THE GLAUCOPHANE FACIES METAMORPHISM IN THE SCHISTES LUSTRÉS NAPPE OF CORSICA

BY

H. A. BROUWER AND C. G. EGELER

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CONTENTS

INTRODUCTION

There are only few areas known where rocks containing soda-amphiboles and/or soda-pyroxenes of metamorphic origin are as widely distributed and occur in such a diversity of types, as in the eastern part of Corsica. Although, in a general sense, much is known of the geology of this island, it appears that the glaucophane-bearing and related rocks, in contrast with those from several other areas, have never been subjected to a detailed petrological study. Some descriptions of glaucophane-bearing rock-types from various localities are found in the older literature, the principal work having been done by NENTIEN (Lit. 13). Furthermore the studies of LACROIX (Lit. 11 and 12) and of ORCEL (Lit. 15) may be mentioned. A short review of the metamorphism of the basic eruptive rocks in relation to general structural features, was given by PILGER (Lit. 16). In 1948 one of the writers of the present paper published the results of the microscopical study of some glaucophane-bearing rocks from the northern part of the island (EGELER, Lit. 6), whereas in 1951 the writers published a preliminary note comprising a number of the principal results of the investigations to be dealt with more in detail in the following pages (BROUWER and EGELER, Lit. 3). Recently a petrological study of the region to the south of Vezzani was published by NETELBEEK (Lit. 14).

The object of the investigations dealt with in the present paper was to study, by means of field-work combined with microscopical and chemical examination, the nature of the metamorphism responsible for the formation of the glaucophane-bearing and related rocks in eastern Corsica. With this purpose in mind a number of areas were selected for a more detailed study. Preliminary investigations carried out in 1947 and indications given by students of the University of Amsterdam working on the island for their doctoral dissertation, facilitated the choice of these areas. The field-work was carried out in the summer of 1949. The principal work was done in the Serra di Pigno area between Bastia and St Florent, in the San Petrone area south of Morosaglia and in the area northwest of Vezzani. Further studies were made along parts of the coast of Cap Corse, in the neighbourhood of Matra and at some other localities.

The microscopical determination of the material collected during these investigations was carried out by C. G. EGELER.

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GEOLOGICAL SETTING

The rocks dealt with in this paper form part of the schistes lustrés nappe, which covers a large part of Corsica east of the autochthonous massif. The schistes lustrés series is chiefly composed of metamorphic sediments, now mainly argillaceous schists (phyllites and calcareous phyllites, grading towards the north into muscovite-bearing schists) and further marbles and some quartzites. Ophiolites, comprising ultrabasic rocks (mainly serpentines), gabbros, dolerites, spilites and tuffaceous rocks in varying stages of transformation, appear to be abundantly intercalated between the other rocks of the schistes lustrés series. The ophiolites are sometimes intimately associated with radiolarian cherts.

It is in the first place out of the gabbroic, doleritic, spilitic and tuffaceous varieties that the glaucophane-bearing and related rocks have been formed. These glaucophanitic types are abundantly represented in different parts of Cap Corse, in the region west of Bastia, in the Insecca southwest of Biguglia, along the belt extending over more than 50 kilometres north and south of Morosaglia, near Cervione, Tox and Moita, west of Piedicorté, and lastly at several localities around Vezzani and northeast of Lugo [1]).

Besides the rock-types already mentioned as making out part of the schistes lustrés series, there occur at several places quartzo-felspathic gneisses. Those known by PILGER (Lit. 16) were interpreted by him as granites, which had been syntectonically intruded into the schistes lustrés. These so-called "alpine granites" [2]) indeed appear largely syntectonic. However, our present investigations seem to indicate that they have been chiefly formed by transformation of preexisting rocks. They grade out into the non-granitized varieties through zones of composite rock-types. PILGER records the occurrence of the "granitic" rocks in the areas west and south of Bastia, near Centuri on Cap Corse and west of St Florent, whereas they are now also known to occur in the area of San Pietro di Tenda, where they form part of the Tenda range, and further within the schistes lustrés series more to the south, e.g. near Venaco and Vezzani (BROUWER, Lit. 2, NETELBEEK, Lit. 14) and near Castirla.

Besides in the schistes lustrés series of Corsica, rocks containing sodic amphiboles of metamorphic origin are also locally found in the

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[1]) See Plate I of PILGER's publication (Lit. 16), chiefly based on MAURY's field results (Carte Géologique de la France 1 : 80.000) with some additions.

[2]) The name "alpine granite" for these rocks was introduced by PILGER. It should be pointed out, however, that they are mainly gneissic rock-types essentially consisting of quartz, albite and colourless mica and sometimes containing potash felspar (see also NETELBEEK Lit. 14, p. 107).

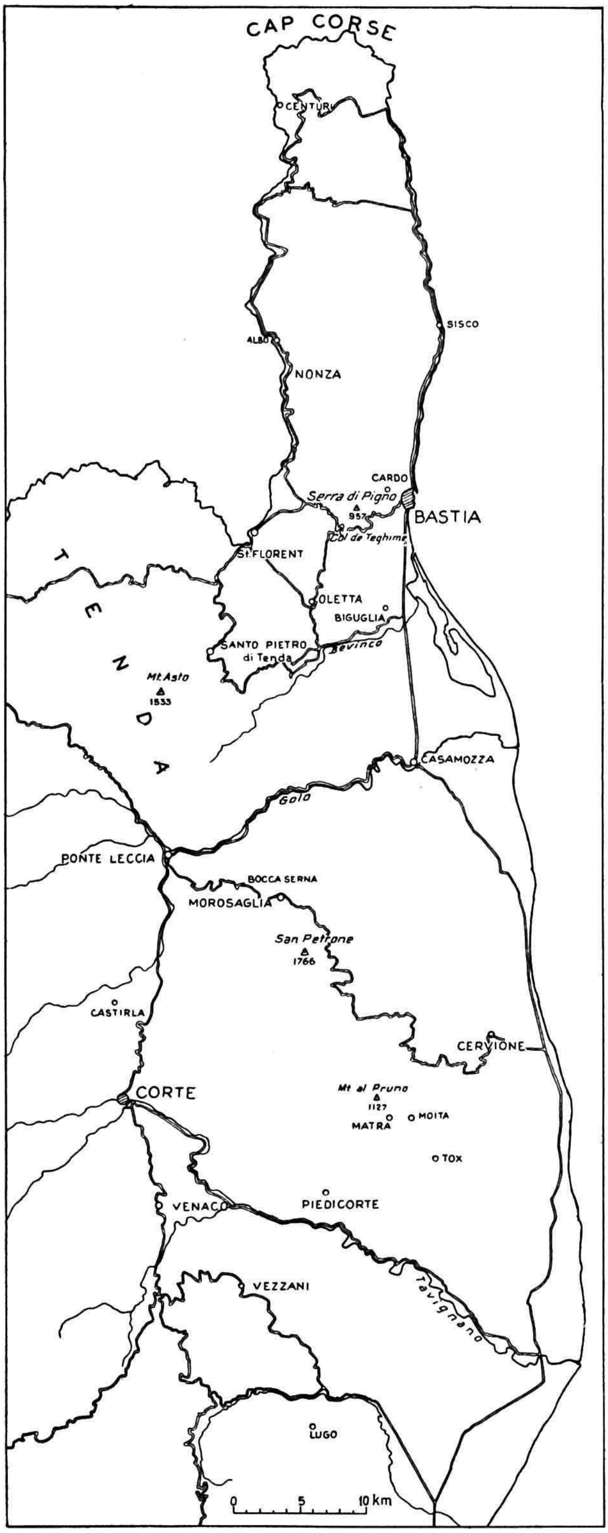

Fig. 1. Map of northeastern Corsica with principal localities mentioned in the text.

eastern part of the autochthonous massif, sometimes at a considerable distance from the main overthrust zone. They generally occur in mylonitized zones in the hercynian granite (NETELBEEK, Lit. 14, p. 113) and also in dioritic rocks showing the influence of the alpine dislocations. Furthermore, sedimentary rocks of the autochthonous and parautochthonous series also sometimes appear to be influenced by the glaucophane facies metamorphism, examples being found e.g. approximately 3 km southeast of Corte, where eocene conglomerates occur containing newly formed prisms of blue amphibole, both in the pebbles and in the matrix [1]).

[1]) Oral communication by Mr L. RITSEMA.

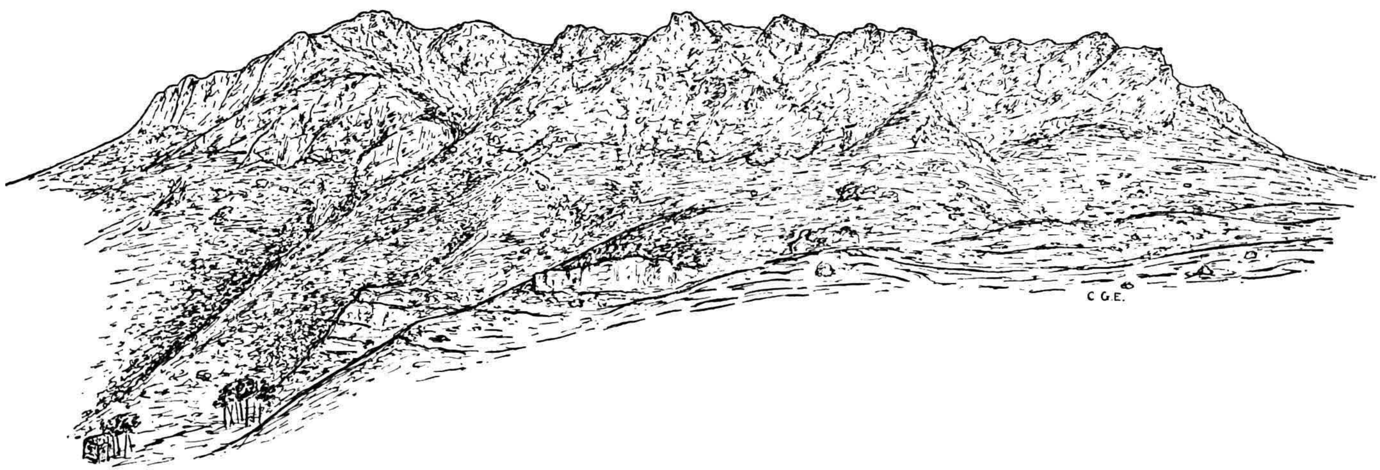

Fig. 2 *The Serra di Pigno range viewed from the east.* The sloping plateau at the base of the steep rocks is mainly formed by glaucophane-schists. The steep rocks above the plateau consist of glaucophane-schists and massive glaucophanites partly alternating with or grading into albitic gneisses ("alpine granites").

PETROLOGY OF THE VARIOUS AREAS INVESTIGATED

SERRA DI PIGNO AREA

In the region west of Bastia a mountain range, which comprises the Serra di Pigno (957 m) and the Mt Muzzone (941 m) as chief summits, stretches from the Col de Teghime in a northern direction.

On the eastern side, the base of this range appears to be mainly formed by a thick series of intensely folded glaucophane-rich schists with intercalations of micaceous schists and phyllites of the schistes lustrés. Where the sloping plateau formed by this glaucophane-schist series passes into the steep rocks which form the ridge between the Serra di Pigno and the Mt Muzzone, the predominant rock-types are of a more massive variety, considered to be of igneous origin, viz. mostly glaucophanites, sometimes passing into glaucophane-gabbros. Higher up, glaucophane-schists again predominate, partly in association with schistes lustrés (including marbles). It is considered that the lower and upper glaucophane-schist series comprise, besides normal sedimentary types, many rocks of tuffaceous origin, while it seems well possible that in the lower series highly sheared basic igneous rocks are also represented (fig. 2).

Often the rocks of the glaucophane-schist series are speckled with porphyroblastic albite crystals; occasionally also thin bands are found to consist almost exclusively of albite. The upper part of the lower glaucophane-schist series and the rocks above are more or less affected by granitization [1]), this giving rise to various types of composite rocks. Especially conspicuous are certain banded complexes, formed by alternating layers of highly micaceous felspathized glaucophane-schist, and of albitic gneiss ("alpine granite"), good examples being found at the base and near the top of the steep part of the eastern Pigno slope. Furthermore certain eyed glaucophane-gneisses may be mentioned, occurring i.a. east of the Cima Orcaio along the road leading to the Col de Teghime; they are locally associated with more or less irregular bodies of quartzo-felspathic gneiss ("alpine granite"). Lastly, attention may be drawn to the larger bodies of albitic gneiss occurring high up on the slope, i.a. northeast of the summit of the Serra di Pigno, in which often more or less irregular patches of glaucophanitic rocks in varying stages of granitization are found.

The southwestern slope of the Serra di Pigno shows a different character.

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[1]) The use of the term granitization may lead to ambiguity. In the present paper it indicates all such changes (by felspathization and introduction of quartz) as lead to the formation of albite-rich and microcline-rich gneisses. In the schistes lustrés series of Corsica these rock-types are closely associated.

Here serpentines appear to be very abundant in the west, whereas more towards the southeast greenschists and other metamorphic rock-types, partly containing glaucophane and mostly exhibiting varying stages of felspathization or granitization, show a widespread distribution. High on the southwestern slope, quartzo-felspathic gneisses ("alpine granites"), often very rich in microcline, are abundant, although always containing patches and streaks of more or less granitized basic rocks.

PILGER (Lit. 16, Pl. II) considered the so-called "alpine granites" in the Pigno area to have a much larger distribution than is actually the case. In fact, the present investigations show, that a considerable part of the rocks from the eastern Pigno slope interpreted by PILGER as granites, are actually the metamorphic representatives of basic (partly gabbroic) igneous rocks, which, although often showing phenomena of granitization like the formation of new felspar and the introduction of quartz, have mostly retained their original character to a considerable extent.

The glaucophane-schist series at the base of the Pigno

In this series the following main types are distinguished:

Lawsonite-rich glaucophane-schists, comprising lawsonite-glaucophane-schists rich in albite and partly containing brown mica, muscovite-lawsonite-glaucophane-schists and garnet-lawsonite-glaucophane-schists partly rich in and partly almost devoid of albite.

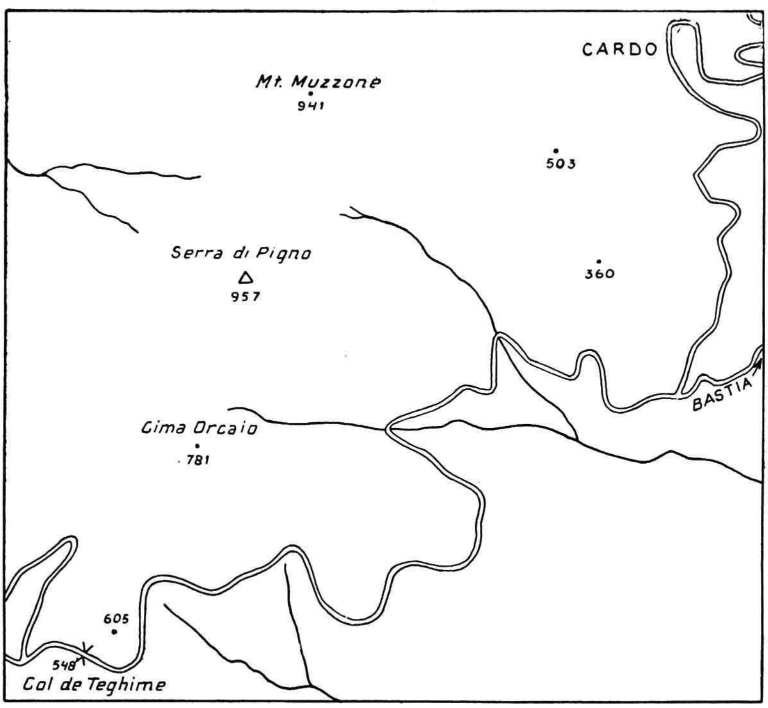

Fig. 3. *Serra di Pigno area.*

Epidote-rich glaucophane-schists, comprising epidote-glaucophane-schists partly rich in albite, chlorite-epidote-glaucophane-schists rich in albite, and muscovite-epidote-glaucophane-schists partly rich in and partly devoid of albite.

Glaucophane-bearing epidote-muscovite-quartz-schists.

Glaucophane-muscovite-schists.

Epidote-crossite-muscovite-schists.

Chlorite-lawsonite-sodapyroxene [1])-schists rich in albite.

Lawsonite-bearing albite-chlorite-schists.

A number of the more characteristic types of the different groups distinguished will be described in some detail [2]).

Lawsonite-rich glaucophane-schists. — A garnetiferous lawsonite-glaucophane-schist collected where the road from Bastia to the Col de Teghime crosses the stream descending from the Serra di Pigno ridge, was selected as a type representative of the glaucophane-schists almost devoid of felspar. It is a fairly fine grained, highly schistose rock, especially characterized by its conspicuous blue colour. Under the microscope the glaucophane appears to be developed in pale blue elongated prisms, mainly parallel-ranged and with an average length of 0.3 millimetre. Locally some larger, broad glaucophane crystals occur, which are very rich in titanite with a patchy distribution; these crystals are considered to be pseudomorphic after either amphibole or pyroxene of igneous origin. In general they appear, however, almost completely destroyed. Lawsonite is very abundant, forming fairly small, tabular crystals. Some interstitial muscovite occurs. The chlorite present is, at least partly, of secondary origin, formed out of amphibole and also out of garnet. The latter mineral is quite abundant, forming small rounded crystals, enclosing i.a. glaucophane and titanite. Locally some small crystals of a green coloured soda-pyroxene occur. Titanite is very abundant in small grains scattered throughout the rock. Accessory constituents are epidote and much limonitized opaque oxidic iron ore. Lastly the occurrence of albitic felspar must be mentioned, although here this mineral is very rarely found [3]).

SiO_2	46.64
Al_2O_3	16.88
Fe_2O_3	5.13
FeO	4.79
MgO	6.45
CaO	8.47
Na_2O	4.51
K_2O	0.91
H_2O^+	3.08
H_2O^-	0.08
CO_2	0.79
TiO_2	1.87
P_2O_5	0.12
MnO	0.13
	99.85

A more highly felspathic variety (Plate I, fig. 1) is represented by an

[1]) Sodic pyroxenes of metamorphic origin are found to be widely distributed in many of the rocks influenced by the glaucophane facies metamorphism. At least part of these pyroxenes have a considerable jadeite content. As a detailed mineralogical study of these pyroxenes is outside the scope of the present paper, the various representatives of the group will all be mentioned as soda-pyroxene.

[2]) A number of the above mentioned rock-types were described already in an earlier publication (EGELER, Lit. 6).

[3]) The chemical analysis of this garnetiferous lawsonite-glaucophane-schist is given in the text. (Anal. J. W. A. BODENHAUSEN.)

albite-rich lawsonite-glaucophane-schist collected somewhat further along the road to the Col de Teghime, some 60 metres before reaching the bridge across the stream descending from the Cima Orcaio. It is again a blue coloured rock with a tabular schistosity. Though it shows many features in common with the variety described above, the high content of porphyroblastic felspar, which is easily recognizable in the specimen, forms a distinctive feature. The albite forms elliptical crystals with the long axis in the plane of schistosity. These crystals may measure over a millimetre across. Generally they appear untwinned and pellucid, whereas the development is markedly poiciloblastic, the original schistosity of the rock still being traceable through the albite as trails of directed inclusions (mainly of lawsonite, glaucophane and titanite). Occasionally these trails appear to be slightly S-shaped, indicating a synkinematic crystallization of the felspar, which, for reasons to be discussed later, is considered to be metasomatically formed. Even though the distribution of the porphyroblasts is fairly uniform, a distinct tendency towards local segregation is observed. Other points in which this rock differs from the variety described above, are the absence of garnet and the relative abundance of epidote, this latter mineral being mainly developed in fairly large individuals, locally concentrated in particular bands. It appears that this epidote forms at the expense of the lawsonite, which, however, is still the more abundant of the two. Glaucophane is again present in great quantity in slender prisms with a mainly parallel orientation; large, broad glaucophane individuals resembling those found in the rock described above, again occur. Other minerals present are chlorite, mainly formed out of glaucophane and lawsonite, much finely granular titanite and minor amounts of muscovite, carbonate and apatite, the latter often granulated and drawn out to lenticular patches [1]).

SiO_2	50.63
Al_2O_3	17.58
Fe_2O_3	2.99
FeO	5.07
MgO	5.83
CaO	6.69
Na_2O	4.24
K_2O	1.01
H_2O^+	3.48
H_2O^-	0.17
CO_2	0.14
TiO_2	2.37
P_2O_5	0.34
MnO	0.15
	100.69

Occasionally lawsonite-rich schists of the types described above are found to alternate with green coloured rock-types rich in epidote and almost devoid of lawsonite, while also blue amphibole appears to be very subordinate. Here almost the entire mesostasis is formed by albite crystals with interstitial chlorite. The epidote is present in rounded grains, often concentrated in particular bands and sometimes forming streaks. The amphibole in these rocks is chiefly a very pale greenish actinolitic variety, which occurs in fine needles mainly enclosed by felspar and chlorite and which only locally appears associated with some pale blue soda-amphibole.

Epidote-rich glaucophane-schists. — Examples of the epidote-rich glaucophane-schists were collected both at Cardo and at various places

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[1]) The chemical analysis of this albite-rich lawsonite-glaucophane-schist is given in the text. (Anal. Lab. LOBRY DE BRUYN).

along the road from Bastia to the Col de Teghime. They often show a striking resemblance to the varieties rich in lawsonite, the chief distinctive feature being the occurrence of epidote as principal lime-silicate. In fact, the various samples investigated all appear wholly devoid of lawsonite, while epidote often becomes quite abundant, occasionally forming greenish yellow porphyroblasts in which glaucophane needles may be enclosed. Large epidote crystals with orthitic cores are also observed, whereas in some of the rocks investigated the epidote group is represented by low-birefringent members, forming more finely granular aggregates or swarms of small prisms.

