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H.P. ZECK
mta@mta.gov.tr

Taner ÜNLÜ
tunlu@eng.ankara.edu.tr

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SHOSHONITIC, MONZONITIC PLUTON NEAR MURMANO, EASTERN CENTRAL TURKEY - A PRELIMINARY NOTE

H.P. ZECK* and Taner ÜNLÜ**

ABSTRACT— The major and trace element composition of three series of samples from the Murmano pluton (Divriği-Sivas), eastern central Turkey, has been investigated in this study. Element distribution patterns as shown in variation diagrams favour the hypothesis that the pluton has a composite character, consisting of a number of intrusive bodies, representing separate magma batches. Earlier geochronological investigations suggest that the Murmano pluton postdates the ophiolite obduction in the area. Mineralogical criteria and the chemical data presented here indicate that the rocks are I-type plutonic rocks which have many characteristics of the calc-alkaline rock series for which current classification diagrams indicate an active subduction zone setting. High total alkalies versus SiO_2, K_2O versus SiO_2, K_2O/Na_2O, Rb, Ba, Al and Fe_2O_3/FeO, and low TiO_2 suggest that the pluton has a shoshonitic character.

INTRODUCTION

The Murmano pluton intrudes the ophiolites of the Inner Tauride suture zone, located between the Kırşehir and Tauride blocks (Fig. 1), and postdates the ophiolite obduction (Zeck and Ünlü, 1988a; 1988b). The pluton bears a composite

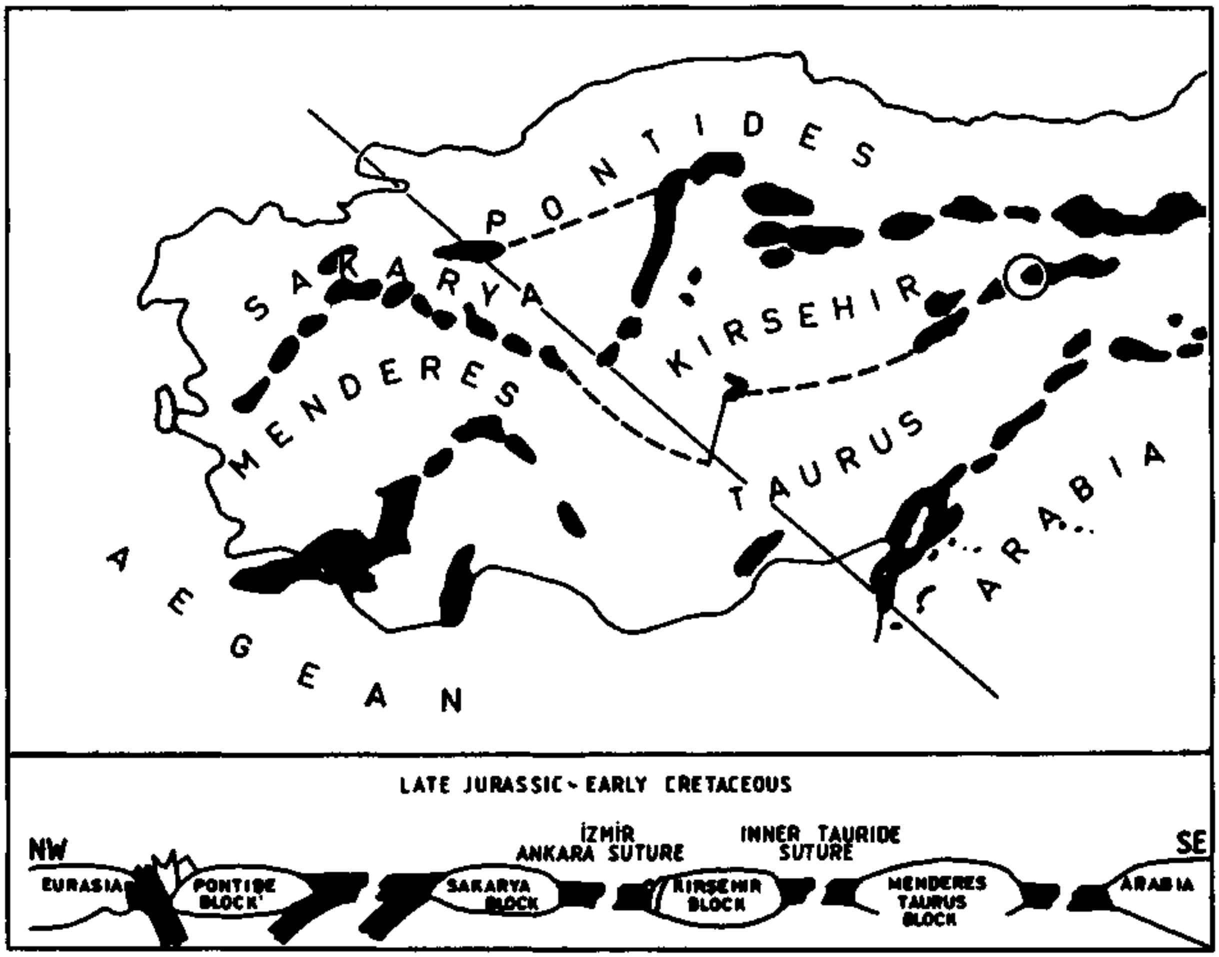

Fig. 1 - Geological sketch map showing the distribution of ophiolite complexes in Turkey. The cross section outlines the proposed plate tectonic model for the Late Jurassic-Early Cretaceous (Şengör and Yılmaz, 1981; Görür et al., 1984; Robertson and Dixon, 1984). Circle indicates location of the area investigated.

* Geological Institute, University of Copenhagen, Denmark.
** Ankara Üniversitesi, Fen Fakültesi, Jeoloji Mühendisliği Bölümü, Ankara- Turkey.

character and at least two magma batches are thought to be involved. In a Nicolaysen diagram these magma batches define parallel isochrons which indicate an intrusion age of 110±5 Ma (Zeck and Ünlü, 1987). The initial $^{87}Sr/^{86}Sr$ ratios for these two isochrons are 0.7069 and 0.7059, respectively, suggesting that two different magmatic sub-systems were involved. An origin of these two magmas by fractional crystallization of the same starting magma seems unrealistic in view of the large difference in initial $^{87}Sr/^{86}Sr$ ratio between the two magmas. More feasible models for the origin of these magmas are, for example, different degrees of crustal assimilation by the same starting magma, mixing of two magmas in different proportions, various proportions of restite/melt mixing in an anatectic setting and anatexis of different source rock complexes. All these models except the last would be expected to give rather simple variation diagrams determined by mixing lines between two compositions.

The present paper focusses on the major and trace element geochemistry of the pluton and the interpretations in Zeck and Ünlü (1987,1988a, 1988b) are verified. The data obtained are used to characterize the plate tectonic setting of the rocks. Chemical variations between the various sub-areas of the pluton are discussed with the aim to further constrain the choice of possible petrogenetic models for the pluton.

GEOLOGICAL SETTING, FIELD RELATIONS AND PETROGRAPHY

The inner Tauride suture zone within which the Murmano pluton is located is characterized by the occurrence of many ophiolite complexes (Fig. 1). The geological map of the area NNW of the town of Divriği which contains the Murmano pluton was made by Koşal (1973). The ophiolite complex in the area studied appears dismembered, consisting mainly of serpentinites. The Murmano pluton is intrusive into the serpentinites (Zeck and Ünlü, 1988a; 1988b).

The Murmano pluton typically consists of massive rocks. An obscure flow foliation has only been observed locally. Interpenetrative foliation or lineations of metamorphic-tectonic origin are absent. Modal compositions vary from quartz syenitic through monzonitic to dioritic (plutonic rock classification and nomenclature is according to Streckeisen, 1976). Monzonite is the predominant rock type in the composite pluton. Some petrography is given here; for more details see Zeck and Ünlü(1987).

