Bulletin of the Mineral Research and Exploration

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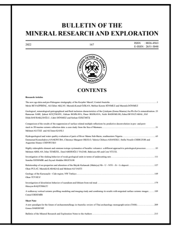
BULLETIN OF THE MINERAL RESEARCH AND EXPLORATION

CONTENTS

The new age data and pre-Paleogene stratigraphy of the Kırşehir Massif, Central Anatolia

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Research Article

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ABSTRACT

The metamorphics belonging to the Kırşehir Massif, which form the pre-Paleogene basement units in Central Anatolia around Kırşehir, are formed from bottom to top by conformable and transitional Late Devonian Kalkanlıdağ, Carboniferous-Early Permian Kervansaray and Late Permian Bozçaldağ formations and by the unconformably overlying Triassic Demirtepe and Jurassic-Cretaceous Saytepe formations. The sedimentation age of 237 Ma were obtained from the clastic zircons in the quartzites of the Demirtepe formation by the U/Pb method, and the metamorphism age ranges from 94.5 Ma and 83.7±3.3 Ma from the metabasites from the Whole Rock by the $^{40}Ar/^{39}Ar$ method. The Kasımağa and Sırataşlar formations within the Çiçekdağı Nappe belonging to the northern branch of Neotethys, which were tectonically emplaced over these units and the Turonian-Santonian Kargınkızıközü formation, which were the product of ensimatic island arc magmatism, were distinguished. The metamorphics and the Central Anatolian plutonic rocks, which cut the overlying ophiolitic rocks, were differentiated according to their composition, origin and age, and ranges from 71.9±1.7 Ma from the Baranadağ pluton; ranges from 84.0±1.9 Ma and 71.9±7.2 Ma from the Çayağzı pluton; ranges from 69.1±1.2 Ma by the $^{40}Ar/^{39}Ar$ method, and 65.3±1.1 Ma were obtained from the Buzlukdağı pluton by the U/Pb method. The age ranges from 79.1±1.2-68.2±1.2 Ma and 74.5 Ma were obtained from the whole rock by $^{40}Ar/^{39}Ar$ method from trachyandesites belonging to the Kötüdağ volcanics, which are surface-semi-depth rocks of granite, monzonite and syenite composition plutonic rocks. The cover units overlie all these units with an angular unconformity.

1. Introduction

The study area located on the Kırşehir Block in the Central Anatolia (Şengör and Yılmaz, 1981; Okay and Tüysüz, 1999) covers Kırşehir province and Mucur, Boztepe and Kaman districts, Kırıkkale province Çelebi district and Ankara province Evren district (Figure 1). The Kırşehir Block generally consists of ophiolites and nappes of oceanic origin emplaced on high grade metamorphic rocks, granitic plutons intersects these two and their surface equivalents. All these units are covered by the cover sedimentary rocks. This study is about the metamorphic and igneous rocks that compose the massif. The Kırşehir Massif has been the subject of detailed research for many years. However, there are debates about the internal distinctions and ages of the rocks that make up the massif. In this study, it is aimed to reveal the

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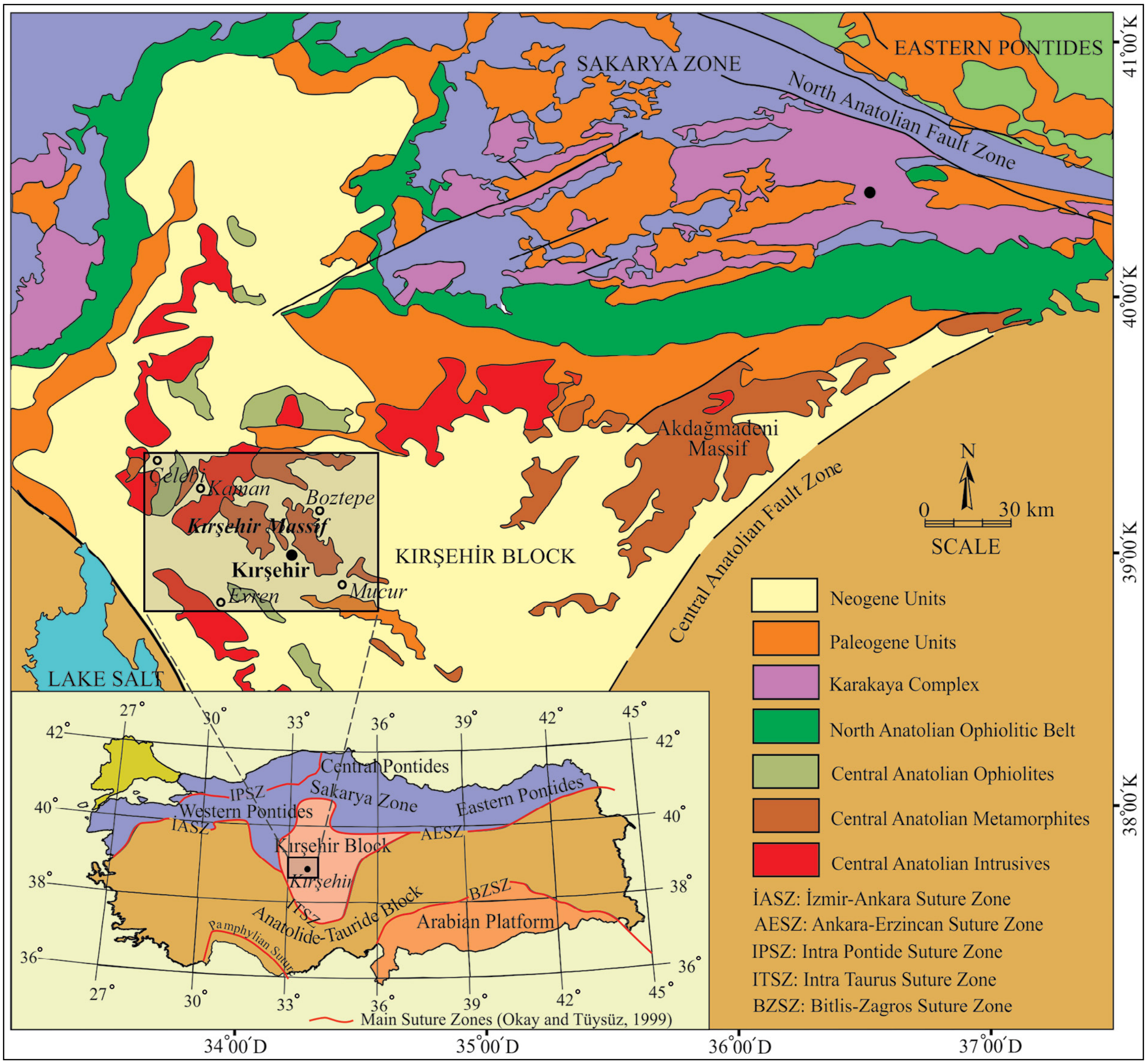

Figure 1- Location map of the study area (modified from Akçay and Beyazpirinç, 2017).

distinctions and contact relationships of the above-mentioned rocks with a regional survey, to determine their age using radiometric data, and to discuss the evolution of the massif in the light of these data.

Seymen (1981*a, b*; 1984) distinguished the Kaman group consisting of metamorphic rocks, the Ankara complex, which forms the ophiolitic rocks, the Karakaya ultramafic, and the Kartal and Asmaboğazı formations and the Kötüdağ volcanic that overlie them with angular unconformity. The researcher stated that the Early Paleogene-Neogene sedimentary cover units unconformably overlie all these units cut by the Baranadağ and Buzlukdağı plutons. The author divided the lower part of the Kaman group metamorphics, consisting of gneiss, biotiteschist, pyroxeneschist, amphiboleschist, calcsilicatic fels, quartzite and quartzschists as the Kalkanlıdağ formation; the upper part, composed of marble-schist and gneiss intercalation as the Tamadağ formation, and the uppermost part, composed of marble, metachert semi-marble and metachert assemblage as the Bozçaldağ formation. Erkan (1976), who investigated the metamorphic that are in and around Kırşehir, stated that the degree of metamorphism increased towards N-NE. Erkan and Ataman (1981) obtained metamorphism ages from biotites in gneiss, micaschists and amphibolites in the region as 69.7±1.7 Ma, and from hornblende mineral as 74.1±3.2 Ma using the K/Ar method. Researchers argued that the metamorphics were affected by the granitoidic intrusion and interpreted the intrusion/cooling age of intrusive rocks as 71 Ma. Oktay (1981) investigated the Paleogen-Recent sedimentary cover units around Kaman. The investigator argued that the thrusts that had activated from the Late Eocene to recent have developed, and that, as a result, the basement rocks were forced to move to the north and the Savcılı thrust zone was formed. Yalınız and Göncüoğlu (1998) stated that the pseudo-stratigraphy of the ophiolites located on the Central Anatolian metamorphic rocks could be recognized despite the tectonic deformation and cut by the granitoids. Görür (1998) states that there is no Triassic data due to the high-grade metamorphism in the Kırşehir Massif, but the stratigraphic development shows great resemblance to the stratigraphy of some autochthonous zones in the Menderes Massif and the Menderes-Taurus platform. Boztuğ et al. (2009) argued that the Central Anatolian granitoid melts emerged after the collision, an oceanic arc emplaced on the Tauride-Anatolide platform in the Campanian-Maastrichtian and rapidly uplifted in the Early-Middle Paleocene resulted from continent-continent collisions. Beyazpirinç and Akçay (2017), in their study on the geology and geodynamic evolution of the Akdağmadeni Massif; the metamorphics of the Akdağmadeni Massif, which form the basement, were distinguished from bottom to top as; the Yahyasaray formation (Late Devonian), the Akçakışla formation (Carboniferous-Early Permian), the Topaktaş formation (Late Permian), the Hisarbey formation (Mesozoic) and the Davulbaz formation (Early Cretaceous).

In this study, the rock units in different ages and lithologies in the study area were distinguished by using new stratigraphic, petrographic, geochemical and geochronological data obtained from previous studies and the stratigraphic features of metamorphic and magmatic masses were tried to be revealed.

The paleontological and petrographic analyses were carried out at the Department of Geological Researches of the General Directorate of Mineral Research and Exploration (MTA), Turkey. The analyses of the samples taken from the field for geochronological dating were carried out in the Geochronex (Canada) laboratory using the U/Pb method from the zircon mineral and the $^{40}Ar/^{39}Ar$ method from the Whole Rock. The LP-6 biotite packets and K and Ca salts interspersed among the analyzed samples were packaged with aluminum foil and taken into small quartz tubes (vials) for analysis. By running flux monitors, the J values were calculated for each sample according to the flux gradient. The age of LP-6 biotite is accepted as 128.1 Ma. The $^{40}Ar/^{39}Ar$ staged heating experiments were carried out using a thermo-external heater furnace. The gasses released as a result of staged heating were purified three times with SAES receiver and the Ar isotope concentration was measured with Micromass 5400 static mass spectrometer. The Ar-Ar data has been corrected for the ^{40}Ar cavity formed at 1200^0C, and the errors in age and primary Ar isotope ratios are indicated as 2 sigma. The chemical analyzes were performed in ICP-OES and ICP-MS devices by drying at 105^0C in the Laboratories of the Department of Mineral Analysis and Technology, MTA, solving in the UQ program of Thermo-ARL brand XRF device and according to TS ISO 14869-1 and TS ISO 14869-2.

2. Regional Geology

In the Central Anatolia, the area bounded by the İzmir-Ankara-Erzincan Suture (North Anatolian Ophiolitic Belt) in the north and the Inner Tauride Suture in the south forms the Kırşehir Block, one of the main tectonic units of Turkey. Tuz Gölü (Lake) and Central Anatolian faults largely follow these suture zones (Figure 1). The metamorphic, magmatic and ophiolitic rock assemblages of the Kırşehir Block were named as the Central Anatolian Crystalline Complex (CACC) (Göncüoğlu et al., 1991, 1993). The metamorphic masses in the CACC, considering the geographical areas they outcrop; were defined in different names like the Akdağ Massif (Baykal, 1947), the Kırşehir Crystalline Massif (Bailey and McCallien, 1950; Egeran and Lahn, 1951), the Central Anatolia Massif, the Kızılırmak Massif (Ketin, 1955, 1963; Erkan and Ataman, 1981), the Niğde group, the Niğde Massif (Göncüoğlu, 1977, 1981), the Kaman group (Seymen, 1981*a, b*) and the Central Anatolian Crystalline Complex (Erler and Bayhan, 1995).

