THE FRACTURE CRITICALITY OF ROCKS IN THE UPPER HALF OF THE CRUST

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The shear-wave splitting observed along almost all shear-wave raypaths in the Earth’s crust is interpreted as the effect of stress-aligned fluid-filled cracks, microcracks, and preferentially oriented pore-space. Once away from the free-surface, where open joints and fractures may lead to strong anisotropy of 10% or greater, intact ostensibly-unfractured crustal rock exhibits a limited range of shear-wave splitting from about 1.5% to 4.5% differential shear-wave velocity anisotropy independent of rock-type. Interpreting this velocity anisotropy as normalized crack densities, a factor of less than two in crack radius covers the range from the minimum 1.5% anisotropy observed in intact rock to the 10% observed in heavily-cracked almost disaggregated near-surface rocks.

This narrow range of crack dimensions and the pronounced effect on rock cohesion suggests that there is a state of fracture criticality at some level of anisotropy between 4.5% and 10% marking the boundary between essentially intact, and heavily fractured rock. When the level of fracture criticality is exceeded, cracking is so severe that there is a breakdown in shear strength, the likelihood of progressive fracturing and the dispersal of pore fluids through enhanced permeability.

This recognition of the essential compliance of most crustal rocks, and its effect on shear-wave splitting, has implications for monitoring changes in any operation that affects the rockmass.