HYPERVELOCITY IMPACT INTO DRY AND WET SANDSTONE. T. Kenkmann[1], K. Thoma[2], A. Deutsch [3] and the MEMIN-team[4]; [1]Museum für Naturkunde, Humboldt-Universität Berlin, Invalidenstrasse 43, 10115 Berlin, Germany, Thomas.kenkmann@museum.hu-berlin.de, [2]EMI-Freiburg, Germany, thoma@fhg-emi.de, [3]Westfälische-Wilhelms-Universität Münster, Germany, deutsca@uni-muenster.de [4]MEMIN-Team: T. Behner (EMI-Freiburg), K. Wünnemann, W.U Reimold, R.T. Schmitt, L. Hecht, M. Patzschke (HU-Berlin), U. Yaramanci, S. Mayr, (TU-Berlin), C. Grosse (IWB Stuttgart), G. Dresen (GFZ-Potsdam)

Introduction: The effect of intergranular water during a shock event is that of a fluid cushioning the high energy grain-to-grain impacts [1]. Water reduces the compressibility of porous materials, so that the shock states attained during compression are less dense than those of dry material shocked to the same pressure [2]. A second effect is the mechanical disruption of the target material by expanding steam after the passage of the shock wave. If peak pressures are below 5 GPa, water will remain a liquid [3]. For Hugoniot pressures between 5 and 70 GPa, partial vaporization will occur upon pressure release, and above 70 GPa, water will be completely vaporized [4]. The formation of steam is accompanied by a large increase in volume and en-hances the crater cavity growth in comparison to that in dry rocks. Moreover, fluids are likely to change the mode and yield of impact induced failure in rocks [5]. A detailed microstructural study of shock processes on water-bearing, porous sandstones has been carried out previously on Coconino Sandstone from Meteor crater, Arizona [6]. Within the framework of the recently established *M*ultidisciplinary *E*xperimental and *M*odeling *I*mpact crater research *N*etwork (*MEMIN*), our team is studying experimentally the influence of pore space water in sandstone.

Experiments: Two pilot experiments [7] with a two-stage light gas gun have been conducted with 1.0 x 1.0 x 0.5-m-sized blocks of quartz sandstone ("Seeberger Sandstein", Seeberg near Gotha, Germany, Fig. 1), set into a steel frame. This sandstone has an average grain size of 0.17 +/- 0.01 mm, is relatively pure in composition (about 97 wt.% SiO_2) (Fig. 1), and displays a layering with a fluctuating porosity of 12-20 vol.%. One of the blocks was placed into a water basin for four months and attained a water saturation of 44 vol.% of the pore space, on average, the other block remained untreated. Steel spheres with a di-ameter of 10 mm and a mass of 4.1 g were launched against these blocks. The impact velocity for both experiments was ~5.3 km/s.

Results: The resulting craters had a diameter of 24.3 and 28.7 cm, with a depth of 5.6 and 4.5 cm, for the dry and wet experiments, respectively. A peak shock pressure of about 50 GPa is estimated. The crater in the dry target has a shape of an inverted spherical cone (Fig. 2), whereas the crater in the wet rock is much broader with a flat floor (Fig. 3). Volumetrical analyses of the craters based on 3D-scans resulted in 715 and 1099 cm^3 of excavated material in the dry and wet case, respectively. Ejecta cone angles recorded with high-speed cameras are 69.8° and 58° after 1.2 msec for the dry and wet experiments. Parabolas fitted to these angles and to the maximum crater depth yielded crater diameters of 8.2 and 11.3 cm for the dry and wet experiments, respectively. Hence, about 79 vol.% of the crater volume is ejected outside the crater cavity in both shots.

Discussion: The experiments demonstrate the strong influence of pore fluids on cratering mechanics. Pore space collapse and successive compaction were more effective in the dry sandstone experiment. Target water also affected the ejection angles and the ejecta flow. Different ejecta angles can be attributed to differences in the bulk mechanical properties. The effect of pore water to reduce the effective mean stress may increase the size of the zone in which tensile failure occurs.

References: [1] Allen, C. C., et al. (1982) Geophys. Res. Lett., 9, 1013-1016. [2] Kieffer, S. W. (1975) The Moon, 13, 301-320. [3] Riney, T. D. et al., (1970) Systems, Science and Software Report 35R-267. [4] Butkovich, T. R. (1971) J. Geophys. Res., 76, 1993-2011. [5] Ahrens, T. J. and Rubin, A. M. (1993) J. Geophys. Res., 98,1185-1203. [6] Kieffer, S. W. and Simonds, C. H. (1980) Rev. Geophys. Space Phys., 18, 143-181. [7] Thoma, K., et al. (2005). Met. Planet. Sci., 40, #5049, A151.

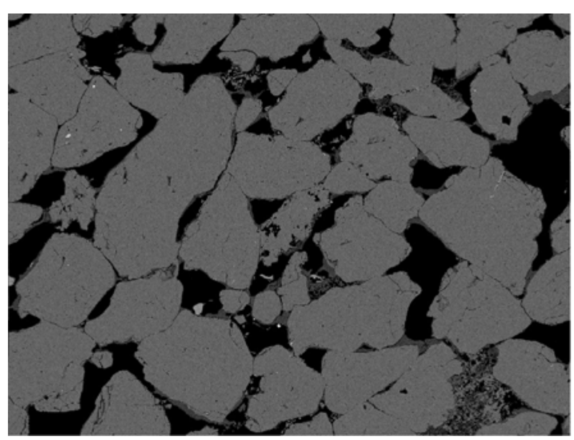

Fig. 1 SEM-BSE image of "Seeberger Sandstein", the target rock for the impact experiments, image width ~900 µm

