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Research Article

PETROLOGICAL CHARACTERISTICS OF PLUTONIC ROCKS IN THE KO'HITANG RANGE (SOUTHWESTERN SPURS OF THE HISSAR MOUNTAIN RANGE)

K.M. Ileshov[1], A.A. Qurbonov[2]
[1]Kh.M. Abdullayev Institute of Geology and Geophysics (Tashkent, Uzbekistan)
[2]University of Geological Sciences (Tashkent, Uzbekistan)
**Author for Correspondence: quanishbekileshov@gmail.com*

ABSTRACT
This article presents data on the petrological characteristics of magmatic complexes distributed within the Ko'hitang mountain range. Morphologically, the intrusion has the form of a large oval-shaped stock; its exposed (outcropping) surface occupies an area of 145 km² and is elongated in a northeasterly direction. The composition of the complex (from oldest to youngest) is as follows: 1) medium-grained pyroxene-amphibole leucocratic, melanocratic, and mesocratic gabbros; 2) medium- to coarse-grained, locally weakly porphyritic amphibole-bearing biotite granites (main phase) and alaskites; 3) fine- to medium-grained porphyritic biotite granites; 4) fine, medium, and uneven-grained porphyritic biotite granites; 5) phenocryst-rich biotite granite porphyries; 6) sparsely porphyritic biotite granite porphyries. The vein rocks consist of aplites, pegmatites, aplitic granites, and leucogranites. The absolute age of the Zarabog complex (using the K-Ar method) is 311–288 Ma for amphiboles and 273–252 Ma for biotites. The dykes comprise the following petrographic types: gabbro-diabases, diabases, diorite porphyrites, quartz diorite porphyrites, lamprophyres, granodiorite porphyries, granite porphyries, rhyolites, etc. Almost all dykes are calc-alkaline rocks belonging to the potassic and potassic-sodic series.

Keywords: *Gabbro, Granite, Leucogranite, Ko'hitang, Intrusive, Plagioclase, Quartz, Hissar Mountains*

INTRODUCTION

In recent years, world practice has increasingly emphasized the study of magmatic and metasomatic formations in individual areas to forecast precious- and rare-metal deposits and develop modern scientific foundations for ore formation. In developed countries, the results of research aimed at determining the petrological-geochemical characteristics of these formations serve as an important source of information for solving a number of problems, such as their formation conditions and their role in the formation of mineral deposits.

The problems of the relationship of magmatic formations of various compositions and ages to mineralization—including "magmatic processes and mineralization," "dyke and mineralization," and "mineralization associated with granitoid intrusions"—were among the first to be raised in our Republic by H.M. Abdullayev [1, 2, 4]. Academician D.S. Belyankin characterized Abdullayev's monograph "Mineralization associated with granitoid intrusions," which concerns the genetic relationship between granitoids and ores, as devoted to one of the most important geological problems of the century. Before H.M. Abdullayev, although magmatism and mineralization are among the fundamental roots of interconnected processes, in most cases, they were studied separately. From the middle of the last century, many researchers—I.H. Hamraboyev, N.P. Petrov, H.N. Boymuxamedov, A.F. Sosedko, V.M. Jeleznov, V.F. Popov, X.R. Raxmatullayev, I.V. Shvey, V.V. Baranov, A.V. Tolokonikov, Yu.F. Baskakov, E.P. Izox, Z.A. Yudalevich, I.V. Mushkin, T.Sh. Shoyaqubov, T.N. Dolimov, and others [1, 2, 3, 4, 5, 14, 15]—conducted scientific investigations on the subject of magmatism, and their results are reflected in numerous monographs, major scientific collections, articles, and theses. Although a solution to the problem was found to one degree or another in all of these works, certain issues still require more detailed investigation.

The geological study of the region in which the research was conducted has a long history, in which four stages can be distinguished, reflecting the consistent accumulation and refinement of data on the geology, petrology, and mineral resources of this area.
The main part of the study area is composed of intrusive rocks, consisting of granitoid bodies of various compositions and ages and dykes of diverse compositions. These magmatic formations in the Koʻhitang mountains have been studied over many years by I.H. Hamraboyev, I.M. Isamuhamedov, P.L. Kupchenko, N.M. Vasilevskiy, M.S. Sultonov, E.L. Izox, Z.A. Yudalevich, V.A. Arapov, I.V. Mushkin, T.N. Dalimov, V.A. Sharipov, V.V. Mixaylov, V.A. Xoxlov, A.V. Pokrovskiy, F.K. Divayev, R. Axundjanov, A.A. Qurbonov, K.M. Ileshov, and others [7, 8, 9, 10, 11, 13, 17, 18].

