



Stable isotope composition of fluid inclusions preserved in halite derived from Wieliczka and Bochnia Salt Beds (Southern Poland)

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Halite deposits located in the southern Poland, near Krakow, are famous mostly due to the medieval salt mine located in Wieliczka. Contrary to most salt deposits in Europe forming large domes, the halite deposits near Krakow form distinct beds, extending from west to east on the area of ca. 10 km², with several types of salt identified. The deposits were formed in shallow environment, ca. 15 mln years ago and represent initial stages of Miocene sea water evaporation.

Stable isotope composition of fluid inclusions trapped in the halite crystals originating from Wieliczka and Bochnia salt mines was investigated. Three distinct groups of samples were analysed: (i) samples derived from so-called "green salt" beds forming extensive horizontal structures, (ii) samples derived from so-called zuber-type salt, and (iii) large monocrystals of halite collected in two crystal caves existing in the mine. The samples belonging to the first and second group were heated under vacuum to extract the fluid inclusions, according to the procedure used previously to extract inclusions from speleothem samples. The macro-inclusions present in some monocrystals of halite collected in crystal caves were removed for analysis without any thermal treatment. The concentration of bivalent cations (Ca²⁺, Mg²⁺) was measured in the bulk material (green salt). K⁺, Mg²⁺ and SO₄⁻² content was measured in the fluid inclusions derived from macro-crystals.

The stable isotope data points form two clusters in the δ²H-δ¹⁸O space, representing crystal caves and green- and zuber-type salts, respectively. The cluster representing green- and zuber-type salt deposit is shifted to the right-hand side of the Local Meteoric Water Line (LMWL), towards more positive δ²H and δ¹⁸O values, pointing to evaporative conditions during formation of these deposits. Although the evaporation trajectories for the sea water in the δ²H - δ¹⁸O space suggest that fluid inclusions might represent remnants of the original solution, this notion has to be excluded due to the fact that only halite is present in the deposits. Other salts are present locally only in trace amounts. The isotopic composition of fluid inclusions formed during precipitation of halite phase from pure sea water would be characterised by positive δ²H and δ¹⁸O values. The results of isotope analyses suggest that the green- and zuber-type salt deposits might have been formed in a lagoon-type environment, from mixture of sea water and water of continental origin.

The data points representing monocrystals of halite collected in the crystal caves lie close to the LMWL and cover the range of δ²H and δ¹⁸O values typical for glacial/interglacial infiltration waters. This provide the proof that large monocrystals of halite in the crystal caves are of secondary origin and were formed with participation of infiltration water, most probably during the Quaternary.