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POSSIBLE PAN-AFRICAN METAVOLCANICS IN THE ÖDEMİŞ, SUBMASSIF OF THE MENDERES MASSIF, WESTERN TURKEY

Osman CANDAN* and Nejat KUN*

ABSTRACT. - Menderes massif located in the Western Anatolia, in Turkey, is made up of the old crystalline rocks. The last main metamorphism of this massif has been completed during Upper Paleocene - Lower Eocene. The general sequence of the study area which is situated in the Ödemiş submassif of the Menderes massif consists of, in ascending order, basal gneiss complex, blue augen gneiss, leptite (metavolcanic), schist and marble. This metamorphic sequence was cut by the post-metamorphic acidic and basic plutons and covered by the young volcanics. Leptites occuring between gneiss and schist units are the metamorphic equivalents of the dacitic and rhyolitic volcanics. These island arc volcanics have a calc-alkaline kindred. According to the age, geological position and chemical characteristics, these metavolcanics of the Ödemiş submassif may be correlated with the island arc volcanic bell widely exposed in the NE Africa and Arabian Peninsula, in relation to the late phases of the Pan-African orogenesis.

INTRODUCTION

Menderes massif consists of the old crystalline rocks which are exposed widely in Western Anatolia, in Turkey. The previous studies began with Phillippson (1911) and continued later by various investigators until today. The presence of some different rock types from the others such as gneiss, schist and phyllite in the Menderes massif was first noted by Schuiling (1962). It was determined by Kun (1983) that these rocks exposed in the Çine submassif of the Menderes massif were clearly originated from the old volcanic rocks and they were called as leptite by the same auther based on the similar chemical properties, with those of in Sweden.

In recent years, the relation between the volcanics of the Pan-African orogenesis exposed in NE Africa and Arabian Peninsula and the metavolcanics which show widespread distribution in the Menderes massif has been the subject of investigation by many investigators. In this paper, an attempt is made to solve the problem of the origin and geotectonic position of the leptites in the Ödemiş submassif of the Menderes massif in Turkey.

LITHOSTRATIGRAPHY

The study area is located in the Ödemiş submassif of the Menderes massif, in Western Anatolia in Turkey (Fig. 1 A-B). The generalized columnar section of this area can be given as follows: The lowest level of the rock succession consist of a basal gneiss complex made up of migmatite, augen, granitic and banded gneisses (Fig. 2). In these rocks which contain almandine-rich garnet, the feldspar porphyroblasts amount up to 7-8 cm in length. Through the microscobic studies, the general mineral assamblage of the gneisses which show widely cataclastic texture, was found as "Quartz-plagioclasc (oligoclase)-K. feldspar (orthoclase and microcline)-biotite-muscovite-garnet-tourmaline-zircon and apatite".

The blue augen gneisses which have been firstly pbserved in the Menderes massif, are found near the contacts of the leptites and basal gneisses as interlayers and lenses in both unit with different lengths. This kind of gneisses typified by the very large blue-violet K-feldspar porphyroblasts, show great similarity to the basal gneiss complex occuring at the bottom of the sequence in terms of mineralogical composition. But, by contrast with basal gneisses, sillimanite is accompanied to garnet in these rocks. The bluc-augen gneisses containing abundant relicts of leptite are appearently related to the volcanic origin.

The leptite which lies conformably on the gneisses, vary in thickness from 20-25 m to several kilometers. Some key minerals, such as sillimanite and kyanite, are found in these metavolcanics. The leptites are overlain by the schists with an

* Dokuz Eylül Üniversitesi, Jeoloji Mühendisliği Bölümü, İzmir-Turkey.

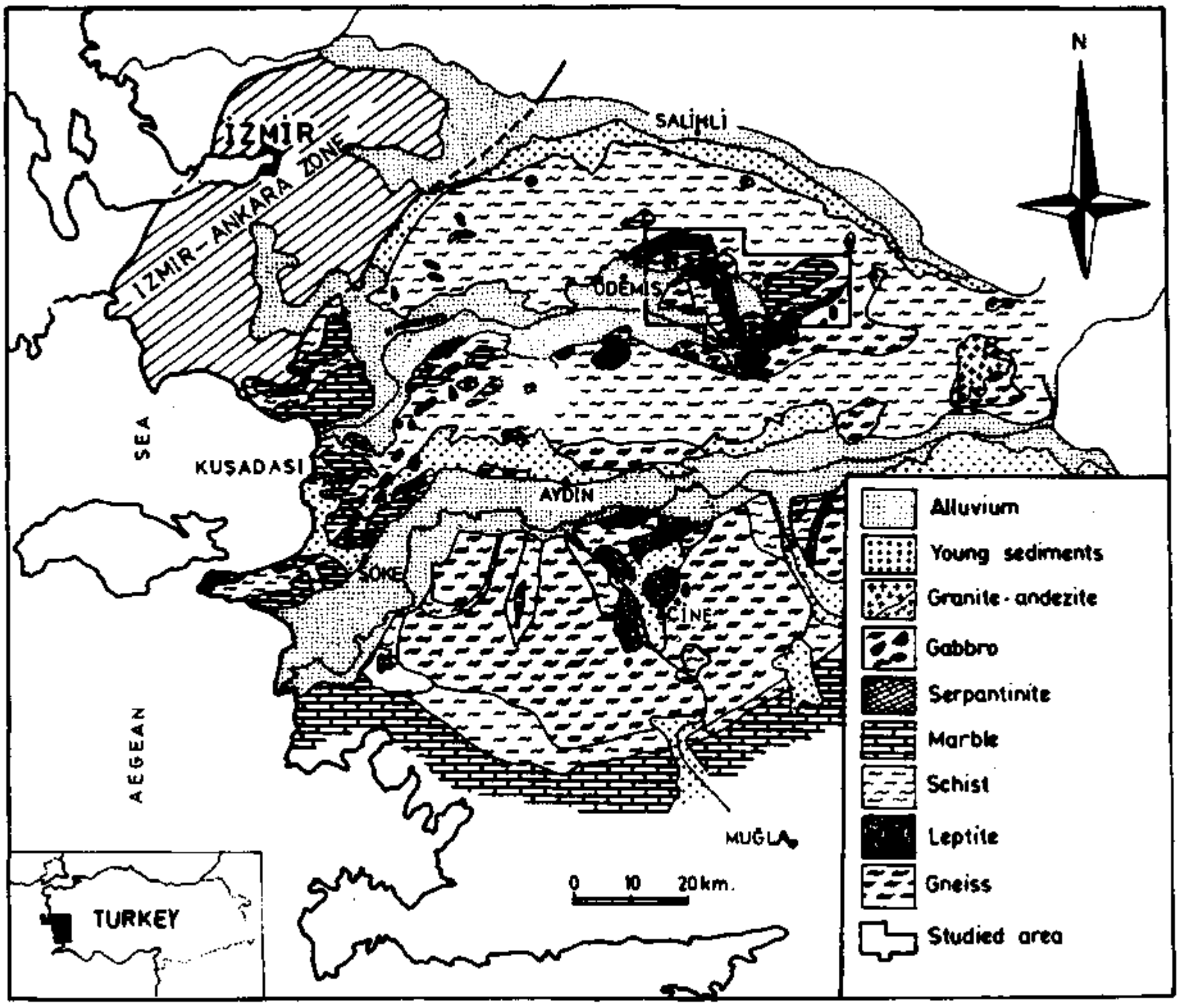

Fig. 1 A - Location map of the study area.

appearently conformable contact. The schist series starts with the kyanite-staurolite-gamet schist at the base and passes to the garnet-mica schists towards the upper level.

Phyllite, marble and muscovite-quartz schists occure as interlayers and lenses in this schist sequence with highly variable thicknesses. Coarse-grained kyanite-staurolite-gamet schists contain widely distributed kyanite-pegmatoid lenses which are parallel to the schistosity. This schist unit consist of Quartz-plagioclasc-kyanite-staurolite-garnet-biotite-muscovite-chlorite-rutil-apatite and zircon". Also, garnet-mica schists are mainly composed of "Quartz-plagioclase-biotite-muscovite-chlorite-gamet-apatite-tourmaline and zircon". The phyllites which are observed as interlayers and lenses show a number of different mineral paragenesis as follows:

Quartz-muscovite-garnet-chloritoid;

Quartz-muscovite-garnet-chloritoid-slaurolite;

Quartz-muscovite-gamet-staurolite;

Quartz-muscovite-garnet-staurolite-kyanite.

