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オマーンに産する超塩基性岩－水相互作用における水素生成
Hydrogen generation by interaction between ultramafic rocks and water

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Hydrogen is generated by the interaction between ultramafic rocks and ground water in the Oman Ophiolite and Lost City in the Atlantic Ocean. Previous studies have shown that hydrogen is generated via low temperature serpentinization. However, this process has not been verified experimentally. Previous experimental studies have succeeded in generating hydrogen only at high temperatures (>200 degree C). Therefore, the objective of this study is to clarify the mechanism of hydrogen generation by low temperature serpentinization.

In order to clarify the process of hydrogen generation by low temperature serpentinization, batch experiments were conducted at 90 degree C and 180 degree C using three different ultramafic rocks, (dunite, harzburgite and wehrlite) from the Oman ophiolite reacted with deionized water. Samples were taken at various reaction times. Liquid samples were analyzed by ICP-AES, ion chromatography, UV-Vis, and pH and ORP meters. Mineral phase changes in the solid samples were characterized by SEM-EDX and XRD. The concentration of dissolved hydrogen was determined by GC-TCD. A geochemical reaction model of the hydrogen generation process was then constructed.

Hydrogen generation was observed only at 90 degree C because the experiment utilized a system designed to minimize hydrogen loss. In the experiment at 180 degree C, the generated hydrogen would be loss during experimental procedure. The solutions after the interaction with dunite and harzburgite at 90 degree C showed higher concentrations of dissolved hydrogen than that of wehrlite. Eh and pH of all the solutions decreased and increased, respectively, indicating the occurrence of serpentinization. However, the changes in Eh and pH are inconsistent with the observations in Oman. XRD analysis of the solids did not show significant changes in the amounts of olivine, magnetite and serpentine. Geochemical modeling of the reaction showed that hydrogen generation was accomplished by the dissolution of olivine, which is the dominant mineral in the ultramafic rocks.

However, the amount of hydrogen produced calculated by the geochemical model is lower than the amount observed in this experiments. This discrepancy would be attributed to the catalytic effect of the other components such as Fe-Ni alloy mineral in the samples. This also explains the higher hydrogen amounts generated by dunite and harzburgite, both of which contain the higher amounts of Ni.

In this study, the hydrogen generation has been confirmed at a temperature of less than 100 degree C using experimental techniques. The hydrogen generation process catalyzed by the Fe-Ni alloy mineral would be checked by the experiments using materials composed by mono-mineral such as olivine, pyroxyne and Fe-Ni alloy mineral.

Keywords: hydrogen, ultramafic rocks, Oman ophiolite, serpentinization, Fe-Ni alloys