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Cracking of pebbles in sediments (SE Vienna Basin, Austria): Lithostatic pressure versus static stress change

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We investigated brittle fractures in pebbles that are frequently radially cracked at indentation sites, in unconsolidated sediments within a gravel pit south of St. Margarethen (Burgenland, Austria). The outcrop is located in the Neogene Eisenstadt-Sopron Basin, which is a sub-basin on the SE border of the Vienna Basin. The sediments, which were deposited during the Sarmartian and Pannonian, represent a succession of deltaic gravels with intercalations of shallow-marine calcareous sands. The overburden on the exposed sediments never exceeded 200m. Extensional tectonics in these sediments resulted in the generation of conjugate sets of predominately WNW- and subordinate ESE-dipping normal faults. These faults were primarily localized in meter-thick gravel layers and, with increasing displacement, eventually crosscut other lithologies.

The gravel layers contain a significant number of cracked pebbles. Detailed structural mapping revealed that these are not uniformly distributed: The abundance is higher within layers of matrix-free, well sorted gravels, but also seems to be related to the mechanics of faulting within the sediment. In order to find the controlling factors for the localization of pebble fracturing, grain-size distribution and shape and the number of point contacts of the pebbles were statistically measured. The results were then used as input parameters for numerical modelling.

The Discrete Element Method (PFC3D, Itasca Cons.) was applied to simulate the effect of overburden on a certain volume of particles (i.e. the pebbles). The magnitude and the distribution of contact forces between the particles were observed and compared with the fracture resistance of natural pebbles, determined by point load testing in the laboratory.

Results from numerical modelling indicate that the estimated maximum overburden of 200m would not have been able to generate contact forces high enough to crack a significant number of pebbles. We therefore conclude that cracking was related to static stress changes caused by fault-slip.