CHARACTERISTICS AND ALPINE DEFORMATION OF LATE PALEOZOIC GRANITOIDS AND RELATED ROCKS FROM THE BITLIS METAMORPHIC BELT, SE-TURKEY

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ABSTRACT

Dynamo-metamorphic granitoids and felsic pyroclastics occur as discontinuous bodies within the alpine tectonic slices of the Bitlis Metamorphics. The granitoids have intrusive contacts with the pre-Devonian (pre-Cabrian?) high-grade metamorphic basement and its pre-Permian cover, respectively. Geochemical data suggest that the granitoids are peraluminous leucogranitoids, displaying I and S type characteristics and within plate tectonic setting.
Alpine regional deformation and recrystallization of the granitoids along mega shear-zones have produced phengite bearing orthogneisses. Rb/Sr and K/Ar data on phengites clearly indicate that this tectono-metamorphic overprint is developed in two successive phases and alpine in age.
Considering the differences in their tectonic settings, the Late Paleozoic axes in Anatolia have been separated into two distinct zones.

INTRODUCTION

The Bitlis Metamorphic Belt is an allochthonous tectonic unit, which is composed of numerous northward dipping slices of metamorphic rocks, ophiolites and their Lower Tertiary cover. It overlies the Paleozoic-Tertiary platform sequences of the Arabian Autochthon with a sandwiched tectonic zone of Tertiary flyschoidal complexes.

Detailed studies on different parts of the Belt (Boray, 1975; Yilmaz, 1975; Hall, 1976; Yilmaz et al., 1981; Goncuoglu and Turhan, 1983; 1984; 1985; Caglayan et al., 1984) differentiate between an intensively metamorphosed basement (Hizan Metamorphic Complex) of pre-Devonian and probably Precambrian age (Goncuoglu, 1983) and a moderately metamorphosed Paleozoic-Lower Mesozoic cover (Mutki Group).

Deformed granitoids and felsic pyroclastics are commonly located in the upper tectonic slices of the belt and cover extensive areas in its central part (Fig. 1).

The suggestions on the geodynamic setting of this Late Paleozoic igneous activity, whose products are the granitoids and related rocks described in this study are contradictory. Considering the Iranian representatives (Sanandaj-Sirjan Zone) Dewey et al. (1973) interpreted the granitoids in the Bitlis belt as products of an extension related igneous activity. Goncuoglu (1989) correlated the Carboniferous granitoids of the Bitlis zone with those of Western Anatolia and proposed an extensional "Hercynian" back-arc setting.

Sengor (1990) originally suggested this igneous activity to be related to the formation of Cordilleran-type core complexes that had accompanied the opening of "Neo-Tethys".

Sengor (1991) recently changed his model and interpreted the "calc-alkaline" granitoids as subduction-related magmatics which were formed on the active margin of the southward subducting "Palaeo-Tethys".

The aim of this study is to present the chemical compositions, geological relationships and geodynamic setting of the granitoids as well as to report the type and age of the dynamic overprint in such a way that it may easily be utilized for interregional correlations within the ambit of IGCP Project No. 276.

GEOLOGICAL SETTING OF GRANITOIDS AND FELSIC PYROCLASTICS

Granitoids

Out of numerous granitoid bodies within the Bitlis Metamorphic Belt only four occurrences of similar geological setting are studied in detail. These are: Mus-Kizilagac Metagranitoid (Goncuoglu, 1984), Mutki Meta-granitoid (Mason, 1978; Tolluoglu, 1988), Yayla Meta-granitoid (Helvaci and Griffin, 1984) and Cacas Meta-granitoid (Yilmaz, 1971).

