PINCOCK perspectives

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CALENDAR

- ***Elko Mining Expo***
  June 5–10, 2005
  Elko Convention Centre
  Elko, Nevada
  e-mial: brenda@elkocva.com

- ***National Coal Show 2005***
  June 7–9, 2005
  The David L. Lawrence Convention Center
  Pittsburgh, Pennsylvania
  www.mining-media.com

- ***AUSTMINE 2005***
  July 5–6, 2005
  Brisbane Convention & Exhibition Centre
  Brisbane, Australia
  e-mail: lorraine.ward@informa.com

- ***XXVII Convencion Minera - EXTEMIN 2005***
  September 12–16, 2005
  Arequipa (TECSUP)
  Lima, Peru
  e-mail: msovero@iimp.org.pe

Mineral Sand Deposits

Were you the child that tried to mine the sandbox one shovel at a time? Well maybe there's a future for you in mineral sands. Most people know what sand is, it is generally formed from quartz, one of the most common minerals on the earth. Quartz has a specific gravity of 2.65 (the density as compared to water, so quartz weighs 2.65 times the weight of a similar volume of water). Mineral sands is a term applied to sands that have a higher specific gravity than your average sands, typically above 4.0.

MSDs are variously referred to as:

- Heavy Mineral Sand Deposits,
- Mineral Sands, or
- Heavy Mineral Deposits

They consist of sand accumulations that contain significant amounts of "heavy minerals." Heavy Minerals consist of high density minerals that occur as disseminated, associated or concentrated deposits within the sands; they most commonly include gold, cassiterite, titanium minerals, zircon, and garnets. This paper presents an overview of the exploration, development, and application of titanium mineral sand deposits.

Exploration for MSDs has intensified since the mid 1980s due to increasing use and demand for titanium oxides, metals and alloys. Major exploration for MSDs are reported in the following countries:

- Australia (Coburn, Douglas, Lodlow, Mindarie, Murray, Poonscarie,Wemen)
- Canada (Athabasca oil sands, Truro)
- India (Tamil Nadu)
- Kenya (Kwale)
- Madagascar (Fort Dauphin)
- Mozambique (Corridor Sands, Moebase, Moma)
- South Africa (Xolobeni)

Numerous preliminary exploration programs are under way in other localities and countries.

Titanium sand deposits have been identified in countries around the world in a relatively short-lived history of development, mostly from the 1950s but with work reported in Australia as early as 1934. Current Resources and Reserves of known deposits are estimated by the US Geological Survey, as of 2004, in millions of tonnes (metric tons) as follows:

Mineral	Reserve Base (million tonnes)	Reserves (million tonnes)
Ilmenite	1,300	660
Rutile	130	55
Total	1,430	715

Commercial demand for titanium commenced in the 1950s when the metal was named "The Wonder Metal of the Age." Uses and applications of titanium include two principal forms:

- As a metal, titanium foil, sheet, sponge and rod make up approximately 5 percent of world consumption, and
- As an oxide, titanium dioxide (TiO_2), is used as a pigment, in a granular or powder form.

World production for 2004 was 5.2 million tonnes, 4.8 million tonnes of ilmenite and 0.4 million tonnes of rutile.

■ ***XSTRATA ESTABLISHES SOUTH AMERICAN HEADQUARTERS IN CHILE***

Diversified miner Xstrata it is setting up its South American headquarters in Chile. Xstrata is not the first international miner to set up operations in Chili — Canada's Noranda and Anglo-Australian BHP Billiton already have a local presence. Xstrata's Santiago offices will manage its mines in Argentina and Peru and could eventually develop mines in Chile, which produces a third of the world's copper. Xstrata also has 50 percent of the $1.350 billion Bajo de la Alumbrera copper mine in Argentina, which began operations in 2003 and produces 180,000 tonnes of copper and 600,000 ounces of gold a year. Xstrata, based in Switzerland, also has mines in Australia, South Africa, Germany, Spain and Britain.

■ ***LEGAL FRAMEWORK FOR ENVIRONMENTAL LIABILITIES PROPOSED***

Specialists from several countries have proposed creating a legal framework to regulate PAMs (mining environmental liabilities). The specialists participated in an international conference on PAMs in Santiago. Peru's soon to be established law should help to resolve PAMs whereby the state will step in when the entity causing mining liability cannot be identified and when a company is not taking corrective measures while generating a liability. Peru's congress has unanimously approved the mining environmental liability bill and the executive branch of Peru's congress should make it law over the next few days. In Chile, local copper commission Cochilco has analyzed advances in areas such as mine closure legislation, an issue that would complement a PAM measure and for which a bill is being prepared.

