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The effect of hydrocarbons on the microstructural evolution in rock salt: a case study on hydrocarbon bearing Ara salt from the South Oman Salt Basin

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It has been shown that dilatant deformation promotes the incorporation of hydrocarbons into typically low permeable rock salt (Schoenherr et al., 2007). However, there is not much knowledge on subsequent mechanisms related to recrystallization processes, which cause morphological and chemical changes of the carbonic inclusions. This work aims to contribute to an increased understanding of fluid inclusion dynamics related to grain boundary migration recrystallization and hence to facilitate the interpretation of complex microstructures in recrystallized, multiphase salt rocks.
In this case study we investigate hydrocarbon-impregnated salt from the Cambrian Ara Group in the South Oman Salt Basin. The samples were cored from cm-m thick anhydrite-salt sequences overlying hydrocarbon bearing carbonate stringers in 3300 m depth.
The anhydrite layers consist mainly of fine-grained anhydrite, which contains calcite, dolomite, and olivine inclusions. Solid bitumen and lighter hydrocarbon phases are observed in between the anhydrite grains and along cracks. Anhydrite layers host salt veins, which contain fragments of anhydrite. These fragments do not differ in composition or structure from the host material and the related vein microstructures indicate crack-seal mechanisms.
Halite in the salt layers is almost entirely recrystallized with solid inclusions consisting of anhydrite, calcite, dolomite and olivine with hydrocarbon-coatings present inside grains and along grain boundaries. Solid inclusions cause pinning indicated by a decreased recrystallized grain size and by the presence of grains with preserved substructures representing earlier deformation phases.
We observe two types of carbonic inclusions: I) solid bitumen coatings along grain boundaries and microcracks, interpreted to be incorporated into the salt in an overpressure state that allowed dilatancy of the salt, and II) less degraded, liquid hydrocarbons along grain boundaries in the vicinity of the anhydrite, interpreted to be incorporated into the salt in a subsequent deformation phase. Type II inclusions usually form arrays of isolated inclusions (liquid hydrocarbons, vapor, and aqueous phases in minor proportions) along grain boundaries of the recrystallized grains, presumably formed in a surface-energy controlled shrinking process from thin fluid films. Here, the contact with mobile grain boundaries promoted necking down and decomposition of multiphase inclusions. We present a model, which describes the dynamic behavior of liquid hydrocarbons in mobile grain boundaries after their enclosure into the salt layers. The model is based on numerous microanalytical methods, such as optical microscopy, fluorescence microscopy, cryo-SEM, and EDX.

Schoenherr, J., et al. (2007), Limits to the sealing capacity of rock salt: A case study of the infra-Cambrian Ara Salt from the South Oman salt basin, AAPG Bulletin, 91(11), 1541-1557