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Geology and Mineralization of Derekoy Porphyry Copper Deposit, northern Thrace, Turkey

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Abstract : Ore deposits and prospects of porphyry Cu-Mo and Cu-Mo-W are accompanied with Cretaceous intrusive rocks in the Derekoy-Demirkoy area, northern Thrace, Turkey. The basement of the area is so-called Kirklareli gneiss of pre-Ordovician granitoid origin, and is overlain by pre-Cretaceous metamorphic rocks, which are intruded by Upper Cretaceous granitoids.

Granitoids at Derekoy are classified into three groups. The first group **A** consists mainly of equigranular rocks which show a wide range in chemical compositions from alkali olivine gabbro to granite. Contamination of the gabbro with the basement monzonitic gneiss is evident. Though this group is not the main host of the porphyry copper deposit at Derekoy, similar felsic intrusions are closely related to Cu-Mo-W mineralization at Ikiztepe and Sukrupasa. Rocks of the second group **B** have quartz dioritic to tonalitic modal compositions, and are marked by hornblende phenocrysts and porphyritic textures. They are the main host of the porphyry Cu-Mo ore at the Derekoy deposit. The tonalite porphyry is younger than the gabbro but older than the felsic rocks of group **A**, hence groups **A** and **B** are essentially of the same age. Quartz monzodioritic, monzodioritic and monzonitic porphyry dikes of the third group **C** intrude the Derekoy ore bodies, and are obviously post-mineralization. All these groups and the basement gneiss, as a whole, have chemical compositions characteristic to magnetite-series I-type granitoids. The main difference in chemistry between groups **A** and **B** is higher alkali contents of the former. The felsic rocks of group **A** have chemical compositions intermediate between the basement gneiss and group **B**. When compared to other groups, group **B** is poor in alkali, lead and strontium, and rich in sulfur and copper. A potassium-argon age of a hornblende tonalite porphyry of group **B** from the potassic alteration zone at Derekoy is 76.7 ± 3.8 Ma., while that of a fresh monzonite porphry of group **C** is 70.9 ± 3.5 Ma. The former indicates the age of the mineralization at Derekoy, which is slightly younger than the previously reported ages of granitoids from Derekoy-Demirkoy area. The latter gives the younger age limit of the magmatism at Derekoy, and suggests there had been no Tertiary magmatism in this area.

At Derekoy, potassic alteration is recognized within major intrusions of the tonalite porphyry, and phyllic alteration extends over most part of the mineralized area. Propylitic alteration is seen outside the phyllic zone, and partly overlaps the potassic alteration. Two ore bodies, east and west, are recognized within the phyllic zone.

Conclusions are:

(1) The alkali-rich character of group **A** is attributed to reactions between an alkali-poor parent magma and the basement monzonitic gneiss.

(2) The Cu-Mo mineralization at Derekoy is closely related to the tonalite porphyry, whereas Cu-Mo-W mineralization is associated with granodioritic to quartz monzonitic granitoids at Sukrupasa and Ikiztepe.

(3) The occurrence of tungsten at Sukrupasa and at Ikiztepe is attributed to the reaction of the

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parent magma with the gneiss.

(4) The ages of magmatism and related mineralizations in the Derekoy-Demirkoy area are Upper-Cretaceous or older.

Introduction

Derekoy porphyry copper deposit was confirmed through a joint survey of MTA, Mineral Research and Exploration General Directorate of Turkey, and JICA, Japan International Cooperation Agency. Twenty five drills, about 8,800 meters total length, have been performed between 1982 and 1985, and more than 200 million tons of ore with 0.27 percent average copper equivalent grade* has been estimated. Though this grade is not high enough to be economically mined at present, the good topographic condition and easily accessible location, as well as a possible contribution of gold grade which has not been evaluated yet, may provide a moderate size porphyry copper mine in the future.

The purpose of this report is to describe mineralization and alteration of the Derekoy porphyry copper deposit, and the petrography and rock chemistry of the related igneous rocks. The Cu-Mo mineralization with or without W is discussed in conjunction with the characteristics of the related magmatism. The result is generalized for prospecting porphyry copper deposits along the Bulgarian border of Turkey.

Location

Derekoy village is located in a creek 40 kilometers north-northeast of Kirklareli, Thrace, Turkey, and is easily accessible by a paved road which connects Kirklareli city to the Bulgarian border 10 kilometers to the northeast of Derekoy. Demirkoy village is 40 kilometers east-southeast of Derekoy. In this report, the whole area shown in Fig. 2 is described as Derekoy-Demirkoy area. This area occupies the central part of the Istranca Mountains which run through northern Thrace in a northwest-southeast direction (Fig. 1). Peaks of the mountains rarely exceed 1,000 meters above sea level, and are covered by much vegetation.

Geology and occurrences of Cu, Mo, and W in Derekoy-Demirkoy area

The basement of the Derekoy-Demirkoy area is so-called Kirklareli gneiss of pre-Ordovician (Brinkmann, 1976) widely distributed to the south and to the northwest of Derekoy (Fig. 2). The gneiss is overlain by pre-Cretaceous metamorphic rocks which are roughly classified into three units, though their lithology changes both laterally and vertically. The first unit consists of Triassic dark green to black schist and phyllite, which are interbedded with the second unit, white marble and black-and-white banded limestone. The third unit is presumably Jurassic dolomite and limestone which is believed to sit on the former two units. But the relation of this unit to the others is not always clear, therefore all these units are marked as metamorphic rocks of Triassic to Jurassic sediments origin in Fig. 2. The northeastern part of the area is underlain by Cretaceous sedimentary and volcanic rocks, whereas in the central part, many granitoid stocks are hosted by the metamorphic rocks. These stocks intrude along an anticlinal axis of the pre-Cretaceous metamorphosed sedimentary rocks (Kamitani, 1978), and hence are aligned in northwest-southeast directions parallel to regional main folding axes in the area, and many of them are associated with disseminated Cu-Mo-W ore and Pb-Zn-Fe skarn as shown in Fig. 2. Though the relation between the volcanic rocks and the granitoids is not clear, the

* Calculated as (copper grade) + 10 × (molybdenum grade)

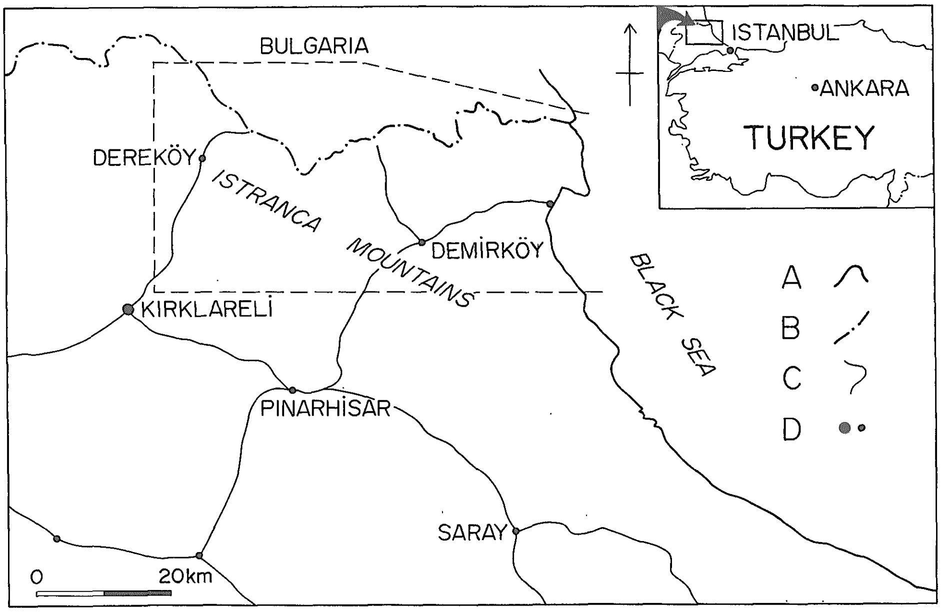

Fig. 1 Location map of Derekoy-Demirkoy area (Marked by broken line). A: coast line B: Bulgarian border C: main roads D: cities and villages

