Developing a Bytownite Shock Calibration Curve as a Lunar Analogue

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Introduction

Planetary analogue materials are useful to help interpret and predict planetary processes on other planetary bodies that we cannot observe directly. Lunar analogue materials include terrestrial rocks and minerals with compositions and textures like those on the moon. This project investigates the lunar analogue mineral plagioclase to quantify shock effects on the moon. These data may be compared to observations from lunar meteorites. Bytownite, a Ca-rich plagioclase, is an excellent analogue for lunar rocks because this mineral is widespread on the moon. Lunar rocks have experienced extensive shock metamorphism from meteorite impacts. Strain is calibrated by collecting strain-related mosaicity (FWHMx) data by µXRD for samples which have been artificially shocked to known maximum pressures. Calibrating strain information as a function of shock pressure for these minerals will enable us to extract peak shock pressures (in GPa) from naturally shocked materials, such as lunar meteorites and Apollo samples, using µXRD.

Methods

Optical microscopy was used to make qualitative shock observations and then 2D µXRD data was collected for 6 bytownite samples shocked from 17 to 54 GPa, including an unshocked sample. FWHMχ was then measured in the chi dimension for 5-6 targets per sample and the mean FWHMχ values from each were taken to develop a linear calibration curve.

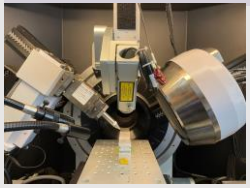


Fig. 1: Image of Western University's Bruker D8 Discover Micro X-Ray Diffractometer (µXRD)

Effects of shock on Bytownite

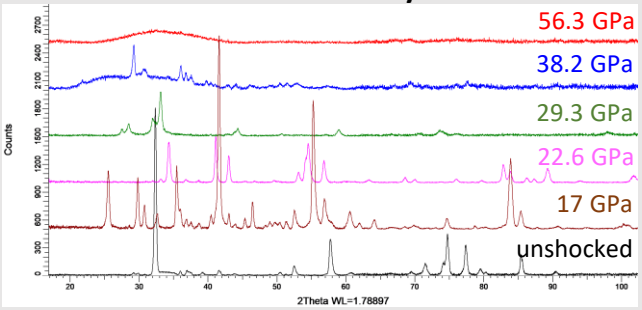
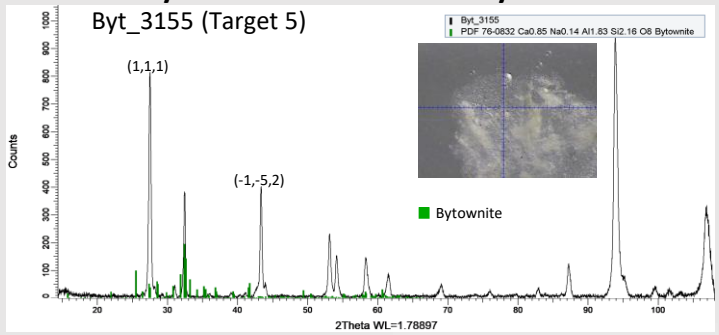


Fig. 2: Stack plot of XRD patterns from experimentally shocked bytownite samples acquired from Dr. Steven Jaret, arranged by shock pressure.

X-ray diffraction of shocked bytownite



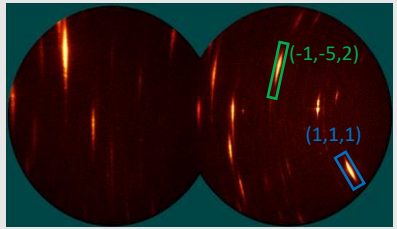


Fig. 3: Byt_3155 2D XRD image (bottom left) shows streaking along χ due to SRM with miller indices (hkl) associated with the noted streaks. The XRD pattern (above), indicates the corresponding peaks. Phase was matched using the ICDD database. Bytownite: PDF 76-0832. Target grain also shown above.

Strain-related Mosaicity

Large, plastically-deformed crystals contain streaks along χ due to a mosaic spread of subdomain orientations (SRM), which is expressed using FWHMχ.

FWHMχ calculation and shock calibration curve

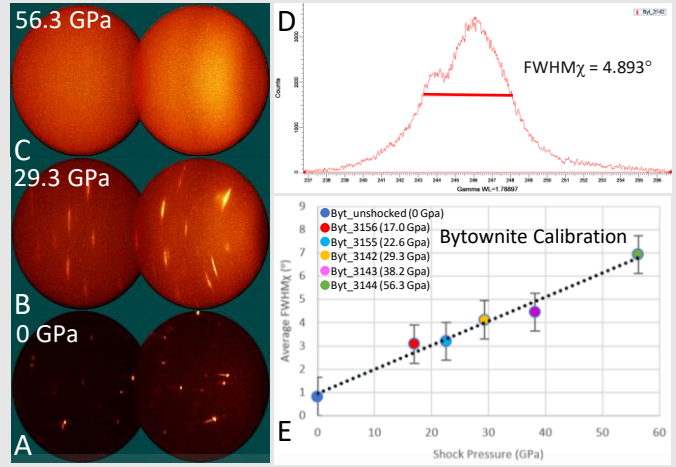


Fig. 4: Experimentally shocked bytownite and shock calibration curve. A: Unstrained crystals show diffraction spots. B: Plastically-deformed crystals show streaks along χ due to SRM. C: Highly shocked amorphous crystals show no spots or streaks. D: SRM is quantified by FWHMχ. E: Calibration curve shows FWHMχ vs. GPa for experimentally shocked bytownite grains.