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Magmatic signature of the closure of the northern branch of the Neo-Tethys: Upper Paleocene-Middle Eocene magmatism at the boundary of the Tavşanlı-Sakarya Zone (Turkey)

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Numerous plutons composed of granite, granodiorite, diorite-porphyry, monzonite, granodiorite-porphyry and diorite/microdiorite-porphyry occur at the boundary of the Tavşanlı-Sakarya Zone, in the eastern part of the northwestern Anatolian magmatic belt, Turkey. These rocks belong to two different types: a medium-K calc-alkaline granodiorite series (with associated dykes and sub-volcanic rocks) and a shoshonitic series of granites. The rocks of the shoshonitic series have SiO_2 from 67.5 to 75.6 wt.% with Mg# from 35.1 to 59.5, whereas the medium-K calc-alkaline series rocks have SiO_2 between 54.6 and 67.7 wt.% with Mg# from 43.5 to 60.8. There is a clear enrichment of LILE with respect to the HFSE in all magmatic units of the region. These magmatic rocks reflect properties of collision-related arc magmatism in the various geochemical discrimination diagrams. The initial $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ istopic ratios of the magmatic units range from 0.705506 to 0.710902 and 0.512178 to 0.512594, respectively. Collision-related granitoids yielded a $^{40}Ar/^{39}Ar$ cooling age age of 59.13 ±1.87 Ma, and arc-related granitoids and associated sub-volcanic units 44.3 ±0.47 and 44.11 ±0.89 Ma. The data obtained revealed that continent-continent collision in the Paleocene together with the initiation of the closure of the Neo-Tethys took place between the Anatolide-Tauride Platform and Sakarya Plate from the end of the Cretaceous. The shoshonotic granite may cooled in the Middle Paleocene, as regards the subduction-accretion zone in which subduction impacts have been observed. The medium-K calc-alkaline magmatic products in the region were formed by partial melting of the continental lithospheric mantle caused by the upwelling of asthenospheric mantle after the subducted slab was delaminated.

Key words: cooling age, sub-volcanic phase, shoshonites, enclave, petrological modelling.

INTRODUCTION

The closure of the Tethys Ocean is represented by two main suture zones in Turkey: the İzmir-Ankara-Erzincan and Intra Pontid suture zones. Both suture zones were formed during continental collisions following the northwards subduction of the Tethys oceanic lithosphere. In addition, the closure of the Tethys Ocean occurred in two intervals in Turkey: the Carboniferous-Triassic (Palaeo-Tethys) closure and the Triassic-Cretaceous (Neo-Tethys) closure (Okay and Tüysüz, 1999).

The closure of the Neo-Tethys, which played an important role in shaping the microcontinents and platforms of Anatolia, started in the Triassic-Cretaceous and continued until the continental collision in the Paleocene-Early Eocene (Altunkaynak and Dilek, 2013). The magmatic belt along the İzmir-Ankara-Erzincan Suture Zone is represented by intrusive, sub-volcanic and related volcanic rocks (Keskin et al., 2008; Dilek and Altunkaynak, 2009; Karslı et al., 2010; Kaygusuz et al., 2011; Eyuboglu et al., 2011; Altunkaynak and Dilek, 2013; Aysal et al., 2018; Özyurt and Altunkaynak, 2020). In previous studies, which included limited radiometric data, it was generally accepted that the magmatic rocks in the region related to the post-collisional setting formed during the Late Paleocene-Early Eocene (Harris et al., 1994; Altunkaynak and Dilek, 2006; Dilek and Altunkaynak, 2009). These magmatic rocks, which shed light on Turkey's geodynamic evolution, have been variously investigated (Güleç, 1991; Genç, 1998; Aldanmaz et al., 2000; Okay, 2002; Aydoğan et al., 2008; Dilek and Altunkaynak, 2009; İlbeyli and Kibici, 2009; Zoroğlu, 2009; Altunkaynak et al., 2012a, b; Güllü, 2012).

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The granitoids located at the boundary of the Tavşanlı-Sakarya Zone are the first products of Paleogene magmatism in northwestern Anatolia. These granitoids are significant to the interpretation of the consequences for closure of the northern branch of the Neo-Tethys, which shaped the geodynamic structure of the region. There are three main models for the genesis of the magmatic bodies in the region. The first and widely accepted model is that these magmatic bodies are associated with the northwards subduction of the Neo-Tethys under the Sakarya microcontinent (Altunkaynak, 2007; Karacık et al., 2008). The second model is collision-driven via slab break-off (Altunkaynak et al., 2012a; Demirbilek et al., 2018). The third and less widely accepted model is that these magmatic bodies are derived from the subduction of Neo-Tethys under the Tauride-Anatolide Platform (Bağcı et al., 2019). There are different opinions regarding the subduction direction. Previous studies on the regional geology propose that the neo-Tethys was consumed by subduction under the Sakarya continent. This paper examines the controversial geodynamics of the magmatic rocks in the region together with the isotopic and radiometric data of the Karakaya, Topkaya and Yürükkaracaören magmatic units. The Topkaya and Yürükkaracaören magmatic units have not been considered in previous studies. Also, the original relationship between the Yürükkaracaören sub-volcanic rocks and the Topkaya magmatic units, which were classified as "granodiorite" in previous studies, has been revealed for the first time in this study with radiometric, isotopic and extensive geochemical data. In addition, the comparative petrogenetic relations of the magmatic bodies formed by the differentiation of the magma forming the intrusive rocks in the region are also discussed in detail for the first time.

GEOLOGICAL SETTING

Northwestern Anatolia consists of many micro-blocks involved in the continent-continent collision following the closure of the Tethys Ocean by northwards subduction (Şengör and Yılmaz, 1981; Okay and Tüysüz, 1999). The basement of northwestern Anatolia consists of Permian metamorphic rocks (Altınlı, 1973; Yılmaz, 1981; Okay, 1984a). Apart from these, there are three main metamorphic belts consisting of the Mesozoic Karakaya complex and the Tavşanlı and Afyon zones in the northwestern Anatolia (Okay, 1984a, b; Fig. 1A).

The Karakaya complex represents an accretionary prism which originated as a result of subduction of the Paleotethys in the Triassic towards the north along the active margin of Laurasia (Okay and Göncüoğlu, 2004). The complex underwent metamorphism at greenschist facies in the Triassic (Okay, 1984b).

The Tavşanlı Zone is represented by Cretaceous high pressure/low-temperature metamorphic rocks derived from the northern section of the Anatolide-Tauride Block (Okay, 1984a, b; 2011). Okay (1984a, b) stated that the units forming the Tavşanlı Zone consist of ophiolitic melanges and Eocene sedimentary and the intrusive units. The units of the Tavşanlı Zone in the Ordovician metagranitic basement are considered to be a tectonic slice (Okay et al., 2008). The crystallization age of the intrusive unit is 467.0 ±4.5 Ma based on U/Pb single zircon evaporation analyses. These Ordovician rocks are inferred to have originated during rifting and separation of small plates such as the Istanbul Plate from the northern margin of Gondwana (Okay et al., 2008). While the thick sedimentary units of the Tavşanlı Zone have been obducted onto the Afyon Zone. The Afyon Zone has undergone low-grade regional metamorphism, and consists of Permo-Carboniferous clastic, Triassic-Campanian platform carbonate and Maastrichtian pelagic strata. Ophiolite nappes lie on top of it (Okay, 1984a, b).

The oldest unit in the study area is formed by the metamorphic Sivrihisar Massif having a similar protolith to the rest of the Tavşanlı Zone (Whitney et al., 2011). The greenschist facies rocks at the bottom and the marbles at the top form the dominant lithologies among the Sivrihisar metamorphic rocks. The marbles forming the upper levels of the metamorphic units have tectonic contacts with the Karakaya (Kaymaz) granites.

This study covers the magmatic bodies located in the easternmost part of the northwestern Anatolian magmatic belt, at the boundary between the Sakarya microcontinent and the Tavşanlı Zone (Fig. 1A). The first geochronological study regarding the emplacement and cooling ages of the magmatic suites under discussion was by Gautier (1984), who made a U-Pb radiometric analysis of zircons and apatites in the pluton, obtaining ages of 84.98 ±6.27 and 65.91 ±3.84 Ma for two magmatic units. Shin et al. (2013) found that crystallization of the Sivrihisar and Kaymaz granitoids occurred during the Eocene, following subduction in the Early-Late Cretaceous. Demirbilek et al. (2018) stated that the Karakaya (Kaymaz) granite originated at 52.1 ±2.0 and 54.0 ±2.1 Ma from K-Ar dating.

SAMPLING AREA

The field observations were made of three intrusive units (Fig. 1B–D). The Karakaya (Kaymaz) granite is located in the south-west of the study area. It covers an area of 16 km^2, and has a very hilly topography. In the pluton, regular join ting has been observed; while fresh surfaces are pale grey, subaerial surfaces undergoing weathering are yellowish-grey (Fig. 2A).

The Karakaya granite is cut by aplitic dykes ranging from 1 cm up to 2 m thick, with tectonic trends N 30°W to N 60°W. Tourmaline-bearing quartz veins up to 20 cm thick have also been observed in the pluton. Quartz, plagioclase, alkali feldspar, biotite, tourmaline and rarely reach up to 15 cm across were observed within the main unit, mainly composed of quartz, plagioclase, hornblende and biotite (Fig. 2C).

The Topkaya granitoid crops out over an area of ~45 km^2 in the northwestern part of the study area. Light grey diorite porphyry and granodiorite varieties can be distinguished here. The pluton shows a diorite porphyry composition with porphyro-aphanitic texture as a marginal facies, and granodiorite with phaneritic texture developed towards the central part (Fig. 2D). Mafic microgranular enclaves from 1 to 25 cm in size are mostly distributed at the margins of the pluton. These ellipsoidal-spheroidal enclaves could be easily distinguished from the Topkaya granitoid due to their darker colour and finer-grained texture (Fig. 2E). Also, there are some zones with needle-shaped mafic minerals within felsic minerals, 10–20 cm across, in the granodiorites. These zones, termed appanite (Fig. 2F), were interpreted by Sha (1995) as as a result of local mixing of mafic and felsic magmas. The Topkaya granitoid is cut by felsic and intermediate veins. The intermediate veins range in width from 1 cm to 2 m and are up to several hundred metres in length. These rocks have porphyritic textures and have the composition of microgabbro porphyry, microdiorite porphyry, diorite porphyry and granodiorite porphyry.

There are Yürükkaracaören sub-volcanic units, originally related to the Topkaya granitoid, in the northeastern part of the study area. Sub-volcanites show porphyritic texture and consist of biotite, amphibole and feldspar (Fig. 2G). Quartz-hornblende ocellar texture and magmatic segregation enclaves are macro-

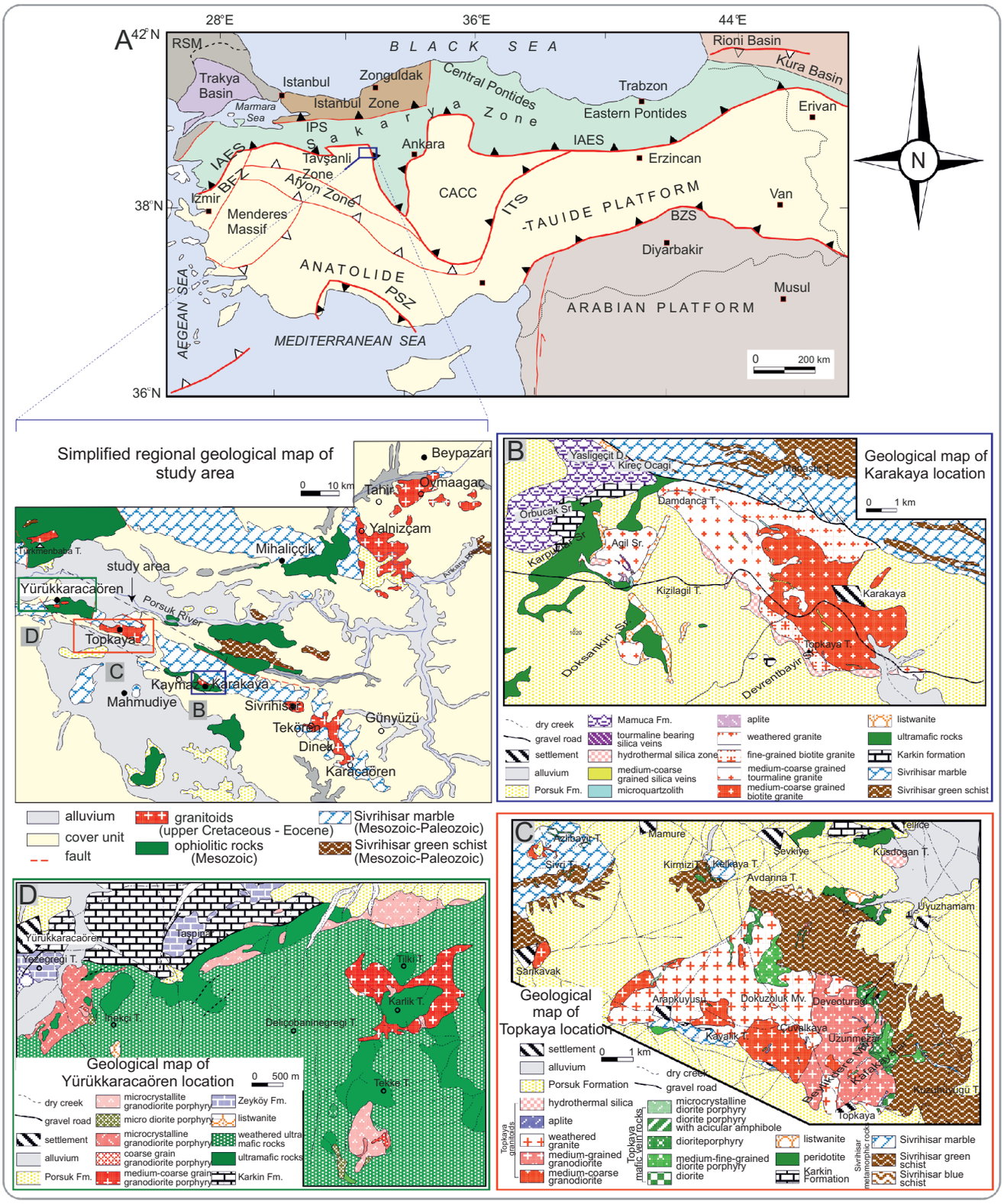

Fig. 1A – location of the study area with respect to the tectonic units of Turkey (simplified from Okay, 2011) and magmatic facies maps of the rocks located in the (B) Karakaya, (C) Topkaya and (D) Yürükkaracaören areas

BFZ – Bornova Flysch Zone, BZS – Bitlis-Zagros Suture, CACC – Central Anatolian Crystalline Complex, IAES – Izmir-Ankara-Erzincan Suture, ITS – Inner Tauride Suture, PSZ – Pamfilia Suture, RSM – Rhodope-Strandja Massif

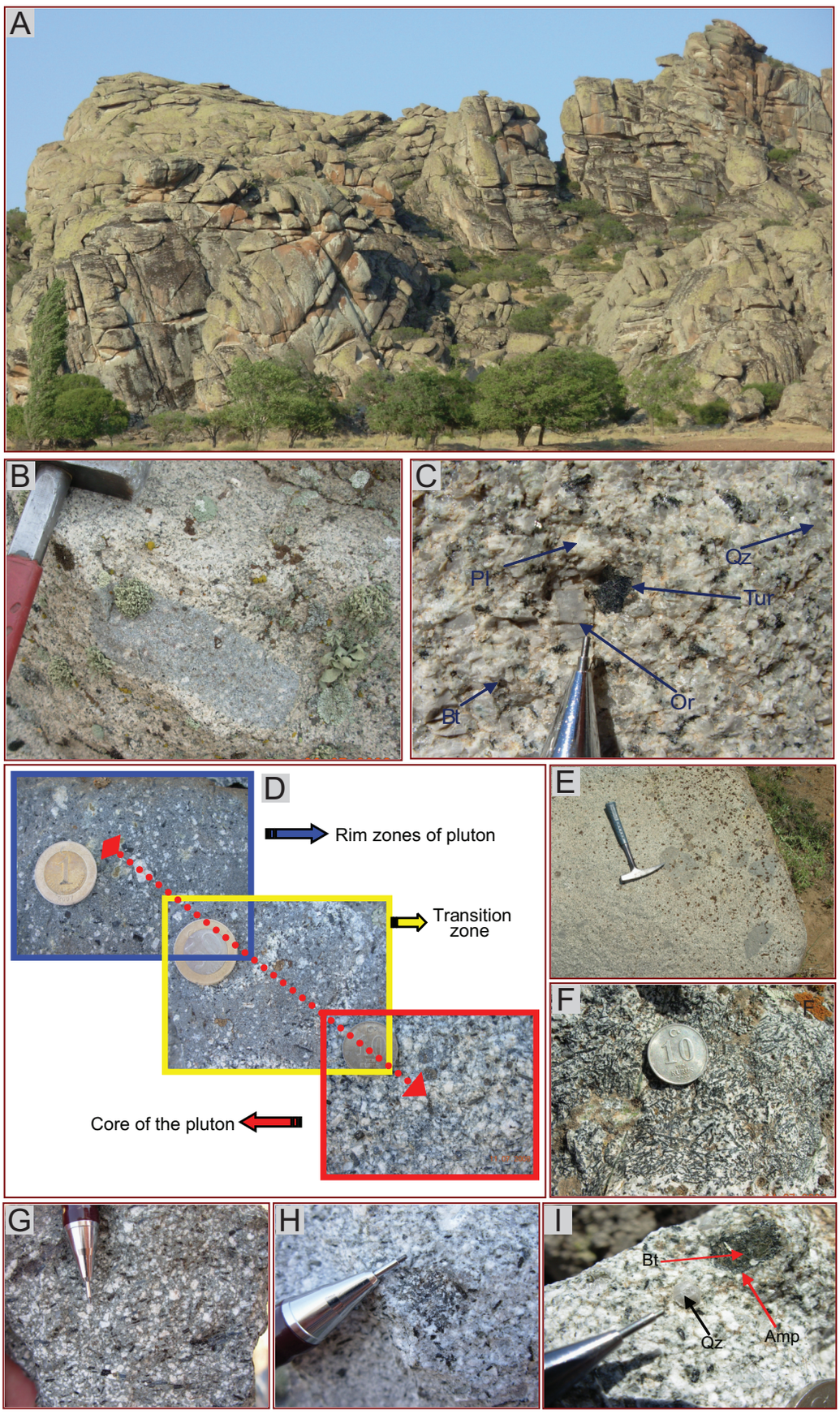

Fig. 2A – view of the Karakaya granite; B – enclaves within the granites; C – close-up view of the Karakaya granite; D – mineralogical and textural changes of the Topkaya pluton from rim to core; E – mafic microgranular enclaves within the granodiorites; F – apanite-type enclaves within the granodiorites as local units; G – macroscopic view of diorite porphyry; H – mafic magmatic enclave within Yürükkaracaören diorite porphyries; I – euhedral quartz and magmatic segregation enclave in diorite porphyry

Amp – amphibole, Bt – biotite, Or – orthoclase, Pl – plagioclase, Qz – quartz, Tur – tourmaline

scopically observed in the host rock (Fig. 2H). Biotite, amphibole and secondary quartz are seen in the rock (Fig. 2I).

Sub-volcanitic rocks, considered to be originally related to the Topkaya pluton, may represent the upper levels of a pluton.

The magmatic units are unconformably overlain by Neogene-Quaternary strata. Magmatic facies maps of all three locations have been prepared based on the textural properties and petrographic characteristics of the magmatic rocks as observed in the field (Fig. 1B–D).

ANALYTICAL TECHNIQUES

Petrographic analyzes were carried out in the petrographic research laboratory of the Ankara University Earth Sciences Application and Research Center using a *Leica DM 2500P* polarizing research microscope.

The geochemical analyses were conducted in the Earth Science Application and Research Center Laboratory (YEBİM) of Ankara University. The chemical composition of the samples was determined using a *Spectro XLAB 2000 Polarized Energy Dispersive X-Ray Fluoresan*s (PEDXRF) device. The analytical results were calibrated using the *GEO-7220, K02-GSR-09* and *G01-GS-N-Granite USGS* standards. The samples were finely grounded in a ball mill to a dimension of 20 microns. Afterwards, a 4 g sample was mixed with 0.9 gr wax and compressed with a press at 15 x 10^4 N/m^2.

Trace element analyses were made by ICP-MS in the Bureau Veritas Mineral Laboratories (Canada), using the *SO-18* standard according to USGS standards and with calibration of the device. For ICP-MS, the samples were calcined and dissolved in appropriate acids in preparation for analysis.

Sr and Nd isotope analysis was performed in the METU Central Lab R&D Training and Measurement Center Radiogenic Isotope Lab. The Sr was separated with 2.5 N HCl acid using *Bio Rad AG50 W-X8*, 100-200 mesh resin with 2 mL volume. After the collection of strontium, 6 N HCl was used and the rare earth element fraction was collected. Strontium was loaded onto single Re-filaments using a Ta-activator. $^{87}Sr/^{86}Sr$ data were normalized to $^{86}Sr/^{88}Sr$ = 0.1194. During the measurements, a Sr NBS 987 standard was measured as 0.710260 ±5 (n = 2) and necessary corrections were made to the measurement results. Neodymium was separated from other rare earth elements by passing over 2 mL volume HDEHP (bis-ethyexyl phosphate) covered biobeads acid by using 0.022 N HCl. The separated neodymium was loaded onto a filament together with 0.005 N H_3PO_4. During the analyses; $^{143}Nd/^{144}Nd$ data were normalized with $^{146}Nd/^{144}Nd$ = 0.7219 and the Nd LaJolla standard was measured as 0.511850 ±5 (n = 2). $^{143}Nd/^{144}Nd$ and $^{87}Sr/^{86}Sr$ ratios, initial $^{87}Sr/^{86}Sr$ ratios of the rock groups and εNd values were calculated according to Ar-Ar age analysis results.

Ar-Ar age analysis was made on biotite minerals with a *Finnigan MAT-262 Thermal Ionisation Mass Spectrometry* (TIMS) device in the Institute of Geology and Geophysics, Chinese Academy of Sciences, Radiogenic Isotope Geochemistry Laboratories. The mineral selection for Ar-Ar analysis was made manually from crushed rock samples. The selected samples were then irradiated to produce ^{39}Ar from ^{39}K. Heating causes the crystal structure of the mineral (or minerals) to degrade, and, as the sample melts, trapped gases are released. All the measurements were performed by mass spectroscopy.

RESULTS

PETROLOGY

During the crystallization of magma, many groups of igneous rock can form by differentiation. The original relationships, mineralogical compositions and textural properties of these rock groups, forming different magmatic facies, can be revealed by petrological studies. More than 500 thin-sections of different varieties of granitoid rock were examined.

KARAKAYA (KAYMAZ) GRANITE

According to the IUGS classification, all magmatic rocks in Karakaya location are of granitic composition. In the magmatic facies distinction based on mineralogical composition, the magmatic products in the region were classified for the first time in this study as biotite granite and tourmaline biotite granite according to the dominant mineral composition. The Karakaya granite is cut by felsic vein rocks such as alkaline feldspar granite, granophyre and quartzolite.

Biotite granite; biotite granite mineralogically consists of quartz + orthoclase + plagioclase (An_{11}-An_{15}) + biotite ± titanite ± allanite ± zircon ± opaque mineral. In addition, sericite, chlorite, calcite and rarely epidote are observed as alteration products. Biotite granites generally possess holocrystalline hipidiomorph granular texture (Fig. 3A). Zircons are observed as inclusions in the biotites (Fig. 3B) and allanite (orthite) and titanite are seen as euhedral crystals (Fig. 3C).

Tourmaline-biotite granites*;* tourmaline-biotite granites have a similar mineral composition to the biotite granites and are characterized by a significant tourmaline content. The tourmalines are observed in myrmekitic-like textures in the shape of anhedral crystal forms (Fig. 3D). Güllü and Kadıoğlu (2017) stated that these tourmalines are of schorl composition. Fluorite has been detected for the first time in this study within the tourmaline-biotite granites (Fig. 3E). The tourmaline-bearing granite may have been affected by metasomatic processes, and the presence of tourmaline distinguishes these granites from the non-metasomatic biotite granite.

Felsic vein rocks and hydrothermal products*;* aplites which alkali feldspar granite, granophyre and quartzolite in composition represent veins cutting host rock. Quartz + orthoclase + plagioclase + biotite + tourmaline are the main components of these aplites. These units, representing the late-stage products of the Karakaya granite, include varieties with and without tourmaline. Güllü and Kadıoğlu (2012) stated that the tourmaline-bearing quartz veins may be the products of residual Na-depleted melts (Fig. 3F).

TOPKAYA GRANITOID

These rocks can be classified as granodiorite and quartz monzonite. The intermediate vein rocks are microdiorite, diorite porphyry and microcrystalline diorite porphyry in composition.

Granodiorite; granodiorite mainly consists of quartz + plagioclase (An_{22}-An_{48}) + orthoclase + hornblende + biotite ± titanite ± apatite ± zircon. Chlorite and epidote are alteration products (Fig. 3G). The granodiorite has holocrystalline

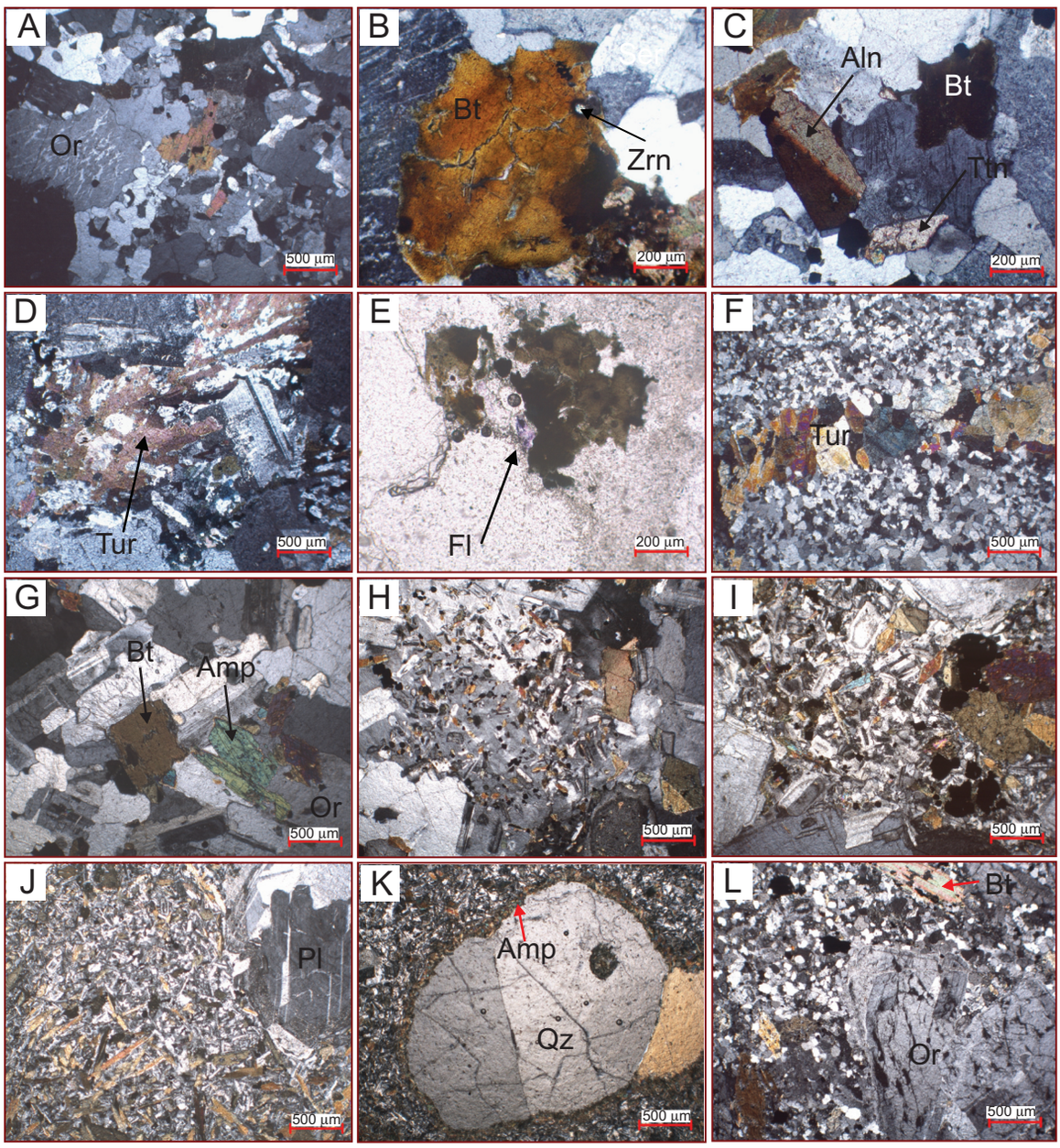

Fig. 3A – general microscopic view of the Karakaya granite; B – zircon (Zrn) inclusion within biotite (Bt) in granite; C – euhedral titanite (Ttn) and allanite (Aln) within granite; D – crossed-polars view of tourmaline (Tur) within tourmaline biotite granite under a polarizing microscope; E – fluorite (Fl) observed in tourmaline biotite granite; F – view of tourmaline-bearing silica vein under a polarizing microscope; G – general microscopic view of the Topkaya granitoid; H – poikilitic K-feldspar occurrences in the granitoid; I – general microscopic view of diorite porphyry; J – microphoto views of acicular amphibole microdiorite porphyries; K – quartz-hornblende ocellar texture occurrences in diorite porphyries; L – general microphoto views of Yürükkaracaören granodiorite porphyries (mineral abbreviations are according to Whitney and Evans, 2010)

hipidiomorph granular texture (with features such as poikilitic K-feldspar, acicular apatite; Fig. 3H).