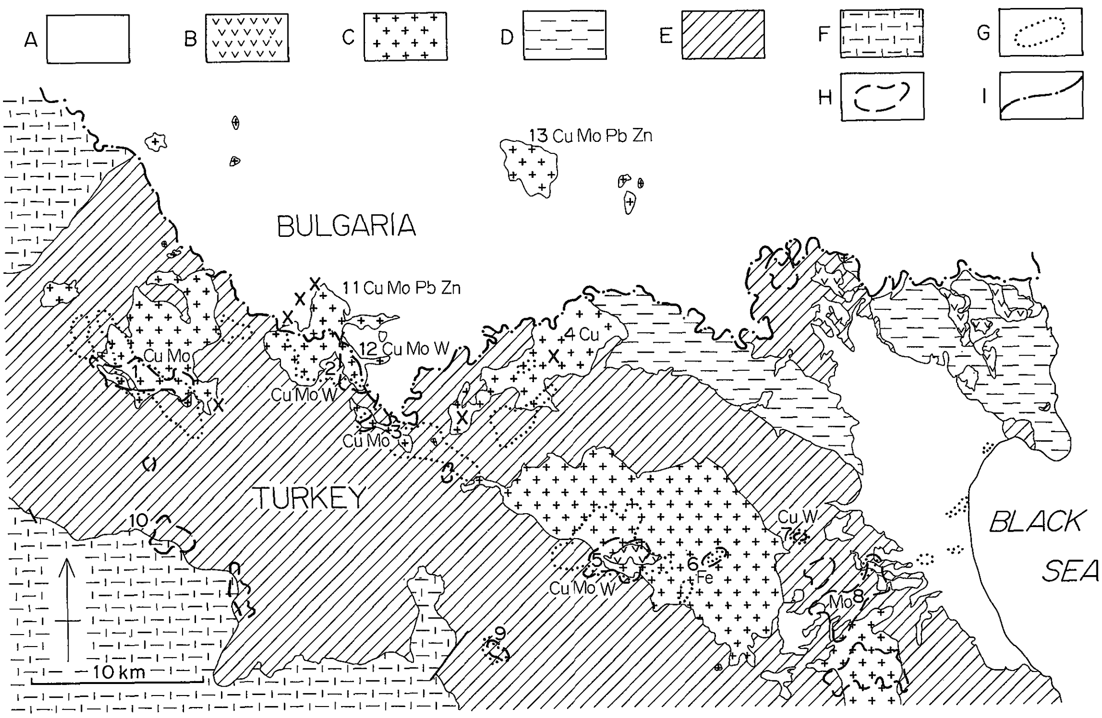

Fig. 2 Geology, ore deposits and geochemical anomaly of Derekoy-Demirkoy area (modified after unpublished data of MTA). Note that geochemical anomaly and detailed geology data for Bulgarian side are not available. 1:Derekoy 2:Sukrupasa 3:Armutveren 4:Karacadag 5:Ikiztepe 6:Demirkoy 7:Korutepe 8:Yurdadere 9:Mahya Dagi 10:Duzorman 11:Malko Tirnova 12:Bartseto 13:Gramatikova X:other Cu deposits and prospects A:Pliocene to Quaternary sediments B:Upper Cretaceous felsic tuff and dacite C:Upper Cretaceous granitoid stocks D:Cretaceous sedimentary rocks, spilite and spilitic tuff E:Metamorphic rocks of Triassic to Jurassic sedimentary rock origin F:Gneiss of pre-Ordovician granitoid origin G:Cu anomaly H:Mo anomaly I:border line

associations of the younger sedimentary rocks with the volcanic rocks, and the older metamorphic rocks with the granitoids indicate presence of deepseated granitoid stocks beneath the volcanic rocks in the northeastern part of the area.

Many ore deposits and geochemical anomalies are recognized along the granitoid stocks on both sides of the Bulgarian border. Drill data (MTA, unpublished) indicate that Derekoy, Sukrupasa, and Ikiztepe are porphyry copper, that is, large-scale low-grade granitoid-related Cu-Mo deposits. In an economic sense, copper is the most important metal, and tungsten minerals are not observed at Derekoy, whereas scheelite is minor but one of the common ore minerals at Sukrupasa, and tungsten is as important as copper and molybdenum at Ikiztepe. Other deposits and prospects shown on Fig. 2 are not classified yet because of few available data, though their ore mineral assemblages and close associations to granitoid stocks are characteristic of porphyry copper deposits. Some geochemical anomalies of molybdenum which are not associated with intrusions could be related to a mineralization similar to one at Yurdadere, where molybdenite is accompanied by minor amounts of pyrite and chalcopyrite in the pre-Cretaceous schist along the contact with a biotite granite. This granite is probably an extension of a large granitoid stock which is located 2 kilometers south of the deposit and is associated with a molybdenum anomaly. Therefore anomalies which seem to have no direct relation to granitoid stocks, such as those at Mahya Dagi and at Duzorman, may be good indicators of hidden granitoid stocks and ore bodies.

Granitoid stocks and basement gneiss at Derekoy

The igneous rocks described in this paper are named based on the modal composition diagram proposed by IUGS, though a quartz-anorthite + albite-orthoclase diagram of CIPW norm was used to discuss chemical characters of rocks.

Petrography:

Though wide-range variety of the chemical compositions and textures of the basement gneiss is observed, the samples in the vicinity of Derekoy have monzonitic composition (Fig. 5 and Table 1), and show less gneissose texture. Small outcrops of the gneiss are observed 2 kilometers to the north of Derekoy; outside northwestern edge of the geological map in Fig.3a. The gneiss, or rather meta-monzonite here, is composed mainly of large potash feldspar laths up to 6 centimeters long, and less coarse-grained plagioclase, with subordinate amounts of biotite, green hornblende and quartz, and minor amounts of apatite, opaque minerals and sphene. The gneiss and pre-Cretaceous metamorphic rocks described above are intruded by a series of granitoids which can be classified into three groups.

The first group **A** occurs as complex bodies of equigranular gabbro and younger felsic rocks which have granodioritic to granitic modal compositions. These bodies are exposed aligned in northwest-southeast directions on the northern part of the mapped area in Fig.3a. Small bodies of this group are exposed also in the mineralized zone which extends along the northern edge of the Kocadere. The gabbro is the oldest among the igneous rocks, and is intruded by the felsic rocks. Many half-assimilated xenolithes of the monzonitic gneiss in the gabbro indicate intense contamination of the gabbro with the gneiss. Medium-grained alkali olivine gabbro at 2 kilometers northeast of Derekoy consists of aegirineaugite, olivine, plagioclase, orthoclase, apatite, and opaque minerals. Abundance of magnetite is indicated by strong magnetism of the samples. The aegirineaugite is subhedral to euhedral, and partly surrounded by small flakes of biotite, whereas the olivine is anhedral and is changing to biotite along its rim and internal cracks. The biotite occurs mainly as anhedral or interstitial crystals which appear to be as young as

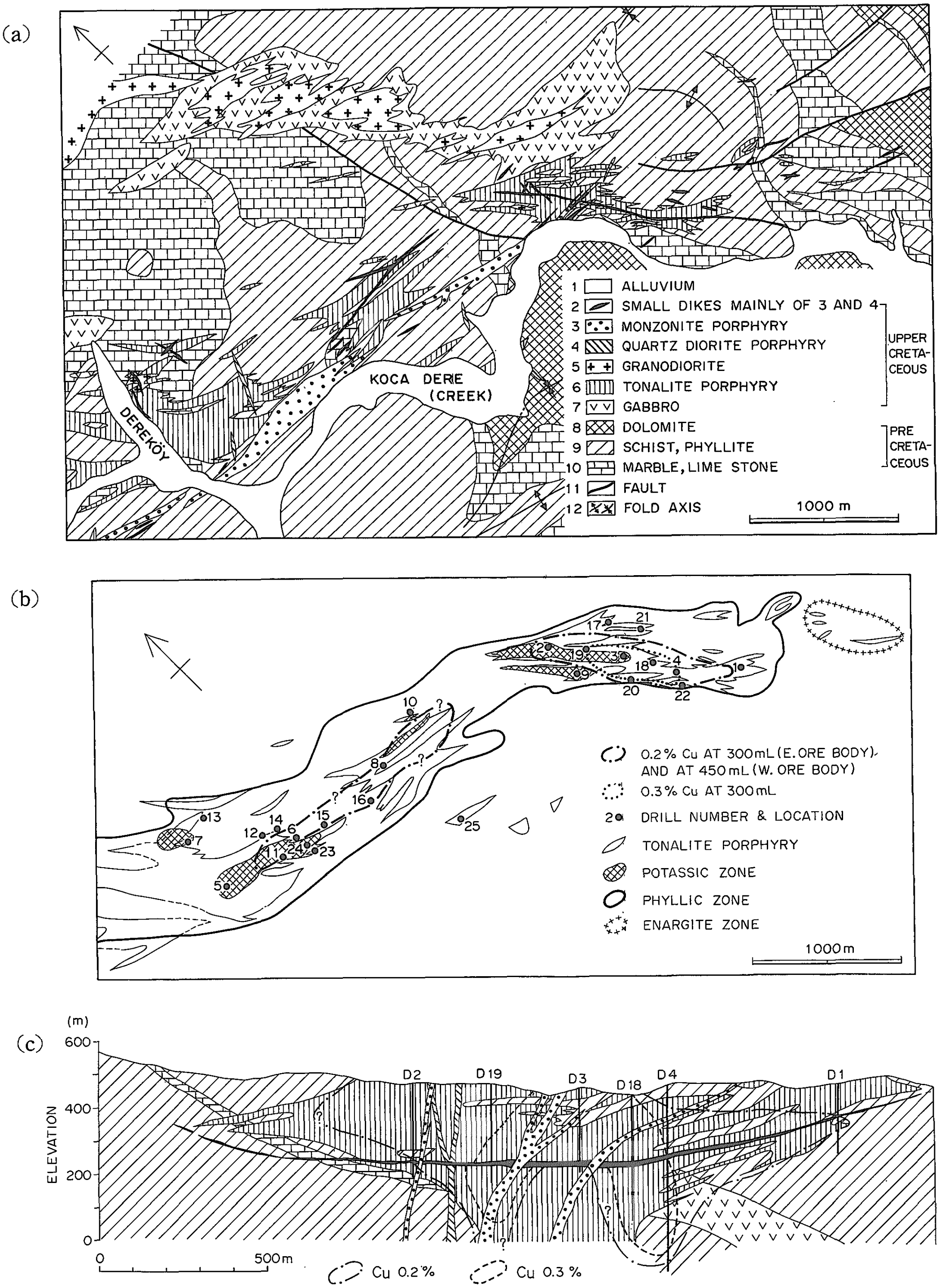

Fig. 3 Geological map(a), alteration and ore location map(b), and geological section(c) of Derekoy. The ore grade contour lines shown on 3b and 3c are inferred using data of drills shown on the map to give an image of ore body. 3c is a geological section along drills 2, 19, 3, 18, 4 and 1, and not in the same scale with 3a nor b.