The diorites occur mainly in the SW part of the pluton. The rocks are coarse-to medium-grained. Light grey, euhedral-subhedral, 0.5-2 cm. large crystals of plagioclase dominate the hand specimen. Thin sections demonstrate the otherwise obscure mega-crystic nature of the rocks and the presence of a flow foliation, both mainly supported by the plagioclase crystals set in a mm-sized matrix consisting of plagioclase, biotite an clinopyroxene. Plagioclase typically has a composition of An_{60-30} K-feldspar is absent or forms a few rare crystals in the matrix. Biotite forms independent crystals within the plagioclase framework, but also forms crystals surrounding, and probably grown on, crystals of clinopyroxene and opaque material, and, together with amphibole these replace the clinopyroxene to some extent. The colour index is 30-40. LT alteration products amount to 1 -2 vol % of the rocks.

The monzonites are medium-to coarse-grained, have a massive structure and a greyish appearance, somewhat lighter in colour than the diorites. Many of them have clinopyroxene and biotite as major mafic minerals, amphibole being present as minor replacements of clinopyroxene. In others, hornblende (-like amphibole) is the dominant mineral, most sections enclosing remnants of clinopyroxene. In many samples titanite is a rather important mafic mineral (1-2 vol %), rather than an accessory. K-feldspar is perthitic and forms up to 2 cm. large poikilitic crystals enclosing all other components, namely smaller euhedral plagioclase crystals. Plagioclase also forms larger, 1-2 cm. large crystals. LT alteration products form up to c.1 vol % of the rocks.

Within the coarse-to medium-grained, typically plutonic rocks which make up the bulk of the Murmano pluton, fine-grained, in part porphyritic rocks were found which in many cases form dykes with sharp contacts towards the plutonic rocks; in some cases the field relations are somewhat uncertain. Many of these fine-grained rocks show the same mineralogical relations as the plutonic rocks, indicating close genetic relations. Some others show a somewhat different mineralogy, suggesting more complex genetic relations towards the monzonites-diorites.

The fine-grained rocks with a similar mineralogy as the monzonites-diorites comprise micro diorites, micro syenites, and micro quartz syenites. Most rocks are porphyritic with a (very) fine-grained groundmass (f = 50-400 m m.) and pheno-

Table 1- Chemical composition, major and trace elements, of a suite of rocks from the Murmano pluton.

	AREA "A" △							AREA "C" ○									AREA "B" ●								
%	85Z126	85Z127	85Z128	85Z129	85Z130	85Z131	85Z132	85Z134	85Z136	85Z137	85Z138	85Z139	85Z140	85Z142	85Z143	85Z150	85Z151	85Z152	85Z153	85Z154	85Z155	85Z156	85Z157	85Z158	85Z159
SiO_2	52.72	51.55	47.45	60.73	56.44	66.33	60.19	63.01	63.06	63.66	62.65	64.51	64.19	60.34	59.56	64.23	59.59	60.07	59.91	50.99	68.00	59.69	60.20	59.66	59.01
TiO_2	1.05	0.71	0.99	0.52	0.76	0.42	0.80	0.58	0.58	0.54	0.55	0.52	0.52	0.79	0.85	0.54	1.07	0.98	0.82	1.00	0.35	0.99	0.95	1.10	1.07
Al_2O_3	18.92	16.43	18.44	17.01	18.66	15.96	17.41	16.73	17.01	16.51	16.84	16.80	16.67	17.00	17.08	16.60	17.57	17.95	18.17	16.71	15.86	17.60	17.40	17.71	17.57
Fe_2O_3	1.88	1.28	2.83	0.34	0.78	0.36	0.47	1.23	1.21	1.59	1.65	1.38	1.38	1.01	1.70	1.33	2.25	0.40	1.62	0.44	0.80	1.99	1.81	0.52	2.20
FeO	4.42	3.32	5.09	0.52	1.22	0.39	1.05	2.37	2.46	2.17	2.33	2.26	2.14	3.63	3.34	1.90	2.58	1.22	2.19	2.39	0.85	2.05	2.04	1.29	2.64
MnO	0.11	0.10	0.14	0.03	0.04	0.02	0.05	0.06	0.06	0.07	0.06	0.66	0.66	0.09	0.09	0.06	0.06	0.05	0.04	0.06	0.02	0.04	0.05	0.05	0.05
MgO	3.66	6.06	6.88	1.56	3.52	0.76	2.33	1.67	1.67	1.58	1.70	1.49	1.51	2.16	2.36	1.56	1.97	1.91	1.47	4.70	0.50	1.95	1.84	2.03	2.06
CaO	7.40	13.86	11.29	4.20	8.19	2.34	6.12	3.71	3.73	3.39	3.63	3.27	3.46	4.29	4.72	3.55	4.20	6.29	4.04	13.90	2.24	4.59	4.44	6.48	4.69
Na_2O	4.40	3.19	2.96	2.54	6.22	4.15	4.50	4.62	4.58	4.42	4.67	4.56	4.55	4.57	4.38	4.47	4.80	5.08	5.23	5.07	4.17	5.02	4.91	4.97	5.02
K_2O	3.28	1.49	2.09	9.90	1.01	7.09	5.81	4.79	4.61	4.71	4.41	4.74	4.57	4.65	4.66	4.71	5.09	4.97	4.90	0.78	6.39	4.87	5.09	4.90	4.91
P_2O_5	0.46	0.69	0.45	0.20	0.26	0.21	0.31	0.24	0.25	0.23	0.24	0.22	0.23	0.30	0.34	0.23	0.34	0.33	0.27	0.33	0.16	0.35	0.33	0.37	0.36
LOI	1.03	0.98	1.18	2.08	2.46	1.16	0.57	0.67	0.69	0.47	0.66	0.57	0.54	0.72	0.60	0.46	0.49	0.38	0.44	2.89	0.23	0.41	0.36	0.33	0.51
TOT	99.33	99.66	99.79	99.63	99.56	99.19	99.61	99.68	99.91	99.34	99.39	100.98	100.42	99.55	99.68	99.64	100.01	99.63	99.10	99.26	99.57	99.55	99.42	99.41	100.09
ppm																									
Rb	97	43	108	286	33	206	141	169	171	173	157	193	177	160	184	159	154	117	134	29	189	133	143	134	141
Ba	1200	541	1636	1536	248	1042	1107	972	970	886	944	937	920	1053	1101	929	1355	1188	1296	122	757	1349	1406	1266	1237
Pb	8	7	1	1	5	5	7	8	9	5	7	8	7	5	6	5	11	9	7	34	6	3	9	6	7
Sr	555	676	966	242	425	185	346	340	351	323	337	332	334	338	390	328	352	352	337	372	207	366	363	375	364
La	32	51	20	36	19	25	38	57	39	41	42	41	49	32	61	39	31	57	52	23	63	40	41	47	48
Ce	61	70	43	43	41	41	66	66	67	64	73	67	64	60	71	64	58	92	59	47	66	61	68	71	61
Nd	27	35	20	21	22	18	29	27	34	28	29	27	25	29	34	26	27	33	28	24	26	29	31	29	30
Y	23	30	19	25	23	24	27	24	33	26	23	26	25	24	30	25	27	29	25	25	28	30	29	30	28
Th	8	8	4	26	23	24	15	20	20	24	21	23	23	14	22	21	21	23	16	12	43	23	22	18	17
Zr	115	103	57	221	208	190	204	200	183	218	200	206	216	266	289	200	233	236	189	146	262	223	202	239	237
Nb	24	9.8	20	27	32	23	25	24	29	28	25	27	26	27	28	25	29	27	30	15	30	29	28	30	30
Zn	72	31	75	1	7	1	6	12	17	14	18	14	11	19	24	6	8	17	11	107	1	3	9	2	9
Cu	16	5	24	2	8	3	4	2	4	2	2	2	2	2	2	2	2	3	12	22	2	2	2	2	2
Co	47	50	42	34	23	51	42	52	50	66	60	68	73	64	57	68	48	75	60	48	96	58	54	58	53
Ni	38	59	114	32	30	18	30	17	22	17	15	17	18	23	25	15	14	14	14	9	14	18	15	18	13
Sc	11	26	19	5	5	4	7	8	8	7	9	7	6	8	8	6	10	7	8	13	5	9	10	7	9
V	130	121	230	30	43	25	65	56	56	50	53	48	49	80	82	51	82	64	64	126	18	81	77	80	85
Cr	75	154	288	13	10	9	31	20	21	18	21	17	17	35	33	19	17	14	13	22	11	18	18	20	19
Ga	19	13	15	17	12	17	17	15	19	20	15	16	17	17	16	18	18	17	18	18	16	19	16	19	19