Like the lawsonite-rich varieties, the epidote-rich glaucophane-schists are also frequently more or less intensively felspathized, good examples being found i.a. at the base of the steep rocks on the eastern Pigno slope. Here epidote-muscovite-glaucophane-schists, which alternate in bands with albitic gneisses ("alpine granite"), are very rich in albite, which in this case is synkinematically crystallized, as proved by enclosed S-shaped trends of glaucophane, muscovite, epidote, titanite and sometimes quartz (Plate I, fig. 2).

Among the epidote-glaucophane-schists some highly micaceous varieties may especially be mentioned on account of the fact that the faintly greenish mica is developed in poiciloblastic individuals measuring several millimetres across, this giving rise to a well-marked tabular schistosity. Other epidote-rich glaucophane-schists are more massive, even though the schistosity is still clearly distinguishable megascopically. This is caused by the glaucophane being developed in fairly stout crystals, often with a more or less arbitrary orientation. These stoutly built glaucophane individuals, which always enclose numerous minute inclusions of titanite, may contain relict cores of a brownish green hornblende considered to be of igneous origin.

Glaucophane-bearing epidote-muscovite-quartz-schists. — Occasionally the glaucophane-schists become rich in both mica and quartz, in which case they may grade into epidote-rich muscovite-quartz-schists with glaucophane occurring in a more subordinate quantity.

Glaucophane-muscovite-schists. — High in the glaucophane-schist series other types of highly micaceous schists occur, e.g. certain glaucophane-muscovite-schists which form narrow bands alternating with bands of albitic gneiss ("alpine granite"). Megascopically these rocks show a phyllitic habit. Under the microscope they appear to consist almost exclusively of the two minerals mentioned in the name, the mica partly grading into a more sericitic type and forming the mesostasis in which are embedded numerous small prisms of glaucophane. An intensive minute folding is observed, both the mica and the amphibole appearing postkinematically crystallized. Some garnet may occur in small grains, whereas titanite is present in considerable quantity, as finely granular crystals scattered throughout the rock. Furthermore some apatite may be

PLATE I

Fig. 1

Glaucophane-schist with beginning felspathization; along the road from Bastia to the Col de Teghime, approximately 60 m before the bridge across the stream descending from the Cima Orcaio. The highly schistose rock is essentially composed of glaucophane with lawsonite, chlorite and some epidote. The albite, which forms lenticular porphyroblasts, tends to concentration in special layers. // nicols (× 19).

Fig. 2

Synkinematically crystallized albite porphyroblast enclosing S-shaped trends of glaucophane, epidote, muscovite, titanite and some quartz. In felspathized muscovite-epidote-glaucophane-schist from the banded complex of glaucophane-schists and albitic gneisses ("alpine granites") at the base of the steep rocks on the eastern slope of the Serra di Pigno. // nicols (× 80).

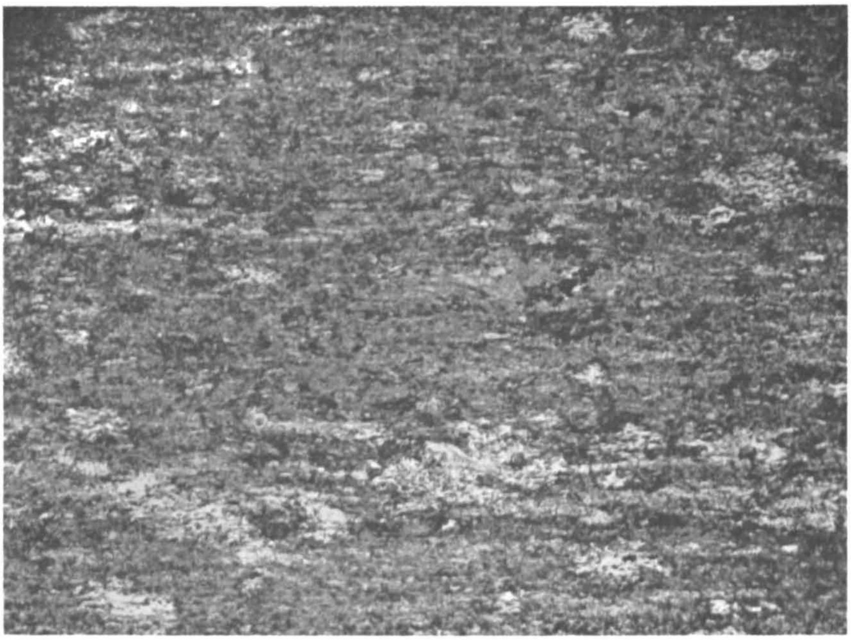

Fig. 1

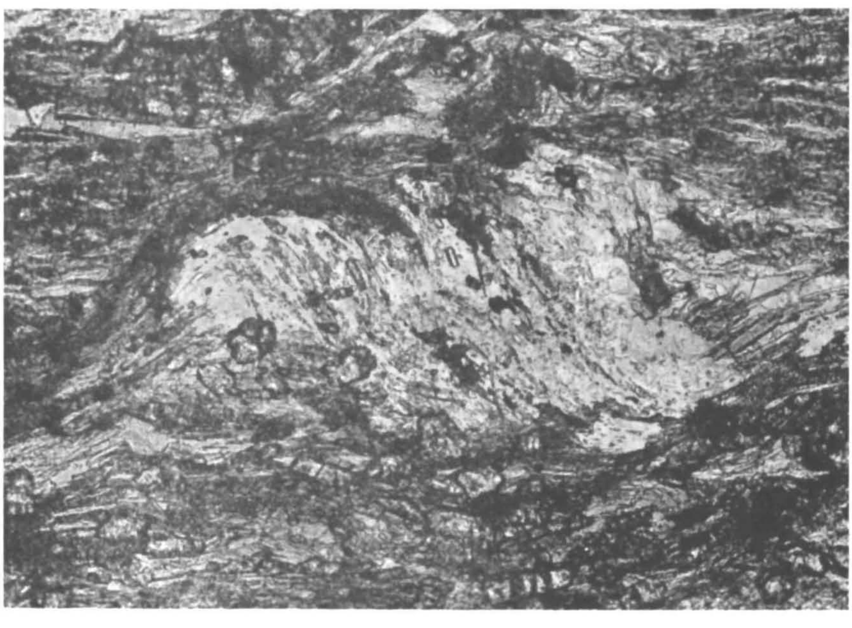

Fig. 2

Fig. 1

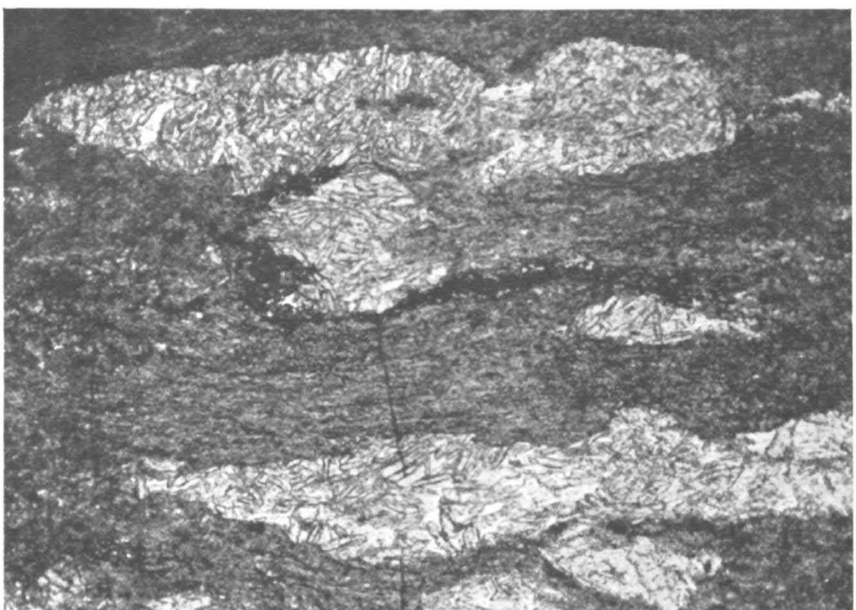

Fig. 2

PLATE II

Fig. 1

Folded trends consisting of lawsonite, muscovite and titanite crystals in postkinematically crystallized albite. The albite is embedded in a mass of chlorite rich in titanite. In felspathized schists in the glaucophane-schist series at the base of the Mt Muzzone, southwest of Cardo. // nicols (× 42).

Fig. 2

Relict igneous structure in micaceous lawsonite-glaucophane-schist from the eastern slope of the San Petrone, just above the contact between serpentine and glaucophane-schist series. The "groundmass" which consists essentially of glaucophane, muscovite, lawsonite and titanite, is highly schistose. The light coloured patches, which represent original plagioclase phenocrysts, are drawn out to lenticles conforming with the general parallel orientation, though they may, to a certain extent, have retained their original shapes. The pseudomorphosing minerals are lawsonite with some muscovite; the lawsonite crystals in the pseudomorphs are oriented at random. // nicols (× 18).

mentioned. Epidote, though present, occurs only in a very subordinate amount. Occasionally the rocks of this type also appear to be albitized.

Epidote-crossite-muscovite-schists. — Another distinctive type occurring intercalated in the glaucophane-schist series is formed by certain intensely folded epidote-crossite-muscovite-schists, which megascopically appear very conspicuous by their fine silvery lustre and high degree of schistosity. The distinct banding observed in these rocks is caused by highly micaceous beds alternating with beds rich in blue amphibole. Under the microscope epidote, muscovite and alkali-amphibole appear to be the main constituents; the latter is in this case a deep blue crossite. The mineral is developed in well-shaped, elongated prisms of considerably varying size; the larger ones are sometimes more than 2 millimetres in length. Often they appear to be bent or broken; small rutile needles are frequently enclosed. Epidote forms, partly large, idioblastic crystals of a yellow colour, sometimes with cores of brownish orthite and inclusions of i.a. crossite and rutile. Some bands are very rich in colourless mica. Green chlorite occurs associated with muscovite and crossite; some irregularly rounded chlorite patches may represent original garnets. Quartz is present locally in large irregular crystals presumably introduced in a late stage of the metamorphism. Titanite is an important accessory constituent, while tourmaline appears to be present in unusual quantity, forming small prisms. Apatite is locally developed in large prisms, which sometimes enclose the soda-amphibole and which may contain chlorite in their cracks. Lastly the occurrence of some iron ore may be mentioned.

Chlorite-lawsonite-sodapyroxene-schists. — Locally, for example on the slope southwest of Cardo, characteristically blue coloured lawsonite-glaucophane-schists of the type described earlier in this chapter are found to alternate with green coloured albite-rich chlorite-lawsonite-soda-pyroxene-schists. The albite is present here in an exceptionally large quantity, in often well-twinned porphyroblasts, which frequently measure over a millimetre across. They are mostly embedded in a matrix of green chlorite. Their poiciloblastic development is very striking. The most conspicuous feature of these rocks is the occurrence of a soda-pyroxene instead of an amphibole as principal coloured alkaline mineral. In fact, glaucophane is found only in a very subordinate amount in slender prisms mostly associated with the pyroxene. The latter is an apple-green variety developed in rather fibrous crystals of much varying size, though seldom longer than 0.5 millimetre. The mineral is distinctly pleochroic from green with a bluish tinge (n_α) to yellowish green (n_β) and greenish yellow (n_γ). The extinction angle n_α/c varies; in the cores of the crystals angles between 26° and 29° were measured, passing to 38°—40° in the rims. Particular bands appear to be especially rich in these pyroxene crystals, which distinctly tend towards parallel arrangement. Lawsonite, developed in small tabular crystals, is very abundant in these pyroxene-rich bands and also occurs elsewhere in the rock in considerable quantity. Carbonate is especially concentrated along the contact with the lawsonite-glaucophane-schist and is considered as a later infiltration product. From among the accessories titanite may especially be mentioned as being abundant; epidote occurs locally.

Lawsonite-bearing albite-chlorite-schists. — Besides passing into the chlorite-rich rocks mentioned above, the glaucophane-schists on the slope southwest of Cardo are also found to pass locally into chlorite-schists, which are wholly devoid of both alkali-amphibole and alkali-pyroxene, but which are very rich in albite. Megascopically the latter mineral is very conspicuous. It not only occurs in separate porphyroblasts and rounded or oval patches, measuring several millimetres across, but it appears more often concentrated in light coloured discontinuous bands parallel to the general schistosity. Microscopically the felspar, which shows no cataclastic features, encloses folded trends consisting of small crystals of lawsonite, muscovite and titanite (Plate II, fig. 1). It is clear that in this case the albite has developed subsequent to the deformation, possibly simultaneously with the chlorite.

Glaucophanites and related rocks on the eastern Pigno slope

Among the more massive rock types occurring in the Serra di Pigno area glaucophanites, glaucophane-gabbros and crossitites may be distinguished.

Glaucophanites. — Certain massive epidote-glaucophanites are widely distributed, high on the eastern Pigno slope. Megascopically most of these rocks appear to be devoid of schistosity. The alkali-amphibole is a pale blue glaucophane, only occasionally showing some small patches of crossite. The mineral is developed in stout crystals with a more or less random orientation. They enclose finely granular titanite and are considered to have been formed by conversion of either pyroxene or amphibole of igneous origin. Albitic felspar occurs in varying quantities in irregularly rounded crystals which contain much finely granular epidote material, originated from sausuritization of originally lime-rich plagioclase. Often the epidote is also associated with sericite. Chloritization of the glaucophane is a widespread phenomenon. Titanite and leucoxene are the principal accessory constituents.

SiO_2	51.81
Al_2O_3	12.36
Fe_2O_3	3.68
FeO	5.85
MgO	12.52
CaO	4.03
Na_2O	2.15
K_2O	0.87
H_2O^+	4.52
H_2O^-	0.27
CO_2	—
TiO_2	0.98
P_2O_5	0.44
MnO	0.27
	99.75

A somewhat divergent type of glaucophanite, which was found to occur in irregular bodies in albitic gneiss ("alpine granite"), was selected for chemical analysis[1]). It consists essentially of glaucophane, developed both as broad crystals and as smaller, fibrous individuals. Further this

1) The chemical analysis of this chlorite-rich glaucophanite is given in the text. (Anal. Lab. LOBRY DE BRUYN).

somewhat cataclastic rock is rich in chlorite, developing at the expense of the amphibole. Epidote, sometimes with an orthitic core, is locally concentrated, although in a much smaller quantity than in the epidote-glaucophanites described above. Some muscovite is present in fairly large flakes, whereas a small quantity of presumably introduced quartz sometimes occurs between the glaucophane-crystals. No albite was found. Titanite is abundant, often containing leucoxene or rutile in the core.

Glaucophane-gabbros. — Actually belonging to the group of the glaucophanites, but separated from this on account of the good preservation of the igneous structure, are the so-called glaucophane-gabbros. Examples were collected high on the eastern Pigno slope, directly southeast of the summit of the Mt Muzzone. As closely related gabbroic rocks from the east coast of Cap Corse and from San Petro d'Accia in the San Petrone area, will be dealt with in some detail later, only a short description will be given here. The rocks in question show a strongly varying grain size; the amphibole crystals in more coarsely grained types occasionally attain a length of over 2 centimetres. In general glaucophane is the principal dark constituent, occasionally associated with a bluish green amphibole and in one case found to contain very thin lamellae probably of alkali-pyroxene in the core. The larger glaucophane crystals, which are pseudomorphic after pyroxene crystals, always contain minute grains and parallel strings of titanite and leucoxene. Fresh, fibrous glaucophane crystals occur locally. Chloritization of the amphibole has often reached an advanced stage. The decomposition of the original lime-plagioclase of the gabbro has mostly resulted in the formation of albite filled with finely crystalline minerals of the epidote group. Sometimes the felspar is very rich in sericite. Apatite is a very abundant accessory constituent, occurring sometimes in relatively large crystals and partly forming granular patches. Other accessories are rutile, leucoxene and ore. Some secondary quartz may occur.

Crossitites. — A divergent type is represented by the crossitites. A sample collected northeast of the summit of the Serra di Pigno consists almost exclusively of large fibrous crossite crystals, often several millimetres in size and showing a random orientation. Often these crystals, which generally contain titaniferous material, are intimately intergrown. They also show a very advanced degree of chloritization. Titanite and leucoxene are the principal accessory constituents. A small amount of quartz occurs.

The glaucophane-bearing and related rocks from the Pigno area frequently appear affected by alpine granitization, this giving rise to various types of composite rocks, which will be discussed in some detail later, when dealing with the granitization phenomena. In this connection it may be pointed out that the widespread development of porphyroblasts of albite in many of the rocks of the glaucophane-schist series, is considered to be related to the granitization. As the non-felspathic varieties grade into those rich in felspar, through a series of gradational types, making a sharp discrimination impossible, they have been dealt with together.

SAN PETRONE AREA

The highest summit of the schistes lustrés nappe is the San Petrone (1766 m), southeast of Morosaglia. The base of this mountain is almost entirely formed by massive serpentines, but the higher parts consist of a thick series of glaucophane-schists (fig. 4), striking approximately

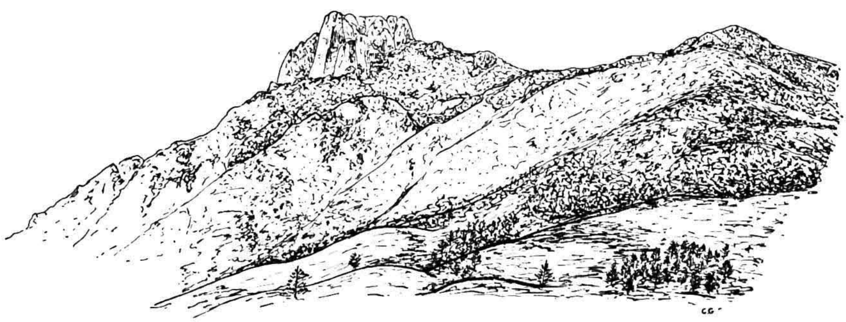

Fig. 4. *The San Petrone viewed from the east.* The summits consist of glaucophane-schists resting upon a large mass of serpentine.

N—S and dipping fairly steeply to the west. These schists have paid more resistance to erosion than the softer serpentines, a fact especially evident on the eastern side of the San Petrone, where they form the steep cliffs of the summit-ridge. Towards the base the serpentines pass into schistes lustrés, mainly represented by phyllites and calcareous phyllites, with only local intercalations of quartzitic and other glaucophanitic rocks. The general distribution of the various rock types is shown in fig. 5.

The glaucophane-schist series of the San Petrone

The rocks constituting the glaucophane-schist series which forms the actual summit of the mountain and a large part of its western slope, show very little variation, the representative type being a dense, though in most cases distinctly schistose rock, of a greenish blue to deep blue colour, sometimes with garnet in megascopically recognizable crystals. Occasionally these schists are speckled with more or less angular to elongated patches of a greyish white colour; these patches attain a length of over 5 millimetres.

Microscopical investigation of a number of samples shows that these consist essentially of two minerals, viz. glaucophane and lawsonite. A sample collected on the western slope of the mountain with the special

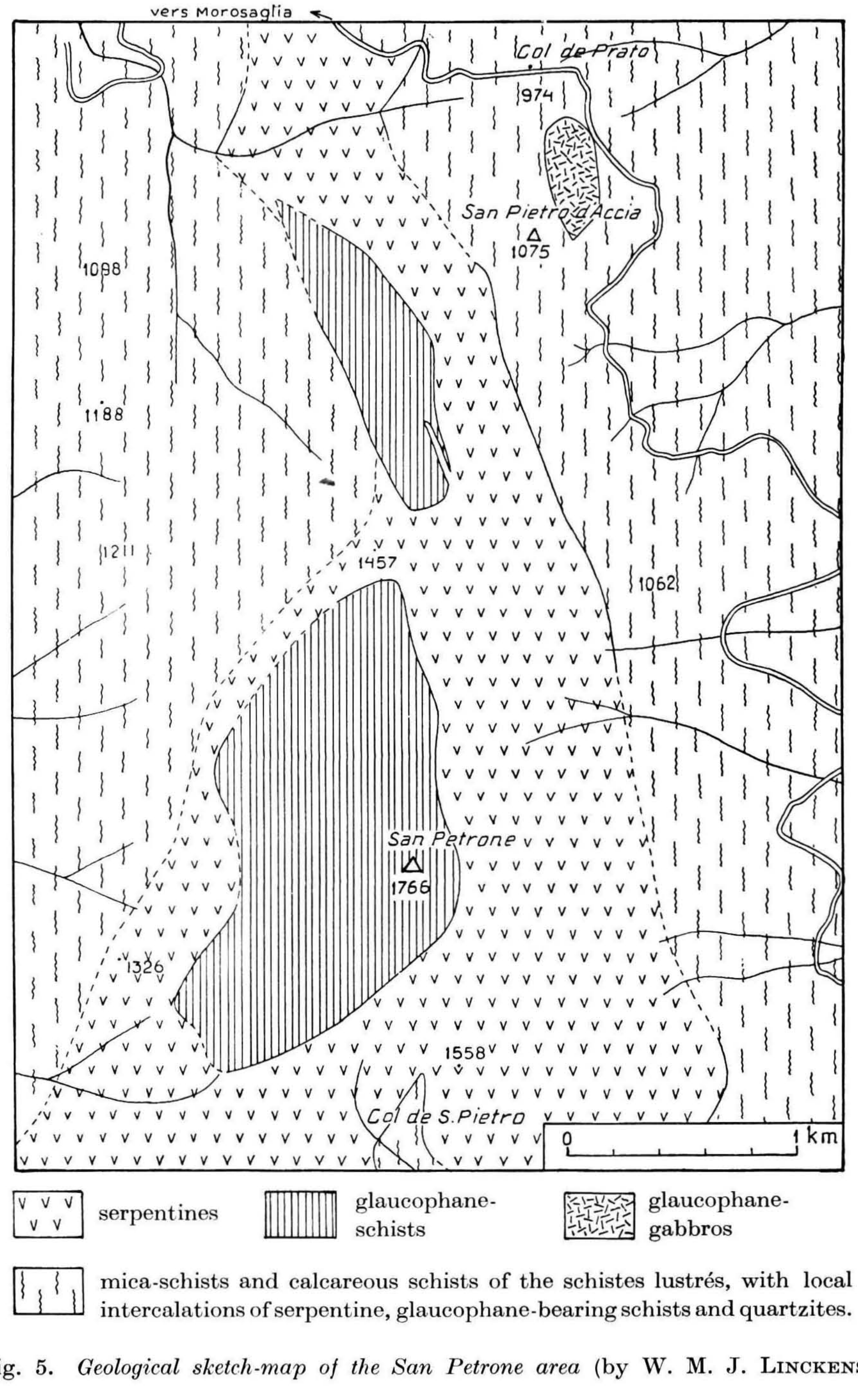

Fig. 5. *Geological sketch-map of the San Petrone area* (by W. M. J. LINCKENS).

intention of obtaining a truly representative type for chemical analysis [1]), is found to be a lawsonite-glaucophane-schist containing a considerable amount of soda-pyroxene. The lawsonite, which is distributed throughout the rock in small angular grains, is also concentrated in lenticular patches, often associated with a green pyroxene. The latter mineral forms small xenoblastic crystals, showing a pleochroism from green (n_α) to yellowish green (n_β) and green-yellow (n_γ). An extinction-angle $n_\alpha/c = \pm 26°$ was measured, but often the mineral is slightly zonal. Epidote, albite, garnet, muscovite and iron ore are present in only subordinate amount. Chlorite is fairly abundant as a secondary mineral, formed by transition of glaucophane, lawsonite, garnet and pyroxene. Titanite occurs in a large quantity in small, mostly spindle-shaped grains.