orthoclase. The plagioclase is lath-shaped, and is associated with a minor amount of interstitial orthoclase. The apatite occurs as small needle-like laths. On the other hand, a small body of fine-grained gabbro located 1.5 kilometers to the north of Derekoy contains much augite and plagioclase, less amounts of biotite, orthoclase and opaque minerals, minor apatite, rare hornblende, and no olivine. The apatite is equidimensional, and plagioclase phenocrysts are not so elongated as those in the olivine gabbro.

The felsic rocks vary in their textures from coarse-grained equigranular to porphyries with aphanitic groundmasses. Their compositions are mainly of granodiorite and of quartz monzodiorite, and are fairly fresh except some small bodies distributed in the mineralized zones. Samples from small stocks intruded in the olivine gabbro to the northeast of Derekoy are equigranular, and consist of plagioclase, quartz, orthoclase, minor amounts of biotite and hornblende, less amounts of sphene, magnetite, apatite, and accessary alteration minerals such as pyrite, chlorite and actinolite. Fluid inclusions with or without daughter minerals are often seen in quartz of these fairly fresh samples, and probably indicate that these intrusions were once situated at a root of a hydrothermal system which may be, directly or indirectly, related to the Derekoy porphyry copper deposit.

The second group **B** is marked by hornblende phenocrysts up to 3 centimeters long, and porphyritic textures. The rocks of this group mainly have tonalitic compositions, and are closely related to the disseminated Cu-Mo ore, hence make a belt which corresponds to the main phyllic alteration zone, and runs in east-west to northwest-southeast directions (Fig. 3a, b). Nevertheless, some small dikes of this group, even those distributed in the phyllic zone, appear to be suffered only from propylitic alteration, and their copper contents are remarkably lower than the adjacent similar rock which is much mineralized and affected by phyllic alteration. Thus some of the dikes must be slightly younger than the main stage of the mineralization. Fresh samples of this group are composed mainly of large euhedral hornblende and smaller plagioclase phenocrysts, groundmasses of equidimensional quartz and plagioclase, and a considerable amount of magnetite which is easily observed under naked eyes. Grain size of the groundmass varies from 10 micron to 200 micron hence the texture from aphanitic porphyry to slightly porphyritic. Igneous biotite is not observed, and potash feldspar is rare in this group. It is notable that the younger and/or smaller dikes of this group tend to show flow structure of abundant hornblende phenocrysts, while the well-mineralized larger dikes or stocks have less amounts of hornblende phenocrysts which show less or no flow structure.

The last group **C** consists of monzodiorite, monzonite or quartz monzodiorite porphyry dikes, which make at least two belts stretched in east-west directions, and obviously are post-mineralization, though they generally are affected by propylitic alteration in the mineralized zone. One belt is shown in Fig. 3a, and the other is situated 3 to 5 kilometers northwest of Derekoy. The former is characterized by monzodiorite porphyry which has more hornblende than biotite, and a cryptocrystalline groundmass, while the latter consists mainly of monzonite porphyry with more biotite than hornblende, and a holocrystalline groundmass of potash feldspar associated with minor or rare quartz and apatite.

Rock chemistry:

Based on their chemical compositions and the petrographic characters, the granitoid and gneiss samples from Derekoy are classified into sub-groups as follows:

Group A

Aog Olivine gabbro: contains olivine in both modal and normative compositions, and nepheline in norm but not in mode.

This discordance is attributed to the abundance of biotite.

Agb Gabbro: is named as gabbro because of its high color index, though if its silica content is considered, it rather is to be defined as diorite.

Agd Granodiorite: mainly has granodioritic to quartz monzodioritic compositions.

Group B

Btp Tonalite porphyry: is main host rock of the porphyry copper ore. Marked by hornblende phenocrysts about 1 centimeter long.

Bqd Quartz diorite porphyry: as described already, is believed to be slightly younger than main stage of the porphyry copper mineralization. Though there is not much difference between this rock and **Btp** in both petrographical nor chemical characteristics, a different name is employed to avoid confusions.

Bin Intermediate rock: has intermediate chemical and textural characteristics between **Btp** and **Agd**.

Group C

Cmd Monzodiorite porphyry: is distributed mainly in the mineralized zone, and has more hornblende than biotite.

Cmz Monzonite porphyry: is similar to **Cmd**, but is more felsic, has more biotite than hornblende, and is distributed mainly northwest of Derekoy, outside the geological map in Fig. 3.

Others

Amd Monzodiorite: is "monzonite" of AYDIN (1974). Data for only one sample are available. Though its detail is unknown, the chemical composition is similar to those of two monzodiorite samples of TERASHIMA *et al.* (in prep.) from Sukrupasa. These three samples have intermediate chemical compositions between **Aog** and the monzonitic gneiss, and presumably belong to group **A**.

Mgn Coarse grained monzonitic gneiss: This is the basement of the Derekoy-Demirkoy area, and has monzonitic composition, though similar rock, Kirklareli metagranite (Figs. 4 to 8) from 20 kilometers to the south of Derekoy has granitic composition. Data of two **Mgn** samples plotted in the figures are after AYDIN (1974) and TERASHIMA *et al.* (in prep.). Their chemical compositions are very close to the one determined by the present authors.

Tables 1 and 2 show chemical compositions, CIPW norm, and descriptions of granitoid samples from Derekoy area. Though $Fe^{+3}/Fe^{+3}+Fe^{+2}$ of these samples are mostly more than 0.35 indicating that majority of the granitoids in this area belongs to magnetite-series (ISHIHARA, 1977), it is notable that four **Agd** samples out of nine show the values less than 0.35. These data as well as other chemical data of rocks from other locations in Derekoy-Demirkoy area are plotted on the diagrams in Figs. 4 to 9. All data are plotted either in I-type field or at around the boundary between I-type and S-type (Fig.4). On the other hand, these rocks show wide variation of the normative quartz-albite + anorthite-orthoclase ratios (Fig. 5), which clearly show the difference between groups **A** and **B**.

Variation diagrams of differentiation index and each chemical component are shown in Fig. 6, which, as well as Fig. 5 and diagrams in Fig. 7 to 9, reveal that:

1) when compared to other groups, group **B** is remarkably poor in alkali (Figs. 6 to 8) and strontium (Fig. 9).
2) **Aog**, **Amd** and **Mgn** are on a trend in the alkaline field, and **Aog**, **Agb** and **Agd** are on another trend which seems to reach up to Kirklareli metagranite (Fig. 7).
3) these two trends are recognized as fairly straight lines also on the diagrams in Fig. 6b.
4) no chemical difference between **Btp** and **Bqd** is recognized.
5) all group **B** samples but one exception show a very small variation of differentiation index, and of SiO_2 content, and both of them are between those of **Aog** and **Agd**.

