Earthquakes without aftershocks: Is there a link to fluid-absent geodynamics?

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One question that remains unanswered is why some earthquakes are preceded by foreshocks and generate aftershocks by the thousands, while other similarly-sized (or larger) earthquakes produce few, if any, foreshocks or aftershocks. Current understanding equates large magnitude earthquakes with hundreds or even thousands of aftershocks, however a magnitude 7.1 earthquake in Mexico in 2017 and a magnitude 8.0 earthquake in 2019 in Peru generated no foreshocks and no aftershocks (M>4), while the 2020 M6.4 earthquake in Puerto Rico was preceded by ten foreshocks (M>4) and more than sixty aftershocks (M>4) in the first week. The 2019 Ridgecrest earthquake (M7.1) in California was preceded by a M6.4 foreshock and thousands of aftershocks, and this is relevant because this sequence occurred in the fluid-rich Coso hydrothermal/volcanic region. Other examples include the 2001 Kunlun (Tibet) earthquake (M=7.8) that generated a mere 12 aftershocks (M>4) in the first three weeks, while the tectonically similar 2002 Denali earthquake (M=7.9) spawned nearly 160 aftershocks (M>4) in the first three weeks. We attribute this contrasting behaviour to the geodynamic setting; subduction (and thus devolitization) underlies Denali, while a fluid-absent thickened crust (from the Himalayan orogeny) underlies Tibet.

In this work, we performed a global inventory of large earthquakes and their aftershocks, and find strong evidence that aftershock productivity correlates with the geodynamic and petrological settings hosting the earthquakes. In cases where deep fluid sources are likely (using geodynamic arguments), we find that earthquakes are sometimes preceded by foreshocks, and always produce rich aftershock sequences. On the contrary, using the same geodynamic arguments, we show that regions without an obvious deep fluid source produce few, if any, aftershocks. From this study, we hypothesize that, in general, fluid-absent geodynamic environments generate a dearth of aftershocks, while fluid-rich environments generate aftershock sequences that follow the typical Gutenberg-Richter, Bath and Omori Laws.