Intermediate vein rocks*;* the vein rocks have been classified as medium-coarse crystalline gabbro/diorite porphyry, fine-grained diorite porphyry, acicular amphibole microdiorite porphyry and microcrystalline granodiorite porphyry (Fig. 3I, J). In addition, the intermediate vein rocks have lath-shaped plagioclases and quartz-hornblende ocellar texture (Fig. 3K).

YÜRÜKKARACAÖREN SUB-VOLCANIC UNITS

This rock unitwas previously termed “granodiorite” (Gautier, 1984; Demirbilek et al., 2018). However, a characteristic holocrystalline hypidiomorph porphyritic texture was observed in all samples collected from Yürükkaracaören. With the textural features of microcrystalline porphyry, the rocks of the Yürükkaracaören location show shallow-emplacement sub-vol-

canic rock characters. Therefore, these rocks are here described as sub-volcanic based on detailed field and petrographic features. This sub-volcanic unit is generally diorite porphyry and granodiorite porphyry in composition (Fig. 3L). The mineralogical composition is mainly plagioclase + orthoclase (in granodiorite porphyry) + quartz (in granodiorite porphyry) + biotite + hornblende ± opaque mineral ± titanite ± apatite.

WHOLE-ROCK GEOCHEMISTRY

One of the most characteristic features of granitoid bodies is magmatic differentiation and/or magma mixing during crystallization. In order to detect the presence of magmatic differentiation or magma mixing, a large number of geochemical analyses are required on systematically collected samples. Geochemical analysis was performed on 329 samples (Appendix 1) to constrain magmatic differentiation or magma mixing in these granitoid bodies and to map the magmatic facies.

MAJOR ELEMENT VARIATIONS

All units and enclaves within the Karakaya granite are granitic in composition according to the total alkali *versus* silica diagram (Cox et al., 1979; Fig. 4A). While SiO_2 content is in the range of 67.5–76.0% in the granitic rocks, it is within the range of 62.4–72.7% in enclaves. The enclaves of the Topkaya granitoid fall within the gabbro/diorite-diorite and rarely monzonite area on the same diagram. The main body of the Topkaya intrusion plots in the granodiorite field (Fig. 4A).

The aplite dykes that cut all the magmatic units in the Topkaya granitoid are of granitic composition. The intermediate vein rocks which are observed commonly in the granitoids range from gabbro/diorite to granodiorite. The Yürükkaracaören sub-volcanic units lie in the diorite and granodiorite fields on the total alkali-silica diagram (Fig. 4A). Na_2O wt.%, SiO_2 wt.%, and K_2O wt.% contents increase, whereas CaO wt.%, MnO wt.%, MgO wt.%, Fe_2O_3 wt.%, and TiO_2 wt.% decrease from microcrystalline diorite porphyries to microcrystalline granodiorite porphyries in the sub-volcanic rocks.

The Karakaya, Topkaya and Yürükkaracaören magmatic units lie in the sub-alkaline field on the $Na_2O + K_2O$ (wt.%)-SiO_2 (wt.%) diagram (Irvine and Baragar, 1971; Fig. 4B). In additon, on the AFM diagram, while the Karakaya granite shows calc-alkaline character, the Topkaya granitoid and Yürükkaracaören sub-volcanic rocks show a trend from tholeiitic to calc-alkaline (Fig. 4C).

On the alumina saturation diagram (Maniar and Picolli, 1989), based on the Shand (1943) indices, while the Topkaya granitoid and Yürükkaracaören sub-volcanic units show metaluminous character, the Karakaya granites are characteristic in showing a transition from peralkaline to metaluminous (Fig. 4D). The ACNK (where ACNK = molar $Al_2O_3/CaO + Na_2O + K_2O$) ratio of the granitoid samples ranges between 1.13 and 1.54 in the Karakaya granite, 1.17–1.63 in the Topkaya granitoid and 1.45–1.74 in the Yürükkaracaören sub-volcanic rocks.

The Karakaya granite shows K series character on a K_2O *versus* Na_2O diagram (Middlemost, 1975; Fig. 4E). In addition, shoshonitic character is dominant on a K_2O-SiO_2 diagram (Rickwood, 1989; Fig. 4F). The Topkaya granitoid and the Yürükkaracaören sub-volcanic rocks may be clearly distinguished from the Karakaya granite through their Na series and medium K calc-alkaline magma characters.

The granite and granodiorite/sub-volcanic rock units are regionally separated on discrimination diagrams of the major elements. According to these diagrams, the igneous rocks, including enclaves at the Karakaya location, differ chemically from the rocks from Topkaya and Yürükkaracaören (Fig. 5A–G).

On the Harker variation plots of SiO_2 *versus* major oxides by the rock units. Alkali ($Na_2O + K_2O$) content increases with SiO_2, whereas TiO_2, Fe_2O_3, CaO, Al_2O_3, MgO and in part P_2O_5 decrease as SiO_2 increases. As in the major element oxide changes, while a common trend has been observed in the Topkaya and Yürükkaracaören magmatic rocks on the trace element distribution diagrams, the Karakaya granite shows a different trend.

Sr, Ni, Zn and Y show a decreasing trend relative to increasing SiO_2 (Fig. 5H–K). This decrease could be expressed through the plagioclase fraction for Sr and expressed through the crystallization of accessory minerals for Zn and Y. Similarly, zircon crystallization may impoverish magma in Zr and this is evident from a SiO_2 *versus* Zr diagram (Fig. 5L). Th and Rb are notable as the final phase products of crystallization in all the magmatic units. The Karakaya granite contains higher concentrations of Th, Rb and Nb than do the other rock masses (Fig. 5M–O). The high concentrations of Th and Rb reflect the interaction of a shoshonitic granite with the continental crust. The high Nb concentrations in the Karakaya granite may represent enrichment during the transition from a magmatic to a pegmatitic phase (Ballouard et al., 2016; He et al., 2021). No significant change has been observed in the Hf concentrations (Fig. 5P). The linear trends in all major elements *versus* SiO_2 and trace elements *versus* SiO_2 indicate magma mixing (Słaby and Martin, 2008).

Temperature (T) during the crystallization of igneous rocks can be calculated with the help of empirical formulae recommended by different researchers (Harrison and Watson, 1984; Schmidt, 1992; Miller et al., 2003; Koralay et al., 2021 and references therein). Zircon and apatite saturation temperatures were calculated from whole-rock geochemical analyses according to Watson and Harrison (1983) and Harrison and Watson (1984). The chemical dependencies of apatite and zircon saturation temperatures are different. Apatite saturation depends on SiO_2 and P_2O_5 concentrations in magma. The zircon saturation depends on the M factor [$(Na + K + 2 \cdot Ca)/(Al \cdot Si)$]. Magma crystallization depth, pressure and H_2O content do not have a significant effect on zircon and apatite saturation temperature (Janasi et al., 2007). Temperatures from zircon saturation calculations are 740–793°C (~767°C) for the Karakaya granite, 716–763°C (~735°C) for the Topkaya granitoid and 710–764°C (~734°C) for the Yürükkaracaören sub-volcanic units. Apatite saturation temperatures range from 871 to 961°C (~906°C) for the Karakaya granite, from 846 to 960°C (~906°C) for the Topkaya granitoid and from 813 to 921°C (~861°C) for the Yürükkaracaören sub-volcanic units. The saturation temperatures were calculated for Karakaya and Topkaya enclaves, which can be considered as the mafic end members of the magma mixture, as 774–917°C and 735–905°C respectively. When the saturation temperatures are evaluated, it can be said that the magma mixture products started to crystallize from this temperature. According to the calculated results, it is seen that the zircon saturation temperatures are significantly lower. This is because this mineral is not seen in the early crystallization phase.

TRACE AND RARE EARTH ELEMENT VARIATIONS

An Ocean Ridge Granites (ORG) normalized spider diagram of magmatic rocks has been plotted. In this diagram, there is an enrichment of LIL elements (K, Rb, Ba), while there is a depletion in HFS (Th, Ta, Nb, Ce, Zr, Hf, Sm, Sm, Y, Yb) ele-

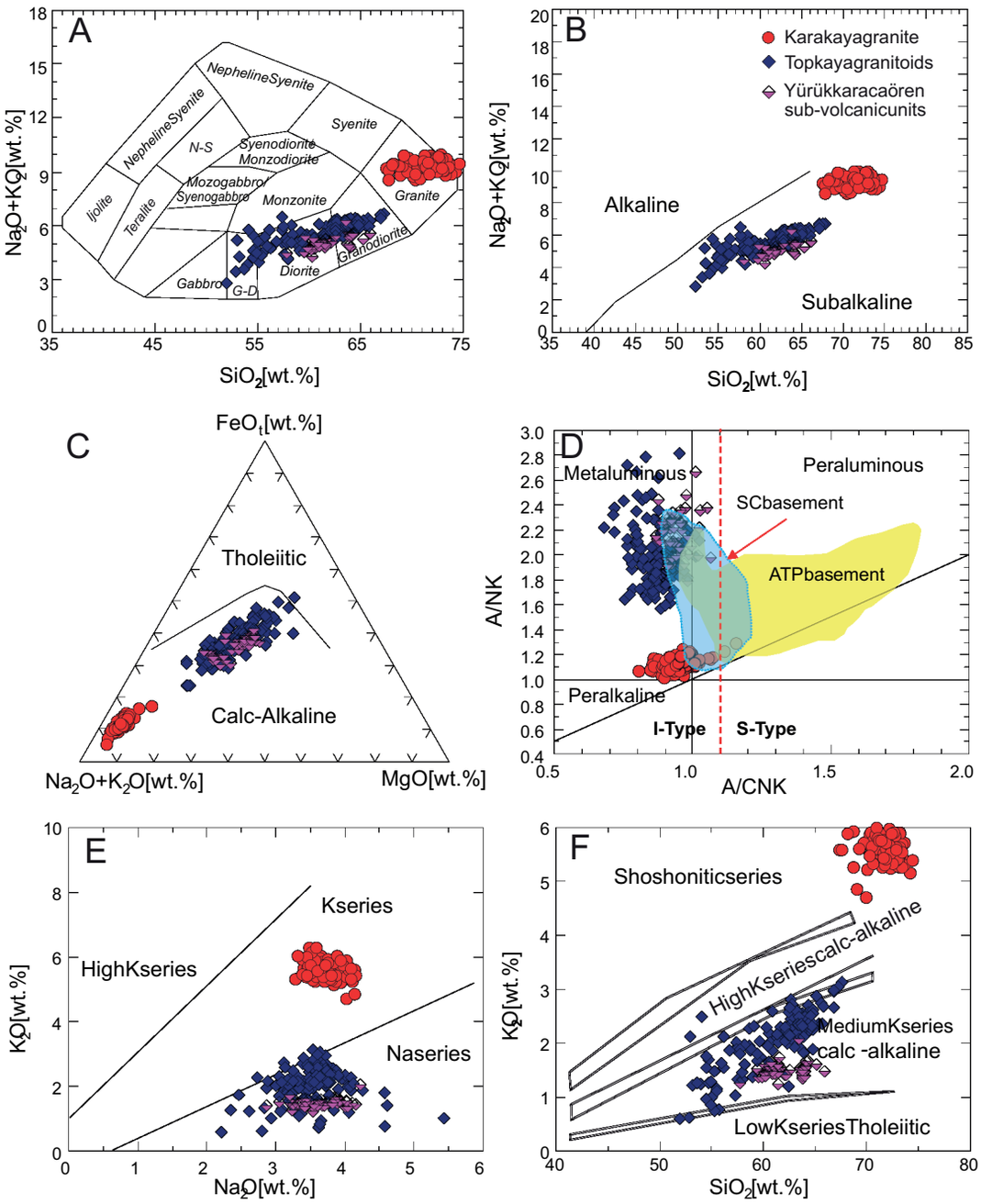

Fig. 4A – distribution of the magmatic rocks on a geochemical classification diagram (Cox et al., 1979); B – total alkali *versus* silica diagram and (C) AFM diagram (Irvine and Baragar, 1971); D – distribution of magmatic rocks on A/NK-A/CNK diagram (Shand, 1943; Maniar and Picolli, 1989); Sakarya Continent (SC) and Anatolite Tauride Platform (ATP) basement boundary is taken from Altunkaynak et al. (2012a); E – Na_2O *verus* K_2O diagram (Middlemost, 1975); F – K_2O *versus* SiO_2 diagram (Rickwood, 1989)

ments (Fig. 6A). The enrichments in Rb and Th in the granite is more than in the other magmatic units. This enrichment may be related to the fact that the Karakaya granite interacted more with the continental crust during emplacement and/or the presence of radioactive minerals such as zircon and allanite (orthite). On the other hand, there is a negative Ba anomaly indicating feldspar fractionation during the formation of the Karakaya granite.

All the magmatic units display enrichment in light rare earth elements (LREE) relative to heavy rare earth elements (HREE) in chondrite-normalized multi-element diagrams (Fig. 6B). In the diagram, the enrichment in LREE in the granite is clearly higher than in the granodiorites and sub-volcanic units, which is considered to have been due to the greater degree of interaction of the Karakaya granite with the continental crust during its emplacement. While the distribution patterns of these multi-element diagrams prepared according to the trace elements and REE elements also support the original relation of the Topkaya granitoid and the Yürükkaracaören sub-volcanic rocks, they also indicated that Karakaya granite was derived from a magma source different from the Topkaya granitoid and the Yürükkaracaören sub-volcanic rocks.

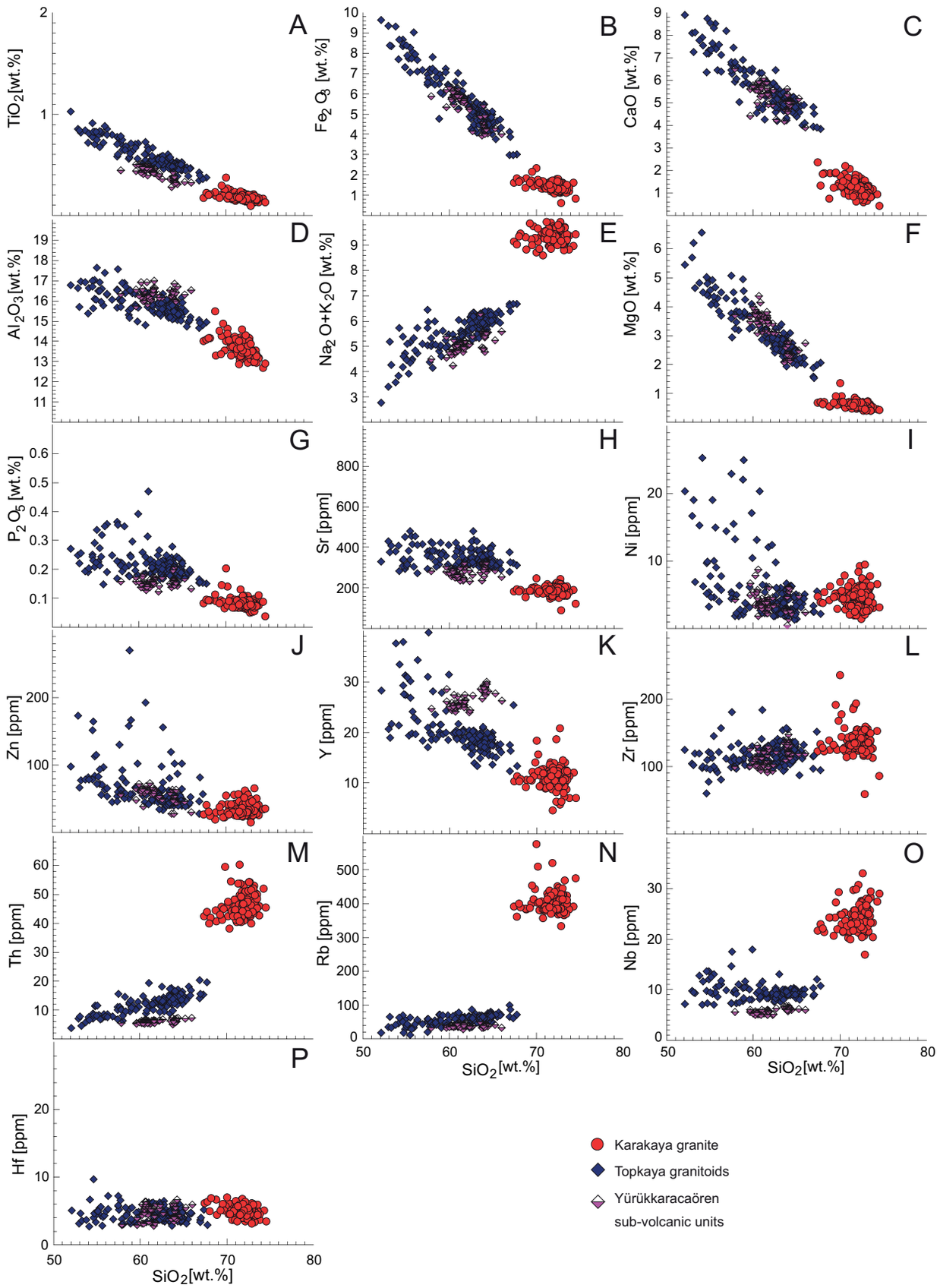

Fig. 5. Harker diagrams of selected major and trace elements

GEOCHRONOLOGY

The Ar-Ar method (performed on biotite and hornblende) was used for determining the crystallization ages of the magmatic units. The argon release values of the samples according to $^{40}Ar/^{39}Ar$ step-heating are given in Appendix 2.

In the study; a 59.13 ±1.87 Ma Ar-Ar weighted plateau and 59.55 ±2.54 Ma inverse isochron age (Fig. 7A, B) were obtained from biotite for the granite (shoshonitic character), and a 44.30 ±0.47 Ma Ar-Ar weighted plateau and 44.27 ±0.48 Ma inverse isochron age (Fig. 7C, D) were obtained from the granodiorite and a 44.11 ±0.89 weighted plateau and 43.88 ±1.01 Ma inverse isochron age (Fig. 7E, F) were obtained from the sub-volcanic calc-alkaline rocks.

Nd AND Sr ISOTOPIC COMPOSITION

The Rb, Sr, Sm and Nd concentrations measured on all the magmatic units and $^{143}Nd/^{144}Nd$ and $^{87}Sr/^{86}Sr$ ratios are given in Table 1. For the calculation of $(^{87}Sr/^{86}Sr)_{initial}$, $(^{143}Nd/^{144}Nd)_{initial}$, εSr, εNd, $(\varepsilon Sr)_{initial}$ and $(\varepsilon Nd)_{initial}$ values, the emplacement ages of 44.11 Ma for the Topkaya and Yürükkaracaören magmatic rocks and 59.13 Ma for the Karakaya granite were used (Table 1).

DISCUSSION

NATURE OF THE MAGMAS

Geochemical and isotope data were used to determine the origin of the intrusive rocks. In the discrimination diagram of the magma forming the intrusive units, it is seen that all the samples reflect an orogenic nature (Wilson and Bianchini, 1999; Krmíček et al., 2011; Fig. 8).

Considering the Rb fractionation index, significant differences in Rb (419 to 575 ppm for Karakaya; 37 to 80 ppm for Topkaya-Yürükkaracaören) point to differences in the magma sources that formed the Karakaya and Topkaya-Yürükkaracaören rock groups. The geochronological data and geochemical discrimination diagrams also support these suggestions.

The Sr and Nb isotope ratios of the Karakaya and Topkaya-Yürükkaracaören units reveal that their respective magmas cannot derived from the same source magma. The Karakaya granite differs from the Topkaya and Yürükkaracaören magmatic units in its higher $(^{87}Sr/^{86}Sr)_i$ (0.7096436–0.7109025) and lower $(^{143}Nd/^{144}Nd)_i$ (0.512178–0.512243) isotopic ratios. Although the low $(^{87}Sr/^{86}Sr)_I$ (0.7055928–0.7061354) and high $(^{143}Nd/^{144}Nd)_i$ (0.512502–0.512594) values of the Topkaya and Yürükkaracaören units indicate an Ocean Island Basalt (OIB)-like magma source (Fig. 9), the same isotopic signature may be indicative of typical Volcanic Arc magmas. The low εNd and relatively higher Mg# values of the Topkaya and Yürükkaracaören magmatic units indicate a magma derived from a continental lithospheric mantle source. Furthermore, low εNd and $^{87}Sr/^{86}Sr$ ratios of the Topkaya and Yürükkaracaören magmatic rocks indicate that metasomatized mantle can be a source. These isotopic ratios may represent different magma sources and/or different degrees of continental contamination. On the Zr/Nb-Zr diagram, it is seen that the magmas forming all magmatic units were widely exposed to crustal contamination during crystallization (Fig. 10A). Sr isotope ratios are seen in the $^{87}Sr/^{86}Sr$ *versus* Sr diagram (Briqueu and Lancelot, 1979; Nelson, 2003); while crustal contamination of ~40–60% is inferred during the emplacement of the magma forming the Topkaya and Yürükkaracaören magmatic units, this ratio rises to >80% in the Karakaya granite (Fig. 10B).

Magmatic rocks of study area have been plotted on Th/Yb *versus* Ta/Yb diagrams (Pearce et al., 2005) with the aim of revealing the magma source (Fig. 11A). These ratios are almost independent of the effects of fractional crystallization and partial melting. Th/Yb and Ta/Yb ratios may indicate magma source variations and crustal assimilation. The high Th/Yb ratios in the magmatic units of the study area, which have similar distributions to the Eocene granitic rocks of north-west Anatolia, are remarkable. An increase in Th/Yb ratios caused by enrichment in Th content (average 46.6 ppm in the Karakaya granite, 12.4 ppm in the Topkaya granitoid and 6.2 ppm in the Yürükkaracaören sub-volcanic rocks) may be explained by subduction-related processes and metasomatism of mantle material. Subduction components cause enrichment of Th rather than of Ta and Yb. In addition, crustal contamination can increase the Th/Yb ratio.

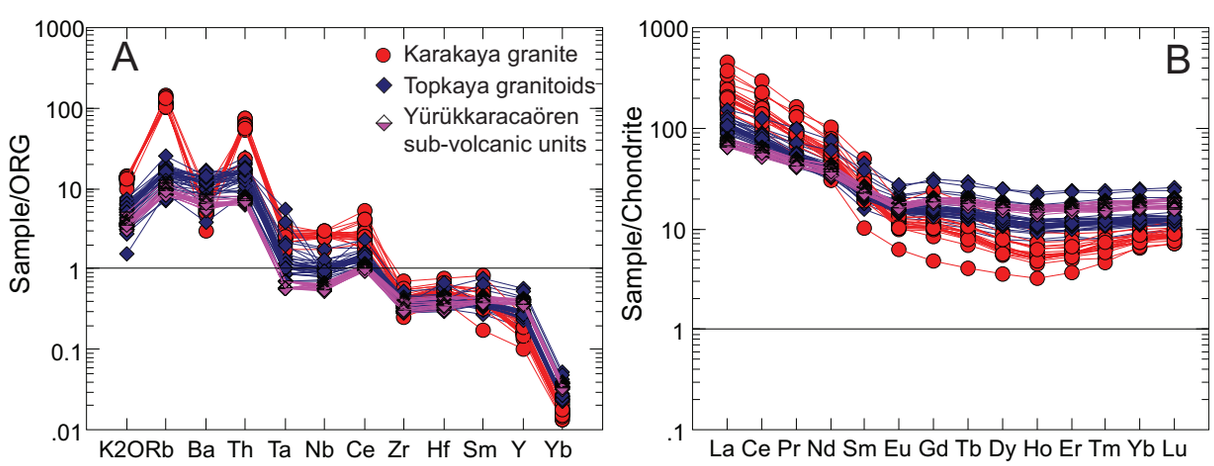

Fig. 6A – multi-element diagrams of the magmatic rocks on ORG-normalized trace element; B – chondrite-normalized REE diagrams (ORG values from Pearce et al., 1984; chondrite values from Evensen et al., 1978)

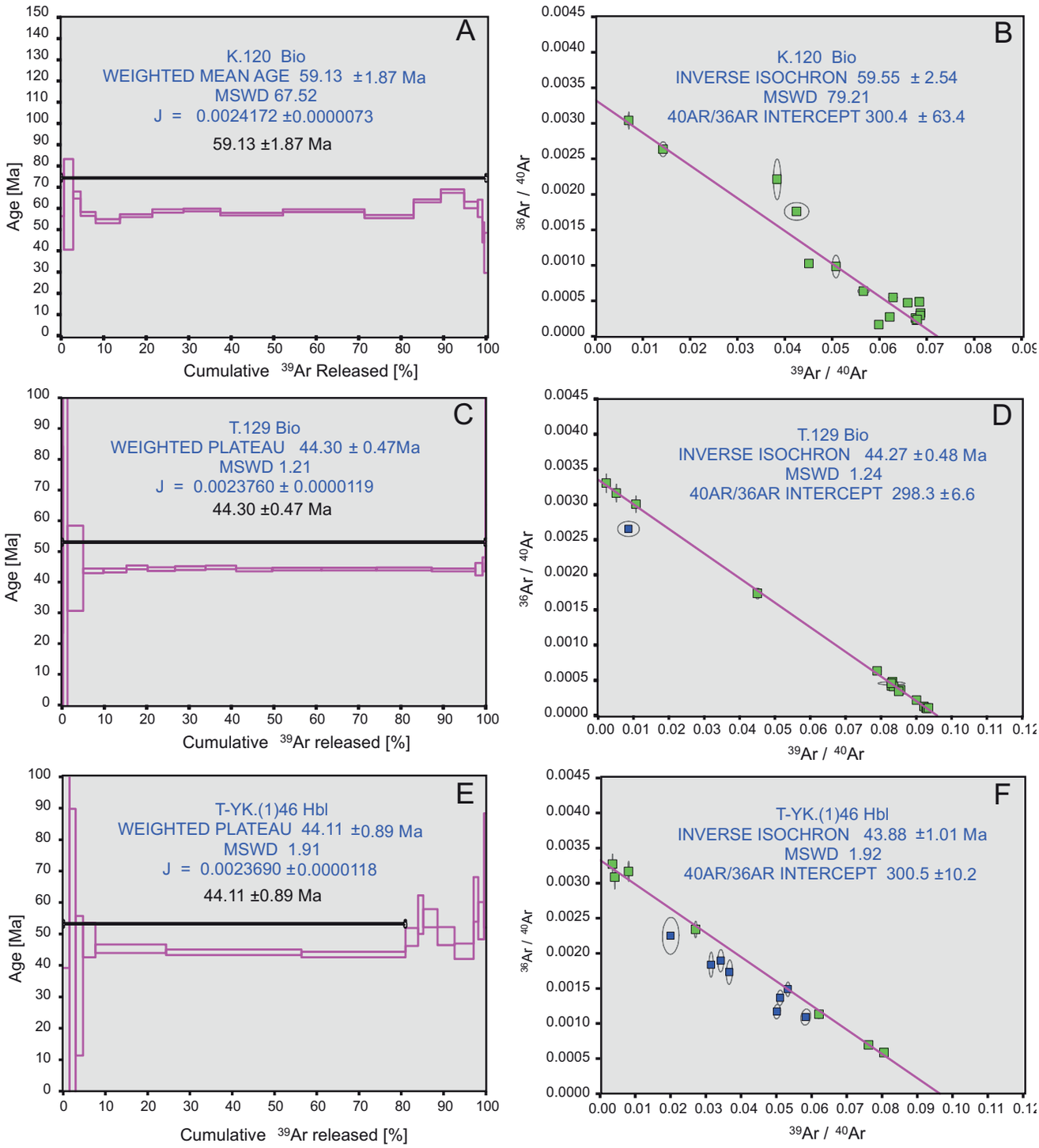

Fig. 7A – Ar/Ar weighted plateau; B – inverse isochron age graphics of the Karakaya granite; C – Ar/Ar weighted plateau; D – inverse isochron age graphics of the Topkaya granitoid; E – Ar/Ar weighted plateau; F – inverse isochron age graphics of the Yürükkaracaören sub-volcanic rocks

The distinction between source contamination and crustal assimilation can be more easily defined by using the Th/Y *versus* Nb/Y diagram (Pearce, 1983). On the Th/Y *versus* Nb/Y diagram, all granitoid samples plot along a line with Th/Nb = 1, reflecting a magma source which was affected by subduction zone enrichments (Fig. 11B). Similarly, it is seen that the parental magma source forming the Topkaya granodiorite and Yürükkaracaören sub-volcanic rock groups may be enriched in subduction-related and/or crustal compounds according to the Rb/Y *versus* Nb/Y diagram (Edwards et al., 1991). In addition, it is clear that within-plate enrichment is also efficient, as well as subduction/crust interaction, on the magma source forming the Karakaya granites (Fig. 12A).