From north to south, the metamorphic and non-metamorphic units of the Sakarya Zone, the İzmir-Ankara-Erzincan Suture, the Kırşehir Massif, the Inner Tauride Suture and the Anatolide-Tauride Block are observed in tectonic relationship with each other. The units belonging to the Kırşehir Massif, which will be explained in detail in this study, constitute the basement of the study area on the Kırşehir Block. At the bottom of the Sakarya Zone, which overlies the units belonging to the İzmir-Ankara-Erzincan Suture with a tectonic contact, there are Permo-Triassic units, which are tectono-stratigraphically related with each other from bottom to top (Figure 1). These units which were named as the Karakaya formation for the first time by Bingöl et al. (1973) then was defined as the Karakaya Complex by Okay et al. (1990). In the region, the Permo-Triassic units (Karakaya complex) overthrust the rocks of the İzmir-Ankara-Erzincan Suture, while the units belonging to the Kırşehir Massif are tectonically overlain by the Çiçekdağ nappe, a product of the İzmir-Ankara-Erzincan Ocean. Along the edge of the İzmir-Ankara-Erzincan Zone of the Kırşehir Massif, there are volcanic sedimentary deposits in the foreland basin, which was developed during the Late Paleocene-Middle Eocene (Akçay and Beyazpirinç, 2017). In the western part of the Kırşehir Block, the units relating to the Tuz Gölü (Lake) Basin represented by deep marine sediments consisting of the remains of the Inner Tauride Ocean are observed, while the residual basin and post-collisional basin sediments from the Inner Taurus Ocean are observed in the south. The metamorphic rocks, ophiolitic rocks, the Central Anatolian plutonic rocks and cover units crop out in the study area (Figure 2).

3. Stratigraphy

The Çiçekdağı nappe tectonically overlies the metamorphics of the Kırşehir Massif, which forms the basement of the study area, and both units are cut by

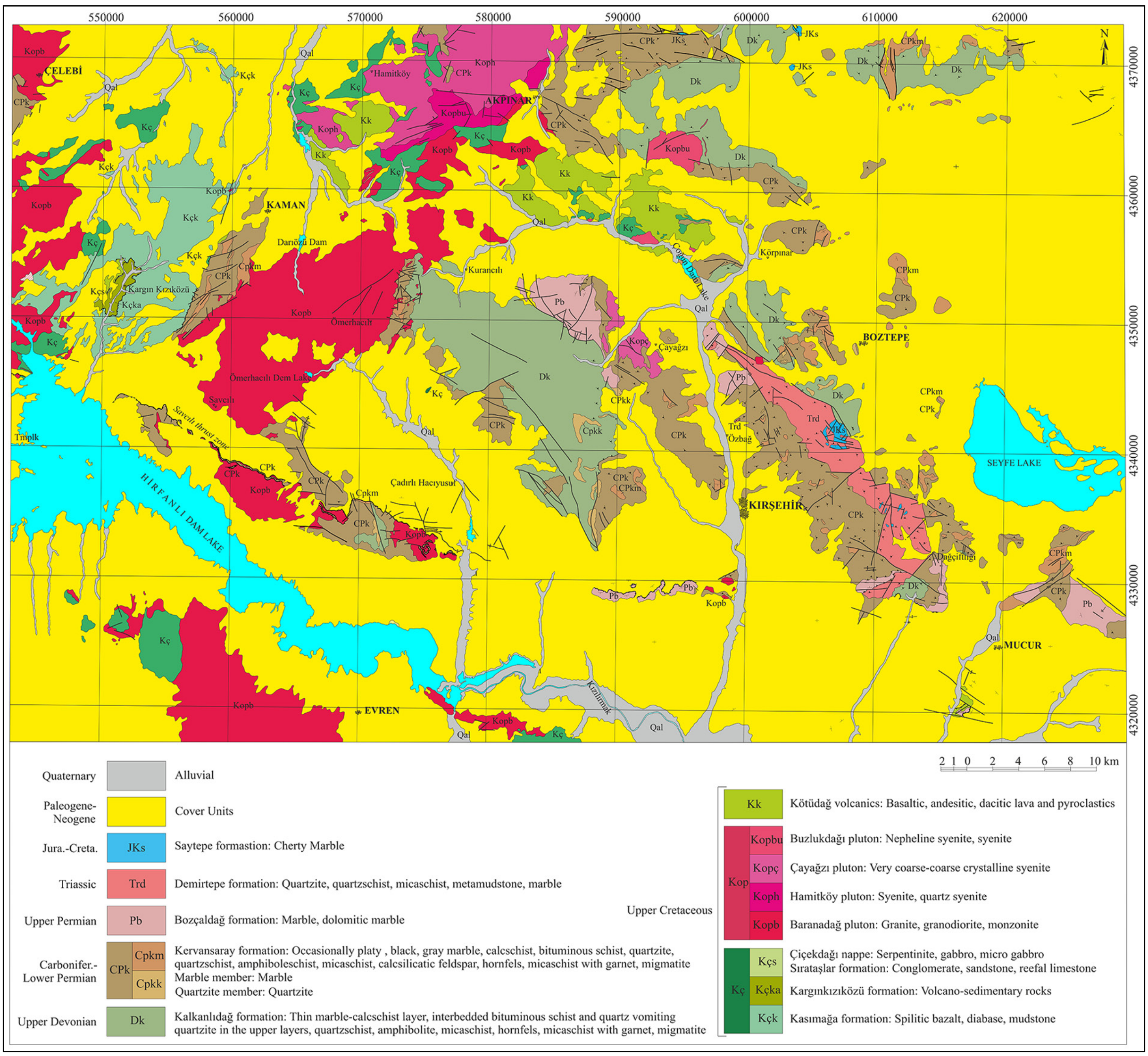

Figure 2- Geological map of the study area.

the Central Anatolian plutonic rocks and their semi-depth/surface rocks, the Kötüdağ volcanics. The cover units overlie all these with angular unconformity (Figure 3).

3.1. Kırşehir Metamorphics

The metamorphics belonging to the Kırşehir Massif, which form the basement of the study area and are transitional from bottom to top, are formed by the Late Devonian Kalkanlıdağ formation, the Carboniferous-Early Permian Kervansaray formation, the Late Permian Bozçaldağ formation, and by the unconformably overlying Triassic Demirtepe and the Jurassic-Cretaceous Saytepe formations, which were emphasized for the first time in this study. The units, which were formed during the Late Devonian-Early Cretaceous period, progressed in amphibolite and above facies and regressed to greenschist facies in places and undergone metamorphism from bottom to top; are the alternation of amphibolite-amphiboleschist-quartzite-quartzschist-micaschist,

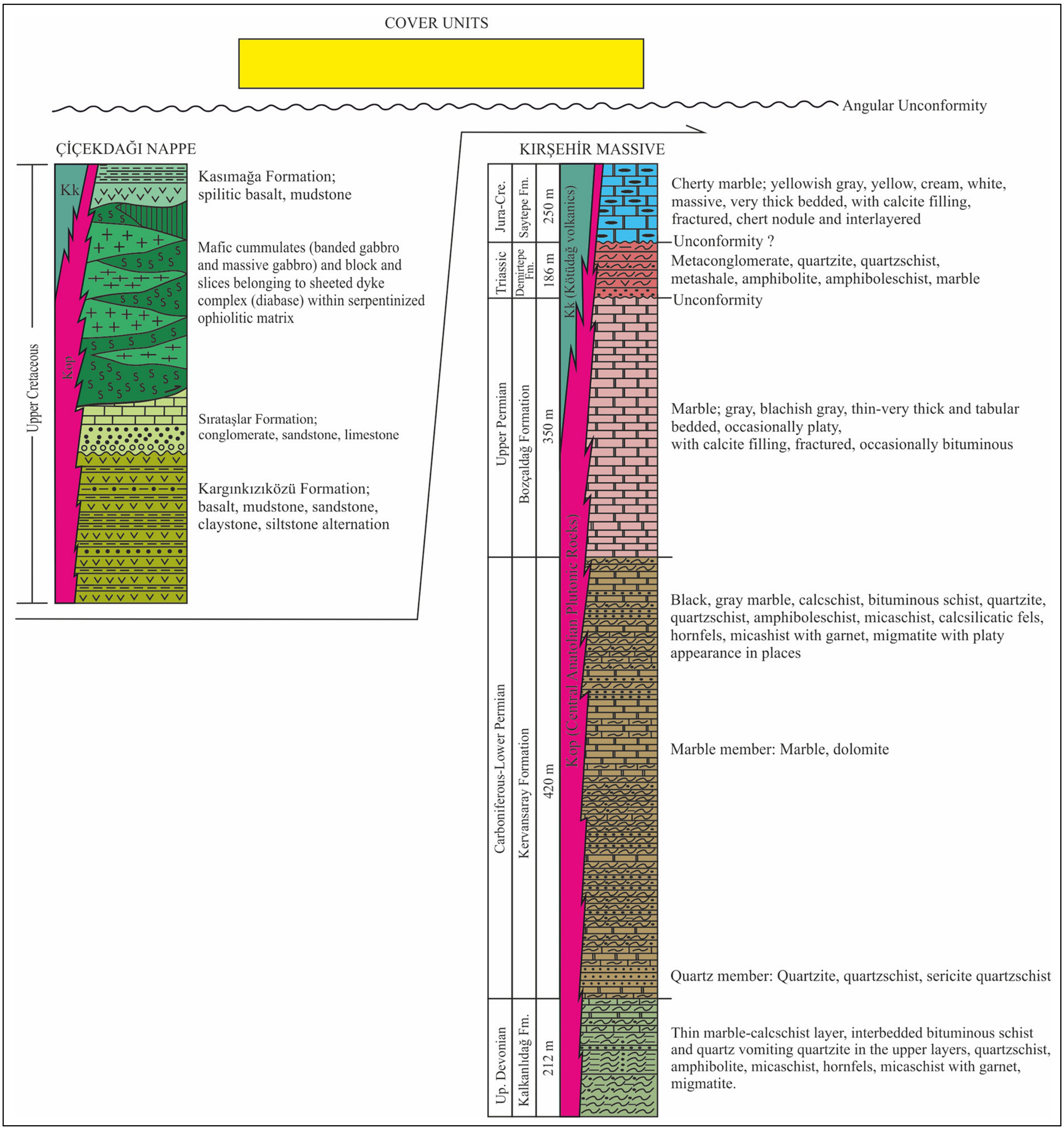

Figure 3- Tectonostratigraphic section of the study area.

the alternation of calcschist-marble-schist, and marble, amphibolite intercalated schist, metashale and cherty marble.

3.1.1. Kalkanlıdağ Formation

The unit, deposited at the bottom of the Kırşehir Massif and named by Seymen (1982), is generally greenish, gray in color, and is composed of quartzschist, quartzite, micaschist including calcschist marble and locally intersecting metabasites (amphibolite, amphibole schist, tremolite actinoliteschist, etc.). In the measured section of Yağmurlu Yayla (Kırşehir J31 sheet; UTM ED50 Zone 36 585092; 4344635) from bottom to top; epidote amphibolite, epidote calcite biotite amphiboleschist, amphibole clinozoisite micaschist, tremolite actinoliteschist, muscovite quartzschist, amphibole epidoteschist, actinolite chloriteschist, mica albiteschist, micaschist, garnet epidote biotiteschist, calcschist, muscovite chlorite actinoliteschist, garnet actinoliteschist, clinozoisite actinolite quartzschist, biotite quartzschist, quartzite, garnet muscovite quartzschist, epidote biotite amphiboleschist, biotite gneiss, clinozoisite mica quartzschist, garnet clinozoisite mica quartzschist, garnet micaschist, garnet mica quartzschist, epidote calcite, clinoamphibole biotiteschist, epidote biotite clinoambihole schist, clinoamphibole epidoteschist were observed. In the measured section carried out in Körpınar (Kırşehir J32 sheet; UTM ED50 Zone 36 599357; 4753927) from bottom to top; the alternations of quartz micaschist, mica quartzschist, calcschist, chlorite mica quartzschist, muscovite quartzschist, amphibole quartz micaschist, calcschist-marble-quartz micaschist were observed. In the south of Demirci village (UTM ED50 Zone 36 581219; 4347449) located on the Kırşehir J31 map, the basic rocks such as epidote amphibole schist and amphibolite are encountered. In addition, the rock types such as pyroxene-amphibolite, epidote augite amphibolite (clinopyroxene amphibolite) and calcsilicatic gneiss were detected in the unit. The Kervansaray formation transitionally overlies the Kalkanlıdağ formation, which forms the bottom of the Kırşehir Massif. The unit cut by the Central Anatolian plutonic rocks is unconformably overlain by the cover units. A thickness of 212 m was measured for the unit, which presented a folded-fractured structure and did not show much change in lateral directions. The unit was given Late Devonian age by considering its stratigraphic position and correlating it with similar facies in the Taurus Mountains (Late Devonian successions in the Geyikdağı Union and the Aladağ nappe and their metamorphic equivalents in the Bolkardağı nappe and Yahyalı nappe). The unit can be correlated with the Yahyasaray formation at the bottom of the Akdağmadeni Massif (Beyazpirinç and Akçay, 2017), metapelites within the Akdağmadeni metasedimentary group (Şahin, 1991), a part of the Köklüdere formation within the Akdağ metamorphic group (Dökmeci, 1980) and with the Gümüşler formation at the bottom of the Niğde Massif (Göncüoğlu, 1981).

