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AMPHIBOLITES AND OTHER METAMORPHIC MAFIC ROCKS OF THE BLASTOMYLONITIC GRABEN IN WESTERN GALICIA, NW SPAIN: FIELD RELATIONS AND PETROGRAPHY

BY

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ABSTRACT

Within the strongly migmatized axial zone of the Hesperian massif in western Galicia a graben-like structure has been distinguished, characterized essentially by the presence of non-migmatic rocks that comprise orthogneisses with blastomylonitic textures, leucocratic gneisses, plagioclase-blast-bearing paragneisses, pelitic schists, and numerous amphibolitic layers and lenses.

In the southern and central part of the graben and at the borders in the north the majority of the amphibolites are metamorphosed mafic dike swarms that intruded in the Early Palaeozoic after the emplacement of biotite granites but before the intrusion of subalkaline and peralkaline granites. Few amphibolites are of sedimentary origin.

The other amphibolitic rocks in the north are of inferred Proterozoic age and have a different appearance. They consist of retrograde eclogite facies mafites and garnet- and epidote-amphibolites that are typically associated with leucocratic gneisses and younger subalkaline orthogneisses.

It is inferred that the northern part of the graben mainly represents a lower basement segment that underwent Precambrian and Early Palaeozoic catazonal metamorphism and subsequent retrogradation, while the central and southern parts represent higher basement levels of mesozonal metamorphic grade.

RESUMEN

Dentro de la zona axial del macizo Hisperico de Galicia occidental que presenta una fuerte migmatizacion se puede distinguir una fosa tectónica, caracterizada esencialmente por la presencia de rocas non-migmaticas como ortoneises con texturas blastomiloniticas, neises leucocraticos, paraneises con blastos de plagioclasa, esquistos peliticos y numerosas anfibolitas.

En la parte meridional y central de la fosa y en sus bordes septentrionales la mayoria de las anfibolitas se originan de diques maficas intrusadas en el Palaeozoico inferior despues de la intrusion de los granitos subalcalinos y peralcalinos. Pocas anfibolitas son de origen sedimentario.

Las demas rocas anfiboliticas en la zona septentrional (edad Proterozoico probable) tienen un aspecto diferente y comprenden mafitas de facies eclogitica retrograda y anfibolitas con granates y con epidota, asociadas con neises leucocraticos y ortoneises subalcalinos de una edad mas reciente.

Se llega a la conclución de que la parte septentrional de la fosa representa un segmento del basamento profundo con un metamorfismo catazonal Precambrico y del Paleozoico inferior con retrogradaciones subsecuentes, mientras la parte central y la meridional representan niveles del basamento mas altos con un metamorfismo mesozonal.

THE BLASTOMYLONITIC GRABEN

In the western extremities of Galicia a relatively narrow but long geotectonic unit occurs, situated between Malpica in the north and Túy at the Portuguese border in the south (Fig. 1). This zone has been interpreted as a separate unit called 'Complejo Antiguo' by Parga Pondal (1956) and was redefined as 'Blastomylonitic Graben' by Den Tex & Floor (1967).

This graben is one of the meso- to catazonal complexes in western Galicia (Arps et al., 1977; van Calsteren & Den Tex, 1978; Den Tex, 1978; Den Tex, 1981) and consists of non-migmatic rocks of probably Late Proterozoic age (Table I). It is separated by steeply inward dipping faults from other infracrustal rocks, the majority of which were strongly affected by Late Palaeozoic migmatization and intruded by two generations of granitic rocks, i.e. calcalkaline megacrystal-bearing granites and alkaline granites. The (par)-autochthonous alkaline granites are the latest more or less homogeneous products of the regional migmatization, while the calkalkaline granitic rocks may possibly be regarded as true intrusive rocks that originated from deeper levels (van Calsteren & Den Tex, 1978). The terms 'alkaline' and 'calcalkaline' used here, have been defined for granitoids of the northwestern Hesperian massif on the basis of microscopical data (Capdevila et al., 1973). Variations are present in both groups, but they are most widespread within the alkaline granitoids and are primarily due to variable degrees of partial melting of greywacke and pelite as has been suggested by Albuquerque (1978) for granitic rocks in northern Portugal. A Rb-Sr whole rock age of 311 $\pm$ 21 Ma was obtained from a syntectonic alkaline granite (van Calsteren et al., 1979). Post-tectonic granites have ages of about 290 Ma (recalculated from Priem et al., 1970).

During the evolution of the Hesperian orogenic belt of western Galicia in the Palaeozoic five phases of deformation and four phases of metamorphism were active (van Zuuren, 1969; Engels, 1972; Arps et al., 1977; van der Wegen, 1978; Table I). But also processes of rifting have acted more than once upon the Hesperian crust (van Calsteren & Den Tex, 1978). In at least two cases, one pre-F_2 and the second between F_3 and F_4, it facilitated the intrusion of granitic magmas into higher levels. The granite emplacements in

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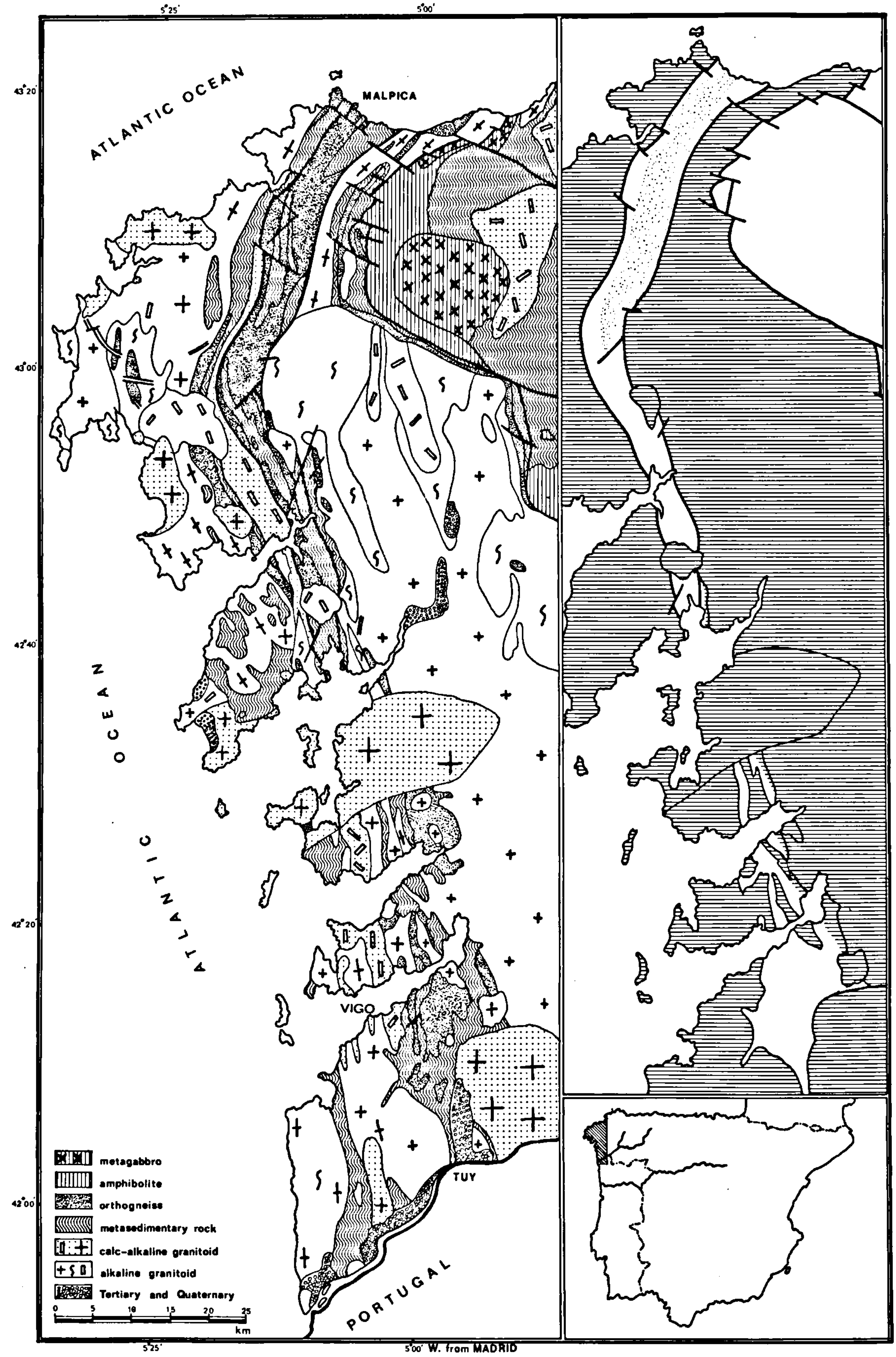

Fig. 1. Geological sketchmap of western Galicia (mainly after Parga Pondal, 1967). The positions of the blastomylonitic graben and the Ordenes complex are indicated on the right. The catazonal basement segment in the northern part of the graben is dotted.

