GEOLOGICAL SETTING, PETROGRAPHY AND PETROGENESIS OF OLIVINE MELILITITES ON THE NATAL COAST, SOUTH AFRICA

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INTRODUCTION

Six olivine melilitite intrusions are present in Northern Natal. They occur to the northeast of Eshowe which is approximately 100 km north of Durban (Fig. 1). The closest known alkaline intrusives to these occurrences occur to the north and southwest and are represented by the Dokolwayo kimberlite, nephelinite lavas that occur at the base of the Lebombo basalts and the Griqualand East kimberlite province.

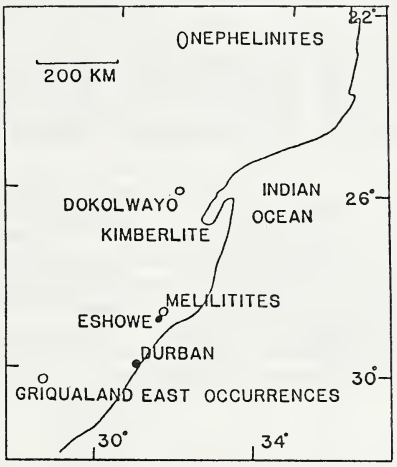

FIG. 1

GEOLOGICAL SETTING

The Eshowe melilitites occur at the junction of the Archaean Kaapvaal craton and the Upper Proterozoic Natal Mobile Belt. Two melilitites intrude the craton and four intrude a zone of mobile belt metamorphic sequences overthrust on to the craton (Mathews, 1981). The region has been affected by extensional tectonics recurring along the same zone of approximately north-south oriented weakness. This tectonism is believed to have been initiated in the Palaeozoic with the formation of the Pan African Mozambique Belt and culminated in the Cretaceous with Gondwana fragmentation. The Eshowe melilitites intrude an area of tilted and step-faulted horst and graben structures that developed in response to two different styles of Gondwana fragmentation: east-west extension and northeast-southwest transpression. The structural development of the region is associated with the extensional and transpressional forces interacting with pre-existing crustal structures found within the Kaapvaal craton, the Natal Mobile Belt and the Mozambique Belt.

GEOLOGY AND PETROGRAPHY

The intrusions consist of four dykes; Tembani Ranch, Emtilombo, Ndundulu and Umgoya and two pipes; Cowards Bush and Nqoleni. The dykes, in general, occur on uplifted horsts while the pipes occur in a graben structure. The level of preservation of the occurrences probably reflects differential rates of erosion. Surface exposures of the melilitites are rare and where present are extremely weathered.

The dykes vary from 30 cm up to 2 m in width and they trend in two directions: Ndundulu strikes approximately 80° while the remaining three trend approximately 120°. These strike directions may reflect some structural control by the underlying basement. Both pipes are small. Cowards Bush is 1.2 ha in area and is irregular elliptical in outline while Nqoleni is 0.5 ha in area and is circular.

Cowards Bush and Nqoleni consist of single intrusions that are, in general, texturally consistent. Both pipes comprise xenolith-rich, fluidised tuffisitic melilitite breccia that is texturally similar to diatreme-facies, tuffisitic kimberlite breccia. The most conspicuous features of the rock type are the abundance of country rock xenoliths, the fragmental, disrupted nature, and the close packing of the larger constituents. Minor differences in mineralogy and texture between the two occurrences are evident.

Little is known about the petrography of Ndundulu and Umgoya dykes, as they are extremely weathered. Tembani Ranch dyke, a narrow anastomosing intrusion, is a fine-grained porphyritic hypabyssal rock. This consists of altered olivine, melilite and minor phlogopite phenocrysts and rare clinopyroxene macrocrysts set in a finer-grained groundmass of altered melilite laths and accessory phlogopite, clinopyroxene, apatite, perovskite and opaque spinels. The groundmass minerals have a uniform distribution, although, small irregular 'pools' of isotropic serpentine (?) are locally present.

The Emtilombo dyke (Fig. 2) is mineralogically similar, but texturally more complex than the Tembani Ranch dyke. Five textural varieties are present: one variety is a fluidised, hypabyssal-facies, globular segregationary melilitite breccia and four are textural and mineralogical varients of a macrocrystic hypabyssal melilitite.