SiO_2	50.33
Al_2O_3	14.67
Fe_2O_3	3.69
FeO	5.88
MgO	6.03
CaO	8.07
Na_2O	4.26
K_2O	0.13
H_2O^+	4.18
H_2O^-	0.20
CO_2	—
TiO_2	2.32
P_2O_5	0.24
MnO	0.12
	100.12

Other varieties, such as for instance the lawsonite-glaucophane-schists forming the summit-block of the San Petrone, are essentially composed of the minerals mentioned in the name, almost to the exclusion of all other minerals. In contrast with the variety described above no soda-pyroxene is found.

Concentrations of red garnet, occurring in samples collected north of the summit, appear to be associated with large crystals of a pale bluish green amphibole and of green soda-pyroxene, together with carbonate, some albitic felspar and quartz.

A distinctive type is further represented by the varieties with greyish white patches, mentioned above. Under the microscope the patches in question are found to be composed chiefly of lawsonite, developed in well-shaped crystals and mostly associated with muscovite and occasionally with some soda-amphibole. Though they generally form elongated streaks these patches sometimes remind of felspar phenocrysts (Plate II, fig. 2) with straight boundaries, in which the individual lawsonite crystals appear orientated in all directions. The matrix of these rocks is essentially composed of glaucophane, forming a felt-like aggregate of parallel fibrous crystals, and of lawsonite and some muscovite. Titanite is very abundant, developed in small granular crystals forming strings parallel to the general direction of the schistosity. The accessories include garnet and apatite. It is clear that the "pseudo-porphyritic" structure caused by the above-mentioned lawsonite concentrations, is an inherited one, and that the parent rock has been a variety with porphyritic crystals of a lime-rich plagioclase. There seems to be little doubt that the less well defined lenticular concentrations of lawsonite noticed in most of the glaucophane-schists occurring in the area, are of a similar origin.

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[1]) The chemical analysis of this lawsonite-glaucophane-schist is given in the text. (Anal. Lab. Lobry de Bruyn).

The glaucophane-gabbros of San Pietro d'Accia

South of the Col de Prato, near the ruins of the little chapel of San Pietro d'Accia, exposures occur of metamorphosed gabbroic rocks, showing a considerable variation in the degree of transformation. The least changed types, which have retained their massive habit, are still rich in relict diallage, generally partly changed to glaucophane, though alterations to soda-pyroxene and to chlorite and talc are also observed. In these varieties the original lime-plagioclase is represented by irregular patches of albite, mostly filled with lawsonite and epidote-minerals.

With increasing schistosity the degree of glaucophanization is often considerably higher. This leads to gneissic varieties, rich in soda-amphibole, epidote and lawsonite. Occasionally these types also contain much newly formed green soda-pyroxene, forming concentrations of small fibrous crystals associated with zoned soda-amphibole crystals, which are generally crossitic in the cores while the rims consist of glaucophane. In the rocks of this type the principal lime-rich silicate present may also be zoisite, forming granular aggregates within albitic felspar.

Associated with the glaucophane-gabbros, are finely granular glaucophanites rich in epidote minerals, lawsonite and albite.

Glaucophane-quartzites and associated schists northwest of the San Petrone

On the northwestern slope of the San Petrone, directly to the southeast of point 1188, an interesting exposure is found. It shows intricately folded rocks, mainly consisting of quartzites of greyish white to more greenish or bluish colour. These highly schistose quartzites are interbedded with thin layers of blue glaucophane-schists. The schistosity is parallel to the stratification.

Glaucophane-quartzites. — In the quartzites the content of soda-amphibole can generally be recognized even megascopically; individual amphibole crystals, lying more or less at random in the planes of schistosity, may attain a length of more than 5 millimetres. Furthermore the high content of colourless to pale greenish mica should be mentioned.

Microscopical investigation shows these quartzites to be fairly fine-grained rocks, averaging 0.4 mm. in grain-size. The following minerals may be present besides quartz: soda-amphiboles, mica, chlorite, epidote-minerals (including orthite), albite, lawsonite, carbonate, titanite, rutile, tourmaline, apatite and iron ores.

The quartz shows a rather even-grained development; mostly the crystals have an undulose extinction, while sometimes there is a tendency towards mortar-structure. The soda-amphibole appears in most cases to be represented by both glaucophane and crossite, the former often forming pale coloured rims around deeper coloured cores of crossite. In other cases this zonal structure appears to be much less pronounced, whereas occasionally the rims are even deeper coloured than the cores. Generally the transition between both minerals is more or less gradual, but sharp boundaries may occur too. The amphibole crystals, which are chiefly concentrated in thin layers, show a considerable variation in size; bands with abundant porphyroblasts alternate with bands containing only small, more even-grained prisms. It is a notable fact that in some of the rocks investigated the soda-amphibole prisms appear broken and drawn out, while the quartzose matrix has penetrated into the cracks (Plate III, fig. 1). Chloritization of the amphibole is also often found; occasionally this process appears even to have been complete, giving rise to highly chloritic rock-types in which a considerable part of the chlorite is pseudomorphic after soda-amphibole.

Chlorite may also be present in considerable quantities in close association with epidote. In one of the slides investigated the chlorite forms large rounded patches, the cores of which are often intergrown with a deep reddish brown biotite-like mineral. The pale coloured mica, which mostly shows a faint greenish tinge, is present in thin plates of varying size. Albite is very rare. When present this mineral is developed in large porphyroblasts, which may be recognized megascopically. Epidote is generally fairly abundant, in well-shaped crystals often containing brown orthite cores. Separate orthite grains cause pleochroic haloes in the amphibole. Lawsonite may occur too and occasionally even becomes quite abundant. Chloritization of the lawsonite is a local phenomenon, whereas sometimes this mineral is replaced by epidote. The fine reddish dust occurring in the cores of the lawsonite crystals may consist of haematite; the minute needles that are sometimes enclosed are considered as rutile. Carbonate is generally rather scarce. Tourmaline, on the other hand, is frequently present in a considerable quantity, forming well-shaped greenish to blue coloured prisms, which are sometimes drawn out and broken along the basal parting. Occasionally the tourmaline is enclosed by the large irregular titanite grains, which are often scattered through the rocks. Limonitized cubes of pyrite, often over a millimetre in size, may be present in large quantity [1]).

SiO_2	87.78
Al_2O_3	3.98
Fe_2O_3	1.55
FeO	1.83
MgO	1.17
CaO	0.53
Na_2O	0.99
K_2O	0.93
H_2O^+	1.04
H_2O^-	0.10
CO_2	–
TiO_2	0.23
P_2O_5	0.05
MnO	0.03
S	0.03
	100.24

Glaucophane- and crossite-schists. — The blue sodaamphibole-rich rocks, which alternate with the quartzitic varieties described above, are lawsonite-glaucophane and -crossite-schists rich in albite. Besides the minerals already mentioned in the name they may also contain chlorite, muscovite and carbonate as important rock-forming constituents. The soda-amphibole is often developed in felt-like aggregates, sometimes

[1]) The chemical analysis of one of these glaucophane-quartzites is given in the text. (Anal. Lab. LOBRY DE BRUYN).

PLATE III

Fig. 1

Schistose glaucophane-quartzite from the western slope of the San Petrone (pnt 1188). The larger soda-amphibole crystals are cracked and broken and the separate parts appear displaced. Minerals seen besides quartz and amphibole are muscovite and some chlorite. // nicols (× 21).

Fig. 2

Strongly folded schistes lustrés comprising schists rich in soda-amphibole and/or soda-pyroxene alternating with thin beds of highly calcareous or quartziferous rocks. Col de S. Pietro (comp. textfig. 5).

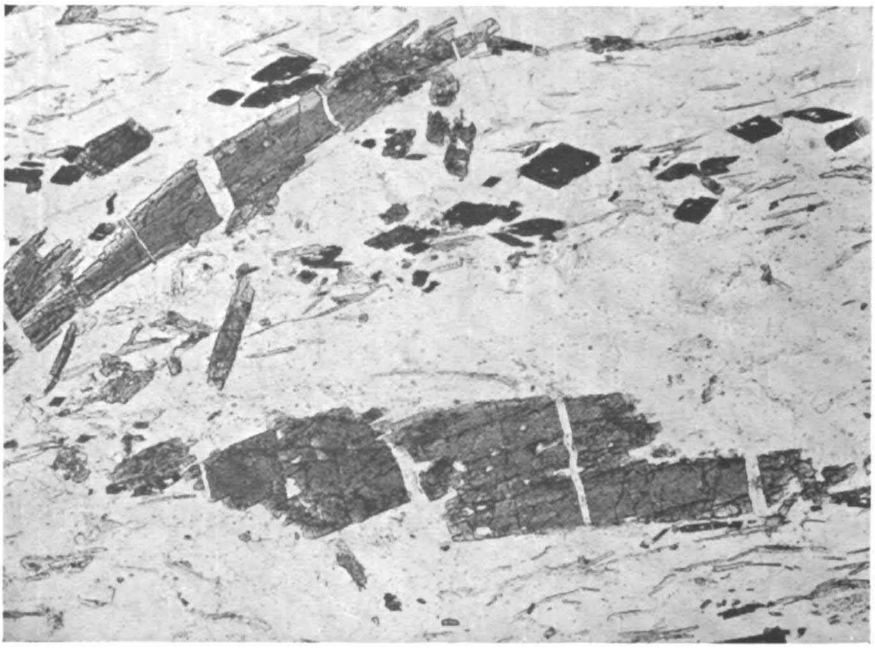

Fig. 1

Fig. 2

Fig. 1

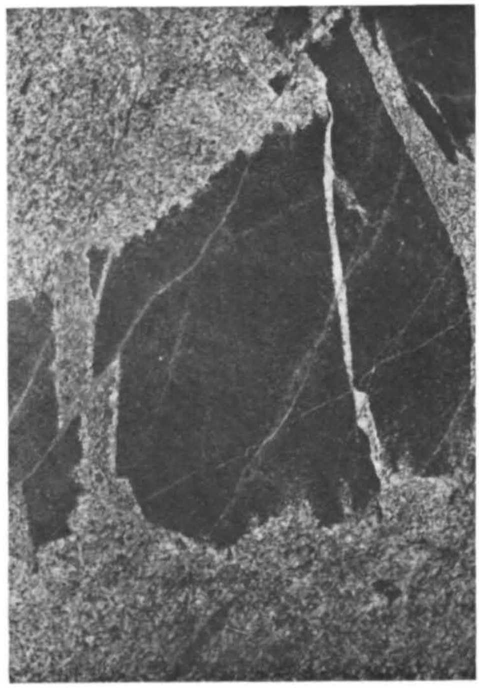

Fig. 2

Fig. 3

PLATE IV

Fig. 1

Zonal structure of soda-amphibole in an albite-crossitite from Bocca Serna, The patchy core consists of crossite; towards the outside there is a gradual transition to glaucophane, but locally the rim is again formed by crossite. The original subophitic structure of the rock is clearly seen; // nicols (× 45).

Fig. 2

Specimen of leucocratic crossite-bearing quartzo-felspathic rock enclosing fragments of albite-crossitite. Though the boundaries of the fragments are mostly sharply drawn, more gradual transitions occur too. Late movements have caused faulting. Point 836 west of Rospigliani (comp. textfig. 7). (× 0.67).

Fig. 3

"*Blue mountain*" (point 836, textfig. 7) northwest of Vezzani, mainly consisting of metamorphic spilitic and doleritic rocks rich in sodic amphiboles and pyroxenes.

consisting of pale coloured glaucophane, sometimes also passing into deeper coloured crossite. In these rocks albite may be quite abundant, developed in large poiciloblastic crystals measuring up to 2 millimetres across; they are occasionally twinned and rich in inclusions i.a. of glaucophane, titanite and lawsonite. Some quartz may occur, associated with the felspar, or forming clusters of small grains. Lawsonite is by far the most abundant lime-silicate present, mainly concentrated in bands; concentrations of lawsonite are also observed in association with calcite. Chloritization of lawsonite is quite common, while replacement by epidote occurs too. Titanite is the chief accessory constituent. As the associated quartzites, these rocks may contain large limonitized pyrite cubes [1]).

SiO_2	46.87
Al_2O_3	16.44
Fe_2O_3	1.75
FeO	6.92
MgO	7.27
CaO	7.58
Na_2O	3.75
K_2O	0.27
H_2O^+	5.07
H_2O^-	0.14
CO_2	2.34
TiO_2	1.35
P_2O_5	0.17
MnO	0.17
	100.09

Rocks rich in soda-amphibole and soda-pyroxene at the Col de S. Pietro

On the southern slope of the San Petrone, directly above the Col de S. Pietro, outcrops of intensely folded schists occur (Plate III, fig. 2). The principal rock-types represented here are greyish white calcite- and quartz-rich varieties with abundant intercalations of green and bluish coloured schists, rich in soda-amphiboles and -pyroxenes. These coloured bands may vary considerably in thickness, whereas more rounded to lenticular intercalations of green coloured material are found to occur locally. The stratification is marked both by differences in colour and by the occurrence of deep parallel furrows in the weathered surface, due to the fact that the amphibole- and pyroxene-rich schists have paid more resistance to weathering than the softer calcareous ones. The amphibole- and pyroxene-rich schists are considered to be derived from tuffs or from sediments rich in tuffaceous material.

Under the microscope the calcite- and quartz-rich rocks appear to vary between highly micaceous varieties, e.g. albite-rich calc-muscovite-quartz-schists and varieties rich in chlorite and garnet, represented e.g. by garnetiferous calc-chlorite-quartz-schists with albite- and lawsonite-rich bands.

Microscopical investigation of the coloured rocks mentioned above shows that these may conveniently be divided into three groups, the division being based on the relative amounts of soda-amphibole and soda-pyroxene present.

Schists rich in soda-amphibole. — This first group is represented i.a. by chlorite-epidote-crossite-quartz-schists showing a certain relationship to the quartzitic rocks described from the northwestern slope of the San Petrone. A distinct banding is observed; the individual layers are of varying thickness and are often discontinuous. Quartz, developed in

[1]) The chemical analysis of an albite-rich chlorite-lawsonite-glaucophane-schist is given in the text. (Anal. Lab. Lobry de Bruyn).

interlocking grains with undulose extinction, is the main constituent. Other important minerals are soda-amphibole and epidote. The amphibole, which is mainly crossite, with local transitions to glaucophane, is developed in well-shaped elongated prisms with a distinct parallel orientation. The epidote, which often shows a brown orthite core, is associated with chlorite. Mica is also fairly abundant; the mineral again shows the faintly greenish tinge observed in the other quartzitic varieties. The accessories include titanite, calcite, apatite and haematite. Some bands, that are rich in dark coloured minerals, also contain some albite, tending to porphyroblastic development.

Other sodaamphibole-bearing types are represented by certain micaceous calc-chlorite-crossite-schists, related to the non-amphiboliferous chlorite- and calcite-rich quartzitic rocks with which they appear associated. These crossite-bearing schists contain a variable amount of mica, mostly represented by an almost colourless variety, but occasionally also by an emerald green variety. Under the microscope this coloured mica is found to be pleochroic from green to almost colourless. As the optic axial angle is large and microchemical investigation proved a considerable quantity of Cr to be present, it seems that this mineral is fuchsite. Transitions to the pale coloured muscovite were frequently observed. It may be noted that fuchsite has also been found in rocks from New Caledonia (Lit. 12).

Schists rich in soda-pyroxene [1]). — These rocks are characterized by the predominance of soda-pyroxene. Under the microscope this appears to be mostly a pale greenish variety, showing a pleochroism from pale green with a faint bluish tinge (n_α) to pale greenish yellow (n_β) and pale yellow (n_γ). Occasionally, however, this colour becomes more intense, and differences in colour may occur within a single crystal. In general the extinction-angle n_α/c is very small, and often the extinction appears to be parallel. Sometimes zonal crystals are observed.

This pyroxene is sometimes present in such abundance that it gives the rocks a green colour. The rocks are mostly distinctly banded, the bands showing slight differences in composition. In many cases these green rocks show transitions to more blue coloured varieties in which soda-amphiboles predominate.

The principal minerals associated with the soda-pyroxene are: soda-amphiboles, lawsonite, epidote, albite, muscovite, chlorite, garnet and calcite. The relative proportion of the main constituent minerals may vary considerably.

The most extreme type is represented by lawsonite-sodapyroxene-schists composed essentially of the two minerals mentioned in the name. Here pyroxene and lawsonite are often closely associated, but in other cases discontinuous bands are found to consist almost exclusively of one of these minerals only. In that case the soda-pyroxene forms close aggregates of small fibrous crystals tending to parallel orientation.

[1]) See foot-note 1 on page 11.

The lawsonite associated with the pyroxene is mostly developed in small tabular crystals; in the lawsonite-rich bands the crystals may attain a length of 2 millimetres and more. The mineral is often considerably chloritized. In rocks of this type calcite and chlorite may occur locally concentrated, sometimes together with albite; muscovite shows local concentration too. Garnet is present in strongly varying quantities, forming small polygonal crystals. Soda-amphibole is only of subordinate importance. Titanite is again the principal accessory constituent, while in one particular case tourmaline was found to be exceedingly abundant, forming bands consisting almost exclusively of small prisms, pleochroic from deep brown to pale reddish brown.

Sometimes the principal constituent occurring besides the soda-pyroxene is mica. These micaceous types are well exemplified by certain close-textured fairly homogeneous muscovite-sodapyroxene-schists. Here the pyroxene crystals again show a distinctly parallel arrangement, either forming aggregates of small fibrous crystals or occurring separately in close association with the mica. Occasionally these two minerals also attain larger dimensions (up to more than a millimetre). Lime-rich silicates are represented by both lawsonite and epidote, the former often concentrated in special bands. Some crossite is present; albite occurs unevenly distributed in porphyroblastic individuals. Other constituents are: titanite, chlorite, apatite, iron ore and tourmaline, the latter often concentrated locally in considerable quantities [1].

SiO_2	46.61
Al_2O_3	18.55
Fe_2O_3	10.45
FeO	0.94
MgO	1.94
CaO	8.25
Na_2O	5.12
K_2O	3.06
H_2O^+	2.77
H_2O^-	0.08
CO_2	0.23
TiO_2	2.20
P_2O_5	0.21
MnO	0.03
	100.44

The micaceous varieties may also be rich in garnet, while crossite sometimes becomes an important constituent, forming elongated prisms, closely associated with pyroxene, muscovite and lawsonite.

Another distinctive type is formed by somewhat coarser grained garnet-rich albite-muscovite-sodapyroxene-schists containing also soda-amphibole, chlorite and lawsonite as important rock-forming constituents. Megascopically the schistosity of these patchy blue and greenish rocks is not very conspicuous. Under the microscope, however, a distinct tendency is observed, towards parallel orientation of the various constituents, even though spherulitic aggregates of pyroxene may lie at various angles with the schistosity. Soda-pyroxene appears to be considerably less abundant than in the rocks described above, forming discontinuous streaks and more rounded patches consisting essentially of small pyroxene crystals associated with lawsonite. The streaks are embedded in a matrix rich in albite, forming well-twinned crystals often measuring more than a millimetre across. Muscovite is also present in a considerable quantity

[1]) The chemical analysis of a muscovite-sodapyroxene-schist is given in the text. (Anal. K. H. STRADMEYER).

in this matrix, often in fairly large plates which sometimes are intergrown with green chlorite. The latter mineral also forms separate patches. Garnet is developed in small polygonal crystals of a pink colour, which mostly enclose finely granular titanite and minute needles, which presumably consist of rutile. The small zoned crystals of soda-amphibole vary as usual from glaucophane to crossite. The accessory minerals include epidote, calcite, titanite, apatite and ilmenite.

