An *In Operando* Strain-Rate Study of Amorphization in Plagioclase Feldspars

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Introduction: Plagioclase ($(Na_{1-x}\,Ca_x)Al_{1+x}\,Si_{2-x}\,O_8$) is a mineral that is ubiquitous on rocky bodies throughout the solar system, particularly on the Earth and in lunar mare and highlands. Maskelynite, amorphous plagioclase, forms in the range between 25 and 45 GPa [1] and is used as an indicator of petrographic type S5 (strongly shocked). Establishing the formation pressure is an important problem. Amorphization pressures determined during shock experiments were found to be over 10 GPa greater than in DAC experiments [7]. Amorphization pressure has been found to decrease with increasing temperature [3, 7]. However, pressures found in shock experiments are higher than those of DAC experiments, despite greater temperatures in the shock experiments. Kinetics or strain rate may play a role. The usage of high pressure phases to suggest peak pressures may be problematic. Their stability fields were determined using experiments that involve static or dynamic pressure and temperature generation. These experiments have different timescales of completion as well as strain rates from $10^{-3}s^{-1}$ for shock experiments to $10^{5}s^{-1}$ for static experiments. Diamond anvil cell (DAC) studies usually have low strain rates ($10^{-2}\ s^{-1}$) and observation timescales lasting up to an hour. They study the equilibrium state instead of observing metastable states. They additionally follow different pressure-temperature paths than natural impacts or shock experiments. Shock experiments, involving explosive devices or reverberation types, have much higher strain rates ($10^{5}\ s^{-1}$) and take place on timescales up to six orders of magnitude shorter than natural events. Analysis can only be performed on recovered samples. Shock experiments also follow Hugoniot conditions.

Methods:

We utilize a new technique, dynamic compression, in order to study the effect of strain rate on maskelynite. We completed a series of high pressure, fast compression powder X-ray diffraction DAC experiments. Due to recent advances in experimental apparatuses available, pressure can be remotely controlled using an inflatable helium membrane that alters pressure on the sample by pressing against the cell [6]. This allows low to medium strain rates of $10^{1}\ s^{-1}$ at the faster rates. These developments allow both the study of different loading paths and isolation of specific variables.We studied anorthite and albite at four constant compression/decompression rates (1 bar/min, 10 bar/min, 20 bar/min, and 40 bar/min) up to 80 GPa at ambient temperature and preheated to 300°C.

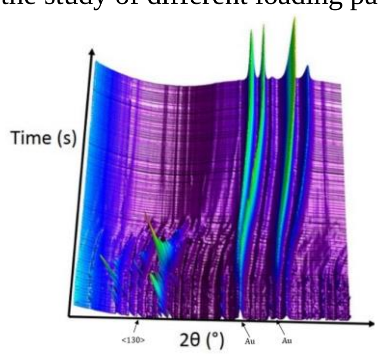

Figure 1. 3-d plot of room temperature rapid compression of anorthite data consisting of a series of 1200s total integrated X-ray diffraction patterns. Pressure increases in time upwards for a 1 bar/min test experiment.

Results:

We examine the changes in peak to background ratio with pressur1e in order to determine an amorphization point. We use LeBail analysis [5] and Williamson –Hall plots [8]. LeBail analysis provides changes in lattice parameters with pressure and enables us to determine equation of state. Williamson-Hall plots demonstrate the relationship between stress and strain in-situ. We look for differences in mode of amorphization with strain rate using these two methods. A waterfall plot of the change in diffraction pattern with pressure is included in Figure 1. Further analysis is underway.

References:

[1] Chao, E.C.T., 1968. “Pressure and temperature histories of impact metamorphosed rocks – based on petrographic observations” in Shock metamorphism of natural materials, ed. by B.M. French and N.M. Short: 135 [2] Huffman, A.R. and Reimold, W.U., 1996. *Tectonophysics*. 256: 165-217 [3] Langenhorst, F.et. al, 1992. *Nature*, 356: 507-509 [4] Langenhorst, F., and Deutsch, A. 1994. *Earth Planet. Sci. Lett*., 128: 683-698 [5] LeBail, A., 2005. *Powder Diffr*., 20: 316 [6]Lee, G.et.al. , 2006. *PNAS* 104 , 22: 917–918 [7] Tomioka, N.,et.al., 2010. *Geophys. Res. Let*t. 37: L21301 [8] Warren, B.E. and Averbach, B.L., 1950. *J. Appl. Phys*. 21: 595-596