UDK 552.143 : [(549.283 : 553.068.2)] (477)

RARE ELEMENTS IN WEATHERING CRUSTS OF BRUSILOVSKY SUTURE ZONE OF UKRAINIAN SHIELD

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Principles have been found out of the distribution of rare elements in the gold mineralization in the weathering crusts of crystalline rocks within Brusilovsky suture zone of the Ukrainian shield. It has been discovered that the highest concentration of chemical elements, including gold, is typical for hydromica-clay zone of weathering crust. It has been shown that arsenic is an indicator of the zones of tectonic disturbances, with which the gold ore occurrence (gold mineralization) is associated. Correlation has been found between the contents of Au in weathering crusts and mobile forms of Y, Yb (ppb) in surface deposits (sediments) which allows recommending conventional multiplicative factor $k = Y(n\times10)\cdot Yb(n\times10^2)$ when searching for gold ore occurrences.
Key words: rare elements, weathering crusts, Brusilovsky suture zone, gold mineralization.

Introduction. Weathering crusts (WCs) are associated with the formation of a number of minerals. About 1/3 of all chemical elements reach elevated concentrations within the CWs which has practical importance.

Among the rare are the chemical elements which Clark (percentage abundance) within the crust does not exceed one hundredth of a percent, and which have a low capacity for mineral formation.

On the territory of Brusilovsky suture zone of the Ukrainian shield (USh) weathering crusts on crystalline rocks are widespread – granitoids, gneisses and amphibolites. Due to the fact that the WCS are being treated as potential sources of many minerals, particularities of the behavior of major elements for them are discussed in numerous publications. At the same time, the nature of the distribution of rare elements (RE) within WCs is not sufficiently studied, yet these elements can be widely used for the reconstruction of WCs' formation conditions and identification of the presence of gold.

Purpose of research. To demonstrate the opportunity to search for gold according to mobile forms of indicator elements among which the special role is played by RE.

Research methods. A content of gold and ER in the WCs has been analyzed as well as mobile forms of RE in the surface deposits of the ore occurrences. Mobile forms of chemical elements have been determined by the method of ICP-MS.

Characteristic of research territory. Nemirov-Kocherovskiy or Brusilovsky (Brusilov) suture zone separates the Dniester and Bug granite-gneiss megablock and Belotserkovskiy granite-amphibolite megablock.

In this territory, the most studied is the gold mineralization with the contents of up to 10 g/t in the WCs of the field (landfill) №1 in Belaya Tserkov region of the Kyiv oblast. Elevated concentrations of gold and its accompanying elements have been discovered under the cover of Cenozoic sediments of 10m thickness, in the weathering crust of granitoids.

A characteristic feature of the research territory is the development of sheetlike WCs, for which the vertical zonation of the structure is typical, both in terms of chemical and mineral composition, which is due to the staging of weathering processes.

The geological structure of the field №1 includes surface deposits with the thickness of about 40 m; WCs: a zone of primary kaolin (10–15 m), hydromica-clay (30–40 m), gravel-clay (5–10 m) and crystalline rocks – gneiss, plagiogranites [1].

Results and discussion. WCs of crystalline rocks are characterized by intense redistribution, i.e. integration and differentiation of chemical elements. When studying the principles of the gold contents and RE within the WCs, conditions have been considered of the formation of secondary halos and their relationship with the primary halos, and directly with ore occurrences.

In the WCs of the crystalline foundation of the USh, the following forms of gold occurrence have been discovered: macroscopically visible; pulverized and fine; in the form of an impurity in the secondary minerals; and "hydrogenic" gold. Denudation processes were leading to partial or complete washout of the WCs and redeposition of its products in the areas of low relief (river valleys, lake, marine and oceanic lacunas), while enriching the sedimentary with gold formations [2].

High migratory properties and the distribution of gold in the weathering crust are primarily caused by

the degree of resistance to the weathering of its minerals concentrators. The lower the gold content in the original rock, the smaller is the content thereof in the WCs. Crystalline rocks contain RE either in the dispersed state or as accessory minerals. The accessory minerals of granites containing RE include apatite, zircon, garnet, monazite, titanite and others [3]. Among granites, reduced content of lanthanum and cerium predominance over other RE is typical for monazite.

