Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.35971

U-tube Reactor for Measuring Mineral Solubility in Supercritical Water up to 800 °C and 400 bar

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Hydrothermal fluids and their interactions with solid phases govern the chemical evolution of the Earth's crust, controlling processes such as metal transport, ore deposition, and the development of geothermal systems. Because these crustal processes ultimately depend on the solubility and mobility of minerals and elements at high temperature and pressure, quantifying element–fluid interactions require reliable solubility data under extreme conditions. However, experimental measurements in supercritical fluids, particularly near magmatic temperatures, remain scarce due to substantial technical challenges.

To address this gap, we present the design, operation, and performance of the novel U-tube flow-through reactor developed at the University of Iceland for measuring mineral solubility in water vapor at temperatures of 350-800 °C and pressures of 10-400 bar. The system integrates an HPLC pump, in-line vacuum degasser, high-temperature preheater, U- and W-shaped single pass tubular reactor, cold-seal connections, cooling jacket, and back-pressure regulator, enabling precisely controlled supercritical flow and continuous sampling.

Experiments of halite and quartz demonstrate fast and reproducible results, with measured solubilities agreeing with published data where overlap exists and extending into previously unexplored temperature–pressure regimes. Beyond these benchmark systems, we present examples of various metal chlorides, hydroxides, sulfates, and oxides, illustrating the versatility of the reactor for investigating a wide range of mineral classes relevant to crustal processes.

Overall, the U-tube reactor represents a robust and versatile platform for advancing quantitative understanding of solid–fluid interactions under extreme conditions, with applications spanning magmatic–hydrothermal environments, and high-temperature industrial processes.