MESOZOIC MAFIC DYKES OF NORTHEASTERN SOUTH AMERICA AND CORRELATIONS WITH SIMILAR DYKE SWARMS IN WEST AFRICA AND EASTERN NORTH AMERICA

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Parallel mafic dyke swarms of probable late Triassic to early Jurassic age in eastern North America, West Africa and northeastern South America form a radial pattern when these continents are placed back to their positions in Triassic time (MAY, 1971). These dykes seem to converge on the Blake plateau, the Bahamas platform and the western Senegal basin. Except for the dykes of eastern North America and Morocco, little is known about the petrology and chemistry of dykes in the radial pattern that would help to understand the Atlantic Ocean.

In South America, the swarms or parallel dykes of Apatoe (Suriname), Cayenne (French Guiana), Cassiporé-Jari and the western of Maranhão basin (Brazil) are the most important ones among those which are part of the radial pattern. On the African side, the mafic dyke swarm in Liberia-Ivory Coast is the most important and seems to be a counterpart of the Cassiporé-Jari dyke swarm. The Rio Grande do Norte mafic dyke set, which is slightly younger (Jurassic-Cretaceous), does not seem to fit May s radial pattern however. Apparently this pattern was established during the opening of the North Atlantic Ocean (Triassic and early Jurassic), while dykes in Rio Grande do Norte State are probably related to the formation of the Benué trough in Nigeria and the opening of the South Atlantic (late Jurassic to Cretaceous). Other Mesozoic dyke swarms (e.g. Minor dykes of Guyana, Obidos-Mapuera and in the western Maranhão basin) do not conform to the radial pattern and were probably emplaced during the rapid northward movement of South America and the opening of the South Atlantic Ocean.

Among the dyke swarms mentioned above, those which form the early Jurassic province of eastern North America (ENA) are the best studied. They comprise quartz- and olivine-normative tholeiites over more than 2000 km in the eastern portion of the Appalachians. A transitional to alkaline group of Triassic(?) age in eastern New England represents a sub-province of the ENA province.

About 650 whole-rock chemical analyses are available in the ENA province (McHONE et al., 1987). In the southern portion of the province, the dykes are olivine-normative tholeiites, while quartz-normative tholeiites predominate in the northern region. Chemically, these dykes have been grouped as (a) quartz-normative, Fe-rich, (b) quartz-normative Ti-rich and Fe-poor and (c) quartz-normative, Ti- and Fe-poor (WEIGAND & RAGLAND, 1970). RAGLAND & WHITTINGTON (1983), however, suggested that the Fe-rich group corresponds merely to a differentiated product of the two other groups and not to a separate group.

Although high TiO_2-dolerites predominate in the northern region of the Appalachians,

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they seem to coexist with low-TiO_2 in several regions of the ENA province.

BERTRAND & COFFRANT (1977) demonstrated the similarity between dykes of the ENA province of the northern Appalachians and early Jurassic dolerite dykes of northwest Africa (Morocco) where quartz-normative dolerites predominate with TiO_2 varying from 0.97 to 1.15% (BERTRAND et al., 1982) and with a large variation in the trace and major element composition.

In South America, chemical data are scarce and limit correlation studies. There is very little data on the Apatoe (Suriname), Cayenne (French Guiana), Cassiporé-Jari, Itaituba-Altamira and Penatecaua swarms in northern Brazil. The dykes in Suriname and northern Guyana are high in TiO_2 (2.84-3.54%) and SiO_2 (53%), while dykes in southern Guyana show low TiO_2 (1.41%) and SiO_2 (48%). Some REE, U and Th data for the dykes in Guyana are found in CHOUDHURI et al. (1984). These dykes are LREE-enriched and lack an Eu-anomaly. Based on Th/U ratios, these authors suggested that the basaltic magmas were derived from a relatively non-depleted source. The Jari, Penatecaua and Itaituba-Altamira dykes are low in TiO_2 (1.16-1.84%), with SiO_2 varying from 47 to 53.5%.

The Mesozoic mafic dykes in Liberia intruded the Liberian (~1700 Ma) and the Pan-African provinces (~550 Ma) as well as the unmetamorphosed Paleozoic Paynesville Sandstone. They are quartz-normative dolerites, K- and Na-enriched in relation to other Mesozoic dykes related to the opening of the North Atlantic (DUPUY et al., 1988). Dolerites which intruded the Paynesville Sandstone show higher Mg and Th values than those which intruded the Liberian province Sr and Nd isotope ratios display a well correlated, curved array. These authors interpreted the trace element and isotopic data as indicating the existence of five groups of dolerites not related to each other by simple processes of mineral fractionation from a common source. They assumed that there was not much interaction with the continental crust during the emplacement of these dykes.

The Maranhão basaltic province (Brazil), which occupies an area of 700 x 250 km, contains sills and SW-NE and SE-NW- trending dykes. The province contains low-TiO_2 basalts (around 1.1% TiO_2) varying in age from 150 to 190 Ma in its western portion, and high TiO_2 basalts (3.4 to 4.4% TiO_2) in the eastern portion with ages between 115 and 122 Ma. Chemically, they resemble the Mesozoic basalts of the Paraná basins in southern Brazil. FODOR et al. (in press) observed similar Nd isotope values for the two groups, while the low TiO_2 group has higher radiogenic Pb and Sr and higher $\delta\ ^{18}O$ (9 to 13 $permil_{SMOW}$). The low-TiO_2 magmas are probably related to the opening of the North Atlantic and the high-TiO_2 group to the opening of the equatorial Atlantic Ocean.

The set of parallel mafic dykes in Northeast Brazil (Rio Grande do Norte and Ceará), where dykes trend E-W, shows a maximum length of 200 km of discontinuous outcrops, total width of the province being 80 km. There are six dykes that intruded Precambrian rocks with ages varying from 130 to 144 Ma. Coarse-grained olivine-diabases predominate in the dykes to the south, while porphyritic tholeiites often occur in the northern dykes The presence of coarse-grained hypersthene-diabase of uncertain relationship to these dykes has also been recorded. The emplacement of this dyke set resulted from the crustal extension that gave rise to the Benué trough in Nigeria and marked the initiation of the opening of the equatorial Atlantic Ocean.

About fifty chemical analyses are available for these dykes. Two groups are identified, one of high TiO_2 (2.4 to 3.6%) and one of low TiO_2 (1.2 to 2.0%) The first is also higher in K, P, Sr, Rb, Ba and Zr, but lower in MgO than the second group. Both groups display fractionated REE patterns, are LREE-enriched, and lack (or have a slightly positive) Eu anomalies. The low-TiO_2 group shows lower total REE. Both groups exhibit mantellic values of $\delta\ ^{18}O$ (5.9 to 6.5 $permil_{SMOW}$).

In light of the present data, the presence of two groups of diabases, one high and another low in TiO_2, was recorded in all provinces here examined. Ages, chemical compositions

and isotopes, where available, suggest that these two groups were independently derived from an enriched subcontinental mantle.

The similarity between the composition of the dykes and oceanic crust formed by sea-floor expansion indicates that tensional fractures reached the upper mantle. The chemical variations are explained by heterogeneities in the mantle and various degrees of partial melting at deep crustal levels. The radial pattern represents a response of the continental crust to the stress field imposed by movements in the upper mantle during the opening of the North Atlantic, as has already been pointed out by MAY (1971).

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