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Tectonic geomorphology and paleoseismology of the Gatún fault in central Panamá: seismic hazards and the Panamá Canal

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The Gatún fault, a primary east-west structural feature in central Panamá [1], has a strong geomorphic signature that can be readily observed in aerial photographs and digital elevation models (Fig. 1). The fault forms an abrupt southern margin to the Sierra Maestra Mountains, and all rivers and streams that cross the fault are affected at the fault crossing. Most large rivers are left-laterally deflected, and all streams that cross the fault have a 1 to 2-meter, and locally as high as 5-meter near-vertical knickpoint at or directly upstream of the fault. Paleoseismic trenching of the Gatún fault east of Gatún Lake has shown that this fault has experienced at least two, and possibly three, surface-rupturing earthquakes since 1490 AD. Based on 3-D trenching of an ~ 3 ka channel thalweg that is offset 19-20 m, the left-lateral slip rate on the Gatún fault is 6-9 mm/yr with a maximum of 20% north-side up normal slip, and the most recent earthquake in the mid-late 1800s generated at least 0.7 ± 0.2 meters of left-lateral surface offset that apparently went unnoticed at the time (Fig. 2). Our best estimate is that this 40 km segment of the Gatún fault has a recurrence interval of $\sim M6.8$ earthquakes every 110-170 years based on the last three events, but if the fault is capable of multi-segment, less-frequent ruptures, the earthquakes could potentially be as large as $M7.4$ if the entire 120 km fault were to rupture. We suspect, but cannot prove, that triggered slip resulted in soil fracturing on the Gatún fault during the 1991 $M7.6$ earthquake on the North Panamá Deformed Belt off the Caribbean coast of eastern Costa Rica. These findings are important for the seismic stability analysis of the AD 1913 Gatún Dam across the Chagres River, one of the most critical structures in the Panamá Canal.

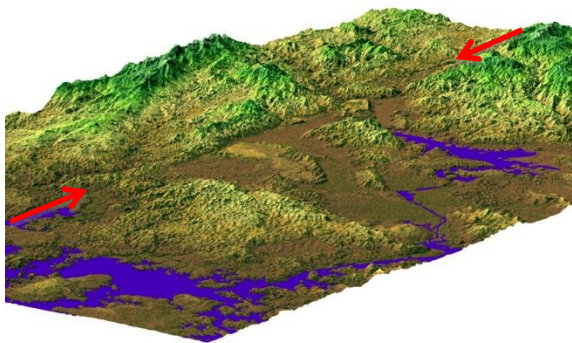


Fig. 1: DEM terrain model showing the spectacular geomorphic expression of the \sim E-W trending Gatún fault (red arrows) across the southern front of the Sierra Maestra range in central Panamá. It is tectonically tempting, but geologically unproven, to reconstruct the two mountain ranges by back-slipping 20 km along the Gatún fault.



Fig. 2: Hand excavation of small trenches into the eastern bench of Trench T-3 allowed us to define and measure the fault displacement for the most recent (blue flags) and penultimate (yellow flags) events based on the offset of discrete channel margins. The MRE was measured at 0.7 ± 0.2 m and the penultimate event a cumulative 1.4 ± 0.3 m. The ~ 500 year third event was displaced beyond the 2 m exposure afforded by the bench.

Reference:

[1] Earth Consultants International, 2005, Paleoseismic investigation of the Gatún and Limón faults in Central Panamá, ECI Project No. 2505; unpublished consulting report prepared for the Autoridad del Canal de Panamá, Project No. 2505, September 2005, 89p.

