FEBRUARY 2023

Ti Observer™ Insights

TiO_2 Forecast: Feedstocks

TiO_2 Pricing Trends & Outlook 2023 - 2028

TiPMC Consulting

Consultants to the Financial, Chemical and Minerals Industries

Global Mineral Sands Price Forecast

All Prices in USD/t, FOB

TiPMC Feedstock Forecast is based on our analyses and observations of TiO_2 feedstock operations and our calculations of anticipated future prices. Forecasts are all projections, grounded in TiPMC research and hands-on experience.

TiO_2 Sulfate/Chloride Ilmenite Feedstocks Price Forecast

		2H22	1H23	2H23.	2024	2025.	2026	2027	2028
*Sulfate Ilmenite**	*High*								
	Mid								
	Low								
Chloride Ilmenite	*High*								
	Mid								
	Low								

High Grade C

→2

Chloride Slag	*High*								
	Mid								
	Low								
Rutile	*High*								
	Mid								
	Low								
Sulfate Slag	*High*								
	Mid								
	Low								
Zircon	*High*								
	Mid								
	Low								

Prices reflect TiPMC Solutions analyses of data and our evaluations to determine the range of average pricing.

TiO_2 FEEDSTOCK STRATEGIC REVIEW AND FORECAST

Mineral Sands More Resilient than Downstream Pigments

2022 proved to be a profitable year for Mineral Sands companies. Companies reported an excellent year as low inventories and supply limitations led to favorable supply/demand dynamics for suppliers, despite a pigment market that experienced a dramatic downturn in the last half of the year. Current market dynamics are favoring feedstock producers. The difference in results in 2022 between pigment and feedstock companies is incredibly divergent.

Feedstock inventories were extremely low when the downturn in pigment demand began in the second half of 2022. Chloride suppliers have recognized the drop in demand. Despite 1Q23 concerns, indications are that demand is strong enough to balance supply, at least through the first half of 2023. Sulfate ilmenite demand appears much stronger, as Chinese producers expect demand to return to their domestic pigment market. Chinese chloride slag is in greater demand, as chloride pigment and titanium sponge manufacturing in China continue to grow. Given new projects are not expected to make a significant impact in 2023, TiPMC expects a balanced market for most of 2023.

→3

> *The difference in 2022 results between pigment companies and feedstock companies is extremely divergent.*

Several projects have progressed within the past six months, and TiPMC has highlighted an increased probability of success for several projects within this report.

TiPMC notes several developments since the September forecast and has incorporated these developments in the current mineral sand's forecasts. Significant developments include:

- Chloride feedstock consumption was reduced as part of the destocking activities during the last two quarters of 2022. Demand was stronger, as inventories entered the period very low. Signs are mixed in terms of demand for early 2023.
    - Although highly speculative, TiPMC estimates that chloride production outside China may have been reduced by 200-250kt vs. 4Q21. Producers noted reduced demand for rutile within the pigment sector. However, Iluka noted a spot shipment of 5kt of natural rutile in December. Demand softened in European and Asian welding markets. Sierra Rutile noted strong demand in the titanium sponge market. Base Minerals noted plans for western

pigment producers to ramp up production in early 2023. TiPMC believes this is true, but very much relative to 4Q22 chloride TiO_2 production.

- Iluka noted sales of natural rutile and SR to closely match production, keeping inventories at low levels.
- Pigment production from Chemours and Tronox was significantly reduced 4Q22. Expectations are for a gradual improvement, but sales and TiO_2 production to remain relatively low through 2023. In the case of Chemours, this has traditionally led to greater ilmenite consumption and lower consumption of high grade feedstock. TiPMC believes chlorine pricing will influence the ilmenite/high grade feedstock ratio more than previously. Chlorine pricing is likely to influence most producers in North America to favor high grade feedstocks based on value in use, supporting SR and natural rutile process.

- Chloride supply appears to be remaining in balance, without signs of significant over-supply potential in 2023.

  - The Tronox operating issues both at KZN and Atlas Campaspe impacted natural rutile supply. The KZN fire, coupled with excessive flooding of roads around the Atlas Campaspe mine site impacted 4Q production, continuing in 1Q23. TiPMC expects kt of chloride feedstock were not produced as a result.
  - Rio Tinto noted an 18% increase in chloride slag production. Power load sharing disruption caused production constraints in Q4 2022, which were offset by improved operations in Canada.
  - Strandline's Coburn project began production of HMC in 4Q22. The project will increase supply of chloride ilmenite, natural rutile and Zircon in 2023.
  - Jazan has operated through 2022. Only one of the two smelters is operating with operating rates believed to be near 50%, short of sustainable operating rates. Tasnee announced the successful operation of the first slagger at 42MW vs. the target 45MW as part of its sustainable operations test. Tasnee is targeting complete evaluation of viable options, including upgraded electrical equipment, to sustain the desired power level in H2 2023. Tronox has noted on several occasions the production from the slagger was required to sustain operations at Yanbu. Increasing production to sustainable rates on one smelter, coupled with new natural rutile sources, will decrease dependency on outside sources of feedstock.
  - The start-up of SR1 commenced in 4Q22. Iluka noted increased take or pay volumes of synthetic rutile for the next four years, amount to approximately 200ktpa. The company will sell SR1 volumes on a spot basis as planned.

→4

- The growth of the Chinese chloride industry accelerated in 2022, and likely will continue in 2023. Chloride slag prices in China are continuing to increase. Back integration is a competitive advantage for LB Group. Opportunities for global producers to import some of their products to China, are likely to grow, given the growing demand and the elevated prices of chloride slag within China.
- TiPMC continues to believe chloride feedstock producers will manage production to match sales, supporting pricing within the sector. Depleting natural rutile reserves, coupled with preference for natural rutile within several operations, support natural rutile pricing. North American chlorine prices greatly favor higher grade feedstock.
- A weaker coatings season in North America could have a significant impact on second half demand for chloride feedstocks. Improved market conditions for TiO_2 in Europe and Asia, ahead of North America, will help sure up demand.

• Several longer-term developments for chloride feedstocks include:

- Two key players in the current natural rutile market, SRL and Base Minerals, noted progress in extension programs for current mining areas. Both support longer term projects, Sembehun and Toliara, respectively.
- Significant progress towards a 2H2024 start-up of Nordic Mining's' Engebo project. The project supplies 30ktpa of natural rutile, helping offset some of the loss production from Africa.
- Base Resources noted the Toliara Rare Earth Concept Study is progressing toward completion in 2Q23. The study examines the commercial potential for monazite from the project. Given the potential large volume of chloride ilmenite available from the project, enhancing opportunity for profitability from the project increases probability of success.
- Despite short-term difficulties, TiPMC believes Tronox remains committed to maintaining 85% of their requirements from internal sources. Reducing rates on their smelters, even with the impact of Atlas Campaspe and the KZN fire, speaks loudly to the weaknesses experienced in the downstream TiO_2 market. Longer term, external sources will still likely be required, particularly given the uncertainty with the potential volumes of the Jazan smelter.

→5

• Sulfate demand continues to be dominated by Chinese producers, who continue increase production. The early days of the recovery within China appears positive.

- Chinese slag production and direct ilmenite consumption by sulfate producers continues to increase. Increasing chloride slag requirements supports foreign alluvial sources, required to produce chloride slag. This lends to support price differentials for foreign ilmenite

and sulfate ilmenite produced locally from foreign sources of concentrate. Foreign sulfate ilmenite producers are supporting higher prices for Chinese chloride slag. As China has little resources for alluvial ilmenite, foreign ilmenites are required for chloride slag production. Strong foreign sulfate ilmenite prices have increases producer costs, keeping chloride slag prices in China elevated.

- The recent developments within the European TiO_2 market creates high potential for more demand destruction for high grade sulfate feedstocks. Realistically, pigment produced from these feedstocks will be mostly produced in China. In turn sulfate ilmenite demand will increase, either as chloride slag feed or direct use in pigment plants.

- The rapid increase in demand and minimal short term new projects have tightened the supply of sulfate feedstocks. Projects are emerging to help offset the deficit.

  - LB Group is planning capacity increases at their mine in Sichuan of approximately 400ktpa of ilmenite.

  - New sources continue to emerge in the form of concentrates. This material is shipped to China and other location, and minerals separated by local Mineral Separation Plants (MSPs) within China for final processing. Much of the ilmenite requirements to sustain growth in China are being provided by concentrate producers, shipping to Mineral Separation Plants (MSPs). Concentrate shipments from Mozambique are estimated to reach nearly 1.25M tonnes in 2022. Estimated ilmenite content is about 40%, with recovery losses elevated in Chinese MSPs vs. traditional operations.

    The equivalent sulfate ilmenite is approximately 300-350kt of TiO_2. Chibuto Mine, funded by the Chinese company Ding Sheng Minerals, is reported to have increased capacity to 1.8Mtpa. The increase in dependency on concentrates support sulfate ilmenite prices, as delivered costs for sulfate ilmenite remains elevated. As smelter of ilmenite increases in China, consistent supply and quality of sulfate suppliers will support foreign ilmenite producers.

  - Sheffield's Thunderbird project is advancing alongside the Yan Steel smelter, the primary consumer of the ilmenite for its smelter and chloride ilmenite plant, currently under construction. The ilmenite quality is fit for chloride slag consumption.

  - Bluejay Mining announced the feasibility studies for its 2019 PFS for its Dundas project was inappropriate and sub-optimal. Revisions to the work will be undertaken as part of a new feasibility study. The full feasibility study will be concluded by mid-2024 at the latest. Project start-up will be delayed.

→6

  - Small projects producing concentrate, including ilmenite, Zircon and rare earths, are continuing to enter into supply. Examples include Doral Yayalup and Westland Nine Mile project. These projects are small, producing 100-200ktpa of concentrates. TiO_2 content of these projects are in the 20-25% range.
  - Multiple projects are being developed as concentrate projects, foregoing the need for on-site MSPs and reducing project start-up costs. Many of these projects are being marketed primarily on the value of the contained rare earths. Still, these projects contain substantial quantities of ilmenite that will remain within China.

- Port inventories within China have increased. With the reported recovery of the domestic TiO_2 market and continually export demand, TIPMC expects sulfate ilmenite prices will be supported in the short term.
- 2023 project start-ups are lean. The Kimberly Mineral Sands Thunderbird project is set to begin shipments in 1Q24. As the product is in concentrate form, product will not enter the market until later that year. TiPMC believes most other new projects will not enter the market until 2025 at the earliest, more likely 2026. The new project portfolio is welcomed relief to the industry.

TiPMC has reflected these trends within our forecast. As 2023 offers numerous challenges for the pigment market, particularly outside China in 2023, recovery in 2024 supports chloride and sulfate feedstock demand. The appetite for ilmenite in China remains intact.

→7

Chloride Feedstocks: Chloride Ilmenite, Chloride Slag and Natural Rutile

Chloride Feedstocks: Short Term

One year ago, TiPMC stated the restock of chloride units to normal inventory units may have reached as much as 250kt of TiO_2, spread across all feedstocks. Although highly speculative, the estimate closely matches TiPMC's estimate for chloride units removed from production during 4Q22. Given the uncertainty with 1H23 demand, many producers are seeing softening of pricing in early 2023. Still, most Titanium feedstock producers are reporting strong demand through the first half of 2023, consistent with he need to recover inventories and be prepared for a potential late 2023 market recovery.

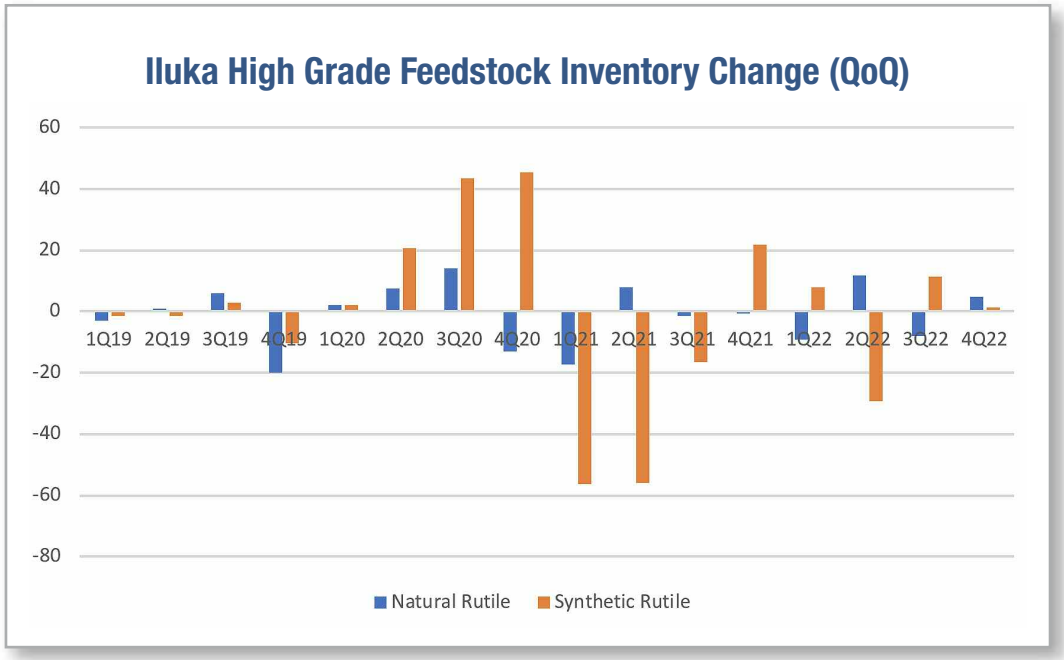
SRL Area 1 and Base Resources Bumamani project will sustain natural rutile production where depletion was a major concern. The start-up of the Strandline Coburn project along with Chemours' Trail Ridge South will help the supply side of chloride ilmenite. The start-up of SR1 will provide much needed high grade ore units, with 100kt.

TiPMC sees the supply demand balanced influenced by specific elements:

1. The current developments within Tronox. TiPMC believes Tronox has a great deal of elastic demand, based on its own supply. The flooding in the Murray Basin, along with the KZN fire impacted the industry, as natural rutile and zircon supply from KZN and Atlas Campaspe were impacted overall supply. Two consecutive quarters of 30% YoY decreased sales has countered the impact of loss supply, as Tronox still needs to cut production from its smelter operations.
2. Chemours response to a decrease in demand and increasing chlorine prices will influence the high-grade ore and ilmenite demand balance. More units are likely to be removed from chloride ilmenite demand than would normally occur in an industry downturn. Demand in China for chloride ilmenite upgrading supports chloride ilmenite prices.
3. China's chloride growth based on high grade feedstock from outside of China. Although the Chinese wish to stay as fully back integrated as possible, increasing chloride demand, ease of operability, and high domestic slag prices are favoring high grade chloride feedstock consumption in some cases.

