Geodetic Constraints of Rift Initiation Across the Somalia-Lwandle Plate Boundary in Madagascar

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GeoPRISMS Theme: Plate Boundary Deformation and Geodynamics (RIE EARS: 1-3,5)
Key Data Types/Infrastructure: GPS observations across an initiating rift in the EARS, GPS geodesy capacity building

Madagascar may be an ideal setting to study the onset of continental rift formation, however GPS observations are required to confirm extension across the hypothesized Lwandle-Somalia plate boundary. Evidence for deformation across the continental island includes active seismicity (*i.e.* Rambolamanama et al., 1995; Rakotondraompiana et al. 1999), geologically recent volcanism (Bertil and Regnoult, 1998; DeWit, 2003), hot springs (Bertil and Regnoult, 1998), and regional uplift (*i.e.* Kusky et al., 2010; Roberts et al., 2012). Most earthquakes are low magnitude (<M5),

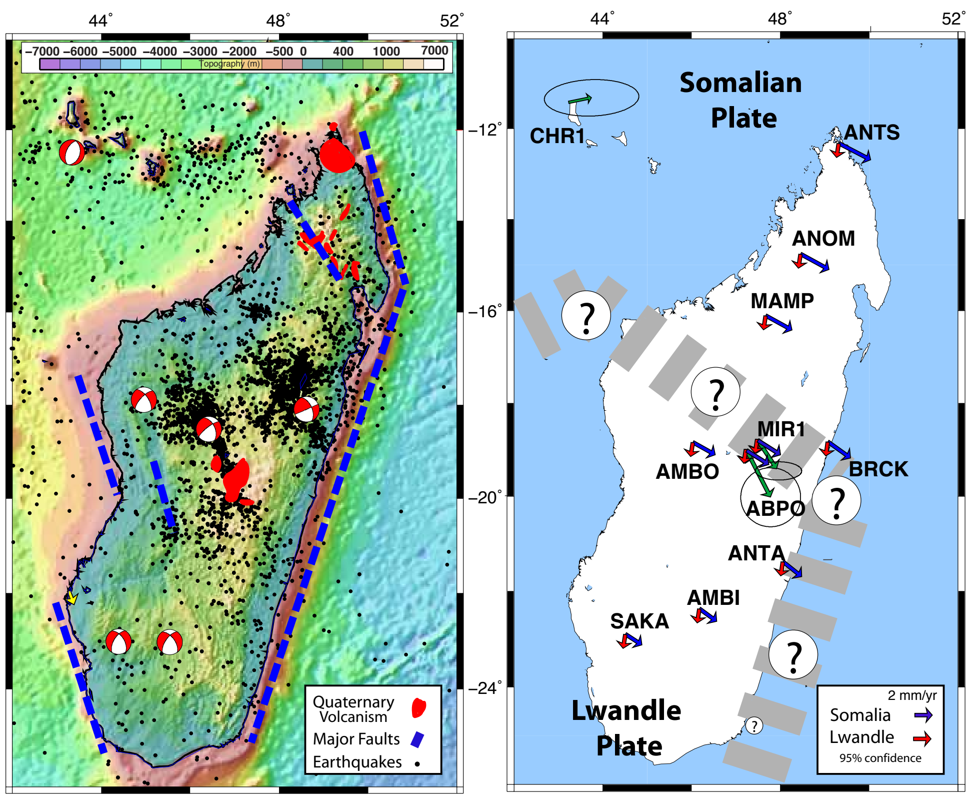

Figure 1: A. Present-day tectonic setting of Madagascar. Seismicity <M_o6 is shown as black circles (per. comm. G. Rambolamanana). Focal mechanisms depict earthquakes >M_o5. Blue dashed lines represent major faults and red indicates Quaternary volcanism (Bertil and Regnault, 1998). Topography is from ETOPO2.B. Existing geodetic markers in Madagascar. ABPO is a continuous site installed in 2008. MIR1 and CHR1 are campaign sites. SAKA, AMBI, ANTA, AMBO, BRCK, MAMP, ANOM, and ANTS were in stalled by Stamps et al. in 2010 and remeasured in 2012. Predicted velocities for Somalia are blue vectors and Lwandle plate motions are red vectors. All velocities are with respect to Nubia and shown with 95% confidence ellipses. A hypothesized plate boundary for Lwandle-Somalia is shown as a gray dashed line (Horner-Johnson et al., 2007; Stamps et al., 2008).

shallow (15-28 km; Rambolamanama, 1995) and tend to localize on multiple fault segments (*i.e.* Bertil and Regnoult, 1998). ∼E-W extension associated with active seismicity may be related to the broader, present-day ∼E-W extension of the East African Rift (Pique et al., 1999; Kusky et al., 2010).

As the easternmost boundary of the East African Rift, Madagascar hosts the only continental segment of the Lwandle-Somalia plate boundary (Horner-Johnson et al., 2007; Stamps et al., 2008; DeMets et al., 2010). The exact location and extensional nature of the Somalia-Lwandle plate boundary is still controversial. For example, Kusky et al. (2010) suggest that extension across Madagascar is diffuse, but no geodetic evidence currently supports this conclusion. A kinematic study of the East African Rift that incorporates seismic data, transform azimuths, spreading rates, and sparse geodetic velocities predicts 1) extensional rates of ∼1-4 mm/yr in Madagascar from S to N with respect to the Nubian plate and 2) part of the Lwandle-Somalia plate boundary crosses central Madagascar (Stamps et al., 2008; Figure 1). The Stamps et al. model incorporates only 1 GPS velocity at site MIR1 in Antananarivo, Madagascar, therefore additional geodetic observations are needed to quantify the present-day kinematics in this region.

We propose developing a velocity field for Madagascar with the long-term goals of:

1. Quantifying strain distribution across the continental island
2. Elucidating the location of the Lwandle-Somalia plate boundary
3. Describing the kinematics of potential continental rift initiation across Madagascar

This work will build upon a new network of geodetic markers established in 2010 and remeasured in July of 2012 (Figure 1, Right). Additional measurements with high-precision Global Positioning System (GPS) instruments will result in the first Malagasy velocity field.

Broader Impacts

This work will support constructing, testing, and implementing instructional materials (traditional and multi-media) aimed at the undergraduate and graduate level students for (1) occupying GPS benchmarks in the field and (2) processing GPS data to obtain precise positions and velocities using GAMIT-GLOBK processing software. The content will be developed with the support of a coauthor of the software and the Education and Outreach staff at UNAVCO (www.unavco.org), an NSF-funded consortium devoted to advancing and supporting geodesy research. All instructional materials will be made available for public download through the UNAVCO website as an educational resource.

Initially, these educational activities will build upon an existing GPS geodesy training program initiated in 2012 at the University of Antananarivo in Madagascar. This team will serve as a mentor and coach to students as they use the new instructional materials to collect their own data and process it for precise positions and velocities using GAMIT-GLOBK. The skills gained by Malagasy students will be new to the country, hence opening up opportunities for both independent and collaborative science related to GPS geodesy. The pilot program at the University of Antananarivo will be documented such that it can serve as a model for future GPS geodesy capacity building efforts in developing countries and within the US.

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