ON METAPORPHYRITES OF THE SIZMA REGION PROVINCE OF KONYA

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ABSTRACT. — Several volcanic rock specimens of Paleozoic age from the Sızma - Karatepe region, province of Konya, are described petrographically (Fig. 1).

Observations reveal that volcanic rocks of this region were subjected to metamorphism of the glaucophanitic-greenschist facies, as indicated by the presence of stilpnomelane and glaucophane.

INTRODUCTION

The rocks to be described were collected by G. v. d. Kaaden (numbers 3568 and 3569), and Wiesner, Lehnert-Thiel (numbers 3379 to 3383), from Karatepe 2 km north of Sızma, province of Konya, at an altitude of approximately 1500 m.[1] The geological map (scale 1 :25,000) of Wiesner, Lehnert-Thiel (1964), shows these rocks to occur in three lenses enclosed in a series of epi-metamorphic quartz schists of Devonian age (Wiesner—personal communication). The easternmost lens is designated, as Karadağ, the central one as Karatepe and the western lens is unnamed and is located 4 km WNW of Sızma. Combined outcrop of the three is about 8.5 km^2 (Fig. 2).

DESCRIPTIONS OF SPECIMENS

Thin section number 1119 of rock number 3379

Macroscopic description. — Rectangular crystals of feldspar up to 10 X 3 mm are more or less parallel, in a dense, gray groundmass showing brownish dots. Density of the rock is 2.62. Volumetric analysis of the hand specimen gives 25% of alkali feldspar phenocrysts.

Microscopic description. — The rock is holocrystalline porphyritic. Phenocrysts are anhedral to subhedral microcline-perthite (Fig. 5) and lesser albite. Albite crystals are often studded by fine aggregates of flaky sericite (Fig. 3). Stilpnomelane formed late and is very abundant in the groundmass and occassionally replaces and penetrates phenocrysts of feldspar (Fig. 4). Subordinate sphene, partially altered to leucoxene, is present; sometimes concentrated along cracks crossing stilpnomelane. Smalt euhedral crystals of apatite are mostly seen as inclusions within stilpnomelane and secondary quartz has formed along cracks in feldspars.

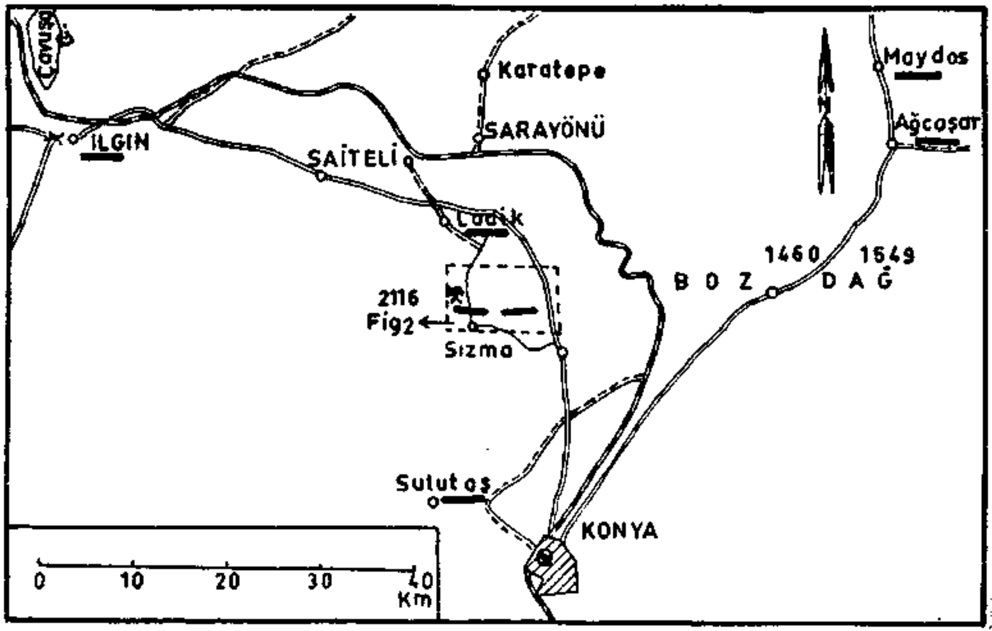

Fig. 1 - Location of the Sızma area and of glaucophane-occurrences (underlined), **mentioned by v. d. Kaaden (1966).**

