

Petrology and Geochemistry of Chaleh Kaftar Granites, Northeast of Torud

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ABSTRACT

According to petrographic and geochemical studies on the Chaleh Kaftar granitoids in Torud, these granitoids have an alkaline composition range including feldspar granite, quartz monzonite, and syenite. The dominant texture of the region is granular. Rock samples are of calc-alkaline nature and are situated along the calc-alkaline series. The rocks in the region are enriched with large ion lithophile elements (LILE) such as Rb, K and Th. Elements with a high ionic strength or high field strength elements (HFSE) such as Ti, P, Nb show depletion, which is the characteristic of volcanic arc granites. Such granites are formed as a result of the processes associated with subduction zones. By moving from the left to the right of spider diagrams a negative slope is observed. The zigzag pattern of these diagrams also reflects the crustal contamination of these granites. Light rare earth elements are found to be richer than heavy rare earth elements in the region. These granitoids belong to active continental margin arc environments.

Key words: Chaleh Kaftar, granular, calc-alkaline, volcanic arc, large ion lithophile elements.

INTRODUCTION

The study area is located in the northeast of Torud, 120 km of the south of Shahroud County, a suburb of Semnan Province. This area is located in a region with latitude of 35 to 36°N and longitude of 54 to 55°E. It is shown on the map of Troud (Fig. 1) at a scale of 1:250000. Moreover, considering the geological divisions of Iran, this region is situated in Central Iran. The best access to the region is provided by the Shahroud-Troud asphalt road.

Research Method and Objectives:

This objective was aimed to attain the following goals: 1) analysis of the petrography and the lithography of the region; 2) analyzing the geochemistry of the regional rocks and using them in the analysis of their formation; 3) determining the tectonomagmatic granitoid environment of the region. A total of 10 samples were dispatched to the SGS Laboratory in Canada for ICP analysis. There, GCD Kite Ispet was used to interpret

the geochemical information and determine the corresponding magma series.

Petrographic Description Alkaline feldspar granites

The major minerals in these rocks at the microscopic levels include orthose, pertite orthose, microcline, and quartz as well as plagioclase. These minerals are mostly shaped or semi-shaped. Phenocrysts normally include orthose and quartz and orthose is in the form of pertite at the microscopic level. The granular texture is among the main characteristics of these rocks, while other textures such as microcline and pertite textures are also found in these rocks. Another characteristic of these rocks is their high-temperature sub-magma construct shown as fractures filled with quartz and feldspar. These constructs are formed at the final phase of crystallization of magma in the presence of the remaining magma. They reflect allotropy of rocks at high temperatures (Bouchez *et al.*, 1992)

Quartz monzonite

These are fully crystallized coarse-grained to medium-grained rocks. They have granular texture along with perthite textures (Fig- 5). These rocks are rich with iron and magnesium ores lying in a fully broken down alkaline feldspar texture. The largest part of the ores forming these rocks is formed of plagioclase and amphibole (mainly green longhorn). The epidote in these rocks includes zoisites and clinozoisites (Fig - 6). These rocks have experienced a wide range of production chlorite and epidote. Considering the presence of considerable amounts of minerals such as the chlorite, epidote, calcite, and sericite, it is concluded that these rocks have experienced the pressure temperature metamorphism at the greenschist facies. Quartz,

plagioclase, orthose, and biotite are among the major minerals forming these rocks while zircon, apatite, rutile, allanite, and opaque are among the minor minerals found in these rocks.

Geochemistry

In the rating diagram (O’connor,1965) samples are of the following types: granite, granodiorite, and trondhjemite (Fig- 7). According to the silica-alkaline series diagrams (Middlemost,1994) (Middlemost,1985) the rock samples under study were of the following types: granite, gabbro, gabbro diorite, monzodiorite, syenite, alkaline feldspar granite, quartz monzonite and quartz diorite (Fig- 8 &9).