4Q22 results appeared strong for all feedstock producers. Natural rutile pricing remained very strong. Iluka, Sierra Rutile Limited (SRL), and Base Resources all reported strong natural rutile pricing, with significant price gains throughout 2022. Iluka reported a weighted average natural rutile price of

→8



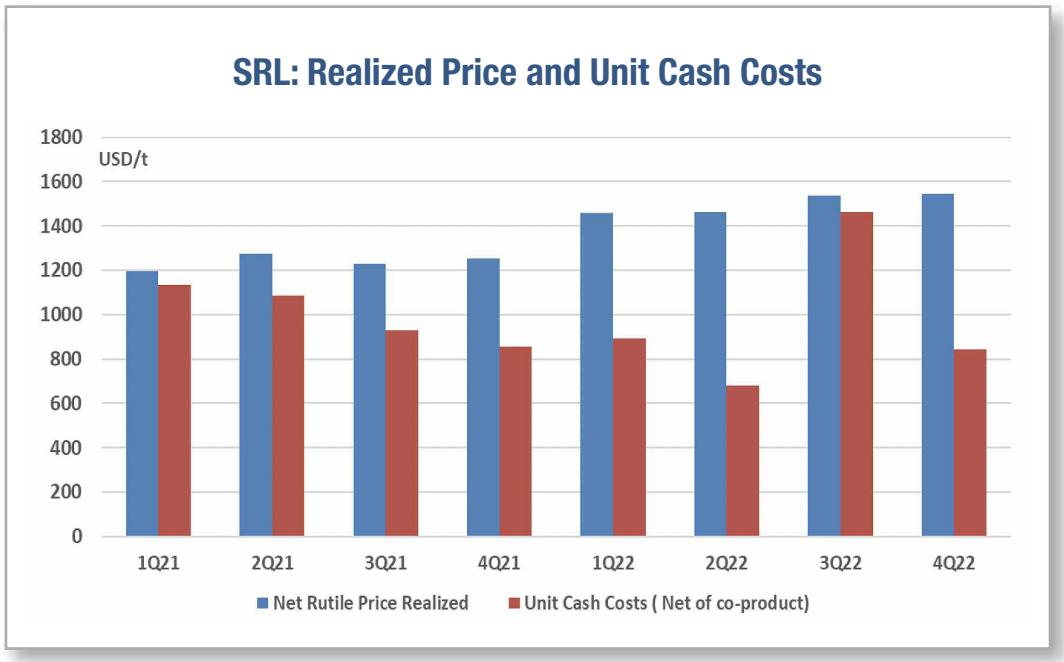
Source: Company 10Qs and TiPMC Estimates

US$1681/t, up 12% sequentially. SRL reported a net realized price of US$1544/t. Eramet quoted the market price for chloride slag FOB price as USD850/t, for Q322.

Iluka has stated its own inventory of key mineral sands producers remains low. This is consistent with reported quarterly differences in sales and production.

SRL has a unique position within the TiO2 feedstock industry. It produces 25-30% of the world's natural rutile. The company needs to raise significant cash to sustain its operation with the Sembehun Project. The reported unit costs provide a floor on profitability. With the need to raise cash, the company is not likely to drive pricing to floor prices based on profitability.

The company released data on its realized prices as well as unit cash costs. 3Q22 saw a significant reduction in rutile production because of adverse mining conditions due to weather. As conditions improved, production increased and costs were reduced to normalized levels. The company is projecting sales of natural rutile of 140-145kt in 2023.

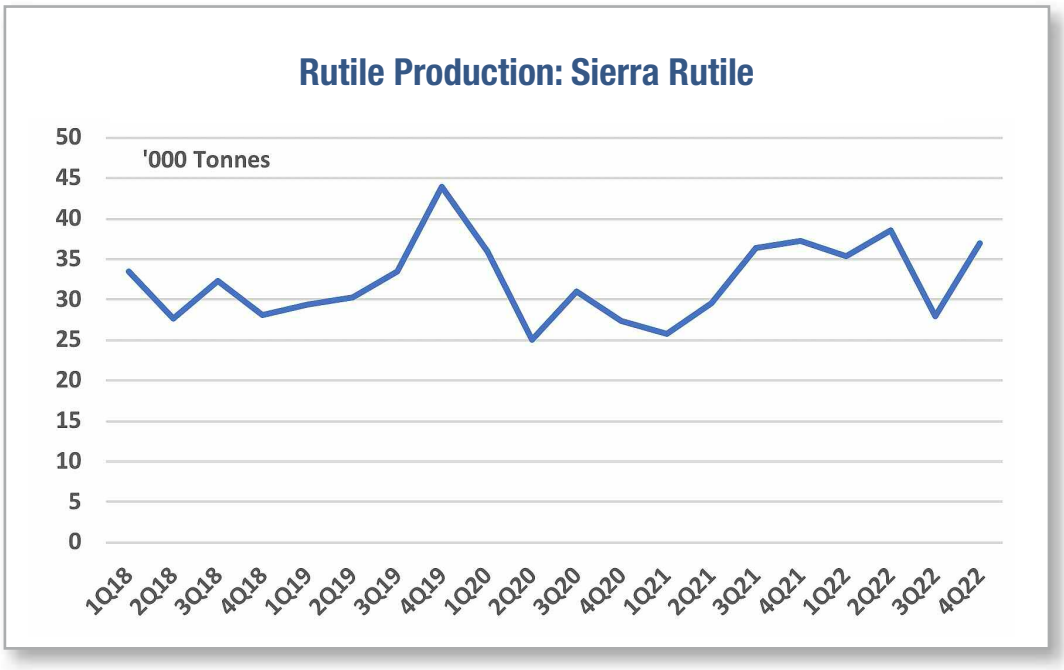


Source: Iluka / SRL Demerger Briefing / Sierra Rutile

→9

As SRL moves into its Area 1 extension, there is a potential increase for augmented operating difficulty. The company remains very motivated to maximize production. They also are positioned to be the price leader, given their large share of the merchant market.

Suppliers have successfully differentiated prices between the welding and ti-metal markets and the TiO_2 pigment markets. Delivered prices for natural rutile for welding applications is much higher than typically seen for pigment producers.



Source: Iluka / Sierra Rutile

→10

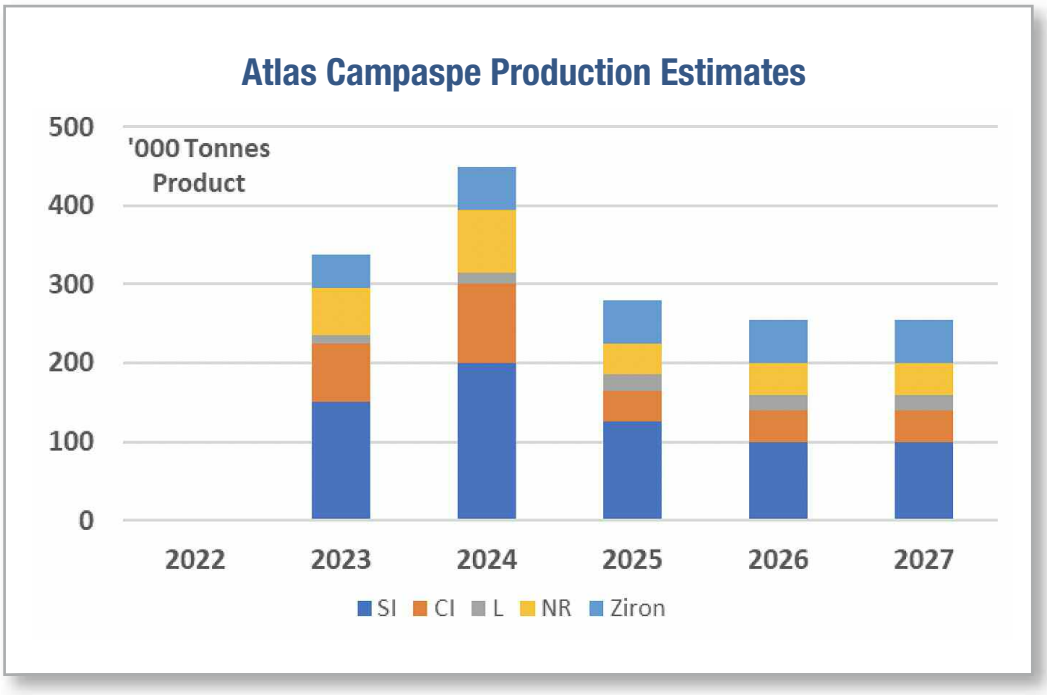
The timing of key new projects is unique given the current response of MNPs to the current downturn. Strandline Coburn will add 24ktpa of natural rutile supply in 2023. The immediate impact on Tronox cannot be overstated.

The Tronox issues, both due to the KZN fire and the flooding in Australia, have helped balance the chloride market in a period of reduced pigment demand. Atlas Campaspe was slated to produce significant volumes of rutile and chloride ilmenite. During their Investor Day, Tronox noted 100ktpa of rutile production in the first two years of operation, reducing to 60ktpa thereafter.

Production was planned to replace current production from Snapper Gingko. The flooding of the main road to the Broken Hill required Snapper Ginkgo to be operational, even in a sharp decline of TiO_2 demand.

Coupled with the KZN fire, TiPMC estimates the impact on natural rutile supply could be as great as 50-75kt removed from the market in a six-month period. Tronox, noted the cost impact as $25M in costs in 4Q22 continuing into 1Q23.

Additionally, lost revenue from Zircon created a quarterly earnings impact of $60M. The impact would have been much worse if pigment demand was strong.



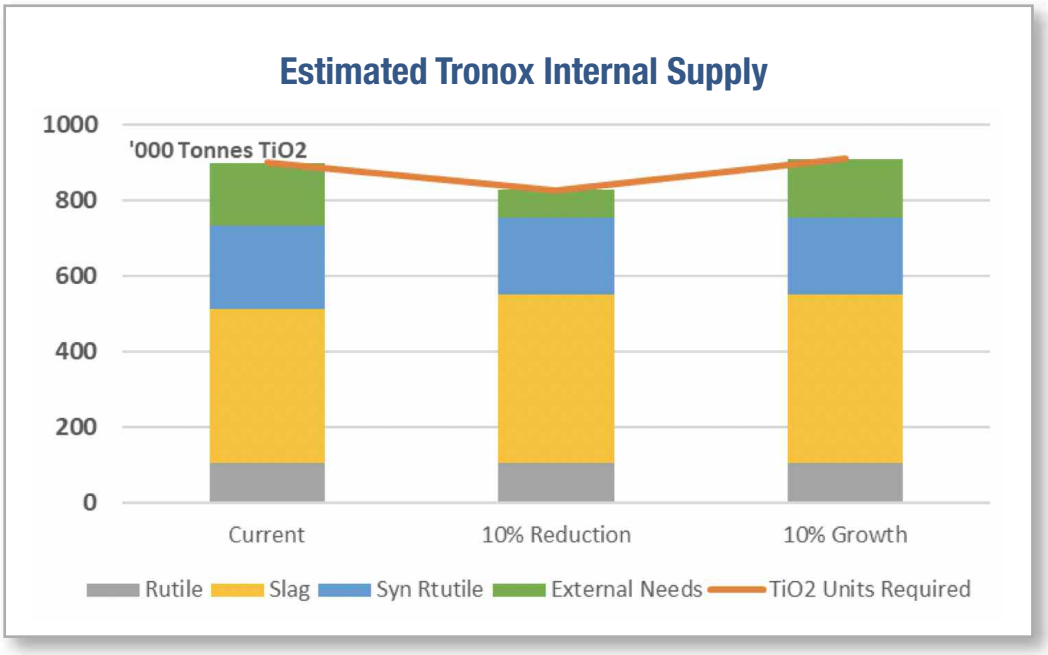
Source: Tronox Investor Day / TiPMC Estimates

→11

Longer term, the Atlas Campaspe project will yield multiple benefits to Tronox. Chloride ilmenite from Atlas Campaspe will be utilized as feed to the SR kiln at Chandala, allowing them to maintain a key piece of their 85% back-integrated goal. Chandala produces about 240kt of SR, or approximately 210ktpa TiO_2 units.

TiPMC believes this chloride ilmenite will support the SR operation while Coojaloo depletes, allowing Tronox to delay the implementation of the Dongara project until next decade. The sulfate ilmenite from Atlas Campaspe will be a source for Jazan and Tronox sulfate operations in China. Although not stated explicitly, TiPMC believes Tronox consumed about 75-100kt of Jazan slag at Yanbu in 2022. Ilmenite shipments were observed to Saudi Arabia. These coincide with the announcement by Taznee to implement improvements to allow for at least 70% of design capacity.

TiPMC believes Tronox will remain a long-term buyer of chloride feedstocks, with a yearly goal of 85-90% of feedstock purchased from outside sources. If Jazan is fully implemented, the potential exists to further minimize purchases which will result in lower SR demand. Tronox will not sell feedstock to competitors, but may consider opportunistic sales into the welding market, as earnings per tonne on natural rutile sales are greater than conversion to pigment.



