INDUSTRIAL TYPES OF URANIUM DEPOSITS IN KAZAKHSTAN

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Abstract

The main industrial uranium deposits of Kazakhstan that can be commercially mined, are located in two ore regions and are represented by two types of the uranium deposits. The first region is named Chu-Syrdarya (75.6% of total resources of Kazakhstan) and is located in the South of Kazakhstan and this one is the largest in the world among the regions of the deposits connected with the bed oxidation zone, localized in the permeable sediments and amenable for in-situ leach mining. The second region is named Kokshetau (16% of total resources) and is located in the North of Kazakhstan at the north edge of Kazak Shield and is characterized by the vein-stockwork type of deposit. Other industrial deposits (8.4% of total resources) are grouped in two regions that have been determined and are retained as reserves for economical and ecological reasons. These are: Pricaspian region with the organic phosphate type of uranium deposits; and Ili-Balkhash region with mainly the coal-uranium type. There are 44 industrial uranium deposits with resources ranging from 1000 t to 100000 t U and more in each of them, in all, in Kazakhstan. Seven of them are completely mined now. Total uranium resources in Kazakhstan are determined at 1670000 t U.

1. INTRODUCTION

Uranium mining in Kazakhstan is at present being carried out by in-situ leaching (ISL) method in the South of the Republic. Conventional mining that had been intensively carried out to the beginning of 1990s in the North and South of Kazakhstan, has now stopped. In the South of Kazakhstan the most profitable deposits are presently being mined and in the North of Kazakhstan stoppage of the mining operation was due to the economic position of the Republic and the relatively low quality of the ores. The average grade of uranium ores in those deposits does not exceed 0.1–0.3%. Nevertheless, up to date preservation of the industry infrastructure that has up to 2500 t U per year production capacity, under improved economic conditions in both Kazakhstan and the world uranium market, mining of these deposits could be quickly reactivated. Therefore, the region in the North of Kazakhstan continues to be regarded as a significant region with industrial uranium resources.

Discoveries of uranium deposits in Kazakhstan have a long and interesting history that started in 1951 with the discovery of Kurday deposit that have continued to recent years.

The surface of the Kazakhstan territory is characterized by the combination of the outcrop folded structures and the areas which are covered by the different friable sediments from Triassic period to the present (Fig. 1). The thickness of these sediments varies from several metres to thousand or more metres in areas of structural depression.

Folded structures are well exposed and well investigated using different exploration methods. Structural depression were intensively investigated using geophysical methods and drilling during the last decades and is considered thoroughly investigated for uranium deposits.

Various geological conditions in Kazakhstan provided the possibility for the discovery of different types of uranium ore occurrences that totaled to several thousands in the entire territory of Kazakhstan. All occurrences were investigated with the use of geophysical, geochemical, mining and drilling techniques. As a result, more than 50 uranium deposits from

