RECONSTRUCTION OF THE STONE ELEVATION OF THE ROYAL CASTLE IN WARSAW ON THE BASIS OF PETROGRAPHICAL STUDIES

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The Warsaw Castle, largely extended in the Renaissance style to the royal residence in XVI/XVII centuries, has displayed an enormous role in Polish history and culture. At the time of the siege of Warsaw in 1939 it was partly destroyed, and afterwards completely ruined by the Nazi troops during the Warsaw Uprising in 1944.

After the World War II finished, one collected and saved about 4,000 various fragments of sculptures and achitectural details from the ruins of the Royal Castle. The fragments of the elevation masonry (1,300 pieces) were housed in the lapidary at the Vistula escarp foot.

In 1971 it was decided to reconstruct the Royal Castle with the careful maintenance of its original design and most exact reconstitution of the historical details in the Castle achitecture. The studies of the raw materials for the stone masonry of the Castle elevation were performed by the geologists of the University of Warsaw, Geological Institute and Warsaw Polytechnical University.

On the basis of the preserved plans, drawings, photographs and the works preparing the Castle reconstruction, performed till 1971, as well as the detailed stock-taking joined with petrographical investigations of the saved fragments of the stone masonry, it was possible to re-establish the original elevations of the Castle and to indicate the stone raw materials used both during the Castle construction and its later modernisations and reconstructions.

The performed studies shown, that for the Castle elevation one used rocks from Central Polish region, commonly applied to sacral buildings and palaces in Poland. The construction stone materials comprise:

1. Lower Jurassic sandstones of the Szydlowiec type, excavated in the quarries in the northern margins of Świętokrzyskie Mts. Tertiary sandstones of distinctly lower technical parametres were found later, probably being used for late restorations.
2. Middle Triassic Diplopora and ore-bearing dolomites from Silesian-Cracow Upland, exploited till present at Ojcuz.
3. Upper Jurassic (Oxfordian) limestones from Silesian-Cracow Upland, exploited at Sułoszowa.

Moreover, in the preserved stone materials one stated fragments of stairs and tile floors, prepared from Wołyń granitoids, but not, as supposed earlier, from Tatra granitoids.

The petrographic studies jointly with the results of the architectural works resulted in preparation of the detailed list of the rock types, necessary to the Castle reconstruction, and allowed to submit the stone raws from the historical quarries and pits, or, if it was impossible, from the nearest locations within the same rock formations. For the reconstruction one attempted to select the rocks of the best technical parametres.

The performed investigations led to the very exact re-establishing of the historical elevation, in which one used the preserved original fragments and the parts, prepared from newly indicated stone materials. Due to the mellowing of the new materials, similar to that of the original fragments, the visual differences between the new and old parts of the elevation after years, that have passed from the time of the Castle reconstruction, completely disappeared.

PRIMARY AND SUPERGENE ORE MINERALS ASSOCIATED TO ALKALINE ROCKS: SOME BRAZILIAN CASES

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Alkaline intrusions are very common in Brazil. Their ages range from 160 to 60 million years from Mesozoic to Terciary, besides some oldest ones. Most of them occur in the border of sedimentary basins, as the Paraná basin.

A lot of primary and supergene apatite, pyrochlore, bauxite, lateritic nickel, rare-earth, zircon, baddeleyite, vermiculite, anatase and uranium deposits are related and hoisted by alkaline rocks. Several are being mined and producing large tonnages of apatite and niobium ores, bauxite and carbonatite rock as cement raw material. Also known, there are large deposits of nickel, rare-earth, zircon, baddeleyite, vermiculite and anatase not exploited at present, but representing an important reserve base to be well investigated and developed in the future.

All phosphate production in Brazil come from alkaline rocks carbonatites mainly. The mines are located in Araxá, Tapira, Catalão and Cajati (formerly Jacupiranga), but other unexploited reserves are known in Iperó, Anitápolis, Angico do Dias, Morro do Serrote and Maecuru. The apatite was formed by igneous processes and enriched by supergene weathering/laterization. The mines operate with low grades in the run-off-mine, about 6 to 12% P_2O_5. Mining and ore dressing operations are much more complex when compared to phosphorite sedimentary mines. Flotation concentrates presents about 32-36% P_2O_5 and are being used for fertilizer, food and feed grade products.

Carbonatite as apatite by-product produced in Cajati is used as cement raw material, aggregates and in agriculture.

About 85% of the niobium world supply is produced in two mines, both in Brazil and associated to alkaline rocks. They are located in Araxá (CBMM, the largest producer in the world) and Catalão/Ouvidor, both with large reserves and producing pirochlore/pandaíte high grade ores (3 to 1,5% Nb_2O_5). Middling products as niobium oxide and FeNb are exported, besides a small internal consumption. Other important reserves and resources potencial are known in Catalão II, Morro dos Seis Lagos and Tapira also.

