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Giant seismites and megablock uplift in the East African Rift: Evidence for large magnitude Late Pleistocene earthquakes

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Due to rapid population growth and urbanization of many parts of East Africa, it is increasingly important to quantify the risk and possible destruction from large-magnitude earthquakes along the tectonically active East African Rift System. However, because comprehensive instrumental seismic monitoring, historical records, and fault trench investigations are limited for this region, the sedimentary record provides important archives of seismicity in the form of preserved soft-sediment deformation features (seismites). Extensive, previously undescribed seismites of centimeter- to dekameter-scale were identified by our team in alluvial and lacustrine facies of the Late Quaternary-Recent Lake Beds Succession in the Rukwa Rift Basin, of the Western Branch of the East African Rift System. We document the most highly deformed sediments in shallow, subsurface strata close to the regional capital of Mbeya, Tanzania, primarily exposed at two, correlative outcrop localities ∼35 km apart. This includes a remarkable, clastic 'megablock complex' that preserves remobilized sediment below vertically displaced breccia megablocks, some in excess of 20 m-wide. The megablock complex is comprised of (1) a 5m-tall by 20m-wide injected body of volcanic ash and silt that hydraulically displaced (2) an equally sized, semi-consolidated, volcaniclastic megablock; both of which are intruded by (3) a clastic injection dyke. Evidence for breaching at the surface and for the fluidization of cobbles demonstrates the susceptibility of the substrate in this region to significant deformation via seismicity. Thirty-five km to the north, dekameter-scale asymmetrical/recumbent folds occur in a 3 m-thick, flat lying lake floor unit of the Lake Beds Succession. In between and surrounding these two unique sites, smaller-scale seismites are expressed, including flame structures; cm- to m-scale folded beds; ball-and-pillow structures; syn-sedimentary faults; sand injection features; and m-dkm-scale clastic injection dykes. Our documentation provides evidence for M 6-7.5+ Late Pleistocene earthquakes, similar to the M7.4 earthquake at the same location in 1910, extending the record of large-magnitude earthquakes beyond the last century. Our study not only expands the database of seismogenic sedimentary structures, but also attests to repeated, large-magnitude, Late Pleistocene-Recent earthquakes along the Western Branch of the East African Rift System. Understanding how seismicity deforms the crust is critical for predicting and preparing for modern seismic hazards, especially along the East African Rift System and other tectonically active, developing regions.