■ ***COLOMBIA GOVERNMENT DECENTRALIZES MINING AUTHORITIES***

Columbia's mines and energy ministry (Miminas) is completing for the time being the mining authority's decentralization process, which will delegate the mining resource management to some departmental governments. The goal of this movement is to help the government provide more attention to the mining procedures of each department. Ingeominas, the country's mining sector management authority, would support the departments. Another focal point for the government's attention is on mining and environmental polices. While policies are clear in the mining code, greater focus is needed to create synergy between mining and environmental policies. The government is also working to promote mining in the country.

Uses

High strength-to-weight ratio and corrosion resistance make titanium a preferred metal for fabrication of alloys for strategic and critical applications in aircraft, military, marine, power generation and ordinance applications. In 2004, demand for titanium metal was soaring due to increased demand by commercial aircraft and military markets.

Due to its lightweight strength and high resistance to corrosion, titanium alloys are used in a wide variety of commercial products replacing heavier and less chemically-resistant metal parts. Additional applications are being developed based on its fire and shock resistance, favorable cryogenic properties, unique bio-compatibility and non-toxicity characteristics. The lightweight strength, bio-compatibility and non-toxic characteristics make titanium an ideal material in the medical field for joint replacements including hips, balls and sockets.

Titanium dioxide pigments are used to enhance colors and quality. Titanium oxide has high whiteness, high refractive index, and light scattering ability. These characteristics make titanium the predominant component of white pigments in paints, paper, plastics, and rubber.

Geology of Mineral Sand Deposits

MSDs are defined as a loose aggregate of unlithified mineral or rock particles of sand size (generally 0.02 to 2.0 mm) forming an unconsolidated or moderately consolidated sedimentary deposit consisting essentially of medium grained clastics. These are derived from the weathering of pre-existing rocks, and accumulated by wind or water. MSDs are syngenetic concentrations of valuable mineral particles with high specific gravity accumulated within the sand deposits.

Valuable heavy minerals associated with sand deposits (placer deposits) are primarily gold, cassiterite, ilmenite, rutile, magnetite, monazite, kyanite, sillimanite, tourmaline, and garnet. The origin and concentration of these minerals depends on the disintegrating rocks and landforms from which the rock particles are transported and on which they are deposited. The transportation mechanism is generally wind or water. A typical scenario would be a source of heavy minerals being eroded and washed out to sea by heavy rains. The sands are carried back to the beach by waves, sometimes even tsunamis. The waves wash back the lighter grains of sand, leaving behind the heaviest grains on the beach. Over geologic time, the shorelines move and some deposits are found well inland.

Titaniferous heavy minerals in MSDs are generally present as black concentrates composed of:

- Ilmenite (4.5 to 5.0 specific gravity), the most abundant mineral of titanium on earth
- Rutile (4.25 specific gravity), a high grade titanium mineral
- Zircon (4.6 to 4.7 specific gravity), constitutes the main ore for zirconium
- Monazite (4.6 to 5.4 specific gravity), with thorium as its principal component, a rare earth phosphate
- Other heavy minerals that may occur are magnetite, kyanite, sillimanite, garnets, and tourmaline.

MSDs are classified in the following two groups:

- Autochthonous or trap placers, and
- Allochthonous or bed placer deposits.

The trap placer deposits occur when the grains of heavy minerals are deposited or trapped in lower levels or scour surface with implied minimal transport. These types of deposits are represented by coastal deposits like those in Australia, and generally contain smaller volumes of sand with higher grade concentrations of heavy minerals.

The bed placer deposits represent generally thicker sand deposits with a more homogeneous distribution of the heavy minerals within the sand body; these are represented by coastal, alluvial or dune deposits. Examples of this type of MSD occur in Sierra Leone, West Africa, Kenya, India, New Jersey and Florida in the US, and in the Nacala Corridor in Mozambique and Malawi.

Monazite is a significant component in many MSDs due to its content of thorium and uranium, which can run as high as 5 to 7 percent, making the deposit slightly radioactive. As these minerals are separated into heavy mineral concentrates the radiation levels are increased, creating the need for special handling.

Mining and Processing

Mining of MSDs is usually performed by open-pit methods, which may include wet techniques such as dredging, or dry methods using trucks, loaders, scrapers and bulldozers.

Heavy mineral fractions are recovered by gravity concentration. Minerals are separated by the use of cones, spirals, and shaking tables. The sand often contains coated grains with impurities that require attrition and scrubbing with chemical solutions, such as caustic soda, following primary concentration prior to dry ore processing. Primary gravity concentrates consist of titanium minerals, zircon, monazite, and garnets, which need to be separated. This separation is done using high-tension electrostatic separators and by magnetic separators of different intensities.

