Building Blocks For Titanium Alloys
An update on titanium and vanadium feedstocks

David McCoy
About TZMI

TZMI is a global, independent consulting and publishing company with offices in Australia, the US, Europe, Africa and China. The strength of TZMI’s consulting services stems from extensive practical experience in the mineral sands, titanium dioxide and coatings industries and from a comprehensive database, which has been built up over many years.

TZMI has proven expertise gained from our consultants having many years of direct operating experience in the industry in chief executive, senior operational, analytical and marketing roles.

TZMI’s publications and data services support the consulting activities and ensure up-to-date, high quality and comprehensive data, analysis and information across the mineral sands, zircon and TiO₂ pigment industries.

Associated Companies

**Allied Mineral Laboratories**

Resource assessment and flowsheet development for mineral sands, iron or and other heavy mineral deposits.

TZMI provides operational and technical expert advice on many areas including:

- Mergers and acquisitions
- Market assessments and industry analysis
- Due diligence
- Pre-feasibility studies incl. preliminary capital and operating cost estimation
- Competitive cost analysis and benchmarking
- Technical reviews and audits
- Resource assessments
- Physical separation test work
- Flowsheet development
- Customised data analysis and reporting
Titanium minerals
Some definitions so we are all on the same page

- **TiO₂ Units** – Titanium feedstocks come in a spectrum of compositions. Some are naturally occurring and others are beneficiated. TiO₂ units only count the contained titanium dioxide content in a feedstock. This equalises all feedstocks an enables global supply/demand balances to be completed.

- Most titanium feedstocks are used to make TiO₂ pigment. There are two routes:
  - Chloride – using chlorine and carbon to make TiCl₄ as an intermediate. This is the same route for titanium sponge.
  - Sulfate – using sulfuric acid to leach the titanium from the feedstock.

- Every number is in this presentation is metric.
Titanium feedstocks into sponge have declined

TiO₂ units into the global titanium sponge plants (000s tonnes): 2005 – 2015

Source: TZMI database
Titanium feedstocks into sponge have declined

TiO$_2$ units into global titanium sponge plants (000s tonnes): 2005 – 2015

Source: TZMI database
Rutile & UGS Supply in 2015

Total 908,000 tonnes of TiO₂ units.

- **Australia**: 34%
- **Kenya**: 11%
- **Sierra Leone**: 8%
- **Canada**: 21%
- **South Africa**: 13%
- **Others**: 13%

Total rutile & UGS supply in 2015 was 908,000 tonnes of TiO₂ units.
Iluka is making industry acquisitions
Recent changes in the titanium slag industry
Titanium Slag Supply in 2015

- **South Africa**: 70%
- **Canada**: 13%
- **China**: 12%
- **Others**: 5%

Total 1,121,000 tonnes of TiO₂ units.
Inventory overhang is keeping the market in balance in the short term. Supply has also been adjusted to match market demand.

New chloride slag supply from TiZir TTI operation and the ramp up of Cristal Jazan plus higher utilisation of existing titanium slag capacity.

Beyond 2018, global output of chloride-grade feedstocks is expected to decline progressively, influenced by a lack of ilmenite feed for beneficiation unless new projects are commissioned.
Sponge markets
There is additional sponge capacity available

Global titanium sponge capacity utilization (% of nameplate): 2008-2015

Source: TZMI
Japanese sponge exports increased in 2015

Source: TZMI database
US sponge imports have flat lined


- **Others**
- **Japan**
- **Kazakhstan**

Source: TZMI database
Chinese sponge exports have fluctuated

China’s sponge exports (000s tonnes): 2005 – 2015

Source: TZMI database
The scrap & sponge dynamic

US quarter ending stocks (‘000 tonnes): 2008-2015

Source: USGS
Vanadium markets
Vanadium Production 2016 by Raw Material Type

Total 77,800 MTV annualized from H1 2016

- Co-product steel slag: 72%
- Primary V: 17%
- Secondary: 11%

Data: TTP Squared, Inc.
V Production by Country 2016

- China: 57%
- Russia: 7%
- South Africa: 4%
- North America: 2%
- Europe: 11%
- Japan: 1%
- Korea: 2%
- Taiwan: 0%
- India: 2%
- Australia: 2%
- Brazil: 6%

Data: TTP Squared, Inc.
What’s happening in South Africa

- On 12 April 2016, **Evraz Highveld Steel and Vanadium** (Highveld) announced that it "...does not have adequate funding to meet its obligations for the short term", and that its board had filed for voluntary business rescue.

- The company mines vanadiferous titanomagnetite ore at its Mapochs mine, and produces iron and steel products and vanadium-bearing slag at its steelworks in Mpumalanga province.

- In September 2015, Hong Kong-based **International Resources Limited** was announced as the winning bidder for Highveld, but the deal fell through in January 2016.

- In May 2016, **Bushveld Minerals Limited**, announced that its wholly owned subsidiary, Bushveld Vametco Limited ("BVL"), signed a Share Purchase Agreement ("SPA for the conditional purchase of its 78.8% economic interest in Strategic Minerals Corporation ("SMC"), which owns the producing Vametco vanadium mine and plant in South Africa.

- Bushveld Vametco Limited, in which Bushveld will have a 45% interest, has reached agreement with Evraz to restructure the two stage completion into one. **Yellow Dragon Holdings Limited** will hold the remaining 55%. Completion is required by end-Q1 2017.
Chinese supply dominated by Pangang and Chengde Xinxin

- Vanadium is produced from mining of titaniferous magnetite deposits located in Sichuan and Anhui provinces in central and eastern China and subsequently extracted as a co-product in steelmaking. Small quantities of vanadium are also recovered from slags imported from Russia, South Africa and New Zealand.

- In addition, a small proportion of vanadium can be produced from stone coal extraction by chloride roasting and leaching in Shaanxi, Gansu and Hubei Provinces (~1,960 tonnes Veq). It is understood these operations have been idled due to unfavourable economics.

- With a capacity of 39,000 tpa of V$_2$O$_5$ equivalent (21,840 Veq), Panzhihua New Steel and Vanadium Co. Ltd (a subsidiary of Panzhihua Iron and Steel Group) is the largest producer that operates out of the Panzhihua region in Sichuan Province. This includes the combined output (all forms of V) of both the Panzhihua and Xichang operations.

- The second largest vanadium producer in China is Chengde Xinxin Vanadium & Titanium Co. Ltd, associated with the steel and vanadiferous slag production in Hebei Province (capacity of 28,000 tpa of V2O5 or 15,680 Veq).

- Together, Pangang and Chengde Xinxin account for approximately 64% of total vanadium supply in China.
Largo Resources continues to ramp up

Maracás Menchen Mine, Brazil
Production commenced August, 2014
Glencore Off-take: 100% Take-or-Pay Contract for 6 years

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Vanadium Production by Country

Vanadium production (000s tonnes V): 2005 – 2015

Data: TTP Squared, Inc.
Steel dominates global vanadium demand

- Steel alloy: 90%
- Super/titanium alloys: 4%
- Chemicals: 3%
- Energy storage: 2%
- Other: 1%
Vanadium Consumption by Region

Data: TTP Squared, Inc.
Global delivery of insight and expert advice