crysts of plagioclase, K-feldspar and amphibole, which latter may have replaced earlier magmatic clinopyroxene. LT alteration products are more abundant than in the monzonites-diorites, amounting to c.3-5 vol %. Some more even-grained micro quartz syenites occur and these are very similar to the monzonites.

Of the rocks with deviating mineralogy, two types were recognized. Micro-dioritic rocks with kersantitic character, showing grain sizes of 0.1-3 mm, consist mainly of plagioclase, clinopyroxene, biotite and opaque material. Some olivine occurs and the colour index is c. 45, mainly due to c. 25 vol % of biotite. The alteration products amount to c. 2 vol % of the rock. Scapolite-rich rocks were found in clear cut, 0.5-1 m wide dyke bodies. The rocks consist of c. 50 vol % of scapolite, forming a poikiloblastic matrix enclosing all other components of the rock (clinopyroxene, 30-35 vol %, plagioclase, c. 15 vol %, titanite, amphibole, biotite, carbonate, and chlorite). The rocks are interpreted as sub-volcanic dykes, the glassy or very fine-grained groundmass of which has been completely replaced by scapolite (Zeck and Ünlü, 1987).

GEOCHEMISTRY

Major element analyses were made by X-ray fluorescence analysis of glass discs prepared with a sodium tetraboraie flux, except for Na and Mg which were analysed by atomic absorption and volatiles which were obtained as loss on ignition.

Trace elements were analysed directly on pressed powder pellets by X-ray fluorescence using a Philips PW 1400 and the techniques of Norrish and Chappell (1977). Results were corrected for background interference from tube and sample spectral lines, and for matrix variation (using the major element composition). USGS Standards (G-2, GSP-1, AGV-1, W-l, BCR-1, PCC-1) were used for calibration (Gladney et al., 1983).

The results of the analyses are presented in Table 1, and a number of variation diagrams. Figs. 3-11.

INTERPRETATION AND DISCUSSIONS

A crucial element in the interpretation of the Rb-Sr isotopic systematics of the pluton is the observed composite character of the intrusive body (Zeckrand Ünlü, 1987). This suggestion was based on the study of Rb-Sr isotopic relations in two restricted areas, 3-4 km apart (Fig. 2). In the present paper a new series of samples is introduced, consisting of 9 samples collected along the main road, c. 2-3 km SE of the village of Murmano. The area in the south-western part of the body will be referred to as area "A", that in the southern part as area "B" and the new area along the road as area "C".

A number of selected chemical components have been plotted for these three sample series. In the selection of these components emphasis has been placed on relatively immobile components. The distribution of these components may be expected to give an indication of the original, magmatic relations within the intrusive body. These components will not have been affected, or only to a limited degree, by the post magmatic alterations which were observed in the rocks.

Two major components, TiO_2 and MgO, were plotted in Harker diagrams. The two diagrams (Fig. 3a,b) show rather different relations. TiO_2 shows a separate trend and distribution for area A compared to the other two areas. Areas B and C show the same trend, but the distribution along the trend is different. Considering that the rocks of these two sample series show a very similar mineralogy, indicating a similar level of differentiation, this suggests that also these two sample series may represent different magmatic material. Note the position of sample 85Z154, a heavily scapolitized rock (Zeck and Ünlü, 1987). Apparently the scapolitization process involved a Considerable loss of SiO_2.

MgO shows a well defined common trend for all three sample series. This diagram on its own merit could explain the rocks in the pluton as members of the same differentiation series. The difference between the three series here is mainly one of different distribution along the same trend. The position of the scapolitized sample may suggest that a considerable increase in the MgO percentage has taken place, combined with a SiO_2 decrease.

Sr shows a rather well defined trend (Fig. 3c), when the scapolitized sample is disregarded. In detail, the three areas might possibly define three parallel trends, with C defining the highest, B the intermediate and A the lowest in the Sr-SiO_2 diagram. Scapolitization seems not to affect the Sr content.