A sulfate or chloride chemical process is used to make high-purity titanium oxides. The sulfate process is capable of processing low-grade ilmenite directly, but has the disadvantage of producing acidic ferrous sulfate waste. The chloride process requires a higher-grade feedstock than the sulfate process, necessitating the upgrading of the ilmenite in an intermediate thermal production step to remove most of the iron and other impurities. Thermal reduction is done in rotary kilns to produce synthetic rutile or in a furnace to create a titaniferous slag. The thermally-reduced product is then processed with chlorine to make a high-purity TiO_2.

To produce titanium metal, titaniferous concentrates are generally processed by chlorination to produce titanium tetrachloride, which is reduced with magnesium to produce titanium metal.

Titanium Properties

The titanium element was discovered in 1791 and first made into metal in 1910. Its commercial use began in the 1950s. According to the US Geological Survey (USGS), titanium is the ninth most abundant element on the Earth's crust, representing approximately 0.6 percent. It occurs in nature as a chemical compound mostly in combination with oxygen and iron. It occurs in about 45 different minerals, but most commonly as ilmenite, rutile and titanomagnetite. The most valuable minerals for their titanium content are rutile and ilmenite.

The origin of titanium minerals has been determined to be from magmatic segregation in slow crystallizing tholeiitic basaltic magmas; these may be associated with ferrodiorite or iron, titanium, and phosphorous enriched magmas (nelsonites) that eventually become anorthosites. In secondary igneous and metamorphic processes the heavy mineral concentrations in the molten stage may be injected to fill fractures or form parallel fractionated stratiform bodies. Another natural occurrence of titanium minerals is in hydrothermal systems, where it is present as rutile.

Prices

Market prices for titanium minerals are not published due to high competition between countries and corporations; however, the estimated value of domestic production in the US during 2004 was as follows:

- Sponge metal, US$190 million, which resulted in a selling price of $8.50 per kilogram

■ ***AFRICA RICH WITH GOLD AND COPPER***

During the recent Geological Society of Nevada Symposium held in Sparks, Nevada, talks centered on the renewed prospectivity of Africa. Speakers addressed some of the fears that many companies have such as, African politics, government corruption, mining taxation, unskilled labor, HIV/Aids, and security. Also mentioned was the fact that the prospectivity of Africa can literally be buried under covers of sand and laterites that can obscure modern exploration search techniques. Despite these obstacles, companies were urged to keep in mind that seven new gold mines have been discovered in Africa during the past eight years for a total of 55 million ounces, more than any other continent. One speaker pointed out that even African mining companies were so busy exploring off-shore that they, too, failed to recognize a century of alterations which could have helped guide them to deposits. It is estimated that 2 billion ounces in reserves and resources remain in Witwatersrand. Within the last 10-15 years, geologists have began to discover the large, stacked, reefed systems, which have generated new multi-million ounces gold deposits from one of the world's richest gold districts.

Minerals Corner—

Labradorite $CaNaAlSi_2O_8$, Calcium Sodium Aluminum Silicate

By definition, Labradorite must contain 50-70 percent calcium to 50-30 percent sodium in the sodium/calcium position of the crystal structure. Labradorite is a beautiful mineral but if not looked at from the proper position its beauty might go unnoticed. Labradorite usually produces intense colors ranging from blues and violets, to greens, yellows, and oranges. Some specimens, although rare, can display all these colors simultaneously. This vivid color display is from lamellar growths inside the crystal. These growths result from compatible chemistries at high temperatures becoming incompatible at lower temperatures. This causes separation and layering. Labradorite, a member of the plagioclase series of minerals, can be found in Labrador, Canada and Scandinavian Peninsulas.

- Titanium dioxide pigment, $2.9 billion, at a reported price of $0.93 per pound of rutile.

