

## Geochemical composition and genesis of brines from two Upper Permian salt deposits, Germany

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Brines were detected in Upper Permian (Zechstein) salt structures, 666 m<sup>3</sup> (1979-2012) in Gorleben and 3312 m<sup>3</sup> (1907-2017) in Morsleben, mainly linked to anhydrite bearing salt rock formations and to lithological boundaries.

In the Gorleben site, all investigated solutions are at least halite and anhydrite saturated. The majority of the brines (ca. 297 m<sup>3</sup>) originate from the z3OSM. In the Jänecke diagrams (at 25°C, 35°C), they plot in the carnallite stability field or at the edge to the kieserite field. Further, they are characterized by max. 214 µg/g Li (401 µg/g in fissure fillings [1]) and max. 6778 µg/g Br. The z3HA brines (ca. 250 m<sup>3</sup>) plot in the carnallite field or at the edges to the kieserite, bischofite or sylvite stability field; ≤ 9.40 wt. % Mg and 1721–3680 µg/g Br are typical values. At the lithological change from z2 to z3, ca. 40 m<sup>3</sup> brine were observed. These brines can be attributed to the kieserite, bischofite or the boundary to the carnallite and kieserite stability field. CaCl<sub>2</sub> (fictive) and a low K/Mg ratio of 0.005 is typical. The z3AM brines plot in the stability field of kieserite and the z3BK/BD brines in the field of carnallite. With exception of technical solutions, all captured Gorleben brines are of salt dome internal origin, developed during diagenesis and in parts by subsequent rock–fluid interaction. Frequently high Li concentrations in the brines indicate probably interaction with phyllosilicate bearing strata.

Most of the Morsleben brines (3082 m<sup>3</sup>), detected in the metamorphic overprinted potash seam z2SF, are halite, anhydrite, gypsum, sylvite and kainite saturated. The Rb/Br [2] and Li/Mg ratios indicate groundwater dilution in relation to evaporated seawater (≤ 3 µg/g Li) [1]. These brines show mainly groundwater and minor signatures of dissolved salt rocks. The brines from the z3HA (230 m<sup>3</sup>) are halite, anhydrite, carnallite and sylvite saturated. These brines show Rb/Br ratios of typical marine origin, 2259-3429 µg/g Br and Li/Mg ratios partial slightly enriched in Li (≤ 24 µg/g), which are comparable to high-evaporated relictic seawater, or metamorphic brines of salt structure internal origin [1].

[1] Mertineit & Schramm (2019) *Minerals* 9, 766; doi:10.3390/min9120766.

[2] Mattenklott (1995) *Kali und Steinsalz*, 11, 341–344.