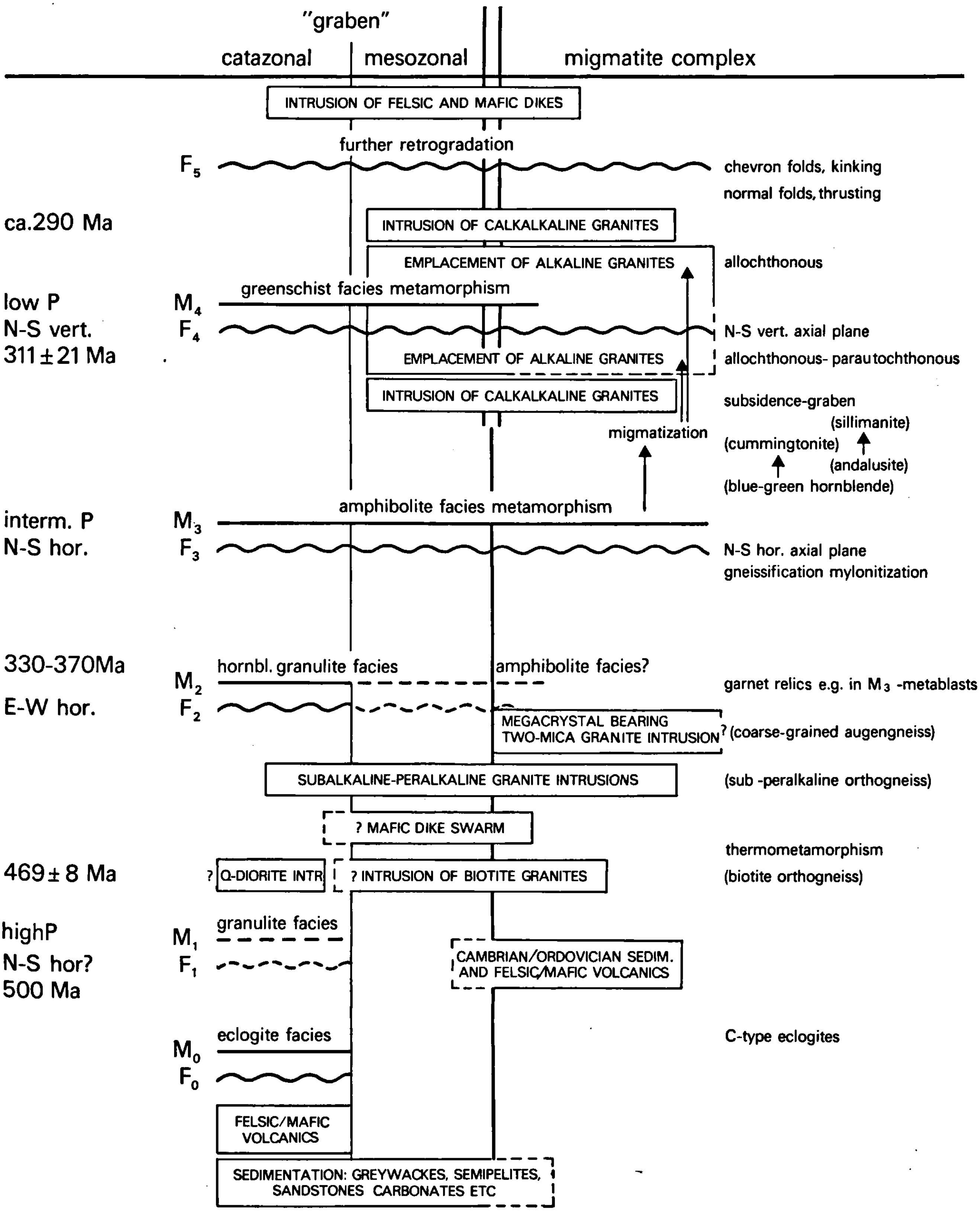

Table I. Geological correlation table.

western Galicia followed major N–S trending fault-lines; an example of this is the large elongate megacrystal-bearing granodiorite intrusion along the western border of the graben.

The tensional stresses between F_3 and F_4 also caused a subsidence that placed non-migmatic rocks adjacent to the migmatized basement. The demarcation of the blastomylonitic graben from the surrounding migmatized basement by important faults is only apparent in the northern and central sector, further south subsidence must have been less distinct as the non-migmatic metasedimentary rocks grade into migmatized rocks or are cut off by the granitoid products of progressive migmatization. Lateral transitions from strongly migmatized to weakly migmatic and non-migmatic rocks must be primarily connected with the migmatization process itself, e.g. differences in rock composition and P_{H_2O}. On the other hand the transitions may also have been accentuated by later folding (F_3, vertical axial plane).

The infracrustal rocks of the graben can be divided into two units on the basis of their lithology and metamorphic history. The southern and central part and the northern borders mainly consist of metagreywackes, metapelites, amphibolites and gneisses. The latter group of rocks comprise gneisses of granitic to granodioritic compositions, i.e. biotite orthogneisses, subalkaline* granitic gneisses, i.e. hastingsite** orthogneisses and peralkaline* granitic gneisses, i.e. aegirine-riebeckite orthogneisses (Floor, 1966; Arps, 1970). The biotite orthogneisses are locally augen-bearing (Geul, 1964). The hastingsite orthogneisses are mainly restricted to the northern part of the graben together with the catazonal rocks discussed hereafter. The peralkaline rocks outcrop some 40 km SSW of Malpica, and in the south between Vigo and Túy.

Effects of thermometamorphism resulting from these older granite intrusions are encountered in the area east of Vigo (Floor, 1966) and some 16 km NNW of Noya (Arps, 1970).

Rb-Sr whole-rock ages of the biotite orthogneisses have been determined as 469 ± 8 Ma in the south and about 460 Ma in the central and northern part of the graben (van Calsteren et al., 1979; Kuijper, 1979).

Subsequent Palaeozoic deformations (Table I, F_3 and F_4) and metamorphism under mesozonal conditions (M_3) gave rise to the development of characteristic blastomylonitic structures in the orthogneisses with mineral assemblages indicating low-pressure amphibolite facies conditions, locally followed by retrogradation in the greenschist facies (M_4).

The northern part of the graben is primarily characterized by the presence of leuco- to mesocratic gneisses, indicated as orthogneisses in Fig. 1, occurring together with a variety of mafic rocks, such as weakly retrogressed eclogites and garnet- and epidote-amphibolites (van der Wegen, 1978), and bodies of a rather coarse-grained, locally strongly deformed granodioritic to tonalitic rock in which bluish quartz may be macroscopically visible. A different, partly catazonal metamorphic history may be assumed for the rocks in the north on the basis of their metamorphic mineral assemblages. This basement segment has been indicated by light dotting in the upper right-hand part of Fig. 1. The southern boundary of the segment is a fault, while to the west the catazonal rocks are bordered by peralkaline orthogneisses and augenbearing biotite orthogneisses. In the extreme northwest of the graben the catazonal rocks are bordered by locally strongly albitized oligoclase-blast bearing paragneisses. The faults forming the western border of the graben are situated in this zone of metasedimentary rocks.

Bodies of leucocratic to mesocratic hastingsite orthogneisses outcrop at various places within the catazonal rocks and are locally, e.g. near faults, retrograded into magnetite gneisses.

Within the different catazonal rock-types five phases of metamorphism, one of pre-Palaeozoic age that was responsible a.o. for the formation of eclogites, and four in Palaeozoic times (see Table I), resulted in successive metamorphic mineral assemblages of decreasing metamorphic grade.

Rb-Sr and K-Ar mineral ages of between 370 and 330 Ma were a.o. determined on phengites and paragonites from an eclogite body (van Calsteren et al., 1979) and were interpreted as representing the age of the termination of the catazonal metamorphic recrystallization (hornblende granulite facies metamorphism, Arps et al., 1977).

THE AMPHIBOLITES AND OTHER METAMORPHIC MAFITES

One of the characteristic aspects of the blastomylonitic graben is the presence locally of numerous amphibolite lenses and other comparatively small metamafic bodies. Outside the graben, amphibolitic rocks are rather rare; they have been found in the area west of the graben (Woensdregt, 1966; Gil Ibarguchi, 1978). Amphibolites probably derived from tuffs and calcareous sediments are known from the Lower Palaeozoic supracrustal metasedimentary rocks, west of the central and southern parts of the graben (von Raumer, 1963; Arps, 1970; Buiskool Toxopeus et al., 1978) and have also been reported from the peripheral zone bordering the western part of the Ordenes complex (Warnaars, 1967).

The larger mafic rockmasses in western Galicia occur within the meso- and catazonal rock-complexes, e.g. at the western and eastern peripheries of the Ordenes complex (Warnaars, 1967; van Zuuren, 1969; Kuijper, 1981).

The metamorphic mafites within the graben can be divided into two groups with respect to mineral content and petrogenesis: 1) an older group of mafites of probable Proterozoic age with a catazonal metamorphic imprint in the northern part of the graben, and 2) amphibolites of Early Palaeozoic origin in other parts.

THE CATAZONAL METAMORPHIC MAFITES

The mafic metamorphic rocks in the north occur as lenses and layers of variable thickness intercalated with felsic catazonal

* The term subalkaline gneiss has been used by Den Tex & Floor (1967) to define granitic gneisses with albite, microcline, quartz, biotite and ferrohastingsite as major constituents. Peralkaline gneisses contain albite, microcline, quartz, aegirine, riebeckite, lepidomelane and astrophyllite.

** These rocks were previously denominated as ferrohastingsite orthogneisses. According to IMA recommendations (Leake, 1978) the name ferrohastingsite should be changed into hastingsite.