Global Perspective

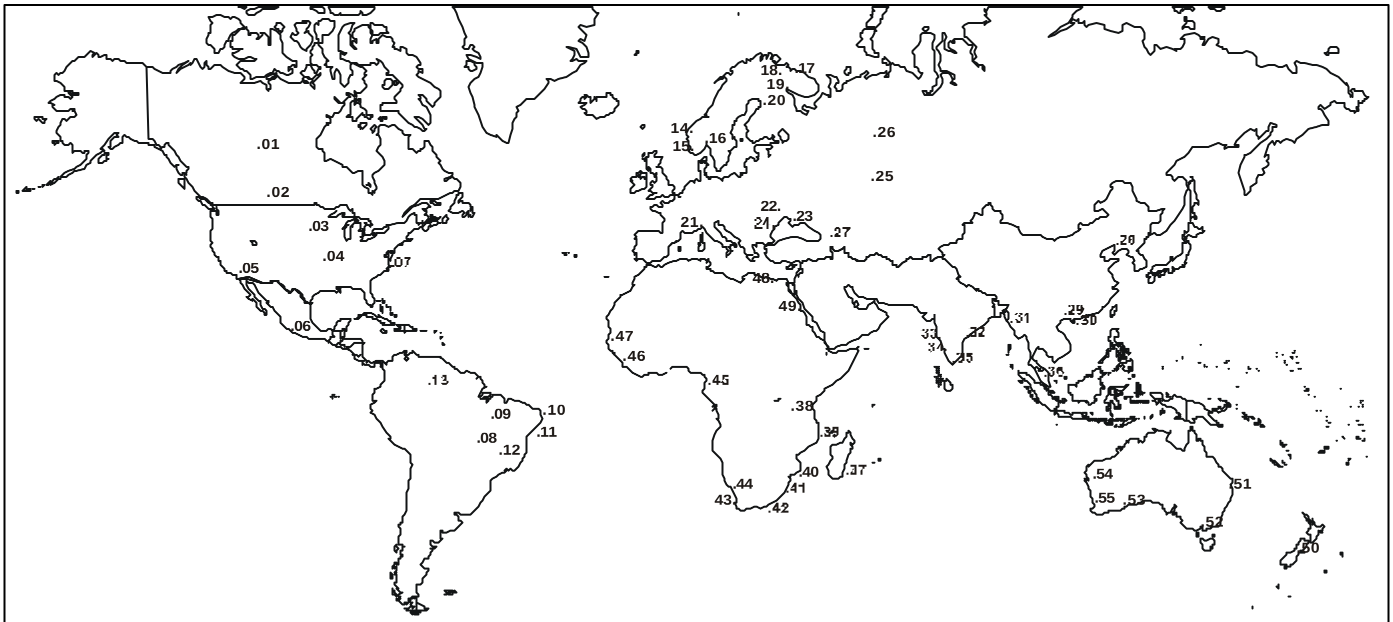
A global increase in mine capacity is currently underway with numerous new projects around the world. These will be replacing, in part, dwindling reserves from existing producers. Titanium demand hit a low after the World Trade Center attack and the related reduction in aircraft manufacturing. Current demand is steadily increasing but may not be sufficient to support the projected production from all the new projects.

Because the TiO_2 pigments are widely used by many industrial sectors, the general performance of the world economy appears to be an indication of the projected consumption; therefore, the demand for TiO_2 is expected to grow within the next 2 to 5 years at a similar ratio as that of the world economy. China, India and other Asian Countries may have a major impact on the world markets.

Research programs are under development to produce titanium metal at a lower cost, in which case its applications would increase significantly, since current use is limited by cost. Numerous industrial sectors, especially automotive, are eagerly anticipating such a development.

Figure 1 shows mineral sand deposits of the world.

This month's article was provided by Leonel Lopez, C.P.G., Principal Geologist leonel.lopez@pincock.com. Leonel is currently working on a major mineral sand property in India.



01 Athabasca
02 West Shore Cretaceous Interior Seaway
03 Powderhorn
04 Wichita Mountains
05 San Gabriel Mountains
06 Pluma Hidalgo
07 East North America Province
08 Brazilian Carbonatites
09 Campo Alegro de Lourdes
10 Natal Coast District
11 Vitoria Coast District
12 Sapucal
13 Maicuru
14 Rodsand
15 Tellnes
16 Kragero, Kodel
17 Tsanginsk
18 Afrikanda
19 Yelet Ozero
20 Otanmaki
21 Piampaludi
22 Kiev District
23 Dnepropetrovsk District
24 Chituk, Glogova, Tigveni
25 Shubino Village
26 Kopansk
27 Kamkorskoye
28 Heishan
29 Panzhihua
30 Hainan District
31 Cox's Bazaar
32 Chatrapur
33 Rathnagiri
34 Chavara
35 Pulmoddai
36 Malaysia Tin Province
37 Fort Dauphin
38 Lingana
39 Pebane Congolone
40 Richards Bay
41 Umbgaba
42 Transkei
43 Western Cape
44 Bothaville
45 Akonolinga
46 Gbangbama
47 Senegal
48 Nile Delta
49 Abu Ghalaka
50 Westport - Barrytown
51 East Australia Province
52 Murray Basin (WIM)
53 Eucla Basin
54 Murchison District
55 West Australia Province

FIGURE 1
MINERAL SAND DEPOSITS OF THE WORLD

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