ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫНЫҢ
Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

# Х А Б А Р Л А Р Ы

# ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Казахский национальный исследовательский технический университет им. К. И. Сатпаева

# N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
Kazakh national research technical university named after K. I. Satpayev

## SERIES
## OF GEOLOGY AND TECHNICAL SCIENCES

**2 (434)**

**MARCH – APRIL 2019**

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

*NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.*

*Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.*

*НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.*

**«ҚР ҰҒА Хабарлары. Геология мен техникалық ғылымдар сериясы».**
**ISSN 2518-170X (Online),**
**ISSN 2224-5278 (Print)**
Меншіктенуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).
Қазақстан республикасының Мәдениет пен ақпарат министрлігінің Ақпарат және мұрағат комитетінде 30.04.2010 ж. берілген **№10892-Ж** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Мерзімділігі: жылына 6 рет.
Тиражы: 300 дана.

Редакцияның мекенжайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., 220, тел.: 272-13-19, 272-13-18,
http://www.geolog-technical.kz/index.php/en/

---



Редакцияның мекенжайы: Қазақстан, 050010, Алматы қ., Қабанбай батыра көш., 69а.
Қ. И. Сәтбаев атындағы геология ғылымдар институты, 334 бөлме. Тел.: 291-59-38.

Типографияның мекенжайы: «Аруна» ЖК, Алматы қ., Муратбаева көш., 75.

**«Известия НАН РК. Серия геологии и технических наук».**
**ISSN 2518-170X (Online),**
**ISSN 2224-5278 (Print)**
Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан (г. Алматы)
Свидетельство о постановке на учет периодического печатного издания в Комитете информации и архивов Министерства культуры и информации Республики Казахстан **№10892-Ж,** выданное 30.04.2010 г.

Периодичность: 6 раз в год
Тираж: 300 экземпляров

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, ком. 219, 220, тел.: 272-13-19, 272-13-18, http://nauka-nanrk.kz /geology-technical.kz



Адрес редакции: Казахстан, 050010, г. Алматы, ул. Кабанбай батыра, 69а.
Институт геологических наук им. К. И. Сатпаева, комната 334. Тел.: 291-59-38.

Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75

**News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.**
**ISSN 2518-170X (Online),**
**ISSN 2224-5278 (Print)**
Owner: RPA "National Academy of Sciences of the Republic of Kazakhstan" (Almaty)
The certificate of registration of a periodic printed publication in the Committee of information and archives of the Ministry of culture and information of the Republic of Kazakhstan N 10892-Ж, issued 30.04.2010

Periodicity: 6 times a year
Circulation: 300 copies

Editorial address: 28, Shevchenko str., of. 219, 220, Almaty, 050010, tel. 272-13-19, 272-13-18, http://nauka-nanrk.kz/geology-technical.kz

---



Editorial address: Institute of Geological Sciences named after K.I. Satpayev
69a, Kabanbai batyr str., of. 334, Almaty, 050010, Kazakhstan, tel.: 291-59-38.

Address of printing house: ST "Aruna", 75, Muratbayev str, Almaty

**N E W S**
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
**SERIES OF GEOLOGY AND TECHNICAL SCIENCES**
ISSN 2224-5278
Volume 2, Number 434 (2019), 150 – 158 **https://doi.org/10.32014/2019.2518-170X.49**

UDC 553.493.45(574)

**V. S. Portnov, A. N. Kopobayeva, A. Amangeldikyzy, N. S. Askarova**

Karagandy state technical university, KSTU, Karaganda, Kazakhstan.
E-mail: vs_portnov@mail.ru, aiman_25.87@mail.ru, amangeldykyzy@inbox.ru, srajadin-nazym@mail.ru

# THE DISTRIBUTION OF BERYLLIUM IN MAGMATIC ROCKS OF CENTRAL KAZAKHSTAN

**Abstract.** The paper presents clarks of beryllium in magmatic rocks of Central Kazakhstan. As well as the present work examines the patterns of distribution of Be to assess the possibility of using Be clarks in assessing the potential ore presence in geochemical anomalies in soils. The purpose of this work is to study the distribution of beryllium in magmatic rocks of Central Kazakhstan for establishing potentially beryllium ore-bearing geological formations. The paper compares the results of previous studies on the distribution of beryllium in magmatic rocks. The analysis of the distribution of beryllium in rocks of Central Kazakhstan is carried out according to the available data of regional clarks of beryllium.

**Keywords:** magmatic rocks, beryllium, Central Kazakhstan, volcanic rocks, plutonic rocks, distribution, clark, potential ore presence, soil.