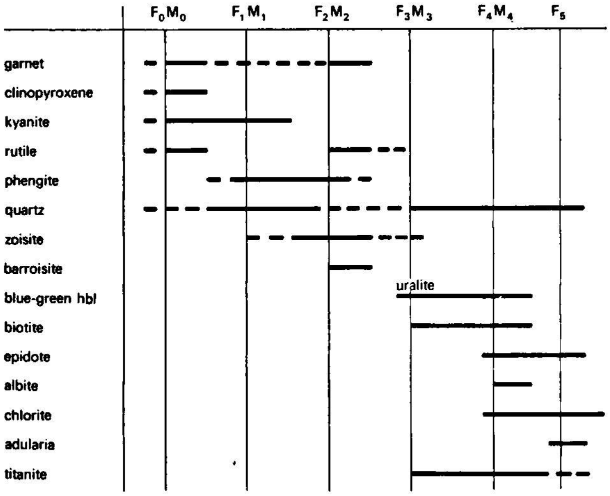

Table II. Paragenetic table showing the relations between mineral growth and deformation/metamorphism in the catazonal mafic rocks (mainly after van der Wegen, 1978).

gneisses and bluish quartz-bearing orthogneisses. Field relations are difficult to establish due to penetrative deformations, but the latter orthogneisses may enclose metamafic inclusions.

The mafites are always very fine-grained and banded compact rocks. Macroscopically their original catazonal character can be assumed by the presence of numerous small garnets (Fig. 2) within greenish coloured masses; only occasionally are emerald-green omphacites visible. The two largest mafic bodies outcrop some 35 km SSW of Malpica and are in fact an intricate subhorizontal alternation of mica-rich leucogneisses with numerous eclogitic to garnet amphibolitic layers and boudins of variable thickness. This alternation constitutes a 'lithostratigraphical section' that may be tentatively correlated with a similar sequence at Cabo Ortegal, i.e. the Masanteo group (Arps & Kuijper, in prep.).

Some mafic layers contain macroscopically visible kyanite and zoisite (Fig. 3), and also relatively large (up to 3 cm in length), mostly parallel oriented amphibole metablasts (barroisitic hornblende, see below; Fig. 4).

An extensive contribution to the mineralogy and geochemistry of the garnet-bearing metamafites of the graben has recently been published (van der Wegen, 1978). From this study it follows that the eclogites can be compared with C-type eclogites (Coleman et al., 1965). The metamorphic mineral assemblages of the metamafites and their relationship with the different phases of metamorphism and deformation are shown in Table II. The metamafic rocks have variable mineral compositions and textures. Apart from a few true eclogites and amphibole eclogites, the majority of the rocks are eclogitic amphibolites and garnet amphibolites; epidote amphibolites occur locally (Figs. 5, 6, 7 and 8). All these

Fig. 2. Weathered surface of weakly retrograde fine-grained banded eclogite. Isometric garnets are weathered out.

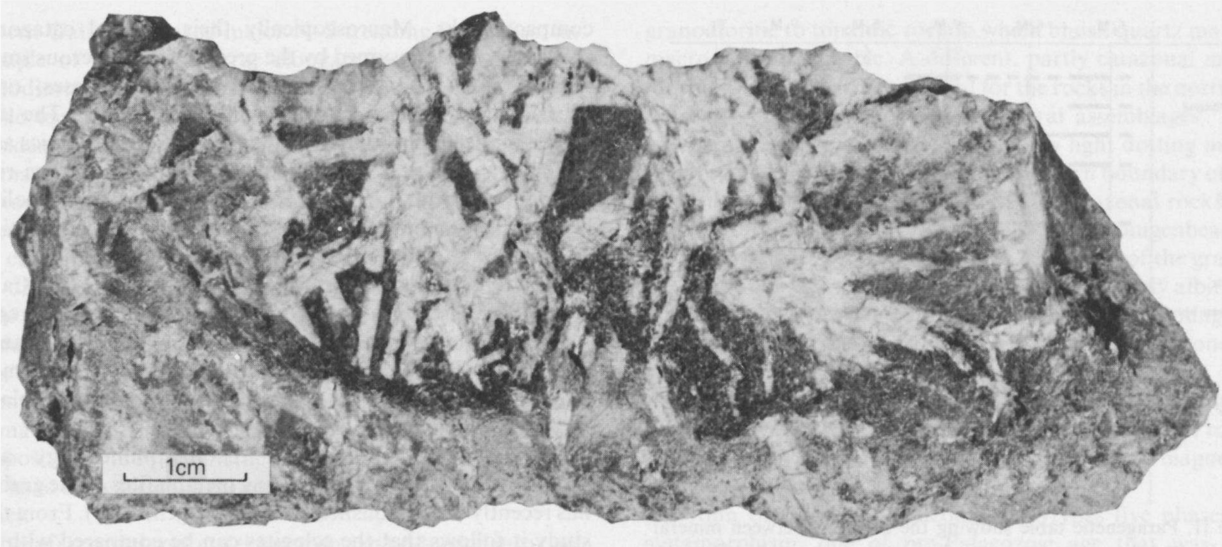

Fig. 3. Relatively large zoisite crystals in hornblende eclogite.

Fig. 4. Weathered surface of weakly retrograde hornblende eclogite. The parallel-oriented lensoid metablasts are barroisitic hornblendes. Perpendicular to the amphibole foliation (F_2) are tension joints (F_3) along which a retrogradation took place.

varieties may be present in the same outcrop. The first phases of metamorphism (M_1 and M_2, Tables I and II) resulted in the formation of eclogites containing garnet, omphacitic clinopyroxene, kyanite, quartz, phengitic mica and rutile, while during the hornblende-granulite facies metamorphism (M_3) light bluish-coloured barroisitic* hornblende metablasts, zoisite and more phengitic mica appeared that transformed the rocks into hornblende eclogites (Figs. 5 and 6). The barroisitic hornblende developed at the expense of clinopyroxene. Kyanite is less frequent or absent where the amphiboles occur abundantly.

The extent to which retrogradation to amphibolite and greenschist facies transformed the catazonal rocks depends on rock composition and the penetrative influences of the deformation phases F_3 and F_4. The original catazonal character of the rocks was best preserved within the mafic rocks. The eclogitic layers and bands were locally folded and boudinaged, while also tension joints have developed oblique or perpendicular to the banding of the mafites and to the regional foliation. Retrogradation was initiated along these joints and around the contacts with the host-rocks. Blue-green hornblende developed at the expense of clinopyroxene (uralitization) and barroisitic hornblende.

In the eclogitic amphibolites and garnet amphibolites variable amounts of zoisite and partly to completely altered garnets are present, and less frequent also remnants of clinopyroxene, kyanite, phengitic mica and rutile. Blue-green hornblende may have developed as relative large metablasts; this mineral is nearly always associated with albite, epidote and chlorite. Rutile may alter into ilmenite or titanite.

These later formed metamorphic mineral assemblages are indicative of mesozonal to epizonal metamorphic conditions

* Van der Wegen (1978) examined the light bluish amphiboles and concluded that the composition strongly resembles barroisite, an amphibole variety with a composition between common hornblende and glaucophane.

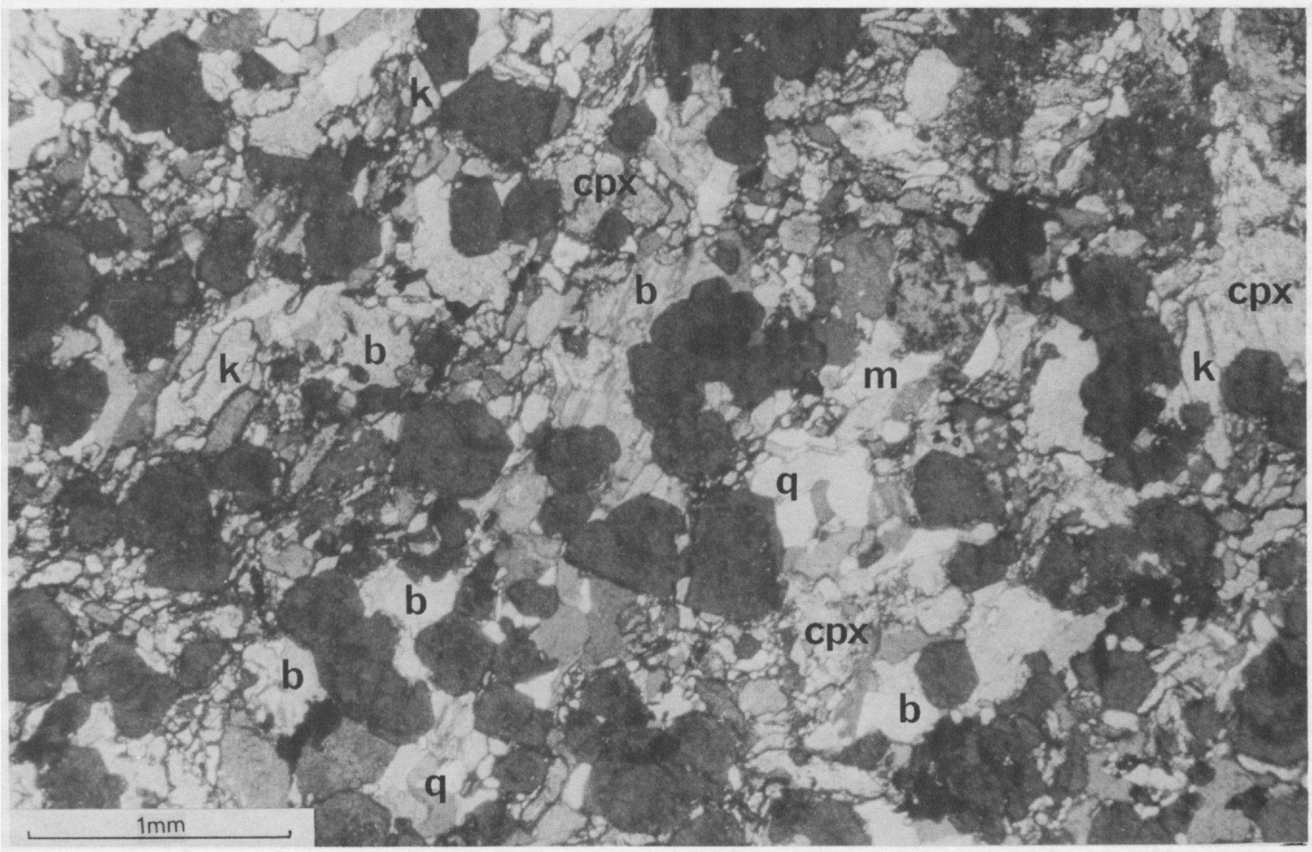

Fig. 5. Photomicrograph of a hornblende eclogite. Cpx: clinopyroxene, k: kyanite, garnet: isotropic. b: barroisitic hornblende, m: phengite, q: quartz.

