The 3-D Seismic Structure Beneath Madagascar

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Figure 8: Ocean-bottom seismometer locations for the RHUM-RUM proposal. Leg1 track is indicated by the green dashed line, Leg2 by the yellow dashed line. Red & black circles indicate the location of the 9 INSU OBS which are true broadband seismometers. White circles represent the distance of about 150, 300 and 500 km from La Réunion. Permanent stations are indicated by the black dots. Pink dots: planned deployments in the Iles Eparses. Grey dots: planned deployment in Madagascar.
Recent (<1 Ma ago) volcanism has occurred within Madagascar.
Two hypotheses for the recent intraplate volcanism within Madagascar: Grand Comorean plume model, or Fracture Zone Model.
Question: Is surface volcanism connected to the sub-African LLSVP? (Large low-velocity shear velocity province)

Figure 1. Shear-wave tomographic models of Ritsema et al. [1999] (Left) and Simmons et al. [2007] (Right), showing the structure of the African LLSVP (Large Low Shear Velocity Province). (Left) The cross-sections are centered on Madagascar, so that the small white dot corresponds to the location of northern Madagascar, the site of continuing Cenozoic intraplate volcanism. (Right) The top shows the shear-wave velocity anomaly and the bottom shows the calculated temperature anomaly. In all figures, notice how the LLSVP extends beneath east-central Africa, but also bends eastward toward Madagascar.
Reconstruction of the position of the microcontinent Azania within Gondwana (Tucker et al., 2010)

Fig. 1. The microcontinent of “Azania” (Az) and its position within Gondwana (after Collins and Pisarevsky 2005 and Collins 2006). The “Betsimisaraka suture” (BS) is interpreted as the Neoproterozoic site of the India–Azania collision, and a provenance boundary between terranes derived from East Africa (It, Itremo; Ant, Antananarivo) and the Dharwar Craton of India (A, Antongil; M, Masora). A–A, Afif–Abas terrane; B, Bemarivo domain; MB, Mozambique belt (accreted southern terranes of Androyen and Vohibory); Sey, Seychelles.
Madagascar broke away from Africa during 165-120 Ma ago (Rabinowitz et al., 1982), so the NW part of Madagascar is an ancient rift zone.
Fig. 3. Chronogram of Archean events across the Antananarivo and Antongil–Masora domains. The data are from published work (cited in the text), as well as information from the report of consultants (presented with permission from the PGRM, Madagascar). Also shown are the major periods of Archean sedimentation and volcanism for the Mananara Group (DeWaele et al. 2008) and the newly defined Fenerivo Group (this paper). TTG, tonalite–trondhjemite–granodiorite.
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Many MACOMO seismometers were colocated at Missouri Botanic Garden research sites.
Altered Habitats:

Ecologic Corridors
Rose diagram for data coverage for preliminary receiver function study of crustal thickness
Examples of depth profiles from receiver functions for four stations

- Codes by Herrmann & Ammon (2002)
- 57 events of direct P arrivals
- Iterative deconvolution used to generate radial and transverse receiver functions
- Only radial receiver functions that recreated 80% of the original signal were used in the inversion.
Sedimentary Cover
Volcanic
Bemarivo Group
Mainly Antanananivo Group
Antogil Craton

Metamorphic
Phanerozoic
Proterozoic
Archean

Simplified version of 2012 geologic map
**Crustal Thickness:**

~ 40 km along the spine of the Proterozoic Antananarivo Group

Thins to ~20 km to the rift zone at the northwest

Thins to ~20 km to the orogenic belt to the SW

Thickens to ~45 for the Antongil craton to the east
Preliminary 2-station Green’s Functions for 1st-yr Madagascar stations
Paths for 1st-year 2-station Green’s Functions

Example of a phase velocity map, calculated using the P-omega method for a 2-station noise Green’s Function
Preliminary Seismic Noise Tomography using Rayleigh Wave Group Velocities

20 sec

30 sec
Preliminary Seismic Noise Tomography using Rayleigh Wave Phase Velocities