**Introduction.** Let us consider the clarks of the earth's crust and the main groups of magmatic rocks. The distribution of beryllium and its clarks (g/t) in the earth's crust was examined by a number of researchers:

| | |
|---|---|
| Clark and Washington, factored in the hydrosphere (1921) | 10 |
| Goldschmidt V.M. (1932) | 1.8 |
| Fersman A.E., factored in the hydrosphere (1939) | 4 |
| Sandell E.B. (1952) | 2 |
| Beus A.A. (1955, 1967) | 3.5 |
| Vinogradov A.P. (1962) | 3.8 |

In geochemical processes, beryllium behaves like a typical lithophilic element, which, first of all, is confirmed by its distribution in various rocks. Table 1 shows data of different authors on determining the average content of beryllium in different groups of rocks. The work [1] lists clarks of 168 types of rocks of Central Kazakhstan, including magmatic, sedimentary and metamorphic rocks; following the purpose of this paper, a group of magmatic rocks will be considered.

7 types of rocks from table 2 (numbers of clarks 1, 2, 3, 5-8) were combined into a group of basalts and andesibasalts. For them, the same average beryllium content of 0.0001 % was obtained. 8 rocks from table 2 (clark numbers: 38-40, 42-46) were combined to a group of diorites and quartz diorites. All the rocks of the average composition, except for nepheline syenite, were involved in the calculation of Be clarks. Calculations of the average beryllium content by Sandell E.B. (1952) and Glukhan I.V., Serykh V.I. (1996) are close to each other and equal to 0.00016 % and 0.00022 % respectively. To determine the average beryllium content in acid rocks, clarks of only plutonic rocks were taken from table 2: (clark numbers in table 2 are as follows: 47-52, 55-60). The obtained values of the average Be content significantly vary from 0.00018 % [2] to 0.0007 % [3]. For granites, the average content of six rocks was calculated (Table 2, clark numbers: 55-60). Clark of beryllium, in granites themselves, varies from 0.00019 % [2] to 0.0006% (Beus and Fedorchuk, 1966). It should be noted that all K varieties of calc-alkaline and sub-alkaline rocks are richer in beryllium as compared to N and K-Na rocks. Be clark in nepheline syenites is high and varies from 0.0021 % (Glukhan I.V., Serykh V.I., 1996) to 0.0036 % (Goldschmidt and Peters, 1938).

Table 1 – Average content of beryllium in rocks, weight%

| | |
|---|---|
| **Ultrabasic rocks** | |
| Goldschmidt V.M, Peters K. (1938) | 0 |
| Sandell E.B. (1952) | 0.00002 |
| Vinogradov A.P. (1962) | 0.00002 |
| Glukhan I.V. and Serykh V.I. (1996) | 0.00004 |
| **Basalts and andesibasalts** | |
| Sandell E.B. (1952) | 0.0001 and less |
| Glukhan I.V., Serykh V.I. (1996) | 0.0001 |
| **Diorites and quartz diorites** | |
| Sandell E.B. (1952) | 0.00016 |
| Glukhan I.V., Serykh V.I. (1996) | 0.00022 |
| **Acidic rocks** | |
| Goldschmidt V.M., Peters K. (1938) | 0.00036 |
| Fersman A.E. (1940) | 0.0006 |
| Sandell E.B. and Goldic C.S. (1943) | 0.0007 |
| Vinogradov A.P. (1962) | 0.00055 |
| Glukhan IV, Serykh V.I. (1996) | 0.00018 |
| **Actually granites** | |
| Beus A.A. and Fedorchuk SN (1966) | 0.00038 |
| Granites hr. East Tannu-Ola (Tuva) | 0.00032 |
| Granites of the Prikhanka district (Primorye) | 0.0006 |
| Glukhan I.V., Serykh V.I. (1996) | 0.00019 |
| **Nepheline syenites** | |
| Rankama K. (1950) | 0.0036 |
| Glukhan I.V., Serykh V.I. (1996) | 0.0021 |

Table 2 – Clarks of beryllium (g/t) in magmatic rocks of Central Kazakhstan by [1, 2]

| N clark | Group of rocks | Magmatic rocks | Be, g/t |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| **Volcanic rocks** | | | |
| 1 | Basic | Tholeiitic basalt | 0.8 |
| 2 | | Basalt | 1.0 |
| 3 | | Trachybasalt | 1.1 |
| 4 | | Epileucite basalt | 8.4 |
| 5 | Intermedia-te -basic | Basaltic andesite | 1.1 |
| 6 | | Trachybasaltic andesite | 1.4 |
| 7 | | Latite (K-Na trachybasaltic andesite) | 1.8 |
| 8 | | K trachybasaltic andesite | 1.7 |
| 9 | | Epileucitic phonolite | 5.1 |
| 10 | | Andesite | 1.2 |
| 11 | | Na trachyandesite | 1.5 |
| 12 | | Quartz latite (K-Na trachyandesite) | 1.6 |
| 13 | | K trachyandesite | 1.8 |
| 14 | | Trachyte | 2.1 |
| 15 | Acid | Plagiodacite (Na dacite) | 1.2 |
| 16 | | Dacite (K-Na dacite) | 1.5 |
| 17 | | Na trachydacite | 1.5 |
| 18 | | K-Na trachydacite | 1.6 |
| 19 | | K trachydacite | 1.6 |
| 20 | | Plagio rhyodacite (Na rhyodacite) | 1.1 |
| 21 | | Rhyodacite (K-Na rhyodacite) | 1.6 |
| 22 | | K rhyodacite | 1.7 |
| 23 | | Na trachyrhyodacite | 1.7 |
| 24 | | K-Na trachyrhyodacite | 1.7 |
| 25 | | K trachyrhyodacite | 1.9 |