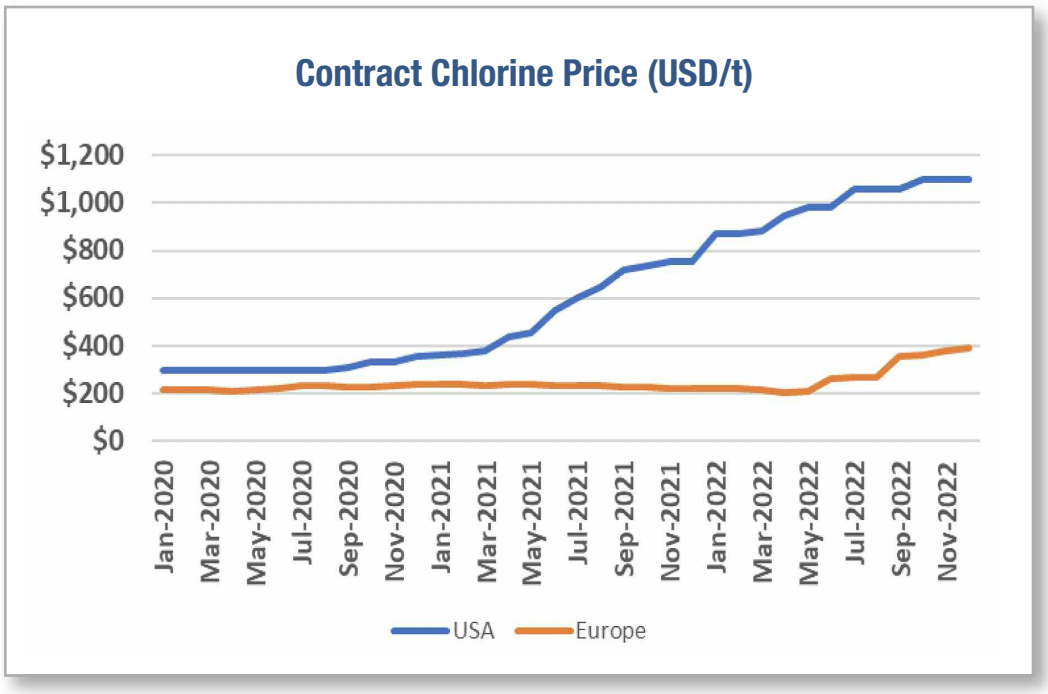
Source: Company 10Qs and TiPMC Estimates
Note: Chloride slag includes 50% operating rate for Jazan 1 slagger.

→12

TiO_2 Chloride Feedstock: Value in Use

A dynamic that cannot be overlooked is the impact of North American merchant chlorine prices. This continues to be a very unique problem facing the industry, one that has not been encountered in previous downturns. Chloride feedstock consumers, particularly those dependent on merchant chlorine in North America, have been facing continually increasing costs from chlorine. European producers have not been faced with these challenges. This can also have a large impact on feedstock choice.

George Eisenhower, Editor, *Chlor-Alkali Americas* at Argus Media, summarizes these developments. "The fundamental structure of the merchant chlorine market has changed since the Fall of 2020 when Olin lost a lawsuit with Occidental Chemical over a 'non-market adjustment' to a once popular chlorine price index in the US. Since then, the production of polyvinyl chloride (PVC) in the US no longer relies upon chlorine shipped by rail. The traditional link between the merchant chlorine market and PVC has been broken. Between the rationalization of chlor-alkali plants and the shutdown of primary magnesium production in the US, the market has become structurally short on chlorine production. Today, the chlorine market is well-supplied as several chlorine derivatives are either at seasonal lows for demand or their offtake has slowed because the demand for the chlorine derivative has slowed. US producers expect the chlorine market to rapidly tighten this summer when water treatment season peaks and other chlorine derivatives increase their offtake."



Source: Argus Media

→13

The impact can easily be seen as one reviews the consumption of chlorine for each feedstock.

The cost impact can easily translate into feedstock selection.

The dynamics of the chlor-alkali industry led Ineos to purchase Ashta Chemical, back-integrating its TiO_2 operation with a local chlorine source. It is very speculative to comment on similar transactions by other TiO_2 producers. Given the current outlook for chlorine price, options are likely being investigated.

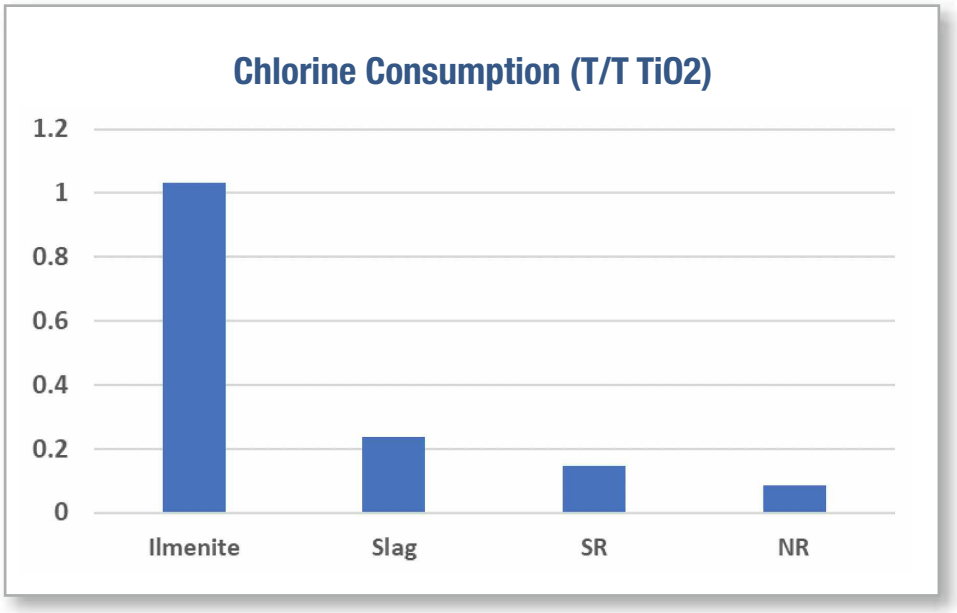
TiPMC believes high chlorine prices and strong competition for chloride ilmenite may lead to increased demand for chloride slag and other high grade feedstocks in 2023. This is a situation that will require close attention. Europe and Mexico enjoy more stable stabile chlorine prices than US producers.

As the basis for its short term forecast, TiPMC believes the following:

Higher value-use and reduced short-term supply will support pricing for high grade feedstocks, particularly natural rutile. The reduced chloride production in the second half of 2022 and 2023 cannot be ignored. Prices for natural rutile will soften, but more towards the second half of 2023. As demand returns and depletion continues, prices will recover in 2024.

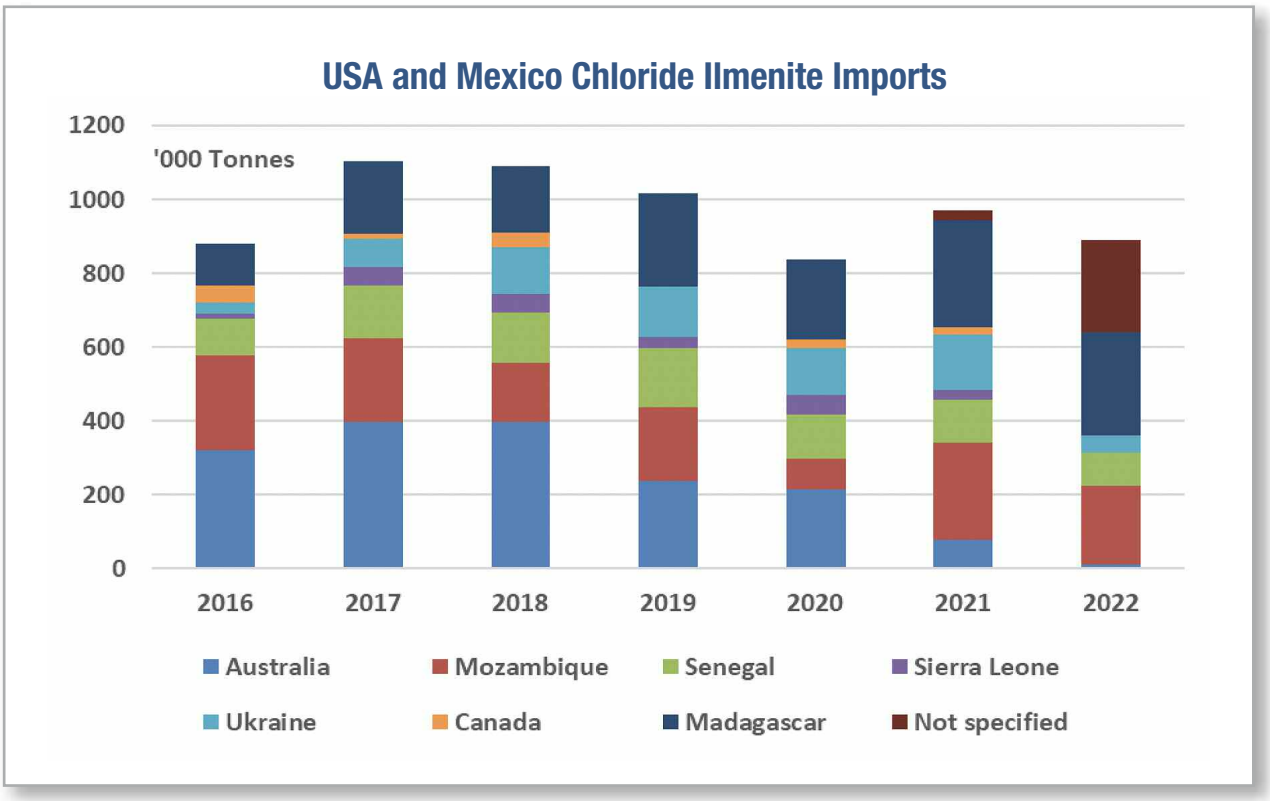
Chloride slag supply will be managed in line with supply. Production costs also support prices, particularly increasing energy costs in South Africa. The likelihood of stronger demand from Chemours due to increased chlorine costs may favor demand.

Chloride ilmenite prices will moderate, based on reduced demand. Market strength will remain, as China and others outside Chemours have become buyers in the merchant market.



Source: TiPMC Estimates

→14



Source: Global Trade Tracker and TiPMC Estimates

Chinese Chloride Slag Impact

As the Chinese chloride industry grows, so does the significance of its chloride slag industry. Estimates range from 575-650kt of chloride slag and SR will be produced in China in 2023. Like everything else in China, over 1M more tonnes of capacity has been announced.

The chloride slag piece has risen substantially over the last two years, correcting slightly when demand fell in 2022. This is significant:

1. It demonstrates cost that non-integrated producers in China are absorbing for feedstock. It explains why new chloride producers find low Chinese pigment pricing unsustainable.
2. Provides insight on the value of high grade chloride feedstock outside China.

Source: Ferroalloynet

→15

Further, estimates are that China produced 900-950kt if SR and chloride slag combined in 2022. This in turn requires 1.5-1.6M tonnes of ilmenite, that is required to be imported into China. Given the volumes available as either foreign product or in the form of concentrate, this is a very large share of total ilmenite imports.

Chloride Feedstocks: Long Term

TiPMC sees pigment demand long-term returning to trend lines, likely in the late 2024 or 2025. Growth from Multi-National Producers (MNPs) will be more muted than Chinese producers. Significant new capacity outside of China in unlikely. TiPMC believes the rate of chloride growth

in China to remain highly uncertain but accelerating particularly as Lomon Billions ramps its capacity to nearly 700ktpa and Yan Steel prepares to enter both the titanium smelting and chloride pigment markets, supported by the Thunderbird project. TiPMC believes the majority Chinese chloride will remain supplied internally, from its own smelters and SR plants.

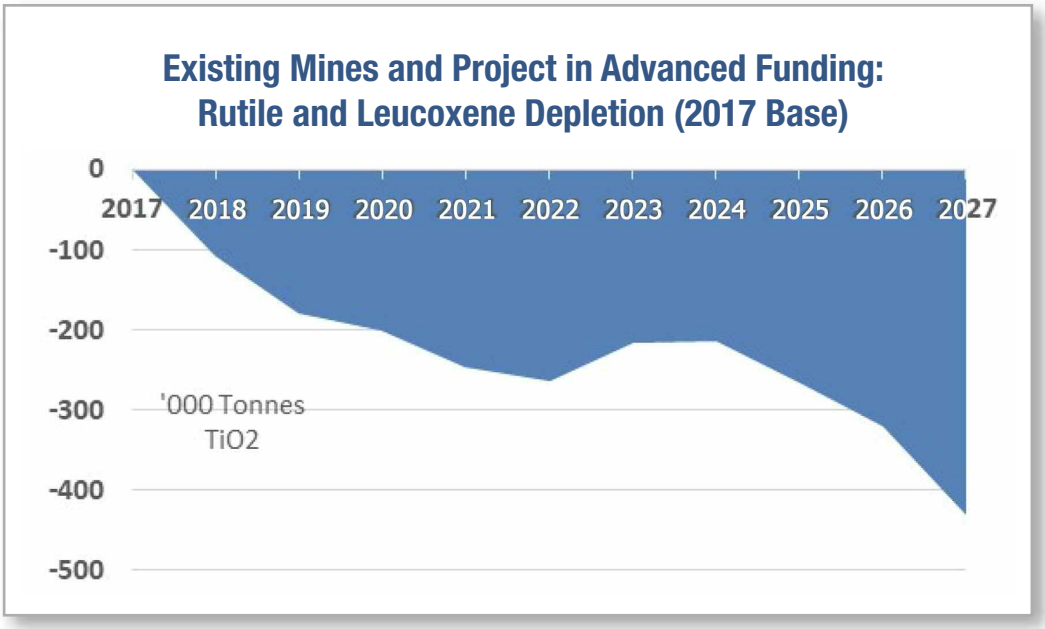
Given the price of Chinese slag and the likelihood of improved operations utilizing natural rutile, synthetic rutile, and UGS, the Chinese market for foreign sources of high grade chloride feedstock is expected to grow. This will provide the majority of growth for high grade chloride feedstock producers outside of China.

TiPMC believes the 2023 will see a return to a more normalized state of inventories, with pricing remaining firm. A greater than expected drop in chloride pigment demand could see the lower price case in 2024.

Projecting demand increases from welding, titanium sponge, and pigment, demand for natural rutile units continues to outpace supply, based on current probability of success. 2023 appears as a pivotable year. Global need will be met, either by alternative sourcing (lower head grade where possible), or less attractive projects being funded.

Our analysis indicates supply to remain stable, while demand increases for the natural rutile bucket. Significant natural rutile projects remain at a premium. TiPMC believes a key element of stabilizing prices within this bucket will be Iluka and their developments around SR1.