Table 1

Isotopic ratios of the magmatic rocks in the study area

MEASURED											CALCULATED				
Samples	Loc.	Unit	Age [Ma]	$^{87}Sr/^{86}Sr$	$^{143}Nd/^{144}Nd$	Rb	Sr	Sm	Nd	$(^{87}Sr/^{86}Sr)_i$	$(^{143}Nd/^{144}Nd)_i$	εSr	εNd	$(εSr)_{initial}$	$(εNd)_{initial}$
K-192	KK	*	59.13	0.716645 ±3	0.512233 ±5	575.7	246.0	7.60	49.1	0.710902	0.512178	168.061862	–7.900312	87.630284	–7.489175
K-168	KK	*	59.13	0.714492 ±5	0.512291 ±5	419.3	222.8	3.93	28.9	0.709886	0.512243	137.514188	–6.768909	73.210158	–6.227505
K-76	KK	*	59.13	0.715306 ±5	0.512278 ±5	424.6	183.7	3.93	35.1	0.709644	0.512238	149.063564	–7.022499	69.767606	–6.314886
AK-49	TK	**	44.30	0.705915 ±4	0.512632 ±15	65.8	370.5	3.52	24.8	0.705593	0.512594	15.820091	–0.117042	12.026864	0.258376
T-68	TK	**	44.30	0.706310 ±5	0.512602 ±5	39.6	411.7	3.94	19.5	0.706135	0.512548	21.424518	–0.702250	19.725990	–0.638599
T-86	TK	**	44.30	0.706244 ±5	0.512606 ±12	67.8	314.3	3.42	19.8	0.705853	0.512560	20.488082	–0.624222	15.711768	–0.408515
T-108	TK	***	44.11	0.706056 ±4	0.512618 ±12	75.8	360.9	3.00	17.6	0.705677	0.512573	17.820658	–0.390139	13.211701	–0.163600
T-11	TK	****	44.11	0.706074 ±5	0.512617 ±6	80.5	395.3	3.45	18.8	0.705706	0.512568	18.076050	–0.409646	13.630734	–0.250516
YK-6	YKÖ	******	44.11	0.705742 ±7	0.512581 ±3	42.6	325.6	4.09	20.3	0.705506	0.512528	13.365494	–1.111896	10.787548	–1.045597
YK-42	YKÖ	*****	44.11	0.706194 ±7	0.512557 ±9	39.0	326.7	3.68	17.6	0.705978	0.512502	19.778661	–1.580062	17.493132	–1.553115
YK-78	YKÖ	****	44.11	0.706131 ±5	0.512589 ±19	37.8	285.3	3.48	17.4	0.705892	0.512536	18.884790	–0.955840	16.263177	–0.881897

Standard errors belong to the last one or two steps, SRM987 standard was measured as 0.710260 ± 5 (n = 2) during the measurement period and Sr isotope measurement results were corrected according to this value (* – granite, ** – granodiorite, *** – diorite porphyry, **** – microcrystalline diorite porphyry, ***** – fine-grained diorite porphyry, ****** – microcrystalline granodiorite porphyry) Sr abundance, Sr isotope mass and Sr-Rb atomic weight from Faure (1986); Nd isotope ratios from Wasserburg et al. (1981); Sm isotope ratios from Russ et al. (1971), Jacobsen and Wasserburg (1980); Nd isotop mass and Sr-Nd isotope ratios from Wapstra and Bos (1977)

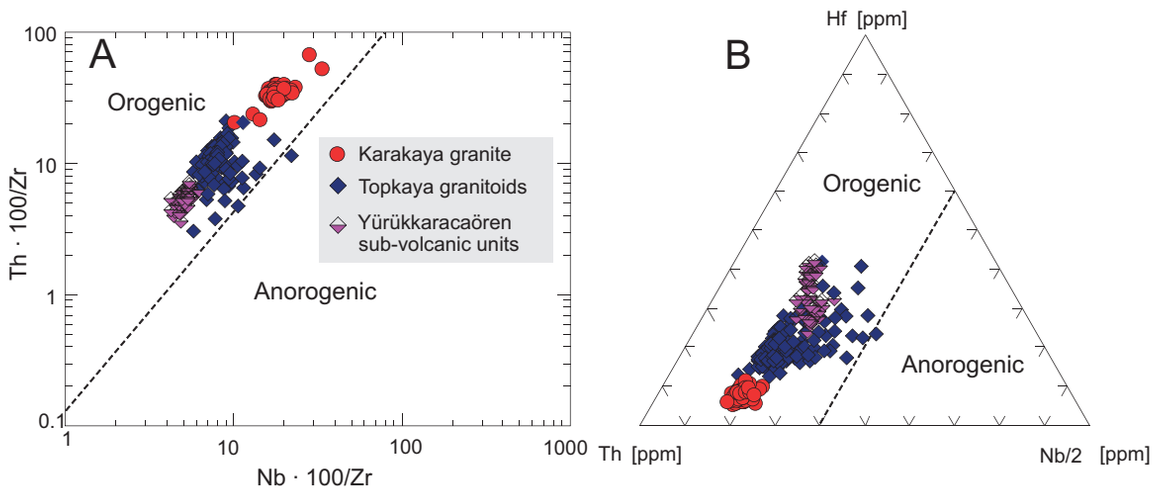

Fig. 8A – distribution of magmatic rocks on Th · 100/Zr *versus* Nb · 100/Zr (Wilson and Bianchini, 1999); B – Th-Hf-Nb/2 diagrams (Krmíček et al., 2011)

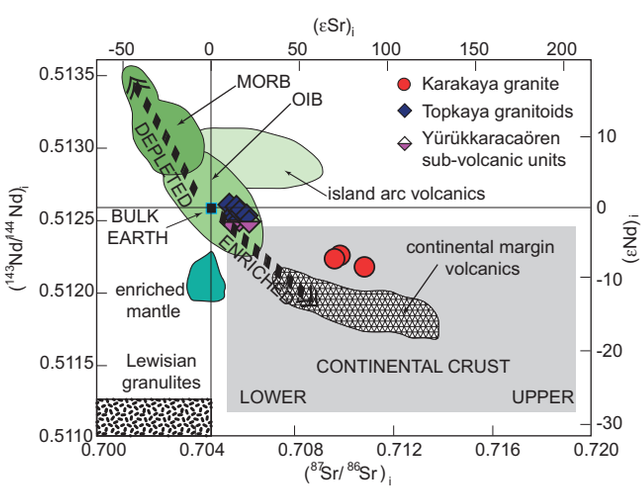

Fig. 9. Sr-Nd isotopic correlation diagram of the magmatic rocks in the study area (field lines are taken from Zindler and Hard, 1986; Faure, 1986)

CRYSTALLIZATION EVOLUTION OF MAGMAS AND MIXING

A Sr *versus* MgO diagram, which shows the controls on the crystallization of ferromagnesium minerals at medium to high temperatures, can be used to evaluate the crystallization of magmas. The Sr *versus* MgO distribution diagram here shows that the crystallization of magma forming the granodiorite and sub-volcanic magmatic units was controlled by ferromagnesian minerals. Feldspar played an important role during the crystallization of the granite magma (Fig. 12B).

Moreover, Fe_2O_3, CaO, Al_2O_3, MgO depletions in the residual magma could be explained by the crystallization of Ca-rich plagioclases and mafic minerals such as amphibole, biotite and partly pyroxene. P_2O_5 and TiO_2 are consumed by the retention in accessory minerals such as apatite and ilmenite (Mason and Moore, 1966).

SiO_2 *versus* CaO/(CaO + Na_2O) and SiO_2 *versus* MgO/(MgO + Fe_2O_3) diagrams have been used to reveal the source and fractionation of a magma (Fig. 13A, B). The Topkaya granitoid and Yürükkaracaören sub-volcanic rocks are the crystallization products of magmas originally related to each other. But, it is clearly seen that in the diagrams the Karakaya granite is derived from a magma source different from that of the Topkaya granitoid and Yürükkaracaören sub-volcanic rocks. During fractionation, CaO/(CaO + Na_2O) and MgO/(MgO + Fe_2O_3) concentrations should produce exponential trends with increasing SiO_2 (Johnston, 2001). However, the CaO/(CaO + Na_2O) and MgO/(MgO + Fe_2O_3) concentrations show linear trends with increasing SiO_2. These linear relationships provide evidence of mixing.

The presence of some specific textures within the host rock and enclaves points to coeval crystallization and magma mixing (Słaby and Martin, 2008). Also the presence of microgranular enclaves of various sizes with different compositions in the host rocks may reflect the nature of the Karakaya and Topkaya granitoid, showing various chemical compositions within the discrimination diagrams. The development of some specific textures in the magmatic rocks of the study area is also a fingerprint of magma mixing, which may also be revealed by geochemical discrimination diagrams.

When felsic magma and more mafic magmas are mixed, some specific textures may result, such as the poikilitic K-felspar, quartz-hornblende ocellar texture and small lath-shaped plagioclases inside coarse plagioclases (see Petrology section) (Didier and Barbarin, 1991) observed in the magmatic rocks of the study area. When felsic and relatively more mafic magmas are mixed in melt form, fine-grained calcic plagioclase, hornblende and/or biotite minerals occur in the hybrid system. K-feldspars containing these fine crystals or coarse plagioclases containing small lath-shaped plagioclases as inclusions can form in an equilibrated hybrid system. Additionally, quartz may crystallize in the early phase of mixing and form a cooling surface for some mafic minerals in the equilibrated hybrid system. Thus, fine-grained mafic minerals attached around quartz crystals can be observed (Hibbard, 1991).

Crystalline differentiation and/or continental contamination may also affect crystallization after the mixing of magmas. When a Y *versus* Rb diagram, expressing crystal differentiation tendencies, is considered according to the mineral crystalliza-

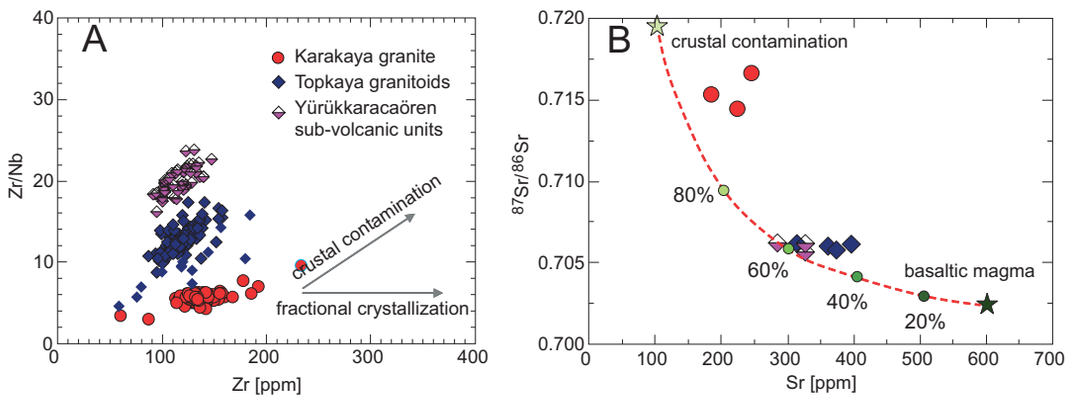

Fig. 10A – distribution of the magmatic rocks on Zr/Nb-Zr diagram; B – $^{87}Sr/^{86}Sr$-Sr diagrams defining approximate crustal contamination rates

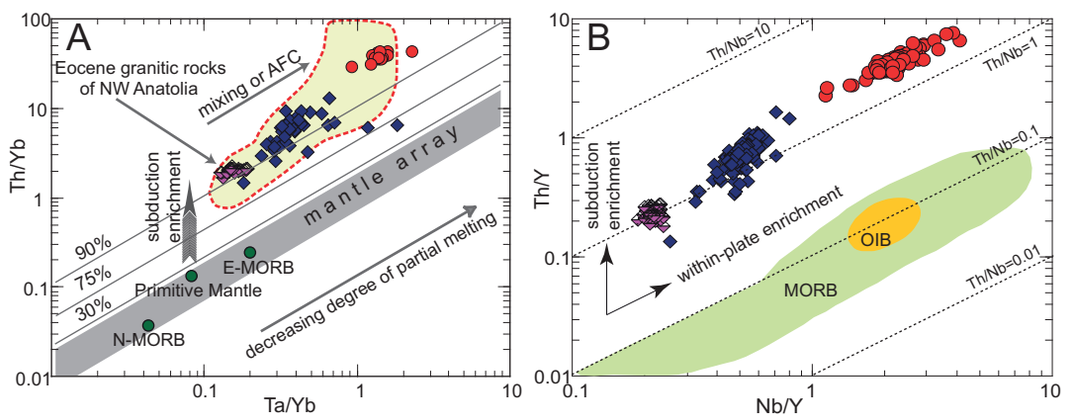

Fig. 11A – distribution of the magmatic rocks on a Th/Yb *versus* Ta/Yb diagram (Pearce et al., 2005) (NW Anatolia Eocene granitic rock boundaries are taken from Altunkaynak et al., 2012b); B – distribution of the magmatic rocks on a Th/Y *versus* Nb/Y diagram (Pearce, 1983)

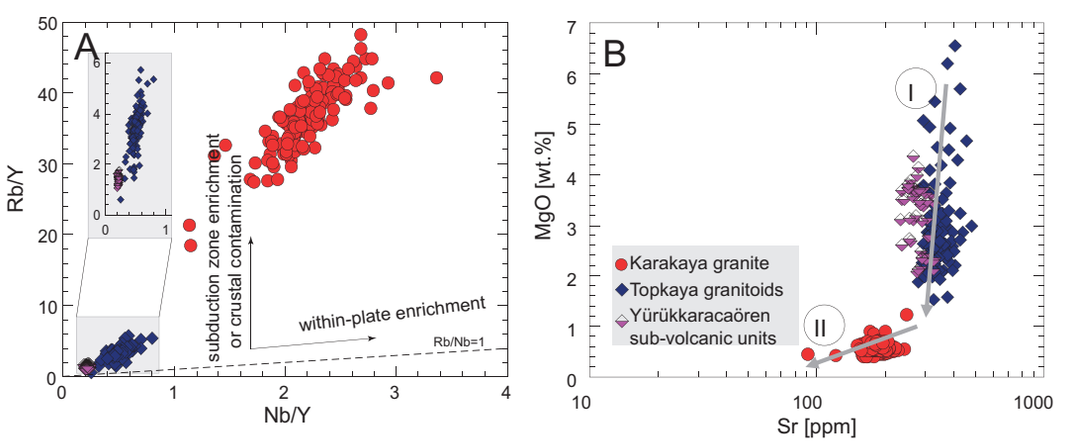

Fig. 12A – Rb/Y *versus* Nb/Y diagram (Edwards et al., 1991); B – distribution of the magmatic units on a MgO *versus* Sr crystal differentiation diagram (I – differentiation trend of ferromagnesian minerals, II – differentiation trend of feldspar minerals)

tion of the magmatic units as revealed by Keskin (2002), it is seen that the granite samples are in close relation with the differentiation vector 7. In this situation; it may be said that the magma giving rise to granite of felsic composition shows conformity to a 30% amphibole, 40% plagioclase, 20% biotite and 10% quartz crystal differentiation tendency. It has been observed in the same diagram that the other rock groups show tendencies in parallel with the vector 5. Forty percent amphibole, 50% plagioclase, 5% clinopyroxene and 5% orthopyroxene crystal differentiation is foreseen for this magma of intermediate character (Fig. 13C).

TECTONIC REGIME

Immobile trace elements such as Ti, Zr, Y, Nb and Hf can be used to classify magmatic rocks according to their tectonic setting (Pearce and Cann, 1973; Pearce et al., 1984; Pearce, 1996). Pearce et al (1984) proposed Rb-(Yb + Ta) and Rb-(Y + Nb) diagrams to determine the tectonic setting of granitoids. On the Rb-(Yb + Ta) and and Rb-(Y + Nb) diagrams, the Karakaya granite show syn-COLG characteristics, whereas granodiorite and sub-volcanic units exhibit VAG characteristics (Fig. 14A, B). On the other hand, in the Hf-Rb/30-Ta · 3 triangular diagram suggested by Harris et al. (1986), the granites are of collision character, while the other magmatic units show collision-related arc granitoid character (Fig. 14C). Although the Karakaya granite plots on the syn-collision part of the tectonic discrimination diagrams, the presence of possibly more mafic end-member MMAs within the granites may imply a lower continental crust-like source. MMAs in the Karakaya granite indicate the presence of a more mafic end member. Because the Karakaya granite samples plot along a line with Th/Nb = 1 (see Nature of the Magmas section), the mafic magma injections into the continental crust may actually be explained as volcanic arc and enriched within-plate occurrences. These more mafic magmas may rise through

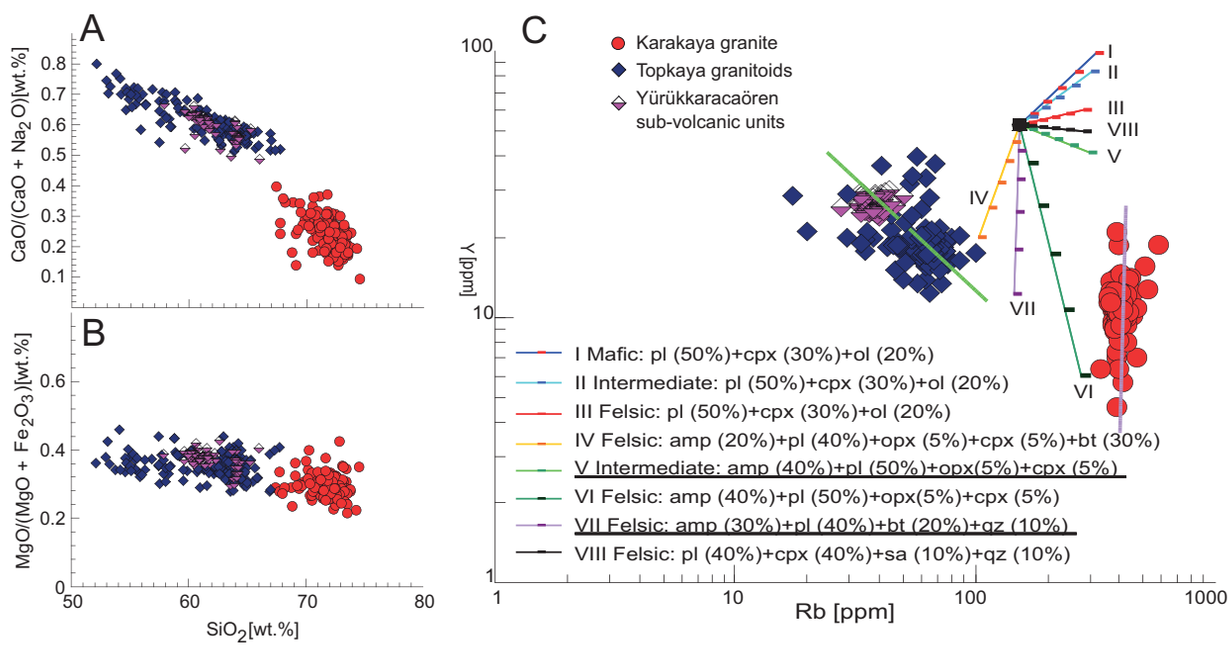

Fig. 13A – distribution of the magmatic rocks on CaO/(CaO + Na_2O) *versus* SiO_2; (B) MgO/(MgO+Fe_2O_3) *versus* SiO_2 and (C) Y *versus* Rb diagrams for modelled general direction of crystal differentiation (Keskin, 2002)

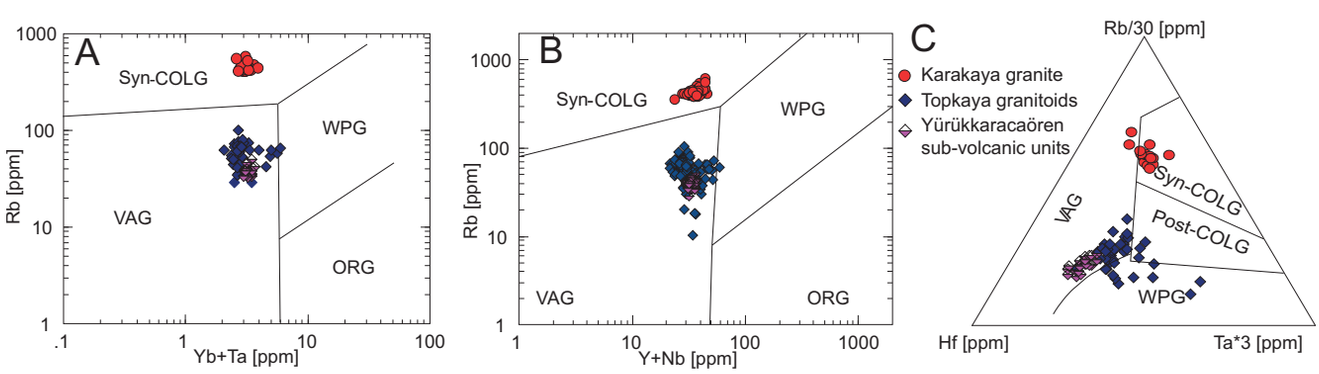

Fig. 14A – distribution of the magmatic rocks on Rb-Yb + Ta; B – Rb-Y + Nb and C – Hf-Rb/30-Ta · 3 tectono-magmatic discrimination diagrams

the continental crust, heating and partially melting it (Shellnutt et al., 2011; Zheng et al., 2016 and references therein). The melting of continental crust may in consequence produce Syn-Colg character granitic rocks in the region.

GEODYNAMIC EVOLUTION OF THE MAGMATIC UNITS

Comparison of the rock units representing the magmatism developing during closure of the northern branch of the Neo-Tethys after the collision of the Anatolide-Tauride Platform with the Sakarya Continent (Harris et al., 1994; Altunkaynak, 2007; Altunkaynak et al., 2012a; Karslı et al., 2020) is given in Table 2. All magmatic units (Karakaya granite, Topkaya granitoid and Yürükkaracaören sub-volcanites) are located among the northwestern Anatolian Suture Zone granitoids (Altunkaynak, 2007) or northwestern Anatolia southern belt granitoids (Altunkaynak et al., 2012a) and it is accepted that they were formed as a result of similar geological events. These magmatic suites show changes from calc-alkali to high K calc-alkali (Köprübaţı and Aldanmaz, 2004; Okay and Satır, 2006; Karacık et al., 2008; Sunal et al., 2019) and even to shoshonitic composition (Altunkaynak et al., 2012b). The granodiorite and sub-volcanic units are Na series-calc-alkaline in character, while the granite shows a shoshonitic character. Although the Karakaya granite does not show alkaline tendency in the main element oxide discrimination diagrams, its alkaline enclave and fluorite content are interpreted as traces of alkali magma contribution.

Petrographic, geochemical, isotopic and radiometric data from the study area show that the Yürükkaracaören sub-volcanic units show very similar properties to the Topkaya granodiorites; in close relation with Topkaya pluton, they could be sub-volcanic apophyses of the Topkaya pluton. Similarly, there are many volcanic equivalents of Eocene plutons in northwestern Anatolia to the north of the İzmir-Ankara-Erzincan Suture Zone (Keskin et al., 2008; Altunkaynak and Dilek, 2013; Ersoy and Palmer, 2013; Gülmez et al., 2013; Elmas et al., 2016; Kasapoğlu et al., 2016; Sunal et al., 2019; Göçmengil et al., 2019).

The geological-petrological-geochemical and geochronological data lead to a geodynamic evolution model suggested for the formation of the magmatic rocks of the study area.

The closure of the northern and southern branches of Neo-Tethys have been very influential in shaping the geological structure of Turkey. This closure and continent-continent collision are known to have continued until the end of the Late Cretaceous and even until the Paleocene (~70 Ma; Fig. 15A). The subduction of the Neo-Tethys from the Middle Triassic to the Cretaceous (Okay, 2011) towards the north and the isotopic ages taken from blueschist and eclogites indicate an Albian (~105 Ma) age (Okay et al., 2006).

Altunkaynak (2007) suggested that the age of suture zone granitoids in northwestern Anatolia is between 52–48 Ma. This study shows that Karakaya granite is 59.13 ±1.87 Ma old. Therefore, it is thought that the suture zone granitoids may be between 60–48 Ma old. Mafic magma may have been present at the lower continental crust-upper mantle boundary (dominantly lower continental crust-like character) together with intense heat transfer from an asthenospheric window opened as a result of the sinking lithospheric slab during this interval (Fig. 15B; Okay and Satır, 2006; Altunkaynak et al., 2012a). The Anatolide-Tauride Platform collision with the Sakarya Plate related to the closure of the Neo-Tethys and continental crust thickness has increased in the collision zone. The magma upwelling as a result of the resulting partial melting in the lower crust strongly interacted with the continental crust (~80% in the model diagram plotted according to the isotopic data). This may have produced magma of very acidic character. It is possible also that this acid magma formed the granites at this stage.

