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COURTE NOTE

PERIDOTITE NODULES IN NEPHELINITES FROM SAL (CAPE VERDE ISLANDS)

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(3 fig. dans le texte)

RÉSUMÉ

Les auteurs donnent une description pétrographique succincte de nodules lherzolitiques provenant de Morro do Açucar, dans le nord de l'île de Sal (Archipel du Cap Vert), qui se trouvent englobés dans des néphélinites mélilitiques à olivine.

Ces enclaves provenant du Manteau sont remarquables par la présence d'importants phénomènes de mylonitisation et de fusion.

Sal is a deeply eroded island situated in the north-eastern part of the Cape Verde archipelago (fig. 1). A number of studies have been dealing with the petrography of the various volcanic and intrusive rock types occurring on the island (J. Bebiano, 1932; L. Berthois, 1950). In spite of this, only few data are available concerning structure, geologic relationships and absolute ages of those essentially undersaturated and strongly sodic formations. A first approach towards dating these formations was possible thanks to the presence of fossiliferous limestone beds which are widely distributed on the island and range in age from Cretaceous to Quaternary (J.-M. Pires Soares, 1948; G. Lecointre, 1962). Recently, tentative age determinations from palaeomagnetic data have been published (N. Watkins *et al.*, 1968).

Several well-preserved tuff cones (Monte Grande, Rocha de Salina, etc.), up to 406 m high, dominate the landscape of northern Sal. These volcanoes are the highest points of the island. They are surrounded by a very flat area, hardly a few m. above sea-level, which is covered by lava flows and pyroclastics. Both the cones and the surrounding lavas apparently result from one of the last volcanic periods on Sal. At a certain distance south of Ponta Palhona (fig. 1), two plug-like hills appear in the same area : Morro do Açucar (47 m) and Morro do Filho (54 m). They consist of dark lavas, often with prominent columnar jointing, characterized by the presence of numerous ultramafic nodules. These inclusions have not been reported by earlier investigators. Textural features and mineralogy of the main inclusion types are described here, while the chemistry and the origin of the nodules will be discussed in a next paper. The following data are dealing with the nodules enclosed in the lavas from Morro do Açucar, the northernmost of the two plugs.

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The lavas exposed at Morro do Açucar are rather massive olivine melilite nephelinites. They contain abundant phenocrysts of olivine (up to 3 mm across) and scattered zoned augite phenocrysts. The olivine phenocrysts are often partly resorbed and

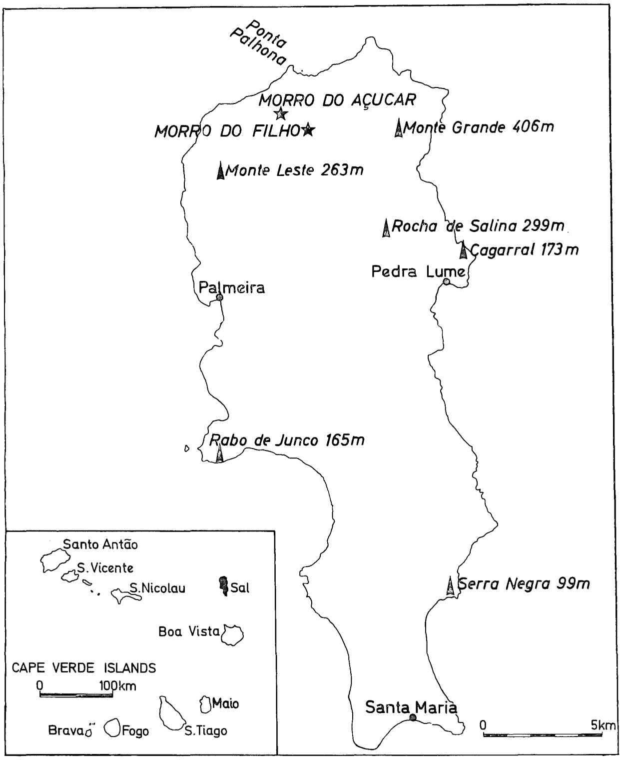

Fig. 1. — Map of Sal showing the location of Morro do Açucar.

some of them display either a marked undulatory extinction or translation lamellae. As the olivine found in the xenoliths exhibit similar optical features we are inclined to consider at least part of the olivine phenocrysts of the lava to be derived from the desintegration of the enclosed peridotite nodules. The matrix of the lava is mainly composed of automorphic titanaugite, poikilitic nepheline, magnetite and olivine. Minor constituents are melilite, biotite, apatite and dark green volcanic glass. In some samples biotite and apatite are relatively enriched near the contact with the nodules. In other specimens the boundary between the xenolith and the host rock is lined with ore minerals (magnetite).

The analyzed nodules are widely varying in size but in general the diameter does not exceed 10 cm. Their form is almost elongated with subrounded to rounded edges. Grain size variation within a single xenolith is not uncommon and in some nodules olivine crystals range up to 1.5 cm. Olivine xenocrysts of the same size are also observed in the host rock. The contact between the lava and the ultramafic fragments is always sharp, although microscopically marginal reactions are displayed everywhere. Similar phenomena occur along the lava veinlets crossing the nodules.