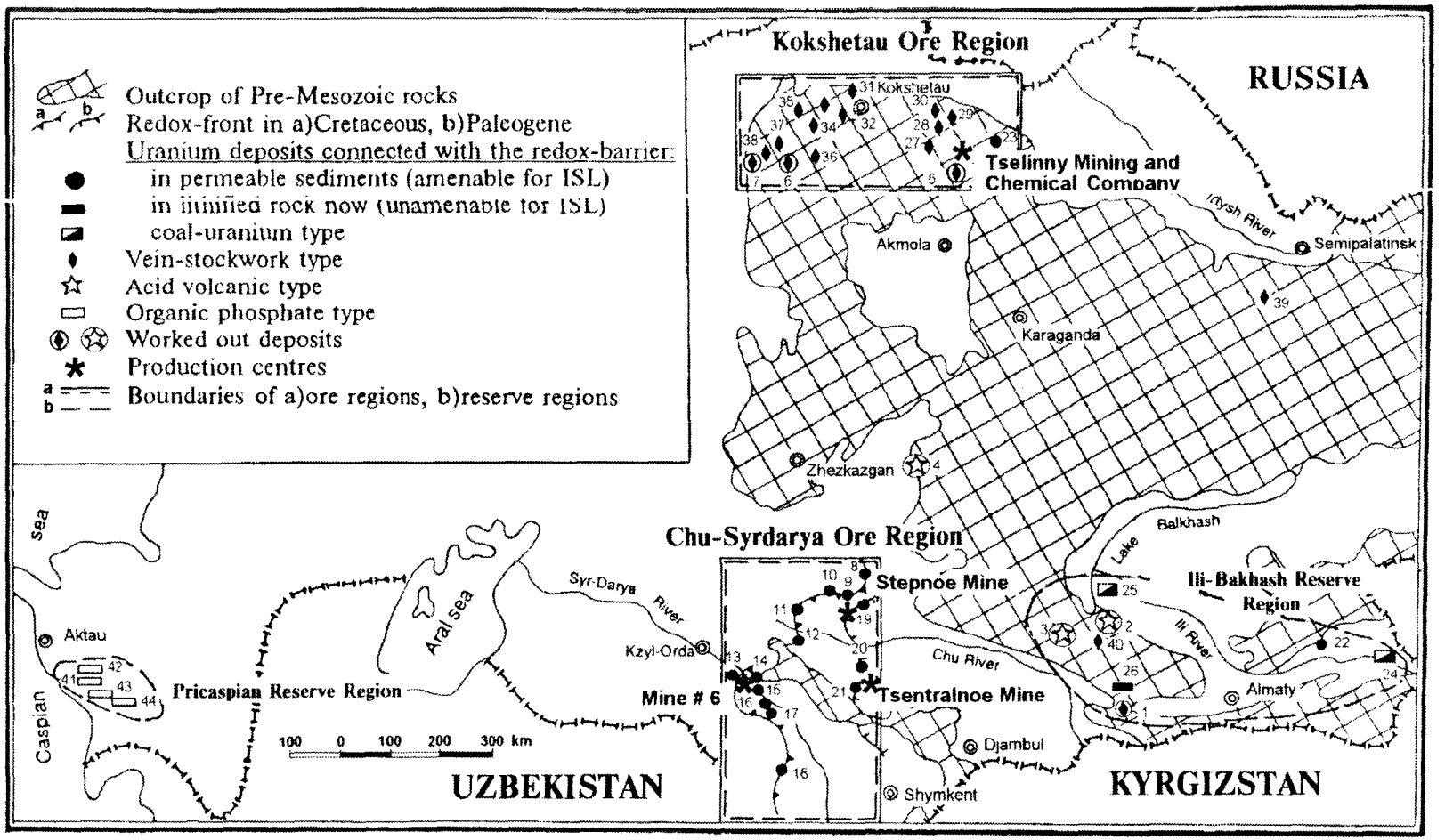

FIG.1. Uranium Deposits and Ore Regions in Kazakstan

Deposits: 1-Kurday, 2-Botaburum, 3-Kyzylsay, 4-Djidely, 5-Manybay, 6-Balkashino, 7-Ishimskoe, 8-Zhalpak, 9-Akdala, 10-Mynkuduk, 11-Inkay, 12-Budyonovskoe, 13-Irkol, 14-North Karamurun, 15-South Karamurun, 16-North Harasan, 17-South Harasan, 18-Zarechnoe, 19-Uvanas, 20-Moyunkum, 21-Kanzhugan, 22-Sulushokinskoe, 23-Semizbay, 24-Koldjat, 25-Nizhne-Iliyskoe, 26-Kopalysay, 27-Zaozyornoe, 28-Agashskoe, 29-Shatskoe, 30-Glubinnoe, 31-Slavyanskoe, 32-Chaglinskoe, 33-Grachyovskoe, 34-Kosachinoe, 35-Fevralskoe, 36-Vostok, Zvyozdnoe, 37-Viktorovskoe, 38-Kamyshovoe, 39-Ulken-Akzhal, 40-Dfusandalinskoe, 41-Melovoe, 42-Tomak, 43-Tasmurun, 44-Taybogar.

small to unique ones were discovered in Kazakhstan. Seven of them are completely mined out now. Thirty seven industrial uranium deposits with resources from 1000 t to 100 000 t U, or more, in each are the base of the uranium resources in Kazakhstan. Total uranium resources in Kazakhstan including discovered and speculative are determined of 1670000 t U. In this case, the known (RAR+EAR I) resources are about 850000 t U.

