DECOMPRESSION CRACKS IN ALTERED BASALT UNDER SOLID-STATE SHOCK PRESSURES: A NEW MACROSCOPIC SHOCK TEXTURE S.P. Wright, Department of Geology and Geography, Auburn University, Auburn, AL

Brief Summary: Solid-state transformation of labradorite plagioclase feldspar to maskelynite occurs at a specific range of shock pressure [1] referred to as "Class 2" [2] for shocked basalt. A new texture labeled as "decompression cracks" forms where the protolith prior to shock was an altered basalt, which likely indicates the importance of volatiles while not melting. At higher shock pressures, glass is formed and flows, which does not permit decompression cracks. Although only a small range of shocked basalt allows for decompression cracks to form, this can be used as a macroscopic texture in the field to locate shocked basalt and the impact melt-bearing breccia unit. Currently, shatter cones, at lower pressures, are the only macroscopic indicator of shock metamorphism.

Introduction: With three processes analogous to Mars (basaltic volcanism, aqueous alteration, and shock), Lonar Crater shocked basalts are excellent analogs for analyzing results from instrumentation sent to Mars. ~80 kg of "intermediately" (20-80 GPa) shocked basalt, which exist as clasts in the uppermost, impact-melt-bearing breccia (formerly, "suevite" [3]) layer at Lonar Crater, India [2], along with float that were former breccia clasts, were collected during a 2-month field season. These add to a large collection [4] of unshocked basalts and impact melts/glasses (aka Class 5 [1,2]). Petrographic and electron microprobe images reveal of range of shock pressures (deduced by phases and mineralogies of labradorite and augite); various protoliths such as fresh Deccan basalt, altered basalt (altered before shock) (**Table 1**) showing hematite, calcite, and silica veins/pockets (Figure 1); and what is interpreted as a consolidated soil or a sample from weathering horizons in-between individual basalt flows [4]. A shocked hematite-rich sample is likely from a "bake zone" in-between basalt flows. Impact melt veins and pockets were also found.

Decompression Cracks: Whereas thinly-bedded sedimentary rocks have layers or beds, and regional metamorphic rocks are foliated due to directed stress over long periods of time, typical Deccan basalt shows no such bedding or foliation. However, a subset (~25) of the collection of intermediately-shocked basalt have quasi-parallel "cracks" ~1 cm apart throughout the sample. These features are apparent in natural samples found in the Lonar ejecta both in-situ and as float, and cut sides display the feature. Petrography of these 25 samples showed all of them to be Class 2 [2] shocked basalt, with solid-state maskelynite and no melted plagioclase glass ("Classes 3 to 4") [2], which provides constraints on the approximate shock pressure.

age	"strata":
formed ~65 Ma – 570 ka	**thin layer of soil [4]**
emplaced ~65 Ma	**3 flows of "fresh" basalt – contain the primary minerals listed below**
emplaced ~65 Ma, then aqueously altered by groundwater	**3 flows of "altered" basalt:** **primary → secondary** **augite, pigeonite → chlorite, serpentine, celadonite** **labradorite → zeolites** **volcanic glass → palagonite** **titanomagnetite → hematite** **deposited: quartz / silica calcite, hematite**

Table 1. Pre-impact stratigraphy is listed along with primary and secondary minerals. Lower flows are likely subjected to more aqueous alteration over ~65 million years prior to impact ~570 ka [5]. Groundwater level is suggested by a white line. All three of these materials have been shocked to various pressures to exist as clasts in the upper impact breccia unit, and the lower, altered basalts exhibit "decompression cracks" described here at Class 2 shock pressures.

Figure 1. Example of "decompression cracks" on a cut surface of a Lonar Class 2 shocked altered basalt. Note red hematite to right and greenish tint of alteration minerals throughout.

Interpreted Formation: For microseconds, the altered Deccan basalt was held under a shock pressure to compress labradorite; tectosilicate bonds were broken to produce maskelynite without melting (aka "solid-state"), whereas clinopyroxenes, as single-chained inosilicates, fracture. The lack of flowing glass, along with no decompression cracks found in Class 1/3/4/5 shocked basalts, suggest that these features form when the sample decompresses after being held at Class 2 shock pressures. At higher shock pressures, when plagioclase melts to a glass, the near-instantaneous change in volume results in the glass flowing to account for the slight change in volume from ambient to compression to decompression. In Class 2 basalts, with no melted, flowing glass, the sample "cracks" to account for …

