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# URANIUM PRODUCTION IN CAETITÉ, BRAZIL

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## INTRODUCTION

Brazil's two nuclear power plants average consumption is 400 tons of $U_3O_8$ per year. To supply this demand, the state company Indústrias Nucleares do Brasil (INB) runs a mining/ore processing operation in Caetité, southwest region of Bahia, 5th largest Brazilian state. At the present time this is the only uranium site production in the country (as well as in South America) and is called Unidade de Concentrado de Urânio - URA.

INB is almost fully in charge of so called "nuclear fuel cycle", a chain of processing operations ranging from ore mining to the electrical energy generation (this one is made by another state company), including the uranium concentrate production and the technologically restrict step of isotopic enrichment.
Brazil has the 6th world's largest uranium reserves, with only 35% of its territory already prospected. The identified resources (reasonably assured resources plus inferred resources, according to the International Atomic Energy Agency standards), of about 278.700 tons of U are enough to supply the internal demand for several years even in the case of the building of new nuclear power plants, as seems to be the plans of the government.

## GEOLOGICAL AND MINING ASPECTS

URA facilities are localized in a region usually called as Uraniferous Province of Lagoa Real (UPLR). This region has been searched for uranium deposits since 1971. More than a hundred anomalies were found until 1976. Nowadays, the province of Lagoa Real has 35 uranium anomalies distributed over a surface area of 1.200 km2, roughly along three semi-arched lineaments, covering an approximate extension of 30 km. There are twelve among these 35 anomalies that exhibit important uranium content. Ten of these areas account for 94.000 tons of reasonably assured resources of $U_3O_8$ **[2].** The UPLR is considered the most important monometallic province in Brazil. Uranium is economically the only mineral wealth, occurring mainly in the oxide form, constituting the mineral ore known as uraninite, with mean grade of 2100 ppm of $U_3O_8$.

The geological aspect of the region is constituted mostly of migmatites, granites, gneisses and albitites partially covered by residual soil or poorly transported sediments. It comprises Lagoa Real granite complex, which constitutes the only known occurrence of middle proterozoic plutonism in the Bahia state.

Primary mineralization constituted of uraninite and pitchblende has a lithostructural control, and occurs in albitites carrying sodic, calcic and ferromagnesian minerals, as multi-sized phylolian lenticular bodies. Secondary uranium minerals (uranophane and autinite) are restricted to weather change zones, mostly dependant on fracture systems.

The uranium mining activities in the province started by 2000, with the beginning of exploration of the Cachoeira mine (Figure 1), by open pit mining. This initial period of exploitation is about to be finished at the end of 2011. Until this time there will have been exploited 1.650.000 tons of uranium ore. The open pit mining is conducted with conventional techniques, according to the mining plan guidelines, with help of concurrent lythological and radiological survey. Until the present time, the mean uranium grade of the ore was found to be 3000 ppm of $U_3O_8$. It was used the cut-off grade of 700 ppm and the waste rock/ore ratio was 6:1. Despite the exploration of the others anomalies and, consequently, opening of new mines in the province, the Cachoeira mine is going to be explored by underground mining for at least 5 years more after 2011.

*Figure 1. Cachoeira Mine*

The waste rock is disposed in ascending way, forming modular benches, facilitating promptly re-vegetation. The waste rock deposits are surrounded by draining pipes, in order to avoid radio nuclides leaching by rain water. During the rainy season, the water drained from the mining pit or from the waste deposits may be used by the chemical plant or treated and discharged into the environment.

## URANIUM CONCENTRATE PRODUCTION

The URA's physical and chemical ore beneficiation plant can produce 400 tons of $U_3O_8$ per year. The chemical beneficiation process is based mainly in an acid heap leaching followed by solvent extraction purification/concentration. The general flow sheet of the process is shown in Figure 2.

After being transported from the mine by 25-ton dump-trucks, the ore feeds the crushing circuit. Two independents jaw crushers and a closed circuit comprised of two hydrocone-type crushers and a two deck vibrating screen reduce the ore size to less than 13 mm. The undersize of the screen is transferred to a drum mixer where concentrated sulfuric acid is added to agglomerate the fines and start the leaching process through an initial acid cure.

The drum's discharge feeds a set of bet conveyors and a radial stacker that unloads the ore into a pile in a pad lined by a high-density polyethylene membrane. Each pile has up to 35,000 tons of ore at a height not exceeding 5.5 m, and occupies an approximate surface area of 45 x 80 meters. The pile is submitted to three successive washes by dropping systems, being the two first ones of sulfuric acid aqueous solution and the third one of water. The uranium rich water solution, called pregnant liquor and the washing water are collected in three ponds.

Uranium is separated from impurities solubilized at leaching by the solvent extraction, using a solvent containing 7% weight of a tertiary long-chain amine in aliphatic kerosene Uranium is then stripped in another set of cells by sodium chloride solution with pH adjusted to 1.2 by sulfuric acid, where it is precipitated as ammonium diuranate (yellow cake) by the addition of a solution of ammonium hydroxide. The whole process is thoroughly monitored by a sampling and chemical analysis program to ensure the optimal efficiency for the recovery of uranium contained in the ore and the environment preservation.

