Mineral Res.Expl.Bull., 110, 17-28, 1990

GEOCHEMICAL IMPLICATIONS FOR TECTONIC SETTING OF THE OPHIOLITIC ROCKS FROM THE OPHIOLITE MELANGE BELT OF THE ANKARA MELANGE

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ABSTRACT.— Ophiolite melange of Cretaceous age is the youngest belt of the Ankara melange and consists mainly of ophiolitic rock fragments such as serpentinite, gabbro, dolerite and basalt of varying sizes, together with pelagic radiolarites and limestones. The ophiolitic melange includes also large isolated masses which are considered to be preserved slices of oceanic lithosphere. The mafic clasts in the melange and the basic dyke rocks of an oceanic lithosphere fragment, Edige body, have comparable compositions. The petrographic and geochemical characteristics of the ultrabasic rocks of the ophiolite melange are correlated with those of depleted mantle peridotite whereas trace element contents, particularly REE, of the basic rocks are within the range of abyssal tholeiites. These ophiolites are believed to be representative of suboceanic environment. However the basic rocks, with their higher LIL and lower HFS element contents relative to MORB, demonstrate island arc characteristics. Such features imply a marginal basin tectonic setting rather than a major ocean basin for the ophiolitic rocks of the melange. The magmas of the basic rocks have most probably been generated by back arc spreading and have been modified by subduction related fluids later.

INTRODUCTION

Ophiolitic melange of Cretaceous age (Norman, 1973) is the youngest belt of Ankara melange (Fig.l) and characterized by the existence of ophiolitic rocks. The Ankara melange has been the subject of a number of publications since its first description (Bailey and McCallien, 1950). Although much attention has been paid to geological and structural features the field distribution and geochemistry of ultramafic and mafic rocks, which record important information about the original geotectonic environment, have not yet been well documented. Tankut (1985) reported limited geochemical data on the mafic volcanic clasts from the ophiolitic and metamorphic melange belts. Tankut and Sayın (1989) studied petrography and major element geochemistry of an isolated peridotite-gabbro body within the ophiolitic melange near Edige. Incompatible trace element chemistry of rocks of the same body has been discussed by Tankut and Gorton (in press) to demonstrate its similarity to oceanic lithosphere. On the other hand, the ophiolitic rocks are reported (Pearce, 1980; Saunders et al., 1980; Hawkins, 1980; Millward et al., 1984) to be generated at the major oceans or at the back arc regions (marginal basins). In this respect, no attempt has so far been made to identify the most probable tectonic setting of that body.

The purpose of the, present paper is to define the geochemical features of the ultramafic and basic rocks of the ophiolitic melange; to demonstrate the relationship between these rocks and the ultramafic and basic dyke rocks of the Edige peridotite-gabbro body; and to discuss the tectonic setting of the ophiolitic rocks of the melange, in terms of incompatible element discriminants, by comparing basic rocks of the melange with those from different geologic settings.

GENERAL FEATURES

The ophiolitic melange belt includes almost all the magmatic rock members of an ophiolite suite, such as serpentinite, occasionally unserpentinized peridotite, gabbro, mafic volcanic and dyke rocks together with pelagic radiolarites and limestones. They occur as clasts of rudite size, but, individual serpentinite lenses and detached