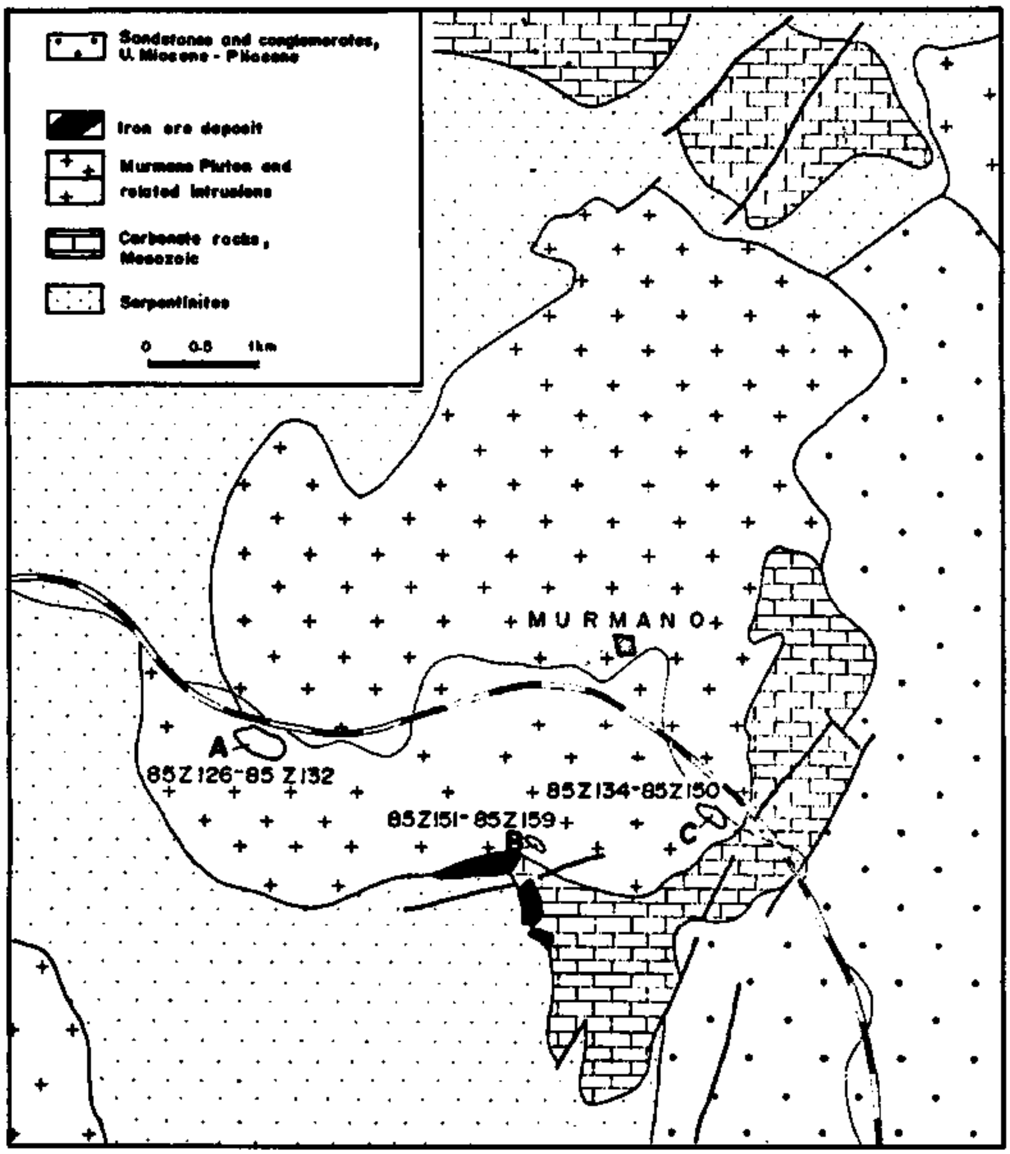

Fig. 2 - Geological map of the area containing the Murmano pluton, Koşal (1973).

Y shows rather complex relations (Fig. 3d). The samples from area A show a distribution which is different from that from the other two areas. Areas B and C show similar patterns. Scapolitization seems to involve a decrease in Y content. The relations for Zr (Fig. 3e) and Nb (Fig. 3f) conform to those for Y.

Ni and Sc show very similar behaviour (Figs. 3g, h). Area A shows clear differences from the other two areas. Areas B and C show considerable similarity. Scapolitization seems hardly to affect Ni and may involve a slight increase in Sc combined with a decrease in SiO2.

K/Rb ratio distribution versus SiO_2 (Fig. 4) shows clear differences between the three areas. The Scapolitization seems to involve a decrease of K/Rb combined with a decrease in SiO2.

Rb/Sr relations (Fig. 5) show systematic differences between the three areas. Scapolitization resulted in a strong Rb depletion, whereas Sr seems hardly affected (Fig. 3c).

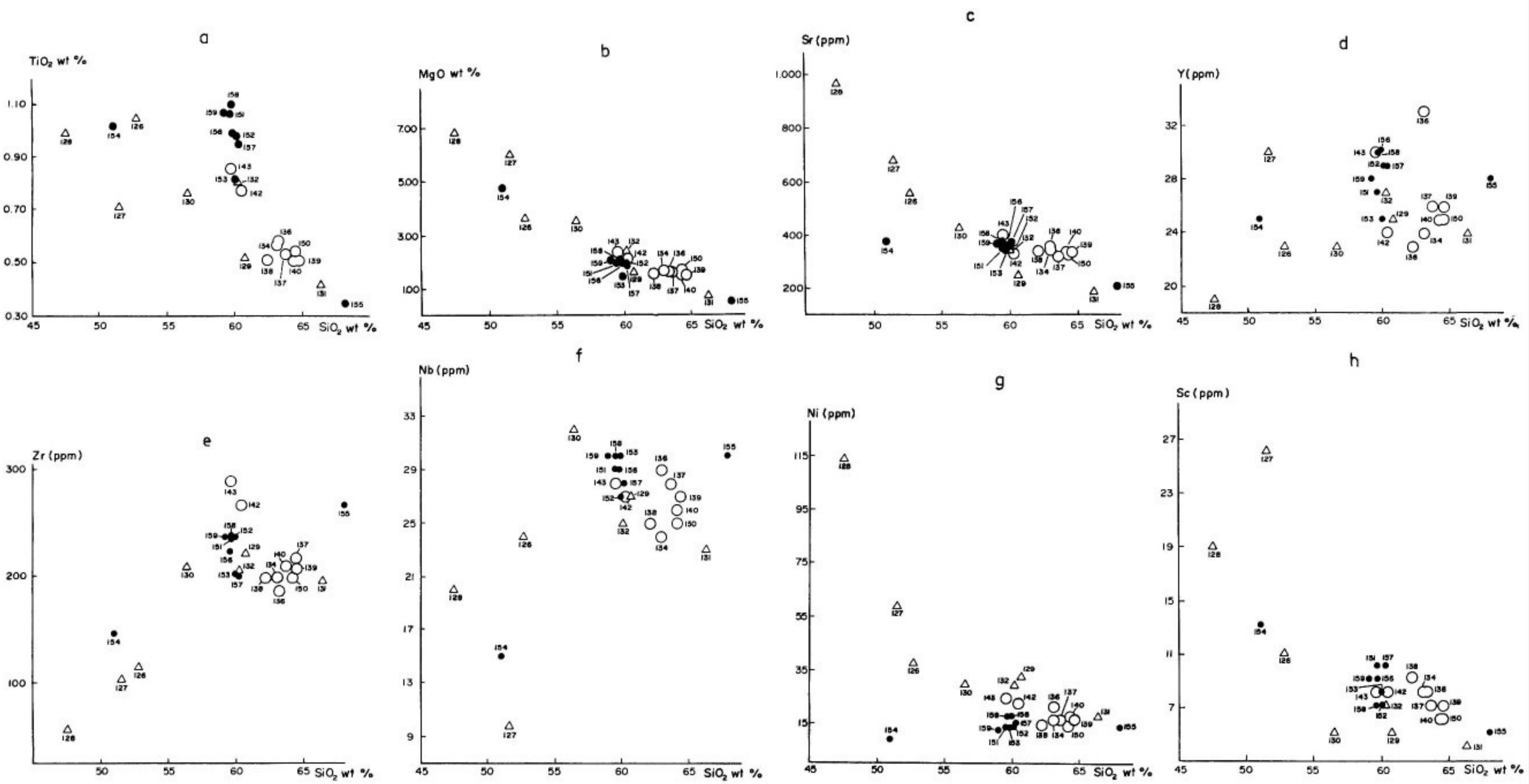

Fig. 3 - Eight Harger diagrams of two components (TiO2 and MgO) and six trace elements (Sr, Y, Zr, Nb, Ni and Sc). Signatures: triangles-sample series at the south western side of the body (85 Z 126-85 Z 132); closed circles-sample series at the southem side of the body (85 Z 151-159); open circles-sample series along the road, c.2-3 km SE of Murmano (85 Z 134-150)

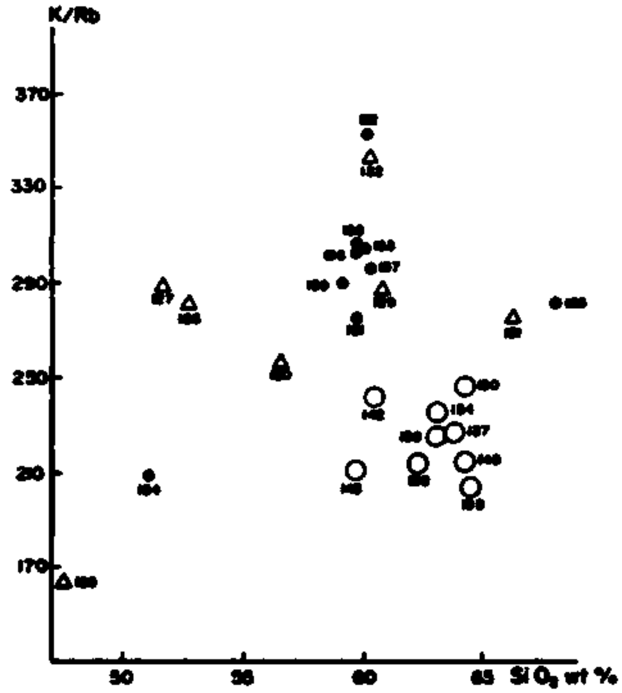

Fig. 4 - K/Rb-SiO_2 diagram. Signatures as in Fig.3.

