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GEOCHRONOLOGICAL DATA FROM THE SOUTHERN PART (NİĞDE AREA) OF THE CENTRAL ANATOLIAN MASSIF

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ABSTRACT. — In the Niğde massif, which forms the southern end of the Central Anatolian massif, three formations are exposed. These are, from bottom to top: 1. Gümüşler formation, composed mainly of metaclastics; 2. Kaleboynu formation, which is formed by the alternation of carbonates and elastics, 3. Aşıgediği formation, consisting of carbonates. Overlying this sequence, Niğde group, is an ophiolitic melange which has undergone deformation and metamorphism together with the underlain formations. It is assumed that the metamorphism of the sequence has transformed into low P-high T condition from the initial medium P-high T condition. The Niğde group is intruded by posttectonic Üç-kapih granodiorite which is concluded to have crystallized in lower Cenomanian (95±11 m.y.) according to the wholerock Rb/Sr analyses. The initial Sr value (Sr=0.7104), which is obtained from the wholerock isochrone, indicates that the granodiorite magma is generated either by the melting of the continental crust itself or by the extensive contamination of the continental crust. The cooling ages of granodiorite and gneisses acquired by Rb/Sr wholerock-mineral method and by K/Ar method are 77.8±1-2 m.y. and 76.5±1.1-m.y., respectively. These are the ages for granodiorite and gneisses to cool together down to 300±50^{0}C, which is the blocking temperature for micas whose isotope ratios have been measured. These data, obtained by geochronological methods are correlated with the other radiometric ages from the other parts of the Central Anatolian Massif and it is put forward that the main metamorphism and ophiolite emplacement have occurred pre-Cenomanian in the massif.

INTRODUCTION

The Niğde massif is located in the SE of Niğde (Fig. 1) and forms the southern end of the Central Anatolian massif (Ketin, 1956).

The metamorphic rocks in the Niğde massif are all together called Niğde group and according to their lithological characteristics they are differentiated and described as Gümüşler, Kaleboynu, Aşıgediği formations and Üçkapılı granodiorite (Göncüoğlu, 1977, 1981 *a).*

The indirect paleontological data is inadequate to date the deposition and the metamorphism of the Niğde group as well as the intrusion of the granitic rocks in the Niğde massif.

In the north of Çamardı (SE of Niğde massif) in the clayey limestone including granitic and gneissic pebbles and unconformably overlying the Niğde group rocks some Upper Paleocene-Lower Eocene ? microfauna were determined which indicate the metamorphism age as Early-Upper Paleoeene-Lower Eocene in the previous studies (Göncüoğlu, 1981 *b).*

In a recent study in south of study area, west of Kılavuz köy, in an unmetamorphosed turbiditic sequence overlain by Paleocene elastics, are found *Globotruncanita stuarti, Rosita contusa* and *Ganserina ganseri* which dates down to Upper Maestrichtian (Sirel, 1985, personal communication). This turbiditic sequence, whose relation is not clear with Niğde group rocks, can be correlated with Haymana formation which is well defined in the north, in many places in Central Anatolian massif while the Paleocene restricted shelf elastics overlying the turbiditic sequence can be correlated with Kartal formation (Sirel, 1985, personal communication). This unit which is defined as Çamardı formation by Yetiş (1978) is intruded by microgranite dykes in south of Çamardı. This new evidence indicates the presence of a magmatism other than the Üçkapılı granodiorite which crops out widespread. Oktay (1982), verifying the above idea states that, in further south, the basement of the Ulukişla basin comprises the products of an island arc magmatism which starts in Upper Cretaceous or in lowermost Paleocene. He puts forward that a part of the oceanic crust which extends between Tuzgölü-Ulukışla has subducted under Niğde massif (Central Anatolian Continent). Under this circumstances, further research is necessary to reveal the fact if Niğde massif is effected by the subduction. and island arc magmatism.

