URANIUM DEPOSITS IN RUSSIA

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Summary
Uranium deposits have been discovered within 15 uranium-bearing districts Russian Federation. Streltsovsk district with active mining includes 19 molybdenum-uranium deposits of structure-bound volcanic type in caldera: 17 deposits are situated in volcanic rocks and sediments and 2 deposits occur in granite and marble of the basement. Vitim, Transural, and West-Siberian districts contain sandstone basal-channel type deposits (paleo-valley type in Russian classification) which are amenable for in situ leaching operation and favourable for new uranium production. Most deposits of 10 uraniferous districts include small deposits of vein, volcanic, and metasomatite types with high cost sub-economic resources and low uranium grades. Principal exploration activities are targeted on new sandstone basal channel type and unconformity type deposits discovery.

Introduction
More than 100 uranium deposits in Russia have been discovered within 15 districts in Russian Federation since 1944, when uranium exploration started. They can be subdivided into four groups (table 1):

1. Streltsovsk district with existing uranium production;
2. Vitim, Transural and West-Siberian districts prospective for uranium production contain deposits with known resources recoverable at costs below $80/kg U, which have a potential for in situ leaching mining;
3. 10 uranium bearing districts contain deposits with high cost uranium resources which may have an economic potential in the future.
4. Stavropol district with depleted deposits.

District with Existing U Production
"Priargun Mining-Chemical Production Association" is the only producing centre in Russian Federation. It processes uranium ores of the Streltsovsk district deposits, which are classified as structure-bound volcanic type in caldera.
There are 19 deposits in the district: 17 deposits are situated in volcanic rocks and sediments (13 of them are in stratificated effusives of sheet facies and 4 in effusives of neck facies) and 2 large deposits occur in basement rocks (Antei in granite and Argunskoye in granite and marble). Mineralization is largely controlled by structures and reflected by predominantly vein and stockwork ore lodes. Approximately 75 % of the resources are in a depth interval from 200 to 600 m below surface where ore lodes are distributed at several levels in stratified sedimentary volcanogenic rocks of Jurassic-Cretaceous age. Principal uranium mineral is pitchblende while coffinite and brannerite are of minor abundance.
High level of total production marks the volcanic type Streltsovsk deposits as one of the outstanding uranium production districts world-wide. The current annual production is about 2 500 mt U: the dominant part comes from conventional underground mining and insufficient amount is produced from the low-grade ores by heap leaching and in place leaching methods. However, high grade resources of Streltsovsk district are significantly exhausted and are not sufficient to satisfy the future requirements of the Russian Atomic industry and export commitments.

Districts Prospective for Uranium Production
A number of basal channel sandstone type deposits of Vitim, Transural and West-Siberian districts are considered as most prospective for new ISL uranium production in Russia. Their total prognosticated resources evaluated as 280 ths.t U.
Transural and West-Siberian districts have similar geological setting locating correspondingly in the southwestern and southeastern edges of Siberian platform. Paleodrainage systems consist of 1 to 5 km wide channels filled with 30 to 120 m thick permeable alluvial-fluvial sediments. Deposits are located in Upper Jurassic - Lower Cretaceous and Paleogene-Neogene platform sediments. The productive horizon is presented by alternating sand, gravel, clay and siltstone beds, which are enriched by coal and organic material and occur on volcanic Paleozoic basement. Uranium and associated mineralization occur in disseminated form along redox interfaces. Deposits are from 1 to 25 km long, 50 to 1,500 m wide and up to 50 m thick and occur at a depth in excess of 300 m. Ore bodies display in planview an elongated lens or ribbonlike configuration and in section predominantly lenticular and roll shape. Ore grade averages 0.04%. Dalmatovskoe deposit in Transural district is prepared for ISL mining.
Up to 50 m thick or more Oligocene-Miocene ore hosting sediments of Vitim district deposits occur on Proterozoic granitic-metamorphic basement and are overlapped by Quaternary to 200m thick basalt sheets. It includes Khiagda ore field and some deposits and occurrences hosted by recent paleochannel structures.