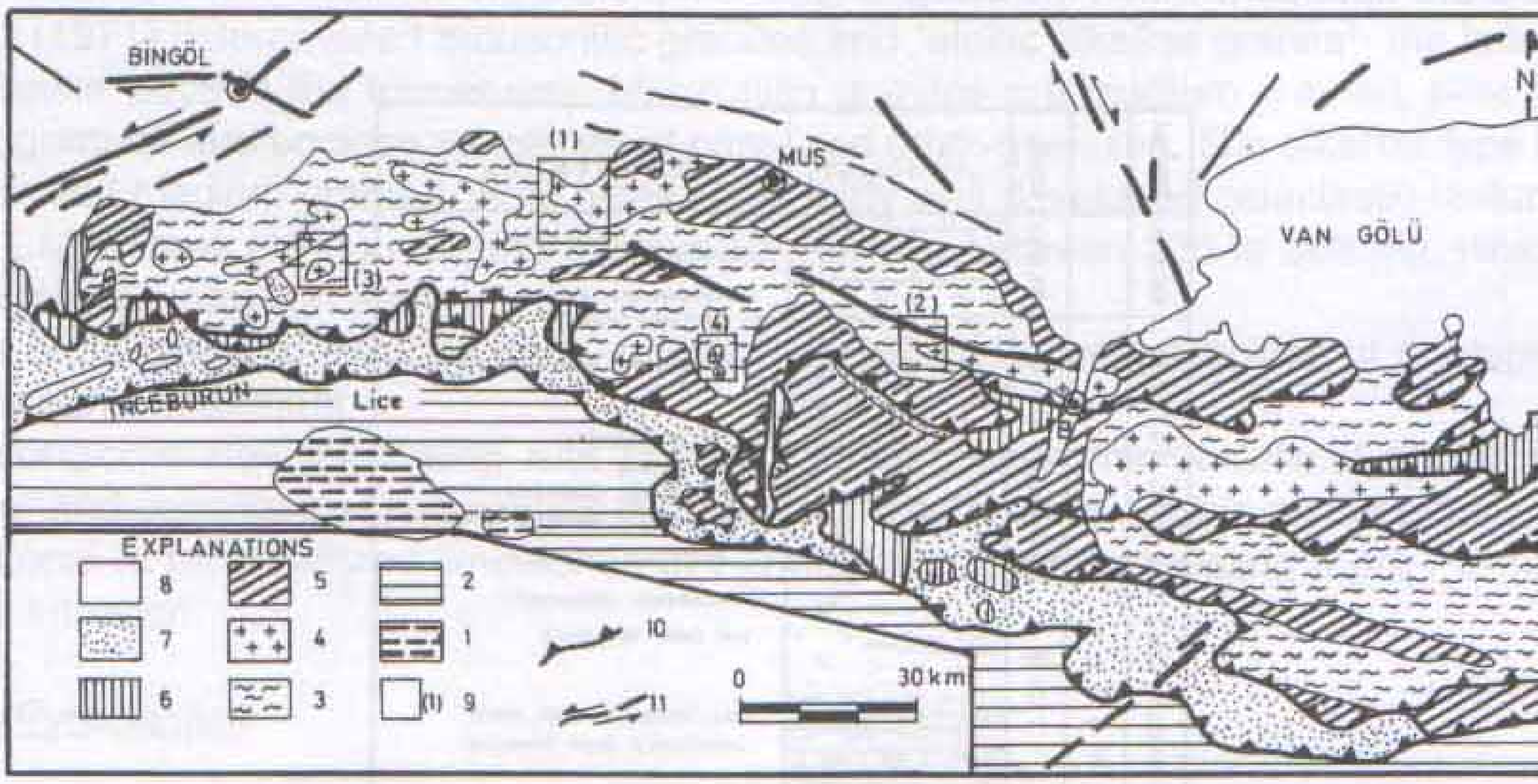

Fig. 1 - Simplified geological map of the Bitlis Metamorphic Belt. 1: Paleozoic-Mesozoic sediments of the Arabian Platform, 2: Tertiary sediments of the Arabian Platform, 3: Pre-Cambrian metamorphics of the Bitlis Metamorphic Belt (BMM), 4: Meta-granitoids of the BMM, 5: Paleozoic-Mesozoic metamor phics of the BMM, 6: Ophiolites and ophiolitic melanges (Upper Cretaceous), 7: Tertiary cover of the BMM, 8: Neogene, 9: Studied meta-granitoids; (1): MKM, (2): MM, (3) YM and CM, 10: Overthrusts, 11: Strike-slip faults.

Mus-Kizilagic Meta-granitoid (MKM).

MKM is located to the southwest of Mus and forms the largest granitoide body in the Bitlis Metamorphic Belt. The main body consists of medium grained, leucocratic granitoids with fairly well-developed foliation.

MKM shows severe disturbance of its Rb-Sr systems and no whole-rock isochron age could be obtained (Goncuoglu, 1984). However, MKM intrudes the gneisses and amphibolites of the Hizan Metamorphic Complex and the lower units (Meydan Formation, Goncuoglu and Turhan,1984) of the Mutki Group, respectively. Recrystallized limestones of Meydan Formation contain Middle Devonian fossils. On the other hand, the basal conglomerates of Lower Permian sequence (Cirrik Limestone), are dominated by granitic clasts. This geological data clearly indicate that the intrusion age of MKM is post Middle Devonian but pre Early Permian.

Multi Meta-granitoid (MM)

MM is situated in the central part of the Bitlis Metamorphic Belt, to the north of Mutki. The main body is of ellipsoidal shape and thrusted on the Cretaceous ophiolites. The trhust surface is irregular in shape. Approaching the thrust contact a rapid change from massive, medium-grained granite to foliated granitic gneiss and finally to mylonite is observed (Mason, 1978).

Mm has not yet been dated by radiometric methods. However, at its northwestern boundary MM is intruded into amphibolites and gneisses of the Hizan Metamorphic Complex. Well developed skarns at the contact to the dolomites of the Meydan Formation suggest a post Devonian age for the intrusion.

Yayla Meta-granitoid (YM)

YM is located to the east of Avnik, southwestern part of the Bitlis Metamorphic Belt. The main body is coarse grained and fairly foliated at its southern contact. Alpite and pegmatite dykes and veins are abundant within the body.

