A Fluid-Driven Earthquake Cycle

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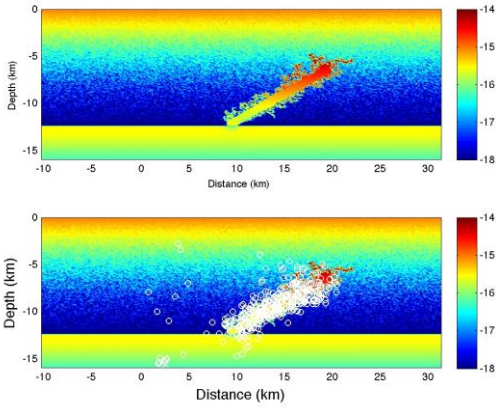
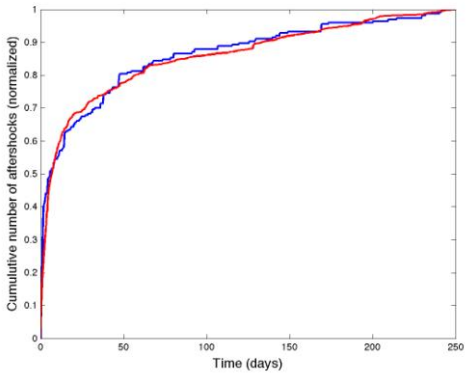
ABSTRACT

Increasing evidence suggests that fluids play an integral role in tectonics and the earthquake cyclef, including the 1997 Colfiorito earthquake sequence [*S. A. Miller et al.*, 2004] that showed the aftershock sequence was driven by degassing of a deeply sourced and overpressured reservoir of CO_2. Subsequently, it was demonstrated that high-pressure fluids (presumably also CO_2) played an important role in the 2009 L'Aquila earthquake [*Terakawa et al.*, 2010]. That CO_2 played a role in these Apennine earthquakes is not surprising considering the ubiquity of CO_2 degassing observed in Italy [*Chiodini et al.*, 2011].

The non-linear diffusion model used to simulate the Colfiorito earthquake sequence also successfully modeled the Basel fluid injection experiment [*S.A. Miller*, 2014] with the caveat that permeability was allowed to increase by a factor of about 500 when the failure condition was reached. Recently, this model was combined with a model that mimics precipitation by requiring the permeability to decrease exponentially with time, consistent with a distance from equilibrium type relationship. This addition to the model produces exciting results because the combination of the physically reasonable exponential dependence of permeability on the effective normal stress with the exponential decrease in permeability with time due to precipitation produces Omori's Law.

The model was applied to the 1994 Northridge thrust earthquake, using a high pressure source at depth and an initially high fluid pressure within a model slip zone. The well-constrained hypocenter data from Northridge earthquake was compared to the evolved permeability (Figure 1a), and Figure 1b compares the (normalized) cumulative number of aftershocks between observation and model, and demonstrates convincingly that this simple mechanistic model reproduces Omori's Law.





References (Font: Arial, 11, Bold)

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