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Different types of solid inclusions as indicators for the formation of laminated halite beds of Late Permian rock salt sequences

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Laminated halite beds and their relics (Kristallbrocken) are a characteristic and potentially unique type of halite in Late Permian rock salt sequences of the Zechstein basin. Surprisingly, these beds do not show any grain boundaries macroscopically, raising the question if this halite type might be monocrystalline, as well as how it formed. Based on samples from various locations of the Zechstein Basin, the laminated halite was subjected to a detailed compositional and microstructural investigation by means of scanning electron microscopy (SEM) and electron microprobe. The analyses show that the internal lamination of this halite type can contain three types of solid inclusions: (1) anhydrite aggregates enclosed in cavities, (2) anhydrite crystals or aggregates directly included in the halite crystal, and (3) polyhalite crystals enclosed in cavities. Strontium analyses of anhydrite indicate that anhydrite formed by a conversion from primary gypsum. The presence of a cavity around some of the anhydrite aggregates suggests that they were most likely originally incorporated as gypsum aggregates during the formation of the halite bed. Subsequently, these gypsum crystals converted into anhydrite and water with the latter being undersaturated with respect to sodium chloride. The cavity around the anhydrite crystals therefore primarily results from the solid volume reduction in consequence of a complete gypsum-anhydrite conversion and secondarily from the partial dissolution of halite through the released undersaturated water. Accordingly, the absence of cavities around the anhydrite crystals that are directly included in halite indicates that these anhydrites converted from gypsum before they could be overgrown by halite and thus before the formation of the halite beds. In addition, calculations have shown that the amount of potassium within the

brine inside an inclusion would have been insufficient to explain the large amount of polyhalite observed in the cavities. This implies that the conversion of anhydrite into polyhalite must likewise have taken place before the formation of the halite beds. The occurrence of anhydrite crystals directly included in halite as well as polyhalite crystals that cannot have originated from anhydrite within the inclusion indicates that the laminated halite beds did not form by primary growth, but are more likely a result of diagenesis.