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Mineral Resources of the Geothermal Sources of the North Caucasus

Magomed Mintsaev[a], Fatima Machigova[a], Zulai Khadasheva[b], Sergei Cherkasov[c] and Tatiana Churikova[c]

[a]Grozny State Oil Technical University named after acad. M.D. Millionshchikov, Grozny, RUSSIA;
[b]Chechen State University, Grozny, RUSSIA;
[c]V. I. Vernadsky Federal State Institution of Science State Geological Museum RAS, Moscow, RUSSIA

ABSTRACT
The growth in the world consumption of raw materials resources accompanied by depletion of ore deposits explains the interest of many countries in the mineral potential of thermal waters. The Russian Federation has vast stocks of geothermal resources, this said, 74.3% of reserves are located in the North Caucasus. The paper contains material indicating substantial hydromineral potential of the North Caucasus, exploitation of which will allow extending the raw material resources base of not only this region but also the country as a whole.

KEYWORDS
Mineral resources; geothermal sources; geothermal potential; thermal waters; valuable elements; raw material stocks.

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Introduction

An increase in the volume of deployed resources and steady decrease in stocks are inevitable in the modern world in the age of high technologies and expanding consumption of final products.

According to experts' estimates, consumption of different types of mineral raw materials has increased 5 times over the last 100 years, besides, the large part of extraction falls at the last 60 years. In the coming 50 years, the consumption of minerals, including non-ferrous and alloying metals, will increase 2.5-3.5 times (Kozlovsky, 2007).

The intensive growth in the consumption of almost all types of mineral raw materials results in depletion of stocks and loss of raw material quality as extraction progresses and, consequently, the growth of deficit of some of them.

The problem of mineral resources depletion is especially acute in Russia. According to experts, profitable exploited stocks of many metals will be exhausted by 2020. Therefore, the own mineral raw material base of our country won't meet the demand of the domestic economy in the foreseeable future, which results in ever increasing volume of imported raw materials (Igrevskaya, 2007; Fedoseyev, 2010).

CORRESPONDENCE Fatima Machigova ✉ machigova@mail.ru

In this respect, the use of alternative sources of mineral resources is a topical issue not only in Russia but also abroad.

Materials and Methods

Thermal waters, which contain valuable components sufficient to provide their commercial production, are used as alternative raw sources in a number of countries. In the 80s 30% of the world's output of lithium, 31% of cesium, 8% of boracium, 5% of rubidium and other valuable elements in significant quantities had been extracted from hydrothermal sources in foreign countries (Kurbanov, 2001).

It's important to note that thermal waters are renewable, regionally widespread and are characterized by more favourable development conditions, which exclude costly processes typical for traditional recovery methods and processing of solid commercial minerals (Lanina et al., 2006; Kotsupalo, 2001; Taegong et al., 2015; Taimaskhanov et al., 2016; Xu, 2010; Iredale, 2010; Chin et al., 2012).

The interest in the mineral raw materials potential of thermal waters is proved by a number of national and foreign researchers (Lanina et al., 2006; Taegong et al., 2015; Machigova et al., 2013a; 2013b; 2015; Zaurbekov et al., 2016).

The limits of element concentration when waters can be of production interest are set in Russia and abroad: iodine -10, lithium – 10, cesium – 0.5, germanium – 0,5, bromine – 200, rubidium – 3, strontium – 300 mg/l (Svalova, 2009).

Today there are 65 discovered thermal water deposits and 5 deposits of steam-water mixture in Russia, 74.3% of which fall at the Northern Caucasian region – this is about 50 deposits with stocks over 200 thous. m^3/day (Gordeeva et al., 2002) (Table 1). The data presented in Table 1 indicate available thermal water deposits in the North Caucasus, however, their extraction is not high – from 0,9 to 23% depending on regions.

Table 1. Hydrogeothermal recource stocks of the North Caucasus

#	Region	Number of deposits	Temperature, ^{0}C	Proven reserves (R), thous.m^3/day	Extraction (E), thous.m^3/day	E/R, %
1	Chechen Republic (CR)	14	60-108	56,635	-	-
2	Republic of Dagestan (RD)	12	40-104	86,2	10,4	12
3	Krasnodar Territory	13	72-117	35,574	4,39	12,3
4	Kabardino-Balkar Republic (KBR)	2	56-67	5,3	0,05	0,9
5	Republic of Adygeya (RA)	3	70-91	8,98	2,1	23
6	Karachay-Cherkess Republic (KCR)	1	50-75	6,8	0,4	5,9
7	Stavropol Territory	5	55-119	12,2	1,0	8,2
8	Total North Caucasus	50	-	211,689	18,34*	11,83*

