Japan Association of Mineralogical Sciences

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A NOVEL SYNCHROTRON EXPERIMENT TO STUDY MINERAL SHOCK DYNAMICS

The collision of solid celestial bodies has been considered a fundamental process in planetary formation and evolution. Impact events recorded in the rocks of a planet's crust often show the traits of shock metamorphism, and shock metamorphosed minerals can be used for identifying and dating impact events as well as functioning as barometric indicators. To date, shock recovery experiments and associated wave profile measurements have contributed to our present understanding of how shocks affect minerals. However, due to a lack of temporal or spatial resolution, the microscopic view of a mineral's experience during an intense shock event has not proved possible to determine. To understand the fundamental mechanisms of shock deformation, in situ measurements at the microscopic scale are required.

Recently, a powerful pulsed X-ray obtained at the synchrotron and X-ray free electron laser (XFEL) facility was used to visualize the ultrafast material dynamics. The combination of the X-ray pulse and the shock-driving source—for example a high-power laser shock, or impact, technique—now allows for the observation of material responses under shock compression and release states at the crystal structure level.

In this article, we introduce our own shock experimental system at the Photon Factory Advanced Ring (PF-AR) synchrotron facility at the Inter-University Institute Corporation High Energy Accelerator Research Organization (KEK) (Japan). The PF-AR is a unique synchrotron radiation source operated in single-bunch mode. The time-resolved X-ray beamline, known as the NW14A, has two undulators, which can produce 5–20 keV X-rays with a photon flux of more than 1×10^{12} photons s^{-1} (Nozawa et al. 2007). An X-ray chopper and a shutter allows us to isolate one X-ray pulse from a 794 kHz X-ray pulse train emitted from PFAR. This one X-ray pulse has a pulse duration of ~100 ps and can be used to obtain a snapshot of a crystal during shock. The X-ray diffraction (XRD) image was obtained using a charge-coupled device detector.

Our research group used a laser as the shock driving source (Ichiyanagi et al. 2007). In the laser shock experiment, the laser irradiation that ablates the material surface generates a shock wave in the material. This shock pressure increases with laser power density. In order to generate higher shock pressures, we just installed a higher power laser system for the shock-driving source (Takagi et al. 2020). The laser consists of a Nd:YAG oscillator and three Nd:glass amplifiers, which have rod diameters of 9 mm, 16 mm, and 25 mm, respectively; the maximum pulse energy is 16 J, the pulse duration is 12 ns, and the wavelength is 1,064 nm. Owing to the cooling time of the Nd:glass amplifier rods, a laser irradiation repetition time of least 20 minutes is needed for each shot. The pulse laser irradiation produced the shock condition, and a concomitant pulse X-ray detected the crystal structure. The relative delay in time between the laser and the X-ray pulses was controlled by a delay generator in the nanosecond range. For each laser shot, the damaged target was replaced and the delay time was changed to collect time-resolved data.

We recently reported experimental results obtained using this system with aluminum as the test sample (Takagi et al. 2020). We used a commercially available polycrystalline aluminum foil (purity ≥99% from Nilaco Co. Ltd) with a preferred orientation of each crystallite. From the time progressive XRD, it was observed that the *d*-spacings of each lattice plane reduced in the compression state and enlarged in the release state (Fig. 1). The shock pressure reached a maximum of approximately 17 GPa and had a strain rate of at least 4.6×10^7 s^{-1}, a condition which remained for nanoseconds. The broadening of the XRD spots of aluminum in the 2θ axis and the spreading of it along an azimuthal direction started from the compression state, implying that crystallite fragmentation occurred immediately. Moreover, the intensity distribution of the Debye–Scherrer rings remained constant during the shock compression and release processes, suggesting that the preferred orientation of the created subgrains were almost identical to the original sample.

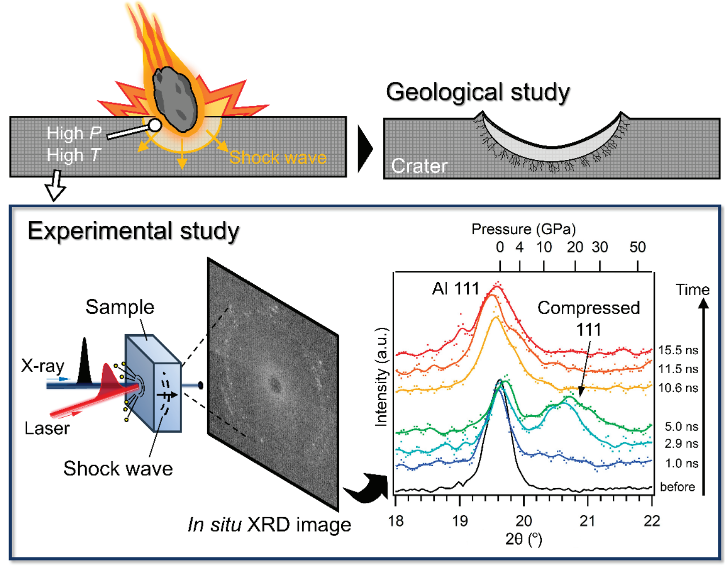

Figure 1 Schematic illustration of the new experimental shock system set up at the Photon Factory Advanced Ring (Japan) and, at right, some resultant sample data. The time-resolved X-ray diffraction data shows the dynamics of the Al (111) plane from shock compression to release (following the time arrow).