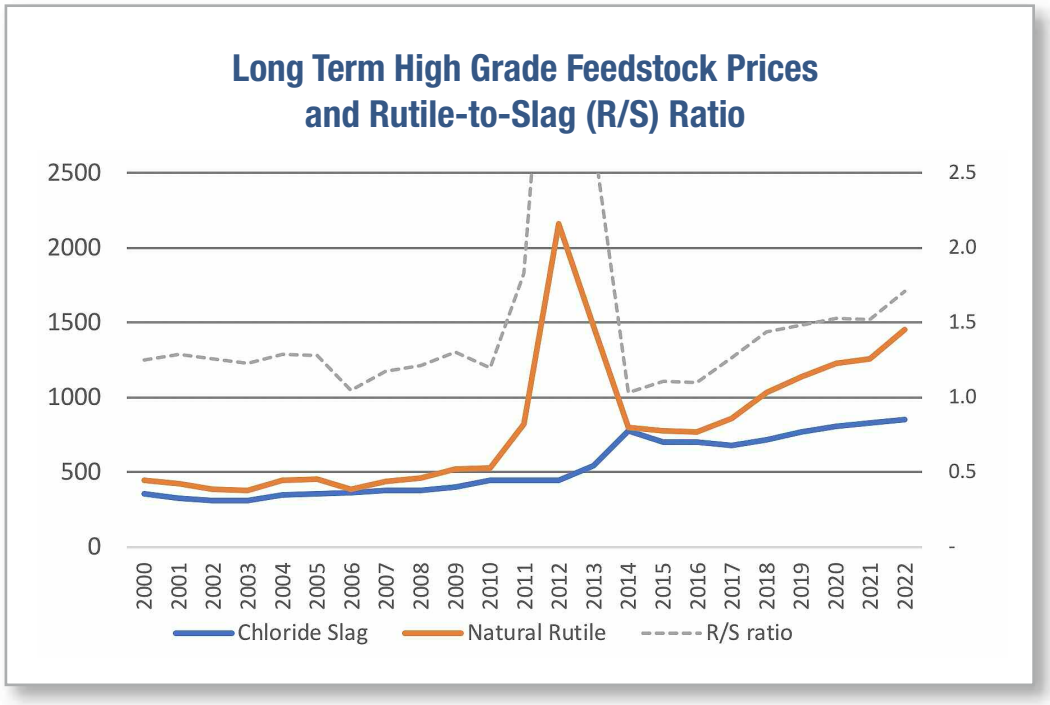
→16



Source: Company Reports and TiPMC Estimates

TiPMC continues to monitor price for natural rutile, and subsequent SR pricing, based on modeling historic pricing relative to chloride slag. Growing supply and demand imbalance within the natural rutile bucket, has been demonstrated by the increasing gap between natural rutile and chloride slag. For nearly all periods, except for the unique industry dynamics during the "supercycle", Natural Rutile price was set by chloride slag price with a VIU adjustment. The pricing ratio has averaged about 1.3.

Since 2017 we have entered a new trend, where declining rutile production is has pushed the ratio higher. 2022 saw the differential grow to 1.7. TiPMC believes the current reduction in chloride demand outside China will adjust natural rutile prices slightly downward. The lack of supply growth will ensure the adjustment is not considerable.

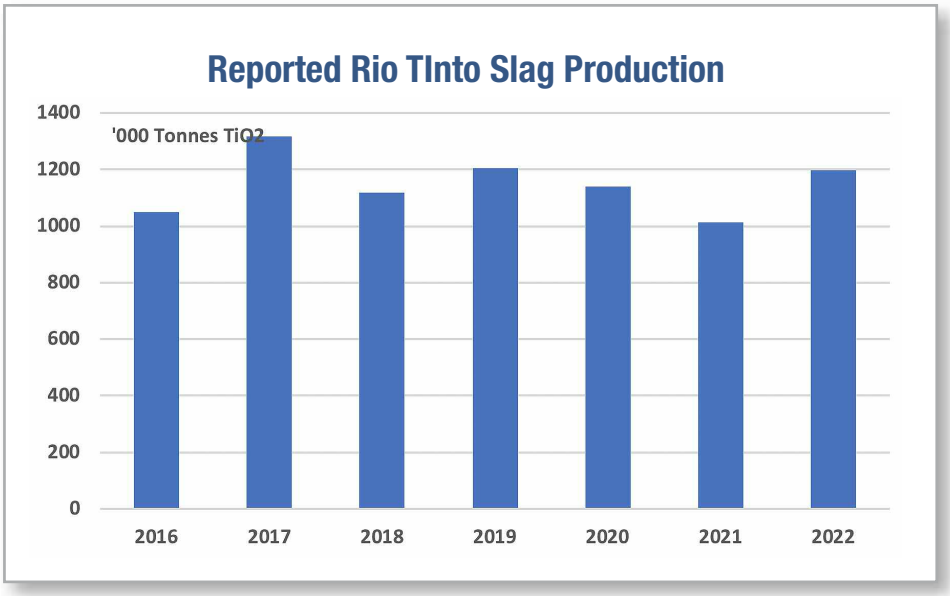


Source: TiPMC Estimates

→17

TiPMC does not expect downward pressure on chloride slag prices. Recent data indicates slag supplied by Rio Tinto in 2022 to be similar to 2019, allowing consumer inventories to build to more normalized levels. Rio Tinto is likely to carefully match chloride slag demand to market need. The potential for decreased high grade sulfate slag demand creates an interesting option for Rio Tinto.

Smelters in Sorel utilized for sulfate slag could be converted to chloride slag, or an expansion of UGS capacity. In the event of a plant shutdown, the extra capacity could be utilized to produce more RTCS at a 90% TiO_2 content or expand UGS production. Both will support supply for the natural rutile bucket.



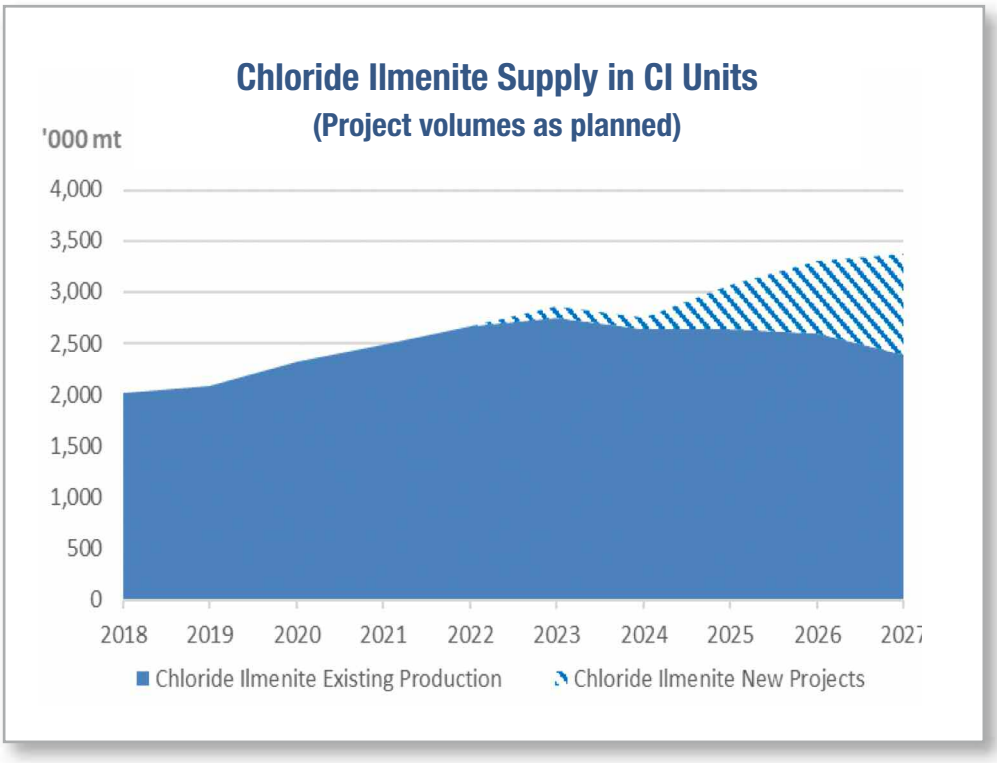
Source: Rio Tinto and TiPMC Estimates

Chloride ilmenite is likely to return greater balance, as the combination on new projects and reduced TiO_2 pigment demand will help stabilize the balance. Coburn and the full year production of Trail Ridge South should eliminate the supply concerns seen in 2022. Supplies from the Ukraine continue to being challenged, and delivered at higher costs, but supplies appear available.

→18

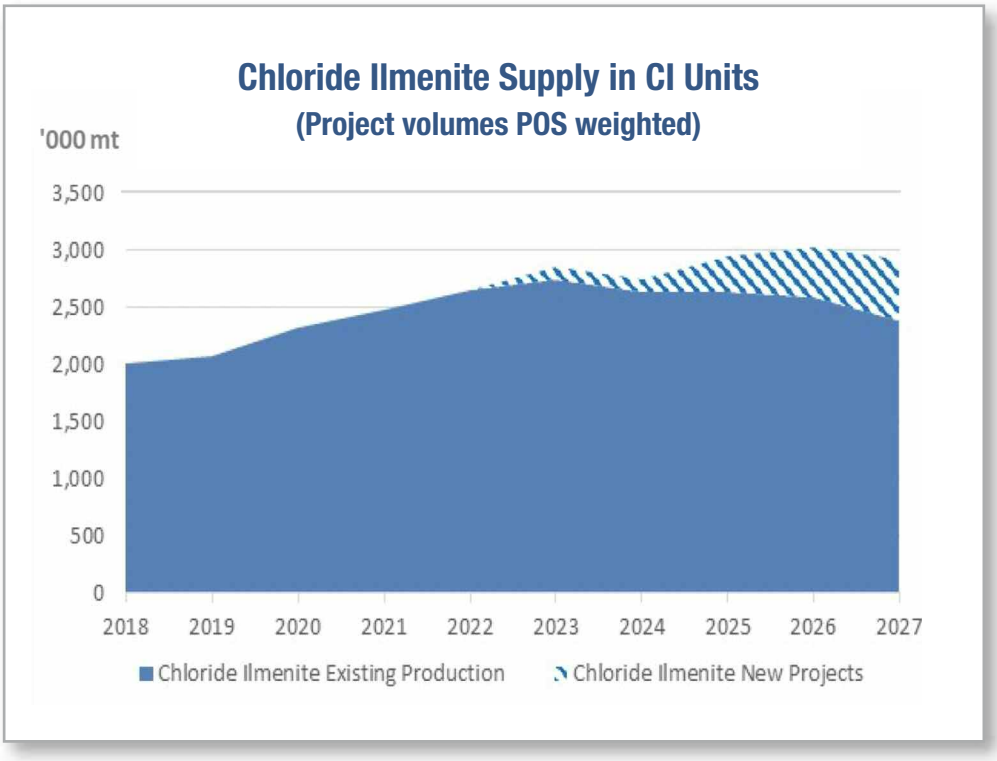
Chloride ilmenite will remain in tight balance for most of the forecast period. Key inputs toward the end of period are:

- The extent chloride ilmenite is utilized within China for beneficiation, particularly for SR and chloride slag.
- Impact of North American chlorine prices on direct ilmenite consumption, mainly from Chemours.
- The potential for SR supply from Australia. These products will supply the swing capacity within the industry. SR demand is closely linked closely to developments in South Africa, the potential for sales into the Chinese market, and the development of the Jazan smelter. As these other sources of high grade feedstock can be variable, SR from Australia will fill the void or conversely reduce oversupply. This in turn, could impact the availability of chloride ilmenite.
- Success of the Toliara Project is critical to the future of chloride ilmenite. The scale of the project exceeds any other throughout the world, in terms of the ability to produce chloride and sulfate ilmenite. The pure increase in volume relative to current chloride ilmenite supply will have huge impact on available reserves. Most of the impact is noted post 2026.



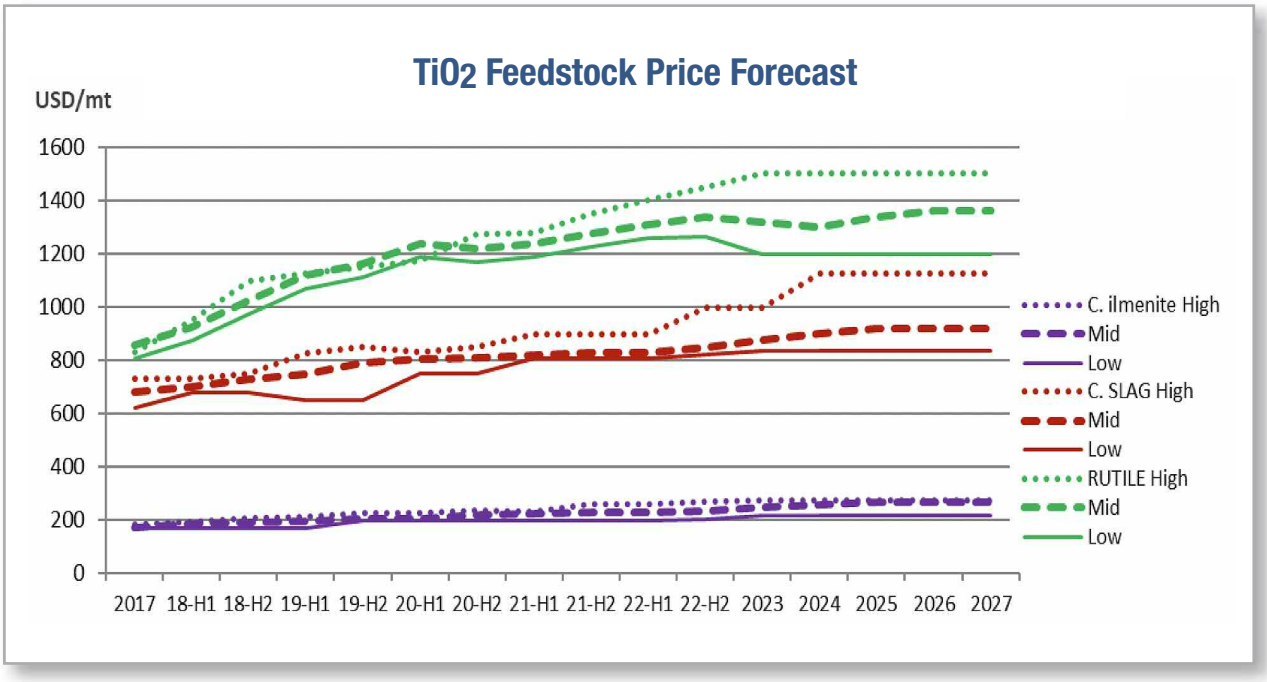
→19

Source: TiPMC Estimates



Source: TiPMC Estimates

TiPMC has taken both elastic and inelastic demand for natural rutile into account while developing its feedstock forecast. TiPMC expects the forecast chloride slag price increase will offset either case, ensuring global supply of chloride slag returns to a balance state. As demand for high grade chloride feedstocks outside of China remains subdued in 2023, natural rutile prices should soften, but more in line with the normal.



→20

Source: TiPMC Estimates

TiPMC has reviewed potential scenarios that could impact the forecast and has included this impact in its assessment of future chloride feedstock prices.