Commercial resources are allocated in the sediments of different ages from Paleogene to Paleozoic and more ancient. In this case, the most part of the resources, 68.4%, is found in the Cretaceous friable permeable sediments. In the Paleogene, 10.8% resources are concentrated in the same friable and permeable sediments. Impermeable Jurassic rocks have 7%, while Paleozoic rocks have 13.8% resources. Of these, 78.4% uranium resources of Kazakhstan are amenable for ISL and other 21.6% are suitable for conventional mining.

2. ORE-FORMATION PROCESSES AND TYPES OF URANIUM DEPOSITS IN KAZAKHSTAN

Uranium occurrences and industrial deposits are forming as a result of different processes and formation of the uranium mineralization are detected in the wide spectrum of endogenic and exogenic oregenesis. Without going into details of whole variety of the ore occurrences, we have concentrated on the processes of the forming of the industrial uranium deposits.

Processes of endogenic oregenesis formed two industrial types: acid volcanic and vein (more exactly-vein-stockwork).

Acid volcanic deposits are located in South of Kazakhstan (Botaburum and Kyzylsay) and also in the central part (Djidely). These deposits have been completely mined out at this time.

The group of vein-stockwork deposits are more numerous. These deposits are found in both South of Kazakhstan (Kurday and Djusandalinskoe) and especially in the North, where they have formed a very important ore region. Smaller vein-stockwork deposit Ulken-Akzhal (about 2000 t U) is located separately in the East of Kazakhstan.

Exogenic processes are widely noted in the territory of Kazakhstan where they have formed different occurrences and deposits connected with the oxidation-reduction geochemical barrier. In the arid climate condition of Kazakhstan numerous uranium occurrences were formed in different settings. The formation of industrial deposits were developed only in the oxidation of young Cenozoic bed that was developed due to Paleogene artesian aquifers, where as in the Cretaceous and Jurassic sediments they were formed on the redox-front only. It needs to be noted that at the same geochemical barrier in the top parts of the coal beds of Jurassic sediments, the industrial uranium ores could be formed as a result of an influence of the oxidation of ancient Mesozoic soil. In this case, it was possible that the formation of the uranium deposits be classified as deposits of the coal-uranium type.

The belt of depression structures located in the South of Kazakhstan (south of the Aral Sea-Lake Balkhash), is the area where bed oxidation zones and ancient soil oxidation zones occurred. These depression structures are artesian basins with infiltration regime. In the South, they are in contact with mountain system Tyan,-Shan, acting as water supplying area for the aquifers of the depression structures. The bed oxidation zones are developed primarily in the Chu and Syrdarya depressions (in the region of Chu River and Syrdarya River) where 14 large and unique uranium deposits were discovered (Fig. 2). Only one industrial deposit connected

with the bed oxidation zone in Cretaceous sediments is found in the Eastern part of Kazakhstan in Ili and Balkhash depressions (in region of Ili River and Lake Balkhash). However, here too deposits of coal-uranium types in Jurassic sediments were also noted.

A very interesting genesis is considered for the Kopalysay deposit. It is agreed that this deposit is also associated with the oxidized bed zone but this one is found in ancient sediments of Lower Silurian age. The oxidized bed zone has perhaps been developed in the Upper Silurian or some later time. Then, the host rocks and ore bodies underwent recrystallisation and eventually transformed to the hard impermeable rocks that are now not amenable for ISL. It is interesting to note that the Kopalysay deposit is the single example of the ancient oreforming epigenesis in Kazakhstan.