*Continuation of table 2*

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| 26 | Ultra-acid | Rhyolite | 2.0 |
| 27 | | Alkalifeldspathoserhyolite | 2.4 |
| 28 | | Ayulite* | 2.1 |
| 29 | | Ayurhyolite* | 2.3 |
| 30 | | Ultrapotassic aulite* | 2.0 |
| **Plutonic rocks** | | | |
| 31 | Ultra-basic | Peridotite | 0.4 |
| 32 | | Apoperidotitic serpintinite | 0.5 |
| 33 | | Picrite, apopicritic serpintinite | 0.4 |
| 34 | Basic | Pyroxenite | 0.5 |
| 35 | | Alkaline pyroxenite | 0.7 |
| 36 | | Gabbro | 0.7 |
| 37 | | Syenogabbro ( subalkaline gabbro ) | 1.3 |
| 38 | Intermediate | Diorite | 0.9 |
| 39 | | Na monzonite | 1.4 |
| 40 | | K monzonite | 7.5 |
| 41 | | Nepheline syenite | 21 |
| 42 | | Quartz diorite | 1.2 |
| 43 | | Quartz monzodiorite (quartz K-Na diorite) | 1.8 |
| 44 | | Quartz Na monzonite | 1.4 |
| 45 | | Quartz K-Na monzonite | 1.7 |
| 46 | | Quartz K monzonite | 1.8 |
| 47 | Acid | Plagiogranodiorite (N granodiorite, tonolite) | 1.1 |
| 48 | | Granodiorite (K-Na granodiorite) | 1.3 |
| 49 | | Monzogranodiorite (K granodiorite) | 2.1 |
| 50 | | K-Na granosyenite | 1.8 |
| 51 | | K granosyenite | 1.6 |
| 52 | | Sub-alkaline quartz K-Na syenite | 1.8 |
| 53 | | Sub-alkaline quartz K syenite | 5.3 |
| 54 | | Alkaline quartz K-Na syenite | 2.6 |
| 55 | | Plagiogranite (Na granite) | 1.0 |
| 56 | | Granite (K-Na granite) | 1.8 |
| 57 | | Monzogranite (K granite) | 2.1 |
| 58 | | Na syenogranite (sub-alkaline Na granite) | 1.4 |
| 59 | | K-Na syenogranite (sub-alkaline K-Na granite) | 2.1 |
| 60 | | K syenogranite (sub-alkaline K granite) | 3.0 |
| 61 | | Alkalina granite | 4.3 |
| 62 | Ultra-acid | Subgranite | 2.7 |
| 63 | | Leukogranite | 4.5 |
| 64 | | Alcaline – feldspathoser leukogranite | 5.2 |
| 65 | | Alaskite leukogranite | 3.2 |
| 66 | | Alaskite | 3 |
| 67 | | Alcaline alaskite | 3.4 |
| * Volcanic analogues of alaskite, leucogranite alaskite, ultrapotassic alaskite. | | | |

Table 3 shows the average content of beryllium in magmatic rocks of different $SiO_2$ content. The calculated average value of acid rock clarks according to [2] is equal to 1.8 g/t, which differs significantly from the data given earlier by Vinogradov (1962), where the average Be content is 5.5 g/t in acid rocks. For ultra-acid rocks, data are available only in Glukhan I.V. and Serykh V.I. (1996). In this group, the calculated clark is 3.7 g/t. The maximum Be clark in alkaline rocks was obtained by Goldschmidt V.M. and Peters K. (1938), 36 g/t, whereas according to [4, 5] it is only 6.0 g/t, which is close to the value obtained from the calculation of the average value of alkaline rock clarks according to [2], 6.4 g/t.

It implies that the Be content increases from the ultra-basic, basic to intermediate, acid, ultra-acid and alkaline rocks. In the ultrabasic and basic rocks, the values of the average Be content are very low and do not exceed 0.4 g/t, unless one takes into account the data of Goldschmidt V.M. and Peters K. (1938), which obtained an average beryllium content of less than 3.6 g/t for basic rocks. Plutonic acid and ultra-acid rocks have a high beryllium clark value, from 1.8 to 5.5 g/t. To calculate the average content of beryllium in alkaline rocks, clarks from Table 2 were taken (clark number 4, 9, 35, 41, 53, 54, 61, 67).