Schists rich in soda-amphibole and soda-pyroxene. — In these transitional types soda-amphibole and -pyroxene are present in approximately equal amounts. They form the principal constituents, while other minerals present are: lawsonite, albite, chlorite, calcite, pale coloured mica, titanite, leucoxene, rutile, apatite, epidote and ore. Garnet is sometimes absent but may also become unusually abundant, forming concentrations of fairly large idioblastic crystals.

BOCCA SERNA

Albite-crossitites

At Bocca Serna, along the main road from Morosaglia to Ponte Leccia, some exposures of albite-crossitites occur (fig. 6). The crossitites[1]) are

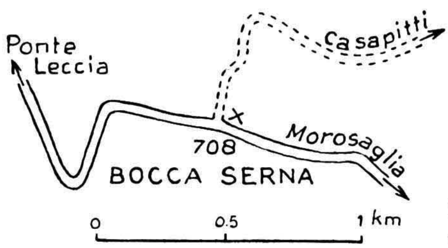

Fig. 6. × indicates the outcrop from which the *albite-crossitites* were collected.

characterized by their massive character and considerably varying grain-size. Moreover there is a marked variation in the proportion of albite to alkali-amphibole, though in general the felspar is the more abundant of the two. Some of the rocks are found to be distinctly slickensided.

SiO_2	63.57
Al_2O_3	16.16
Fe_2O_3	3.71
FeO	2.66
MgO	1.58
CaO	1.10
Na_2O	9.55
K_2O	0.15
H_2O^+	0.84
H_2O^-	0.10
CO_2	—
TiO_2	0.70
P_2O_5	0.17
MnO	0.08
	100.37

Under the microscope it is especially the structure which shows some interesting features. The felspar, which is mainly even-grained, is developed in lath-shaped crystals of an igneous type; larger amphibole individuals sometimes partly enclose these felspar crystals, giving rise to blastophitic structures. The felspar is a pure albite, showing polysynthetic twinning; the twin-lamellae are sometimes distorted. The cores of the crystals generally have a dusty appearance due to the inclusion of minute particles. Porphyritic felspars are rare. The alkali-amphibole is generally present both in relatively small

[1]) The chemical analysis of one of these albite-crossitites is given in the text. (Anal. Lab. LOBRY DE BRUYN).

crystals and in porphyritic individuals which may measure up to 5 millimetres across. They have a marked zonal structure: in the cores deep coloured crossite occurs in patches (Plate IV, fig. I). Glaucophane often forms a narrow zone around these cores, whereas the outer rim may again consist of crossite. In some cases, however, a reverse succession was observed. One of the slides investigated contains a certain amount of a deep reddish brown mica-like mineral, developed in thin, often spherulitic crystals, which are often replaced by the soda-amphibole. The strong pleochroism from deep reddish brown ($n_\gamma = n_\beta$) to orange-yellow (n_α) combined with a distinct transverse cleavage indicate that the mineral is stilpnomelane. Titanite is the chief accessory constituent of these rocks; it partly occurs in small grains in the alkali-amphiboles and is also distributed elsewhere. Furthermore, the occurrence of zircon in small well-shaped prisms should be mentioned.

It is considered that these rocks are related to some of the leucocratic varieties described from the Vezzani area, which have been interpreted as the metamorphic representatives of more acid residual differentiates of the ophiolitic magma.

VEZZANI AREA

The most southern part of eastern Corsica, that was investigated, is the area west of Vezzani. Here exposures were examined along the slopes west and south of Padula, while further several of the rocky hills, occurring in a row between point 927 near the road to Vivario and the abandoned copper-mine along the Rospigliani-Noceta road, were studied more in detail. These rock-masses form part of a heterogeneous complex chiefly consisting of ophiolitic rocks. Especially the hill indicated on the map as point 837, shows features of interest. It is essentially composed of basic igneous rocks in various stages of metamorphic alteration to varieties rich in soda-amphibole and -pyroxene and forming more or less irregular bodies in a calcareous mass rich in tremolite and containing also soda-amphiboles or -pyroxenes. These calcareous rocks have been formed out of basic to ultrabasic rocks by calcification, the carbonate-rich materials having mainly affected strongly crushed and brecciated rocks (principally serpentines). Selective weathering has caused the blue amphiboles to protrude on the weathered surface, causing a characteristic bluish hue, (for which reason the hill in question was named the "blue mountain"). (Plate IV, fig. 3),

Besides the rock-types already mentioned, there also occurs a leucocratic type, generally forming segregations and veins in the darker ophiolitic rocks. Leucocratic rocks of this type are, however, represented in far greater abundance farther north, near the above mentioned copper-mine, where they often form large irregular masses. They are considered to represent acid residual differentiates of the ophiolitic magma.

In the neighbourhood of Padula ophiolitic rock-types are very abundant too, and here also the leucocratic veining appears to be a common phenomenon.

A sketch-map of the area is given in fig. 7.

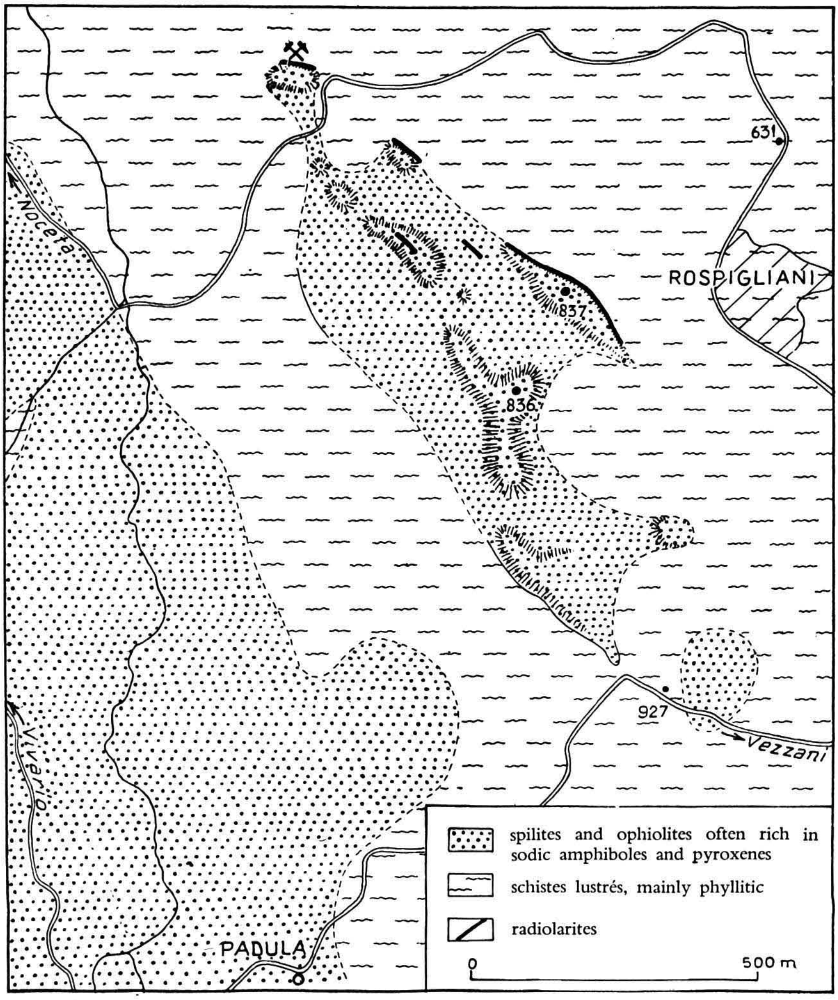

Fig. 7. *Geological sketch-map of the area west of Vezzani* (by S. B. Spijer).

Metamorphic doleritic rocks

As already mentioned above, metamorphic rocks of doleritic origin appear to be very abundant in the area west of Vezzani. They show varying grades of transformation; in general soda-pyroxenes and/or soda-amphiboles appear to be the most conspicuous newly formed constituents, and a subdivision may be made based on the occurrence of these minerals.

Rocks with predominant soda-pyroxene [1]). — Transitional varieties are

[1]) See foot-note 1 on page 11.

represented in the first place by certain almost unchanged dolerites and dolerite-porphyrites which are exposed west of Padula (outside the map of fig. 7). Here the characteristic ophitic fabric is still completely preserved and the only signs of metamorphism are the pumpellyitization of the felspar laths and the beginning conversion of the igneous augite to soda-pyroxene, this mineral forming minute rims around the augite crystals.

A somewhat higher degree of transformation results in the breaking down of the igneous structure, while both soda-pyroxene and -amphibole become more and more abundant. Examples of these more intensely changed types occur at the same locality as the doleritic varieties mentioned above. They may still retain some relict igneous pyroxene, but now this mineral is strongly replaced by the blastic soda-rich pyroxene. The latter forms rims, which, towards the margin, pass into a narrow zone of crossite surrounded by fibrous glaucophane. The albite in these rocks mostly forms irregular crystals often rich in chlorite.

Varieties in which all the original igneous pyroxene is converted are abundant too. Rocks of this type are represented, i.a. on the "blue mountain" (point 837) west of Rospigliani, by certain massive green to more bluish green finely crystalline rock-types, containing soda-pyroxene and albite as principal constituents, mostly in association with some soda-amphibole. Though in these rocks mineralogical relics are absent, their general appearance and undirected structure leaves no doubt as to their igneous origin. In these albite- and sodapyroxene-rich varieties, the pyroxene is developed in crystals of much varying size, though mostly fairly small. Usually they occur as somewhat turbid crystals with broad, more or less homogeneous cores and highly fibrous ends. Besides as turbid crystals considered to be pseudomorphic after igneous pyroxene, the soda-pyroxene is, however, generally also developed in long thin needles, sometimes occurring separately but more often forming little tufts and spherulitic aggregates. It is mostly a pale yellow to greenish variety, distinctly pleochroic from pale yellow-green (n_α) to green-yellow (n_β) and pale yellow (n_γ). The extinction-angle n_α/c is always very small and in general the extinction is parallel; often the crystals appear zonal, the dispersion is strong. Sometimes the pyroxene-content of these rocks becomes unusually high. Occasionally the soda-pyroxene is also concentrated in veins. The cores of the pyroxene crystals are often very rich in granular titanite or leucoxene, evidently representing the Ti-content of the original augite. The felspar, which appears to be entirely recrystallized, forms irregularly bounded pellucid grains, occasionally twinned and usually enclosing other minerals. Sodic amphibole may be present in varying quantities, in close association with the pyroxene, at the expense of which it is formed. In some varieties, amphibole may become quite abundant. Often it is a crossite, but sometimes also other varieties of the crossite-riebeckite series occur, with a negative elongation. These form highly fibrous crystals with a strong pleochroism from blue with a faint greenish tinge (n_α) to pale yellow or almost colourless (n_β) and violet (n_γ). The extinction-angle n_α/c is fairly small, but difficult to measure owing to the very strong dispersion of the mostly zonal crystals. The optic axial-plane is parallel to (100); $2V_\gamma$ is large. Larger crystals of this soda-amphibole sometimes contain patches of deeper coloured crossite in their cores. Chlorite may be present in considerable quantities, chiefly formed at the expense of the pyroxene or occurring in the felspar. Occasionally some pale-coloured mica also occurs. Other accessory minerals that may be present in varying amounts are: titanite, leucoxene, zircon, apatite, epidote (occasionally with a core of orthite), and mostly titaniferous iron ore. Occasionally the ore-content becomes very high. Calcite is sometimes concentrated in little veins.

In one case veins occur, which are filled with a green soda-pyroxene developed in fibrous crystals, which sometimes attain a length of more than 5 millimetres. This pyroxene is characterized by a distinct pleochroism from pale green (n_α) to greenish yellow (n_β) and pale yellow (n_γ). The extinction n_α/c is almost parallel. The soda-pyroxene crystals, which megascopically form a felt-like aggregate, form groups of radiating individuals, which are often intricately interwoven. Occasionally the pyroxene veins are also intersected by younger veinlets of pellucid albite.

Rocks with predominant soda-amphibole. — Varieties in which the amount of amphibole predominates over that of pyroxene, are very abundant too.

One interesting variety may be mentioned. It contains much relict brown hornblende, glaucophanization being chiefly restricted to a several millimetres broad zone, which occurs along the contact with a coarsely granular felspathic vein. This glaucophane-rich zone is megascopically recognizable. Under the microscope the rock is found to be a porphyritic variety, containing, besides abundant small brown amphibole prisms, relict phenocrysts of felspar in an advanced stage of pumpellyitization. At some distance from the above mentioned vein the brown amphibole is unchanged. Towards the contact the mineral shows a gradually increasing degree of glaucophanization, and complete glaucophane prisms occur in the outer zone. Narrow zones of pale greenish actinolitic amphibole, observed between some of the glaucophane rims and brown hornblende cores, indicate that the glaucophanization has been preceded by actinolitization. Concentrations of fairly small grains of brownish to greenish amphibole occur; these may represent former pyroxene phenocrysts. Locally some pellucid albite crystals were observed, presumably formed by felspathization, while further some narrow albitic veins may be mentioned. It appears that separate brown amphibole prisms, when partly protruding into the albitic material, pass abruptly into glaucophane. Some soda-pyroxene grains are found locally in the contact zone.

A type without relict amphibole but containing a blue sodic variety as only important dark constituent, is represented by certain albite-crossitites, which are exposed directly south of the abandoned copper-mine between Rospigliani and Noceta. These massive, deep blue coloured rocks have been intruded by leucocratic quartzo-felspathic material, forming broad irregular veins, which sometimes enclose parts of the invaded rock (fig. 8). The albite-crossitite is a fairly fine-grained variety, mainly composed of albite and alkali-amphibole, the latter developed in prismatic crystals of uniform size, lying in all directions. It is chiefly a crossite, but as usual the mineral is distinctly zoned, the rims consisting of glaucophane. The albite forms the matrix of the rock. Some lawsonite occurs. Numerous small grains of titanite occur, irregularly distributed throughout the rock and often associated with leucoxene. Other accessories, occurring in very subordinate amount are apatite and iron ore. Some secondary chlorite is locally concentrated, occasionally with some fine scaled muscovite and granular epidote [1]).

SiO_2	54.65
Al_2O_3	12.52
Fe_2O_3	5.55
FeO	5.97
MgO	5.32
CaO	3.87
Na_2O	6.30
K_2O	0.21
H_2O^+	2.15
H_2O^-	0.07
CO_2	—
TiO_2	2.99
P_2O_5	0.36
MnO	0.15
	100.11

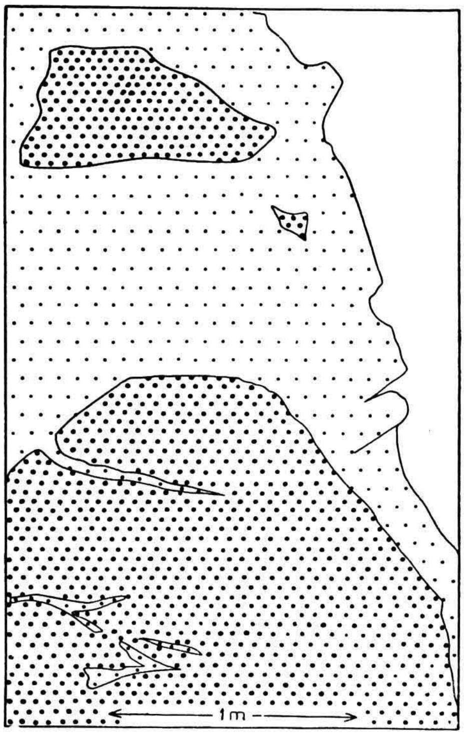

Fig. 8. *Leucocratic crossite-bearing quartzo-felspathic veins in albite-crossitite*; small hill south of the abandoned coppermine near the road from Rospigliani to Noceta (comp. textfig. 7).

Metamorphosed residual differentiates of the ophiolitic magma

The leucocratic rocks which occur in association with the metamorphic

[1]) The chemical analysis of this albite-crossitite is given in the text. (Anal. Lab. LOBRY DE BRUYN).

dolerites and related varieties in the area to the west of Vezzani, are all considered to be of the same origin, viz. residual differentiates of the ophiolitic magma, intruded into the already cooling more basic members, in a period that preceded the metamorphism. It should be noted that the distribution of these leucocratic rock-types is very irregular and that basic rocks occur, which are devoid of all leucocratic veining over considerable distances.

The metamorphosed leucocratic rocks occasionally form irregular masses, measuring many metres across. More often, however, they are present in veins of much varying size, frequently forming an irregular, light coloured network in the dark coloured rocks. The latter often show a homogeneous blue colour, but transitions to more greenish varieties occur too, whereas occasionally the blue colour is restricted to a narrow zone bordering the veins. In general the boundaries of the veins are sharp, but impregnation by the acid material may also have taken place, giving rise to transitional rock-types. Frequently the invaded rock is also preserved in angular or rounded inclusions. These appear to have paid more resistance to weathering than the coarser grained leucocratic material and now protrude on the weathered surface, which is a very characteristic feature in the field. Larger, more homogeneous masses of the leucocratic rocks also frequently enclose remnants of the invaded rock. Many different varieties of leucocratic rocks occur in the area. They show considerable variation both in initial composition and in degree of transformation. A number of the most representative types will be briefly described.

Microscopical examination shows that subdivision may conveniently be made into varieties rich in both quartz and felspar and varieties with felspar only.

Quartzo-felspathic types. — A good example of the quartzo-felspathic type was found on the hill 836 directly west of Rospigliani. It is a massive greyish variety, speckled with small dark crystals of soda-amphibole. Irregularly shaped, blue coloured fragments of a fine-grained albite-crossitite are enclosed (Plate IV, fig. 2).

Microscopical investigation of the leucocratic rock shows the structure to be clearly an igneous one, the felspar being developed in well-twinned elongated crystals, quartz filling up the interspaces and amphibole forming irregular prisms with a random orientation. The larger felspar individuals attain sizes of over 2 millimetres. It is mainly an albitic variety but some of the crystals still appear distinctly zoned, the composition of the cores ranging up to albite-oligoclase ($\pm$ 10 $^0/_0$ An). These cores are rich in inclusions, often of chlorite, but also of such lime-rich silicates as epidote, lawsonite and pumpellyite, indicating an originally higher anorthite-content. The amount of quartz present is by far subordinate to that of felspar; the quartz crystals are xenoblastic and often show undulose extinction. The soda-amphibole mostly forms fairly broad ragged crystals with deep blue crossite cores and broad, lighter coloured glaucophane rims. Some reddish brown stilpnomelane is present too, often formed by conversion of amphibole, but also developed in separate spherulitic aggregates. Other minerals present are lawsonite, in fairly large much altered crystals, epidote, sometimes forming elongated aggregates in the cores of felspars, zircon, titanite, leucoxene and ore.

Closely related examples of the metamorphosed quartzo-felspathic rocks, though showing some divergent properties, occur directly south of the abandoned copper-mine along the road from Rospigliani to Noceta. Here the leucocratic material appears to be very abundant, often forming irregular veins but sometimes also large masses associated with deep blue coloured crossitites, a description of which has been given above (p. 34, fig. 8). This greyish white rock appears under the microscope to be essentially composed of albitic felspar, quartz and soda-amphibole. In this case, however, the relict igneous fabric is partly destroyed; the elongated felspar crystals are sometimes broken, there is a beginning of the formation of mortar-structures, and the felspar laths are embedded in a finely granoblastic mosaic of quartz and pellucid albite. The cores of the larger felspar crystals are turbid, with inclusions i.a. of epidote, lawsonite, sericite and chlorite. The rims, however, are clear, with scalloped borders indicating growth during metamorphism. The sodic amphibole, developed in crystals of much varying size with a tendency towards parallel orientation, is chiefly a deep blue coloured crossite with narrow rims of glaucophane. Epidote is locally very abundant, partly concentrated in small veins and often associated with some chlorite. Other accessories are titanite, leucoxene and zircon [1]).

SiO_2	74.19
Al_2O_3	13.99
Fe_2O_3	0.81
FeO	0.92
MgO	0.94
CaO	0.68
Na_2O	7.32
K_2O	0.08
H_2O^+	0.64
H_2O^-	0.07
CO_2	0.02
TiO_2	0.28
P_2O_5	0.03
MnO	0.03
	100.00

Felspathic types. — Types with felspar as the only light coloured constituent are more abundant than those containing both felspar and quartz. In the first place a coarsely crystalline type may be distinguished, well exemplified by a rock occurring on the col west of Padula. Here the angular felspar crystals sometimes attain a length of over one centimetre (Plate V, fig. 1). Their cores are again filled with finely crystalline matter, mainly consisting of such lime-silicates as pumpellyite and lawsonite. Dark minerals are represented by both soda-amphibole and soda-pyroxene. The former is developed in aggregates of highly fibrous crystals, concentrated within the interspaces between the felspar crystals and along their edges. The amphibole crystals are zoned, varying as usual from crossite to glaucophane. They are often closely associated with the soda-pyroxene, chiefly represented here by a grass-green variety. Some chlorite

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[1]) The chemical analysis of this crossite-bearing quartzo-felspathic rock is given in the text. (Anal. Lab. LOBRY DE BRUYN).

occurs. Apatite, zircon, leucoxene and titaniferous iron ore are the principal accessories.

