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The role of decarbonization and dehydration in aftershock genesis.

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The 2011 Tohoku earthquake in northern Japan triggered thousands of aftershocks within a few days. The 2016 Amatrice-Visso-Norcia (AVN) earthquake sequence in the central Apennines (Italy) triggered hundreds of thousands of aftershocks in the first year, and the 2021 earthquakes in Greece (March 3, 2021 and in Crete on September 12, 2021) triggered numerous sizable aftershocks within a few days. In contrast, an earthquake 100 km east of the Crete earthquake (Oct. 12, 2021) generated almost no aftershocks. Additionally, great earthquakes in Pakistan (M7.8, 2011) and Iran (M7.7, 2013) also spawned no aftershocks. These observations contradict generally accepted physical models for aftershock genesis.

In this talk, I compare the rich AVN earthquake sequence with earthquakes that generate few aftershocks and demonstrate through modeling that aftershocks are driven by co-seismically generated (high-pressure) fluid sources through thermal decomposition. Earthquakes without trapped fluid sources at depth, or without thermal decomposition generate few, if any aftershocks.

The AVN sequence showed dramatic differences in aftershock rates along strike, with non-Omori type aftershock behavior. Using a non-linear diffusion model that captures permeability dynamics in the crust combined with a source term to account for thermal decomposition, we show excellent agreement between model and observations for the entire Italy AVN sequence.