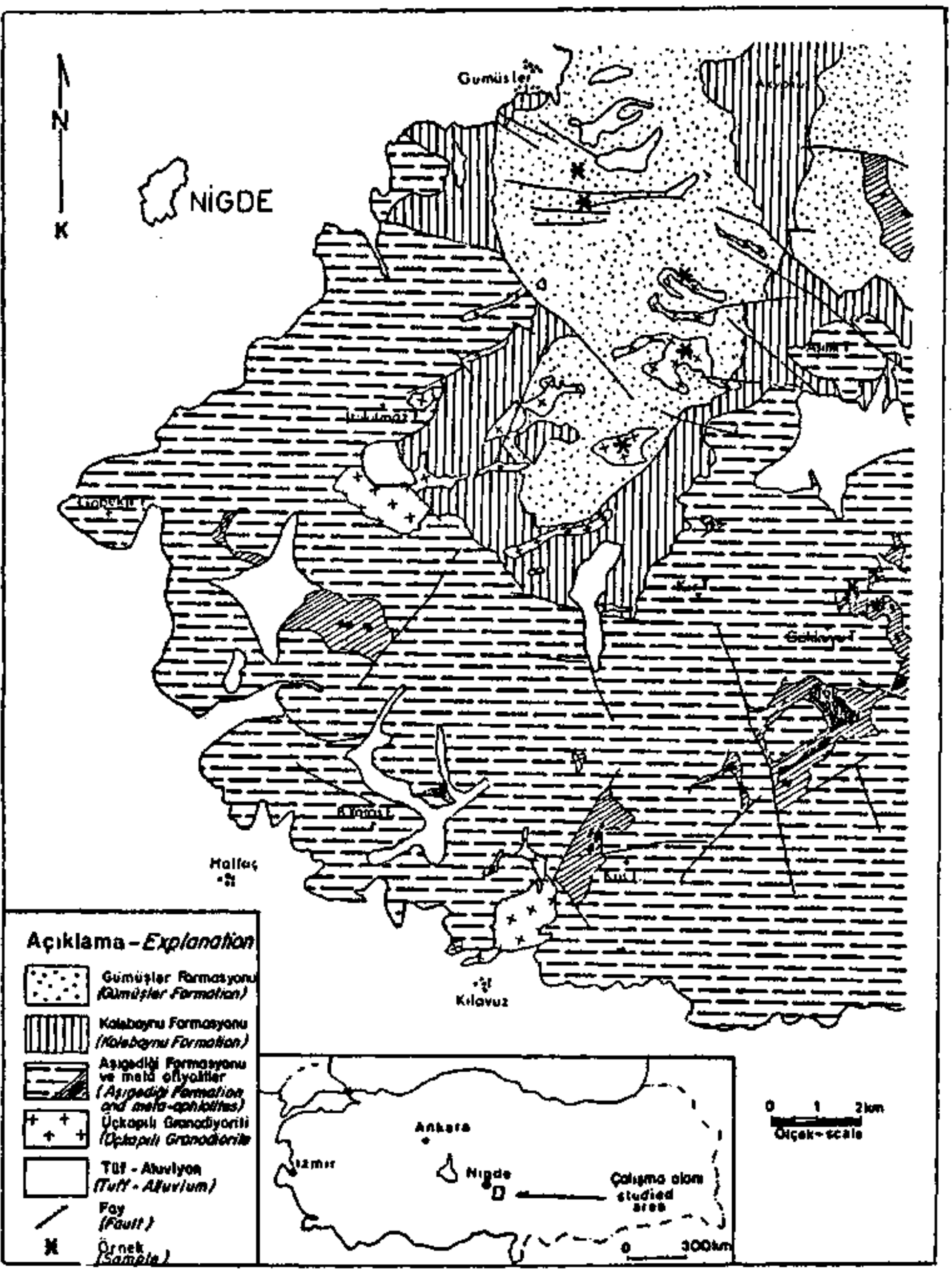

Fig. 1 - A guide map of the studied area and the geological map.

Researches on the age of magmatism and metamorphism in Kırşehir massif which forms the main body the Central Anatolian massif are much more than the ones in Niğde massif. The contradictions in the local and regional studies are still continuing even present day about the age of metamorphic rocks of the region. Some researchers, as discussed in Seymen (1985), suggest that the deposition and the metamorphism ages of the rocks are pre-Mesozoic while Ketin (1956) advocates that the development and the metamorphism of the massif was completed by Laramian phase.

As it is seen by this short discussion, the concrete data that will reveal the geological evolution of the Central Anatolian massif are contradictory and not adequate yet. The inadequacy is very clear if the data is examinated which is obtained by the study of the metamorphic and magmatic rocks with various geochronologic methods.

The first geochronologic study in the Central Anatolian massif was carried out by Ayan (1963). He, using the total Pb method, analysed a zircon sample taken from Barana Dag monzonitic granite and proposed the age of intrusion as 54 m.y. in other words, post-Upper Cretaceous. Ataman (1972) pointing out the methodologic disadvantages of Ayan (1963) used Rb/Sr method for two wholerock analyses and a biotite analysis for the samples from Cefalık Dağı granitic mass located in the south of Barana Dag and calculated 71±1 my isochrone age which is equivalent to the age for biotite to cool down for a blocked system for Rb/Sr. The intrusion age for the granite whose origin was interpreted as depending on the palingenesis of juvenile and arkose-graywacke type rock, «regarding the petrological events», is preassumed as 80 m.y. Ataman (1972) reports that this age is consistent with the field observations without mentioning them.

Erkan and Ataman (1981) made some hornblende and biotite K/Ar age determinations from enriched samples of gneisses, mica-schists and amphibolites situated in the NW of Kırşehir. The average age of the three analyzed biotite samples is *69.7*± 1.7 m.y. while the same value is 74.1± 3.2m.y. for two hornblende samples. Comparing their data with the data of Ataman (1978), the authors suggest that the isotopic system of the metamorphics were wound up by the thermic effect of the intrusion of the granodioritic masses. Also they suggest that the age they calculated as 71 my corresponds to the intrusion/cooling age of the intrusive rocks. The authors, depending on this interpretation, conclude that the effective regional metamorphism has completed its evolution in pre-Cretaceous times. However, since the authors express the age they calculated as «intrusion/cooling age», this data has been used incorrectly by the preceeding researchers.

