EGU24-2815, updated on 24 Mar 2025
https://doi.org/10.5194/egusphere-egu24-2815
EGU General Assembly 2024

Degradation pathways and mechanisms of oilwell cement exposed to H_2S under high temperatures

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The extraction of geothermal energy faces the hazard of H_2S, a highly toxic and strongly corrosive gas. H_2S exposure can lead to the failure of oilwell cement, decreased extraction efficiency, and even pose serious risks to operational personnels near the wellsite. High temperature is a prominent environmental feature in geothermal resource extraction. However, current research works primarily focus on the corrosion effects of H_2S on cement at moderate to low temperatures. This study utilizes Class G oilwell cement to conduct corrosion experiments of cement by H_2S under high temperature in a H_2S-rich reaction vessel. The impact of H_2S on the structure, chemical composition, and mechanical strength of oilwell cement is analyzed via SEM-EDS, XRD, nanoindentation tests, and unconfined compressive strength tests. The results indicate a reduction in compressive strength for cement samples corroded by H_2S. The surface nano-hardness and elastic modulus of cement samples decrease while the internal values of nano-hardness and elastic modulus significantly increase. Under the corrosion of H_2S, the structure of cement is characterized by a yellow and black surface layer and stratified cracks. The external surface of the cement exhibits a yellow color due to the formation of pyrite (FeS_2), while internally, pyrrhotite (FeS) and gypsum ($CaSO_4{\cdot}2H_2O$) are generated.