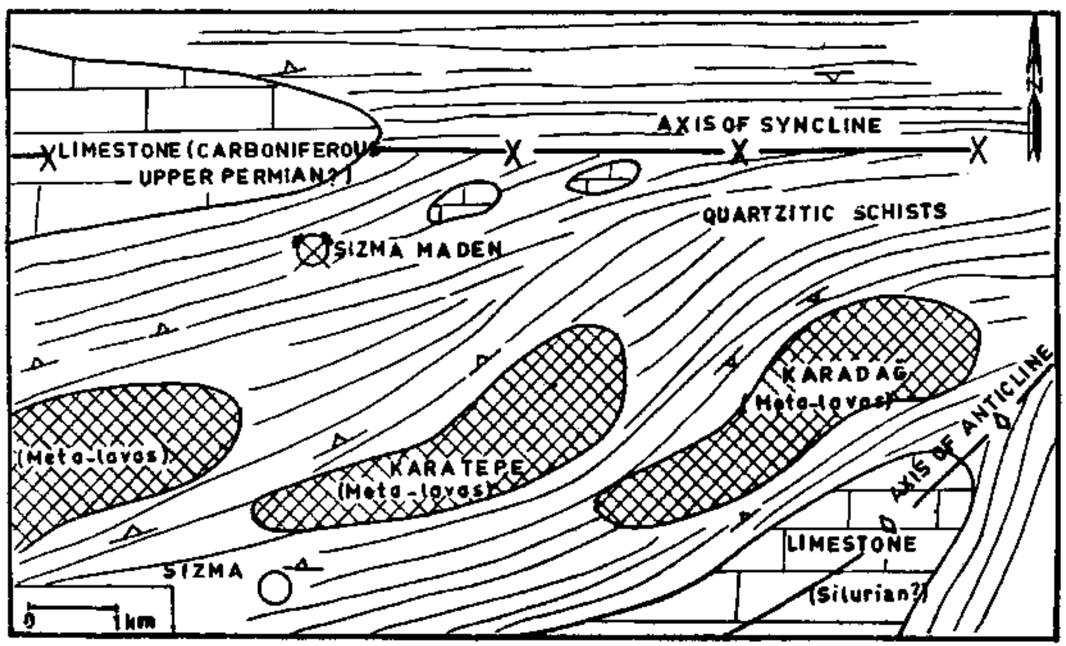

Fig. 2 - Geological sketch-map after Wiesner, Lehnert-Thiel.

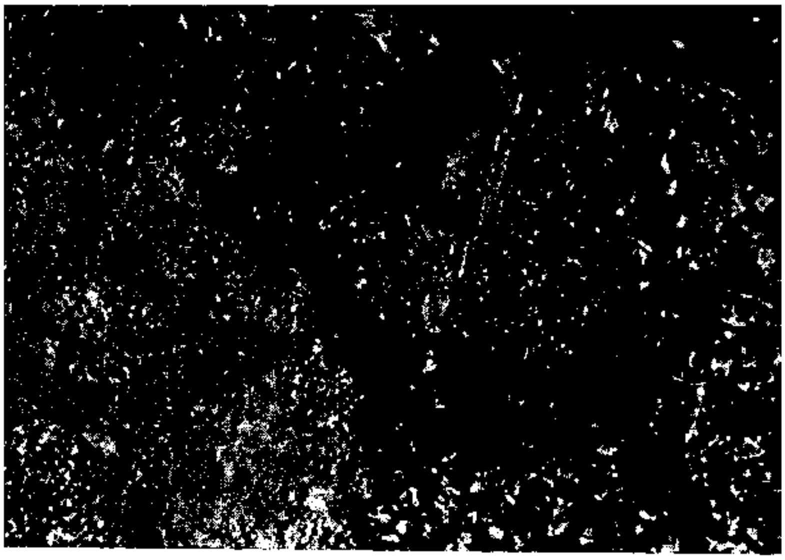

Fig. 3 - Locally sericitized albite crystals with stilpnomelanes-around it (with cross nicols, × 17.5).

The groundmass is small laths of albite with abundant stilpnomelane, as porphyroblastic aggregates and single fibrous individuals.

Volumetric analysis of the thin section gives : groundmass 66%, stilpnomelane 20%, muscovite 6.5 %, alkali feldspar 3%, sphene 2.5 %, and quartz 1.7 %.

Ore microscopy[2]. — The opaque mineral is magnetite. Hematite is observed as an inclusion in the magnetite and is formed partly parallel to (111) direction of magnetite. Magnetite has also a brownish tinge which may be an indication for Fe_2TiO_4.

Thin section number 1120 of rock number 3380

Macroscopic description. — Phenocrysts of feldspar up to 2 X 1 mm, are distributed throughout a dark-colored homogenous matrix. Density of the rock is 2.81.

Microscopic description. — The rock is holocrystalline porphyritic, showing flow texture and small porphyroblastic aggregates. Phenocrysts are anhedral microcline-perthite and a few crystals of twinned albite. Sericitization is present on phenocryst margins and some complete feldspar phenocrysts are replaced. Sphene and abundant stilpnomelane are also concentrated on phenocryst margins, and sphene is seen in aggregates of muscovite, on cracks orientated perpendicular to schistosity (flow texture). Some muscovite aggregates have been deformed and the enclosed sphene shows snowball texture (Fig. 6). The association of sphene and muscovite suggests pseudomorphoses after Ti-rich biotite. Sphene is partly altered to leucoxene. Opaque minerals are rare and probably magnetite.