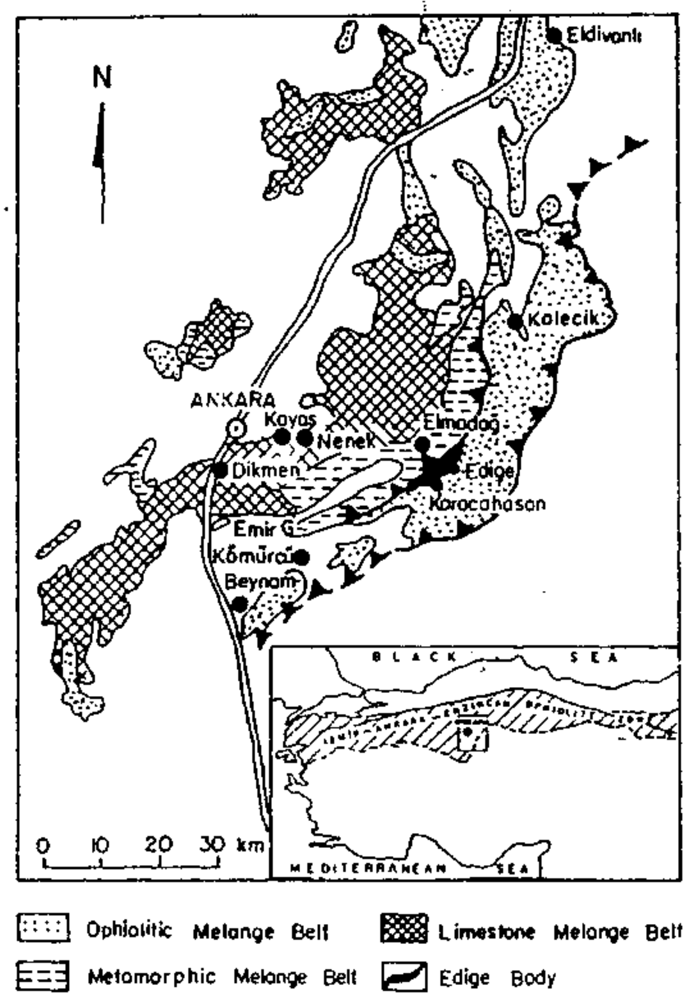


Fig.1 – Distribution of Belts in the Ankara Melange (Bailey and McCallien, 1950; Çapan et al., 1983). Inset shows the location of the Ankara melange.

cumulate gabbro blocks from a meter up to hundred meters in size, are not uncommon. The melange is also reported to contain a few isolated peridotite gabbro bodies, comprising ophiolite sequences, which are considered to be preserved slices of oceanic lithosphere(Akyürek, 1981; Norman, 1985; Tankut and Sayın, 1989;Tankut and Gorton, in press). One of these bodies is located near Edige village, called Edige ultramafic body. Tankut and Saym (1989) described it to be a north east trending lens shaped mass, 10 km in length and 0.2-4 km in width. It is constituted by an ultramafic-tectonitc unit composed of ultramafic rocks only, and a mafic-cumulate unit, composed mainly of cumulate gabbros and some ultramafic rocks. Subparallel doleritic dyke rocks cut both of the units. Since the pillow lava and sedimentary sequences are missing in the body it is an incomplete sequence. Detailed geochemical study by Tankut and Gorton (in press) revealed that, it is a remnant of an oceanic lithosphere fragment in the melange.

The ultramafic rocks of the melange, the clasts within the melange and those from the Edige body, display tectonic fabrics and comprise serpentinite, serpentinized harzburgite, dunite and websterite. The gabbros (clasts and those of the Edige body) show primary cumulate textures, and are commonly layered. The basic rock clasts are basalts and dolerites. They are holocrystalline, the basalts are mostly porphyritic with low proportion of phenocrysts. Basic dyke rocks of the Edige body are dolerites. There are also vesicular and occasionally amygdaloidal mafic volcanics which are reported from Kalecik area (Tankut, 1985).

GEOCHEMISTRY

Major elements were determined on glass pellets, Sr, Rb, Zr, Nb, Y, Ni, Cr, V on powder pellets, by X—Ray fluorescence at the Geology Department of the University of Toronto, and other trace elements by the instrumental neutron activation analysis technique after irradiating the rocks in the Slowpoke Reactor of the University of Toronto according to the technique of Barnes and Gorton (1984).

Ultramafic rocks and gabbros

The trace element data of a serpentinized dunite (92 A) from the clasts in Beynam area and ultramafic rocks from the Edige body are given in Table 1. The rocks have high compatible (Cr and Ni) and very low incompatible

Table 1 Trace element contents of ultramafic roeks **from the ophiolitc melange**

	P1	P5	92A
Nb	2.35	1.85	1.27
Zr	0.59	2.13	1.75
Sr		8.47	-
Rb	4.49	4.39	4.90
Sc		2.65	-
Cr	4450	3687	4388
Ni	2511	498	2237
V	74	100	40
La	0.4	0.1	0.16
Sm	0.02	0.02	0.51
Eu	0.9	-	0.14
Yb		0.13	0.2
Lu	0.02	0.03	0.51

P1- serpentinized harzburgite, tectonite unit, Edige body; P5- websterite, cumulate zone, Edige body;
92A- serpentinized dunite, Beynam.

element contents such that, some of the rare earth elements (REE) could not even be detected. However, the incomplete REE patterns, obtained by the elements detected, generate the "U" shape (Fig.2), typical of ophiolitic ultramafic rocks (Coleman, 1977). The profile (Fig.2) of an average of three cumulate gabbros from the Edige body (Tankul and Gorton, in press) is comparable with that of "average mafic cumulate gabbros" of an ophiolite sequence (Coleman, 1977).

Basic rocks

The geochemicai data (Table 2) presents major and trace elements of the basic rocks (SiO_2, < 52 %). The clast samples BM1 and BM5 are basalts, BM3 is a doleritic rock from Beynam area, U44 is a very fine grained do-