Table 3 – Average content of beryllium in various magmatic rocks, g/t

| Groups | Goldschmidt | Sandell E.B. | Beus A.A. | Beus A.A. | Vinogradov | Glukhan IV, |
|---|---|---|---|---|---|---|
| Ultrabasic | 0 | Less than 0.2 | Less than 0.2 | – | 0.2 | 0.4* |
| Basic | Less than 3.6 | 1 and less | 0.4 | – | 0.4 | 0.9* |
| Intermediate | – | 1.6 | 1.8 | 1.8 ± 0.2 | 1.8 | 2.0* |
| Acidic | 3.6 | 3.0 | 5.0 | 5.0 ± 0.5 | 5.5 | 1.8* |
| ultra-acidic | –- | – | – | – | – | 3.7* |
| Alkaline | 36.0 | – | 7.0 | 6.0 ±1.0 | – | 6.4* |
| *Calculated according to table 2. | | | | | | |

The specifics of the methodology for creating clarks. The latest and newest work on determining the average content of chemical elements in rocks and creating a system of large rock clarks unique in global geochemical practice based on the results of the study of 12 000 composite samples prepared from 400 000 primary samples is the work of Kazakhstani geologists Glukhan I.V. and Serykh V.I. [1]. The samples were analysed by quantitative methods for 40-56 elements, including rock-forming elements. This system of clarks was published in the book "Granite-Related Ore Deposits of Central Kazakhstan and Adjacent Areas" [2] and in "Geochemistry" journal [6-9]. The proposed system of clarks in Central Kazakhstan confirms the fact that it is practically meaningless now to use the previously obtained global clarks in local and even regional studies in this region.

Due to the fact that the study continued for a long period [1, 2, 6-9], it was necessary to work out general criteria for assessing the reliability of research results. Since 1972, quality control of analytical data has been confirmed by 14 industry standard samples of the chemical composition of rocks prepared in the Central Laboratory of PGO "Tsentrkazgeologiya" under the direction of Kozyreva Ye.K. and approved in the USSR in 1984 as a standard for "Geology" industry. Coded reference samples were put to all analytics orders, which were composed of samples that were close to each other in composition and origin (usually they were samples of the same type of rock). Before 1993, the coded reference samples were used in chemical analysis 430 times, 375 times in the analysis of certified elements, and 11 530 times for spectral photometry. These samples were also analysed for all other small elements (except certified ones) to evaluate the reproducibility of the results obtained.

The data obtained from the analysis of the reference samples underwent both the running check and final check-out. The running check consisted in redefining the elements that were significantly different from the standard value. At the final stage, the main statistical data (mean value, its calculation accuracy, standard deviation and variation coefficient) for each reference sample analysed for two years (1972-1973 and before 1992) were calculated to identify possible variations with time and throughout the study period (1972-1992). For more convenient comparison, in the processing of the results a compliance index (CI) was calculated that was equal to the ratio of the obtained average content to the certified content. It is clear that the closer the CI to the unit, the more reliable the data are. The processing results showed no significant time-dependent changes in the quality of analysis. In 70% of cases, the average content of components obtained by chemical analysis (115 mean values) deviates from certified values only by 5%, and in 30% of cases it coincides with them completely (CI is equal to one).

Clarks of magmatic rock of Central Kazakhstan. Table 2 shows the regional clarks of Be in magmatic rocks of Central Kazakhstan. The results of analysis of data [1, 2] on magmatic rock established and confirmed (see table 2) that beryllium accumulates in acid, ultra-acid and alkaline rocks. In magmatic rocks, the beryllium content naturally increases from ultrabasic (0.4 g/t) to ultra-acid (5.2 g/t); in different groups of sub-alkaline rocks, it varies from 1.1 g/t (trachybasalt) to 5.3 g/t (K sub-alkaline quartz syenite); in various groups of alkaline rocks, the beryllium content varies from 0.7 g/t (alkaline pyroxenite) to 21 g/t (nepheline syenite).

Figures 1, 2 show graphs of distribution of beryllium clarks in magmatic rocks of Central Kazakhstan. The digits along the abscissa axis are the ordinal numbers of the rocks in table 2, the ordinate axis is the average content of beryllium. Below are the output data for plotting the graphs 1a and 1b.