The more unique genetic example is noted in the deposits of the Pricaspian region where the ores are located in the Oligocene beds along with the numerous detritus of fish bones. These ores have the diagenetic nature and have been determined as an organic phosphate type.

Thus, only four types of uranium deposits form the industrial resources in Kazakhstan, despite the presence of different and numerous occurrences of uranium mineralization. These are: sandstone type, connected with zone of oxidized beds (78.4% of total uranium resources), vein-stockwork (15.4%), coal-uranium (4.5%), organic phosphate (1.7%).

Undoubtedly, the uranium resources from the first two types of deposits are of major importance and form the two main industrial uranium regions of Kazakhstan known as Chu-Syrdarya and Kokshetau.

3. ORE REGIONS OF KAZAKHSTAN

Metallogenic zoning of Kazakhstan territory has been frequently investigated by many researchers for the preparation of metallogenic provinces, zones and other subunits. This zoning was used successfully for prognosis mapping and definition of further efforts to carry out the search and exploration of uranium both in Kazakhstan and in other regions. In this article the ore regions, their industrial importance and the appropriate timing for their exploitation are discussed. These decisions were made possible by the knowledge gained from adequate research that has been carried out in Kazakhstan. It is most probable that additional uranium resources in Kazakhstan will be discovered in the above mentioned regions.

3.1. Chu-Syrdarya region (Fig. 2)

The region is located in the South of Kazakhstan and includes exclusively the sandstone deposits connected with bed oxidation zones. Chu-Syrdarya region is located at the edge of a huge platform and, beginning from Cretaceous, this region was in the form of a large alluvial plain. Sedimentation on this plain is connected to the activity of the large paleochannels. At the beginning of Upper Cretaceous the continental conditions gave way to marine conditions with the formation of the gray-green clay horizon with a thickness of up to 150 m. This horizon is the regional upper confinement and creates the favourable conditions for the bed oxidation zones development in the Cretaceous-Paleogene sediments as in the common hydraulic system.

Bed oxidation zones have a regional nature and extend from the mountain system of Tyan-Shan, that are located in the South, to beyond the borders of the Republic, and to the north-