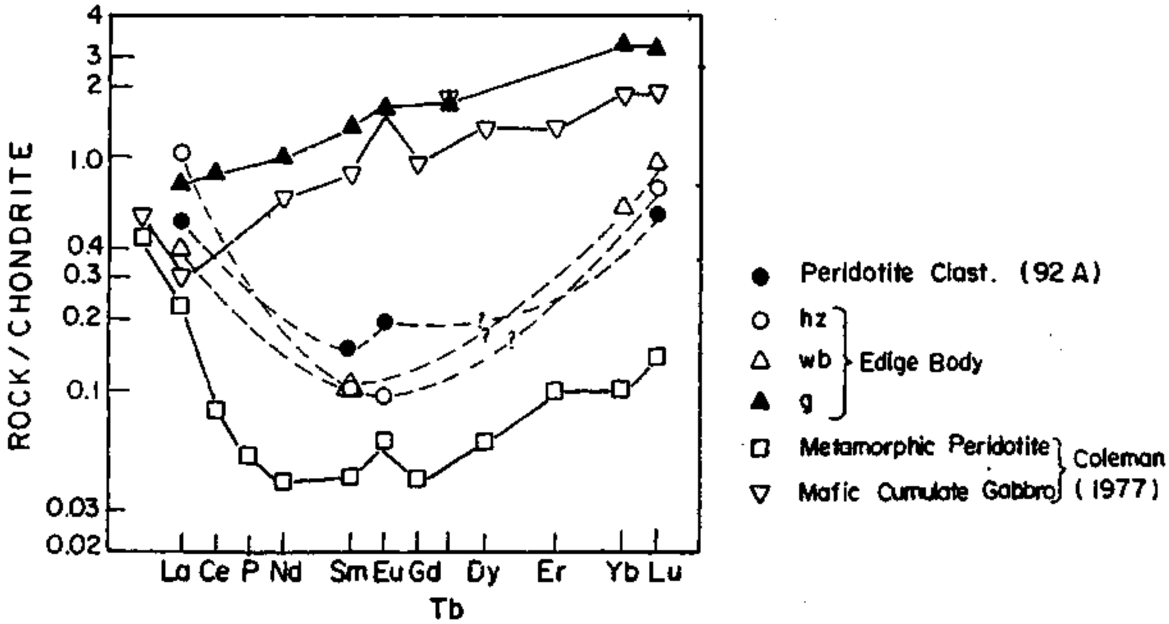


Fig.2— REE patterns of the ultramafic rocks and gabbros, from the ophiolitic melange, hz- harzburgite tectonite unit (Edige body); wb- websterite, cumulate unit (Edige body); g- averages of three cumulate gabbros.

leritic rock from Karacahasan village and EK3 is a basalt from Kalecik area. The basic rocks of the Edige body are represented by the averages of dyke rocks from the tectonite and cumulate units.

The basic rock clasts of the melange and basic dyke rocks of the Edige body have comparable compositions. Jensen (1976) plots (Fig.3) and P2O5 -Zr variation (Flg.4) demonstrate the tholeiitic character of all the rocks. In the Ti/100—Zr—3Y diagram (Fig.5) the majority of the rocks fall in the ocean floor basalt (OFB) field. The

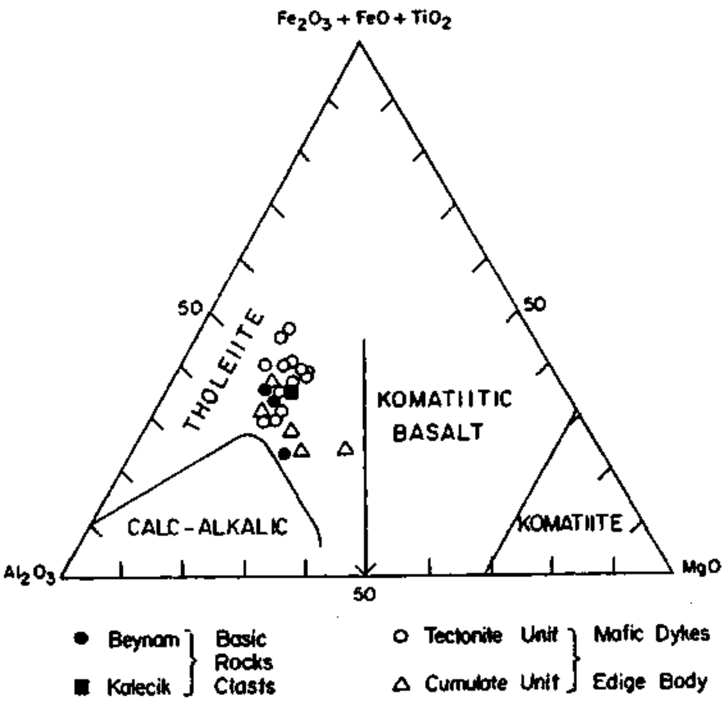


Fig.3— Jensen plots of the basic rocks from the ophiolitic melange.