A somewhat divergent rock, occurring on a hill (point 836) west of Rospigliani, is of special interest on account of its content of relict igneous amphibole. This rock forms irregular veins in a more finely granular amphibole-bearing variety already described above as a metamorphic doleritic rock (p. 33). The amphibole is a brownish to more greenish variety, always showing an advanced stage of conversion to alkali-amphibole. In general the cores of relict amphibole are bounded by a narrow zone of dark coloured crossite, which, however, passes towards the margin into glaucophane, the latter forming the principal dark constituent. Often the cores surrounded by the crossite zone are also entirely converted, in which case not crossite but glaucophane has been formed, the narrow crossite zone still being preserved. Soda-amphibole also occurs in separate needles and aggregates. The larger felspar crystals again show cores filled with finely crystalline lime-rich silicates. Furthermore the occurrence of red-brown stilpnomelane should be mentioned, often closely intergrown with the soda-amphiboles, at the expense of which it is formed, but also developed in separate segregations. Some clinopyroxene is present locally. Chlorite is abundant as a secondary mineral, often filling the interspaces between the felspar crystals. Titanite, often associated with leucoxene and ore, is a very important accessory constituent, and zircon too is present in well-shaped prisms of considerable size.

Some greenish grey veins occurring on the southern side of the "blue mountain", represent a considerably divergent variety, especially characterized by the shape of the albite which here appears to have lost its

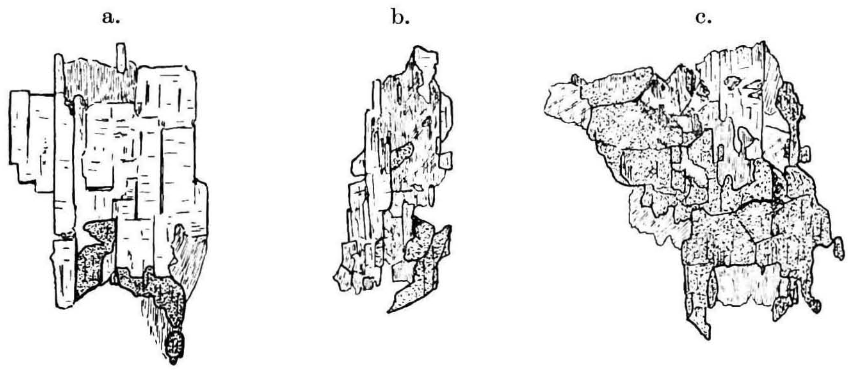

Fig. 9. *Lawsonite in various stages of replacement*; in sodapyroxene-rich felspathic vein; "blue mountain", west of Rospigliani.

a. the lawsonite crystal is still largely intact though some transition to epidote (speckled) and colourless mica (lineated) has taken place along the edges. × 125

b. sericitic mica is the chief replacing mineral though some epidote has been formed too. × 62

c. the original lawsonite crystal is almost completely pseudomorphosed, mainly by epidote, with some mica and carbonate (cross-hatched). × 62.

PLATE V

Fig. 1

Highly felspathic residual differentiate. The large angular crystals of sodic felspar are filled with finely granular patches of pumpellyite and lawsonite. The interspaces between the felspar crystals are mainly filled with soda-amphibole and soda-pyroxene, partly concentrated in spherulitic aggregates. West of Padula. // nicols. (× 19).

Fig. 2

Veins of metamorphosed acid residual differentiate mainly consisting of albite and soda-pyroxene in a finely granular sodapyroxene-rock. // nicols (× 15).

Fig. 3

Zoned porphyritic crossite crystal with pressure shadows, in apatite-rich crossite-chlorite-schist; along the main road south of Albo; west coast of Cap Corse. // nicols (× 23).

Fig. 1

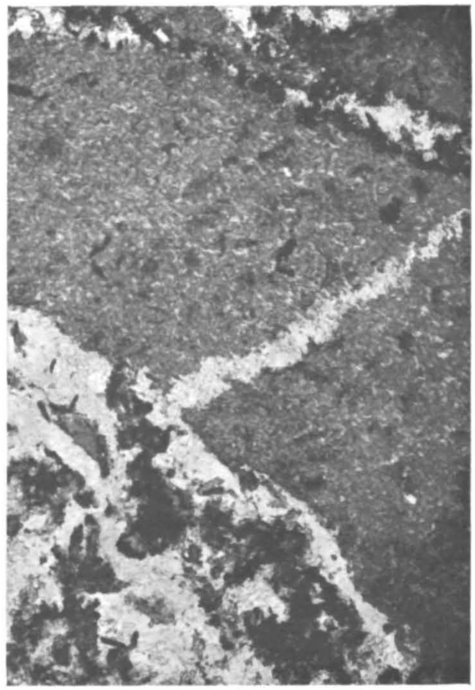

Fig. 2

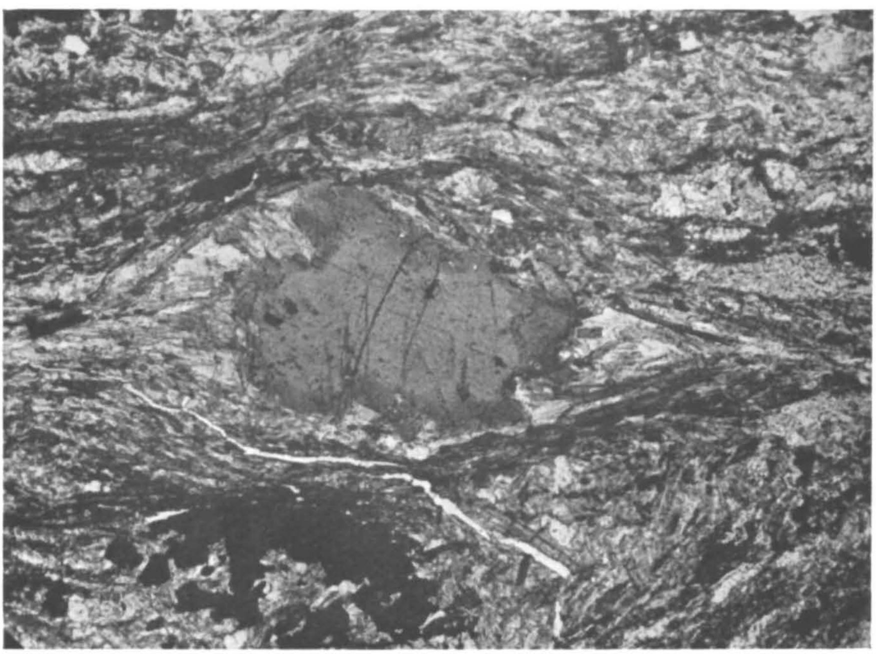

Fig. 3

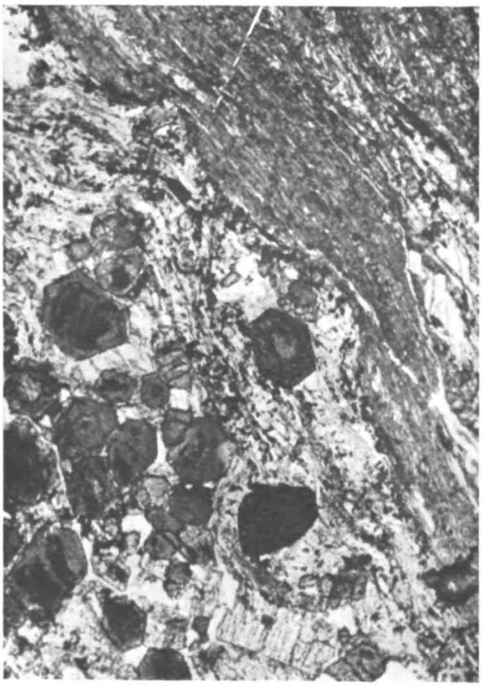

Fig. 1

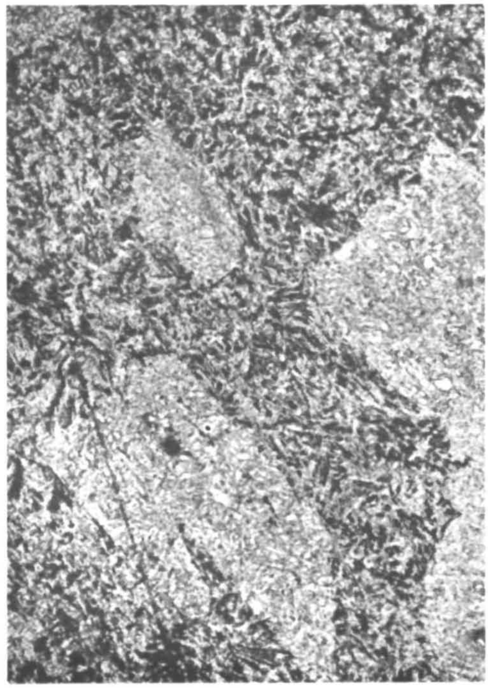

Fig. 2

Fig. 3

PLATE VI

Fig. 1

Concentration of tourmaline in muscovite-glaucophane-schist. All except one of the tourmaline prisms show a parallel orientation, which is parallel to the axis of folding of the rock (see also textfig. 12). Along the road south of Albo, Cap Corse. // nicols (× 21).

Fig. 2

Relict igneous structure in lawsonite-glaucophanite from the southeastern slope of the Mt al Pruno, northwest of Matra. The original plagioclase phenocrysts are entirely replaced by an aggregate, consisting essentially of small tabular lawsonite crystals. The "matrix "is formed by lawsonite and glaucophane with some clinopyroxene; // nicols (× 14).

Fig. 3

Banded complex of albitic gneisses ("alpine granites") alternating with glaucophane-schists. Highest part of the eastern Serra di Pigno slope, north of the summit. (hammer below the centre of the picture).

igneous character and now occurs in crystals of a more blastic appearance, with lobate boundaries, and often embedded in chlorite. In the cores of these felspar crystals lawsonite is concentrated, indicating their original lime-content. The other principal constituent is crossite, forming felt-like aggregates.

Some narrow albite-rich veins, occurring on the "blue-mountain" (point 837) west of Rospigliani, contain soda-pyroxene as most conspicuous constituent, partly developed in broad crystals with highly fibrous ends, but also in separate thin needles, which often form spherulitic aggregates (Plate V, fig. 2). The felspar is present in clear, well-twinned crystals of irregular shape, often closely associated with calcite, which is also concentrated in small veins. Epidote is quite abundant in crystals of considerable size, often found to be pseudomorphic after lawsonite, which mineral is still present locally in large skeleton crystals in course of replacement not only to epidote but also to scaly micaceous material and to chlorite (fig. 9). Soda-amphibole is fairly abundant locally.

Lastly, another considerably divergent felspathic type may be mentioned, occurring on the slope south of Padula, as a broad irregular vein in massive porphyritic rocks rich in newly formed actinolite and stilpnomelane (fig. 10). The variety under consideration is almost entirely

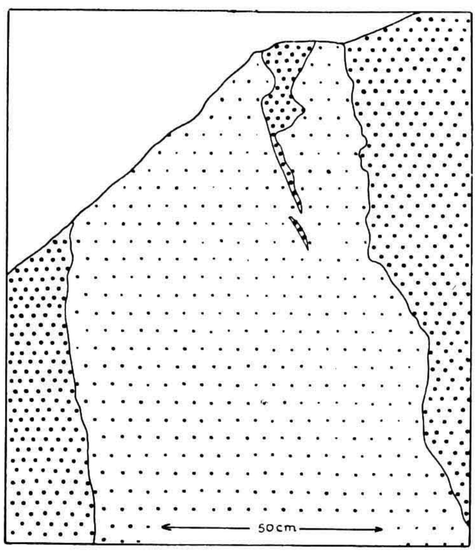

Fig. 10. *Leucocratic vein* (essentially consisting of albite with some actinolite) in a porphyritic rock with newly formed actinolitic amphibole and stilpnomelane. Slope south of Padula.

composed of albite, other minerals being present in only very subordinate amount. Among these there is some amphibole, mainly represented by actinolite, formed at the expense of a brownish hornblende of igneous origin. Very locally transitions occur into a bluish coloured sodic amphibole, while some stilpnomelane is present too.

Calcareous rocks rich in soda-amphibole and soda-pyroxene

The calcareous varieties, which, together with metamorphosed doleritic rocks, form the bulk of the "blue mountain" (point 837) west of Rospigliani, show several features of interest.

Types rich in soda-amphibole show a marked selective weathering; deep blue amphibole-rich streaks, often with a distinct tendency towards parallel orientation, protrude on the weathered surface, forming an irregular network with the "mashes" filled with deep brownish red carbonate material. These rocks often show a certain degree of schistosity. More massive types occur too, the place of amphibole being largely taken by an olive-green pyroxene, developed in large stout crystals embedded in a reddish brown carbonate matrix. Occasionally the percentage of carbonate present is very high, giving rise to brown-red varieties, with only a subordinate amount of green material.

As mentioned already they are considered to have been formed by calcification of basic and ultrabasic rocks, especially in zones of strong crushing and brecciation.

Types rich in soda-amphibole. — This type is well exemplified by a variety consisting essentially of carbonate, soda-amphibole and tremolite. The soda-amphibole forms narrow rims around larger tremolite crystals, but also occurs in fibrous crystals, frequently forming a felt-like aggregate. Swarms of these fine needles occur in brecciated zones, which also contain abundant tremolite fragments. The blue amphibole appears to be chiefly the variety with negative elongation and strong dispersion also found in some of the metamorphic ophiolites with which these calcareous rocks are closely associated (p. 32). Some crossite occurs too. The tremolite is mainly developed in fibrous crystals of much varying size, which lie in all directions. The mineral is considerably chloritized. The carbonate forms closely interlocking crystals, sometimes measuring over 5 millimetres across; these are often bent or broken and show strain-twinning; small amphibole needles tending to parallel orientation are enclosed. The red colour of the carbonate appears to be caused by abundantly enclosed fine haematite material, showing a patchy distribution. Some epidote is present, occasionally with brown orthite in the core. The accessories also include titanite.

Types rich in soda-pyroxene. — Gradations are found from the soda-amphibole-rich varieties described above, to rocks with small amounts of pyroxene and to calcareous rocks in which sodic pyroxene is by far the most important dark constituent. In these latter rocks the pyroxene is generally developed in broad crystals, attaining a length of over 7 millimetres. These highly fibrous crystals are mostly broken and partly replaced by carbonate material and pale green chlorite. It is clear that they are pseudomorphic after a pyroxene of igneous origin, remnants of which may occur in their cores. Besides these large pyroxenes, there also occur smaller grains, locally forming segregations but also developed in cracks and along the borders of the larger individuals. These smaller grains show a considerably less fibrous development. Some soda-amphibole appears to be formed along cracks in the pyroxene crystals but the mineral, which is again a variety with negative elongation, also occurs separately, often in swarms of small needles, and occasionally also in somewhat larger prisms. The soda-amphibole is again closely associated with tremolite and often forms the rims of larger crystals of this mineral. Chlorite occurs in large quantity, very often formed at the expense of the other minerals, in the first place at the expense of the igneous pyroxene. The carbonate, which represents more than 50 % of the rock, is again developed in closely interlocking crystals of much varying size, enclosing a large amount of haematite with a highly patchy distribution. Some titanite is present. Small pellucid patches, occurring within the carbonate mass, may consist of quartz.

Besides these carbonate-bearing rocks containing sodic amphiboles and pyroxenes, more highly calcareous varieties occur, devoid of these minerals. Here some tremolite is still present, while further the occurrence of relict crystals of picotite must be mentioned, a fact giving some indication as to the origin of these rock-types.

CAP CORSE

Glaucophane-bearing and related rocks south of Albo, west coast of Cap Corse

Crossite-chlorite-schist. — At a point along the main road, approximately 0.5 km south of the village of Albo, a heterogeneous formation occurs, comprising talc-serpentine-schists, talc-chlorite-schists rich in bluish green amphibole and amphibole-albite-epidote-chlorite-schists. Intercalated in the amphibole-rich talc-chlorite-schists, strongly folded streaks and lenses of bluish coloured rock are found (fig. 11). Under the microscope this

Fig. 11. *Folded lenses and streaks of apatite-rich crossite-chlorite-schist in amphibole-bearing talc-chlorite-schists.* Below an albite-epidote-chlorite-schist with some actinolite and soda-amphibole. Approximately 700 m south of Albo, along the main road; west coast of Cap Corse.

appears to represent an interesting type of porphyroblastic crossite-chlorite-schist, especially remarkable because of an unusually high content of apatite [1]). The alkali-amphibole is present both in broad porphyritic crystals (Plate V, fig. 3), which may attain a length of 2 millimetres, and in smaller prisms with a parallel orientation. It is a dark blue crossite; the larger crystals are distinctly zonal, the rims being somewhat deeper coloured than the cores. Very locally, fringes of a pale green actinolitic variety are found around the larger alkali-amphibole individuals. Green chlorite, sometimes forming rosettes, is very abundant. The main feature of the rock is its extraordinary richness in apatite. Occasionally this mineral even tends to be porphyroblastic; inclusions of crossite, chlorite and titanite may occur. Titanite is also abundant, sometimes containing rutile in its core. Ore is mainly represented by magnetite, occasionally associated with pyrite and some secondary quartz.

SiO_2	37.70
Al_2O_3	10.38
Fe_2O_3	5.56
FeO	12.56
MgO	12.85
CaO	6.05
Na_2O	2.05
K_2O	0.20
H_2O^+	6.42
H_2O^-	0.46
CO_2	—
TiO_2	2.85
P_2O_5	2.21
MnO	0.11
Cl	0.18
F	—
	99.58

Muscovite-glaucophane-schists. — Somewhat further south along the road, glaucophane-bearing rocks are found to become more abundant. Intensely folded schists occur, which are characterized by a well-marked banding caused by an alternation of thin bluish and greenish layers (fig. 12).

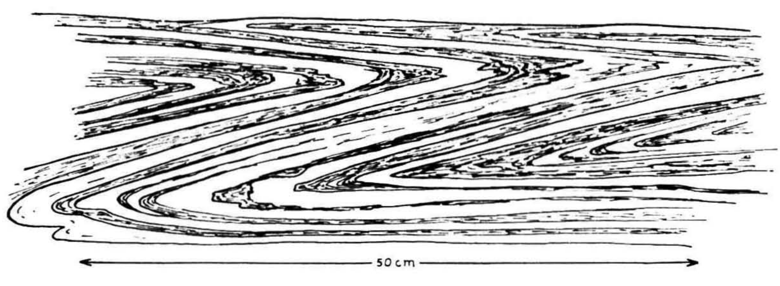

Fig. 12. *Folded schists* along the road south of Albo, west coast of Cap Corse. Blue coloured muscovite-glaucophane-schists (dark in the figure) and green coloured epidote-bearing muscovite-chlorite-schists alternate in thin bands.

The former consist of muscovite-glaucophane-schist and the latter of muscovite-chlorite-schist often rich in epidote. These banded schists pass into more homogeneous green coloured albite-epidote-chlorite-schists with pale blue-green amphibole, while they are also associated with glaucophane-albite-chlorite-schists.

Under the microscope the fairly fine-crystalline glaucophane-rich bands show an intricate minute folding, the fibrous alkali-amphibole crystals appearing to be postkinematically crystallized. Besides the glaucophane, muscovite is also found to be very abundant, forming small

[1]) The chemical analysis of this apatite-rich crossite-chlorite-schist is given in the text. (Anal. Lab. LOBRY DE BRUYN).

tablets. Furthermore, there occur large elongated crystals (several millimetres in length) of clear albite, enclosing all other minerals and evidently formed in a late stage of crystallization.

The layers rich in chlorite are coarser grained. They are essentially composed of green chlorite and muscovite, sometimes with abundant idioblastic epidote and with albite, developed in large lenticular patches in which small glaucophane needles are often concentrated in considerable quantity. Titanite is a very important accessory mineral.

Not always is the boundary between the blue and the green bands sharply defined; layers of a transitional mineral composition are quite common. A fact of special interest in these banded schists is further the occurrence of tourmaline, locally concentrated in well-shaped prisms attaining a length of several millimetres, and generally orientated parallel to the axis of folding (Plate VI, fig. 1). It is a bluish to brownish variety, often with a zonal structure. Individual tourmaline prisms sometimes enclose other minerals.

Garnet-crossite-schists. — About 750 metres south of Albo exposures are found of a rock-type in which the abundance of a red garnet, forming crystals of several millimetres in diameter, is especially striking.

Under the microscope these rocks appear to be garnet-crossite-schists, consisting essentially of the minerals mentioned in the name, together with epidote, brown mica and apatite. The soda-amphibole is mainly crossitic; local transitions to glaucophane and to a more blue-green amphibole variety are found. The pink garnets, which are generally more or less rounded, contain abundant inclusions, i.a. of apatite, amphibole and titanite; a system of cracks perpendicular to the general direction of the schistosity is noticed. Fan-shaped aggregates of crossite and mica are often found to end abruptly at the borders of the larger garnet crystals. Epidote is developed in well-shaped prisms of a pale yellow colour, which sometimes appear to be concentrated in particular bands. The mica is pleochroic from deep reddish brown ($n_\gamma = n_\beta$) to orange-brown (n_α). The mineral is partly formed secondarily at the expense of garnet, but is also developed in large separate plates and aggregates, often associated with epidote and locally with chlorite. Apatite is again very abundant, forming finely granular concentrations but also large individual crystals containing brown mica in their cracks. Albite is present in separate individuals but more often in aggregates of small grains along the borders and in the cracks of the garnets. Titanite is mostly concentrated in granular streaks, conforming with the schistosity. The mineral is often associated with titaniferous iron ore.

