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High-resolution experimental measurements of quartz solubility under supercritical geothermal conditions

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Recently, there is increasing interest in developing the supercritical geothermal resources due to their very high enthalpy fluids relative to conventional geothermal resources. The solubility of quartz (SiO_2) in aqueous fluids is a fundamental for understanding geochemical processes in supercritical geothermal systems, as well as other natural hydrothermal processes. In this work, a novel experimental system has been constructed to allow the water-rock (or mineral substrates) reaction at supercritical conditions up to 550 ℃ and 60 MPa. In-situ fluid sampling is designed to guarantee the high-resolution experimental measurements of quartz solubility. In addition, the real-time resistance monitoring is employed to assist in determining whether the mineral dissolution is in equilibrium. Based on the developed experimental system, a series of high-resolution experimental measurements of quartz solubility are conducted covering the temperature and pressure range of 300-500 ℃ and 25-50 MPa. The experimental results indicate that a more accurate and reliable measurements of quartz solubility can be obtained using the in-situ sampling method and resistance record, especially near the supercritical point and in the low-density region (e.g., under the high temperature and low pressure). The quartz solubility in water is significantly affected by temperature and pressure at subcritical and supercritical conditions, showing a positive correlation with pressure at isothermal and a retrograde behavior near the supercritical point. These phenomena are well interpreted by the thermodynamic theory, quartz hydrolysis process, and empirical prediction model. Based on these measured data and combining with previous high-quality results, a five-parameter density model is provided for the quantitative calculation of silica concentrations in aqueous fluids under supercritical geothermal conditions. The findings of this study can help for a better understanding of geochemical processes in supercritical geothermal systems, as well as ore deposits and vent structures.