

70 kbar. The Majuan kimberlites of the Caledonian age contain xenolithes of peridotite, garnet-mica pyroxenite and the early large crystals of phlogopite. In thin sections of rocks from Majuan bodies, the fresh acicular clinopyroxene crystals and the fresh platy phlogopite crystals show their microspinifex texture respectively, and the early large crystals of phlogopite show exsolution texture with platy intergrowths of magnetite. These facts indicate that the pressures and temperatures were unstable in the upper mantle.

Under the electron microscope, the (111) crystal faces of magnesiocromite show a growth texture from polycrystalline seeds which indicates that magnesiocromite might be formed at high pressures in the mantle. The (111) crystal faces of the rhombic-dodecahedron-octahedron shaped diamond shown the dislocation growth lamellae, which lie at an angle of 35° with the stress plane, and the arcuate impact texture has been found on the (111) crystal faces of diamond octahedra. This dislocation of growth lamellae on the crystal face

(110) of diamond shows that some diamond crystals have grown in the solid or sub-solid state, but not in the liquid or gas state. The arcuate impact texture on the (111) crystal face of diamond octahedra appears as a result of the impact stress after crystal growth.

The Tumen kimberlites are the product of the Himalayan movement. In these kimberlites, some altered pyroxene exhibits chrom spinel exsolution textures. It is suggested that the depth of the original kimberlitic magma in this area was probably less than that of Huangjiachuan kimberlitic magma.

The Shenchong and Penjiabang kimberlites were formed during the Caledonian period. In the Shenchong kimberlites, the picrotanite is rare, too; but anatase and rutile contain more niobium. The lherzolite xenolithes found in the Penjiabang kimberlites indicate that the depth of magma chambers for the Shenchong and Penjiabang kimberlites might be less than 250 km.

## H2

### GEOLOGY OF BRAZILIAN KIMBERLITES

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In the Late Cretaceous, the South American Platform was affected by a huge magmatism accompanied by the intrusion of a great amount of kimberlites, rocks with kimberlite affinities, alkaline rocks and associated carbonatites (Svisero et al. 1979a). The majority of the bodies with kimberlite characteristics are located in the west part of Minas Gerais State; nevertheless, there are several occurrences in the States of Mato Grosso, Piaui, Santa Catarina and Rondônia.

Svisero et al. (1979b) summarized the main geological surveys of kimberlites carried out in Brazil in the last decade by local and foreign mining companies. Although much of these results have not been published yet, it is admitted that the number of diatremes and rocks with kimberlite affinities surpasses two hundred bodies. Some of these intrusions have been proved to be kimberlites, namely the Vargem 1 and the Redondão (Svisero et al 1977), as well as the diatreme of Limeira 1, Limeira 2 and Indaiá (Svisero et al. 1980). Others are still being investigated.

In an attempt to increase the information regarding Brazilian kimberlites, this paper presents mineralogical and geological data on Limeira 1, Limeira 2, Indaiá 1, Indaiá 2, Vargem 2, Santa Clara, Japecanga, Pimenta Bueno, Mamões, Poço Verde and Morungaba kimberlites. Excepting Pimenta Bueno in Rondônia, all the other mentioned kimberlites are located in west Minas Gerais which seems to be the most important kimberlitic province in Brazil.

Kimberlites occur in west Minas Gerais as diatremes which range from 50 to 400 meters in diameter or as small dikes, mostly clustered in the headwaters of the Paranaíba River. Although weathered on the surface, the yellow-ground usually contains several kimberlitic minerals such as Cr-pyrope garnet, Mg-ilmenite and diopside, whose chemical compositions are similar to their counterpart kimberlites from worldwide localities. Twelve diatremes have been proved to be true kimberlites up to now; geological and geophysical data, however, suggest that the total amount may reach for beyond that number.

Limeira 1 is a dark porphyritic kimberlite with large amounts of olivine, monticellite, phlogopite, perovskite and opaque minerals, dispersed in a fine-grained

matrix having the same mineral assemblage plus serpentine and carbonates. Geophysical surveys (scintilometry, electro-resistivity, magnetometry and thermometry) showed a regular almost oval outline measuring 300 x 250 meters. Limeira 2, the twin body of Limeira 1, is a small elliptic diatreme whose N-S main axis is no longer than 80 meters. Limeira 2 has a gray aphanitic matrix rich in phenocrysts of fractured olivines and numerous xenoliths of crustal rocks, breccias and dunite. Indaiá 1 is similar in size, color, texture and mineralogy to Limeira 1. Indaiá 2 is a small satellite of Indaiá 1, similar to Limeira 2. Limeira's and Indaiá's diatremes, 1.5 Km apart, are all intrusive in rocks of the crystalline basement, mostly granites, schists and cataclastics. Vargem 2, Santa Clara, Japecanga, Mamões, Poço Verde and Morungaba kimberlites have been characterized by mineral chemistry of their resistant minerals recovered from yellow-ground.

As mentioned before, kimberlites occur scattered throughout Brazil, such as Pimenta Bueno in Rondônia and Redondão in Piaui. Despite the lack of specific studies, the kimberlites of Paranatinga, Mato Grosso State, and the recent discoveries of Lajes, Santa Catarina State, should be mentioned as well. Geologic and tectonic characteristics of these occurrences suggest the existence of at least four more kimberlitic provinces in Brazil besides that of west Minas Gerais: Pimenta Bueno in Rondônia, Gilbués in Piaui, Lajes in Santa Catarina and Paranatinga in Mato Grosso.