Post-collisional VAG character magmatic rocks are observed in different parts of north-west Anatolia, on the boundary of the Tavşanlı-Sakarya Zone and within the Tavşanlı Zone during the Eocene (48–34 Ma; Altunkaynak, 2007; Okay, 2011). At

Table 2

Comparative petrological-petrogenetic characteristics of the magmatic units

	Granite (Karakaya)	Granodiorite (Topkaya)	Sub-volcanic unit (Yürükkaracaören)
Rock type	tourmaline/biotite granite	granodiorite/diorite porphyry	diorite porphyry/ microdiorite porphyry
Enclave	alkaline character microgranular	mafic microgranular	mafic microgranular (rare)
Dyke	aplites	aplites+mafic dykes	mafic dykes
Contact relationship	closely contact with ophiolites tectonic contact with metamorphic rocks	closely contact with ophiolites closely contact with metamorphic rocks	closely contact with ophiolites not observed
Magma character	metaluminous/ shoshonitic and K series	metaluminous/calc-alkaline and Na series	metaluminous/ calc-alkaline and Na series
Tectonic discrimination	collision-related granitoids (Syn-Colg)	collision-related arc granitoids (Post-Colg)	collision-related arc granitoids (Post-Colg)
Assimilation/contamination	crustal interaction is too high	crustal interaction is low	crustal interaction is low
εNd	–6.7/–7.9	–0.1/–0.7	–0.9/–1.1
$^{87}Sr/^{86}Sr$	0.714–0.716	0.705–0.706	0.705–0.706
Ar/Ar age	59.13 Ma (Selandian)	44.3 Ma (Lutetian)	44.11 Ma (Lutetian)
Magma source	derived from a magma generated at the lower continental crust-upper mantle boundary; collision-subduction related	subduction-related partial melting of lithospheric mantle-like source	differantiation from the main granitoid magma
Emplacement	deep	deep and shallow	shallow

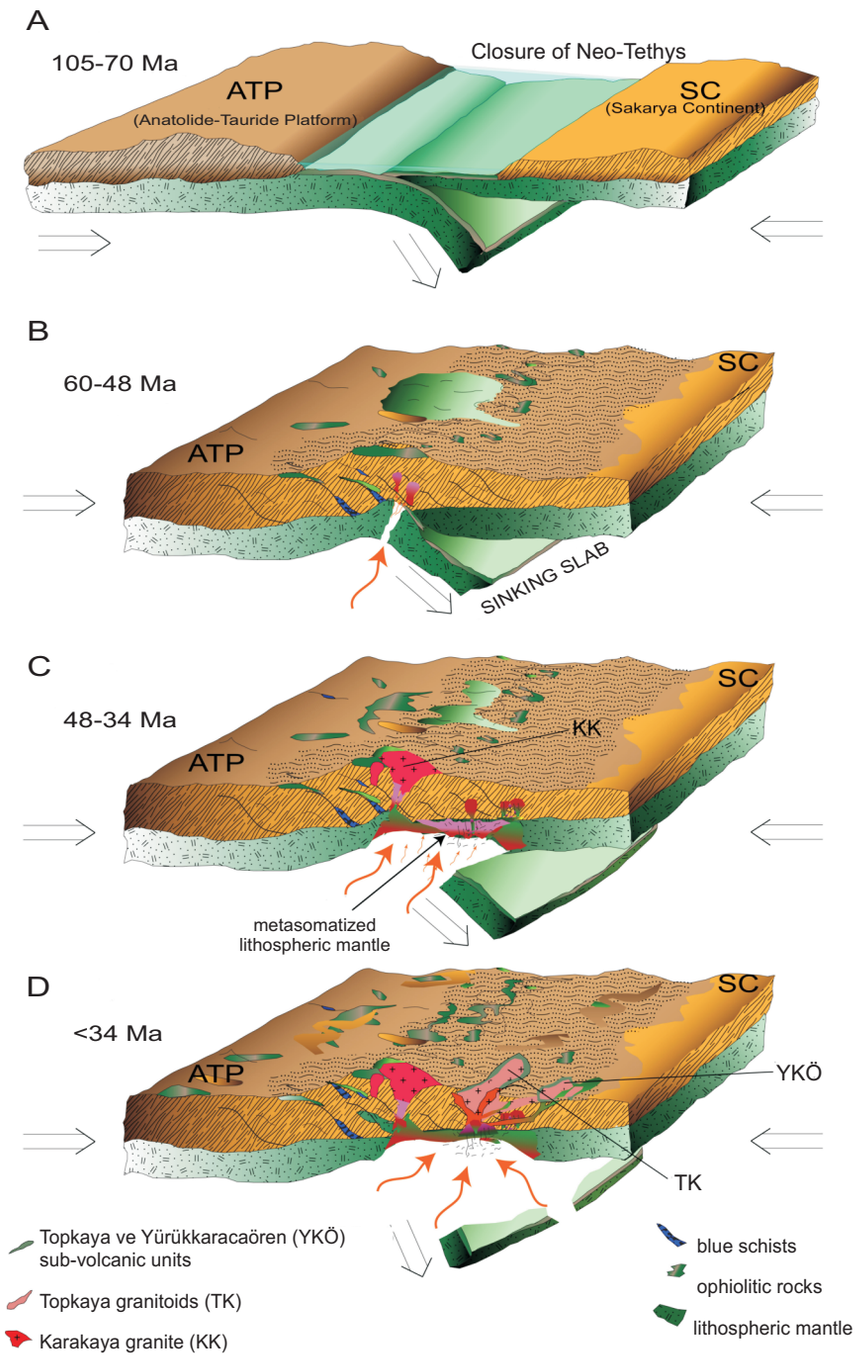

Fig. 15. Schematic model of geodynamic evolution of the magmatic units in the study area

this time, mafic magma has formed which partial melting of the continental lithospheric mantle associated with asthenospheric upwelling during delamination of the sinking lithospheric slab after the collision (Fig. 15C). Various interactions developed between this mafic magma, derived from the upper mantle, and the more felsic magma derived from the lower continental crust (Fig. 16A), in the form of thermal, chemical and mechanical changes, depending on the rheological properties of these magmas at different depths in the crust. In this phase, responsible for the formation of granodiorite and sub-volcanic units, magma emplacement in the continental crust turned towards a more felsic character with continental crust interaction (~40–50% in the model diagram plotted according to the isotope data). However, the partial melting that continued in the lower continental crust continually fed this magma chamber (Fig. 16B). At this stage, magma mixing occurred together with chemical changes in the mafic and felsic magmas. Thus, a hybrid calc-alkaline granodioritic magma formed leading to various microscopic textural features associated with the thermal changes taking place at this stage. At the same stage, mafic granular textured enclaves developed as a result of the magma mingling, with intense mechanic interaction of the mafic and fel-

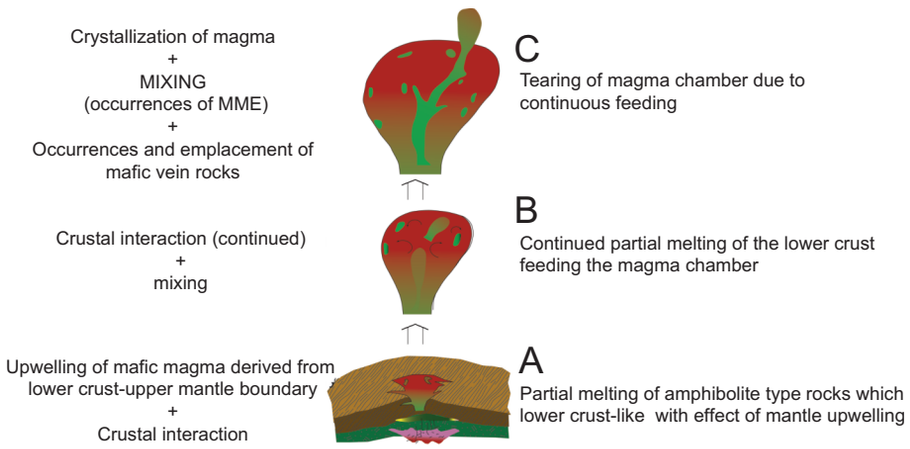

Fig. 16. An emplacement model for the granodiorite and sub-volcanic magmatic units

sic magmas. The magma chamber, continuously fed, grew towards the end of the third phase and during this, rupture of the magma chamber was able to occur (Fig. 16C). Magma flow occurred towards the outside from the ruptured magma chamber, cutting through both the granodiorite bedrock and diorite porphyry sub-volcanic rocks. It is inferred that the mafic to intermediate vein rocks characterized by microgabbro porphyry/acicular amphibole diorite porphyry compositions may have begun to form during this phase.

Surface processes of these rocks, with erosion and uplift, may have begun when emplacement of the intrusive units in the study area was completed (Fig. 15D).

CONCLUSION

The collision of the Tavşanlı and Sakarya zones, during subduction after consumption of the Neo-Tethys, started in the Paleocene. This continental collision produced a heterogeneous mantle that would generate magmas related to the collision in central-northwestern Anatolia. This heterogeneous mantle source may have formed a resource for the magmatism that began in the Paleocene in different parts of the region. A $^{40}Ar/^{39}Ar$ radiometric age from biotite of the Karakaya granite yielded a cooling age of 59.13 ±1.87 Ma, while amphiboles from the Topkaya granodiorite and Yürükkaracaören sub-volcanic rocks gave cooling ages of 44.3 ±0.47 and 44.11 ±0.89 Ma respectively. The Karakaya magmatic units are represented by collision-related magmatic rocks and the Topkaya and Yürükkaracaören magmatic units represent arc-related magma products. The geochemical element distribution and isotopic data of the granodiorites are quite similar to those of the sub-volcanic samples. This may indicate a similar magma origin injected as different stocks in the region. The petrographical textures of the Yürükaracaören subvolcanic rocks may represent the upper part of the Topkaya granitoid in the study area. It is clear that the granite forms the first magmatic product along the northwestern section of the İzmir-Ankara-Erzincan Suture Zone. This suggests that the closure evolution of the Neo-Tethys in the northwestern Anatolia follows a scissor-shaped pattern from the east towards the far west of the closure.

All geological, petrographical, geochemical, isotopic and geochronological data indicate that the granites formed before the granodiorites and subvolcanic units. Subduction-related magma caused the formation of the Karakaya, Topkaya and Yürükkaracaören granitic bodies in the same geodynamic regime though with different textural features and mineral composition.

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APPENDIX 1 Geochemical analysis results of magmatic units in the study area

