminary results of potential strategies to overcome the given limitations.

Material



Fig. 1: Antimonite sample (HF 1, left) and surrounding material (galena and sphalerite in vein quartz, right) from the geological rock collection of BGR.

- Samples in geological rock collections often exhibit arbitrary geometries.
- It is usually not allowed or even possible to drill cylindrical samples matching a common four-point measuring cell for measuring the complex resistivity.

Method

- Spectral Induced Polarisation: measurement of the amplitude ρ and the phase shift ϕ of the complex resistivity
- Frequency range 1 mHz 45 kHz
- Device SIP ZEL (Zimmermann et al., 2008)
- measurement cell: four-point with Agar-Agar gel as coupling agent for the current and ring electrodes for the voltage
- stuck electrodes at chunk samples: test of different conductive glue materials, calculation of the geometry factor by 3-D scanning of the rock and subsequent numerical modeling
- sand box: filled with pure unpolarisable homogeneous fine sand and saturated with tap water, electrode material: stainless steel nails

Procedure





Fig. 2: Used four-point measuring cell for the cylindrical samples.

Fig. 3: 3-D scan of a sample: a) photo, b) data points, c) mesh.

Three different data acquisition approaches are tested:

- **1.)** If possible, cylindrical core samples are measured in the measuring cell.
- **2.)** Chunk samples with irregular geometry are measured using small (nail) electrodes stuck on the rock surface.
- **3.)** Samples with irregular geometry are buried in a sand-filled terrarium for measuring exact phase values.

Cylindric core samples





Chunk samples



Sand box





Fig. 4: Cylindrical, anisotropic samples of antimonite (left) and quartz (right).

antimonite sample *KB* 7



Fig. 5: SIP spectra of quartz (black) and antimonite core samples for different orientations (red and blue).



Fig. 6: 3-*D* model of sample Schleiz 2 with electrode positions.

Fig. 7: Chunk sample "Schleiz 2" with stuck electrodes connected.

uck electrodes connected. HF

Fig. 9: Buried antimonite sample *Fig. 10:* Pictures of the measurements in the sand box.



Fig. 8: SIP spectra of chunk samples with different glue materials for connecting the electrodes.



Fig. 11: SIP spectra of an antimonite sample buried in a water-saturated quartz sand box.

Comparison of all three approaches using a cylindrical slag sample (SB 2)







Fig. 12: SIP spectra of the slag sample in a four-point measurement cell (two repetitions).

Fig. 13: SIP spectra of the slag sample with stuck electrodes.

Fig. 14: SIP spectra of different electrode arrays over the buried slag sample, black line shows the result for the array centered over the sample position.

Conclusions

- Although each approach itself provides mostly reproducible results, a direct comparison of the three approaches show differences in amplitude and phase (reasons still unknown).
- Direct measurements of rock samples with stuck electrodes seems to be a promising tool for irregulary shaped samples (altough the sample is not too resistive) together with the 3-D scan of the rock (phase information is still crucial).
- Measurements using a sand-filled box appear to be a suitable option. Further detailed investigations (e.g. inversion of the data) need to be carried out.

Outlook

- Limitations must be considered such as electrode polarization or sample size compared to resolution properties of the used array.
- > Further comparison of the three approaches considering possible anisotropy effects.
- Verification for a broader range of samples with irregular geometry.
- Clarification of occurring phase effects.

Contact: tina.martin@bgr.de +49-30-36993359 Literature:

Zimmermann et al. (2008): Zimmermann E., Kemna A., Berwix J., Glaas W., Münch H-M. and J.A. Huisman: *A high-accuracy impedance spectrometer for measuring sediments with low polarizability*, Meas. Sci. Technol. 19, 105603 (9pp)

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