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Evidence of sealing and brine distribution at grain boundaries in natural fine-grained Halite (Qum Kuh salt fountain, Central Iran): implications for rheology of salt extrusions

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When grain boundary movement is stopped, surface energy related forces reassert themselves driving the system to its equilibrium conditions ([2], [6], [7], [8]). This could result in growth of islands and shrinking of channels and hence in healing the boundary by internal redistribution of fluid and solid in the contact region. Such islands are proposed to grow preferentially close to the contact rim and promote the healing of the grain-grain contact, which in turn prevents transport in or out the boundary region and thus traps the fluids in isolated inclusions.

This contribution is focused on observation of grain boundary microstructures in natural mylonitic rocksalt collected from the distal part of Kum-Quh salt fountain (central Iran) in order to give unprecedented insight of grain boundary microstructures using argon-beam cross-sectioning to prepare high quality polished surfaces suitable for high-resolution SEM imaging. The possibility to use our SEM under cryogenic conditions allows also imaging the in-situ distribution of fluids.

Results show that brine at grain boundaries occurs as thick layers (> μm in scale) corresponding to cross-sectioned wetted triple junction tubes, as filling at triple junction and as array of isolated fluids inclusions at grain-grain contacts. Close observations at islands contacts suggest the presence of a very thin fluid film (<100 nm). The most remarkable is evidence for sealing of pore space appearing as subhedral crystals filling the void space and decoupled from surrounding crystals by a thin brine layer.

In parallel to this microstructural study, we deformed the same samples in order to simulate the simple shear flow at very low mean stress as in the salt fountain. First results suggest a complicated rheology. Samples loaded at < 0.7 MPa show no measurable deformation in a month, indicating strain rates less than 10-12 s-1 though, in fully activated pressure-solution (PS) creep, strain rates of several orders of magnitude are expected for similar grain size ([5]). Other samples, which were loaded to 1 MPa before reducing the stress to 0.5 MPa deformed at much higher but variable rates, up to 10-8 s-1, in good agreement with activated PS creep.

If, at first look, our pilot deformation experiments seem to reflect a kind of "yield stress" for activation PS creep ([7]); the experimental stress does not reach the theoritical condition to enable activation of PS. Thus, we interpret that the apparent "yielding stress" may not reflect strictu senso the "yielding stress" as described in [7] but rather to a "yielding stress" corresponding to the elastic reassessment of the grain system before the initiation of PS at privileged seal-brine-grain contacts.

In salt fountain conditions, mylonitic samples are expected to be in the healing domain, but „jumps" in active stress required to activate PS creep is hardly probable. Thus, we suggest that rainwater influx plays a fundamental role in activation of PS. Rainwater should enable the marginal dissolution of healed contacts and then decreases in the area fraction of grain boundary occupied by solid island contact causing an increase in island stress. Therefore, this points to cyclic deformation of salt fountain: (1) during rainy periods the fountain will deformed at relative high strain rate by dominant PS; while (2) during dry seasons, it will not significantly flow because the grain boundary healing will prevent PS and lead to dominant dislocation creep. This interpretation is in good agreement with recent structural studies ([1], [4]), which gives evidence for both dynamic dislocation and pressure-solution creeps, and measurement of rapid flow after rainy periods with flow rates compatible with fully activated PS ([3]).

[1] Desbois G., Zavada P., Schleder Z. and Urai J.L. (In review). Deformation and recrystallization mechanisms in naturally deformed salt fountain: microstructural evidence for a switch in deformation mechanisms with increased availability of meteoric water and decreased grain size (Qum Kuh, central Iran). Submitted to Journal of Structural Geology.

[2] Ghoussoub J., and Leroy Y.M. (2001), Solid-fluid phase transformation within grain boundaries during compaction by pressure solution, J. Mech. Phys. Solids, 49, 737 2385-2430. 738

[3] Jackson, M.P.A., (1985). Natural strain in diapiric and glacial rock salt, with emphasis on Oakwood dome, East Texas, Bureau of Economic Geology, The University of Texas at Austin, Texas.

[4] Schléder Z. and Urai J.L. (2007). Deformation and recrystallization mechanisms in mylonitic shear zones in naturally deformed extrusive Eocene-Oligocene rock salt from Eyvanekey plateau and Garmsar hills (central Iran). Journal of structural geology, 29, 241-255.

[5] Spiers C.J. and Carter N.L. (1988). Microphysics of rock salt flow in nature. In: M. Aubertin and H.R. Hardy, Editors, The Mechanical Behaviour of Salt: Proceedings of the Fourth Conference Series on Rock and Soil Mechanics, TTP Trans Tech Publications, Clausthal-Zellerfeld, 22: 115–128.

[6] Urai J. L. (1983). Water assisted dynamic recrystallization and weakening in polycrystalline bischofite. Tectonophysics 96 (1-2): 125-157.

[7] Van Noort R., Visser H.J.M., Spiers C.J. (2008) Influence of grain boundary structure on dissolution controlled pressure solution and retarding effects of grain boundary healing. Journal of Geophysical Research, 113, B03201.

[8] Visser, H. J. M. (1999). Mass transfer processes in crystalline aggregates containing a fluid phase, Ph. D. thesis, Utrecht University, Utrecht.