No	Sample	Location	Identification	Na2O %	MgO %	Al2O3 %	SiO2 %	P2O5 %	K2O %	CaO %	TiO2 %	MnO %	Fe2O3 %	LOI	TOTAL	V2O5 µg/g	Cr2O3 µg/g
1	**K-101**	Karakaya	*medium-coarse grain biotite granite*	3.68777	0.5838	14.02688	70.74718	0.08133	5.8158	1.194346	0.1613	0.03738	1.412715	0.8518	98.6002496	78	579.1
2	**K-102**	Karakaya	*biotite granite*	3.57957	0.66954	14.0091	67.46488	0.08408	5.5703	2.360617	0.171	0.04512	1.63162	0.7008	96.2866829	80.8	514.7
3	**K-103**	Karakaya	*biotite granite*	3.88746	0.59004	14.19721	71.74224	0.08829	6.0016	0.847146	0.1639	0.0385	1.199254	0.7709	99.5266026	20.8	66.3
4	**K-105**	Karakaya	*enclave*	3.92218	0.58942	14.07823	70.51165	0.08852	5.9359	1.920555	0.1829	0.05261	1.193089	0.5581	99.0330669	15.2	98.9
5	**K-107**	Karakaya	*tourmaline biotite granite*	3.5891	0.64431	13.67535	72.05232	0.07362	5.5123	1.474559	0.1597	0.06176	1.397804	0.6496	99.2903572	46	313.6
6	**K-109**	Karakaya	*biotite granite*	3.85583	0.57188	13.9178	71.65773	0.08686	5.6332	1.234731	0.1624	0.05925	1.408027	0.6665	99.2541007	85.9	584.5
7	**K-111**	Karakaya	*medium-coarse grain biotite granite*	3.72736	0.60663	13.16858	72.94518	0.06526	5.4319	1.151316	0.1761	0.04315	1.521916	0.6555	99.492866	151	763
8	**K-113**	Karakaya	*biotite granite*	3.79987	0.68992	13.72412	71.99589	0.0882	5.6839	1.248226	0.1723	0.04933	1.475369	0.6555	99.5825438	72.5	580
9	**K-114**	Karakaya	*medium-coarse grain biotite granite*	3.88261	0.61995	13.5098	72.30971	0.07829	5.7911	1.04418	0.1359	0.09838	1.414456	0.7372	99.6216685	120.9	813.9
10	**K-115**	Karakaya	*medium-coarse grain biotite granite*	3.72016	0.65511	13.34416	72.76146	0.08487	5.596	1.181821	0.1636	0.04803	1.437549	0.6963	99.6891737	111.75	671.5
11	**K-116**	Karakaya	*tourmaline biotite granite*	3.73879	0.66916	14.07358	72.16295	0.09867	5.6602	0.859497	0.2013	0.02863	1.479585	0.6037	99.5761234	140.2	943.4
12	**K-117**	Karakaya	*tourmaline biotite granite*	3.75746	0.48688	14.19367	72.51369	0.08203	5.7992	0.74059	0.1729	0.04819	1.189686	0.6369	99.621261	23.5	107.4
13	**K-118**	Karakaya	*tourmaline biotite granite*	3.69936	0.57434	13.68652	70.51001	0.08576	5.6224	1.850791	0.1857	0.06113	1.698595	0.7157	98.6903198	8.7	103.3
14	**K-119**	Karakaya	*tourmaline biotite granite*	3.71655	0.52475	13.27187	73.20116	0.08288	5.4059	0.956377	0.2099	0.05415	1.5014	0.7229	99.6478592	77.6	639
15	**K-12**	Karakaya	*alkali feldspar granite*	3.84359	0.51659	13.06595	71.63861	0.07082	5.4841	1.395121	0.2281	0.06018	1.406326	0.7466	98.456048	110	342
16	**K-123**	Karakaya	*tourmaline biotite granite*	3.71141	0.42476	14.17276	72.74581	0.06981	5.6092	0.599924	0.1775	0.02944	1.172302	0.973	99.6858822	12.8	31.6
17	**K-124**	Karakaya	*tourmaline biotite granite*	3.45466	0.60991	14.0662	70.36476	0.09194	5.8392	1.202941	0.2195	0.08673	1.67219	0.7305	98.338558	94.9	719.7
18	**K-125**	Karakaya	*enclave*	3.76955	0.59693	13.85016	72.02721	0.08895	5.5977	0.999091	0.2219	0.05139	1.619945	0.6711	99.4939495	68.9	468.8
19	**K-126**	Karakaya	*tourmaline biotite granite*	3.82858	0.48425	13.84627	72.63218	0.07155	5.6716	0.758852	0.1842	0.04163	1.245742	0.8708	99.6356912	61.4	186.8
20	**K-128**	Karakaya	*biotite granite*	3.44044	0.55936	13.93264	70.5518	0.10344	5.8943	0.963323	0.2551	0.06967	1.536806	0.6627	97.9695638	26.6	209.4
21	**K-129**	Karakaya	*tourmaline biotite granite*	3.6271	0.51922	13.92681	72.67955	0.0754	5.8499	0.829793	0.1837	0.04141	1.2679	0.6327	99.6334247	26.2	139.1
22	**K-130**	Karakaya	*biotite granite*	3.94112	0.55351	13.48441	73.09643	0.08718	5.4809	0.998228	0.1628	0.06965	1.337608	0.6665	99.8783361	42.9	282.85
23	**K-131**	Karakaya	*biotite granite*	3.83994	0.55891	13.36218	73.43506	0.07783	5.3728	0.99911	0.1565	0.06822	1.393144	0.5928	99.856557	79.7	549
24	**K-132**	Karakaya	*medium-coarse grain biotite granite*	4.04157	0.54813	13.60558	72.75847	0.09646	5.5883	0.997331	0.1691	0.07106	1.2824	0.7401	99.8984011	6.1	16.7
25	**K-133**	Karakaya	*biotite granite*	4.02718	0.44495	13.87368	72.80848	0.07859	5.8863	0.893601	0.1365	0.05055	1.110306	0.5827	99.8927268	6.6	12.2
26	**K-134**	Karakaya	*tourmaline biotite granite*	3.57446	0.49934	13.14967	72.87557	0.06716	5.4473	1.22398	0.2042	0.06217	1.415701	0.7283	99.2477329	130	539
27	**K-135**	Karakaya	*medium-coarse grain biotite granite*	3.89507	0.48935	13.47364	72.4702	0.06199	5.3971	0.83914	0.2086	0.04411	1.357239	0.7462	98.9826434	124	14
28	**K-136**	Karakaya	*biotite granite*	3.70234	0.5219	14.09566	70.76824	0.07472	5.7342	1.418487	0.1904	0.0673	1.349347	0.6737	98.5961695	22.4	171.6
29	**K-137**	Karakaya	*biotite granite*	3.6872	0.45616	13.21071	73.76505	0.0749	5.693	0.911476	0.1326	0.04469	1.17569	0.5338	99.6853787	26.8	131.6
30	**K-138**	Karakaya	*biotite granite*	3.85696	0.4895	13.68762	72.72249	0.07419	5.8821	1.184564	0.1224	0.05811	1.137752	0.74	99.9557139	11	51.2
31	**K-139**	Karakaya	*enclave*	3.83569	0.54287	13.62404	72.68949	0.07493	5.6404	1.185291	0.1527	0.05249	1.247124	0.6914	99.7363816	53.3	336.8
32	**K-140**	Karakaya	*biotite granite*	3.84779	0.58786	13.76655	72.5309	0.10752	5.4532	1.000854	0.1606	0.04607	1.218468	0.7545	99.4742927	7.3	47.8
33	**K-141**	Karakaya	*medium-coarse grain biotite granite*	3.50031	0.66252	13.72518	71.62934	0.07972	5.5387	1.244431	0.1767	0.06885	1.447604	0.7616	98.8349124	77	607.9
34	**K-142**	Karakaya	*medium-coarse grain biotite granite*	3.78546	0.6	13.25457	72.2292	0.07451	5.4044	1.25782	0.2006	0.06164	1.480366	0.7562	99.1047748	138	650
35	**K-143**	Karakaya	*biotite granite*	3.7004	0.60375	13.48157	72.59059	0.07974	5.5517	1.076037	0.1658	0.05993	1.281074	0.6814	99.2719279	19.7	73.8
36	**K-146**	Karakaya	*enclave*	3.9402	0.91395	14.62107	70.21803	0.14057	5.2069	1.577165	0.263	0.05529	1.753009	0.5348	99.2240535	13.5	38.5
37	**K-147**	Karakaya	*biotite granite*	3.51384	0.5212	13.40385	73.2566	0.08299	5.8838	0.906656	0.1484	0.03584	1.182316	0.5633	99.4987817	31.9	150.5
38	**K-148**	Karakaya	*biotite granite*	3.49945	0.64267	13.7447	71.39759	0.08694	5.7345	1.32715	0.1686	0.06104	1.547241	0.7097	98.9195626	111.7	950.3
39	**K-149**	Karakaya	*tourmaline biotite granite*	3.59657	0.59871	13.61445	71.50264	0.08078	5.6736	1.277828	0.1741	0.06489	1.445597	1.3549	99.3839938	na	na
40	**K-150**	Karakaya	*medium-coarse grain biotite granite*	3.68374	0.55621	13.47224	71.50412	0.07482	5.608	1.229303	0.1791	0.06845	1.347224	2	99.723228	96.3	790.2
41	**K-151**	Karakaya	*biotite granite*	3.9666	0.51888	12.98869	72.58775	0.06633	5.4544	0.898319	0.1967	0.06133	1.28998	0.6632	98.6921385	105	41.6
42	**K-152**	Karakaya	*medium-coarse grain biotite granite*	3.6414	0.57728	13.54484	71.51632	0.07777	5.6414	1.253466	0.1766	0.0667	1.396002	1.6774	99.5692605	na	na
43	**K-154**	Karakaya	*tourmaline biotite granite*	3.72109	0.4753	13.34173	73.47332	0.09318	5.4368	0.822288	0.1776	0.03561	1.476971	0.7359	99.7897353	137.8	902
44	**K-155**	Karakaya	*biotite granite*	3.79236	0.49689	13.38356	73.2104	0.07595	5.6371	0.966369	0.1483	0.05624	1.224901	0.7165	99.7086254	42.3	256.8
45	**K-156**	Karakaya	*biotite granite*	3.73349	0.58715	13.35973	72.42548	0.08105	5.5875	1.664648	0.1633	0.04245	1.300872	0.6101	99.5557304	62.6	533.5
46	**K-157**	Karakaya	*tourmaline biotite granite*	3.83352	0.50232	13.47326	73.27422	0.0662	5.8764	0.891879	0.129	0.07321	1.238523	0.6029	99.9614486	67	541.1
47	**K-158**	Karakaya	*tourmaline biotite granite*	3.87842	0.52293	13.13869	72.38261	0.06264	5.225	1.277917	0.1696	0.06134	1.783419	0.6402	99.1427315	189	869
48	**K-159**	Karakaya	*tourmaline biotite granite*	3.59581	0.61502	13.58297	71.11598	0.0797	5.6645	2.0654	0.1468	0.0634	1.440518	0.6411	99.0111993	115.3	747.2
49	**K-160**	Karakaya	*tourmaline biotite granite*	3.90364	0.54885	13.51914	72.15883	0.06659	5.681	1.74866	0.144	0.04595	1.097699	0.6396	99.5539972	9.2	60.7
50	**K-161**	Karakaya	*tourmaline biotite granite*	3.87447	0.50405	13.09792	73.26468	0.07728	5.4039	1.331962	0.1571	0.04544	1.356327	0.6481	99.761124	53.9	401.15
51	**K-162**	Karakaya	*medium-coarse grain biotite granite*	3.84312	0.46035	12.68025	74.27298	0.08755	5.1317	0.928309	0.1695	0.0449	1.605069	0.6814	99.9051846	98.6	741.6
52	**K-163**	Karakaya	*medium-coarse grain biotite granite*	3.58155	0.56426	13.29003	71.4452	0.09523	5.3813	1.428059	0.1825	0.04809	1.628029	0.6759	98.3201374	149.5	1029.1
53	**K-164**	Karakaya	*medium-coarse grain biotite granite*	3.5698	0.5676	13.30346	68.81387	0.09162	5.2393	1.886045	0.1922	0.05687	1.843207	0.6963	96.2602601	163	1165
54	**K-166**	Karakaya	*enclave*	3.91234	0.54794	13.2717	71.76229	0.08711	5.4265	1.813511	0.1794	0.03817	1.556291	0.6963	99.2915894	136	893.3
55	**K-167**	Karakaya	*enclave*	3.941	0.68544	13.80408	71.89138	0.07585	5.6615	1.166407	0.1584	0.03961	1.464101	0.7168	99.6044952	106.1	725.7
56	**K-168**	Karakaya	*enclave*	3.75419	0.54239	13.096	72.59551	0.0777	5.3999	1.11316	0.1825	0.07039	1.50604	0.7587	99.0965189	170	712
57	**K-169**	Karakaya	*biotite granite*	4.14351	0.4475	13.53891	72.70821	0.0721	5.5803	1.071097	0.1245	0.03015	1.152931	0.9674	99.8365767	66.7	433.8
58	**K-170**	Karakaya	*medium-coarse grain biotite granite*	3.87397	0.5256	13.05633	73.25995	0.07162	5.2393	1.010478	0.1654	0.03661	1.440699	1.0496	99.7295666	105.3	697.3
59	**K-173**	Karakaya	*tourmaline biotite granite*	3.67787	0.69471	13.38076	72.63541	0.07722	5.7002	0.938225	0.1652	0.04387	1.518302	0.8966	99.7283711	120.8	903.2
60	**K-175**	Karakaya	*medium-coarse grain biotite granite*	3.72405	0.53008	13.53729	72.76943	0.06929	5.5332	1.341281	0.1896	0.03304	1.367215	0.7385	99.8329929	58.3	428.9
61	**K-176**	Karakaya	*medium-coarse grain biotite granite*	3.53473	0.53907	13.14836	73.79137	0.1098	5.2812	1.159474	0.1698	0.03595	1.357586	0.6621	99.7894638	112.2	793.3
62	**K-177**	Karakaya	*tourmaline biotite granite*	3.69408	0.59602	13.54495	73.43663	0.07223	5.4997	1.150649	0.1375	0.03996	1.129953	0.5581	99.8598059	8.8	36.7
63	**K-180**	Karakaya	*biotite granite*	3.74122	0.5921	13.40341	72.50836	0.07514	5.4578	1.188387	0.1432	0.0304	1.564604	1.0167	99.7212228	158.5	1158
64	**K-181**	Karakaya	*biotite granite*	3.79582	0.55221	13.69616	72.61982	0.08028	5.8684	1.08467	0.1505	0.03573	1.169946	0.7566	99.8101602	15.5	72.5
65	**K-182**	Karakaya	*biotite granite*	3.5421	0.55739	13.57082	71.93947	0.0841	5.612	1.385332	0.1821	0.04178	1.416841	0.8461	99.1779582	61.2	400.9
66	**K-183**	Karakaya	*biotite granite*	3.62361	0.51046	13.37059	72.82926	0.06691	5.7148	1.230976	0.1378	0.03331	1.413732	0.7763	99.7077159	118.8	991.1
67	**K-184**	Karakaya	*biotite granite*	3.61255	0.53648	13.32535	72.83516	0.05073	5.5519	0.962194	0.1746	0.05181	1.437451	0.7359	99.2740414	157	588
68	**K-185**	Karakaya	*biotite granite*	3.55089	0.48228	13.69477	72.5653	0.07293	5.868	1.208362	0.1521	0.04401	1.242281	0.7165	99.5974349	33.9	191.1
69	**K-187**	Karakaya	*biotite granite*	3.74927	0.54285	13.62412	72.72536	0.07361	5.6619	1.083593	0.1593	0.04568	1.382479	0.6029	99.6510594	99.5	717.8
70	**K-190**	Karakaya	*medium-coarse grain biotite granite*	3.58403	0.6812	13.5435	69.87709	0.06548	5.7069	1.439355	0.2526	0.04308	1.527807	0.9289	97.649869	122	175
71	**K-191**	Karakaya	*tourmaline biotite granite*	3.6612	0.53938	13.67534	72.85263	0.09437	5.7104	1.08392	0.1584	0.04458	1.368565	0.6914	99.8802328	73.8	564.2
72	**K-192**	Karakaya	*enclave*	4.01468	1.3576	14.03024	70.04557	0.20433	4.6877	1.746385	0.3744	0.08684	2.333796	0.7566	99.6380979	180	177
73	**K-193**	Karakaya	*tourmaline biotite granite*	3.58903	0.71677	13.51832	73.10442	0.0934	5.4818	1.003583	0.1587	0.03186	1.309425	0.8461	99.8533207	87.1	571.1
74	**K-194**	Karakaya	*tourmaline biotite granite*	3.60809	0.86721	13.84158	71.71879	0.13082	5.64	1.437963	0.1872	0.04223	1.446403	0.7367	99.6569985	78.9	593.8
75	**K-196**	Karakaya	*tourmaline biotite granite*	3.77024	0.64798	13.68417	72.51667	0.08055	5.5587	0.993809	0.1618	0.04513	1.562705	0.6914	99.7132315	170.1	1158
76	**K-197**	Karakaya	*tourmaline biotite granite*	3.72616	0.48927	13.43229	71.39727	0.06886	5.6062	1.132571	0.1573	0.04728	1.330771	0.7545	98.142475	47.7	308.9
77	**K-198**	Karakaya	*tourmaline biotite granite*	3.58433	0.57948	13.33535	73.174	0.07499	5.3755	1.28602	0.1511	0.04103	1.502939	0.7616	99.8663522	106	828
78	**K-199**	Karakaya	*medium-coarse grain biotite granite*	3.55989	0.55881	13.70084	72.37042	0.07975	5.5744	1.325717	0.1844	0.04631	1.483113	0.7562	99.6398745	90	767.6
79	**K-200**	Karakaya	*tourmaline biotite granite*	4.0906	0.57047	13.42161	71.28708	0.07087	5.5102	1.163058	0.1948	0.05163	1.566591	0.8671	98.7939814	156	792
80	**K-201**	Karakaya	*tourmaline biotite granite*	3.43913	0.72243	13.2113	73.22836	0.08021	5.3684	1.278141	0.1575	0.04784	1.344198	0.8461	99.7235717	58.6	451.1
81	**K-202**	Karakaya	*medium-coarse grain biotite granite*	3.68522	0.55169	13.84682	72.49411	0.07414	5.4504	0.863082	0.1685	0.04478	1.202602	0.7367	99.1180453	11.2	42.5
82	**K-25**	Karakaya	*tourmaline biotite granite*	4.04276	0.44103	12.89483	74.57577	0.03707	5.3711	0.419817	0.1333	0.02631	0.823043	0.9374	99.7023935	21	196
83	**K-26a**	Karakaya	*tourmaline biotite granite*	3.97019	0.57824	13.68092	72.10243	0.07584	5.7238	1.13868	0.1431	0.05253	1.275908	0.9855	99.7271062	101.7	687.7
84	**K-29**	Karakaya	*tourmaline biotite granite*	3.73805	0.60937	14.06746	71.00087	0.09688	5.5783	0.86506	0.2316	0.0602	1.407852	1.1051	98.7607624	20.8	108
85	**K-30**	Karakaya	*tourmaline biotite granite*	3.64113	0.67762	13.65147	71.56848	0.07909	5.6135	0.987174	0.1797	0.04244	1.569754	0.8989	98.909312	105.9	807.8
86	**K-33**	Karakaya	*tourmaline biotite granite*	3.45555	0.71622	14.07331	67.73601	0.09649	5.5731	1.323632	0.2261	0.07349	1.848541	0.8764	95.9989119	86	554.2
87	**K-34**	Karakaya	*tourmaline biotite granite*	3.92551	0.61251	13.67089	72.07998	0.07104	5.6431	1.209226	0.1688	0.0591	1.28079	0.9543	99.6752329	14	60.7
88	**K-35**	Karakaya	*tourmaline biotite granite*	3.66149	0.65666	13.69222	70.94961	0.08847	5.5931	1.684944	0.1873	0.05933	1.580799	0.8388	98.9927634	109.9	707.3
89	**K-36**	Karakaya	*tourmaline biotite granite*	3.64047	0.69573	13.35995	69.41166	0.09303	5.5844	1.882644	0.1988	0.05015	1.725468	0.8076	97.449842	118.7	752.7
90	**K-37**	Karakaya	*tourmaline biotite granite*	4.10313	0.56038	12.94951	73.56243	0.07493	5.2365	0.854835	0.1827	0.04323	1.48594	0.6694	99.7229708	115	76.1
91	**K-38**	Karakaya	*enclave*	4.14529	0.91615	14.26598	69.48878	0.14685	4.841	1.898456	0.2963	0.07016	2.167459	0.6472	98.8836388	35.2	224.1
92	**K-39**	Karakaya	*tourmaline biotite granite*	3.86285	0.51767	13.31787	70.6094	0.07546	5.6393	2.188577	0.1628	0.04432	1.349753	0.642	98.4100739	18.9	79
93	**K-40**	Karakaya	*enclave*	3.40697	0.71913	12.97794	73.13983	0.0846	5.6105	0.636842	0.1826	0.03522	1.570352	1.3381	99.7020906	85.9	713.1
94	**K-41**	Karakaya	*enclave*	4.09656	0.56689	12.95282	72.58287	0.07156	5.3662	1.084572	0.2054	0.03968	1.80548	0.6953	99.4672332	210	1225
95	**K-43**	Karakaya	*tourmaline biotite granite*	3.6895	0.66411	13.87476	70.93905	0.08184	5.8451	1.091757	0.1656	0.0652	1.406483	0.7008	98.5241583	27.3	136.4
96	**K-44**	Karakaya	*enclave*	3.79249	0.6328	13.98818	71.41277	0.09336	5.8649	1.012048	0.1795	0.05368	1.58898	0.7709	99.3897167	70.3	489.2
97	**K-45**	Karakaya	*tourmaline biotite granite*	4.02896	0.56848	13.1205	72.91158	0.08417	5.3684	1.073687	0.1796	0.05117	1.615804	0.6621	99.664544	144.1	1024
98	**K-51**	Karakaya	*tourmaline biotite granite*	4.05365	0.54609	13.71518	72.48253	0.09367	5.5785	0.788465	0.1663	0.07174	1.430328	0.7826	99.7090664	20.2	71.9
99	**K-54**	Karakaya	*tourmaline biotite granite*	3.83732	0.54811	13.53269	72.58444	0.09114	5.4413	1.10989	0.1747	0.06228	1.438601	0.9154	99.7359035	13.55	42.7
100	**K-55**	Karakaya	*tourmaline biotite granite*	3.86771	0.52255	13.43412	72.91046	0.0861	5.4025	1.209688	0.1607	0.0578	1.244662	0.9933	99.8894849	6.9	13.5
101	**K-57**	Karakaya	*tourmaline biotite granite*	3.69799	0.57386	12.88659	71.56962	0.06821	5.2437	1.374344	0.2185	0.06235	1.631399	0.9308	98.257393	124	229
102	**K-59**	Karakaya	*tourmaline biotite granite*	3.62768	0.55403	13.32576	73.04223	0.07079	5.5496	1.09766	0.1783	0.06031	1.367918	0.9333	99.8075428	20.1	79.5
103	**K-60**	Karakaya	*tourmaline biotite granite*	4.15905	0.48783	13.30061	73.04909	0.05243	5.4047	0.823783	0.1739	0.05358	1.471822	0.8095	99.7862067	173	673
104	**K-61**	Karakaya	*tourmaline biotite granite*	3.77163	0.46633	13.26218	73.32123	0.05483	5.5867	0.989847	0.1551	0.04415	1.396936	0.8675	99.9164084	42	285.5
105	**K-64**	Karakaya	*tourmaline biotite granite*	3.55434	0.52897	13.59013	72.40402	0.09367	5.7758	1.304652	0.1637	0.04117	1.436372	0.862	99.7548055	77.9	581.2
106	**K-65**	Karakaya	*tourmaline biotite granite*	3.96456	0.59521	13.66037	72.31899	0.08266	5.7292	1.043299	0.1592	0.0386	1.390224	0.7145	99.6968009	60.6	334.5
107	**K-68**	Karakaya	*medium-coarse grain biotite granite*	4.08158	0.48743	12.98394	73.30783	0.06706	5.6124	0.871916	0.1969	0.05999	1.256614	0.5285	99.4542149	102	16.8
108	**K-71**	Karakaya	*tourmaline biotite granite*	3.67326	0.41679	13.2511	73.55991	0.07262	5.5278	0.814116	0.1597	0.04609	1.527192	0.642	99.6905595	140.3	922.1
109	**K-75**	Karakaya	*tourmaline biotite granite*	3.68381	0.5247	13.74049	72.12389	0.07368	5.7487	0.972437	0.1828	0.04375	1.398097	0.586	99.0783446	5.9	60.5
110	**K-76**	Karakaya	*tourmaline biotite granite*	3.69512	0.57442	13.28005	71.7078	0.07278	5.387	0.892652	0.2353	0.0477	1.695278	0.8736	98.4617585	127	374
111	**K-78**	Karakaya	*tourmaline biotite granite*	3.89153	0.64644	13.85085	71.21608	0.08201	6.0088	1.285384	0.1566	0.05544	1.46656	0.766	99.4257355	108.3	712.8
112	**K-79**	Karakaya	*medium-coarse grain biotite granite*	3.6708	0.55062	14.28839	72.25296	0.08462	5.662	0.725838	0.1836	0.04002	1.236762	0.8005	99.4961284	12.3	100.5
113	**K-80**	Karakaya	*biotite granite*	3.39137	0.55797	15.50176	68.78977	0.11285	5.9143	0.755611	0.2287	0.04372	1.358839	1.066	97.7208558	23.9	75.5
114	**K-83**	Karakaya	*biotite granite*	3.46471	0.538	14.59051	71.90884	0.07822	5.7071	0.625907	0.2023	0.02855	1.278284	0.9294	99.3518216	10.6	36.1
115	**K-84**	Karakaya	*biotite granite*	3.48986	0.59937	14.89009	69.67542	0.08752	6.2563	1.295128	0.1919	0.03484	1.421427	0.807	98.7488288	9.1	81.2
116	**K-85**	Karakaya	*biotite granite*	3.57597	0.70251	14.16547	68.22035	0.09401	5.8634	1.889498	0.2095	0.03932	1.729156	0.9998	97.4890367	102.2	659.2
117	**K-87**	Karakaya	*medium-coarse grain biotite granite*	3.51642	0.69447	14.36883	70.19064	0.07623	6.1245	1.280352	0.1668	0.03653	1.509636	0.8968	98.8611671	146.25	863.5
118	**K-88**	Karakaya	*tourmaline biotite granite*	3.94291	0.51451	13.77472	72.54142	0.0755	5.8675	0.873961	0.1415	0.03161	1.283739	0.9002	99.9475459	87.8	646.8
119	**K-90**	Karakaya	*enclave*	4.08807	0.77231	13.46151	71.85943	0.08392	5.2983	1.188668	0.2004	0.04854	1.722598	0.6098	99.3335186	148	743
120	**K-91**	Karakaya	*biotite granite*	3.58009	0.67324	14.51175	69.2376	0.08342	6.2629	1.232767	0.175	0.04383	1.609915	0.8941	98.304577	88.8	576.2
121	**K-92**	Karakaya	*biotite granite*	3.50274	0.67988	13.44268	72.46234	0.07398	5.4969	1.148982	0.1627	0.03778	1.696609	1.1466	99.8512617	144.5	984
122	**K-94**	Karakaya	*biotite granite*	3.30957	0.62591	14.15566	68.04934	0.0929	6.0281	1.853357	0.2005	0.06778	1.667557	1.1618	97.2124574	71.2	474
123	**K-96**	Karakaya	*biotite granite*	3.28874	0.68459	13.71426	70.76379	0.06935	5.3157	1.439662	0.1714	0.04847	1.677927	1.2686	98.4424867	89.6	779
124	**K-97**	Karakaya	*biotite granite*	3.38731	0.69547	14.06691	70.34578	0.0898	5.4602	1.511348	0.1914	0.04642	1.618257	0.9026	98.315532	96.3	847
125	**K-98**	Karakaya	*medium-coarse grain biotite granite*	3.50325	0.65283	13.62373	71.29939	0.09409	5.7298	1.28786	0.1795	0.04133	1.430214	0.8097	98.6516283	25.3	121.9
126	**K-99**	Karakaya	*biotite granite*	3.44986	0.67135	13.71182	71.70228	0.08269	5.4113	1.522318	0.1853	0.0467	1.306565	0.9164	99.0065987	9.4	68.3
127	**KZ-2**	Karakaya	*tourmaline biotite granite*	3.59925	0.45102	13.88599	72.91809	0.07776	5.5622	0.879927	0.0928	0.04406	0.608317	0.5862	98.7055835	20.9	114
128	**AK-01**	Topkaya-Arapkuyusu	*microcrystalline dioriteporphyry*	3.21255	2.90768	15.94652	62.24322	0.19545	2.2224	4.918694	0.5128	0.11191	5.603475	1.7063	99.5809682	200.05	209.4
129	**AK-02**	Topkaya-Arapkuyusu	*microcrystalline dioriteporphyry*	3.05604	2.88764	15.87269	63.09574	0.20374	2.3128	4.886542	0.5172	0.10914	5.582986	1.2695	99.7941159	214.7	385.6
130	**AK-03**	Topkaya-Arapkuyusu	*microcrystalline dioriteporphyry*	3.37253	2.9268	16.01413	61.32844	0.18678	2.1277	4.949237	0.5079	0.11471	5.621595	2.1431	99.2929101	185.4	33.2
131	**AK-04**	Topkaya-Arapkuyusu	*medium-coarse grain dioriteporphyry*	3.51654	3.20275	16.05704	61.28511	0.23469	2.0894	4.26637	0.5279	0.11902	6.006244	1.8691	99.174132	192.9	131.7
132	**AK-05**	Topkaya-Arapkuyusu	*medium-coarse grain dioriteporphyry*	2.86953	4.94861	15.29706	58.78809	0.179	1.9479	6.898613	0.5598	0.1647	6.478317	1.3339	99.4655396	239.2	300.9
133	**AK-06**	Topkaya-Arapkuyusu	*dioriteporphyry with accicular amphibole*	2.8883	3.63086	14.82048	60.69536	0.18702	2.1713	6.306131	0.5425	0.1564	5.941509	2.5399	99.8798133	265.4	500.4
134	**AK-07**	Topkaya-Arapkuyusu	*medium-coarse grain dioriteporphyry*	3.00292	4.08294	14.99405	59.80168	0.18115	2.0163	6.39185	0.5567	0.17417	6.452935	2.2153	99.8700293	261.95	339.3
135	**AK-08**	Topkaya-Arapkuyusu	*dioriteporphyry*	3.11785	4.53684	15.16739	58.89968	0.17524	1.8604	6.477524	0.571	0.19201	6.966296	1.8967	99.860934	258.5	178.2
136	**AK-09**	Topkaya-Arapkuyusu	*granodiorite*	3.91007	2.82704	15.72304	63.63692	0.1805	1.9023	4.797595	0.4583	0.20761	4.729324	1.4587	99.8313999	117	22
137	**AK-11**	Topkaya-Arapkuyusu	*granodiorite (transition)*	3.66631	2.8893	15.85261	63.55626	0.20727	2.18	4.690164	0.4829	0.11436	5.417176	0.7402	99.7964758	197.1	316.2
138	**AK-12**	Topkaya-Arapkuyusu	*granodiorite*	3.5439	2.06745	14.96431	67.72322	0.15206	3.1212	3.854125	0.3768	0.06733	2.99812	0.8228	99.6912564	74.5	17.4
139	**AK-13**	Topkaya-Arapkuyusu	*granodiorite*	3.7185	1.88618	14.66683	66.9433	0.15423	2.9458	3.944299	0.3424	0.05917	2.99137	2.1431	99.7951796	128.1	477.1
140	**AK-14**	Topkaya-Arapkuyusu	*enclave*	3.63207	1.97624	14.81529	67.33417	0.15316	3.033	3.899777	0.3595	0.06323	2.994891	1.4829	99.7442484	101.3	247.25
141	**AK-25**	Topkaya-Arapkuyusu	*granodiorite*	3.51036	2.67732	15.35112	63.77694	0.24218	2.5131	5.167854	0.5414	0.11529	4.876934	0.6402	99.4126419	209.6	779.2
142	**AK-26**	Topkaya-Arapkuyusu	*granodiorite*	3.67865	2.54343	15.6527	64.34999	0.24275	2.3432	4.931918	0.5297	0.11247	4.647323	0.6411	99.6731636	211.3	713.9
143	**AK-27**	Topkaya-Arapkuyusu	*enclave*	3.76314	3.29301	15.65056	59.83915	0.39157	1.7135	6.529313	0.7073	0.18197	6.43343	1.3589	99.8617874	225.9	348.2
144	**AK-28**	Topkaya-Arapkuyusu	*granodiorite*	3.53779	2.85934	15.65136	62.79578	0.22973	2.8056	4.826397	0.5594	0.11144	4.365141	0.7402	98.4821951	101.4	130.9
145	**AK-29**	Topkaya-Arapkuyusu	*granodiorite*	3.62998	2.45456	15.42742	63.14656	0.22903	2.5075	4.85078	0.522	0.10062	4.089132	2.2185	99.1760999	176.2	688.4
146	**AK-30**	Topkaya-Arapkuyusu	*granodiorite*	4.25701	2.20657	16.15375	64.88563	0.22836	1.8652	4.93772	0.497	0.09694	4.016581	0.6615	99.8062412	104.3	41.9
147	**AK-32**	Topkaya-Arapkuyusu	*dioriteporphyry with accicular amphibole*	3.17093	5.0788	15.66378	57.4374	0.16936	1.8654	6.697141	0.5842	0.14487	6.469131	2.2185	99.4995679	281.8	101.3
148	**AK-33**	Topkaya-Arapkuyusu	*medium-coarse grain dioriteporphyry*	3.6591	3.03067	15.42701	61.74858	0.19238	2.2918	5.46331	0.5413	0.10947	5.623459	1.8691	99.9560794	232	52.4
149	**AK-34**	Topkaya-Arapkuyusu	*medium-coarse grain dioriteporphyry*	3.48326	2.83579	15.40831	62.14549	0.24864	2.1873	5.806803	0.5698	0.11403	5.774019	1.3339	99.9073638	242.7	67.4
150	**AK-35**	Topkaya-Arapkuyusu	*dioriteporphyry*	3.21389	3.79653	16.46339	60.38996	0.2597	2.2715	4.564755	0.5101	0.13571	5.626374	2.5399	99.7717283	211.2	49
151	**AK-36**	Topkaya-Arapkuyusu	*medium-coarse grain dioriteporphyry*	3.37916	2.63092	15.04531	64.41523	0.15598	2.6792	4.721772	0.39	0.10419	4.247081	2.2153	99.9841164	129.6	35.3
152	**AK-37**	Topkaya-Arapkuyusu	*medium-coarse grain dioriteporphyry*	3.64541	2.22764	14.95528	65.70831	0.18439	2.7426	3.987738	0.3903	0.10031	4.214945	1.8156	99.9725671	122.8	30.4
153	**AK-38**	Topkaya-Arapkuyusu		na	na	na	na	na	na	na	na	na	na	na	na	na	na
154	**AK-39**	Topkaya-Arapkuyusu	*granodiorite*	2.73359	3.63567	15.52201	58.80774	0.21465	2.251	5.799955	0.6435	0.1204	4.77902	1.6312	96.1386953	118.1	50.8
155	**AK-40**	Topkaya-Arapkuyusu	*enclave*	3.31466	3.70437	16.37208	59.21907	0.29514	2.3065	5.907081	0.6299	0.16118	5.989683	1.6547	99.5543243	207.9	194.5
156	**AK-41**	Topkaya-Arapkuyusu	*granodiorite*	3.11529	3.281	15.7311	62.94651	0.22337	2.7143	4.765729	0.5393	0.12826	4.192383	1.1463	98.7835051	113.8	136.4
157	**AK-42**	Topkaya-Arapkuyusu		na	na	na	na	na	na	na	na	na	na	na	na	na	na
158	**AK-43**	Topkaya-Arapkuyusu	*enclave*	3.70083	4.16559	16.9227	55.41567	0.27466	1.4545	7.45223	0.678	0.20247	7.049872	1.9599	99.2764688	188	17.7
159	**AK-45**	Topkaya-Arapkuyusu	*granodiorite*	3.82432	2.74367	15.92272	64.48036	0.18312	2.5581	4.814752	0.4875	0.10015	4.139087	0.6654	99.9192249	171.3	375.3
160	**AK-46**	Topkaya-Arapkuyusu	*dioriteporphyry with accicular amphibole*	2.60842	6.53947	15.38457	54.08127	0.19036	1.2387	7.916303	0.7186	0.174	7.689217	3.3303	99.871214	359	280
161	**AK-47**	Topkaya-Arapkuyusu	*granodiorite*	3.48526	3.08944	15.62711	64.26648	0.19976	2.4356	4.736453	0.505	0.1099	4.295399	1.1387	99.8890475	125.3	21.5
162	**AK-48**	Topkaya-Arapkuyusu	*enclave*	3.16629	3.81805	16.53872	58.94095	0.24939	1.8715	6.431603	0.6091	0.15788	6.059482	1.2695	99.112491	221.5	158.5
163	**AK-49**	Topkaya-Arapkuyusu	*granodiorite*	3.5805	2.9855	15.66995	63.85925	0.23126	2.5422	5.106423	0.5131	0.11057	4.359784	0.7214	99.6798698	191.8	572.6
164	**AK-50**	Topkaya-Arapkuyusu	*enclave*	4.03275	3.18639	16.87631	58.31667	0.34804	1.9602	6.545311	0.6464	0.15569	6.446279	1.4125	99.9265174	208.6	14.8
165	**AK-51**	Topkaya-Arapkuyusu	*granodiorite*	3.54731	3.01879	15.76356	63.56538	0.21478	2.2746	5.362882	0.5443	0.10795	4.74338	0.7899	99.9327606	142.6	32.1
166	**AK-52**	Topkaya-Arapkuyusu	*granodiorite*	3.49192	2.85261	15.62396	63.64575	0.21247	2.4422	5.359198	0.5361	0.11436	4.581692	0.794	99.6543003	119	26.2
167	**AK-53**	Topkaya-Arapkuyusu	*granodiorite*	3.70172	2.58302	15.49199	64.55509	0.23795	2.2088	5.248872	0.5157	0.1131	4.800984	0.481	99.9381838	160.7	376.4
168	**AK-56**	Topkaya-Arapkuyusu	*granodiorite*	3.39993	3.09748	16.00889	63.51409	0.20733	2.1505	5.227136	0.5127	0.1579	4.501261	0.9958	99.7730081	128.9	27
169	**AK-57**	Topkaya-Arapkuyusu	*enclave*	3.32656	4.37654	17.02288	54.88282	0.29224	1.2396	7.176484	0.7059	0.33959	7.302178	2.4334	99.0982464	206.2	7.9
170	**AK-59**	Topkaya-Arapkuyusu	*granodiorite*	3.86757	2.49255	15.3278	63.80475	0.22361	2.3613	4.943367	0.4809	0.10341	4.225831	2.1	99.9310378	100	14.1
171	**AK-65**	Topkaya-Arapkuyusu	*granodiorite*	3.86407	2.31303	15.14241	63.9791	0.18628	2.4711	5.011389	0.4714	0.10329	4.17255	1.4846	99.1991674	128.5	110.8
172	**T-01**	Topkaya	*enclave*	3.72294	3.77366	16.5428	57.48434	0.36506	2.005	6.810281	0.7762	0.20471	6.943012	0.6914	99.3194156	215.4	415.4
173	**T-02**	Topkaya	*enclave*	3.04873	4.92085	16.10145	54.86548	0.20912	1.6785	7.328535	0.8218	0.30383	7.312306	0.7545	97.345053	235.5	24.9
174	**T-03**	Topkaya	*dioriteporphyry*	3.5905	3.3939	15.31394	63.26313	0.2176	2.0964	5.254337	0.516	0.11672	5.328838	0.7616	99.8529642	188.8	263.3
175	**T-04**	Topkaya	*dioriteporphyry*	na	na	na	na	na	na	na	na	na	na	na	na	na	na
176	**T-05**	Topkaya	*dioriteporphyry*	3.98564	2.24205	15.51877	64.28484	0.19605	2.232	4.820101	0.5017	0.10322	4.95531	1.1419	99.9815558	151.9	11.8
177	**T-06**	Topkaya	*dioriteporphyry*	3.68615	2.07255	14.73422	65.50965	0.18566	2.3353	4.876103	0.4767	0.10066	4.678816	1.1529	99.8086924	147.4	73.8
178	**T-07**	Topkaya	*granodiorite (transition)*	3.70862	2.40442	15.4629	64.28279	0.18213	2.3014	4.991188	0.5072	0.10353	4.867567	1.0651	99.876822	156.6	89.4
179	**T-08**	Topkaya	*medium-coarse grain dioriteporphyry*	3.41909	2.86503	15.71544	60.98743	0.31451	1.862	6.306771	0.6747	0.1347	7.020454	0.5932	99.8932233	262.8	328.5
180	**T-09**	Topkaya	*enclave*	3.60025	2.48831	15.95154	63.00964	0.2277	2.1389	5.587287	0.5062	0.12011	5.260185	0.6829	99.5729988	178.1	303
181	**T-10**	Topkaya	*microcrystalline dioriteporphyry*	3.36263	4.05566	16.60812	55.68847	0.31822	1.1462	7.390614	0.8125	0.17469	8.068266	2.2544	99.8797378	366	507.5
182	**T-100**	Topkaya	*dioriteporphyry*	3.59172	2.26371	15.59861	63.8539	0.20112	2.2171	4.859687	0.5214	0.12866	5.336857	1.26	99.8327632	168.6	24.4
183	**T-101**	Topkaya	*medium-coarse grain dioriteporphyry*	3.64047	2.09276	15.37538	64.93861	0.19951	2.3104	4.667526	0.52	0.10423	4.993948	1.1099	99.952726	162	60.6
184	**T-103**	Topkaya	*granodiorite (transition)*	3.76312	2.93817	15.8701	62.83051	0.17558	2.4392	4.8973	0.4627	0.08681	4.500023	1.7209	99.6844608	126.4	43.2
185	**T-104**	Topkaya	*enclave*	4.57277	4.29658	15.76188	55.82418	0.14821	0.7639	6.448411	0.7157	0.17492	9.025144	2.2287	99.9603537	275.6	19.7
186	**T-105**	Topkaya	*dioriteporphyry*	3.94846	2.68395	15.394	62.35568	0.16544	2.2171	5.836724	0.574	0.09192	5.30893	1.4243	100.00054	201.6	30.2
187	**T-106**	Topkaya	*dioriteporphyry with accicular amphibole*	3.07907	4.4802	16.10746	57.67997	0.22406	1.3109	7.434909	0.7591	0.19768	7.190188	1.5311	99.9946016	292.4	148
188	**T-107**	Topkaya	*microcrystalline dioriteporphyry*	3.8096	2.03547	15.43944	64.89388	0.16977	2.2757	4.899206	0.4452	0.12062	4.462962	1.438	99.9898886	132.5	29.8
189	**T-108**	Topkaya	*dioriteporphyry*	3.59882	2.09898	15.26987	64.6783	0.17964	2.3473	5.253478	0.504	0.12616	4.719686	1.2146	99.990849	177.6	64.8
190	**T-109**	Topkaya	*microcrystalline dioriteporphyry*	3.60665	2.02071	15.19732	65.92753	0.19021	2.6699	4.104661	0.4661	0.0887	4.329953	1.4008	100.00253	140.7	132.8
191	**T-11**	Topkaya	*microcrystalline dioriteporphyry*	3.74618	2.1178	15.50838	64.7324	0.19516	2.2497	5.01807	0.5035	0.10015	4.905282	0.912	99.9886285	164.1	190.9
192	**T-111**	Topkaya	*microcrystalline dioriteporphyry*	3.60881	1.58072	15.06155	66.96673	0.16602	2.9666	4.799812	0.4215	0.08932	4.116823	0.22	99.9978758	131.9	10.9
193	**T-112**	Topkaya	*dioriteporphyry with accicular amphibole*	2.93384	4.917	16.48881	55.23188	0.22724	0.995	7.635145	0.7879	0.15477	7.749637	2.7677	99.8889501	340.2	51.3
194	**T-113**	Topkaya	*microcrystalline dioriteporphyry*	3.72969	1.54488	14.90895	66.97738	0.15635	2.653	4.512925	0.394	0.12377	3.879859	1.1055	99.9862193	133.4	11.5
195	**T-114**	Topkaya	*dioriteporphyry with accicular amphibole*	2.7985	5.70623	16.62455	52.93222	0.24968	0.6073	8.110448	0.8516	0.52329	9.365091	1.9881	99.7571217	376.5	50.9
196	**T-11a**	Topkaya	*microcrystalline dioriteporphyry*	3.68344	2.08256	15.38141	64.71325	0.19925	2.2941	5.081938	0.4974	0.1183	4.976697	0.9462	99.9744624	157.2	16.5
197	**T-12**	Topkaya	*enclave*	3.57924	2.64489	15.17015	63.9893	0.21132	2.1808	4.878794	0.4905	0.12028	5.493715	1.0353	99.7942627	173.6	125.8
198	**T-123**	Topkaya	*medium-coarse grain dioriteporphyry*	4.00831	2.42102	15.68253	63.83241	0.17667	2.3188	4.23278	0.4556	0.10762	5.000373	1.7597	99.99591	149	37.8
199	**T-124a**	Topkaya	*enclave*	4.09439	2.93093	17.56331	57.52414	0.35461	1.8719	6.282455	0.6031	0.17837	6.759796	1.7947	99.9577138	200.2	31.1
200	**T-125**	Topkaya	*granodiorite*	3.12619	2.86661	15.48423	63.44925	0.2352	2.5822	4.641884	0.5685	0.10936	4.543697	0.6552	98.2622551	115	111.3
201	**T-126**	Topkaya	*granodiorite*	3.64471	2.60436	15.31978	63.43191	0.20697	2.358	5.040509	0.5039	0.11265	4.482789	2.2913	99.9968703	106.9	76.4
202	**T-127**	Topkaya	*granodiorite*	3.49749	2.51461	15.67552	64.8722	0.21069	2.5936	4.495123	0.5221	0.09768	4.266522	0.9195	99.6650231	60.7	10.1

