NON-DESTRUCTIVE TESTING OF THE FRACTURE ZONE GENERATED BY MODEL IMPACTS UNDERNEATH SANDSTONE CRATERS BY MEANS OF ULTRASOUND AND ACOUSTIC EMISSION.

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Introduction: The research project MEMIN (**M**ulti-disciplinary **E**xperimental and **M**odeling **I**mpact Research **N**etwork) funded by the German Research Foundation (Deutsche Forschergemeinschaft, DFG) as FOR 887 is a collaborative project investigating body-body collisions including the dynamic rock failure due to hypervelocity impact (Poelchau et al. [1]). The subproject led by the Technical University of Munich is devoted the characterization of the target sandstone before, during and after the impact including the damaged fracture zone beneath the crater with high spatial resolution. To detect inhomogeneities and cracks methods are developed based on ultrasound and acoustic emission techniques.

Acoustic emission techniques will in particular contribute to a better understanding of the timely and spatial formation of the damage zone underneath crater structures in terms of the degree of fragmentations. In-situ inspection of the change in acoustic properties due to the impact induced fracturing will provide important information for the interpretation of geophysical (seismic) signatures of natural impact structures.

Through-transmission ultrasound techniques are a proper tool to characterize these structures. Usually, the target is evaluated by interpreting transient waves being propagated by analyzing signal amplitude, frequency content, travel time and wave velocity.

Techniques used for measurements: Three different methods in particular are used to evaluate the target.

- **a. Ultrasonic phase spectroscopy:** Compared to seismic applications higher frequencies in the range of 20 kHz up to 1 MHz are used to apply ultrasonic techniques. It is necessary to consider all parts of the measurement chain quantitatively by means of frequency transfer functions. With the ultrasonic phase spectroscopy (UPS), also known as the pi-phase-comparison method, the phase velocity can be determined along the ray path eliminating all other influences including the transfer function of the sensing equipment. This technique was developed by Wanner [2] and Ruck [3]. Applications at concrete structures are reported by Finck et al. [4] and Grosse et al. [5].
- **b. Acoustic Emission Technique:** Using the acoustic emission technique (AET) the fracturing of a structure is observed during an experiment. Acoustic emissions can be considered to be a form of microseismicity that is similar to earthquakes generated during the failure process as materials are loaded and are related to a spontaneous release of localized strain energy in stressed material. With AE transducers attached to the surface the elastic waves released during the formation of cracks can be recorded and analyzed in respect to their origin (hypocenter determination) and to the fracture mechanical process responsible for cracking ([6]; [7]). The evaluation techniques can be applied analog to seismological data evaluation techniques but used on a different - i.e. much smaller - scale (Fig.1).

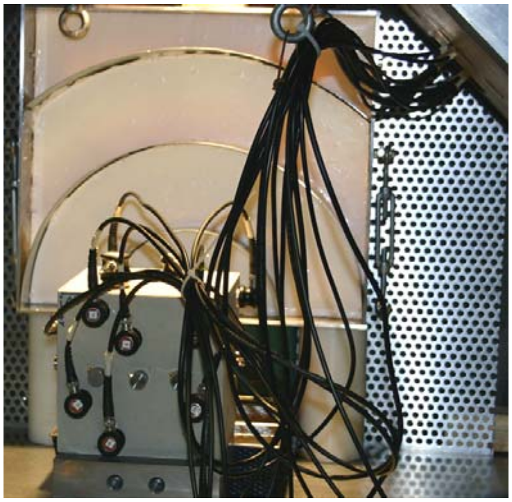

Figure 1: Setup of sensors and sandstone target ($20cm^3$) for the acoustic emission experiment in the target chamber of the Ernst-Mach-Institut (EMI) [1].

- **c. Tomography:** Through-transmission ultrasound techniques can be used to characterize rocks. Using tomographic algorithms 2D material properties have to be derived from many 1D measurements, or 3D properties from many 2D measurements, respectively. Assuming homogeneous media and short emitter-receiver distances the signals can be considered as traveling on straight rays through the medium. In a more general point of view the exact travelpath is unknown. Tomographic techniques can make use of different types of waves, e.g. shear waves (Fig.2). Using diffraction techniques [8] additional information can be obtained using a velocity background model to calculate scatting hyperbolas for each grid-point.

Measurements: To get detailed information about the changing target during the experiments we make several measurements before, during and after the impact. Ultrasound tomography and phase spectroscopy techniques are

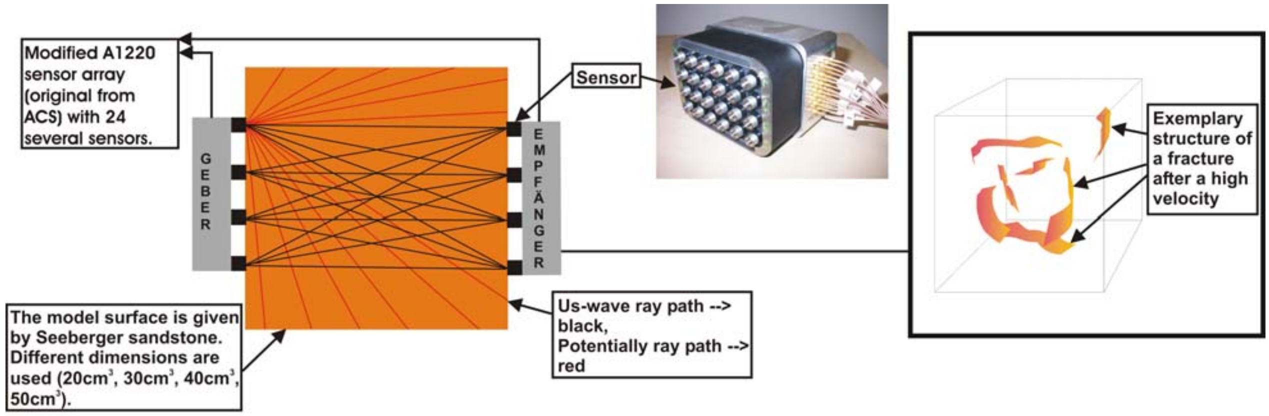

Figure 2: Schematic diagram of shear wave tomography using a modified shear wave sensor array.

applied to study the stratigraphy, porosity and moisture content. This information is required for a start model. To conduct the measurements different sensor types are used varying also the grid size for a better resolution. During impact the AE activity is recorded continuously to observe the formation of micro-cracks. Additionally it is planned to determine the crack size, orientation and crack type of the localized cracks.

Intention of the measurements: Assuming the damage below the crater is available the Acoustic Emission Technique (AE) data contain information about the position as well as the orientation of the cracks, so that there is further information about the mechanical process. Ultrasonic phase spectroscopy and Tomography methods can then support the findings of the AE.

The information gained in these experiments has the potential to be compared to geophysical mearurements the subsurfaces damage zone in terrestrial craters.

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