Anatase (Titanium Ore) Concentration Project of CVRD

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ABSTRACT

Cia. Vale do Rio Doce—CVRD, from Brazil, is implementing its Titanium Project since 1972 for exploitation of its huge anatase ore deposits (500 million tons) in southeast region. After long and costly research work on geological and technological studies, CVRD started up in 1983 the operation of a Pilot Plant in order to evaluate this new raw material for titanium industry.

The beneficiation process that was developed yields a high grade (90% TiO₂) concentrate that is an alternative to rutile for chloride route TiO₂ pigment industry.

Pilot work was successful so that now, in 1987, CVRD has started the engineering of a commercial anatase plant of 200,000 tpy capacity to come on stream in 1990.

The anatase ore deposit is of such complexity that other valuable components and by-products are being considered in the Project.

Rare-earths, titaniferous magnetites for steel mills and petroleum drilling operations are the main by-products.

New development programs are also being implemented by CVRD for better anatase industrial application, such molten salt chlorination for fines. Metal Titanium, based on this process, is another goal.

INTRODUCTION

In Brazil, Cia. Vale do Rio Doce—CVRD, the largest iron ore international supplier, is proceeding with a diversification strategy since 1970 for mineral raw materials. Today, CVRD is already involved in gold, manganese and aluminum commercial activities and develops pilot work program for copper and titanium ores.

This presentation highlights the Titanium Project which aims the production of anatase concentrate, a new raw material for world titanium industry.

The commercial beneficiation plant will be constructed in Araxa and Tapira, Minas Gerais state. In Tapira CVRD has a 190 million tons anatase ore deposit (21% TiO₂ average content) and, there, a pilot plant, still in operation, completes a long and important work of technological development.

A second deposit, located in Salitre not far from Tapira, has other 300 million tons of anatase ore with 15% TiO₂ content. Additional, in Amazonas region (Maicuru), a new 500 million tons of anatase ore deposit was recently found and is still under geological research studies by CVRD.

(Slide (1): Geographical location of CVRD anatase deposits)

MINERAL RESEARCH

Mineral deposits of Tapira and Salitre, in State of Minas Gerais, are located inside alkaline ore
bodies known as “pipes” in reference to their volcanic origin.

They are a complex association of titanium, phosphate, niobium and rare earths minerals formed under special conditions of weathering.

( Slide (2): Tapira Typical Geological Section)

First geological research works were carried out by DNPM, the Brazilian Government Mineral Production Department. Later on CVRD joined the project so that in 1972 a complete development program was established through DOCEGEO (a CVRD’s subsidiary), in geological research, and CVRD’s Technological Research Center.

Technology for economic exploitation of such large and important titanium bearing ore finally came up from Technological Research Center development work and, in end of 1981, CVRD started construction of a Pilot Plant for anatase beneficiation.
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Two years later operation started up thus enabling a safe evaluation of a new technology together with a potentially new titanium raw material.

Results were positive as expected and now, in 1987, CVRD starts the implementation of Anatase Beneficiation Commercial Plant first step of its Titanium Project.

(Slides (3) (4) (5): Pilot Plant)

PROCESS

The anatase beneficiation process starts with a mechanical concentration step where the run-of-mine, with 22% TiO₂ content, is dislimed, crushed, magnetically separated and classified reaching 56% TiO₂.

(Slides (6): Process Flow-sheet)

Grinding the ore is the next step, using a closed circuit system together with magnetic separation, classification and filtration operations. The filtered non-magnetic fraction carries the anatase material with a 64% TiO₂ content.

After being dried, anatase is heat treated in fluid bed furnaces, in a magnetising roasting process, so as to free more iron (as magnetite) and other impurities, which are removed through magnetic and electrostatic separations. This heat treatment also enables a more efficient leaching action afterwards as the particles become highly porous. Anatase ore is now with 80% TiO₂ content.

Final upgrading is obtained through hydrometallurgical treatment: a counter current leaching with hydrochloric acid, followed by washing with water and caustic soda solution.

Slide 3

Slide 4

Slide 5
ANATASE BENEFICIATION PROCESS

ANATASE CONCENTRATE
CHEMICAL COMPOSITION

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>%</th>
</tr>
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<tbody>
<tr>
<td>TiO₂</td>
<td>89.0</td>
</tr>
<tr>
<td>Fe₂O₃(*)</td>
<td>4.3</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>2.0</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>1.5</td>
</tr>
<tr>
<td>SiO₂</td>
<td>1.5</td>
</tr>
<tr>
<td>CaO</td>
<td>0.2</td>
</tr>
<tr>
<td>BaO</td>
<td>0.04</td>
</tr>
<tr>
<td>MgO</td>
<td>0.05</td>
</tr>
<tr>
<td>Nb₂O₅</td>
<td>0.9</td>
</tr>
<tr>
<td>Re₂O₇(***</td>
<td>0.5</td>
</tr>
<tr>
<td>V₂O₅</td>
<td>0.15</td>
</tr>
<tr>
<td>ZrO₂</td>
<td>0.30</td>
</tr>
<tr>
<td>Cr₂O₃</td>
<td>0.15</td>
</tr>
<tr>
<td>MnO</td>
<td>0.15</td>
</tr>
<tr>
<td>SrO</td>
<td>0.03</td>
</tr>
<tr>
<td>Th+U</td>
<td>&lt;400 ppm</td>
</tr>
</tbody>
</table>

