Experimental evidence of impact-induced serpentine formation from olivine and water

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Phyllosilicates, water-bearing minerals, have been found in a large number of planetary materials such as carbonaceous chondrites, interplanetary dust particles and comets. They have long been considered to be a major carrier of water to the early Earth, because the hydrogen isotope ratio of the present sea is similar to that of carbonaceous chondrites. How phyllosilicates were formed in the solar systems remains controversial. In this study, we demonstrated the formation of serpentine through the shock-recovery experiments for the mixture of olivine powder and water. The shock compression in water is at pressure of 6 GPa and proceeded for 1.2 micro seconds. Detailed observations with the aid of transmission electron microscopy revealed the presence of serpentine and partly altered olivine in the products. The yields were found to be dependent on the concentration of water in the initial samples. Shock-induced state of supercritical water and microstructures in olivine crystal, suggested by the previous researches, may explain rapid hydration of the shocked olivine to serpentine. Such shock-induced hydration might have occurred commonly in silicate minerals to form phyllosilicates during high-velocity collisions at the time of planetary formation. These collisions condition could have occurred on icy objects in the solar system such as comets or icy planetesimals. This impact-induced phyllosilicate formation explains well the presence of phyllosilicates in comets and in planetesimals. They might be the water source of the Earth. The present experimental results also imply strongly that large masses of phyllosilicates, especially serpentine, might have been formed on the early Earth, where numerous extraterrestrial objects impacted into the early oceans, as indicated by geological evidence.