



The New Geophysics: a new understanding of fluid-rock deformation

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Widespread observations of stress-aligned shear-wave splitting (seismic birefringence) demonstrate that almost all *in situ* rocks at depth in the Earth's crust (and almost certainly upper mantle) are pervaded by distributions of stress-aligned fluid-saturated grain-boundary cracks, aligned pores, and pore throats. The evolution of such fluid-saturated microcracks can be modelled by Anisotropic Poro-Elasticity (APE), where the mechanism for deformation is fluid movement by flow or dispersion along pressure gradients between neighbouring microcracks at different orientations to the stress field.

Numerical modelling with APE matches exactly deformation in those few occasions where changes at depth can be accurately specified. APE approximately matches all changes involving cracks, stress, and shear-wave splitting in some 20 different phenomena (and millions of individual observations).

The reason for the success of the nearly-parameterless dimensionless APE is that the fluid-saturated microcracks in almost all igneous, metamorphic, and sedimentary rocks in the crust are so closely spaced, and so near fracture-criticality and fracturing that they are critical systems with all the universality and calculability that implies. This new understanding of fluid-rock (pre-fracturing) deformation is a New Geophysics with advantages and disadvantages over conventional sub-critical geophysics. The advantages are substantial. Low-level pre-fracturing deformation can be: *monitored* with shear-wave splitting; *calculated* by APE; future behaviour *predicted* by APE (when changed conditions can be specified); and in some circumstances, future behaviour potentially *controlled* by feedback. Consequently, the New Geophysics is likely to have a fundamental effect on the theory and practice of most solid earth geophysics ranging from earthquake prediction (stress-forecasting) to monitoring hy-

drocarbon production with time-lapse seismics.

The evidence for and implications of the New Geophysics will be discussed.