The Apparent Stress Controversy: Does Earthquake Self-Similarity Hold and Who Cares?

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A number of recent studies, both from seismic observations and state-of-the art laboratory friction experiments, challenge the idea of self-similarity of earthquakes. Using a novel technique based on the stable properties of seismic coda (Mayeda et al., 2007; Mayeda and Malagnini, 2010) 19 large magnitude seismic sequences (Mw 6+) from different faulting regimes and tectonic environments, show a gradual increase in apparent stress up to around Mw 5.5, then becomes self-similar at higher magnitudes. This magnitude range typically corresponds to fault slip up to a few tens of centimeters, and amazingly this amount of fault slip corresponds to recent laboratory friction experiments that show complete lubrication when slip exceeds a few tens of centimeters at seismic slip velocities (V=1 m/s) and normal stresses representative of crustal depths. The laboratory results strongly suggest that real faults will weaken considerably when seismic slip exceeds a few tens of centimeters, however the mechanism of slip weakening can vary greatly depending upon the rock type (Di Toro et al., 2011). The seismic and laboratory observations taken in total support that there is a gradual increase in apparent stress up to Mw ~5.5 as the fault surface begins to weaken, then becomes more or less constant due to complete fault lubrication, thus resulting in constant apparent stress, or self-similar behavior.