Geophysical Research Abstracts
Vol. 20, EGU2018-2684, 2018
EGU General Assembly 2018

Geomechanical aspects of SSIC container for nuclear waste disposal

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To meet long-term safety requirements for underground storage of high-level nuclear waste engineered barriers have to be considered in interaction with the host rock. The new TRIPLE C waste package concept - a multi-barrier design – includes as main retention barrier a cylindrical canister made of pressureless sintered silicon carbide (SSiC). This material is characterized by high corrosion resistance, gas-tightness, extreme long-term stability and high temperature resistance. A potential drawback of ceramics in general is their brittleness. Therefore, the behavior of SSiC material under static and dynamic loading has to be investigated. Depending on the waste form (dimensions of spent fuel elements) the SSiC canisters have a length of 0.5 to 5 m, an outer radius from 10 to 70 cm and a wall thickness between 1.5 and 5 cm, approximately.

This paper presents first investigations in respect to the mechanical properties of SSiC. The interaction of a simplified SSiC model canister (height 0.5 m, inner and outer radius are 0.10 and 0.12 m, respectively) with the rock mass is considered by assumption of different extreme loading conditions. Both, analytical solutions and numerical simulations are used to characterize the mechanical response due to mechanical impacts.

First results indicate, that static loading will not create any relevant damage, even if stresses are extremely high and highly anisotropic. Only extreme dynamic impacts or point loading can lead to potential fracturing. First dynamic simulations indicate that, under very unfavorable circumstances, the model canister falling down from a height of 2 meters can experience tensile stresses bigger than its tensile strength. Also, a 7.5 kg falling rock block can induce critical tensile stresses up to about 112 MPa. Analytical solutions for line load acting on the model canister showed that increasing outer radius and radius ratio while reducing length can enhance resistance. Also, point loading may cause damage to the canister under special conditions.

Based on the performed calculations the SSiC canister design can be improved, so that damage even of the unprotected main retention barrier under extreme conditions of static and dynamic nature can be excluded.