The very fine-grained matrix is composed of albite microlites and small, fibrous crystals of stilpnomelane.

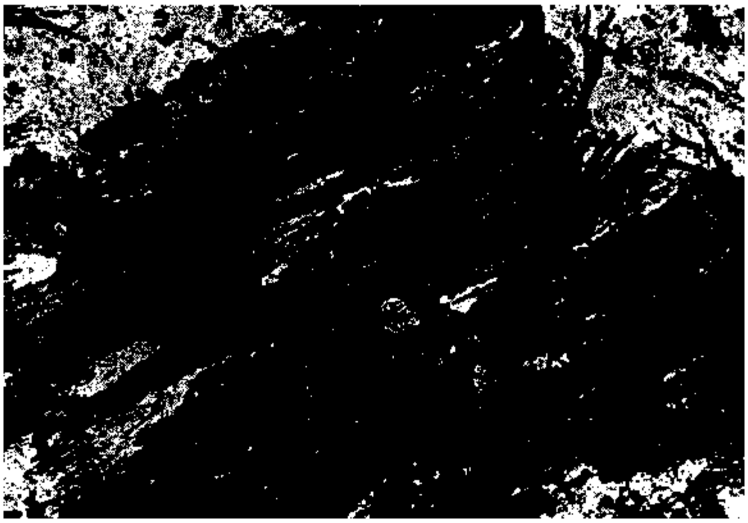

Fig. 4a- Porphyroblasts of brown stilpnomelane in a groundmass of sphene and feldspar laths (without analyzer, x 50).

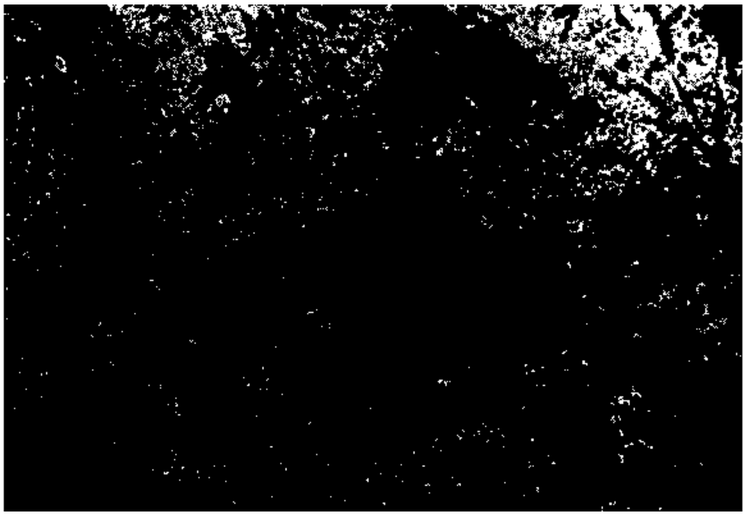

Fig. 4b - Porphyroblasts of brown stilpnomelane in a groundmass of sphene and feldspar laths (with cross nicols, x 17.5).

Volumetric analysis of the thin section gives: groundmass 44%, perthite 31%, muscovite 12%, stilpnomelane 4.8°%, sphene 3%, albite 2%, quartz 2%.

Thin section number 1121 of the rock number 3381

Macroscopic description. — The rock is porphyritic with distinguishable schistosity and trachytic texture. Tabular phenocrysts of feldspar 3-7 X 2-4 mm, appear in a dark-colored matrix. Density of the rock is 2.7.

Microscopic description. — The rock is holocrystalline porphyritic showing flow structure. Phenocrysts of microcline-perthite and of albite are partly altered to sericite. Coarse aggregates of white mica show bent cleavages and small grains of sphene on margins and cracks, which are sometimes orientated perpendicular to the schistosity, suggesting derivation from Ti-rich biotite.

The fine-grained sericitized matrix contains minor stilpnomelane as fibrous crystals and seems to represent devitrification of volcanic glass (Fig. 7).

Volumetric analysis of the thin section gives: groundmass 70 %, feldspar 17%, sphene 7.8% muscovite 4%, stilpnomelane 0.06%, and quartz 0.1 %.

Thin section number 1122 of rock number 3382

Macroscopic description. — The very fine-grained rock shows an almost equigranular texture, but some small feldspars can be recognized with the aid of a hand-lens. Density of the rock is 2.62.

Microscopic description. — In section, this rock appears much the same as specimen 3381 with greater abundance of sericitized groundmass and a few small crystals of zircon.

Volumetric analysis of the thin section gives: groundmass 82 %, feldspar 14 %, muscovite 3 %, and quartz 0.2 %.