Table 4 – Initial data for plotting the distribution graphs

| **Volcanic rocks** | | | | | |
|---|---|---|---|---|---|
| Number of clark according to table 3 | Average content of Be, grams per tonne (g/t) | Number of clark according to table 3 | Average content of Be, grams per tonne (g/t) | Number of clark according to table 3 | Average content of Be, grams per tonne (g/t) |
| 1, 2, 5 | 1 | 11, 12 | 1.6 | 23, 24, 25 | 1.8 |
| 3, 6 | 1.3 | 13, 14 | 2 | 26, 27, 29 | 2.2 |
| 7, 8 | 1.8 | 15, 20 | 1.2 | 28, 30 | 2 |
| 4, 9 | 6.8 | 16, 21, 22 | 1.6 | | |
| 10 | 1.2 | 17, 18, 19 | 1.6 | | |
| **Plutonic rocks** | | | | | |
| 31, 32, 33 | 0.4 | 44, 45, 46 | 1.6 | 55 | 1 |
| 34 | 0.5 | 43 | 1.8 | 59, 58 | 1.8 |
| 36, 38 | 0.8 | 47, 48 | 1.2 | 60 | 3 |
| 35 | 0.7 | 49, 57 | 2.1 | 61, 67 | 3.8 |
| 37, 39 | 1.4 | 50, 51 | 1.7 | 63, 64, 62 | 4.1 |
| 40 | 7.5 | 56 | 1.8 | 65, 66 | 3.1 |
| 41 | 21 | 52, 53 | 3.6 | | |
| 42 | 1.2 | 54 | 2.6 | | |

Figure 1 shows graphs of beryllium distribution in volcanic (a) and plutonic (b) rocks, grouped into 35 groups up to 67th consecutive number included. As can be seen from figure 1a, the highest average content (6.8 g/t) among volcanic rocks is a group of alkaline rocks: epileucite basalt and epileucitic phonolite. The minimum average content (1 g/t) is in the group including tholeiitic basalt, basalt, and basaltic andesite.

Figure 1b shows that beryllium is contained in small amount not exceeding 0.5 g/t in ultrabasic plutonic rocks (ultrabasic volcanic rocks in Kazakhstan are defined by implication, no data is available for them) [2]. In them, Be is usually present in amount many times smaller than its average clark in the earth's crust. Certain accumulation of beryllium, slightly exceeding its clark in the earth's crust, is observed in granites, syenites, leucogranites and alaskites (figure 1b).

In basic rocks, in particular, tholeiitic basalt and pyroxenite, alkaline pyroxenite, and gabbro, the average beryllium content is 0.7 g/t and only in subalkaline gabbro, it exceeds 1 g/t, whereas in the alkaline epileucite basalt the content of this element reaches a high value equal to 8.4 g/t.

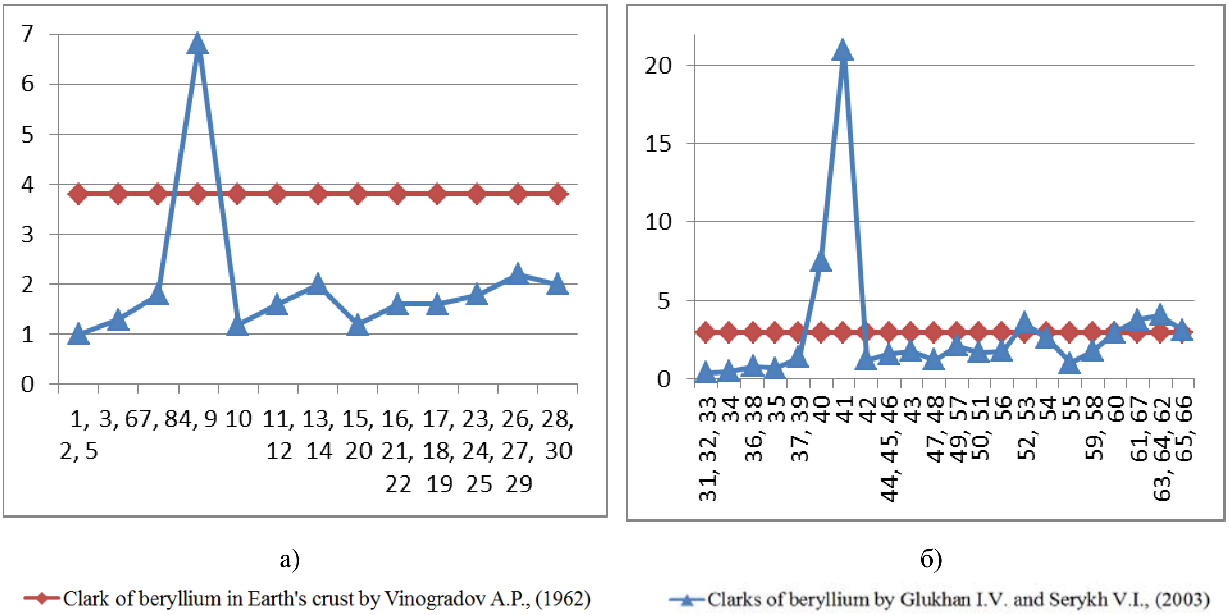


Figure 1 – Graphs of the distribution of beryllium clarks in magmatic rocks of Central Kazakhstan.
a) in volcanic and b) in plutonic rocks. Numbers of clarks according to table 3

