EXPERIMENTAL CONSTRAINTS ON PROGRESSIVE SHOCK DEFORMATION OF ZIRCON IN POROUS TARGET ROCKS SHOCKED TO PRESSURES BETWEEN 2.5 AND 17.5 GPA.

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Introduction: Dynamic shock recovery experiments constrain conditions of mineral transformations during shock metamorphism. For zircon, existing dynamic experiments involve either single crystals or powder [1, 2]; no dynamic experiments have been conducted on zircon in a host rock (porous or non-porous). We report a microstructural study of 597 zircon crystals in sandstone samples experimentally shock-deformed under the auspices of the MEMIN program [3]. The samples are Seeberger sandstone with 25-30% initial porosity, dynamically shocked in 2.5 GPa increments from 2.5 to 17.5 GPa. They are the same thin sections analyzed by Kowitz et al. [3, 4] to characterize shock deformation of quartz. A total of 414 zircons were mapped by electron backscatter diffraction.

Reidite formed in samples from 10 to 17.5 GPa, including irregular lenses and coherent domains up to 10 µm across. The abundance of grains with reidite (10 to 40 %) increases with pressure. **Deformation Twins** along {112} planes formed in samples from 10 to 17.5 GPa. Twins occur as sets of parallel lamellae with widths <1 µm in one {112} orientation. **Planar Fractures** formed in samples from 2.5 to 17.5 GPa; their abundance did not increase with pressure. **Planar Deformation Bands** formed in samples from 2.5 to 17.5 GPa; their abundance did not increase with pressure. **Vesicular melt films** along zircon margins formed in samples from 7.5 to 17.5 GPa.

Reidite and {112} deformation twins formed in samples shocked from 10 to 17.5 GPa. Zircon {112} twins have not previously been reported from dynamic experiments (c.f. [2]). The twins demonstrate shear stresses sufficient for twinning [5] occur at and above 10 GPa in porous targets. Previous dynamic experiments have not formed reidite below 30 GPa [1, 2]. We attribute reidite formation at 10 GPa in Seeberger sandstone to heterogeneous pressure excursions at the pore-scale, which have been shown to result in localized amplification of shock pressures up to 4x within these porous sandstones [4, 6]. Based on [4], we present a shock stage classification system for progressive deformation of both zircon and quartz in dry porous sandstone (25-30 % porosity) shocked between 0 and 17.5 GPa.

Table 1. Shock stage classification for zircon and quartz in dry, porous (25-30%) sandstone.

Shock Stage	Effects in sandstone target (from [4])	Shock features in quartz, vol. % (from [4])	Calculated applied pressure (GPa)	**Shock effects for zircon (this study)**
0	Undeformed sandstone (reference material)	0	0	irregular fractures (not impact-related)
1a	Compacted sandstone with remnant porosity	0	< 1.5	(not evaluated here)
1b	Compacted sandstone with zero porosity	0 to 2	2.5	PF, PDB
		0 to 2	5.0	PF, PDB
1c*		0 to 2	7.5	PF, PDB, melt films
2	Dense (non-porous) sandstone with dialectic quartz glass, SiO_2 melt, SiO_2 high-pressure phases, SiO_2 glass (lechatelierite), and quartz	2 to 20	10.0	PF, PDB, melt films {112} twins, reidite
			12.5	PF, PDB, melt films {112} twins, reidite
3		20 to 50	15.0	PF, PDB, melt films {112} twins, reidite
4		50 to 85	17.5	PF, PDB, melt films {112} twins, reidite
5	Vesicular (pumaceous) rock, dominantly SiO_2 glass (lechatelierite)	>85	>18	Granular (FRIGN) zircon (data from [7])

*Shock stage 1c is a newly proposed stage (c.f., [4]), based on the appearance of melt films around zircon at 7.5 GPa.

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