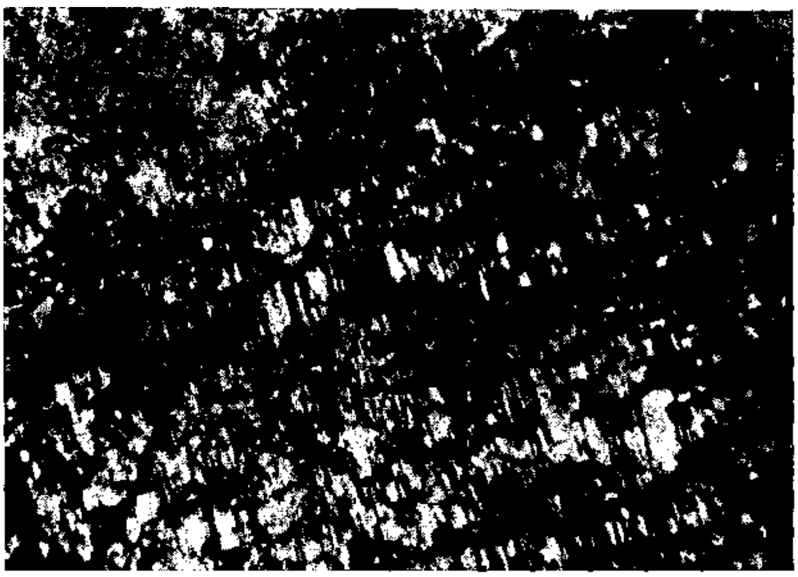

Fig. 5 - Microcline perthite (with cross nicols, × 17.5).

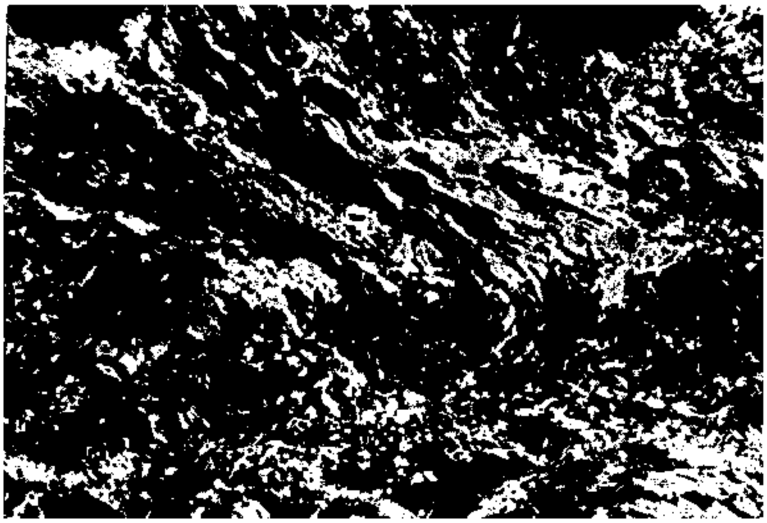

Fig. 6a - Muscovites and sphenes showing showball texture in a matrix of albite microlites and fibrous stilpnomelane (with cross nicol s, x 50).

Fig.6b - Muscovites and spheaes showing snowball texture in a matrix of albite microlites and fibrous stilpnomelane (without analyzer, x 50).

Thin section number 1123 of rock number 3383

Macroscopic description. — The medium colored rock is very fine-grained, slightly schistose and dotted with brown spots. Density of the rock is : 2.64.

Microscopic description. — The holocrystalline rock shows porphyroblastic texture and appears to be a slightly metamorphosed tuff. Angular to subangular fragments of feldspars up to 0.1-0.5 mm and showing bent twinning, are scattered in the groundmass in somewhat parallel arrangement. Fragments are mostly microcline-perthite and lesser twinned albite. Porphyroblasts of white mica after Ti-rich biotite arc again present. Sphene is concentrated on fractures in feldspar and muscovite and dispersed in the groundmass.

The groundmass is again sericite with minor, fibrous stilpnomelane and a few small crystals of apatite. Locally, secondary quartz is found in small veins.

Volumetric analysis of the thin section gives : groundmass 60 %, perthite 17 %, albite 1 %, stilpnomelane 10 %, muscovite 6.9 %, sphene 2 % (Fig. 8).

Thin section number 1199 of rock number 3568

Macroscopic description. — The porphyritic, flow-textured rock shows tabular feldspar crystals, up to 20 X 50 mm, distributed in a dense, bluish groundmass. Small prismatic, bluish crystals an some yellowish-brown and greenish minerals are visible in the croundmass. Density of the rock is 2.85. Volumetric analysis of the hand specimen gives 15 % of microcline-perthite phenocrysts.

Microscopic description. —- The holocrystalline rock shows porphyritic texture. Phenocrysts are anhedral to subhedral microcline-perthite, twinned crystals of Na and K feldspar, and euhedral pale green to colorless crystals of pyroxene showing reaction rims of actinolite.