3.1.2. Kervansaray Formation

The unit, which was named by Kara and Dönmez (1990), is generally yellowish gray in color and consists of quartz micaschist, micaschist, quartzschist, quartzite, calcschist, marble and dolomite with intercalations of bituminous schist, and in places quartzite and marble in the form of lenses with distinguishable thicknesses at 1:25.000 scale. In the measured section made for the unit in the Kervansaray District (Kırşehir J32 sheet; UTM ED50 Zone 36 604279; 4338631) from bottom to top; quartz muscovite calcschist, calcite quartz muscovite schist, calcite chlorite muscovite schist, muscovite quartzschist, quartz muscovite, chlorite muscovite quartzschist, calcite mica quartzschist, garnet mica quartzschist, muscovite quartz calcschist, calcite muscovite quartzschist, quartz calcite muscoviteschist, muscovite calcschist, mica quartzschist and quartz micaschist were observed. There are also marble interlayers in the succession. In addition, the rock types such as; tremolite actinolite calcschist, garnet clinozoisite clinoamphiboleschist, calcite clinoamphibole quartzschist, muscovite quartzschist, sericite quartzite, amphibolite, calcschist, garnet quartz micaschist, clinopyroxene amphibole calcite quartzschist and bituminous schist were also encountered in the unit. The Bozçaldağ formation conformably and the Demirtepe formation unconformably overlies the Kervansaray formation, which comformably overlies the Kalkanlıdağ formation. The unit cut by the Central Anatolian Plutonic rocks is unconformably overlain by the cover units. The true thickness of the unit, which presents a folded-fractured structure with apparent thickness of 420 meters and shows facies changes in the lateral directions, was measured as 224 meters. No fossils were found that can be dated from the unit. However, 279.7±5.9 Ma, 281.6±2.9 Ma and 337.8±1.2 Ma (Carboniferous-Early Permian) ages were obtained from the radiometric age determinations by the U/Pb method from the clastic zircons of the Akçakışla formation in the Akdağmadeni Massif, which can be correlated with the Kervansaray formation (Beyazpirinç and Akçay, 2017). The Carboniferous-Early Permian age for the Kervansaray formation was suggested, considering the radiometric dating data obtained, the stratigraphical position of the unit and its correlation with similar facies in the Taurus Mountains (Carboniferous in the Geyikdağı Union and Carboniferous-Early Permian successions in the Aladağ nappe and their metamorphic equivalents in the Bolkardağı nappe and Yahyalı nappe). The unit can be correlated with the Akçakışla formation in the Akdağmadeni Massif (Beyazpirinç and Akçay, 2017), the semimetapelites in the Akdağmadeni metasedimentary group (Şahin, 1991), a part of the Köklüdere and Özerözü formations in the Akdağ metamorphic group (Dökmeci, 1980), the Tamadağ formation around Kaman, Kırşehir (Seymen, 1981b) and the Kaleboynu formation in the Niğde Massif (Göncüoğlu, 1981).

3.1.3. Bozçaldağ Formation

The unit, which was named by Seymen (1982), consists of marble, dolomitic marble and dolomite. The weathering surfaces of marble and dolomites are gray, freshly fractured surfaces are white, locally gray, blackish in color, they are thin-medium-thick and generally regularly bedded, and medium to coarse crystalline. The unit, which is completely represented by metacarbonates, presents a folded and highly fractured structure. The Demirtepe formation unconformably overlies the Bozçaldağ formation, which conformably overlies the Kervansaray formation at its bottom. The unit, which does not show much change in lateral directions, has an apparent thickness of approximately 350 m. The layers considered to have fossil traces (Mizzia, *Hemigordius*) are encountered in the Topaktaş formation in the Akdağmadeni Massif, which can be correlated with the Bozçaldağ formation, but a definitive age determination could not be made (Beyazpirinç and Akçay, 2017). Considering its stratigraphic location and correlating with similar facies in the Taurus Mountains (Late Permian successions in the Geyikdağı Union and Aladağ nappe and their metamorphic equivalents in the Bolkardağı nappe and Yahyalı nappe), a Late Permian age has been suggested for the unit. The unit can be correlated with the Topaktaş formation in the Akdağmadeni Massif (Beyazpirinç and Akçay, 2017), the metacarbonates in the Akdağmadeni metasedimentary group (Şahin, 1991), and a part of the Aşıgediği formation in the Niğde Massif (Göncüoğlu, 1981).

3.1.4. Demirtepe Formation

Triassic metamorphics in the study area were distinguished in this study for the first time and named as the Demirtepe formation. The unit, which is generally red, yellow, mottled in color and consists of quartzite and quartzschist with rare metaconglomerates at the bottom, starts with an unconformity at the bottom and includes metamudstone, metashale, talcschist, amphibolite (metabasite), micaschist, calcschist and marble (Figure 4a, b, c, d) in upper layers.

The unit, which unconformably overlies the Kervansaray formation and Bozçaldağ formation, unconformably underlies the Jurassic-Cretaceous Saytepe formation. A thickness of 186 m was measured for the unit, which presents a folded-fractured structure. In the village of Karacaören (UTM ED50 Zone 36 607218; 4339561) located on the Kırşehir J32 map, 237 My (Ladinian) age was obtained from the zircon minerals selected from quartzite for the purpose of geochronological dating using U/Pb method (Table 1, Figure 5a, b).

In Dağçiftliği village (UTM ED50 Zone 36 613410; 4332777) located on the Kırşehir J32 map sheet, the metamorphism age of 83.7±3.3 Ma (Coniacian) was obtained by $^{40}Ar/^{39}Ar$ method from the Whole Rock analysis of the metabasites for geochronological dating purposes (Table 2, Figures 6a, b).

In addition, in Özbağ (UTM ED50 Zone 36 553333; 4353468) located on the Kırşehir J31 map sheet, the metamorphism age of 94.5 Ma (Cenomanian) was obtained by the $^{40}Ar/^{39}Ar$ method from the Whole Rock analysis of the sample taken from the metabasites for geochronological dating (Table 3).

Although there are risks such as the inadequacy of the number of zircons analyzed and the percentage of concordance not being very clear, considering the fact that these ages support the stratigraphic position of the Demirtepe formation (the marbles of the Late Permian to unconformably overlie the Bozçaldağ formation) and in the Taurus Mountains, the Triassic depositional age was suggested for the unit by being correlated with similar Lower-Middle Triassic sequences (in

Figure 4- View of ; a), b) calcschist-metamudstone, c) talcschist, and d) metabasites in the Demirtepe formation.

Table 1- Table of quartzsite isotope ratios taken from the Demirtepe formation.

	Th, ppm	U, ppm	Pb, ppm	T/U	$^{238}U/^{206}Pb$±1s		$^{207}Pb/^{206}Pb$±1s		$^{207}Pb/^{235}U$±1s		$^{206}Pb/^{238}U$±1s		Used Age±2s	
G-23201	134.6	974.8	59.799	0.138	15.5	0.2	0.0591	0.0007	0.5262	0.0066	0.06456	0.00077	403.27	9.30
G-23202	640.3	849.2	35.249	0.754	26.6	0.3	0.0517	0.0006	0.2680	0.0033	0.03758	0.00044	237.82	5.44
G-23203	572.2	1286.0	171.318	0.445	7.8	0.1	0.0679	0.0008	1.1985	0.0162	0.12805	0.00158	776.74	18.09
G-23205	229.0	236.1	45.766	0.970	6.2	0.1	0.0741	0.0008	1.6593	0.0200	0.16235	0.00191	969.82	21.11
G-23208	92.7	406.0	207.120	0.228	2.1	0.0	0.1673	0.0018	11.0870	0.1363	0.48078	0.00579	2530.32	35.70
G-23209	105.9	157.5	19.084	0.672	9.1	0.1	0.0618	0.0007	0.9410	0.0114	0.11037	0.00126	674.93	14.64
G-23211	65.8	115.7	17.357	0.569	7.2	0.1	0.0707	0.0009	1.3588	0.0186	0.13936	0.00168	841.06	18.97
G-23212	503.9	592.6	51.899	0.850	12.9	0.2	0.0589	0.0007	0.6290	0.0081	0.07745	0.00094	480.91	11.19
G-23213	64.6	173.3	20.505	0.373	9.3	0.1	0.0813	0.0010	1.2075	0.0159	0.10767	0.00129	659.19	15.03
G-23217	38.1	162.0	20.234	0.235	7.9	0.1	0.0654	0.0008	1.1372	0.0158	0.12618	0.00153	766.03	17.48
G-23224	132.2	277.5	45.124	0.477	6.5	0.1	0.0726	0.0008	1.5287	0.0178	0.15277	0.00174	916.45	19.41
G-23225	33.6	343.8	55.966	0.098	5.8	0.1	0.0784	0.0010	1.8675	0.0262	0.17285	0.00216	1155.95	49.24
G-23226	124.5	234.5	44.284	0.531	5.7	0.1	0.0742	0.0008	1.8068	0.0218	0.17658	0.00206	1047.28	43.55
G-23228	232.4	296.2	86.780	0.784	3.9	0.0	0.0889	0.0010	3.1243	0.0406	0.25479	0.00309	1402.75	43.95
G-23229	112.2	173.0	24.221	0.649	7.9	0.1	0.0672	0.0008	1.1793	0.0146	0.12732	0.00148	772.53	16.97
G-23230	435.3	852.0	76.703	0.511	11.6	0.1	0.0610	0.0007	0.7236	0.0089	0.08606	0.00102	532.20	12.09

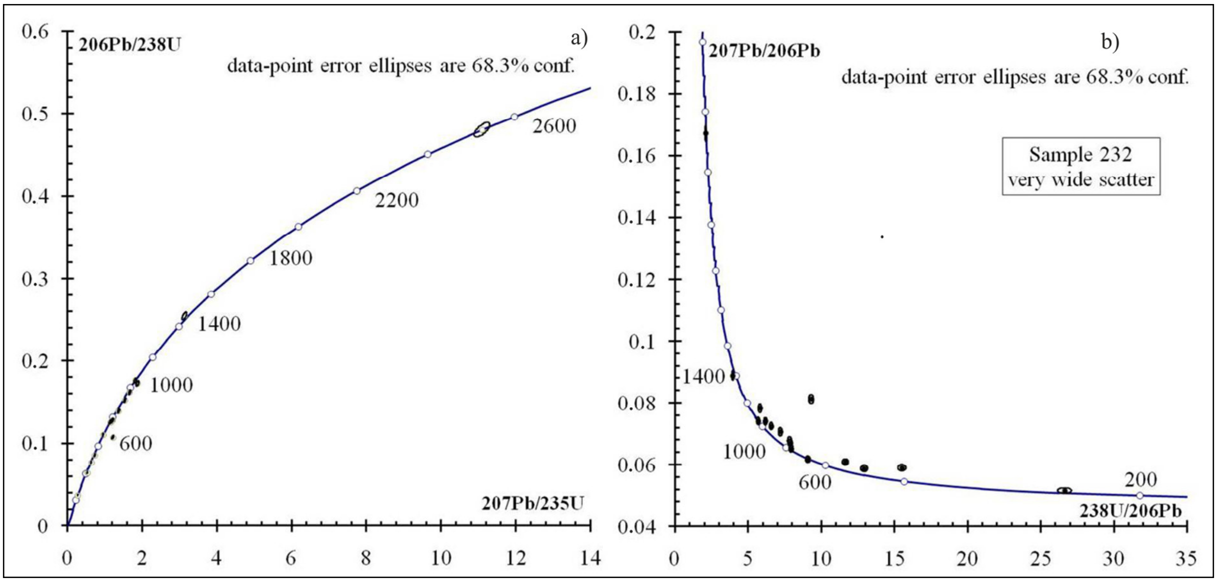

Figure 5- Concordia ages belonging to the Demirtepe formation (a, b).

