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Dyke emplacement at the incipient Namibian margin – structural and anisotropy of magnetic susceptibility (AMS) studies in the Henties Bay – Outjo Dyke Swarm

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During the Cretaceous breakup of western Gondwana, the conjugate Namibian and South American margins were the site of flood basalts, mafic dyke swarms and subvolcanic intrusive complexes which make up the South Atlantic Large Igneous Province and the volcanic margin of northwestern Namibia.
This contribution presents data on internal fabrics in mafic dykes (mostly subalkaline tholeiitic dolerites) from the major Henties Bay-Outjo dyke swarm (HOD) in coastal and inland NW Namibia, which are discussed in terms of magma emplacement. The HOD is some 100 km wide and extends at least 500 km from the continental margin. The dykes were emplaced in Neoproterozoic (Panafrican) Damara mobile belt, which is bounded by the Angola/Congo craton on the north and the Kalahari craton on the south. Field relations and radiometric dates indicate Early Cretaceous emplacement ages for the dykes. In coastal exposures north of the HOD, dolerite dykes are mainly coast-parallel (NNW-SSE) and syn-tectonic with normal faults that offset Etendeka lavas. Coast-parallel dykes are also common within the HOD, but the great majority of dykes strike NE-SW. We observed the latter dykes to crosscut coast-parallel ones. But the opposite relationship is also found locally. The dominant NE-SW strike of HOD indicates the influence of the Damara Belt structural grain at a regional scale, but locally the dykes commonly crosscut basement foliations and lithologic contacts. Depending on dyke thickness, which varies in the HOD from a few cm to about 50 m), the dykes are variably fine grained with chilled margins. Vesiculation is seldom observed. Typical textures are intersertal to subophitic, with plagioclase, clinopyroxene and olivine being the main mineral phases. Common minor minerals include opaque oxides and acicular apatite. Linear dykes are composed of segments, 10 m to some km in length, which are connected by transfer zones. Often a minor horizontal displacement can be observed between these segments. Dyke margins are often offset at pre-existing fractures or they may follow suitably oriented ones. These observations imply a major horizontal principal stress parallel to the dykes, at a high angle with the coastline. Successive, multiple intrusions of subparallel dykes imply a crack-seal mechanism of emplacement.
We analysed by the anisotropy of magnetic susceptibility (AMS) or magnetic fabric of dykes and sampled at 24 different stations in the area between Henties Bay at the coast and Outjo ca. 300 km inland. Most of the dykes were sampled on both margins and some also in the centre. This strategy allows inferring magma flow directions from the AMS results. Magnetic susceptibility is relatively high, around 20x10E-3 SI units. Microscopic studies and kappa-T measurements indicate magnetite and titanomagnetite as dominating magnetic minerals. The anisotropy of magnetic susceptibility is mostly low, indicating a primary fabric with little secondary overprint. A few samples show higher anisotropies and distinctly prolate fabrics, which are interpreted as the expression of a strong flow fabric. Steep long axes of such fabrics may be related to vertical melt emplacement at intrusion centres, and shallow plunges to horizontal flow along the dyke fractures. Oblate fabrics were observed in places, which define a flat-lying magnetic foliation, that we tentatively attribute to a rheologic disturbance or gravitational deformation at the top end of dykes, where the melt was prevented from flowing further upwards.