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Research Article

Petrography and Textural Characteristics of Late Cretaceous Orbicular Gabbro West of Elazığ (Turkey)

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Abstract – The lithological units outcropping in the study area are located in the Southeast Anatolian Orogenic Belt, one of the most important parts of the Alpine-Himalayan Orogenic Belt. The units of the study area are Middle Devonian-Lower Cretaceous Keban Metamorphics, Upper Cretaceous Elazığ Magmatics, Upper Maastrichtian-Paleocene Seske Formation, Middle Eocene-Upper Oligocene Kırkgeçit Formation and Quaternary cover units. The study area crops out in a local area within the Hısırık creek in the north of Sarıgül village of Baskil county, which is located in the west of Elazig province in Southeast Turkey. Elazig magmatic complex contains plutonic and sub-volcanic rocks, mainly felsic and mafic compositions. Plutonic rocks with felsic composition include granite, granodiorite, tonalite and quartz monzonites, while sub-volcanic rocks include aplite. Plutonic rocks with mafic composition are represented by diorite, quartz diorite, gabbro and orbicular gabbro, and sub-volcanic rocks are represented by diabase and diorite porphyries. The orbicular gabbros contain orbicles ranging in size from 1 cm to 15 cm, formed by repetitive concentric circles of fine and coarse grains. All these orbicles consist of concentric circles that show magmatic textures both in macro specimens and under the microscope. Orbicular circles were formed by the crystallisation of basic magma in the form of a circular texture by conventional repetition as a result of adding a basic new magma that was later included in the magma chamber during the crystallisation of basic magma. Mineralogical and petrographic features suggest that the orbicular gabbro is part of mafic igneous enclaves within intrusive mafic rocks.

Keywords – Orbicular Gabbro, Late Cretaceous, Petrography, Mineralogy, Magma Mixing, Elazığ, Turkey

I. INTRODUCTION

The Southeast Anatolian Orogenic Belt (SAOB), one of the most complex parts of the Alpine-Himalayan system, is situated between the Anatolid/Tauride Platform and the Arabian Platform in Southeastern Anatolia. It extends from the Iskenderun Gulf in the west to the Turkey-Iran border in the east. The Anatolian orogeny formed in response to the subduction of the Paleo-Tethys and Neo-Tethys oceanic crusts [1-2]. The Southeastern Anatolian Orogenic Belt (SAOB) is the southernmost segment of the Anatolian orogeny that extends eastward to the Zagros Mountains of Iran [1]. In an east-west trending part of the Alpine-

Himalayan Orogenic Belt, Turkey presents various arc, collision and post-collision geological environments. Igneous rocks formed by subduction or collision are common in many tectonic environments. Such rocks are classified based on the amount of crust, mantle or mixture components involved during their petrogenesis. The origins and lithospheric evolution of igneous rocks have a very important place in understanding the geodynamic processes throughout the history of the world [3-5].

Orbicular gabbro, which is rarely seen in the world, was first announced by Schaller [6] based on the orbicular gabbro balls he encountered in the California region of the USA. The first occurrence of orbicular rocks in Turkey was reported by Yazgan and Mason [7] and later the existence of these rocks was mentioned by [8-9]. Orbicular rocks are rarely encountered in different parts of the world, such as the Sierra Nevada Batholith-Canada [10-11], Karamea, New Zealand [12].

II. Analytical Method

Twenty-five rock samples were collected from the orbicular gabbros studied within the scope of this study. Samples taken from the Orbicular gabbros, within the scope of petrographic studies, were cut in 0.5x2x4 cm dimensions in Fırat University, Department of Geological Engineering, Thin Section Laboratory, and glued on 2.5x4.5 cm glass after one surface was smoothed (25 units of Epoxy resin, three units of mixed with epoxy hardener). After the glued rock piece was cut to approximately 0.5 mm, it was thinned to a thickness of 0.025 mm with the help of abrasives and was prepared for petrographic examinations.

III. Geological Setting

The study area is tectonically located west of the Baskil region in the Tauride block (Figure 1). Units outcropping in the study area are Paleozoic-Mesozoic Keban metamorphics, Late Cretaceous Elazığ magmatic complex, Upper Maastrichtian-Thanetian Seske formation, Middle Eocene-Upper Oligocene Kırkgeçit formation. It includes the formation and Quaternary units (Figure 2).

