HISTORIC GEODETIC CONSTRAINTS ON CARIBBEAN-SOUTH AMERICA RELATIVE PLATE MOTION, PLATE BOUNDARY ZONE KINEMATICS AND SEISMIC RISK

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ABSTRACT

We are undertaking a cooperative geodetic experiment in Trinidad and Tobago to quantify historic and current strain rates and their distributions in this part of the Caribbean (Ca)-South American (SA) plate boundary zone (pbz). In May and June of 1994 we re-measured, with GPS (Global Positioning System), ~10 recently recovered first-order monuments from a historic triangulation network built and originally measured by the British Ordinance Survey in 1901-03 across Trinidad. We also establish new baselines from these historic marks to several monuments in Tobago, from which we can monitor motions with second-epoch and subsequent GPS campaigns. Our objectives are to constrain the rate and direction of Ca-SA motion in the ppz. These data, which are now lacking, are critical in the establishment of earthquake hazard exposure levels in the region. The low level of shallow (<50 km) seismicity, at all magnitudes, in Trinidad and Tobago since 1953 indicates that lithospheres in this portion of the pbz are either: (1) not straining or straining at a very low rate; or (2a) they are straining completely aseismically (creeping) or (2b) straining away from locked faults with large seismic potentials.

Our historic data should allow us to distinguish between possibilities (1) and (2). Geodetic strains approach total strains, that is, the sum of seismic plus aseismic strain. Hence we should be able to "see" straining that studies of seismicity alone cannot. We will be measuring the accumulation of strain over nearly a century; this is much longer than our record of seismicity in the region. Monuments in the 1901-03 network may be sufficiently closely spaced that we are able to establish whether spatial gradients exit along which displacements and strains diminish to zero on locked faults (possibility 2b).

Our strain rate determination threshold is fixed by: (1) the precision of the 1901-03 triangulation data; (2) strain and plate motion rates and their spatial partitions in the pbz; (3) the precision of our GPS measurements; and (4) the time duration between the 2 sets of geodetic measurements. Regional GPS measurements are precise to at least parts in 10^8 tracking satellites with a global network (e.g., Tralli and Dixon, 1988; Dixon, 1991), which is our plan. Angular measurement errors between first-order triangulation stations represent distance errors of less than 1 part in 10^5; these are often as low as several parts in 10^6 (Bornford, 1971; Turcotte and Schubert, 1982; Billiris et al., 1991). Hence our strain rate threshold is fixed by triangulation, not GPS measurement errors. Given average baseline lengths in the network of ~30 km, we should be able to detect relative motions of at worst several tens of cm, and at best, at the cm-level. NUVEL-1 (DeMets et al., 1991), a global model of current plate motions, indirectly estimates relative Ca-SA angular motion to be $\omega = 63.1^0$ N, 15.2^0 W, 0.13 my^{-1}; that is 13±3 mm/yr of relative Ca-SA motion directed toward S 68 ± 10^0 E in Trinidad and Tobago. Hence, over the past century, >1 m of displacement may have accumulated in the pbz. We should be able to determine whether a significant portion of this motion is being taken up in Trinidad, and if so, how; and after second-epoch GPS measurements, the nature of deformation between Trinidad and Tobago, where many place the lithospheric Ca-SA boundary.