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Thorium and Uranium Ore Occurrences in Georgia, and their potential for industrial use

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Abstract. Georgia is located in the central part of the Caucasus, which is the northern segment of the Eastern Mediterranean orogen system and extends over 1,200 km in a NW-SE direction between the Black and the Caspian Seas. In this study, our goal was to investigate the Th and U ore occurrences in the country. As a result of the research, we have identified 3 uranium and 4 thorium occurrences that need more in-depth investigation. Among them, there should be mentioned the Shkhara uraninite occurrence that we discovered in the pre-Jurassic Shkhara crystalline massif. This occurrence formed in the Paleozoic biotite plagiomigmatites is in full correlation with uraninite deposits found in different parts of the world.

Keywords: Uranium, Thorium, ore occurrences, Georgia, Caucasus.

1. Introduction

The Caucasus orogen represents a Phanerozoic collisional formation that developed along the continental margin of Eurasian North and extends for over 1200 km from the Caspian to the Black Sea. Currently, it is a Tethyan segment connecting the Mediterranean and Irano-Himalayan orogenic belts, between the Gondwana-derived Arabian plate and the Scythian platform. Three major geological units are distinguished in its construction: the Greater and Lesser Caucasian mobile belts and the Transcaucasian microplate [e.g., 1, 2]. Georgia is located in the central part of the Caucasus orogen and covers the southern part of the Greater Caucasus, the Transcaucasus and northern part of the Lesser Caucasus. That is why it is characterized by a diverse and complex geological structure. Accordingly, different genetic types of ore deposits and occurrences are observed on its territory.

The objective of this investigation was a detailed study of thorium and uranium occurrences in Georgia. We have made significant progress in these studies, discovering new ore occurrences, as well as exploring the old ones.2. Materials and Methods During the field investigation, we studied the radiation background of rocks using the FAG-FH40F2 and POLIMASTER dose rate meters. We took more than 300 samples of rocks for geochemical analysis while working in the field. Analytical works of these samples were carried out by Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) in the MSALABS analytical laboratory (Canada), using the

IMS-230 method and in the Denver Regional Center Laboratory of the United States Geological Survey, using the ICP-ES method. Chemical composition and U-Pb chem- ical ages of uraninite were determined at the Electron Microanalysis Laboratory of the Center for Geosciences in Potsdam (Germany) on microprobe JEOL-JXA-8230.

3. Results

As a result of our research, new deposits of both thorium and uranium were identified in Georgia. The significant results of our research as well as the relatively well-reasoned data on thorium and uranium available in the funds of the Geological Department of Georgia are summarized in Table 7.1. The location of these ore occurrences is shown in Figure 1. As a consequence of our research, we have identified the following ore occurrences of uranium and thorium: 1. Stori Th-Bi, 2. Nadaburi Th-Bi, Vakijvari Th-Fe, Merisi Th, Khrami U-Th, Mukhuri U-Th, and Shkhara U-Th. The location of these ore occurrences is illustrated in Figure 1.

The occurrence of Stori Th and Bi is exposed within the Stori hydrothermal ore field, which is formed on the southern slope of the eastern segment of the Great Caucasus. In this occurrence, carbonate quartz-plagioclase veins of 30-40 cm thick intersect the Plinsbachian clay-shales. In one of these veins, thorium content reaches 3882 ppm and bismuth - 4806 ppm. The occurrence of Vakijvari Th and Fe is outcrop in Vakijvari ore field (~70km2) of the Eocene Adjara-Trialeti fold-thrust belt, in the region of Guria. The occurrence was formed in the areas of magmatic-hydrothermal alteration zones of the Middle Eocene monzonite-syenite pluton. This occurrence is spatially and genetically related to iron-ore-pegmatoid associations. The thorium concentration in this occurrence varies from 42.3 ppm to 289 ppm and Fe content ranges from 12.3% to 32.7%. The Merisi Th ore occurrence is located in the Meris ore field of the Adjara-Trialeti fold-thrust belt in the region of Adjara. The host rocks of this occurrence are represented by a large-scale hydrothermally altered quartz-biotite formations, which undergo intense chloritization. The geochemical study of these rocks has shown that thorium concentration ranges from 52.3 g/t to 157.7 g/t.