Table 2– Major (%) and trace element (ppm) contents of basic rocks from the ophiolite melange

	Basic Rock Clasts					*Edige Body*	*Dyke Ave.*
						*Tect.**	*Cumul.**
	BM1	*BM3*	*BM5*	*EK3*	*U44*	*unit*	*unit.*
SiO_2	50.53	51.34	50.47	44.72	–	49.90	52.02
TiO_2	1.12	0.26	1.13	0.75	–	1.63	0.72
Al_2O_3	15.96	17.16	15.93	13.29	–	14.70	15.51
Fe_2O_3T	11.14	7.57	11.11	10.42	–	12.07	8.84
MnO	0.14	0.12	0.14	–	–	0.17	0.14
MgO	6.32	8.17	5.89	6.25	–	6.08	7.52
CaO	4.88	11.07	5.33	12.33	–	7.65	8.58
Na_2O	3.31	2.30	3.34	0.38	–	4.82	3.61
K_2O	0.28	0.28	0.29	5.76	–	0.35	0.26
P_2O_5	0.13	0.07	0.12	–	–	0.19	0.12
LOI**	6.81	2.05	6.94	5.54	–		
Total	100.62	100.39	100.69	99.44	–		
Nb	3	2.6	4	4	–	4	1.5
Zr	96	21	98	112	–	104	31
Y	25	7	25	36	–	30	18
Sr	441	100	420	752	–	187	123
Rb	11	9	12	136	–	8	8
Hf	1.7	0.3	2.2	–	1.2	2	1.4
Ta	–	–	–	–	–	0.26	0.1
Cr	53	166	36	–	–	122	151
Ni	10	101	8	–	–	94	126
La	3.9	2.9	4.3	–	2.1	6	3
Ce	10.7	3.7	8.2	–	5.2	16	5
Nd	5.7	2.2	6.9	–	4.1	10	2
Sm	2.9	0.5	3	–	2.5	3.5	2
Eu	0.9	0.18	1	–	0.75	1	0.5
Tb	0.6	0.15	0.7	–	0.7	0.7	0.5
Yb	3.1	0.96	2.9	–	3.0	3.1	2.16
Lu	0.49	0.16	0.5	–	0.5	0.48	0.34

B- Beynam, EK- Kalecik, U- Karacahasan.

* Tectonite, cumulate

** Loss on ignition

Fe_2O_3T=Total Fe_2O_3

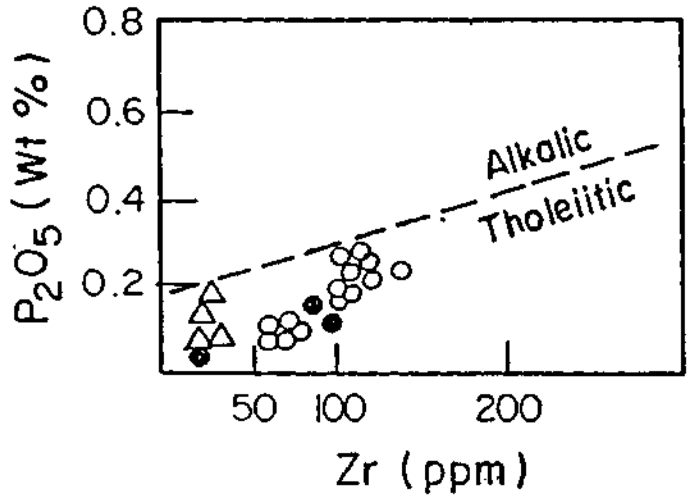


Fig.4— P_2O_5—Zr variation of the mafic rock from the Ankara melange. The symbols are as in Figure 3 (discrimination line after Floyd and Winchester, 1975).

REE contents of the Beynam (BM1, BM3, BM5) and the Karacahasan (U44) samples are within the range of the dykes of the Edige body and are comparable with the rocks of the depleted MORB (Fig.6). Only one of the Beynam samples, BM3, displays a profile with much lower values than the other rocks.

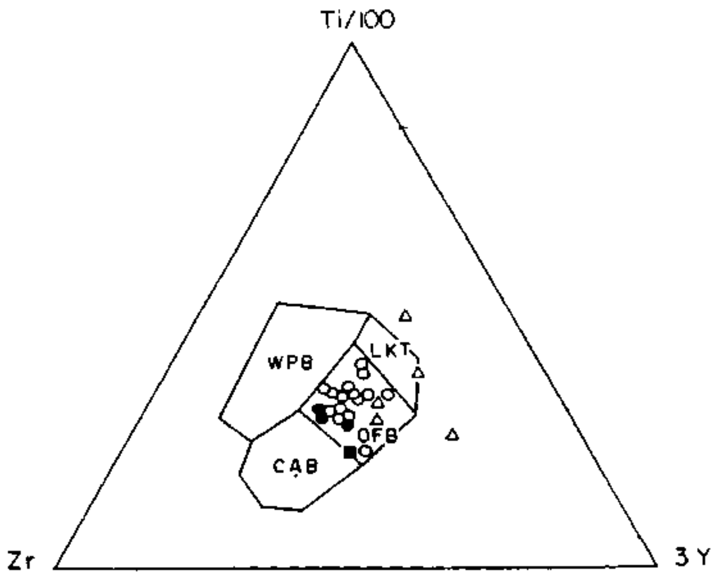


Fig.5— Ti/100-Zr-3Y variation for the mafic rocks from the ophiolitic melange. The symbols are as in Figure 3 (Pearce and Cann, 1973).