MATERIALS AND METHODS

In writing this article, a high-precision mass spectrometer (ICP-MS) and "Nikon ECLIPSE LV100N POL" microscopes were used. Under laboratory conditions, the results of the petrographic, mineralogical, petrochemical, and geochemical investigations were re-analyzed with the aid of computer software.
Geological structure. The Koʻhitang mountain range has an anticlinal structure belonging to the Alpine tectonic stage. Its central part comprises Middle Proterozoic–Upper Paleozoic intrusive, volcanic, and metamorphic formations. Up to 90% of the area consists of intrusive (Koʻhitang intrusion) rocks, while the limbs of the anticline comprise Triassic and Jurassic terrigenous and carbonate deposits.
Zarabog gabbro-granite complex. The main part of the rocks constituting this intrusion belongs to the Zarabog complex, which is distributed within the Boysun-Koʻhitang zone. This complex was named in 1984 by F.K. Divayev and others. The formation of rocks belonging to the complex was previously studied by N.P. Poddubniy (1959), I.M. Isamuhamedov (1962), Yu.I. Krasko (1970), V.P. Mushkin (1976), and V.N. Em (1978) [7, 8, 9].
The rocks belonging to the complex are located almost entirely on the southeastern slope of the Koʻhitang mountains, and they constitute the main part of the Koʻhitang intrusion. Morphologically, the intrusion has the form of a large oval-shaped stalk; its exposed surface occupies an area of 145 km² and is elongated in a northeasterly direction. They are enclosed by Precambrian gneisses, crystalline schists, quartzites, and others, as well as by the sedimentary-volcanogenic formations of the Lower Carboniferous Vakhshivar Suite. The composition of the complex (from oldest to youngest) is as follows: 1) medium-grained pyroxene-amphibole leucocratic, melanocratic, and mesocratic gabbros; 2) medium- to coarse-grained, locally weakly porphyritic amphibole-bearing biotite granites (main phase) and alaskites; 3) fine- to medium-grained porphyritic biotite granites; 4) fine-, medium-, and uneven-grained porphyritic biotite granites; 5) phenocryst-rich biotite granite porphyries; 6) sparsely porphyritic biotite granite porphyries; the vein rocks consist of aplites, pegmatites, aplitic granites, and leucogranites. The absolute age of the Zarabog complex (by the K-Ar method) is 311–288 Ma for amphiboles and 273–252 Ma for biotites [4, 6, 8, 9, 10, 11, 13].
Shalqon complex—identified in the Boysun-Koʻhitang zone in 1984 by F.K. Divayev and others. The rocks belonging to the complex were studied by N.P. Poddubniy (1959), N.P. Isamuhamedov (1962), A.Z. Yoʻldoshev (1965), V.M. Em (1978), A.Z. Yoʻldoshev and others (1980).
The complex is represented by the following succession of rocks (from oldest to youngest): 1) very fine- and fine-grained pyroxene-amphibole-biotite monzodiorites and quartz monzonites; 2) medium-grained amphibole-biotite adamellites; and 3) fine-grained porphyritic amphibole-biotite adamellites. Stage I of the vein facies: fine-grained porphyritic quartz monzodiorites, aplites, and pegmatites. Stage II of the vein facies consists of micromonzonites, monzonites, quartz monzonites, quartz micromonzodiorites, quartz monzodiorite porphyries, monzogranodiorite porphyries, adamellite porphyries, and granosyenite porphyries. The absolute age of the complex (amphibole, pyroxene, and biotite; K-Ar method) corresponds to the Early Permian (264–277 Ma).
Koʻhitang dolerite-lamprophyre-granitoid dyke complex—forms a large regional dyke belt and is widely distributed in the Boysuntov, Surxontov, and Koʻhitang mountains within the Sangardak, Xoʻjaipak,

Obizarang, Qizilolma, Zarabog, Vandob, and other river basins. The composition of the dykes is contrasting, and the Koʻhitang dyke belt is the archetype. According to B.F. Vasilevskiy (1968), the dykes are arranged according to a definite regularity, i.e., they form dyke belts, small stocks, and necks within submeridional fault zones.