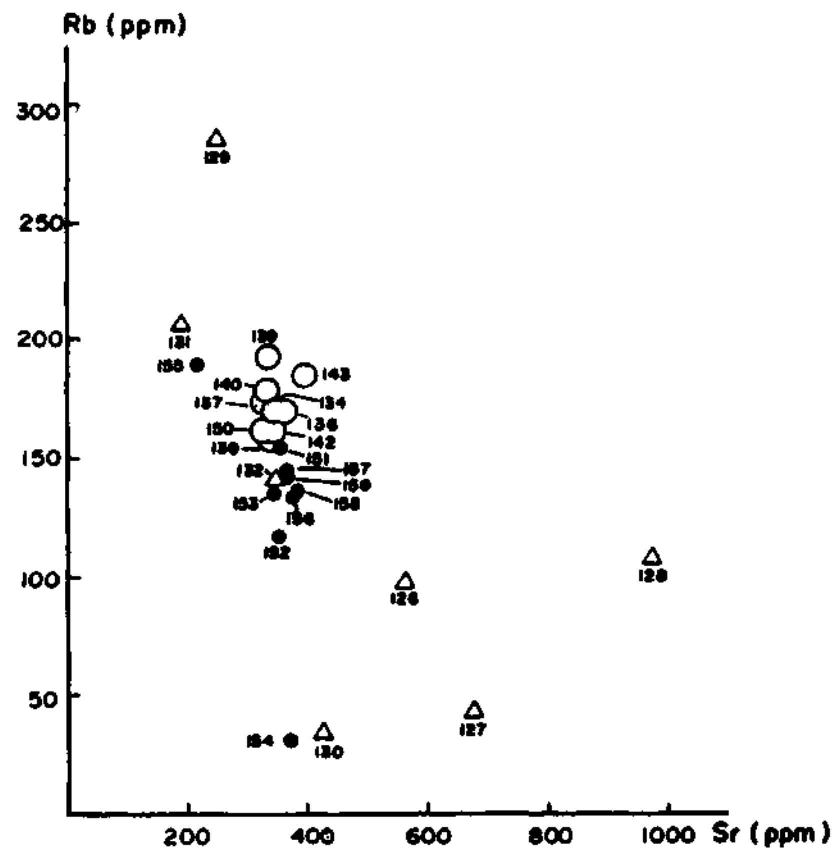

Fig. 5 - Rb-Sr diagram. Signatures as in Fig.3.

The geochemical relations discussed above seem to indicate that there is a clear difference between area A on the one hand and B and C on the other. The differences between B and C are less well defined, but in some of the diagrams, for example K/Rb, differences are suggested. The conclusion on the basis of the available data therefore would be that the hypothesis, that the Murmano pluton consists of a number of separate intrusive phases which represent different batches of magma, is confirmed by the major and trace element geochemistry.

The geochemical character of the intrusion as a whole gives valuable information about its plate tectonic setting. Fig. 6 shows the distribution of 25 samples plotted in the AFM diagram. The pattern is indicative for a calc-alkaline ser-

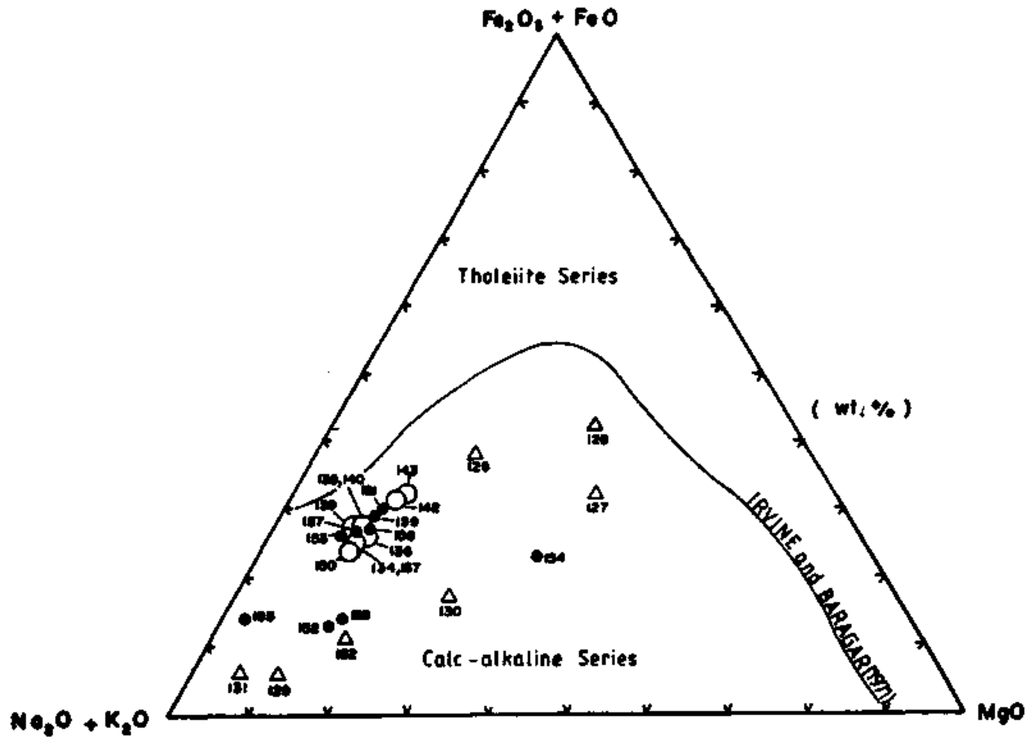

Fig. 6 - AMF diagram. Dividing line after Irvine and Baragar (1971). Signatures as in Fig.3.

ies related to lithosphere subduction (Irvine and Baragar, 1971). Figs. 7a and b support the non-tholeiitic, calc-alkaline nature of the pluton. Earlier investigations (Bayhan, 1980; Bayhan and Baysal, 1982) have indeed classified the Dumluca pluton. which is located only c.1.5 km SW of the Murmano pluton, as calc-alkaline. However, a number of discrimination diagram plots and other geochemical criteria seem to indicate a shoshonitic character for the Murmano pluton studied here. The (Na_2O+K_2O) versus SiO_2 diagram (Irvine and Baragar. 1971; Morrison, 1980), see Fig. 8, suggests a shoshonitic or alkaline rather than a calc-alkaline nature. The K_2O versus SiO_2 diagram (Peccerillo and Taylor, 1976; Morrison, 1980; Rickwood. 1989). see Fig. 9. suggests a shoshonitic rather than a calc-alkaline character. The MgO versus FeO* diagram, see Fig. 10, suggests a shoshonitic rather than a calc-alkaline or alkaline nature for the rock complex. It is noted that this latter diagram demonstrates that the Murmano rock series is decidedly poorer in FeO* than the rocks compiled by Morrison (1980).