The multielement patterns (Fig.7), normalized to an average MORB composition (Pearce, 1980), of the mafic rock clasts of the melange and of the dykes from the Edige body show similarities. Most of the rocks are comparable in HFS (high field, strength) element content with MORB, except the rocks from the cumulate unit, which give similar HFS values to that of island arc tholeiite. In all the samples the content of LIL (large ion lithophile)

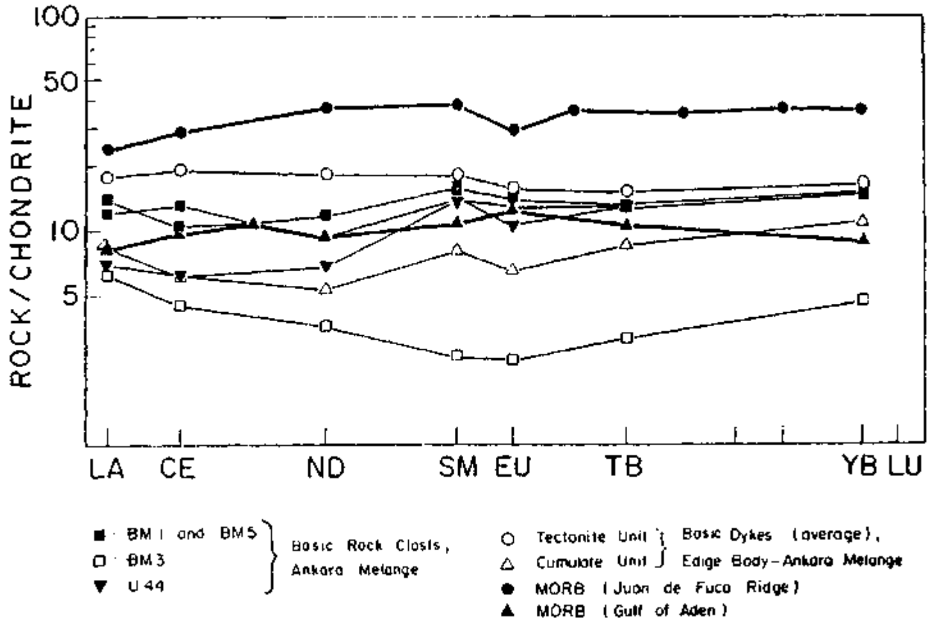


Fig.6— REE patterns of the mafic rocks from the ophiolitic melange. Values for the dykes in Edige body from Tankut and Gorton (in press), for Juan de Fuco Ridge from Pearce (1980), for Gulf of Aden from Schilling (1970).

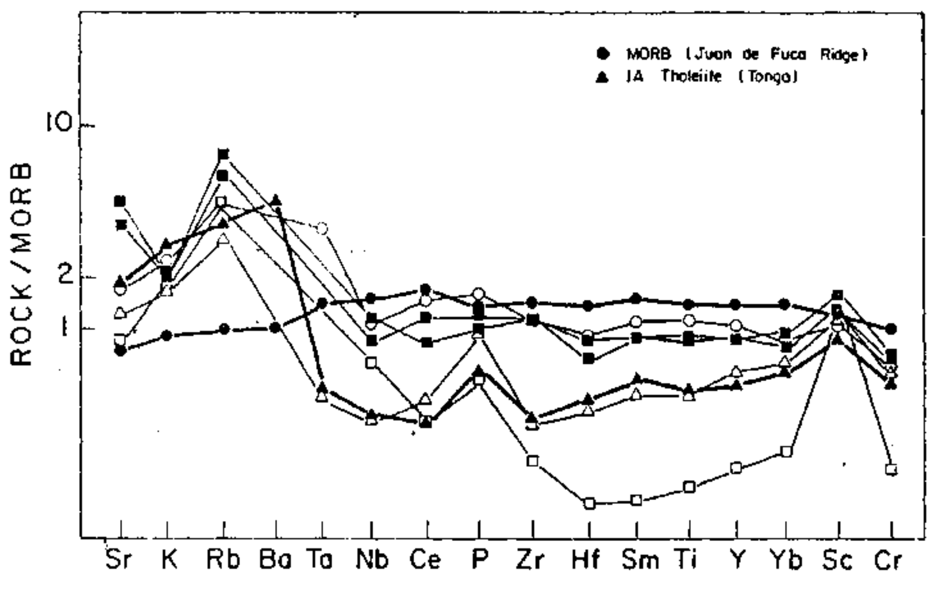
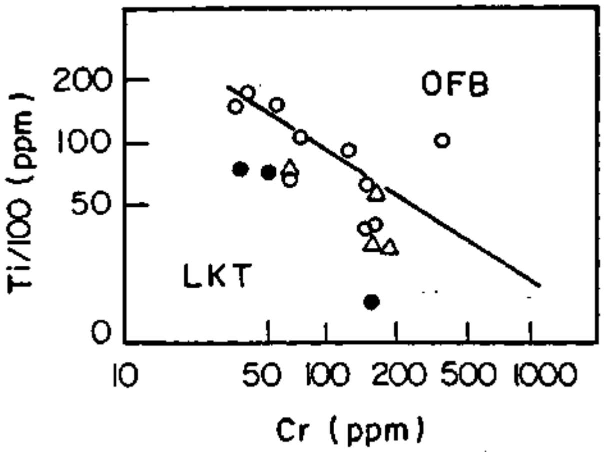