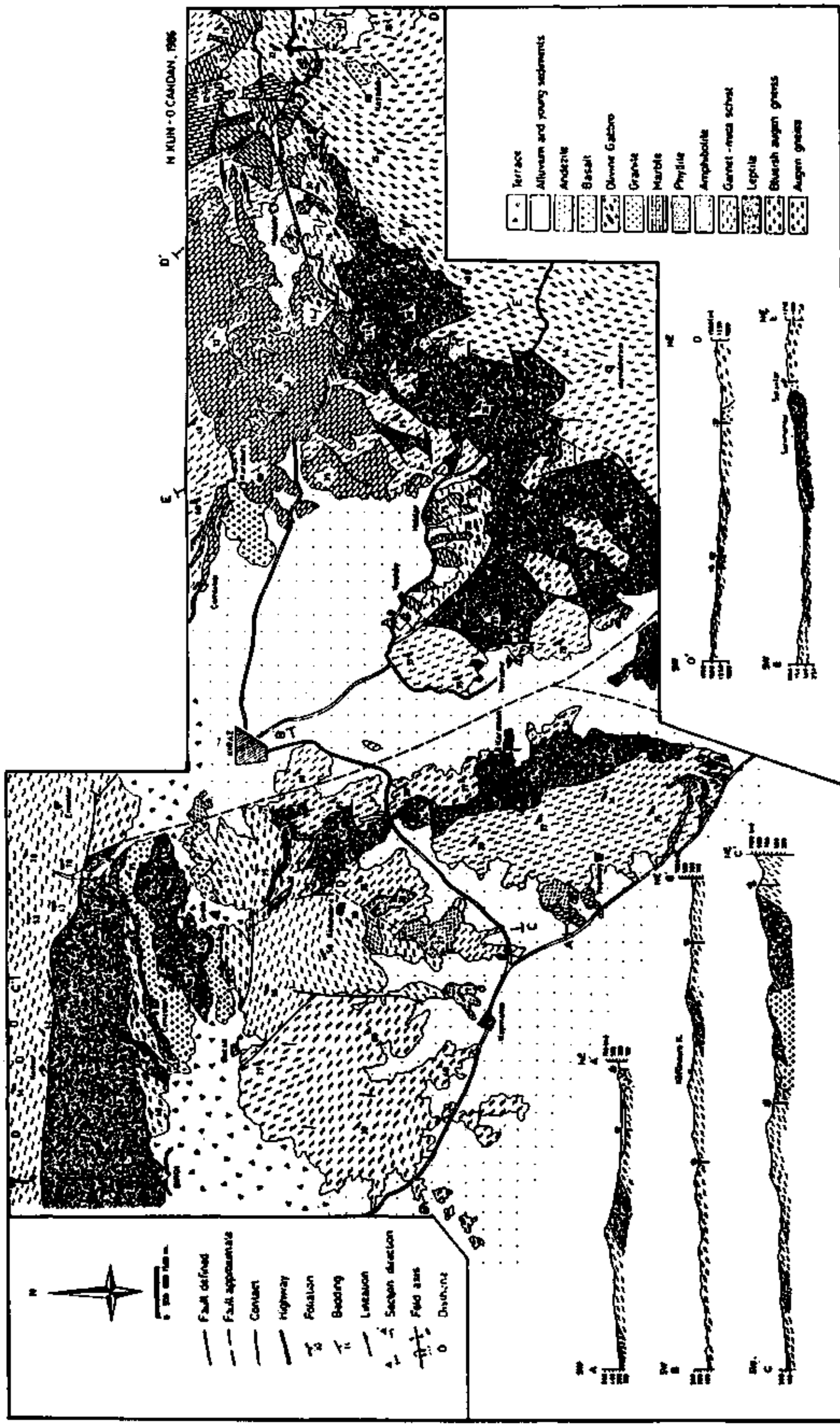

Fig. 1 B - Geological map of the study area.

The marble interlayers become dominant at the upper level of the metamorphic sequence and these rocks form thick calcerous series at the NE part of the study area.

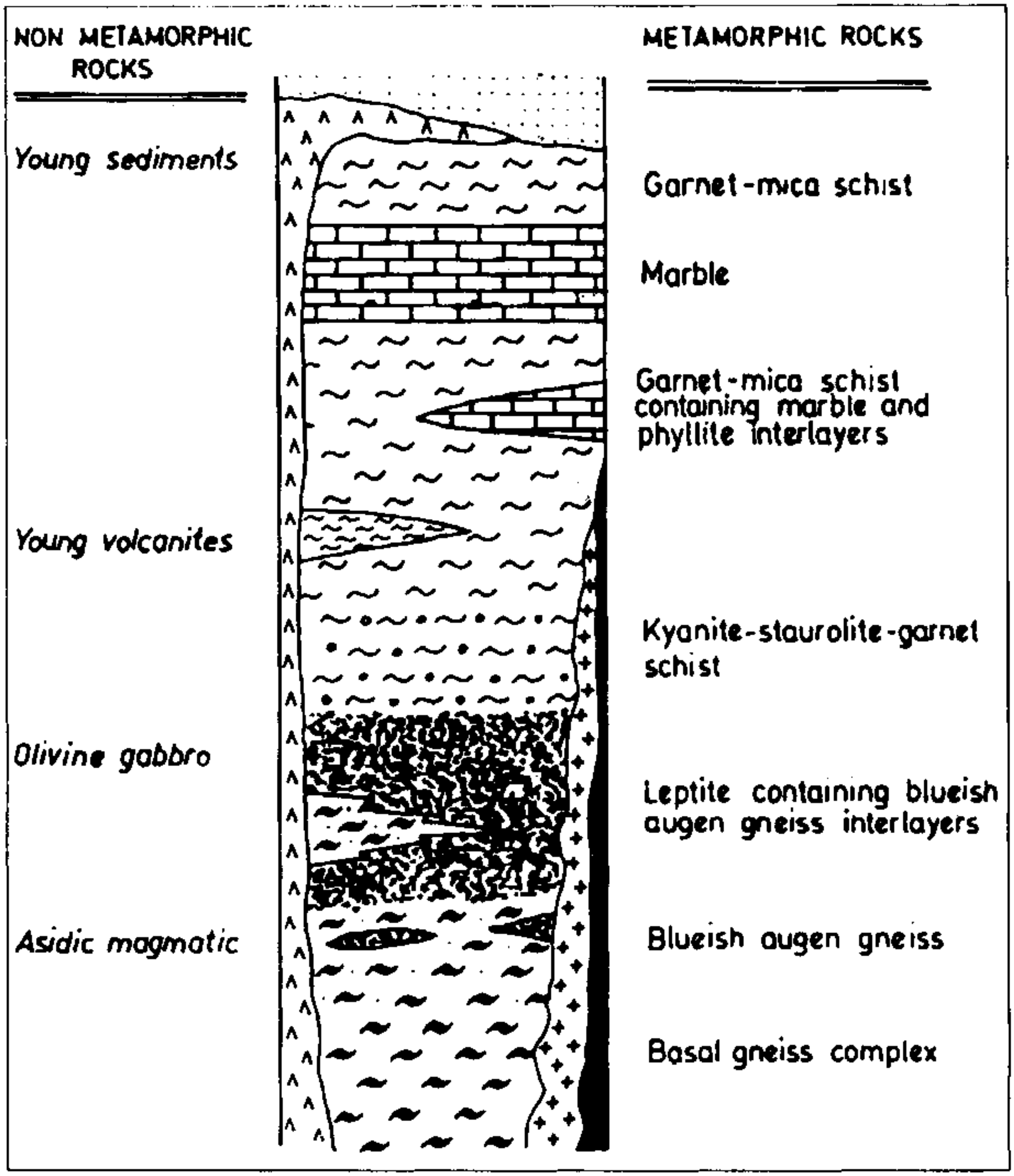

Fig. 2 - Generalized columnar section of the Ödemiş submassif.

All these metamorphic units were cut by the unmetamorphosed acidic and basic plutons and covered by the Neogene aged volcanic rocks. The acidic magmatitcs which arc of granitic and granodioritic composition, are exposed in gneisses and leplitcs as slocks with different sizes. The general mineral composition of these rocks were determined as

"Quartz+plagioclase+orthoclase+biotite+muscovite+apatite+zircon±sillimanite and ±gamet". The basic plutons, olivine gabbros, were observed as stocks with different sizes in the blue-augen gneisses, at the vicinity of Birgi town. The mineral composition of these unmetamorphosed basic plutons consists of "Plagioclase + orthopyroxene + clinopyroxene +olivine + biotite+apatite + zoisite + zircon and +garnet". The extrusive rocks which are the volcanic equivalents of these basic and acidic plutons are observed at two different parts of the area. According to their mineralogical and chemical composition, these volcanic rocks arc of andesite and basalt in composition. All the rock units exposed at the investigated area are unconformably covered by the Neogene aged unmetamorphosed sedimentary rocks.

