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Who cracked the pebbles in the gravel pit - lithostatic pressure or a bunch of faults?

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The occurrence of radially, brittle fractured pebbles from unconsolidated sediments were investigated in 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 Sarmatian and Pannonian (12.7-7.2 Ma), represent a succession of deltaic gravels with intercalations of shallow-marine calcareous sands. Extensional tectonics in these sediments resulted in the generation of conjugate sets of predominately WNW- and subordinate ESE-dipping normal faults (shear deformation bands). These faults were primarily localized in meter-thick gravel layers and, with increasing displacement, eventually cross-cut other lithologies.

The gravel layers contain a significant number of cracked pebbles. Detailed structural mapping of the distribution of cracked pebbles revealed their preferential occurrence in the vicinity of the normal faults and, in these, within zones of roughly uniform-sized pebbles. The findings indicated a strong relation to the mechanics of faulting within the sediment. To find the controlling factors for the localization of pebble fracturing, the grain-size distribution and shape and the number of point contacts of the pebbles were statistically measured. Furthermore, on the basis of point load tests, a breakage criterion was statistically defined which characterizes the breakage behaviour of the pebbles. The results were then used as input parameters for numerical modelling.

The Discrete Element Method was applied to simulate the effect of overburden on a certain volume of particles (i.e. the pebbles). In numerical uniaxial compression simulations, the magnitude and the distribution of contact forces between the particles were monitored during compressive loading and repetitively compared with the breakage criterion. If a particle in the simulation reached the criterion, it was automatically considered as cracked. In this way the relative occurrence of cracked pebbles could be estimated.

Results from numerical modelling indicate that a maximum estimated overburden of a few tens of meters would not have been able to generate contact forces high enough to crack the significant number of pebbles that have been observed in some parts of the outcrop. We therefore conclude that cracking was related to faulting by force jamming due to pebble reorganization and/or by contact force concentrations due to boundary effects of layering.