Table 2- $^{40}Ar/^{39}Ar$ table of the sample G-272 taken from the Demirtepe formation.

Sample: G-272 Whole rock J=0.003555 ± 0.000033

	$^{40}Ar_{cc}$ (STP)	$^{40}Ar/^{39}Ar$	±1σ	$^{38}Ar/^{39}Ar$	±1σ	$^{37}Ar/^{39}Ar$	±1σ	$^{36}Ar/^{39}Ar$	±1σ	Ca/K	$\sum^{39}Ar$ (%)	Age (Ma) ±1σ	±1σ
500	$18.0*e^{-9}$	874.87	192.47	0.2056	0.2544	4.83	1.51	2.6883	0.6310	17.4	1.6	453.9	336.0
625	$82.1*e^{-9}$	680.47	30.38	0.4877	0.0878	6.77	0.38	2.0521	0.1019	24.4	10.8	421.8	69.1
725	$33.7*e^{-9}$	401.79	8.98	0.2750	0.0345	6.31	0.16	1.2982	0.0366	22.7	17.2	112.8	39.9
850	$84.0*e^{-9}$	819.33	34.83	0.5372	0.0410	6.49	0.29	2.7427	0.1241	23.4	25.0	55.9	78.1
950	$117.2*e^{-9}$	1502.77	109.07	0.8938	0.0712	11.44	0.86	4.8613	0.3602	41.2	31.0	381.6	114.2
1050	$77.5*e^{-9}$	323.02	4.38	0.2291	0.0044	12.85	0.20	1.0299	0.0195	46.3	49.3	116.0	24.2
1130	$117.1*e^{-9}$	226.67	0.41	0.1677	0.0057	14.02	0.10	0.7222	0.0022	50.5	88.8	83.1	3.3
1170	$22.4*e^{-9}$	152.75	3.83	0.0820	0.0194	13.78	0.41	0.4333	0.0273	49.6	100.0	151.9	43.8

Sample	IIA (Ma)±1σ	TFA±1 σ	WMPA (Ma)±1σ	Ca/K	Comments
G-272 Whole Rock	77.4±18.2 452.0±110.6	155.5±15.2	83.7±3.3	17.4-50.5	Two steps intermediate plateau

Explanation:

±1 σ=Estimated uncertainty (1 sigma) IIA=Inverse isochrone age TFA=Total fusion age

WMPA=Weighted mean plateau age Ca/K=Apparent Ca / K ratios WMIPA=Weighted mean intermediate plateau age

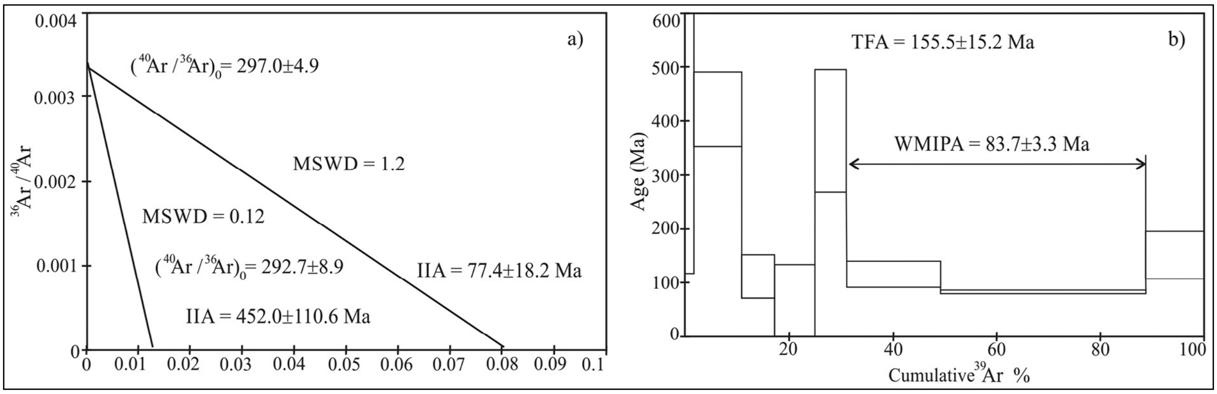

Figure 6- a) Isochronous and b) plateau ages of the sample G-272 taken from the Demirtepe formation.

Table 3- $^{40}Ar/^{39}Ar$ table of the sample taken from the Demirtepe formation.

step	T(C)	t (min.)	^{36}Ar	^{37}Ar	^{38}Ar	^{39}Ar	^{40}Ar	%^{40}Ar*	%^{39}Ar rlsd	Ca/K	^{40}Ar*/^{39}ArK	Age (Ma)	1s.d.
1	750	12	1.204	29.262	0.361	5.809	582.589	42.4	9.2	21.52431454	42.167823	127.03	1.20
2	850	12	0.387	9.577	0.146	3.340	204.312	50.0	5.3	12.21848336	28.509178	86.85	0.86
3	950	12	0.380	49.937	0.271	7.151	269.563	65.7	11.3	29.91261784	23.039689	70.51	0.34
4	990	12	0.287	105.356	0.386	6.462	245.624	77.1	10.2	70.67457979	27.351714	83.41	0.46
5	1020	12	0.298	180.505	0.519	7.023	279.816	82.6	11.1	112.7757395	31.486855	95.69	0.56
6	1050	12	0.182	108.224	0.383	5.410	208.256	89.0	8.6	87.1300346	31.515911	95.78	0.75
7	1100	12	0.180	65.626	0.256	4.210	154.866	87.2	6.7	67.5095718	27.360774	83.44	0.84
8	1160	12	0.146	47.537	0.149	2.024	89.481	85.8	3.2	102.7591264	27.791129	84.72	1.25
9	1200	12	0.171	65.543	0.209	2.647	115.811	84.4	4.2	108.5151178	29.756443	90.56	1.13
10	1220	12	0.151	54.494	0.187	2.211	108.728	88.5	3.5	107.9973793	34.462853	104.48	1.40
11	1240	12	0.171	62.658	0.247	2.789	131.762	86.5	4.4	98.1640642	34.054561	103.27	0.94
12	1260	12	0.176	65.151	0.229	2.936	136.981	86.1	4.6	96.92469313	33.781840	102.47	1.01
13	1280	12	0.168	62.354	0.225	2.652	127.996	86.8	4.2	102.8736751	34.728065	105.26	1.48
14	1400	12	0.366	247.156	0.661	8.526	342.501	90.9	13.5	127.7426708	32.780193	99.51	0.67
Cumulative %^{39}Ar rlsd=100.0 Total gas age=94.50													

units such as the Geyikdağı Union, Aladağ nappe, Bodrum nappe, Bolkardağı nappe).

3.1.5. Saytepe Formation

The Jurassic-Cretaceous marbles, located at the topmost part of the metamorphic succession of the Kırşehir Massif, were distinguished for the first time in this study and named as the Saytepe formation. The unit is represented by yellow, cream, white colored, massive, very thickly bedded, fractured and locally dolomitic cherty marble. The cherts are located in the form of nodules, tuber and interlayers (Figure 7a, b, c, d). The unit unconformably overlies the Kalkanlıdağ formation and the Demirtepe formation. The unit, which has an apparent thickness of approximately 250 m and does not show much change in lateral directions, presents a folded and fractured structure. No fossil data that can be dated from the Saytepe formation were encountered. Jurassic-Cretaceous age was given by considering the stratigraphic position

Figure 7- a) General view from the Saytepe formation, b) , c) , and d) view from cherty marbles (Kırşehir-J32 sheet; looking N to Say Tepe).

of the unit and correlating it with similar facies in the Taurus Mountains (Jurasic-Cretaceous units in the Geyikdağı Union and Aladağ nappe and their metamorphic equivalents in the Bolkardağı nappe, Yahyalı nappe and Bodrum nappe, etc.).

3.2. Çiçekdağ Nappe

The rocks of oceanic origin, which were emplaced in the study area as a nappe and thought to belong to the northern branch of Neotethys, were named as the Çiçekdağı nappe by Dönmez and Akçay (2016). The parts of the Çiçekdağı nappe consisting of sheeted dyke (diabase), spilitic basalt-radiolarite mudstone are named as the Kasımağa formation; the parts which consists of volcano-sediments as the Kargınkızıközü formation, and the sections consisting of conglomerate, sandstone and limestone are named as the Sırataşlar formation. The Çiçekdağı nappe consists of mafic cumulates (banded gabbro, massive gabbro) within serpentinized ophiolitic matrix sheeted dyke (diabase) block-slices and spilitic basalt-radiolarite mudstone, volcano-sediments, conglomerate, sandstone and limestone. The Çiçekdağı nappe (Figure 8), which was tectonically emplaced on the metamorphics of the Kırşehir Massif, was partially cut by the Central Anatolian plutonic rocks.

The age of 105.4±5.3 Ma (Albian) was obtained by the $^{40}Ar/^{39}Ar$ method from the Whole rock analysis for the sample number G-270 taken from the microgabbro for geochronological dating in the SE of Hirfanlı village located on the Kırşehir J31 sheet (UTM ED50 Zone 36 6544551; 4347214) (Table 4, Figures 9a, b). In previous studies, 179±15 Ma (Dilek and Thy, 2006) and 180 Ma (Sarıfakıoğlu et al., 2011) ages were obtained from the samples for geochronological purposes. Tithonian-Early Cenomanian age was obtained from the samples collected from the deep sea sediments belonging to the ophiolitic series (Beyazpirinç and Akçay, 2017). Considering these data, Early Jurassic (Toarcian)-Late Cretaceous (Cenomanian) can be suggested for the formation age of the ophiolite forming the matrix of the Çiçekdağı Nappe. During the depletion of the oceanic crust of the northern branch of Neotethys starting from the Cenomanian, the presence of Cenomanian-Maastrichtian ensimatic arc was detected due to the oceanic subduction (Beyazpirinç et al., 2019). Considering all these data, it can be said that the oceanic crust of the northern branch of Neotethys and thus the units of the Çiçekdağı nappe were formed in the Early Jurassic-Maastrichtian period. During the closing period of the northern branch of Neotethys (probably Aptian-Middle Eocene), the ophiolitic masses of the oceanic crust and ensimatic arc products were emplaced over the Kırşehir Block in the form of nappe (Çiçekdağı Nappe).

