FORMATION OF LECHATELIERITE AND IMPACT MELT GLASSES IN EXPERIMETALLY SHOCKED ROCKS. C. Schrand and A. Deutsch, Institut für Planetologie, Universität Münster , Wilhelm-Klemm-Str. 10, D-48149 Münster, Germany, <schrchr@uni-muenster.de>

Background. Lechatelierite is a highly vesiculated shock-fused quartz glass occurring in shocked quartzite, sandstone, and tektites. In impact melt glasses, whose precursor material is non-porous, Lechatelierite forms schlieren and inclusions with flow structures [1]. Formation of Lechatelierite requires a very high degree of shock metamorphism and starts only at the onset of whole rock melting. In order to better understand the formation conditions and textural setting of lechatelierite, we initiated an experimental study.

Samples and techniques. The shock experiments were carried out with granitic whole rock samples from the Nevada test site, Arizona, USA. This rock with a mean grain size of 0.1 to 1 mm, was selected by reason of the known Hugoniot data. The main minerals of this granite are quartz, orthoclase, plagioclase (An_{20-45}), and biotite, which is partly alterated to chlorite and epidote. Accessory phases are magnetite, zircon, apatite, sphene and ilmenite.

For the experiments at 59 GPa, 72.5 GPa and 85 GPa, we used a previously described reverberation technique [2 - 3]. In this type of experiments, the peak pressure is reached stepwise by multiple reflection of the shock wave at the ARMCO steel container to sample interfaces. The use of a whole rock as specimen yields additional reflections at grain boundaries between phases of different shock impedance. The applied technique may better simulate conditions in natural shock events than impedance experiments with a single unreflected shock wave as multiple reflections also occur in natural case [see 4, 5 for discussion]. After shock loading, the sample containers cooled down on air. The recovered material is studied by optical microscopy, SEM and microprobe techniques.

Results and discussion. *59 GPa experiment*. Fig. 1 illustrates characteristics of the granite shocked at 59 GPa. Quartz, orthoclase, and plagioclase have roughly preserved pre-shock textural features like grain boundaries. However, shock metamorphism caused the total loss of birefringence and a high density of irregular fractures. The fracturing, which is very distinct in both feldspars, may result from the increase in volume during decompression. The optical isotropization, the preserved pre-shock morphology and the absence of flow structures and vesicles, substantiate the transformation of the tectosilicates into diaplectic glasses. These glasses represent rapidly quenched high-pressure melts [e.g., 4, 6].

Biotite is the only phase showing signs of transformation to a shock-fused melt glass. We found such melt glass with flow structure, and a high density of vesicles in the rims of the mica grains. In some places, this glass is injected into irregular fractures of the diaplectic SiO_2 glass. In contrast to the rims, cores of the biotite flakes are not amorphous but show undulose extinction. The observations indicate (i) high temperature and pressure heterogeneities, and (ii) that the melting temperature of biotite was only reached at the outer parts of the grains.

72.5 GPa experiment. Compared to the 59 GPa sample, the higher shocked granite displays a significantly increased fracture density and a higher content of vesicles (Fig. 2). Biotite is almost totally transformed to an extremely vesiculated, shock-fused melt glass with a high degree of mobility. The glass is injected into the surrounding material for distances reaching hundreds of µm. In the 72.5 GPa experiment, melting conditions were also reached for plagioclase and orthoclase. They undergo incipient melting along the original grain boundaries; these zones display vesicles and a flow structure. Quartz, however, lacks any evidence for a transformation into shock-fused melt glass.

85 GPa experiment. The high shock pressure results in drastic changes of the initial granitic texture, which can not be recognized anymore in the thin section (Fig. 3). Again, the number of vesicles has increased compared to the samples, shocked at 59 and 72.5 GPa. Plagioclase, orthoclase, and biotite are completely transformed to impact melt glass with schlieren and flow structures. The rim of SiO_2 fragments is transformed to schlieren and veins of lechatelierite, in contrast to the cores which lack evidence of melting. Lechatelierite is intensively mixed with highly vesiculated schlieren of feldspatic or biotitic composition (Figs. 4 a, b).

Despite the only short duration of post-shock annealing and the lack of secondary thermal alteration processes the formation conditions of lechatelierite were reached in the 85 GPa experiment at the edges of quartz fragments. This implies extremely heterogeneous pressure and temperature distributions due to shock wave reflection at the initial boundaries of grains with different impedance. Tab. 1 summarizes the shock features observed in the recovered granite samples. Our results for whole rock samples suggest that a higher pressure is required for shock-fusion of orthoclase, plagioclase and quartz in solid rocks than proposed by e.g. [1]. This is in accordance with the fact that unambiguous proof for the formation of such shock-fused glass has not been detected so far in experiments with single crystals using an identical experimental set-up [7,8].

