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PETROPHYSICAL INVESTIGATION OF THE VOLCANIC ROCKS OF STYRIA (AUSTRIA)

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The petrophysical investigation of the volcanic rocks of Styria was part of the project "Lithothek" financially supported by the VALL (Vereinigung für Angewandte Lagerstättenforschung Leoben). The main objective of this research was to investigate the physical properties of the large variety of volcanic rocks occurring in Styria. Further we were interested if it is possible to differentiate between volcanic layers deposited during different phases of activity.

As known the two geological periods of volcanic activity in Styria are the Miocene and Plio/-Pleistocene. The volcanic rocks of the Miocene are characterised by latitic composition (high SiO_2-contents and potassium accentuated). In contrast the Plio/-Pleistocene delivered mainly basic rocks (low SiO_2-contents and sodium accentuated).

These differences in mineralogy should allow a discrimination by physical properties. Moreover variations in grain size distribution, pore volume and density are expected to be accompanied by different petrophysical responses and thus enable a differentiation of stratigraphic arrangements, e.g tuff layers.

Seven sites were sampled including Altenmarkt (Riegersburg), Bad Gleichenberg, Burg Kapfenstein, Beistein (Petersdorf I), Burgfeld (Fehring), Klöch and Pertlstein.

Altogether 16 different volcanic rock types were sampled: basalt, basaltic scoria, tuff, lapilli-tuff and latite.

The physical properties that have been determined are the complex electrical resistivity, magnetic remanence, magnetic susceptibility, elastic properties and thermal conductivity.

The porosity of the rocks varied between 4 and 63 % and as a result the electrical resistivity showed large variations between 70 and 3300 Ωm. All measurements concerning electrical properties were carried out at the Institut für Geophysik of the TU Clausthal. There we were able to determine the complex electrical resistivity. Compared to a conventional measurement of the resistivity this methods also determines the phase angle or time shift between the injected current and the measured voltage. Thus an additional parameter is obtained.

As the electrical resistivity delivers mainly information about the connectivity of the pores, the phase angle provides information about the pore geometry and electrochemical interactions between pore-fluid and mineral matrix. Figure 1 shows a spectral measurement of the complex resistivity of three tuff samples from Burg Kapfenstein. The samples differ in their grain size distribution. As a result the phase response is also different for all three samples (Fig. 1).

The correlation of the porosity with thermal conductivity and ultrasonic velocity is shown in Figure 2. As expected the thermal conductivity decreases with increasing porosity. But the ultrasonic velocities especially of the basaltic rocks from Klöch (KL) do not show a clear correlation with porosity.

The ultrasonic waves within the basaltic scoria propagate faster than in the denser "Sonnenbrenner-Basalt". This result shows that the influence of porosity is limited as long as a sufficient bulk modulus is guaranteed by a connected mineral matrix.

Concluding the previous results we can say that petrophysical parameters are able to distinguish between the different volcanic rocks abundant in Styria. Well-known interrelations between mineralogy, texture and structure and physical properties are valid, but the results, especially concerning basalt scoria showed that there is still a need of modification in order to explain the observed phenomena.