The Koʻhitang dyke belt (20–30 km long, 0.5–1.5 km wide) forms two types of contrasting dykes along the axis of the northwestern contact of the intrusion of the same name: 1) gabbro-diabases, diabases, diabase porphyrites, and lamprophyres; 2) granite, rhyolite, spherulite-porphyries, rhyolites, trachyrhyolites, and granophyres. The acidic dykes predominate over the basic ones. The basic dikes occur in the Pashaxona river basin with a thickness of 2.5–4 m in the unmeridional and sublatitudinal directions. The acidic dykes occur in the unmeridional direction with thicknesses up to 10–15 m and consist of rhyolites, trachyrhyolites, spherulite porphyries, and granophyres. According to Yu.I. Krasko (1970), the rhyolite and granite-porphyry dykes are identical in composition and structure and belong to the vein facies of Lower Permian intrusive rocks.

South Tien Shan alkaline basaltoid complex. Distinguished and described by I.V. Mushkin (1973, 1977). This is a regional complex. A number of dikes related to it occur in almost all mountain structures of Western and Southern Uzbekistan. The dykes are elongated mainly in the unmeridional and northeasterly directions. Most are 0.5–2 m thick and range from several tens of meters up to 2 km in length. Along with small diatremes (explosion pipes) measuring from 20×15 m to 120×70 m, several explosion pipes occur in the territory of Uzbekistan, such as those in the North Bukantau (“Koʻksoy” group — the Koʻksoy pipes and others), the South Nurota range (the “Chagʻatoy” explosion pipe and the recently identified “Tusun” and “Qoratosh” pipes in the east), and the area of the Koʻhitang massif in the southwestern spurs of the Hissar range (the “Qizilolma” explosion pipe).

The material composition of the dykes and explosion pipes varied. These are characterized, on the one hand, by picrite porphyries, dolerites, analcime diabases, crinanites, teschenites, and olivine trachybasalts representing the potassic-sodic petrochemical series of the complex; and, on the other hand, by theralite porphyries, camptonites, camptospessartites, monchiquites, limburgites, camptovogesites, and trachybasalts.

Data on the absolute age of the rocks of the South Tien Shan complex (K-Ar method, amphiboles, and biotites) indicate a time interval from 200 to 275 Ma, with most measurements yielding 223–245 Ma. Within the region under study, dykes and several diatremes belonging to this complex are present.

Petrochemical characteristics. To determine the chemical composition of the intrusive rocks distributed in the Koʻhitang massif, the collected samples were chemically analyzed in the laboratory, and their petrochemical coefficients and normative composition were calculated. In order to determine the position of the intrusive rocks within the classification fields, the results of the chemical analyses were plotted on the TAS diagram (SiO_2–Na_2O+K_2O), and it was established that the magmatic rocks of the studied area are predominantly normal and subalkaline (Fig. 1). The gabbros of the Zarabog complex plot within the gabbro and gabbronorite fields of the TAS diagram. The medium- to coarse-grained biotite granites, alaskites, porphyritic fine-grained granites, biotite granite-porphyries, and leucogranite-porphyries that make up the main part of the

Zarabog complex occupy the very closely spaced fields of the normal-series granites, leucogranites, and low-alkali leucogranites on the TAS diagram.

The monzodiorite of the Shalqon complex are located in the monzogabbro field. The diabases of the Koʻhitang dyke complex plot in the gabbrodiorite field; its mesoplagioclase leucobasalts and diorite porphyrites plot in the diorite field; the quartz diorite porphyrites plot on the boundary between diorites and quartz-diorites; and the rhyolites occupy the low-alkali leucogranite field.

The olivine trachybasalts of the South Tien Shan dyke complex plot mainly in the subalkaline monzogabbroid field, the essexite porphyries in turn in the subalkaline monzogabbrodiorite and monzodiorite fields, the vogesites in the normal-series gabbrodiorite field, and the monchiquites in the diorite field on this diagram. In particular, the large number of xenoliths of oval, corroded-margin

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crystalline schists, pyroxenite-peridotites, granitoids, and other rocks present in the monchiquites indicates their enrichment in silica.