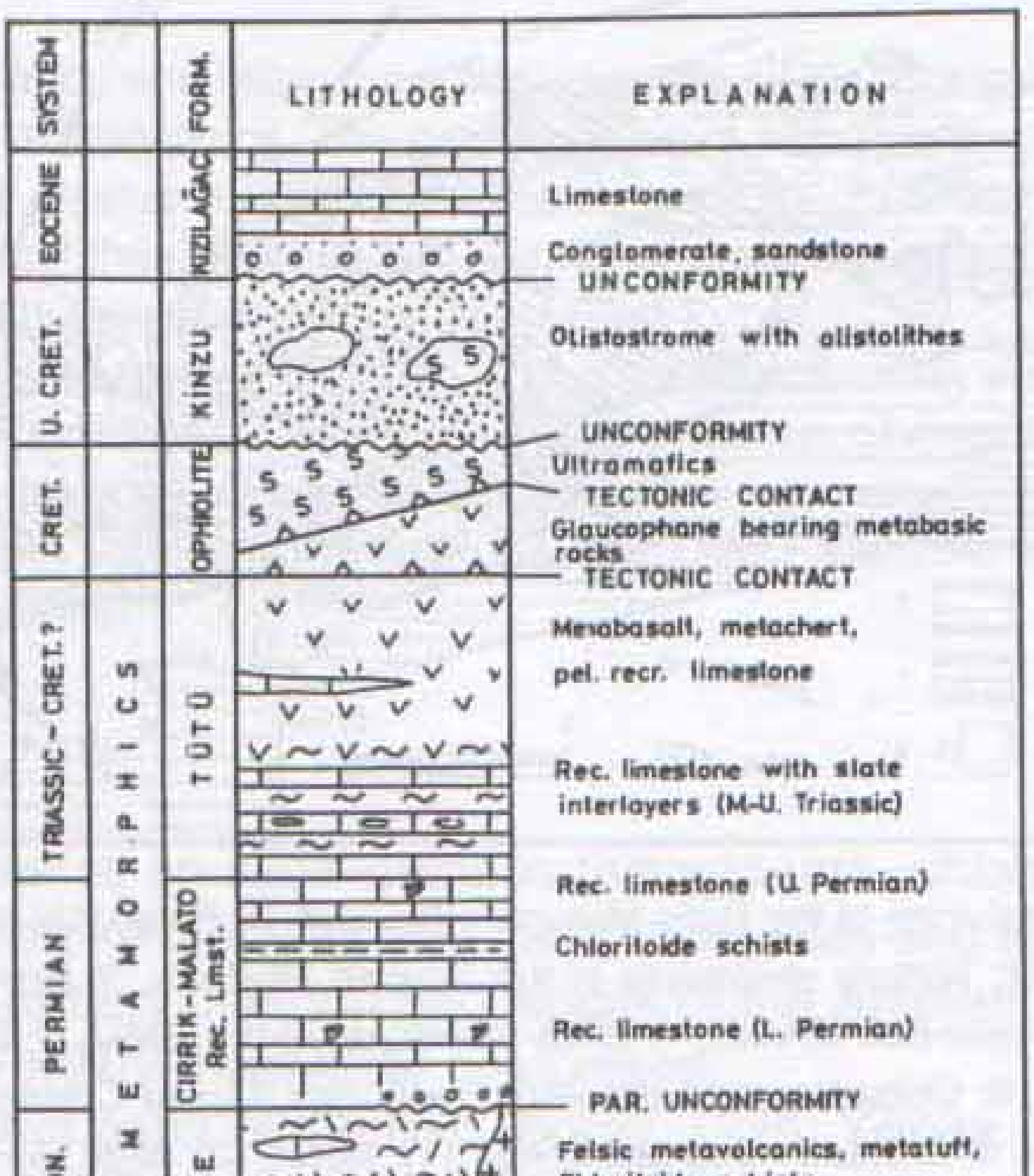

Fig. 2 - Generalized columnar section of the BMM (after Goncuoglu and Turhan, 1984).

The Yayla meta-granite gives a reasonably well-defined Rb/Sr whole-rock isochron of 347 +- 52 Ma (Helvaci and Griffin, 1983, 1984). It intrudes the quartzo-feldspatic gneisses, amphibolites and felsic meta-volcanics with sharp contacts. The felsic metavolcanics yield an Rb/Sr whole-rock isochron age of 454 + 13 Ma. Avnik Granitoid, on the other hand is an extremely albitized (Avnik Meta-albitite), heterogeneous and foliated body and shows transitional, migmatitic contacts with surrounding metamorphics. Helvaci and Griffin (1984) suggest that Yayla and Avnik Granitoids are not genetically related to one each other. The difference in albitization is a further evidence to interpret them separated intrusions which also differ in age. The angular disconformity reported by Helvaci and Griffin (1984) between the "basement" which is intruded by granitoids and the overlying "lower cover", consisting of garnet-bearing mica-schists and calc-schists, cannot be confirmed in later fieldwork (Goncuoglu and Turhan, 1985).

The unconformity is rather between the albitezed garnet-bearing mica-schists and the overlying massive marbles which contain Permian fossils. Goncuoglu and Turhan (1985) further report that aplitic and pegmalitic dykes are intrusive in the "lower cover".

Cacas Meta-granitoid (CM)

CM is located to the south of the Bitlis Metamorphic Belt.

Yilmaz (1971) differentiated monzonitic granites and "albitic alkaline granite", the latter found as irregular pods in the former one. Monzonitic granites are medium grained, pink colored, heterogranular and enclose xenolithes of para- and otho -gneisses. The alkaline type is white in color and medium grained. Both types show fairly well developed cataclastic textures.

From CM, Yilmaz (1971) reported Rb/Sr ages ranging between 336 to 363 Ma, which were interpreted as intrusion ages.

Cacas Meta-granitoid intrudes ortho- and para-gneisses and amphibolites of the high-grade metamorphic basement.

Microconglomerates alternating with chlorite-schists contain microclasts of "albitic alkaline granite" and unconformably cover the basement. These chlorite-schists on the other hand are transitional to recrystallized limestones of Permian age, thus suggesting a pre-Permian age for the intrusion.

Felsic Pyroclastics

Two distinct and widespread meta-felsic units are described from the Bitlis Metamorphic Belt. The first one is located within the high-grade metamorphic basement and has been studied in detail by Yilmaz (1977) and Helvaci and Griffin (1983). This unit is Lower Paleozoic in age and irrelevant to the Late Paleozoic magmatism, the main topic of this paper.

The second and more critical meta-felsic unit is described by Goncuoglu and Turhan (1983, 1984, 1985) as Cesme Unit (Fig. 2), which consists of felsic meta-tuffs and porphyritic meta-rhyolites alternating with meta-agglomerates and mafic/intermediate meta-volcanics (meta-latites?). Blocks and bands of fine-grained recrystallized limestones and calc-schists are the other constituents. Rare mylonitic aplite dikes cut the meta-rhyolites.

Cesme Unit shows graditional contacts with the underlying fossiliferous meta-carbonates of Middle-Upper Devonian age.

A thin, carbonate-rich basal meta-conglomerate with granite and felsic volcanic pebbles disconformably cover the Cesme Unit. The meta-conglomerate is followed by medium to thick bedded, dark colored, fossil-bearing recrystallized limestones of Lower Permian age. This geological data clearly indicate the presence of an important subareal volcanism during Carboniferous, which is termporally in accordance with the granitic intrusions described above.

GEOCHEMISTRY

The available major and trace element analyses of 20 rock samples from Late Paleozoic meta-granitoids (MKM, MM, YM and CM) are given in Table 1.

Classification of these granitoids based on Q and P parameters of Debon and Le Fort (1982) is shown in Figure 3.

TABLE 1

Chemical compositions of the Bitlis granitoids.

Squares: MM (Tolluoglu, 1988) triangles : YM (Helvaci and Griffin, 1983), circles: MKM (Goncuoglu, 1984), asteriscs: CM (Yilmaz, 1971).