Fig.7— Multielement variation of the mafic rocks from the ophiolitic melange (values for the dykes in Edige body from Tankut and Gorton (in press); for MORB and IA from Pearce (1980). Symbols are as in Figure 6.

elements is high compared to MORB. The plots of Ti and Y jagainst thefractionationindex Cr fall in LKT (low potassium tholeiite) and IA (island arc) fields (8a, 8b). Hf-Ta-Th variation (Fig.9) also show the intermediate features of these rocks between MORB and IAT.



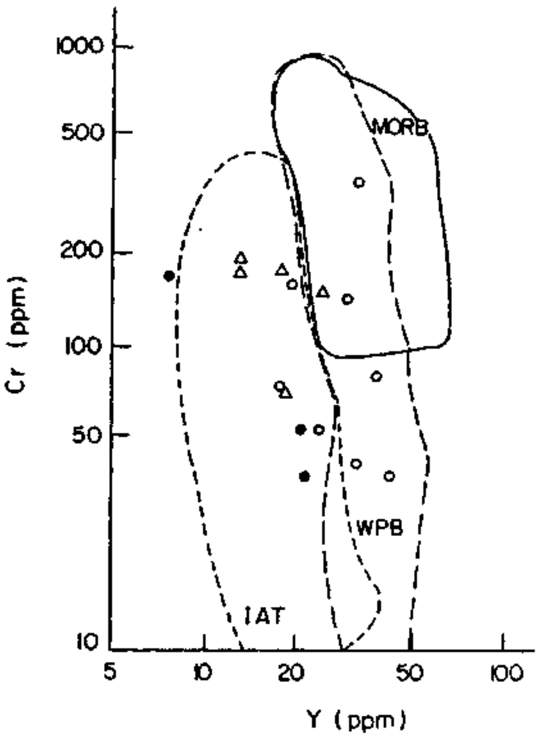


Fig.8— Ti-Cr variation of mafic rocks from the ophiolitic melange.

a- Symbols are as in Figure 3 (discrimination fields after Pearce, 1975).

b— Cr-Y variation of mafic rocks from the ophiolitic melange. Symbols are as in Figure 3 (the discrimination fields after Pearce, 1980).

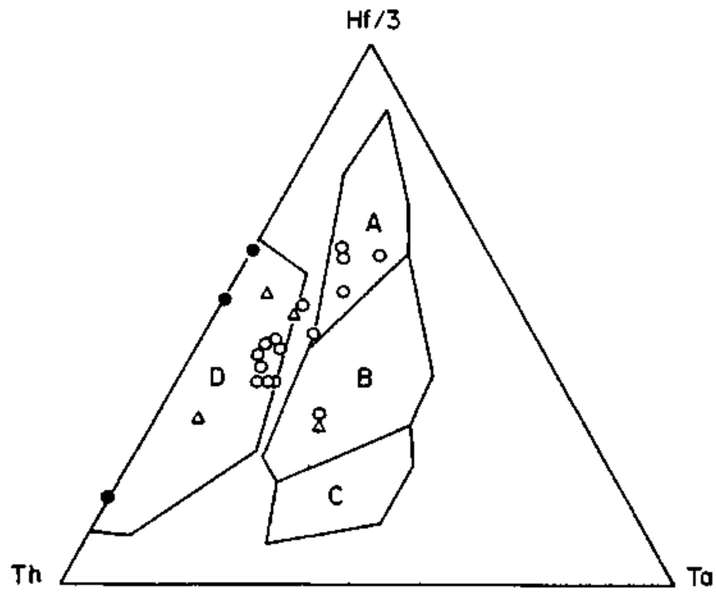


Fig.9- Hf-Th-Ta variation of basic rocks from the ophiolitic melange. Symbols are as in Figure 3. Thefields:

A- N-type MORB; B- E-type MORB; C- WP basalt; D- IA volcanics (after Wood, 1980).

