

Borate & Boric Acid Market Whitepaper Euro Lithium Inc. May 2020

1. Introduction

The term “borates” is used to describe the family of naturally occurring minerals that contain the element boron. Boron is the fifth element on the periodic table, but is not found in nature in an elemental state. Rather, boron combines with oxygen to form boric oxide (B_2O_3), which then compounds with other elements to form boric acid or inorganic salts called borates.

There are more than 300 known naturally occurring borates, with 11 currently being extracted economically, including Ulexite, Colemanite, Kernite, Tincal (Borax), and Probertite^{1,2,3}.

The use of borates in industry date as far as 2000 years ago through various Arabic, Chinese, and European dynasties². Today, there are more than 200 common uses of borates across key sectors such as housing, construction, agriculture, energy, electronics, manufacturing and others⁴. The versatile nature and cost-effective functionality of borates make them critical for everyday use in products and industrial processes.

Approximately 80% of global demand for borates today is driven by the glass (borosilicate, textile and insulation fiberglass), frits/ceramic, agriculture (fertilizer) and detergent sectors^{1,4}. The largest uses of borates worldwide is for the production of insulation fiberglass and borosilicate glass^{5,6}. Although to smaller degree, borates are also used in other sectors such as pesticides and insecticides, oil field chemicals, flame retardants, adhesives, lubricants and greases, wood preservatives, nuclear energy, energy storage, steel production and metallurgy^{3,4,7}.

Borates are a “Critical Raw Material” according to the Commission of the European Union (EU), citing their economic importance of borates to industry within the EU, their low substitutability, near-zero recycling rates, importance to the green economy, and the medium-high risk of future supply constraints⁸. Approximately 80% of the borates placed in the EU market are used for intermediate purposes such as the manufacture of glass & frits, and/or for the synthesis of new substances. The remaining 20% of imported borates

¹ Ronald, E. – ‘Borates in a Nutshell’ (2017) (<https://www.mininggeologygroup.com/borates-in-a-nutshell/>)

² Schubert, D. – ‘Boric Oxide, Boric Acid, and Borates’ (2015), Ullmann’s Encyclopedia of Industrial Chemistry

³ US Geological Survey – Boron (January 2020) (<https://pubs.usgs.gov/periodicals/mcs2020/mcs2020-boron.pdf>)

⁴ Eti Maden – 2017 Annual Report

(<http://www.etimaden.gov.tr/storage/pages/November2018/2017Yil%20FaaliyetRaporuEN.pdf>)

⁵ European Borates Associate – Borate Factsheet (https://www.ima-europe.eu/sites/ima-europe.eu/files/minerals/Borate_An-WEB-2011.pdf)

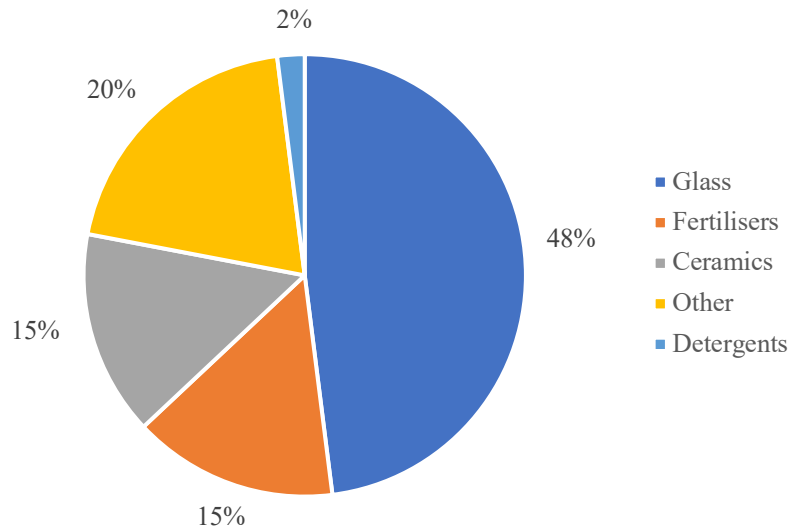
⁶ Orocobre 2019 Annual Report (<https://www.orocobre.com/wp/?mdocs-file=5947#page=31>)