203	**T-129**	Topkaya	*granodiorite*	3.57527	2.56228	15.50313	64.17514	0.20892	2.4744	4.777819	0.5131	0.10542	4.380224	1.6054	99.8810954	110.95	93.85	295.95	127.2	2.55	1.65	44.25	1.2	0.5	0.5	0.4	1.7	0.65	0.75	0.9	1.25	1.7	0.65	0.8	1.5	11.5	595	14.55	3.95	16.85	4.15	9.3	65.85	1	353.8	2.9	16.15	2.75	98.75	122.75	16.9	42.3	69.05	15.85	21.2	na	na	na	na	na	na	na	na	na	na
204	**T-13**	Topkaya	*medium-coarse grain dioriteporphyry*	3.66918	2.44719	15.51692	63.45029	0.19058	2.2441	4.963501	0.4855	0.11635	5.180462	1.2528	99.516786	148.8	45.6	521.5	108.7	2	1.1	50.4	1.1	0.6	0.4	0.2	1	0.5	0.7	0.5	1.2	1.5	0.5	0.9	1.3	16.5	546	13.8	1	17.2	3.5	9.6	65.8	1	357.2	0.9	13.1	3.7	99.2	114.1	19	25.8	47.6	5.08	19	3.3	0.91	3.05	0.53	3.06	0.64	1.9	0.29	2.03	0.32
205	**T-130**	Topkaya	*dioriteporphyry with accicular amphibole*	3.24569	4.28308	16.04357	56.84068	0.24795	1.8509	8.176882	0.7977	0.12613	7.178523	1.1055	99.8964875	319.8	71.1	564.7	288.2	14.4	0.9	45.2	1	0.6	0.5	0.2	0.5	0.5	0.7	0.9	1.2	1.5	0.7	0.4	1.4	9.6	476.5	22.3	2.6	17.6	3.8	9.9	43.3	0.9	416.6	2.7	7.8	3.1	120.8	111.5	18.3	19.9	39.6	8.9	10	na	na	na	na	na	na	na	na	na	na
206	**T-131**	Topkaya	*granodiorite*	3.72701	2.59374	15.5581	63.65168	0.19079	2.0748	5.18206	0.4712	0.10771	4.848362	0.8293	99.2347048	137.6	71.9	461.3	78.8	3.2	0.8	40.8	1.1	0.5	0.4	0.4	1	0.5	0.7	0.9	1.2	1.5	0.5	1.2	1.3	11.9	555	13.6	1.1	16.8	2.8	10	68.5	1	363.9	0.7	14.5	3.4	92.6	101.1	18.8	26.7	50.1	5.12	18.7	3.21	0.89	2.99	0.5	3.03	0.58	1.88	0.29	1.95	0.31
207	**T-132**	Topkaya	*dioriteporphyry with accicular amphibole*	4.05717	3.24474	15.47294	62.57791	0.18098	1.1953	6.456672	0.581	0.13345	5.877928	0.22	99.9981005	241.1	305.3	614.6	239.6	9.8	0.9	63.4	1.5	0.6	0.5	0.3	0.5	0.5	0.7	0.9	1.2	1.5	0.5	0.9	1.8	11.7	792	21.2	0.6	17.5	3.6	10.1	34.7	2	430.3	0.8	12.2	3.6	227.1	128.4	17.7	23.3	42.6	4.47	16.3	3.09	0.93	2.89	0.5	2.96	0.59	1.76	0.29	1.85	0.3
208	**T-133**	Topkaya	*dioriteporphyry with accicular amphibole*	3.34083	4.65427	15.96523	55.58688	0.24447	1.099	8.49987	0.8243	0.14716	7.738035	1.6659	99.76598	279	37.4	3.9	70	14.9	1.5	56.2	1.3	0.8	0.6	0.4	3.4	0.9	0.9	0.9	1.3	6.5	0.9	1.6	2.1	8.1	493	24.4	2.6	16.7	2.8	9.5	29.1	2	455.4	0.6	7	2.5	78.3	96.8	19.8	16.3	33.8	3.96	15.5	3.37	1.01	3.39	0.57	3.3	0.67	1.98	0.31	1.93	0.3
209	**T-136**	Topkaya	*microcrystalline dioriteporphyry*	3.65511	2.11013	15.33713	64.90124	0.22187	2.2412	5.170394	0.4993	0.09728	5.131488	0.5646	99.9297046	224.9	547.6	810	223.7	3.9	0.9	48.4	0.5	0.6	0.4	0.2	1.5	0.5	0.7	0.7	1.2	1.4	0.4	0.5	1.4	16	620.2	9.4	7.1	17.3	4.7	9.2	72.2	1.2	343.8	3.1	14.5	5.6	122.9	117.2	18.5	35.7	53.5	13.4	12	na	na	na	na	na	na	na	na	na	na
210	**T-138**	Topkaya	*dioriteporphyry*	3.72872	1.99432	15.91454	64.96772	0.21982	2.3562	4.388495	0.4554	0.08842	4.553438	1.3333	100.000445	144.3	100.4	627.5	135.5	1.4	0.7	42.6	1	0.6	0.4	0.2	1	0.5	0.7	0.4	0.5	1.5	0.6	0.9	1.3	14.5	577.8	12.5	2.6	17.2	4	9.5	69.6	0.7	300	3.3	15.2	4.7	116.7	121.1	17.3	27.4	44	11.7	12.8	na	na	na	na	na	na	na	na	na	na
211	**T-14**	Topkaya	*granodiorite (transition)*	3.72412	2.27847	15.96053	63.37151	0.18396	2.1342	4.937535	0.4664	0.10692	5.070539	1.6737	99.9079064	149.3	14.3	584.5	93.8	2.4	4	62.7	0.6	0.6	0.4	0.3	0.5	0.5	0.7	0.9	1.3	2.2	0.6	0.9	1.4	16.1	648	16.1	0.8	17.9	4.2	10	69	1	382.9	0.7	12.3	3.7	126.2	153.8	19.2	25.3	46.6	4.99	18.3	3.24	0.94	3.16	0.53	3.07	0.62	1.88	0.3	2.1	0.32
212	**T-140**	Topkaya	*microcrystalline dioriteporphyry*	3.57958	3.23606	15.81411	59.51182	0.19569	1.6629	6.449435	0.7016	0.15453	7.228278	1.3245	99.858448	236.1	29.3	571.6	84	6.1	8.8	66.5	1.8	0.7	0.5	0.2	1	0.5	0.7	0.9	1.2	1.5	0.6	0.8	1.5	16.2	468.9	22.4	2.6	19.3	4.8	10.1	44.3	1	359.5	5	10.4	4.4	126.9	100.4	24.3	23.5	44.3	10.2	17.7	na	na	na	na	na	na	na	na	na	na
213	**T-144**	Topkaya	*granodiorite (transition)*	4.57788	2.50546	15.99163	64.04901	0.21807	1.7982	5.05216	0.5102	0.20972	4.991328	0.9021	99.9035711	121.3	76	645.9	118.7	4.3	0.8	102.6	1.9	0.6	0.4	0.2	1	0.5	0.7	0.9	1.2	1.5	0.6	1	1.3	17.8	802.8	13.7	5.9	17.7	4.8	9.5	57.1	1.1	363	4.5	16.6	4.2	119.6	124.4	18.7	37	58.8	26.9	22.6	na	na	na	na	na	na	na	na	na	na
214	**T-15**	Topkaya	*dioriteporphyry*	3.58875	2.22919	15.07275	65.80415	0.19775	2.3457	4.910866	0.4598	0.09999	4.745471	0.369	99.8234146	184.2	445.1	1292	201.2	4.4	11.7	44.5	0.9	0.6	0.4	0.2	1.1	0.5	0.7	0.4	1.2	1.1	0.5	0.9	1.1	15.5	601.2	11.3	6	17.1	4.8	9	69.3	1.2	328	4.8	15	5.5	79.4	132.6	17.6	34.2	45	10.1	10	na	na	na	na	na	na	na	na	na	na
215	**T-153**	Topkaya	*granodiorite*	3.4026	2.20106	15.49249	65.29811	0.17194	2.8688	4.576504	0.4488	0.09029	3.759878	1.2119	99.522404	129.1	320	594.7	135.8	3.9	0.7	39.1	0.7	0.6	0.4	0.2	1.8	0.5	0.7	0.7	1.8	1.5	0.5	0.5	1.2	13.1	716	17.1	8.6	16.4	3.1	8.1	70.9	1	308.1	3.9	13.4	4.2	110	86.8	15	38.8	56.4	36.8	20.8	na	na	na	na	na	na	na	na	na	na
216	**T-154**	Topkaya	*enclave*	3.67951	2.99421	16.33112	62.72036	0.16742	2.6568	4.187683	0.5491	0.11513	5.118631	1.1241	99.6441013	121.8	22	740.5	10	3.8	71.5	73.9	1.2	0.6	0.5	0.2	0.5	0.5	0.7	0.9	1.2	1.8	0.6	1.2	1.3	14.6	827.8	14.4	7.9	14.8	6.5	9.5	67.7	1.3	480.9	7.2	14.4	4.1	112.9	106.3	16.4	32.2	51.5	37.5	10	na	na	na	na	na	na	na	na	na	na
217	**T-155**	Topkaya	*granodiorite*	3.65813	2.48325	15.24392	64.91911	0.19004	2.5485	4.752515	0.5233	0.08271	4.653674	0.8919	99.9470554	199.2	547.5	695	208.4	3.3	10.6	282.4	1	1	0.5	0.8	1.7	1.1	0.7	0.9	0.8	1.5	0.6	0.7	1.5	46	574	13.3	0.8	16.1	4	10	64.4	1	330.8	0.8	14.3	3.9	135.3	133.8	19.1	24.2	45.6	4.72	17.2	3.24	0.86	2.99	0.52	3.16	0.64	1.87	0.3	1.95	0.33
218	**T-156**	Topkaya	*granodiorite*	3.71358	2.88822	15.38781	62.52411	0.19279	2.5514	5.525386	0.5538	0.1385	5.348599	0.9211	99.7452372	136.8	15.4	650.3	86	3.5	2.8	168.2	1.6	1.7	0.4	0.6	0.9	12.4	0.7	0.7	0.9	1.5	0.8	1.3	1.3	136.9	576.5	12.6	4.2	16.4	4.7	10.3	86.5	1.5	337.2	5.5	18	2.4	94.5	133.1	20.1	33.4	53.1	24.3	13.5	na	na	na	na	na	na	na	na	na	na
219	**T-157**	Topkaya	*dioriteporphyry*	3.47149	2.63145	15.4041	64.34908	0.20556	2.1993	4.657667	0.4893	0.10313	5.090844	1.3669	99.968834	165.6	272.1	613.8	129.8	2.9	0.7	48.6	0.8	0.6	0.4	0.2	0.9	0.5	0.4	0.9	1.2	1.5	0.6	0.7	1.2	14.8	579	14.1	1.2	16.9	3.5	10.2	58.8	1	364.8	0.7	13.3	4.3	103.9	136	20	27.5	49.7	5.22	19.5	3.34	0.91	3.18	0.53	3.14	0.63	1.92	0.3	2.06	0.31
220	**T-158**	Topkaya	*microcrystalline dioriteporphyry*	4.09703	2.35404	15.44652	64.74114	0.18782	2.2549	4.777201	0.4628	0.10508	4.784213	0.7876	99.9983499	153.1	8.5	507.3	160.6	1.3	0.7	51.3	1.1	0.6	0.5	0.4	0.4	0.5	0.7	0.9	1.2	1.5	0.7	0.8	1.5	14.8	596	15.1	1	17	3.6	10.1	63	1	369.4	1.4	13.7	3.7	145	124.6	19	26.1	49.5	5.08	18.4	3.32	0.94	3.1	0.53	2.89	0.61	1.82	0.29	1.98	0.32
221	**T-159**	Topkaya	*medium-coarse grain dioriteporphyry*	3.5349	2.52653	16.01944	63.14805	0.19636	1.9227	5.360586	0.5578	0.11494	5.569002	0.9815	99.9318897	184	12.7	601.3	116.2	2.2	3.2	53.9	1	0.6	0.4	0.2	1	0.5	0.7	0.9	1.2	1.5	0.6	0.6	0.6	16.8	529.7	17.6	2.6	17.2	4.7	8.5	48.6	0.9	344.9	4.3	12.5	3.2	89.4	112.5	18	19.7	39.1	15.8	11.1	na	na	na	na	na	na	na	na	na	na
222	**T-16**	Topkaya	*dioriteporphyry*	3.74676	2.43539	15.3658	64.73907	0.19573	2.4937	4.521702	0.4503	0.09995	4.844169	1.0268	99.91947	184.8	383.6	1188	416.6	4.6	0.8	54.3	1.1	0.6	0.4	0.2	1	0.5	0.7	0.4	1.2	1.5	0.6	0.9	1.3	15	593.2	16.1	4.5	17.7	4.1	9.7	71.2	1.2	309	3.5	15.6	4.9	102.4	111.1	18	31.9	47.7	24.4	12.9	na	na	na	na	na	na	na	na	na	na
223	**T-17**	Topkaya	*enclave*	3.46341	3.24771	16.00057	57.87548	0.22259	1.8644	5.945528	0.7113	0.14026	6.591627	3.8719	99.9347348	249.7	26.5	1049	89.6	1.9	9.2	65.1	0.8	0.7	0.4	0.2	1.3	0.5	0.7	0.9	1.2	1.5	0.6	0.7	1.2	17.1	485	18.7	0.9	17.4	2.9	9.8	50	1	426.3	0.6	10.3	2.5	77	99.1	19.5	22.5	43.6	4.73	17.5	3.38	1	3.34	0.55	3.12	0.61	1.86	0.29	1.86	0.3
224	**T-22**	Topkaya	*enclave*	3.39441	3.35513	16.02525	60.69652	0.24244	1.6317	5.887341	0.7212	0.12742	6.604498	1.2994	99.9853398	253.5	114	641.5	231.8	3.9	4.3	57.5	1	0.6	0.4	0.2	0.9	0.5	0.7	0.9	0.5	1.5	0.6	0.7	1.3	10.3	424	20.8	0.7	18.3	3.3	10.9	44.2	1	422.9	0.7	8.7	2.7	87.1	117	20.3	23.1	45.7	4.88	19.1	3.63	1.05	3.46	0.57	3.3	0.68	1.96	0.31	2.06	0.32
225	**T-23**	Topkaya	*enclave*	3.06509	4.65081	16.96227	53.28466	0.25678	1.2094	8.142305	0.8197	0.19694	8.345602	2.7677	99.7011977	372.7	330.7	1171	444.3	6.9	73.8	77.7	1.1	0.6	0.3	0.2	0.5	0.5	0.7	0.5	1.2	1.5	0.6	0.8	1.1	11.7	352.7	21.5	2.6	18.2	3.6	9.3	32.9	1.3	408	7.6	4.5	1.6	30.3	119.2	21.6	24.1	48.5	13.8	17.2	na	na	na	na	na	na	na	na	na	na
226	**T-24**	Topkaya	*medium-coarse grain dioriteporphyry*	3.48402	2.88243	15.81876	61.76024	0.22257	2.072	5.45758	0.5065	0.12043	5.807064	1.1055	99.2370504	207.5	337.7	1105	250	4.1	1.3	52.7	0.7	0.6	0.3	0.2	0.8	0.5	0.7	0.9	1.2	1.5	0.5	0.6	1	16.6	602.5	11.5	2.5	17.4	4.8	8.9	61.5	1	340.5	4.1	12.3	4.3	42.9	131.5	18.9	25.1	47	18.7	14.6	na	na	na	na	na	na	na	na	na	na
227	**T-27**	Topkaya	*medium-coarse grain dioriteporphyry*	3.63501	2.07227	15.34784	64.45677	0.19552	2.3488	4.596066	0.4536	0.09236	4.489398	2.1104	99.7979822	135.8	75	1115	225	2.7	0.8	39.5	0.7	0.6	0.3	0.3	0.8	0.5	0.7	0.9	0.8	1.5	0.5	0.6	1	14.3	624.1	12.8	5.5	17.8	4	9	64.6	0.9	310.9	3.1	14.7	4.8	51.9	108.2	17.6	31.4	52.1	24.8	23	na	na	na	na	na	na	na	na	na	na
228	**T-28**	Topkaya	*enclave*	3.18178	3.68251	16.30529	56.30177	0.35605	1.5314	6.378155	0.8507	0.13864	7.080232	3.8408	99.6473913	227.7	226	1090	193.2	7.8	16.1	53.6	0.7	0.6	0.3	0.2	0.9	0.5	0.7	0.5	1.2	1.5	0.6	0.8	0.8	11.6	585.6	10.1	2.6	18	7.2	11.1	51.3	1.2	412.4	5.9	8.5	3	33.2	157	22.2	21.1	47.7	8.2	12.6	na	na	na	na	na	na	na	na	na	na
229	**T-29**	Topkaya	*enclave*	2.33954	4.81509	16.92083	53.75491	0.19456	1.2492	7.786844	0.8418	0.2246	9.325497	1.6266	99.0794574	385.8	107.6	550.8	222.4	15.3	60.9	78.6	1.6	0.6	0.4	0.2	0.8	0.5	0.7	0.9	1.2	1.5	0.6	0.7	1	9.1	422	26.9	1.5	19.5	3.7	12.8	41.7	2	381.1	0.7	5.7	2	19.8	119.4	37.5	23.9	55.2	6.78	28.3	5.81	1.6	5.89	1	6.25	1.24	3.85	0.58	3.9	0.6
230	**T-30**	Topkaya	*medium-coarse grain dioriteporphyry*	3.7123	2.45094	15.02354	64.85245	0.18879	2.2971	4.7942	0.4991	0.10255	4.843424	1.1415	99.9058843	155.4	92	1171	244.4	2.1	0.8	47.7	0.7	0.6	0.4	0.2	0.5	0.5	0.7	0.9	1.2	1.5	0.6	0.8	1.3	14.4	608.1	15.5	2.7	16.9	4.7	9	67.4	0.7	321.5	2.5	13.7	4.2	115.9	136.2	17.5	25.9	45.4	13.4	10	na	na	na	na	na	na	na	na	na	na
231	**T-33**	Topkaya	*enclave*	3.22096	3.84566	17.39729	56.04883	0.34918	1.6218	7.56413	0.8853	0.14761	7.960082	0.8703	99.9110795	357.4	166.1	1056	143.3	4	14.2	64.1	0.8	0.6	0.4	0.3	0.9	0.5	0.7	0.9	1.2	1.5	0.6	0.7	1.2	9.7	430.4	20.5	2.6	18.7	5	10.7	43.1	1.1	455.8	4.6	7.9	2.8	73.5	121.5	19.6	20	37.2	8	10	na	na	na	na	na	na	na	na	na	na
232	**T-34**	Topkaya	*enclave*	3.17099	3.6675	16.33475	59.51857	0.21926	1.7868	5.808954	0.6679	0.13299	7.063788	1.3833	99.7547464	248.8	11.9	539.7	62.9	3.1	8.6	66.8	0.8	0.6	0.4	0.2	1	0.5	0.7	0.4	0.7	0.9	0.6	0.9	1.2	15.1	476.1	16.2	4.5	18.9	3.3	8.1	46.8	1.2	357.4	4.1	10.1	3.3	71.9	117.2	19.9	24.6	41.3	13.8	10	na	na	na	na	na	na	na	na	na	na
233	**T-36**	Topkaya	*granodiorite (transition)*	3.49523	3.23334	15.50942	61.45686	0.21603	2.089	5.244876	0.5629	0.11607	6.135496	1.8691	99.9282961	256.2	483.1	1372	373.1	2.9	7	58.4	0.8	0.6	0.4	0.2	1.6	0.5	0.7	0.5	1.2	1.5	0.6	0.6	0.6	14.2	548.7	14.8	2.6	17.8	4.2	8.9	48.5	0.9	354.9	4	11.5	4.4	96.8	128.2	18.3	25.5	45	15.7	9.6	na	na	na	na	na	na	na	na	na	na
234	**T-37**	Topkaya	*granodiorite (transition)*	3.17638	3.29847	16.14057	60.81683	0.22131	1.9989	5.833367	0.6062	0.12323	6.284475	1.3339	99.8337025	258.8	417.6	1236	311.8	2.7	8.7	55.9	0.6	0.6	0.4	0.2	1.3	0.5	0.7	0.6	1.2	1.5	0.4	0.7	0.9	15.4	533.3	19.2	2.7	18	6	8.6	45.7	0.8	381.6	5.6	9.7	2.6	79.9	115.8	18.7	28.2	48.3	13.1	12.2	na	na	na	na	na	na	na	na	na	na
235	**T-38**	Topkaya	*enclave*	2.83409	3.45846	16.00556	58.05002	0.21989	1.3237	6.632427	0.7438	0.14713	7.798639	1.8871	99.100799	265	17	7.5	8.2	2.3	4	92.6	1.7	1.1	0.6	0.3	3.1	1.8	0.8	0.9	4.9	2.3	1	0.8	2	20	386	23.1	0.9	18.6	3	7.4	40.6	1	418.3	0.5	6.3	2.3	60.5	104.8	21.5	19.3	39.2	4.46	18.9	3.5	1.07	3.44	0.59	3.56	0.7	2.14	0.32	2.13	0.33
236	**T-41**	Topkaya	*microcrystalline dioriteporphyry*	3.66625	2.3172	15.07352	63.83777	0.19291	2.1926	4.920338	0.5067	0.10233	5.074546	2.0276	99.9118143	183.8	427.6	1237	385.7	4.7	0.8	43.4	1.2	0.5	0.4	0.4	0.5	0.5	0.7	0.7	1.2	2.1	0.5	1.2	1.3	11.1	621.5	17.6	9.3	17.2	4.8	9	59.8	1.1	325.9	3.1	14	4.3	116.3	113.9	18	39.8	64.2	37.5	28.2	na	na	na	na	na	na	na	na	na	na
237	**T-42**	Topkaya	*enclave*	3.48205	2.73881	15.75069	61.54683	0.20465	2.0098	5.868584	0.6654	0.13012	6.516124	1.0353	99.948294	237.2	15.2	519.5	71.1	2.3	0.8	61.3	1.9	0.5	0.4	0.4	0.4	0.5	0.8	0.9	1.2	1.5	0.6	0.6	1.3	7.5	483	18.2	3	17.5	3.8	8.4	62.6	2	395.7	0.7	10	3.1	99.4	127.8	20.5	22.2	42.7	4.72	18.4	3.4	0.99	3.4	0.57	3.37	0.69	1.92	0.31	2.08	0.33
238	**T-44**	Topkaya	*granodiorite*	3.61001	2.87538	15.49253	63.3594	0.22007	2.5786	5.003498	0.6024	0.10735	4.959294	0.8703	99.6788902	216.5	750.8	1312	598.9	5.2	0.7	47.3	1.2	0.5	0.4	0.4	1.7	0.5	0.7	0.9	0.9	1.4	0.5	0.5	1.1	10.9	569.9	16.2	4.9	17.2	3.6	9	63.2	1.5	319.1	2.7	13.9	4.2	75.8	116.7	18.9	32.2	48.4	22.6	17.3	na	na	na	na	na	na	na	na	na	na
239	**T-45**	Topkaya	*granodiorite*	3.83887	2.67177	16.03474	62.72897	0.22992	2.3301	5.365154	0.5283	0.08103	5.070806	1.0058	99.8854523	230.5	604.8	1213	610.6	5.9	0.7	33.6	0.9	0.5	0.4	0.3	1.9	0.5	0.7	0.9	1.2	1.5	0.5	0.6	1.4	10.8	504	15	2.5	17.9	4.8	9.3	65.8	1.4	351.7	3.3	13.2	3.7	128	131	19.3	29.8	51.9	14.6	10	na	na	na	na	na	na	na	na	na	na
240	**T-46**	Topkaya	*enclave*	5.43219	3.60001	16.53916	57.45461	0.22878	1.0096	6.455337	0.7058	0.12668	6.549214	1.5153	99.6167347	263.8	40.2	1256	307.5	4.4	0.9	46.7	2.1	0.4	0.4	0.2	1.5	0.5	0.7	0.9	1.2	1.5	0.6	0.4	0.4	5.1	300.4	21.5	2.6	18.5	5.8	7.3	19.7	1.9	357.5	4.3	6.8	3.4	61	108	20.9	20.9	39.2	9.4	15	na	na	na	na	na	na	na	na	na	na
241	**T-47**	Topkaya	*granodiorite*	3.91247	2.42058	15.25863	62.45536	0.2227	2.2857	4.841166	0.5018	0.10191	4.284154	3.5236	99.8081122	90.4	80	1079	532.4	1.9	0.8	46.4	1	0.6	0.5	0.2	0.5	0.5	0.7	0.9	1.2	1.5	0.5	0.8	1.4	12.9	572.3	17.5	5.4	17.6	3.8	8.9	56.1	1.1	377.6	3.1	13.3	3.6	136.3	136.3	17.8	34.9	55	20	22.3	na	na	na	na	na	na	na	na	na	na
242	**T-48**	Topkaya	*granodiorite*	3.70431	2.71792	16.04488	63.14403	0.2482	2.2824	5.395265	0.5211	0.11156	4.700307	0.6315	99.501412	130.5	180.4	841	198.2	3.6	0.8	40	1.3	0.5	0.4	0.2	0.5	0.5	0.7	0.9	1.2	1.5	0.5	0.8	1.2	10.5	598	13.2	1.1	17.8	3.9	8.7	61.6	1	430.4	0.7	11.4	2	76.4	138.2	18.8	24.9	48.3	5.09	18.7	3.34	0.97	3.03	0.51	3.01	0.59	1.84	0.28	1.94	0.3
243	**T-49**	Topkaya	*granodiorite*	3.74109	2.61876	15.47164	63.588	0.22404	2.4708	4.770421	0.5441	0.11202	4.693274	1.3655	99.5997411	122	78.1	1227	405.7	3.5	0.7	52	1.4	0.6	0.4	0.2	1	0.5	0.7	0.9	0.7	1.5	0.5	0.8	1.4	13.1	593.9	17.3	3.8	18	4.7	9.1	59.3	0.6	362.7	3	14.4	2.7	130.3	126.8	17.1	26.9	50.7	18.2	12.4	na	na	na	na	na	na	na	na	na	na
244	**T-50**	Topkaya	*enclave*	4.07977	2.766	15.72718	62.47539	0.22513	1.9828	5.313209	0.5154	0.11235	4.759376	1.6267	99.5832345	128.2	175.5	1009	210.3	2.7	0.8	60.5	1.3	0.5	0.4	0.3	1	0.5	0.7	0.9	1.2	1.5	0.5	0.7	1.1	10.9	561.4	11.4	4.2	16.8	3.8	7.8	49.3	0.9	398	4.4	11.3	3.7	81.6	102.7	15.7	30.6	49.3	24.6	19	na	na	na	na	na	na	na	na	na	na
245	**T-52**	Topkaya	*enclave*	3.25562	4.24182	15.62274	59.0768	0.24343	1.3583	6.184619	0.7083	0.29956	6.773379	1.8073	99.5718318	214.6	252.8	1185	190.8	3.8	0.9	166.6	1.8	0.6	0.4	0.2	0.6	0.5	0.7	0.4	1.2	1.5	0.6	0.8	1.2	14.1	487	13.5	2.6	18.3	5.5	11.6	33.2	1.1	366.2	6	10.8	2.9	79.5	102.6	27.8	22.6	45.3	10.8	15	na	na	na	na	na	na	na	na	na	na
246	**T-54**	Topkaya	*granodiorite*	3.15931	2.87267	15.16887	63.38496	0.18527	2.1801	4.95656	0.5669	0.09776	5.000497	2.1166	99.6895717	180.2	381.1	1215	308.4	3.2	1.3	40.9	0.8	0.6	0.4	0.2	1.1	0.5	0.7	0.9	1.2	1.5	0.5	0.9	0.6	14.4	567.4	9.9	2.6	17.2	4.8	9	55.4	1.8	306.4	3.4	12.5	1.4	102.5	111.5	19.6	23.9	42	8	10	na	na	na	na	na	na	na	na	na	na
247	**T-59**	Topkaya	*enclave*	3.45854	2.68678	15.65952	62.70213	0.21296	2.643	5.17821	0.5865	0.12158	4.950843	1.26	99.4600329	151.1	333.3	1154	398.8	2.9	0.8	63.1	0.8	0.9	0.4	0.6	1	0.5	0.7	0.9	0.6	1.5	0.6	1	1.3	39.3	549.4	15.6	3.1	16.5	5.9	9.5	66.8	1.3	323.8	6.1	12.7	2.6	110.9	106.1	18.3	21.7	39	18.2	10	na	na	na	na	na	na	na	na	na	na
248	**T-60**	Topkaya	*enclave*	3.87021	4.41226	16.97832	54.60482	0.25056	1.528	7.184679	0.7744	0.2069	8.688473	1.1415	99.6401105	257.5	70.7	690	237.1	5.2	0.7	78.3	1.8	0.6	0.4	0.4	0.6	0.5	0.7	0.9	1.2	1.5	0.6	0.8	1.1	14.3	388.2	28.1	3	21.5	4	13.6	68.3	3	309.6	3.4	7.1	5.6	46.7	60.7	37.8	17	37.5	10.4	18	na	na	na	na	na	na	na	na	na	na
249	**T-63**	Topkaya	*enclave*	3.90854	2.4321	15.79135	63.47977	0.20769	2.3242	5.44786	0.4943	0.10478	4.917639	0.6324	99.7406043	192.2	393.6	619.3	273.9	4	0.8	43.8	0.8	0.6	0.4	0.8	1	0.5	0.7	0.4	0.9	1.5	0.5	0.5	0.6	15	601.5	11.4	4.3	17.1	4.7	8	54.4	0.8	319.4	2.7	8.8	3	83.4	111.8	19.4	23.7	41.1	24.4	16.7	na	na	na	na	na	na	na	na	na	na
250	**T-64**	Topkaya	*enclave*	3.24925	4.48116	16.64432	54.18282	0.20356	2.4735	7.543203	0.8084	0.21744	8.683668	0.8703	99.3577046	284.2	41	642.5	393	6.3	0.8	78.9	1.5	0.6	0.3	0.2	0.8	0.5	0.7	0.9	1.2	1.5	0.6	0.7	1	12.4	1039	22.8	3.3	19.8	6.7	11.6	62.3	1.7	285	4.5	6.5	4	26.6	100	33.4	18.5	47.5	30.1	19.5	na	na	na	na	na	na	na	na	na	na
251	**T-68**	Topkaya	*granodiorite*	4.19608	2.95994	16.08325	60.64208	0.22671	1.5382	6.27659	0.5981	0.1166	5.80234	1.4202	99.8600478	190	37.7	487.5	160.3	3.1	0.7	53.5	1.6	0.6	0.4	0.2	0.6	0.5	0.7	0.5	0.9	1.5	0.6	0.4	1.4	10.7	668	24.9	0.8	17.4	3.4	10.1	39.6	1	411.7	0.7	9.1	1.5	110.2	129.9	24.7	19.5	40.3	4.81	19.5	3.94	1.06	3.96	0.68	4.04	0.83	2.46	0.39	2.44	0.38
252	**T-71**	Topkaya	*dioriteporphyry with accicular amphibole*	2.21124	5.45548	16.77942	52.04005	0.27012	0.5742	8.91217	1.0288	0.20075	9.625404	2.0276	99.1251747	433.7	53.1	492.8	110.2	20.3	0.8	98.4	1.8	0.6	0.3	0.2	1	0.5	0.7	0.9	1.2	1.5	0.6	0.8	1	8.6	223.2	28.1	2.6	18.8	5.1	7.2	17.3	1.2	330.6	3.6	3.8	2.5	24.2	125.1	28.3	19.1	39.8	7.8	14.4	na	na	na	na	na	na	na	na	na	na
253	**T-73**	Topkaya	*enclave*	0.06656	6.21357	9.883367	49.16723	0.21045	2.4395	21.788	0.6787	0.22165	6.99568	1.0268	98.6915445	152.6	259.7	573.5	10	54.1	17.3	79.4	1.9	1.6	0.4	0.3	0.6	0.5	0.7	1	1.2	1.5	0.4	0.8	1	9	450.6	22.7	2.6	14.1	4	14.6	54.6	1.7	448.2	5.5	7.4	3	15	94.4	27.8	30	47.5	13.9	15.8	na	na	na	na	na	na	na	na	na	na
254	**T-74**	Topkaya	*granodiorite*	4.60521	2.55201	15.36892	62.28517	0.26691	1.4144	5.875195	0.5372	0.07565	4.876489	1.1534	99.0105022	187.5	20.5	446.3	229.7	1.9	2.1	34.1	1	0.5	0.3	1.1	1	0.5	0.7	0.4	1	0.9	0.5	0.6	1	12.2	256	10.7	2.8	16.8	5	8.8	33.3	4.5	315.1	6.5	9.3	4.2	50.1	98	18.8	23.5	46.3	12.8	12.8	na	na	na	na	na	na	na	na	na	na
255	**T-79**	Topkaya	*dioriteporphyry with accicular amphibole*	3.077	6.18616	15.71735	53.11306	0.22021	2.1196	7.242202	0.8377	0.14945	8.400097	2.2544	99.3172031	342.4	56.5	471.5	93	19	35	67.3	2.1	0.6	0.4	0.2	1	0.5	0.7	0.6	1.2	1.5	0.6	0.9	1	10	453	27.9	3.4	16.4	4.6	9.5	65	1	378	5.8	7.8	2.6	26.7	102.2	19	18	34.4	13.6	10	na	na	na	na	na	na	na	na	na	na
256	**T-80**	Topkaya	*dioriteporphyry with accicular amphibole*	3.22963	4.18425	15.69986	57.88878	0.21456	1.7778	6.791387	0.7825	0.13897	7.111293	2.1059	99.9250068	295.4	49.4	539.7	90.7	13.2	23.1	63.7	1.9	0.6	0.5	0.2	1	0.5	0.7	1.2	1.2	1.5	0.6	0.7	1.5	12.5	508.9	21.7	5.2	18.2	3.8	9.9	48.4	1.6	351.4	5.3	10	3.8	121.6	110.1	18.5	22.7	36.7	10.2	10	na	na	na	na	na	na	na	na	na	na
257	**T-81**	Topkaya	*granodiorite*	2.45645	5.00558	16.69269	54.62252	0.24419	1.7351	6.340991	0.9138	0.22354	8.344114	1.8469	98.4258982	307.9	384	973	323.4	9.7	858.9	152.1	1.6	2.7	0.4	0.3	8.1	0.5	0.7	0.9	1.2	1.5	1.2	1.1	1.1	338.8	491.5	29.1	3.2	17.7	9.7	9.7	50.8	1.3	337.1	22	8.7	1.5	29.8	97.5	29.3	21.7	43.5	15.9	12.2	na	na	na	na	na	na	na	na	na	na
258	**T-84**	Topkaya	*microcrystalline dioriteporphyry*	3.78751	2.44072	15.70018	63.49896	0.19869	2.3529	4.828545	0.4867	0.10576	4.98195	1.2119	99.593779	137.7	44.3	549.5	170.7	3.8	0.7	43.8	1.3	0.6	0.3	0.2	0.4	0.5	0.7	0.9	0.8	1.5	0.5	0.8	1.1	14.1	632.3	19	3.1	17	5	9.3	65.4	0.8	330.5	4.7	14.5	4.4	55.4	122.8	17.8	30.9	48.1	16.3	14.4	na	na	na	na	na	na	na	na	na	na
259	**T-85**	Topkaya	*dioriteporphyry*	3.78653	2.50896	15.51552	63.99127	0.20821	2.1077	5.037414	0.4689	0.10487	5.048702	1.1241	99.9021659	207	474.4	709.7	131.4	4.8	0.7	45.5	0.7	0.4	0.4	0.2	1.4	0.5	0.7	0.5	1.2	0.9	0.5	0.6	1.1	15.3	633	11.4	4.4	16.7	5	8.9	65.4	0.5	340.9	2.9	14.4	5.3	67.5	122.6	18	28.8	48.8	21.5	24.4	na	na	na	na	na	na	na	na	na	na
260	**T-86**	Topkaya	*granodiorite*	3.48044	2.87082	15.70576	62.19919	0.21145	2.2721	5.368415	0.5553	0.11459	5.353092	0.8919	99.0231246	171.2	175.3	597.9	163.5	4.2	0.8	58.2	0.6	0.6	0.4	0.2	0.7	0.5	0.7	0.9	1.2	1.5	0.5	0.5	1.2	16.9	684	13.6	0.8	16.3	3.7	9.5	67.8	1	314.3	0.7	13.7	2.8	135.4	134.4	20.3	29.4	53.2	5.42	19.8	3.42	0.87	3.11	0.54	3.37	0.65	2.05	0.32	2.18	0.34
261	**T-87**	Topkaya	*enclave-apinit*	3.61859	4.33909	16.48231	55.42782	0.21443	0.741	8.327058	0.8297	0.19521	8.291624	0.9211	99.3879086	299	64.7	493.8	307.8	10	0.8	93.7	1.1	0.6	0.4	0.6	1.2	0.5	0.7	0.4	1.2	1.5	0.6	0.7	1	13	368.5	25.8	2.6	16.8	5.6	7	10.1	1.3	340	5.9	6.7	3.1	34.1	100.4	26.8	16	34.7	9.3	11.3	na	na	na	na	na	na	na	na	na	na
262	**T-88**	Topkaya	*enclave*	3.65504	4.7813	15.64015	54.66615	0.23195	0.946	8.743397	0.8255	0.21314	8.454394	1.3669	99.5238032	308.4	114.1	665.7	523.9	9.9	0.8	164.1	1.5	1.2	0.3	0.2	7.3	1.6	0.7	0.9	1.2	1.5	0.7	0.4	1.1	60.3	402.8	21.4	2.6	18	4.6	7.3	17.8	1.2	342	2.7	8.3	3.3	37.5	110	27.5	19.3	36.3	8.9	13.6	na	na	na	na	na	na	na	na	na	na
263	**T-89**	Topkaya	*enclave*	3.63701	4.56148	16.05946	55.04651	0.22324	0.844	8.536561	0.8276	0.20423	8.37367	1.144	99.4577689	303.7	89.4	579.75	415.85	9.95	0.8	128.9	1.3	0.9	0.35	0.4	4.25	1.05	0.7	0.65	1.2	1.5	0.65	0.55	1.05	36.65	385.65	23.6	2.6	17.4	5.1	7.15	13.95	1.25	341	4.3	7.5	3.2	35.8	105.2	27.15	17.65	35.5	9.1	12.45	na	na	na	na	na	na	na	na	na	na
264	**T-90**	Topkaya	*microcrystalline dioriteporphyry*	4.12451	2.85993	15.9333	62.75502	0.16952	2.0683	4.729568	0.5032	0.12777	5.344715	1.3655	99.9813616	168.8	106.6	619.8	119.4	3.8	0.7	156.2	1.1	1.2	0.4	0.2	1.1	2.2	0.7	0.4	1.2	1.5	0.9	1	1.3	71.3	593.2	20.2	2.8	18.6	4	9.3	53.9	0.8	314.3	3.4	13.6	3.7	98.4	124.7	20.3	24.3	41.1	15.8	10.2	na	na	na	na	na	na	na	na	na	na
265	**T-91**	Topkaya	*microcrystalline dioriteporphyry*	3.60209	2.08564	15.18548	63.60888	0.17737	2.3146	4.941056	0.5745	0.10628	5.444089	1.6267	99.6666712	159.3	14.8	543.7	86.3	2.9	3.6	52.1	1.7	0.7	1	0.5	1	0.5	0.7	0.5	1.2	1.5	1.3	1.3	2.5	18	605.8	23.4	5.2	18.2	4.7	9.8	60.4	0.8	329.3	4.2	12.8	3.9	515.7	122.1	17.4	30.7	55	25.5	19.7	na	na	na	na	na	na	na	na	na	na
266	**T-93**	Topkaya	*granodiorite (transition)*	3.6146	2.93	15.87733	62.24576	0.22392	2.0331	5.061481	0.4934	0.13133	5.389799	1.8073	99.8080028	195.1	223.4	552.8	117.5	4.1	1.8	56.9	1.5	0.6	0.4	0.2	1	0.5	0.7	0.5	1.2	1.5	0.5	0.9	1.1	14.1	699.8	11.4	5.6	16.9	6.2	9.3	65.2	0.9	321.4	3.9	13.8	5.7	71	118.7	19.4	34.5	56.8	28.2	23.5	na	na	na	na	na	na	na	na	na	na
267	**T-94**	Topkaya	*enclave*	3.77206	2.36733	15.47987	63.991	0.19994	2.1138	5.163391	0.4791	0.10378	5.027349	1.1727	99.8703559	160.5	16.1	483.6	81.1	1.9	3.9	45.9	1.4	0.6	0.4	0.2	0.5	0.5	0.7	0.9	1.2	1.5	0.6	0.7	1.1	12.9	592	14.6	2.6	17	5.3	9.1	61.6	1	342	7.1	12.3	4.5	74.2	122.1	17.1	25.3	43	16.1	11.3	na	na	na	na	na	na	na	na	na	na
