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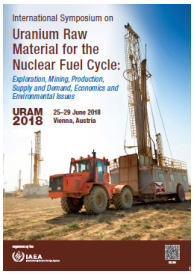

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Uranium Resources and Perspectives for Nuclear Supply in Argentina

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INTRODUCTION

In 1992, due to the low prices in the international market, the import of uranium concentrates began from South Africa, a situation that gradually led to the closure of local production in 1997. Since then, there has been no production of uranium in the country, while the uranium needs from operating nuclear power plants have been met with raw materials imports from abroad (i.e. Uzbekistan, Czech Republic, Kazakhstan and Canada).

However, despite the fact that international uranium market has been depressed in recent years, the Free On Board (FOB) prices that the country has paid for the purchase of yellowcake in the spot market have not necessarily been trivial, mainly due to the increases in transportation charges, insurance premium and taxes [1].

This paper attempts to present a comprehensive vision of and uranium projects, updated resources, and project statuses and the perspective of local production of uranium oxide concentrate regarding the foreseeable demand for nuclear energy generation in the country. Besides, the eventual row material supply from the Latin American region is briefly discussed.

DESCRIPTION

Argentina has three heavy water reactors, namely Atucha I with a gross electrical power of 362 MWe that is fuelled with Slightly Enriched Uranium (SEU) (0.85% U-235), and Embalse (CANDU) and Atucha II, both based on natural uranium fuel with generation capacities of 648 MWe and 745 MWe, respectively. At present, Atucha I and Atucha II, located in Buenos Aires province, are in commercial operation, while Embalse, located in the province of Cordoba, has been out of the generation system for two years for refurbishment tasks designed to extend its useful life for a term of 30 years, which includes an increase in its power by an additional 35 MWe [2].With an approximate installed capacity of 1.7 GWe, nuclear power sources have a 10% share in the national electricity matrix, with natural uranium requirements of about 220–250 tU per year.

Additionally, at the Atucha site, the Argentine prototype small modular reactor CAREM (27 MWe net/32 MWe gross) is under construction and is planned to come into operation in 2020–2022 and in the future plans are to increase the scale of the unit to a higher capacity of possibly 120 MWe.

As part of the nuclear development in Argentina, China and Argentina signed an agreement for the installation of the fourth (CANDU Pressurized Heavy Water Reactor) and fifth (Hualong One Pressurized Water Reactor) nuclear power plants in the country, with construction planned to start in 2019 and 2021, respectively.

Based on various nuclear growth scenarios, it is estimated that by 2030 there will be a generation capacity of some 3,470 GWe, for the low case, and about 4,070 GWe, for the high case. Therefore, the raw material needs would consist of 525 tU and 620 tU in the respective scenarios, which is about double the current consumption.

In 2017, CNEA reported about 19,000 tonnes of uranium (tU) as identified resources (Reasonably Assured Resources + Inferred Resources) for the production cost category <130 USD/kgU in the OECD-NEA/IAEA classification scheme [3]. Approximately 11,000 tU of Canadian National Instrument 43-101 (NI 43-101) certified resources have been reported in recent years by the public mining company named U3O8 Corporation [4]

and the private mining company named UrAmerica Limited [5]. The total uranium resources of Argentina are thus 30,010tU in the aforementioned Identified Resources category. It can be highlighted that if the higher production cost category of <260 USD/kgU is considered there is no substantial variation and identified resources account for 31,060 tU.

In the Cerro Solo Deposit (Chubut Province), the tonnage and grade estimated are expected to ensure sustained uranium production in the future. The identified resources are 9,230 tU at approximately 0.1 to 0.2 per cent U, which are included in the < US260/$kgU production cost category. The reported resources correspond to the most studied mineralized
$feasibility studies, in 1997 the CNEA retained NAC International to complete the Preliminary Economic Assessment (PEA) o$
$environmental baseline is being surveyed in cooperation with national universities and research councils.$

In the Laguna Salada project (Chubut Province) uranium identified resources have been evaluated at 3,880 tU at grades ranging between 55 and 72 ppm U, while vanadium identified resources have been assessed at 21,330 tV at grades ranging from 308 to 330 ppm V. Recently, the NI 43-101 PEA, where U-V comprehensive recovery concept is reinforced. Uranium and vanadium would be extracted from the fine material after screening by alkaline leach, in which the reagents are sodium carbonate (washing soda) and sodium bicarbonate (baking soda) at an optimal temperature of 80℃ [7].

Sierra Pintada uranium Deposit (Mendoza Province) [8] has been the focus of the most significant uranium production in the country, with a total of 1,600 tU produced from 1975 to 1997, after which, the mining-milling facility was put in stand-by status for economic reasons. The level of uncertainty in the estimation of remaining resources in is medium to high, which are evaluated to be 10,010 tU recoverable identified resources at a production cost below US 130/$kgU. Therefore, feasibility has been partiall$
$leaching mining method. Given the possibility of the reopening of the mining-milling complex, all available data have b$

Meseta Central project (Chubut Province) is located in the vicinity of Cerro Solo and comprises the Graben, Plateau West and Plateau East deposits. The total inferred resources for the project are 7,350 tU at an average grade of 260 ppm U. As reported by UrAmerica Ltd., about 75 per cent of the uranium resources evaluated occur in confined aquifers layers [5]. Therefore, further geological and hydrological studies will be undertaken to determine amenability to in situ leaching mining. The results of these studies could play a relevant role regarding the socio-economic viability of this project. It must be noted that in January 2018, the Ministry of Science, Technology and Productive Innovation of Argentina, Uranium One Group, subsidiary of State Atomic Energy Corporation of the Russian Federation (ROSATOM), and UrAmerica Argentina S.A. signed a memorandum of understanding whose main purpose is to promote cooperation and joint development on uranium exploration and production focused on In Situ Leaching. Planned investment in this project amounts to USD 250 million [9].