Fig. 1: The position of the study area in the 1:250000 map of Torud

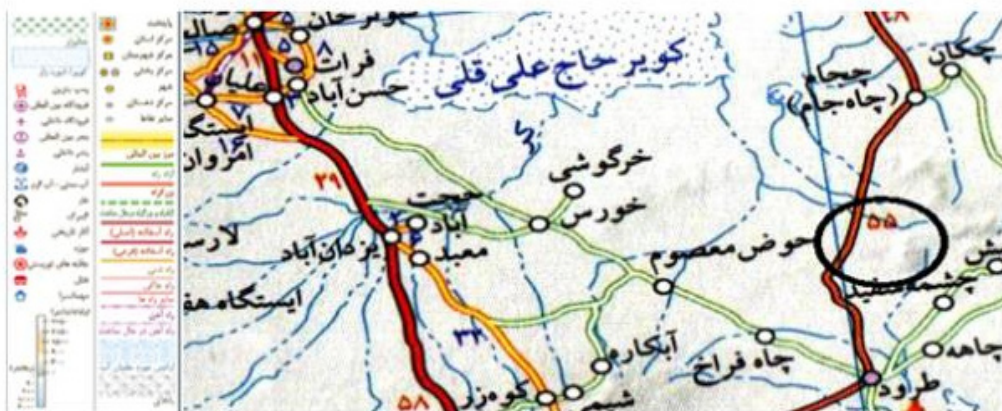


Fig. 2: Accesses to the study area

In granites, with an increase in SiO_2 , the content of Al_2O_3 is reduced. This is consistent with increased differentiation, a reduction in mafic minerals, an increase in the sodicity of plagioclase. In granites, with an increase with felsic minerals, the amount of ferromagnesian minerals such as biotite and opaque minerals (such as magnetite) reduces. As a result, the content of FeO_t also reduces. Moreover, variation of CaO versus SiO_2 reduces in granites due to partial crystallization, plagioclase differentiation and an increase in the sodicity of plagioclase. The trend of K_2O versus SiO_2 also demonstrates diffusion. The alteration of feldspars and plagioclases in the study samples explains this scattering trend. On the other hand, the richness of some granites with alkaline feldspars and biotite and

the lack of such minerals in some samples are also other reasons. Variations of MgO were descending while with an increase in SiO_2 the amount of MgO also reduces. The reason is the consumption of magnesium in the structure of minerals such as longhorn and biotite. This is also consistent with a reduction in the amount of mafic minerals (such as biotite) and an increase in the differentiation of granite rocks. The low levels of MnO in granites are also consistent with a reduction in ferromagnesian minerals and their differentiation. Variations of Na_2O against SiO_2 show a small degree of diffusion which can be either the result of alteration of study samples or the result of contamination of the magma forming the rocks. The trend of variations of P_2O_5 versus SiO_2 was descending which can be ascribed to be

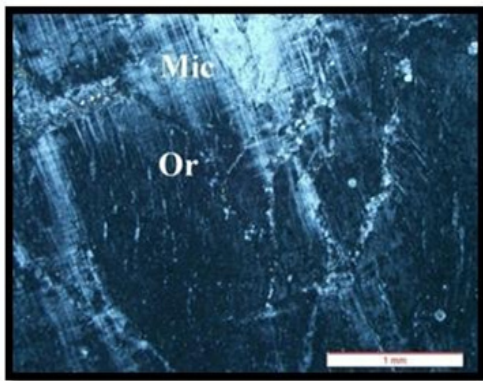


Fig. 3: Image of the transformation of orthose to microcline under XPL light

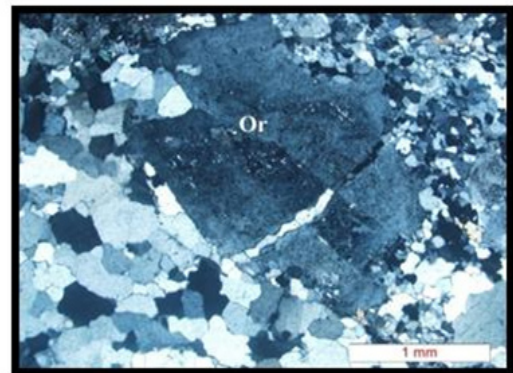


Fig. 4: Construction of sub-magma in the crystallization of orthose; fractures of filled with quartz (XPL)

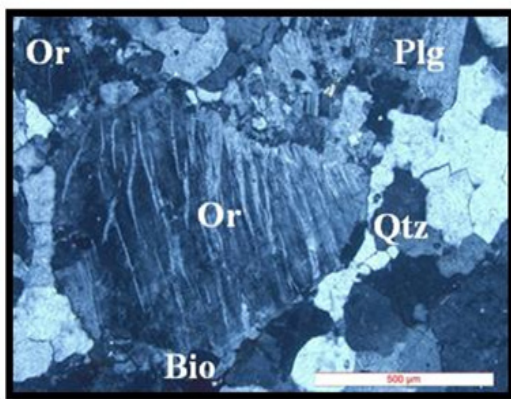


Fig. 5: Pertite texture in quartz monzonite (XPL)