NOTE:

(*) Total as oxides

(**) Rare earths oxides

POTENTIAL BY-PRODUCTS

<table>
<thead>
<tr>
<th>BY-PRODUCT</th>
<th>OUTPUT TON/YEAR</th>
<th>INDUSTRIAL APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>RARE EARTHS (AS 95% REO)</td>
<td>3,350</td>
<td>OPTICAL AND ELECTRONIC INDUSTRIES</td>
</tr>
<tr>
<td>MAGNETITE (COARSE)</td>
<td>700,000</td>
<td>STEEL INDUSTRY</td>
</tr>
<tr>
<td>MAGNETITE (POROUS FINE)</td>
<td>90,000</td>
<td>PETROLEUM INDUSTRY</td>
</tr>
</tbody>
</table>

Upgraded anatase, with 89–90% TiO₂ content, is finally filtered, dried and stored. Grain size is 20–200 mesh.

(Slide 7): Anatase Concentrate—Chemical Composition

During beneficiation process some by-products are recovered, such as magnetites, for steel and petroleum industries, and rare earths.

(Slide 8): Potential By-Products
PLANT GENERAL DESCRIPTION

The anatase beneficiation plant will have a capacity of 200,000 ton/year and facilities will be located in two different sites. In Tapira, close-by the mine and the anatase ore stockpiles, mechanical concentration, grinding section and blending system will be installed.

At this part of the plant roughly 70% of feeding mass will be eliminated, yielding an intermediate blended product with 55–56% TiO₂ and particle size in the range of 20–200 mesh, that will be transported to Araxá by trucks.

In Araxá, in a side close to existing railroad of Rede Ferroviária Federal, will be located the finishing sections of the beneficiation, composed by calcination, reduction, magnetic and electrostatic separation and leaching, besides product storage, railroad loading facilities and general administration.
One important location factor is the possibility of future beneficiation of anatase ore from Salitre, that could be easily transported by railroad to Araxã plant.

Depending of future commercialization of by products, a ropeway transportation system will be built along 35 km between Tapira and Araxã.

The transportation of anatase concentrate for exportation will be done by railroad systems of Rede Ferroviária Federal and CVRD's Vitória-Minas along 1,300 km between Araxã and Vitória.

Shipping system will be built in Tubarão harbour ab existing installation for iron ore pelletizing and steel plants.

**FUTURE COMMERCIAL PLANS**

Besides the production of upgraded anatase as an alternative feedstock for TiO₂ pigments and Ti metal industries, CVRD's Titanium Project has other objectives:

1) Recovery of rare earths associated to anatase.
   
The basic process is being developed and will be tested in Pilot Plant in near future. Rare earths concentrate has 95% rare earths oxides, including 1% europium oxide.

2) Complete commercialization of ore magnetic fractions.
   
   Coarse natural magnetite is a suitable material as protection additive of refractory lines. Brazilian steel mills are already using it regulary in blast furnaces.
   
   Fine porous magnetite may be used as H₂S and SO₂ scavenger in petroleum drilling operation. It is being used already by PETROBRÁS in commercial basis (H₂S) and studies are underway as SO₂ removal for environmental protection systems.

3) Industrial application for fines (minus 200 mesh) of anatase.
   
   An upgrading process is being developed for fine anatase concentrate, in parallel to agglomeration and special chlorination technological studies (molten salt process).
   
   Metal Titanium production is another goal, based on the expected results of this new chlorination process, that certainly will enable lower costs for TiCl₄ generation.

4) Titanium metal production.
   
   Development work is considering titanium sponge production (in a joint program with CTA—Aerospace Technical Center of Brazil's Ministry of Aeronautics) and titanium alloys.
   
   All development work is being implemented by CVRD's Technological Research Center, in Belo Horizonte-MG, through extensive research program that includes joint works with other research centers in Brazil and abroad.

**PROJECT IMPLEMENTATION**

The fixed investment cost for anatase beneficiation plant is estimated in US$130,000,000. Equipments will amount US$50,000,000. almost all brazilian made.

Construction shedule indicates plant start-up in early 1990 and a total implementation time of 36 months. Engineering is underway and site preparation will begin in fourth quarter of 1987.