In intermediate rocks, the beryllium content increases in comparison with basic and ultrabasic rocks and is more than 1 g/t. The alkaline rocks of nepheline syenite formations are characterized by significantly high beryllium content (the most thorough study on the beryllium distribution in them is made by Gerasimovsky V.I. (1965)). It bears testimony to complex distribution of beryllium in the minerals of alkaline rocks, as well as to phenomena of certain accumulation of beryllium in the alkaline rocks subjected to high-temperature late-magmatic and post-magmatic changes (Beus, 1967), epileucite phonolites (5.1 g/t) and in subalkaline K monzonite (7.5 g/t). In acidic rocks beryllium content increases, the average content is 2 g/t. Acid sub-alkaline and alkaline rock show increased beryllium content. In plutonic ultra-acid rocks, an increased beryllium content is identified (alkali-feldspar leucogranite, 5.2 g/t), (figure 1b), in contrast to volcanic acid rocks in which the beryllium content does not exceed 2.4 g/t (alkali-feldspar rhyolite).

Studies [10, 11] identified the important geochemical role of plagioclases as for most granitoids they are both the concentrator and the main carrier of beryllium.

Semi-quantitative emission spectrophotometry (SES) was used to collect a large amount of information on the distribution of over 20 chemical elements in all types of rocks. The law of statistical distribution was revealed for 2116 samplings containing from 11 to 200 pieces, among which samples from 16-45 pieces were 77%. It was proved that normal distribution is predominant; 84% accounted for by samples of basalts and andesibasalts, 85% by andesites, 81% by dacites and rhyodacites, 84% by sandstones and siltstones, 89% of argillites and siltstones, 75% of carbonate and siliceous rocks. Other distributions do not contradict the log-normal law and its modifications [2].

Figure 2 shows a comparison of the 328 clarks obtained with clark contents in the standards. Figure 2 demonstrates that 88% of all values of the compliance index for chemical elements do not exceed 0.8-1.2, and 91% of them are within 0.75-1.25. As for the contents obtained by quantitative methods, the processing of this data showed even more clearly the wide prevalence of normal distribution. This point was discussed in a number of papers on the rocks of both Central Kazakhstan and many other regions (Serykh, Rosen, 1969, Dumler, 1975, Bondarenko, 1966; Vorobyev, 1970; Beus, 1967). In all these studies, the proportion of normal distribution is defined as 90% or more.

The experience of work [2] confirms the conclusion of Dumler F.L. (1975) that an asymmetric distribution arises because of the large dispersion, presence of inhomogeneous samples, and the proximity of contents to the sensitivity limit, or, in other words, not because such a distribution actually exists in nature, but rather because of errors in experiments.

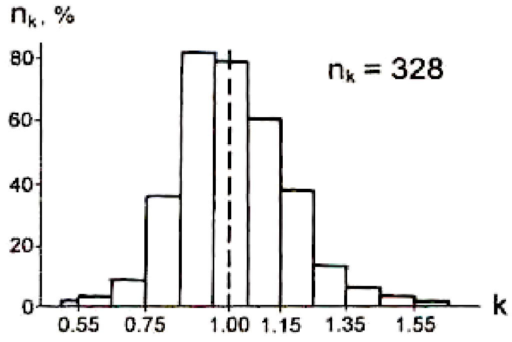


Figure 2 – The distribution of index of correspondence (IC) for trace element mean contents [2]

The statistical parameters were evaluated for normal distribution conditions. In this case, the maximum probabilistic estimate of a mean value is calculated as the arithmetic mean (Rodionov, 1981), which remains fairly effective for other types of distribution, e.g. for log-normal one, if the variation coefficient of does not exceed 60% (Beus, 1967). As a rule, the variation coefficients calculated from the SES data are below this limit, an average of 37% in sandstone and siltstone (366 samples), 38% in basic and intermediate volcanites (316), 37% in gabbroid (28), 39% in ultrabasic rocks (27), 42% in acid volcanites (165), 38% in granitic rocks (74), 52% in siliceous rocks (93), 52% in limestone (80).

Each calculated arithmetic mean (clark itself) is accompanied by a statistical estimate of its accuracy with a probability of 0.95, as well as by an estimate of deviation and the variation coefficient. Clark values were calculated using only quantitative definitions of chemical elements in composite samples [2].

The beryllium distribution in alkaline rocks and granitoids is in good agreement with the log-normal law [5].