According to the texture the sampled nodules may be subdivided in three distinct groups. Inclusions belonging to the first group are allotriomorphic-granular and all constituents of the rock are undeformed. The average grain size is about 4 to 6 mm. Nodules of this type are rather rare. In other xenoliths the fabric is quite the same but most of the components clearly show optical deformation. Kink-banding in olivine e. g. is a common feature in fragments of this group. Finally in nodules of the third group (fig. 2) deformation effects are extreme and, due to crushing and recrystallization, they always contain as well fine as coarse-grained crystalline material. Their mylonitic texture is easily recognized in the hand specimens.

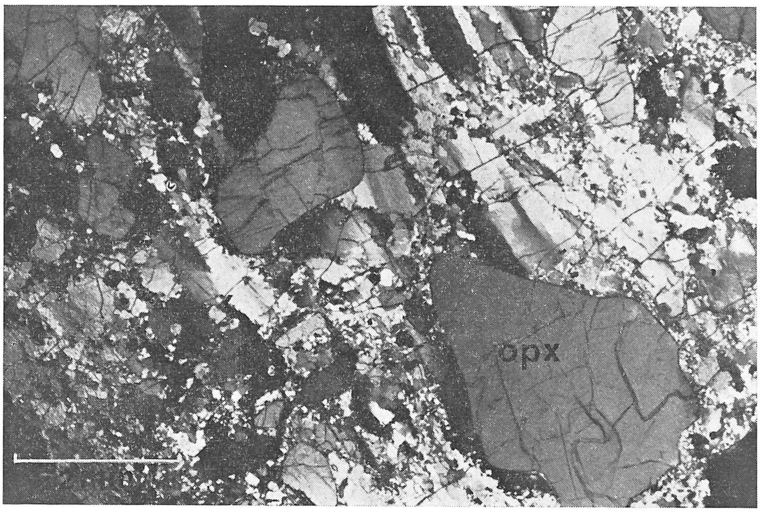

Fig. 2. — Photomicrograph of a strongly deformed lherzolite nodule (sample Sal 93, crossed nicols), illustrating the mylonitic structure; olivine is crushed and shows internal gliding textures and recrystallizes in small grains in the matrix. Orthopyroxene (opx) is undeformed.

The inclusions are built up of but a few constituents. The usual order of abundance is as follows : olivine, enstatite, diopside and spinel. As olivine and both pyroxenes are present in most studied samples the dominant nodule type is lherzolitic in composition. Nevertheless some inclusions are transitional to harzburgite or to wehrlite. As compared with the other components, spinel is only found in very small quantities. Moreover, its distribution is also extremely irregular.

Olivine is by far the main constituent. X-Ray diffraction data point towards a constant magnesium-rich composition (Fo 85-95) and this statement is confirmed by chemical data. The form of the grains strongly varies from one nodule to another but is closely related to the fabric of the examinated fragment. Undeformed xenoliths or nodules affected by rather weak deformations are characterized by anhedral but equant olivine crystals showing normal or faintly wavy extinction. Strongly strained inclusions contain, on the other hand, large elongated and bended olivine porphyroclasts, displaying both irregular extinction patterns and complicated internal gliding structures, which contrast with the small interlocking olivine grains of the matrix.

The orthopyroxene (En_{90-95}) is colourless, pale brown or pale green in thin sections and its form is quite constant in all investigated samples. The grains are anhedral with strikingly rounded contours as a result of reaction phenomena. Hence many enstatite crystals are enveloped by a corona, especially where the mineral is in contact with olivine. Strained enstatite is not uncommon, but compared with olivine, deformation effects are less pronounced. Even in nodules where olivine is completely broken the enstatite still forms large crystals. Fine lamellar structures and exsolution lamellae of clinopyroxene have been observed in a few specimens.

Microprobe data reveal the diopsidic composition of the clinopyroxene ($2V_z = 57^o\text{-}61^o$). The colour range of the diopside is about the same as of the enstatite but the grains are more irregular. In most nodules the diopside has a characteristic spongy appearance or at least shows a turbid corona. This turbidity is due to the presence of numerous particles of varying size, shape and composition, which originate in reaction phenomena. The clouding does not look proportional to the degree of mylonitization. The bulk of the particles enclosed in the diopside is spherical or worm-like and has sub-microscopic dimensions. Larger particles allow optical determination and consist of olivine and rarely of spinel. In the greater part of the nodules olivine and enstatite also carry abundant inclusions which are easily overlooked. In these minerals the inclusions are concentrated in very narrow irregular trails which traverse the crystals in any direction. They have an average diameter of less than 10 μ and are almost spherical or ovoid. Similar inclusions, occurring in olivine-bearing nodules and phenocrysts of basalts from several volcanic provinces in the world, were found to consist of liquid and gaseous CO_2 bubbles (E. ROEDDER, 1965).