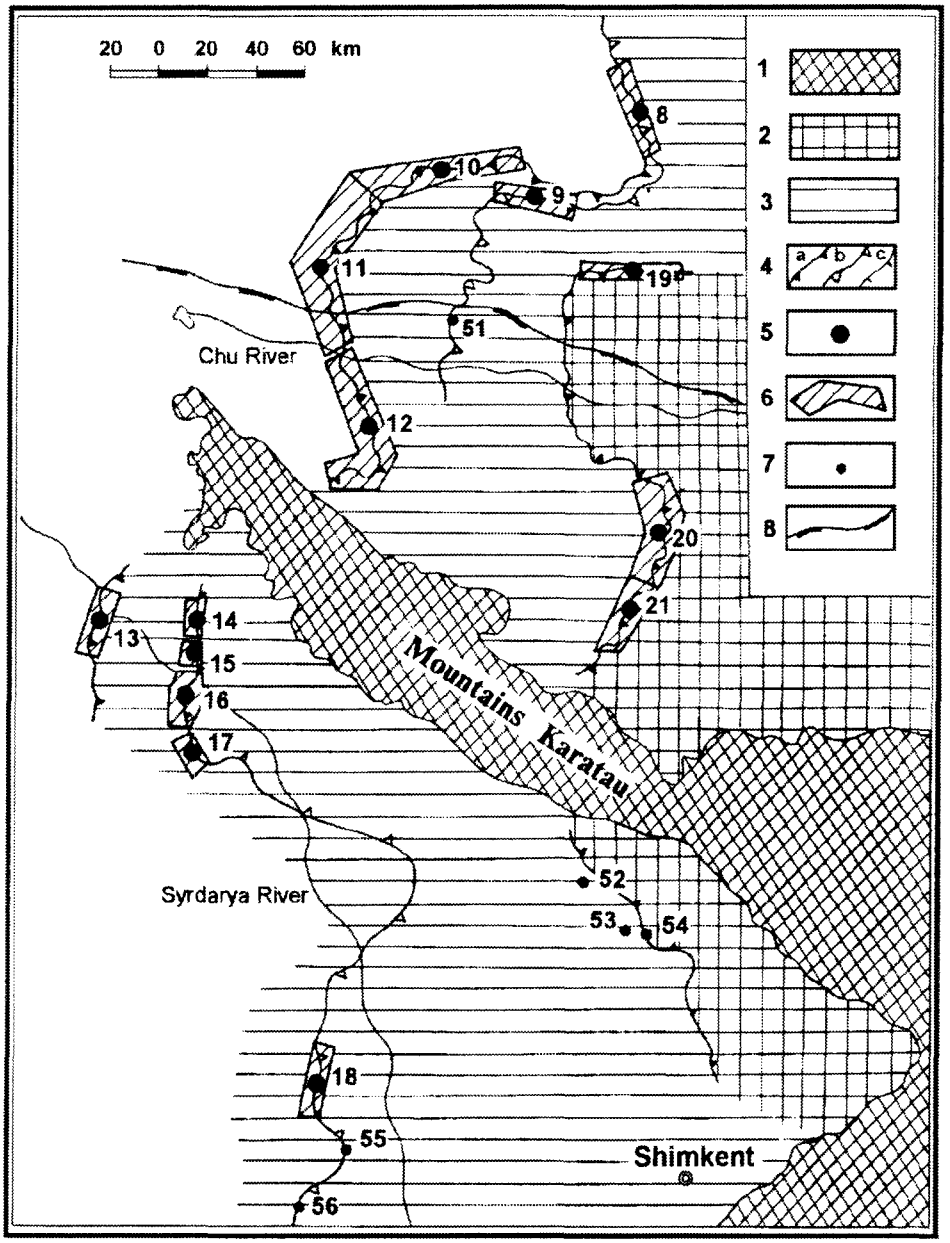

FIG.2. Distribution of uranium deposits in the Chu-Syrdarya ore region in Kazakstan

1-Outcrop of Pre-Mesozoic rocks, 2-Area of the bed oxidation zone development on whole thickness of Cretaceous-Paleogene sediments, 3-Area of the bed oxidation zone development in Cretaceous sediments only, 4-Redox-front a)in Paleogene sediments, b)in Zhalpak horizon of the top of upper Cretaceous, c)in Mynkuduk-Inkuduk horizon of middle part of upper Cretaceous, 5-Industry uranium deposits amenable for ISL, 6-Ore-fields of the industry uranium deposits, 7-Small non-industry uranium deposits, 8-North boundary of the artesian water.

Industrial deposits: 8-Zhalpak, 9-Akdala, 10-Mynkuduk, 11-Inkay, 12-Budyonovskoe, 13-Irkol, 14-North Karamurun, 15-South Karamurun, 16-North Harasan, 17-South Harasan, 18-Zarechnoe, 19-Uvanas, 20-Moyunkum, 21-Kanzhugan

Non-industrial deposits: 51-Sholak-Espe, 52-Kyzylkol, 53-Lunnoe, 54-Chayan, 55-Zhautkan, 56-Asarchik

west direction up to 500 km. At the end of these zones in the redox-front area, uranium deposits are formed. It is postulated that uranium ores began to form at the beginning of the Oligocene time and were still forming up until recently.

The region encloses the territory of the two depressions — Chu-Sarysu and Syrdarya that are divided by the Karatau mountains. The lifting of Karatau started only recently and after the formation of regional bed oxidation zones therefore the recent hydrogeological conditions has insignificantly influences on the distribution ore bearing redox-fronts.

Bed oxidation zones are developing throughout the whole thickness of friable Cretaceous-Paleogene sediments of the region. The thickness of the permeable part of the series reaches 350–500 m. The permeable ore bearing series could be divided into the 9 ore subhorizons with commercial ores.