West Minas Gerais, Lajes and Paranatinga Provinces display geological similarities, as all are located on the border of the Paleozoic Parana Basin; furthermore, they are related to Cretaceous tectonic arcs that favoured the intrusion of a great number of alkaline rocks and associated carbonatites. Gilbués Province in the southern Paranaíba basin, another Paleozoic basin in north Brazil, apparently is related to reactivation of important Precambrian structures. Field relations of Redondão, the only reported kimberlite in this province, indicate the kimberlite as Cretaceous. On the other hand, very little is known about the tectonic evolution of Pimenta Bueno in east Rondônia. The kimberlites could either be related to Proterozoic tectonics or be Cretaceous as in West Minas Gerais, Gilbués, Lajes and Paranatinga Provinces.

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**H3 RICHTERITE-ARFVEDSONITE-RIEBECKITE-ACTINOLITE ASSEMBLAGE FROM MARID DIKES ASSOCIATED WITH ULTRAPOTASSIC MAGMATIC ACTIVITY IN CENTRAL WEST GREENLAND**

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Introduction

Dawson & Smith (1977) proposed that a mica-amphibole-rutile-ilmenite-diopside (MARID) suite of xenoliths in kimberlites were cumulates from a highly oxidized kimberlitic magma in the upper part of the mantle (above 100 km). This letter reports lamproite dikes with MARID-type mineralogy from central West Greenland believed to have been emplaced as a magma and crystallized in the upper crust at a depth of less than 10 km. Systematic Ti-zoning trend in the alkali amphiboles points to a low valence of titanium and consequently reducing crystallization conditions.

Regional setting

Alkaline plutonic activity in the Sisimiut (Holsteinborg) area of central West Greenland is well known (Scott 1979, 1981; Larsen 1980), including ultrapotassic micaceous lamproites (1227 m.y.) and micaceous kimberlite dikes (587-500 m.y.). The regional distribution of the rocks from these two intrusive events is still poorly understood. However, kimberlite dikes seem to be related to the Sarfartôq carbonatite complex (Larsen 1980) and to an area around Sisimiut (Scott 1981). Ultrapotassic lamproites are more widespread and may be related to a regional intrusive event, although the main reported occurrences are related to the Ikertôq and Ndr. Strømfjord shear zones (e.g. Scott 1981) within the Nagssugtoqidian mobile belt (Bak et al. 1975). A third type of ultrapotassic dikes containing high amounts of alkali amphiboles are reported here. Their regional distribution and age relation to the micaceous lamproites and kimberlites are unknown. The few recorded dikes are distributed over the same area as the kimberlites (e.g. Larsen 1980, p. 67).

Petrography of the amphibole lamproites

Large euhedral clinopyroxene macrocrysts occur showing partial resorption and neocrystallization to actinolite. Alkali amphiboles, phlogopite and K-feldspar are ubiquitous groundmass phases together with ilmenite, rutile, actinolite, apatite, quartz and carbonate. Subhedral to euhedral groundmass microphenocrysts of K-feldspar are often replaced by a fine-grained turbid mixture of secondary minerals. Alkali amphiboles are dominated by brown to yellow-green richterite which may be interstitially zoned toward either nearly opaque arfvedsonite or green-bluish magnesio-arfvedsonite. A blue fibrous riebeckitic mineral occurs as a late crystallizing phase overgrowing zoned richterite. Rutile occurs as a discrete anhedral groundmass phase and as rims on subhedral to euhedral groundmass ilmenite.

Crystal chemistry of the alkali amphiboles

The amphibole chemistry is calculated according to the general formula  $A_{0-1}B_2\overset{VI}{Ti}IV_{0-2}(OH)_2$ . Estimation of  $Fe^{3+}$  shows the main part of the amphiboles to contain excess cations for charge balance. In assigning cations to structural positions Ti is therefore assumed to fill the tetrahedral position. This scheme is consistent with chemical analyses of natural richterites (e.g. Prider 1939).

The dominant alkali amphibole is a potassium-titanian-richterite with the simplified formula (Table 1)  $K_{0.7}NaCa(Mg,Fe)_5(Si,Ti)_8O_{22}(OH)_2$ . Only limited Al substitution is observed, whereas Ti occupancy of tetrahedral sites is high. The B sites are occupied by equal amounts of Ca and Na, and the A sites are nearly filled ( $Na_A^+ + K_A^+ = 0.9$ ). The highest  $Mg/(Mg+Fe)$  ratio obtained is 0.8. Two important zoning trends have been detected and texturally related to a volumetrically minor interstitial crystallization.

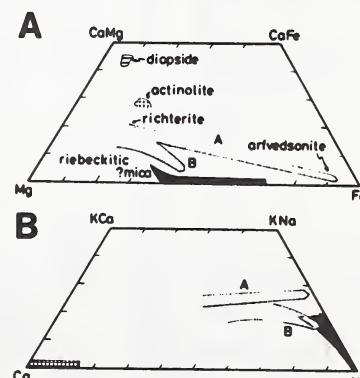


Figure 1. Ca-Mg-Fe (A) and K-Ca-Na (B) trends for alkali amphiboles from amphibole lamproites, central West Greenland. Two zoning trends are identified in the groundmass (A and B).

Zoning A (Fig. 1): Complete solid solution occurs between the richterite and the potassium-titanian-arfvedsonite (Table 1). The tetrahedral sites are nearly filled by Si while Ti occurs mostly as an octahedral coordinated cation in the Fe-rich amphiboles.