Redistribution of RE during supergene processes begins in the WCs and continues in subsequent epigenetic processes. For example, a source of supply and redistribution of iterbium are dark-colored minerals (olivine, pyroxene, amphiboles) and a number of accessory minerals (zircon, garnet, etc.) in the processes of their weathering. Lanthanum and cerium are supplied at the expense of the destruction of feldspar and accessory minerals [4].

We have studied the following rare elements (RE) – As, Sc, Nb, Y, La, Ce, Yb, Zr in the weathering crusts (WCs), crystalline rocks and surface deposits and

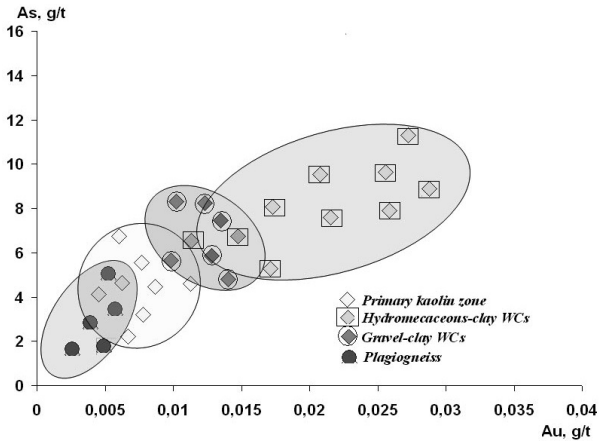

Fig. 1. Connection between Au and As in the zones of tectonic disturbances

indentified their relationship to mineralization.

It is known that the probability of formation of the areas of gold mineralization increases with the combination of favorable lithologic-facies conditions in the presence of zones of tectonic disturbances. Increased fracture of rocks is the way to hydrothermal and metasomatic fluids that carry gold, often with silver, uranium and a number of other elements.

At the first stage of the research, the task was to find out the relationship between the content of gold and arsenic in different types of WCs. Arsenic is an element that can record tectonic disturbances, along with fluorine and lithium, and determine the conditions for the formation of mineralization.

Analysis of the geochemical features of the WCs has revealed the correlation between arsenic and gold content in the zones of tectonic disturbances. Moreover, this pattern is observed regardless of the zone and the type of WCs (Fig. 1).

At the second stage of the research there has been analyzed the connection between gold and RE (Sc, Nb, Y, La, Ce, Yb, Zr) within different types of WCs as well as within mobile forms thereof in the surface deposits. Average content of the elements within the WCs has been identified and the concentration Clark (CC) has been calculated (see Table. 1).

It was found out that in crystalline rocks and WCs the total content of rare elements varies from 30,2 to 43,8 g/t. The general increase in RE occurs mainly due to the increase in the proportion of lanthanum and zirconium.

It is interesting to determine the correlation between gold and RE. When analyzing the connection between these elements in one of the sections of the WCs, correlation has been found between gold, yttrium, ytterbium at different depths, as well as the

Table 1. **The average content of RE and gold in the surface deposits, WCs and crystalline rocks**

Deposits type	RE							RE total	Au
	Sc	Nb	Y	La	Ce	Yb	Zr		
Soils	Surface soil deposits, ppb							–	–
	0.015	0.007	0.82	1.25	2.05	0.07	0.25		
Weathering crusts, g/t									
Primary kaolin	0.67	1.07	2.05	4.14	3	0.23	24.29	35.41	0.005
CC	0.79	0.71	1.03	1.38	1	1.15	1.94		2.5
Hydromica-clay	0.71	1.43	2.3	2.9	2.36	0.25	21.9	31.97	0.007
CC	0.82	0.95	1.2	0.97	0.79	1.15	1.75		3.5
Gravel-clay	0.7	1.75	1.92	3.33	2.83	0.2	19.17	30.25	0.003
CC	0.82	1.17	0.96	1.11	0.94	1	1.53		1.5
Crystalline rocks, g/t									
Plagiogneiss	0.85	1.5	2	3	3	0.2	12.5	23.55	0.002
Graphite-biotite gneiss	0.97	1.95	2.1	4	3.6	0.23	30	43.18	0.004
Biotite plagiogneiss	1	2	2	3.47	2.96	0.2	21.57	33.55	0.004

