The Role of Cracks in the Nonlinear Elasticity of Rocks

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ABSTRACT: Rocks are generally assumed to be linear elastic materials, despite wide acceptance that this is not true. In fact, rocks show a strong dependence of their elastic properties on strain. As a result, it is possible to do wave-mixing experiments in rock samples in which two waves interact with one another, and to infer rock properties from these interactions. We have been developing such an experiment, in which a strong S-wave is used to induce a strain in a rock sample. This strain is then sensed with a much smaller amplitude P-wave propagating orthogonally to the S-wave (so that the two waves have aligned particle motions). We then measure the delay in the P-wave induced by the S-wave, a change of much less than 1/1000th of the total P-wave travel time. It is has long been suspected that grain-scale cracks are a primary cause of the observed nonlinearity in rocks. To test this hypothesis, we have performed this experiment in two orientations on a sample known to have aligned micro cracks. The results highlight that cracks do indeed appear to play a significant role in the observed nonlinearity.e.

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