Table 1 Chemical analyses and CIPW norm of

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SiO_2	49.70	55.00	55.90	63.00	61.40	64.20	66.40	66.40	63.70	66.20	60.70	56.00	66.50	58.90
TiO_2	0.70	0.80	0.80	0.30	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.50	0.20	0.40
Al_2O_3	15.50	14.50	5.70	16.40	18.00	17.00	15.00	15.50	16.60	17.50	15.00	19.70	15.50	18.70
Fe_2O_3	4.35	6.00	5.05	2.40	3.50	1.35	1.70	2.20	2.90	0.55	2.25	3.10	1.80	3.20
FeO	5.15	4.00	4.45	3.30	2.10	2.95	3.30	2.30	1.70	1.65	4.25	4.10	2.80	4.30
MnO	0.20	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
MgO	7.95	4.55	4.50	1.40	1.75	1.75	1.20	1.55	1.75	1.45	2.50	3.05	1.40	2.95
CaO	9.85	8.55	7.15	2.85	3.90	3.35	3.50	3.15	4.30	4.20	4.35	6.40	4.40	6.55
Na_2O	3.05	3.30	3.05	3.70	4.15	3.85	3.90	3.80	4.45	4.30	3.30	1.90	3.55	2.85
K_2O	2.25	3.25	3.00	3.50	4.30	3.05	3.25	4.30	3.75	3.55	3.80	0.70	1.10	1.20
P_2O_5	0.30	0.30	0.10	0.20	0.30	0.10	0.10	0.20	0.10	0.20	0.20	0.10	0.10	0.10
S	0.02	0.01	0.06	1.50	0.01	0.01	0.01	0.01	0.01	0.30	0.90	0.64	1.07	0.50
Total	99.02	100.36	99.86	98.65	99.91	98.11	98.86	99.91	99.76	100.40	97.75	96.29	98.52	99.75
F 3 /F 3 +F 2	0.43	0.57	0.50	0.39	0.59	0.29	0.31	0.46	0.60	0.23	0.32	0.40	0.36	0.40
Na_2O/K_2O	0.30	0.38	0.42	1.29	1.06	1.14	1.11	1.20	1.03	1.02	0.75	0.29	0.80	0.43
K+N+C/Al	1.63	1.68	1.35	0.91	1.03	0.92	1.08	1.07	1.15	1.05	1.16	0.78	0.96	0.95
Q	0.00	4.03	6.84	20.16	10.49	18.91	21.01	18.88	13.23	16.69	14.01	22.93	29.83	17.89
C	0.00	0.00	0.00	1.82	0.15	1.51	0.00	0.00	0.00	0.00	0.00	4.42	0.71	1.04
Or	13.29	19.19	17.72	20.67	25.40	18.01	19.19	25.40	22.15	20.97	22.44	4.13	6.49	7.08
Ab	23.03	27.91	25.79	31.29	35.09	32.56	32.98	32.13	37.63	36.36	27.91	16.06	30.02	24.10
An	21.96	15.16	20.29	12.82	17.38	15.96	13.83	12.54	14.25	17.97	14.90	31.08	21.16	31.83
EnH	0.00	2.89	6.78	3.48	4.35	4.35	2.48	3.39	2.12	3.18	4.88	7.59	3.48	7.34
FsH	0.00	0.31	1.66	0.68	0.46	3.80	3.45	1.68	0.11	1.30	2.83	3.01	1.30	3.74
WoD	10.41	10.55	6.06	0.00	0.00	0.00	1.20	0.74	2,68	0.64	2.24	0.00	0.00	0.00
EnD	7.53	8.42	4.41	0.00	0.00	0.00	0.50	0.46	2.22	0.42	1.34	0.00	0.00	0.00
FsD	1.91	0.91	1.08	0.00	0.00	0.00	0.70	0.23	0.11	0.17	0.78	0.00	0.00	0.00
Fo	8.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fa	2.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ne	1.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mt	6.30	8.69	7.32	3.47	5.07	1.95	2.46	3.18	4.20	0.79	3.26	4.49	2.60	4.63
Hm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Il	1.32	1.51	1.51	0.56	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.94	0.37	0.75
Ru	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ap	0.71	0.71	0.23	0.47	0.71	0.23	0.23	0.47	0.23	0.47	0.47	0.23	0.23	0.23
Pr	0.03	0.01	0.11	2.80	0.01	0.01	0.01	0.01	0.01	0.56	1.68	1.19	2.00	0.93
Total	99.03	100.37	99.85	98.28	99.92	98.11	98.86	99.91	99.76	100.33	97.53	96.13	98.25	99.63
DI	37.81	51.13	50.35	72.12	70.98	69.48	73.18	76.41	73.01	74.02	64.36	43.12	66.34	49.07

Abbreviations: F 3 ; ferric iron, F 2 ; ferrous iron, K+N+C/Al; K_2O+Na_2O+CaO/Al_2O_3, DI; differentiation index (Q+Or+Ab+Ne), EnH; enstatite in hypersthene, FsH; ferrosilite in hypersthene, WoD; wollastonite in diopside, EnD; enstatite in diopside, FsD; ferrosilite in diopside. F 3 /F 3 +F 2 is atomic ratio, Na_2O/K_2O is weight percent ratio, and K+N+Cl/Al is molar ratio. See Table 2 for descriptions of samples.

6) on all diagrams in Figs. 5 to 8, **Agd** samples are distributed between those of **Mgn** and **Btp**.

Ages of the granitoids:

As shown in table 3, whole-rock potassium-argon age of a sample of **Btp** from a potassic alteration zone is 76.7 ± 3.8 Ma., while that of **Cmz** is 70.9 ± 3.5 Ma. The result indicates that the mineralization at Derekoy is slightly younger than the granitoid intrusions at Sukrupasa and Ikiztepe, and it did not last after about 71 million years ago. Field evidences indicate that **Cmz** is the youngest igneous rock at Derekoy, hence the result means that there was no Tertiary magmatism at Derekoy.

Alteration at Derekoy

granitoids from Derekoy-Demirkoy area, Turkey

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
61.00	60.20	60.00	62.30	60.00	60.70	59.50	60.30	57.40	58.40	58.30	60.70	57.60	60.00	55.50	61.20
0.60	0.50	0.40	0.40	0.40	0.40	0.50	0.50	0.40	0.40	0.50	0.40	0.40	0.60	0.60	0.50
19.00	18.70	18.50	15.20	17.40	16.90	17.80	16.50	17.90	16.80	17.20	18.00	16.50	13.50	16.10	18.00
2.95	2.75	3.40	3.00	4.60	2.45	3.10	2.80	4.45	2.95	2.50	3.40	3.35	2.80	3.20	2.45
2.15	3.65	3.80	3.10	3.40	3.75	4.10	4.30	2.95	4.25	5.70	2.80	4.45	5.90	3.90	1.95
0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.20	0.20	0.10	0.10	0.10
2.40	3.15	2.50	3.30	2.95	3.05	2.55	3.70	3.20	2.55	3.65	2.10	2.80	3.60	2.40	1.55
5.70	5.75	6.65	5.85	6.25	7.00	7.95	6.40	7.65	6.70	5.15	6.15	7.05	5.95	5.95	3.35
2.65	1.60	2.55	1.60	2.55	2.30	2.75	2.85	2.20	2.10	3.25	3.25	2.30	3.40	3.30	4.90
0.65	0.55	0.70	0.80	0.80	1.20	0.95	1.15	0.95	0.90	1.60	2.10	1.25	0.50	2.90	6.00
0.20	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.30	0.10	0.20	0.20	0.20
1.80	1.68	0.65	1.10	0.08	1.57	0.01	0.48	2.70	2.20	0.01	0.01	2.15	0.08	0.07	0.01
99.20	98.73	99.35	96.85	98.63	99.52	99.41	99.18	100.00	97.45	98.06	99.41	98.15	96.63	94.22	100.21
0.55	0.40	0.44	0.46	0.54	0.37	0.40	0.36	0.57	0.38	0.28	0.52	0.40	0.29	0.42	0.53
0.46	0.27	0.38	0.27	0.40	0.32	0.34	0.44	0.28	0.31	0.63	0.52	0.32	0.57	0.55	1.46
0.81	0.73	0.92	0.92	0.94	1.05	1.12	1.06	1.03	0.98	0.95	1.04	1.08	1.25	1.20	1.14
27.88	31.91	23.73	32.55	23.79	23.34	18.52	19.08	20.34	24.71	13.57	17.44	20.85	19.09	9.49	1.70
4.05	5.26	1.70	1.30	1.21	0.00	0.00	0.00	0.00	0.43	1.00	0.00	0.00	0.00	0.00	0.00
3.83	3.24	4.13	4.72	4.72	7.08	5.61	6.79	5.61	5.31	9.45	12.40	7.38	2.95	17.13	35.44
22.41	13.35	21.56	13.53	21.56	19.45	23.25	24.10	18.60	17.76	27.48	27.48	19.45	28.75	27.91	41.44
26.96	27.86	32.32	28.36	30.34	32.24	33.42	28.83	36.16	32.57	24.88	28.32	31.00	20.10	20.55	9.41
5.97	7.84	6.22	8.21	7.34	7.00	5.07	8.59	7.56	6.34	9.08	5.16	5.86	7.18	4.07	2.04
0.00	0.33	2.35	0.47	1.80	1.06	3.44	3.69	0.00	0.36	7.74	2.00	0.58	6.04	2.43	0.47
0.00	0.00	0.00	0.00	0.00	0.75	2.23	0.94	0.46	0.00	0.00	0.08	1.37	3.38	3.19	2.46
0.00	0.00	0.00	0.00	0.00	0.58	1.27	0.61	0.40	0.00	0.00	0.05	1.10	1.78	1.89	1.80
0.00	0.00	0.00	0.00	0.00	0.08	0.86	0.26	0.00	0.00	0.00	0.02	0.11	1.50	1.13	0.42
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	3.98	4.92	4.34	6.66	3.55	4.49	4.05	0.00	4.27	3.62	4.92	4.85	4.05	4.63	3.55
2.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49	0.94	0.75	0.75	0.75	0.75	0.94	0.94	0.05	0.75	0.94	0.75	0.75	1.13	1.13	0.94
0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.47	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.71	0.23	0.47	0.47	0.47
3.36	3.14	1.21	2.05	0.14	2.93	0.01	0.89	5.05	4.11	0.01	0.01	4.02	0.14	0.13	0.01
98.76	98.31	99.19	96.58	98.61	99.13	99.41	99.06	99.33	96.90	98.06	99.42	97.62	96.62	94.21	100.21
54.12	48.68	49.42	50.80	50.07	49.87	47.38	49.97	44.55	47.78	50.50	57.32	47.68	50.79	54.53	78.58

Three kinds of alteration characteristic to porphyry copper deposits; potassic, phyllic, and propylitic; and skarnization are recognized at Derekoy (Fig. 3b). It should be emphasized that the rocks of group **A** and **Btp** are affected by all of these alteration, while rocks of group **C** and **Bqd** are affected by the propylitic alteration only.