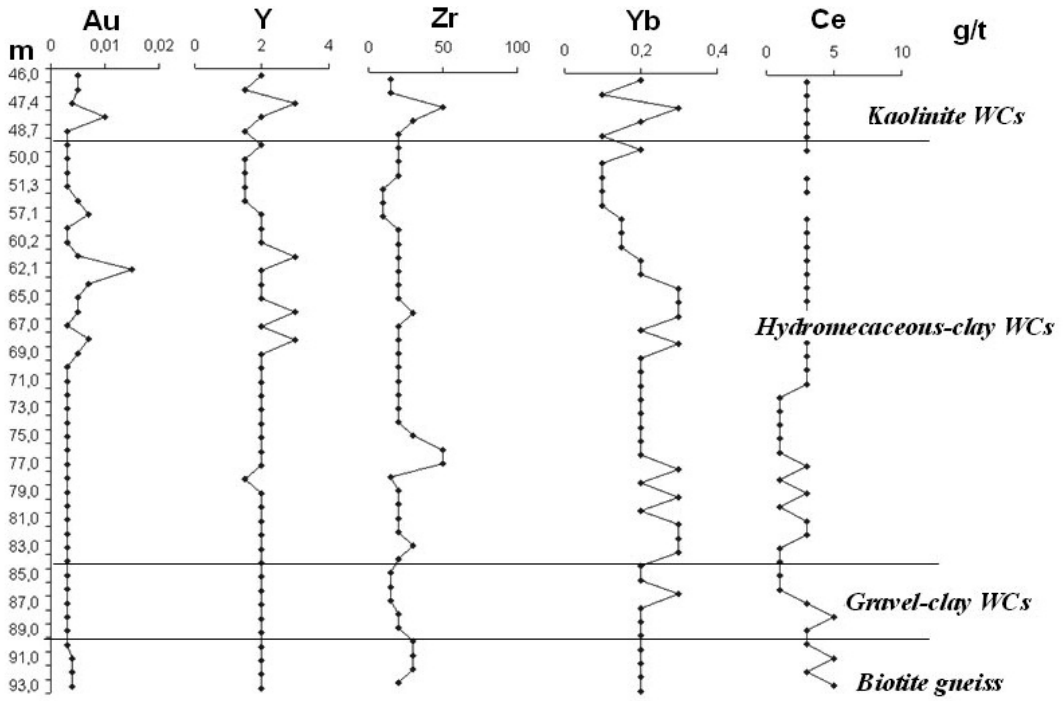

Fig. 2. Distribution of rare elements and gold in geological section

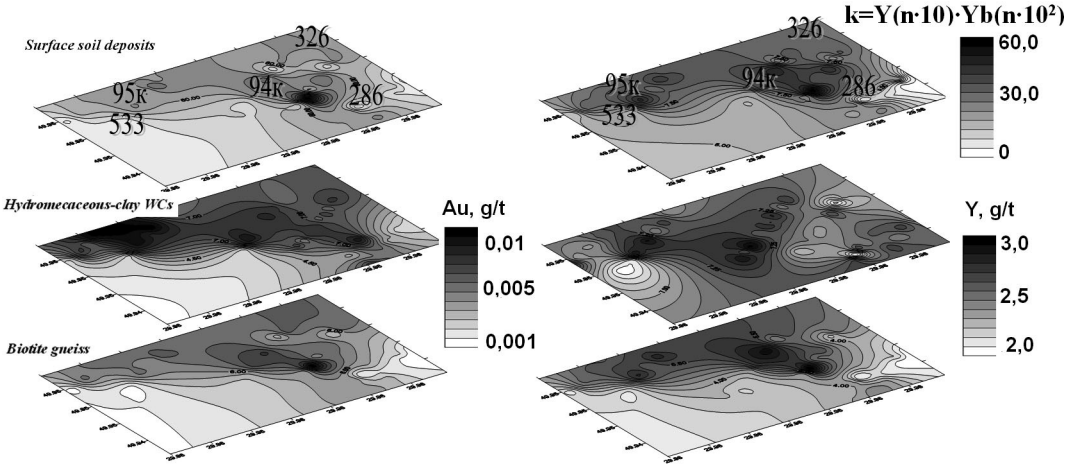

Fig. 3. Distribution of Au in weathering crusts and that of the mobile forms of Y, Yb in surface deposits

relationship with the ore occurrences in the bedrock (Fig. 2) has been demonstrated.