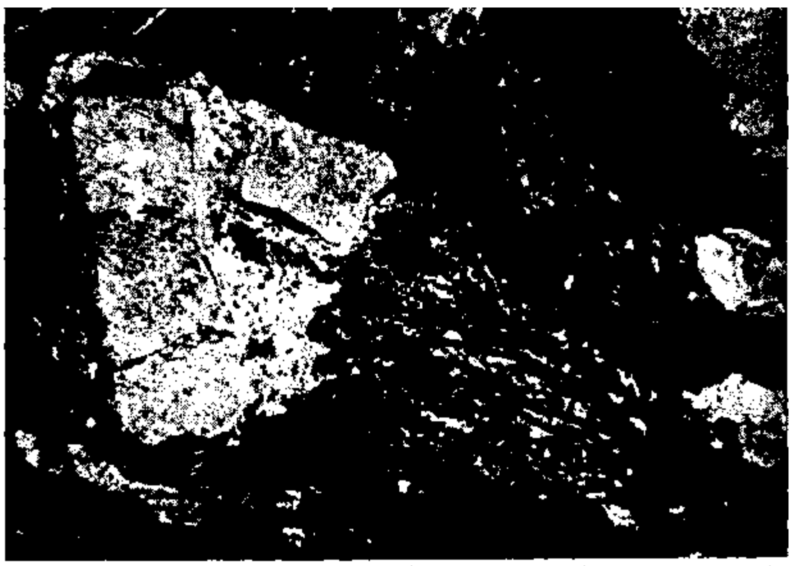

Fig. 7 - Phenocrysts of albite and aggregates of muscovite with abundant sphene and accessory quartz (without analyzer, × 17.5)

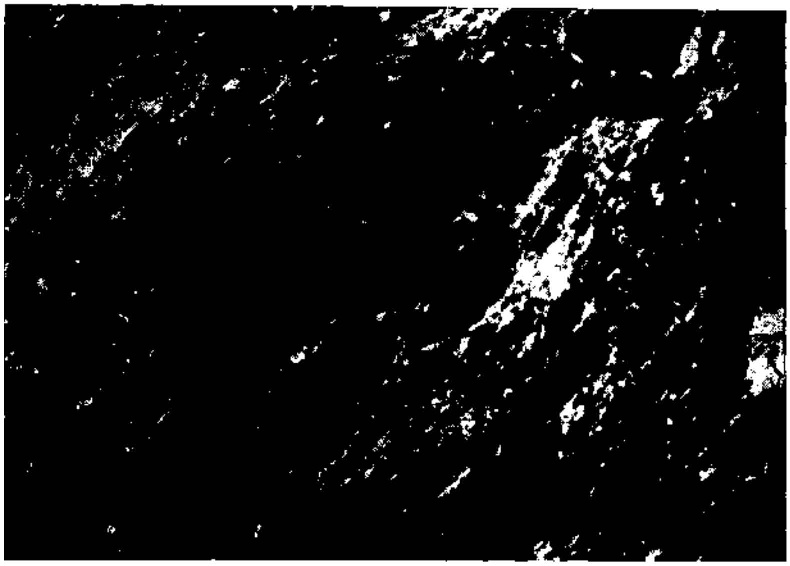

Fig. 8 - Brown stilpnomelane, perthite, sphene and mica in a sericitized matrix (with cross nicols, × 17.5).

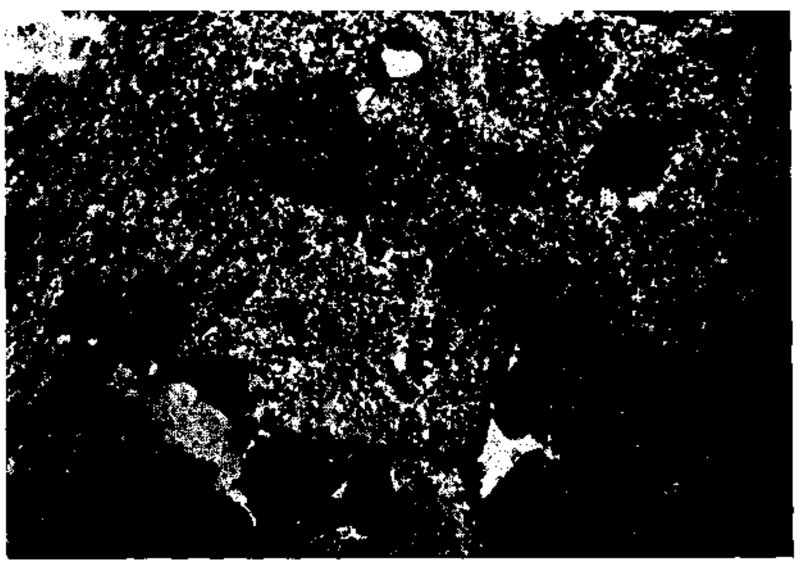

Fig. 9 - Glaucophane needles protruding into the groundmass from the borders of pyroxenes (without analyzer, × 17.5).

Feldspars are partly to completely sericitized, and pyroxenes commonly show uralite (actinolite) on borders and shear zones. Glaucophane needles grow locally along the borders of pyroxene crystals (Fig. 9), and appear as fibrous aggregates in the groundmass, together with both green and brown varieties of fibrous stilpnomelane. Sphene is common and magnetite, apatite and zircon are minor accessories. Zircon occurs as inclusion in clinopyroxene.