Sulfate Ilmenite: Short Term

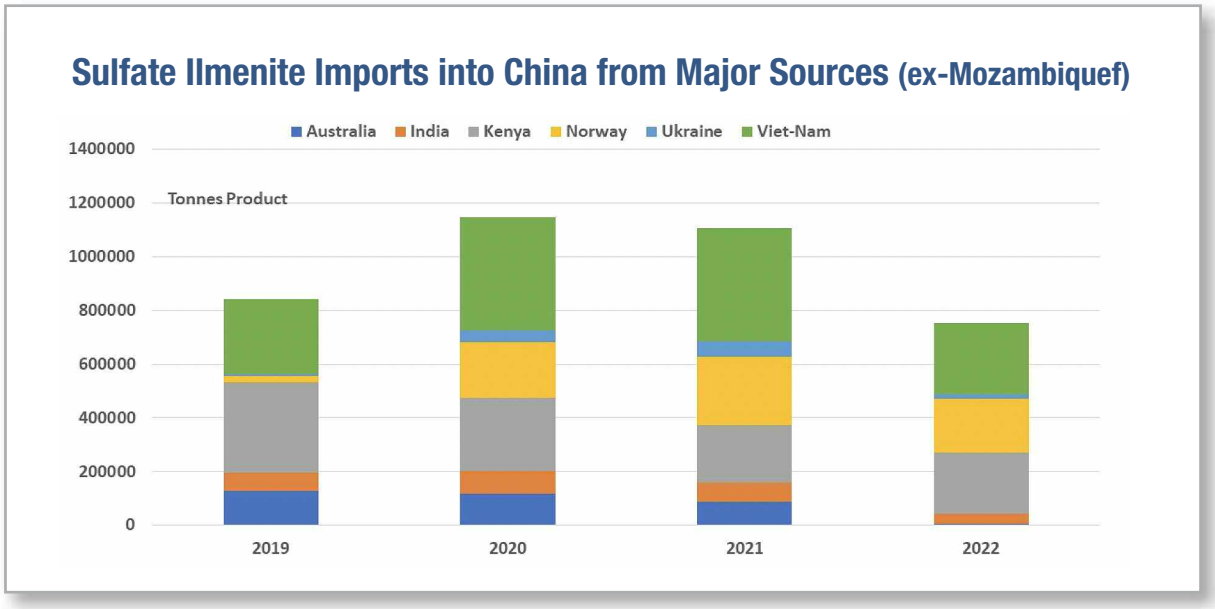
The recent dynamics within China provided significant insight into the status of both the Chinese TiO_2 industry and their ilmenite supply base. Chinese TiO_2 producers have exerted a great deal of pressure on Chinese ilmenite producers, as downstream demand was reduced. Prices fell in the domestic ilmenite market until the Lunar New Year. Since, prices have increased, as demand strengthened and input costs increased.

TIPMC believes Chinese domestic ilmenite prices have bottomed, as increased demand and sustainable foreign ilmenite prices stabilized.

Source: Ferroalloynet

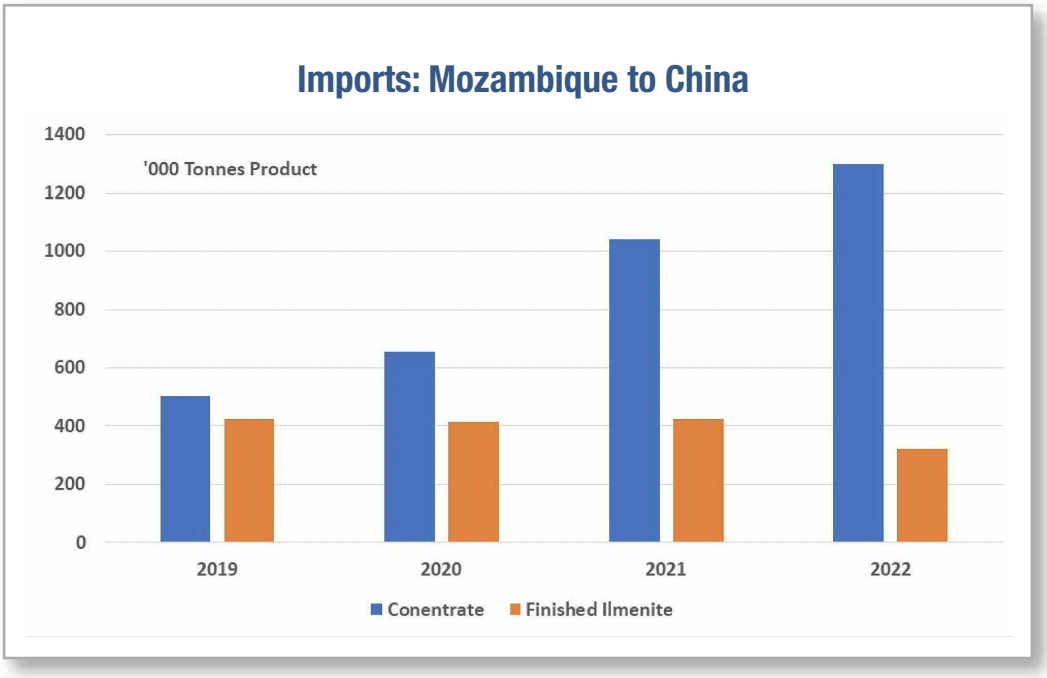
Foreign ilmenite suppliers to China have successfully held price steady throughout 2022. Foreign ilmenite is required for chloride titanium slag production, as domestic sources will not produce a high-quality chloride slag. Alluvial ilmenites are required for chloride slag production. The growth in both the chloride pigment and titanium metal demand more than doubled since the start of 2019, requiring between 400-450kt of both chloride and sulfate ilmenite per quarter.

→21



Source: Global Trade Tracker and TiPMC Estimates

Through 2022, significant reductions of sulfate ilmenite volumes from traditional producers in Vietnam, Norway, and India have contributed to higher prices for foreign ilmenites. These amounts represent TiPMC's best estimate for volumes of finished sulfate ilmenite from traditional major sources. Worth noting is that Norwegian ilmenite, a lower grade rock ilmenite, has seen the most substantial growth. This ilmenite is not suitable for chloride beneficiation.



Source: Global Trade Tracker and TiPMC Estimates

→22

TiPMC believes other concentrates from South Africa and other locations provide about another 50-100ktpa of TiO_2 units of sulfate ilmenite.

Chloride ilmenite is supplied by concentrates generally comes from the USA and Australia. TiPMC estimates over 200 - 230 ktpa of TiO2 units from these sources. Chloride ilmenite is also being imported directly into China, as feed for synthetic rutile kilns and chloride slag smelters. These units are reported to become more and more stretched, as Image Resources transitions their supply base from the Boonarang deposit to their Atlas deposit.

TiPMC sees some downward pressure on sulfate ilmenite prices into 2023, but the supply base is still tight relative to increasing demand for chloride slag and sulfate producers.

2023 promises to see a return to demand growth for TiO_2 pigment within China. As noted in the TiPMC HeatMap, government support to strengthen the overall economy, particularly the housing market, is reportedly producing benefits to the domestic TiO_2 industry. Chinese export prices are increasing but remain extremely competitive in foreign markets.

TiPMC expects Chinese feedstock demand to be near 2022 demand.

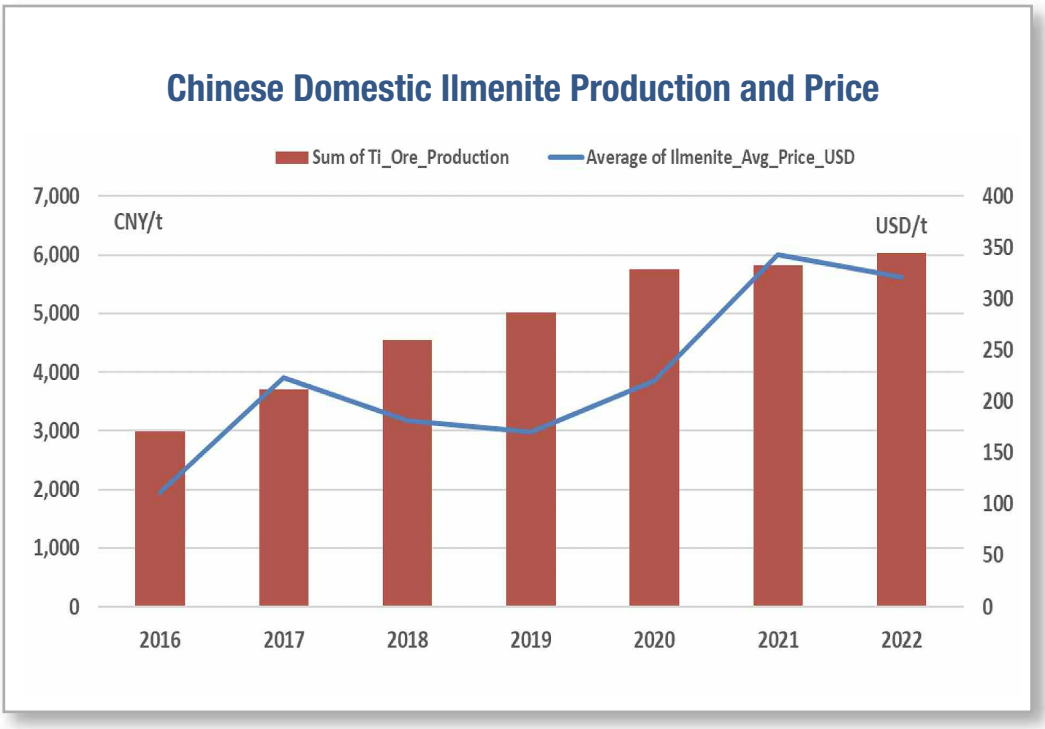
Looking at past data, the trends become increasingly apparent.

- Domestic ilmenite production remains the primary source of Chinese ilmenite. The approximately 2.8M TiO_2 units provides the nearly 4.1M tonnes required by the industry. Direct foreign ilmenite accounts for roughly another .8M, while th remainder is provided through concentrate operations and high grade feedstock from sources outside of China. Reported production has only increased slightly over the last several years, as costs have increased, and margins are becoming squeezed.
- Concentrates continue to be a growing source of ilmenite. TiPMC believes growth will come from US sources, as well as Mozambique and South Africa. Sri Lanka, Indonesia, and Malaysia promise to grow as sources. Capacity can be expanded quickly, at low capital cost for the producer, with a large and motivated group of MSP operators interested in large volumes. Delivered costs to the consumer are increased by multiple handling steps, yield losses, and freight costs for non-usable material.
- The variability from several different sources, creates concerns for beneficiators, particularly chloride slag producers. Foreign alluvial ilmenite are more recognized for the added value to these customers.
- Port stock remain at relatively low levels. Large volume shipments quickly grew stock levels.

→23

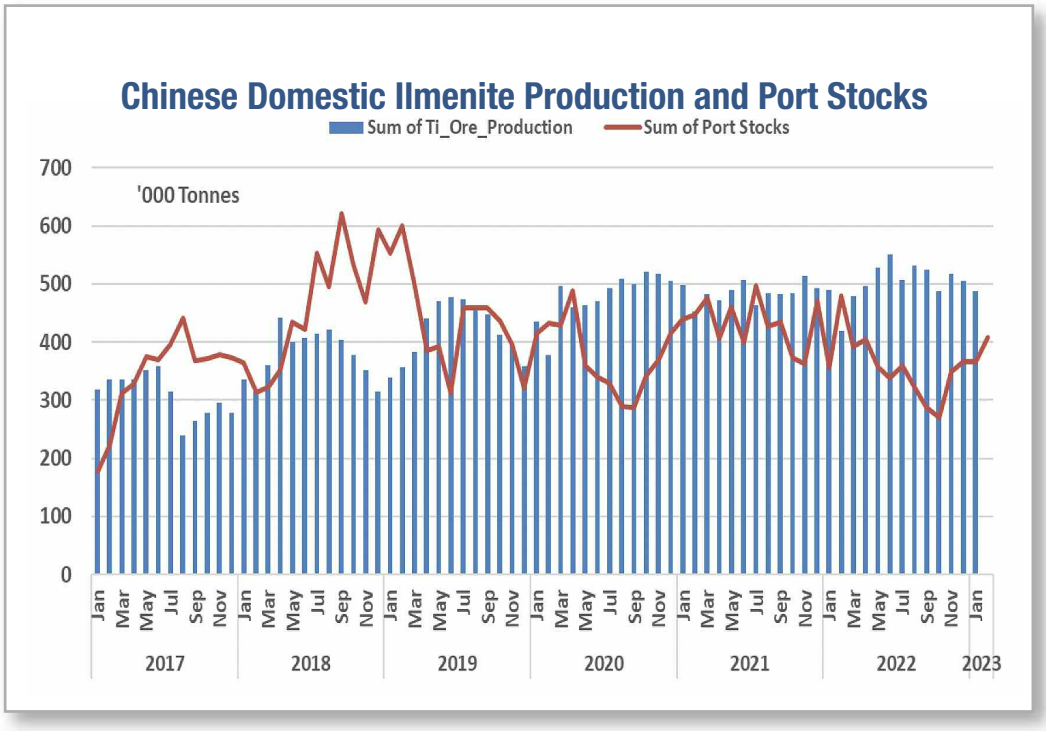
TiPMC maintains the supply side will continue to have significant influence on pricing:

- There is no project with significant sulfate ilmenite with a chance to start-up prior to 2024.
- Domestic producers are trying to increase prices, as costs are exceeding current prices. Foreign producer have held prices well above domestic producers, maintaining price as domestic price increases should be an easier task.
- Foreign ilmenites are the best choice for slag producers in China, as the products are more consistent and end to be of a higher quality. As more chloride slag is required, demand for these products increases, providing a level of differentiation relative to domestic ilmenite and ilmenites from concentrates.