Symbol	●	●	●	●	▲	▲	▲
Sample No	BMa1	BMa2	BMb1	BMb2	S1-25	S1-26	S1-27
SiO2	77.34	76.80	76.75	77.58	74.58	77.92	72.77
TiO2	0.06	0.05	0.05	0.05	0.08	0.07	0.20
Al2O3	12.48	12.53	12.71	12.35	13.94	11.61	14.66
Fe2O3	0.76	1.08	0.94	0.89	0.50	0.40	1.46
MnO	0.01	0.04	0.02	0.01	0.04	0.00	0.07
MgO	0.08	0.02	0.05	0.03	0.12	0.02	0.07
CaO	0.10	0.18	0.20	0.07	0.25	0.09	0.20
Na2O	3.96	3.96	3.88	5.00	4.46	3.44	3.77
K2O	4.75	4.77	7.75	3.56	5.53	5.18	6.23
P2O5	0.02	0.02	0.02	0.03	0.08	0.01	0.16
LOI	0.41	0.12	0.11	0.02	na	na	na
Total	100.06	99.58	99.48	99.59	99.37	98.74	99.59
Rb	241	237	247	125	117	137	191
Sr	8	6	8	12	36	30	22
Ba	85	78	99	120	na	na	na
Zr	108	108	108	109	103	78	104
Y	91	87	100	74	70	64	52
Nb	18	19	18	20	19	15	12

Symbol	▲	▲	■	■	■	■	■
Sample No	S1-29	S1-30	UT-6	UT-22	UT-37b	UT-110	UT-124
SiO2	73.91	69.94	73.48	70.46	75.36	71.47	78.48
TiO2	0.07	0.34	0.38	1.11	0.15	1.12	0.13
Al2O3	13.50	14.68	13.59	12.85	13.44	15.58	13.30
Fe2O3	0.99	2.74	2.07	4.58	1.01	4.54	1.28
MnO	0.05	0.10	0.01	0.06	0.01	0.01	0.07
MgO	0.05	0.10	0.02	0.17	0.01	0.30	0.07
CaO	0.22	1.81	0.52	1.21	0.10	1.51	0.99
Na2O	2.84	3.17	4.06	3.53	3.32	4.20	3.41
K2O	7.56	5.42	3.51	4.21	4.42	2.33	3.82
P2O5	0.20	0.16	na	na	na	na	na
LOI	na	na	0.23	0.16	0.31	0.31	0.25
Total	99.39	98.36	97.86	98.34	98.11	101.39	101.80
Rb	190	177	na	na	na	na	na
Sr	56	63	na	na	na	na	na
Ba	na	na	na	na	na	na	na
Zr	71	195	na	na	na	na	na
Y	43	40	na	na	na	na	na
Nb	10	15	na	na	na	na	na

Symbol	■	■	■	■	☼	☼
Sample No	UT-73	UT-128	UT-166	UT-203	Cs101	Cs138
SiO2	72.24	77.38	72.91	75.21	75.45	77.05
TiO2	0.66	0.23	0.55	0.73	0.15	0.20
Al2O3	13.22	13.20	13.20	12.40	12.75	12.00
Fe2O3	3.45	1.88	2.29	3.39	1.45	1.00
MnO	0.01	0.02	0.02	0.02	0.00	0.05
MgO	0.01	0.12	0.05	0.08	0.50	0.55
CaO	0.62	1.14	0.67	0.62	1.05	0.90
Na2O	3.49	3.76	3.96	3.48	3.90	4.00
K2O	4.41	3.91	4.76	4.44	3.65	3.65
P2O5	na	na	na	na	0.00	0.05
LOI	0.20	0.31	0.28	0.73	0.60	0.25
Total	98.30	101.05	98.59	101.10	99.50	99.70
Rb	na	na	na	na	68	84
Sr	na	na	na	na	76	56
Ba	na	na	na	na	na	na
Zr	na	na	na	na	na	na
Y	na	na	na	na	na	na
Nb	na	na	na	na	na	na

The rock samples plot in the granite - adamellite - granidiorite fields, where YM samples are mainly concentrated in granite, however, most of the others (MM, MKG, and CM samples) in the adamellite field.