*without CR

The maximum development of thermal waters here falls at the 1990-1991s – 71,4-66,3 thous.m^3/day. Then extraction volumes went down to 63,1 thous.m^3/day in

1994. In 2000 extraction of thermal waters in the North Caucasus made up 19,8 thous (Gordeeva et al., 2002).

Currently Northern Caucasian thermal waters are largely used for heating supply, hot water supply and balneological purposes (Zaurbekov et al., 2016; Mintsaev et al., 2015a; 2015c). By the way, a geocirculation heating station with a hothouse complex as consumer built in 2015 has been successfully working in the Chechen Republic on the Khankala deposit.

The hydrochemical areas of fresh brinish and brine water with a mineral content from 0,3 to 282 g/l are distinguished within the North Caucasus.

Results and Discussion

The analysis of the findings of researches of the mineral potential of thermal waters of the North Caucasus allowed identifying promising areas and deposits for rare elements extraction, which are located in the territories of Dagestan, Chechnya, the Stavropol Territory, the Krasnodar Territory, Kabardino Balkariya, Karachaevo-Cherkessiya, Adygea.

There are extensive resources of thermal waters in Dagestan. They occupy 52 prospecting sites 11 thous.km^2 in area and are of great practical interest.

The Dagestanian rare metal province is characterized by unique concentrations of valuable elements, well yields with anomalously high formation temperatures and pressure excesses. Here thermal springs with different types of water are discovered: rare metal, potassic, rubidium-caesium, bromic-rare metal, potassic-magnesium, potassic-rubidium-datolite, iodine-bromine-strontium-caesium, potassic-strontium-datolite-lithium-rubidium-caesium, bromic, iodide (Kurbanov, 2001).

Tarumovskoe, Berikey deposits, Yuzhno-Sukhokumskaya area are of certain interest for development of the mineral potential. The Tarumovskoe deposit has a unique potential for extracting valuable chemical components. In 1971 an emergency stock with a fountain of steam-water mixture with an enthalpy about 200 kcal/kg, a specific yield of 12 thous.m^3/day, an excess estimated pressure on the entry of 250 atm and a high content of lithium, rubidium, cesium, strontium, sodium, calcium, barium, bromine, iodine, potassium was built here.

For the purpose of complex development of thermal and chemical potential of thermal waters the deepest geothermal wells in the world were drilled in the Tarumovskoe deposit (5500 m), the technology for extracting rare element salts, which involved successive steps of water purification from mechanical, organic components and ferrum, depositing calcium and magnesium, depositing lithium in the form of carbonate, fluoride and phosphate, extracting cesium and rubidium by the sorption method with subsequent water feed to evaporation tank for producing mineral salt, or injection back in place, was developed (Kurbanov, 2001). Unfortunately, these projects haven't been implemented because of a number of external reasons.

The results of numerous analyses and calculations showed that under conditions of stable flowing and initial yield the thermal waters of the Tarumovskoe deposit would carry up 60 tons of rubidium, 12 tons of cesium, 5000 tons of strontium, 2110 tons of brome, 75 tons of metaboric acid and hundreds of thousands tons of mineral salts a year, in this regard, the cost of valuable chemical elements extracted only from one well would made up about 100 mln. roubles a year (at the prices of the 90s) (Kurbanov, 2001).

The Berikey deposit is a promising source of rare metal thermal springs with a mineral content of 70-75 g/l, containing a high concentration of strontium (to 360 mg/l), bromine (to 250 mg/l) and many other valuable elements. Here hundreds of springs were formed in the place of a well after emergency fountain with a yield of 40-70 thous.m^3/day. For 26 years over 100 tons of cesium, 400 tons of rubidium, 3 000 tons of lithium, 27 000 tons of strontium, 8 000 tons of boracium, 22 000 tons of brome, 1 600 tons of iodine and over 3 mln. tons of sodium chloride were washed away to the Caspian Sea from these springs (Kurbanov, 2001).

Researches on processing associated water of oil deposits were carried out in Berikey and Yuzhno-Sukhokumskaya areas of South Dagestan in the 80s. As a result, dozens of kilograms of rare lyes were obtained. Here we have over 1000 suspended wells, which recovery, according to specialists, would cost 15-40 times cheaper than drilling of new wells. Development of a chemical-engineering complex would provide cost-effective extraction of rare element compounds and utilization of 26 thous.m^3/day commercial thermal waters of material value, which are being dumped into the Caspian Sea for more than half a century, harming the environment.