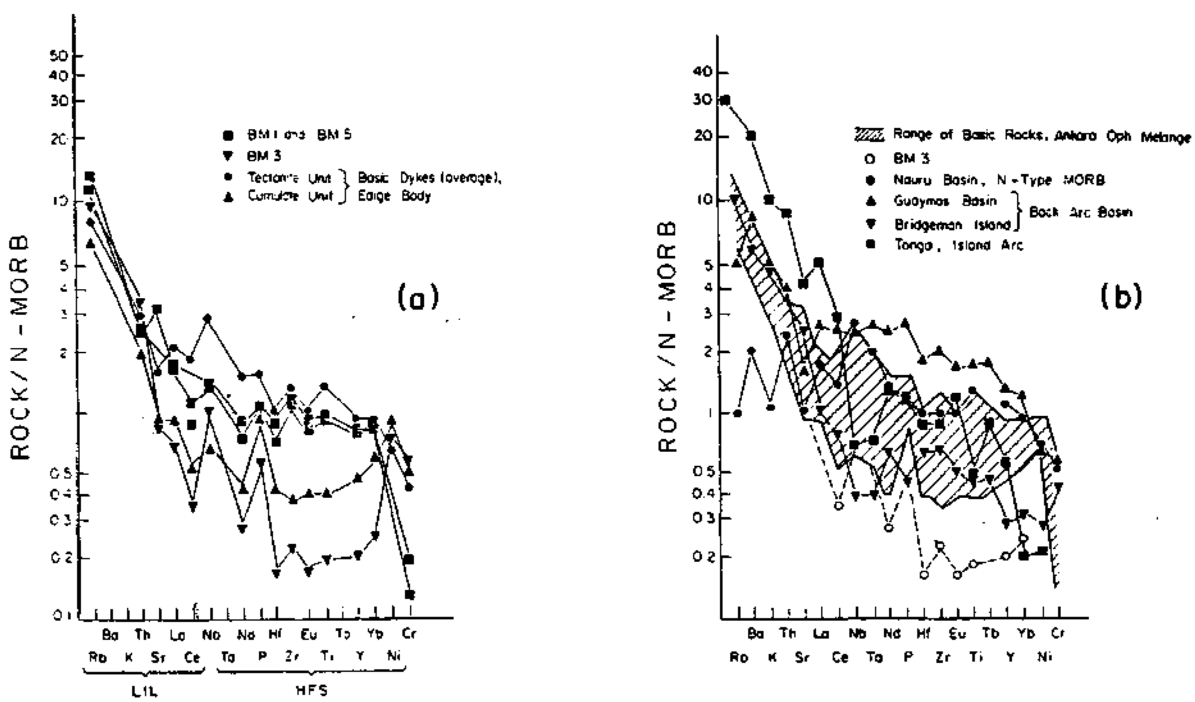


Fig.10– Multielement variation of rocks

a– Basic rocks from the ophiolitic melange

b– Rocks from different tectonic settings (Millward et al., 1984).