Of the thorium and uranium ore occurrences of Georgia, of special attention is the Shkhara uraninite occurrence. It was discovered in 2020 in the pre-Jurassic Shkhara crystalline massif, along the Main Caucasus thrust [3]. The massif is located at the headwaters of the Enguri river and forms a large ridge 15 km long and 5 km high. It is composed of Lower to mid-Paleozoic biotite schists, gneisses and migmatites and cut through by a granitoid pluton of the Variscan generation [4].

The analysis of the Shkhara uraninite occurrence shows that it is in full correla-tion with the vein-type uranium deposits similar to different regions of the world, including the central European Variscides [5, 6]. It is noteworthy that many of the world's hydrothermal uranium deposits are formed in approximately similar geological conditions. Among them are the commonly known uranium deposits of Namibia (Rossing and Husabi), from which about 10% of the world's uranium raw materials are currently extracted. The average uranium concentration in these deposits is 200 ppm [7], which is about the same value as that found in the Shkhara uraninite occurrence.

Uranium and thorium mineralization is associated with uraninite veins and nests, which are formed in biotite plagiogranites and migmatites. This rock was identified as hydrothermally altered biotite-quartz-plagioclase formation, in which the SiO_2 content varies in the range of 75-85%. The content of Th in this rock varies from 26 to 51 g/t and the content of U changes from 55 to 299 g/t. Geochemical studies have shown that the uranium mineral is high-temperature Th-bearing uraninite (UO_2).The study performed on JXA-8230 electron probe microanalyzer has shown that uraninite veins consist of uranium, thorium, lead and yttrium. In these veins, the UO_2 composition varies from 79.5% to 82.6 %, ThO_2 – from 6.7% to 8,4 %, PbO – from 2.95 to 3.9%, Y_2O_3 – from 1.15 to 3.77%.

Table 1. The names, genetic types, locations, bedrocks, and concentrations of Th and U occurrences in Georgia. The concentrations of Th, U and Bi are given in ppm, Fe-in %

Ore occurrences	Genetic type	Location	Bedrocks and age	Concentration of elements
1. Stori Th-Bi occurrences	Hydrothermal	Stori River gorge, Greater Caucasus	Clay-shales, Middle Jurassic	Th = 50-3842 Bi = 197-4806
2. Nadaburi Th-Bi occurrences	Hydrothermal	Dzirula R. gorge, Dzirula massif	Diorite-Gneisses, Late Paleozoic	Th = 117-266 Bi = 143-2470
3. Vakijvari Th-Fe occurrences	Hydrothermal	Natanebi R. gorge, Vakijvari pluton	Monzonite, Middle Eocene	Th = 47.5-272 Fe = 14.3-33.8
4. Merisi Th occurrences	Hydrothermal	Near the Merisi Waterfall	Monzonite, Middle Eocene	Th = 52-158 U = 10.2-17.7
5. Khrami U-Th occurrences	Hydrothermal	Khrami Massive, Ghrma Khevi	Granite, Late Paleozoic	U = ~300 Th = ~80
6. Mukhuri U-Th occurrences	Terrigenous	The beginning of the village Mukhuri Pass	Sandstone, Middle Jurassic	U = 200-250 Th = 150-200
7. Shkhara U-Th occurrences	Hydrothermal	River Enguri R. hed, Shkhara pluton	Plagiogranite, Late Paleozoic	U = 62-291 Th = 26-51

LA-ICP-MS206Pb/238U dating of zircons from the containing uraninite biotite plagiogranites vein indicates an age of 310.2±7.5 Ma that corresponds to the late Variscan orogenic activity. As for the chemical U-Pb age of the veins, which was determined by the JEOL JXA-8230 electron microprobe (EMP), it ranges from 286 to 290 Ma corresponding to the early Permian period.