The ore bodies have the form of rolls or bed bodies of rolls wings. The average thickness of the ore bodies ranges from 4 to 8 m and sometimes reaches 20–30 m. The uranium content could be 0.03–0.08% and sometimes up to 0.1% or more. The major uranium minerals are nasturan and coffinite. Some deposits have Se, Re, V and Sc in commercial grade. These ore bodies have up to 10–15 km in lateral extend and have been determined down to the depth of 100 to 800 m. Approximately as many as 68% of resources are located in the artesian aquifers. The ores have high permeability (up to 5–8 m per day and more) and high recoverability. The properties of the ores combined with the assumed increased water temperature with depth might give to the possibility of commercial profitable ISL mining operation for the ore bearing redox-front at deeper than 800 m.

Total resources of the region represents 75.6% of the total resources of Kazakhstan.

3.2. Kokshetau ore region

The Kokshetau region is located in the North part of the Kazak Shield and includes more than 20 uranium deposits, 16 of which have more than 1000 t U each. All deposits are of the vein-stockwork type except the Semizbay deposit that has the ores associated with redox-front and amenable for ISL mining. Three of these deposits have now been mined out.

Uranium deposits are located in the different geological structures and in different host rocks. But all deposits are characterized by the association of uranium ores with fault structures and a series of metasomatic alterations of the rocks that had been led to formation of vein-stockwork ore bodies.

Ores of this type are characterized by not very high grades (0.1–0.3%). Deposits include from 1000 t U to 10000–20000 t U. The largest deposit is the Kosachinoe deposit that contains 96000 t U with an average grade of 0.1%. This deposit is being explored now.

Total resources of the region represents 16% of the total resources of Kazakhstan. Taking into consideration that the industrial base of Tselinny Mining and Chemical Company, which has a capacity of up to 2500 t U per year, is in place, the region can become a good base of the uranium industry in Kazakhstan.

3.3. Ili-Balkhash ore reserve region

The region is located in the district of Ili river and Balkhash Lake and includes the deposits of different types. Two coal-uranium deposits named Koldjat and Nizhne-Iliyskoe (70% of total resources of the region) and Sulushokinskoe deposit (26% of resources) which is associated with bed oxidation zone and that is amenable for ISL mining, are the main deposits of the region. The vein-stockwork Djusandalinskoe deposit and Kopalysay deposit which is associated with ancient bed oxidation zone are not amenable for ISL mining.

The Sulushokinskoe deposit could be mined under the present economic condition. With regard to the coal-uranium deposits, they have very complicated mine-geological conditions and are located in the recreation area which has a complicated hydrological environment and could not be mined without applying specially designed and costly conservation measures. Therefore, these resources are kept as reserve.

Total resources of the region represents 6.7% of the total resources of Kazakhstan.

3.4. Pricaspian ore reserve region

Uranium mining in the Pricaspian region, on the unique organic phosphate type deposit with low grade of uranium, is stopped now due to economic reasons. However, considering the significant contents of the rare earth elements in the ores, the region might have some importance. Resources of the region represents 1.7% of the total resources of Kazakhstan.

4. SUMMARY

The numerous uranium ore occurrences of different types have been discovered in Kazakhstan through 50 years of investigative history. The enormous industrial uranium resources of Kazakhstan are presented mostly (93.8%) by two major types. There are deposits of sandstone type or subtype which is associated with the bed oxidation zone in Cretaceous-Paleogene permeable sediments and the vein or vein-stockwork subtype with ore formation in the fault structures that appeared in the different Paleozoic and more ancient rocks.

The above mentioned deposit types are found in two main uranium ore regions in Kazakhstan. These deposit types dictates the two mining methods that should be used for their exploitation. The deposits associated with bed oxidation zones found in the Chu-Syrdarya ore region with ISL mining method and the deposits of vein-stockwork type found in the Kokshetau ore region with conventional mining.

The future of uranium industry in Kazakhstan for a long time will be dependence on the uranium mining in these two regions. Therefore, the ISL mining will continue to provide more than 80% of the total uranium production in Kazakhstan.

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