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Slow-slip and low-frequency earthquakes within the shallow, intraplate, Palghar seismic swarm in Western India

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At plate boundaries, the coexistence of classical earthquakes, low-frequency seismicity, and slow slip events is commonly attributed to depth-dependent frictional heterogeneity. Recent numerical studies demonstrate that similar complexity can also emerge from fault–fault interactions even in the absence of frictional heterogeneities. Here we show that this entire spectrum of plate-boundary-style slip processes occurs within an intraplate setting, confined to the upper ~8 km of the crust, during the Palghar earthquake swarm in western India.

Since late 2018, sustained seismicity has persisted within a spatially confined intraplate fault zone traditionally considered tectonically stable. By integrating data from two independent seismic networks (NGRI and NCS), we construct a unified, high-resolution earthquake catalog. Automated detection and precise relocations of 8,629 events with eight or more observations delineate two closely spaced, steeply dipping N–S–striking faults at depths of 6–8 km that host most of the seismicity. The same two fault structures are independently identified through the modeling of surface deformation data within the swarm duration from InSAR. The swarm exhibits broadband rupture behavior, showing both low-frequency events and classical earthquakes, and is characterized by a wide range of stress drops. Moment tensor solutions indicate predominantly normal faulting, consistent with the rake of geodetically inferred slip. InSAR observations further show that cumulative geodetic moment release exceeds the seismic moment by nearly two orders of magnitude, demonstrating that aseismic slip dominates the total strain budget. Both seismicity and slow slip initiate on the western fault and evolve coherently before migrating to the eastern structure. The high-resolution relocated seismicity aligns closely with the advancing front of aseismic slip on both faults, revealing a clear coevolution and coupled migration of seismicity and aseismic deformation.

Together, these observations show that intraplate fault systems can host the same range of slip behaviors observed at plate boundaries, from classical earthquakes to slow slip, driven by

migrating aseismic deformation and fault–fault interactions. Intraplate earthquake swarms, therefore, offer natural laboratories for understanding slip processes and fault interactions beyond plate boundaries.