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# Experimental study on the formation of Al-Cu-Fe natural quasicrystal under meteorite collision condition

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Natural quasicrystals were found from the Khatyrka meteorite, a CV3 carbonaceous chondrite [Bindi et al., 2009; 2015]. It's assumed that the Khatyrka meteorite including icosahedrite (Al63Cu24Fe13) had been exposed to at least 5 GPa and 1500 K conditions induced by impact induced shock. It is thought that the icosahedrite was formed by rapid quenching from high pressure temperature conditions [Hollister et al., 2014]. This event is quite short time phenomena at least microsecond time scale. The complicated formation dynamics from crystal to quasicrystal have not known yet. In order to elucidate the formation mechanism of naturally occurring quasicrystal, shock compression experiments on the Al-Cu-Fe system were performed using both a powder gun and a nano-second laser-induced shock. In addition, we carried out in-situ high-temperature X-ray diffraction (HT-XRD) study on the Al-Cu-Fe system. As a starting material, we used a mixture of Al, Cu, and Fe powders with the molar ratio of 63:24:13. A sample for the powder gun experiment was pressed into a pellet of 10 mm diameter and 0.8 mm thickness, and then loaded into a Cu capsule. It was impacted by Cu flyer accelerated to a velocity of 983 m/s. The capsule pressure was estimated to be 20.5 GPa. After the powder gun experiment the recovered sample was observed by SEM. The SEM-EDS mapping analysis, however, showed the metal distribution was clearly separated into three regions, suggesting no reaction occurred under the shock condition. For the laser shock experiment, samples were pressed into pellets of 1 mm diameter and 0.1 mm thickness. PET films of 25 $\mu$m thickness were attached on the sample surfaces as laser ablator. The laser pulse duration and energy were 12 ns and 16 J, respectively. The laser was synchronized with synchrotron X-ray from the Photon Factory Advanced Ring, KEK, Japan, which enables the TR-XRD (Time-resolved X-ray diffraction) under shock-induced compression. The TR-XRD results showed the Al, Cu, and Fe metals were continuously pressed up to 10 GPa without phase transformation. No quasicrystallization was observed during the shock-wave loading up to at least 600 ns. The results of powder gun and laser shock experiments indicate that quasicrystal is never formed under the shock conditions in this study. The in-situ HT-XRD study revealed that the mixture of Al, Cu, and Fe metals remained unchanged up to 350˚C, which is close to the temperature of the shock condition. Taking into consideration the all results, the natural quasicrystals in the meteorite were experienced at much higher pressure or higher temperature during the meteorite impact.