Thermal waters of promising areas of Dagestan contain commercial concentrations of many valuable elements: K, Li, Rb, Cs, Sr, B, Br, I, Mg (Table 2).

Thermal waters contain maximum concentrations of bromine in the areas of Tereklinskaya, Komsomolskaya, Tarumovskaya – 537, 633, 782, 1350 mg/l, correspondingly.

High concentrations of iodine are contained in the waters of Solonchakovaya and Stepnaya areas – 83 and 85 mg/l, correspondingly; maximum concentrations are in the 13th bed of the Mayskaya area – 158-184 mg/l.

Datolite thermal waters of chloride-natrium type with a mineral content to 136 mg/l and maximum concentrations of bromine 418 mg/l are found in the areas of Nogayskaya and Perekryostnaya at a depth of 3928-3960 m.

High concentrations of lithium are localized in chloride-natrium brine solutions with a mineral content of 60-150-200 g/l in the areas of Komsomolskaya and Tarumovskaya to 210 mg/l.

By rubidium concentration, a number of geochemical anomalies are discoverred, one which includes the areas of Yuzhno-Sukhokumskaya, Oktyabrskaya, Ullubievskaya with an average concentration of rubidium 4,2 mg/l; the Tarumovskaya-Tereklinskaya area with a concentration of rubidium 5,2-15 mg/l; anomalies in the areas of Yubileynaya, Russky Khutor, Emirovskaya – average concentration is 4,5 mg/l; a separate zone – near the Kochubey area with a concentration of rubidium 10,4 mg/l.

Most of the areas contain waters with commercial concentrations of cesium 0,6-3,78 mg/l of chloride-natrium type, a mineral content of 33-118 g/l and a high concentration of hydrogen carbonates and calcium cations, magnesium and strontium. The content of cesium runs up to 5,6 mg/l in the range of 5429-5435 m in the Tarumovskay-Komsomolskaya anomaly in high-mineralized superheat thermal springs of the 6th bed.

Commercial waters with anomalous concentration of potassium (1000-2211 mg/l) relate to the areas of Vostochno-Sukhokumskaya, Talovskaya, Oktyabrskaya, Neftekumskaya, Juzhno-Sukhokumskaya, which also relate to anomalous by the content of lithium, rubidium, cesium, which is reflected in the close correlation of rare alkali elements among themselves. The maximum content of potassium in the thermal springs of the Tarumovskaya-Tereklinskaya anomaly and the Nogayskaya area is 4300-5000, 3853 mg/l.

Table 2. Promising areas of rare metal thermal waters of the Republic of Dagestan