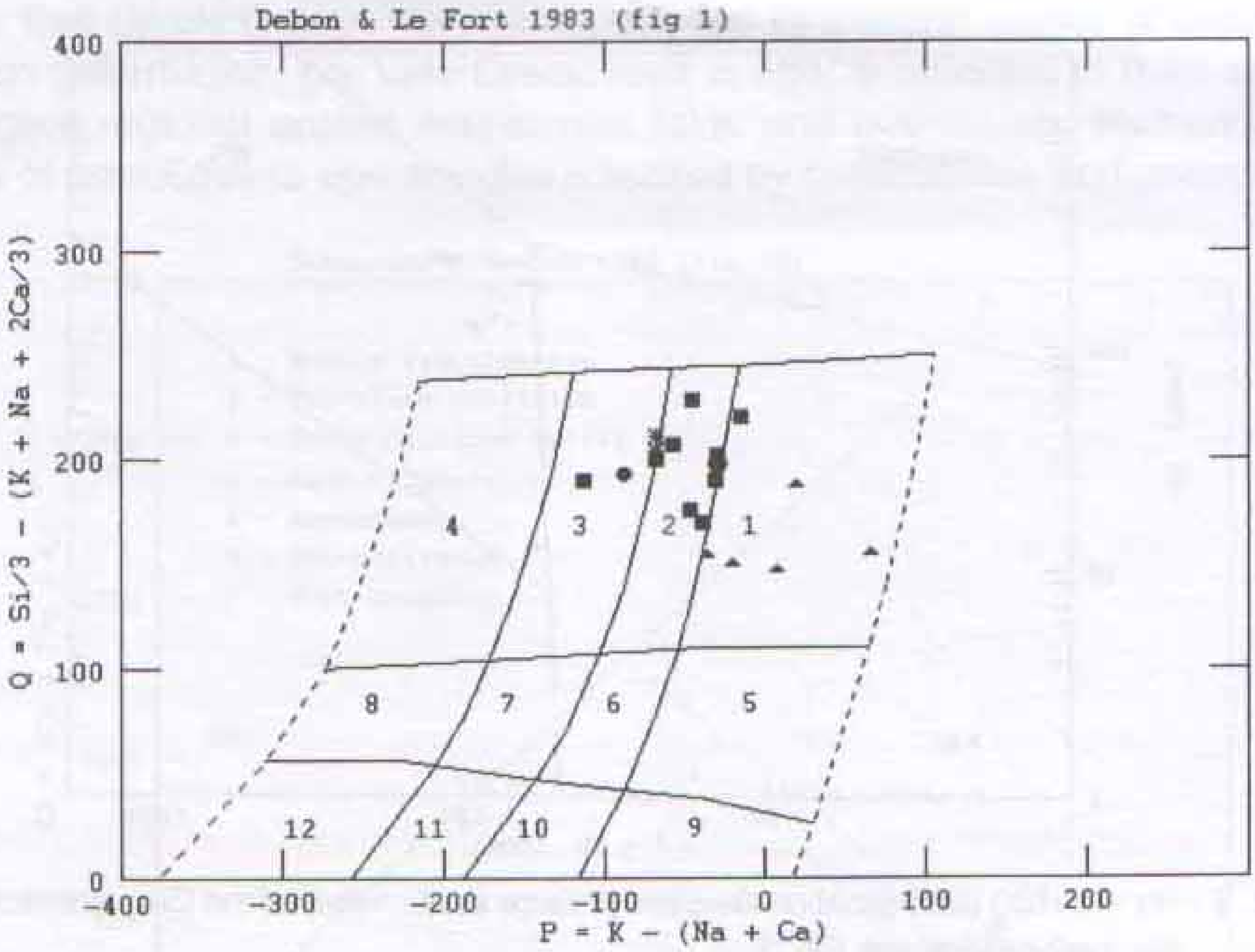

Fig. 3 - Q - P nomenclature diagram (Debon and Le Fort, 1982) of the Bitlis granitoids. Squares: MM, triangles: YM, circles: MKM, asteriscs: CM.

The alumina balance and distribution of samples on characteristic mineral diagram of the Bitlis granitoids are shown in Figure 4. Almost all the samples are leucogranitoids. They have a posotive A value and thus plot in the peraluminous domain. This plot is in accordance with the petrographical observations.

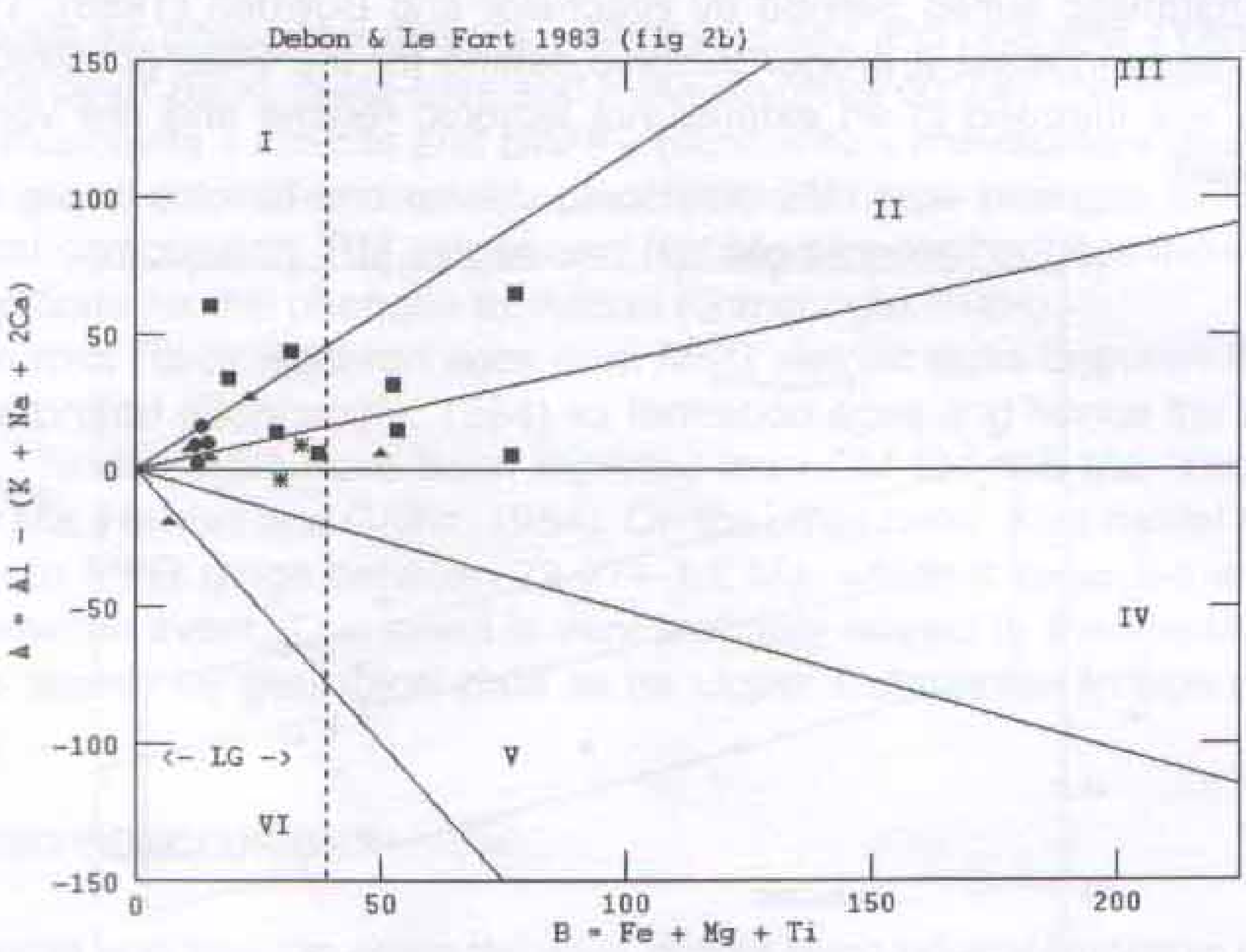

Fig. 4 - A - B diagram (Debon and Le Fort, 1982) of the Bitlis granitoids. For explanations see Fig. 3.

