THE FAULT DAMAGE ZONE AS BARCODE OF EARTHQUAKES

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The spatial footprint of a brittle fault is usually dominated by a wide halo of deformation bands and fractures surrounding a narrow, highly deformed fault core [1, Fig. 1]. This diffuse damage zone relates to the deformation history of a fault, including its seismicity, and has a significant impact on flow and mechanical properties of faulted rock [2, 3]. Here, we propose a new mechanical model for damage-zone formation. It is deduced from a novel mathematical theory postulating fundamental material instabilities in solids associated with volumetric deformation due to solitary elastoviscoplastic P-waves: cnoidal waves [4]. We show that transient cnoidal waves triggered by fault slip events can explain the typical distribution and extent of deformation bands and fractures within natural fault damage zones (Fig. 1). As a result, the damage zone can be considered as a barcode of earthquakes and inverted for earthquake overpressure and material properties of the host rock. Hence, cnoidal-wave theory may open a new chapter for predicting seismicity, material and geometrical properties as well as the location of brittle faults.

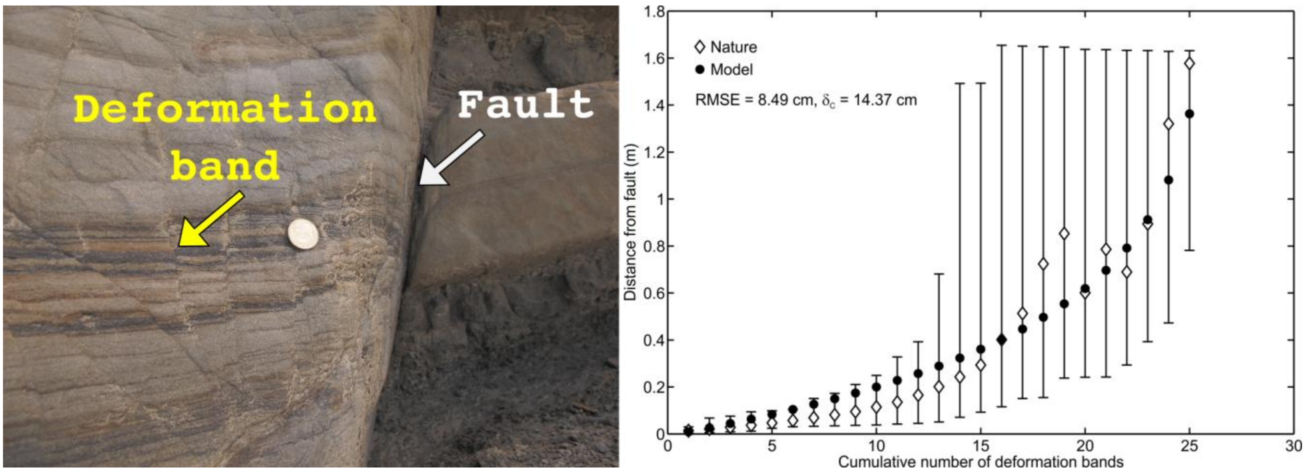

Figure 1. Left: Photograph of a normal fault (white arrow) cutting sand-, silt- and mudstones (Castlepoint, New Zealand). Its slip surface contains entrained mudstone and accommodated a vertical displacement of ~1.75 m. The fault exhibits a marked damage zone where deformation-band spacing increases non-linearly away from the core. Right: Plot of distance of deformation bands normal to the fault versus cumulative number of bands for the natural case and our best-fit model using transient cnoidal waves. The spatial statistics of the natural data were computed along 250 fault-normal scan lines. The diamonds indicate the mean distance of the nth band in nature. The vertical bars denote the lower and upper limit of the related distance distribution.

References

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