Magnetic properties and anisotropy of Permian salt deposits in the North German Basin

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Abstract: Salt deposits play an important role in deformation processes due to their special geomechanical properties, and they are of great economic importance. Therefore, the physical properties and deformation processes of salt rocks have been studied intensively. However, only very few investigations of the magnetic properties of salt rocks are reported. Here, we present the first results of magnetic susceptibility and anisotropy (AMS) measurements of different natural salt rocks originating from salt mines in Germany.

The salt deposits of the North German Basin have been formed mainly in the Permian. They reach thicknesses of several hundred meters and contain very pure rock salt and potash salts. We have collected numerous samples of rock salt, sylvinite and carnallitite from a weakly deformed salt deposit in Sondershausen (Thuringia) and an intensively deformed salt dome (Gorleben, Lower Saxony).

The three rock types show distinct ranges of mean magnetic susceptibility k_{mean}. For the rock salt samples, k_{mean} ranged between -13.9x10^{-6} SI and -6.1x10^{-6} SI; for carnallitite, k_{mean} was in the range of -10x10^{-6} SI to 100x10^{-6} SI and for sylvinite, values around 250x10^{-6} SI were measured. Since the major mineral constituents (halite, carnallite and sylvine) are diamagnetic and they usually do not contain a large amount of Fe ions in their crystal lattice, accessory minerals such as phyllosilicates and hematite are thought to cause an increase in susceptibility. This was confirmed by susceptibility measurements of the insoluble residue: Very high values up to 4800x10^{-6} SI indicate a ferromagnetic phase. Magnetization measurements showed that mainly ferromagnetic minerals with high coercivity such as hematite and goethite are present. In the literature, very fine-grained hematite is frequently described in carnallitite (*cf.* Urai and Boland, 1985). The alignment of the magnetically anisotropic mineral grains such as hematite or clay by deformation of salt rocks would lead to a magnetic anisotropy.

Low-field AMS measurements have been done using a kappabridge (AGICO) and increased accuracy was gained by measuring the samples 10 times at each position using the method of Biedermann *et al.* (2013). The measured anisotropies are close to the sensitivity limit, but in individual specimens of all three rock types, significant anisotropies with $\Delta k=k_{max}-k_{min}$ on the order of $1x10^{-6}$ SI are observed. Because of the very inhomogeneous, coarse-grained material, neighboring specimens can show strongly deviating susceptibilities. Measurement of a larger volume or several specimens is needed to gain a representative value.

The orientation of the AMS ellipsoid in undeformed rock salt samples showed an oblate shape with k_{min} perpendicular to bedding. A specimen with k_{mean}= $-7x10^{-6}$ SI had an anisotropy of $\Delta k=0.13x10^{-6}$ SI. This suggests the development of a weak anisotropy during sedimentation and diagenesis already. Specimens of carnallitite from the core of a tight fold showed also very weak anisotropies (Δk =$0.06x10^{-6}$ SI and $0.22x10^{-6}$ SI, respectively) in spite of their high susceptibility (k_{mean}=$30x10^{-6}$ SI), which indicates a significant ferro-/paramagnetic mineral content. In this case, the deformation mechanism was assumingly solution-precipitation, which does not cause preferred orientation of the accessory minerals. Hence, the development of an AMS in salt rocks seems to be strongly dependent on the deformation mechanism and the behavior of hematite during deformation. These interdependencies will be studied by further analysis of the microstructure, crystallographic preferred orientation and the magnetic mineralogy.

Keywords: salt rocks, magnetic anisotropy, deformation

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