Shock and recovery experiments of petrologic type 3 ordinary chondrite

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One of the classic structure models for an ordinary chondrite parent-body is the onion shell model [e.g., 1]. Based on the onion shell model, the parent-body consists of petrologic type 3, 4, 5, and 6 ordinary chondrites from the outside to inside. Many previous works have worked on the shock features recorded in the petrologic type 5 and 6 consisting of the inside portions of the parent-body. In contrast, few previous works worked on the shock features recorded in the petrologic type 3 and 4 consisting of the outside portions of the parent-body. Our preliminary investigations showed that several petrologic type 3 ordinary chondrites have shock-induced melting textures, deformed chondrules, and high-pressure polymorphs [2]. We expect that the deformation degree of the chondrules depends on the shock pressure. In the present study, we will try to evaluate the relationship between the ellipticity of the chondrule and shock pressure through the shock and recovery experiments.

We used Allan Hills 78084 (ALH 78084) H3.9 and Yamato 793375 (Y-793375) L3.6 ordinary chondrites for our purpose. We prepared the doubly polished disc samples (ϕ = 12 mm, thickness = 1.5 mm) from their piece samples allocated from NIPR. We put the disc samples into the stainless container. We used a propellant gun installed at NIMS for the shock and recovery experiments. We estimated the shock pressure by the impedance matching method. The shock experiments were conducted up to 42.9 GPa (6 shots for ALH 78084 H3.9 and 6 shots for Y-793375 L3.6).

We recovered all stainless containers including the disc samples successfully after each shot. We cut the stainless containers and polished the disc samples in the containers. The polished surface is almost parallel to the shockwave front. We took the back-scattered electron (BSE) images of the polished disc samples using a field-emission scanning electron microscope (FE-SEM) at NIPR. We measured the ellipticity (1 - (short axis/long axis)) of the chondrules using the BSE image and image processing application. We also measured the ellipticity of the chondrules in ALH 78084 H3.9 and Y-793375 L3.6 using their petrographic thin sections stored in NIPR.

The long and short axes of the chondrules in ALH 78084 H3.9 as a starting material are 337 μm and 277 μm (median), respectively. Those in Y-793375 L3.6 as a starting material are 596 μm and 498 μm (median), respectively. The ellipticity of ALH 78084 H3.9 and Y-793375 L3.6 as starting materials are 0.16 and 0.18 (median), respectively. The ellipticity of the chondrules in the recovered samples becomes bigger compared to those in the starting samples. The ellipticity of the chondrules in ALH 78084 H3.9 at 42.9 GPa and Y-793375 L3.6 at 42.5 GPa are 0.36 and 0.43 (median), respectively. The ellipticity of the chondrules in ALH 78084 H3.9 and Y-793375 L3.6 becomes bigger with increasing the shock pressure. The planar fracture almost parallel to the shockwave front becomes distinct in the shocked samples above ~36 GPa both in ALH 78084 H3.9 and Y-793375 L3.6. Melting textures were observed at the boundaries between the chondrule and matrix in the shocked samples above ~10 GPa.

We could reproduce the shock-induced deformation of the chondrules and shock-induced melting by the shock and recovery experiments. We propose that we can estimate the shock pressure recorded in petrologic type 3 and 4 using the ellipticity of the chondrules.

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Keywords: ordinary chondrite, petrologic type 3, Shock experiment