⁷ American Borates Company website (<http://www.americanborate.com/all-about-borates/borate-applications/>)

⁸ European Commission, 2014 (<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0297&from=EN>)

are used in agriculture, in articles, and in other uses such as coatings, industrial fluids and/or metallurgic applications. Furthermore, boron is an essential micronutrient for productive plant growth, is one of seven essential micronutrients for plants according to EU Fertiliser Regulation 2003/2003/EC (CRM Alliance)⁹.

Global Borate Consumption By Industry



Source: Eti Maden 2018 Annual Report

Globally, ~4.2 million metric tonnes (MMt) of borates (measured as Boric Acid-Equivalent, “BAE”) were consumed in 2018, compared to ~3.9 MMt in 2017 and ~3.8 MMt in 2016^{4,6,10,11}. This represents year-over-year demand growth for borates of 8% and 2.5% in 2018 and 2017, respectively. Alternatively, demand for borates can be expressed as demand in “Boric Oxide-Equivalent”, which would mean there was ~2.4 MMt of demand in 2018, ~2.2 MMt in 2017, and ~2.1 MMt in 2016. In either case of measurement, borate annual market size is ~\$3.2B USD¹².

It is expected that the borate market will grow between 3 - 6% per year over the 2019 – 2029 period^{6,11,12}. The on-going development of the world’s middle-class in Asia, particularly China and India, as well as the Americas have formed macroeconomic tailwinds to support a growing demand for borates¹³. These tailwinds include population growth and the continued rise in per capita income, increasing rates of industrialization and urbanization, rising agricultural nutrient demand, and increasing consumption of modern

⁹ CRM Alliance website, Borates (<http://criticalrawmaterials.org/borates/>)

¹⁰ Eti Maden 2018 Annual Report (<http://www.etimaden.gov.tr/storage/uploads/sunumlar/en/22/index.html>)

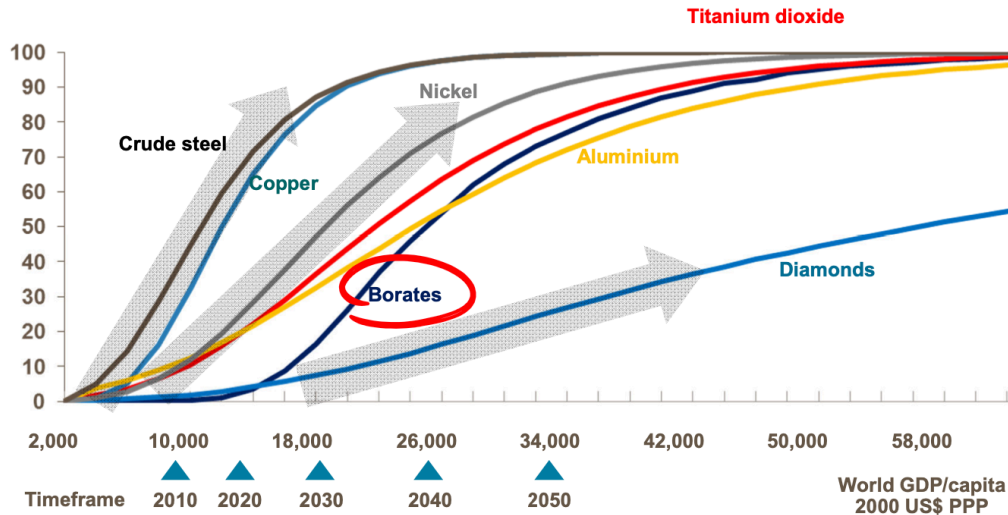
¹¹ Mining Journal, “American Pacific’s Road to the Big Leagues” (<https://www.mining-journal.com/agminerals/news/1372686/american-pacifics-road-to-borax-big-league>)

¹² Hooper, R. (2019), ‘Independent Company Research and Estimate Fair Value’ (<https://www.ioneer.com/files/research-report/files/independent-research-report-rodney-hooper-29april19.pdf>)

¹³ Rio Tinto Ltd., ‘A Global Outlook for Borates’ (2014) (<http://www.indmin.com/events/download.ashx/document/speaker/6613/a0ID000000X0jnzMAB/Presentation>)

high-tech glass products and coatings^{1,13,14}. Such drivers may accelerate demand for borates through the 2030s and 2040s as the world’s Gross Domestic Product (GDP) per capita surpasses \$18,000 (2000 US\$ PPP).

