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Lithospheric Structure Beneath the Paraná-Etendeka Province

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ABSTRACT

The Paraná-Etendeka province comprises one of the largest continental flood basalt provinces on earth. This magmatic province was associated with the opening of the South Atlantic Ocean during the Early Cretaceous. The Paraná lava field covers an area of at least $1.2x10^6$ km^2 over southern Brazil, Uruguay, eastern Paraguay and northern Argentina, and its present extent is bounded by the margin of the underlying Palaeozoic-Mesozoic Paraná basin. The Etendeka lavas, are scattered over an area of $0.8x10^5$ km^2 in northwestern Namibia. The basement beneath the Paraná basin consists of several Archean to Early Proterozoic cratonic blocks surrounded by Brasiliano cycle (700-450 Ma.) mobile belts. The majority of analysed samples of the Paraná-Etendeka magmatism give ^{40}Ar-^{39}Ar ages between 129 Ma and 134 Ma with northward younging, although there is evidence of earlier magmatism inland (135-138 Ma) and younger magmatism persisting along the coast (120-128 Ma).

The pronounced asymmetrical distribution of the lavas relative to the eventual location of continental separation is poorly understood in terms of plume dynamics. It is generally agreed that flood basalts and thermal subsidence on the scale seen in Paraná-Etendeka province requires a large thermal anomaly within the mantle, but details differ on how decompression occurs: In response to lithospheric extension? Thermal erosion and thinning of the lithosphere by mantle plume? The sudden arrival of a large head of plume material near the onset of break-up? In this study we map variations in the present day lithospheric flexural rigidity to probe lithospheric structure and the alteration of continental lithosphere by mantle plumes.

Laboratory and theoretical studies have shown a clear relationship between the elastic properties of oceanic lithosphere and its geothermal gradient, with hotter lithosphere behaving like a thinner plate than a colder plate. The effective elastic thickness (*Te*) of the lithosphere, therefore, does not correspond to a particular geological boundary in the continents, but some theoretical studies suggest that *Te* may track the 500-700^{o}C isotherm. Thus, *Te* estimates only indirectly can be used to probe continental lithospheric rheology, but they provide a comparative means of evaluating regional variations.
The most commonly used technique to estimate Te is to compare the observed coherence between Bouguer gravity and topography data as a function of wavenumber with theoretical models of a thin elastic plate loaded at the surface and base of the crust. Additionally we use a code where the Bouguer coherence method has been previously modified. The two-dimensional Fourier transform of gravity and topography data has been enhanced through the use of wavelets, providing estimates of *Te* at each grid node, rather than averaging across a region of dimensions 200 x200 km or more.
We evaluate variations in effective elastic thickness beneath the Paraná-Etendeka province using both the Fourier coherence approach and the wavelet coherence technique. The comparison of results for the study region between the two methods is in good agreement, considering the inherent averaging of the Fourier methods. The *Te* wavelet coherence contour maps are obtained using fourth order tensor wavelet, chosen after careful comparison of results from other wavelet shapes. Important to note is that no technique provides reliable results where there is little topographic relief at intermediate wavelengths (100-1000 km). There is too little signal to constrain *Te*, and "best-fitting" model has little meaning.

For the South America portion of the province (Paraná) Te is lower along the continental margin and the central-north region, which corresponds to the northwestern portion of the Paraná basin. In the African plate, Te is lower only along the continental margin, eastwards the Te contour map shows a clean break trending N-S, of a cooler/stronger lithosphere. In the region of the lower Te on the western portion of Paraná basin, a buried Palaeozoic rift basin has been previously interpreted. The results from this study do not give any further evidence for Mesozoic crustal extension beneath the Paraná basin but the relatively low Te values indicate considerable heating/weakening of the mantle lithosphere beneath the Paraná basin in Cretaceous time. One possible reason for the initial volcanism in the Paraná-Etendeka province is a result of ponded material due to pre-existing lithospheric thickness variations prior to plume onset at 137 Ma. The mantle plume probably lay beneath the newly forming MOR in South Atlantic, with the basalts spilling asymmetrically due to pre-existing lithospheric structure on both sides. A cratonic keel along the African plate and lithospheric thinning on the South American plate led to flow of plume material westward. This suggests that the source of the Paraná-Etendeka basalts originated from the opening of the South Atlantic, and not an extensional event beneath the Paraná basin contemporaneous to the volcanism. The ponded material may instead be associated to pre-existing lithospheric thickness variations with the thin zones stretched during Cambrian-Ordovician times.

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