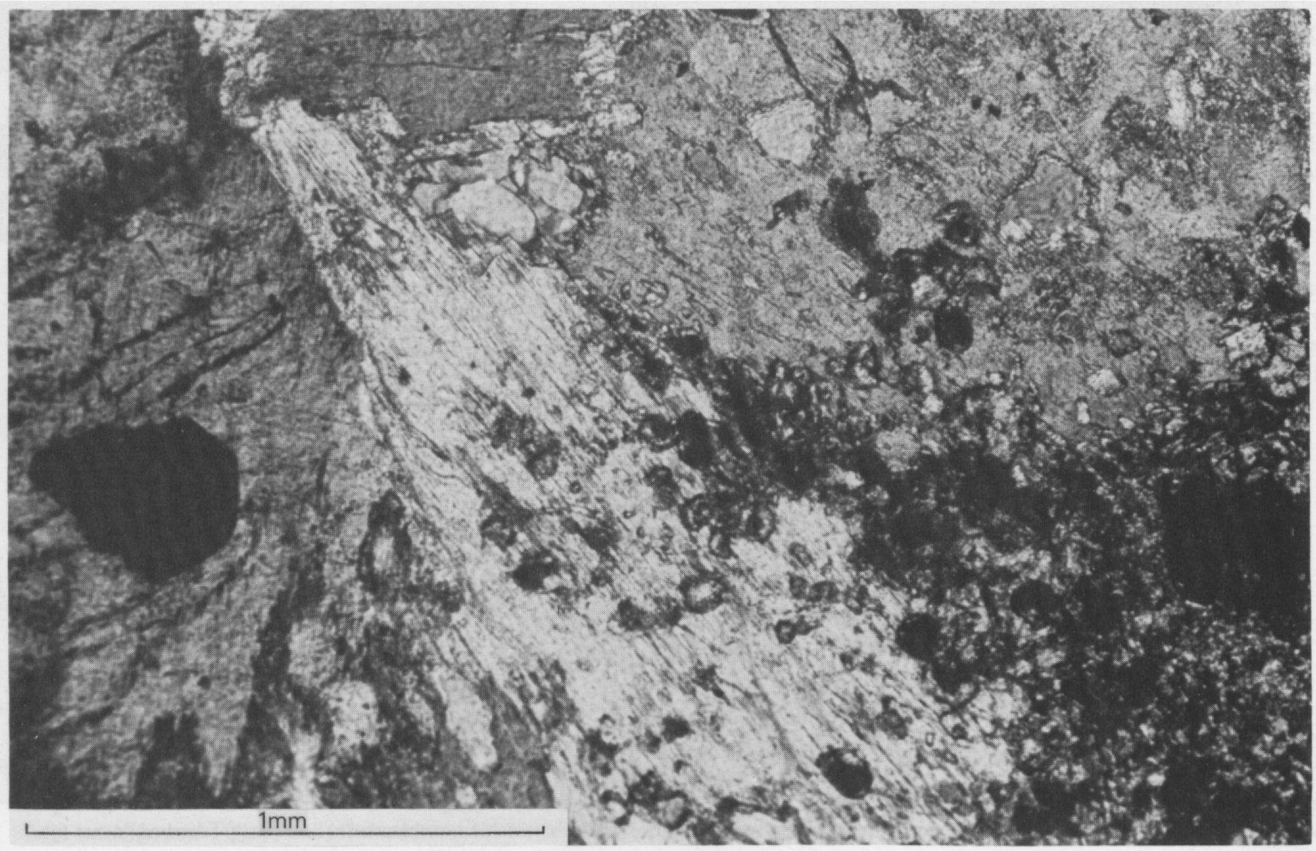

Fig. 6. Retrogressive borderzone of same eclogite body as Fig. 5. Relative large colourless hornblende metablasts with blue green hornblende rims and fine-grained masses of blue-green hornblende, zoisite, clinozoisite, chlorite and titanite enclose relics of garnets.

Fig. 7. Photomicrograph of hornblende eclogite with zoned garnet, kyanite (k) and zoisite.

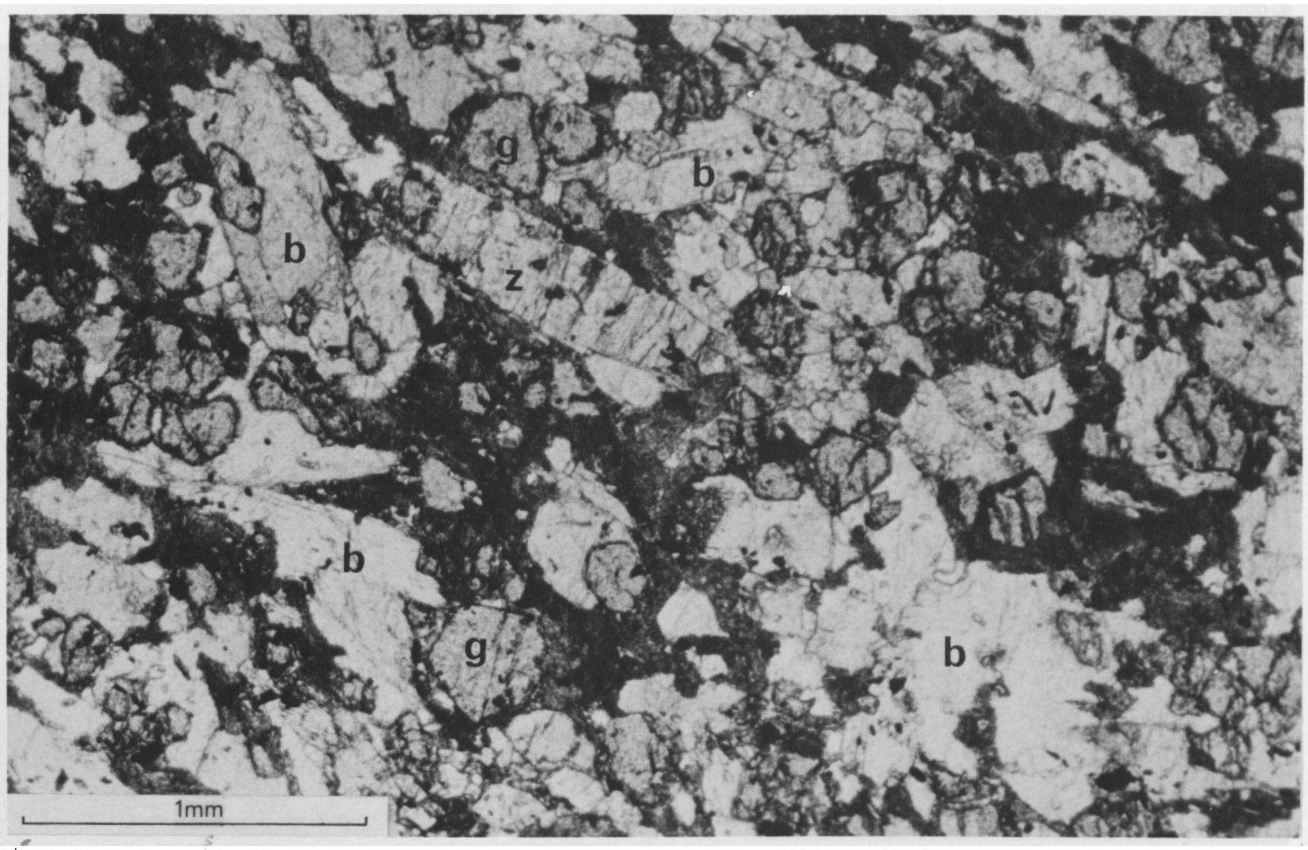

Fig. 8. Photomicrograph of hornblende eclogite with relatively large zoisite (z), barroisitic hornblende (b) and partly resorbed garnet (g).

(M_3 and M_4, Table I and Figs. 7 and 8). A metablastic glaucophanitic amphibole instead of barroisitic hornblende occurs occasionally in the eclogites (a.o. van der Wegen, 1978; J. D. Hilgen, pers. comm.). The intensity of the pleochroic colours is variable from sample to sample. The sporadic presence of this variety of amphibole might be explained by assuming that the original rock composition was a little different. A suggestion in this sense was made by Leake (1965), who came to the conclusion, after an extensive investigation of the literature on amphiboles, that the composition of the amphiboles in rocks is mainly controlled by original rock composition.

It seems most probable that both the glaucophanitic hornblende as well as the more abundant barroisitic hornblende are products of the same metamorphic recrystallization under conditions of the hornblende granulite facies (M_2, Table I).