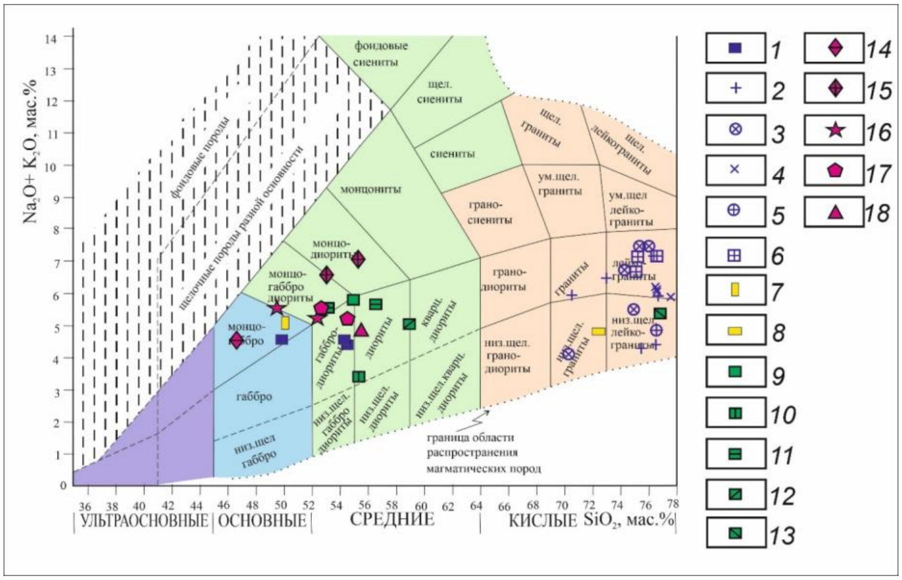

Fig. 1. Position of the composition of the magmatic rocks distributed in the Ko‘hitang massif on the TAS diagram (SiO_2–Na_2O+K_2O) (Sharpenok et al., 2013): 1—gabbro, 2—medium- to coarse-grained biotite granites, 3—alaskite, 4—porphyritic fine-grained granite, 5—biotite granite-porphyry, 6—leucogranite-porphyry, 7—monzodiorite, 8—quartz monzonite, 9—diabase, 10—mesoplagiophyric leucobasalt, 11—diorite porphyrite, 12—quartz diorite porphyrites, 13—rhyolite, 14—olivine trachybasalt, 15—olivine trachybasalt, 16—essexite-porphyry, 17—vogesite, 18—monchiquite.

The most important features of the petrochemical series are that they provide valuable information about the geodynamic genesis of the rocks, magma generation, differentiation, and the general nature of the magma. It was established that the gabbroids of the Zarabog complex, according to their degree of alkalinity, belong predominantly to the potassic series, while its granitoids belong to the potassic and potassic-sodic series (Fig. 2). The monzodiorites of the Shalqon complex belong to the potassic series, and the dykes of the Ko‘hitang and South Tien Shan dyke complexes are observed to plot close together within the potassic and potassic-sodic series fields on the K_2O–Na_2O diagram.

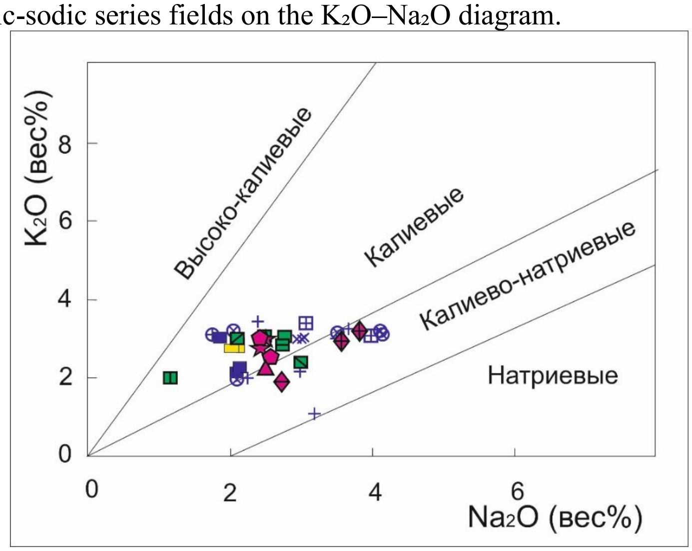

Fig. 2. Position of the magmatic rocks distributed in the Ko‘hitang massif on the K_2O–Na_2O diagram. For the legend, see Fig. 1.