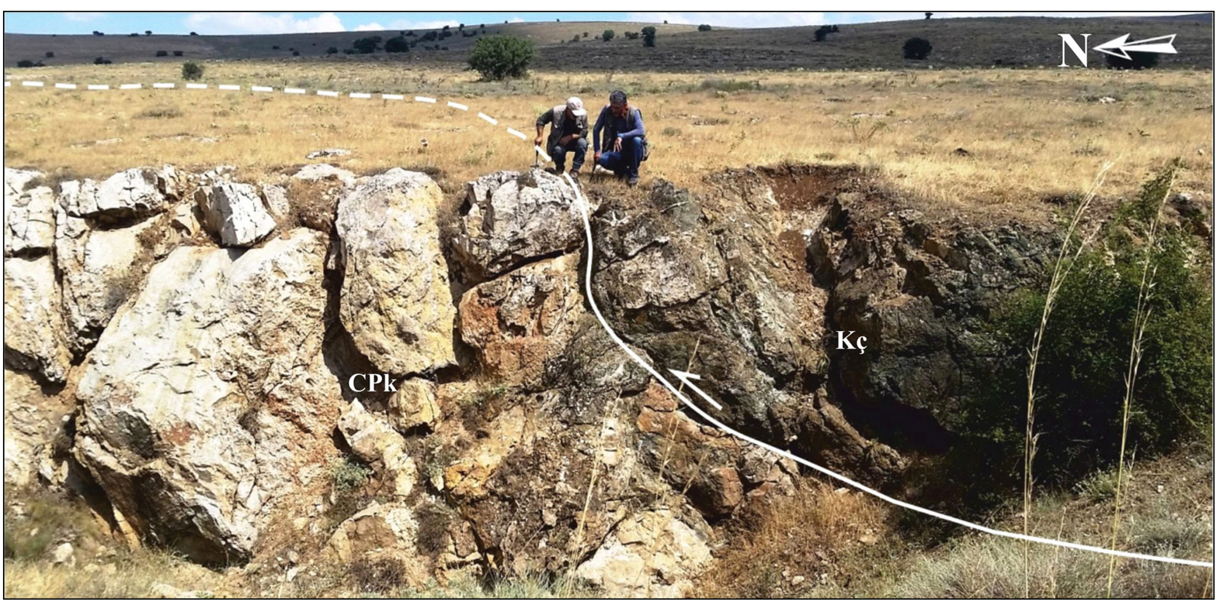

Figure 8- The view from the tectonic contact of the Çiçekdağı nappe with the Kırşehir Massif (Kırşehir-J31 sheet; UTM ED50 Zone 36 4354600; 5558450; CPk: Kervansaray formation, Kç: Çiçekdağı Nappe).

Table 4- $^{40}Ar/^{39}Ar$ table of the sample G-270 taken from the microgabbro of the Çiçekdağı Nappe.

T^0C	$^{40}Arcc(STP)$	$^{40}Ar/^{39}Ar$	±1σ	$^{38}Ar/^{39}Ar$	±1σ	$^{37}Ar/^{39}Ar$	±1σ	$^{36}Ar/^{39}Ar$	±1σ	Ca/K	$\sum^{39}Ar$ (%)	Age (Ma) ±1σ	±1σ
500	$9.6*e^{-9}$	75.19	3.21	0.0256	0.0214	1.95	0.11	0.1620	0.0224	7.02	4.1	152.1	34.2
625	$16.4*e^{-9}$	51.87	1.15	0.0132	0.0139	5.44	0.17	0.0964	0.0113	19.57	14.1	130.9	17.9
725	$19.8*e^{-9}$	39.39	0.25	0.0205	0.0025	4.83	0.09	0.0645	0.0032	17.39	30.0	114.4	5.3
825	$14.8*e^{-9}$	36.73	0.39	0.0017	0.0128	3.66	0.11	0.0635	0.0053	13.17	42.8	101.4	8.7
950	$15.3*e^{-9}$	38.58	0.33	0.0144	0.0077	5.93	0.10	0.0753	0.0043	21.35	55.3	92.4	7.0
1035	$13.4*e^{-9}$	49.01	0.87	0.0313	0.0040	9.47	0.22	0.1363	0.0092	34.08	64.0	50.1	14.9
1140	$45.9*e^{-9}$	40.43	0.26	0.0271	0.0026	8.20	0.10	0.0871	0.0032	29.53	100.0	83.3	5.3

Sample	IIA (Ma) ±1σ	TFA ±1σ	WMPA (Ma)±1σ	Ca/K	Comments
G-270 Whole Rock	86.8±21.8 144.5±11.1	96.6±3.7	105.4±5.3	7.02-34.08	Three steps plateau

Explanation:

±1 σ=Estimated uncertainty (1 sigma) IIA=Inverse isochrone age TFA=Total fusion age

WMP =Weighted mean plateau age Ca/K=Apparent Ca/K ratios WMIP=Weighted mean intermediate plateau age

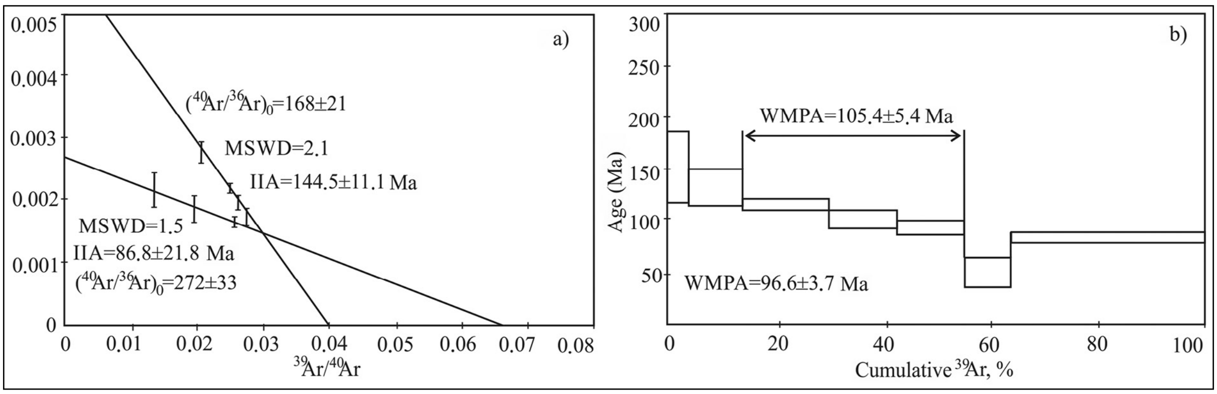

Figure 9- a) Isochronous and b) plateau ages, of the sample G-270 taken from the microgabbro of the Çiçekdağı Nappe.

3.2.1. Kargınkızıközü Formation

The volcano-sedimentary succession observed as a tectonic slice in the Çiçekdağı nappe was distinguished by being correlated with the Darmik formation (Beyazpirinç and Akçay, 2017; Beyazpirinç et al., 2019), which is located around Yozgat and formed by ensimatic arc products, and was named as the Kargınkızıközü formation. The unit consists of alternations of basalt, radiolarite mudstone, clastic mudstone, claystone, siltstone and sandstone. The unit, which is generally composed of volcano-sediments, is blackish basalt with gaseous cavities in places; red colored mudstone with manganese dendrites; brown-colored, thinly bedded interlayer sandy mudstone; greenish gray to gray, very thinly-thinly bedded sandstone-claystone-siltstone and radiolarite alterations. The unit is unconformably overlain by the Sırataşlar formation and has a tectonic contact with the Kasımağa formation. In the measured section made in the village of Kargınkızıközü, which is the type location of the unit, a thickness of 181 m was measured. From the samples collected from the Kargınkızıközü formation; Turonian-Santonian ages were determined with the fossils of *Marginotruncana coronata* (Bolli), *Marginotruncana pseudolinneiana Pessagno, Marginotruncana renzi* (Gandolfi), *Marginotruncana* sp., *Dicarinella* sp., *Globigerinelloides* sp., *Heterohelix* sp. and Radiolarian. The Whole Rock chemical analysis results of the rock samples belonging to the Kargınkızıközü formation volcanics are given in Table 5. As can be seen in Table 5, some of the samples have very high Loss of Ignition (LOI) values. For this reason, the graphs using trace elements that cannot be easily mobilized under alteration and metamorphism conditions were preferred as much as possible in the interpretation of the analysis results since there may be changes in the main element oxide values of the

Table 5- Chemical analysis results of whole rock major (% wt) and trace element (ppm) samples of Kargınkızıközü formation volcanics.

SAMPLE	16K30J	16K30M	16K32K	16K720K	16K722K
SiO_2	53.30	43.00	42.30	38.20	45.10
Al_2O_3	17.30	16.60	16.60	15.00	18.20
Fe_2O_3	5.30	7.30	8.20	7.40	8.00
CaO	6.20	11.50	11.00	15.00	7.30
MgO	4.90	4.20	5.80	5.10	6.80
Na_2O	3.80	4.00	2.80	3.50	5.20
K_2O	0.40	0.60	0.20	0.50	0.30
TiO_2	0.50	0.50	0.50	0.50	0.60
MnO	0.10	0.20	0.10	0.10	0.20
P_2O_5	<0.1	0.10	<0.1	0.10	0.10
LOI	8.00	11.90	12.25	14.45	8.00
TOTAL	99.80	99.90	99.75	99.85	99.80
Ba	52	96	60	74	82
Nb	0.80	1.70	1.40	1.80	1.80
Zr	13.50	17.70	19.80	15.70	24.70
Cs	2.10	2.70	1.40	2.40	1.10
Ga	12.90	14.70	14.10	11.30	16.40
Hf	0.70	0.80	1.40	0.80	3.60
Rb	<10	20	<10	13	<10
Sn	<10	<10	<10	<10	<10
Sr	168	171	171	230	319
Ta	0.20	0.30	0.80	0.80	16.90
Th	0.60	1.60	1.80	1.50	1.50
Tl	<0.1	0.10	<0.1	<0.1	<0.1
U	0.20	0.50	0.30	0.40	0.30
V	181	219	196	179	179
W	<10	<10	<10	<10	<10
Y	8.60	10.30	11.80	9.70	13.00
As	23.50	32.40	32.30	32.60	55.10
Be	0.20	0.30	0.30	0.30	0.30
Bi	<0.1	<0.1	0.10	<0.1	<0.1
Cd	0.10	0.30	0.20	0.30	0.20
Co	24.60	31.40	41.10	29.10	38.30
Cr	416	430	287	496	245
Cu	193.10	29.70	63.40	8.70	38.20
Ge	1.30	1.90	1.90	1.70	2.00
Mo	0.60	0.90	0.70	1.20	1.30
Ni	68.10	112.40	111.40	121.50	101.20
Pb	3.10	8.70	6.60	14.90	15.10
Sb	0.40	1.00	1.10	1.90	1.30
Sc	33.30	39.60	37.90	35.00	35.90
La	1.20	3.00	2.90	1.70	2.20
Ce	2.80	6.30	5.30	3.50	5.10
Pr	0.40	0.90	0.70	0.50	0.80
Nd	2.40	4.00	3.40	2.70	4.10
Sm	0.90	1.30	1.10	1.00	1.50
Eu	0.30	0.40	0.50	0.40	0.60
Gd	1.20	1.60	1.50	1.30	1.90
Tb	0.20	0.30	0.30	0.30	0.40
Dy	1.70	1.90	2.00	1.70	2.50
Ho	0.40	0.40	0.50	0.40	0.60
Er	1.10	1.30	1.40	1.20	1.70
Tm	0.20	0.20	0.20	0.20	0.20
Yb	1.10	1.30	1.40	1.20	1.70
Lu	0.20	0.20	0.20	0.20	0.30

rocks (especially SiO_2, CaO, K_2O and Na_2O) during the hydrothermal alteration processes. The results of chemical analysis of Kargınkızıközü formation volcanics were evaluated in classification diagrams. In Winchester and Floyd (1977) Nb/Y-Zr/TiO_2 diagram, all of the samples fall into the subalkaline basaltic area (Figure 10a). In Pearce (1996) Zr/Ti-Nb/Y diagram, the samples are clustered in the basaltic area (Figure 10b). When the samples of the Kargınkızıközü formation volcanics are projected on Th-Co diagram of Hastie et al. (2007), one sample remains in the tholeiitic series area, while four samples are located in the calcalkaline series area (Figure 10c). Chemical analysis results of the Kargınkızıközü formation volcanics were evaluated on Wood (1980), Meschede (1986), Th/Yb-Nb/Yb diagram (Pearce, 2008), Hollocher et al. (2012), Agrawal et al. (2008), tectonic environment diagrams and normalized to MORB (Pearce, 1983) spider diagram. Considering the projections of the chemical data on the tectonic discrimination diagrams created by Wood (1980), the samples fall into the area of calc-alkaline-volcanic arc basalts (Figure 11a). Considering the projections of the chemical analysis results on the tectonic discrimination diagrams created by Meschede (1986), the samples are clustered in the area of volcanic arc basalts (Figure 11b). According to Hollocher et al. (2012) the samples were clustered in the oceanic arc area (Figure 11c). In the tectonic discrimination diagram used in the determination of tectonic environments of basic and ultrabasic rocks formed by using trace element (La, Sm, Yb, Nb and Th) that cannot be mobilized easily under low alteration and metamorphism conditions of Agrawal et al. (2008) the volcanics of the Kargınkızıközü formation are clustered in the island arc basalt area (Figure 11d). When the Pearce (2008) Th/Yb-Nb/Yb diagram is used, the samples of Kargınkızıközü formation volcanics cluster in the arc sequence area (Figure 11e). The main pattern shown on the N-MORB normalized multi-element distribution diagram of the samples created to examine the trace element anomalies of the Kargınkızıközü formation volcanics in the study area is in the form of enrichment in terms of the large ion lithophile elements (S, K, Rb, Ba, Th, U) on the left of the diagram and Pb, and depletion in terms of Nb, P, Zr, Ti, Y and Yb elements (Figure 11f). With all these data obtained, it was concluded that the Kargınkızıközü formation volcanics represent the Cenomanian-Maastrichtian ensimatic arc volcanics