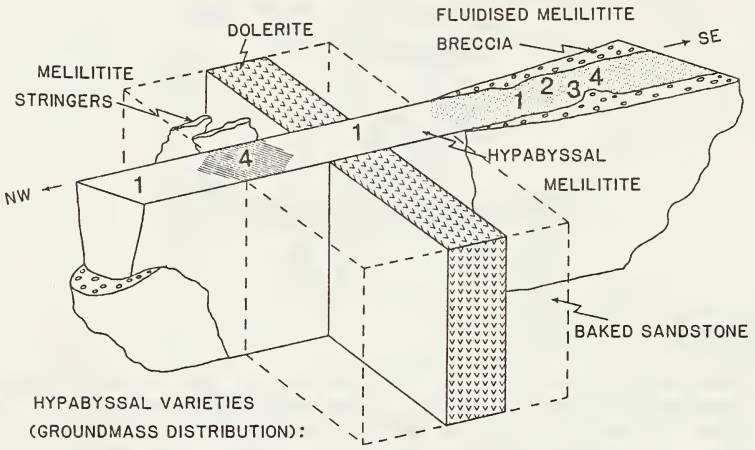

FIG. 2 EMTILOMBO DYKE

The textures and to some extent the mineralogy, reflect the emplacement history of the dyke. The nature of the sandstone country rock appears to have influenced the mode of intrusion. It is envisaged that a single magmatic pulse was associated with simultaneous fluidisation of magma at the dyke contacts. It seems probable the the driving mechanism for the fluidisation was the incorporation of additional volatiles, in the form of water, from the country rock. This, in association with volatiles present in the magma led to a fluidised, subsurface intrusion. The country rock in the vicinity of

the dolerite dyke (?) is baked. This would have driven out much of the original contained water prior to the intrusion of the melilitite and no fluidised melilitite breccia is present in this area.

CHEMISTRY

Bulk chemistry, matrix mineral and concentrate mineral compositions of the Eshowe occurrences are broadly similar to olivine melilitites of Namaqualand, R.S.A. (Moore 1979) and to the Norseman dykes, Australia (Robey et. al., 1986). Subtle differences are, however, apparent. Bulk analyses of the Eshowe rocks, for example, suggest a more magnesian parent magma and olivine tends to have higher Fo contents, with most of the grains ranging from Fo_{83} to Fo_{85}. These and other variations can probably be related to different regional settings and source area characteristics. Chemical compositions and trends of the various minerals (xenocrysts, macrocrysts, phenocrysts and groundmass), such as the complex chemical zonation found in some olivine phenocrysts, have important implications for the evolutionary trend of the parental magma to the Eshowe melilitites, during its ascent to surface.

DISCUSSION

Rb-Sr phlogopite age measurements show that the Eshowe melilitites were emplaced approximately 80 m.y. ago. In regional terms, intrusion of the melilitites followed major basaltic volcanism and rift tectonics. Consideration of the timing and nature of alkaline magmatism along the South African east coast suggests a close relationship between the tectonic development and associated mantle processes operating in the region. Broadly speaking there is a cycle of (i) limited alkaline magmatism (ii) voluminous basalt and felsic magmatism (iii) transitional alkaline basalt magmatism and finally (iv) minor alkaline magmatism (Eshowe olivine melilitites) in the region (Bristow pers. comm.). This cycle reflects early (± 200 m.y.) sodic and potassic magmatism (the Lebombo nephelinites and Dokolwayo kimberlite) and a final phase (± 80 m) of sodic magmatism (the Eshowe melilitites). Chemical and isotopic data suggest that the cycle was initiated by mantle metasomatism and subsequently controlled by the interaction of a varying thermal regime and extensional tectonics leading to continental rifting. These processes resulted in progressive attenuation of the crust in the cratonic and overthrust cratonic region into which the Eshowe melilitites were subsequently emplaced. This attentuation is considered to have an important bearing on the formation of melilitites rather than other types of alkalic rocks in the region.

CONCLUSION

The Eshowe melilitites provide evidence of alkaline ultrabasic magmatism associated with crustal attenuation, rifting and finally continental fragmentation. Overall it is suggested that these rocks represent part of a major magmatic cycle; this magmatism probably developed in response to metasomatic mantle enrichment (see Bristow et. al., 1984) and was a key factor in the fragmentation of eastern Gondwanaland.

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