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Influence of Pore Pressure on the Reconsolidation of Crushed Salt Under Hydrostatic Creep Conditions

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Objective

Characterize the creep deformation of crushed salt to aid in the development of a thermo-poro-mechanical constitutive model.

Introduction

Intact salt has very little porosity and under creep conditions its inelastic deformation is generally characterized as ductile, isochoric and dependent on the magnitude of shear stress (J_2) (Senseny et al., 1992). Similarly, crushed salt readily deforms in a ductile manner under creep conditions, as shown in Figure 1. However, unlike intact salt, crushed salt typically has a substantial porosity and under creep conditions exhibits large inelastic volumetric strains.

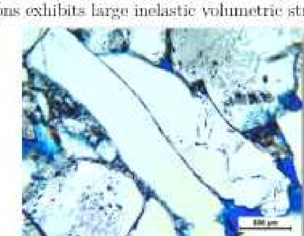

Figure 1: Photomicrograph of deformed crushed-salt grains.

Recognizing the basic differences between the inelastic creep deformation of intact and crushed salt, an experimental program was developed to understand why these differences exist.

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Materials and Methods

Sample Description

- Crushed and dried WIPP salt
- Maximum particle diameter: 9.5 mm
- Samples were preconditioned (Figure 2)
- Samples had similar porosity following preconditioning (ϕ_{pc}), given in Table 1

Figure 2: Sample evolution during testing.

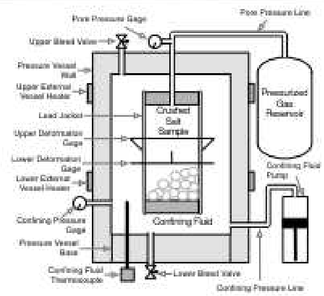

Figure 3: Testing apparatus.

Table 1: Summary of creep test conditions.

Test/Sample Label	P_c MPa	P_p MPa	P_d MPa	ϕ_{pc} %	ϕ^f_{crp} %
A	30	0	30	21.8	10.9
B	30	10	20	21.3	11.8
C	30	20	10	21.0	17.8

Test Description

- Three creep tests were performed
- Both P_c and P_p were prescribed (Figure 3)
- Tests had similar P_c while P_p varied (Table 1)
- All tests were performed at 170 °C

Results

- Volumetric strain rate decreased with decreasing porosity for all tests (Figure 4)
- Increasing P_p reduced volumetric strain rate when samples had a similar P_c and porosity (Figure 5)

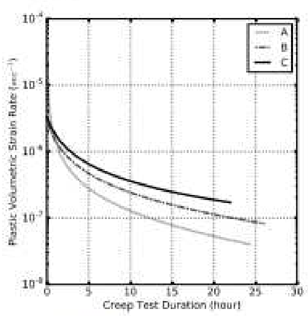

Figure 4: Creep Test Results

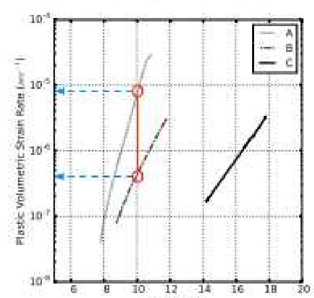

Figure 5: Volumetric strain rates over a range of porosities

Discussion

In a porous material, if $P_p \neq P_c$, then local shear stresses exist; as depicted in Figure 6. The J_2 is a function of the difference between the pressures ($P_d = P_c - P_p$); however, existing constitutive models for crushed salt do not explicitly recognize this.

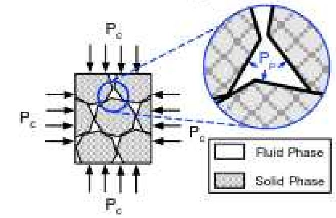

Figure 6: Representative elemental volume of a porous material.

Conclusion

To accurately model the deformation of crushed salt, the constitutive model should account for the influence of P_p on shear within the material. Although these tests were performed with a macroscopically hydrostatic state of stress, a nonuniform state of stress existed within the sample; where, the magnitude of shear was proportional to P_d.

References

P.E. Senseny, F.D Hansen, J.E. Russell, N.L. Carter, and J.W. Handin. Mechanical behaviour of rock salt: phenomenology and micromechanisms. *International Journal of Rock Mechanics and Mining Sciences and Geomechanics Abstracts*, 29(4):363–378, 1992.

Acknowledgements

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