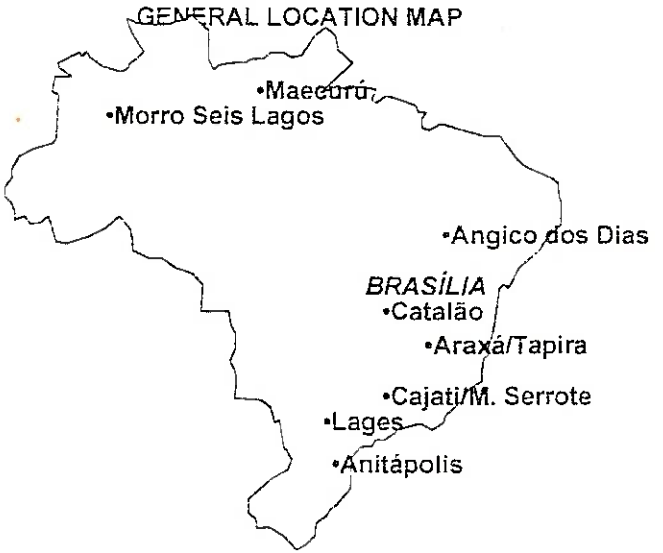
High grade and low contaminant bauxite deposits were formed by laterization of alkaline rocks, as phonolite and tinguaite, at Poços de Caldas.

1. THE ECONOMIC AND TECNOLOGICAL IMPORTANCE OF THE ORE MINERALS ASSOCIATED TO ALKALINE ROCKS

The complexity of igneous primary process and the after weathering, laterization and supergene enrichment which have affected the alkaline intrusions formed large amounts of ore deposits in Brazil[1,2,3].

Several alkaline complexes occur in the border of the most important sedimentary basins as such Amazonas, Maranhão-Piauí and Paraná . A larger number of them is present along the boundary of the Paraná basin, not so far from contact between Precambrian and Paleozoic sedimentary rocks[4]. Some intrusions as such Catalão, Tapira and Serra Negra, the best examples, are plateau and circular in shape, presenting some kilometres in diameter. The ages of the intrusions vary between 160 and 60 million years, from Mesozoic to Terciary, but there are some oldest ones, such as Precambrian (p. eg. the carbonatites bearing apatite in Angico dos Dias, Bahia State[5]). The protore and primary ores are singenetic and have been enriched by supergene process, weathering and laterization by the end of Terciary and Quaternary.

At present, in the intrusions of Jacupiranga (now Cajati[6]), Morro do Serrote[7], Poços de Caldas, Tapira, Araxá and Catalão a lot of large mines are operating, producing carbonatite for cement, bauxite for aluminium and non-metalurgical uses, apatite concentrates for fertilizer, feed and food grade phosphoric acid, niobium and titanium ores. Titanium anatase ore is being mined and stored, not industrialized. There is a non-operating uranium ore mine in Poços de Caldas. Several deposits not exploited at present, but well explored, are known at Anitápolis (apatite), Lages (bauxite[8]) Itapirapuã/Mato Preto (fluorite, rare-earths[9]), Morro do Serrote (baryte), Fazenda Ipanema (apatite, vermiculite[7]), Itatiaia (bauxite), Poços de Caldas (uranium, zirconium, thorium[10,11,12]) , Tinguá-Gericinó (nefeline syienite), Tapira (rare earths, niobium, Ti - anatase), Araxá (barite), Serra Negra (Ti-anatase, niobium), Catalão (vermiculite, Ti-anatase, rare earths[13]), Santa Fé-Salobinha (lateritic nickel), Peixe (zircon, rare-earths[14]), Maecuru (apatite) and Morro dos Seis Lagos (niobium, rare earths[15,16]).



2. APATITE ORE

All the Brazilian production of phosphate - large amounts used for agricultural fertilizer, phosphoric acid, food and feed grade products - comes from apatite ore associated to alkaline intrusions. Both primary and secondary ores are being mined, the later formed by laterization and enriched by supergene process in the upper levels of the deposits. Primary hard rock ore grade is about 5 to 6% P_2O_5 and the supergene 8 to 12% P_2O_5 . Due to the nature of the ore, must be used complex mining and ore dressing operations, when compared to the phosphorite sedimentary deposits exploited in other countries worldwide. The Brazilian annual output is more than 3,5 million tons of P_2O_5 in-concentrates, mined from 4 mines. The largest mine is in Tapira, Minas Gerais State, followed by Araxá, Catalão and Cajati (formerly Jacupiranga). Reserve base are larger than 400 million tons P_2O_5 content, about 10% as proved reserves[17].

The investigations to promote the low grade igneous apatite ores exploitation - once considered as non-profitable resource when compared to the high grade phosphorite mines of Florida and Morrocco - is one of the

most important Brazilian mining tecnology goals. For the sucess of these investigations, a lot of field exploration works as well as mineral characterization, bench and pilot studies suported by *Serrana S.A de Mineração* and oriented by the *Professors Geraldo C. Melcher (who conducted the detailed exploration of the Jacupiranga carbonatite), Paulo Abib Andery (who developed a new flotation process to separate the primary apatite from the carbonatite gangue) , Noé Chaves (together with Abib investigating the apatite of Araxá)* and a team of Brazilian geologists and mining engineers.

