Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.12308

Investigation on the early-stage formation mechanism of silica scale under acidic pH

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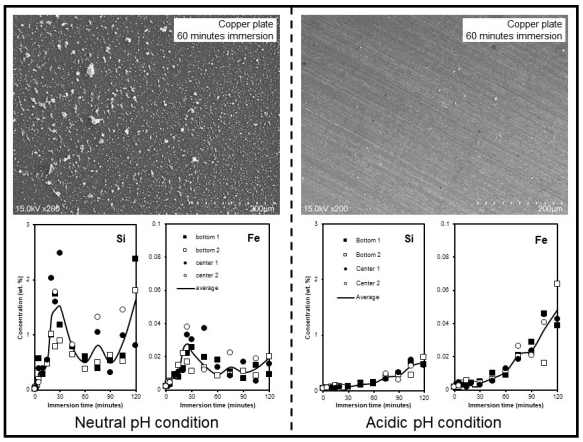

Silica scaling and the polymerization of silicic acid in geothermal water have been studied for the past decades. The study of silica scale formation mechanism can be divided into two areas: observation of aqueous phenomenon (i.e., polymerization of silicic acid) and aqueous-solid interaction (i.e., adsorption of silicic acid on solid surface). This study aims to investigate the formation of silica scale at early stage at acidic pH from the perspective of aqueous processes and the aqueous-solid interaction through simple on-site experiments of polymerization of silicic acid and its adsorption on silica gel and metal plates immersed in geothermal water.

Three different experiments were conducted using geothermal water of pH 7 and 5. For polymerization and adsorption experiment on silica gel, aliquots of geothermal water in reaction vessels were collected and the change in monosilicic acid, total silicic acid, mononuclear Fe, and Al, total Fe and Al concentrations with time were examined. Monosilicic acid, mononuclear Al and Fe concentrations were analyzed spectrophotometrically on-site, while their total concentrations were analyzed using ICP-AES. For immersion experiments of copper and titanium plates, several plates were immersed in a flowing hot geothermal water and was recovered at each designated time for a total duration of 2 hours. The collected plate samples were then observed using SEM-EDS for bulk semi-qualitative analysis, and LA-ICP-MS analysis for quantitative chemical analysis.

Polymerization and adsorption rapidly occurred under pH 7 and gradually under pH 5. Clear correlation was recognized between monosilicic acid and mononuclear Fe concentrations, and between total silicic acid and total Fe concentrations, both under pH 7 and 5. SEM images revealed the globular shape (5-20 μm) of silica precipitates on both metal plates under pH 7, but fewer under pH 5. However, EDS and LA-ICP-MS analyses revealed that silica and iron concentrations on metal plates increased under both pH. However, the increasing rate of silica and iron concentrations under pH 7 was faster than pH 5. We conclude that iron participates in the polymerization process of silicic acid and coprecipitated with silicic acid during the early formation of silica scale, even after acidification of the geothermal water.