SUBSURFACE DEFORMATION OF NONPOROUS ROCKS INDUCED BY HYPERVELOCITY IMPACTS. R. Winkler[1], M. H. Poelchau[1], C. Michalski[2], T. Kenkmann[1], [1]Institute of Earth and Environmental Sciences – Geology, Albertstraße 23B, 70104 Freiburg, (rebecca.winkler@geologie.uni-freiburg.de), [2]Fraunhofer Ernst-Mach-Institute, Eckerstraße 4, 70104 Freiburg.

Introduction: The deformation inventory of the subsurface of hypervelocity impact craters has multiple implications e.g., for the geophysical signatures of impacts, as well as for understanding the deformation history of meteorites.

Fracture propagation and the localization behavior of damage vary with cohesiveness and porosity, as well as with strain rate. In large tectonic fault zones, for example, as the San Andreas Fault zone, both fault gouge as well as pulverized rock occur that form under presence and absence of significant shear strain, respectively [1].

Hypervelocity impacts subsequently create different stress stages. Where pressures in the order of a several GPa above the Hugoniot Elastic Limit (HEL) are achieved nonporous rocks fail under compression, due to shearing under differential stresses [2]. When pressures are around the HEL more localized deformation can occur in the target, e. g. radial fractures in nonporous rocks or deformation bands in porous rocks [3].

We are currently analyzing whether, and how, impact-induced deformation is similar to deformation mechanisms from other fracturing regimes and particularly address the effects of a rate dependency of deformation.

Methods: In two hypervelocity impact experiments into Taunus Quarzite and Carrara Marble we discovered different deformation features in the subsurface. In both impact experiments the projectile was a 2.5 mm steel or iron meteorite sphere with densities between 7.8 – 8.1 g/cm^3 and the impact velocity were ca. 5.0 km/s. The experiments were investigated with respect to the deformation inventory of the crater subsurface and the influence of target porosity on deformation. Thin section analysis with optical and SEM microscopy was used to map the deformation. Orientations of the deformation features were analyzed to infer the deformation mechanisms.

Results: In both experiments, regardless of the target material, tensile fractures directly beneath the crater floor developed, due to the rarefraction wave or as results of relaxation of volumetric compression upon shock pressure release. However, the depth of tensile failure below the crater floor varies with target material: Quartzite 0.6 proj. diameter and Marble 1.2 proj. diameter. Additionally, the low porosity target quartzite reveals localized deformation along discrete narrow zones with strong grain size reduction. Low porosity

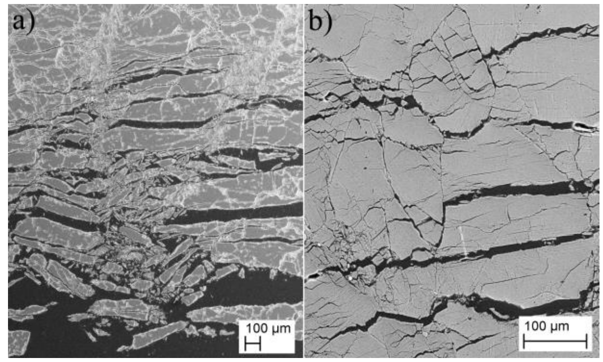

Fig. 1: a) tensile fractures beneath the crater floor in quartzite target. b) tensile fractures beneath the crater floor in marble target.

marble, however, did not develop such fracture zones, but mainly reacts with widespread, small-scale, intragranular fracturing along planes of low critical resolved shear stress (cleavage planes in the crystal lattice) with small displacements. Additionally, the marble target cracked along the grain boundaries in proximity to the crater floor, creating high amounts of secondary porosity in the crater subsurface. This phenomenon does only occur to a much less extend in the quartzite target. In both target materials, shear deformation seems to be a dominant mechanism in subsurface deformation.

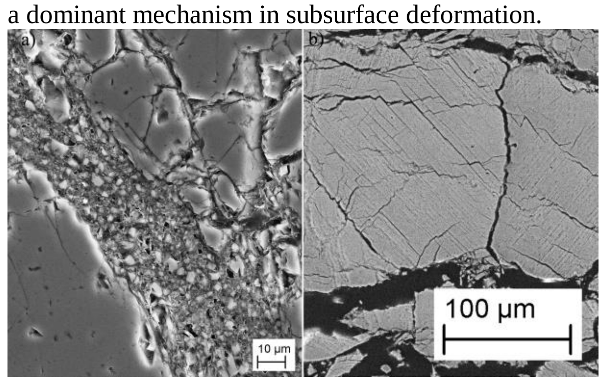

Fig 2: a) localized shear zone in quartzite target, showing intensive grain size reduction. b) typical intragranular fractures along cleavage planes in calcite.

Conclusions: First results of SEM microscopy analysis indicate that deformation mechanisms in impact-induced deformation is similar to deformation in other dynamic fracturing environments. Whether deformation is accumulated along localized zones or within nearly omnipresent small-scale fractures seems to be material dependent. Further investigations will be performed to validate these preliminary results.

References: [1] Wilson B. et al. 2005, *Nature* 434:747-752 [2] Polanskey C. A. and Ahrens T. J. 1990, *Icarus* 87:140-155. [3] Ai H.-A. and Ahrens T. J. 2004, M*eteoritics & Planet. Sci* 39:233-246