The sericitized groundmass is very fine-grained and composed of feldspar microlites.

From the microclinic part of a feldspar phenocryst, the following indices of refraction were obtained: X— 1.519, Y— 1.524; this corresponds to the indices of refraction of microcline-perthite, as listed by V. d. Plas (1966, p. 78).

Volumetric analysis of the thin section gives: groundmass 68 %, feldspar *12%,* pyroxene *12%,* stilpnomelane 3 %, sphene 2 %, glaucophane 2 %, muscovite 0.6 % (Fig. 10).

Ore microscopy. — Same as in 3379.

Thin section number 1200 of rock number 3569

Macroscopic description. — This rock is very similar to specimen 3568. Tabular phenocrysts of feldspar 20 X10 mm appear in a dense bluish groundmass which constitutes about 80 % of the rock. Density of the r9ck is 2.74.

Microscopic description. — The porphyritic, flow-textured rock is holocrystalline. Coarse feldspar phenocrysts are mostly microcline-perthite with some twinned albite. Most feldspars have been altered to sericite. Pyroxenes occur as euhedral to subhedral phenocrysts with reaction rims. Locally, they are uralitized (actinolite) and replaced, along the borders, by glaucophane needles which protrude into the groundmass. Stilpnomelane, green and yellow varieties, occur as fibrous crystals. Sphene is abundant and apatite and opaque minerals are present. The

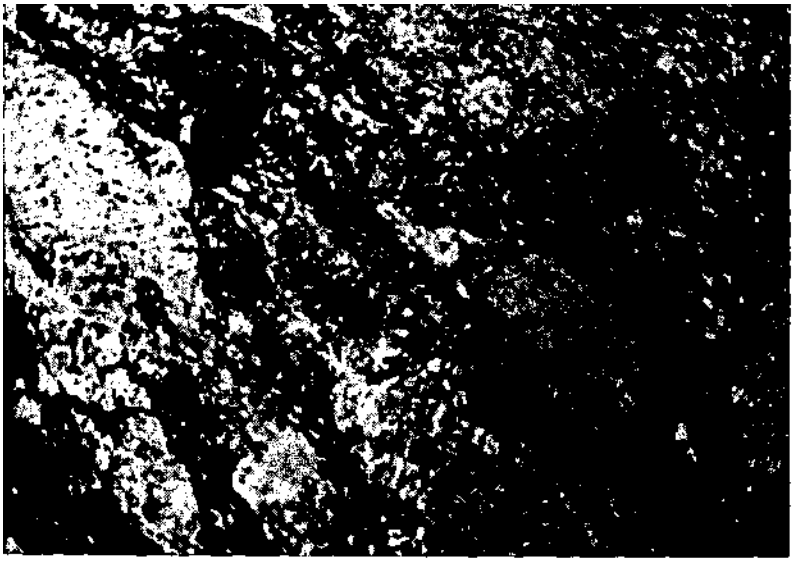

Fig. 10a - Phenocrysts of albite, pyroxene and sphene in a sericitized matrix. Very small anhedral grains are actinolite, glaucophane and stilpnomelane (without analyzer, × 17.5).

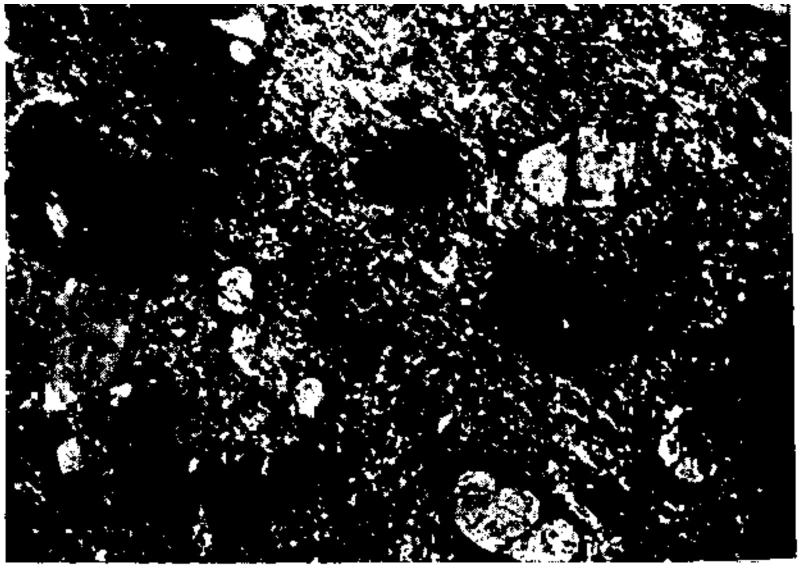

Fig. 10b - Phenocrysts of albite, pyroxene and sphene in a sericitized matrix. Very small anhedral grains are actinolite, glaucophane and stilpnomelane (with cross nicols, × 17.5).

groundmass is very fine-grained and sericitized, containing fibrous, greenish ferro-stilpnomelane microlites of feldspar and tiny needles of glaucophane.

