Geophysical Research Abstracts
Vol. 18, EGU2016-5428, 2016
EGU General Assembly 2016

The Active Solid Earth

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Dynamic processes in Earth's crust, mantle and core shape Earth's surface and magnetic field over time scales of seconds to millennia, and even longer time scales as recorded in the ca. 4 Ga rock record. Our focus is the earthquake-volcano deformation cycles that occur over human time scales, and their comparison with time-averaged deformation studies, with emphasis on mantle plume provinces where magma and volatile release and vertical tectonics are readily detectable. Active deformation processes at continental and oceanic rift and back arc zones provide critical constraints on mantle dynamics, the role of fluids (volatiles, magma, water), and plate rheology. For example, recent studies of the East African rift zone, which formed above one of Earth's largest mantle upwellings reveal that magma production and volatile release rates are comparable to those of magmatic arcs, the archetypal zones of continental crustal creation. Finite-length faults achieve some plate deformation, but magma intrusion in the form of dikes accommodates extension in continental, back-arc, and oceanic rifts, and intrusion as sills causes permanent uplift that modulates the local time-space scales of earthquakes and volcanoes. Volatile release from magma intrusion may reduce fault friction and permeability, facilitating aseismic slip and creating magma pathways. We explore the implications of active deformation studies to models of the time-averaged structure of plume and extensional provinces in continental and oceanic plate settings.