THE MESOZONAL AMPHIBOLITES

In the Early Palaeozoic tensional stresses (van Calsteren, 1977) in the higher crust of western Galicia enabled felsic and mafic magmas to intrude into higher levels.

Two series of felsic rocks were emplaced, firstly biotite granites and secondly subalkaline hastingsite-biotite-granites and peralkaline aegirine-riebeckite-granites.

The mafic dikes intruded the biotite granites and older metasedimentary rocks but do not occur in the sub- to peralkaline granites. The time of intrusion is therefore bracketed between the time of emplacement of the two above-mentioned granite series. The distribution of the dikes is largely restricted to the area of the graben. Amphibolites have not been encountered in the coarse-grained augengneiss, another type of older orthogneiss flanking the graben (Arps, 1970). The mafic dikes are evenly distributed between the biotite orthogneisses and the metasedimentary rocks except for the pelitic schists where they are hardly ever found. An exception can be found at the north coast a few km southeast of Malpica, where staurolite- and chloritoid-bearing schists crop out enclosing garnet-epidote amphibolites. Moreover, amphibolites originally belonging to the Early Palaeozoic dike swarms do not seem present in the catazonal rocks.

The amphibolite bodies have the shape of elongate lenses generally concordantly with respect to the regional foliation. The contacts with the hostrocks are normally sharp. This is accentuated by displacements resulting from subsequent deformations (F_3 and F_4) affecting the less competent rocks. Sometimes the amphibolites are boudinaged. The deformations also obliterated almost all intrusive relations. One of the few exceptions was described by Avé Lallemant (1965).

The average width of the lenses varies between 0.5–2 m, their lengths may be considerable although difficult to ascertain due to the bad or very reduced exposures. The largest amphibolite, with a length of more than 300 m and a width of about 15 m, was encountered in the biotite orthogneiss along the coast ca 55 km SSW of Malpica.

The total amount of amphibolites in the graben is very large, especially in the central part of the graben and the area between Vigo and Túy. Locally as many as 10 to 15 lenses may be encountered within a 50 m section normal to the regional foliation.

The dark green to black amphibolites are fine-grained and homogeneous rocks with a linear structure. They are easy to recognize in the field by their close joint-system and the reddish-brown colour of the soil profile. Some are very fine-grained and very compact, rarely are they schistose or weakly banded. A macroscopic porphyritic relict structure is often still present (Fig. 9). But a macroscopic metablastic habit, so characteristic for the paragneisses of the graben (Floor, 1966; Arps, 1970), is very exceptional for the amphibolites (Fig. 10). On a microscopic scale, however, metablastesis of plagioclase is a regular feature (Fig. 12) especially in the amphibolites in the south.

In the graben as well as outside a number of small aberrant greyish-green amphibolitic lenses were encountered (Arps, 1970). These amphibolites are in fact very compact quartz-rich calc-silicate rocks often displaying a clear compositional banding. The calc-silicate rocks contain ± clinopyroxene ± garnet ± zoisite + blue-green hornblende ± biotite ± epidote in a matrix of quartz and calcic plagioclase.

The metamorphic mineral assemblage: blue-green hornblende ± biotite + intermediate plagioclase (25–40% An) ± quartz + ore mineral, of the mesozonal amphibolites resulted from the M_3-phase of regional metamorphism (Tables I and III). A few garnet relics enclosed in plagioclase and possibly developed during M_2, have been described (Floor, 1966; Arps, 1970). Colourless xenomorphic clinopyroxene is also very rare, but occurs occasionally for instance in layers in a para-amphibolite or enclosed as relics in blue-green hornblende. Cores of brownish hornblende are sometimes present and may indicate an igneous origin of the original rock (Fig. 13).

Other evidence for an igneous origin is supplied by relics of (micro) porphyritic structures (Floor, 1966; Arps, 1970; Fig. 14), either present as polycrystalline plagioclase clusters with angular or oval outlines, often enclosing small crystals of biotite, or by clusters of hornblende.

The presence of 'graphite' (anthracite) bearing para-amphibolites was mentioned by Avé Lallemant (1965).

The suggestion that a metablastic growth of plagioclase, a feature more widespread for amphibolites in the southern part of the graben than elsewhere, is a possible criterium for a sedimentary origin of the amphibolites (Floor, 1966; Den Tex

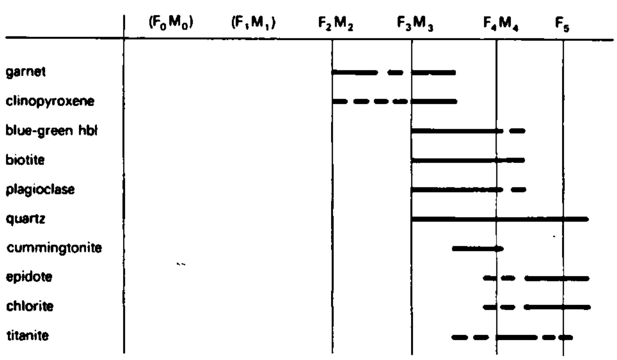

Table III. Paragenetic table showing the relations between mineral growth and deformation/metamorphism in the mesozonal mafites.

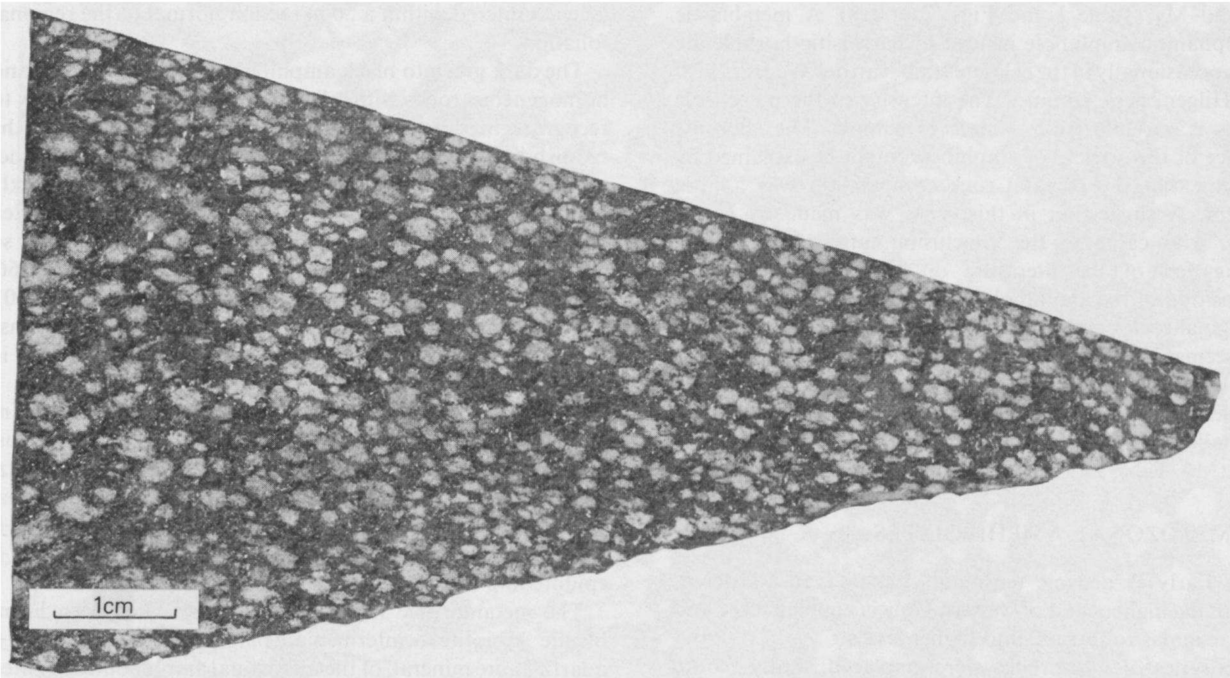

Fig. 9. Ortho-amphibolite with porphyritic relic structure.