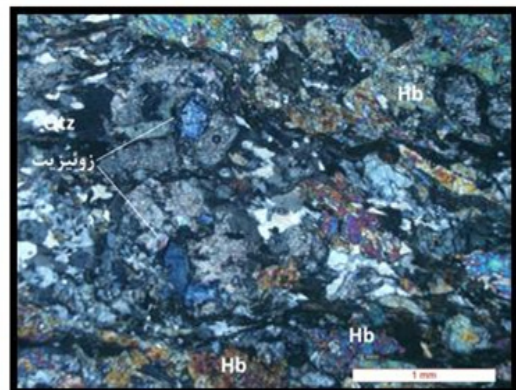


Fig. 6: The presence of zoisites in quartz monzonite (XPL)

reduction in the amount of apatite and its share of the structure of this mineral in differentiated rocks. The amount of TiO₂ reduces with an increase in SiO₂. In granites, with an increase in differentiation and a reduction in minerals such as biotite and titanite the amount of titanium also decreases.

Spider diagram normalized to chondrite

In this diagram (Fig. 11) light rare earth elements are demonstrated versus heavy rare earth elements. In addition, granites in the region are richer with LREE than microdiorites. This can be ascribed to the presence of zircon, biotite, and apatite in the granites. Moreover, a higher level of LREE compared to HREE is the characteristic of the magmatism of the subduction zone (Winter,2001).The granodiorite

samples under study, show more positive anomaly compared to granite rocks which can be ascribed to their higher plagioclase contents (Rollinson,19939). The lack of Eu anomaly indicates that plagioclase crystallization does not play a significant role in the evolution of magma. It also indicates that crystallization and differentiation of plagioclase had taken place in low-pressure conditions.

Multi-element spider diagrams normalized to MORB

The rocks in the region are enriched with large ion lithophile elements (LILE) such as Rb, K and Th. On the other hand, high field strength elements (HFSE) such as Ti, P, and Nb demonstrate depletion. Sr is an element that is fully compliant with

○	G7
+	G2
▲	GR7
✱	GR2
■	L1
△	G1
◆	GR8
◇	G4
⊠	GR1
⊕	GR5

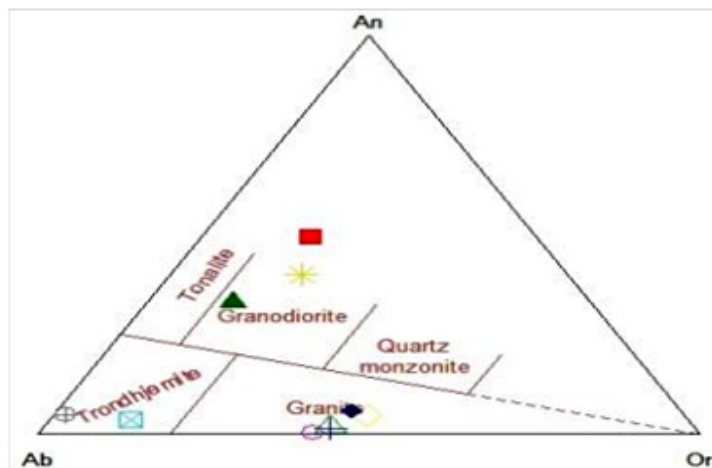


Fig. 7: Normative rating [2]

