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Mineralogical and Petrographic Properties of Beytarla-Kazıkbeli, Taşbaşı, Yaylaköy-Söğüteli Plutons Located to the South of Giresun (Eastern Pontides, Turkey)

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Abstract
The Esatern Pontides comprises of many plutons varying in size, composition and ages from Paleozoic to Tertiary. Those of especially the Late Cretaceous aged ones from these plutonic rocks are commonly observed in the northern part, while the Eocene aged ones are common in the southern part of the Eastern Pontides. In this study, the mineralogic and petrographic properties of the Beytarla-Kazıkbeli, Taşbaşı, Yaylaköy-Söğüteli plutons located to the south of Giresun (NE Turkey) were revealed. The studied plutons mostly extend NE-SW directions and usually contain mafic microgranular enclaves (MMEs) with different size. Petrographically, the rocks of the plutons are not uniform and show variations in both colour and mineralogical content. According to modal mineralogies, these plutonic rocks are gabbroic diorite, diorit, granodiorite, tonalite and monzogranite in composition. The mineralogical assemblage of the plutonic rocks is plagioclase + quartz + K-feldispar + amphibole + biotite + Fe-Ti oxide minerals. They have fine to medium granular, monzonitic, porphyric, poikilitic, micrographic and myrmekitic textures. The ellipse shapes of plutons, the contact relationship with the wall-rocks, xenolith contents and some textural features show that the studied plutons were emplaced at shallow depths of the crust.

Keywords: Plutonic rocks, Mineralogy-petrography, Eastern Pontides, Giresun, Turkey

1. Introduction

The Eastern Pontides (KD Turkey) is one of the important areas where plutonic and volcanic rocks are commonly observed [1,2,11,12,3–10]. The Eastern Pontides comprise many plutons with a wide range of age varying from Permo-Carbonifer to Eocene, and the types of these plutons varies from gabbro to granite in the region (Figure 1).

These plutons intruded mainly at four different time period including Paleozoic, Jurassic, Cretaceous and Eocene (Figure 1). Paleozoic plutons intruded into the metamorphic rocks [13,14,23,15–22], Jurassic plutons intruded into the Early Jurassic volcano-sedimentary rocks [24–26], Cretaceous plutons intruded into the subduction-related volcanic rocks [4,9,11,27–32], Eocene and later plutons are intruded all former units [28,33–40].

Plutonic rocks in the region that included studied plutons were named as the Kaçkar Granitoid by [41]. The ages of these plutons have been considered Late Cretaceous or Eocene based on field observations [41]. Although there are many studies with mine geology in the region [41], the detail studies outside of the geological map was not performed in the plutons. In this study, the mineralogical and petrographic properties of the Beytarla-Kazıkbeli, Taşbaşı and Yaylaköy-Söğüteli Plutons in the south of Giresun were revealed.

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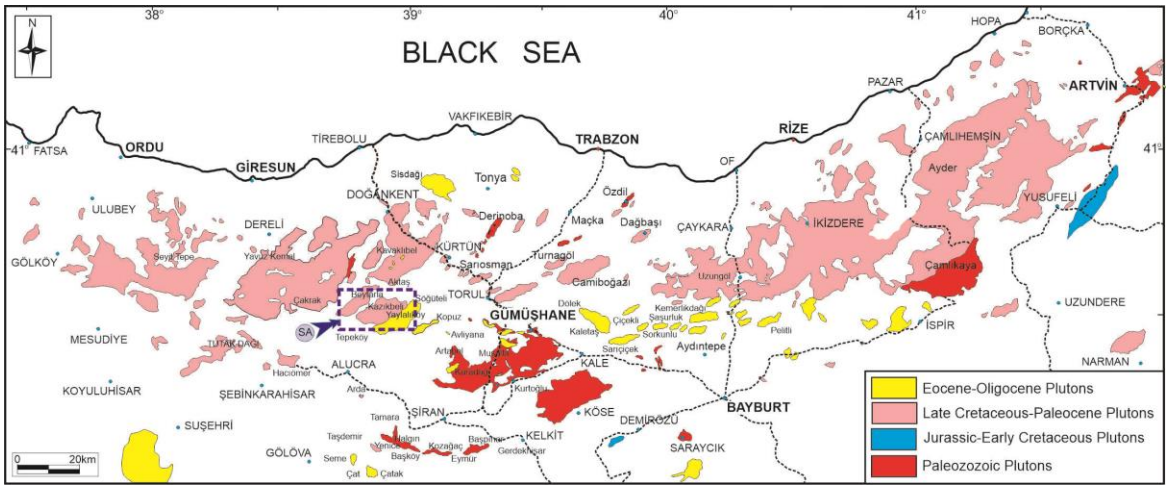