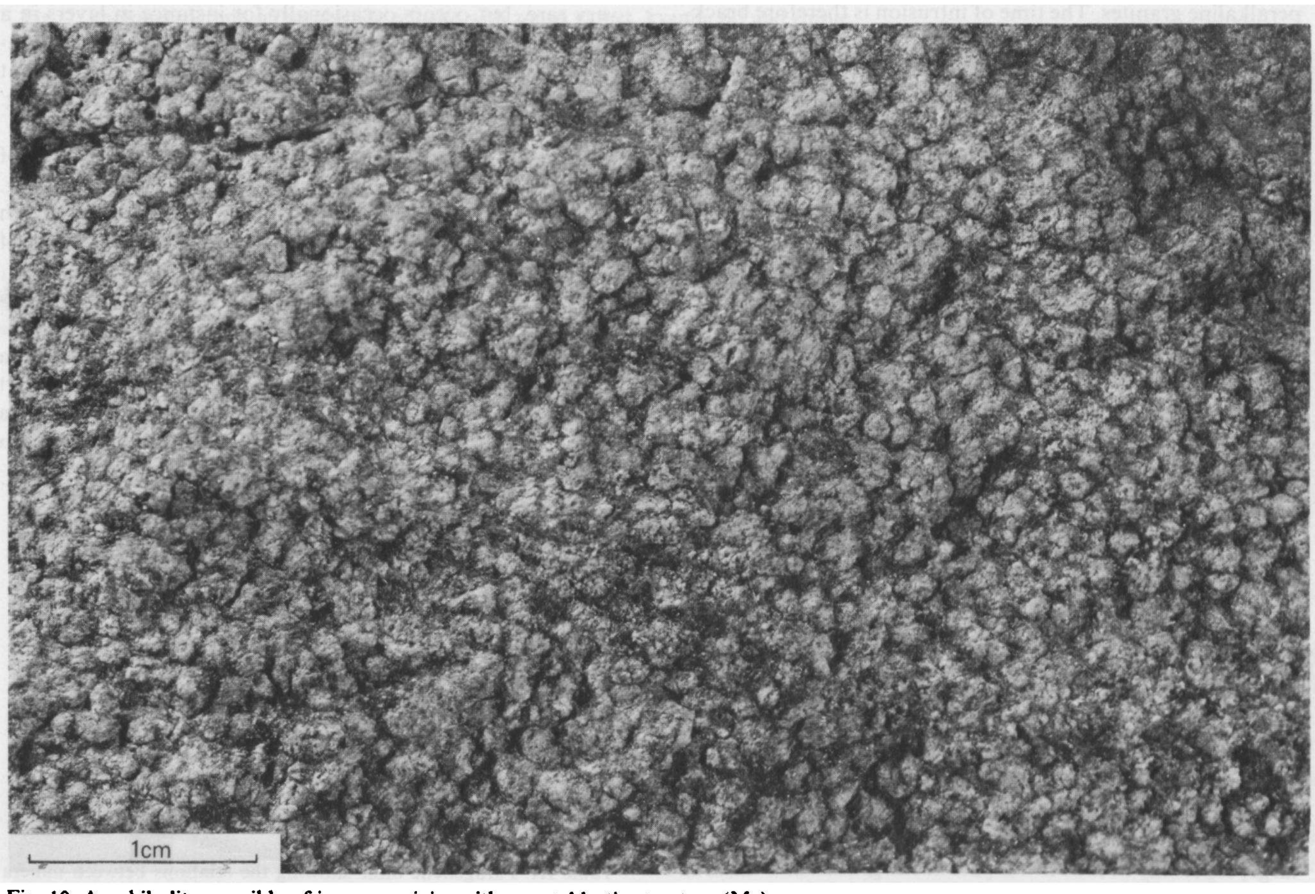

Fig. 10. Amphibolite, possibly of igneous origin, with a metablastic structure (M_3).

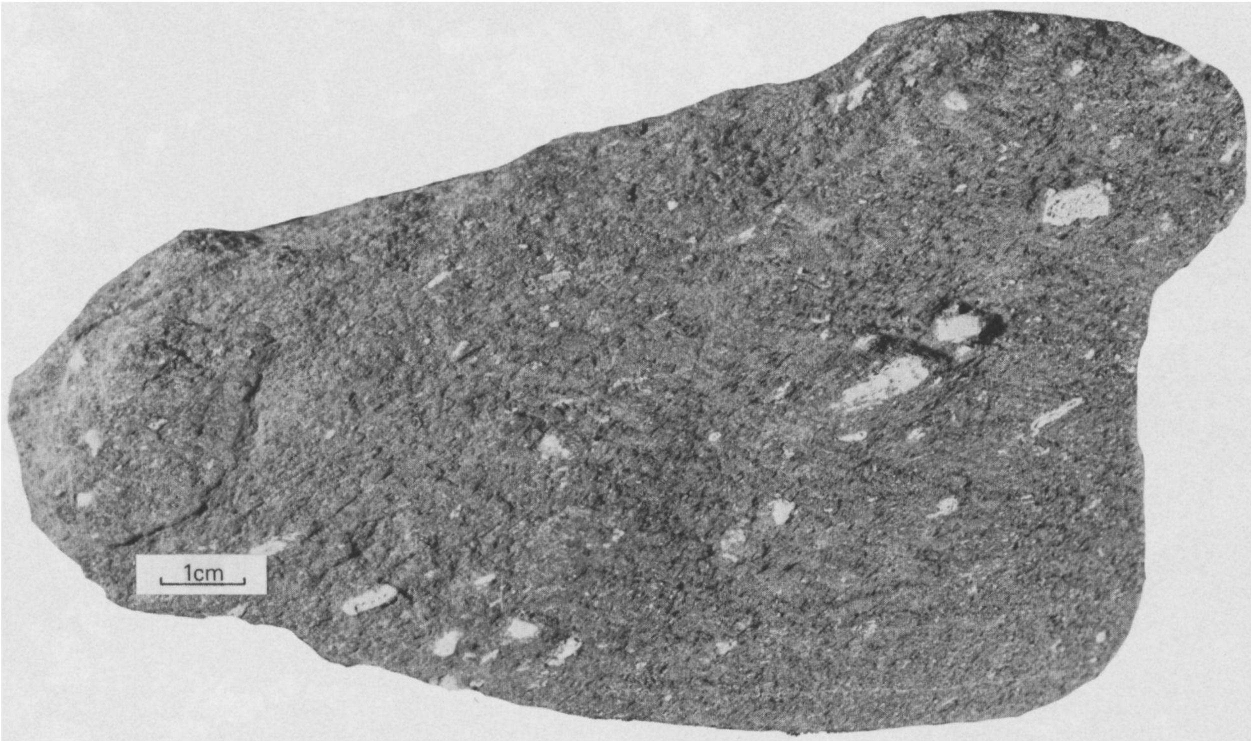

Fig. 11. Albite-epidote amphibolite, possibly of volcanic origin, with relatively large feldspar crystals.

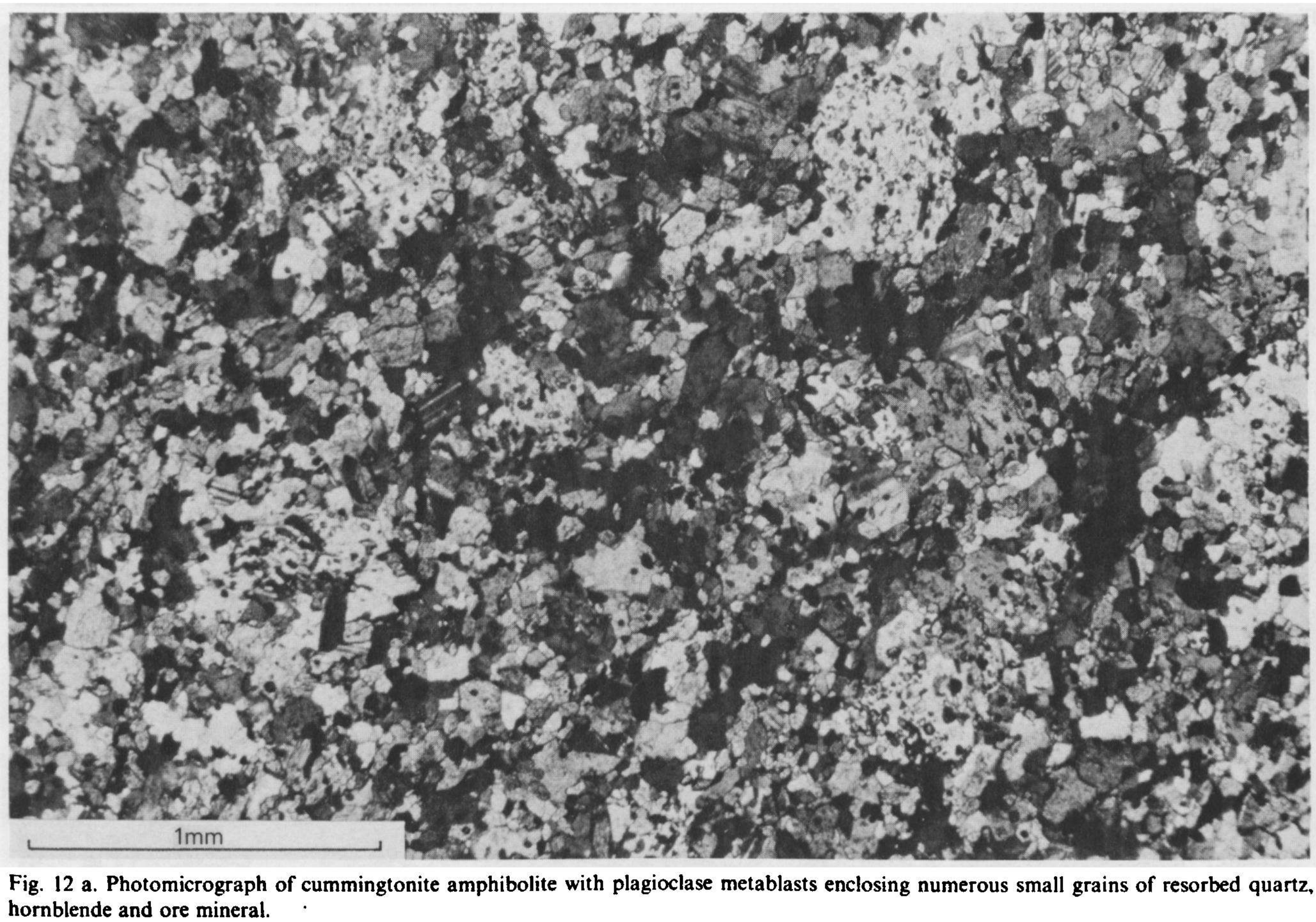

Fig. 12 a. Photomicrograph of cummingtonite amphibolite with plagioclase metablasts enclosing numerous small grains of resorbed quartz, hornblende and ore mineral.