268	**T-95**	Topkaya	*dioriteporphyry*	3.75436	2.61607	16.16573	62.55606	0.17384	2.1368	4.58811	0.5269	0.10734	5.2611	2.1166	100.002949	165.9	29.4	599.1	76.7	4.9	3.5	65.4	0.7	0.6	0.5	0.2	0.5	0.5	0.7	0.4	0.8	1.5	0.6	0.9	1.5	15.3	632.1	18.1	3.6	18.5	4.1	9.9	62.3	0.6	341.7	3.7	12.5	3.7	152.8	117.7	18.7	28.6	45.7	16.1	10	na	na	na	na	na	na	na	na	na	na
269	**T-96**	Topkaya	*medium-coarse grain dioriteporphyry*	3.6642	3.84044	16.87724	58.05971	0.19406	1.4408	6.064855	0.6472	0.15842	7.222863	1.8362	100.006039	266.6	156.9	680.1	286.5	5	14.1	81	1.2	0.7	0.4	0.5	0.8	0.5	0.7	0.7	1.2	1.5	0.6	0.7	1.1	19.8	441	24.3	2.6	19.4	3.1	9.2	40.7	1.2	385	4.2	8.1	2.2	67.4	96.4	28.1	23.3	45.3	8.2	12.8	na	na	na	na	na	na	na	na	na	na
270	**T-97**	Topkaya	*dioriteporphyry with accicular amphibole*	3.33996	3.51404	16.48725	60.60505	0.18339	1.9392	4.804478	0.6046	0.11285	5.84695	2.5171	99.9548612	205.8	34.8	516.6	100.8	3.5	0.7	45.5	1.5	0.5	0.4	0.2	1	0.5	0.7	0.9	1.2	1.5	0.5	0.9	1.1	11	541.6	18.6	2.6	17.9	4.6	9.7	58.7	0.7	355.4	4.6	12.3	5	53.9	127.3	19.9	24.1	41.2	7.7	11.3	na	na	na	na	na	na	na	na	na	na
271	**T-98**	Topkaya	*granodiorite (transition)*	3.58885	2.28027	15.86491	63.79953	0.19684	2.3373	4.328611	0.4916	0.09974	5.098364	1.9146	100.000604	144.9	36.8	1240	82.2	11.4	0.9	45.9	1.9	0.6	0.4	0.5	0.5	0.5	0.7	0.9	0.7	1.5	0.6	1.1	1.2	15.3	1321	21.1	2.6	17.1	3.9	9.9	65.4	1.3	318.7	3.8	13.8	4.9	88.1	127.1	21.1	26.2	42.6	22	10	na	na	na	na	na	na	na	na	na	na
272	**TK-09**	Topkaya	*dioriteporphyry*	3.50486	2.67759	15.86134	62.59284	0.18282	2.1629	4.801556	0.5238	0.10441	4.980483	2.2153	99.60793	153.4	37.3	1114	227.2	2.9	3.7	48.3	1	0.7	0.4	0.2	0.7	0.5	0.7	0.6	1.8	1.5	0.5	0.9	1.1	14.5	640.5	8.9	8	16.3	4.5	8.4	63.3	0.7	349.4	4.2	12.8	3.7	73.8	104.4	17.1	42.6	65.5	42.1	33.5	na	na	na	na	na	na	na	na	na	na
273	**TK-11**	Topkaya	*dioriteporphyry*	3.55443	2.54406	15.59596	62.6429	0.20104	2.1358	5.706774	0.5541	0.10001	5.143039	1.6312	99.8092305	202.4	257.8	1128	223.4	6	0.6	46.4	0.6	2.2	0.4	0.2	1.7	0.5	0.7	0.9	1.2	1.5	0.6	0.8	0.7	14.3	585.4	12	2.6	16.7	5	9	61.3	1	327.8	2.7	13	4	66	112.6	20.2	24.5	42.2	9.8	13.7	na	na	na	na	na	na	na	na	na	na
274	**TK-18**	Topkaya	*dioriteporphyry*	3.31907	3.08138	16.20989	61.49909	0.20407	2.1574	5.359757	0.5421	0.11552	5.65312	1.2695	99.410909	205.2	125.1	985	243.6	7.9	5.3	50.2	1.6	0.6	0.4	0.3	0.8	0.5	0.7	1	1.2	1.5	0.5	0.9	1.2	14.8	655.8	13.9	6.3	17.7	6.3	9.2	62.3	0.8	315.1	3.7	12.1	3.4	81.5	112.7	20.3	36	57.5	29.4	26.5	na	na	na	na	na	na	na	na	na	na
275	**TK-19**	Topkaya	*dioriteporphyry*	3.24337	3.19704	15.80739	61.47319	0.20613	2.1421	5.967371	0.5856	0.12025	5.879014	0.7214	99.3429488	233.6	265.1	1108	331.5	6.2	5.6	48.8	0.5	0.6	0.4	0.2	1.3	0.5	0.7	0.7	0.5	1.5	0.6	0.6	1.3	16.2	634.7	13	2.6	17	4.2	9.3	59.7	0.7	312.7	4.5	12.1	2.8	107.5	120.6	20.1	25.3	42.6	9.8	15.5	na	na	na	na	na	na	na	na	na	na
276	**TK-32**	Topkaya	*granodiorite*	3.6339	1.9359	15.76871	63.86054	0.27751	2.2949	5.271877	0.4844	0.14459	4.980511	0.4713	99.1241496	136.3	303.1	1133	796.3	5.7	0.8	58	0.7	0.6	0.5	0.5	1.1	0.5	0.7	0.5	1.3	1.5	0.6	0.7	1.6	12.2	539.9	11.5	7.6	17.9	5.7	9.6	64.4	1	350.3	5.2	9.9	3.2	211.6	156.9	28.2	34.5	56.6	14.3	14.1	na	na	na	na	na	na	na	na	na	na
277	**TK-40**	Topkaya	*enclave*	3.47394	3.16663	16.36761	61.05008	0.4692	2.5765	4.70875	0.6471	0.10063	5.2844	0.7797	98.6246151	215.3	713.9	1112	254.5	6.5	11.6	42.6	1.2	0.6	0.4	0.2	1.8	0.5	0.7	0.9	1.2	1.5	0.5	0.6	1	11.1	469.6	9.6	2	18.6	5.3	11.7	77.3	1	329.9	3.4	19.3	5.1	48.8	184.1	20	27.7	48.5	13.4	18.1	na	na	na	na	na	na	na	na	na	na
278	**TK-41**	Topkaya	*enclave*	3.83639	4.06139	17.63703	55.05741	0.33625	1.267	7.343061	0.7464	0.19255	7.893635	1.4398	99.8110383	285.4	250.6	1182	560.1	4.6	4.4	71.8	1.5	0.5	0.4	0.2	1.1	0.5	0.7	0.9	1.2	1.5	0.6	0.7	1.2	8.3	311.3	14.5	2.6	21.7	5	12.5	43.3	1.7	315.9	4	11.5	5.2	63.1	119.4	30.8	19.3	44.7	8	20.3	na	na	na	na	na	na	na	na	na	na
279	**TK-8**	Yürükkaracaören	*dioriteporphyry with accicular amphibole*	3.47275	3.81788	16.37462	58.33793	0.20503	1.5869	5.041404	0.6457	0.13257	7.089575	2.5399	99.2442821	253.4	271.8	1060	473.7	6.4	2.2	58.7	1.2	0.6	0.3	0.4	1.1	0.5	0.7	0.9	1.2	1.5	0.6	0.6	0.9	10.9	556.4	9.9	2.6	17.5	4.3	7.5	47	1.4	329	3.5	9.6	3.1	34.2	110.3	18.7	19.4	35.4	13.2	13.8	na	na	na	na	na	na	na	na	na	na
280	**YK-1**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	4.16146	2.128	16.29649	63.79879	0.15094	1.4354	5.070817	0.3501	0.12536	4.549864	1.8073	99.8745201	95.6	17.5	1446	403	2.9	0.8	64	1.4	0.6	0.4	0.4	1	0.5	0.7	0.9	1.2	1.5	0.5	0.8	1.1	12.9	304	9.4	0.9	16.9	4.1	6.8	38	1	325.4	0.4	5.1	1.5	68.8	139.5	28.4	17.1	37.9	4.49	19.1	3.87	0.99	3.99	0.7	4.25	0.91	2.75	0.46	3.04	0.48
281	**YK-12**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.65622	2.49859	16.29601	65.23468	0.16823	1.5881	5.18049	0.3313	0.10029	4.289223	0.6324	99.9755096	112.6	233.5	1566	415.3	4.9	0.7	46.3	1.9	0.6	0.3	0.2	0.9	0.5	0.7	0.9	1.2	1.5	0.5	0.5	1	7.6	314.2	9.3	2.9	16.6	5.5	6.2	41.3	1.1	285.7	3.8	7	1.8	59.3	119.2	27.6	19.2	33.2	11.1	11.9	na	na	na	na	na	na	na	na	na	na
282	**YK-13**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.55669	2.78233	16.13859	63.90285	0.15978	1.3351	5.603115	0.3781	0.12892	4.621555	0.8703	99.4773499	100.7	44.4	1897	391.7	0.5	0.8	54.8	1.7	0.7	0.4	0.2	0.7	0.5	0.7	0.5	0.5	1.5	0.5	0.8	1.2	14.7	271	9.7	0.3	17.4	3.5	6.5	33.5	2	311.9	0.4	5.8	1.3	85.3	128.3	29.3	18	39.5	4.7	20.4	4.12	1.03	4.19	0.75	4.38	0.95	2.89	0.47	3.09	0.5
283	**YK-14**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	4.01558	2.43431	16.36399	63.94753	0.16728	1.5188	5.369012	0.3794	0.1188	4.476431	1.0058	99.7970138	93.5	20.9	1565	381.6	2.5	0.8	50.3	1.2	0.5	0.4	0.2	1	0.5	0.7	0.9	1.2	1.5	0.5	0.7	0.7	10.1	306.4	15.9	2.6	16.5	5	6.4	38.9	1.2	307.1	5.6	6.8	1.7	106.5	122.9	27.8	16	34.3	7.6	10.4	na	na	na	na	na	na	na	na	na	na
284	**YK-15**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.89514	2.80084	16.57721	64.08159	0.16374	1.4625	4.738234	0.3576	0.12245	4.230748	1.5153	99.9453065	93.9	48.6	1889	411.9	2.6	0.8	46.8	1.8	0.5	0.3	0.2	1	0.5	0.7	0.9	0.6	1.5	0.5	0.6	1.1	6.5	301	8.6	0.7	17	4.2	6.5	35	1	313.2	0.5	5.9	1.1	54.7	147.2	27.7	18.6	40.8	4.73	20.2	3.91	1	3.95	0.71	4.16	0.87	2.72	0.46	2.99	0.49
285	**YK-16**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.92808	3.12019	16.15778	62.62657	0.17373	1.4943	4.247997	0.3604	0.14032	4.168018	3.5236	99.9409796	100.2	122.9	1542	403.7	3.7	0.7	50	1.1	0.7	0.3	0.2	0.5	0.5	0.7	0.9	1.2	1.5	0.5	0.5	1	5.8	334.7	7.2	3.3	17.4	4.8	6.3	39.5	1	266.7	2	6.7	2.3	49	123.2	27.2	20	39.4	13.9	11	na	na	na	na	na	na	na	na	na	na
286	**YK-18**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	4.22985	2.08222	16.5291	63.57426	0.14968	2.0601	4.186598	0.3592	0.12447	4.905988	1.4202	99.62157	112	44.4	1467	447.5	2.8	0.8	58.9	1.7	6.1	0.3	0.4	1	0.5	0.7	0.9	0.6	1.5	0.5	0.4	1	5.5	358	8.7	1.1	16.9	3.9	6.6	50.6	1	277.8	0.5	6.2	1.3	39.2	135.8	28.6	17.4	37.5	4.57	17.6	3.9	0.98	4.05	0.74	4.27	0.97	2.89	0.48	3	0.51
287	**YK-19**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.4333	2.61627	16.23105	63.72007	0.13902	1.5206	4.690187	0.2775	0.08606	3.93088	3.3691	100.013965	177.5	385.6	1576	394.8	2.6	0.8	27.7	0.8	0.4	0.3	0.2	1.2	0.5	0.7	0.9	1.2	1.5	1.3	0.4	0.4	7.1	323.9	8	2.6	16.6	6	6.2	32.6	1.2	235.8	3.9	7.3	1.7	44.7	111.2	26.7	15.2	33.8	9.9	12.5	na	na	na	na	na	na	na	na	na	na
288	**YK-2**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.88085	2.35431	16.6897	64.43649	0.14316	1.6638	5.051293	0.3119	0.10363	4.051149	1.1727	99.859012	74.1	19.9	1498	405.6	2.3	0.7	45.1	0.9	0.5	0.4	0.2	0.5	0.5	0.7	0.4	1.2	1.5	0.5	0.6	1.1	8.7	324.4	14.9	2	17.8	4.4	6.1	37.8	1	292.1	2.9	7.3	1.8	70.8	119	28.1	18.7	34.6	13.1	9.8	na	na	na	na	na	na	na	na	na	na
289	**YK-20**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.99996	2.67713	16.26379	63.95872	0.16152	1.3736	4.621271	0.3453	0.06336	4.45376	2.0276	99.9459862	142.6	386.1	1645	419.3	6	0.8	28.5	1.3	0.6	0.3	0.2	1.1	0.5	0.7	0.9	1.2	1.5	0.4	0.5	0.4	7.6	319.9	12	3.2	16.5	6.1	5.7	34.3	1.3	259.7	3	6.5	1.7	36.6	120.5	28.9	19.2	37.8	8	10	na	na	na	na	na	na	na	na	na	na
290	**YK-21**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	4.1049	2.72954	16.52538	65.99574	0.13436	1.4737	3.917637	0.3223	0.06775	4.002274	0.369	99.6426366	81.1	27.9	1451	380.6	2.4	0.8	30.8	1.9	0.5	0.3	0.2	0.5	0.5	0.7	0.9	1.2	1.4	0.5	0.6	1	8.2	318.6	14.4	5.5	16.4	5.9	6	32.9	1.3	255.5	2.4	7.2	1.7	57.9	119.2	26.2	24	40.5	13.9	15.7	na	na	na	na	na	na	na	na	na	na
291	**YK-3**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.92353	2.17802	16.07516	64.06377	0.14613	1.5395	5.067639	0.3386	0.10483	4.29426	2.1166	99.8481313	92.7	18.7	1460	411.7	5.5	0.8	47.1	1.3	0.4	0.6	0.2	0.6	0.5	0.7	0.6	0.8	1.5	0.5	0.7	1.4	7.5	322.5	17.7	2.6	15.9	5.6	6.4	38.9	0.9	285.6	3.7	6.8	1.7	134.4	121.1	27.4	20	35	8	13.3	na	na	na	na	na	na	na	na	na	na
292	**YK-36**	Yürükkaracaören	*microdioriteporphyry*	3.05611	3.67355	16.54442	59.58892	0.15933	1.498	5.615987	0.5024	0.14151	6.215812	2.7747	99.7708216	217	81.6	1506	414.1	16.7	3.6	65.2	0.7	0.5	0.3	0.2	0.6	0.5	0.7	0.8	1.3	1.5	0.5	0.6	0.5	9.8	338	15.7	1	16.6	2.9	5.6	38.8	1	279.1	0.4	5.5	1.6	34.4	100.8	26.1	16.2	33.5	4.06	16.9	3.43	0.94	3.74	0.68	4.11	0.9	2.65	0.42	2.65	0.43
293	**YK-37**	Yürükkaracaören	*microdioriteporphyry*	3.26603	3.79257	16.91637	60.2227	0.1521	1.5995	5.629718	0.5105	0.12834	6.294439	1.2119	99.7242055	233.7	94.8	1758	393.2	7.9	4.4	63.4	1	0.7	0.3	0.2	0.5	0.5	0.6	0.4	1.2	1.5	0.5	0.6	0.9	9.5	384.5	10.6	2.6	16.1	5.9	5.4	38	1.1	263.6	4.6	5.8	2	30.1	114.3	24.4	14	31	8	10	na	na	na	na	na	na	na	na	na	na
294	**YK-38**	Yürükkaracaören	*microdioriteporphyry*	3.41459	3.69671	16.18806	60.9837	0.15043	1.421	5.879754	0.5075	0.13179	6.287838	1.1241	99.7855049	233.2	28.5	1472	409.4	4.4	3.6	63.5	0.4	0.5	0.4	0.2	0.7	0.5	0.7	0.8	1.2	1.5	0.5	0.4	1.1	9.8	281.2	20.2	2.6	16.3	4.7	5.4	35.6	1.1	263	5.2	6.1	3.1	60.3	113.1	25.3	13.6	30.4	10	19.3	na	na	na	na	na	na	na	na	na	na
295	**YK-39**	Yürükkaracaören	*fine grain granodioriteporphyry*	3.74497	3.60841	16.64544	61.62642	0.16563	1.4938	5.428132	0.4411	0.12673	5.677452	0.8919	99.8500403	233.9	189.1	1603	449	4.6	3.4	60.7	0.6	0.5	0.3	0.2	0.7	0.5	0.7	0.9	0.5	1.5	0.4	0.6	0.8	8.7	295	12.8	0.4	16.4	3.4	6.1	39.4	1	318	0.4	5.7	1.6	39	117.8	25.9	16.6	35.5	4.28	17.4	3.58	0.93	3.9	0.67	4.16	0.88	2.61	0.4	2.77	0.43
296	**YK-4**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.85552	2.13592	16.40647	64.23134	0.14745	1.656	4.909637	0.3245	0.1333	4.252353	1.8362	99.8888118	92.1	10.3	1429	381.8	2.7	0.7	64	0.5	0.6	0.4	0.2	0.5	0.5	0.7	0.9	0.5	1.5	0.5	0.8	0.9	13.8	356.6	13	2.7	16.6	6.7	6.4	43.6	1	279	4.2	7.1	1.8	63	113.7	29.9	19.7	36.5	16.8	14.2	na	na	na	na	na	na	na	na	na	na
297	**YK-40**	Yürükkaracaören	*fine grain granodioriteporphyry*	3.73643	3.46999	16.48485	61.62978	0.17493	1.5126	5.461337	0.4503	0.12897	5.595084	0.9211	99.5653361	166.7	41.1	1455	387.4	3.5	1.4	62.8	1.4	0.5	0.7	0.2	1	0.5	0.7	0.9	1.2	1.5	0.6	0.9	2.3	9.4	295.2	38.3	2.6	17.8	4.4	5.7	38.2	0.9	306.5	4	6.4	2.5	388.4	124.1	25.4	15.9	33	9.1	11.4	na	na	na	na	na	na	na	na	na	na
298	**YK-41**	Yürükkaracaören	*fine grain granodioriteporphyry*	3.56639	3.13527	16.62566	61.82436	0.17171	1.5294	5.326503	0.4588	0.13143	5.55727	1.3669	99.6936235	163.1	62.1	1569	394.4	6.1	1.3	63.5	1.5	0.5	0.3	0.2	0.7	0.5	0.7	0.9	1.2	1.5	0.5	0.5	1	9.8	366.6	18.8	2.6	15.8	6	5.7	37.9	1.3	304.7	3.3	6.4	1.7	41.5	126	26.4	16.8	35.2	9.8	10	na	na	na	na	na	na	na	na	na	na
299	**YK-42**	Yürükkaracaören	*fine grain granodioriteporphyry*	3.75922	3.45437	16.41699	61.72336	0.16674	1.4687	5.375175	0.467	0.13935	5.761397	1.144	99.8762211	172.8	22.3	1568	700	4.3	0.8	64.5	1.3	0.5	0.6	0.2	1.2	0.5	0.7	0.9	1.2	1.5	0.6	1	1.8	9.4	283	13	0.6	16	3.4	5.9	39	1	326.7	0.5	5.7	1.7	52.5	130	27.4	17.1	35.8	4.35	17.6	3.68	0.98	3.85	0.7	4.13	0.87	2.73	0.41	2.78	0.44
300	**YK-43**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.33674	4.37322	16.13106	60.64528	0.14171	1.4421	5.648478	0.4654	0.13462	6.074955	1.3655	99.7590485	198.8	25.1	1421	354.8	4	0.7	61.3	0.7	0.5	0.3	0.2	0.6	0.5	0.7	0.9	1.2	1.5	0.5	0.6	0.9	8.7	262.4	16.1	2.6	16	6.4	5.2	36.3	1.4	264.5	4.3	6.4	2.2	31.2	102.7	24.7	15.8	30.5	10.2	10	na	na	na	na	na	na	na	na	na	na
301	**YK-44**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.33877	4.13776	16.18987	60.76974	0.12925	1.4898	5.286379	0.4804	0.13019	6.090623	1.6267	99.6695222	188.9	18.2	1477	347.8	3.9	3.3	69.4	1.3	0.5	0.3	0.2	0.8	0.5	0.7	0.4	0.7	1.5	0.5	0.4	0.6	9.1	292.2	18.4	2.6	15.2	6	5.4	40.2	1.2	281.6	4.4	6.2	2.3	25.9	105.6	25.6	14.6	30.4	9.6	11.9	na	na	na	na	na	na	na	na	na	na
302	**YK-46**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.66192	3.4239	16.29555	62.19162	0.12379	1.4058	4.948679	0.3906	0.10772	5.336232	2.0494	99.9351657	159.7	27	1494	408.1	4.6	0.7	53	1.2	0.8	0.3	0.2	1	0.5	0.7	0.4	1.2	1.5	0.5	0.9	1.1	8.4	324.8	19.7	2.6	15.5	5.4	5.1	39.7	1	287.5	4	6.4	2.4	59.6	93.5	23.9	16.2	33.5	8	10	na	na	na	na	na	na	na	na	na	na
303	**YK-47**	Yürükkaracaören	*microdioriteporphyry*	3.70124	3.10397	16.15361	62.30244	0.14268	1.4004	5.591401	0.4081	0.1083	5.235474	1.8073	99.9549267	162.5	20.4	1453	434.1	3.5	1.7	55	0.9	0.6	0.4	0.2	1	0.5	0.7	0.9	1.2	1.5	0.5	0.6	1	6.5	269.7	16.2	2.6	16.5	5.9	5.2	36.3	1	234.3	4.1	6.5	1.8	58.9	102.9	24.4	16	30.9	8	10	na	na	na	na	na	na	na	na	na	na
304	**YK-48**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.54115	3.68321	16.51492	61.55751	0.15188	1.2357	5.636591	0.4394	0.12807	5.687776	1.1727	99.7489134	187.2	36.1	1457	431	3.8	11.7	57.3	0.8	0.5	0.4	0.2	0.5	0.5	0.7	0.9	1.2	1.5	0.6	0.6	1.1	7.4	287.7	15.1	2.6	16.9	3.4	5.2	27.7	1	237	3.8	6.3	2.3	63.7	109	25.7	20.1	35.3	10.7	10	na	na	na	na	na	na	na	na	na	na
305	**YK-49**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.21968	3.77371	16.28655	60.5571	0.14969	1.4677	5.539308	0.4741	0.13454	5.9794	2.1166	99.6983524	204	87.5	1557	361.7	8.7	11.7	63.7	1.3	0.5	0.3	0.2	1.1	0.5	0.7	0.9	0.6	1.5	0.5	0.4	1	7.4	320.3	15.7	3	16.1	5.6	5.4	38.8	1.1	263.7	4.1	5.4	2.6	44.6	97.9	25.6	19.8	35	14	10	na	na	na	na	na	na	na	na	na	na
306	**YK-5**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.85132	2.35729	16.06233	64.07749	0.14698	1.5668	4.957186	0.3172	0.10432	4.002948	2.5171	99.9609393	84.7	23.3	1501	404.8	1.4	0.8	48	1.2	0.5	0.3	0.2	0.4	0.5	0.7	0.5	0.5	1.5	0.5	0.4	1	8.6	298	9.2	1.1	17.5	4.1	6.8	40.8	1	329.8	0.4	5.9	1.2	51	139.1	29	18.4	39.7	4.69	20.4	3.91	1	4.14	0.74	4.38	0.92	2.83	0.47	3.12	0.51
307	**YK-51**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.61444	3.18812	16.06419	61.37343	0.14746	1.4684	5.925214	0.4408	0.12244	5.676013	1.8362	99.8568221	177.3	24.9	1520	882.9	2.5	5.3	57.9	1.2	0.5	0.3	0.3	0.7	0.5	0.7	0.9	0.7	1.5	0.6	0.6	1	8	317.9	13.2	2.6	16	5.3	5.4	40.1	0.9	272.9	4.6	6.2	2.5	44.6	104.3	25.8	15.7	33.4	8	14.5	na	na	na	na	na	na	na	na	na	na
308	**YK-52**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.31573	3.62876	16.00198	60.44506	0.13881	1.4262	5.804579	0.4672	0.1283	5.963157	2.5171	99.8367942	201.7	19.4	1543	844.8	4.5	1	60.9	1.2	0.7	0.3	0.2	1.1	0.5	0.7	0.4	1.2	1.5	0.5	0.7	0.6	8.7	274.5	17	2.3	16.6	5.3	5.2	36.8	1	275	5.2	5.8	2	48.1	102.2	24.8	15.6	33.3	7.8	10.6	na	na	na	na	na	na	na	na	na	na
309	**YK-53**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.30874	3.8776	16.19927	60.22538	0.13778	1.4529	5.582068	0.4282	0.12964	5.815872	2.5399	99.6972782	184.9	14.2	1460	808.1	3.5	2.1	58.8	0.8	0.8	0.3	0.2	0.6	0.5	0.7	0.4	0.5	1.5	0.5	0.8	0.9	7.6	284.6	13.8	2.6	15.3	4.4	5.1	38.1	1	258.1	8	6.3	2.6	33.9	102.2	25	17.2	32.5	8.8	10	na	na	na	na	na	na	na	na	na	na
310	**YK-54**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.36409	3.72034	16.15179	60.51176	0.15598	1.4543	5.692828	0.4441	0.12913	5.861032	2.2153	99.7006409	185.2	19.9	1518	945.2	1.8	11	59.8	1.1	0.5	0.3	0.2	0.7	0.5	0.7	0.9	1.2	1.5	0.5	0.5	0.9	8.1	280.1	15.4	2.6	16.6	6.4	5.4	37.8	1.1	268	4.2	6.1	1.9	37.7	115.4	24.9	16.2	31.5	8	10.5	na	na	na	na	na	na	na	na	na	na
311	**YK-55**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.31943	3.39487	16.00441	60.65509	0.147	1.4646	5.971746	0.4546	0.13299	5.894149	1.8156	99.25454	189.3	54.1	1592	994.7	3.2	1.8	59.1	1.1	1	0.4	0.3	0.5	0.5	0.7	0.9	1.2	1.5	0.5	0.4	1.3	17.3	304.4	19	2.6	16.3	6.4	5.2	37.6	1.2	294.2	3.4	6.7	2.5	98.7	123.3	24.9	18.6	34.4	8	10	na	na	na	na	na	na	na	na	na	na
312	**YK-56**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.49142	3.73812	16.46405	60.65042	0.14792	1.5408	5.59464	0.448	0.13391	5.880017	1.6312	99.7205101	188.2	16.6	1479	852.6	3.7	0.8	62.1	1.5	0.5	0.3	0.2	0.8	0.5	0.7	0.9	1.2	1.5	0.5	0.6	1	10.1	290.1	13	3	15.4	5.9	5.5	38.7	1.4	252.8	6.5	6.5	2.9	49	102.7	24.1	16.4	31.5	7.3	10	na	na	na	na	na	na	na	na	na	na
313	**YK-57**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.60068	3.7295	15.85988	61.00034	0.14276	1.417	5.746302	0.4612	0.13474	5.84767	1.6547	99.5948009	180.1	16	1459	848.1	3.4	0.8	62.9	1.1	0.5	0.3	0.2	0.6	0.5	0.7	0.5	0.6	1.5	0.5	0.5	1	10.7	367.5	14.5	2.6	16.1	5.6	5.4	37.3	1.3	252.8	5.5	6.2	2.6	51.6	101.4	25.3	16.1	32.5	9.9	10	na	na	na	na	na	na	na	na	na	na
314	**YK-59**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.62159	3.52282	16.10167	61.20691	0.13766	1.5443	5.40872	0.4569	0.11842	5.781167	1.9599	99.8601417	179.9	19.9	1546	872.9	3.2	1.2	62.6	0.6	0.5	0.3	0.2	0.4	0.5	0.7	0.5	1.2	1.5	0.5	0.6	0.9	7.8	303.3	12.2	2.6	16.8	5.3	5.3	40.6	1	236	3.3	5.6	1.8	46.4	101.8	25.2	14.6	29.3	11.6	12.2	na	na	na	na	na	na	na	na	na	na
315	**YK-6**	Yürükkaracaören	*fine grain granodioriteporphyry*	4.01582	2.32206	16.00226	64.22254	0.15575	1.5463	5.053827	0.3233	0.10064	4.283197	1.9146	99.9403363	79	46.4	2001	719.5	29.4	0.8	45.7	1	0.5	0.5	0.2	0.7	0.5	0.7	0.8	0.5	1.5	0.5	0.6	1.8	7.6	297	10.6	0.8	17	3.8	6.3	42.6	1	325.6	0.5	6.1	1.5	85.2	132.5	29.5	19	40.8	4.83	20.3	4.09	1.03	4.2	0.73	4.59	0.96	2.95	0.49	3.17	0.5
316	**YK-60**	Yürükkaracaören	*fine grain granodioriteporphyry*	3.61108	3.64045	16.1846	61.24697	0.16282	1.4172	6.111645	0.4772	0.14771	5.936529	0.2713	99.2075249	176.4	25.1	1438	809.7	4	0.8	73	1.6	0.6	0.3	0.2	0.9	0.5	0.7	0.4	1.2	1.5	0.5	0.5	0.9	7.8	305	11.9	0.5	16.3	3.3	5.7	35.5	1	301.3	0.4	5.3	1.7	32.2	122.5	26.4	16.7	36.1	4.32	17.8	3.66	0.95	3.95	0.69	4.23	0.87	2.58	0.41	2.73	0.42
317	**YK-61**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.54936	3.82084	16.36297	61.52221	0.15835	1.4483	5.946232	0.4277	0.13321	5.61031	0.6654	99.6448908	168.2	27	1510	879.4	4	0.7	66.9	1.4	0.5	0.3	0.2	1	0.5	0.7	0.6	1.2	1.5	0.5	0.5	1	7.9	293	13	0.7	16.6	2.8	5.9	38.2	1	252.1	0.4	5.9	1.6	47.1	95.3	25.5	16.2	34.4	4.08	16.6	3.47	0.89	3.77	0.65	4.01	0.82	2.62	0.39	2.65	0.41
318	**YK-62**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.38693	3.14588	16.28373	61.0055	0.14962	1.4595	5.379428	0.3943	0.12632	5.252291	3.3303	99.9138293	148.4	28.9	1589	701.3	3	0.7	62.6	1	0.5	0.3	0.2	0.6	0.5	0.7	0.5	1.2	1.5	0.5	0.4	0.8	10	295	12.5	0.7	16.4	3.5	6.1	39.6	1	254.7	0.5	5.5	1.3	32	114.5	25.4	16.3	35	4.1	16.7	3.5	0.9	3.72	0.65	4.02	0.83	2.51	0.4	2.6	0.42
319	**YK-63**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.19718	3.41706	16.98437	61.71308	0.15019	1.7324	4.930673	0.4179	0.11981	5.741122	1.1387	99.5424638	167.6	48.1	1538	668.2	3	1	61.5	1.4	0.8	0.3	0.2	0.4	0.5	0.7	0.6	0.9	1.5	0.5	0.4	0.6	7.9	311	12.9	0.9	16.2	3.2	5.7	46.2	1	287.7	0.5	5.5	1.3	30.9	100	26.2	16.3	34.8	4.17	16.6	3.49	0.92	3.89	0.69	4.1	0.86	2.63	0.41	2.68	0.42
320	**YK-64**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.40799	3.51846	16.57094	61.6043	0.15529	1.5841	5.42985	0.4258	0.11996	5.682061	1.2695	99.7683646	159.6	17.2	1488	675.7	2.3	1.9	58.7	1.1	0.5	0.3	0.2	1	0.5	0.7	0.4	1.2	1.5	0.5	0.5	0.9	9.2	297.8	15.9	2.6	16.4	4.3	5	41.1	0.9	243.8	3.3	6.6	2.5	32.2	91.9	24.9	14.6	30.5	10	10	na	na	na	na	na	na	na	na	na	na
321	**YK-65**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.43006	3.56641	16.90531	60.87828	0.142	1.6277	5.692626	0.472	0.12623	5.965326	0.7214	99.5273527	173.5	70.9	1507	679.8	3.5	8	62.5	1.6	0.4	0.3	0.2	0.7	0.5	0.7	0.9	1.2	1.5	0.5	0.7	0.9	7.6	336.7	17.2	2.8	16.8	4.5	5.1	44.7	0.6	264.8	3.7	5.5	1.7	23.7	94.6	27.1	17.6	34.8	10.4	10	na	na	na	na	na	na	na	na	na	na
322	**YK-67**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.42182	2.32535	16.84424	64.10346	0.20965	1.3751	5.069163	0.3901	0.13708	4.934621	0.7899	99.6004199	129.1	211	1908	693.8	16.7	0.8	54.9	1.8	1.3	0.4	0.4	0.8	0.5	0.7	0.9	0.8	1.5	0.5	0.4	1.1	8.1	624	12.3	0.4	17	3.9	6.1	35	1	302.6	0.5	5.9	1.7	44.5	135.3	28.4	17.6	36.2	4.6	18.7	3.96	1.03	4.17	0.73	4.46	0.94	2.75	0.43	2.9	0.45
323	**YK-69**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.43736	2.36633	16.44273	63.90551	0.19838	1.4934	5.399166	0.4333	0.13907	5.450517	0.481	99.7467648	138	222.7	1708	848.6	14.8	0.8	48.9	1.3	1.6	0.4	0.2	1.3	0.5	0.7	0.8	1.2	1.5	0.5	0.6	1.1	9.9	408	10.1	0.7	16.9	4.1	6.1	38.3	1	291.6	0.5	6.3	1.7	52.4	132.8	28.9	17.8	38.6	4.62	18.3	3.89	1.03	4.14	0.74	4.5	0.92	2.79	0.44	2.98	0.46
324	**YK-71**	Yürükkaracaören	*fine grain granodioriteporphyry*	3.81677	3.09313	16.24885	60.43955	0.18234	1.4671	5.010338	0.4101	0.08187	5.502327	2.4334	98.6858606	147.4	207.1	1569	755.7	5.7	0.8	38.7	1.6	1.2	0.5	0.5	1.3	0.5	0.7	1.7	1.2	1.5	0.5	0.7	1.7	7.2	425.2	23.3	2.3	17.2	4.7	5.5	33.9	0.9	291.3	4.4	5.8	0.9	227.3	130.9	27.4	21.8	39.2	19.9	18.5	na	na	na	na	na	na	na	na	na	na
325	**YK-72**	Yürükkaracaören	*fine grain granodioriteporphyry*	4.04362	3.49082	15.72404	59.65105	0.1727	1.3544	4.410103	0.441	0.12735	5.325292	5.083	99.8233554	130	34	1547	671	5	0.8	48.6	0.8	1.2	0.6	0.3	0.6	0.5	0.7	0.5	1.2	1.5	0.7	0.7	1.9	7.8	525	25.1	0.8	17.3	4	6	33.2	1	306.5	0.4	5.4	1.6	272.4	126.9	28.5	17.4	36.5	4.46	18.7	3.79	1.03	4.12	0.72	4.43	0.9	2.68	0.42	2.83	0.46
326	**YK-73**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.24449	3.73224	16.19	60.25018	0.15	1.433	5.764377	0.4273	0.12751	5.727606	2.1166	99.1633311	167.6	32.5	1496	650.9	5.1	2.4	63	1.1	0.5	0.4	0.3	0.5	0.5	0.7	0.9	1.2	1.5	0.5	0.7	1.8	9	315	26	0.6	16.6	3.1	5.7	40.1	1	293.7	0.5	5.6	1.6	233.2	110.9	25.8	16.4	34.4	4.08	16	3.53	0.91	3.72	0.67	3.93	0.83	2.54	0.38	2.66	0.41
327	**YK-74**	Yürükkaracaören	*microdioriteporphyry*	3.41261	4.00045	16.2619	59.9703	0.15731	1.365	5.771257	0.5046	0.12558	6.357019	1.8362	99.7623163	224.4	22.2	1547	672	5.4	3.5	72.4	1.4	0.6	0.7	0.4	0.7	0.4	0.7	0.9	1.2	1.5	1	0.8	2.1	11.4	270	35.1	0.5	16.7	3.3	5.3	34.9	1	274.7	0.4	5.8	1.4	337.3	107.6	25.1	15.8	33.7	3.99	15.9	3.38	0.94	3.74	0.65	4.05	0.83	2.47	0.39	2.73	0.41
328	**YK-75**	Yürükkaracaören	*microcrystalline granodioriteporphyry*	3.22722	3.72423	16.36097	57.89872	0.159	1.2572	6.530895	0.4457	0.13449	5.882078	2.5171	98.1375498	206	264.4	1503	742.6	4.3	2.2	57.1	1.1	0.5	0.5	0.2	1.2	0.5	0.7	0.4	1.2	1.5	0.5	0.7	1.6	8.3	272	25.6	0.5	16.6	3	5.6	33.7	1	284.7	0.4	5.5	1.5	198.5	100.4	24.6	15.8	33.1	3.94	16.5	3.44	0.92	3.67	0.63	3.89	0.78	2.4	0.38	2.6	0.4
329	**YK-78**	Yürükkaracaören	*microdioriteporphyry*	2.86529	3.49129	16.59998	60.36827	0.17534	1.387	5.596653	0.4812	0.136	6.116765	2.5399	99.7575883	226.4	213.7	1626	728	5.4	2.7	65	1.7	0.5	0.6	0.2	0.8	0.5	0.7	0.7	1.2	1.5	0.6	1	1.9	9.2	320	30	1	17	3.1	5.5	37.8	1	285.3	0.4	5.6	1.5	251.3	103.2	25.3	15.9	35.5	4.03	17.4	3.48	0.95	3.76	0.67	4.15	0.83	2.59	0.39	2.69	0.4