This example shows that inside one of the wells in the central part of the field No.1 within depth ranges 47 48 m (kaolinite WCs) there is an increased content of Au (0,01 g/t, while the background is 0,005 g/t) and Y, Zr, Yb, in the range of 60 69 m Au (0,015g/t with the background being 0,007 g/t) and Y, Yb (hydromica-clay WCs); the content of gold in gravel-clay WCs is stable – 0.003 g/t. The highest concentration of Y, Yb, and Au is typical for hydromica-clay zone of WCs.

It was found that the dispersion halos of mobile forms of Y, Yb in surface deposits coincide with their primary halos and gold ore occurrences. Mobile forms of these elements can be indicators for gold prospecting in the WCs. When calculating a multiplicative factor on the mobile forms of Y, Yb (ppb) it is appropriate to use the values of the contents of the same order. Accordingly, during the search for occurrences of gold in weathering crusts it is recommended to make use of the multiplicative factor of mobile forms – k = = Y(n ×10) ×Yb(n ×10²).

Conclusions. As a result of the research, patterns have been identified of distribution of rare elements in the gold ore occurrences in the weathering crusts of crystalline rocks located within Brusilovsky suture zone of the Ukrainian shield. It has been discovered that the highest concentration of chemical elements, including gold, is typical for hydromica-clay zone of weathering crust. It has been shown that arsenic is an indicator of

the zones of tectonic disturbances, which is associated with gold ore occurrence.

It has been found that the dispersion halos of mobile forms of Y, Yb within surface deposits coincides with primary halos and gold ore occurrences. Based on this, conclusion can be made that the mobile forms of these elements may be used as the gold search indicators within the WCs. When calculating a multiplicative factor on the mobile forms of Y, Yb (ppb), it is appropriate to use the content of the same order. Accordingly, during the search for occurrences of gold in weathering crusts it is recommended to use the conditional multiplicative factor of mobile forms – $k = Y(n \times 10) \times Yb(n \times 10^2)$.

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Жовинський Е.Я., Крюченко Н.О., Жук О.А. **Рідкісні елементи в корах вивітрювання Брусилівської шовної зони Українського щита.** Встановлено закономірності розподілу рідкісних елементів на рудопроявах золота в корах вивітрювання кристалічних порід в межах Брусилівської шовної зони Українського щита. Виявлено, що найбільш висока концентрація хімічних елементів, у тому числі і золота, характерна для гідрослюдисто-глинистої зони кори вивітрювання. Показано, що арсен є індикатором зон тектонічних порушень, до яких приурочений рудопрояв золота. Виявлено кореляційний зв'язок між вмістом Au в корах вивітрювання і рухомих форм Y, Yb (ppb) в поверхневих відкладах. Це дозволяє рекомендувати при пошуках рудопроявів золота умовний мультиплікативний коефіцієнт – $k = Y(n \times 10) \times Yb(n \times 10^2)$.

Ключові слова: рідкісні елементи, кори вивітрювання, Брусилівська шовна зона, золото.

Жовинский Э.Я., Крюченко Н.О., Жук Е.А. **Редкие элементы в корах выветривания Брусиловской шовной зоны Украинского щита.** Установлены закономерности распределения редких элементов на рудопроявлениях золота в корах выветривания кристаллических пород в пределах Брусиловской шовной зоны Украинского щита. Выявлено, что наиболее высокая концентрация химических элементов, в том числе и золота, характерна для гидрослюдисто-глинистой зоны коры выветривания. Показано, что мышьяк является индикатором зон тектонических нарушений, к которым приурочено рудопроявление золота. Выявлена корреляционная связь между содержаниями Au в корах выветривания и подвижных форм Y, Yb (ppb) в поверхностных отложениях. Это позволяет рекомендовать при поисках рудопроявлений золота условный мультипликативный коэффициент – $k = Y(n \times 10) \times Yb(n \times 10^2)$.

Ключевые слова: редкие элементы, коры выветривания, Брусиловская шовная зона, золото.

Надійшла 12.07.2014.