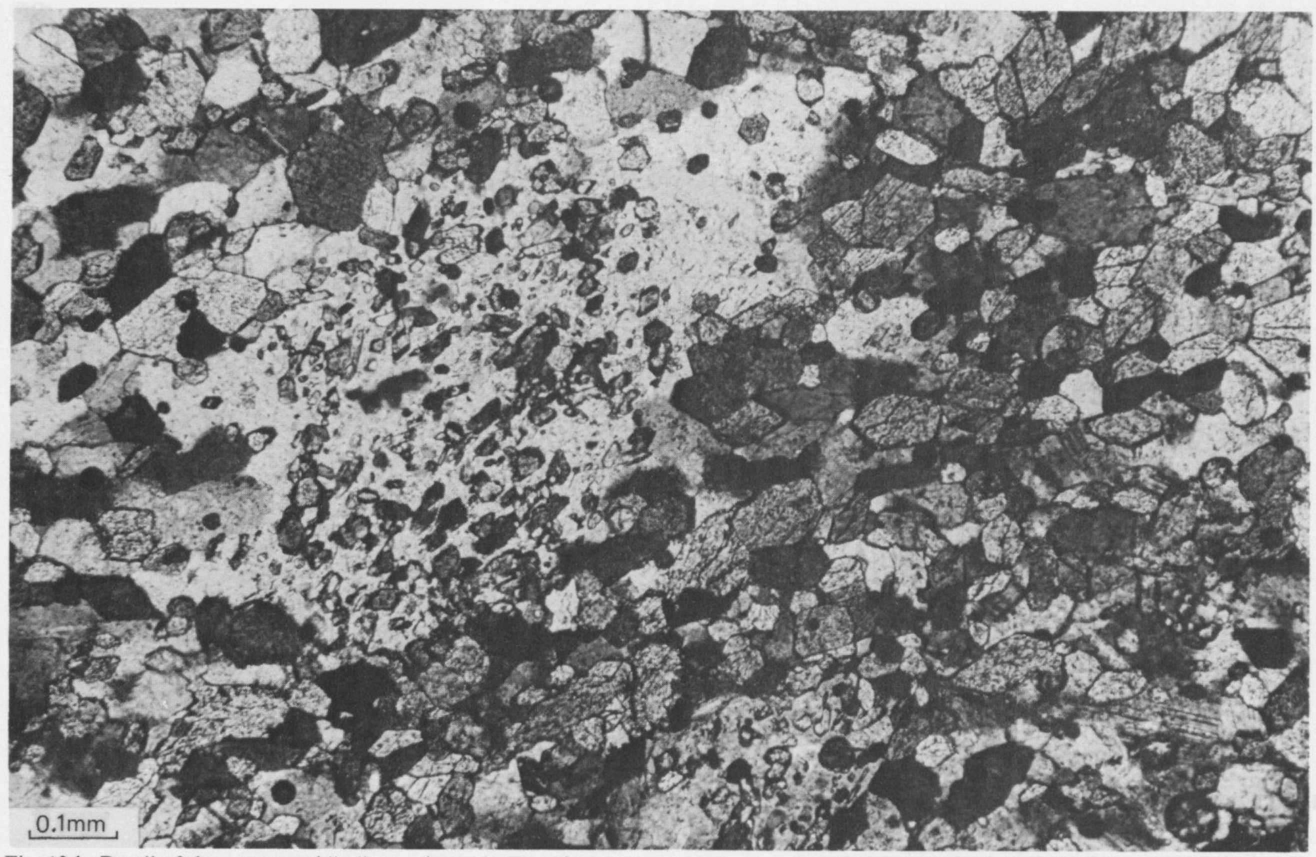

Fig. 12 b. Detail of the same amphibolite as shown in Fig. 12 a.

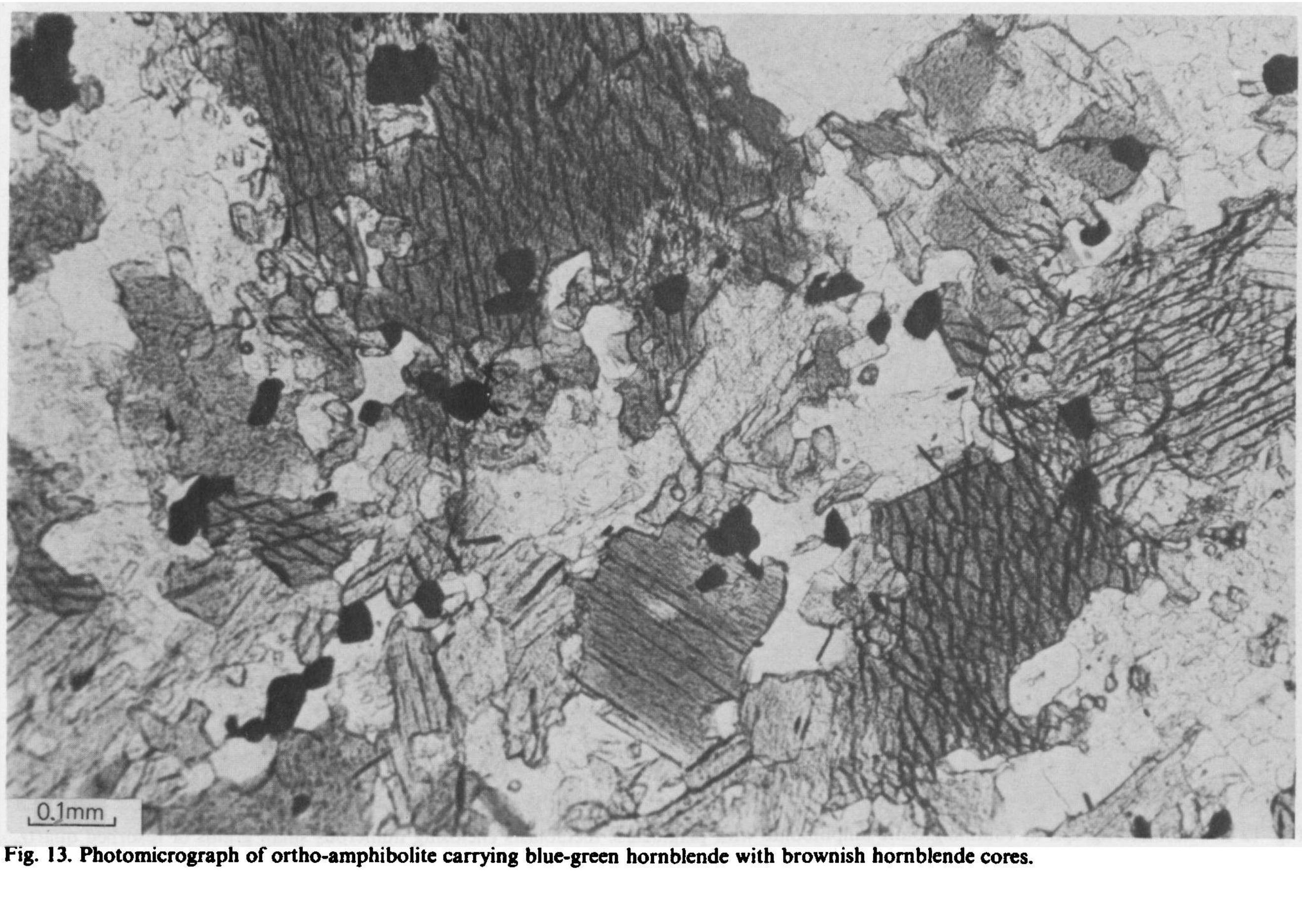

Fig. 13. Photomicrograph of ortho-amphibolite carrying blue-green hornblende with brownish hornblende cores.