Uranium Bearing Districts
There are 10 uranium-bearing areas in Russia containing numerous mainly small deposits of vein, volcanic, and metasomatite types, which are unfavourable for uranium production in the near future due to economic reasons.
Aldan (Elkon) district is the biggest potential district of Russia containing significant uranium resources, which are now subeconomic. Geological setting include three types of formations: Early Archean gneiss, granite, migmatite and schist complex of crystalline basement; Vend - Lower Cambrian platform mantle (to 700 m thick) presented by limestone and dolomite; sediments and alkaline volcanics of Jurassic tectonic-magmatic activation. Location, shape and dimensions of uranium-gold and uranium-gold-silver mineralization are primarily controlled by reactivated ancient and neotectonic NW-SE oriented and steeply SW dipping faults of

Mesozoic age and surrounding pyrite-carbonate-potassium feldspar alteration zones. Principal uranium mineral is brannerite.

The other uranium bearing districts include mainly small and middle size deposits with low U grades. Only some deposits are considered presently as the sources for uranium production.

Central Transbaikal districts include deposits of three principal types. Volcanic type is presented by 5 U- Mo deposits in caldera filled by Upper Jurassic - Lower Cretaceous volcanic rocks (similar to deposits of Streltsovsk district). Vein deposits occur in fault zones within highly radioactive Jurassic granite. Sandstone type stratiform deposits occur in Cretaceous graben structures.

Principal uranium resources in Yenisey district are related to middle-size sandstone type stratiform deposits in Upper Devonian sediments.

Deposits of Ergeninsky district are represented by uraniferous fossil fish bones mineralization hosted in pyritic clays. They are also classified as organic phosphorous type. Tabular ore bodies with low U grades are localised within various Upper Oligocene "fish stratas".

Onezhsky (Onega) district includes some metasomatic type vanadium uranium deposits with elevated gold, palladium, platinum, copper and molybdenum concentrations. The deposits are localised within Onega epicratonnal trough filled by Lower Proterozoic volcanic rocks, sediments and metamorphites in the zones of fold-faulted dislocations. Mineralization occurs in the aureoles of mica-carbonate metasomatites.

Bureinsky and Khankaisky district include several small deposits of volcanic type in Cretaceous rhyolite and felsite similar to deposits of Streltsovsk district and small deposits of vein type in Upper Paleozoic rocks.

Volgo-Uralsky district includes small deposits and numerous occurrences of exogenetic type in lignite, terrigene and carbonate sediments in south-eastern part of Russian platform. Numerous occurrences of bituminous sediments were discovered in Upper Carbonaceous limestone and dolomite.

District with depleted deposits

Two vein-type uranium deposits have been mined since 1950 to 1990 in Stavropol district. Uranium mineralization occurred in xenoliths of bituminous sediments within the apex of granite porphyry and rhyolite bodies. Currently the main activities are related to environmental issues in wastes rehabilitation.

Recent and Ongoing Uranium Exploration Activities

Principal exploration activities are targeted on further sandstone basal channel uranium deposits prospecting and evaluation within above-mentioned districts prospective for ISL mining. There are also good geological prerequisites for sandstone basal channel type mineralization discovery within Russian platform, Voronezhsky and Bureinsky massifs.

The exploration is aimed also on evaluation of unconformity type mineralization. The discovery of deposit Karhu in the Ladoga district is the first result of these activities. Uranium mineralization is located mainly in the subface of arkose stratum upon the weathering crust of Archean basement rocks and minor in the basement rocks and in the upper basal sandstone. Direct indications for unconformity type mineralization were detected in some areas in the foothills of Eastern Sayan Mountains (East Sayan area), in Aldan shield (Uchuro-Maysky area), Baltic shield (Onezhsky and Ladozhsky areas) and in Patom plateau (Chara area).

Conclusion

The only uranium-producing centre in Russian Federation operates volcanic vein-stockwork deposits of Streltsovsk district. Most of known deposits contain subeconomic resources and low grades. To satisfy future uranium requirements 3 new centres are planned for sandstone basal channel uranium deposits in Vitim, Transural and West-Siberian districts in situ leaching mining. Further prospects for uranium resources increase are related to exploration of some areas favourable for sandstone and unconformity type mineralization, as well as new progressive mining and processing methods at some known deposits.