Several samples have been taken from Niğde massif in order to figure out the deposition and the metamorphism of the metamorphic rocks and to date and to study the origin of magmatic rocks. They were analyzed by using Rb/Sr wholerock, Rb/Sr mineral, K/Ar mineral and zircon U/Pb methods. The zircons of biotite-muscovite-sillimanite gneisses taking place in the lowermost part of the Niğde metamorphites have been dated by U/Pb method and it is suggested that the age of the gneiss is 2000 m.y. Also, it is put forward that gneiss has some detritics possibly derived from a magmatic source (Göncüoğlu, 1982). In the same study it was stated that the geological meaning of the second age, 217±3 my, acquired by U/Pb method is not clear since by Rb/Sr, wholerock, Rb/Sr and K/Ar mineral methods, events younger than 217 my were proved. The data obtained by Göncüoğlu (1982) about Alpine events will be given in detail in this study.

For age determination, four samples from Niğde-Üçkapılı granodiorite and two samples from Gümüşler formation, which is represented by gneisses, have been collected. For six of the samples Rb/Sr wholerock, for five of the samples Rb/Sr mineral and for six of the samples K/Ar mineral dating methods have been used for age determinations. Muscovite and biotite grains in different sizes have been used for determinations.

Specimen preparation, chemical analysis and. isotope ratio measurements have been made in BGR (Bundesanstalt für Geowissenschaften und Rohstoffe) laboratories in West Germany.

PETROGRAPHICAL FEATURES OF THE MEASURED SAMPLES

Gümüşler formation

The samples numbered NM1 and NM4 used in isotope measurements have been collected from the Gümüşler formation which forms the lowermost unit of Niğde group. This formation consists of gneisses having different mineral compositions and containing lenses and intercalations of marble, amphibolite, quartzitic gneiss and calcsilicate marbles (Göncüoğlu, 1977, 1981 *a*). The chemical compositions of the samples are given in Table 1b. The sample NM1 was collected from the lowermost level of the unit in Ören Dere, south of Gümüşler village, on the road to antimony mine. The other one, NM4 was collected 1.5 km. south of this location. The mineralogical composition of the samples are as follows:

Table 1 - a- Modal combination, b- Chemical combination, of the Gümüşler formation gneises

	(a)			*(b)*	
	NM1	*NM4a*		*NM1*	*NM4a*
Quartz	45.4	37.3	SiO_2	78.90	70.41
K.Feldspar	12.1	16.4	TiO_2	0.51	0.47
Plagioclase	5.2	7.6	Al_2O_3	9.86	14.85
Biotite	16.1	18.4	Fe_2O_3	2.83	2.73
Muscovite	11.2	9.1	MnO	0.06	0.04
Sillimanite	2.1	3.6	MgO	0.91	1.34
Granat	4.4	1.6	CaO	0.93	2.90
Turmaline	a	a	Na_2O	1.90	4.51
Apatite	a	a	K_2O	2.85	1.41
Zircon	a	a	P_2O_5	0.08	0.18
Chlorite	3.5	6.1	Rb(ppm)	111	86
Opaque	a	a	Sr(ppm)	113	175
			Zr(ppm)	191	147
			Y(ppm)	23	34
			Ba(ppm)	591	306
			Cr(ppm)	72	37
			La(ppm)	49	34
			Sc	13	11
			Zn	39	42

NM1: quartz+plagioclase+biotite+muscovite+K-feldspar+sillimanite+tourmaline (+apatite+zircon+rutile);

NM4: quartz+plagioclase+biotite+microcline+garnet (+zircon+apatite+rutile+opaque). In both samples sericitization in plagioclase and chloritization in biotite are seen.

In Gümüşler formation the dominant regional metamorphism conditions are almandine-sillimanite medium grade whereas in the other parts of the Niğde group (with the possible effect of granite) locally, it is thought to have reached cordierite-almandine high degree (Winkler, 1976) and have caused partial melting in gneisses of pelitic origin.

Sillimanite formation in Niğde metamorphics starts with staurolite and in coarse garnet (almandine) blasts, staurolite blasts are observed as inclusions (Fig. 2). In samples having cordierite the presence of relict sillimanite, staurolite and garnet is striking. Petrographic studies show that staurolite disappears with the development of sillimanite+almandine from the conditions where biotite+staurolite are stable initially. In high temperature paragenesis where cordierite is observed, with the development of this mineral, almandine and staurolite lose their stabilities. In the rocks having cordierite the development of muscovite in the last phase and chloritization of biotite indicates an additional retrograde phase. In the two mentioned samples, although they have different evolutionary paths, in the last phase of prograding metamorphism an increase in the temperature is expected.

Fig. 2 - The locked staurolite sticks in Almandines of the Gümüşler formation gneises.