Based on alumina balance the overall magmatic association trend of the Bitlis granitoids corresponds to the typical trend of "alumino-cafemic (ALCAF)" type of Debon and Le Fort (1982). This type characterises the intermediate rocks between I and S types of Chappel and White (1974).

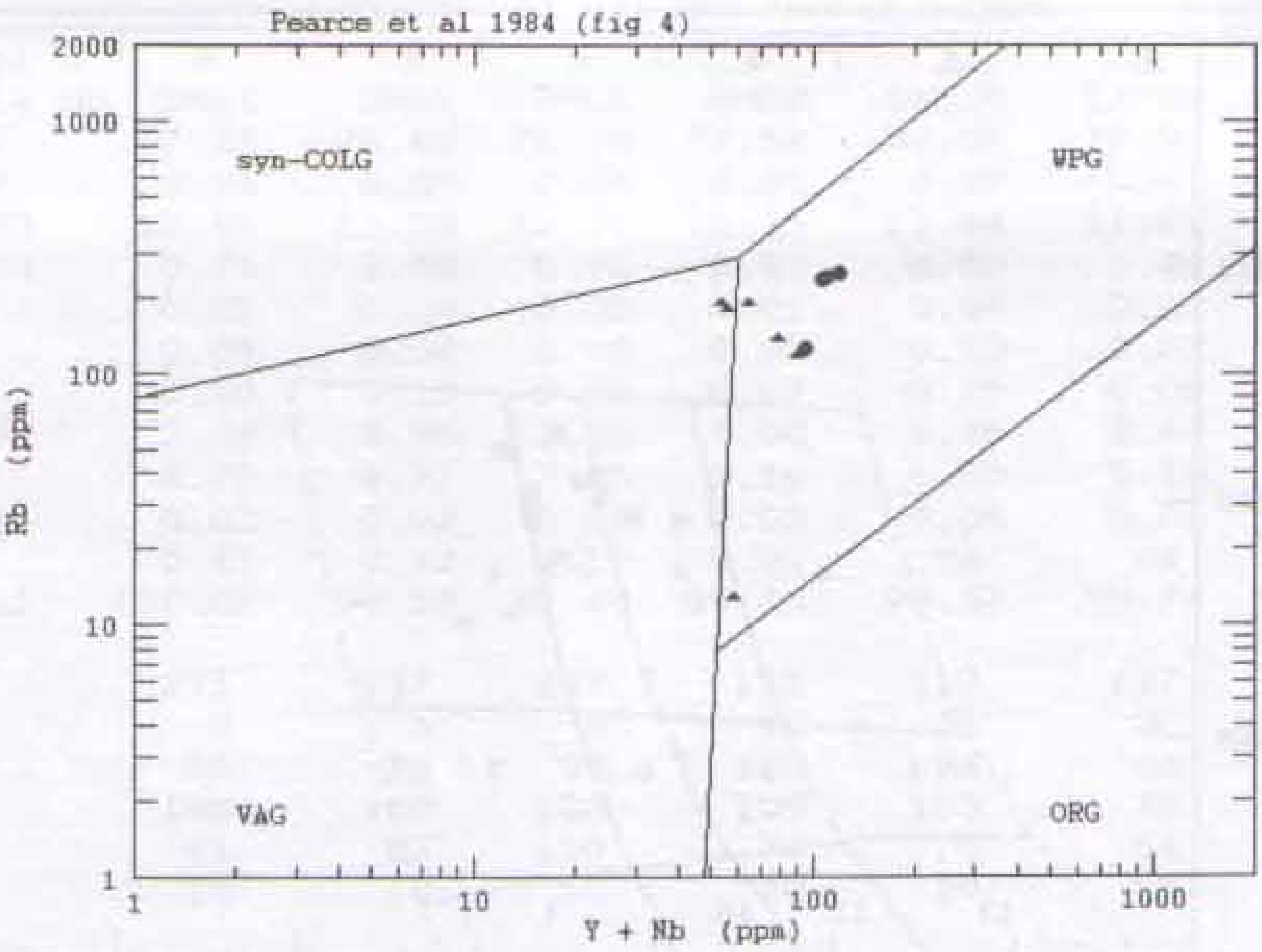

Fig. 5 - Rb - (Y+Nb) discrimination diagram (Pearce et al., 1984) of the Bitlis granitoids. For explanations see Fig. 3.

Trace element data of the Bitlis granitoids are plotted (Fig. 5) on the tectonic discrimination diagrams of Pearce et al (1984). The samples plot mainly within the "within plate granitoids (WPG)" field suggesting a mantle source and crustal contamination in a more or less attenuated continental crust. On the other hand, the same data on Maniar and Piccoli (1989) discrimination diagrams (Fig. 6) display "post orogenic granitoids (POG)" characteristics. In the multicationic R1-R2 diagram (De la Roche et al., 1980) the samples of the Bitlis granitoids show a concentration (Fig. 7) on the boundaries between syn-collisional, anorogenic and post-orogenic magmatic suites defined by Batchelor and Bowden (1985). These observed trends do not clearly indicate a proper tectonic setting for the Bitlis granitoids, but suggest terms that they are intruded in an extensional tectonic regime and are very probably not directly arc-related.