Figure 1: Geologic map showing distribution of Paleozoic to Oligocene plutons in the Eastern Pontides (SA: Study area) (modified from [23,41])

2. Regional Geology and Geological Setting

The Pre-Late Cretaceous units of the Eastern Pontides consist of Early Carboniferous metamorphic rocks [42] and Late to Early Carboniferous Plutonic rocks [15,17–20,22,43], Early and Middle Jurassic volcano-sedimentary rocks [44–47], Mid to Late Jurassic plutonic rocks [21,24,48] and Late Jurassic to Early Cretaceous carbonates [49]. The Late Cretaceous units that unconformably overlie Late Jurassic to Early Cretaceous carbonate rocks consist of plutonic, volcanic and sedimentary rocks [5,27,30,32,50–53] and overlain by the Cenozoic units consisting of volcanic, plutonic and sedimentary rocks [8,34,59–61,36,37,39,54–58]. The youngest units in the region are Quaternary alluvium and terraces.

The study area located in the north zone of the Eastern Pontides and is generally dominated by volcanic, plutonic and sedimentary rocks (Figure 1).

The oldest units in the study area form Early-Middle Jurassic Hamurkesen Formation. Late Jurassic-Early Cretaceous Berdiga Formation conformably overlies this formation. Late Cretaceous Çatak, Kızılkaya and Çağlayan Formations are conformably overlies the Berdiga Formation. All these units are cut by the Late Cretaceous plutonic rocks. Late Cretaceous-Paleocene Bakırköy Formation lies above of these units and undertaken the Eocene aged Kabaköy Formation. All these units are cut by the Eocene plutonic rocks. The youngest units of the study area form Quvaterner-aged alluviums.

The studied plutons are generally ellipse shaped and the long axes extend the northeast-southwest directions. Dimensions of these plutons change between 8 to 48 km^2. At the contacts with the wall-rocks, volcanic rocks and limestones have been transformed to metavolcanic rocks and crystallised limestone, respectivelly. The plutons contain large amounts of angular, partially rounded mafic magmatic enclaves (MMEs). The dimensions of these enclaves are ranging from 1 to 8 cm, and they are finer grained and darker than the host-rocks.

3. Analysis Methods

Scope of this work, a total of thirty-five samples were collected from the studied plutons in the fields. Thin sections of rock samples were made, and detailed petrographic properties were determined under polarizing microscope. Modal analyses were made from the unaltered samples for determine the rock types of the samples. The modal mineralogy of seventy-nine samples was determined by point counting with a swift automatic counter. On each thin-section a total of 1200–1400 points were counted, and modes were normalized to 100%.

4. Results

4.1. Petrography of Plutons

The general mineralogic and petrographic properties of the studied plutonic rocks are given in Table 1 and also QAP diagram based on modal analysis shown in Figure 2.

Table 1. General mineralogic and petrographic characteristics of studied plutonic rocks

Pluton	Kazıkbeli-Beytarla (n=39)	Taşbaşı (n=10)	Yaylaköy-Söğüteli (n=30)
Rock unit	gbrdi, di, to, gd, mg	gd	gd, mg
Texture	granular, poikilitic, monzonitic, graphic, micrographic, myrmekitic, porphyric	granular, myrmekitic, micrographic, poikilitic, porphyric	granular, myrmekitic, poikilitic, monzonitic, graphic, micrographic, porphyric
Grain size	fine to moderate	fine to moderate	fine to moderate
Modal min (%)	min-max	min-max	min-max
Plagioclase	26-80	39-59	25-54
Quartz	2-37	18-26	18-37
Ortoclase	3-30	10-19	16-40
Amphibole	1-21	3-15	1-15
Biotite	1-9	3-9	1-10
Opaque minerals	1-6	1-4	1-4
Accessory minerals	zircon, apatite, sphene, allanite	zircon, apatite	apatite, zircon, sphene
Secondary minerals	sericite, clay minerals, chlorite, epidote, calcite	sericite, clay minerals, calcite, chlorite,	chlorite, sericite, clay minerals, calcite,
gd: granodiorite, di: diorite, mg: monzogranite, gbrdi: gabbrodiorite, to: tonalite, n: number of samples			

The rocks of the Kazıkbeli-Beytarla Pluton are monzogranite, granodiorite, tonalite, quartz diorite and diorite in compositions in the modal QAP diagram [62] (Figure 2). Monzogranites and granodiorites are seen in the center of the pluton, while the diorites are found in the margin regions. The spread of diorites are less.

The rocks of the Taşbaşı Pluton are granodiorite in composition in the modal QAP diagram (Figure 2).

The rocks of the Yaylaköy-Söğüteli Pluton are granodiorite and monzogranite in composition in the modal QAP diagram (Figure 2). Monzogranites are seen in the center of the pluton, while the granodioritites are found in the margin regions. The spread of monzogranites are less.