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Tab. 1 Shock features of the experimentally shocked granite

Shock pressure [GPa]	shock metamorphism
59	diaplectic glass of quartz, plagioclase and orthoclase; irregular fractures; incipient melting of biotite
72.5	diaplectic SiO_2 glass; incipient melting of feldspar, increasing fracturing; injection-veins of biotitic melt
85	impact melt glass with schlieren of lechatelierite (shock fused quartz)

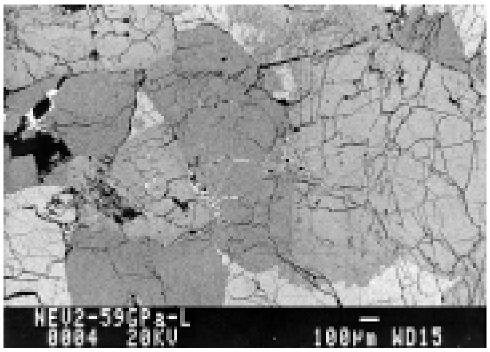


Fig. 1 Backscattered electron image (BSE) of the experimentally shocked granite at 59 GPa. The pre-shock texture is roughly preserved. Only biotite (white) is partly transformed to melt glass with vesicles and injection veins.

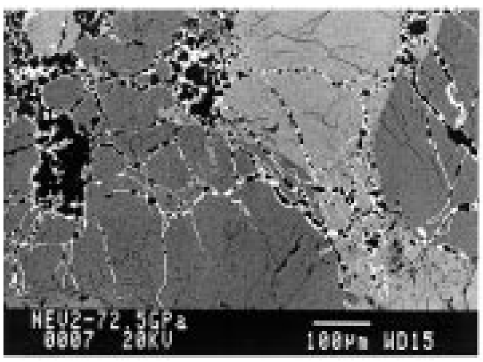


Fig. 2 BSE image of the granite shocked at 72.5 GPa. Highly vesiculated (black areas) biotitic melt is injected into the surrounding material about hundreds of µm.

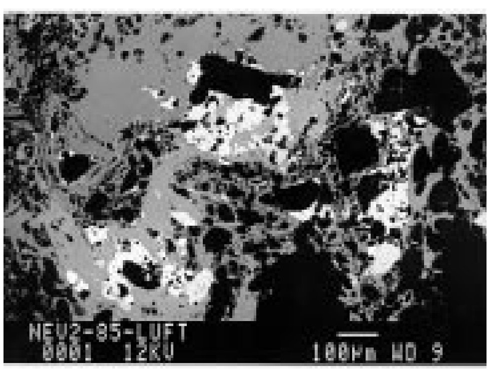
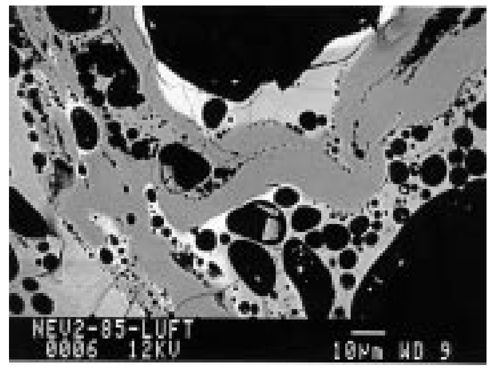


Fig. 3 BSE image of the experimentally shocked granite at 85 GPa. The main characteristic is the total loss of the initial granitic texture by the formation of impact melt glass.

a.



b.

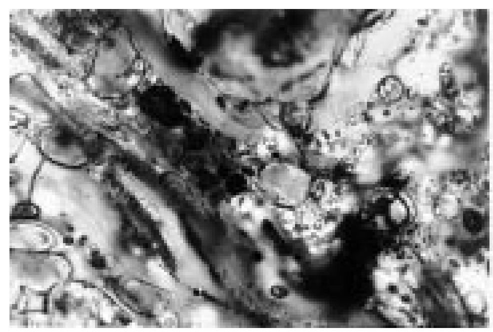


Fig. 4 Lechatelierite schlieren in impact melt glass. Backscattered electron image (dark grey) **(a)** and photomicrograph of the same area **(b)** (optical microscope, plane polarized light).

References. [1] D. Stöffler, F. Langenhorst (1994) *Meteoritics* **29**, 155-181; [2] U. Hornemann (1994*) ESF Network on "Impact cratering on Planet Earth"*, Workshop Nördlingen, Abstr. Vol. 9; [3] F. Langenhorst et al. (1992) *Nature* **356**, 507-509; [4] F. Langenhorst, A. Deutsch (1994) *EPSL* **125**, 407-420; [5] R.A.F. Grieve et al. (1996) *MAPS* **31**, 6-35; [6] F. Langenhorst (1994) *EPSL* **128**, 683-698; [7] R. Ostertag (1983) J. Geophys. Res. 88 B364-B376; [8] Rehfeldt-Oskierski, D. Stöffler (1986) *Lunar Planet. Sci.* **17**, 697-698.