The formation of maskelynite in moonstone \((K, Ca, Na)Al (Si, Al)_3 O_8\)

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Abstract

Feldspars are aminosilicate framework structures of low density. Upon static and dynamic compression they transform into denser structures. Lizardite is a crystalline phase of feldspar composition, which is isotypic to hellandite \(Ba\text{Mn}_4\text{Al}_2\text{O}_9\) and has a higher density than feldspars. Maskelynite is an amorphous solid (meaning it lacks a crystal structure) that forms in \((K,Na,Ca)\text{Alumino}	ext{silicates}\) upon shock compression. There is some debate as to how maskelynite is formed. It may be a true glass formed from a quenched melt, or it may be a diaplectic glass formed from a solid-state transformation of \(K\text{AISi}_2\text{O}_6\) to lizardite (a high pressure form of moonstone). To investigate this, discs of moonstone were loaded into a shock gun and shocked to peak pressures of about 15 GPa to form the glass or lizardite. The shocked sample was examined by Synchrotron microdiffraction at beamline 12.2.2, ALS. We found that most of the sample was still feldspar. However, the cell parameters of the shocked feldspar deviate noticeably from those of unshocked feldspar. The cell parameters of shock-recovered sample correspond to static compression of feldspar to between 2 and 3 GPa. This probably reflects residual stresses in the sample, however it may reflect irreversible compression.

Introduction

Feldspars make up about 60% of the Earth’s continental crust, and are of great interest to geoscientists. The aim of this project is to study the behavior of feldspar (specifically moonstone) at high pressure, mimicking conditions terrestrial impacts of larger asteroids such as the Sudbury or the Vredefort impact events. At sufficiently high dynamic pressures, the crystal structure of feldspar collapses and becomes amorphous. This glass is called maskelynite. The plan is to subject moonstone to high enough dynamic pressures to form maskelynite, and then to re-pressurize the glass in a diamond anvil cell and analyze the re-pressurized glass by x-ray diffraction. If the glass forms by a solid-state transformation instead of from melt, the glass may loosely retain some of its former ordered structure, and static pressure may at least partially reconstitute lattice periodicity. If the glass forms from a melt, there will be a more complete lack of order and the sample will remain amorphous after static compression.

Methods

Moonstone \((K, Ca, Na)Al (Si, Al)_3 O_8\) was used as a representative feldspar. Discs of moonstone were cut from a drilled core, ground down to a thickness of 27-29\(\mu\)m, sanded to a diameter of approximately 4 mm. They were then loaded into a shock gun using a tungsten driver and rhodium flyer. The flyer was launched by compressed helium gas to velocities between 529 and 700 \(m/s\).

Results

From X-ray diffraction data, the crystal structure of moonstone was still present after shock, although some noticeable deformation had occurred.

Conclusion

The moonstone was shocked to high enough pressures for form maskelynite, probably because of a too low orthoclase component. In the future, thinner discs will be used to induce more shock reverberations (and therefore higher peak pressure). Using samples of powdered moonstone will produce higher temperatures during shock due to the rapid increase in density. This may also aid in maskelynite formation.

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