PETROGRAPHY OF THE LEPTITES

Leptites show a widespread distribution in the Ödemiş submassif, the middle part of the Menderes massif. These rocks which occur between the basal gneiss and schist vary in thickness from 20-25 m to several kilometers. Purple, grayish and gray coloured leptites are hard, massive and generally badly schistozed rocks. These metavolcanites are often cut by the pegmatitic veins, ranging from mm to m in thickness. These pegmatitic veins arc composed of feldspar, quartz, muscovite and tourmaline. In the field, one of the characteristic features of the leptites is the presence of the old sills and dykes which exhibit hornfelsic texture and rich-in pyroxene and anorlhite (Kun and Candan, 1987). These gabbroic vein rocks were simullanously metamorphosed with the leptites.

The locally preserved old porphyritic texture can be observed in the leptilcs. This evidence clearly suggests that the origin of these rocks called as leptites in this paper, is volcanic. In these porphyric rocks which show a foliated andesitic appcarence, the old phenocrystals were oriented by the metamorphism (Fig. 3). These phcnocrystal relicts were filled by some light coloured minerals such as quartz, muscovite, feldspar, sillimanite, and gamet.

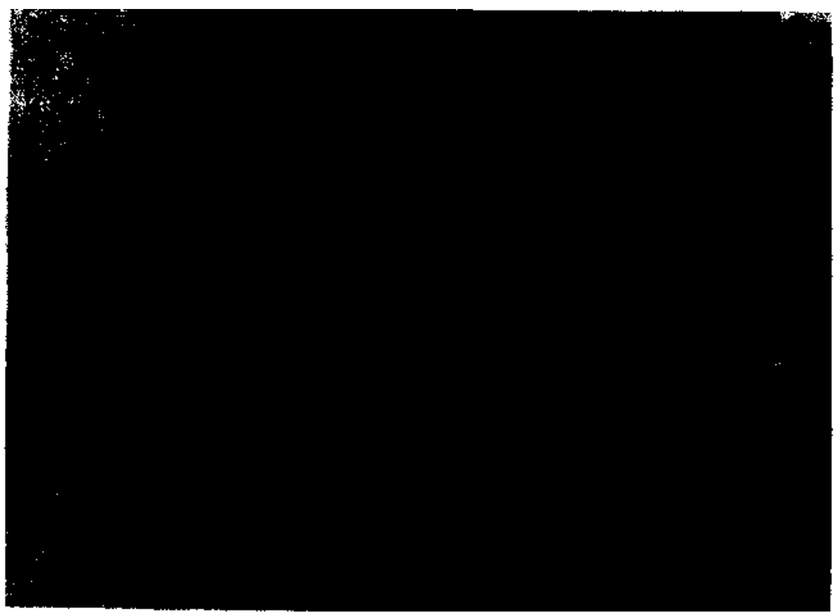

Fig. 3 - Photograph of the relict porphyritic texture of the primary volcanics observed in leptites.

The field observations show that leptiles occur as a gide horizon between the basal gneiss complex which were derived from graywackeys, and schists in the Menderes massifs But, because of the presence of the blue-augen gneisses most probably of volcanic origin like leptites the contact mapped between the basal gneiss complex and leptite, docs not correspond to the primary graywackey/volcanic rock boundary (Fig. 4).

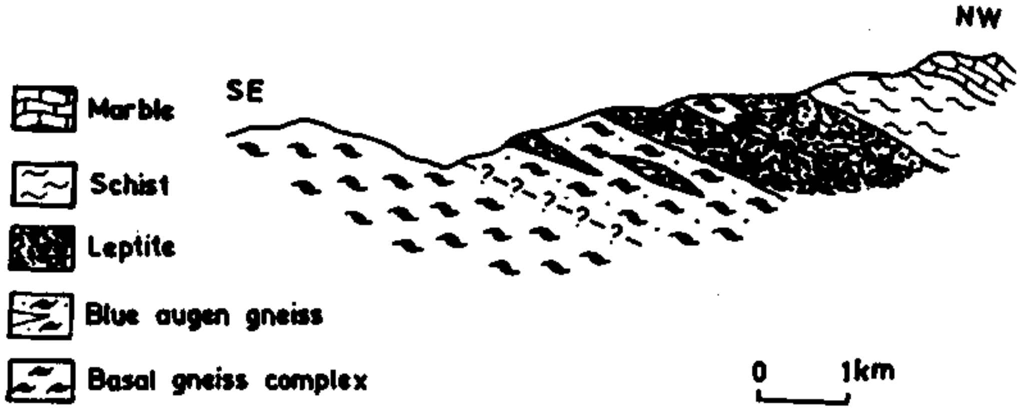

Fig. 4 - Cross-section showing the contact relation between blue augen gneiss and leptite.

From the petrographic studies, it has been observed that the leptites exhibit a typical fine-grained, nondirectional granoblastic and hornfelsic texture (Fig. 5). But some samples, especially those which are rich-in biotite, may show a poorly developed schistosity. The general mineral compositions of the leptites consist of "Quartz-plagioclase-orthoclase-garnet-biotite-muscovite-epidote-sillimanite-kyanite-tourmaline-zircon and apatite". The leptites can be divided into three major groups according to their macro and micro features: 1 - Garnet-biotite leptites; 2 - Sillimanite-kyanite leptites; 3 - Spotted-. leptites.

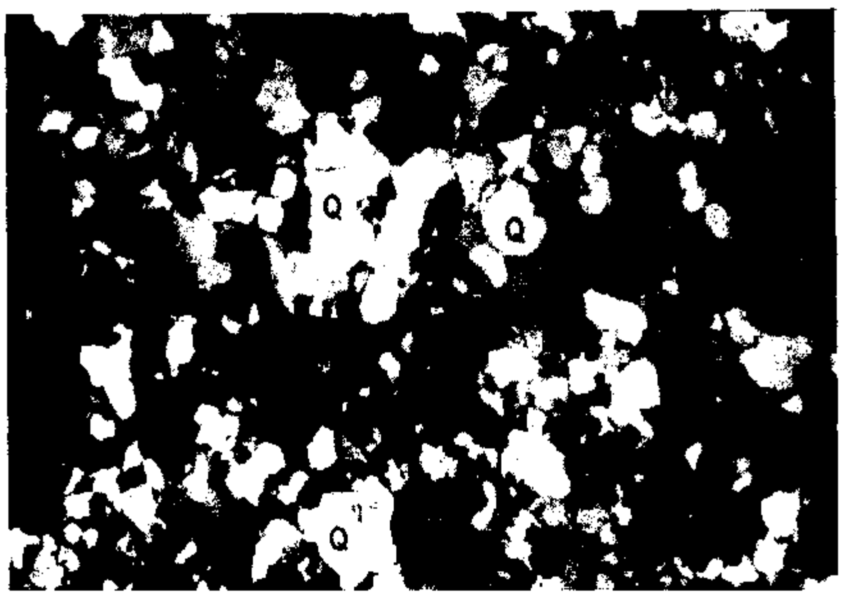

Fig. 5 - Photomicrograph showing the typical fine-grained, nondirectional hornfelsic texture in leptites. 2.5 X, crossed nicols. Q: Quartz, Plj: Plagioclase.

1 - Garnet-biotite leptites

The great majority of the leptites exposed in the study area belongs to this group. While the percentage of garnet reaches up to 35 % and biotite up to 40 %, muscovite is always present in the amounts of less than 5 % in these rocks. Garnet-biotite leptites which exhibit a poorly developed schistosity consist mainly of quartz, orthoclase, plagioclase, biotite, muscovite, garnet, epidote, zoisite, apatite, tourmaline and zircon.

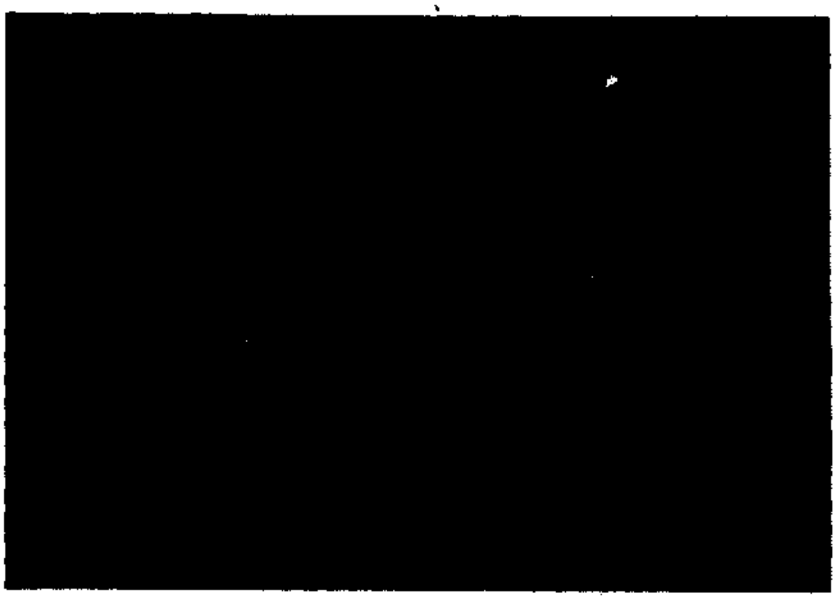

Fig. 6 - Sillimanite fibrolites occuring at the contacts of the feldspars. Sil: Sillimanite, 10 X, plane light.