The garnet-crossite-schists of the above described type pass locally into closely related varieties in which, however, the place of crossite is almost entirely taken by a green-blue amphibole variety. They are also associated with albite-rich epidote-chlorite-glaucophane-schists and tremolite-talc-chlorite-schists, while furthermore they may contain lenticular intercalations of chlorite-schist as well as coarsely crystalline concentrations consisting essentially of epidote and brown mica.

Concentrations of this last-mentioned type were examined microscopically. Some bands are found to consist entirely of epidote in yellow prisms, together with brown mica, which is developed in plates sometimes measuring more than 5 millimetres across. In these layers some albite may occur too, mostly concentrated in small veins. In other places titanite appears to be present in large quantity, mainly forming parallel streaks, while further apatite is unusually abundant, mostly developed in finely granular aggregates associated with the titanite. Some thin bands are also rich in green-blue amphibole associated with glaucophane and sometimes with a green soda-pyroxene.

Glaucophane-schists at Nonza, west coast of Cap Corse

Directly north of the village of Nonza, exposures occur of finely granular schists, in which gradual transitions of colour are noticed over very short distances, the rocks varying from blue glaucophane-schists to green coloured variaties, which megascopically closely resemble normal "green-schists".

Under the microscope the former rocks are found to be rich in alkali-amphibole, viz. mainly a glaucophane showing local transitions to crossite. The mineral is associated with epidote, while furthermore albite is of considerable importance, forming irregularly distributed porphyroblasts. Some pink garnet is present in small grains. The accessory minerals also include muscovite, chlorite, titanite, rutile, tourmaline and iron ore.

The varieties resembling green-schists are much richer in porphyroblastic albite than the above mentioned type. In fact, here felspar is by far the most important constituent, developed in fairly large poiciloblastic crystals. Amphibole, on the other hand, is much less abundant and here mainly represented by a pale bluish green actinolitic variety, with only local transitions to glaucophane. Chlorite is present in considerable quantity. Garnet, developed in small grains, is more abundant than in the other rock. Other minerals are muscovite, titanite and magnetite.

Glaucophane-gabbros and related rocks south of Sisco, east coast of Cap Corse

Some investigations were also carried out along the east coast of Cap Corse, at a point along the road approximately 3 km south of Sisco. Here exposures occur of metamorphosed gabbros, showing different degrees of transformation caused by strong local shearing. In fact, within a distance of a few metres types were found, transitional from fairly massive gneissose lawsonite- and glaucophane-bearing rocks (the origin of which is still clearly shown i.a. by the occurrence of relict igneous pyroxenes) to highly schistose lawsonite-crossite-schists occurring along the zones of strongest shearing.

The most massive types encountered show a strong resemblance to some of the glaucophane-gabbros from San Pietro d'Accia in the San Petrone area, a short description of which has been given on page 22. The large igneous pyroxenes are again much changed to fibrous glaucophane and the original lime-plagioclase of the parent rock is now represented by irregular patches of albitic felspar enclosing abundant small lawsonite crystals. Epidote and sausuritic aggregates are common too, while some green soda-pyroxene is also a product of metamorphism. Muscovite, chlorite and titanite are present in minor quantities.

In more schistose types the higher degree of alteration is proved by a marked increase in the soda-pyroxene content. This fibrous, green coloured mineral ($n_a/c = 8^0$ ca) is partly developed in large individual crystals or in more or less "sheaf"-shaped aggregates sometimes concentrated along the borders of epidote-rich veins, and partly also in aggregates of chiefly parallel-ranged small crystals, considered to be pseudomorphic after the igneous pyroxenes, remnants of which are only seldom preserved. Often these soda-pyroxene aggregates appear to be bent or broken, and it is especially along minute shear-zones in these aggregates that soda-amphibole has begun to develop in small crystals; in a more advanced stage fibrous amphibole aggregates have been formed. Some clear albite is again present, sometimes associated with lawsonite but more often with epidote, which is found to replace the other lime-rich silicate. Titanite is locally very abundant in large irregular patches and also in streaks parallel to the schistosity. In some cases the titanite is associated with a

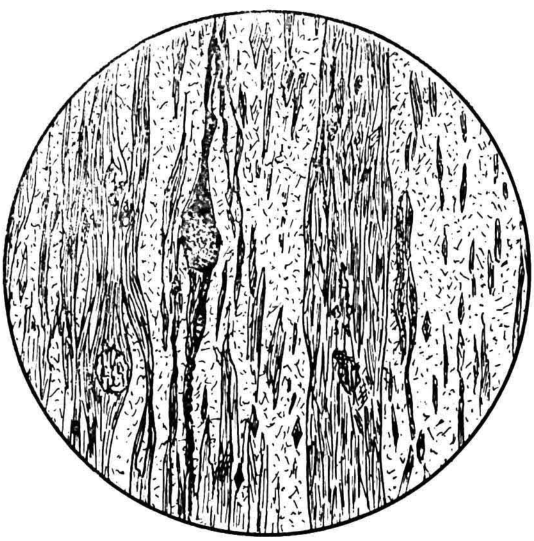

Fig. 13. *Lawsonite-crossite-schist* formed by intensive shearing of a gabbroic rock. Some bands are very rich in lawsonite while others consist almost entirely of soda-amphibole. Almost converted relics of pyroxene occur rarely in the crossite-rich layers. Titanite appears to be intensely drawn out, forming elongated streaks. Approximately 3 km south of Sisco, along the road; east coast of Cap Corse. $\times$ 15.

considerable amount of apatite, which is also shattered and drawn out to irregular streaks. Further some muscovite and chlorite are present.

SiO_2	47.69
Al_2O_3	19.27
Fe_2O_3	4.30
FeO	4.18
MgO	5.06
CaO	8.57
Na_2O	3.20
K_2O	0.69
H_2O^+	5.36
H_2O^-	0.35
CO_2	0.03
TiO_2	1.20
P_2O_5	0.08
MnO	0.11
	100.09

The most intensely sheared member of the transitional series is represented by a lawsonite-crossite-schist, characterized by a high schistosity and a blue and greyish white banding, caused by the alternation of narrow discontinuous layers composed almost exclusively of blue amphibole, and layers composed essentially of lawsonite with subordinate amphibole (fig. 13). The sodic-amphibole, which is mainly a crossite, again replaces soda-pyroxene, but now this process is in such an advanced stage that remnants of the pyroxene are quite rare. Titanite is drawn out to lenticular eyes and thin streaks. Other accessories are muscovite and epidote [1]).

MATRA

The village of Matra, is situated at the foot of the Mt al Pruno (1127 m). The broad ridge, leading up to this mountain from the southeast, consists of massive serpentine but its main bulk is formed by a thick series of glaucophane-schists, striking approximately N—S and dipping towards the west.

The glaucophane-schist series of the Mt al Pruno

The microscopical examination of a number of specimens from this glaucophane-schist series proved lawsonite to be always the principal lime-rich silicate, sometimes associated with both crossite and soda-pyroxene, sometimes with glaucophane. In the glaucophane-bearing varieties garnet is also frequently an important rock-forming constituent.

One type of lawsonite- and glaucophane-bearing rock, which is abundantly represented on the southeastern slope of the Mt al Pruno, is characterized by the occurrence of more or less angular to more lenticular greyish white patches, which may attain a length of several millimetres and are embedded in a blue coloured matrix (Plate VI, fig. 2). There is a strong resemblance to varieties occurring in the San Petrone area, which have been described earlier in this paper (p. 21). In the latter case, the patches, which represent original plagioclase phenocrysts, were found to be composed of lawsonite together with some muscovite, whereas in the present case only lawsonite occurs, forming close aggregates of small tabular crystals, occasionally associated with some glaucophane or with pale green amphibole. Moreover the rocks from the San Petrone are

[1]) The chemical analysis of this lawsonite-crossite-schist is given in the text. (Anal. Lab. LOBRY DE BRUYN).

schistose, while those from Matra are, at least partly, massive lawsonite-glaucophanites devoid of schistosity; accordingly the original shape of the porphyritic crystals has also been much better preserved. The matrix of these rocks is rich in both lawsonite and glaucophane, the latter forming at the expense of an almost colourless clino-pyroxene considered as an igneous relic. Titanite is very abundant as an accessory mineral[1]).

As mentioned above, some of the lawsonite-glaucophane-schists appear to be garnetiferous. In one of the samples investigated garnet is even quite abundant, developed in more or less idioblastic crystals, which occasionally enclose lawsonite and glaucophane. In the garnet crystals a system of cracks perpendicular to the direction of the schistosity is particularly striking.

SiO_2	47.62
Al_2O_3	18.85
Fe_2O_3	2.59
FeO	4.35
MgO	5.50
CaO	10.93
Na_2O	2.74
K_2O	0.03
H_2O^+	6.36
H_2O^-	0.18
CO_2	0.06
TiO_2	0.94
P_2O_5	0.12
MnO	0.11
	100.38

Some lenticular, green coloured intercalations in the glaucophane-schists which form the summit of the Mt al Pruno, are found to consist of close-grained segregations of lawsonite, together with green soda-pyroxene and some epidote, which apparently replaces the lawsonite.

PHENOMENA OF GRANITIZATION[2])

The widespread occurrence of leucocratic albite-gneisses in the schistes lustrés series of Corsica has already been mentioned earlier in this paper. As will be discussed later, these so-called "alpine granites" are considered to be chiefly syntectonic. The granitization phenomena will be dealt with especially in connection with their effect on the glaucophanitic rocks. These phenomena are well developed in the Serra di Pigno area between Bastia and St Florent, and have therefore especially been studied in this region. A more general discussion of granitization is outside the scope of the present paper.

Although some smaller veins give the impression of having been intruded, the usual mode of formation of albitic gneisses appears to have been one of replacement of preexisting rocks by infiltration and/or impregnation by granitizing solutions. In fact in the Pigno area all gradations are found from unchanged glaucophanitic rocks to varieties almost completely granitized. These rocks often show considerable structural and mineralogical variations. This variation appears to be related to differences in the structural properties of the invaded rocks.

a. In the glaucophane-schist series at the base of the eastern slope of the Serra di Pigno and near the summit, the granitizing materials

[1]) The chemical analysis of this lawsonite-glaucophanite is given in the text. (Anal. Lab. LOBRY DE BRUYN).

[2]) See foot-note on page 9.

appear to have chiefly infiltrated along the schistosity planes. In many places (especially at a high level in the series) this has given rise to the formation of micaceous albite-gneisses, developed in bands of varying thickness and alternating with bands of darker coloured schists (Plate VI, fig. 3). The leucocratic gneisses under consideration are mainly composed of finely granular quartz, albite and muscovite, with minor amounts of epidote. The intercalated schists are mainly glaucophane-bearing varieties, often of a highly micaceous type. In general these contain porphyroblastic albite, developed in rounded to lenticular crystals, which in a given rock tend to be of uniform size. They often appear concentrated in certain planes of schistosity. Albite individuals, measuring several millimetres across, have been found, but generally their size does not exceed 1 millimetre. The fact that the development of the felspar took place after the beginning of the glaucophane metamorphism, is evidenced by the frequent persistence of the schistosity through the albite porphyroblasts as trails of glaucophane prisms, mica flakes etc. Occasionally such trails appear S-shaped, this indicating the synkinematic crystallization of the felspar. In general felspathization in the schists has clearly been strongest near the bands of albite-gneiss, and there is often a more or less gradual transition from gneiss to schist. In other cases the boundary between the two is more sharply defined, though mostly some local felspathization still occurs along a narrow border-zone.

Lower down in the glaucophane-schist series at the base of the Pigno massif (e.g. in the zone which is exposed along the lower part of the road leading from Bastia to the Col de Teghime) micaceous albite-gneisses ("alpine granites") are rare or even absent. The fact that albite of porphyroblastic development is also abundant here, is, however, considered significant. The percentage of the albite present appears to be highly variable. Light coloured bands rich in albite pass more or less gradually into darker ones which are poor in this mineral, whereas the felspathic schists also often appear intimately associated with varieties wholly devoid of felspar. These various facts, combined with the resemblance which the albite-porphyroblast-bearing schists show to the undoubtedly felspathized types in the more intensely granitized zones, seem to suggest that also here the development of the felspar is, at least partly, related to the alpine granitization rather than to regional metamorphism without large scale migration of material. With other words, the occurrence of the porphyroblastic albite crystals in the glaucophane-schists along the eastern slope of the Serra di Pigno, seems, at least partly, to represent a first step towards the granitization of these schists.

With this in mind it is of interest to consider the distribution of albite in glaucophane-bearing rocks outside the Pigno area. In fact, albite tending to porphyroblastic development is also quite abundant in regions from where no granitization phenomena have as yet been recorded.

In this connection some examples from the west-coast of Cap Corse may be mentioned. Here late-formed albite has been found to occur e.g. south of Albo in intensely folded glaucophane-bearing schists, which locally also appear to be very rich in tourmaline (p. 43) and further directly north of Nonza where the highly felspathic bands occurring in a series of glaucophane-schists remind of those observed in the Pigno area (p. 45). Some examples from the San Petrone area are also of interest. Here albite porphyroblasts are abundant in some glaucophane- and crossite-rich schists which are intimately associated with quartzites near point 1188 northwest of the San Petrone. In a single case albite was also observed in the quartzites, which are also characterized by the occurrence of i.a. tourmaline, soda-amphibole, epidote and orthite, mica and pyrite (p. 23). Lastly the albite crystals may be mentioned, which occur in the schists rich in soda-amphibole and soda-pyroxene near the Col de S. Pietro, which are sometimes exceptionally rich in tourmaline (p. 28). In none of these cases, "alpine granites" are known to occur in the near vicinity, but the resemblance which some of these rocks show to felspathized varieties from the Serra di Pigno area, might point to a relation between the development of the albite porphyroblasts and the alpine granitization.

a. b.

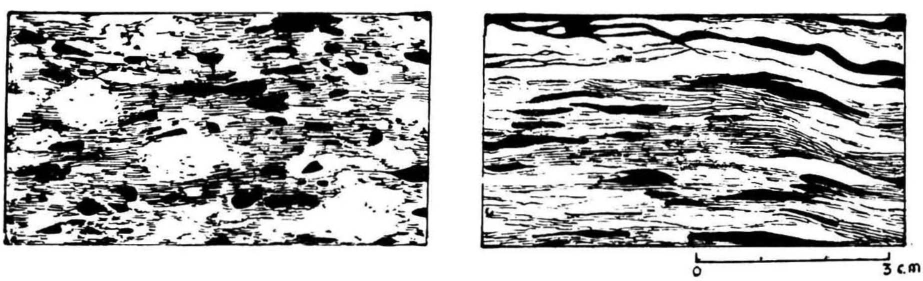

Fig. 14. *Glaucophane-schists with newly formed albite and quartz.*

a. *Eyed structure*; the "eyes" are formed by more or less rounded concentrations of albite, generally with some quartz and muscovite (colourless in the figure) and concentrations of pure quartz (black in the figure) in a schistose mesostasis consisting essentially of glaucophane, epidote and colourless mica.

b. *Lenticular (streaked) structure*; here the felspathic as well as the quartz lenses are stretched out, forming parallel discontinuous bands, which alternate with seams and broader bands of the invaded muscovite-epidote-glaucophane-schist.

b. Some of the invaded rocks on the eastern Pigno slope are decidedly more massive and lit-par-lit infiltration does not appear to have played a rôle of importance. Here a more intimate kind of impregnation must have taken place, causing a more irregular replacement than observed in the highly schistose types. Impregnation has been quite intensive, giving rise to the formation of large-size albite crystals, as well as to considerable quantities of quartz. These composite rock-types often exhibit a markedly gneissose structure. Good examples of rocks of this type are found along the road to the Col de Teghime east of the Cima

Orcaio and also higher on the eastern Serra di Pigno slope, in the granitized complex above the lower glaucophane-schist series. Some of the composite glaucophane-bearing varieties from the former locality, which partly also grade into the more highly schistose types described above, have already been briefly dealt with in former publications (Lit. 3 and 4). They were subdivided into "eyed" and "streaked" varieties, the latter showing transitions to banded rock-types, considered to have been formed by lit-par-lit introduction of material (fig. 14).

The "eyed" gneisses (Plate VII, fig. 1) are characterized by felspathic patches of strongly varying size, occasionally measuring up to 4 centimetres across. These are composed of albite, either as single crystals or as finely granular aggregates formed by granulation of larger individuals. The quartz introduced besides the albite is also locally represented by single large-sized crystals (measuring up to 1.5 centimetres across), showing strong undulose extinction and mortar-structures (Plate VII, fig. 2). More often, however, these crystals have been drawn out and broken down to a finely granular quartzite-like mass, which forms elongated lenticles. The glaucophane-bearing rock, which forms the matrix between these quartz and felspar eyes, often appears to be of a micaceous type, containing finely granular epidote. Remnants of turbid albite crystals rich in sericite and epidote, which are enclosed in clear newly formed albite porphyroblasts, seem to indicate that at least some of the invaded rocks were originally somewhat schistose albite-bearing glaucophanites related to the more massive types abundantly represented higher on the eastern Pigno slope. Though sometimes the glaucophane-bearing matrix has remained remarkably intact, impregnation has usually been of a more intimate kind, leading to the formation of rounded albite crystals, which strongly resemble those occurring in the albite-porphyroblast-bearing schists described above. Furthermore, it may be mentioned that, besides the granular epidote occurring in the matrix, epidote is also often represented in larger crystals which frequently contain orthite in their cores. Their formation seems to be related to the granitization.

As mentioned above, the quartz and felspar concentrations in the gneissic varieties are often flattened out to discontinuous bands, in which case these rocks have a streaked appearance. In rocks of this type bands may also occur, which chiefly consist of a finely granular quartzo-felspathic aggregate, sometimes containing some colourless mica; their composition becomes more and more like that of the albite-gneisses ("alpine granites"). Chlorite is often found along the borders of the quartz lenticles, while large epidote crystals with orthite cores are again abundant. Though the directed structure of these streaked gneisses may have partly originated prior to granitization, there is no doubt that they have been strongly influenced by later stress.

The bodies of homogeneous "alpine granite", which occur associated with the gneissic rocks under consideration, generally show an irregular

PLATE VII

Fig. 1

Eyed glaucophane-gneiss with leucocratic veins; along the road from Bastia to the Col de Teghime east of the Cima Orcaio (comp. textfig. 3).

Fig. 2

Quartz eye showing undulose extinction and partial granulation, in epidote-glaucophane-schist rich in newly formed quartz and albite, along the road from Bastia to the Col de Teghime east of the Cima Orcaio. × nicols (× 23).

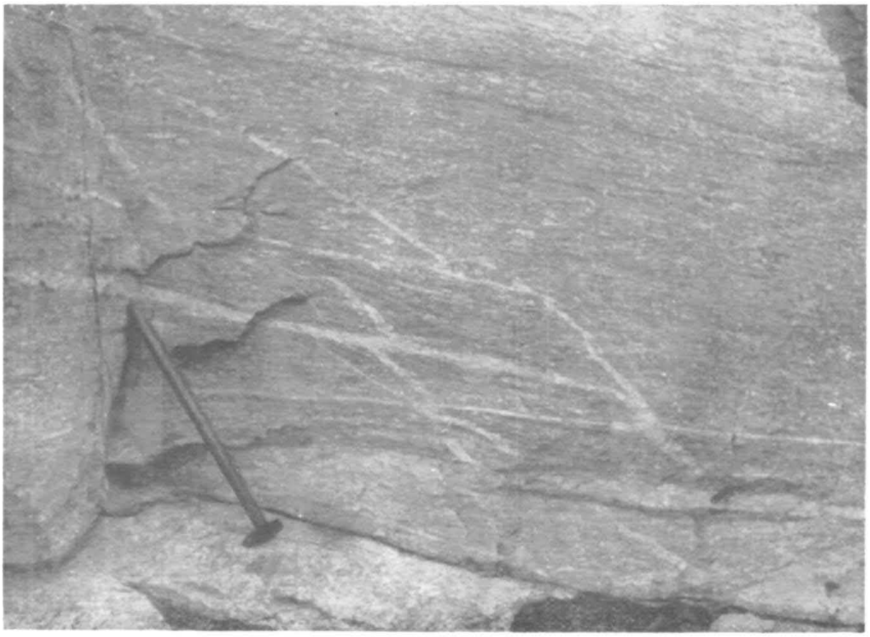

Fig. 1

Fig. 2

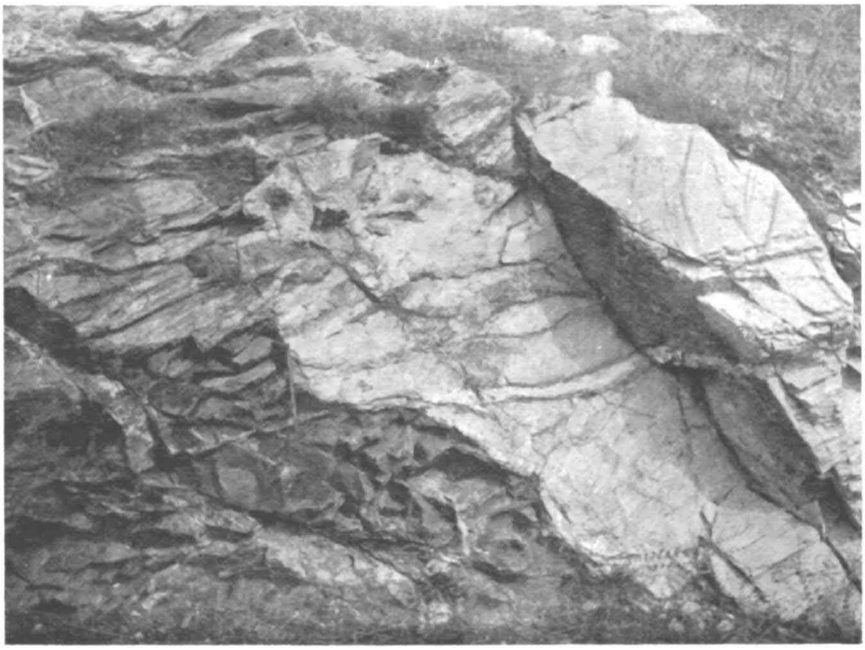

Fig. 1

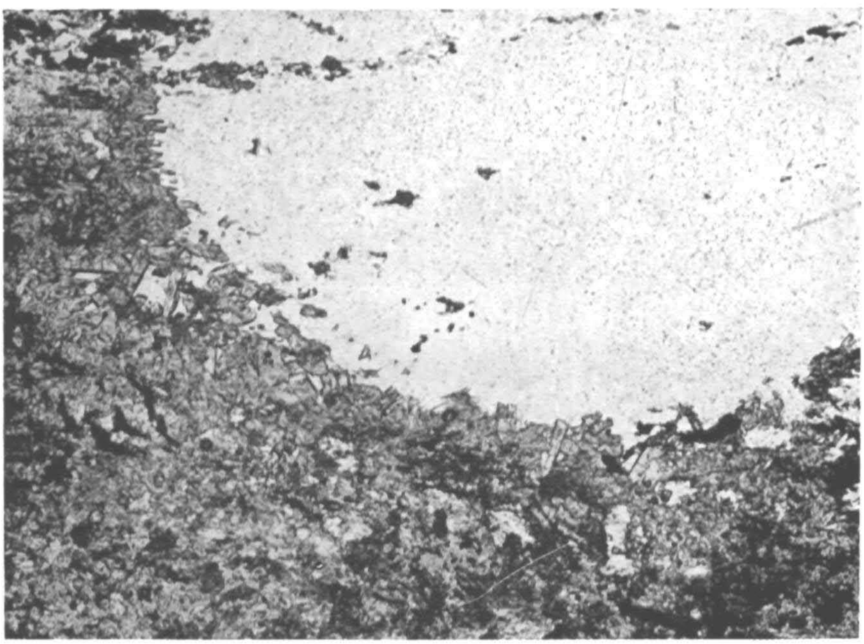

Fig. 2

PLATE VIII

Fig. 1

Contact of micaceous epidote-glaucophane-schist with albitic gneiss ("alpine granite"), along the road from Bastia to the Col de Teghime, east of the Cima Orcaio (comp. textfig. 3). Both rocks are intersected by a quartzo-felspathic vein.