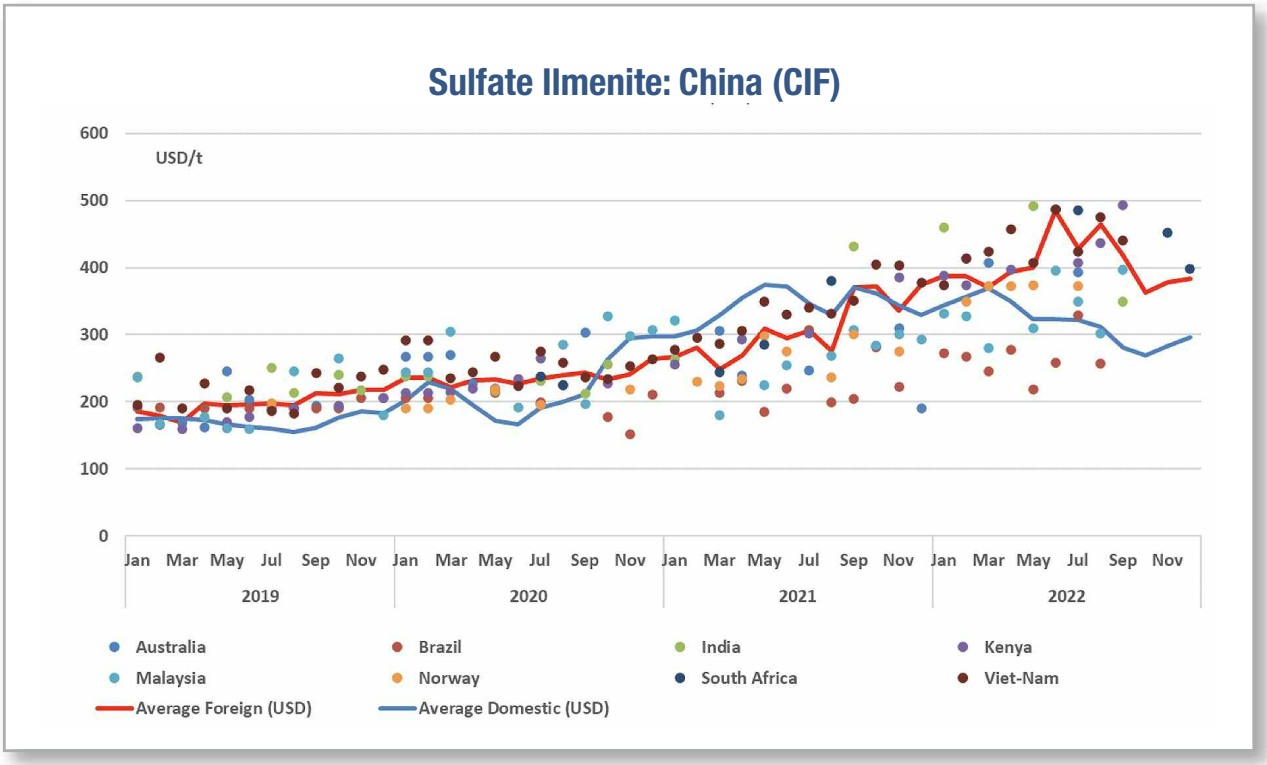


Source: Ferroalloynet

→24



Source: Ferroalloynet



→25

Source: Global Trade Tracker / Ferroalloynet

Sulfate Ilmenite: Long Term

TiPMC continues to expect demand for sulfate ilmenite to continue to grow, outpacing all other titanium feedstocks. TiPMC sees sulfate TiO_2 production outside China to continue to contract. Increasing chloride pigment exports from China present a challenge to all producers outside China, in particularly higher cost sulfate operations without differentiated products. Ilmenite will be the primary source of titanium units for Chinese producers, either as direct consumption or to be beneficiated. TiPMC also believes smelters outside of China will increasingly become more dependent on merchant ilmenite.

In terms of demand, TiPMC expects current trends to continue:

- TiPMC believes chloride growth is gaining speed in China. TiPMC still believes LB Group to remain the leader in Chinese chloride production and remain there for the foreseeable future. Still, it accounts for only about 11% of the total TiO_2 volume produced in China. Chinese chloride smelters remain the primary source, as both LB Group and Yan Steel are poised to increase smelting capacity within China. These will require foreign ilmenite purchases.

- There is a resurgence in interest in sulfate production in China, given the value of producing intermediate for Lithium Iron Phosphate (LFP) as a battery material. TiPMC continues to believe the overall demand for sulfate ilmenite will not depend on chloride or sulfate end use, as most of the feedstock for each process will originate from sulfate ilmenite. Higher sulfate production, particularly with added value from the iron component, may increase demand for domestic ilmenite. The lower TiO_2 content may not have as severe a penalty as prior.
- Sulfate slag in China is already in decline. Ilmenite has now become a preferred feedstock as what was once seen as waste is now viewed as a valuable commodity.
- Chloride slag growth outside China is more likely to come from smelters not directly associated with a sulfate ilmenite mine. Jazan is the primary case. Other factors include:
    - If Jazan moves forward, the ratio of internally supplied ilmenite by Tronox relative to purchased ilmenite. Recent expansions suggest more ilmenite will be available from Tronox internally. Jazan purchased ilmenite for the Jazan slagger from outside sources in 4Q22. As the current operating issues become resolved, it is likely ilmenite for the smelter will be sourced from Tronox.
    - Where does Tronox land in terms of minimum head grades? This would impact the elastic demand for SR and Natural Rutile. In turn, this would impact chloride ilmenite demand.
    - Capacity will be available at Sorel, as demand for sulfate slag continues to contract. Although overall demand for chloride slag will not change, some production may shift from RBM to Sorel, requiring ilmenite from sources outside of their own supply base. This may also impact chloride ilmenite supply, as more Madagascar ilmenite may be converted to chloride slag.

→26

With the increase in demand and pricing sustained at historically high levels, the supply side predictably begins to heat up in terms of new projects. Significant new projects are not scheduled to see market impact on sulfate ilmenite until late 2024 or 2025. Other factors are weighing into the long-term price forecasts.

- New projects are very focused on supplying concentrate to China vs. finished products globally.
    - Traditionally, mineral sands projects had dependent on Zircon and rutile to provide most of the profitability for projects. Some projects, like Iluka JA were developed primarily as a Zircon project. More projects were developed with greater dependence on ilmenite revenue (Kenmare) or combined with smelter or SR operations to move downstream to develop value in two parts of the value chain.

- Increasingly, projects are being developed solely as concentrates. Chinese MSPs have encouraged these projects. Downstream TiO_2 producers, such as YanSteel, have invested in these projects as the front end of their operations in China, which include the MSP and the smelter operations. Above all, new value in monazite as a rare earth bearing mineral has led to projects valued for their rare earth potential and Zircon, with less emphasis on TiO_2.
- Chinese producers are showing less interest in finished products for new projects, as concentrates purchases are seen as a way move down the value chain without requiring operations outside of China. The finished products, ilmenite, rutile, Zircon, and monazite, are seen as Chinese products vs. imports. Chinese companies see this as a way to gain more value from the value chain, leaving less for the miners.
- Total delivered heavy mineral costs for these projects are higher, due to multiple handling steps, yield losses, and ocean freight for non-value producing products. Projects such as Chibuto, which is primarily ilmenite in concentrate, support higher prices for sulfate ilmenite. They also have moderated the cyclicality of pricing, as the supply deficit would have been extreme without the contribution from concentrates.

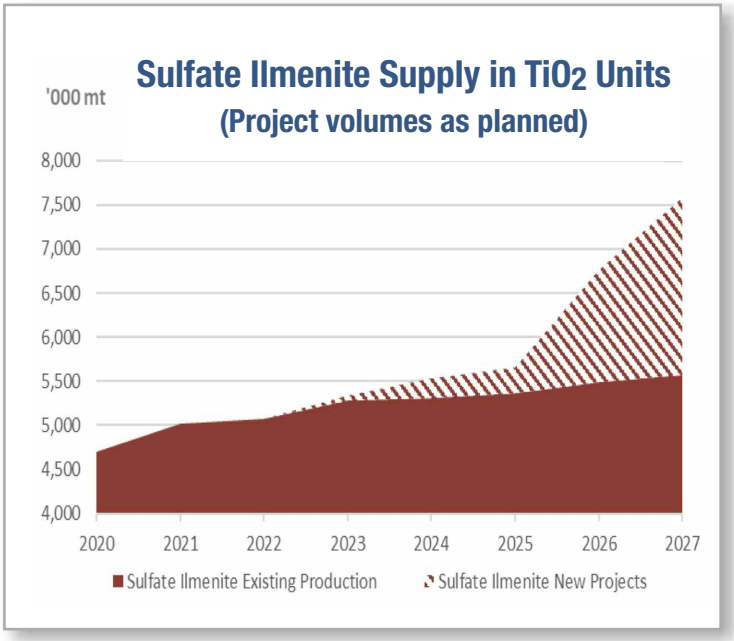
- These projects could have negative impacts on the sulfate ilmenite markets:
  - Allow projects that are valued for Monazite credits, despite economics that would not be sustained in ilmenite, Zircon, and rutile.
  - Increase available ilmenite, which can be sold at lower cost because the benefit of the monazite are Zircon are valuable to the MSP, and ilmenite can be sold in volume but at a discount.

→27

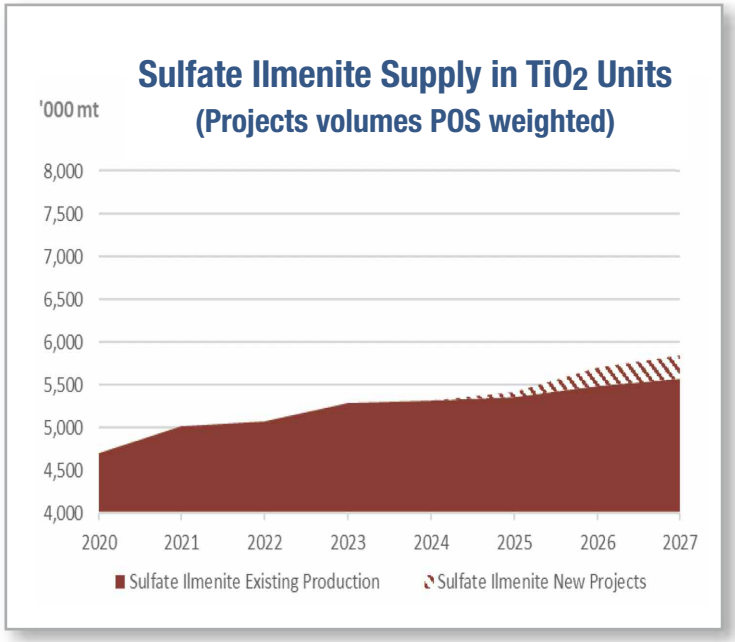
TiPMC believes the impact will be somewhere in the middle. Although later in the forecast period TiPMC believes ilmenite will have greater availability, the cost of multiple handing steps and reduced overall ilmenite yields will sustain higher than traditional ilmenite prices. Traditional suppliers will also be positioned to exert discipline within the market, as the volumes and quality of ilmenite from these sources will be consistent. These suppliers also are established with stronger balance sheets, providing the ability to reduce supply in longer markets.

Demand recovery in 2024-25 will increase sulfate ilmenite demand either as slag feed or direct feed to digestors. TiPMC believes the Sheffield/Yan Steel combination will create more chloride slag supply, regardless of the future of the Yan Steel chloride plants. If the chloride smelters experience start-up issues, ilmenite from the MSP receiving Sheffield concentrate will be diverted to other smelters. The impact of the new volume on the market, combined with other smaller sources, are likely to drive ilmenite prices to lower levels.

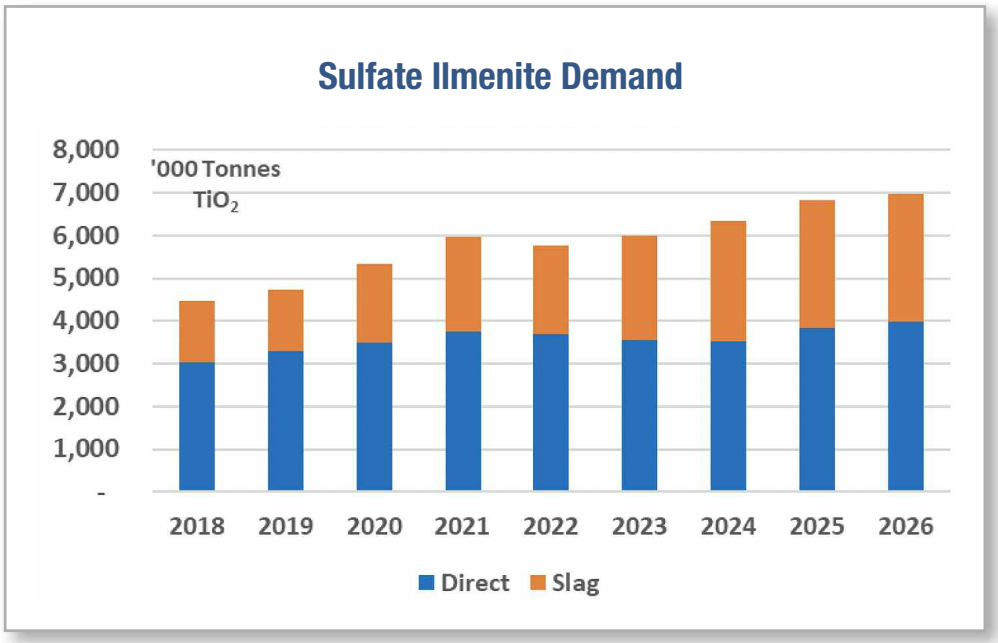
Concentrate producers and along with the less competitive producers, such as Vietnam, will help to stabilize any over-supply situation if demand is not as robust as predicted.



Source: TiPMC Estimates



Source: TiPMC Estimates



Source: TiPMC Estimates

Chloride Slag tonnes calculated as 85% equivalent. Can be replaced as SR/chloride ilmenite tonnes.

Sulfate Slag and Chloride Fines

Sulfate slag demand is decreasing. We are already seeing high-cost plants in Western Europe close. Reduced capacity at Scarlino and the closure of Duisburg TiO_2 have reduced capacity by approximately 107ktpa. The trend is likely to continue, given the Chinese expansion plans.

Sulfate slag is a very high margin product for Rio Tinto at its Sorel site. The source is a low-cost rock ilmenite mine in Quebec, and the iron products are converted to high return co-products as finished iron products, downstream from pig iron.

