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Perspectives of Phosphate - Uranium Comprehensive Extraction Projects in Argentina

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INTRODUCTION

Systematic prospecting studies of phosphates in sedimentary basins were carried out during the 1970s by the Argentine Geological Mining Survey (SEGEMAR). This program delineated eighteen areas in several marine basins with phosphate potential, occupying a total area of about 640,000 km2 [1]. In the mid-80s, a research group of the Department of Geology of the University of Buenos Aires (UBA), faced the study of new areas for the prospection of phosphates, which currently continues, focused on the genesis and sedimentation environment of phosphate deposits in different basins. New data, together with published information about phosphates have been compiled, and principal phosphate occurrences and their correlation with the global phosphogenetic events have been defined (Cambrian, Ordovician, Jurassic-Cretaceous, Cretaceous-Paleocene, Miocene and Modern) [2].

At present, the National Atomic Energy Commission of Argentina (CNEA) and the UBA, in cooperation with the National University of Salta (UNSa), are carrying out the project "Assessment of the uranium potential of phosphate rocks and testing low-grade phosphate ores extraction"in the framework of the IAEA Coordinated Research Project (CRP), which is "Uranium-Thorium fuelled High-Temperature Gas-cooled Reactor (HTGR) applications for energy neutral sustainable comprehensive extraction and mineral product development". This paper briefly describes the specific objectives and activities in progress of this research project which has been underway since 2015 [3].

DESCRIPTION

In Argentina, all of the uranium identified and undiscovered resources belong to conventional sources, and the purpose of the aforementioned RC is to assess the unconventional uranium (Th, REE) resources related to phosphate rocks. The project also pursues the aim of better understanding how thermal extraction can be used to beneficiate and process low-grade phosphates from Argentinean sedimentary basins. This would help to increase the socio-economic viability and technical feasibility to set up productive projects in the long term.

The research project involves studies in three sedimentary basins (Ordovician North-Western Basin, Upper Jurassic –Lower Cretaceous Neuquen Basin, and Paleocene - Miocene Patagonia Basin), where low-grade phosphate mineralization and uranium anomalies (up to 135 ppm U) have been detected. Exploration and beneficiation/extraction studies are being conducted, which would allow an evaluation of the economic potential of the study areas.

During the first year of the project studies have focused on the geological and geochemical characterization of phosphate rocks of the Ordovician North-Western basin. After completion of the evaluation of available information, Mojotoro Range (Salta Province) and Tilcara Range (Jujuy Province) sites, which are located approximately 1500 km away from Buenos Aires city, were selected for specific studies. Two field missions for geological characterization, sampling and ground gamma-ray spectrometry surveying have been carried out. In total, nine stations were set up, where geological studies and collection of 10-kg samples of phosphatic rocks, including all of the mineralized levels and the barren material as a background, were implemented.

These Ordovician phosphate deposits show a temporal and a spatial distribution of phosphate-bioclastic accumulations linked to the paleogeographic basin evolution and mineralization is made of discontinuous lenses from 10 to 60 cm thick of lingula-bearing coquinas outcropping in studied areas.

These phosphatic levels are intercalated in Tremadocian shales, Tremadocian-Floian shales and mudstones, Dapingian-Darriwilian quartz sandstones and Darriwilian-Sandbian shales, and limestones. Phosphatic inarticulate brachiopoda fragments are concentrated in the lower part of the laminated fine quartz sandstone, assigned these deposits to tempestites accumulated in lower to middle shoreface coastal marine environments. The grade varies between 5 to 7 per cent P2O5. There is a positive correlation between phosphorus and U, Th and rare earth elements (REE). According to their P2O5 contents the analyzed samples are classified as: Phosphorites (19 and 21 per cent P2O5), phosphate rock (8 - 18 per cent P2O5) and slightly phosphatic rocks (<8 per cent P2O5). By comparing date from mineralized and barren material, preliminary studies indicate that all samples exhibit significant enrichment in Y, Sr, La, Yb, U, Th, Pb, Zr and REE, which encourage further comprehensive extraction tests [4].