In Cajati (formerly Jacupiranga), an important industrial mining and chemical complex producing apatite concentrates and phosphate products is in operation. The carbonatite gangue is used for cement production and the waste as agregate also. As the primary apatite is very pure in chemical composition, without heavy metals contaminants (as Cd for example) it is being used as feed grade phosphoric acid raw material.

2. NIOBIUM ORE

Pandaite or baryum pyrochlore, is another ore resource associated to alkaline rocks in Brazil. Large high grade reserves estimated as more than 100 million tons Nb_2O_5[18,15,19,20] are known in Araxá, Catalão and Morro dos Seis Lagos. Laterization and supergene enrichment have developed a blanket type near surface deposits over primary alkaline rocks, carbonatite mainly [9]. In Araxá also the primary ores present high niobuim grades. Pyrochlore is mined in Barreiro, Araxá, and Catalão. The high grade ore - 3 to 1,5% Nb_2O_5 - is exploited in open pit mines producing niobium concentrates (base 58% Nb_2O_5 content) and Fe-Nb standard (base 65% Nb content). The world niobium demand is about 15,000 tons/year. Two mines in Brazil supply about 85% of the global niobium requirements.

3. BAUXITE

Bauxite is a common ore in Brazil. The most important and the largests reserves are situated in the Amazonian region, Northern Brazil. Large tonnage of bauxite and aluminium is produced and exported. The Amazonian bauxite deposits were formed by laterization of argilaceous sediments.

But there is also bauxite derived from laterization from alkaline rocks - phonolite and tinguaite - in the intrusions at Poços de Caldas, Itatiaia and Lages, Southeast Brazil . The reserves are not so large the Amazonic, but the mines are located close to the industrialized region and presents high purity. High grade, low iron and silica bauxite is produced in some mines in Poços de Caldas and in Itatiaia, the later in small scale.

4. OTHER MINERAL RESOURCES

Large resources potencial and reserves of zircon, rare-earths, titanium as anatase, vermiculite and lateritic nickel are defined and may be well investigated for future exploitation. At present studies are being conduced on mineral process and economic feasibility of the exploitation of anatase and rare-earths in Tapira, zircon (caldasite and baddeleyite) in Poços de Caldas and rare-earths at Corrego do Garimpinho, Catalão [21].

5. CONCLUSIONS

Mineral resources associated to alkaline complexes play an important role in Brazilian mineral production.

Large tonnages of bauxite, apatite, niobium and carbonatite rock are produced to supply the internal markets. More than 85 % of the world niobium demand is provided for two mines in Brazil.

A lot of other very interesting resources and reserves of titanium, rare-earths, vermiculite, zirconium, fluorite and other ore minerals associated to alkaline rocks must be well investigated to be exploited in the future.

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Zircon: A Host-Phase for the Disposal of Weapons Plutonium

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Introduction

One of the new and daunting challenges in nuclear waste management is the disposal of plutonium recovered from nuclear weapons. Under the first and second Strategic Arms Reduction Treaties, as well as unilateral pledges made by both the United States and Russia, several thousand nuclear weapons will be dismantled. This will result in an estimated 100 metric tons of weapons plutonium that will require long-term disposal. The disposal strategy should not only protect the public and the environment, but should also insure that the plutonium is not readily recoverable for use in weapons. A recent report by the National Academy of Sciences [1] presented two "promising alternatives": 1.) use as a fuel in existing or modified reactors; 2.) vitrification in a mixture with radioactive high-level waste. The latter option uses a metastable phase of relatively low thermal durability which will corrode in the presence of aqueous solutions. In this brief note, we recommend an alternative, zircon ($ZrSiO_4$), a highly durable, naturally occurring phase as a host for the disposal of Pu.

Zircon, $ZrSiO_4$, is a well characterized, naturally occurring phase that is extremely durable. Zircon has been synthesized with Pu-concentrations up to ten weight percent and radiation damage effects studied to saturation doses of nearly 0.8 displacements per atom. There are already several demonstrated processing technologies, of which hot pressing offers the most potential. This highly durable material, even under hydrothermal conditions, with its high waste loading and smaller volume allows deep, permanent disposal of the weapons plutonium in geologic environments in which the borosilicate waste form glass would not be stable.

Additionally, one must note the special features of excess weapons plutonium which distinguish it from typical radioactive wastes:

i.) The plutonium is almost isotopically pure ^{239}Pu; therefore, it is ideal for the synthesis of specific phases of high durability.

ii.) ^{239}Pu has a long half-life (24,500 years), as compared to most fission products; therefore, extended, confirmable durability is a highly desired attribute.

iii.) ^{239}Pu is fissile; hence, one must always be concerned about criticality events; furthermore, ^{239}Pu decays to ^{235}U which has a half-life of 700 million years and is also fissile. Thus, the durability of the waste form is not only essential to the retention of Pu and U, but is also required in order to maintain the presence of any added neutron absorbers (e.g., B, Li, Gd, or Hf).

iv.) The multiple oxidation states of Pu and U make the processes of dissolution, oxidation, transport and reconcentration (= supergene enrichment) over geologic periods a possible event in the development of scenarios for performance assessments, particularly in oxidizing environments.

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