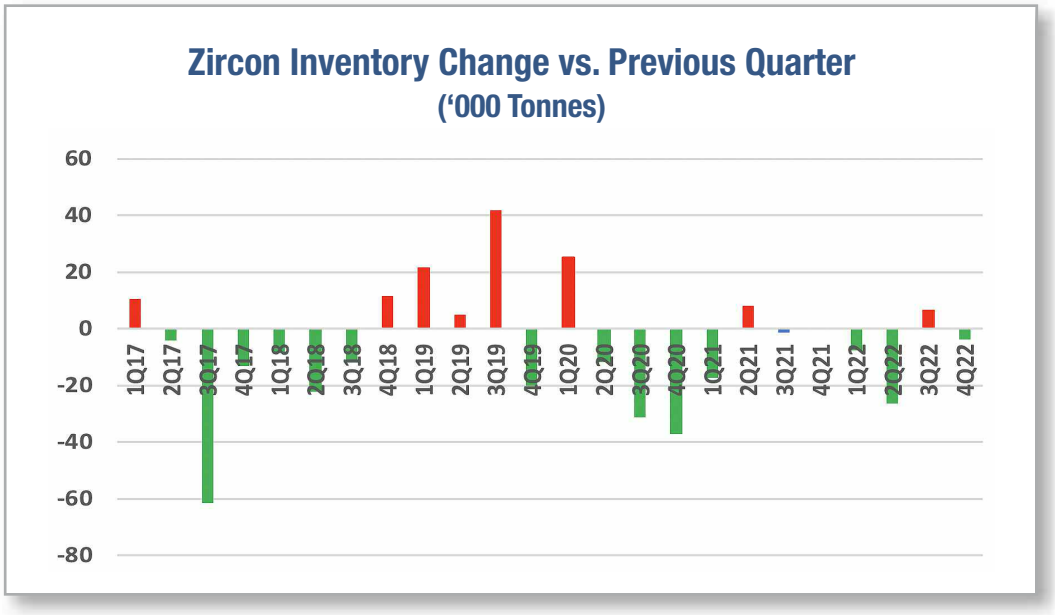
Chloride fines, like all smelter related products, has had its supply chain stretched by the recent developments in South Africa. As only 10-15% of total slag production is fines, impact Is not nearly as widely felt as chloride slag. Any new chloride fines from Jazan can be absorbed within the Tronox system, wither in Brazil or China.

Given the limited number of suppliers, prices for these products tend to be highly inelastic.

Zircon

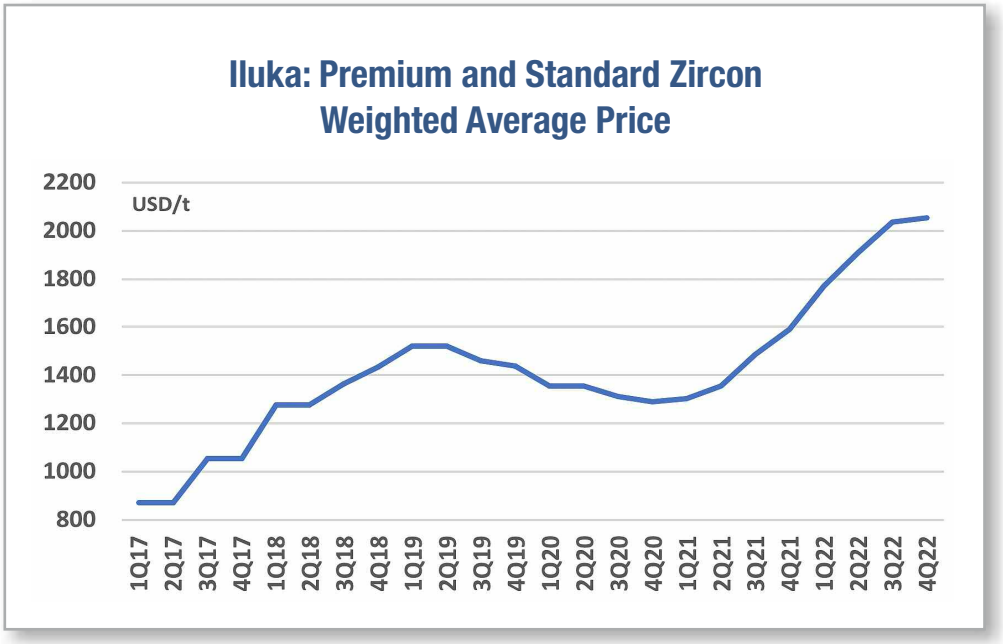
Zircon demand has been very strong through 2022. The slower housing market in China impacted demand during the second half of 2022, similar to the dynamics seen in the pigment market. The Tronox operational issues went very far to balance the market. TiPMC data shows Iluka inventories to be significantly lower than at the end of 2021, but nearly 30kt. Base Resources reported no inventory change, while Tronox is looking for every tonnes that is available to sell.

→29



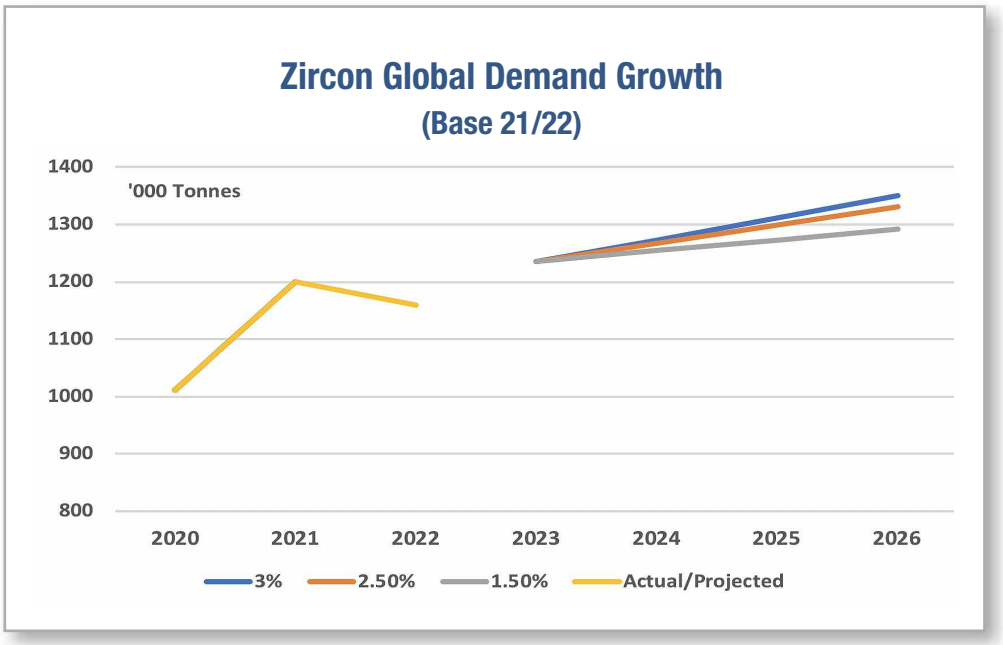
Source: Iluka 10Q's and TiPMC Estimates

Iluka reported not only low inventory, but sales in Q123 at the same price as Q422. In addition, they noted customers expecting for demand to pick up in Q2 and Q3, consistent with recovery in Asia. Supply relief is not likely to be significant until Q3, as Tronox still needs to get their facilities operating.



Source: Iluka 10Q's and TiPMC Estimates

→30



Source: Company Presentations and TiPMC Estimates

Longer term, current sources of Zircon production is expected to decrease, by an average of 40-60kpta over the course of the next five years. Atlas Campaspe, where high grading the mine promised to produce significant volumes of zircon, will add an estimated 65ktpa for the first two years of operation, with an additional 110ktpa from Thunderbird towards the middle of 2024.

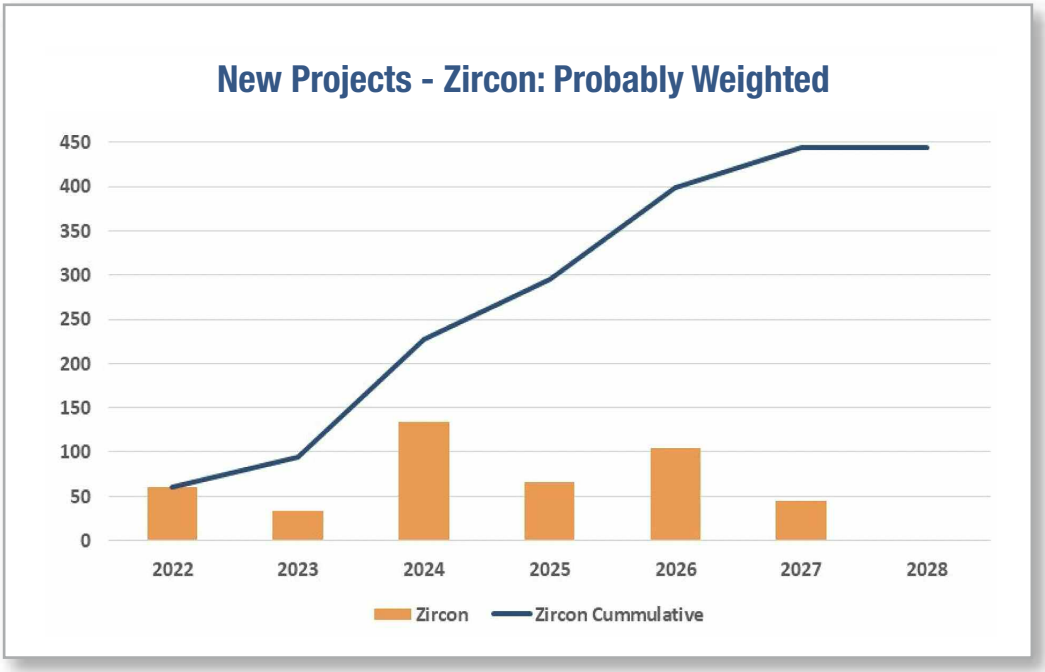
The wildcard becomes the large number of concentrates entering China. As MSP operators are consistently spanning the globe for available concentrates with high Zircon components, this source is likely to increase.

TiPMC believes short to mid-term Zircon prices will be impacted downward as new supply and global economic concerns combine. TiPMC believes Iluka and Tronox will serve as excellent stewards in terms of maintaining supply to match demand, maintaining stable pricing, and managing price to prevent substitution and a market well oversupplied. TiPMC expects some recovery in 2025, as depletion and a more advanced global recovery restore greater balance to the Zircon market.

As with ilmenite, processing of Zircon concentrate adds additional cost to final product. TiPMC believes this will assist in supporting Zircon prices long term.

New projects, particularly Thunderbird, will impact Zircon demand. Large volumes of Zircon is highly sought by MSPs. Smaller concentrate sources may impact supply particularly in China.

→31



Source: TiPMC Estimates

Note: Atals Camapaspe is considered commissioned in 2022.

Putting it Together

TiPMC, along with most others, see the majority of TiO_2 growth in China, primarily produced from products beneficiated in China. European sulfate remains a target for Chinese TiO_2 producers, in terms of taking market share from these producers. Chloride TiO_2 producers outside will be extremely focused on cost reduction. Given inventories, depletion, and timing of new projects, it appears these dynamics will generally stay in place for 2023.

TiPMC has reviewed several new projects beginning operation over the forecast period. TiPMC sees a high probability of success for Coburn, Atlas Campaspe, Engebo, Balranald, and Thunderbird within the next 1-3 years.

Much needed chloride ilmenite and natural rutile units will be developed from earlier projects. The first four projects noted will provide the needed approximately 180k if TiO_2 from rutile and 90kt TiO_2 unites from chloride ilmenite. These will help maintain chloride feedstock supply, as current reserves deplete, and chloride TiO_2 recovers in 2024. As demand recovers these feedstocks will support the supply/demand balance, with SR most likely to either be added or subtracted depending on demand. TiPMC believes there is not a great deal of incentive for chloride slag producers to reduce prices to gain volume. Costs and alternatives to ilmenite feed for smelters outside China provide incentive for value over volume.

→32

China becomes a much bigger wild card, particularly for the sulfate ilmenite market. Expansion from TiO_2 producers are driving growing needs for ilmenite, wither as direct feed for sulfate or as smelter feed. Although ore expensive in terms of cost to final product, concentrate projects can be started much quicker and with less capital. These projects could swing supply and demand out of balance quickly, and potentially reduce prices. Adding substantial ilmenite projects like Thunderbird and LB's ilmenite mine in Sichuan cause concern in the 204-25 timeframe of over supply. TiPMC believes this is balanced by more expensive producers, such as Vietnam and Norway leaving the market. Also current domestic ilmenite producers in China provide a floor as we have seen during the recent COVID related downturn. This is highly dependent on the tight market for iron ore tailings continuing within China. Later projects, particularly the Astron and Neo metals projects, are heavily linked to China and the value derived by MSPs for Zircon and rare earth concentrates. This will add more uncertainty to the future value of ilmenite.

Wimera is perhaps the most interesting project in terms of adjusting the new reality. The project is only 30% ilmenite in its reserve statement. Zircon has been considered an upside in the project economics. The rare earth component, as a feed to the new rare earth processing plant Iluka is constructing, is the primary driver for the project.

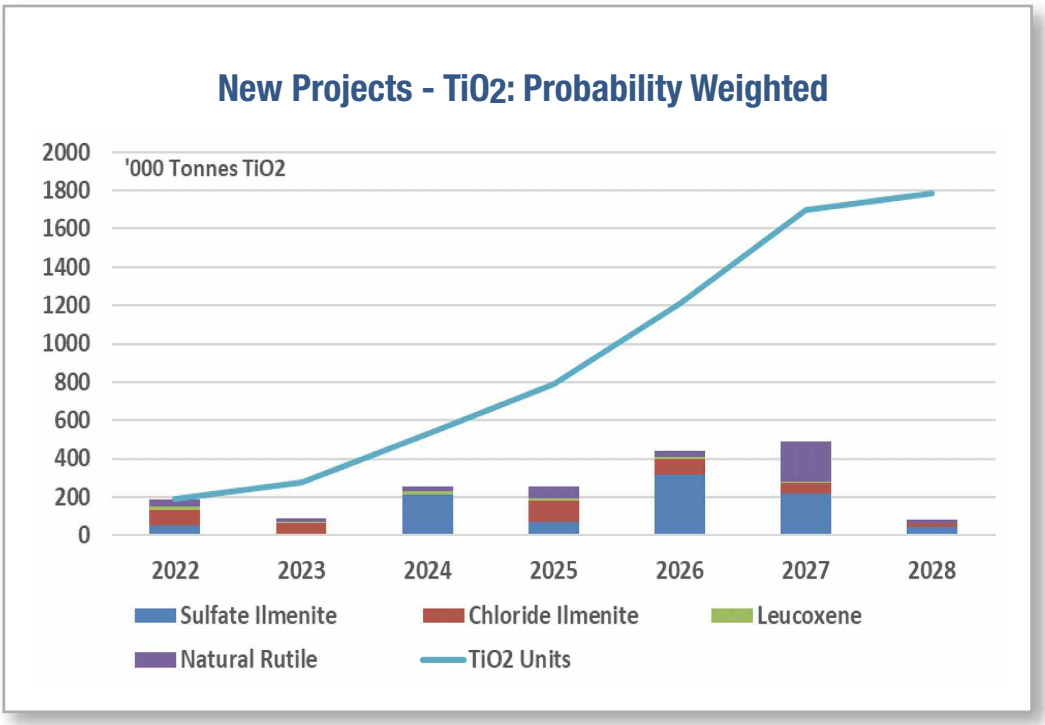
Large projects, such as Sheffield and Toliara, could progress out of sync with projected sulfate and chloride ilmenite demand in China.