2 - Sillimanite-kyanite leptites

This type of leptites closely resemble the garnet-biotite leptites. The distribution of the sillimanite-kyanite leptites in the investigated area may be only identified by the microscopic studies. With the increasing percentage of the sillimanite content, these rocks exhibit a harder and rougher appearence. The percentage of the, sillimanite ranges from 1 % to 15 % (Fig. 6). But, the kyanite content of these leptites does not exceed 3 %. The formation of the sillimanites can be divided into two groups by their textural evidences. 1) Sillimanites, which occur as fibrolites at the contacts of the feldspars, and 2) Sillimanilcs, which replace the garnet and biotite crystals (Fig. 7).

Fig. 7 - Sillimanite crystalls occuring by the replacement of the biotites. Sil: Sillimanite; Bio: Biotite; 10 X, plane light.

3 - Spotted leptites

These leptites, which were rarely observed can be easily recognized in the field by their white spots. These appearance are caused by the preserved relict porphiritic textures of the primary volcanic rocks, and are of great importance to clarify the parent rocks of the leptites. These spots were generally filled by the light coloured minerals such as quartz, feldspar and muscovite. In general, an euhedral garnet crystal is situated at the center of these voids and this core is rimmed by the sillimanite and biotite zones (Fig. 8). The general mineral compositions of the spotted leptites show a great similarity to the sillimanite-kyanite leptites and consist of "Quartz-orthoclase-plagioclase-muscovite-biotite-sillimanite-kyanite-gamet-zircon and apatite".

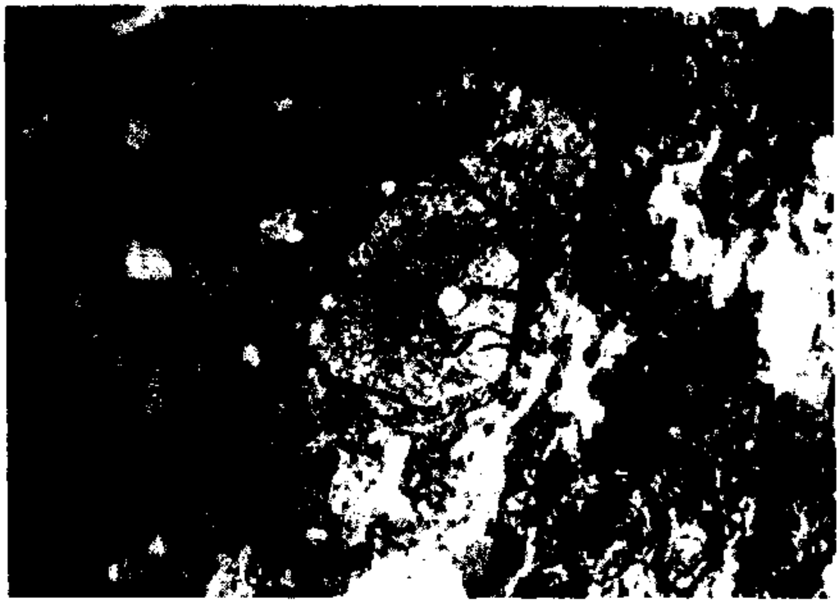

Fig. 8 - Photomicrograph of the white-spots in the leptites. An euhedral garnet crystall is situated at the center of these voids. Sil: Sillimanite; Gr: Garnet; 10 X, plane light.

CHEMISTRY OF THE LEPTITES

In general, the leptites exhibit more or less a homogeneous mineral composition. But, of course, the amount of garnet, biotite and sillimanite in the rocks affect the chemical composition of the leptites. The average contents of SiO2, Al2O3, FeO, CaO, MgO, Na2 and K_2O in the leptites can be given as 61-74 %, 11-18 %, 4-6 %, 0.7-2.6 %, 1-3 %, 1.64.3 % and 2-4.5 % respectively. TiO2 is always present in amounts of less than 1 % (Table 1). A comparision of the Sweden (Löfgren, 1979) leptites with those of the study area in terms of SiO2 contents is given in Table 2. The leptites from Sweden are divided into 6 different groups. But, the leptites in Ödemiş submassif of the Menderes massif show only 3 groups and don't contain the extreme acidic and basic groups.

The chemical analysis were plotted on several diagrams to find out the properties of the original volcanics of the leptites. In order to eliminate the influences of possible element migrations during the high grade metamorphism, in addition to the major oxides, the diagrams based on the trace elements were also used.

In the Na2O+K2O/SiO2 diagram proposed by Zanettin-(1984), the leptites are concentrated in rhyolite, dacite and andesite areas (Fig. 9). In Kistler and Evernden (1971), Winchester and Floyd (1977) diagrams based on the Rb vs Sr and SiO_2 % versus Zr/TiO2 respectively, all the examined metavolcanics plot in the fields of andesite, rhyodacite and rhyolite (Fig. 10 and11).

Table 1 - Comparation of the Sweden and Ödemiş submassif leptites in terms of SiO_2 contents

	Group 1 *% SiO_2* *50-55*	*Group 2* *% SiO_2* *55-60*	*Group 3* *% SiO_2* *60-65*	*Group 4* *% SiO_2* *65-70*	*Group 5* *% SiO_2* *70-75*	*Group 6* *% SiO_2* *75-80*
Leptites of Sweden						
SiO_2	53.66	57.45	62.82	67.20	72.64	77.28
Al_2O_3	18.74	16.49	15.92	14.67	13.06	12.00
TiO_2	.93	1.06	.59	.52	.26	16
Fe_{tot}	8.89	8.33	5.08	4.34	2.60	1.35
MgO	4.18	3.54	2.58	1.81	1.14	80
CaO	5.70	5.06	3.27	2.10	1.36	70
Na_2O	2.86	2.58	2.58	2.46	2.42	3.93
K_2O	3.36	2.93	3.96	4.94	4.90	2.97
Leptites of the Ödemiş submassif						
SiO_2			63.38	65.70	71.68	
Al_2O_3			15.27	15.01	13.09	
TiO_2			.88	.80	.73	
Fe_{tot}			5.40	4.77	3.92	
MgO			2.58	1.98	1.67	
CaO			1.55	1.54	1.33	
Na_2O			3.19	3.02	3.24	
K_2O			3.34	3.11	2.62	

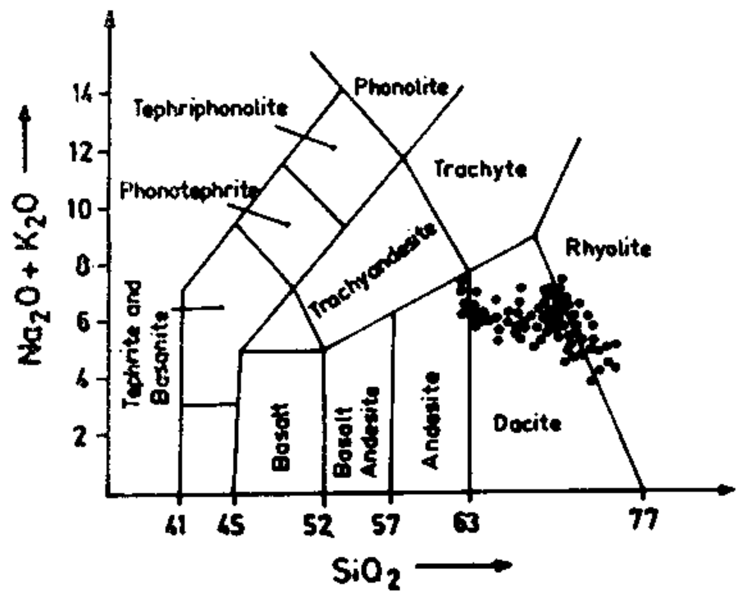

Fig. 9 - $Na_2O + K_2O$ versus SiO_2 diagram after Zanettin (1984).