The potassic zones are distributed mainly within the stocks of **Btp** which essentially contains no igneous biotite, and characterized by hydrothermal biotite which occurs as aggregates after hornblende, and as scattered small fragments in the groundmass. Hornblende in highly altered samples, such as those from around drill 6, is fully replaced by biotite, but generally the replacement is not completed, and the aggregates of the hyd-

Table 2 Descriptions of granitoid samples from Derekoy

Number/name	group	Descriptions
1 : DK−313	**Aog**	considerable amount of Bi
2 : DK−367	**Agb**	fine grained; considerable amount of Bi
3 : S3GD	**Agb**	fine-grained; considerable amount of Bi
4 : DK−335	**Agd**	little Py
5 : DK−363	**Agd**	fine-grained
6 : DK−321	**Agd**	fine-grained
7 : DK−341	**Agd**	fine-grained
8 : 24.5−40	**Agd**	fine-grained
9 : 17−50	**Agd**	coarse-grained; sparse large Ksp phenocrysts; Hb and Bi partly altered to Chl
10 : SARP−DN	**Agd**	small dark green Hb; fluid inclusions abound; Cp+chalcocite+bornite>Py
11 : 30.8−21.8	**Agd**	(Po+Pr); porphyritic; dark groundmass; fresh Bi phenocrysts and disseminated Py; other mafic minerals are altered to fine-grained Bi aggregates, which partly altered to Chl, Cal and anhydrite; Pl partly altered to Ser and Cal; fluid inclusions pretty abound
12 : 10−47.2	**Btp**	(Po); equigranular; much Bi in groundmass partly altered to Chl; Py>Cp
13 : 12−93.3	**Btp**	(Po); fine grained; dark groundmass and disseminated Py; Bi after Hb
14 : 12−347.2	**Btp**	(Po); white groundmass and less Qz than other **Btp**; linearment marked by large Hb phenocrysts; interstitial Bi; Hb altered mostly to Bi, which altered partly to Chl; fluid inclusions abound; Py>>Cp.
15 : 2−120.00	**Btp**	(Po+Pr); Qz veinlets and Chl veinlets; linearment of Hb; disseminated Py>Cp
16 : 3−47.65	**Btp**	(Po+Pr); sparse large Hb phenocrysts; dark green groundmass; Qz veinlets; disseminated Py>Cp
17 : 3−225.9	**Btp**	(Po+Pr) ; small Hb phenocrysts and Chl veinlets ; Hb altered to Act+Chl+Cal+(Epi) ; hydrothermal? Bi in groundmass altered to Chl
18 : 5−41.8	**Btp**	(Po+Pr); dark groundmass; Cal veinlets cut through Qz veinlets; Hb altered to hydrothermal Bi, which altered partly to Chl+Opq; little Py
19 : 6−186.1	**Btp**	(Po+Pr); dark green groundmass; Chl+Cal veinlets; Green Hb rim altered to hydrothermal Bi and then to Chl+Opq+(Cal); Qz+Ksp?+Opq veinlets; Pl cores partly altered to Ser; disseminated Cp>>Py
20 : 7−195.5	**Btp**	(Po+Pr); equigranular; no large Hb, though many small needle-like Hb show linearment; much pale brownish green hydrothermal Bi after Hb; Some Act; Opq along microcracks; Some Chl after Bi; Py>>Cp
21 : 10−325.0	**Btp**	(Po+Pr); white groundmass; needle-like Hb and no sulfide?; Pl altered partly to Ser; Bi altered partly to Chl; Hb altered partly to Bi+Act
22 : 20.8−23.1	**Btp**	(Po+Pr?); Py+Cp veinlets
23 : 16.2−29	**Btp**	(Pr); Py after Hb; Hb partly altered to Chl and Act?; fluid inclusions abound
24 : 9−225.8	**Btp**	(Ph); equigranular; silicified; linearment of Hb; gray groundmass; no mafic remains; more Ser than Chl; fluid inclusions abound
25 : DK−183	**Bin**	(Pr); no sulfide, younger than mineralization?
26 : DK−353	**Bin**	Hb phenocrysts are small; appearence similar to group **A**.
27 : 6−452.6	**Bqd**	(Pr); aphanitic; Qz+Cal veinlets; Large Hb altered to Chl+Opq+Cal+(Ab+Act); Pl core partly altered to Ser; Qz+Cal veinlets; Py>Cp
28 : 3−95.2	**Bqd**	(Pr); many small Hb phenocrysts; pyroxene? altered to green Hb, which is partly altered to anhydrite, Chl, Cal, and/or Act; minor amount of Bi altered mostly to Chl; no sulfide
29 : 9−211.5	**Cmd**	(Pr)
30 : DK−322	**Mgn**	has elongated Ksp porphyroblast

Abbreviations: Py; pyrite, Cp; chalcopyrite, X>Y; more X than Y, X>>Y; far more X than Y, Bi; biotite, Hb; hornblende, Qz; quartz, Ksp; potash feldspar, Pl; plagioclase, Ab; albite, Chl; chlorite, Cal; calcite, Act; actinolite, Epi; epidote, Ser; sericite, Opq; opaque mineral, Po; potassic, Ph; phyllic, Pr; propylitic, (X); alteration type of sample is X, or minor amount of X

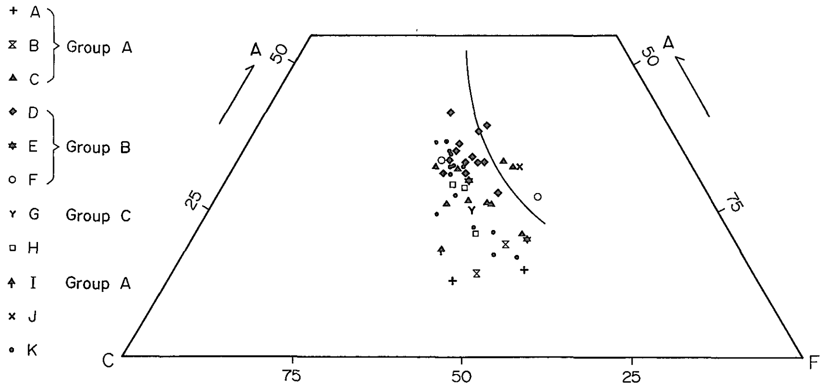

Fig. 4 ACF diagram (molar ratios, A = $Al_2O_3 - Na_2O - K_2O$; C = CaO; F = FeO + MgO) for the granitoids of Derekoy-Demirkoy area. The curve in the figure is an approximate boundary of I-type (lower left) and S-type(upper right) granitoids after WHITE and CHAPPELL (1977).
A: olivine gabbro(**Aog**) B: gabbro(**Agb**) C: quartz monzodiorite and granodiorite (**Agd**) D: tonalite porphyry (**Btp**) E: quartz diorite porphyry (**Bqd**) F: intermediate rock (**Bin**) of **Agd** and **Btp** G: monzodiorite porphyry (**Cmd**) H: monzonitic gneiss (**Mgn**) I: monzonite (**Amd**) after AYDIN (1974) J: Kirklareli metagranite after AYDIN (1974) K: rocks from Sukrupasa and Demirkoy after MOORE *et al.* (1980) and TERASHIMA *et al.* (1988). Kirklareli metagranite is from outside the area of Fig. 2 to the south, and corresponds to the basement gneiss described in the text.

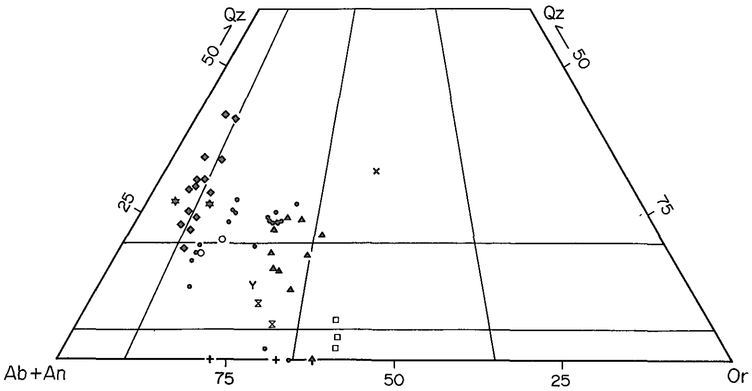

Fig. 5 Norm quartz-albite+anorthite-orthoclase diagram for granitoids in Derekoy-Demirkoy area. See Fig. 4 for explanations of marks.

rothermal biotite have remnants of the hornblende at their cores. Potash feldspar, both igneous and hydrothermal, is quite rare presumably because of tonalitic composition of the rock, and the incomplete potassic alteration. Later propylitic alteration often masks the potassic alteration, which therefore, in some cases, is hardly recognized without the aid of a microscope.