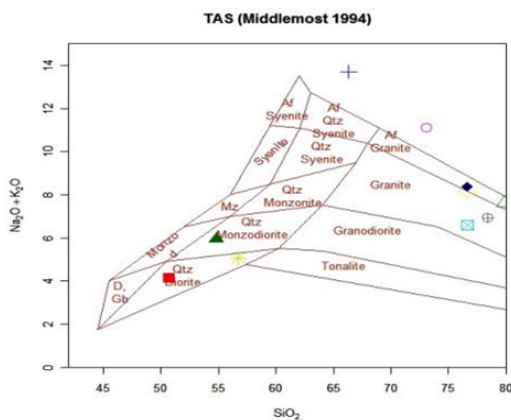


Fig. 8: Alkaline series versus SiO₂ diagram

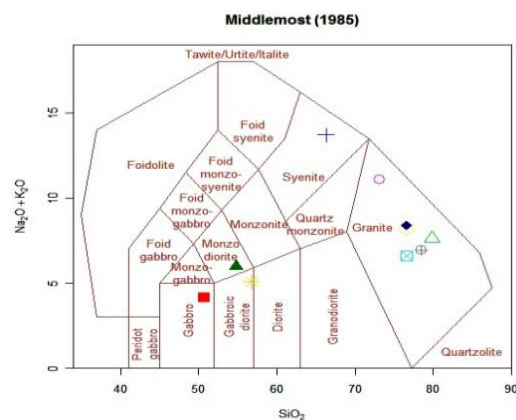


Fig. 9: Alkaline series versus SiO₂ diagram

plagioclase. Therefore, strong depletion of Sr in this diagram shows the stable phase of plagioclase in the remaining liquid (Fig. 12). By moving from the left to the right of spider diagrams a negative slope

is observed. The zigzag pattern of these diagrams also reflects the crustal contamination of these granites(Wilson,1989).

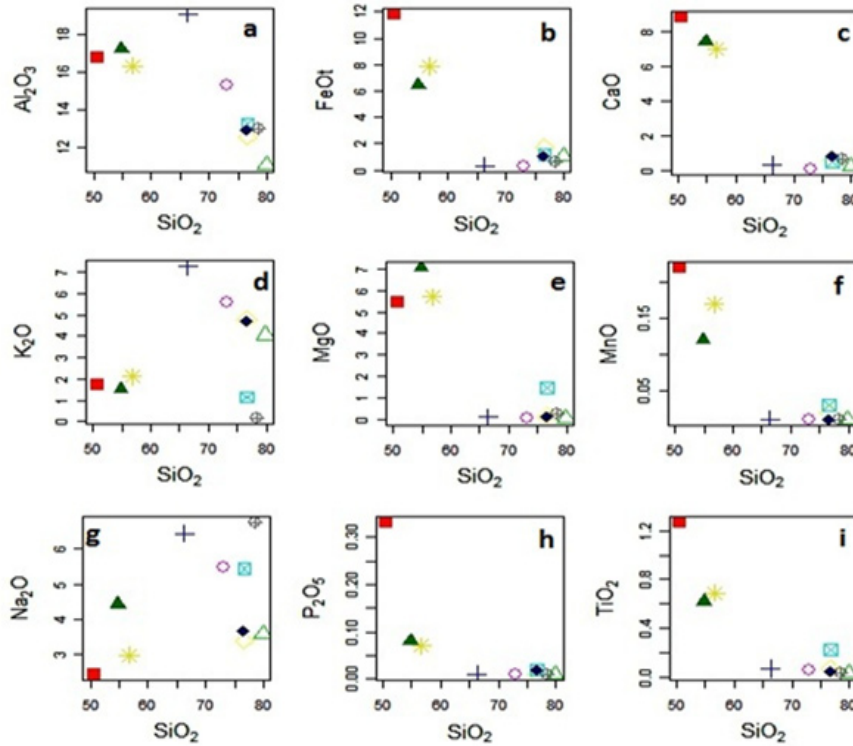


Fig. 10: (Harker, 1909) diagrams for the samples of the region

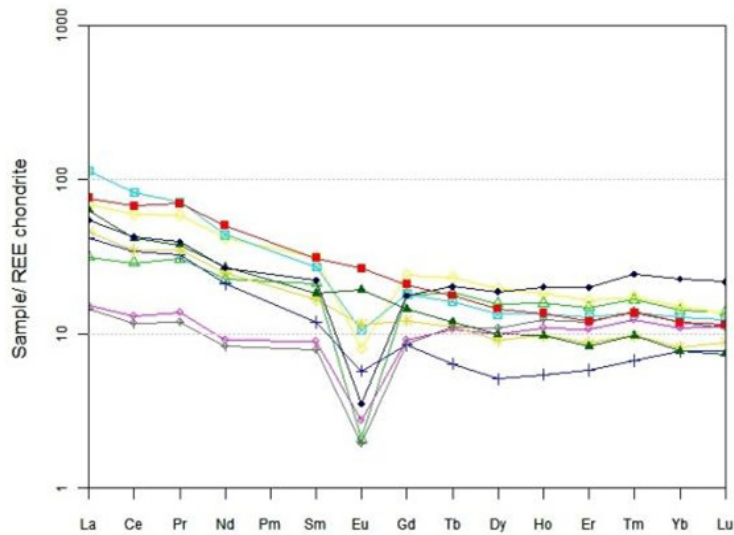


Fig. 11: Spider diagram (REE) normalized to chondrite [9]

