Scale-fragment accumulations blocking geothermal energy extraction – Interacting steel sulfide corrosion and calcite crystallization

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Various minerals precipitating from deep saline thermal water (scaling) often constitute a major obstacle during geothermal energy production. The formation of scale-fragments in pipes, which accumulate and block pumps, filters and heat exchangers, is of particular concern in power plants hindering an efficient energy extraction. Carbonate scale-fragments from different sections of two geothermal facilities in S-Germany were studied in a high-resolution scaling forensic approach including microstructural characterization, elemental mapping and stable isotope profiles. The obtained (isotope)geochemical data were evaluated in the context of favorable vs. unfavorable natural environmental and operational (man-made) production conditions. Our results support a close relationship of metal sulfide mineral layers forming from H_2S corrosion of the steel pipes and $CaCO_3$ nucleation and rapid crystal growth. A conceptual model of scale-fragment evolution is developed considering two key interfaces: i) the corrosion layer between steel and calcite scale; ii) the scale surface vs. thermal fluid flow. The corrosion products with brittle and mechanically weak consistency constitute an attractive substrate for carbonate crystallization. The rough carbonate scale surface promotes the occurrence of (micro)turbulences and higher flow resistance (frictional forces). These effects can lead to partial exfoliation, fragment mobilization, accumulation and severe blocking.