During the second year tasks have been addressed to the Upper Jurassic - Lower Cretaceous Neuquen basin. After completion of the evaluation of geological, geochemical and gamma-ray spectrometry available information, two areas were selected for specific studies: “Cerro Salado” and “Vaca Muerta”, which are located in the Neuquen province, approximately 1300 km away from Buenos Aires city. Therefore, at this basin, a field mission for sampling and ground gamma-ray spectrometry surveying has been carried out including a total of ten stations where geological studies and collection of 10-kg samples of phosphatic rocks for mineralogical, chemical and extraction studies were implemented. P2O5 content is between 3 to 4.5 per cent and U varies from 3.5 to 5.5 ppm [5].

The Quintuco Formation is 218 m thick and hosts phosphate mineralization. The phosphatic beds are wackestones, bioclastic rudstones and hybrid sandstones forming condensed beds with variable mechanical reworking and are grouped into four phosphatic intervals. Phosphatic particles are mainly nodules and subordinated, partially or totally phosphatized shells. It is though that the phosphogenesis took place during sea high stands and low clastic sedimentation rates, and then reworking by waves and currents and concentration of phosphatic particles occurred during periods of sea-level rise and fall [6].

During the third year of the RC, field work and laboratory studies are focused on Cenozoic marine section cropping out near Gaiman (Chubut Province, SE Argentina approximately 1400 km away from Buenos Aires city), which shows that most of the succession was deposited in a shallow, storm-dominated marine environment. Flat-lying Miocene rocks exhibit a 200 m thick column composed of a coarsening upwards succession of mudstones, fine tuffs, sandstones and coquinas, rich in phosphatic concretions, ray teeth, shark teeth and bones from marine vertebrates. Phosphatic strata are related to: a) in situ concretions developed within transgressive-early highstand system tracts, and b) reworked and winnowed lags associated with transgressive surfaces which display a concentration of phosphatic concretions, ooids, vertebrate bones, teeth and shells. P2O5 content in concretions is between 15.61 to 28.97 per cent and U varies from 46 to 135 ppm. Phosphogenesis would have taken place after cold and corrosive water, probably similar to the present Antarctic Intermediate Water (AAIW), flooded the continental shelf and mixed with warmer surficial waters. The development of the phosphorites would have occurred at times of global climatic transition and increased oceanic circulation, probably during the Late Oligocene–Early Miocene [7].

DISCUSSION AND CONCLUSION

It could be pointed out that to date economical phosphate deposits have not been found nor has production been carried out in Argentina. Phosphate identified resources, which belong to restricted sites of Northwest and Neuquen Basins, have been evaluated at 1 M t of P2O5 with grades ranging from 2.5 to 6.3 per cent P2O5 [8].

However, the existence of favorable basins and different mineralization models suggest promising conditions to set up new projects to develop the phosphate potential in the country, taking into consideration the perspective of uranium recovery from this unconventional source of nuclear raw material.

At the current level of knowledge, uranium quantities linked to phosphates are evaluated in the United Nations Framework Classification for Resources (UNFC) scheme as “Additional Quantities In Place Associated with Potential Deposits”, where a portion of these quantities may become recoverable in the future [9].

The IAEA project CRP on neutral uses of HTGRs would allow accounting for a better understanding about heat processing of low-grade phosphates. This process would aid to increase the socio-economic viability and technical feasibility to set up productive projects in the long term by providing positive implications regarding food and energy security.

This contribution is a summary of several studies that were conducted by the National Atomic Energy Commission of Argentina, the University of Buenos Aires, the International Atomic Energy Agency, the National University of Salta and the Argentine Geological Mining Survey. The authors are grateful to many institutions for allowing the information to be assessed and presented here.

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