In Central Anatolian massif, around Kırşehir, it is known that the last stage of the prograding metamorphism is high T low P type. It is claimed that in this region pressure varies between 1.8-2 kb (Seymen, 1985) and 3 kb (Erkan, 1975, 1976) and temperature is approximately 700°C (Seymen, 1982; Erkan, 1975). The degree of metamorphism increases towards NW (Erkan, 1975). On the other hand, contrarily, in far SW of Akdağmadeni staurolite+disthene; in Ortaköy sillimanite; in Kümbet staurolite+sillimanite and in far NW end (İtdağı) disthene are observed (Erkan, 1975,1980; Tülümen 1980; Özcan et al., 1980; Özer and Göncüoğlu, 1983). Considering the distribution of the critical minerals-instead of the presence of different metamorphism conditions stated by Erkan (1975)-it is possible to think that regional metamorphism, in time, changes into low P/high T type from medium P/high T because of the rising thermal zones. Around Niğde, the transition of staurolite to metastable-phase by the formation of sillimanite+almandine and the transition of almandine+staurolite to metastable phase by the formation of cordierite indicates such a change.

Üçkapılı granodiorite

The acidic intrusive rocks taking place in Niğde metamorphites were studied as Üçkapılı granodiorites which together with its aplites cuts Gümüşler formation, Kaleboynu formation, Aşıgediği formation and the overlying metamorphic ophiolitic complex. The distribution of the outcrops of granodiorite indicates the presence of a huge and shallow batholith in the center of the study area. In this region, within Üçkapılı granodiorite partially assimilated gneiss, amphibolite and marble xenoliths are seen. There is a narrow contact metamorphism zone between granodiorite and its border rocks. The determined paragenesis in the contact of granodiorite with gneiss, carbonate, and amphibolite and metagabbro are: cordierite+muscovite+garnet, diopside+hedenbergite+vesuvian+garnet (grossularite/andradite), and epidote+garnet+scapolite, respectively. These paragenesis are characteristic for hornblende-hornfels facies of the contact metamorphism (Winkler, 1976). The thickness of wall-rocks and contact metamorphic zone of the Üçkapılı granodiorite ranges from a few centimeters to decimeters.

Under microscope, granodiorite is seen as granoblastic textured and is fine-to-medium grained. Its modal composition is given in Table 2. The primary minerals forming granodiorite are K-feldspar, plagioclase, quartz and biotite. Muscovite, chlorite and rutile are seen as secondary minerals. Accessory minerals are zircon and opaque minerals. Plagioclase occurs as zoned hypidiomorph crystals. An-rich (An_{35-41}) central parts of the crystals are sericitized. On the edges fresh albite (An_{8-12}) is dominant.

Table 2 - Modal combination of Üçkapılı granodiorite

	NM2a	*NM2b*	*NM2c*	*NM4b*
Quartz	30.9	26.1	21.4	28.4
K-feldspar	32.1	28.4	25.5	21.2
Plagioclase	11.2	19.9	28.7	26.1
Biotite	17.6	20.3	18.2	15.4
Muscovtie	3.6	2.9	2.7	4.2
Clorite	4.2	2.1	3.3	4.4
Zircon	a	a	a	a
Apatite	a	0.2	a	0.1
Opaque	0.4	0.1	0.2	0.2

Quartz fills the space between the other minerals and is mostly xenomorphic. It contains reddish-brown idiomofphic biotite and plagioclase inclusions. There are K-feldspar crystals up to 1 cm and its boundaries with quartz and plagioclase are idiomorphic. In coarse blasts perthite formations are seen as bands or stains. K-feldspar has idiomorph quartz, biotite and plagioclase inclusions. They, in some places, form zones and get coarser from center to the edges.

Biotite is observed as reddish-brown flakes and is 0.7 to 0.2 mm in size. When they are as inclusions in K-feldspar and quartz they are idiomorphic and less chloritized. Coarse biotite flakes contain clear zircon inclusions elongated parallel to C-axis and apatite. There are paleochroic haloes around zircon inclusions. This kind of biotite crystals have been chloritized in a late hydrothermal stage. In the first stages of chlorite formation the paleochroic haloes have been preserved and on the edges of the grains ilmenite needles have been developed. In the last stage chlorite has replaced tetrahedral layers and has developed together with muscovite. In this kind of alteration products ilmenite has been concentrated on the cleavage planes of biotite.

Zircon, as mentioned above, has been concentrated in biotite and shows the characteristics of zircons crystallized from a solution. Apatite and magnetite can be found as accessory minerals.

The distribution of major and minor elements of Üçkapılı granodiorite is given in Table 3. According to Shand (1951) it is in «peraluminous» group. The average SiO_2 amount of the measured samples is 72.7 % The samples numbered as NM2 a-b-c have uniform Na_2O and K_2O values. The sample numbered as NM4 b has greater values of SiO_2 and K_2O but less Fe_2O_3 and Na_2O than the samples numbered as NM2. The chemical characteristics and their interpretation will be given in detail in another paper (Göncüoğlu, in preparation).

