Aqueous alteration processes of primitive planetary materials with redox conditions controlled by fluid compositions

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Abundance, occurrence, compositions and textures of carbonate minerals and phyllosilicates in carbonaceous chondrites show huge variety depending on aqueous alteration processes in the early solar system. Redox conditions in aqueous alteration processes should be controlled by fluid compositions based on the solar nebula. On the surface of planetesimals and protoplanets, excess H2O may be derived by accumulation of ice-dominated planetesimals. In this study, hydrothermal alteration experiments of Allende meteorite were carried out with fluids containing H2O, CO2 and hydrocarbons.
Hydrocarbon-rich fluid prohibited production of carbonate and phyllosilicate minerals. Excess H2O components promote production of phyllosilicates above 200 degree C. and carbonate minerals at 150 degree C and temporally above 200 degree C. Hydrocarbon-poor fluid estimated on protoplanets can produce Mg-Fe carbonate under 200 degree C and Mg-Ca carbonate over 200 degree C. Phyllosilicate is Fe-rich under 200 degree C and Mg-rich over 200 degree C.
Redox conditions calculated by thermodynamic parameters show higher fO2 in H2O-rich fluid compositions in this study. This estimation is concordant with experimental results on reactivity of metal components and compositions of carbonate and phyllosilicate minerals. Water components strongly promote production of carbonate and phyllosilicates. It is quite distinctive that production of carbonate minerals is stimulated by H2O rather than CO2 compositions in aqueous alteration processes.

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