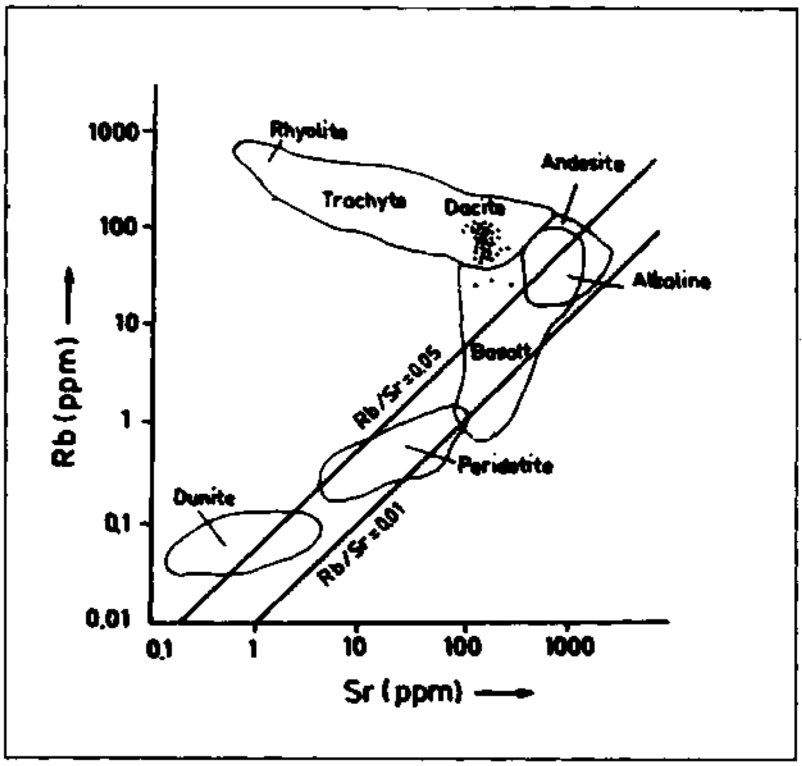

Fig. 10 - Rb (ppm) - Sr (ppm) variation diagram after Kistler and Evernden (1971).

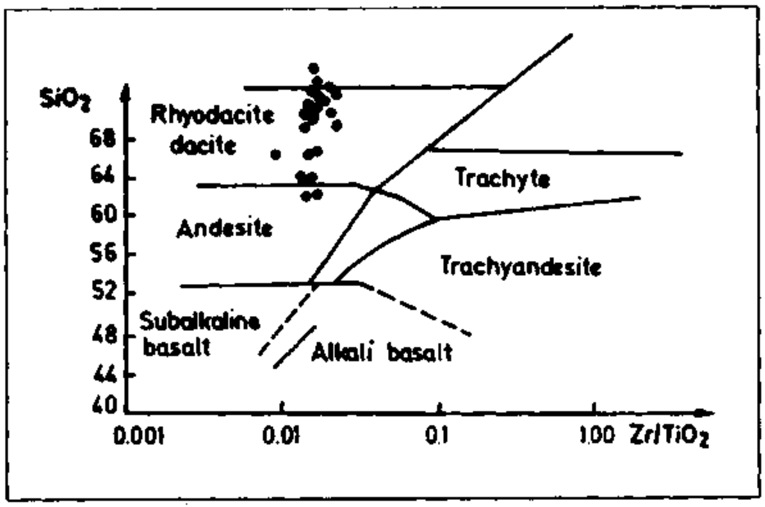

Fig. 11 - SiO_2 (Wt %) vs Zr (ppm) / TiO_2 (Wt %) diagram after Winchester and Floyd (1977).

In order to determine the kindred of the primary volcanics, several diagrams based on major oxides are used. In the Rittmann (1962) diagram, all the leptites are accumulated in the field of calc-alkaline series (Fig. 12). In another diagram using the same oxides, the great majority of the rocks are concentrated in the calc-alkalinc series but only a few samples extended into the tholeiitic area (Fig. 13). In the Miyashiro (1975) diagram, where FeO*/MgO versus SiO_2 is plotted the samples fall again in the calc-alkaline field (Fig. 14).

Table 2- Chemical analyses of the metavolcanics (leptites) in Ödemiş submassif of the Menderes Masif

	O-305	Ş-206/A	Ş-51	Ş-178	O-202/A	O-1/B	O-226	O-316/A	O-292	O-301/C
SiO_2	69.85	71.28	69.24	65.69	70.10	64.01	72.08	71.69	71.57	68.60
Al_2O_3	14.23	13.36	14.60	16.26	13.74	16.88	13.16	13.96	14.14	15.00
TiO_2	.69	.65	.65	.76	.81	.78	.63	.60	.54	.68
Fe_2O_3	1.59	2.02	1.87	4.52	2.25	3.37	.99	3.90	1.54	2.79
FeO	2.78	1.96	2.54	1.52	2.17	2.54	2.70	.00	1.90	1.96
MnO	05	.06	.07	.07	.05	.08	.06	.04	.06	.05
MgO	1.86	1.43	1.78	2.61	1.58	2.54	1.46	1.36	1.35	1.91
CaO	1.09	1.44	1.57	.70	.95	.97	1.16	.76	.98	.83
Na_2O	2.32	2.79	3.63	1.69	2.74	2.33	3.35	2.40	4.07	3.02
K_2O	3.18	3.36	3.08	4.07	3.08	3.84	2.31	2.60	2.20	3.11
P_2O_5	14	18	18	.16	.17	.20	.12	.12	.18	.17
H_2O	1.36	1.36	93	.95	1.37	1.92	.85	2.02	.84	1.53
Total	**99.14**	**99.89**	**100.14**	**99.00**	**99.01**	**99.46**	**98.96**	**99.45**	**99.37**	**99.65**
Zn	73	50	0	128	60	125	51	52	48	70
Ni	61	54	56	40	47	66	45	57	43	49
Cu	3	3	5	24	7	13	6	12	15	14
Cr	120	124	114	133	152	144	125	120	104	125
V	93	86	89	106	100	115	89	82	67	90
Zr	193	238	183	186	337	171	224	206	183	205
Y	23	22	23	24	25	27	21	23	19	21
Sr	192	196	222	131	209	155	258	208	231	201
Rb	118	88	97	133	111	124	78	89	107	102
Hf	8	8	6	8	9	6	10	6	7	8

	A-39	A-18/A	Ş-209/B	G-22	O-203/A	O-268	G-40	480/B
SiO_2	70.37	71.58	69.12	66.90	70.40	69.25	64.82	67.73
Al_2O_3	15.06	13.65	14.64	16.01	13.83	14.14	16.63	14.40
TiO_2	.67	.78	1.01	.72	.84	.70	.84	.70
Fe_2O_3	3.64	5.03	5.16	6.37	4.78	5.30	6.75	5.18
MgO	.96	1.43	1.50	1.76	1.43	1.54	1.91	2.75
CaO	1.87	1.72	2.23	1.04	2.61	2.26	.89	1.64
Na_2O	3.30	3.75	3.53	2.12	4.00	3.59	2.21	4.36
K_2O	4.33	2.33	2.51	3.76	2.17	2.82	4.16	2.33
K.K.	.24	.37	.28	1.19	.22	.38	1.90	.72
Total	**100.44**	**100.64**	**99.98**	**99.87**	**100.28**	**99.98**	**100.11**	**99.96**
Ba	653.3	305.0	921.9	637.0	468.8	510.4	694.9	281.5
Nb	8.9	10.5	15.5	19.2	14.9	11.6	13.6	13.6
Zr	128.0	191.6	122.6	154.9	139.1	125.6	130.4	156.9
Y	19.7	13.7	27.7	14.0	2.5	E	27.2	11.8
Sr	115.5	226.2	480.0	145.7	305.6	260.2	164.3	38.0
Rb	128.8	79.5	64.0	124.3	68.1	96.5	126.2	65.1

