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Mid to Late Miocene Uplift and Doming of Madagascar: Constraints from Topography, Cenozoic Stratigraphy and Paleogeography

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Summary

We here present geological arguments for the age and the timing of the Madagascar Plateau. This analysis is based on a double, coupled analysis of the onshore geomorphology (stepped planation surfaces) and the offshore margin stratigraphy (seismic stratigraphy, and paleogeography).

Madagascar is an Archean to Neoproterozoic continental crust surrounded by transform, oblique and divergent margins: the oblique Morondava Basin to the west, pounded by the Davie Fracture Zone, and to the north, the divergent Mahajanga (Majunga) Basin connected to the Somali Oceanic Basin. This 1600 km long island is a high axial plateau with elevations from 1200 to 1800m. The top of the plateau corresponds to weathered planation surfaces (etchplains), bounded by more or less high scarps.

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The geomorphological analysis is based on a characterization, mapping and dating of stepped planation surfaces (mantled to stripped etchplains, pediments and pediplains). The dating is based on their geometrical relationships with dated magmatic rocks and sediments. The difference of elevation between two planation surfaces (corresponding to local base level) provides a proxy of the uplift. The sequence stratigraphic analysis is based on a biostratigraphic reevaluation of 4 industrial wells (foraminifers and nannofossils on cuttings) and the interpretation of several industrial and academic seimic datasets.

Uplift periods are characterized by (1) seaward tilting of the margins overlain by planar, onlapping reflectors, (2) forced regression wedges and (3) stepping planation surfaces.

(1) During Paleocene to Early Miocene times (66 to 16 Ma), Madagascar is a quite flat low elevation domain with remnants of an oldest pre-Madagascar Trap (90 Ma) surface. This low relief is highly weathered with growth of numerous lateritic profiles and surrounded by large carbonate platforms with very few siliciclastic sands influx.
(2) Late Miocene is the uplift paroxysm with (1) margin tilting (Morondava), (2) increase of siliciclastic sand flux since middle Miocene and (3) major stepping of dated planation surfaces.
(3) This result in a convex up shape pattern for the weathered upper Cretaceous surface, giving the island its present-day dome morphology (with a central plateau).
(4) Uplift amplitude can be estimated based on present-day elevation of Paleocene to Eocene marine sediments located 100 km north-east of Toliara and now at an elevation of 900m. If the absolute sea level was around 50-100 m (Miller et al., 2005) above present-day sea level during Late Eocene times, this means a surface uplift of around 800-850 m.
(5) Uplift mechanism has to explain a very long wavelength deformation (x1000 km) necessary due to mantle dynamics. Relationships with other East African domes (Ethiopia, East Africa, South Africa) are discussed.

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