Ore microscopy. — Opaque minerals are pyrite and magnetite with minute inclusions of hematite.

DESCRIPTION OF MINERALS

Feldspar. — In the examined specimens, feldspar has been found as a main constituent in different generations: (1) as phenocrysts, (2) as porphyroblasts and (3) as microlites in the groundmass. Phenocrysts and porphyroblasts may occur in the same rock specimen.

In all the feldspars, the indices of refraction are smaller than that of Canada balsam.

The composition and twinning laws of feldspars were obtained by making use of a Leitz research microscope (Polar Lux G.m.b.H.), and a Leitz Universal stage with 1.516 indexed segments. The observed values of 2V angles, the positions of the indicatrices and cleavage planes on the stereograms of Troger (1959), after v.d. Kaaden, revealed that the feldspars are albite, microcline and microcline-perthite. The sodium plagioclase of the perthite is almost pure albite, has low temperature optics, and is twinned according to the albite law; no other laws were here observed. Microclines have been formed mostly as untwinned crystals. , The albite phenocrysts and porphyroblasts are twinned mostly according to the albite law, but in some crystals Carlsbad and albite - Carlsbad laws are observed which indicate that these crystals are almost certain of igneous origin, v. d. Plas (1966, p. 153) states: «The presence of Carlsbad twins, ... points to an igneous origin. It must be kept in mind that the twinning pattern present in igneous rocks does not change much after metamorphism Under greenschist facies conditions.»

List of the measuremepts on albite

Thin sec. no.	Ind. no.	X		Y			Z		010		001		2Vz
		N	H	K	N	H	N	H	N	H	N	H	
1119	1	333.5	47.5	320	146	43	242.5	7	227.5	10.5	124	15.5	90
	2	335	44	340	108.5	32.5	215	26					80
1119*	3			315	22	24	113	2	311	4.5	39.5	9.5	
	4			40	59.5	20	329.5	10					
	5			317.5	25.5	25	116	2					
	6			32	64.5	36	324	14	311	3.5			
1120	7	110	31	11.5	204.5	10							86
	8	110	31	357	219.5	26.5	337.5	33					65
On albite of perthite													
1119**	9			33.5	76	20	340	15.5					82
	10			312.5	38	22.5	308	0					86
	11			310.5	143.5	0	52.5	0					81
	12			49	179.5	3.5	88	4					82
1121	13			49	127	4	34.5	1.5					74
	14			319.5	94	12	183.5	6					87
1199	15			327.5	140	3	231	16					83
	16			320	172.5	4	263	6					88

* Rittman's zone method (v.d. Kaaden, 1951, p. 48) was applied to individuals, 3, 4, 5, 6 of thin section 1119. Maximum extinction angle of 16° was measured and albite, Carlsbad and albite - Carlsbad laws were proved.

** Rittman's zone method was applied to the individuals 9 and 10 of a perthite of thin section 1119. Maximum extinction angle of 18° was measured and Albite law was proved.

Pyroxene. — This mineral is one of the remnant minerals of the original rock. It was only found in two specimens which contain glaucophane (numbers 3568 and 3569). The crystals are euhedral clino-pyroxenes.

The mineral is almost colorless to very pale green, shows very faint pleochroism, and is biaxial positive with a large axial angle. The maximum extinction angle Z/\c is 45°, indicating augite. Reaction rims along the borders of the crystals and uralitization, especially on shear zones, are very common. Twinning after (100) is frequently observed.

Metamorphic minerals

Stilpnomelane. — The strongly pleochroic ferri- and ferro - stilpnomelanes are disseminated throughout the rocks in considerable amount. They occur as newly formed metamorphic minerals, in fibrous forms, and often concentrated in porphyroblastic aggregates of numerous individuals.

The ferro-stilpnomelane occurs only in the rocks containing glaucophane and augite; they are, here, associated with ferri - Stilpnomelane.

The ferri - stilpnomelane shows, X- golden yellow, Y- dark brown Z- dark brown and ferro - stilpnomelane, K- pale yellow, Y- dark green, Z- dark green.

The interference figure for both varieties is almost uniaxial negative, the birefringence is high and gives approximately second order colors.

The mineral could be distinguished from biotite by its much less distinct cleavege, parallel to (001), and poorly developed fractures perpendicular to the (001) cleavages, and its somewhat different pleochroism.

Indices of refraction of the crushed material of stilpnomelane from speci-
1.686
men 3379, are measured: Y - Z 1.687, this corresponds to ferri - stilpnomelane.
1.690

(It was not possible to measure the indices of refraction for X, Y, or Z more accurately, because of the dark color and clayish properties of the crushed material.)

Glaucophane. — Glaucophane occurs only in two rock specimens (numbers 3568 and 3569), containing remnant augites. It is bluish, X-colorless, Y-yellowish blue and Z-blue, and has moderate birefringence and positive elongation. Maximum extinction angle for $Z \wedge c$ is about 6°.