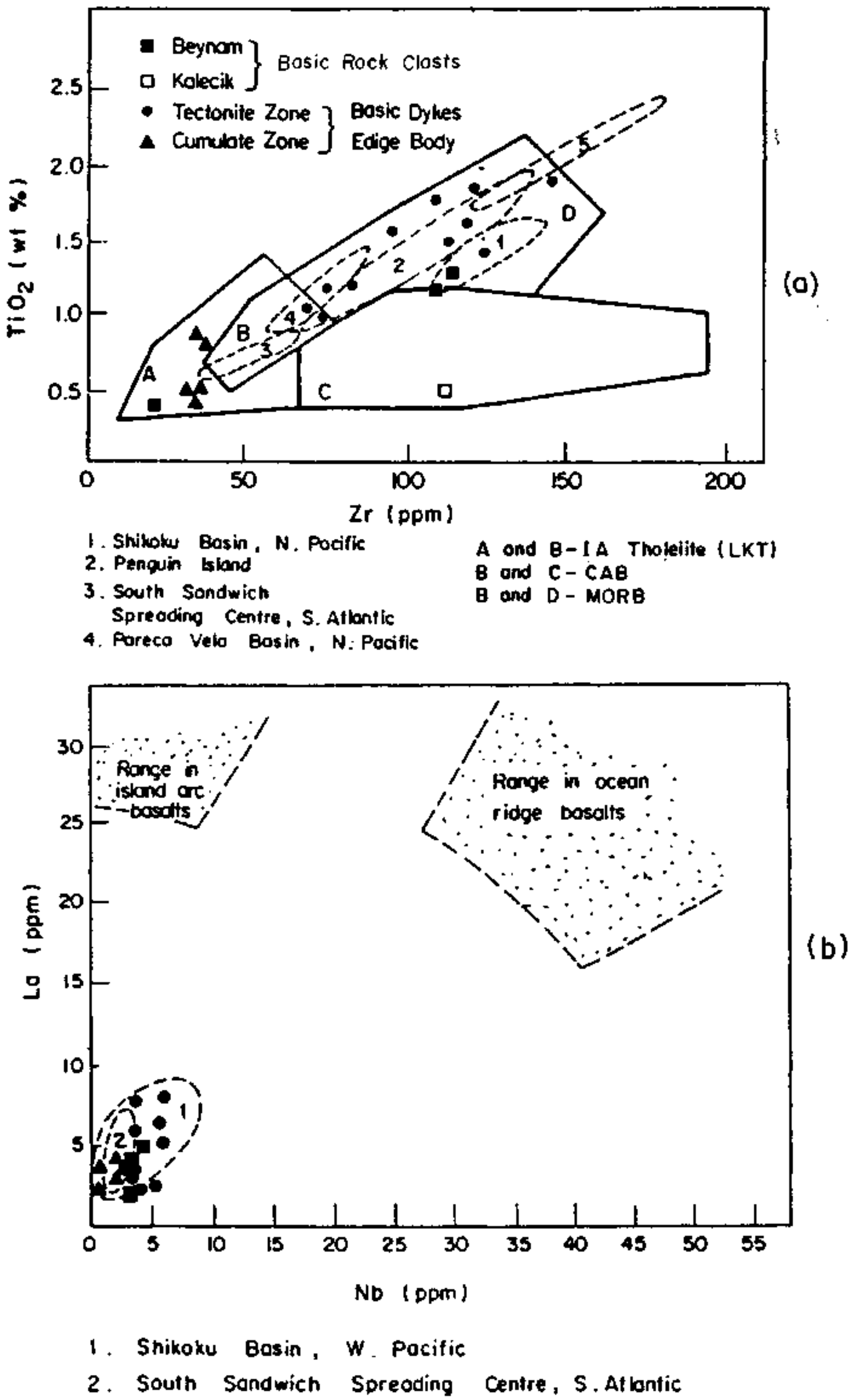


Fig.11 – Comparison of the basic rocks of the melange with basalts from various areas of known back arc tectonic settings. The symbols are as in Figure 3 (Saunders et al., 1980).

a– TiO_2 – Zr variation

b– La – Nb variation

DISCUSSION AND CONCLUSION

The large number of trace element data simply demonstrate the similarity of the ultramafic and basic rock clasts to the corresponding rocks of the lithosphere fragment called Edige body (Tankut and Gorton, in press) in the Ankara melange. According to the Ti, Y, Nb and Zr the rocks form two chemical groups. The basic rock clasts from Beynam and Kalecik, and basic dyke rocks from the tectonite zone of the Edige body have the higher concentrations of these elements particularly of Zr, whereas, the basic rock clasts BM3, except its very low HFS content, somewhat resembles the dyke rocks from the cumulate zone of the lithosphere fragment. Such compositional variation between the two groups may imply different MORB type of magma sources, which have possibly « been produced by variable degrees of partial melting from the oceanic upper mantle. The rocks with low Zr, Ti, Nb, Y have higher Ni and Cr contents relative to those with high Zr, Ti, Nb, Y therefore, seem to be less fractionated and may represent the more primitive source. The possibility of formation of the two groups from a common magma by differention can not be tested in the light of the available data. However the relationship of the two groups will also be better understood with isotope studies and with precise radiometric age determinations of the rocks.

On the other hand, the island arc signature, revealed by LIL, HFS distribution (Fig.7), implies a magma type, transitional between abyssal tholeiite and arc tholeiite for the above discribed two groups of mafic rocks. Millward et al. (1984) compared the chemical composition of basaltic rocks from various modern tectonic environments, using the multielement plots normalized to N-type MORB (Fig.10 a, b). The patterns of high-Zr group display similarity to Bridgeman island whereas the low-Zr group to Guaymas Basin basalts, both areas are reported to be of back arc type of basins (Millward et al., 1984).Saunders et al.(1980) plotted the basalts from various back arc tectonic environments and defined discrimination fields on the Zr-$Ti0_2$ diagram of Pearce and Cann (1973). The plots of the high-Zr group rocks fall in the fields of characteristic back arc basin basalts (Fig. 11 a). Similarly, the La-Nb,discriminants (Saunders et al.,1980) also indicate the back arc setting (Fig. 11 b) for all the rocks. In the Eastern Mediterranean part of the Tethyan domain, Hatay, Baer-Bassit (Delaloye and Wagner, 1985) and Oman (Pearce, 1980) are defined to show features in common with the back arc basins.

Finally, all the evidences discussed above may lead to the conclusion that the studied ophiolitic rocks of the melange have possibly been formed by back arc spreading in a basin close to the subduction zone where the source magmas of the basic rocks were modified by subduction related contamination.

ACKNOWLEDGEMENT

The author wishes to thank Drs. M.P. Gorton, C. Cermignani, R. Hancock for their help during the analytical part of the.work. Prof. T. Norman is thanked for valuable discussions. Drs. A. Türkmenoğlu, Mr. N. Sayın, acknowledged with thanks for their help in various stages of the work.

The gratitudes are extended deeply to Prof. T. Tankut and Prof. M. Üzümeri for their kind concern.

Manuscript received January 18, 1989

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