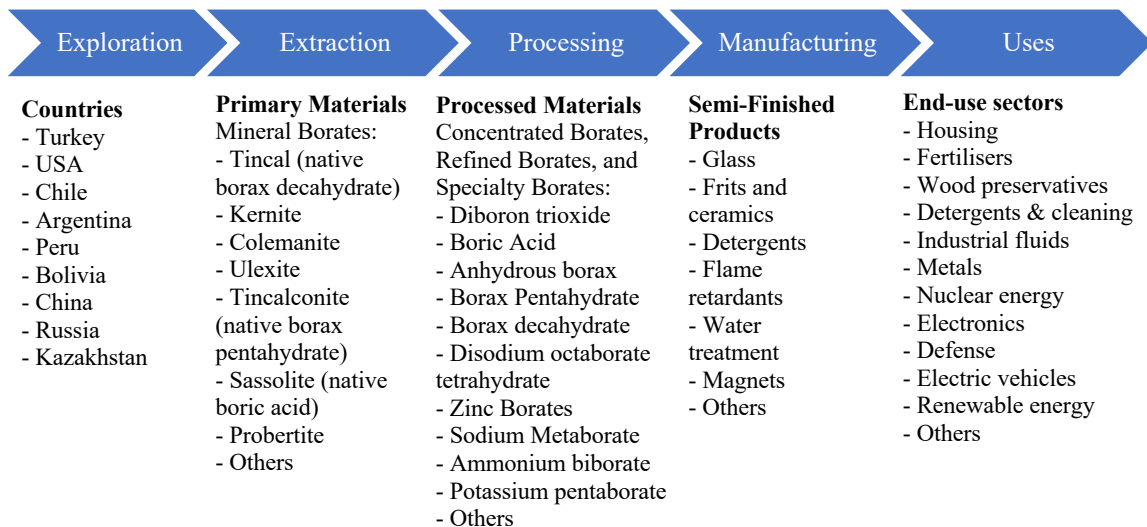
Saturation Levels for Borates at Global GDP/Capita, PPP*



Saturation Level is defined as the point at which consumption per capital does not increase levels.
Source: Rio Tinto Ltd., “A Global Outlook for Borates” (2014)

Other global demand drivers of borates include the deployment of electric vehicles and renewable energy technologies (wind, solar), and increasingly stringent energy efficiency standards in residential and commercial buildings^{11,15}.

2. Supply Chain



Source: European Commission Joint Research Center

¹⁴ Prudour (2019), ‘Global Boric Acid Market Research Report 2020’