Fig. 2

Aureole of glaucophane around a quartz-eye, in glaucophanite from the eastern slope of the Serra di Pigno. The glaucophane in the glaucophanite is present as more or less irregular crystals; along the boundary with the quartz there is clearly an enrichment in soda-amphibole, now developed in well shaped prisms. // nicols (× 29).

shape (Plate VIII, fig. 1). As the "alpine granites" described from other places, they are again mainly composed of quartz and albite, together with a colourless to pale greenish mica. Occasionally some microcline occurs too, tending to porphyroblastic development.

c. The granitization phenomena occurring in the truly massive rocks, of which a large part of the higher eastern Serra di Pigno slope is composed, show much resemblance to those observed in the eyed gneisses described above. The rocks subjected to the granitization appear to have been more or less massive glaucophanites of igneous origin, essentially composed of soda-amphibole and albite, together with a considerable amount of finely granular epidote, which represents an anorthite content of the original igneous felspar. The granitization phenomena are occasionally restricted to small irregular areas, but they may also occur in zones tens of metres thick. Even in places of comparitively intensive granitization, the original glaucophanites have generally retained their original habit up to a certain degree, the principal changes being the formation of some new albite and the introduction of quartz. In other cases these newly formed minerals become very abundant, the rocks grading into highly quartzose varieties which have lost their resemblance to the glaucophanites from which they have been derived, the more so because possible remains of soda-amphibole are entirely chloritized.

The granitization in this glaucophanite complex has proceeded very irregularly, some rocks having been intensely influenced and others entirely spared. Transitions occur over remarkably short distances, almost unchanged glaucophanites often forming patches of varying size within intensely granitized rock-masses. Remnants of this kind are conspicuous for their irregular shapes, in contrast with the glaucophane-schist bands preserved in the banded complex described earlier in this chapter.

As has been mentioned, the principal newly formed minerals in the granitized glaucophanites are quartz and albite. In many cases it is difficult to distinguish megascopically, which part of the felspar is produced by granitization. Under the microscope it appears that the newly formed albite often forms granular patches, in which case the principal distinctive feature is its clearness, while the older albite contains finely granular epidote. In other cases the newly formed felspar forms large porphyroblastic crystals, which may measure over 4 centimetres across. The newly introduced quartz, is developed in large rounded, highly undulose individuals or in more irregular, granulated patches, strongly resembling those in the eyed glaucophane-gneisses. Strings of other minerals often persist through the quartz crystals. It is particularly striking that the turbid sodic amphiboles of the original glaucophanites often show clear rims at the boundaries with quartz, while patches of this last mineral also occasionally appear surrounded by aureoles of newly formed glaucophane prisms (Plate VIII, fig. 2). Most of the granitized glaucophanites contain large epidote crystals with cores of orthite, while green chlorite is often concentrated in clear crystals along the boundaries of quartz impregnations, sometimes together with haematite. The granitization products have been strongly influenced by late stress, as evidenced by deformation of porphyroblastic felspars and granulation of quartz crystals. The fact that glaucophane prisms have occasionally been newly formed in granulated parts of the quartz patches, is significant with regard to the relative age of the glaucophane facies metamorphism.

In the zone of granitized glaucophanites described above, sharply bounded bodies of "alpine granite" have not been found. The ultimate product of granitization seems to be the highly quartzose gneissic rocks already mentioned. Here quartz is mainly developed in more or less rounded porphyroblasts often measuring half a centimetre across, with highly undulose extinction and partly showing mortar-structure. Furthermore albitic felspar is very abundant, mostly in areas of fairly small crystals often rich in finely granular epidote minerals, which are also found to be concentrated in patches and streaks. Epidote is also present in large irregular crystals partly associated with chlorite. Large chlorite patches containing much finely granular titanite may be formed secondarily out of soda-amphibole. Some muscovite is present, locally grading into a fine scaled sericitic mica. Other accessories are apatite, zircon, titanite (sometimes associated with leucoxene and occasionally enclosing rutile), and iron ore [1]).

SiO_2	62.48
Al_2O_3	17.51
Fe_2O_3	2.27
FeO	2.59
MgO	2.03
CaO	4.43
Na_2O	3.81
K_2O	1.46
H_2O^+	2.17
H_2O^-	0.11
CO_2	—
TiO_2	0.62
P_2O_5	0.23
MnO	0.06
	99.77

Elsewhere in the Pigno area, e.g. at Cardo, along the road to the Col de Teghime east of the Cima Orcaio, and high on the southwest slope of the Serra di Pigno, the leucocratic gneisses ("alpine granites") also include varieties rich in potash-felspar. A sample from the last named locality was found to be exceptionally rich in microcline, developed as large crystals partly measuring over a centimetre across and embedded in a more finely granular quartz-rich matrix. Sodic plagioclase is very rare. Subordinate amounts of colourless mica and of epidote are found and furthermore titanite, leucoxene, zircon and ore. The rock is highly cataclastic; most minerals show an undulose extinction and especially the larger microcline crystals are cracked and broken. The matrix has penetrated into the cracks which also sometimes contain granular epidote. In this rock potash is far in excess of sodium (SiO_2: 74.20%, Na_2O: 2.70%, K_2O: 5.74%) [2]).

[1]) The chemical analysis of a chlorite-rich albite-gneiss ("alpine granite") is given in the text. (Anal. Lab. LOBRY DE BRUYN).

[2]) Analyzed by S. B. SPIJER.

GENERAL CONSIDERATIONS ON THE METAMORPHISM

PRELIMINARY REMARKS

The genesis of metamorphic rock-types, in which the sodium has partly or wholly gone into soda-amphiboles like glaucophane or crossite or into soda-pyroxenes, has long been a subject of discussion in metamorphic literature. This is partly due to the fact that the field relations in regions where this glaucophane facies metamorphism is developed, are not always the same. In fact, in some parts of the world this metamorphism is of a regional kind, without direct influence of magmatic intrusions, whereas in others it has been described as being more local, restricted to zones of pneumatolytic or hydrothermal addition at the contacts of (ultra)basic intrusions (see e.g. Lit. 23). The formation of glaucophane has also been explained as arising from metasomatic alteration of gabbros, probably by alkaline soda-bearing solutions accompanying the formation of sulfides (Lit .26). Lastly it has been mentioned as a product of contact-metamorphism caused by granitic intrusions (Lit 27); it seems, however, that the phenomena, as far as they have been described, might be interpreted in a different way.

ESKOLA (Lit. 7) has given the glaucophane metamorphism a separate place in his facies scheme and named it the glaucophane-schist facies, characterized i.a. by such critical minerals as glaucophane, lawsonite and pumpellyite. This would imply that the problem of the glaucophane facies metamorphism is in the first place one of special pressure-temperature conditions. In rocks of the appropriate chemical composition, these cause the formation of soda-amphiboles and/or soda-pyroxenes, while other minerals may also be formed, in some cases likewise critical for the facies under consideration (e.g. lawsonite).

TURNER, in his manual on the evolution of metamorphic rocks, omits the glaucophane-schist facies from his facies scheme, as he considers that "... neither special physical conditions nor special bulk chemical composition of the rocks affected has been shown to be essential for the development of the glaucophane-schists" and that it is probable that the facies will prove "... substantially equivalent to the greenschist and albite-epidote amphibolite facies..." (Lit. 24, p. 100) [1]).

When considering the metamorphism as developed in eastern Corsica it may be mentioned that here no reasons were found to doubt the existence

[1]) Recently several investigators have again discussed the genesis of glaucophane-bearing and related rocks. Some have again pointed at the importance of physical conditions (e.g. ROUTHIER, Lit. 20; DE ROEVER, Lit. 19; EGELER, Lit. 6; NETELBEEK Lit. 14); others mention the possible importance of other influences (e.g. SCHÜRMANN, Lit. 21 and 22; DENGO, Lit. 5).

of a separate "glaucophane-schist facies". The glaucophane facies metamorphism of Corsica is a metamorphism on a regional scale, which can be interpreted as having been principally controlled by special physical conditions.

No facts were found indicating any direct relationship between this metamorphism and the ultrabasic intrusions (serpentines) often so intimately associated with the glaucophane-bearing and related rock-types. In fact, in some cases it is even possible to prove that these intrusions have preceded the regional metamorphism. It is clear that the same holds good for the gabbros, dolerites and spilites, of which most of the glaucophane-bearing and related rocks of Corsica are the metamorphic representatives. It should be pointed out, however, that in a narrow zone at the contact of ophiolitic bodies, pre-metamorphic introduction of soda has sometimes taken place, e.g. in the region south of Vezzani in phyllites and radiolarites. This introduction of soda has influenced the ultimate products of the regional metamorphism, as shown by the unusual concentration of albite and of soda-pyroxenes or soda-amphiboles of metamorphic origin (NETELBEEK, Lit. 14, p. 63, 66—67).

Neither have indications been found, for a causal relationship between the alpine "granitization" and the formation of the glaucophane-bearing rocks, which does not mean that these metamorphic rocks may not have been influenced by the granitization prior to their final crystallization (formation of albite-porphyroblast schists, glaucophane-bearing gneisses and other composite rock-types). However, the glaucophane-bearing rocks are also developed in great abundance in areas where no traces of granitization occur at the surface (see also EGELER, Lit. 6). Furthermore, it seems certain that, where glaucophane-bearing rocks and granitization phenomena occur together, the formation of the glaucophane and associated minerals was already advanced when the granitization began.

CHEMICAL COMPOSITION AND ORIGIN

That the glaucophane-bearing and related rocks of Corsica have in many cases been derived from basic igneous rocks and their tuffs, is confirmed by their chemical analyses. Some other types have in all probability been derived from spilitic rocks and from more acid rocks representing residual differentiates of the ophiolitic magma. Other types are of sedimentary origin [1]).

The chemical analyses of a number of glaucophane- and/or crossite-bearing rocks that are considered to be of igneous origin are repeated in Table I, together with some analyses of rocks from other regions.

The analysis I is of a lawsonite-glaucophanite characterized by the occurrence of lawsonite concentrations, which are pseudomorphic after phenocrysts of lime-bearing plagioclase (see p. 47). The analysis confirms

[1]) See e.g. Lit. 25.

TABLE I

	I	Ia	II	III	IIIa	IV	V	Va	VI	VIa	VIb	VII	VIIa	VIII
SiO_2	47.62	47.82	47.69	50.33	50.05	51.81	54.65	54.77	74.19	73.07	72.33	63.57	60.00	37.70
Al_2O_3	18.85	19.99	19.27	14.67	14.22	12.36	12.52	14.67	13.99	14.88	12.99	16.16	16.88	10.38
Fe_2O_3	2.59	2.10	4.30	3.69	4.81	3.68	5.55	6.60	0.81	0.04	—	3.71	1.83	5.56
FeO	4.35	6.48	4.18	5.88	8.72	5.85	5.97	6.41	0.92	2.93	2.50	2.66	3.02	12.56
MgO	5.50	4.94	5.06	6.03	5.71	12.52	5.32	3.21	0.94	1.30	0.97	1.58	1.40	12.85
CaO	10.93	11.65	8.57	8.07	9.01	4.03	3.87	4.90	0.68	0.66	1.73	1.10	3.16	6.05
Na_2O	2.74	3.51	3.20	4.26	4.24	2.15	6.30	6.32	7.32	6.17	7.60	9.55	9.31	2.05
K_2O	0.03	0.67	0.69	0.13	0.43	0.87	0.21	0.60	0.08	0.46	—	0.15	0.94	0.20
H_2O^+	6.36	0.21	5.36	4.18	0.35	4.52	2.15	0.36	0.64	0.90 }	1.09 }	0.84	1.53	6.42
H_2O^-	0.18	0.07	0.35	0.20	0.19	0.27	0.07	0.11	0.07			0.10	0.43	0.46
CO_2	0.06	—	0.03	—	0.23	—	—	0.10	0.02	—	1.00	—	0.59	—
TiO_2	0.94	2.00	1.20	2.32	1.67	0.98	2.99	1.51	0.28	0.41	0.74	0.70	0.42	2.85
P_2O_5	0.12	0.56	0.08	0.24	0.26	0.44	0.36	—	0.03			0.17	0.14	2.21
MnO	0.11	tr.	0.11	0.12	—	0.27	0.15	0.39	0.03			0.08	0.12	0.11
Inclusive		BaO: tr.						SO_3:0.15					ZrO_2:0.03 BaO:0.06 SrO:0.02 SO_3: tr. Li_2O: tr.	Cl: 0.18
Sum	100.38	100.00	100.09	100.12	99.89	99.75	100.11	100.10	100.00	100.82	100.95	100.37	99.88	99.58
si	121.10	112.7	123.8	131.5	119.8	126.5	156.0	153.7	391.5	362.5	354.7	230.9	207.5	77.3
al	28.2	27.7	29.4	22.6	20.0	17.9	21.1	24.2	43.4	43.5	37.3	34.6	34.5	12.6
fm	35.4	34.0	37.6	43.9	46.6	65.0	49.3	42.8	14.9	22.0	17.4	27.0	20.7	69.8
c	29.7	29.4	23.8	22.6	23.1	10.5	11.8	14.8	4.1	3.6	9.1	4.4	11.6	13.3
alk	6.7	8.9	9.2	10.9	10.3	6.6	17.8	18.2	37.7	30.9	36.2	34.0	33.2	4.3
ti	1.8	3.5	2.3	4.5	3.0	1.9	6.5	3.2	1.3	1.5	2.9	2.0	1.0	4.4
p	0.1	0.6	0.2	0.2	0.3	0.4	0.5	—	—	—	—	0.2	0.2	1.8
k	0.00	0.11	0.12	0.01	0.06	0.22	0.02	0.06	0.01	0.05	0.00	0.01	0.06	0.06
mg	0.59	0.52	0.53	0.54	0.44	0.70	0.46	0.31	0.51	0.45	0.41	0.32	0.35	0.57
o	0.14	0.11	0.22	0.16	0.19	0.10	0.24	0.32	0.21	0.00	0.00	0.37	0.22	0.12
c/fm	0.84	0.86	0.63	0.51	0.50	0.16	0.24	0.35	0.28	0.16	0.53	0.16	0.56	0.19
qz	− 5.8	− 22.9	− 13.0	− 12.1	− 21.4	+ 0.1	− 15.2	− 19.1	+140.7	+138.9	+109.9	− 5.1	− 25.3	− 39.9

that the rock was derived from a basic igneous rock of gabbroic composition, presumably a diabase-porphyrite. In this connection it is of interest to note that Na_2O is relatively low (2.74). For comparison an analysis (Ia) of an olivine-gabbro ("ossipite") is added. There seems to be no reason to assume any difference of importance between the chemical composition of the metamorphic rock and that of a basic igneous rock, apart from an addition of H_2O from the outside. Comparable phenomena of conversion of plagioclase into lawsonite have also been described by JOPLIN (Lit. 9) from New Caledonia in glaucophane-bearing doleritic rocks in which a relict ophitic structure has been preserved. This author pointed out that the occurrence of these lawsonite pseudomorphs signifies a fairly high anorthite content in the original felspar though there must also have been an addition of lime, possibly from the augite. The same reasoning may be applied in the present case. The initial soda content of the felspar appears now concentrated in the glaucophane.

I. *Lawsonite-glaucophanite*; southeastern slope of Mt al Pruno, Matra. Symbol: II''. 5. 4. 5. See p. 47

Ia. *Olivine-gabbro "ossipite"*; Black Cascade, Slide Brook, Tripyramid Mountain, Waterville, New Hampshire. Anal. C. J. MONAHAN. Symbol: II''. 5. '4. (4) 5. See PIRSSON, Lit. 17, p. 418.

II. *Lawsonite-crossite-schist*; approximately 3 km south of Sisco, along the road; east coast of Cap Corse. Symbol: II. 5. ''4. (4) 5. See p. 47

III. *Lawsonite-glaucophane-schist*; western slope of the San Petrone, southeast of Morosaglia. Symbol: (II) III. 5. 3. 5. See p. 21

IIIa. *Close grained diabase*; Kahleberg near Darmstadt, Hesse. Symbol: ''III. 5. 3. ''5. Anal. K. M. JENE. See KLEMM, Lit. 10, p. 24.

IV. *Chlorite-rich glaucophanite*; eastern slope of the Serra di Pigno, northeast of the summit. Symbol: III. 4 (5). 3''. 4. See p. 17

V. *Chlorite-rich albite-crossitite*; small hill south of the abandoned copper mine near the road from Rospigliani to Noceta. Symbol: II (III). 5. (1) 2. 5. See p. 34

Va. *Fairly coarsely granular diabase*. Ludwigstein near Rossdorf, Hesse. Symbol: II. 5. 2. ''5. Anal STADLER. See KLEMM, Lit. 10, p. 24.

VI. *Leucocratic crossite-bearing quartzo-felspathic rock*; forming irregular veins in the rock V. Symbol: I. 4. 1 (2). 5. See p. 36

VIa. *Aplitic soda granite*; University Mine, Cobalt, Ontario. Symbol: I''. ''4. 1 (2). 5. Anal. R. E. HORE. See HORE, Lit. 8, p. 275.

VIb. *Aplitic soda granite*; University Mine, Cobalt, Ontario. Symbol: I (II). 4. 1. 5. Anal. N. L. BOWEN. See Hore, Lit. 8, p. 275.

VII. *Albite-crossitite*; Bocca Serna, west of Morosaglia. Symbol: (I) II. 5. 1. 5. See p. 29

VIIa. *Soda syenite*, White Creek, Coalinga, Fresno County, California. Symbol: ''II. 5''. 1. 5. Anal. W. F. HILLEBRAND. See ARNOLD and ANDERSON, Lit. 1, p. 159.

VIII. *Apatite-rich crossite-chlorite-schist*; approximately 700 metres along the main road south of Albo, west coast of Cap Corse. See p. 42 Symbol: III (IV). 5. 3 (4). 5.

The symbols and the Niggli values in Table I and Table II (p. 62) have been calculated by Mr S. B. SPIJER.

Closely related to the lawsonite-glaucophanite mentioned above is the lawsonite-crossite-schist, the chemical analysis of which is given in column II. The result of the analysis confirms the view already reached in the field that the rock under consideration was derived from a gabbroic rock.

The analysis III is of a representative sample of the glaucophane-schists in the San Petrone area. It shows a somewhat divergent composition. The higher Na_2O percentage (4.26), if compared with that of the varieties mentioned above, may be pointed out. This, however, does not necessarily lead to the assumption of soda enrichment. For comparison the analysis (IIIa) of a diabase from Kahleberg, Hesse, is given.

In the glaucophanite of analysis IV the relatively high SiO_2 content (51.81) may be caused by introduction of quartz during the metamorphism. The high percentage of MgO (12.52) is accounted for by the advanced degree of chloritization of the glaucophane, a fact also responsible for the relatively low Na_2O content (2.15).

The somewhat chloritized albite-crossitite, the analysis of which is given in column V, shows again a higher SiO_2 percentage, which here may have been originally present in the rock. It is combined with a high percentage of Na_2O (6.30). For comparison the analysis of a diabase from Ludwigstein, Hesse, is given in column Va.

The analysis VI of a metamorphic leucocratic vein in the crossitite mentioned above, shows a more extreme composition, especially with regard to the percentage of Na_2O (7.32). The analyses VIa and VIb, given for comparison, are of aplitic soda granites from the Cobalt District in Ontario, occurring as small veins in diabases.