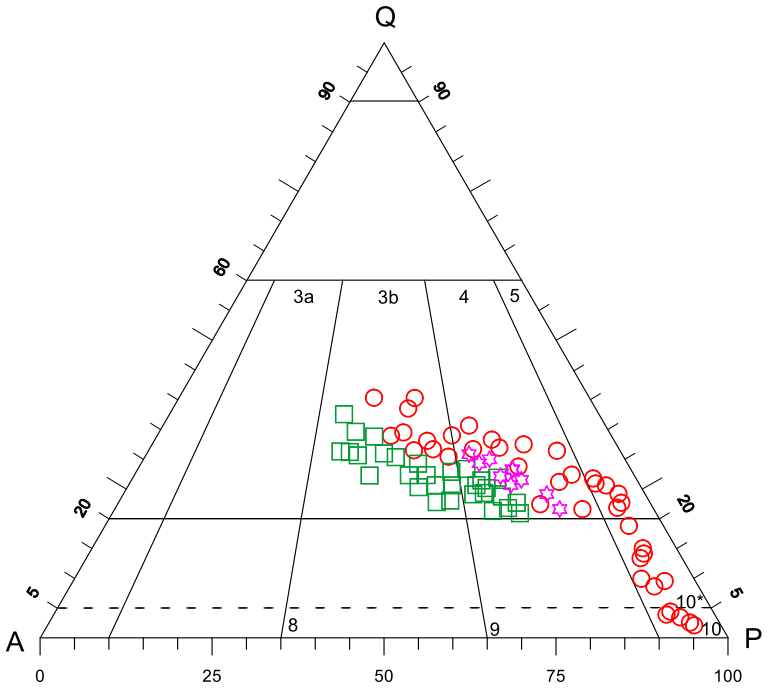

Figure 2. Location of rock samples from the studied plutons on QAP diagram [62]

In the microscopic studies from the rocks of the plutons, they generally show fine to medium-grained, monzonitic, poikilitic, porphyric, occasionally myrmekitic, micrographic and graphic textures (Figure 3). The main minerals are composed of plagioclase, K-feldspar, quartz, amphibole, biotite and opaque minerals. Zircon, sphene and apatite comprise accessory minerals. The most common secondary mineral phases form sericite, chlorite, calcite, clay minerals and epidote.

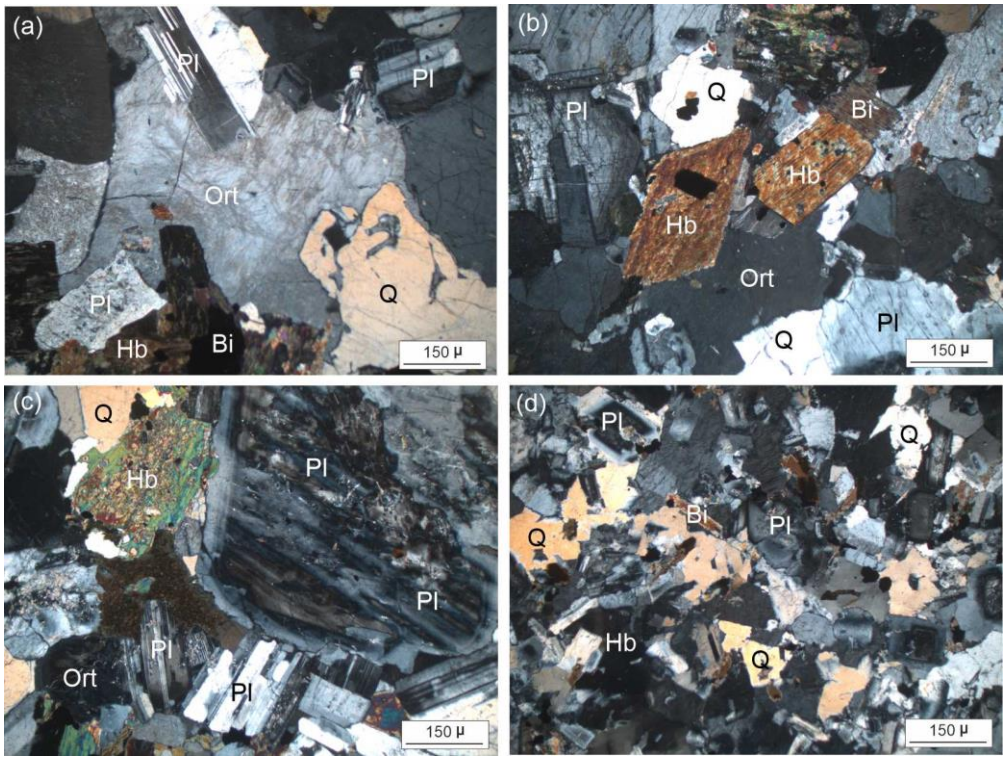

Figure 3. Microscopic features of rocks from the studied plutons (a) monzogranite, (b) granodiorite, (c) diorite, and (d) tonalite (crossed polars, Q: quartz, Pl: plagioclase, Ort: orthoclase, Bi: biotite, Hb: hornblende)