Most types of natural concentrations of beryllium are products of activity of postmagmatic solutions associated with acid and ultra-acid rocks (including alkaline and sub-alkaline granitoids). The general regular pattern is that with increasing $SiO_2$ in rocks the beryllium content increases, and it confirms its lithophylic nature. The studies carried out traced and confirmed this regular pattern. Alkaline rocks (despite the presence of increased contents of dispersed beryllium in some cases) are associated with a very small number of deposits of beryllium minerals, which also products of postmagmatic solutions. However, in all known deposits associated with alkaline rocks the amount of beryllium concentration is limited [5]. Examples of such beryllium deposits in Central Kazakhstan are Tleumbetskoye and Upper Espe deposits.

**Findings.**

1. The results of research by different authors showed that the average Be content increases from ultrabasic to ultra-acid rocks. The calculated average value of clarks of acid rocks according to [2] is equal to 1.8 g/t, which differs significantly from the data given earlier by Vinogradov (1962), where the average Be content in acid rocks is 5.5 g/t. For ultra-acid rocks, data are available only in [2]. In this group, the calculated clark is 3.7 g/t. The maximum Be clark in alkaline rocks was obtained by Goldschmidt V.M. and Peters K.(1938), 36 g/t, and according to Beus A.A. (1956, 1966) it is 6.0 g/t, which is close to the values obtained by Glukhan I.V. and Serykh V.I. (1996), 6.4 g/t.

The latest work on defining clarks of elements of a large region is studies by Kazakhstani scientists Glukhan I.V. and Serykh V.I. [1, 2, 6-9].

2. The system of rock clarks [3] was obtained by modern methods of analysis using standards of chemical composition of rocks, approved as mandatory standards for the "Geology" industry in the USSR. These standards were used to control over 25% of all the samples taken into account when creating the rock clark system. Standards allowed to achieve high reproducibility and sufficient accuracy of sample analysis. Standards were analyzed in 10 leading laboratories in the USSR. As an average of the results of these 10 laboratories, they have become the mandatory standard for the "Geology" industry. The conducted control of standards enables to consider the proposed clarks of beryllium as the most reliable and accurate and to recommend their use for further prospecting and forecasting.

3. The established connection between the increased Be contents and acidic, ultrabasic, and alkaline rocks allows to approach the assessment of potential ore mineralization of geochemical anomalies in soils and to justify the expediency of further forecast studies. We can assume that if the content of elements in the soil during lithogeochemical testing proved to be higher than the clark of this element in the underlying rock, then this may indicate the presence of an ore anomaly in this place.

**В. С. Портнов, А. Н. Копобаева, А. Амангелдіқызы, Н. С. Аскарова**

Қарағанды мемлекеттік техникалық университеті, ҚарМТУ,
Қарағанды, Қазақстан

**БЕРИЛЛИЙДІҢ ОРТАЛЫҚ ҚАЗАҚСТАН ТАУЖЫНЫСТАРЫНДАҒЫ ТАРАЛУЫ**

**Аннотация.** Мақалада Орталық Қазақстанның магмалық таужыныстарындағы бериллийдің кларктарі ұсынылып отыр. Сонымен қатар осы мақалада бериллий кларктарін топырақтағы геохимиялық аномалиялардың потенциалды кенденуін бағалау үшін бериллийдің таралу заңдылықтары қарастырылады. Орталық Қазақстанннның магмалық таужыныстардағы бериллийдің таралуын зерттеуі, кенді геологиялық формацияларын анықтауы осы жұмыстың басты мақсаты болып саналады. Магмалық таужыныстардағы бериллийдің таралуы бойынша бұрын жасалған зерттеулер нәтижесінде салыстырмалы талдау жасалды. Қолда бар деректерге сәйкес Орталық Қазақстанның магмалық таужыныстардағы бериллийдің таралудың талдауы жасалған.

**Түйін сөздер:** магмалық таужыныстар, бериллий, Орталық Қазақстан, вулкандық таужыныстар, плутондық таужыныстар, таралу, кларк, кендену, топырақ.

**В. С. Портнов, А. Н. Копобаева, А. Амангелдіқызы, Н. С. Аскарова**

Карагандинский государственный технический университет, КарГТУ,
Караганда, Казахстан

**РАСПРЕДЕЛЕНИЕ БЕРИЛЛИЯ В МАГМАТИЧЕСКИХ ПОРОДАХ ЦЕНТРАЛЬНОГО КАЗАХСТАНА**

**Аннотация**. В статье представлены кларки бериллия в магматических породах Центрального Казахстана. А также в настоящей работе рассматриваются закономерности распределения Be для оценки возможности использования кларков Be при оценке потенциальной рудоносности геохимических аномалий в почвах. Целью настоящей работы является изучение распределения берилллия в магматических породах Центрального Казахстана для установления потенциально бериллиевых рудоносных геологических формаций. В работе проведен сравнительный анализ результатов предыдущих работ по изучению распределения бериллия в магматических горных породах. Выполнен анализ распространения бериллия в горных породах Центрального Казахстана по имеющимся данным региональных кларках бериллия.