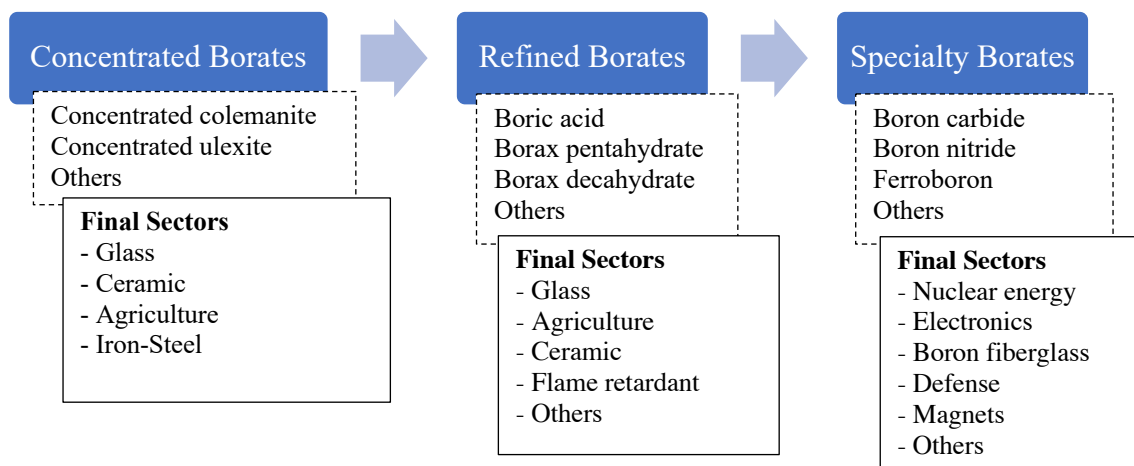
¹⁵ US Geological Survey – Boron (January 2019) (<https://prd-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/atoms/files/mcs-2019-boron.pdf>)

Sodium borates (Kernite, Tincal (borax)), calcium borates (Colemanite) and sodium-calcium borates (Ulexite) provide the source of roughly 90% of borate production today^{2,3}.

3. Products and Prices

Borate products are generally priced and sold based on their boric oxide (B_2O_3) content, varying by ore and compound, and by the absence or presence of calcium and sodium¹⁵.

The broad categories of borate products are described below:



Source: Eti Maden 2017 Annual Report

Borates can be sold as concentrated mineral borates, such as concentrated colemanite or concentrated ulexite. Market prices for these mineral borates often sell at a discount to refined borates and specialty borates. Concentrated colemanite, for example, sells between \$500 and \$800 USD per metric tonne^{1,16}.

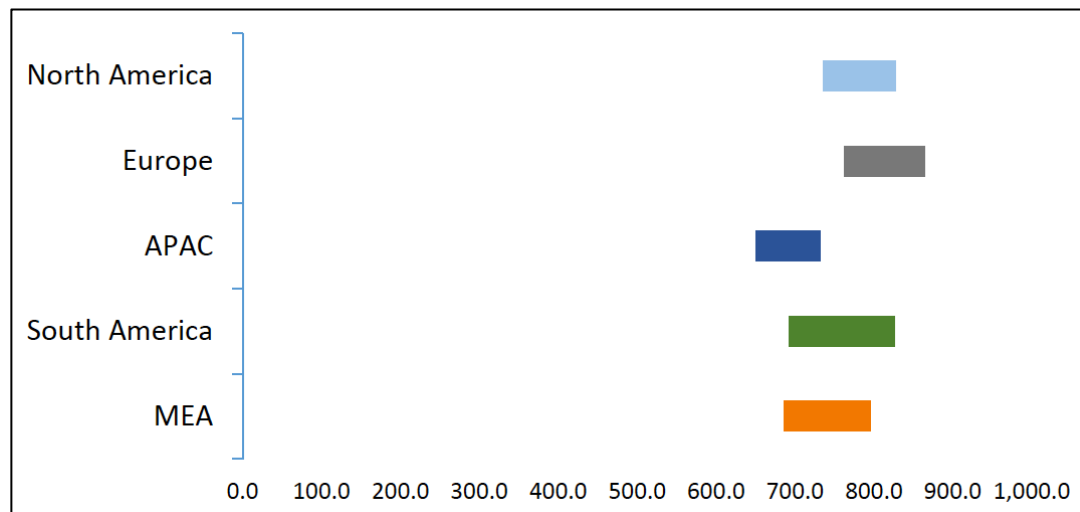
Boric acid (H_3BO_3), a refined borate, is considered the common feedstock chemical for industry, and most often used as a benchmark in the borate industry. The average price for boric acid ranges between \$600 and \$1000 USD per metric tonne^{1,14,17}. Factors affecting price are grade, end-use application, and regional factors such as regulations and import/export duties^{1,12,14}. The global market size of boric acid in 2019 was approximately \$800M USD, and is forecasted to grow 4 – 6% annually over the 2020 to 2029 period^{14,17,18}.

