NUMERICAL MODELING OF SEISMIC SIGNALS GENERATED BY HYPERVELOCITY IMPACTS IN COMPARISON TO EXPERIMENTAL OBSERVATIONS N. Güldemeister[1], D. Moser[2], K. Wünnemann[1], T. Hoerth[3] and F. Schäfer[3], [1]Museum für Naturkunde, Leibniz-Institut für Evolutions- und Biodiversitätsforschung, Berlin, Germany. (nicole.gueldemeister@mfn-berlin.de) [2]Technische Universität München, Non-destructive Testing Laboratory, München, Germany. [3]Fraunhofer-Institute for High-Speed Dynamics, Freiburg, Germany.

Introduction: Meteorite impacts can be considered as a source for seismic shaking similar to earthquakes. Shock waves that attenuate and turn into seismic waves result in seismic signals that have been recorded in explosion experiments [1] and in hydrocode models of large impact events [2]. To determine how much of the kinetic energy E_{kin} of the impactor is turned into seismic energy E_{seis} can be investigated experimentally or by numerical models. The ratio of E_{seis}/E_{kin} is the so-called seismic efficiency k which depends on material properties and is usually estimated to range between 10^{-2} and 10^{-6} [1,3].

In the framework of the "MEMIN" (multidisciplinary experimental and modeling impact crater research network) project the stress wave was recorded in a suite of hypervelocity impact experiments on a decimeter scale [4] by acoustic emission (AE) technique and newly developed pressure gauges. An important complementary method to analyze wave propagation is numerical modelling. The study aims at the validation and calibration of material models against static observations (US tomography) and dynamic measurements of the acoustic signal. Considering a nonporous quartzite and a porous sandstone target we focus on the detection of the propagation of the elastic wave. In a further step these data may be used to quantify the seismic efficiency of hypervelocity impacts.

Methods: We used special AE transducers attached to all sides of the target block at different distances from the impact point. Additionally, we employed pressure gauges, developed and manufactured at Fraunhofer EMI that allow for relating the measured voltage signal with mechanical stress amplitudes. The experimental setup enables to determine the attenuation of the signal with distance. For the numerical models we used the multi-material, multi-rheology hydrocode iSALE [e.g. 5] coupled with ANEOS [6] for quartzite [7] and the ε-α compaction model [5, 8]. The model accounts for the linear dependency of wave velocity on porosity [8]. Elastic wave velocities were determined to be 5000 m/s for nonporous quartzite and 2800 m/s for porous sandstone by ultrasound measurements before the experiment. Numerical gauges recorded thermodynamic and mechanical parameters as a function of time. Thus, the elastic waves and the arrival of the first wave signal can be analyzed.

Results: First-arrival-times of impact-induced waves picked from time-series recorded at impact experiments into quartzite and sandstone targets are plotted vs. distance in Fig. 1. We obtained a wave velocity of about 5090 m/s experimentally and 4900 m/s numerically for the quartzite target (Fig. 1). For the sandstone target the velocity is 2700 m/s in the experiment and 2900 m/s in the numerical model (Fig.1). The pressure gauges yielded a velocity of about 2900 m/s. The dynamic measurements are all in excess of the US velocity of 5000m/s (quartzite) and 2800 m/s (sandstone). Generally, we find a good agreement between numerical and experimental data in terms of the arrival time and signal phase. We estimated the seismic efficiency k of $2 \cdot 10^{-2}$ for quartzite and of $3 \cdot 10^{-4}$ for sandstone using the expressions in [1,3]. The seismic efficiency is significantly smaller for porous targets and thus less seismic energy is induced.

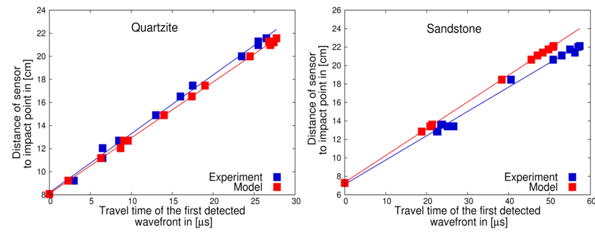

Fig. 1: Linear propagation of the elastic wave front. The plot shows the distances of different sensors versus first arrival time for quartzite (**left**) and sandstone (**right**).

Discussion: It is in general possible to use acoustic emission technique to record the seismic signal during laboratory impact experiments. The dynamically obtained results (AE, pressure gauges and numerical model) verify static ultrasound measurements. The experimentally determined propagation speed of the seismic signal during impact events agrees well with numerical models for quartzite and sandstone targets. The propagation velocity of the elastic wave is reduced in porous material. Thus experiments on the laboratory scale enable a good validation and calibration of numerical models against experimental observations. Additionally, we will use special sensors to determine pressure amplitudes to further calibrate our material models. Rigorously tested material models will enable to quantify the seismic efficiency of meteorite impacts by numerical models. The present results are generally consistent with estimates from the literature. However, further improvements will allow for a much more accurate determination of seismic shaking generated by meteorite impact.

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