DECODING THE R CHONDRITE RECORD OF A VOLATILE-RICH ENVIRONMENT.

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The Rumuruti (R) chondrites are distinguished by their high oxidation state [1], high sulfidation state [2, 3], and high bulk $\Delta^{17}O$ values [4, 5]. Together, these traits suggest interaction with a distinctive volatile-rich environment. Most R chondrites are thermally or hydrothermally altered, with petrologic types commonly above 3.6. Previous work on primitively textured R chondrite clasts indicate a highly heterogeneous parent body [6], with chondrule oxygen isotopes that are most closely related to the ordinary chondrites [7-10]. Our recent work on unequilibrated (type $\leq$ 3.2) material in two thin sections clarifies the setting of the volatile enhancement recorded by the R chondrites.

The material is from thin sections 19 and 21 of Antarctic meteorite Mount Prestrud (PRE) 95404. The primitive texture, unequilibrated chemistry, dark, fine-grained matrix, and preservation of glassy mesostasis suggest minimal parent body alteration. Chondrules include both FeO-rich (> 10 wt.%) and FeO-poor (< 10 wt.%) members. Non-porphyritic chondrules include cryptocrystalline and barred olivine. The average chondrule size is 308 μm in thin section 19, and 413 μm in thin section 21. The clasts are consistent with accretion of oxidized and reduced components.

Both thin sections contain abundant sulfide assemblages. These assemblages average ~200 μm in diameter, and are nearly as numerous as the silicate chondrules. They are composed of pentlandite, pyrrhotite, and accessory iron oxide. Cu-rich and Ca-,P-rich inclusions are common. Assemblage morphology is rounded. In both thin sections, multiple sulfide assemblages have concave shapes that are filled by silicate grains or chondrules, similar in appearance to compound chondrules. We hypothesize that the sulfide assemblages originated as pre-accretionary, molten droplets, and that the compound objects formed during collisions above the solidus temperature. There is one instance of deformation of a silicate chondrule in a sulfide-silicate compound.

We will present isotopic, petrologic and thermodynamic data constraining the formation environment for silicate chondrules and sulfides in the R chondrites.

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A KINETIC STUDY ON HYDROUS MINERAL FORMATION REACTION BETWEEN AMOPRHOUS SILICATE FORSTERITE AND WATER VAPOR IN PROTOPLANETARY DISKS.

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Hydrous silicates formed by a reaction between anhydrous silicate and water vapor are one of the possible water carriers to the rocky planet forming region because hydrous silicates are thermodynamically stable at ~250−225 K in protoplanetary disks. Prinn and Fegley (1989) explored this possibility through the Simple Collision Theory (SCT) with the activation energy of MgO hydration, which yielded ~70 kJ/mol. It was concluded that the reaction between anhydrous crystalline Mg-silicate and water vapor is too sluggish to occur within the lifetime of protoplanetary disks. Infrared observations and investigations of extraterrestrial materials have shown that both crystalline and amorphous silicate dust exist as primary solids in protoplanetary disks. Amorphous silicates are thermodynamically unstable and may thus react with water vapor more effectively and/or rapidly than crystalline silicates. In this study, in order to explore the possibility of hydrous mineral formation by the reaction between amorphous silicates and water vapor in protoplanetary disks, we performed reaction experiments between amorphous forsterite and water vapor at relatively low temperatures and water vapor pressures.

Gas-solid reaction experiments were carried out using an autoclave with an inner capsule at 323−373 K and water vapor pressure (P_{H2O}) of ~0.1−1 bar for 0.5−60 hours. The starting material was 10–100 nm-sized amorphous forsterite powder synthesized by a thermal plasma method. Run products were analyzed with FT-IR and XRD.

Infrared spectra of run products showed that 10 μm broad feature attributed to Si-O stretching vibration in amorphous have gradually changed to sharp features as the reaction proceeded. We also found the gradual development of ~2.7 μm sharp feature, which is assigned to free -OH stretching vibration of hydrous mineral(s). The XRD pattern of run products changed the original halo peak of amorphous forsterite to those of serpentine polymorphs and brucite. Quantitative analysis of the serpentinization degree was made based on the spectral fitting at ~10 μm and the development of the free -OH stretching vibration. The time evolution of the serpentinization degree was fitted with the Johnson-Mehl-Avrami (JMA) equation and the equation of interface-controlled reaction.

The reasonable fit of experimental data by the JMA equation with Avrami exponent n~1 and the equation of interface-controlled reaction suggests the reaction is controlled by the hydrous mineral formation reaction at the interface between amorphous forsterite and hydrous phases. The activation energy of the rate constant for serpentinization are ~21 kJ/mol and ~16 kJ/mol for the spectral evolution at ~10 and ~2.7 μm, respectively.

When the obtained activation energies are applied to the SCT by Prinn and Fegley (1989), amorphous forsterite may hydrate to form serpentine and brucite within the lifetime of protoplanetary disks (<10 Myr) at the total pressure of solar nebula of 10^{-3} bar, which will be discussed in more detain in the presentation.

Reference: Prinn R. G. and Fegley B. J. (1989) In *Origin and Evolution of Planetary and Satellite Atmospheres* (Eds. S. Atreya ey al.). Univ. Arizona Press. Tucson.