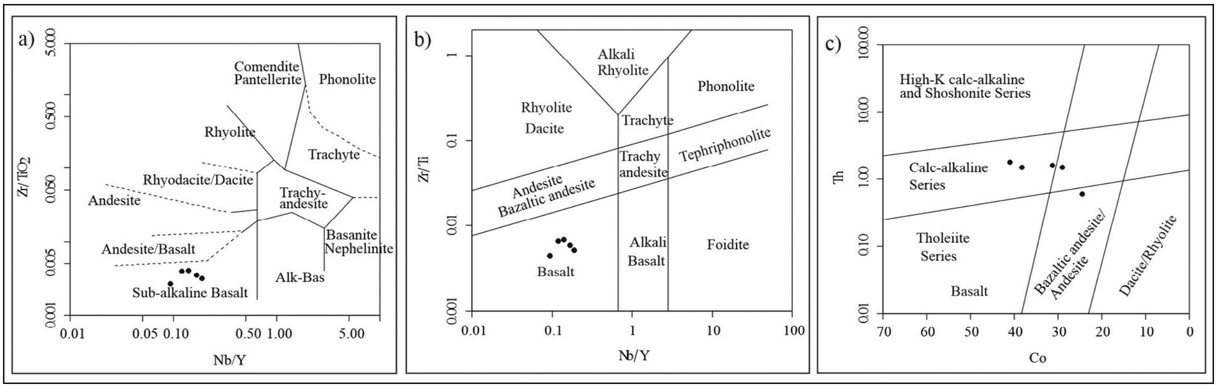

Figure 10- The locations of the rocks of the Kargınkızıközü formation in the classification diagrams; a) Winchester and Floyd (1977), b) Pearce (1996), c) Hastie et al. (2007).

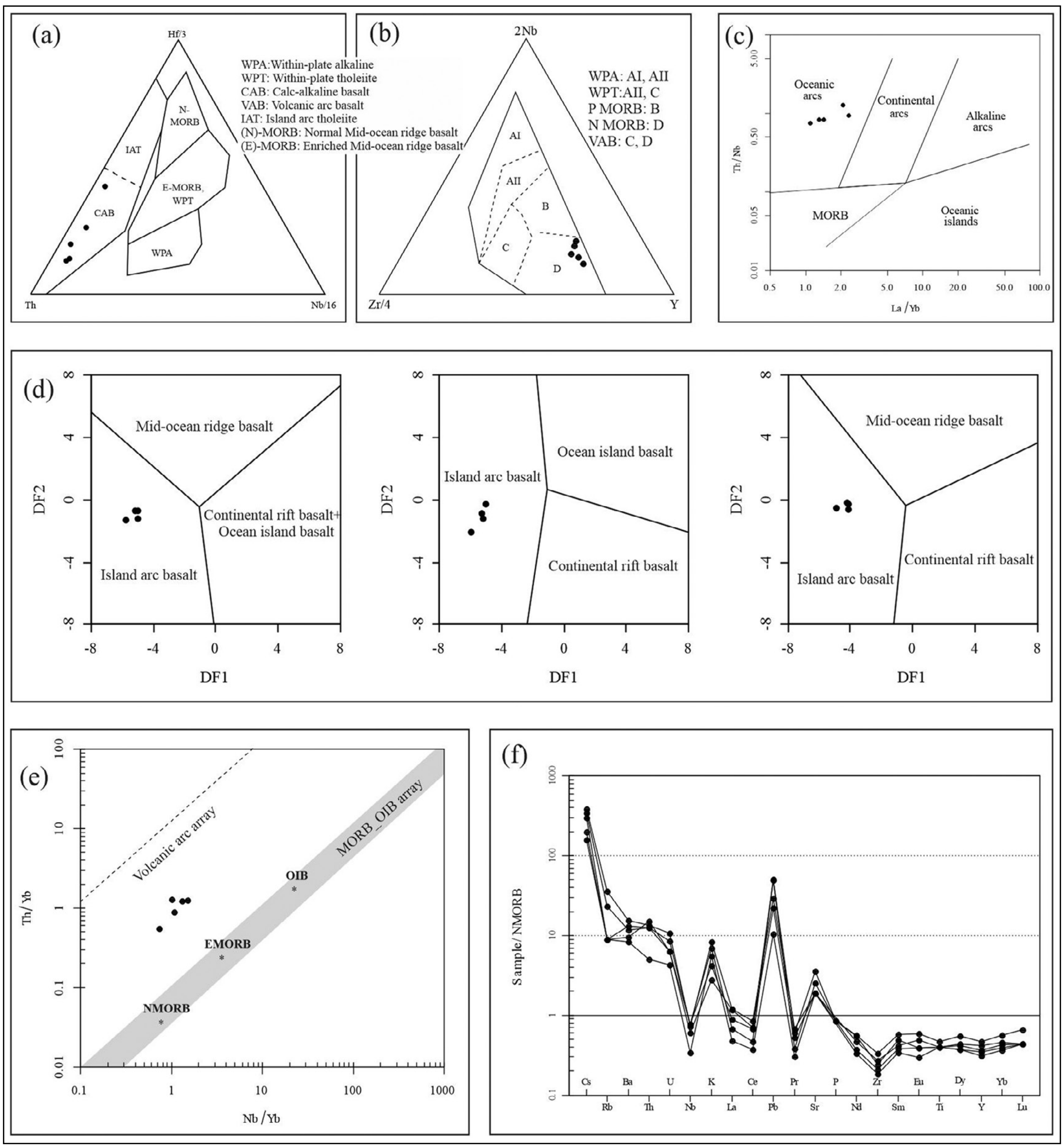

Figure 11- The locations of the rock samples belonging to the Kargınkızıközü formation in the tectonic discrimination diagrams; a) Wood (1980), b) Meschede (1986), c) Hollocher et al. (2012), d) Agrawal et al. (2008), e) Th/Yb-Nb/Yb diagram (Pearce, 2008), f) Spider diagram normalized to MORB (NMORB).

that developed due to the intra-oceanic subduction during the depletion of the oceanic crust of the northern branch of Neotethys and can be correlated with the Darmik formation located around Yozgat.

3.2.2. Sırataşlar Formasyonu

The sequence (Seymen, 1982; Kara and Dönmez, 1990) consisting of conglomerate, sandstone, and limestone and distinguished as Asmaboğazı and Kartal formations in previous studies was re-evaluated in this study in terms of both its stratigraphy and formation environment. The unit, consisting of conglomerate, sandstone, and limestone, deposited as patch reefs on the ensimatic arc sequence, was named as the Sırataşlar formation. Conglomerate-sandstone is green, brown and massive with volcanic pebbles, very small to small, rounded with few corners and well sorted. The limestone is gray, cream colored, very thickly bedded, massive, fractured and contains Hippurites fossils in places. The unit overlying the Kargınkızıközü formation with intraformational conglomerate-sandstone is overlain by the Kötüdağ volcanics with a tectonic contact. The Sırataşlar formation has a thickness of 25-30 m. The Maastrichtian age can be suggested for the unit, which contains abundant Hippurites, algae, bryzoa and lamellar shell fragments.

3.2.3. Kasımağa Formation

The unit, which was named by Bilgin et al. (1986), consists of basalt, trachybasalt, diabase, sandstone, mudstone and radiolarite. The gabbros of the Çiçekdağı nappe overlie the unit cut by the Buzlukdağı pluton and the Kötüdağ volcanics with a tectonic contact. The unit is thrusted over the metamorphics of the Kırşehir Massif along the N-S extending contact of Akpınar village north (Kırşehir-J31 sheet), and tectonically overlies the Kargınkızıközü formation and Kötüdağ volcanics around Kargınkızıközü village (Kırşehir-J31 map). Cenomanian-Campanian age was obtained with fossils (Kara and Dönmez, 1990; Dönmez and Akçay, 2016) from the samples compiled from the unit; *Globotruncana lapparenti Brotzen, Globotruncana* cf. *arca* (Cushman*), Globotruncana* cf. *tricarinata* (Quereau), *Rosita* cf. *fornicata* (Plummer), *Heterohelix* sp., *Hedbergella* sp., *Rugoglobigerina* sp. and *Globigerinidae, Ticinella* sp. The unit is a volcano-sedimentary cover belonging to the ophiolitic series and represents a deep sea environment.

3.3. Central Anatolian Plutonic Rocks

Granodiorite, granite, monzonite, syenite, nepheline syenites outcropping in the study area and named as the Central Anatolian granitoids (Dönmez et al., 2005) are discussed under the main title of the Central Anatolian plutonic rocks in this study. The unit is distinguished according to its composition, texture, age and origin differences. The plutonic rocks represented by quartz monzodiorite, quartz monzonite, granite, granodiorite, monzogranite (adamellite), syenite and quartz syenite are named as the Baranadağ pluton (Seymen, 1981*a*, *b*); the plutonic rocks represented by syenite and nepheline syenite are named as the Buzlukdağı pluton; the plutonic rocks represented by syenite, granite and monzogranite containing mega-orthoclase crystals in places are named as the Çayağzı pluton, and the plutonic rocks composed of granite, monzogranite, syenite and quartz syenite are named as the Hamitköy pluton. The cover units unconformably overlie the Central Anatolian plutonic rocks that cut the metamorphics of the Kırşehir Massif.

3.3.1. Baranadağ Pluton

The Baranadağ pluton has been defined as granite porphyry, quartz monzonite porphyry, quartz monzodiorite porphyry, monzodiorite porphyry, quartz monzonite, monzogabbro, granite, diorite and monzonite in petrographic studies. When evaluated according to the results of chemical analysis, it is classified as quartz monzodiorite, quartz monzonite, granite, granodiorite, monzogranite (adamellite), syenite and quartz syenite (Beyazpirinç et al., 2020). Homogeneous and heterogeneous magma mixtures (magma mixing and magma mingling) are also observed in the unit. In previous studies, ages range from 74.1±4.9 Ma (Campanian) with zircon; and range from 72.04±0.4-69.3±0.4 Ma (Maastrichtian) were obtained with $^{40}Ar/^{39}Ar$ method (Boztuğ et al., 2009). In this study, the crystallization age of 71.9±1.7 Ma (Maastrichtian) was obtained from the zircon mineral in the granite of the Baranadağ pluton for geochronological dating (Kırşehir J31 map; UTM ED50 Zone 36 6572180; 4350748) by U/Pb method (Figure 12a, b).