na: not analyzed

APPENDIX 2 The argon release values of the samples according to 40Ar/39Ar step-heating

Temp. (℃)	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$	$^{40}Ar^*/^{39}Ar_k$	$^{40}Ar^*$ (%)	^{39}Ark (%)	Age ± 2s (Ma)
T-129 Bio weight=5.4mg							
650 ℃	195.00646	0.13978	0.61693	12.719315	6.52	0.26	53.84 ±30.41
700 ℃	431.05235	0.02855	1.42429	10.176396	2.36	1.04	43.20 ±70.13
750 ℃	93.68346	0.01046	0.28153	10.490732	11.20	3.74	44.52 ±13.86
790 ℃	12.66620	0.00716	0.00801	10.299199	81.31	4.76	43.72 ± .74
830 ℃	12.01506	0.00657	0.00571	10.328945	85.97	5.44	43.84 ± .60
870 ℃	12.05556	0.00481	0.00502	10.571880	87.69	4.98	44.86 ± .60
910 ℃	11.68889	0.00479	0.00426	10.431266	89.24	6.47	44.27 ± .57
950 ℃	11.96374	0.00707	0.00490	10.515058	87.89	7.22	44.62 ± .58
980 ℃	11.75665	0.00843	0.00402	10.569389	89.90	7.21	44.85 ± .55
1010 ℃	11.10006	0.00627	0.00242	10.385651	93.56	8.53	44.08 ± .50
1040 ℃	10.84941	0.00756	0.00140	10.437786	96.21	11.60	44.30 ± .46
1070 ℃	10.77984	0.00639	0.00115	10.440028	96.85	12.93	44.31 ± .46
1100 ℃	10.74702	0.00580	0.00104	10.439543	97.14	13.07	44.31 ± .47
1130 ℃	10.70008	0.00661	0.00112	10.368614	96.90	10.33	44.01 ± .46
1160 ℃	12.05440	0.03598	0.00550	10.431316	86.53	1.69	44.27 ± 2.04
1310 ℃	22.18160	0.10555	0.03852	10.810586	48.73	0.65	45.86 ± 2.30
1400 ℃	116.64498	0.28992	0.30964	25.182268	21.58	0.07	105.08 ±39.88
T-YK. (1)46 Hbl weight=7.4mg							
850 ℃	237.90049	1.35428	0.73451	20.982942	8.81	1.51	87.73 ±48.51
950 ℃	282.23281	5.27585	0.92478	9.421014	3.32	1.43	39.91 ±49.87
1000 ℃	122.16787	10.02720	0.38962	7.901459	6.41	1.77	33.54 ±22.19
1020 ℃	36.60272	8.44221	0.08796	11.367267	30.83	2.93	48.05 ± 5.46
1040 ℃	15.94268	11.01245	0.02102	10.711546	66.56	16.72	45.31 ± 1.35
1050 ℃	13.00299	10.86477	0.01197	10.430257	79.47	32.02	44.14 ± .87
1060 ℃	12.30257	10.71083	0.01009	10.270608	82.72	24.60	43.47 ± .88
1070 ℃	17.03755	6.61056	0.02040	11.604524	67.73	3.00	49.04 ± 2.84
1110 ℃	26.91443	14.31873	0.05047	13.304596	48.83	1.26	56.12 ± 6.13
1140 ℃	19.71088	12.25152	0.02636	13.035809	65.44	3.35	55.00 ± 2.87
1170 ℃	19.34970	13.65632	0.03014	11.669765	59.61	4.00	49.31 ± 2.87
1200 ℃	18.54805	13.36812	0.03122	10.511988	56.03	4.50	44.48 ± 2.47
1260 ℃	31.26069	17.09813	0.06211	14.487137	45.67	1.11	61.02 ± 7.10
1290 ℃	28.78991	16.22877	0.05895	12.843558	43.99	1.38	54.20 ± 5.92
1350 ℃	49.08700	18.40130	0.11546	16.710463	33.51	0.43	70.21 ±18.16
K-120 Bio weight=5.8mg							
650 ℃	69.91473	0.03776	0.18428	15.462684	22.12	0.62	66.36 ±10.00
730 ℃	141.59322	0.01123	0.43044	14.398283	10.17	2.21	61.87 ±21.34
770 ℃	22.16321	0.00631	0.02272	15.449079	69.71	1.74	66.30 ± 1.64
810 ℃	15.90924	0.01224	0.00871	13.335243	83.82	3.52	57.37 ± .92
850 ℃	14.61026	0.00178	0.00707	12.520506	85.70	5.72	53.92 ± .93
890 ℃	14.56484	0.00157	0.00478	13.152495	90.30	7.66	56.60 ± .66
920 ℃	14.79198	0.01240	0.00380	13.670653	92.42	7.31	58.79 ± .80
950 ℃	14.75457	0.00026	0.00333	13.770868	93.33	8.70	59.21 ± .65
980 ℃	14.57406	0.00000	0.00428	13.308359	91.32	14.73	57.26 ± .62
1010 ℃	14.71118	0.00007	0.00345	13.692105	93.07	19.19	58.88 ± .64
1040 ℃	15.15922	0.01809	0.00715	13.046646	86.06	11.58	56.15 ± .72
1070 ℃	16.08245	0.01461	0.00436	14.794989	91.99	6.38	63.54 ± .71
1110 ℃	16.70203	0.01522	0.00278	15.880681	95.08	5.46	68.12 ± .81
1150 ℃	17.66774	0.00000	0.01124	14.344290	81.19	3.24	61.64 ± 1.57
1190 ℃	19.68375	0.00000	0.01936	13.960890	70.93	1.08	60.02 ± 4.08
1230 ℃	23.53029	0.00523	0.04141	11.295265	48.00	0.41	48.71 ± 4.71
1330 ℃	26.05049	0.05932	0.05763	9.025809	34.65	0.47	39.03 ± 9.47