Microscopic Defect Dynamics of a Brittle-to-Ductile Transition

Hamed Ghaffari[1], Uli Mok[1], Hilary Chang[1], Tushar Mittal[1], Alejandra Quintanilla Terminel[1], Brian Evans[1], *Matej Pec[1]

1. Massachusetts Institute of Technology

The strength of the Earth' s crust likely reaches a peak in the "brittle-to-ductile " transition region where fracturing gives way to crystal-plastic deformation. The activity and interactions of microscopic defects such as cracks, twins and dislocations are important elements in determining whether rocks creep steadily or fail abruptly resulting in an earthquake. Here, we use ultrasound probes to study acoustic emissions in marbles that are deforming within the brittle-to-ductile transition. The acoustic signals provide insight into the microscopic defect dynamics. We identify three dominant classes of emitted waveforms: 1) long-period signals, abundant at low confining pressures associated with microcracking, 2) short-period signals localized in frequency domain associated with twinning, and 3) low-amplitude, high-frequency signals common at higher pressures associated with glide of dislocations. With increasing pressure, the dominant frequency of events increases from ~0.5 MHz to >40 MHz and deformation de-localizes on the sample scale; cracking is suppressed, and twinning and dislocation glide become dominant. Complex hybrid events indicate that interactions between the defects are common over the whole studied pressure range.

Keywords: brittle-ductile transition, rheology, acoustic emission