#	Area	Element, mg/l									Mineral content, g/l
		K	Li	Rb	Cs	Sr	B	Br	I	Mg	
1	Solnechnaya	654	14,4	2	-	394	115	199	7,8	293	83,7
2	Russky Khutor	335-1075	37,5-42,2	4	0,4-3	750-1035	80-120	83,7-360	16-50	800	40-125
3	Sukhokumsk	1030	44	3,36	0,6	756	80-114	269	13	775	104,8
4	Vostochno-Sukhokumsk	2211	63,7	5,46	-	559	112,6	330	6,2	-	133,8
5	Stepnaya	765-1875	48-62	3,2	1,1	688	19,6	194	9-86	925	86,9-128
6	Severno-Kochubeevskaya	1600	86	5,4	0,9	575	30-140	297	10	525	126,9
7	Juzhno-Suhokumskaya	1274	53,6	3,59	0,69	1162	39-346	80-427	10	1200	132
8	Martovskaya	375-1409	14,9-47,3	1,6-4,78	0,1-0,94	161-923	56-80	101-373	6,2-10	766	55-159
9	Oktyabrskaya	1466	44	4,3	0,7	243	14,6	-	-	-	109
10	Solonchakovaya	654-1810	14-122	2-5	0,2-0,94	394-625	8-115	199-236	7,8-84	293-1000	60-124
11	Ullubievskaya	1357	36,9	4,3	-	279	56,3	190	7,3	-	87,5
12	Talovskaya	1727	53,75	5,5	0,9	596	89	304	6,2	169	112,4
13	Bazhigan	550-1542	21-37	2-4,5	0,2	180-234	72-112	129-225	6,1-10,4	-	90,3
14	Mayskaya	1421	5-80	3,2-6	0,8-1,9	84-790	10,2-100	380	30-42-184	275-825	49,5-130,5
15	Perekrestnaya	542-875	18-39	2-4,4	0,3-0,8	305-750	50	140-412	10	-	60,4-132,5
16	Yubileynaya	485-2000	25-93	2,2-5,5	0,2-1,09	123-481	77	114-1350	6,2-8	530	50,5-125
17	Granichnaya	500	21-37,5	2,5-3	0,68	194-577	72	137-212	10,4	275	59,4-77,3
18	Kapievskaya	850	26-55	2,6-3,2	0,2-2,1	340-700	44-82	96-415	8	800	27,7-130
19	Kochubeevskaya	700	30-88	3,38	0,1	323	92	163	13,5	-	82,9
20	Duzlak	-	25,2	0,68	-	211	18,6	177	16	-	66
21	Berikey	560	42	3,4	0,85	520	106,2	170	16	326	70
22	Emirovskaya	1200	75,4	4,24	1,5	780	58,3	412	13,3	-	134
23	Smolyanskaya	1750	65	2,48	0,48	500	-	-	-	-	-
24	Kumukhskaya	-	54	1,7	0,55	-	38,4	218	5	-	110
25	Kumbatorskaya	-	21	0,68	0,18	-	-	-	-	-	-
26	Talgi	-	45	-	-	-	-	-	-	-	-
27	Nogayskaya	3853	78	4,3	0,53	427-739	414	-	11,5	398	136,4
28	Tyubinskaya	-	38	2,3	0,6	600	5,5	229	37,5	-	86,2
29	Tereklinskaya	2500	-	7,4	-	1100	75	537	10,6	-	153,6
30	Komsomolskaya	-	166	10,4	3	1607	51,7	782	9,5	1195	203
31	Tarumovskaya	5000	210	9,3-1!	5,6	1400	93,3	633	5,9	650	210
32	Dakhadaevskaya	1785	70,3	4,1	0,4	741	104	351	8,17	-	131
33	Ravninnaya	1500	64	-	-	529	92	333	11,4	929	132
	Commercial water conditions	350-1000	10	3	0,5	300	250 (60)	250 (200)	18 (10)	1000-5000	-

Commercial strontia waters with a mineral content of 300-1600 mg/l are found in Yuzhno-Sukhokumskaya, Tarumovskaya-Komsomolskaya groups of deposit.

Magnesium waters of chloride-natrium and chloride-natrium-calcareous types with a mineral content of 132-203 g/l, with a content of magnesium 1000-5000 mg/l are discovered only within three areas of Yuzhno-Sukhokumskaya, Komsomolskay, Solonchakovaya (Kurbanov, 2001).

The Chechen Republic is another promising region of the North Caucasus, which ranks 3rd among the regions of the Russian Federation by thermal water reserves. Following the exploration which has been carried out since 1965 in 11 areas, thermal water reserves with a yield of 56 635 thous. m^3/day were discovered. Upper Cretaceous and Chokrak-karagansky are most promising aquifer systems.

There are 14 deposits of high thermal waters within the territory of the Chechen Republic (fig. 1). The Khankala deposit 7,3 km^2 in area is the largest and most developed one (Zaurbekov et al., 2016; Svalova, 2009; Gordeeva, G.V. et al. 2002; Mintsaev et al., 2015a; 2015b; 2015c; Machigova et al., 2014).

Chechen hydrothermal sources are characterized not only by heavy stocks, high yields and temperatures (to 103 0C) but also low mineralization, usually below 2,0 g/l, and relatively high content of silicic acid (to 120 mg/l), that makes them silicious (Machigova et al., 2012).