As mentioned already, the leucocratic veins and patches occurring in the metamorphosed doleritic rocks from the Vezzani area on Corsica, are considered as residual differentiates; the rock of analysis VI is a quartz-rich variety. The assumption that these rocks represent residual parts of the ophiolitic magma is made acceptable by the fact that the quartz-rich varieties grade into the basic rocks through a number of transitional types, partly devoid of quartz but with felspar clearly in excess of the dark constituents. The relatively leucocratic albite-crossitite from Bocca Serna (analysis VII) is also considered to be a representative of this latter type, characterized by an exceptionally high percentage of Na_2O (9.55). Its composition appears to be closely approximated by that of a soda-syenite from the Coalinga District in California (analysis VIIa), which, according to ARNOLD and ANDERSON (Lit. 1, p. 158), appears to be intrusive in serpentine.

Some remarks may be made on the high soda content of the residual differentiates in the ophiolites of Corsica. It appears that in some varieties the albite crystals contain finely granular inclusions of such lime-silicates as pumpellyite or lawsonite, indicating a lime-content of the felspar at the time of crystallization from the magma. As other varieties appear to be almost devoid of lime-minerals, it seems that the residual differentiates originally comprised types with lime-bearing felspar as well as types with more or less pure albite. There seems no reason to assume that in the latter case the albite was formed by autometamorphic albitization of an originally more calcic plagioclase.

The relation between relatively basic glaucophanites from Piedicorte and associated more leucocratic rocks, which presumably are comparable to the residual differentiates dealt with above, has been discussed by LACROIX (Lit. 12, p. 92—95). According to this author the variations in chemical composition are due to migration of soda and lime, causing rocks of calc-alkaline character to pass abruptly into alkaline types. Although some exchange of material may indeed have taken place, the results of the present investigations suggest that the variations in chemical composition are chiefly pre-metamorphic.

The apatite-rich crossite-chlorite-schist of analysis VIII is an exceptionally basic variety, the ultimate composition of which may have been influenced by differentiation during the metamorphism.

Besides this rock there are also others of more or less extreme composition, as for instance bands and veins consisting almost exclusively of sodic pyroxene. It is difficult to estimate the rôle played by metamorphic differentiation during the glaucophane facies metamorphism of Corsica.

The chemical analyses of a number of rocks rich in soda-amphibole or soda-pyroxene, which are supposed to be derived from tuffs or from rocks rich in tuffaceous material, are repeated in Table II, together with those of a metamorphosed quartzite and an "alpine granite".

The garnetiferous lawsonite-glaucophane-schist of which the analysis is given in column IX, is a representative sample of the glaucophane-schists at the base of the Serra di Pigno. Obviously there is a close relationship with the rocks of doleritic or gabbroic origin dealt with above. However, in the present case the mode of occurrence together with quartzitic and phyllitic varieties seems to indicate a tuffaceous origin. The rock is very poor in albite.

The analysis X is of a highly felspathic lawsonite-glaucophane-schist from the same series. Here the albite is considered to arise from felspathization which may be related to the alpine granitization. As the composition prior to the felspathization is unknown it is not possible to estimate the amount of the introduced elements.

Other rocks for which a tuffaceous origin is assumed, are a muscovite-sodapyroxene-schist from the Col de San Pietro (analysis XI) and a chlorite-rich lawsonite-glaucophane-schist from point 1188 northwest of the San Petrone (analysis XII). The first rock-type occurs in thin beds alternating with strongly folded schistes lustrés comprising i.a. highly calcic and quartzitic varieties as well as rocks rich in soda-amphibole. The large albite crystals occurring in the rock might well be of metasomatic origin.

TABLE II

	IX	X	XI	XII	XIII	XIV
SiO_2	46.64	50.63	46.61	46.87	87.78	62.48
Al_2O_3	16.88	17.58	18.55	16.44	3.98	17.51
Fe_2O_3	5.13	2.99	10.45	1.75	1.55	2.27
FeO	4.79	5.07	0.94	6.92	1.83	2.59
MgO	6.45	5.83	1.94	7.27	1.17	2.03
CaO	8.47	6.69	8.25	7.58	0.53	4.43
Na_2O	4.51	4.24	5.12	3.75	0.99	3.81
K_2O	0.91	1.01	3.06	0.27	0.93	1.46
H_2O^+	3.08	3.48	2.77	5.07	1.04	2.17
H_2O^-	0.08	0.17	0.08	0.14	0.10	0.11
CO_2	0.79	0.14	0.23	2.34	—	—
TiO_2	1.87	2.37	2.20	1.35	0.23	0.62
P_2O_5	0.12	0.34	0.21	0.17	0.05	0.23
MnO	0.13	0.15	0.03	0.17	0.03	0.06
Inclusive			CuO: tr.		S: 0.03	
Sum	99.85	100.69	100.44	100.09	100.24	99.77
si	111.9	134.4	121.8	117.8	975.5	234.5
al	23.9	27.6	28.5	24.3	26.0	38.8
fm	42.4	40.7	30.4	45.6	50.0	26.2
c	21.8	19.1	23.0	20.5	6.7	17.8
alk	11.9	12.6	18.0	9.6	17.3	17.3
ti	3.5	4.8	4.4	2.6	2.0	1.8
p	0.1	0.3	0.2	0.1	—	0.2
k	0.12	0.14	0.29	0.05	0.38	0.21
mg	0.55	0.57	0.25	0.60	0.39	0.44
o	0.22	0.15	0.68	0.07	0.27	0.24
c/fm	0.51	0.47	0.76	0.45	0.13	0.68
qz	− 35.7	− 16.0	− 50.2	− 20.6	+806.3	+ 65.3

IX. *Garnetiferous lawsonite-glaucophane-schist*; along the road from Bastia to the Col de Teghime, where it crosses the stream descending from Serra di Pigno. See p. 11

X. *Albite-rich lawsonite-glaucophane-schist*; along the road from Bastia to the Col de Teghime, near where it crosses the stream descending from the Cima Orcaio. See p. 12

XI. *Muscovite-sodapyroxene-schist*; Col de S. Pietro, S. of the San Petrone. See p. 28

XII. *Albite-rich chlorite-lawsonite-glaucophane-schist*; northwest of the San Petrone (point 1188). See p. 26

XIII. *Schistose glaucophane-quartzite*; alternating in bands with the rock XII. See p. 23

XIV. *Chlorite-rich albite-gneiss* ("*alpine granite*"); eastern slope of the Serra di Pigno, northeast of the summit. See p. 55

The same holds good for the albite in the chlorite-rich lawsonite-glaucophane-schists, which are found alternating with schistose glaucophane-quartzites of which an analysis is given in column XIII. These quartzites are rich in tourmaline and both the glaucophane-schists and the quartzites contain rather much pyrite. In one or two cases the quartzites also contain porphyroblasts of albite.

The analysis XIV is of a chlorite-rich albite-gneiss ("alpine granite") from the Serra di Pigno. Rocks of this type occur in close association with basic glaucophane-bearing rocks of igneous origin. Irregularly shaped bodies of these glaucophanites pass more or less gradually into the albitic gneisses indicating that the latter have been formed by metasomatic replacement of the basic rocks. The chlorite in the gneiss may partly be formed secondarily out of soda-amphibole.

METAMORPHIC GRADE

When considering the glaucophane-bearing and related rocks in the schistes lustrés series of Corsica, with regard to their degree of metamorphism, two facts stand out: (1) the distinct difference in the degree of metamorphic recrystallization between the rocks of the Vezzani area and those further north, and (2) the restriction of certain mineral assemblages to particular areas.

As to the first point it appears that in the south both relict minerals and relict structures are considerably more common than farther north. In fact, in the region south [1]) and northwest of Vezzani the doleritic and spilitic rocks are often almost or entirely devoid of metamorphic features, while even the more intensely changed types have generally retained original undirected structures. The increase in degree of recrystallization is already obvious at Matra and in the San Petrone area, where relict minerals of igneous origin are seldom found. The same is the case in the Serra di Pigno area and in those parts of Cap Corse that were investigated. In the more or less completely recrystallized rocks from the last four areas, original undirected structures may still be partly, or even completely preserved, but in others they are replaced by markedly schistose structures, considerable variations occurring over remarkably short distances.

The increase in the degree of metamorphism from the region near Vezzani to those further north may be related to a southward axial plunge.

With regard to the second point mentioned above, the regional distribution of the mineral assemblages (see Table III) seems to indicate that three different assemblages are represented. In the glaucophane rocks from the area south of Vezzani, lawsonite appears to occur as the principal lime-rich silicate. According to NETELBEEK (Lit. 14), these rocks have been metamorphosed in the lawsonite-glaucophanite subfacies, which is mainly characterized by the stability of lawsonite and the

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[1]) See NETELBEEK, Lit. 14.

TABLE III

	Vezzani area				Matra		San Petrone area						Serra di Pigno area					Cap Corse W coast		
glaucophane .			▬	(—)		▬		—		▬	▬	—	—	▬	▬	▬		▬	▬	—
crossite		▬	—	▬	▬		—	▬	▬		▬	▬		(—)	(—)		▬		(—)	▬
soda-pyroxene	▬	▬	▬		▬		▬	▬		—			▬	(—)						
lawsonite. . . .	(—)	—		—	▬	▬	▬	(▬)	▬	▬	▬		▬	▬						
epidote	(—)	(—)		(—)			—	—	—	(—)	—	▬	—	—	▬	—	▬	▬	▬	▬
garnet.						▬	(—)	(▬)		(—)		(—)		(—)		—			(—)	▬

The association of characteristic minerals and their distribution in various areas investigated.

▬ important rock-forming minerals.

— minerals present in more subordinate amounts.

( ) not encountered in all the rocks of the assemblage.

instability of both garnet and epidote (DE ROEVER, Lit. 18, p. 161). In the area to the northwest of Vezzani described in the present paper lawsonite also occurs as principal lime-silicate [1]) and garnet is absent. In the area to the northeast of Matra, in the main part of the San Petrone area and in part of the Serra di Pigno area lawsonite also occurs, but here the mineral is often associated with garnet. A glaucophane-bearing mineral assemblage, mainly characterized by the occurrence of garnet besides lawsonite, while epidote is not stable, has been distinguished by DE ROEVER in southeast Celebes (Lit. 19, p. 1457), and named the garnet-lawsonite-glaucophane-schist subfacies. In addition to the rocks mentioned above there occur, both in the San Petrone and in the Pigno area, glaucophane-rich varieties which are devoid of lawsonite, while epidote occurs as apparently stable lime-silicate mineral. Moreover no lawsonite has been found in the rocks investigated from the west coast of Cap Corse, while here epidote is widely distributed. EGELER (Lit. 6, p. 563) considers the epidote-rich glaucophane-schists of the Serra di Pigno area to be metamorphosed in a subfacies of the glaucophane-schist facies having alkali-amphibole and epidote as critical association, while lawsonite is unstable. The present investigations show that in these epidote-rich glaucophane-schists the epidote may also be associated with garnet [2]). It seems reasonable to assume that the epidote-rich glaucophane rocks

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[1]) The fact that this is not very obvious in the assemblages from the Vezzani area, given in Table III, may be ascribed to hysterogene alteration of the lawsonite.

[2]) The existence in southeast Celebes of a comparable subfacies with both epidote and garnet as stable minerals, while lawsonite is unstable, has been pointed out by DE ROEVER (Lit. 18, p. 161).

As pointed out by EGELER (Lit. 6, p. 563) the epidote-rich glaucophane-schists from the Serra di Pigno area show a strong resemblance to varieties from the Val de Bagnes in Wallis, where no lawsonite is known to occur.

from the San Petrone area (where the epidote crystals are often found to contain orthite in their cores), and those from the west-coast of Cap Corse, are isogradic with those from the Pigno area.

In the glaucophane-bearing and related rocks of Corsica alteration phenomena are quite common. The soda-amphiboles and -pyroxenes are sometimes bent or broken and often more or less chloritized, while in the same rocks the lawsonite often shows conversion to chlorite, sericite and epidote. The association of these phenomena points to a retrograde metamorphism towards the greenschist facies [1]).

A few remarks may be made on the mutual relation existing between the various mineral assemblages. According to DE ROEVER (Lit. 19, p. 1460) his garnet-lawsonite-glaucophane-schist subfacies represents the adjoining higher metamorphic equivalent of his lawsonite-glaucophanite subfacies. On Corsica, the association lawsonite-garnet is also found in rocks showing a relatively high degree of metamorphic recrystallization, while garnet does not occur in the low grade rocks from the Vezzani area, which, as already mentioned, grade into varieties devoid of metamorphic features. This higher degree of recrystallization is also obvious in the glaucophane-schists showing the assemblage with epidote. The relation between these latter rocks and the glaucophane-schists with lawsonite and garnet is not clear. Both show the advance in degree of recrystallization and they often appear closely associated in the field. The possibility might be taken into consideration that the assemblage with epidote is more closely related to the albite-epidote-amphibolite facies [2]).

Lastly it may be pointed out that no reasons have been found on Corsica, to assume a relationship between the variation in the degree of metamorphism and the granitization process, as granitization (felspathization) phenomena have been found in rocks of each of the metamorphic grades distinguished.

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[1]) It should be pointed out, that in other cases the replacement of lawsonite by epidote might also be interpreted in a different way, for instance in certain rocks of the San Petrone and Serra di Pigno areas, which contain considerable quantities of both lawsonite and epidote, the latter being younger than the lawsonite and clearly formed at its expense. As in the areas in question rocks with the garnet-lawsonite-glaucophane assemblage occur in close association with epidote-rich varieties devoid of lawsonite, and as the rocks often appear to be devoid of chloritization of soda-amphibole and sericitization and/or chloritization of lawsonite, the possibility should be taken into consideration that here the conversion of the lawsonite is caused by a transition into an epidote-bearing glaucophane-schist subfacies.

[2]) It is clear that the ideal mineral assemblages of the various subfacies are often imperfectly developed, as shown by the widespread occurrence of zoned minerals and alteration phenomena.

METAMORPHISM IN THE OROGENIC HISTORY

As mentioned earlier in this paper, the widespread distribution of metasomatically formed albite porphyroblasts in the glaucophane-schists, especially observed in the Serra di Pigno area, is considered to be related to the granitization process.

As to the age of the granitization process with regard to the tectonic movements the following facts may be stated.

Important zones of strong differential movement and mylonitization were not observed near the contacts of the leucocratic gneisses ("alpine granites") and the adjacent rocks; in general there is a concordant relation and a more or less gradual transition between the two, which suggests that the granitization process has been, at least partly, syntectonic. This is confirmed e.g. by the occurrence of S-shaped trends of glaucophane, muscovite and epidote in some of the albite porphyroblasts, formed during the granitization process in micaceous glaucophane schists. Furthermore in most cases the movements appear to have outlasted feldspathization and granitization, as evidenced by the intensive cataclasis of newly produced quartz and felspars, as well as by the folding of rocks subsequent to their granitization (fig. 15).

Felspathization and granitization may in part also have outlasted the orogenic movements, as indicated both by the occurrence of dis-

Fig. 15. *Folding of muscovite-albite-gneiss ("alpine granite") and glaucophane-schists.* The more incompetent schists show a minute folding. Quartz lenses (black) occur especially along the contact between gneiss and schist. Northwest of the summit of the Mt Muzzone (Pigno area).

cordant veins of quartz and pegmatite related to the granitization, and by the occurrence of non-cataclastic albite crystals, which sometimes contain fold-arcs of muscovite- and lawsonite-bearing materials.

From these various facts it may be concluded that the granitization in the schistes lustrés has taken place in a relatively advanced stage of the orogenic movements, occasionally even outlasting them.

The fact that the so-called "alpine granites" and the granitization phenomena in the schistes lustrés are often localized to the zone where the schistes lustrés nappe borders the autochthonous massif (see p. 6), suggests a relationship between the thrust planes and the ascent of the granitizing solutions, a conception well in accordance with the above-mentioned considerations on the relative age of movements and granitization.

The age of the granitization in relation to the deformation now having been established, its relation to the metamorphism responsible for the formation of the glaucophane-bearing and related rocks may be discussed.

It is clear that the production of glaucophane and accompanying minerals has, for the main part, preceded the felspathization, as proved by the widespread occurrence of e.g. glaucophane and lawsonite as inclusions in the albite porphyroblasts. On the other hand, the study of the glaucophane-bearing rocks from the Pigno area shows that minerals of the glaucophane facies have also been formed simultaneously with or even after the granitization, as evidenced by: (1) the occurrence of clear rims of glaucophane along turbid glaucophane crystals at the boundaries of eyes of quartz introduced during granitization, (2) the occurrence of small, newly formed glaucophane prisms in granulated zones in such quartz eyes, (3) the enrichment of glaucophane along quartzo-felspathic veins and around quartz impregnations and (4) the crystallization of lawsonite in granitic gneisses (Brouwer and Egeler, Lit. 3, p. 303). All these facts indicate that in the Serra di Pigno area the conditions permitting the development of glaucophane have prevailed during at least part of the period of granitization. Netelbeek's observations in the area to the south of Vezzani led to much the same conclusions (Lit. 14, p. 112).

Taking the relative age of granitization and deformation into consideration, it may be concluded that on Corsica the formation of minerals of the glaucophane facies has continued into a fairly advanced stage of the orogenic movements. The fact that the metamorphism also appears to have affected the autochthonous massif in places where the influence of the alpine dislocations is apparent, is consistent with this conclusion (see also Netelbeek, Lit. 14, p. 113). Some insight into the age of the metamorphism is given by the occurrence of newly-formed soda-amphiboles in (par)autochthonous eocene conglomerates (see p. 7).

As mentioned already in the discussion of the metamorphic grade (p. 65), it appears that the products of the glaucophane facies metamorphism have often been affected by later processes, resulting in the deformation of crystals (bending and breaking of alkali-amphiboles and -pyroxenes) or in alteration of minerals (e.g. conversion of glaucophane into chlorite and of lawsonite into chlorite, sericite or epidote). These and closely related phenomena are recorded from many other regions characterized by the glaucophane type of metamorphism. Considerable value is attached to them by DE ROEVER (Lit. 19, p. 1463), who considers them as representing a dynamic metamorphism in the greenschist facies that accompanied the overthrusting, while "... the age of the metamorphism in the glaucophane-schist facies is confined as yet to the period between the oldest phase of folding of the geosynclinal deposits .... and the paroxysm of the overthrust movements". The age-relations found on Corsica between the glaucophane facies metamorphism and the orogenic movements make it clear, however, that in this case such a division into two phases of metamorphism — the one geosynclinal the other paroxysmal — is not justified. Here the metamorphism in the glaucophane-schist facies continued into an advanced stage of the orogenesis and the young metamorphism in the greenschist facies is considered merely a retrograde metamorphism accompanying late movements.

Closely linked with the position of the metamorphism in the orogenic history, is the problem of the physical conditions responsible for its development. The abundant occurrence within the glaucophane-schist facies of dense minerals has frequently been commented upon and connected with pressure conditions. ESKOLA (Lit. 7) considers that the facies develops over a considerable range of relatively low to medium temperature and relatively high confining pressure, a combination of physical conditions which, according to TURNER (Lit. 24, p. 100), "could not be attributed to great depth.... but could conceivably be due to local development of high pressure fields in regions of strong alpine deformation". DE ROEVER (Lit. 19, pp. 1459, 1463) stresses the importance of relatively high confining pressure as the essential factor, with more subordinate thermal influence and shearing stress, conditions which he considers inherent to the geosynclinal environment. It indeed seems likely that relatively high pressure is an important factor in the production of the glaucophane-bearing and related rocks. Our investigations on Corsica show, however, that other than geosynclinal conditions may be responsible, as here the metamorphism in the glaucophane facies was not restricted in time to the geosynclinal stage, and in space it extends into the autochthonous massif (p. 6 and 7).

CONCLUDING REMARKS

The principal conclusions may be summarized as follows.

The glaucophane-bearing and related rocks in the schistes lustrés nappe of Corsica have been formed by a regional metamorphism out of rocks of widely varying origin and mineralogical and chemical composition, comprising basic igneous rocks and their tuffs, spilites, acid differentiates and various types of sedimentary rocks.

No facts have been found indicating a direct relationship between the metamorphism and the basic and ultrabasic magmas, though these may have caused pre-metamorphic soda-enrichment at their contacts.

Neither have indications been found for a causal relation to the alpine granitization, although the metamorphic rocks are in many cases influenced by the granitization (felspathization) prior to their final crystallization.

These and other indications of chemical reactions between the constituent minerals and metasomatically introduced materials, do not lead to the supposition that an addition of sodium has been essential for the formation of the soda-amphibole- and/or soda-pyroxene-bearing rocks. Nor is it necessary to assume an initially high alkali-content, as is made particularly clear when considering the analyses of some glaucophane-rich varieties representing the metamorphic derivates of basic igneous rocks.

The observations on Corsica lead to the conclusion that the regional metamorphism has been mainly controlled by special physical conditions.

As the granitization (felspathization) appears to have taken place in a relatively advanced stage of the orogenic movements (occasionally even outlasting them), and as the conditions permitting the development of glaucophane and related minerals appear to have continued during at least part of the period of granitization, it may be concluded that the metamorphism in the glaucophane-schist facies has also continued into a fairly advanced stage of the orogenic movements. This metamorphism is not restricted to the rocks of the schistes lustrés nappe; it also occurs locally in the autochthonous massif, in places where the influence of the alpine dislocations is apparent.

An increase in the grade of the glaucophane facies metamorphism is observed, from the southern region near Vezzani to those further north, a phenomenon which may be related to an axial plunge towards the south.

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