Glaucophane needles protrude from the margins of pyroxenes into the groundmass and it also occurs as fibrous aggregates in the groundmass.

Sphene. — Sphene occurs in moderate amount in all the rocks, and is especially concentrated along fractures of muscovites, feldspars, and stilpnomelanes. The feldspars, containing sphene are always strongly sericitized.

Probably, it has come into existence partly by decomposition of Ti-rich biotite, as especially white micas are full of sphenes.

In some specimens almost all the stilpnomelanes are bordered by sphenes.

Some of the sphenes are coated by leucoxenic products. Sphene shows sometimes the typical wedge-shaped form, a very high relief, and strong birefringence, and is slightly pleochroic.

Accessory minerals

Apatite. — Prismatic and six-sided basal sections of tiny apatite are frequently observed in the rock specimens. The existence of a slightly pleochroic variety of apatite in specimen 3569 is remarkable.

Apatite shows parallel extinction, a very weak birefringence and a moderate relief. Elongation is negative.

Zircon. — This mineral has been sporadically observed in few of the specimens. It is colorless and shows very high relief and strong birefringence.

Opaque minerals

Red-colored, semi-opaque, limonite and magnetite with inclusions of hematite and pyrite are observed.

Secondary minerals *Whitemica.* — Slightly pleochroic (from - pale green to colorless) white micas associating frequently with sphene are considered as pseudomorphoses after Ti - rich biotite.

The effect of metamorphic stress is shown by the distortion of the micas in the form of curved outlines. These curved outlines are accentuated by tiny crystals of sphene.

Sericite. — Sericites are alteration product of feldspars. They are distorted showing curved outlines. They occur on the borders and fractures of feldspars, sometimes complete feldspar phenocrysts are converted to an aggregate of sericite.

Sericite shows parallel extinction, positive elongation and moderate birefringence and scaly habit.

Quartz. — Sporadic occurrence of quartz, especially as veins along cracks of feldspars, and sometimes in the groundmass has been observed. It is of secondary origin. It shows undulatory extinction, almost uniaxial positive interference figure and low positive relief and weak birefringence.

CONCLUSIONS

The observations revealed metamorphic effects on volcanic rocks which is proved by the presence of stilpnomelane, glaucophane and porphyroblastic albite. The once homogenous feldspar porphyrites have now a microcline-perthitic composition. The habit of the crystals suggests that sanidine was present in the rock before metamorphisin. As a result of metamorphism, sanidine became unstable and unmixed in two stable components, microcline and albite, retaining the original shape of the sanidine.

The igneous volcanic character is evident by the texture of the rock by the composition and shape of the feldspar porphyrites remnant augites that survived metamorphism. It was probably a saturated to slightly under-saturated rock, and may be called metatrachyte. For the following reasons the rock is called metamorphosed :

1. Presence of microcline-perthite, which is pseudomorphic after sanidine.
2. Presence of ferri- and ferro-stilpnomelane.
3. Presence of glaucophane.
4. Albitization.
5. Slightly schistose texture.

The mineral assemblage of the rocks is summarized as follows :

Remnant minerals. — Augite, in process of glaucophanization and uralitization, certain albites and microeline-perthites, pseudomorphic after sanidine, zircon, apatite and opaque minerals.

Metamorphic minerals. — Glaucophane, stilpnomelane, sphene, albite, microcline, colorless mica pseudomorphic after Ti-rich biotite.

All the above observations are consistent with a rock in the glaucophanitic-greenschist facies as defined by Winkler (1965, p. 65). The presence of stilpnomelane and of glaucophane indicates that the rocks were subjected to burial metamorphism at relatively low temperatures. Stilpnomelane is known to occur in the quartz-albite muscovite-chlorite subfacies of the greenschist facies of the Barrowian-type of facies series, and is also recorded in the glaucophane-lawsonite and glaucophanitic greenschist-facies. These facies are characterized by high load pressure and relatively low temperature.

Uralite is usually considered to be associated with autohydratation (deuteric alteration), of pyroxenes. In this process pyroxenes are converted into green fibrous hornblende due to reaction with residual post-magmatic (deuteric) solutions. However, the uralitization phenomena of pyroxenes of the rocks of Sızma, might be attributed to the early stage of later metamorphism (G.W.Tyrell, p. 311) rather than autohydratation, because of the fact that they have been subjected to metamorphism. Wahlstrom also states that (p. 328), «Deuteric stage or low-temperature hydrothermal-stage minerals in igneous rocks resemble, in certain respects, minerals in metamorphic rocks formed at relatively low temperatures...»

In the area of Konya, several other glaucophane rocks became known, as is summarized by v. d. Kaaden (1966), (Fig. 1). The described occurrence is part of a larger area subjected to the same grade of metamorphism.

The age of the metamorphism could not be established. According to v. d. Kaaden it might be of Paleozoic age, but proof is lacking.

ACKNOWLEDGMENTS

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