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The Okavango Dike Swarm (ODS) of Northern Botswana: Was it associated with a failed Rift System?

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Dikes and dike swarms often play a significant role in the initiation and extension of rift zones. The giant ODS in northern Botswana, Africa represents a Jurassic aged (∼180Ma) thermo-tectonic event which developed during the initial lithospheric weakening phase of Gondwana. Detailed investigations of the mafic dike swarm over the last four decades have provided insights into its age, shape, orientation, and chemistry but have thus far been limited in addressing the crustal structure below the swarm. Historically, the ODS has been interpreted as a failed rift arm based on its association with the Bouvet Hotspot and geometric relationship with two other prominent dike swarms. More recent studies suggest instead that the ODS was emplaced along a preexisting Precambrian basement fabric. Accordingly, the origin of the swarm still remains a matter of debate. The objectives of this study were: (1) determine the role of crustal heterogeneities on the emplacement of the dikes, (2) determine variations in crustal thickness below the ODS and geographically related Okavango Rift Zone (ORZ), a zone of incipient rifting and (3) determine along-strike variations in Curie Point Depth (CPD) below the swarm. We used high resolution aeromagnetic data and applied mathematical filters to enhance structures associated with the swarm's oblique geometry. Crustal thicknesses were estimated using the radial average power spectrum method, applied to 1.2km spatial resolution gravity data. 3D inversions were used to map the magnetic basement and determine the depth to the base of the swarm. Our results showed: (1) There were no apparent basement structures with the same 110° orientation as the ODS. (2) Crustal thickness below the swarm ranges from 39 to 45km with an average of 42± 3km, comparable with thicknesses derived from the Southern African Seismic Experiment (SASE). In contrast, crustal thickness below the ORZ is 9 to 16km thinner than the surrounding blocks. (3) The magnetic basement extends to a depth of about 24km and is segmented into a number of along-strike magnetic bodies. The lack of significant crustal thinning below the ODS and poor relationship with the Precambrian basement fabric suggests either the ODS was not associated with a failed rift system or the remnants of the crustal disturbance have since been modified to depict a normal continental crust. The along-strike magnetic bodies conceivably represent mid-crustal feeder chambers, similar to those found in modern extensional environments such as Afar, or magma pooling zones developed along Proterozoic discontinuities. Due to the relative inconsistency of the magnetic anomaly below the swarm we speculate that a majority of the dikes are confined to the upper 5-10km of the crust. The ODS is thus interpreted to be a magma enhanced fissure network emplaced within the upper crust during an extensive period of regional tension induced by a continental wide upwelling of the asthenosphere caused by thermal incubation of the mantle.