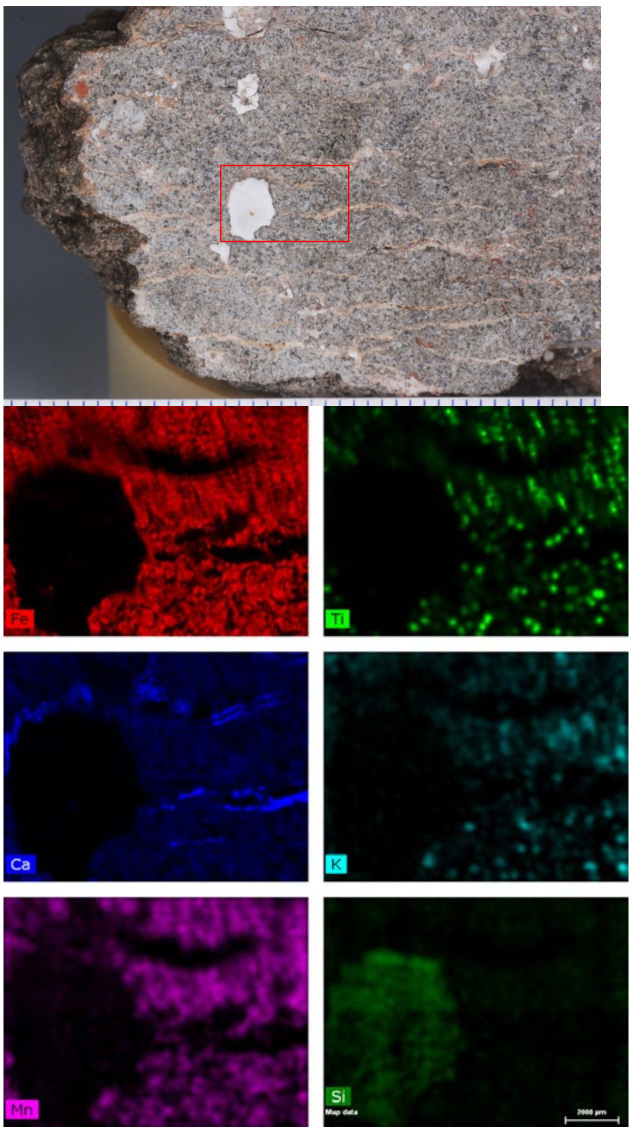

Figure 2. Elemental maps of the sample shown at top that show a two-stage alteration history. The context of the elemental maps is the red rectangle on the sample image. Secondary quartz has been shock-melted to silica glass (w/ evidence for coesite), whereas the basaltic groundmass is NOT melted. Calcite was then deposited in the decompression cracks after shock.

… decompression, and hence "decompression cracks" are formed. These are generally a feature of Class 2 shocked basalts with altered protoliths (altered before shock; **Table 1**), and thus volatiles may play a role. Fresh basalts subject to Class 2 pressures do not contain decompression cracks.

Implications for field geology: Only data of three shocked-altered basalts are shown here. Decompression cracks are not a feature of all shocked basalts and are limited to a small subset: Class 2 solid-state shock pressures of altered protoliths. However, this feature is beneficial to locating such samples and thus identifying 1.) outcrops of impact melt-bearing breccia that may be 2.) altered basalts ejected from depth. Both of these are of interest for field geology at Lonar and on Mars.

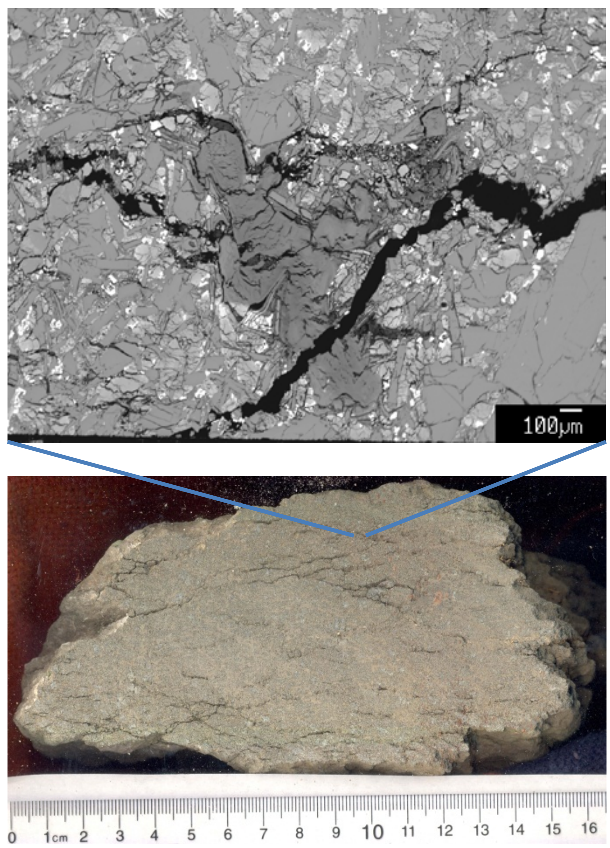

Figure 3. BSE image (top) and context (bottom) of a large (~16 cm) Class 2 shocked altered basalt exhibiting decompression cracks. All needles are now maskelynite. Black in the BSE image are decompression cracks.

References: [1] Stoffler et al. (1971) [2] Kieffer et al. (1976) 7^{th} *LPSC*, 1391-1412 [3] Osinski and Pierrazzo (2012) *Impact Cratering: Processes and Products* [4] Newsom et al. (2011) *LPSC 42*, #1298; Wright and Newsom (2011) *LPSC 42*, #1619; Wright (2012) *LPSC 43*, #2765 [5] Jourdan et al. (2011) *Geology 39*, 671-674 doi: 10.1130/G31888.1