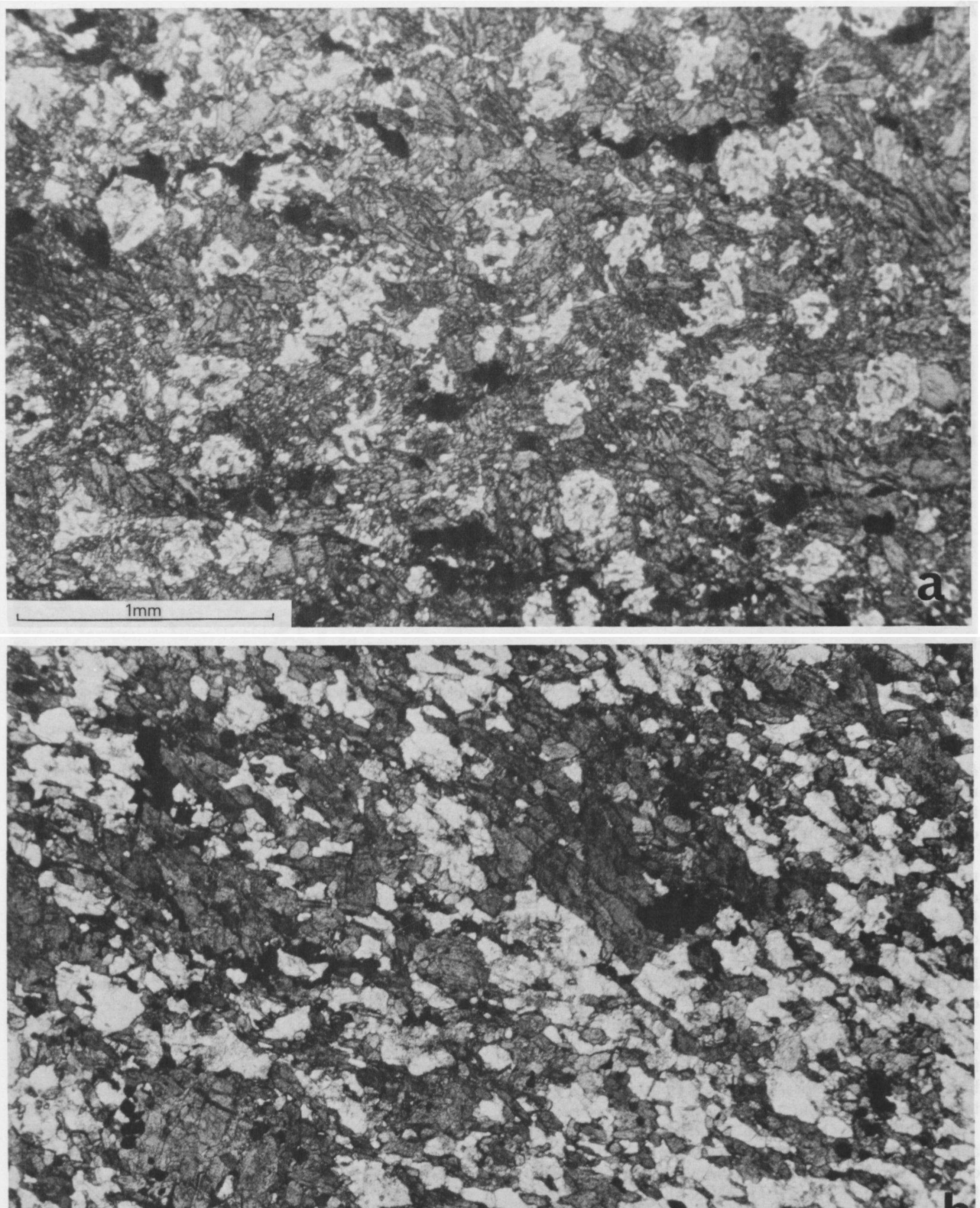

Fig. 14. Photomicrograph of ortho-amphibolite with relic microporphyritic structures. a. isometric plagioclase aggregates enclosing a.o. biotite. b. coarsely-grained hornblende clusters.

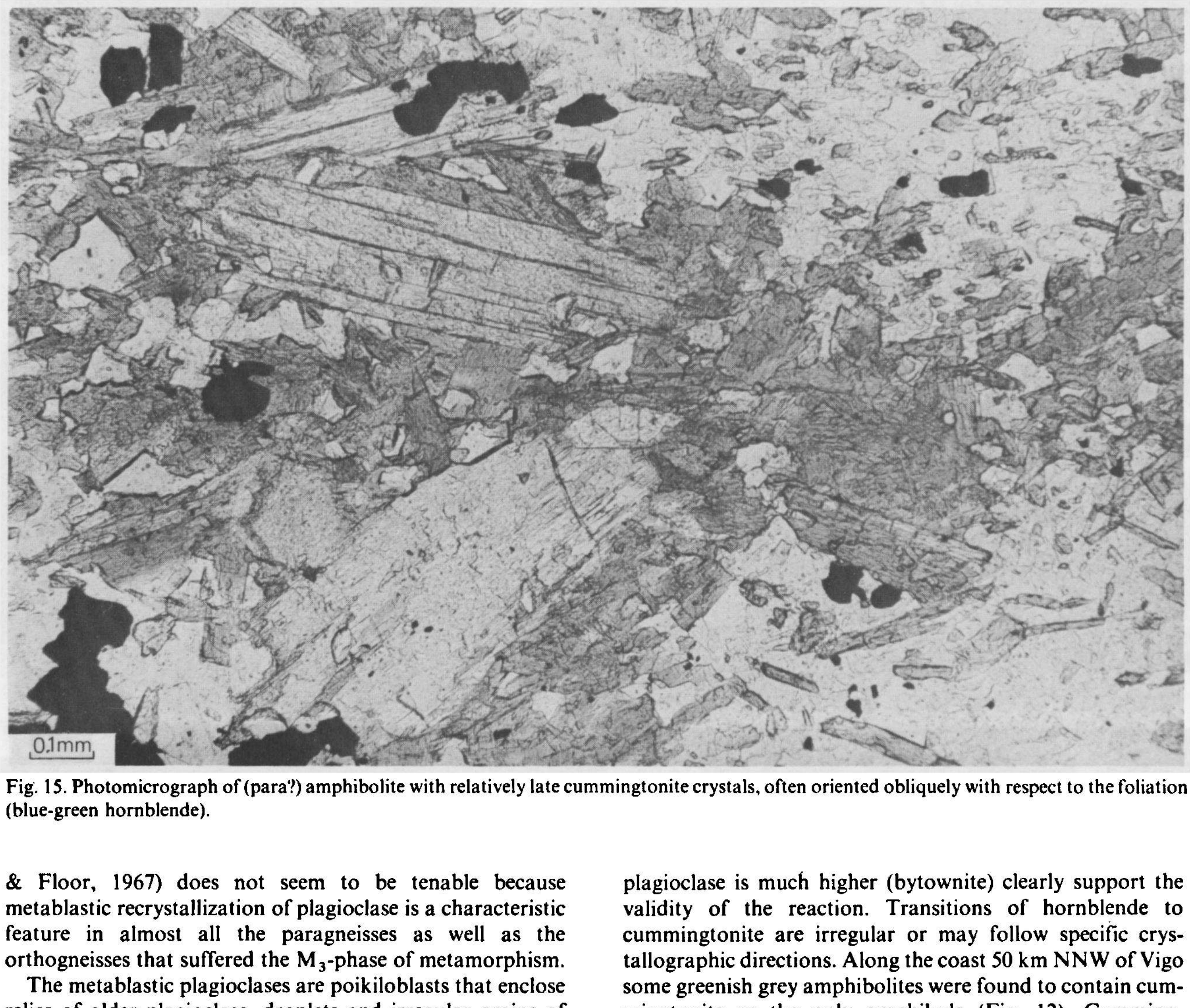

Fig. 15. Photomicrograph of (para?) amphibolite with relatively late cummingtonite crystals, often oriented obliquely with respect to the foliation (blue-green hornblende).

& Floor, 1967) does not seem to be tenable because metablastic recrystallization of plagioclase is a characteristic feature in almost all the paragneisses as well as the orthogneisses that suffered the M_3-phase of metamorphism.

The metablastic plagioclases are poikiloblasts that enclose relics of older plagioclase, droplets and irregular grains of quartz, ore minerals and small hornblende grains (Fig. 12). Due to later deformation (F_4) a sinusoidal structure may be developed, whereby the inclusion trail (Si) of occasionally parallel orientated hornblende laths in the oval-shaped plagioclase poikiloblasts is oblique to the external fabric (Se) of larger hornblende crystals.

Blue-green hornblende, the main constituent in all the mesozonal amphibolites, is generally short prismatic but may form relatively large metablasts. The crystals occasionally have an actinolitic appearance with a fibrolitic habit and a light bluish-green colour.

In addition to blue green hornblende, many of the amphibolites, especially in the southern part of the graben, contain cummingtonite (Fig. 15). Growth was initiated during M_3 at the expense of hornblende according to the reaction: Tschermak's molecule + quartz $\rightleftarrows$ cummingtonite + anorthite + water (Shidô, 1958). The crystallization of cummingtonite is favoured by a pressure decrease.

The fact that the cummingtonite-bearing amphibolites are all quartz-bearing, and that the anorthite percentage of plagioclase is much higher (bytownite) clearly support the validity of the reaction. Transitions of hornblende to cummingtonite are irregular or may follow specific crystallographic directions. Along the coast 50 km NNW of Vigo some greenish grey amphibolites were found to contain cummingtonite as the only amphibole (Fig. 12). Cummingtonite-bearing amphibolites have also been described by Gil Ibarguchi (1978) in the area west of the graben, some 50 km SW of Malpica.

The metamorphic mineral assemblages of the amphibolites together with other mesozonal rocks of the graben indicate that during M_3 Abukuma-type low-pressure facies conditions prevailed corresponding with the cordierite-amphibolite facies (Winkler, 1967). During the metamorphism pressure and temperature conditions changed slightly favouring for example the growth of cummingtonite in the quartz-bearing amphibolites. Retrogradation during M_4 affected the amphibolitic rocks and produced minerals as epidote and chlorite.

Within restricted areas in the graben epizonal low-grade metamorphic amphibolites are also present. Thus for example a few weakly banded quartz-albite-epidote amphibolites (Fig. 11) occur in a small area of supracrustal metasedimentary rocks some 45 km SSW of Malpica. Blue-green hornblende encloses dusty brownish hornblende cores. The weakly deformed relatively large feldspar phenocrysts in the amphibolites are altered to saussuritic masses, clinozoisite and albite. These rocks are comparable with other greenschist facies metavolcanic mafic rocks in Galicia, e.g. around the Cabo Ortegal and Ordenes complexes (Arps et al., 1977).

Intercalations of garnet-bearing amphibolites in staurolite- and chloritoid-bearing schists at the north coast near Malpica are another example of epizonal mafites. The amphibolites are fine-grained and schistose and enclose relatively large garnet poikiloblasts. Epidote is always a main constituent; a smaller generation occurs as inclusions in the garnet crystals, either at random or in parallel orientation. The properties of these amphibolites are markedly different from the mesozonal mafites. They may have originated as mafic tuffaceous intercalations within pelitic deposits. A correlation of these rocks with the sequence bordering the complex of Bazar (Warnaars, 1967; Arps et al., 1977) seems to be possible.

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