Solution Mining Research Institute Fall 2014 Technical Conference

Groningen, The Netherlands, 29 - 30 September 2014

Discontinuum-Mechanical Behavior of Salt Rocks and the Practical Relevance for the Integrity of Salt Barriers

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Abstract

Up to now salt rocks have been predominantly regarded as a continuum and the mechanical effect of the present discontinuities have been neglected to a great extent. However, for a complete understanding of geomechanical phenomena this approach proves to be insufficient. Discontinuum-mechanical aspects are of importance for the integrity of saliniferous barriers, not only in the macro-, but also in the micro-scale. In the grain scale, polycrystalline salt represents a discontinuum constituted of intergrown crystal grains. Grain boundaries are micro-mechanical weakness planes that preferably fail under loading. For the mechanical description an elasto-visco-plastic model for the salt crystals is applied as well as an adhesive frictional model for the grain boundaries. The discontinuum-mechanical approach has been deduced from experimental investigations in the laboratory and in situ. Based on this discontinuum-mechanical approach, hydro-mechanical coupling like the pressure-driven percolation of fluids, intergranular microcracking and hydraulic fracturing can be analyzed.

The results demonstrate how the integrity of salt barriers depends on hydro-mechanical processes on the grain-scale. The discontinuum-mechanical approach for the micro-structure of salt rocks characterizes essential properties and is one key to the physical understanding of pressure-driven percolation of fluids. This process can understood as the creation of connectivity within the salt rocks as soon as the fluid pressure overcomes the normal stress on the grain boundaries. Laboratory tests and in situ observations on rock salt have been made showing the fluid-pressure driven grain boundary percolation and the fluid breakthrough in the case of over-pressurization. Those and other phenomena are well explained by using the discontinuum-mechanical approach.

Furthermore, practical examples will be presented describing the investigation of the integrity of the saliniferous barrier during high-frequency cavern storage and the process of brine squeeze out from a sealed cavern.

Key words: Geomechanical modeling, Cavern Storage, Cavern Abandonment, Hydro-mechanics