Table 3 - Chemical combination of Üçkapılı granodiorite

	NM2a	*NM2b*	*NM2c*	*NM4b*
SiO_2	73.49	71.33	71.47	74.47
TiO_2	0.16	0.26	0.20	0.07
Al_2O_3	13.95	15.20	14.70	14.29
Fe_2O_3	1.23	1.64	1.27	0.52
MnO	0.04	0.04	0.04	0.04
MgO	0.26	0.50	0.38	0.16
CaO	0.91	1.71	1.35	1.05
Na_2O	4.07	4.26	4.16	3.69
K_2O	4.29	3.82	4.40	4.89
P_2O_5	0.05	0.08	0.07	0.04
LQI	1.00	0.70	1.50	0.60
Total	99.51	99.60	99.58	99.81
Nb (ppm)	12	11	8	14
Rb	206	166	159	153
Sr	65	165	133	80
Th	23	27	22	14
U	7	6	5	6
Y	28	13	13	26
Zr	110	144	118	62
Ba	412	489	477	236
Ce	32	53	24	39
La	27	33	16	10
V	7	16	12	4
Zn	14	44	33	0
Cr	8	12	7	5

GEOCHRONOLOGY

For the preliminary geochronological investigation, as a first step, Rb/Sr wholerock method has been used to determine the age of gneiss and granite and then by K/Ar and Rb/Sr method the age of micas have been determined.

Methods

The samples whose weight varies between 3 and 5.5 kg. were first broken by a jaw-crusher to sizes less than 5 cm and the altered parts were removed. Then the fragments separated for Rb/Sr wholerock analysis have been prepared according to Muller's (1979) method. Some of the prepared samples have been analyzed by x-ray fluorescence method in order to observe the distribution of the oxides and minor elements. The samples greater than 200μ have been studied under microscope and it is determined that muscovite and biotite are suitable for mineral Rb/Sr and mineral K/Ar age determinations.

The BGR-Hannover method was applied for the Rb and Sr chemistry of the samples. For the analysis of Rb a spike ($Rb^{85}/Rb^{87}=0.007935$) which has been prepared in the same laboratory and for the analysis of Sr the spike SRM 988 was used. The Rb isotope ratios were measured by an «Aldermaston Micromass 30» type mass-spectrometer with double filament and the Sr isotope ratios were measured by an «Atlas CH4» type mass-spectrometer with a single filament.

The relative errors in measurements of Rb^{87}/Sr^{86}, Sr^{87}/Sr^{86} are 1.5 % and 0.1 %, respectively. Also, they are determined for wholerock isochrone and mineral isochrone calculations as $X^2=1.4$ and $X^2=0.9$, respectively. The constants for Rb/Sr were taken from Steiger and Jager (1977) and York's (1967) method has been used for isochrone calculations.

In K/Ar measurement, the K content of the micas comparing with the internal standard was measured by a double channel digital pipetted flame photometry of type EEL-170 which has Li-internal standard. The Ar isotope ratios were measured by the Ar-extraction system developed by H. Kreuzer through increasing the temperature up to 1500°C for biotite and 1460° for muscovite. In K/Ar measurements two series of different grain size from each sample have been measured and by grinding one of the biotite fractions cross-control has been provided. The acquired values and the model ages have been corrected by laboratory standards.

Rb/Sr wholerock systematics

In the rocks of Niğde group six samples have been measured to determine the Rb/Sr wholerock systematics. Two of these samples have been collected from the gneiss of Gümüşler formation and four of them have been collected from Üçkapılı granodiorite. The analytical data of the measured samples can be seen in Table 4. Plotting these data on Nicolaysen diagram (Fig. 3) isochrones of 460±53 m.y. for gneiss and 95±11 m.y. for granodiorite are obtained.

Table 4 - Rb/Sr wholerock analitical data of the samples of Niğde groups gneises and Üçkapılı granodiorites

Sample	*Rock type*	*Rb^{87} ppm*	*Sr^{86} ppm*	*Rb^{87}/Sr^{86}*	*Sr^{87}/Sr^{86}*
NM1	Gneiss	31.30	11.03	2.805	0.72.464
NM4a	Gneiss	23.65	16.68	1.402	0.71.544
NM2a	Granodiorite	57.36	6.433	8.814	0.72.212
NM2b	Granodiorite	46.43	15.86	2.894	0.71.336
NM2c	Granodiorite	45.87	12.61	3.596	0.71.633
NM4b	Granodiorite	42.17	16.68	5.364	0.71.775