	448	431	486	465/A	Ş-24	Ş-22/D	463/A	Ş-101	Ş-44	Ş-65	A-27
SiO_2	71.66	74.23	71.94	70.99	65.87	71.06	63.30	71.33	72.67	69.02	62.96
Al_2O_3	12.24	11.71	12.91	13.18	16.76	13.93	16.94	14.12	13.28	14.50	16.76
TiO_2	66	.73	.75	.76	.88	.70	.86	.64	.71	.85	.88
Fe_2O_3	4.21	4.36	4.39	4.56	5.08	4.21	5.97	4.03	3.77	4.21	6.50
MgO	2.28	1.65	1.72	1.64	1.86	1.43	2.08	1.43	1.34	1.47	3.03
CaO	.99	.82	1.96	1.21	.70	.84	2.66	1.16	.97	2.27	2.36
Na_2O	3.47	2.76	3.34	2.90	2.54	2.91	4.22	3.57	3.17	4.17	3.20
K_2O	3.19	2.27	2.24	2.60	3.85	2.99	2.43	2.58	2.74	2.27	2.66
K.K.	85	1.22	.54	1.27	1.94	1.64	1.50	1.02	1.12	1.02	1.43
Total	**99.55**	**99.75**	**99.79**	**99.11**	**99.48**	**99.71**	**99.96**	**99.88**	**99.77**	**99.78**	**99.78**
Ba	563.9	423.2	451.6	598.3	618.3	707.6	468.2	694.2	609.6	485.6	1038.2
Nb	10.8	13.6	15.2	5.3	18.9	—	12.9	13.4	11.7	8.8	13.1
Zr	111.8	148.4	141.7	126.5	151.5	—	137.4	149.4	180.8	266.9	181.3
Y	14.1	20.7	6.6	19.4	27.7	—	13.9	21.4	17.1	14.0	12.5
Sr	179.0	191.9	182.0	180.2	181.3	—	279.2	247.7	246.5	34.9	272.6
Rb	81.6	77.4	73.0	79.7	104.1	—	94.5	80.7	81.2	77.2	55.9

	465/C	467	449	432/A	463/D	426	437/B	380	469	363	466/C
SiO_2	73.16	64.82	72.03	71.51	71.50	69.65	63.04	71.29	72.76	66.56	62.11
Al_2O_3	10.68	15.15	12.99	12.96	12.69	12.99	16.19	12.19	11.97	14.27	18.26
TiO_2	.98	.81	.59	.70	.72	.90	1.09	.84	.79	1.15	.85
Fe_2O_3	5.25	5.37	3.94	3.95	4.54	4.47	6.04	4.57	4.94	6.02	6.34
MgO	2.29	3.07	2.11	2.14	2.35	2.32	3.17	2.40	1.41	2.17	2.29
CaO	1.68	2.01	1.71	1.28	1.00	3.16	2.81	1.54	1.34	2.35	.95
Na_2O	2.99	4.31	3.52	4.22	3.11	3.55	3.99	3.50	2.94	3.08	1.66
K_2O	2.18	2.43	2.35	2.16	2.58	2.31	2.46	2.35	2.33	2.77	4.72
K.K.	.59	1.53	.85	.76	1.27	.85	.80	1.05	1.32	1.22	1.79
Total	**99.80**	**99.50**	**100.09**	**99.68**	**99.79**	**100.20**	**99.59**	**99.73**	**99.80**	**99.59**	**98.98**
Ba	655.6	363.6	426.3	413.3	820.0	442.3	639.4	530.7	528.2	604.0	704.1
Nb	12.3	13.6	12.9	14.9	11.6	13.6	—	10.1	12.8	5.8	13.0
Zr	282.1	116.3	117.1	104.9	131.3	161.5	—	190.6	214.1	188.0	120.1
Y	17.0	16.7	12.1	14.8	10.0	21.0	—	114.4	17.9	14.4	27.3
Sr	172.1	143.0	182.3	203.2	183.3	405.7	—	35.1	37.9	257.4	111.6
Rb	57.3	109.1	79.1	78.5	76.5	52.9	—	76.4	75.2	94.9	131.8

	482/B	391	Ş-59	432/B	447	O-316	465/B	Ş-102	Ş-167	467	476
SiO_2	66.61	71.79	67.27	69.50	68.06	65.40	61.62	62.96	66.94	64.15	66.55
Al_2O_3	15.74	12.14	16.05	13.82	14.00	17.04	18.26	16.94	15.12	17.58	15.65
TiO_2	.82	.86	.82	.81	.77	.77	.95	.91	.85	.80	.75
Fe_2O_3	6.26	5.32	5.18	4.75	5.53	5.53	5.97	6.41	5.09	6.65	6.15
MgO	2.16	1.65	1.74	1.76	1.86	1.79	2.30	2.47	1.54	2.95	3.28
CaO	1.21	1.18	.80	2.58	1.75	.80	1.88	.65	2.13	.29	.14
Na_2O	2.94	2.39	2.60	3.14	3.44	2.48	4.48	2.62	3.11	2.85	2.11
K_2O	3.30	2.71	3.86	2.86	2.75	3.42	3.07	4.50	3.24	3.16	3.59
MnO	.06	.07	04	.05	.05	.05	—	—	.07	.04	.03
K.K	1.13	1.26	1.49	.80	1.23	2.69	.83	.39	1.29	1.25	1.68
Total	**100.23**	**99.37**	**99.85**	**100.07**	**99.44**	**99.97**	**99.36**	**99.85**	**99.38**	**99.72**	**99.93**
Ba	952.8	583.4	624.9	715.9	536.0	599.0	857.2	710.6	539.09	—	699.6
Nb	11.8	13.7	12.0	—	10.7	14.1	14.3	15.6	11.6	—	8.3
Zr	76.6	240.0	133.0	—	103.2	122.7	123.9	125.1	172.0	—	72.5
Y	10.6	17.0	22.6	—	12.0	13.8	33.5	40.3	25.3	—	11.4
Sr	157.7	172.5	169.9	—	266.7	189.2	275.4	182.3	134.2	—	121.1
Rb	109.9	85.1	118.0	—	128.3	114.5	101.9	142.7	102.7	—	115.2

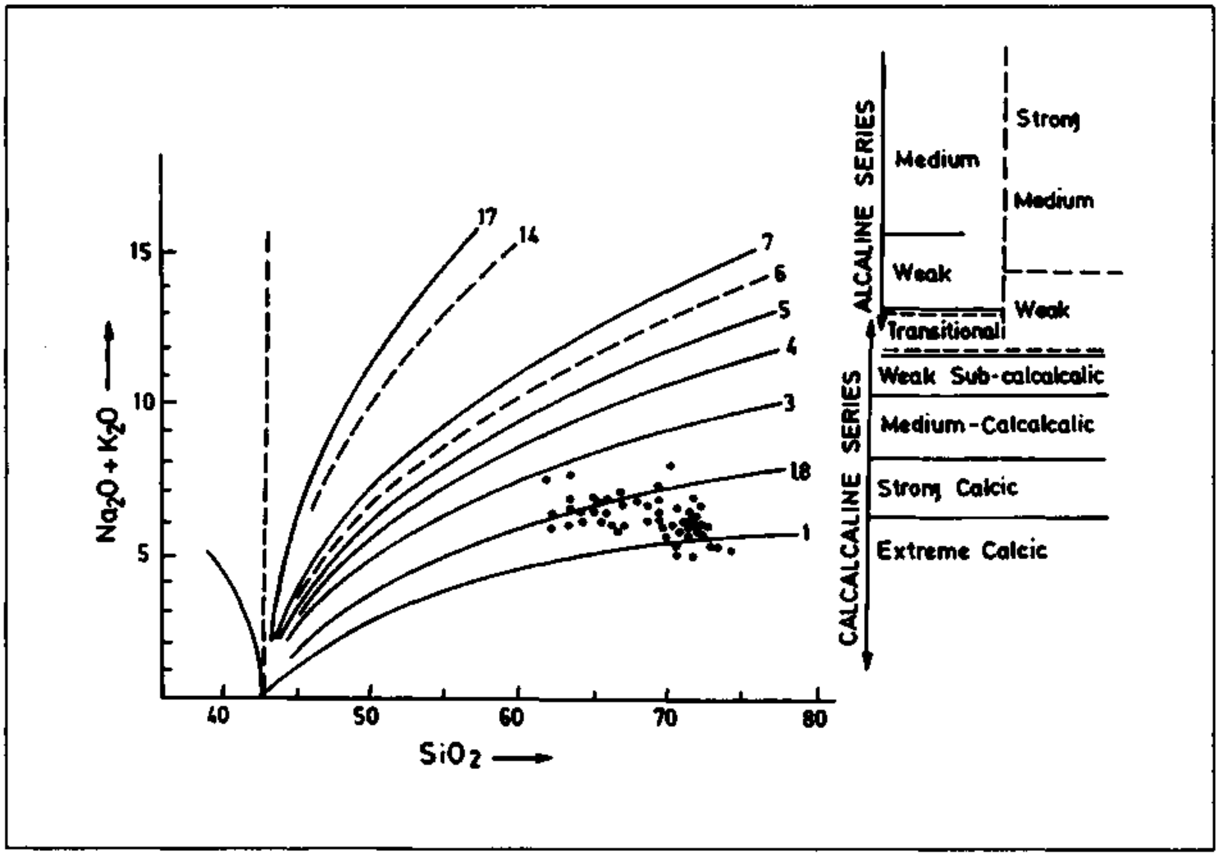

Fig. 12 - Place of the Ödemiş leptites on Rittmann (1962) diagram.