Bayhan and Tolluoğlu (1987) investigated the mineralogical, petrographical and chemical properties

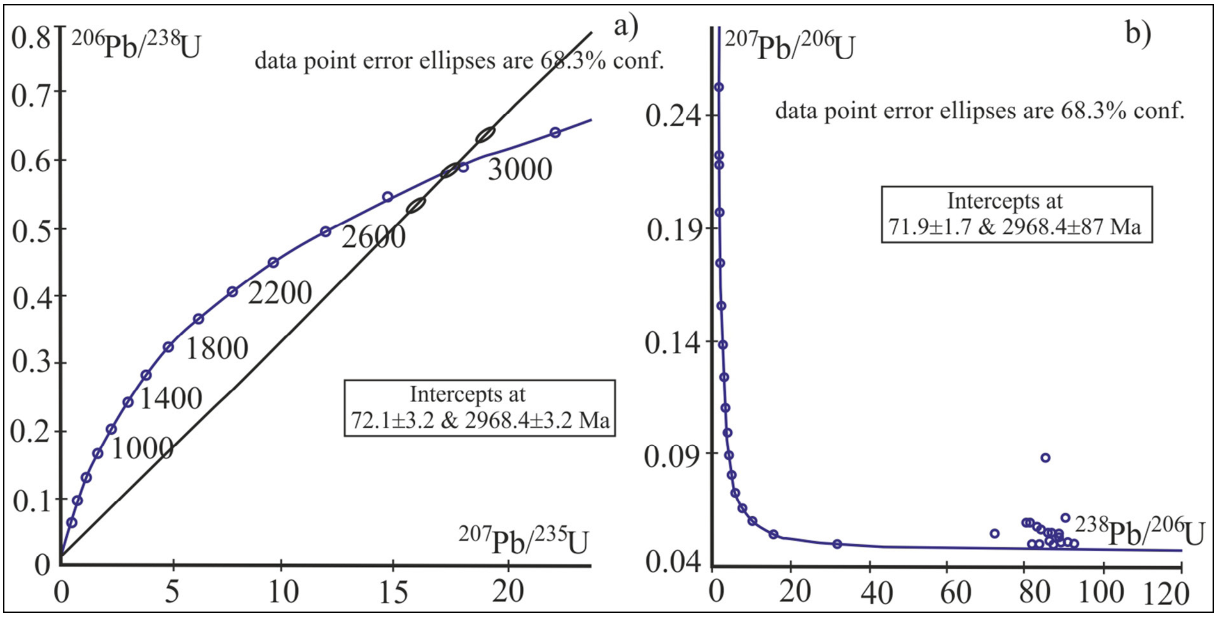

Figure 12- a), b) Concordia ages belong to the Baranadağ pluton.

of the Cefalıkdağ and Baranadağ plutons. Two petrographic rock groups, subalkaline and alkaline, were identified in these plutons. The investigator stated that both petrographic groups are derived from two different magmatic melts formed as a result of partial melting of the same source material (crust + mantle) in two different phases, and subalkaline rocks resembled monzonitic-I type and alkaline rocks are similar to syenitic-A type granites. Aydın and Önen (1999), who examined the Baranadağ pluton, stated that these rocks were similar to H-type (hybrid) and post-collisional granites. Otlu (1998); Otlu and Boztuğ (1998) examined the alkaline rocks in the pluton in two groups as silica saturated (ALKOS) and silica unsaturated (ALKUS) and stated that these rock groups were derived from two different alkaline magmas. İlbeyli and Uras (2005) stated that the Baranadağ intrusive rocks are similar to I-type granites and were derived from the mantle source which was enriched by subduction before the collision. Beyazpirinç et al. (2020), on the other hand, interpreted the Baranadağ pluton, which is composed of subalkaline rock group consisting of granodiorite, granite, quartz monzonite and monzonite with no boundary relations in the field, and alkaline rock group consisting of monzonite, syenite, quartz syenite as the post collisional granites derived from a hybride source formed by the mixing of crust and mantle derived materials similar to Aydın and Önen's (1999) interpretation.

3.3.2. Hamitköy Pluton

The Hamitköy pluton has been identified mainly as syenite, granite (syenogranite), quartz monzonite porphyry, alkaline feldspar-syenite, quartz syenite and quartz monzonite in petrographic studies. When evaluated according to the results of chemical analysis, it was determined that the unit consists of plutonic rocks in alkaline quartz monzonite, quartz syenite, granite, monzonite and syenite (Beyazpirinç et al., 2020). The unit is cut by nepheline syenite, pseudoleucite syenite, foided microsyenitic dykes. In this study, nepheline syenite, pseudoleucite syenite and foided microsyenitic dykes that cut the unit were interpreted as the products of the Buzlukdağı pluton and not included in the rock group of the Hamitköy pluton. In previous studies from the Hamitköy pluton; 75±11 (Campanian); 72.7±0.2 and 73.6±0.2 My (Campanian) ages were obtained with Ar-Ar method (Boztuğ et al., 2009).

In previous studies, İlbeyli (2004) stated that the source region for the intrusive rocks of the Hamitköy pluton was mantle enriched by the pre-collisional subduction event. Otlu and Boztuğ (1998) state that Baranadağ quartz monzonite, Hamitköy quartz syenite and Çamsarı quartz syenite form an assemblage in terms of geological location, textural features, mineralogical and chemical composition, and show fractional crystallization from Baranadağ to Çamsarı in mineralogical and geochemical terms. In other words, they argue that these three units were formed by fractional crystallization from a single magma source. Aydin et al. (1998) divided the Central Anatolian granitoids into two main groups as C-type (crustal) leucogranites and granites containing H-type (hybrid) hornblende±K-feldspar megacrystals±mafic microgranular enclaves. They state that granitoid magmatism is followed by syenitoid magmatism, and the first phase of this magma is formed by quartz syenitoids and the second phase by feldspathoid syenitoids. According to Aydin et al. (1998), C-type granitoids represent the early granitoid phase and are the products of collisional magmatism. H-type granitoids and syenitoid intrusions represent the advanced and final stages of post-collisional magmatism, respectively. Beyazpirinç et al. (2020), on the other hand, interpreted the rocks forming the Hamitköy pluton as the products of post-collisional magmatism originating from a hybrid source mainly consisting of the mixing of crustal and mantle-derived materials, in which the mantle origin is dominant.

3.3.3. Çayağzı Pluton

The Çayağzı pluton has been identified as K-feldspar megacrystalline quartz syenite, alkaline feldspar syenite and syenite in petrographic studies. When evaluated according to the results of chemical analysis, it was classified as granite, monzogranite (adamellite), and quartz syenite (Beyazpirinç et al., 2020). In previous studies, 97.0±12.0 My (Cenomanian) with zircon; 72.04±0.4-69.3±0.4 My (Maastrichtian) ages were obtained by Ar-Ar Method (Boztuğ et al., 2009). In this study, the ages of 84.0±1.9 Ma (Santonian) and 71.9±7.2 Ma (Maastrichtian) were obtained using the method (Figure 13a, b) U/Pb, from two samples of zircon mineral numbered as G-234 (Kırşehir J32 map; coordinate: 592475; 4348490) and G228 (Kırşehir J32 map; UTM ED50 Zone 36 591836; 4349037) were taken from the syenites of the Çayağzı pluton for geochronological dating.

In previous studies, Bayhan and Tolluoğlu (1987) grouped the unit, which are called the Çayağzı syenitoid, into three different groups as microcline syenites, felsic vein rocks and nepheline syenite. As a result of the investigations, it is stated that these rock groups were formed not by the fractional crystallization of a single magma, but by the magmas formed by the partial melting of different source materials. Beyazpirinç et al. (2020), on the other hand, interpreted the rocks forming the Çayağzı pluton as the products of magmatism originating from a mantle source that conforms to the cafemic assemblages, or from a hybrid source consisting of the mixing of crust + mantle-derived materials.

3.3.4. Buzlukdağı Pluton

The Buzlukdağı pluton was defined as syenite, foid-syenite, micro monzosyenite (with quartz), foid monzosyenite, syenite porphyry, foid monzosyenite porphyry, foid-monzodiorite, foyaite porphyry in petrographic studies. When evaluated according to the results of chemical analysis, it was classified mostly as nepheline syenite and a few samples as syenite. In

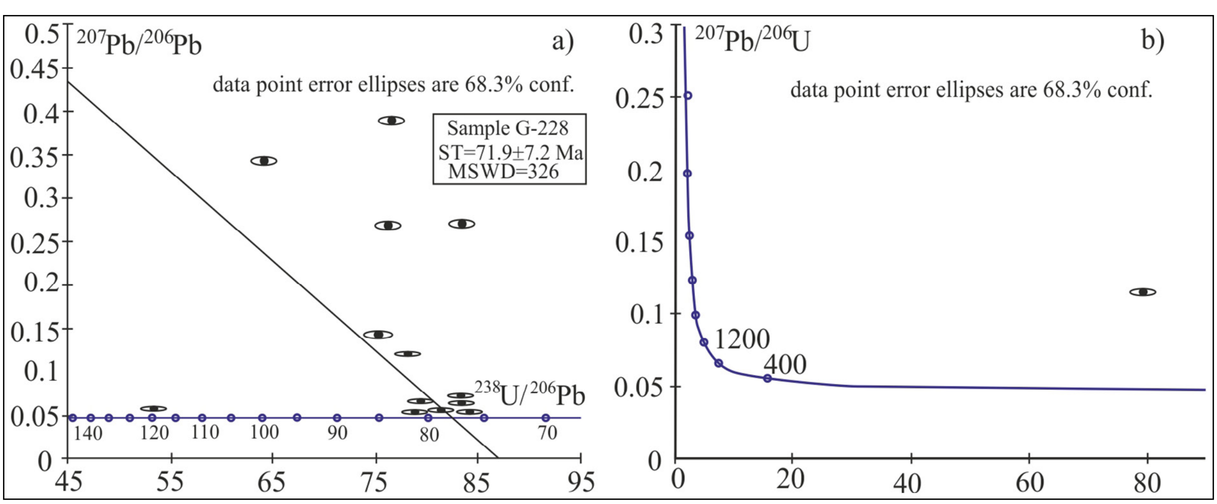

Figure 13- a), b) Concordia ages belonging to Çayağzı pluton.

previous studies, 84.4±7.5 Ma (Santonian) age was obtained with zircon (Boztuğ et al., 2009). In this study, the sample numbered as G-231 (Kırşehir J32 sheet; UTM ED50 Zone 36 594900; 4363846) taken from the Buzlukdağı pluton for geochronological dating was detected as 69.1±1.2 Ma (Maastrichtian) crystallization age from the zircon minerals by U/Pb method and 65.3±1.1 Ma (Maastrichtian-Paleocene) cooling age was obtained by using the method $^{40}Ar/^{39}Ar$ from the Whole Rock (Table 6, Figure 14a, b).

According to Deniz (2010), depending on the extensional movement and crustal thinning in the region during Late Cenozoic, the products from the upper mantle caused the formation of the Buzlukdağı pluton following the interaction with the lower crust, which was poor in silica and mostly foid-containing crystallization and differentiation. Tolluoğlu (1993) stated that the rock samples belonging to the Buzlukdağ syenitoid had leucocrate and supersaturated alkaline (ALKOS) character. Boztuğ (2000) stated that post-collisional, A type, intraplate character alkaline union might have been formed as a result of the fractional crystallization under some special physicochemical conditions of uplifted upper mantle peridotites as a result of the extensional regime replacing the compression because of isostatic equilibrium following the crustal thickening. Beyazpirinç et al. (2020) on the other hand interpreted the rocks constituting the Buzlukdağı pluton as the products of intraplate A type magmatism in metallumina-peralumina character, which had a trend suitable for cafemic and partially alumino-cafemic assemblages.