The phyllic alteration zone is widely developed as a belt which covers most part of **Btp** dikes. The assemblage of quartz and sericite with accessary hematite, rutile, apatite and ore minerals is essential, and no mafic mineral nor feldspar is stable in this zone. The limestone or marble in the phyllic zone is skarnized, and the schist or phyllite is sericitized to change its color from dark green or black to gray or white.

The propylitic alteration is observed out-

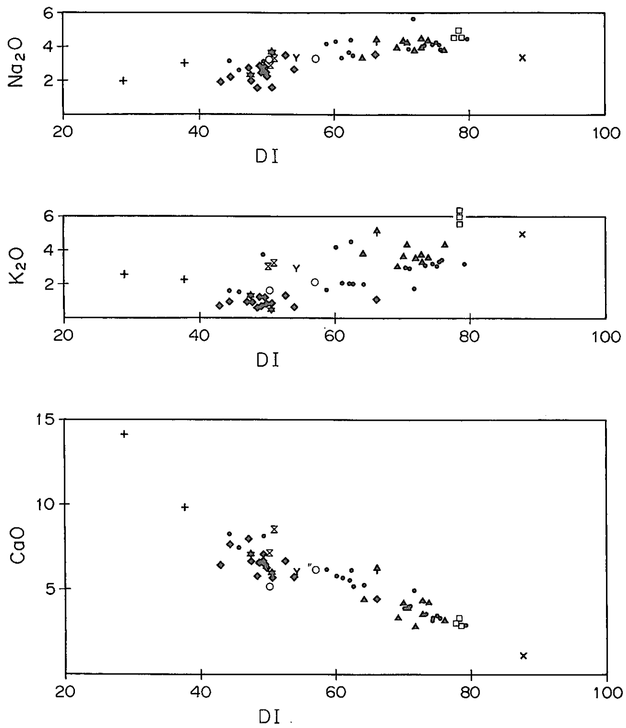

Fig. 6 Relations of differentiation index to Na_2O, K_2O and CaO (weight %) of granitoids in Derekoy-Demirkoy area. See Fig. 4 for explanations of marks.

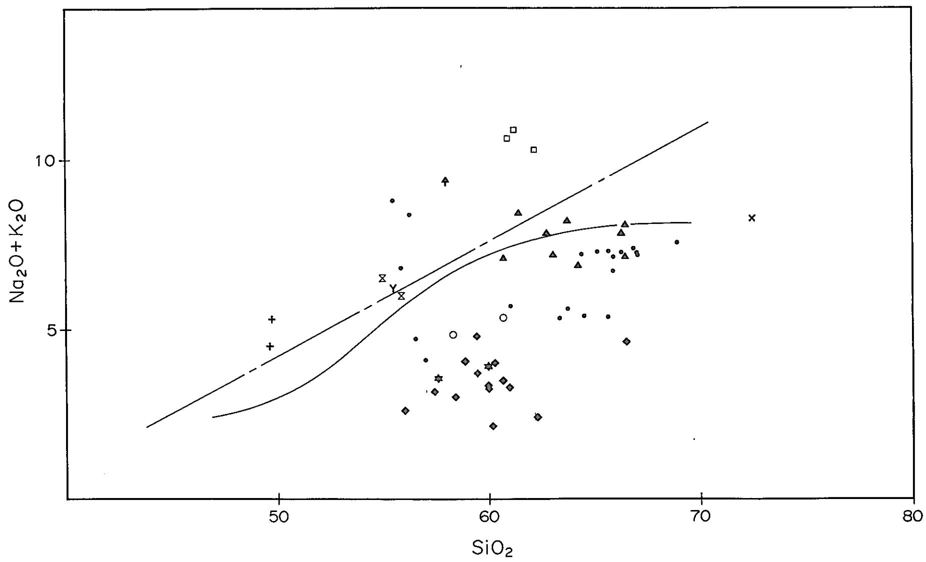

Fig. 7 $SiO_2-K_2O+Na_2O$ (weight %) diagram of rocks from Derekoy-Demirkoy area. Dotted line is after MACDONARD and KATSURA (1964), solid curve is after KUNO (1960). See Fig. 4 for explanations of marks.

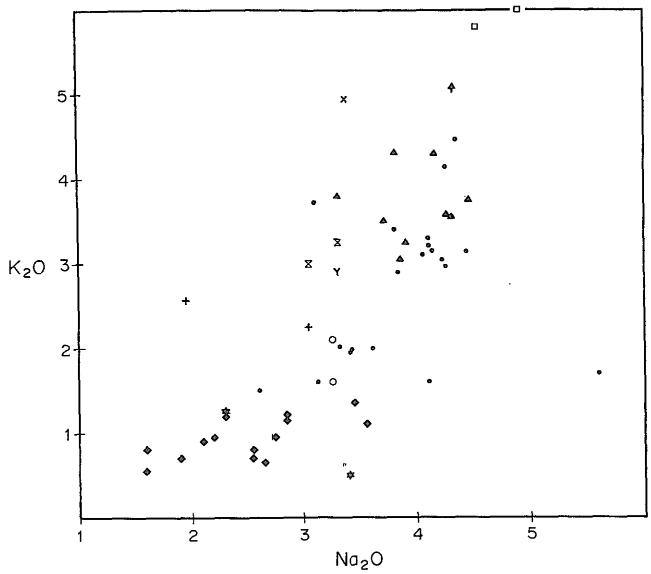

Fig. 8 K_2O-Na_2O (weight %) diagram of rocks from Derekoy-Demirkoy area. See Fig. 4 for explanations of marks.

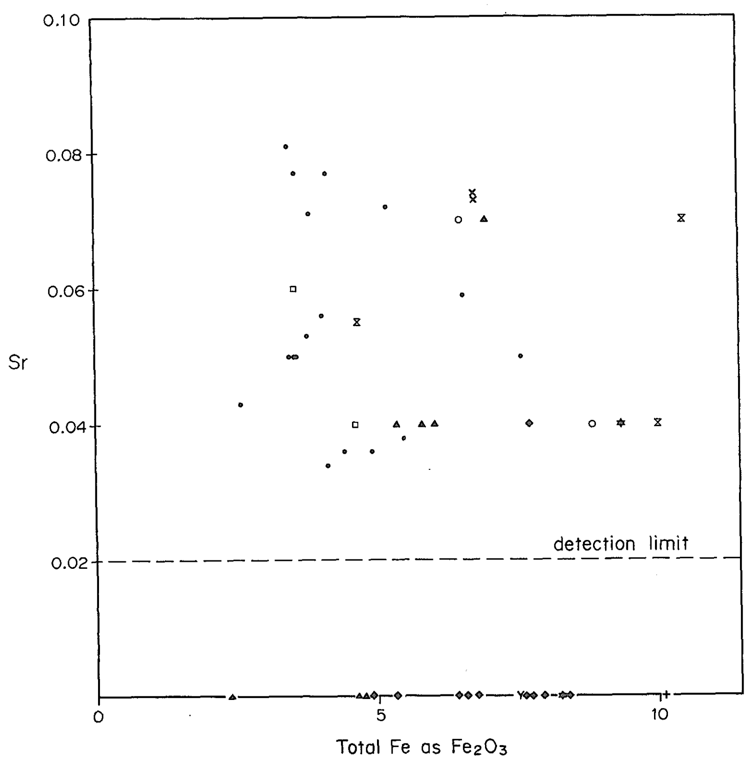

Fig. 9 Total iron oxide-Sr (weight %) diagram of granitoids from Derekoy-Demirkoy area. See Fig. 4 for explanations of marks.

Table 3 Radiometric ages of granitoids from Derekoy-Demirkoy area, Thrace, Turkey.

Locality	Rock name	Measured material	Method	Age	Note
Derekoy	tonalite porphyry	WR	K/Ar	76.7± 3.8	this work from potassic zone
	monzonite porphyry	WR	K/Ar	70.9± 3.5	this work
Sukrupasa	monzodiorite or granodiorite	Hb	K/Ar	81.7± 1.6	MOORE *et al.*, 1980
Demirkoy	granodiorite	Bi	K/Ar	78.3± 1.3	ditto
	ditto	Hb	K/Ar	79.1± 2.3	ditto
	ditto	Bi	K/Ar	79.9± 2.3	ditto
	ditto	Hb	K/Ar	80.2± 2.4	ditto
	ditto	Bi	K/Ar	84.0± 1.6	ditto
Kirklareli	metagranite	Bi+WR	Rb/Sr	144.0± 2.0	AYDIN, 1974
	ditto	WR	Rb/Sr	245.0± 8.0	ditto
	ditto	WR	Rb/Sr	244.0±11.0	ditto

Abbreviations: WR; whole rock, Bi; biotite, Hb; hornblende, K/Ar; potassium-argon, Rb/Sr, rubidium-strontium. Note that textures of rocks from Sukrupasa and Demirkoy are unknown.

side the phyllic zone and in the dikes of **Bqd** and **Cmd** distributed in the mineralized area, and as mentioned already, overlaps some parts of the potassic zones. This indicates that the propylitic alteration had been still in progress when **Cmd** intruded into the ore body. It is practically impossible to identify the outer limit of the propylitic alteration because of the widely developed schist which has similar mineral assemblages to that of propylitic alteration. In the propylitic zones, mafic minerals are altered to chlorite, actinolite, and/or epidote, and feldspars are slightly altered to albite, sericite, calcite, and/or epidote.