Because we have established a laser shock system at a pressure range that is synchronized with the synchrotron X-ray source, we have been able to observe in detail, and for the first time, a crystal's shock deformation dynamics. Now, we are investigating mineral shock dynamics as would be experienced during a meteorite impact, and we will develop this further so as to better understand, in detail, planetary shock history.

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German Mineralogical Society

DMG Deutsche Mineralogische Gesellschaft

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FROM THE PRESIDENT

Reinhard X. Fischer

Dear friends and members of the DMG,

The concluding remark in my message in the February 2020 issue (v16n1) of *Elements* was "The next council meeting of the DMG will be integrated into the 3rd European Mineralogical Conference in Krakow (Poland), which will be held 6–10 September 2020." Then the coronavirus hit. As a result, the European Mineralogical Conference 2020 (emc2020) was postponed to 2021, which itself caused a series of knock-on effects. The joint meeting of the DMG with the Austrian and Slovakian mineralogical societies, originally scheduled for 2021 in Vienna (Austria), had to be shifted to another year. And the idea of celebrating the 100th DMG meeting in 2022 in Cologne (the German city of our first meeting in 1908) might now be jeopardized by being one meeting short, so messing up the count. We did manage to set up an electronic platform to present the results of recent scientific work, which could be considered to be the 98th DMG meeting under very special circumstances. Then, the 3rd emc in Krakow in 2021 would be our 99th meeting and the anniversary in 2022 could be celebrated back on schedule. Nevertheless, we still have to schedule our council meeting and our general assembly of members. This will be organized as a combination of personal gathering, online voting, and video conference, and we will keep you updated via the DMG mailing list and our journal *GMit* (*Geowissenschaftliche Mitteilungen*).

It is my great pleasure to announce that Prof. Dr. Ekkehart Tillmanns from the University of Vienna will receive the gold Abraham Gottlob Werner Medal of the DMG for his outstanding commitment to the development of mineralogy. Born in 1941 in Münster, Tillmanns studied mineralogy at the universities of Tübingen and Göttingen (both Germany), and obtained his PhD (Dr. rer. nat.) at the University of Bochum (Germany). He was appointed professor of mineralogy and crystallography at the universities of Mainz and Würzburg (both Germany), and finally Vienna, where he retired in 2009. From 2010 to 2012, he served as President of the International Mineralogical Association. During his long career, he continuously promoted mineralogical topics the world over.

The increasing complexity in the administration of our society prompted us to appoint Klaus-Dieter Grevel, our secretary, as business manager of the DMG. Among his tasks will be the management of the online database, assistance to the president, organizing board meetings, cooperating with other societies, coordinating member administration, and updating our archive. This will be done in close collaboration with our bursar, Andreas Nägele, and our treasurer, Gerhard Franz. This is a step closer to our society being more professionally managed.

Our representative on the managing committee of the *European Journal of Mineralogy* (*EJM*), Gerhard Franz, informed us that the transition of the *EJM* to becoming a fully open access journal went very smoothly, and we hope that all problems concerning DMG members having access to back issues were solved – for any continuing problems, please contact Klaus-Dieter Grevel or Gerhard Franz. Our new publisher, Copernicus, has hired Dr. Johannes Wagner, a mineralogist from the Technische Universität Berlin and the GeoForschungsZentrum Potsdam, as the new *EJM* editor and the person largely responsible for keeping standards high. Submit your manuscripts to the *EJM* and *support journals from learned societies!* See: https://www.european-journal-of-mineralogy.net/.

I hope that I can write my next From the President when daily life has returned to something like normal. We all want to interact with colleagues and students again, but the enforced social distancing has had the benefit of making us use online tools to improve (or, at least, vary) the way we can communicate. I expect there to be a big step towards online tutorials and workshops in the future. Thus, there might be some advancements emerging from this difficult period.

All the best,
Reinhard X. Fischer (DMG President)

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Preservation conditions of CLIPPIR diamonds in the earth's mantle in a heterogeneous metal–sulphide–silicate medium (experimental modeling) – Anatoly I. CHEPUROV, Valeri M. SONIN, Egor I. ZHIMULEV, Aleksei A. CHEPUROV

High resolution X–ray computed tomography and scanning electron microscopy studies of multiphase solid inclusions in Oman podiform chromitite: implications for post–entrapment modification – Yuan YAO, Eiichi TAKAZAWA, Sayantani CHATTERJEE, Antonin RICHARD, Christophe MORLOT, Laura CRÉON, Salim AL–BUSAIDI, Katsuyoshi MICHIBAYASHI, Oman Drilling Project Science Team

Structure changes of nanocrystalline mackinawite under hydrothermal conditions – Yoshinari SANO, Atsushi KYONO, Yasuhiro YONEDA, Noriko ISAKA, Sota TAKAGI, Gen–ichiro YAMAMOTO

Estimation of emplacement depth for the Miocene Kaikomagatake granitoid pluton: constraints on crustal denudation history of the Izu collision zone – Saki WATANABE, Satoshi SAITO, Kenichiro TANI

Petersite–(La), a new mixite–group mineral from Ohgurusu, Kiwa, Kumano City, Mie Prefecture, Japan – Daisuke NISHIO–HAMANE, Masayuki OHNISHI, Norimasa SHIMOBAYASHI, Koichi MOMMA, Ritsuro MIYAWAKI, Sachio INABA

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Phase transitions of tridymite MC: A low frequency Raman spectroscopic study – Masami KANZAKI