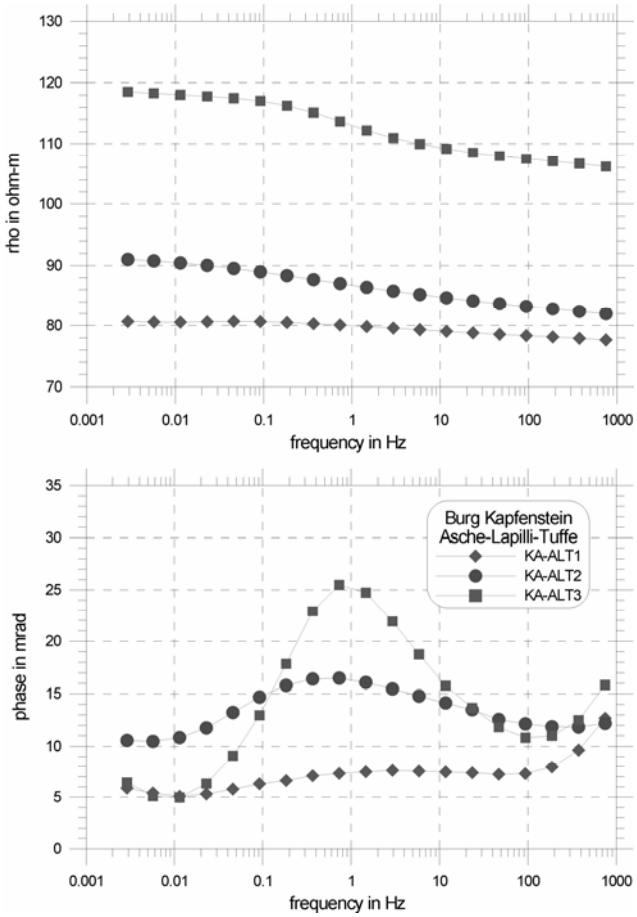

Figure 1: Spectral measurement of the complex resistivity of three volcanic rock samples from Burg Kapfenstein. top: spectral resistivity measurement, bottom: spectral measurement of the phase angle

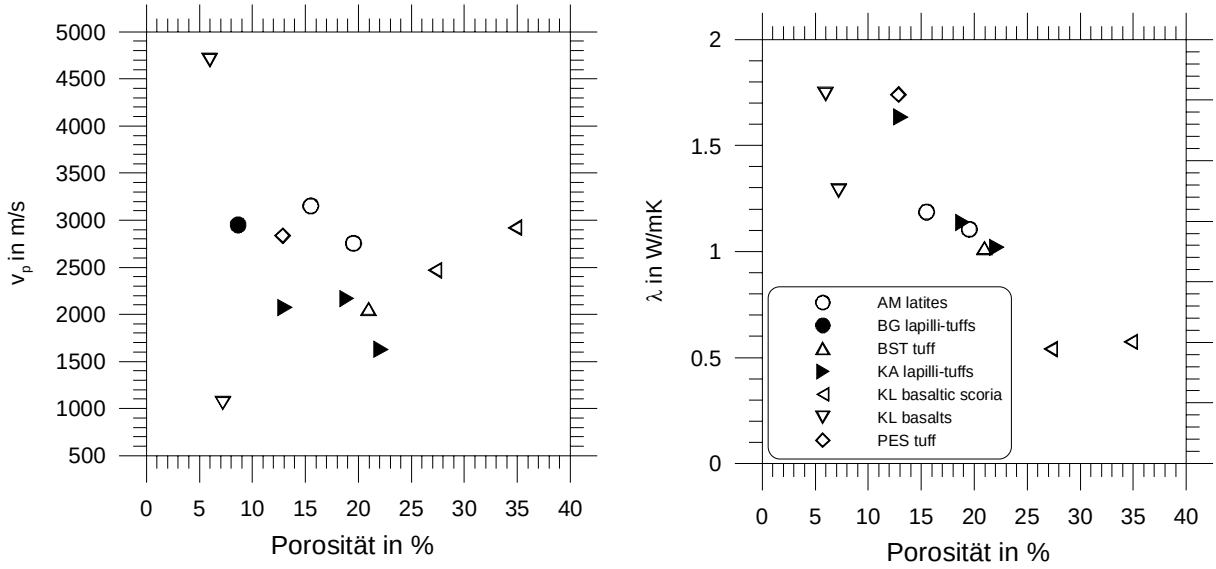

Figure 2: Correlation of the compressional wave velocity (left) and the thermal conductivity (right) of the investigated volcanic rocks of Styria with porosity.

The complex electrical resistivity, so-far not applied on volcanic rocks, is able to distinguish between tuffs with different grain size distributions. We therefore plan to extent our investigation on tuffs of further geological formations, e.g. Eifel. Future research should also prove that it is possible to transfer the laboratory results to field measurements.