Spinel is corroded and displays in all peridotites a marked colour zoning. In thin sections the core of the spinel crystals is always reddish brown while the margins are nearly opaque. Frequently, a thin shell of pale yellow spinel is developed at the limit between the transparent core and the opaque rims. The colour zoning is probably closely related to changes in chemical composition induced by secondary processes. Myrmekitic intergrowths of spinel and olivine are not common.

The four constituents of the peridotite nodules reacted quite differently with the host lava. Evidence for such reactions is found near the margins of the xenolith Although the resulting changes in mineralogical composition and in structure are important they are very limited in space. The reaction zone is only exceptionnally thicker than 2 mm. This contrasts with the large-scale deformation features which intensively modified the nodules as a whole moreover both phenomena are completely independant. Olivine did not react with the lava but got resorbed. Enstatite, on the other hand, became unstable in the prevailing conditions and hence is never observed at the nodule margins. The xenolith shows at this place a characteristic embayment and the mineral is replaced by a mixture of olivine (olivine II), diopside (diopside II) and spinel (spinel II) with interstitial glass. The diameter of the secondary minerals usually ranges from 0.05 to 0.1 mm but the average grain size gradually increases from spinel over diopside to olivine. Olivine II is magnesium-rich and carries spinel inclusions. The latter mineral can also occur as separated grains. Diopside II is yellow green and contains appreciable amounts of chromium. These secondary minerals are often perpendicular to the nodule margins. The glass is colourless to yellow but the colour may change within a small patch. Where the primary diopside of the peridotite touches the host rock, it is surrounded by a jacket of inclusion-free titanaugite. Spinel is seldom observed at the border of the xenoliths. Xenocrysts of this mineral are either entirely converted to magnetite or display a thick opaque corona. In both cases the spinel has striking dendate contours.

Evidence of melting can be observed at the margins as well as in the inner parts of the nodules. In both cases the fusion products are alike but it is not clear at all if different causes have to be invoked to explain them. Fusion inside the xenoliths usually started where enstatite and olivine are touching (fig. 3). In the early stage of

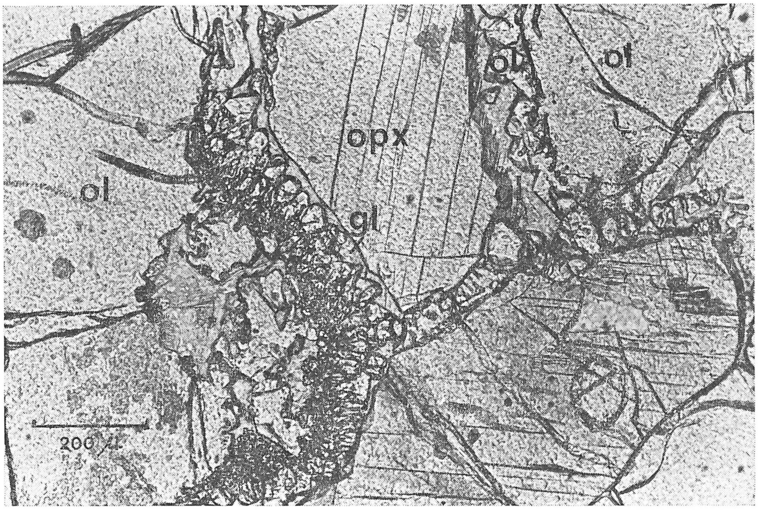

Fig. 3. — Photomicrograph (sample Sal 87 $a + b$), showing the fusion zone at the contact between orthopyroxene (opx) and olivine (ol). The glass (gl) contains small olivine crystals (ol).

the melting process a thin glassy film was formed near the contact of the two minerals and minute drop-like or tear-like projections of the same nature went into the olivine. At the full development of fusion the reaction zone invariably got composed of automorphic to subautomorphic olivine, diopside and spinel in a matrix of colourless glass. The olivine in this zone is either an isolated part of the adjacent primary olivine or a product of recrystallization (olivine II). Recrystallized olivine may contain small euhedral spinel (spinel II) and spherical or elongated liquid and gaseous bubbles. Diopside II has a green colour probably due to its high chromium content. Reaction rims do not only occur where enstatite is surrounded by or in contact with olivine but are also developed where spinel borders orthopyroxene grains. If the spinel is entirely enclosed in the enstatite, the former is subrounded and shows at its border a distinct opaque jacket, surrounded in turn by a corona composed of an aggregate of olivine and glass. The presence of diopside is doubtfull. Reaction rims around the clinopyroxene are lacking.

The association of forsteritic olivine, enstatite, diopside and spinel in the peridotite nodules found at Morro do Açucar, together with the alkaline character of the host rock, suggest a mantle origin for all investigated samples (C. Ross *et al.*, 1954; R. Forbes & H. Kuno, 1964 and 1967). The textural features indicate that most of those nodules have strongly been deformed prior to their incorporation in the nephelinitic host lava but the origin and the nature of the reaction phenomena which partly transformed the inner parts is still uncertain.

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