Determining Magma Series

According to the Na_2O+K_2O versus SiO_2 (Irvine *et al.*,1971) diagram, felsic samples fall in the sub-alkaline range. Moreover, based on the AFM triangular diagram (Irvine *et al.*,1971) almost all of the rock samples have calc-alkaline nature and come along the calc-alkaline series. Moreover, according to the K_2O versus SiO_2 diagram (Peccerillo *et al.*,1976) the granites under study fall in the calc-alkaline range and have a high potassium content.

Determining the tectonic diagrams using rare earth elements

According to the (Pearce *et al.*,1984) diagrams obtained based on the variations of rare elements (Y, Nb, Rb, Yb, Ta), granitoids in the Chaleh Kaftar region are in the range of VAG with syn-COLG granites (simultaneously with collision). They are located on the subduction of oceanic plate into the continental plate.

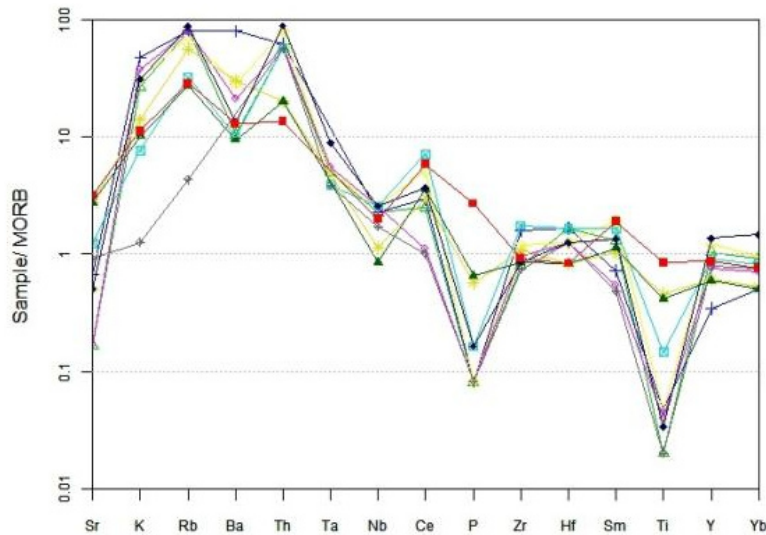


Fig. 12: Spider diagram normalized to MORB [10]

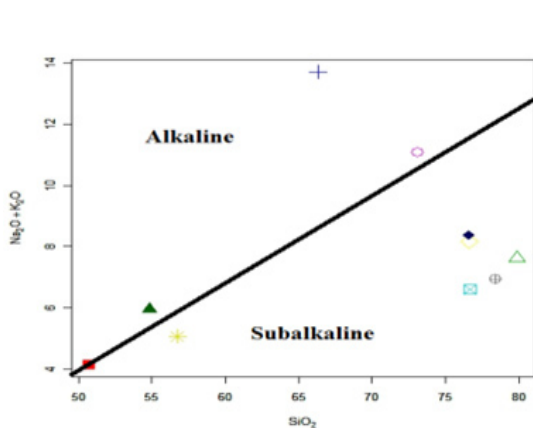


Fig. 13: Na_2O+K_2O versus SiO_2 diagram (Irvine *et al.*,1971)

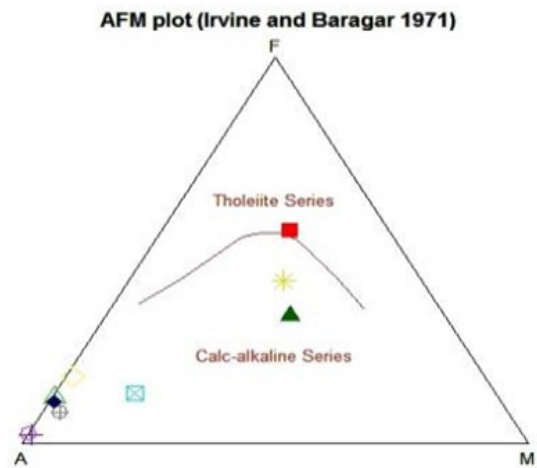


Fig. 14: AFM diagram (Irvine *et al.*,1971)