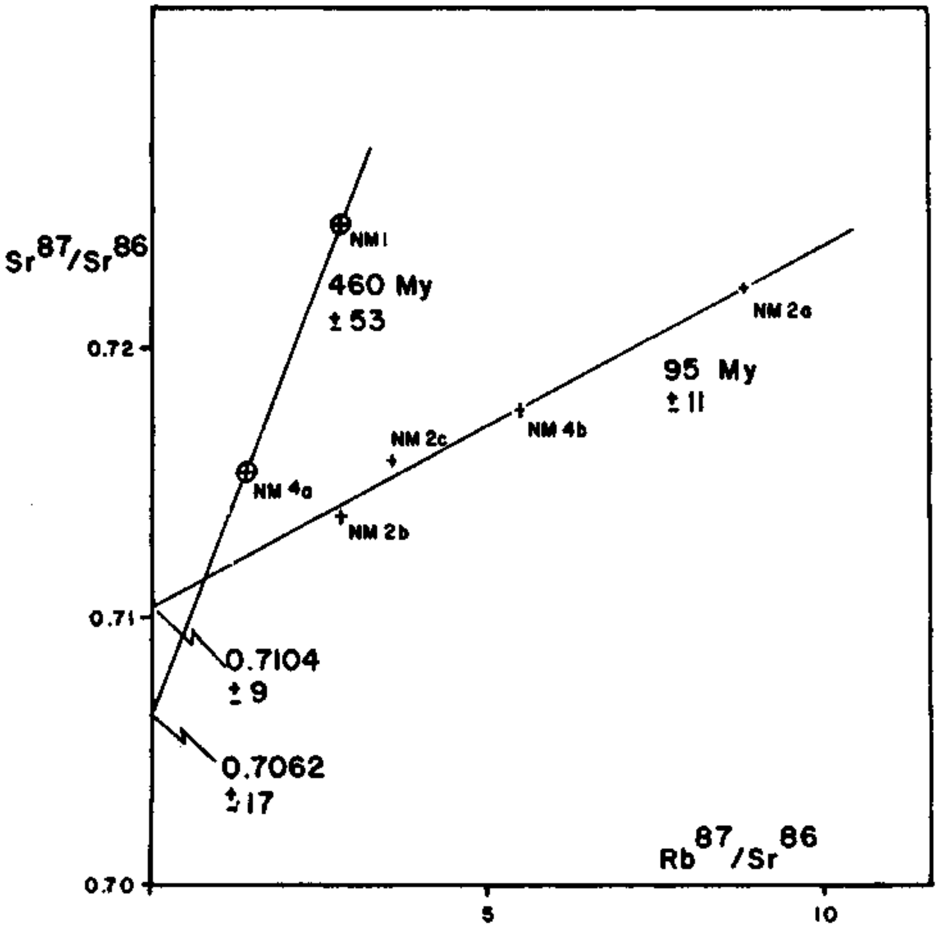

Fig. 3 - Niğde groups, gneises and the positions of Rb/Sr wholerock of Üçkapılı granodiorite samples in the Nicoloysen diagram (Gümüşler formation gneises: NM1, NM4 a, Üçkapılı granodiorites: NM2 a, NM2 b, NM2c, NM4b).

The isochrone drawn from gneiss is not so important since it is represented only by two points. But it is the Pb^{207}/Pb^{206} model age calculated during the age determination of zircon fractions enriched from the sample numbered NM1 (Göncüoğlu, 1982). Şengör et al. (1984) suggests that in various regions of Turkey this age corresponds to late Pan-African events. For this reason, it is necessary to sample the gneiss of Niğde group and determine its age by wholerock method and study its geological meaning.

The four samples collected from Üçkapılı granodiorite give an isochrone of 95 m.y. In unmetamorphosed granitea, as known, wholerock isochrone age indicates the time by which Rb/Sr migration ends. This phenomena means, after the intrusion, material transportation in the solution was finished because of the crystallization. Then the calculated age, 95 m.y., corresponds to the crystallization age of Üçkapılı granodiorite.

On the other hand, the initial Sr^{87}/Sr^{86} Value of isochrone gives an important clue about the origin of Üçkapılı granodiorite. The calculated value (Si=0.7104±0.0009) indicates that the origin of the granodiorite is continental crust or an extensive contamination of continental crust. This data, when considered with the presence of the sections where partial melting is reached locally in gneiss as mentioned in the introduction, may support the idea stating that the Üçkapılı granodiorite has been formed by the partial melting of continental crust.

Rb/Sr mineral analyses

In order to study the Rb/Sr distribution and Sr homogenization, biotite from the samples NM1 and NM4, biotite from the sample NM2b and muscovite and biotite from sample NM4b have been analyzed and the results were given in Table 5.

Table 5 - Rb/Sr mineral analitical data of the samples of Niğde groups gneises and Üçkapılı granodiorites

Sample	*Rb^{87} ppm*	*Sr^{86} ppm*	*Rb^{87}/Sr^{86}*	*Sr^{87}/Sr^{86}*
BNM1	182.3	0.4644	387.8	1.1390
BNM4a	171.6	0.9269	183.0	0.9098
BNM2b	270.3	0.2395	115.5	1.9489
BNM4b	230.0	1.0673	213.0	0.9463
MNM4b	143.9	0.9419	151.0	0.8805

Evaluating the measured minerals and the samples together (Fig. 4), a certain mineral-wholerock isochrone which dates 77.8±1.2 m.y. and gives and initial value of 0.7111±0.0037 for Sr, is obtained. Then from the isochrone it is deduced that Sr homogenization for wholerock and has been realized. Isochrone line has less inclination than wholerock isochrone. This data which appears as the wholerock/mineral age of gneiss and granodiorite may be interpreted in two ways:

