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Fault spacing enhanced by sedimentation at the Andaman Sea spreading center

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Tectonic models commonly predict that erosion and sedimentation enhance strain localization onto a few major faults at subaerial plate boundaries such as orogens and continental rifts. By contrast, the influence of “seafloor-shaping processes” on the tectonic makeup of submarine plate boundaries has received far less attention. Submarine plate boundaries are however subjected to a wide range of sedimentation rates, and as such constitute excellent natural laboratories to investigate the influence of sediment deposition on seafloor shaping tectonics. Here we assess the impact of sedimentation on fault development at the Andaman Sea spreading center (ASSC), by comparing it to unsedimented mid-ocean ridges (MORs) of commensurate spreading rate (38 mm/yr).

Seafloor spreading has been occurring for the last ~4 Myrs along the ASSC, which is located at the center of a pull-apart basin in the back-arc domain of the Sumatra subduction. Recent bathymetric and seismic reflection data show that fault-induced topography at the ASSC is buried under a sedimentary layer of thickness up to 1.5–2 km. This massive sedimentary input is largely provided by the Irawaddy river, and amounts to an average deposition rate of ~0.5 mm/yr over the last 4 Myrs. The structure of the ASSC is analogous to an intermediate- / slow-spreading MOR, with symmetric, evenly spaced axis-facing normal faults. The characteristic spacing of these faults is however unusually large (8.8 km) and their dips are unusually shallow (~30º) compared to typical MORs.

We use numerical modeling to assess whether sedimentation can explain the unusual longevity of ASSC normal faults. We use the FLAC method to model a spreading ridge subjected to a sedimentation rate ranging from 0 to 1 mm/yr. In our models, a fraction M of plate separation (between 0.6 and 0.8) is taken up by magma injection. This allows the sequential growth of regularly-spaced, axis-facing faults. In the absence of sedimentation, fault lifespan and spacing decrease with increasing M. We find that, for a given M of 0.7 or above, increasing the sedimentation rate increases fault lifespan by as much as ~50%, and the effect plateaus for rates > 0.5 mm/yr. By contrast, we cannot resolve any significant effect of sedimentation on fault lifespan for M < 0.7. The effect of sedimentation is more pronounced on fault spacing, with rates as fast as 1 mm/yr nearly suppressing the decrease in spacing with increasing M.

We propose that sedimentation prolongs slip on active faults by leveling seafloor relief and raising the threshold for breaking new faults. The effect is more pronounced for faults with a slower throw rate, which is favored by a greater *M* fraction. Our simulations show that enhancement of fault lifespan by sediment blanketing is a viable explanation for the anomalously high spacing of normal faults at the ASSC. This could therefore constitute the first field evidence of topographic reworking promoting strain localization at a major plate boundary, a mechanism predicted by over two decades of geodynamic modeling.

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