The majority of the samples have a SiO_2 content within the range for andesites. With some reservations for the plutonic character of the Murmano rock series, we could therefore apply the criteria given by Bailey (1981) to discriminate between three erogenic settings: oceanic island arc, continental island arc and andean. Eleven of our samples (Table 1) have a SiO_2 content between 59.00 and 62.00, which represents the andesite screening window preferred by Bailey (1981). For these samples K_2O/Na_2O ranges from 0.94 to 1.06 (not counting two outliers at 1.29 and 3.90) with a mean

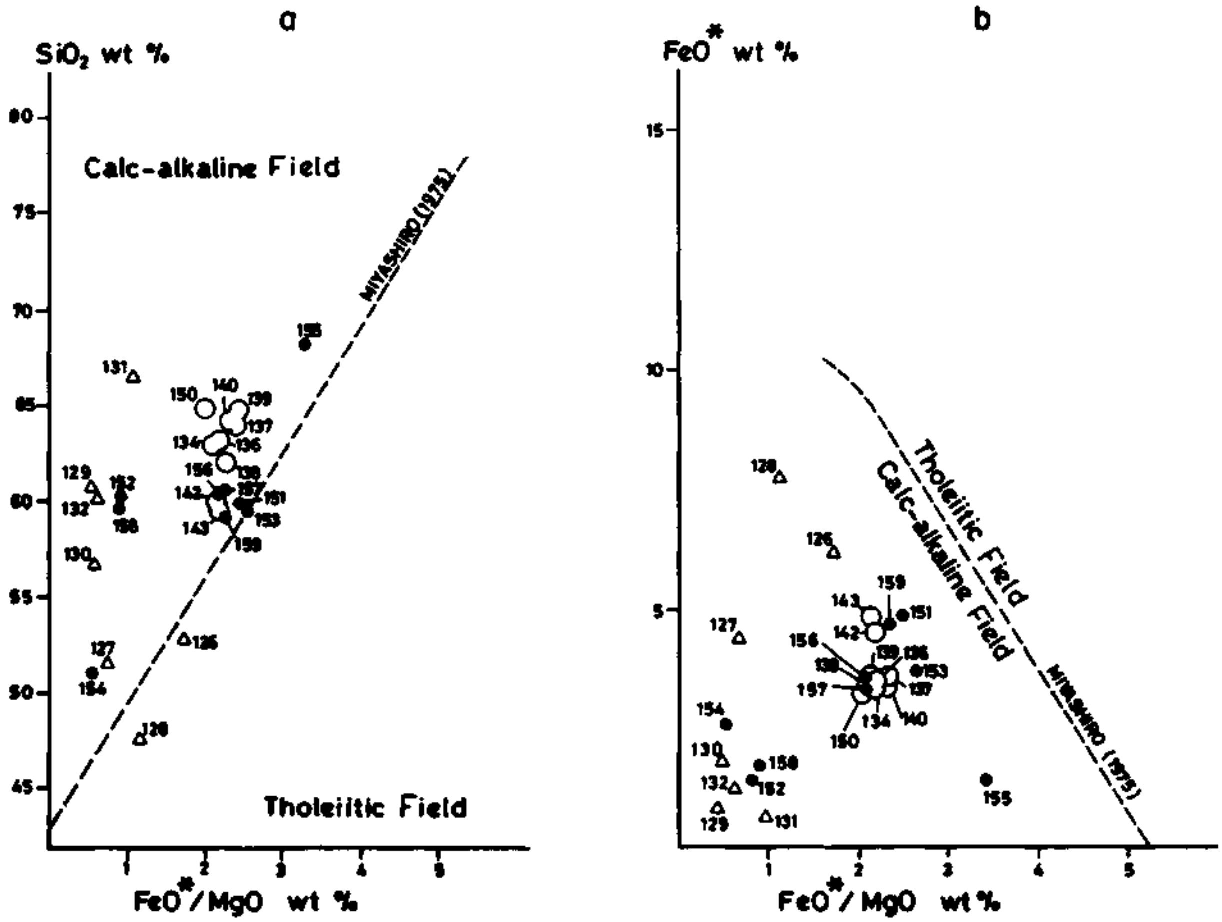

Fig. 7 - a - SiO_2-(FeO*/MgO) and b-FeO*- (FeO*/MgO) diagrams. Dividing lines after Miyashiro (1975). Signatures as in Fig.3.

value of l.(X). which conforms to the value given for shoshonitic andesites. Rb content is high (ranging from 117 to 184 ppm. with a mean value of 144 ppm). and also Ba content is high (ranging from 1053 to 1536, with a mean value of 1263 ppm). which also is in agreement with a shoshonitic character. Sr on the other hand is rather lower (range 338-390, mean 358 ppm). than suggested by Bailey (1981).

A continental island arc setting is suggested by 1) P/La values ranging from 23 to 48, with a mean value of 33, 2) K/La values ranging from 634 to 1363, with a mean of 975, and 3) Zr/Y values ranging from 6.97 to 11.08, with a mean of 8.39. Th contents ranging from 14 to 26, with a mean of 20 ppm. and Ni contents ranging from 13 to 32. with a mean of 20 ppm favour an Andean or continental island arc setting, in that order. La/Y values ranging from 1.15 to 2.08. with a mean value of 1.58 favour an oceanic or continental island arc environment, in that order. It may be concluded that the trace clement content seems to favour a continental island arc setting.

Also for granitic rocks geochemical distribution diagrams have been calibrated in order to discriminate between rocks from different geotectonic settings, e.g.. Didier and Lameyre (1969), Chappell and White (1974), Pitcher (1983) and Pearce el al (1984). The diagrams given by Pearce et al. (1984) employ Y. Nb. Rb and SiO_2 contents to discriminate between granitic rocks from within plate settings (WPG), ocean ridge settings (ORG) collision settings (COLG) and volcanic arcs (VAG). The Murniano plutonic rocks consistently plot in the VAG field (Fig. 11a-d). in agreement with the continental island are setting suggested above.

Another system of discriminating between different granitic rock types on the basis of their plate tectonic setting, employs 5 different, types of granitic material. The M-type includes the rare plagiogranites of oceanic island arcs. The

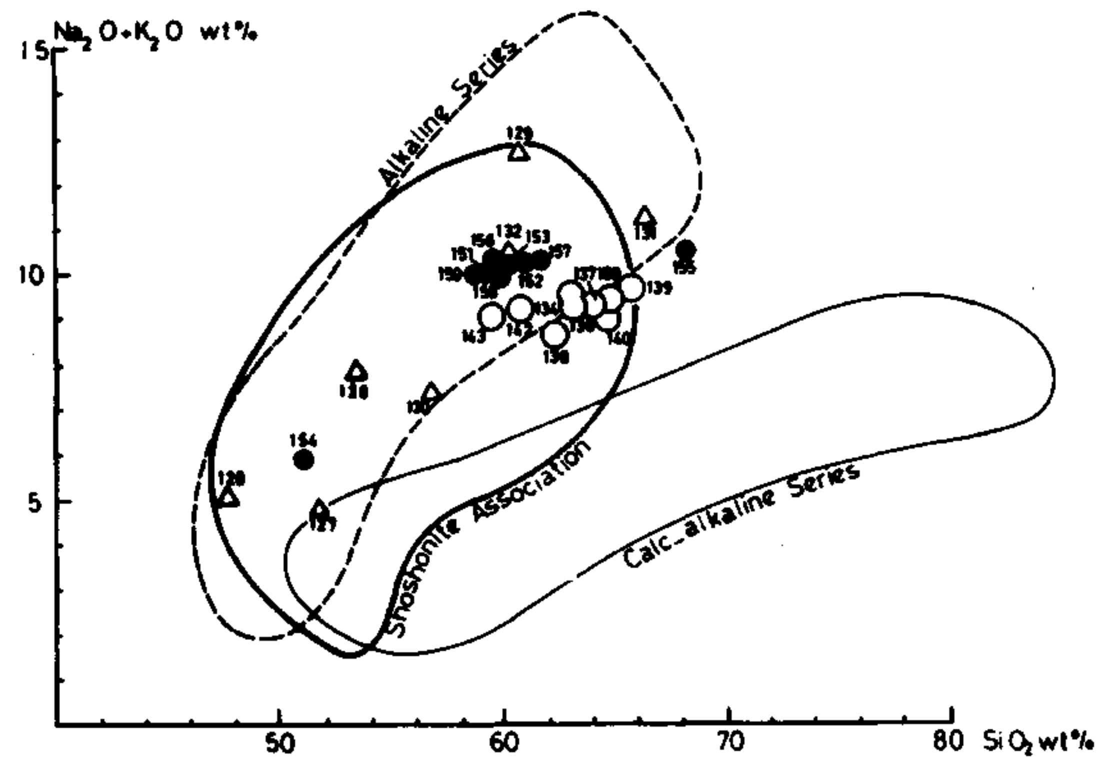

Fig. 8 - (Na_2O+K_2O)-SiO_2 diagram. Fields for calc-alkaline and alkaline series Irvine and Baragar (1971), shoshonite association Morrison (1980). Signatures as in Fig.3.