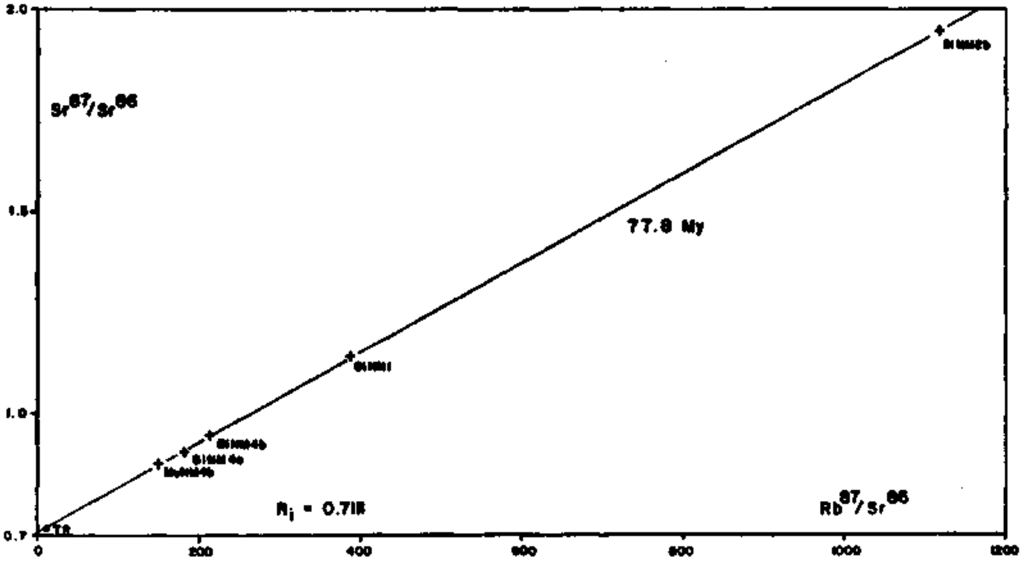

Fig. 4 - Distributions of mineral analysis of Niğde groups gneises and Üçkapılı granodiorites in the Sr-evolution diagrams (B=biotite, M=muscovite, TR=wholerock, see figure 3 for the number of the samples).

a. The determined age indicates a metamorphism event which leads to Sr homogenization both in gneiss and granodiorite.

b. The determined age indicates a stage in which micas, at a certain temperature, have been blocked for Rb/Sr. In this case 77.8±1.2 my is the cooling age of the measured samples for Rb/Sr. Considering the studies in the Alps (Dodson, 1973; Wagner et al., 1977) the above age is obtained by a decrease in the temperature of the measured samples down to 300±50°C.

The first interpretation may be eliminated since no trace of metamorphism or deformation is seen in Üçkapılı granodiorite. The second interpretation is especially supported by the wholerock-biotite-muscovite isochrone of the sample NM4b. From the structure of this isochrone, it is deduced that muscovite acted as an open system until biotite is blocked for Rb/Sr around 300°C. If it is considered that, in case of the formation of muscovite by metamorphism, the blocking temperature for Rb/Sr is around 500C (500±50°C) (Jager and Hunziker, 1979), because of the above stated reason, wholerock-muscovite-biotite isograd does not give metamorphism age. Another data supporting that 78 my reflects the cooling age is K-Ar mineral ages.

K-Ar mineral analyses

The following samples of Niğde group rocks have been analyzed for K-Ar: Two fractions from gneiss sample (NM1), biotite from gneiss (NM4a), ground biotite from granodiorite sample (NM2b), biotite and muscovite from granodiorite (NM4b). Analytical data is shown in Table 6. In this table biotites from gneisses and granodiorites give model ages varying between 74.9±1 and 77.9±1.2 m.y. These ages are consistent with Rb/Sr ages within error limits. Considering biotites have almost the same blocking temperatures for K-Ar and Rb/Sr (Jager and Hunziker, 1979), it is obvious that the acquired model ages reflect the cooling age, below 300°C (±50°C), as in Rb/Sr mineral ages. One of the muscovite sample taken from a granodiorite sample (NM4b) gives higher model age than that of biotites. This age, 78.5±1.2 m.y. gives the blocking age of muscovite for K-Ar. Actually, the blocking temperature of muscovite is around 350°C for K-Ar and it blocks before biotites. Muscovite, therefore, must have a higher model age.

Table 6 - The mineral K-Ar analitical datas (B=biotite, M=muscovite) of Niğde groups gneises and Üçkapılı granodiorites

Sample	*Grain size*	*% K*	*^{40}Arrad*	*% radAr*	*^{40}K/^{36}Ar*	*^{40}Ar/^{36}Ar*	*Model age (my)*
BNM1	500-250	7.75	234.9	95.22	1357.9	6442	76.28±1.2
BNM1	250-160	7.76	234.2	95.26	1448	6827	76.0±1.0
BNM4a	400-160	7.66	235.3	97.11	2325	10972	77.4±1.2
BNM2b	200-100	6.89	208.3	96.88	2216	10313	76.2±1.2
BNM4b	500-160	6.27	186.3	94.93	1310	6115	74.9±1.2
MNM4b	500-160	8.69	270.9	95.24	1413	6879	78.5±1.2

When the blocking temperatures of muscovite and biotite and the acquired model ages are evaluated roughly together, a cooling rate of 15°C/m.y. is obtained. This value may be considered as a preliminary data about the uplift of Niğde. group rocks after 75 my.

