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Correlation Between Macro- and Micro- Mechanical Behavior of Rock Salt under Uniaxial Compression

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Abstract

The mechanical properties of rock salt have been extensively studied in recent years due to the growing interest in underground energy storage within salt caverns. Rock salt is a polycrystalline aggregate that primarily consists of halite grains and some impurities. Thus, its deformation mechanism is governed by the mechanical properties of the grains and grain boundaries. The micromechanical behaviour and mechanisms acting at the grain scale play a crucial role in shaping the macro-mechanical behaviour of rock salt.

To investigate how deformations at the microscale affect the stress-strain behaviour and mechanical properties of rock salt, samples were tested under uniaxial compression using both standard test procedures and experimental micromechanical techniques. The experimental tests at the microscale employed a device that enables uniaxial compression tests to be performed with simultaneous microscopic observations. White and pink rock salt samples from the Góra salt dome (Zechstein salt formation, central Poland), which exhibit significant differences in petrological features and impurity content, were selected for mechanical tests at both the micro- and macro-scale.

A comparison of test results at the macro- and microscale revealed that uniaxial compressive strength at the microscale (mUCS) correlates with the values of uniaxial compressive strength (UCS) recorded in standard tests. Moreover, the macrodilatancy boundary is characteristic of each type of rock salt, and its value is consistent across both micro- and macro-scales. However, the mUCS values exhibit greater variability within each type of rock salt compared to UCS values. This variability arises because the UCS value reflects local strength variations related to the petrological features of the rock salt. Specifically, rock salt with weak strength properties may contain small fragments with higher strength that do not significantly influence the overall strength of the sample. However, the failure of the sample is determined by its weakest parts. Therefore, determining the mechanical parameters and deformation behaviour at the microscale is a critical aspect of the geotechnical assessment of salt caverns for energy storage, particularly for hydrogen storage.

Key words: rock salt, micromechanical strength, microfabrics, uniaxial compression, comparison micro- and macro scale