Towards Understanding Slip on Oceanic Transform Faults through Relatively Predictable Earthquakes

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The long-standing hypothesis that the timing of the largest earthquakes is primarily controlled by seismic cycles, where stress builds up for an extended period of time and then is released suddenly in a large earthquake, has been difficult to verify due to the long repeat times (50-1000 years) of the largest earthquakes on most faults. By contrast, repeat times of the largest oceanic transform fault earthquakes are remarkably short and regular. Furthermore, earthquakes on mid-ocean ridge transform faults (RTFs) show high levels of predictability over many spatial and temporal scales. On short time scales (hours to days) RTFs display high levels of foreshock activity. On intermediate time scales (years) RTFs show the clearest evidence of quasi-periodic seismic cycle behavior in the instrumental record. And on long temporal and spatial scales (decades) the magnitude-frequency distributions of RTF seismicity can be predicted from transform fault lengths and slip rates. We have recently shown that the largest earthquakes on both fast slipping RTFs on the East Pacific Rise and intermediate rate RTFs on the Blanco RTF repeatedly rupture fixed asperities. These asperities are consistent with fully coupled fault patches embedded within regions that fail primarily aseismically. Using the basic hypothesis that the timing of the largest earthquakes is primarily controlled by seismic cycles, we developed a scaling relation for repeat time of the largest RTF earthquakes. This results in repeat times of about 5 years on the EPR faults and about 14 years on the Blanco Transform Fault for stress drops of 3-10 MPa. The periodic nature of the seismic cycles on RTFs allowed us to successfully position an array of ocean bottom seismometers on the Gofar Transform Fault on the East Pacific Rise in 2008 to capture a M_w 6.0 earthquake. The recent Gofar earthquake ruptured a previously documented asperity and was preceded by abundant foreshocks. Our successful experiment on the Gofar Transform Fault has further demonstrated that RTFs have predictable seismic characteristics and clear seismic cycles. From our scaling relation for repeat time of the largest expected RTF earthquakes, we propose additional tests for the timing of earthquakes on the Blanco, Gofar, Discovery, and Clipperton RTFs, which are all expected to have large ruptures in the next few years.