Around the complex intrusions of group **A** rocks in the northern part of the area mapped in Fig. 3, skarnization associated with some sulfide minerals is recognized. The gabbro, limestone, marble, and calcareous schist have changed to garnet-epidote-diopside skarn along the contacts to the younger **Agd**. It is notable that the skarnization of the gabbro is observed only at around the margin of the igneous complex to the metamorphic rocks, and in the core of the complex, no chilled margin nor skarnization is recognized at the contacts between the gabbro and the felsic rocks of group **A**.

Mineralization

Three types of mineralization occur in Derekoy area, magnetite skarn, porphyry copper, and enargite vein. Magnetite skarn is not dominant in the mapped area, and its detail is still unknown except that it is closely related to **Agd**. In the phyllic zone, skarn minerals are observed around the contacts of the **Agd** or **Btp** to the calcareous sedimentary rocks. However, they are not dominant, and should rather be included in the porphyry copper mineralization. Enargite veins are recognized around small tonalite porphyry dikes in the southwestern part of the mapped area (Fig. 3b). Porphyry copper mineralization is not observable in the vicinity of these veins, however, they might be situated at an upper part of a porphyry copper system (SILLITOE, 1983).

Though the porphyry copper mineralization is observed everywhere within and around the belt of gruop **B** rocks or the phyllic zone at Derekoy, two ore bodies, east and west, are recognized at around drill 3 and drill 6, respectively (Fig. 3b). Grade of copper is higher at the central axes of the ore bodies, especially along the line connected by drill 2, 19, 3, 18 and 4 (Fig. 3b,c), and molybdenum seems to be abundant on the northern side of the line. Both of the ore bodies are related to the large **Btp** intrusions, and geochemical anomalies of molybdenum and copper similar to those around drill 3 have been detected on the eastern side of the large tonalite porphyry intrusion located to the south of drill 10 (MTA, unpublished data). Therefore another ore body or an extension of the west ore body is expected at this location.

Mineral assemblages in the two ore bodies are similar. Pyrite, chalcopyrite and molybdenite are common, bornite is rare, and no tungsten mineral is observed. Copper and molybdenum grades of drill cores are averaged for every ten meters, and plotted in Fig. 10, which clearly shows the correlation between them is negative. Two-phase and multiphase fluid inclusions are observed in the specimens from the phyllic and potassic zones, and from **Agd** as mentioned already. Leached capping is widely distributed, though an important amount of secondary enriched ore has been recognized only at the upper part of drill 3. This is presumably because of the wet climate of this area.

Discussion

Alpine granitoids in Turkey are mainly of granodiorite, adamellite, and alkaline rock compositions, and are often associated with gabbro and/or diorite, and generally belong to Ishihara's magnetite-series (Kamitani and Akinci, 1979). Granitoids from Derekoy-Demirkoy area show these characteristics exactly.

As shown in Fig. 3, the main belt of group **A** rocks comes down from northwestern edge of the map, and at around drill 3 where high-

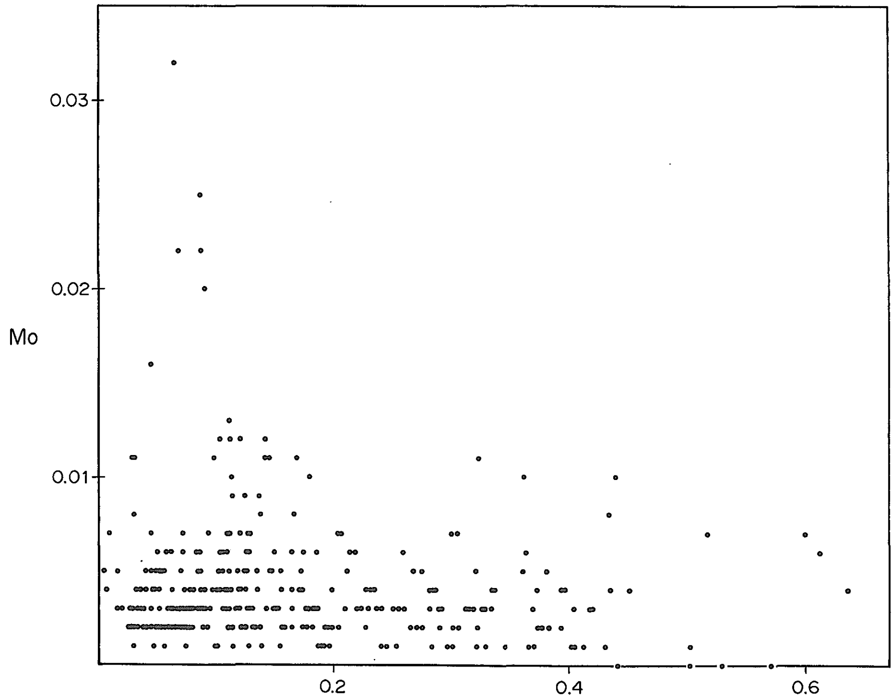

Fig. 10 Cu—Mo (weight %) diagram of drill cores from Derekoy.

est grade of ore is distributed, it joins to the belt of group **B** rocks. It is noteworthy that, at this point, these belts change their directions; group **A** from northwest-southeast to east-west, and group **B** from east-west to northwest-southeast. These belts change their directions also at the western part of the map, and it appears that they outline a lens-shaped area. The southeastern end of the lens is the junction at around drill 3 while the other end is outside the map. A hornblende tonalite porphyry intrusion with disseminated pyrite and chalcopyrite is exposed at three kilometers northwest of Derekoy. Here could be the northwestern end of the lens. One more point to be mentioned is that the textures of the rocks and the distribution of the alteration mentioned above indicate that group **A** in the northern part of the map in Fig. 3 solidified at levels deeper than those of group **B** in the mineralized zone, and that there might be a post-mineralization dome structure with a northwest-southeast axis which declines southeastward along the belt of group **A**. This fits well to the facts that the basement monzonitic gneiss is seen along the northwestern extension of the axis and that a mineralized gabbroic intrusion is seen at the deeper part of drill 4.

The cutting relations of the igneous rocks indicate that **Btp** is younger than **Aog** and **Agb**, and older than **Agd**. All of these groups are affected by the porphyry copper mineralization, though group **C** is definitely younger than the mineralization. The existence of the fluid inclusions in **Agd** also indicates that **Agd** is related to Derekoy deposit or another porphyry copper mineralization. However, in order to conclude that groups **A** and **B** are of the same origin, the remarkable difference of their compositions and distribution must be explained. One explanation is that they are co-magmatic, and the difference of the compositions is due to the difference of their histories. That is, a parent magma which can be differentiated to a tonalitic magma also can produce alkaline magmas if it is much contaminated with the monzonitic gneiss and minor amounts of the metamorphic rocks. This idea is supported by evidences as follows:

1) Many assimilated **Mgn** xenolithes are observed in **Aog** and **Agb**.
2) The fact that **Aog**, **Amd** and **Mgn** are on a fairly straight trend in every variation diagram also suggests a mixing of **Mgn** into the magma.
3) About half of **Agd** samples show $Fe^{+3}/Fe^{+3}+Fe^{+2}$ less than 0.35 (Table 1), which may be attributed to contaminations of the magma with graphite in the schist or phyllite. This also suggests that **Agd** is a product of a contamination.
4) Strontium contents are low in group **B**, and high in group **A** which again indicates contributions of crustal material to form group **A**.
5) The chemical compositions of **Cmz** distributed around group **A** are more alkaline and more felsic than those of **Cmd** around group **B**. This also can be explained by similar contaminations.

This idea is not inconsistent with the domination of I-type granitoids in Derekoy-Demirkoy area because both of the chemical and mineral characteristics of the gneiss indicate its igneous origin. The trend from **Aog** to Kirklareli metagranite through **Agb** and **Agd** may be due to differentiation of **Aog** or to contamination of the original magma with the basement gneiss of granitic composition, though the former process is preferable to produce the ore deposits at Sukrupasa and at Ikiztepe where porphyry copper deposits are hosted by rocks similar to **Agd**. The occurrences, associations and chemical characteristics of the rocks suggest that the magmatism in Derekoy-Demirkoy area was related to a subduction under an undeveloped island arc where some fragments of continental crust from the Istranca massif (e. g. BRINKMANN, 1976) are distributed.

The difference of metal assemblage, Cu-Mo at Derekoy and Cu-Mo-W at Sukrupasa and Ikiztepe, is presumably attributed to the difference of the chemistry of related intrusions, **Btp** at Derekoy, and granitoids similar to **Agd** at Sukrupasa and at Ikiztepe. A simple mineral assemblage of chalcopyrite-pyrite replacing large hornblende phenocrysts in a quartz diorite porphyry at Karacadag (Fig. 2) may be an additional example. This presumably means that contamination of crustal material is needed to form tungsten ore, and is consistent with the tungsten occurrences in Anatolia (KAMITANI and AKINCI, 1979) and in Climax type ore deposits (WALLACE *et al.*, 1978).