Palaeozoic-Mesozoic Keban metamorphics constitute the basement rocks in the study area. The unit is generally represented by calcschists and marbles [13-15]. Keban Metamorphics have an intrusive relationship with Upper Cretaceous Elazığ Magmatic Rocks, generally tectonic [7]. Keban magmatic rocks with A_1-type geochemical signatures modified by crustal melts represented by syenite and quartz monzonite intruding into the Keban metamorphic complex [15].

The Late Cretaceous Elazig magmatic complex is observed in two groups as mafic and felsic compositions [15-19]. Mafic plutonic rocks are represented by quartz diorite, diorite, gabbro and orbicular gabbro and felsic plutonic rocks are represented by granite, granodiorite, tonalite. Orbicular gabbro crops out in a very local area in the study area (Figure 2). The orbicular gabbros macroscopically contain orbicles ranging from 1 cm to 15 cm, formed by repetitive concentric halos of fine and coarse grains. All these orbicles are concentric circles that show magmatic textures both in macro specimens and under the microscope.

The Upper Maastrichtian-Thanetian Seske Formation unconformably overlies the Elazig Magmatic Complex in the study area. At the top of the formation, it is overlain by the Middle Eocene-Upper Oligocene Kırkgeçit Formation [7]. The unit generally consists of medium-thick layers. Türkmen et al. (2001) determined the age of the unit as Upper Paleocene-Lower Eocene based on benthic and planktic foraminifera they obtained from the unit.
Kırkgeçit Formation has a conglomerate, sandstone, limestone and marls lithology.

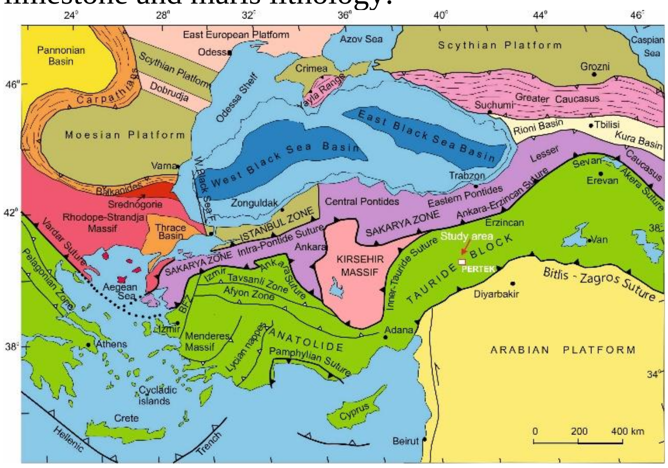

Fig. 1 Tectonic location of the study area [20].

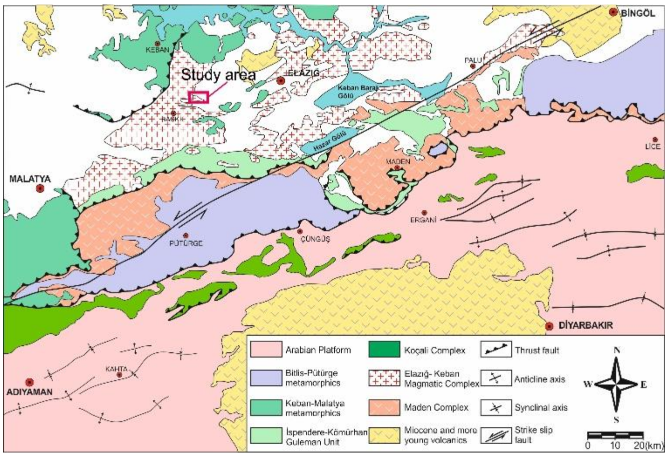

Fig. 2 Geological map of the study area [21]

IV. Petrography

Orbicular gabbro is frequently grey and displays thin to coarse-grained porphyritic holocrystalline textures. The felsic mineral assemblage is characterised by plagioclase, and the mafic mineral assemblage is dominated by olivine, pyroxene and opaque minerals.

Plagioclases show albite and polysynthetic twinning. They are observed as prismatic crystals. Some plagioclase crystals are altered into sericite. Olivines are characteristic of their colourless in single nicol, yellow, green, blue and orange interference colours in double Nicols and their abundant cracked structures.