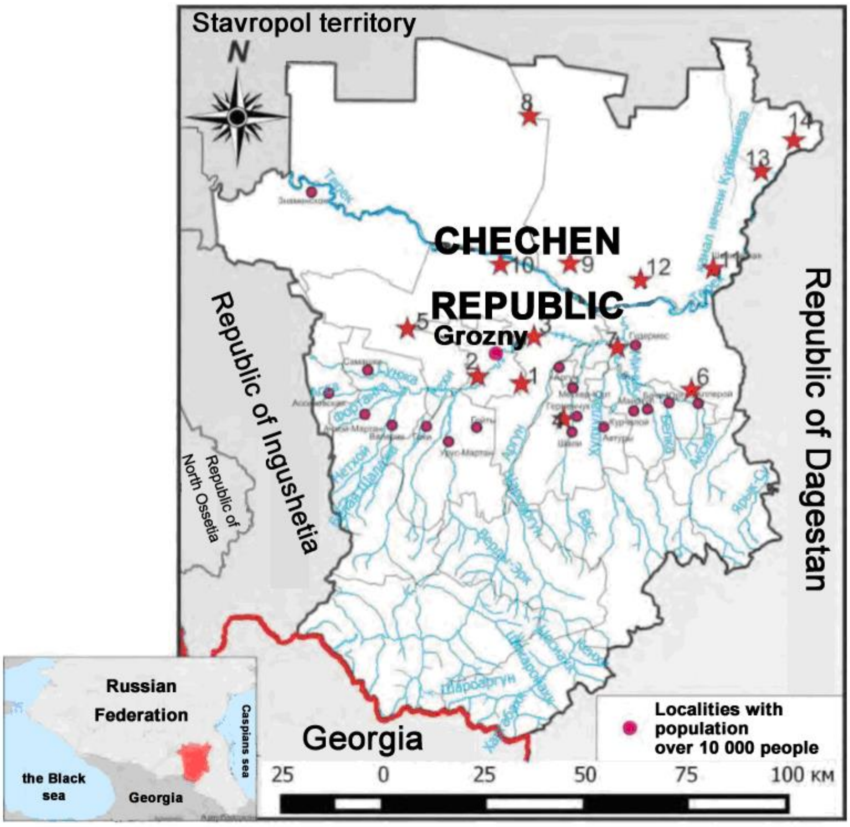

Figure 1. Thermal ground waters deposit map of the Chechen Republic (Farkhutdinov, 2016): 1 – Khankala, 2 – Goytinskoe, 3 – Petropavlovskoe, 4 – Germenchukskoe, 5 – Gunyushki, 6 – Novogroznenskoe, 7 – Gudermesskoe, 8 – Tsentralno-Burunnoe, 9 – Chervlennoe, 10 – Komsomolskoe, 11 – Shelkovskoe, 12 – Novoschedrinskoe, 13 – Kargalinskoe, 14 – Dubovskoe.

It is worth noting that extracting valuable components from low mineralized thermal springs has advantages. Special processes (Lin et al., 2000) developed for thermal water with low mineralization contribute to extracting valuable silica with such indicators of purity, specific area, pore and particle sizes, which make it possible to prepare fine zoned high-resolution chromatographic plates (Potapov et al., 2006).

The papers (Machigova et al., 2013a; 2013b) show the opportunity of extracting silica (to 90%) from the thermal waters of Khankala and Komsomolsk deposits. Highly mineralized waters discovered in the areas of Khayan-Kort, Zamankul, Karabulak-Achaluki, Datykhskaya and confined to Cretaceous and Jurassic aquifer systems are potentially lithium, potassic, rubidium and caesium mineral stock bearing areas. (Table 3).

Table 3. Promising areas of rare metal thermal waters of the Chechen Republic

#	Area	Element, mg/l			
		K	Li	Rb	Cs
1	Khayan-Kort	911	16,2	0,27	0,094
2	Zamankul	308	14-19	0,06-0,91	0,94
3	Karabulak-Achaluki	273	18,35-21	0,91-31,2	0,94-7,8
4	Datykhskaya	-	160	18,28	3,3
5	Commercial water conditions	350-1000	10	3	0,5

Cesium waters of chlorous-natrium type, with a mineral content of 105-125 g/l form geochemical anomalies in the areas of Zamankul-Karabulak-Achaluki and Datykh-Karabulak-Achaluki. A content of cesium makes up to 7,8 mg/l, rubidium – 18 mg/l in thermal waters within Datykh and Karabulak-Achaluki areas. The maximum concentration of lithium is discovered in the Datykhskaya area – 160 mg/l.

In the Kabardino-Balkarian Republic Lower-Baksan and Eastern-Baksan deposits also spread to the Krasnodar, Territory Adygea, the Karachay-Cherkess Republic and are in heat and power exploitation. Explorations of thermal water sources weren't carried out in the Republic of North Ossetia-Alania and the Republic of Ingushetia, however there are certain areas of interest there. Anomalous high temperature zones are found in the mountain regions of Kabardino-Balkaria and Northern Ossetia. These are composite volcanoes Elbrus and Kazbek, as well as the area of Tyrnyauzsky split. There are submontane troughs, which contain thermal waters in neighboring regions, in the lowland parts of these republics (Kurbanov, 2001).