I_{co}-type (Cordilleran type) is transitional to the M-type and comprises the voluminous gabbro/quartzdiorite/tonalite assemblage of active continental plate edges. The I_{ca}-type (Caledonian type) is different from the Cordilleran type; it represents the granodiorite/granile series of post-orogenic uplift regimes. Clearly separate is the S-type series which incorporates the peraluminous granite assemblage of eucratonic and continental-collision fold belts. Also rather well defined is the so-called A-type (Loiselle and Wones. 1979). which comprises the alcalic granites of both the stabilized fold belts and rifting systems of cratonic areas.

A number of chemical and mineralogical criteria have been put forward to differentiate between the various types of granitic rocks. A major mineralogical criterion is given by the nature of the mafic minerals. In the Murmano pluton, clinopyroxene, hornblende and biotitce are the major mafic minerals. This is common in M-and I-series, and seems to rule out the S-and A-types, which show muscovitc, brown-red biotite, garnet and cordierite, and green biotite, alkali amphiboles and pyroxenes, respectively. The widespread occurrence oftitanitefavours the I_{co}-type over M-type and I_{ca}-type .

Isotope geochemistry data, such as the initial $^{87}Sr/^{86}Sr$ ratio can also be used to characterize the plate tectonic setting. Initial $^{87}Sr/^{86}Sr$ ratios for the Murmano pluton are between 0.7059 and 0.7069. These values seem to rule out an M-typification for which values < 0.704 are given. For I_{co}- and I_{ca}-types, values of <0.706, and 0.705< <0.709 are given, respectively (Pitcher, 1983). The Murmano values seems to fit the I_{ca} range best.

It is of special interest to note that on the basis of a global compilation, porphyry Cu and Mo mineralisations are connected to this type of granitic rocks. However, in the case of the granitic rocks in the Inner Tauride suture zone, this seems not to have been realized. A special investigation to ascertain this aspect seems warranted.

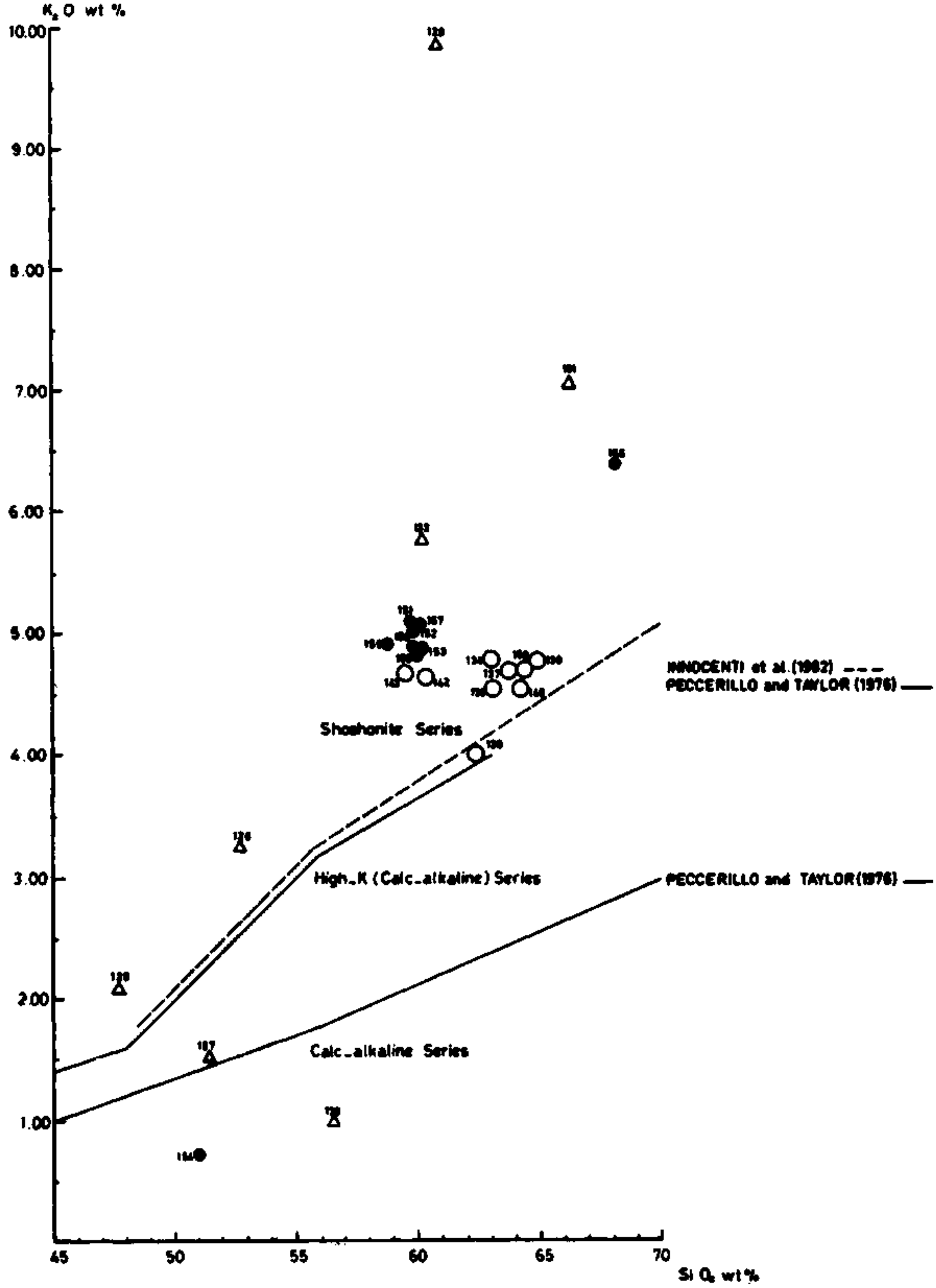

Fig. 9 - K_2O-SiO_2 diagram after Rickwood (1989). Dashed lines Innocenti et al. (1982) and solid lines Peccerillo and Taylor (1976). Signatures as in Fig.3.