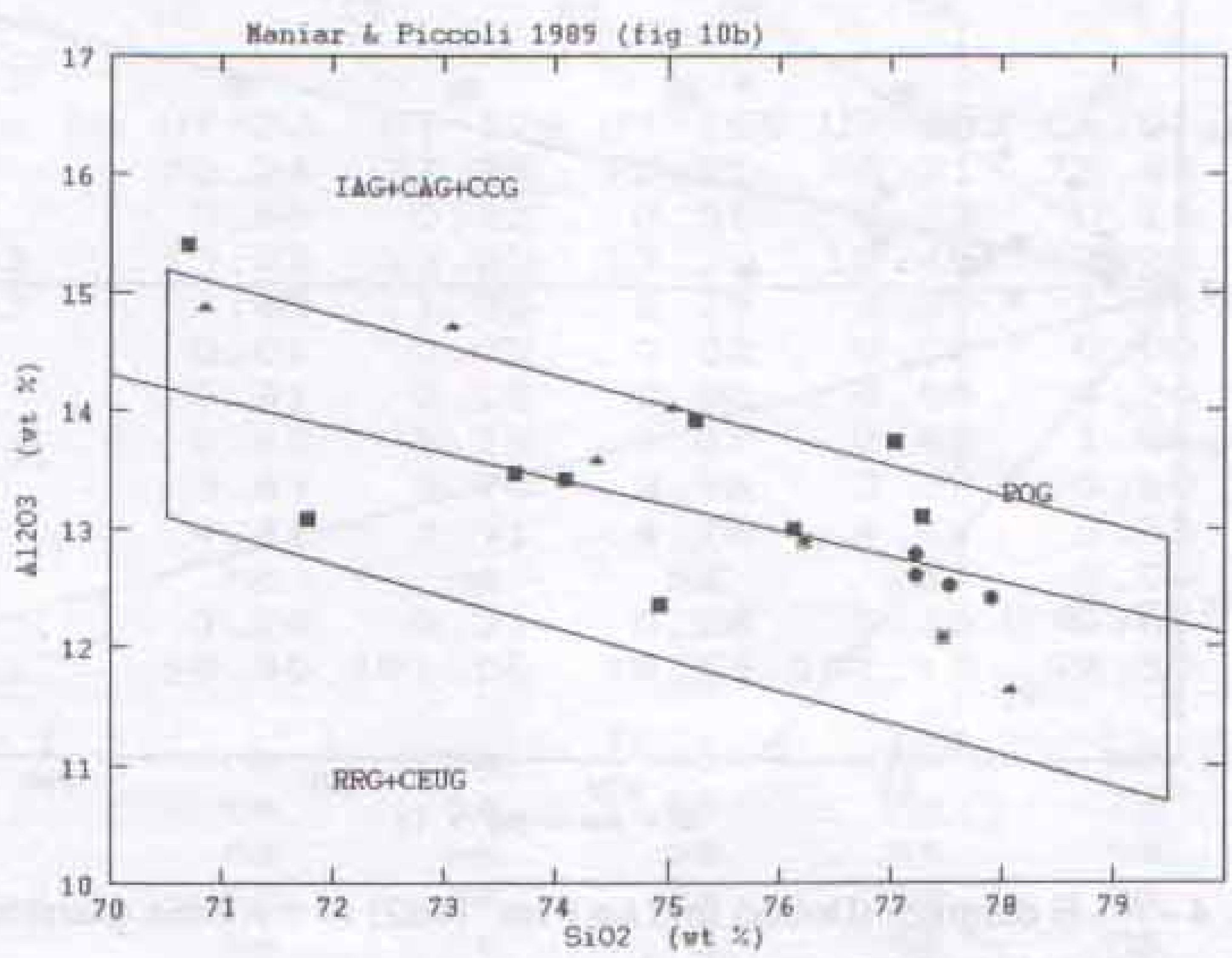

Fig. 6. - Al203/Si02 tectonic discrimination diagram (Maniar and Piccoli, 1989) of the Bitlis granitoids. For explanations see Fig 3.

ALPINE DEFORMATION AND METAMORPHISM

The Lower Paleozoic-Carboniferous meta-sediments and intruding granitoids as well as the unconformably overlying Lower Permian-Mesozoic sequences of the cover of the Bitlis Metamorphic Belt (Mutki Group) have been effected by several stages of regional deformation. The main deformation, pre Late Cretaceous in age, is reflected in Bitlis and Mus areas by north-vergent regional scaled over-turned folds and overthrusts. Numerous imbricated thrust planes of post Eocene age are characterized by cataclastites and pseudotachylites.