¹⁶ Stormcrow, 'Industry Coverage, Borates' (2015) (<https://static1.squarespace.com/static/535e7e2de4b088f0b623c597/t/55365c32e4b09956c7c42fc0/1429625906212/Stormcrow-Borate+Industry+Report-Apr2015-Final.pdf>)

¹⁷ Ioneer Ltd., 'DFS Press Release' (2020) (https://www.ioneer.com/files/announcement/files/dfs-press_release-300420-vf4.pdf)

¹⁸ Ioneer Ltd., 'Rhyolite Ridge Lithium-Boron Project Definitive Feasibility Study' (<https://vimeo.com/411551419>)

Diagram: Boric Acid Pricing Analysis (US\$/MT) by Region



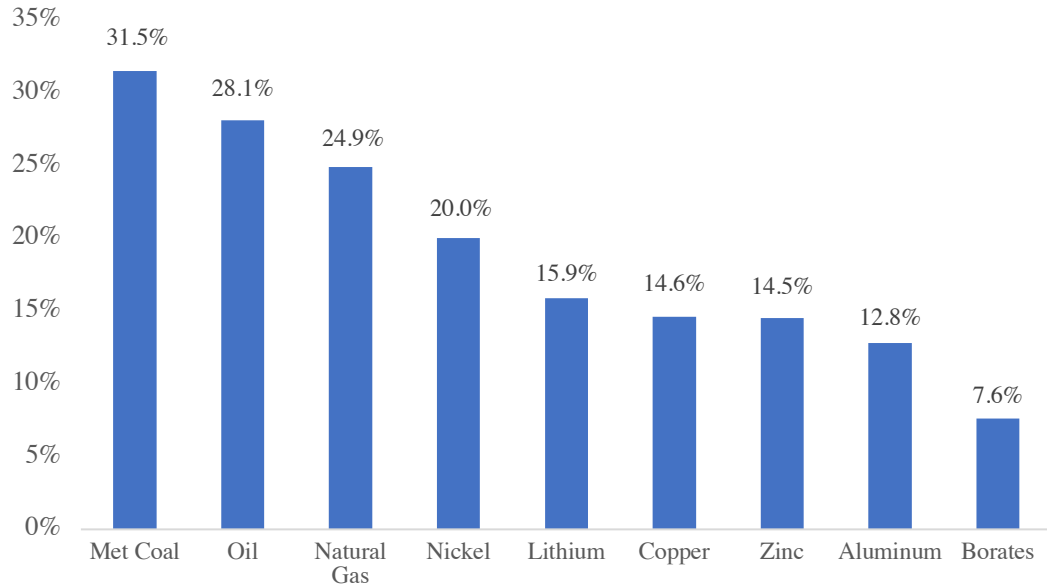
Source: Prudour, 2019

Given the wide array of possible applications of borates, major borate producers have in-house research and product development teams to create specialty borates and establish new applications for borates. Prices for speciality borates can widely vary, with some used in with the nuclear energy industry fetching more than \$10,000 USD per metric tonne. Although there are 200 common applications of borates today, there are thousands of possible applications of borates due to their ability to produce various desirable effects. These effects include, but are not limited to, natural metabolic processing, bleaching, pH buffering, particle dispersing, vitrification, flame-proofing, and neutron-absorption⁵. The versatility of borates provides for tangible opportunities for new borate product development and innovative commercial applications.

Historically, demand of refined borates have accounted for a significant majority of global borate demand (85%), followed by concentrated borates (14%), and specialty borates (1%)¹⁹. Unlike other natural resource commodities, borates products do not tend to have a history of price volatility¹⁷.

