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The soil formation experiment by hydrothermal alteration on the Martian surface

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Soil formation processes on terrestrial planets have an important role on evolution of environments of the planets. On the Martian surface, high energy processes including impacts and hydrothermal alterations may be more important than those processes on the Earth.

In this study, we carried out hydrothermal alteration experiments to elucidate the soil formation processes on the Martian surface. Major rock of the Martian crust is iron-rich basaltic rock, and subject to sulfuric acid-bearing hydrothermal alteration (Papike et al., 2006).

The experiments are carried out on the starting material of the simulated Martian basalt with H_2SO_4 solution in hydrothermal conditions. Experimental temperatures and pressures are 100˜300C, water vapor pressure, and 400 ˜500C, 100 MPa. Acidity of the solution and fluid-rock ratio are pH1.5 or 3.0, and 50:1 or 10:1 (100 ˜150 degree C), 10:1 or 2:1 (200 ˜500 degree C). Run durations are 1 week or 4 weeks.

Composition of the starting material is referred to the average Martian surface composition analyzed by Mars Pathfinder probe. The starting material is prepared from a basaltic rock from Aso, iron rich dunite and San Carlos peridotite.

In the run products, olivine grains reacted with low pH fluid at low temperature condition including 100 ˜150 degree C. Characteristic phases in the run products are hematite and clay minerals. Hematite occurs in products at 100 ˜150 degree C and 400 ˜500 degree C. More hematite grains occur in products with pH1.5 and larger fluid-rock ratio. Morphology of the hematite is granular to spheroidal with diameters of 0.5 to 3 micron meters in products at 100 and 150 degree C. Hematite in products at 400 ˜500 degree C is euhedral crystals with the diameter of 5 to 20 micron meters. Clay minerals with Fe-rich rim substituted olivine crystals were formed under low pH and over 300 degree C conditions. Clay minerals found by SEM observation from run products at 400 and 500 degree C are amorphous phase.

Hydrothermal alteration with sulfuric acid-bearing fluid and mafic minerals including olivine occurs efficiently at lower pH and higher fluid-rock ratio. The characteristic products of this alteration are hematite and clay minerals. Acidic hydrothermal alteration may have essential role to form the Martian soil which is rich in iron oxide. Especially, morphology of hematite is strongly depends on temperatures of the hydrothermal alteration.

Direct observation of the Martian soil may provide us information on the conditions of hydrothermal alteration which occurred on the Martian surface.