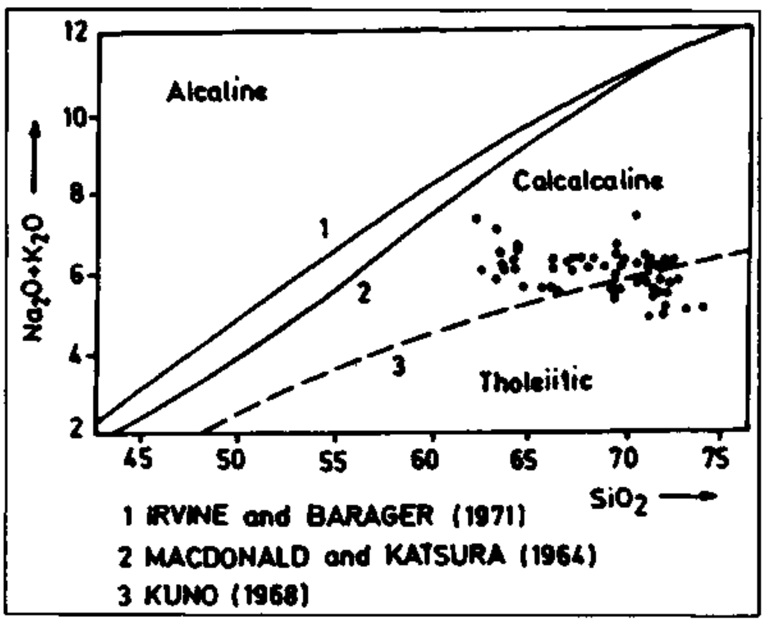

Fig. 13 - Place of the Ödemiş submassif leptites on alkali-silica diagram.

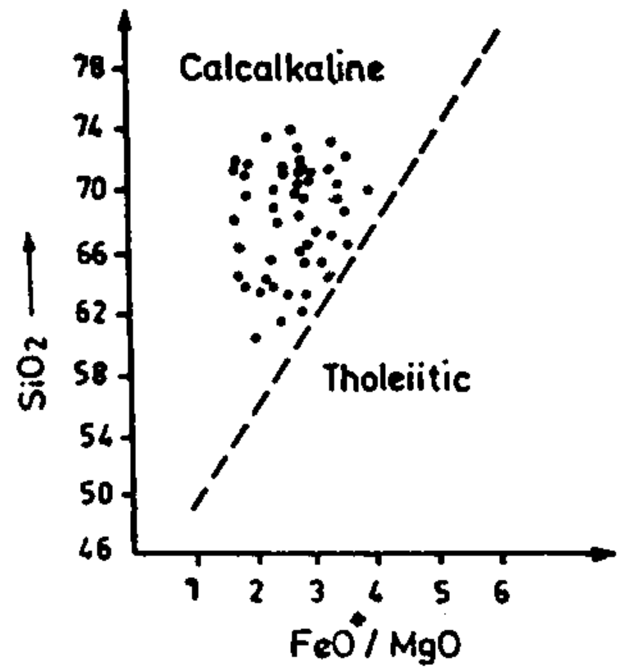

Fig. 14 - FeO* / MgO versus SiO_2 diagram after Miyashiro (1975).

In the log t versus log d diagram suggested by Gottini (1968), all the samples fall in the sialic origin (Fig. 15). There are several diagrams to explain the tectonic environment of the volcanics on the light of the plate tectonic theory. In the Morrison (1980) diagram, where K_2O are plotted against SiO_2, all the samples lie within the calc-alkaline island arc fields (Fig. 16). In the TiO_2 versus FeO/MgO diagram advanced by Glassley (1974), the leptites of Ödemiş submassif are concentrated in the island arc field too (Fig. 17).

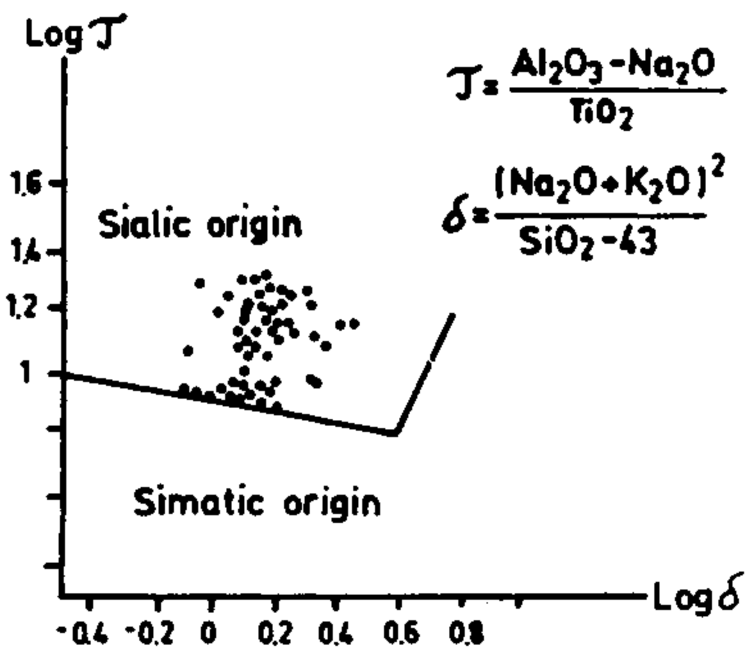

Fig. 15 - Log τ vs log δ diagram after Gottini (1969).

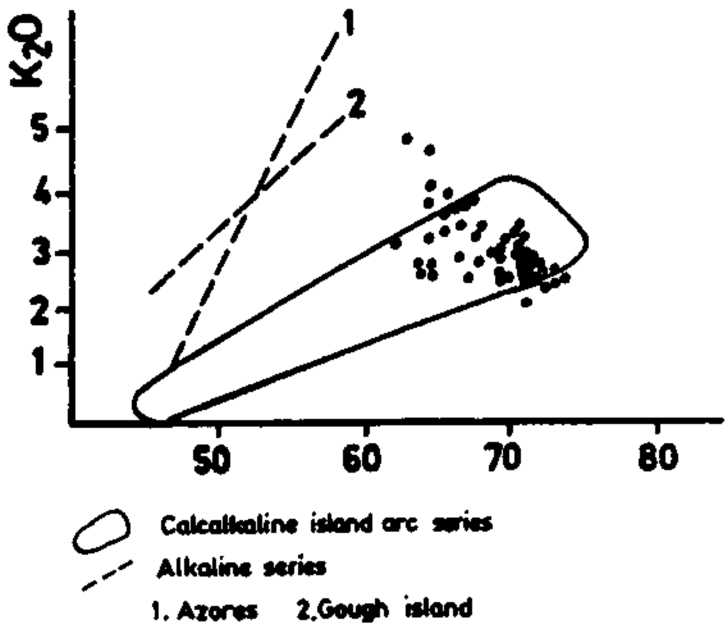

Fig. 16 - Variation diagram of K_2O contents with SiO_2 after Morrison (1980).

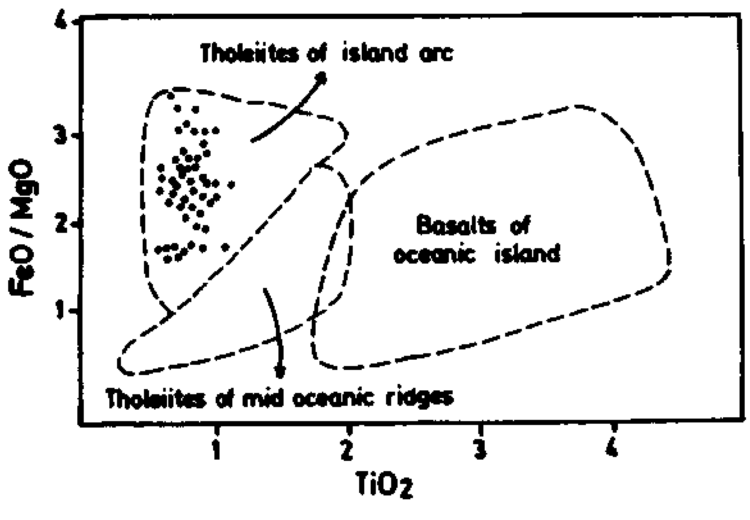

Fig. 17 - TiO_2 versus FeO* / MgO diagram after glassley (1974).

The Tixl0-^{2}/Zr/Yx3, Tixl0-^{2}/Zr/Sr:2 and Ti/Zr diagrams proposed by Pearce and Cann (1973) were applied to the leptites and it has been seen that the original rocks of the leptites were the calc-alkaline island are volcanics(Fig. 18). The analysis of the leptites were plotted on the TiO2 (%) versus Zr (ppm) diagram which was used by Gass (1982) to find out the tectonic environment of the metavolcanics belonging to the Upper Pan-African orogenesis (Fig. 19). It may be concluded from this diagram that the Menderes massif leptites show great similarity with the metavolcanics exposed at the NE Africa and SW Arabian Peninsula.

