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Depth dependent stress revealed by aftershocks

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Characterising the state of stress in the brittle upper-crust is essential in mechanics of faulting, industrial production processes and operational earthquake forecasting. Nevertheless, unresolved questions concern the variation of pore-fluid with depth and the absolute strength on tectonically active faults. Here we show that, along the San Andreas fault system, the time- delay before the onset of the power-law aftershock decay rate (the c-value) varies by three orders of magnitude in the first twenty kilometres below the surface. Despite the influence of the lithostatic stress, there is no continuous change in c-value with depth. Instead, two decay phases are separated by an abrupt increase at an intermediate depth range of 2 to 5 km. This transitional regime is the only one observed in fluid-injection-induced seismic areas. This provides strong evidence for the role of fluid and a porosity reduction mechanism at depth of few kilometres in active fault zones. Aftershock statistics can then be used to predict changes in differential shear stress with depth until the brittle-ductile transition is reached. The research was partially supported by Russian Science Foundation (Project 16-17-00093).