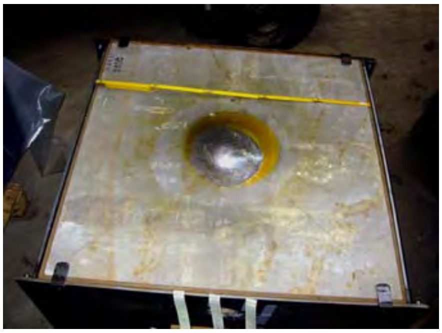

Fig. 2a Exp 2808, crater in dry sandstone block

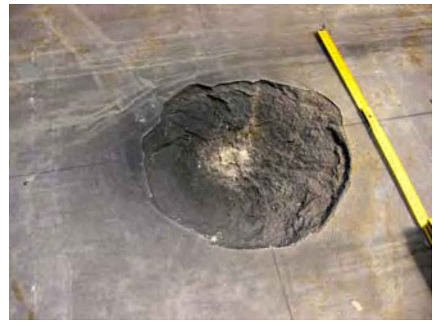

Fig. 3a Exp 2809, crater in wet sandstone block

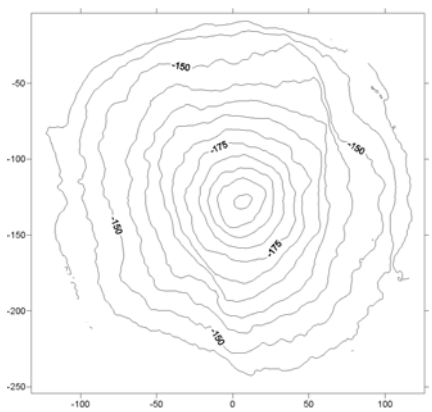

Fig. 2b Contour line plot of the dry target crater; the -140 mm contour represents target surface

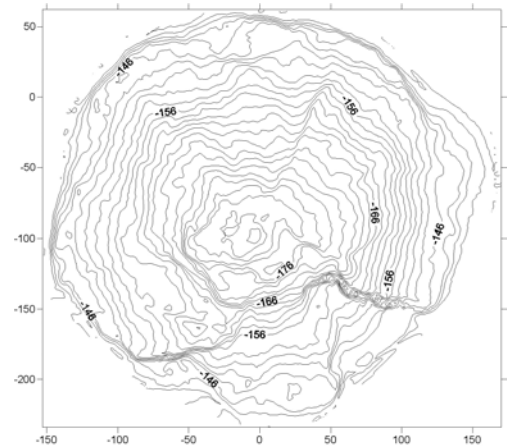

Fig. 3b Contour line plot of the wet target crater; the -140 mm contour represents the target surface

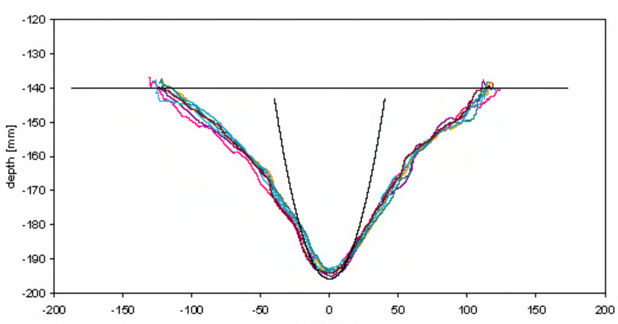

Fig.2c Profiles in various directions across the dry target crater

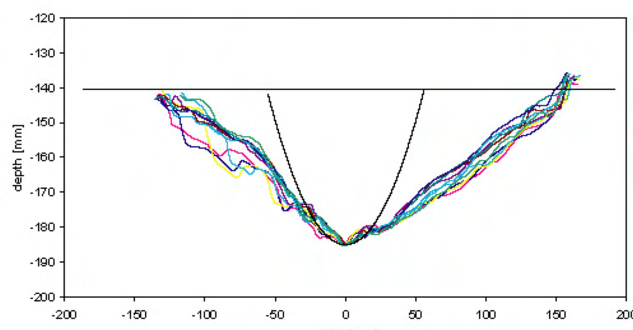

Fig. 3c Profiles in various directions across the wet target crater

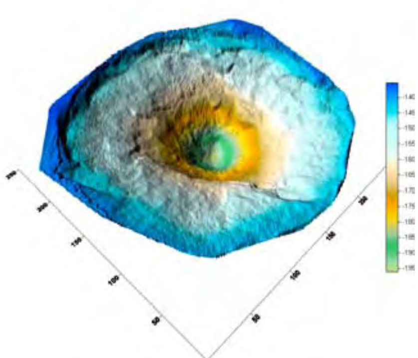

Fig. 2d 3D-scan of dry target crater with coloured depth contours

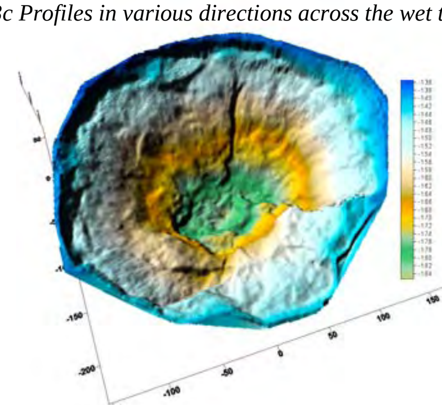

Fig. 3d 3D-scan of crater in wet target with coloured depth contours