9 deposits and areas in the Krasnodar Territory are located in the zone of cross-effect that leads to problems in the course of exploring. Cherkessk (Karachay-Cherkessia), Kazminsk (the Stavropol Territory), Maykop and Dagestan-Kurdzhipsk (the Republic of Adygeya) deposits of the Lower Cretaceous aquifer system are also in the area of cross effect. Despite relatively low level of water intake, a decrease in excessive pressure is typical for all wells of interdependent deposits, up to complete cessation of well flowing (Kurbanov, 2001).

Only one of four deposits of the Stavropol Territory are exploited - the Kazminsk deposit (2,9 thous. m^3/day); waters contain high concentrations of arcenic and carbolic acids. Here another typical geothermal problem arises – an ecological one caused by discharge of high-mineralized thermal water with a high content of harmful mixtures into environment.

Commercially significant concentrations of rare elements are found in thermal waters in the areas of the Stavropol Territory (Table 4). The Bezvodnaya area is a potentially datolite water bearing area. Waters of the Maksimovskaya area contain commercial concentrations of lithium (12-14 mg/l). Rubidium with a concentration of 3-4,4 mg/l is found in the zone of a large geochemical anomaly within the areas of Vladimirskaya, Podsolnechnaya, Maksimovskaya, Arbalinskaya.

Table 4. Promising areas of rare metal thermal waters of the Stavropol Territory

#	Area	Element, mg/l									Mineral content, g/l
		K	Li	Rb	Cs	Sr	Mg	B	Br	I	
1	Kolodeznaya	632	18,8	0,1	0,1	385	486	-	-	-	98
2	Velichaevskaya	578	20,5	0,1	-	446	511	-	-	-	107
3	Povarkovskaya	520	:2,24	1,07	1,06	-	-	-	-	-	-
4	Pravoberezhnaya	486	9,28	1,04	0,6	-	-	-	-	-	-
5	Zimnyaya stavka	680	21	0,1	0,489	403	535	-	-	-	49-106
6	Vostochnaya	-	23,1	1,5	0,09	-	-	54	218	11,7	81,6
7	Urozhaynaya	1000	15,8	2,7	0,6	356	426	-	-	-	42
8	Ozek-Suat	690-750	21,3	1,7	3,12	312	243	-	-	-	79
9	Kurgan-Amurskaya	731	0,04	1,72	0,09	-	-	-	-	-	-
10	Achikulak	-	26,3	3,02	0,57	-	-	-	-	-	-
11	Yamangoyskaya	-	19,2	-	-	-	-	-	-	-	-
12	Podsolnechnaya	153	21	0,1-4,2	0,1	73	73	-	-	-	41
13	Bezvodnaya	-	i3-60	3,2	2,1	823	-	45-65	260	28	118
14	Vladimirskaya			4,4							
15	Maksimovskaya		2-14	3,3							
16	Arbalinskaya			4,3							
Commercial water conditions		350-1000	10	3	0,5	300	1000-5000	60	250	18	-

The Neftekumskaya anomaly with a cesium content to 0,66 mg/l includes Urozhaynaya, Achikulakskaya, Vladimirskaya areas. Other two cesium anomalies are discovered in two wells of the Povarkovskaya area in chlorous-natrium associated oil water with a mineral content of 105-125 g/l and Yamangoy-Pravoberezhnaya – with a cesium content to 0,61 mg/l.

Commercial waters with an anomalous potassium concentration (1000-2211 mg/l) relate to the areas of Velichaevskaya, Urozhaynaya, which are also considered anomalous in respect to the content of lithium, rubidium, cesium. The Ozek-Suatskay cluster of fields contains commercial potassic waters (Kurbanov, 2001).

The Eastearn Ciscaucasia artesian basin (ECAB) spreads within the North Caucasus over 200 thous. km^3 in area (fig. 2). The depth of formation of the most potent and wide-spread Mesozoic hydrogeological complex of ECAB reaches 5500 m.

