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Tectonic Implications of the Skeleton Coast Dyke Swarm on the Formation of the Walvis Basin, North-West Namibia

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ABSTRACT

This paper examines the distribution and kinematics of the Skeleton Coast Dyke Swarm (SCDS) of northwest Namibia, and suggests a possible relationship between the lithospheric extension recorded by these dykes and the structural architecture of the Walvis Basin offshore. Dyke swarms possess a special tectonic significance for geodynamic interpretations. Based on the principles of kinematic analysis and through the identification of asymmetrical features, such as zigzags and bridges between dyke segments, we have estimated the conditions of regional stress active during dyke emplacement. A genetic relationship between the Etendeka basalts and the dykes of SCDS is inferred by their late Cretaceous age (134-131 Ma), as indicated by field relationships and limited geochronological dating. Early Cretaceous volcanic rocks also occur offshore as thick wedges of seaward dipping reflectors (SDRs), which underlie post-rift sediments in the Walvis Basin. These SDRs are assumed to post-date the onshore Etendeka basalts and represent subaerial flood basalts erupted during continental break-up and initial sea-floor spreading. Their large volume and areal extent is attributed to a paleo-position of the Tristan da Cunha plume close to the north-east limit of the Walvis Basin. The dykes of the SCDS have been mapped onshore using high-resolution aeromagnetic data and satellite imagery. The SCDS parallels the trend of the Pan-African Kaoko Belt, with the majority of the dykes orientated SSE-NNW (155-335). Dykes of this orientation can be observed up to two hundred kilometers inland, but are more frequent closer to the coast. Asymmetrical features are not common, but when present they indicate both sinistral and dextral shear senses for different dykes of the same orientation. This suggests an ENE-WSW (65-245) direction of maximum extension, normal to the trend of the SCDS. In contrast, WSW-ENE (65-245) trending dykes, which are common along the coast, display asymmetrical features which indicate a sinistral shear component related to a SE-NW (135-315) extension vector. Field relationships suggest that these ENE-WSW dykes are younger, as they appear to be cut by the dominant NNW-SSE trending dykes. This raises the possibility of more than one generation of dykes, intruded at different times under contrasting stress conditions.

WNW-ENE trending dykes of the SCDS present geochemistry similar to N-MORB compositions, possibly indicative of an asthenospheric sourced magma, with only minor crustal contamination. This suggests that these dykes may have been coeval to the eruption of the offshore SDRs, when the continental lithosphere had already undergone significant extension. If this is the case then the north-west margin of Namibia experienced different stress regimes during the rifting episode that led to the break-up of Gondwana and the formation of the Walvis Basin. An early stage was characterized by ENE-WSW directed extension leading to coast-parallel block faulting and the intrusion of NNW-SSE trending dykes. While later NW-SE extension was possibly coeval with the eruption of the SDRs, and was marked by the intrusion of WNW-ENE and NE-SW trending dykes. Within the basin this extension may have led to the reactivation of existing NNW-SSE trending structures as oblique normal faults with a dextral shear component.

The overall structural architecture of rifted margin basins is often controlled by basement structures as reactivations can occur during later syn-depositional tectonic events. Thus, a strong structural control is exerted on depositional patterns post-breakup, with important implications for potential petroleum systems through the creation of local depocentres. For example, within the Walvis basin, Aptian source rocks are thicker within fault bounded sub-basins, which in turn also controlled the distribution of potential reservoirs such as Albian carbonates, or turbidites within Barremian age basin floor turbidite fan systems or the Santonian-age Baobab confined channel complex.