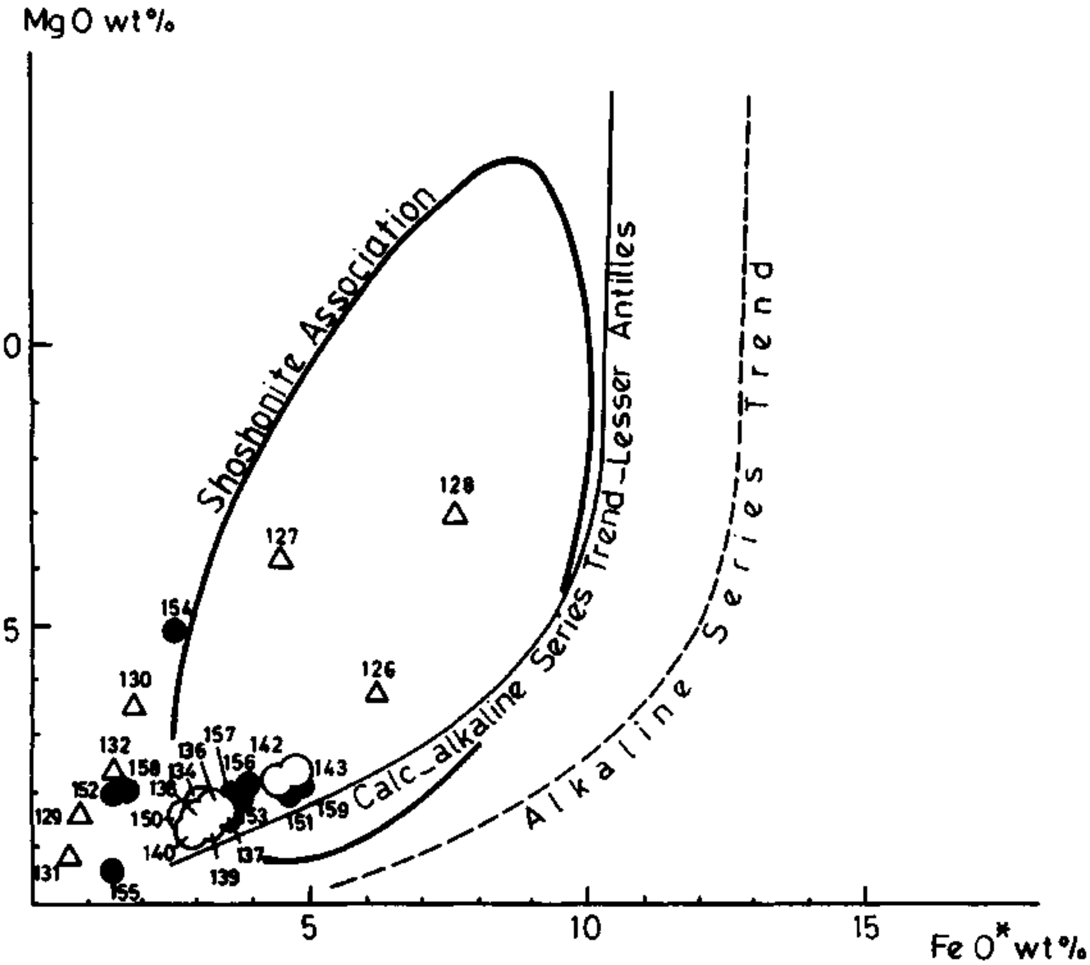

Fig. 10 - MgO-FeO* diagram. For further information, see Morrison (1980). Signatures as in Fig.3.

CONCLUSIONS

The conclusion of the present investigation is that the Murmano pluton is a composite pluton of predominantly monzonitic character. Current literature classifies the closely related Dumluca pluton, located only 1.5 km from the Murmano pluton, as calc-alkaline (Bayhan, 1980; Bayhan and Baysal, 1982). A large number of geochemical classification diagrams suggest a shoshonitic character for the Murmano pluton.

Geochemical plate tectonic discrimination diagrams and other geochemical and mineralogical criteria suggest that the magmatic material from the Murmano pluton has an I-type character and was formed in a continental island arc environment, in connection with an active subduction zone. The geological information (Zeck and Ünlü, 1988a; 1988b) suggests that the subduction took place in the same general period, during which the ophiolite complexes were obducted. As a result the subduction related magmas intruded into the obducted ophiolite series.

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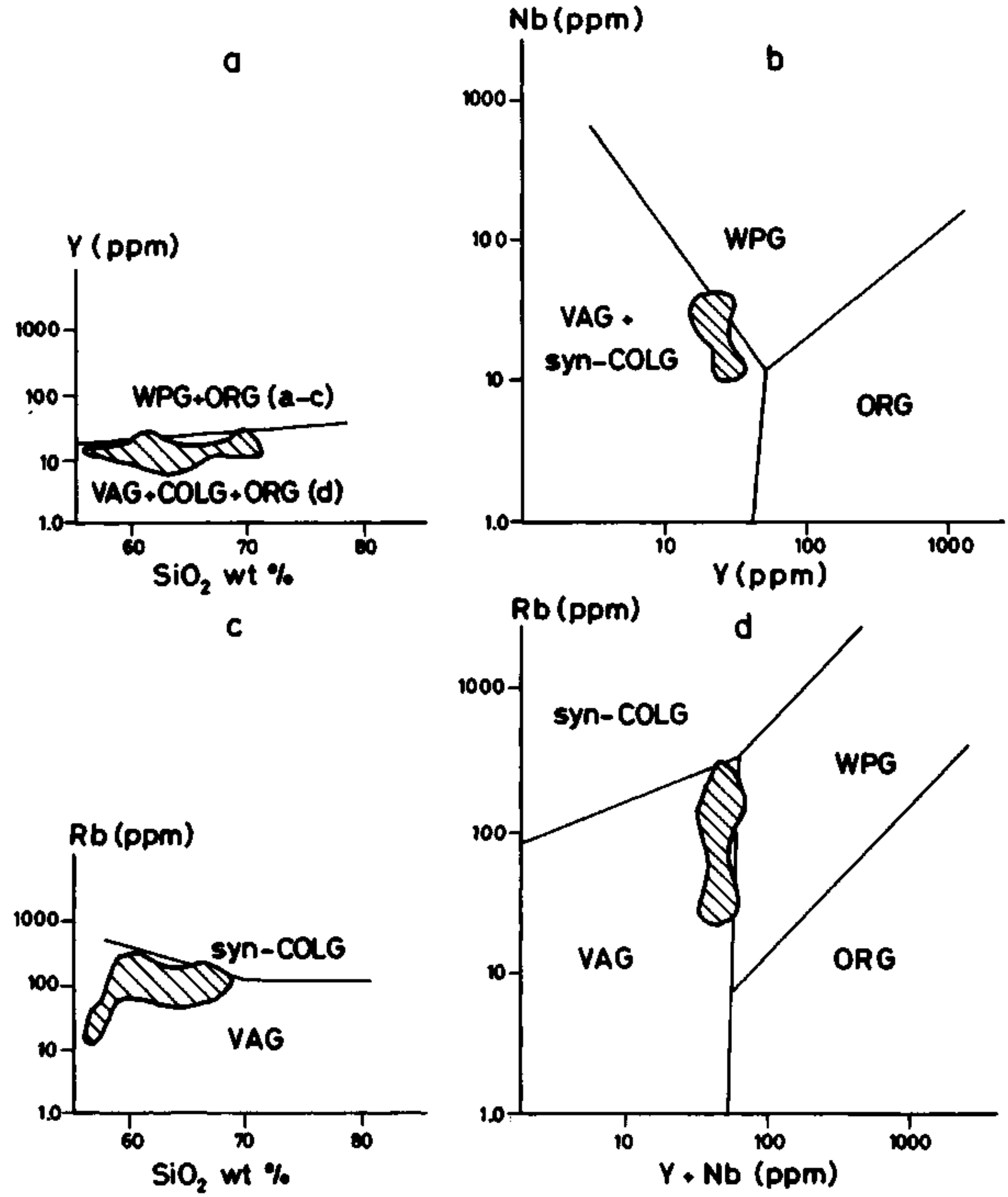

Fig. 11 - a-Y-SiO_2, b-Nb-Y, c-Rb-SiO_2 and d-Rb-(Y+Nb) variations diagrams (WPG: within plate granitoids, ORG: ocean ridge granitoids, VAG: volcanic arc granitoids, COLG: collision granitoids). For further information, Pearce et al. (1984).

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