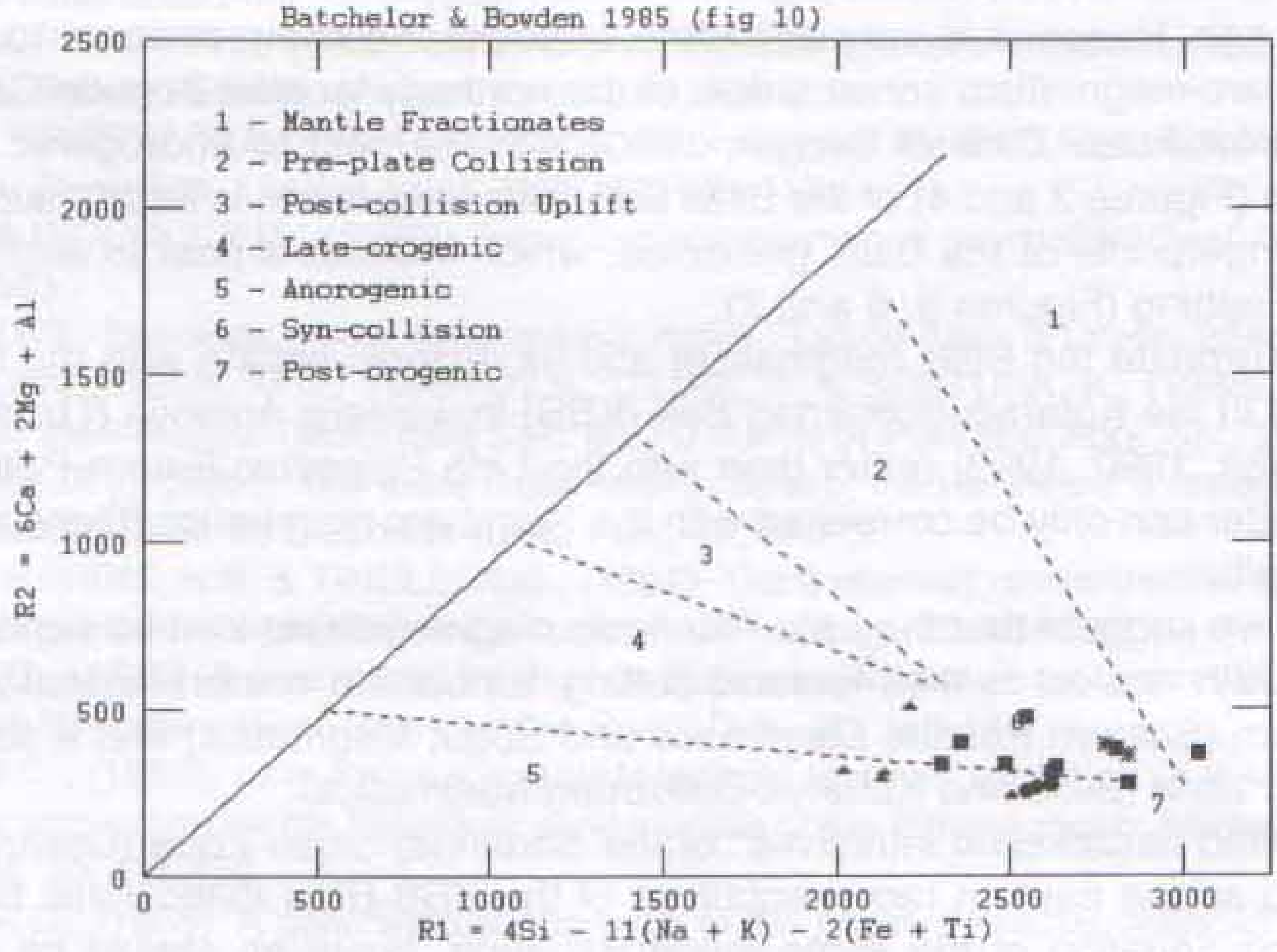

Fig. 7 - Multicationic R1-R2 discrimination diagram (Batchelor and Bowden, 1985) of the Bitlis granitoids. For explanations see Fig 3.

The granitoids display well developed mylonitic textures and dynamo-metamorphic mineral assemblages such as: phengite + chlorite + albite + quartz and phengite + clinozoisite + albite + quartz. On the other hand, meta-tuffs and meta-rhyolites contain the metamorphic assemblage: albite + muscovite + chlorite and albite + muscovite + chloritoide + quartz. In the meta-granitoids pale green colored and weakly pleochroic 2M1-type phengite furnishes the shear zones. Chemical composition, RM values and Na/ Mg plot of phengites indicate low T/medium-high P conditions for the phengite formation (Goncuoglu, 1984).

Phengite-whole rock Rb/Sr isochron ages from MKG yielded ages between 99-108+-1.5 Ma, which were interpreted (Goncuoglu, 1984) as formation ages and hence the age of dynamo-metamorphism. Similar ages have been reported from CM (94-118 Ma, Yilmaz et al, 1981) and YM (90+-9 Ma, Helvaci and Griffin, 1984). On the other hand, K/Ar model ages on 8 phengite samples from MKG range between 73-77+-1.2 Ma, which is regarded as a post-crystallizational deformation event. This event is very probably related to the emplacement of ophiolites, which is shown by geological data to be Upper Campanian in age (Gancuoglu and Turhan, 1984).

DISCUSSION AND CONCLUSIONS

Field, geochemical and isotopic characteristics of four dynamo-metamorphic granitoid bodies from the Bitlis Metamorphic Belt, SE Turkey have been reviewed. The granitoids have intruded the pre-Devonian (most probably pre-Cambrian) high grade metamorphic basement (Hizan Group) as well as its post Devonian -pre Lower Permian sequence of the lower cover

(Meydan Formation) and are coeval with the felsic meta-volcanic/meta-pyroclastic units (Cesme Formation) of Carboniferous age. Fossiliferous Lower Permian marbles overlie them with a local unconformity.

This magmatism clearly postdates the pri-Cambrian/pan-African orogenic event in nothern Gondwana (Arabian Platform, Tauride Belt and the Bitlis Metamorphic Belt). The Late Ordovician-Early Carboniferous metamorphism, which was suggested by Sengor (1991) for this region, however, is not supported by the field and geochronological evidences at least in Tauride and Bitlis Belts. On the contrary, it is clearly documented that the metamorphism that had effected the lower cover, intruding granitoids as well as the overlying upper cover is Late Cretaceous in age. Hence, it is very difficult to correlate the compressional tectonics, metamorphism and arc-magmatism sensu strictu of the northerly located Pontide-Caucasus Zone (part of the Podotaksasi Zone of Sengor, 1990) with the post to anorogenic peraluminous leucogranitoids (Figures 3 and 4) of the Bitlis Belt. This suggestion is further supported by the geochemical fingerprints of the Bitlis granitoids, which indicate a post to anorogenic extensional tectonic setting (Figures 5, 6 and 7).

We therefore correlate the Bitlis magmatism and its tectonic setting with the Carboniferous back-arc event in the Kutahya-Bolkardag Belt (KBB) in western Anatolia (Ozcan et al, 1988; Goncuoglu, 1989, 1990, 1993) rather than with the Late Paleozoic Eatern Pontide arc magmatism. The latter can only be correlated with the Sogut arc magmatics (Goncuoglu, 1989) of the Sakarya Belt.

Consequently, we suggest that the Late Paleozoic magmatic axes can be separated into two distinct zones with respect to their tectonic setting: a northern compressional zone with arc-type magmatism (Eastern Pontide Magmatics and Sogut Magmatics) and a southern extensional back-arc zone (Bitlis and Kutahya-Bolkardag Magmatics).

"Extension related calcalkaline intrusives" of the Sanandaj-Sirjan Zone (Dewey et al., 1973) are considered as the eastern representatives of the KBB-Bitlis extensional back-arc zone. The western continuation of the same magmatic zone, however, should be sought in the Pelagonian Zone in Greece (e.g. Carboniferous granitoids in Kastoria and Kaimaktsalan units of Papanikolaou, 1984).

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