Table 6- $^{40}Ar/^{39}Ar$ analytical data table of the Buzlukdağı pluton.
Sample: G-231 Whole rock J=0.003539 ± 0.000033

T^0C	$^{40}Arcc$ (STP)	$^{40}Ar/^{39}Ar$	±1σ	$^{38}Ar/^{39}Ar$	±1σ	$^{37}Ar/^{39}Ar$	±1σ	$^{36}Ar/^{39}Ar$	±1σ	Ca/K	$\sum^{39}Ar$ (%)	Age (Ma) ±1σ	±1σ
450	$3.3*e^{-9}$	112.295	6.015	0.1652	0.0323	0.0785	0.0730	0.3075	0.0559	0.28	0.1	131.8	94.0
600	$13.2*e^{-9}$	14.571	0.039	0.0212	0.0017	0.0443	0.0053	0.0180	0.0023	0.16	4.6	58.0	4.2
700	$27.5*e^{-9}$	13.214	0.026	0.0196	0.0006	0.0393	0.0053	0.0121	0.0015	0.14	14.8	60.4	2.8
800	$18.7*e^{-9}$	12.562	0.039	0.0218	0.0009	0.0411	0.0023	0.0070	0.0028	0.15	22.1	65.8	5.1
900	$71.5*e^{-9}$	11.453	0.011	0.0204	0.0003	0.0326	0.0007	0.0027	0.0005	0.12	52.9	66.7	1.1
950	$16.8*e^{-9}$	12.780	0.035	0.0184	0.0008	0.0686	0.0039	0.0069	0.0023	0.25	59.3	67.3	4.2
1000	$26.5*e^{-9}$	13.201	0.025	0.0194	0.0003	0.0863	0.0070	0.0074	0.0010	0.31	69.2	68.9	1.9
1000	$14.9*e^{-9}$	13.039	0.025	0.0196	0.0009	0.1213	0.0046	0.0098	0.0009	0.44	74.8	63.6	1.8
1060	$29.0*e^{-9}$	12.740	0.021	0.0194	0.0007	0.1454	0.0055	0.0102	0.0012	0.52	86.0	61.0	2.2
1130	$35.5*e^{-9}$	12.458	0.020	0.0188	0.0007	0.1134	0.0018	0.0073	0.0008	0.41	100.0	64.7	1.6

Sample	IIA (Ma) ±1σ	TFA ±1 σ	WMPA (Ma) ±1σ	Ca/K	Comments
G-231 Whole Rock	67.7±1.6	64.9±1.0	65.3±1.1	0.12-0.52	Eight steps plateau

Explanation:
±1 σ=Estimated uncertainty (1 sigma) IIA=Inverse isochrone age TFA=Total fusion age
WMPA=Weighted mean plateau age Ca/K=Apparent Ca/K ratios WMIPA=Weighted mean intermediate plateau age

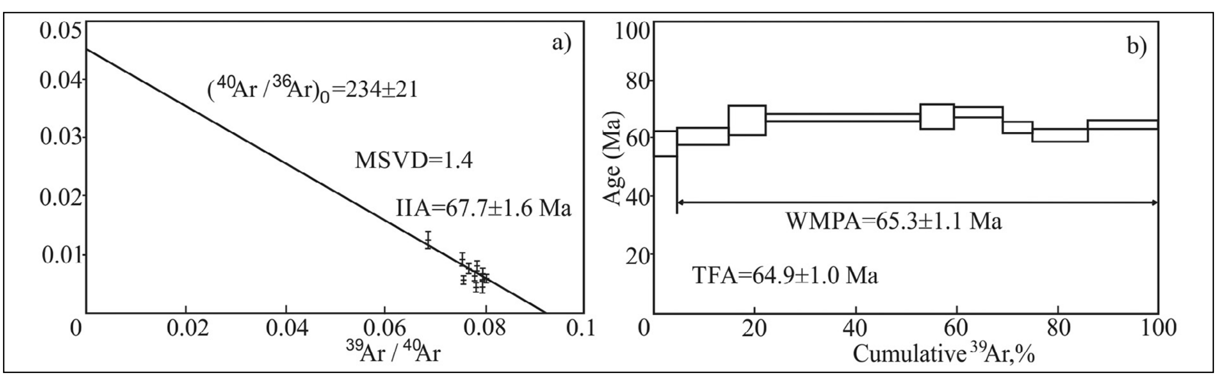

Figure 14- a) Isochron and b) plateau ages of the Buzlukdağı pluton.

3.4. Kötüdağ Volcanics

In petrographic investigations of the unit, which is named as the Kötüdağ volcanic by Seymen (1982), dacite, rhyolite, rhyodacite, syenite porphyry and quartz-bearing monzonite porphyry rock types were identified. It is classified as trachyte and trachyandesite when evaluated in classification diagrams where the elements are not easily mobilized under low alteration and metamorphic conditions (Beyazpirinç et al., 2020). Samples G-269 (Kırşehir J32 map; UTM ED50 Zone 36 6590598; 4360011) and G-270 (Kırşehir J32 map; UTM ED50 Zone36 589600; 436965) taken for geochronological dating from the Kötüdağ volcanic, which cuts the metamorphics of the Kırşehir Massif and the Central Anatolian plutonic rocks in the form of sills and dykes, three-step plateau age spectrum of 79.1±1.2 Ma, 68.2±1.2 Ma and 74.5 Ma (Campanian-Maastrichtian) was obtained by $^{40}Ar/^{39}Ar$ method from the Whole Rock analyses (Table 7, 8, Figure 15a, b). Beyazpirinç et al. (2020) interpreted the Kötüdağ

Table 7- $^{40}Ar/^{39}Ar$ table of the sample G-269 taken from the Kötüdağ volcanic.

Sample: G-269 Whole rock J=0.003222 ± 0.000027

T°C	$^{40}Ar_{cc}$ (STP)	$^{40}Ar/^{39}Ar$	±1σ	$^{38}Ar/^{39}Ar$	±1σ	$^{37}Ar/^{39}Ar$	±1σ	$^{36}Ar/^{39}Ar$	±1σ	Ca/K	$\sum^{39}Ar$ (%)	Age (Ma) ±1σ	±1σ
500	14.7*e-9	23.219	0.042	0.02341	0.00142	0.0536	0.0056	0.02009	0.00198	0.193	4.3	97.8	3.3
600	65.3*e-9	17.213	0.011	0.01867	0.00081	0.0552	0.0026	0.00860	0.00057	0.199	30.1	83.3	1.2
700	55.4*e-9	16.338	0.058	0.01215	0.00071	0.0405	0.0040	0.01032	0.00081	0.146	53.2	75.6	1.5
800	63.4*e-9	14.715	0.043	0.00089	0.00087	0.0040	0.0049	0.00422	0.00063	0.015	82.5	76.6	1.2
900	16.8*e-9	13.864	0.033	0.01639	0.00168	0.0030	0.0058	0.00697	0.00176	0.011	90.7	67.3	3.0
1000	11.7*e-9	16.567	0.040	0.02073	0.00152	0.0181	0.0085	0.01823	0.00187	0.065	95.5	63.8	3.2
1130	10.9*e-9	16.445	0.053	0.02106	0.00379	0.0168	0.0087	0.01474	0.00064	0.060	100.0	68.9	1.2

Sample	IIA (Ma)±1σ	TFA±1 σ	WMPA (Ma)±1σ	Ca/K	Comments
G-269 Whole Rock	66.9±5.8 68.9±3.5	77.3±0.9	79.1±1.2 68.2±1.2	0.01-0.20	Three steps plateau Three steps intermediate plateau

Explanation:

±1 σ=Estimated uncertainty (1 sigma) IIA=Inverse isochrone age TFA=Total fusion age

WMPA=Weighted mean plateau age Ca/K=Apparent Ca/K ratios WMIPA=Weighted mean intermediate plateau age

Table 8- $^{40}Ar/^{39}Ar$ table of the sample G-270 taken from the Kötüdağ volcanic.

Sample: G-270 Whole rock J = 0.00174 ± 0.36%

step	T(C)	t(min.)	^{36}Ar	^{37}Ar	^{38}Ar	^{39}Ar	^{40}Ar	%^{40}Ar*	%^{39}Arrlsd	Ca/K	^{40}Ar*/ $^{39}Ar_K$	Age (Ma)	1s.d.
1	530	12	0.488	1.233	2.502	184.039	4706.85	97.1	7.7	0.028992123	25.003851	76.83	0.28
2	550	12	0.196	1.419	2.089	160.914	4084.16	98.8	6.8	0.038160719	25.335701	77.83	0.29
3	570	12	0.199	2.229	2.453	193.130	4918.77	99.0	8.1	0.049944748	25.365969	77.92	0.29
4	590	12	0.219	3.001	2.826	219.737	5634.40	99.0	9.2	0.059100817	25.551269	78.48	0.29
5	620	12	0.341	4.867	3.685	285.158	7257.09	98.7	12.0	0.073859841	25.301111	77.72	0.30
6	650	12	0.402	6.592	3.508	268.190	6761.37	98.3	11.3	0.106368096	24.973934	76.74	0.28
7	690	12	0.262	8.048	3.001	233.968	5714.16	98.8	9.8	0.148858537	24.289236	74.68	0.34
8	740	12	0.173	5.469	2.423	183.187	4342.19	99.1	7.7	0.129197164	23.613279	72.64	0.35
9	800	12	0.136	2.568	1.846	142.019	3314.11	99.2	6.0	0.078249526	23.234983	71.50	0.29
10	870	12	0.204	0.586	1.845	136.651	3144.07	98.5	5.7	0.018557107	22.746968	70.03	0.26
11	970	12	0.338	0.700	2.057	152.451	3520.22	97.6	6.4	0.019869795	22.587033	69.55	0.26
12	1070	12	0.451	0.775	1.846	129.870	2963.79	96.1	5.4	0.025823747	21.945077	67.61	0.25
13	1180	12	0.291	0.527	0.921	61.544	1407.23	95.8	2.6	0.037055505	21.681215	66.81	0.25
14	1400	12	0.371	1.402	0.684	32.453	694.966	90.7	1.4	0.186956388	18.203105	56.26	0.25
Cumulative %^{39}Ar risd=100.0 Total age=74.49													

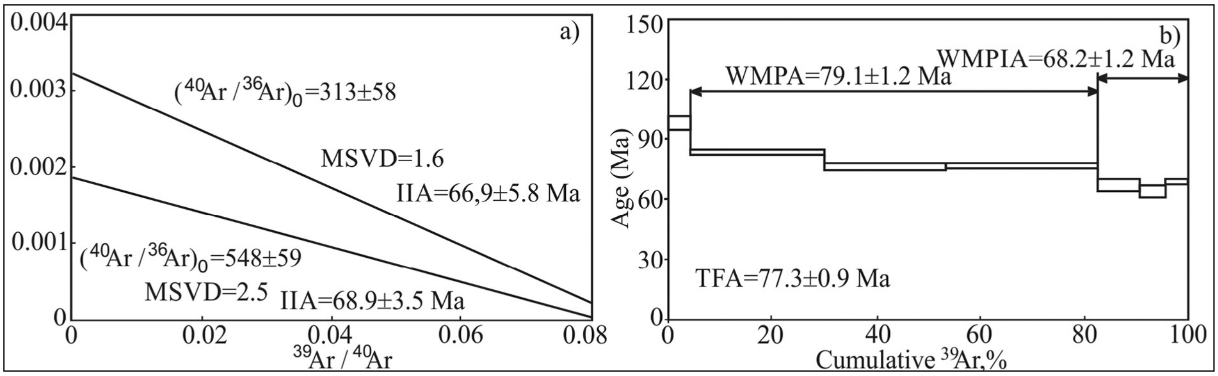

Figure 15- a) Isochronous and b) plateau ages of the sample G-269 taken from the Kötüdağ volcanics.

volcanics as surface and shallow intrusive/semi-depth products of granite, monzonite and syenite plutonic rocks in the study area.

4. Results

In this study, the tectono-stratigraphic features of the rock units in the Kırşehir Massif are tried to be enlightened. Radiometric age determinations were made from metamorphic and magmatic masses, and metamorphic masses were differentiated at the generation stage. The existence of the Triassic Demirtepe formation and the Jurassic-Cretaceous Saytepe formation is revealed for the first time in this study. The depositional age of 237 Ma (Ladinian) was obtained from the quartzites in the Demirtepe formation by the U/Pb method, and 94.5 Ma (Cenomanian) and 83.7±3.3 Ma (Coniacian) ages were obtained from the metabasites by the ^{40}Ar/^{39}Ar method. The age of 105.4±5.3 Ma (Albian) was obtained from the gabbros of the Çiçekdağı nappe by ^{40}Ar/^{39}Ar geochronological dating method (Beyazpirinç et al., 2020). The geochemical analyses were carried out in the Turonian-Santonian volcano-sedimentary sequence (Kargınkızıközü formation), which was distinguished for the first time in this study within the Çiçekdağı nappe, and it was concluded that they were the products of the ensimatic island arc. By considering the granodiorite, granite, monzonite, syenite, nepheline syenites and the Central Anatolian plutonic rocks cropping out in the study area; the Baranadağ pluton, Hamitköy pluton, Çayağzı pluton and Buzlukdağı pluton were distinguished. The age of 71.9±1.7 Ma (Maastrichtian) was obtained from the Baranadağ pluton by the U/Pb method. The ages of 84.0±1.9 Ma (Santonian) and 71.9±7.2 Ma (Maastrichtian) were obtained from the Çayağzı pluton by U/Pb method. The ages of 69.1±1.2 Ma (Maastrichtian) from U/Pb method and 65.3±1.1 Ma (Maastrichtian-Paleocene) from ^{40}Ar/^{39}Ar method were obtained from the Buzlukdağı pluton. The ages of 79.1±1.2Ma, 68.2±1.2 Ma and 74.5 Ma (Campanian-Maastrichtian) from the Kötüdağ volcanics, which are the surface and shallow intrusion products of some of the plutonic rocks with calc-alkaline character, intraplate, post-collisional granite, monzonite and syenite composition, has been obtained.

Acknowledgements

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