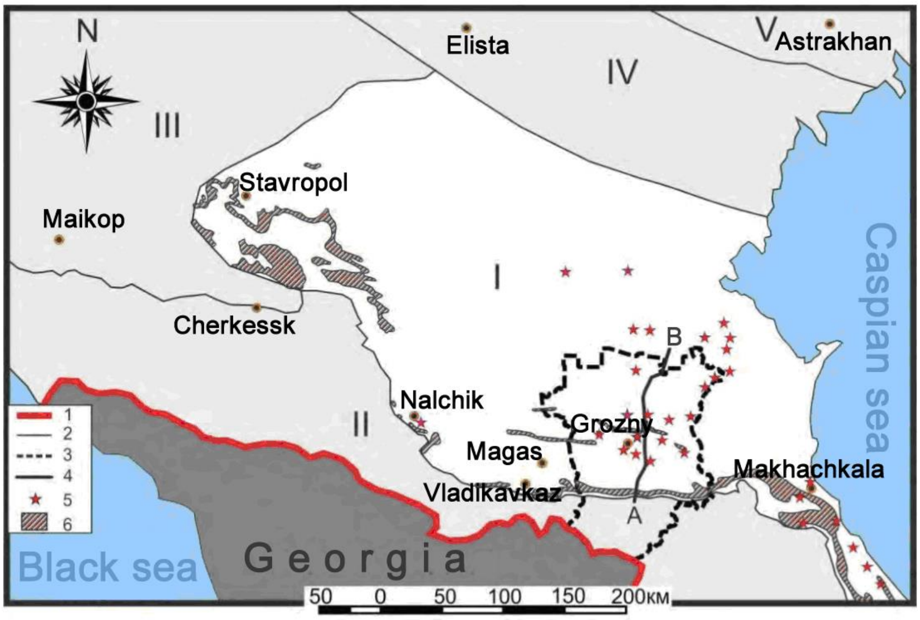

Figure 2. Eastearn Ciscaucasia artesian basin sketch map (Farkhutdinov, 2016): 1 – state border, 2 –hydrogeological structure border, 3 – Chechen Republic border, 4 – hydrogeologic section A-B, 5 –underground thermal water deposits, 6 – karagan-chokraksk deposits outcropping; I – ECAB, II – Caucasian hydrogeological fold area, III – Azov-Kuban artesian basin, IV – Ergeninsk artesian basin, V – Caspian artesian basin.

While depth increases, water mineralization and microelements content, as a rule, grows. The Mesozoic complex is a huge basin of high-thermal rare metal water with a mineral content from 30 to 50, sometimes to 200 g/l, formation temperatures reaching 250 0C, and substantial content of rare elements: lithium, bromine, iodine, rubidium, cesium, boracium, strontium, magnesium, potassium, which makes them commercial hydromineral raw materials. According to specialists, the potential resources of thermal waters of the Mesozoic complex make up 2,6 mln. m^3/day.

Over 130 sites (beds) with rare metal commercial waters of the Mesozoic complex occupy 92 areas, 55 of which are located in the territory of Dagestan, 29 – in the Stavropol Territory and 8 – in the Chechen Republic.

The hydromineral resources of the Mesozoic complex are associated with Cretaceous, Jurassic, and Triassic formations.

Thermal waters of Cretaceous and Jurassic sediment areas contain the highest concentrations of rare elements (Table 5).

Table 5. Types of Mesozoic complex commercial waters

#	Commercial water types	Aquifer systems		
		Cretaceous	Jurassic	Triassic
1	Bromic*	250-330/10	250-330/43	-
2	Iodine**	>18/2	18-184/17	> 18/3
3	Boric***	30-346/38	12-422	2,5-81/2
4	Lithium****	6-87	12-210/10	10-60/7
5	Rubidium*****	2-4,4/25	2-5,4/47	3,21-3,78/3
6	Caesium	0,5-0,9/22	0,5-3,2-5,6-7,8/53	0,91-3,78/16
7	Potassic	1000-2211/58	590-5000/52	-
8	Strontium	300-800-1162/29	500-700-1600/53	300-800/12
9	Magnesium	1200/1	1000-1195/2	

The concentrations of rare alkali elements in the Mesozoic formation of ECAB are closely correlated. For example, while depth and general water mineralization increase, concentrations of cesium grows and positively correlates to the content of lithium, rubidium, and potassium. Moreover, cesium commercial waters are more widespread than rubidium waters. Lithia waters are most widespread as distinct from magnesium waters, which are very limited in the deposit waters of ECAB.

The bromine content also grows with the growth in depth and water mineralization, while maximum concentrations of iodine are independent of depth.

The Cretaceous thermoaquifer complex lies at a depth to 4000 m. There are waters with a mineral content from 40 to 133 g/l in 78 sites, which relate to 50 areas within the Lower Cretaceous complex (3000-4000 m). Concentrations of valuable components are as follows (mg/l): lithium – 14,4-48, rubidium – 0,1-5,5, cesium – 0,08-0,7, strontium – 13,5-847, boracium – 51-168. In the waters of Upper Cretaceous deposits at a depth of 1000-1500 m the content of rare elements reaches (mg/l): 50-60 of lithium, 5-6 of rubidium, 1-1,5 of cesium, 1600 of strontium.