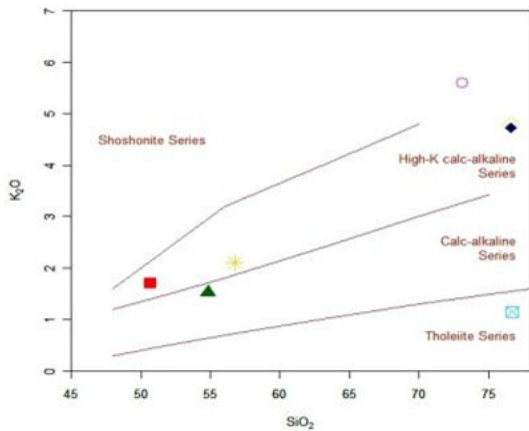


Fig. 15: Magma series diagram (Peccerillo *et al.*, 1976)

CONCLUSION

The lithology of the Chaleh Kaftar granites in Torud region includes alkaline feldspar granite, quartz monzonite, and syenite. These rocks have granular texture and have high-temperature sub-magma constructs. These constructs are in the form of fractures filled with quartz and are rarely in the form of feldspar. Alkaline feldspars are normally of orthose kind and perthite texture is their most important characteristic. These rocks are of calc-alkaline nature with high potassium contents. The rocks in the elements are enriched with large ion lithophile elements (LILE) such as Rb, K and Th. Elements with a high ionic strength or high field strength elements (HFSE) such as Ti, P, Nb show

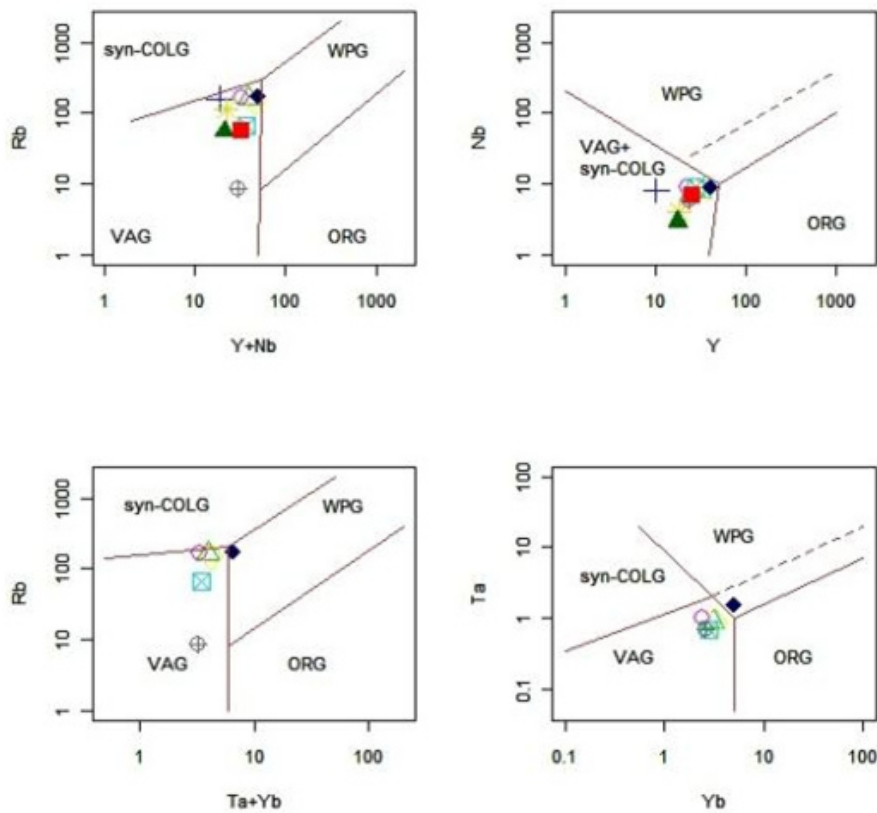


Fig. 16: Diagrams of separation of tectonic environment of granitoids (1984) Pearce *et al.* (1984).

depletion, which is the characteristic of volcanic arc granites. Such granites are formed as a result of the processes associated with subduction zones. By moving from the left to the right of spider diagrams a negative slope is observed. The zigzag

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