In addition to the diagrams presented above, petrological studies employ various binary diagrams used to establish the petrogenesis of the magmatic melt. Among these, the Harker diagram is widely used. Here, the contents of the major petrogenic oxides were compared against silica.

Analysis of the distribution of the aluminum, iron, magnesium, titanium, potassium, calcium, and sodium oxides on the Harker diagram shows that the rocks distributed in the Koʻhitang massif lie along a single evolutionary trend. This indicates that the formation of these acidic magmatic rocks is associated with a single magmatic source. Very high alumina content is observed for the alumina coefficient — al′ (which indicates the relative proportion of the colored [mafic] and colorless [felsic] minerals in the rock) — in the gabbros of the Zarabog complex (al′ = 1.34–1.76), in the medium- to coarse-grained biotite granites (al′ = 3.18–7.31), in the alaskites (al′ = 4.33–6.16), in the porphyritic fine-grained granites (al′ = 5.17–5.61), and in the biotite granite-porphyries and leucogranite-porphyries (al′ = 4.18–5.01). The alumina coefficient increases from the monzodiorites (al′ = 1.16) toward the quartz monzonites (al′ = 3.29) of the Shalqon complex. The diabase and mesoplagiophyric leucobasalt dikes of the Koʻhitang dike complex (al′ = 1.32–1.40), the diorite porphyrites and quartz diorite porphyrites (al′ = 1.26–1.41), and the rhyolites (al′ = 4.90) and—for the South Tien Shan dike complex—the olivine trachybasalt and trachybasalt dikes (al′ = 0.95–1.56), essexite-porphyries (al′ = 1.04–1.28), vogesites (al′ = 1.30–1.49), and monchiquites (al′ = 1.04–1.28), taken as a whole, have moderate to high alumina coefficients.

The fractionation coefficient—Kf (which expresses the degree of differentiation of the magma during rock formation)—shows relatively high values in the gabbros of the Zarabog complex (58.23–69.63), in the medium- to coarse-grained biotite granites (43.55–71.78), in the alaskites (61.61–71.14), in the porphyritic fine-grained granites (61.55–64.27), and in the biotite granite-porphyries and leucogranite-porphyries (60.85–71.08). This coefficient increases from the monzodiorites (60.19) toward the quartz monzonites (68.43) of the Shalqon complex. The diabase and mesoplagiophyric leucobasalt dikes of the Koʻhitang dike complex (52.87–59.06), the diorite porphyrites and quartz diorite porphyrites (59.57–63.86), and the rhyolites (68.98) and—for the South Tien Shan dike complex—the olivine trachybasalt and trachybasalt dikes (54.36–67.54), essexite-porphyries (57.38–72.45), vogesites (64.54–65.61), and monchiquites (51.12) show the indicated fractionation coefficients. Thus, the fractionation coefficient increases from the basic rocks toward the acidic rocks.

In terms of normative mineralogical composition (by the CIPW method), almost all rocks — with the exception of a few analyses — are corundum-normative, which indicates that their source was formed within the Earth's crust.

CONCLUSION

As is evident from the data presented above, it was established that the medium- to coarse-grained biotite granites, alaskites, porphyritic fine-grained granites, biotite granite-porphyries, and leucogranite-porphyries that occupy the main part of the Zarabog complex are mainly potassic, while the granitoids belong to the potassic and potassic-sodic series. The Zarabog complex constitutes a compositionally contrasting petrochemical series. In the Koʻhitang massif, SiO_2 and a number of the petrogenic oxides of the rocks of the gabbro-granitoid complex lie along a single evolutionary trend. This indicates that the formation of these acidic magmatic rocks is associated with a single magmatic source. At the same time, the most widely distributed Koʻhitang diabase-granophyre dyke complex consists of contrasting dykes—such as diabase, mesoplagiophyric leucobasalt, diorite porphyrite, quartz diorite porphyrite of the normal and moderately alkaline series belonging to the high-potassium and potassic series, and acidic rhyolite. As separate small independent intrusions, the Koʻhitang diabase-granophyre dyke complex is specialized in phosphorus, gold, silver, polymetals, and rare-earth elements (REE). The basic dykes were formed not by differentiation of gabbroic magma, but by the local partial melting of rocks.

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