Finally, it can be suggested that the parent rocks of the leptites in the Ödemiş submassif of the Menderes massif are dacitic and rhyolitic volcanics. These island arc volcanics have sialic origin and dominant calc-alkaline kindred.

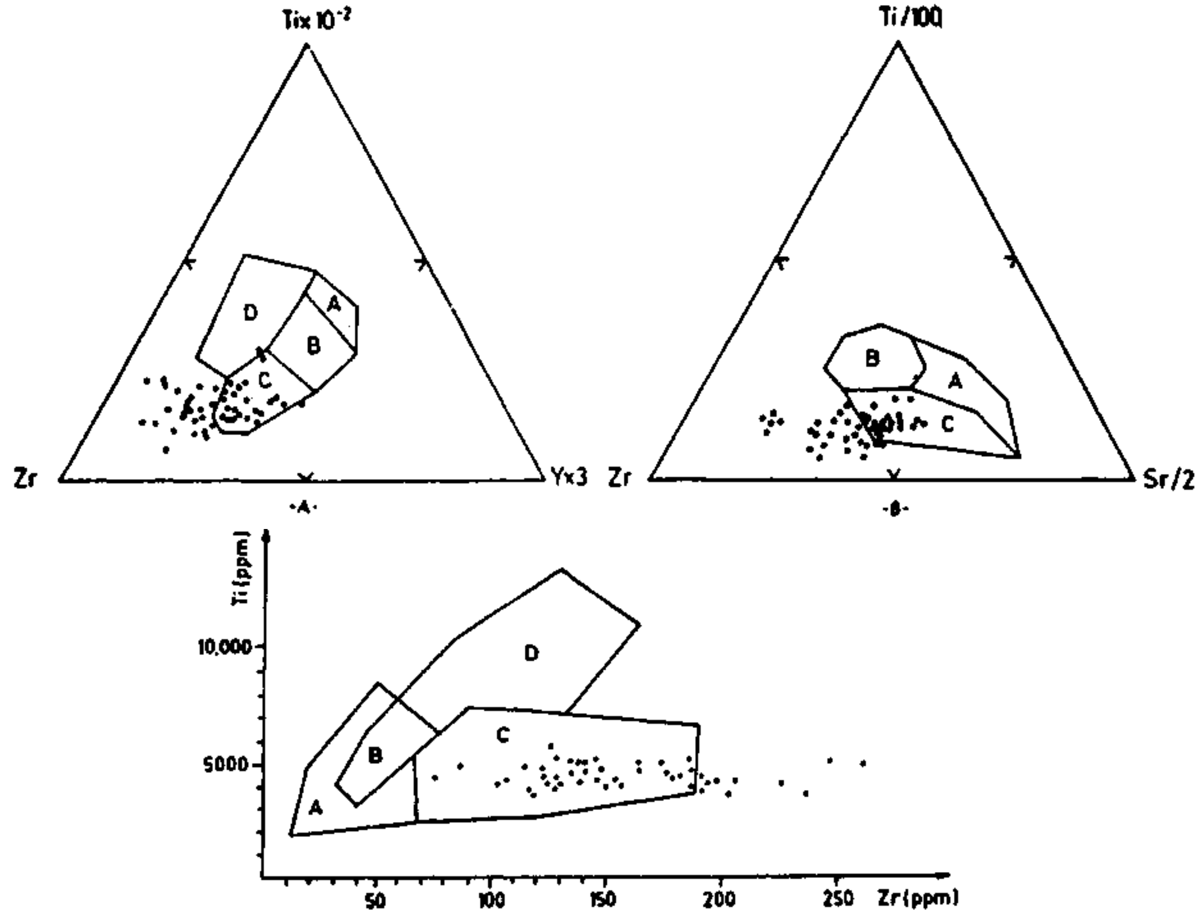

Fig. 18 - Ti x 10^{-2}/Zr/Y x 3, Ti: 100/Zr/Sr: 2 and Ti/Zr diagrams after Pearce and Cann (1973). A = A and B: Low K-Tholeiites, C and B: Calc-alkaline basalts, B: Ocean floor basalts, D: Within plate basalts. B = A: K-Poor tholeiites, B: Ocean floor basalts, C: Calc-alkaline basalts, C = D and B: Ocean floor basalts, A and B: Low K-Tholeiites, C and B: Calc-alkaline basalts.

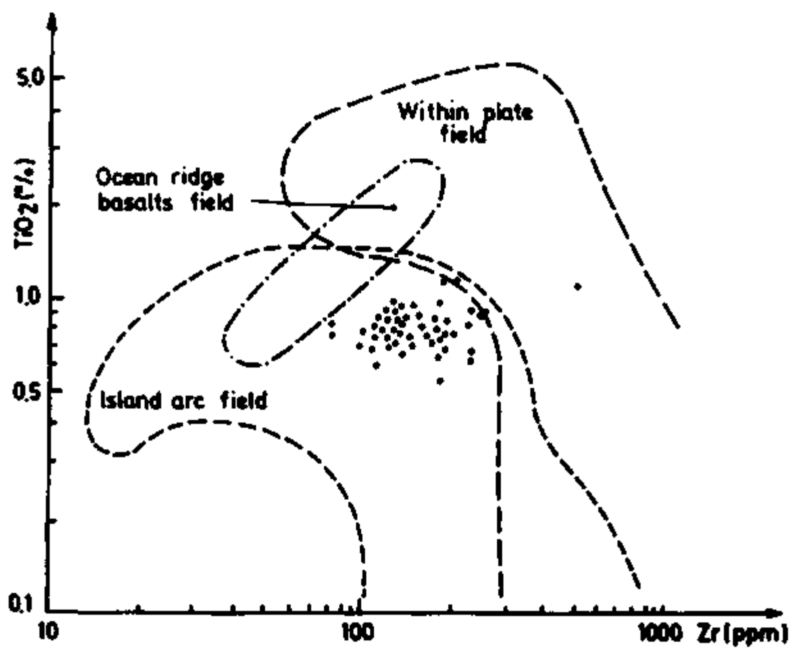

Fig. 19 - Place of the leptites of Ödemiş submassif on the TiO_2(%) / Zr (ppm) diagram.

DISCUSSION AND CONCLUSIONS

The general evolution of the Menderes massif and the position of the leptites (metavolcanics) which are situated at the Ödemiş submassif can be briefly summerized as fallows:

According to the recent studies in the Menderes massif, the initial sedimentation age of the gneisses occuring at the lower level of the metamorphic sequence is about 545-670 Ma old (Satır ve Friedrichsen, 1986). These sediments which were widely composed of graywackeys were subjected to a high grade metamorphism about 500 Ma ago and were cut by the tonalitic-granitic intrusions about 470 Ma ago (Satir and Friedrichsen, 1986). In most places, these gneissic basement was covered by the primary volcanic rocks of the leptits which were the surface equivalents of these post-metamorphic acidic plutons (Kun and Candan, 1987; Dora et al., 1988). These volcanics, rhyolite and dacite in-composition, are the initial rocks of the leptites. In Ordovician, the sedimentation was started in the region and until the Paleocene, sedimentary series which was composed of the flysh type sediments and platform type limestones were deposited on these volcanics (Dürr 1975; Çağlayan et al., 1980; Konak et al., 1987; Dora et al., 1989). The last main metamorphism which was affected the Menderes massif has occured in Upper Paleocene-Lower Eocene time (Dürr, 1975; Dürr et al., 1978; Şengör et al., 1984; Kun and Candan, 1987; Andreissen et al., 1979). The leptites in Ödemiş submassif which are of acidic in-composition were formed by this high grade metamorphism (Kun and Candan, 1987).

In recent years, it has been claimed that the Menderes massif is part of the Pan-African continental crust exposed in NE Africa and Arabian Peninsula (Şengör et al., 1984; Dora et al., 1988). According to Gass (1982), the Upper Pan-African orogenesis in these regions is especially characterized by the silicarich magmatic activity and acidic volcanics which vary in composition from andesite to rhyolite. These island arc type volcanic rocks have a calc-alkaline kindred.

It follows that the leptites (metavolcanics) exposed in the Ödemiş submassif of the Menderes massif shows a great similarity with the Upper Pan-African volcanics in NE Africa in terms of chemical composition and geotectonic position. It may be suggested by these chemical and geological evidences that the leptites of the Ödemiş submassif represent the Northwestern extension of the island are volcanic belt widely occurring in NE Africa and Arabian Peninsula, in relation to the late phases of the Pan-African orogenesis.

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