Plagioclase's form subhedral and euhedral laminated prismatic crystals. Large plagioclase crystals contain small opaque mineral and amphibole inclusions. They have albite and albite-carlsbad twins. Zoned plagioclase crystals generally have oscillatory zoning and occasional sieve texture (Figure 3). Some large minerals are fractured and partially sericitised. Placioclasses are found as 26 to 80% (modal) on the studied plutonic rocks, and at the highest rate of Kazıkbeli-Beytarla Pluton, and at the lowest rate of the Yaylaköy-Söğüteli Pluton (Table 1). K-feldispars are generally anhedral with both large and small crystals (Figure 3). Perthitic textures are generally observed, and the carlsbad twins are observed in some minerals. The poikilitic textured contains small plagioclasse, biotite and opaque mineral inclusions (Figure 3). Some minerals are fractured and partly argillised. K-feldispars are found as 3 to 40% (modal) on the studied plutonic rocks, and at the highest rate of Kazıkbeli-Beytarla Pluton, and at the lowest rate of the Taşbaşı Pluton (Table 1). Quartz comprises small and large anhedral crtstals, and has filled the spaces between the other minerals. There is a wavy extinction in some minerals. It has usually fractured and broken structures. Quartz is found as 2 to 37% (modal) on the rocks, and at the highest rate of the Yaylaköy-Söğüteli Pluton, and at the lowest rate of the Kazıkbeli-Beytarla Pluton (Table 1). Amphiboles are subhedral and euhedral large laminated and small crystals. Some examples are separated by calcite and actinolite. Some minerals decompose to the calcite and some of the other examples transformed to the actinolite. Amphiboles are found as 1 to 21% (modal) on the rocks, and at the highest rate of the Kazıkbeli-Beytarla Pluton, and at the lowest rate of the Taşbaşı Pluton (Table 1). Biotites appears as subhedral and euhedral rod-like prismatic crystals. The poikilitic textured minerals include smaller opaque minerals and plagioclase (Figure 3). In some sections, especially in zone transitions, chloritization has been observed. Biotites are found as 1 to 10% (modal) on the studied rocks, and at the highest rate of the Yaylaköy-Söğüteli Pluton, and at the lowest rate of the Taşbaşı Pluton (Table 1). Apatites are generally needle-like and found in feldspar and quartz as inclusions. Zircons are seen as small euhedral prismatic crystals. Opaque minerals are found as subhedral and euhedral both small and large crystals. They are found as 1 to 6% (modal) on the studied rocks and at the highest rate of the Kazıkbeli-Beytarla Pluton (Table 1).

4.2. Emplacement Conditions of Plutons

The Eastern Pontides have been under a compressional regime dominated by nearly N-S orientation especially since the beginning of the Mesozoic. The NW-SE and NE-SW oriented fracture systems developed related to this compressional regime. In general, the long axis of most plutons in the Eastern Pontides shows good agreement with these main fracture orientations (NE-SW, NW-SE). The correlation of pluton emplacement with main fracture lines was first determined by [63]. New studies in the region clarifying these correlations [9,11,18,64,65]. It seems therefore likely that the studied plutons emplaced parallel to the NE-SW oriented fracture lines.

The shapes of the studied plutons are elliptical. They have predominantly sharp and discordant contacts with wall-rocks and have finer-grained contact facies with these rocks. At the contacts with wall-rocks, granophyritic and porphyritic textures are observed. In addition, the plutons contain abundant country rock xenoliths at the endocontact. All these features indicate that the studied plutons emplaced into the shallow crustal depths.

5. Conclusions

The studied plutons generally have NE-SW orientation. The sizes of the plutons vary from 8 to 48 km^2 with the smallest Taşbaşı Pluton (8 km^2) and the largest Kazıkbeli-Beytarla Pluton (48 km^2).

The studied plutons do not have a uniform composition, and the compositions ranges from gabbroic diorite to monzogranite. The main minerals consist of quartz, plagioclase, K-feldspar, biotite, amphibole and Fe-Ti oxides. Fine to moderate granular, monzonitic, poikilitic, porphyric, micrographic, graphic and myrmekitic textures are common in the studied plutonic rocks.

The shapes of plutons, the contact relationship with the wall rocks, xenoliths contents and some textural features indicated that the studied plutonic rocks were emplaced at shallow depths of the crust.

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