**Ключевые слова:** магматические породы, бериллий, Центральный Казахстан, вулканические породы, плутонические породы, распределение, кларк, рудоносность, почва.

**Information about authors:**

Portnov Vassiliy Sergeevich, Doctor of technical sciences, Head of Department of Geology and mineral deposits exploration, Karagandy state technical university, Karaganda, Kazakhstan; vs_portnov@mail.ru; https://orcid.org/0000-0002-4940-3156

Kopobayeva Aiman Nygmetovna, Master of Engineering and Technology, student of PhD, Department of Geology and mineral deposits exploration, Karagandy state technical university, Karaganda, Kazakhstan; aiman_25.87@mail.ru; https://orcid.org/0000-0002-0601-9365

Amangeldikyzy Altynay , Master of Engineering and Technology, student of PhD, Department of Geology and mineral deposits exploration, Karagandy state technical university Karaganda, Kazakhstan; amangeldykyzy@inbox.ru; https://orcid.org/0000-0002-6665-8804

Askarova Nazym Srajadinkyzy – Master of Engineering and Technology, lector of Department of Geology and mineral deposits exploration, Karagandy state technical university Karaganda, Kazakhstan; srajadin-nazym@mail.ru; https://orcid.org/0000-0002-2103-6198

**REFERENCES**

[1] Glukhan I.V., Serykh V.I. Clarks of Rocks of Central Kazakhstan // Bulletin of the Academy of Sciences of the Republic of Kazakhstan, geology series. 2003. N 3. P. 81-116 (in Russ.).

[2] Glukhan I.V., Serykh V.I. The Mean Chemical Compositions (Regional Clarks) of Igneous Rocks of Central Kazakhstan // In book: Granite-Related Ore Deposits of Central Kazakhstan and Adjacent Areas. St. Petersburg, 1996. P. 269-286 (in Eng.).

[3] Sandell E.B., Goldich S.S. The rarer metallic constituents of some American igneous rocks. Part 1. 1943. P. 99-115 (in Eng.).

[4] Beus A.A. Beryllium. Estimation of Deposits in Prospecting and Exploration. 1956. 148 p. (in Russ.).

[5] Beus A.A., Dikov Yu.P. Geochemistry of Beryllium in the Processes of Endogenous Mineral Formation. "Nedra" Publishing house, 1967 (in Russ).

[6] Glukhan I.V., Serykh V.I. Clarks of Sandy Rocks of Central Kazakhstan // Geochemistry. 1999. N 9. P. 976-993 (in Russ.).

[7] Glukhan I.V., Serykh V.I. Clarks of Siltstones and Argillites of Central Kazakhstan // Geochemistry. 2000. N 9. P. 922-940 (in Russ.).

[8] Glukhan I.V., Serykh V.I. The Average Content of Chemical Elements in Carbonate and Siliceous Rocks of Central Kazakhstan // Geochemistry. 2001. N 6. P. 607-620 (in Russ.).

[9] Glukhan I.V., Serykh V.I The Average Contents of Chemical Elements in Metamorphic Rocks of Central Kazakhstan // Geochemistry. 2002. N 2. P. 142-155 (in Russ.).

[10] Kosals Ya.A, Nedashkovsky P.G., Petrov L.L., Serykh V.I. Patterns of Beryllium Distribution in Plagioclases of Granitoids // Geochemistry. 1973. N 7. P. 998-1013 (in Russ.).

[11] Serykh V.I., Ivanov O.V., Kozyreva Ye.K. Behavior of Beryllium in the Process of Crystallization and Metasomatic Transformation of Granites and the Problems of Geochemical Specialization of Late Hercynian Intrusives // Geology of Central Kazakhstan. Alma-Ata: Science of the Kazakh SSR, 1969. P. 96-112 (in Russ.).

**Publication Ethics and Publication Malpractice in the journals of the National Academy of Sciences of the Republic of Kazakhstan**

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.com/publishingethics and http://www.elsevier.com/journal-authors/ethics.

Submission of an article to the National Academy of Sciences of the Republic of Kazakhstan implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier.com/postingpolicy), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The National Academy of Sciences of the Republic of Kazakhstan follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service http://www.elsevier.com/editors/plagdetect.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the National Academy of Sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of Sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайте:

www:nauka-nanrk.kz

**ISSN 2518-170X (Online), ISSN 2224-5278 (Print)**

http://www.geolog-technical.kz/index.php/en/

Верстка *Д. Н. Калкабековой*

Подписано в печать 12.04.2019.
Формат 70x881/8. Бумага офсетная. Печать – ризограф.
15,2 п.л. Тираж 300. Заказ 2.

*Национальная академия наук РК*
*050010, Алматы, ул. Шевченко 28, т. 272-13-19, 272-13-18*