Amphiboles have bidirectional cleavage in their hexagonal sections. They have pleochroism in shades ranging from light green to dark green in a single nicol. It shows interference colours in shades of orange and brown.

Pyroxenes have vibrant interference colours. In some pyroxene minerals, plagioclases form ophitic and sub-ophitic textures in the form of inclusions. This indicates magma mixing. As in macro samples, fine and coarse grains appear as concentric circles under the microscope (Figure 3).

Fig. 2 Field photos of the study area

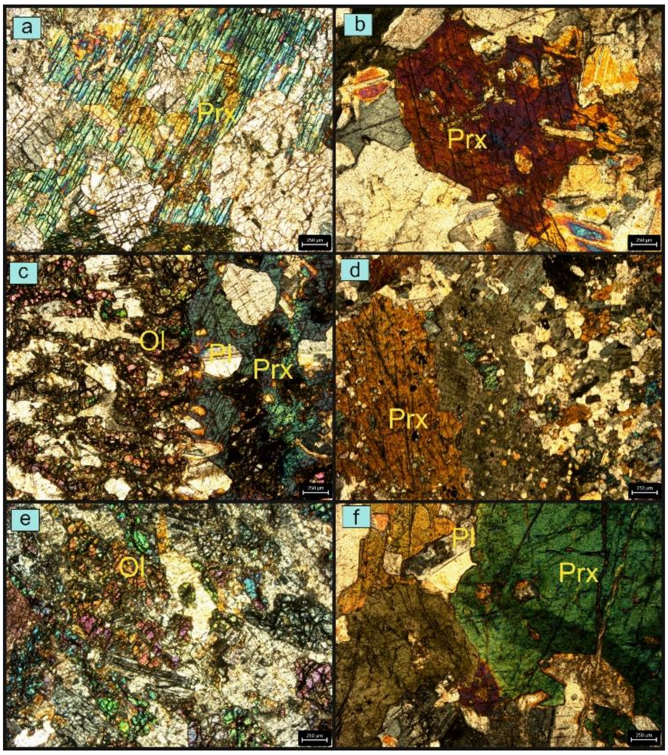

Fig. 3 Polarizing microscope images of orbicular gabbro. Abbreviations: (ol) olivine, (prx) pyroxene, (pl) plagioclases.

V. Discussion

Three stages of Elazığ magmatic complex can be recognised based on the order of formation and geochemistry: (1) a first stage of gabbro, quartz diorite, diorite, tonalite and; (2) a second stage of granite, granodiorite and quartz monzodiorite; and (3) a third stage of quartz monzonite and monzodiorite. Geochemical analyses show that the plütonic rocks are metaluminous I-types that vary in composition from tholeiitic to shoshonitic [18,22]. Orbicular gabbros, which are the subject of the study, were formed in the first stage.

Late Cretaceous Orbicular gabbros within the Elazığ magmatic complex crop out in a narrow area in the study area. In macro and micro samples, it has concentric circles, called orbicular, varying in the 1-15 cm range, formed by coarse and fine grains. Petrographically, it contains plagioclase, pyroxene, amphibole and olivine minerals. Plagioclase minerals found as inclusions in pyroxenes indicate that magma-mixing processes formed these rocks. Orbicular circles were formed by the crystallisation of basic magma in the form of a circular texture by conventional repetition as a result of adding a basic new magma that was later included in the magma chamber during the crystallisation of basic magma. Mineralogical and petrographic features suggest that the orbicular gabbro is part of mafic igneous enclaves within intrusive mafic rocks.

Some researchers suggested that the petrographic, petrologic and geochemical characteristics of the Late Cretaceous Elazığ magmatic complex of the Southeast Anatolian Orogenic Belt are similar to those of modern intra-oceanic arcs. There is a consensus that the rocks of the Elazığ magmatic complex formed in an island arc collisional setting as a result of subduction of the oceanic plate of the southern branch of the Neo-Tethys [18,22-23].

VI. Conclusion

Within the scope of this study, Late Cretaceous Orbicular gabbros were observed to be petrographically composed of pyroxene, plagioclase, amphibole and olivine minerals, and it is thought that fine and coarse-grained concentric rings were formed as a result of magma mixing processes.

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