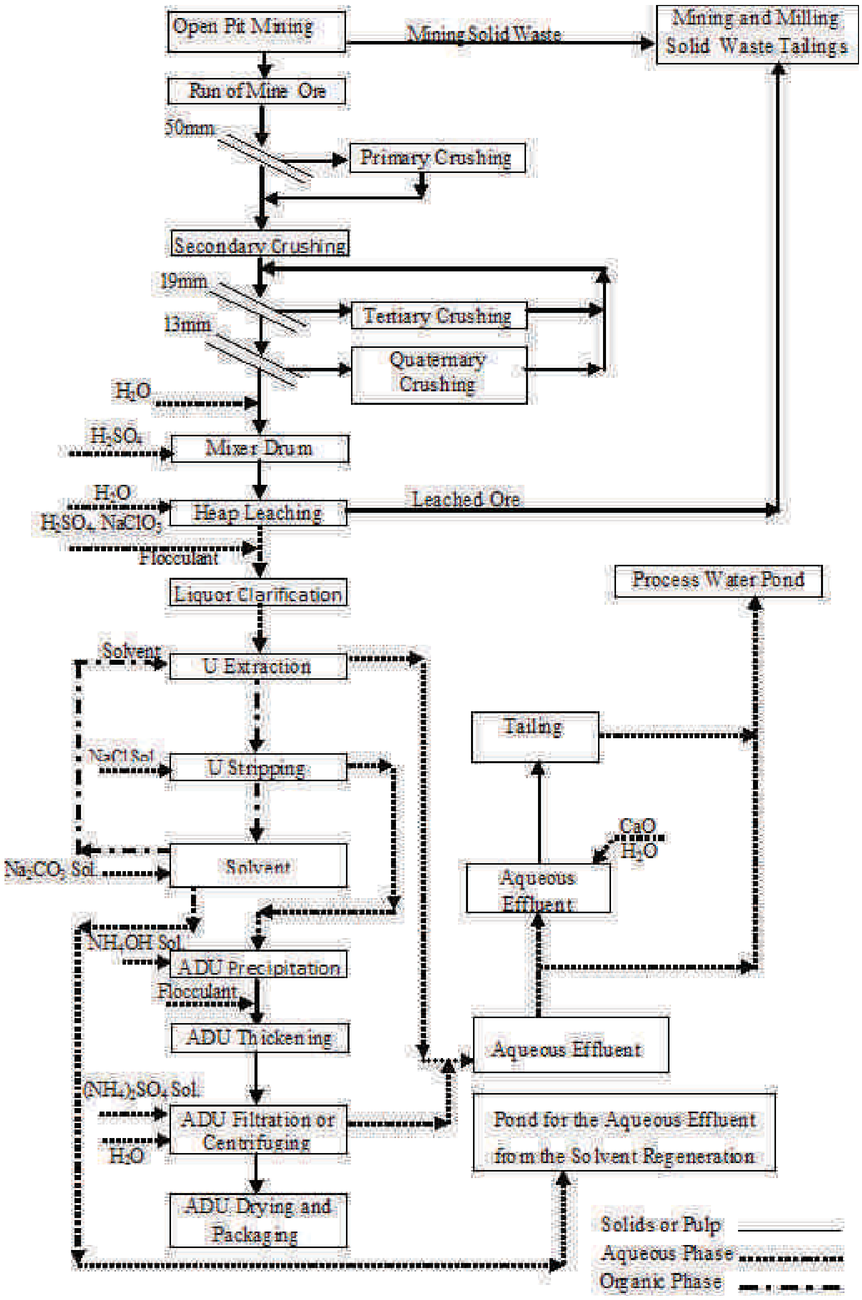


*Figure 2. General Process Flowsheet*

In 10 years of activity, 2.602 tons of $U_3O_8$ were produced ton of $U_3O_8$ at the milling facility from the processing of 56 leaching piles. Average recovery of uranium content is about 78% and the mean grade of the processed ore was found to be 3000 ppm.

## FINAL CONSIDERATIONS

The mining and ore processing at URA facilities can be considered a success case. The facility is about to reach 10 years of operation and has proven to be a solid support to the country development. Recently announced Brazilian government announced plans point to a renewing and improvement of the country's nuclear program. As result of this decision, a new nuclear power plant is already being built and is expected to be ready for operation by the beginning of 2015. There are also plans for the construction of at least 4 another ones until the end of 2030.

If by one side the country's current uranium production is enough to provide the uranium needed by the two existing nuclear power plants, it's not enough to supply the expected growing demand, so INB is managing to improve its output. Several modifications at URA's facilities are being planned. For instance, the turning from open pit mining to underground mining and the changing from heap leaching to tank agitated leaching [3] are already being carried out. The plans also include the exploration of other uranium anomalies in the UPLR region and others process improvements that will, at least, double the annual uranium ore concentrate production.

As a last word, it is worth to note that INB's activities are not restricted to mining and uranium ore processing. The company holds the whole technology of the nuclear fuel cycle, from mining to the fuel element assembly (including the restrict step of isotopic enrichment) and is able to cooperate with the South American countries members of IAEA in the development of its nuclear activities.

### REFERENCES

“Uranium 2007: Resources, Production and Demand”, International Atomic Energy Agency, Vienna, 2008.

E.C. Matos, J.R.A. Silva and L.A. Rubini, "Província Uranífera de Lagoa Real - Garantia de Fornencimento de Concentrado de Urânio (DUA) para as Necessidade Brasileiras", Proceedings of the 20th Northeast Geology Symposium, Fortaleza, Brazil, 2003.

L.A. Gomiero, "Converting the Caetité mill process to enhance uranium recovery and expand production", International Symposium of Uranium Raw Material for the Nuclear Fuel Cycle - Book of Abstracts, Vienna, Austria, 2009.