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High Strain Rate Testing of Rocks using a Split-Hopkinson-Pressure Bar

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Dynamic mechanical testing of rocks is important to define the onset of rate dependency of brittle failure. The strain rate dependency occurs through the propagation velocity limit (Rayleigh wave speed) of cracks and their reduced ability to coalesce, which, in turn, significantly increases the strength of the rock. We use a newly developed pressurized air driven Split-Hopkinson-Pressure Bar (SHPB), that is specifically designed for the investigation of high strain rate testing of rocks, consisting of several 10 to 50 cm long strikers and bar components of 50 mm in diameter and 2.5 meters in length each. The whole set up, composed of striker, incident- and transmission bar is available in aluminum, titanium and maraging steel to minimize the acoustic impedance contrast, determined by the change of density and speed of sound, to the specific rock of investigation. Dynamic mechanical parameters are obtained in compression as well as in spallation configuration, covering a wide spectrum from intermediate to high strain rates (10^0-10^3 s^{-1}). In SHPB experiments [1] one-dimensional longitudinal compressive pulses of diverse shapes and lengths - formed with pulse shapers - are used to generate a variety of loading histories under 1D states of stress in cylindrical rock samples, in order to measure the respective stress-strain response at specific strain rates. Subsequent microstructural analysis of the deformed samples is aimed at quantification fracture orientation, fracture pattern, fracture density, and fracture surface properties as a function of the loading rate. Linking mechanical and microstructural data to natural dynamic deformation processes has relevance for the understanding of earthquakes, landslides, impacts, and has several rock engineering applications. For instance, experiments on dynamic fragmentation help to unravel super-shear rupture events that pervasively pulverize rocks up to several hundred meters from the fault core [2, 3, 4]. The dynamic, strain rate dependent behavior with strongly increasing strength and changing fracturing process has not been consequently considered in modeling of geo-hazards such as earthquakes, rock falls, landslides or even meteorite impacts [5]. Incorporation of dynamic material data therefore will contribute to improvements of forecast models and the understanding of fast geodynamic processes.

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