¹⁹ Schubert, D. – ‘Boron Oxides, Boric Acid, and Borates’ (2011), Kirk-Othmer Encyclopedia of Chemical Technology’

Historical Price Volatility | 5 Years

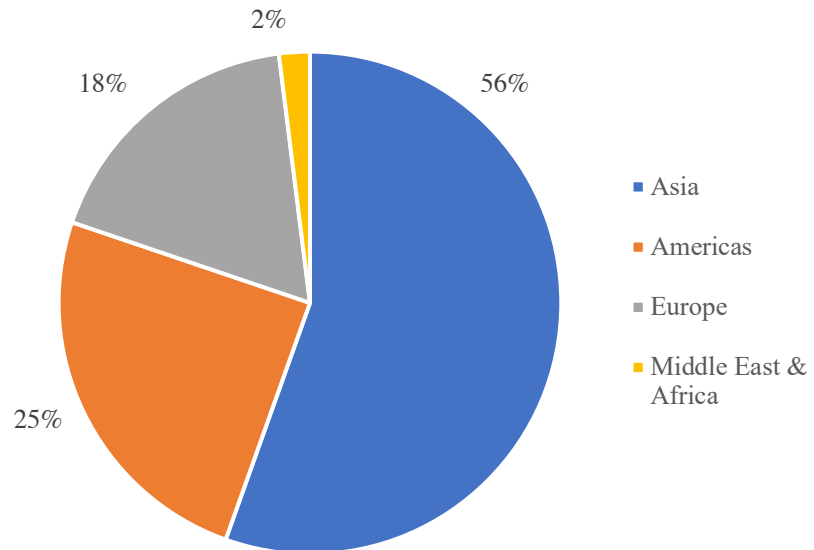


Source: Bloomberg L.P., Ioneer Ltd.

4. Customers/Demand

Asia is the largest regional consumer of borates, accounting for more than 50% of global demand⁶. The Americas and Europe are the second and third largest markets, respectively, while Africa and the Middle East demand relatively little borates.

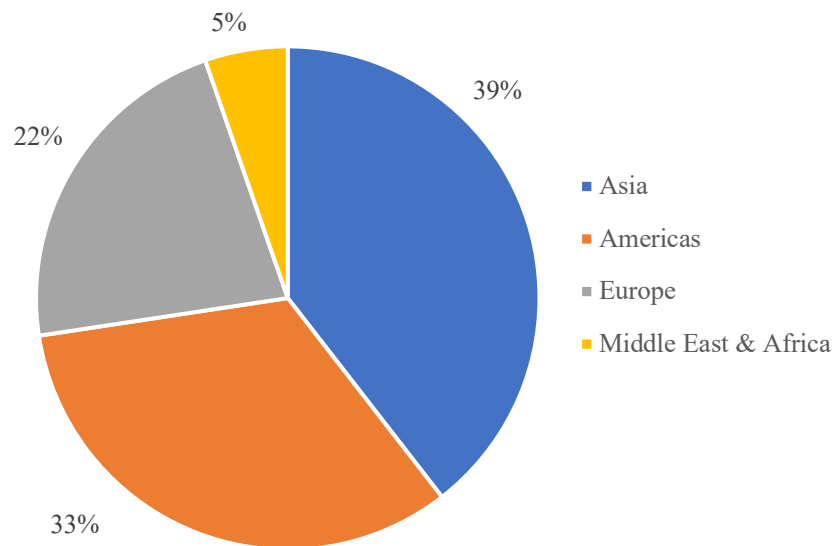
Borate Consumption By Region



Source: Orocobre 2019 Annual Report

Of the ~4.2 MMt of annual borate demand, ~1.2 MMt is boric acid, making up ~25% of the borate market¹⁸. Asia is the biggest market for boric acid, driving ~39% of the global market, while Europe ranked as the third largest market behind the Americas. Boric acid specifically has over 130 uses, such as in magnets for electric cars and wind turbines, advanced glass for televisions, computers, handheld devices and solar panels¹⁷.

Boric Acid Consumption by Region



Source: Prudour 2019

While there are some borate distributors such as American Borates Co. (USA), Toscochimica SpA (Italy), Cofermin Chemicals (Germany), Zibo Xinliyuan Boron Industry Co. Ltd. (China), Chem Ceed (USA), Larderello Group (Italy), or Trinternational (USA), the largest borate mining operations own and operate processing facilities, refineries and distribution infrastructure, most often selling directly to end-users²⁰. For example, the largest single producer of borates, Eti Maden, has over 350 direct customers¹⁰.