New Projects

TiPMC believes several projects are in position to be fast-tracked as COVID-related delays are eliminated.

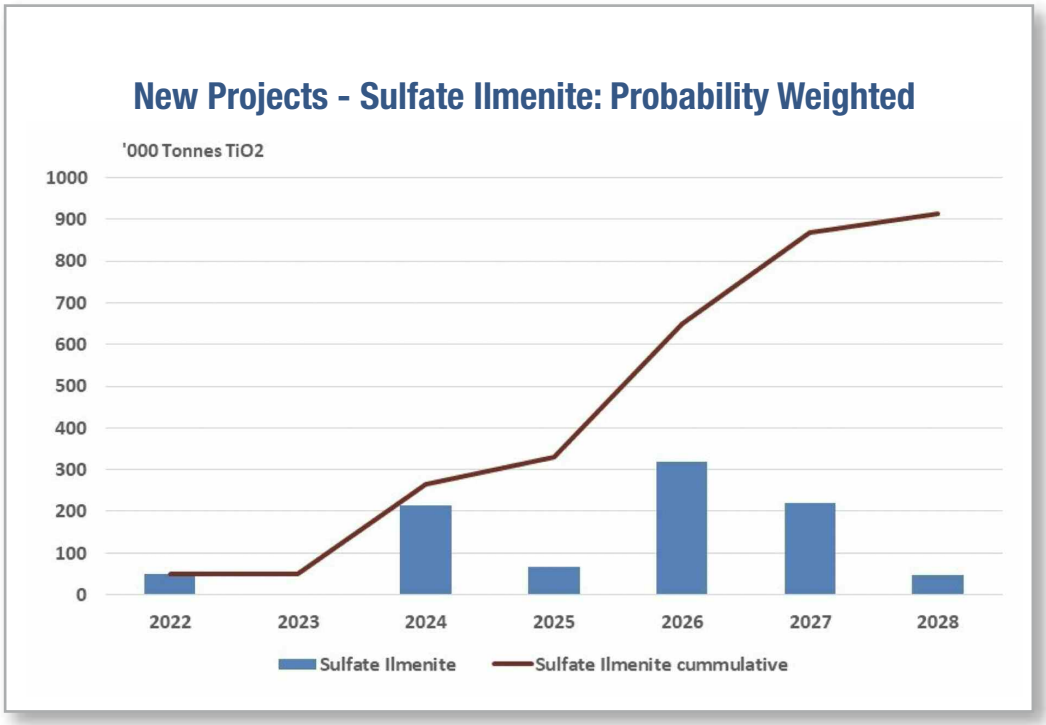
Company	Project	Location	Potential Start Date	Production (Ktonnes) - Forecast									
Company	Project	Location	Potential Start Date	Sulfate Ilmenite	Chloride Ilmenite	Leucoxene	Natural Rutile	TiO2 Units	Zircon	REO	Garnet	Non-Mag Concentrate	POS
Chemours	Trail Ridge South	USA	2022	0	100	0	0	60	50	0	0	0	100%
Tronox	Atlas Campaspe	Australia	2022	100	40	20	40	128	55	0	0	0	100%
Strandline	Coburn	Australia	2023	0	110	7	17	87.75	34	0	0	54	100%
Sheffield	Thunderbird	Australia	2024	450	0	20	0	241	119	0	0.75	0	95%
Relentless	Relentless	Australia	2024	0	0	0	0	0	0	0	0	0	10%
VHM	Gosham	Australia	2024	0	0	0	0	0	0	10.5	0	0	10%
Confidential	Confidential	Confidential	2025	0	120	20	5	92.75	30	0	0	0	70%
Nordic Mining	Engebo	Norway	2024	0	0	0	30	28.5	0	0	176	0	90%
Strandline	Fongoni	Africa	2025	0	40	0	3	26.85	17	4	0	0	30%
Confidential	Confidential	Confidential	2025	0	66	7	20	64.2	33	0	34	0	30%
Iluka	Balranald	Australia	2025	150	85.5	0	60	183.3	50	5	0	0	90%
Base	Toliara	Madagascar	2026	577	232	0	8	435.3	54	0	0	0	50%
Zirco	Kamiesberg	South Arica	2026	490	0	0	0	245	0	3	0.9	45	20%
WIM	Avonbank	Australia	2026	200	0	0	0	100	80	0	0	0	50%
Astron	Donald	Australia	2026	100	0	30	40	112	75	0	0	0	40%
Astron	Niafarang	Senegal	2026	135	0	10	40	113.5	0	0	0	0	40%
UMCC	Stremigorod	Ukraine	2026	400	0	0	0	200	0	0	0.1	0	10%
Velta	Likarivske	Ukraine	2026	66	54	0	0	0	0	0	0	0	30%
Bluejay	Dundas	Greenland	2027	420	0	0	0	210	0	0	0	0	30%
Neometals	Barrambie	Australia	2027	522	0	0	0	261	0	0	0	0	30%
SRL	Sembehun	Sierra leone	2027	0	40	0	170	185.5	10	0	0	0	60%
Iluka	Wimmera	Australia	2027	0	0	0	25	23.75	40	TBD	0	0	40%
RZ Resources	Copi	Australia	2027	0	180	30	20	151	55	5	0	40	30%
Sovereign	Kasiya	Malawi	2027	0	0	0	242	229.9	0	0	0	0	30%
Eramet	Akonolinga	Cameroon	2027	0	0	0	70	66.5	0	0	0	0	30%
Group DF	Motronovsk	Ukraine	2028	0	120	0	27	97.65	15	0	0	0	20%

Source: Iluka Presentation / Company Presentations / TiPMC Estimates

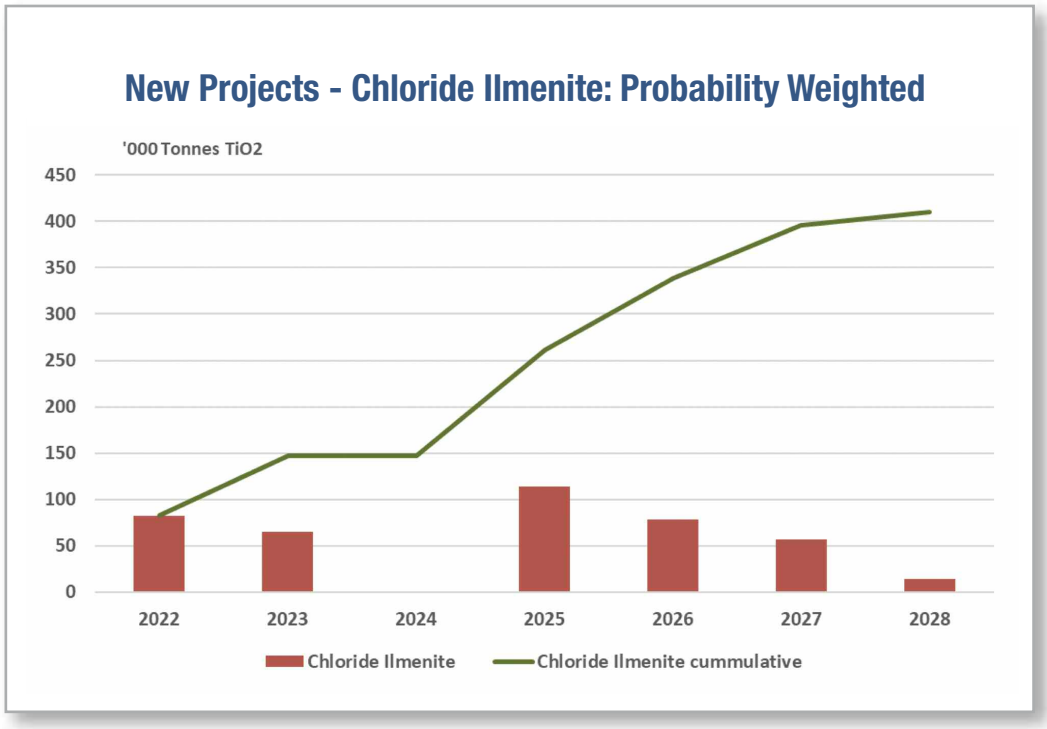


Source: TiPMC Estimates

→34

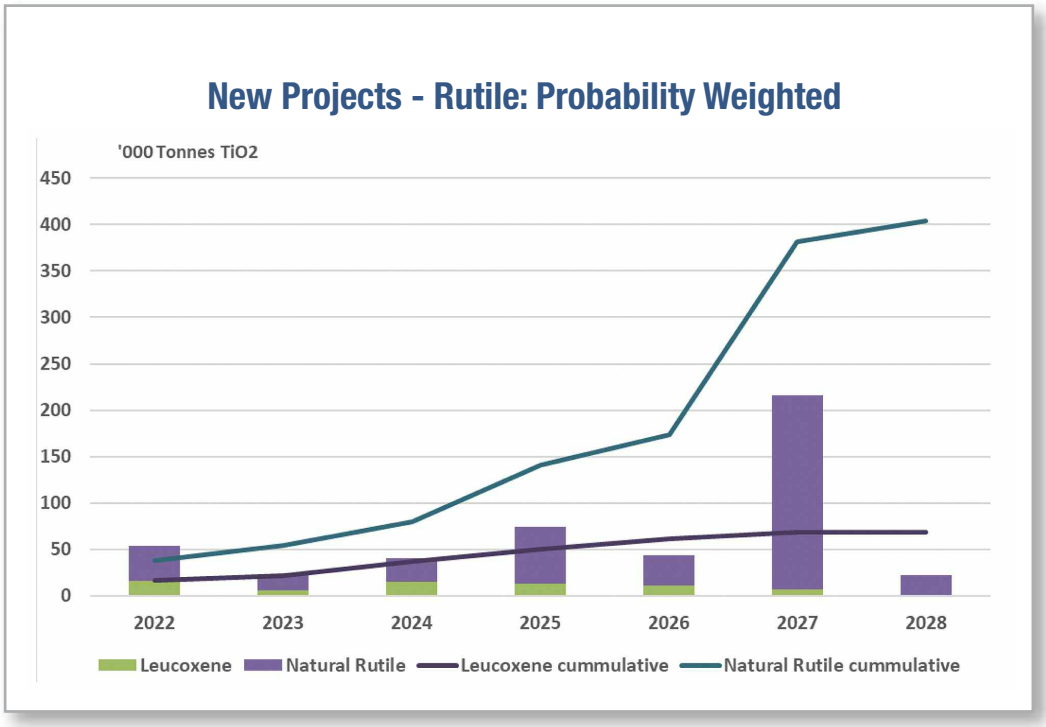


Source: TiPMC Estimates



Source: TiPMC Estimates

→35



Source: TiPMC Estimates

In Summary

TiPMC sees two distinct value chains developing within the TiO_2 feedstock industry.

Chloride and the remaining sulfate outside of China will be a much more disciplined chain, with both feedstock producers and TiO_2 producers closely monitoring inventory and adjusting production to meet demand.

China, and its junior mining partners are more likely to remain very opportunistic and tactical, with greater variability within pricing for the markets and a constant push for volume.

Monazite and rare earth concentrate are adding another dimension outside the value chain, similar to Zircon but with a great deal of uncertainty. The added uncertainty does come with the potential for an extensive upside.

Forecast Notes

The TiPMC forecast is based on the following assumptions:

- No macro-economic event, such as global recession, occurs before the end of the decade.
- Exchange rates, particularly the Euro, remain at current levels.

No assumptions are made for the impact of political events, such as Brevit, continued monetary easing, or outbreak of hostilities.

The methodology for this TiO2 price forecast is based on two key model outputs:

- Short term -- demand vs. inventories
- Longer term -- capacity utilization

TiPMC Standard Disclaimer - Publications

The Report and Forecast is based on information gathered by TiPMC from reliable sources, but no effort has been taken to verify any such information. TiPMC Solutions LLC does not accept any responsibility for any errors or omissions of information presented in this report and accepts no liability for any loss arising from direct or indirect use of this forecast.

TIPMC Solutions LLC and its owner make no warranty as to the accuracy of the information contained in this Report and Forecast and will not accept responsibility or liability for any loss incurred by any person or organization relying on the information in this report and the associated Forecast.

The methodology used in this report relies on models, public information, and empirical data and assumptions as they exist at the time TiPMC Solutions LLC prepared this report. No representation or warranty, either expressed or implied, is provided as to the accuracy or appropriateness of the information provided. TiPMC Solutions LLC specifically disclaims any liability with respect to any reliance on or use of any information or methodology disclosed in this document. This information is not warranted as to completeness and may be subject to change without notice.

→37

This report does not constitute, nor should it be construed to be advice or analysis regarding investment in, or sales or valuation of, any securities, commodities, financial instruments, or contracts.

This report contains forward looking statements. Such information can be identified by the use of forward looking terminology, such as ‘may, ‘will’, expect ‘anticipate’, or ‘continue’ or the negative thereof or other variations or comparable terminology. It also contains cautionary statements identifying important factors with respect to such forward looking statements including risk and uncertainties that could cause actual results to differ, perhaps materially, from information in this report.

With regard to any use or reliance on this document by any party other than the Subscriber, Consultant, its parent, and affiliates:

- Make no warranty, express or implied, with respect to the use of any information or methodology disclosed in this document; and
- Specifically disclaims any liability with respect to any reliance on or use of any information or methodology disclosed in this document.

Any recipient of this report or the forecast other than the Subscriber, by their acceptance or use of this report and forecast, releases TiPMC Solutions LLC and its owner from any liability for direct, indirect, consequential, or special loss or damage whether arising in contract, warranty, express or implied, tort or otherwise, and irrespective of fault, negligence, and strict liability of consent.

Copyright

All TiPMC Solutions publications content is private, privileged, and confidential for your sole use as a subscriber. TiPMC Solutions LLC reserves all rights to its contents. Copying, storing, downloading, forwarding, or distributing this publication in whole or in part is strictly prohibited. TiPMC Solutions LLC reserves the right to terminate the access of any registered subscriber found to be in violation. In addition, such action may violate the copyright laws of the United States and lead to legal prosecution.