The Jurassic aquifer complex with a depth of formation in the range of 3190-5500 m in the lowland part of ECAB is tested in 30 areas. Rare metal commercial thermal sources are obtained based on 44 sites with yields at the spouting of oil wells to 300-400 m^3/day, mineral content – 85-170 g/l and the following content of valuable elements (mg/l): lithium – 24-122, rubidium – 0,93-6,0, cesium – 0,5-3,2, iodine – 10-50, boracium – 40,0-422,0, bromine – 50-425, strontium – 235-1035.

In Cretaceous and Jurassic aquifer systems southward and south-eastward from the Prikumskaya region the highest values of concentrations are as follows (mg/l): lithium – 210, rubidium –15, cesium – 6. Concentrations of lithium in the Datykh area of the Jurassic aquifer system are 160, rubidium – 18,3, cesium –3,3 mg/l.

The Triassic aquifer system with a capacity of 150-500 m is tested in the range of 3550-4800 m in 25 sites belonging to 12 deposits. It has rare metal waters with a mineral content of 60-120 g/l and the following content of microelements (mg/l): lithium – 12-60, rubidium – 0,79-3,9, cesium – 0,2-2,83, iodine – 3,8-28,2, boracium – 9,0-60,0, strontium – 75-823.

Conclusion

According to the approximate results of expert analysis, most part of potential reserves of hydromineral raw materials of the Mesozoic complex, is concentrated in the waters of Jurassic and Early Cretaceous deposits (Kurbanov, 2001).

The geothermal sources of the North Caucasus are, therefore, promising raw materials base for extracting valuable chemical elements.

When extracting hydrothermal minerals, we get heat as a by-product, the use of which will make it possible to save fuel and improve the efficiency of core process. For example, heat and power value (HPV) of one of the wells of the Tarumovsk deposit made up 1,6 *109 cal/day, equivalent to 90 thous. tons of fuel oil equivalent (TFOE) per year. Estimated HPV for 1 km^2 of the Tarumovsk deposit at an aquifer capacity of 330 m and an average openness of 12,3 % is 2,2*1010 TFOE per year. At a deposit radius of 15 km, its total HPV should make up 1,5*1010 TFOE per year (Kurbanov, 2001).

The growth in thermal water extraction and its irrational use lead to environmental issues associated with discharge of wasted water into environment. Over 60 mln. m^3 of thermal waters and about 400 mln. m^3 of associated oil waters were being dumped into environment until quite recently. In Dagestan over 160 mln.

m^3 of thermal waters with a mineral content to 62 g/l were being dumped into environment after the use for geothermal supply over the period of 23 years. In other words, over this period about 160 thous. tons of mineral salts were dumped to the land and into water bodies.

The use of thermal waters as alternative sources of minerals is caused by the growth in valuable chemical elements and their compounds consumption, leading to depletion of traditional raw material stocks.

The findings of researches of national and foreign scientists confirm the profitability of using hydrothermal deposits and areas for extracting valuable chemical raw materials.

The North Caucasus has the richest hydromineral potential and is of raw material value for modern industrial technologies. However, thermal waters are largely used here for heating supply, hot water supply and balneological purposes.

The massive problems, which often arise in the course of field exploitation, are a constraining factor for full-scale exploitation of the raw material potential of the region. As a rule, this is a number of problems related to regional features of conditions and occurence of ground waters, physicochemical characteristics of well fluids. Moreover, this is an ecological problem related to the discharge of wasted and associated oil waters into environment.

For the purpose of the successful development of hydromineral resources it's necessary to develop and introduce optimum technologies aiming at prevention of these problems and involving the integrated use of heat and chemical potentials of thermal waters.

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No potential conflict of interest was reported by the authors.

Notes on contributors

Magomed Mintsaev, PhD, head of the Automation and transport logistics department at the Grozny State Oil Technical University named after acad. M.D. Millionshchikov, Grozny, Russia.

Fatima Machigova, PhD, head of the laboratory "Spektr" of the research center for collective use "Nanotechnologies and Nanomaterials" at the Grozny State Oil Technical University named after acad. M.D. Millionshchikov, Grozny, Russia.

Zulai Khadasheva, PhD, assistant professor at the Chechen State University, Grozny, Russia.

Sergei Cherkasov, PhD, Director of the V. I. Vernadsky Federal State Institution of Science State Geological Museum RAS, Moskow, Russia.

Tatiana Churikova, PhD, research associate at the V. I. Vernadsky Federal State Institution of Science State Geological Museum RAS, Moskow, Russia.

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