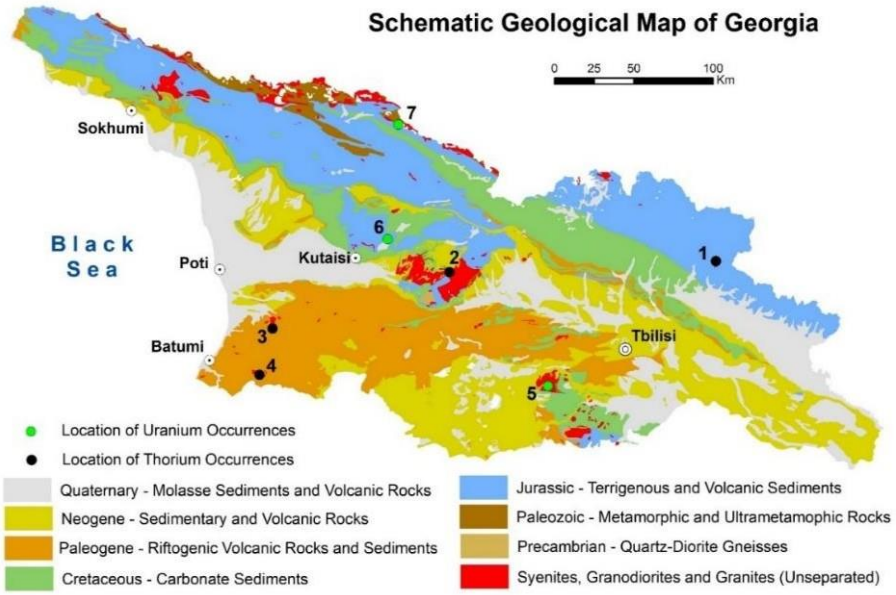

Fig. 1. Locations of Th and U occurrences on the schematic geological map of Georgia. 1. Stori, 2. Nadaburi, 3. Vakijvari, 4. Merisi, 5. Khrami, 6. Mukhuri, 7. Shkhara. The 1st, 2nd, 4th and 7th ore occurrences are discovered based on our research, while the 3rd, 5th, and 6th - are identified according to the Georgian Geological Department data.

4. Discussion

The obtained data showed that alkaline and subalkaline magmatism is the main source of Th in Georgia, as in other countries of the world. As a rule, the thorium deposits associated with this type of magmatism are formed during postmagmatic Na and K hydrothermal alteration processes. It is believed that in this type of deposits, the Th content can reach up to 1500 ppm but in general it rarely exceeds 50 ppm [8]. Our studies provide one more additional argument in favor of this interpretation, according to which thorium mineralization is also genetically related to alkaline and subalkaline postmagmatic hydrothermal processes and its average concentration is within 50 ppm, however, the contents of more than 1500 ppm have been identified [9].

In the case of uranium mineralization, the identified ore occurrences are in full compliance with the existing models of its genesis. The mechanism of their mineralization, most likely, was the U enrichment of residual melts during the crystal fractionation in the magma chamber.Later, during the late orogenic stretching processes, this element is subject of hydrothermal mobilization and accumulates in the form of veins and nests in the host rocks of the magma chamber.

5. Conclusions

Thus, as a result of our research, we can conclude that several prospective ore occurrences of thorium and uranium have been revealed in Georgia that need to be thoroughly studied. Among them, the Shkhara uraninite occurrence formed in the Paleozoic biotite plagiomigmatites and plagiogranites has significant prospects. In terms of composition, dimensions, magma series, geodynamic setting, age and type of U mineralization, this ore occurrence is in full correlation with the same type of U occurrences in different parts of the world. Based on these data, we suppose that Shkhara uraninite occurrence has significant industrial potential. Additionally, as is known, the plagiogranite and plagiogranites formations of Shkhara massif genetic type and age are widely distributed in the granite-migmatite complex of the crystalline basement of the Greater Caucasus. Therefore, we consider that further studies of uranium mineralization should be carried out not only in the Shkhara massif but also in the entire granite-migmatite complex of the Greater Caucasus crystalline basement

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