

Growth dynamics of geothermal carbonate scalings: Petrographic, trace element & stable/clumped isotopic studies

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Thermal waters tend to precipitate various chemical sediments (scaling) due to high dissolved solid and gas contents at elevated temperature and pressure conditions. Mineral precipitates in wells, pumps, pipes and heat exchangers cause major problems in geothermal heat- and electric power production, i.e. clogging or reduction of inner diameters. Natural (hydrochemistry, aquifer) and man-made (production-specific) environmental conditions determine the variable scaling progress and scaling compositions constitute an environmental archive of solid-fluid interaction over time. Using high-resolution analytical techniques we study the nucleation and variable growth of geothermal scalings focusing on forensic tasks and retarding measures. Samples up to 10 cm thick representing mineral precipitation from weeks to 45 years were collected from selected geothermal wells of different aquifer and depth conditions, i.e. fluid-temperature, discharge, operating pressure and hydrochemistry. The carbonates of diverse macro- and microscopic appearance (porosity, lamination, coloring) are studied by optical/electron microscopy and LA-ICP-MS targeting different nucleation and growth mechanisms (e.g. wall- vs. suspended particulate) and precipitation rates (e.g. Sr, Ba conc.). Highly-resolved (micromilled) stable C and O isotope variations are sensitive to changes in temperature and CO₂ degassing and are combined with installation-specific data and hydrochemical modelling. Geothermal carbonate scalings of well characterized but different (T, pH, ionic strength) growth settings are further used in the ongoing evaluation and calibration of established (e.g. oxygen) and novel (multiply-substituted) isotope geothermometers.