Though the granitoids in Derekoy-Demirkoy area have been believed to be Upper-Cretaceous to Tertiary (e.g. MOORE, 1978), the youngest granitoid, monzonite porphyry, at Derekoy has the potassium-argon age of Upper-Cretaceous, and all radiometric ages of granitoids from this area are also Upper-Cretaceous as already mentioned. Therefore there is no evidence of Tertiary magmatism in this area. On the other hand, a belt of Eocene igneous rocks, or magmatic arc, runs from the northern edge of the Aegean Sea to the eastern coast of the Black Sea thruogh the Sea of Marmara and Anatolia (Fig. 11). This probably means that the magmatic arc which was at northern Thrace in Cretaceous migrated southward, and settled in southwestern Thrace to form a part of the Eocene magmatic arc. This episode may be related to the closure of the northern branch of the Neo-Tethys which existed between northeastern Anatolia and central Anatolia (SENGOR *et al.*, 1980), hence to the bunching of island arcs on both sides of the Neo-Tethys. In this regard Derekoy-Demirkoy area contrasts with other areas in Turkey, such as Anatolia and the eastern coast of the Black Sea where Eocene or younger granitoids as well as those of Cretaceous are related to Cu-Mo-W mineralization. The regional distribution of the granitoids in Derekoy-Demirkoy area including groups **A** and **B** is controlled by the northwest trend folding axes. Whereas group **C** dikes which are several million years younger than the two groups intruded into fissures of east-west trend. This presumably indicates that the tectonic stress field in this area changed counter-clockwise in Upper Cretaceous age. This change may also be related to the closure of the Neo-Tethys.

Conclusions

Based on the above discussion following conclusions are reached:

(1) The porphyry Cu-Mo mineralization at Derekoy is closely related to **Btp**, the hornblende tonalite porphyry, and is characterized by the typical metal association, whereas at Sukrupasa and Ikiztepe, granitoids richer in alkali are associated with the porphyry Cu-Mo-W ore bodies.

(2) The chemical characteristics of rocks indicate that group **B** rocks are products of differentiation of subduction-related original magma in an undeveloped island arc circumstance, whereas the other two groups at Derekoy are due to the contamination of the alkali-poor magma with the basement gneiss mainly of monzonitic composition.

(3) The existence of tungsten in Derekoy-Demirkoy area may be attributed to this contamination, hence to the existence of alkali-rich gneiss at the basement.

(4) The granitoids and volcanics, and related mineralizations in Derekoy-Demirkoy area are of Upper-Cretaceous, and the magmatism in this area ceased at around 71 Ma. ago, probably because of a southward migration of the magmatic arc. The migration is presumably related to the closure of the Neo-Tethys.

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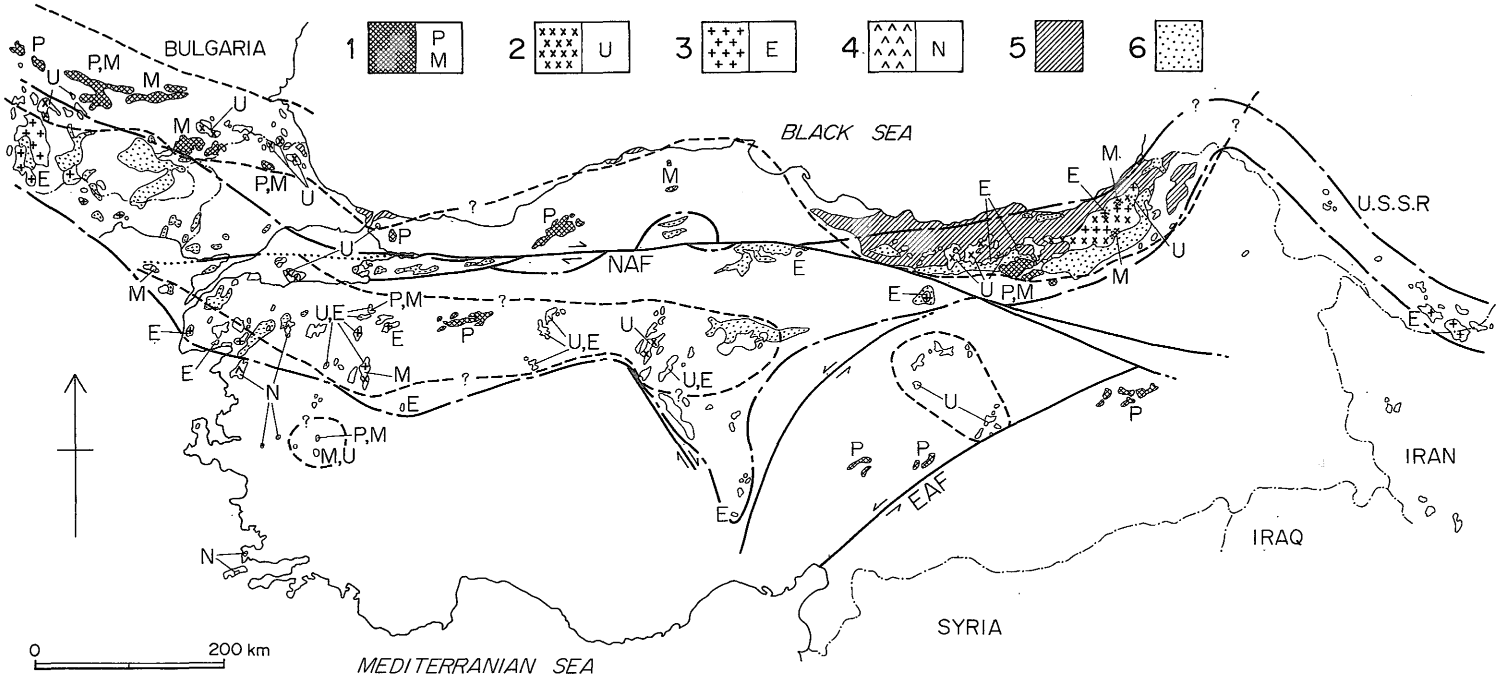

Fig. 11 Distribution of granitoids in Turkey compiled by the senior author after ERCAN and TURKECAN (1984), MOORE *et al.* (1980), etc.

1—P: Paleozoic or older granitoids 1—M: Mesozoic except Upper Cretaceous granitoids 2—U: Upper Cretaceous to Paleocene granitoids 3—E: Eocene to Oligocene granitoids 4—N: Neogene granitoids 5: Cretaceous volcanic rocks 6: Eocene volcanic rocks

Broken lines: areas of Upper Cretaceous to Paleocene magmatism, dotted lines: area of Eocene to Oligocene magmatism, solid lines with arrows are lateral faults, NAF: North Anatolia fault, EAF: East Anatolia fault

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トルコ共和国デレキョイ斑岩銅鉱床の地質と鉱床

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要　旨

トルコ共和国トラキアのデレキョイ－デミルキョイ地域には斑岩型 Cu-Mo や Cu-Mo-W 鉱床が白亜紀の深成岩類に伴っている．デレキョイ周辺に見られる深成岩類は三グループに分類出来る．グループＡはアルカリかんらん石斑れい岩から花崗岩にわたる組成を示す．斑れい岩には基盤のモンゾナイト質片麻岩の捕獲岩片を多数取り込み，同化した形跡が認められる．グループＢは角閃石の斑晶を特徴とする石英閃緑斑岩及びトーナル斑岩からなり，一部に鉱化後の岩脈があるものの，デレキョイ斑岩銅鉱床の主要母岩となっている．野外観察結果からグループＡとＢの貫入は一連のもので，両者の間の時間的隔たりは少ないと考えられる．グループＣは石英モンゾニ閃緑斑岩・モンゾニ閃緑斑岩及びモンゾニ斑岩の岩脈で，明らかに鉱化後の貫入である．大まかに言えばこれら三グループの岩石は全てマグネタイトシリーズのＩタイプに属する．しかし，グループＡとＢの化学組成には著しい違いが見られる．即ちＢはアルカリ・鉛・ストロンチウムが少なく硫黄と銅に富む．カリ変質帯のトーナル斑岩の K-Ar 年代は76.7Ma. で鉱化後のモンゾニ斑岩のそれは70.9Ma. である．前者はデレキョイの鉱化年代を，後者はデレキョイ周辺に於ける最後の火成活動の年代をそれぞれ示す．結論として次のことがあげられる．1)グループＢに対してＡがよりアルカリ質であるのは基盤のモンゾナイト質片麻岩の同化作用による．2）デレキョイではトーナル斑岩が Cu-Mo 鉱床を，周辺のスクルパシャやイキズテペではよりアルカリに富む岩石が Cu-Mo-W 鉱床を伴うこともタングステンの起源を基盤の岩石に求めることにより説明できる．3）デレキョイ周辺に於ける火成活動と鉱化作用は白亜紀末までに終了した．

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