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Shock Recovery Experiments with Dry Sandstone at Low Shock Pressures

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This project is part of the Multidisciplinary Experimental and Modelling Impact research Network (MEMIN) and investigates shock effects in quartz in the low shock pressure range <5 to 15 GPa and the influence of porosity and water saturation on progressive shock metamorphism.
Shock recovery experiments at 5, 7.5, 10 and 12.5 GPa were carried out with dry Seeberger sandstone (grain size of 0.17 $\pm$ 0.01 mm, porosity of $\sim$18 vol.%). The experimental set-up of the Ernst-Mach-Institute was employed with a high-explosive driven flyer plate generating a plane shock wave [1] using the shock impedance method. For shock pressure determination we applied the Hugoniot data of Coconino sandstone [2], which leads to an unknown error in shock pressure determination with respect to the actual sample material, for which Hugoniot data are not yet determined.
The shocked sandstone samples show at the microscopic scale a near-complete closure of pore space and some irregular intergranular fractures. Quartz grains of the unshocked sample show sharp and undulatory extinction under crossed polarizers. In contrast, in the shocked samples quartz grains display mainly undulatory extinction at 5 GPa and weak mosaicism at 7.5, 10 and 12.5 GPa. All quartz grains in the shocked samples display intense intragranular fracturing. The fracture density of quartz is significantly higher than in the unshocked sample, increasing towards the sample shocked at 7.5 GPa, and thereafter, at even higher pressures remaining at a more or less constant level up to 12.5 GPa. Irregular and roughly planar fractures could be observed together in the quartz grains of the shocked samples. At 5 GPa quartz grains display usually only one set of roughly planar fractures, whereas at 7.5, 10 and 12.5 GPa two or more sets could be observed. Besides these two types of fractures, a typical combination of fractures was also observed in the shocked samples. This combination consists of a characteristically longer fracture which is oriented mainly at an angle of 40-50° to the shock wave propagation. This fracture occurs together with a set of roughly parallel, shorter fractures, which have a spacing of 5-20 μm and are oriented at angles of 40-90° to the main fracture. Typical feather featureas as described by [3] could not be observed within these shock experiments.
These shock experiments with Seeberger sandstone have produced shock features in quartz as known from shock experiments with quartz single crystals and quarzites. Nevertheless, in the porous sandstone the on-set of planar fracturing in quartz is at a slightly lower shock pressure and the frequency of planar fractures is higher than in quartz single crystals and quartzite, which might be an effect caused by the porosity of the sandstone.

References: [1] Schmitt (2000) MAPS 35, 545-560. [2] Stöffler (1982) In: Angenheister (ed), Landolt-Börnstein. New series, Group V, vol. 1, sub-vol. A, pp. 120–183. [3] Poelchau and Kenkmann (2010) LPSC XLI, #1987.