Characterization of geological structures by using petrophysical parameters and the effect of anisotropy. Case study: Bad Gleichenberg shield volcano

Christina M. Schell & Norbert Schleifer

Chair of Geophysics, Department of Applied Geosciences and Geophysics, University of Leoben, Peter-Tunner-Strasse 25-27, 8700 Leoben, ch_schell@gmx.at, schleifer@unileoben.ac.at

Petrophysical parameters describe the physical properties of rocks, e.g. density, porosity, ultrasonic velocity and magnetization. These features analysed and considered in comparison to each other allow a distinction of various types of rocks occuring in the subsurface. Hence, these parameters are used to describe the internal structure of geological bodies. The survey at hand examines the internal structure of the shield volcano of Bad Gleichenberg, Styria, by using petrophysical parameters. A special issue of this study is the analysis of the petrophysical data in terms of anisotropy to observe if this specific parameter provides further information for the characterization.

The drilling site is located in the Gleichenberger Vulkanmassiv in the eastern part of the Styrian Basin on the only existing outcrop of the shield volcano, Gleichenberger Kogel. The shield volcano is part of the outbounding volcanic arc of the Innercarpatic Volcano Belt and was formed by the upcoming volcanic activity in the Karpatian Age (17,2–16,5 mya). An intense extension, strike – slip and subsidizing tectonic events caused the forming of this volcano.

The drilling core sited in the spa garden of Bad Gleichenberg was drilled in 1981 and reaches a depth of 900 m. The Forschungsgesellschaft Joanneum provides the drilling core for this investigation. In order to survey the shield volcano core samples were taken in intervals of about 50 m. Further on cylindrical shaped samples (plugs) with a diameter of 2.54 cm (= 1 inch) and a length of about 2 cm were drilled axial and radial out of these samples in order to consider variations of petrophysical parameters with spatial direction. Analyzing these anisotropy effects should yield additional information about the internal structure, e.g. texture of the rocks.

The petrophysical data was obtained by using different laboratory methods. First the samples were weighed in based on the Archimedes´ Principle to determine the porosity and density. These two parameters allow an insight in the mineralogy and the internal pore structure. Moreover the electrical resistivity is quantified. The resistivity is examined at brine saturated samples (0,058 % weight NaCl-solution) yielding further information on the connectivity of pores. Also the magnetic properties of the samples were examined. Anisotropy and average of the magnetic susceptibility were measured to determine mineralogy and alignment of the magnetic minerals.

Further information was obtained by quantifiying the natural remanent magnetization (NRM) and the anisotropy of isothermal remanent magnetization (IRM). The first parameter allows a determination of the predominant palaeomagnetic field while the cooling process took place and the second shows a dependence of anisotropy due to the arrangement of the magnetic particles. Finally the elastic properties of the samples were investigated measuring the ultrasonic transit–time. The obtained velocities are used to characterize the internal structure, porosity and grain-grain contacts. A high velocity represents a good grain contact. Low velocity values occure due to the influence of fractures, layering or high porosity.
In addition to the petrophysical parameters thin sections of each sample were prepared and analysed. The examination of the thin section provides further information on the mineralogical content and the internal structure. Therefore this investigation is used to prove and correlate the results of petrophysics.
The results of these laboratory measurements on the core samples allow a differentiation and characterization of various layers of the volcanic structure. Although not related the investigated petrophysical parameters show a good conformity in determining layer boundaries. Anisotropy of the single parameters is expected to deliver further information concerning hydrothermal activity, primary flow directions of lava sheets and tectonic overprints.