DISLOCATION-DENSITY-BASED CRYSTAL PLASTICITY MODELING OF HALITE AT DIFFERENT TEMPERATURES AND ORIENTATIONS

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Rock salt is a sedimentary rock found in nature as bedded or domal deposits which hosts caverns within the underground deposits that can potentially serve as a long-term and safe repository for carbon dioxide, radio-active nuclear waste, and the waste of oil drilling operations. The accuracy of simulating the constitutive response of rock salt hinges upon the fidelity of both the engineering model and the geometrical representation of the cracked material. The main constituent of rock salt is halite mineral, which has a building block of sodium chloride (NaCl) forming a cubic crystal system with a constitutive response that is dependent on strain rate and deforming temperature. The constitutive behaviour of rock salt has so far been simulated using phenomenological creep models that lack the representation of its microscale crystal structure. Accordingly, this work presents a 3D dislocation density-based-crystal plasticity model that can enhance the current numerical representation of crack mechanisms and growth in rock salt [1]. The model was introduced then validated using literature experiments on single-crystal specimens of artificial rock salt tested in triaxial extension against different crystal orientations, a wide range of strain rates, and various temperatures [2]. When implementing the model to predict the response of natural single-crystal rock salt specimens tested in unconfined 1D compression, the model parameters were recalibrated via a genetic optimization procedure due to the existence of cleavage planes in the natural rock salt material [3]. The viscoplastic nature of the calibrated model also accurately replicated the ratcheting plastic deformations in natural rock salt specimens when tested in cyclic unconfined 1D compression. Overall, the proposed dislocation density-based crystal plasticity model form is able to simulate both the monotonic and cyclic response of high-purity artificial and natural single-crystal rock salt.

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