CONCLUSIONS

The Niğde group rocks consist of gneiss whose origin is possibly clastic and an overlying thick carbonate sequence. In the upper part of the massif is an ophiolitic complex vhich has undergone deformation and metamorphism together with the Niğde group rocks. The Niğde group rocks have been cut by Üçkapılı granodiorite and have undergone contact metamorphism. The oldest and unmetamorphosed unit which has relation with metamorphites contains fossils of Upper Maestrichtian.

When mineral paragenesis of Niğde group rocks have been studied it is noticed that the conditions of regional metamorphism, in time, changes from almandine-sillimanite medium grade to cordierite-almandine high grade. This change, especially in the pelitic originated rocks reach up to partial melting.

Gümüşler gneiss which forms the lowermost part of Niğde-group rocks, implies even if questionably, the existence of a Pan-African event in terms of Rb/Sr wholerock and zircon Pb^{207}/Pb^{206} model age.

The crystallization age of Üçkapılı granodiorite is determined as 95±11 m.y. by Rb/Sr wholerock isochrone. The initial Sr value (0.7104) obtained from isochrone shows that the granodiorite magma has been generated totally or extensively by the melting of the continental crust. This data supports the result reached by field observations and petrographic interpretation and indicates hat the generation of granodiorite depends on the partial melting of the psammopelitic rocks situated in the lower parts of Niğde group. The ages 78 m.y. 78 m.y. and 75 to 78 m.y. determined from biotites and muscovites by mineral-wholerocks, from muscovites by K-Ar analysis and from biotites by K-Ar method, respectively, shows both the homogenization of gneiss and granodiorite together and the cooling of them together below 300 ± 50^{0}C which is the blocking temperature for micas. Especially, the consistence of the mineral model ages of gneiss and granodiorite is interpreted to indicate that with granodiorite intrusion, in metamorphic rocks the Rb/Sr and K-Ar systems are opened below the formation temperatures of micas and closed during cooling. In order to determine the metamorphism ages of Niğde group metamorphites more analyses of gneiss by Rb/Sr wholerock method are needed.

The age determinations obtained from the gneiss and granodiorites of Niğde massif are slightly different than the ones obtained by Erkan and Ataman (1981) from the rocks of Kırşehir region and than the ones obtained by Ataman (1972) from the rocks of Cefalık Dağ region. Ataman concluded that the age is 71 m.y. by biotite-wholerock isochrone and stated that it is the cooling age of biotite. His suggestion about the age of the granite intrusion as 80 m.y. has no evidence. Erkan and Ataman (1981) states the K-Ar biotite age for amphibolites and micaschists of Kırşehir massif is 60 m.y. and the hornblende age for the same rocks is 74 m.y. They express these values as the «intrusion/cooling» age of granodiorite. Accepting these ages as cooling age, the evidences and age determinations of the writers are consistent with the ones obtained in Niğde massif.

In the Kırşehir, Akdağmadeni and Niğde regions of Central Anatolian massif similar rock series are seen (Seymen, 1981, 1985; Özcan et al., 1980; Tülümen, 1980; Göncüoğlu, 1977, 1981a). In these regions, from bottom to top, metaclastics, carbonate interbedded elastics and carbonates are dominant. At the top, -at least in Niğde and Akdağmadeni regions-together with the underlain platform type rocks, an ophiolitic complex which has undergone deformation and metamorphism can be seen. Granitic and granodioritic rocks cut both the metamorphics at the base and the ophiolitic rocks. Around Eskişehir-Sivrihisar region which is claimed to be in a different belt than Central Anatolian massif (Şengör and Yılmaz, 1981), there are great similarities in the sequence of metamorphism, position of ophiolitic complex and in age of the intrusives (91 m.y., Gautier, 1984).

Under such circumstances, in Central Anatolian Massif and probably around Sivrihisar region, granodiorite intrusion has taken place in Cenomanian (95-91 m.y.). Considering granodiorite cuts both the rocks at the base and ophiolite, it can be deduced that ophiolite emplacement must have been occurred in pre-Cenomanian times.

This idea is contradictory with Seymen's (1981, 1982, 1983, 1985) interpretations. Because, although Ataman (1972) states that the age determined in Cefalık Dağı granite mass (what Seymen calls «Barana Dağ Pluton»), 71 m.y., corresponds to the cooling age of granite and as a result the intrusion age must be older, Seymen (1985) puts forward that Uppermost Cretaceous-Lower Paleocene (69-63 m.y.) sediments were cut by the same granitic intrusions.

Görür et al. (1985) who are following Seymen's interpretations accept that the emplacement age of the ophiolitic mass overlying the Central Anatolian massif is Late Cretaceous and the age of the «arc plutonics» cutting them are Latest Cretaceous in age. In the geodynamic models of the authors it is suggested that, depending on Bergougnan (1975), the ophiolites of the northern branch of Neotethys have been thrusted over the Central Anatolian massif in Upper Cretaceous. The magmatism cutting these ophiolites are thought to be related to the Andean type arc plutonism which is caused by the oceanic plate which subducts under Central Anatolian block along Inner Taurus suture. If the magmatism of the Central Anatolian massif is studied under the light of the data brought by this paper, it will be seen that it is necessary to review the geodynamic interpretations of Görür et al. (1985), at least for the time concerned.

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