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Table 1. Characteristics of Uranium Districts in Russia

Districts	**Example deposits**	**Grade U,%**	**Principal deposit type (ore setting)**	**Host rocks Lithology**	**Host rocks Stratigraphy**	**Shape of ore bodies**	**U minera-lization***
District with existing uranium production							
Streltsovsk 19 deposits (4-large, 7-middle, 6-small)	Streltsovskoe, Tulukuevskoe, Antei, Argunskoe	0,2	Volcanic (Mo-U in caldera structure controlled)	Felsite, rhyolite, dacite, basalt, conglomerate	Up. Jurassic-L. Cretaceous	stockwork, vein, tabular	P,C,B,G
				Granite, marble	Proterozoic-Paleozoic		
Districts prospective for uranium production							
Vitim	Khiagda, Zheglovskoe	0.03-0.05	Sandstone basal channel (paleovalleys)	Sandstone, sand, clay, conglomerate	Tertiary	ribbon, lens tabular	P,C
Transural	Dalmatovskoe Dobrovolnoe			Sandstone, sand, Siltstone	Up. Jurassic, Quaternary	tabular, lens	P,C
West-Siberian	Malinovskoe			sand, clay	Up. Jurassic - L. Cretaceous	tabular, lens	P,S
Uranium bearing districts							
Aldan (Elkon)	Elkon, Kurung Elkonkoe Plateau	0.1	Metasomatite (Au-U in K metasomatites)	gneiss, granite	Early Archean	vein, stockwork	B
Central Transbaikal	Gornoe	0,2	U vein	Granite	M-Up. Jurassic	vein	G
	Olovskoe, Akuhtinskoe,	<0.1	Volcanic (Mo-U in caldera structure controlled)	Sandstone, dacite, rhyolite	Mid. Jurassic L. Cretaceous	tabular, vein, lens	P,C
	Stepnoe, Imskoe	<0.1	U sandstone	Sandstone, Conglomerate	L. Cretaceous	tabular	P,C
	Crystalnoe	<0.1	As-U vein	Granite, diorite	M-Up. Paleoz.	vein	P
Yenisey	Primorskoe, Ust-Uyuk	<0.2	U sandstone	Sandstone, siltstone	Up. Devonian	tabular	P,S
	Solonechnoe, Ryabinovoe	< 0.1	Volcanic (Mo-U in volcanic caldera)	Felsite, tuff, rhyolite	Up. Devonian	lens, stockwork	P,C
Ergeninsky	Stepnovskoe, Shargadykskoe	<0.1	Lignite (U-REE in clay and fish bone detritus)	clay, fish bone detritus	Cainozoic	tabular	P,S
Onezhsky	Srednaya Padma, Kosmozero	< 0.1	Metasomatite (U-V in carbonate-mica metasomatites)	Siltstone, schist, dolomite, sandstone	Lower Proterozoic	stockwork, vein, tabular	P,C
Ladozhsky	Karhu	0,1	U unconformity (?)	sandstone	Riphean	lens, tabular	P,C
Bureinsky	Lastochka, Osennee	< 0.2	Volcanic, vein-stockwork (in caldera)	felsite, rhyolite	Cretaceous	vein, stockwork	P.C.G
Khankaisky	Fenix, Lipovskoe	<0.1	Mo-U vein	rhyolite	Devonian	vein	P.C
	Rakovskoe		U in paleovalleys	sandstone	Cainozoic	lens, ribbon	C,S
Volgo-Uralsky	Vinogradovskoe	<0.2	U in paleovalleys	clay, sand	Up. Permian	lens, tabular	C,P
	Repyovskoe, Badyelskoe	0,03	U in bituminous sediments	limestone	L. Permian		
	Babaevskoe	0,01	U epigenetic in lignite	lignite	Quaternary		
Chukotsky	Chaika, Keef, Chaplinskoe	0,1	Volcanic (Mo-U in caldera)	volcanite, terrigene rocks	Jurassic	vein, stockwork	P
District with depleted deposits							
Stavropol	Beshtau, Byk	0,1	U vein-stockwork	rhyolite, mudstone	Quaternary	vein, lens	G,P

* - Uranium minerals: P- pitchblende, C- coffinite, B- brannerite and U-Ti phases, G- supergene minerals, S- sooty pitchblende