The Don Otto (Salta Province) uranium deposit was in operation from 1963 to 1981 and produced 201 tU at 0.1 to 0.2 per cent U grade [10, 11]. The reminding identified resources are 430 tU and current exploration/evaluation studies yielded very encouraging results. Additionally, enlargement of the mining property and resource augmentation are considered key factors to ensure the project feasibility. A comprehensive study that includes updating environmental impact assessment (EIA) reports, block-leaching research and development studies, feasibility of underground extraction, use of a mobile ionic exchange plant, hydrogeological studies to define in situ leaching amenability, vanadium resource evaluation and extraction feasibility, and uranium recovery from the former heaps and remediation of the site, are all factors that would aim to increase project viability [12].

Laguna Colorada is located in the Chubut Province with evaluated resources of 160 t U at 660 ppm U [13]. The limited resources of the project make it difficult to envisage extraction at present unless the characteristics of the ore will allow treatment in a plant that may in the future be located in the area of Cerro Solo.

At the exploration level, there are several projects such as Golfo San Jorge, Amarillo Grande, Alipan, Mina Franca and Laguna Sirven within the basins of great interest in the country that are carried out by both the private sector and the government. Initially, it will be necessary to advance the delineation of resources and raise their level of confidence through preliminary economic assessments of these projects, taking into account that, as general rule, the integral exploration at basin level has not been carried out and resources have generally been evaluated with a low level of confidence. In sedimentary environments, particular attention should be given to those sandstone-type deposits that are amenable to in situ leaching to recover uranium.

Also, there are some unconventional sources of uranium that could provide sustainable alternatives for nuclear supply in the foreseeable future, such as rare earth projects, phosphates, and lake and sea

waters.

DISCUSSION AND CONCLUSION

Despite the apparent growth prospects of the use of nuclear energy for the generation of electricity in the country, which would lead to double the uranium needs by 2030, there are no immediate prospects for the provision of nuclear raw material for fuel fabrication from the local production of uranium oxide concentrates at Argentine deposits. This has implications for supply and energy security [14].

One main concern is that the identified uranium resources in Argentina are mostly located in the provinces of Chubut and Mendoza. These are areas where no metallic mineral mining projects are in operation, and also, the provincial legislations markedly restrict uranium production. These factors need to be taken into account when studying the socio-economic viability of the projects. However, it could also be assumed that the mining laws could be amended as necessary if a requirement of uranium and other critical materials for clean energy projects becomes very important to Argentina.

Also, projects with a higher degree of maturity must complete technical feasibility studies for the recovery of uranium. In the case of possible future production of U, other valuable materials such as V and Mo, can be assumed to be produced as a by- or co-product, contributing to the mineral sector development in Argentina. While U is used for nuclear fuel, V and Mo have critical applications, especially in the renewable energy and steel industry sectors.

In the Latin America region both Brazil and Paraguay could be consider as potential uranium suppliers for Argentina. In Brazil, in the short - medium term, domestic needs would be covered and even significant uranium surpluses could be produced that could contribute to nuclear supply for Argentina. On the one hand, with the expansion, the Lagoa Real deposit would produce about 670 tU/ year. On the other hand, some 1700 tU / year would be obtained as a by-product of the extraction of phosphates in the Santa Quitéria deposit, from 2020-2022. As a recent precedent, in 2016 Industrias Nucleares de Brasil (INB) and Combustibles Nucleares Argentinos (CONUAR) signed an agreement for the provision of four tons of low enriched uranium (1.9% - 3.2% U-235) produced at the Rio de Janeiro facility in Brazil to be used for the fuel of the initial load of the CAREM reactor which is under construction at Lima site in Argentina [15].

While in Paraguay there are two projects of interest found in the eastern part of the country, related to sandstones in the western flank of the Parana Basin: Yuty project, with about 4,290 tU of NI 43-101 certified resources, and Coronel Oviedo project, which constitutes a NI 43-101Exploration Target ranging 8,900 to 21,500 tU. In both projects hydrogeological testing indicates that the uranium bearing unit has aquifer characteristics that would support operational rates for ISR mining. These projects are waiting for better market conditions to be developed and as Paraguay has no prospects for the use of nuclear power, these resources could contribute to the supply of nuclear fuel resources for Argentina. To this regards, it must be highlighted that Argentina is constructing a new uranium purification plant located about 200 km far away from Paraguayan uranium projects. Therefore, the transportation of pregnant resins or elluants could be consider as the best economic and technical option, rather than yellowcake to be precipitated in Paraguay ISL facility and to be dissolved at the uranium purification plant in Argentina [16].

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