Fractured clasts: A tool for estimation of earthquake hazard

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The accuracy of earthquake hazard estimations is seriously limited by the availability of instrumental data only from the last one hundred years and often low reliability of the historical record. These restrictions are especially important for the intraplate areas with a long recurrence interval of earthquakes. It appears that extending the period of observations by including the geological record of earthquakes may facilitate the evaluation of earthquake hazard.

Fractured clasts in gravels and conglomerates occur in numerous areas within Pleistocene and Holocene fluvial terraces. A common feature of strata bearing fractured clasts is their occurrence close to the map-scale faults. It follows that the fracturing is, at least partly, tectonic in origin. Moreover, fractured clasts are observed in numerous areas of recent and historical seismicity. Consequently, the origin of fracturing is believed to be related largely to earthquakes. Our studies of Neogene strata in Outer Carpathians, Red River Fault Zone and Iceland show that: (1) clast cutting fractures comprise neofractures (joints and minor faults) formed *in situ* and fractures inherited from mineralised joints and minor faults cutting host strata in the source area; (2) the *in situ* formed fractures show well organized architecture whereas, the architecture of the inherited fractures is poorly organized; (3) the *in situ* formed fractures are tectonic in origin except for the frost induced fractures; (4) the architecture of the *in situ* tectonic fractures is independent of clasts: lithology, size, shape and orientation, whereas the architecture of frost-induced fractures is largely controlled by clast fabrics.

Fractured clasts occur commonly in the Miocene conglomerates within the Vietnamese segment of the Red River Fault Zone. However, in the latter area the Holocene gravels are devoid of fractured clasts. The area is recently seismically active, with historical earthquakes attaining magnitudes up to 5.5. We believe therefore, that, at first approximation, clast fracturing takes place only if the magnitude of the related earthquake exceeds 5.5. The last conclusion needs verification. Results of our studies show that, within a given clast population, a number of clasts cut by tectonic fractures depends on clast lithology. The accuracy of earthquake hazard estimations for the intraplate areas can be improved by extending the period of observations by including the geological record of earthquakes. The record is provided by tectonic fractures cutting clasts in the Pleistocene and Holocene fluvial gravels and conglomerates. The geological record of earthquake magnitude depends lithology of the fractured clasts.