FORMATION OF SHOCK FEATURES IN THE 2.5 TO 20 GPa SHOCK PRESSURE RANGE IN POROUS SANDSTONE AND QUARTZITE.

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Introduction: The identification of impact craters in porous sandstone targets by recognition of shock deformation is a complex task. There is serious lack of diagnostic shock features, particularly for the low-to-moderate shock pressure regime. This is addressed in this MEMIN project focusing on shock deformation experimentally generated in porous sandstone/water-saturated sandstone/dense quartzite, at pressures $\leq$ 20 GPa. We want to establish a shock classification scheme for porous, quartz-bearing rocks with special attention to the influence of porosity on progressive shock metamorphism.

Experiments: Four series of shock recovery experiments (impedance method) were conducted at 2.5 to 20 GPa shock pressures with two different layers of dry Seeberger sandstone (L3, porosity Φ ~25-30 vol.%; L5: Φ ~12-19 vol.%), a nearly completely water-saturated Seeberger sandstone (L3), and a quartzite (Φ <0.2 vol.%).

Results: Regarding fracture formation, both porous, dry sandstones behave similarly; and the wet sandstone behaves like the quartzite. In porous sandstones the onset of fracturing starts at comparatively lower shock pressures, the number of fractures is higher, and their saturation level is reached at relatively lower pressures – compared to the water-saturated sandstone and the dense quartzite. Fracturing saturation can be directly linked to the formation of diaplectic quartz glass and SiO_2 melt [1, 2]; in the most porous target (L3), glass/melt formation starts at 5 GPa but increases distinctly to over 20 vol.% between 12.5 and 15 GPa (where fracturing saturation is reached) and reaches ~80 vol.% at already 17.5 GPa. In contrast, dense quartzite does not reach such a fracturing saturation until 17.5 GPa, and does not show any glass/melt formation. The less porous, dry sandstone (L5) shows intermediate behavior and slightly lower fracturing intensity with saturation at ~ 12.5 GPa. Onset of glass/melt formation is shifted to comparatively higher pressure and a comparatively lower amount is reached. Wet sandstone behaves like the dense quartzite, but fracturing saturation is reached at ~15 GPa, and glass/melt development only attains ~1 vol.% at 20 GPa.

Conclusion: Shock compression of porous sandstone results in distinctly different effects than observed in non-porous rocks, especially at low-to-moderate shock pressures. The first onset of diaplectic quartz glass and SiO_2 melt was observed in the most porous target L3 already at 5 GPa, whereas these phases usually occur only at 30-35 GPa and >45 GPa, respectively, in shocked quartz single crystals and crystalline rock. The glass/melt amount decreases distinctly with decreasing porosity to about zero in the dense quartzite. The water-saturated sandstone behaves like a non-porous target until ~15 GPa, and after that the water has no influence on shock deformation. Finally, the crushing mechanism is strongly dependent on porosity and leads to a distinctly heterogeneous distribution of localized shock pressure and temperature amplification in the target – and, therefore, to heterogeneous distribution of shock effects [2].

References: [1] Kowitz et al. (2013), MAPS 48:99-114; [2] Kowitz A. et al. (2013), EPSL 384:17–26.