

IMPLICATION RESULTING FROM SEIFERTITE FORMATION IN SHERGOTTITES. U. W. Bläß¹ and F. Langenhorst², ¹Institut für Geowissenschaften, Friedrich-Schiller-Universität Jena, Burgweg 11, 07749 Jena, Germany (Ulrich.Blaess@uni-jena.de), ²Bayerisches Geoinstitut, Universität Bayreuth, 95440 Bayreuth, Germany (Falko.Langenhorst@uni-bayreuth.de).

Introduction: High-pressure silica polymorphs are used as crucial indicators for impact processes in terrestrial bedrocks (e.g., formation of coesite in suevites from the Ries) and serve as pressure and temperature markers in several meteorites. These phases commonly crystallise as tiny crystals during the short shock pulse from silicate melts or glasses at high-pressure.

The discovery of more than 100 μm large post-stishovite polymorphs like seifertite ($\alpha\text{-PbO}_2$ structured silica) in the Martian meteorites Shergotty and Zagami [1; 2], however, point to a completely different and unknown mechanism of formation. Equilibrium pressures for the formation of observed post-stishovite phases are substantially higher [3; 4] than previously estimated shock pressures of ~ 30 GPa for the meteorites embedding these phases [5]. In addition fast solid state transformation processes are not known for the SiO_2 -system, which transforms extremely sluggish at low pressures. In order to get a more profound understanding of the formation of seifertite crystals and resulting implications for the shock history of the host meteorite, we investigated their petrographic characteristics and defect microstructures by using scanning and transmission electron microscopy.

Results: The occurrence of seifertite in Shergotty and Zagami is restricted to the mesostasis of our samples. These mesostasis regions exhibit sometimes an approximately rectangular or even tetragonal shape and show severe radial cracks penetrating far into adjacent phases indicating a strong volume expansion of these regions. However, TEM analyses reveal that all these regions correspond to late stage magmatic differentiation products composed predominantly of a fine-grained (1-5 μm) mixture of seifertite plus maskelynite and tiny accessory minerals like tranquillityite or titanomagnetite.

Seifertite has been characterized by electron diffraction pattern, which can be indexed as a orthorhombic phase with lattice constants of $a = 4.45 \text{ \AA}$, $b = 4.05 \text{ \AA}$ and $c = 5.05 \text{ \AA}$, but not by any other known silica polymorphs. Chemical compositions are close to pure silica but contain 1.1 - 1.5 % of aluminum and $< 1\%$ sodium indicating cristobalite or tridymite as potential precursor phases. The crystals are only a few microns large and are pervaded by characteristic sets of amorphous lamellae as described e.g. by [2]. The lamellae

divide the entire phase into 50 - 200 nm large blocks of roughly equal crystallographic orientation. In contrast accessory phases like tranquillityite exhibit a strongly shock-deformed microstructure.

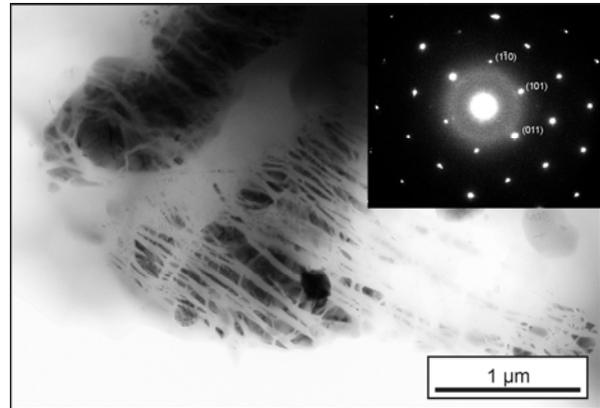


Fig.: TEM bright field image and diffraction pattern (inset) of seifertite showing characteristic lamellae.

Discussion: Shock induced deformation features in tranquillityite indicate that the mesostasis could not be remolten during the shock event. Hence embedded seifertite crystals must have been transformed by a solid state process, independent of their size. The transition occurred likely metastable at pressures far below the stability of seifertite, because no features were observed justifying the assumption of shock-pressures considerably above the previously estimated 30 GPa. Substantially higher shock-pressures would cause severe melting and the resulting high post-shock temperatures would likely prohibit the crystallisation of a high pressure paragenesis like in the Shergottite Dhofar 378.

These investigations demonstrate therefore, that in contrast to high pressure phases crystallised from a melt, solid state transformation processes do not unambiguously indicate minimum shock pressures, but could be misleading due to their metastable nature.

References: [1] Sharp T. G. et al. (1999) *Science* 284, 1511-1513. [2] El Goresy A. et al. (2004) *J. Phys. Chem. Sol.* 65, 1597-1608. [3] Dubrovinsky L. S. et al. (1997) *Nature* 388, 362-365. [4] Teter D. M. et al. (1998) *Phys. Rev. Let.* 80, 2145-2148. [5] Stöffler D. et al. (1986) *Geochim. Cosmochim. Acta.* 50, 889-903.