Neither borates nor boric acid have established spot markets, and pricing and volume are determined by business-to-business contracts¹. In this case, relationships with customers, continuous improvement in service levels and new product development are key factors to success in the borate industry⁵. While often classified as a commodities industry, borates have considerable elements of a specialty chemicals industry. Generally, the borate market is opaque with limited publicly available information^{1,16}.

²⁰ Rio Tinto Ltd., '2017 Annual Report' (<https://www.riotinto.com/invest/reports>)

5. Competitors/Supply

Despite the criticality of borates to modern day life and industry, they are only a handful of locations that produce borates and boric acid. Between 80% - 85% of the world's borates are produced by two companies in two countries: US Borax (Rio Tinto) in California, USA, and Eti Maden in Turkey¹. This has created an oligopoly within the borate market, which helps explain the relative price volatility of borates relative to other commodities¹⁶. The remainder of borate production is split between producers in Chile, Argentina, Bolivia, Peru, China, Kazakhstan and Russia.

Eti Maden, a state-owned Turkish company with exclusive, nation-wide mining rights controls over 55% of the global borate market^{10,16}. Eti Maden is a significant supplier of borates to the European Union, providing 99% of concentrated borates and 86% of refined borates²¹. Turkey is home to ~73% of the world's borate reserves and is expected to maintain a strong position in the borate industry for the foreseeable future^{10,16}.

Approximately 20 - 25% of the global borate market share is currently held by publicly-traded Rio Tinto Ltd., representing a decline in market share from over 30% in 2012²². This reduction in market share is due to the lower quality of ore feedstock material and consequently higher cost of production at the US Borax operation in Boron, California. According to company filings, the mine will end production in 2042 or sooner, which will represent the closure of a 100+ year mine operation and California's largest open-pit mine^{1,19,23}. Over the 2016 – 2018 period, Rio Tinto's borate division made up between 1 - 2% of the company's annual net earnings, and received less than 1% of total capital expenditure²⁴.

The remaining 15 – 20% of global market share of borates is held by a nine other producers¹. These suppliers have reportedly been incapable of dramatic production capacity expansions and maintaining a lower cost base than Rio Tinto and Eti Maden¹⁶. The marginal cost of production of boric acid is ~\$500 per tonne¹⁷.

²¹ European Commission, 'Report on Critical Raw Materials for the EU' (2014) (<http://ec.europa.eu/DocsRoom/documents/11911/attachments/1/translations>)

²² Rio Tinto Ltd., Review of 2019, 2018, 2017, 2016 Annual Reports (<https://www.riotinto.com/invest/reports/annual-report>)

²³ US Borax Inc. company website (<https://www.borax.com/borax-operations/history>)

²⁴ Rio Tinto Ltd., 2019 Annual Report (<https://www.riotinto.com/invest/reports/annual-report>)

Diagram: World Map of Borate Mine Operations



Source: American Pacific Borates & Lithium Ltd. (2019)

The scarce number borate ore bodies in high concentrations is due to the high solubility of borates. Borates readily dissolve in water, so their ability to be preserved in large tonnage requires a specific set of conditions both during and after formation over millions of years¹. Of the limited number of high concentration ore bodies discovered, some never go into production due to various factors, such as high concentrations of contaminants such as arsenic, remote locations and poor existing infrastructure^{1,16}. The Valjevo Project has high grades of borates, low concentrations of arsenic (10 – 50 ppm), existing water, electrical and transport infrastructure, immediate access to major borate markets, and a large inferred resource of borates.

There are two borate projects currently in feasibility stage of study. These include Rhoylite Ridge in Nevada, USA, and Jadar in Loznica, Serbia. Both projects are lacustrine bedded lithium-boron projects, similar to the Valjevo Project.

6. Substitution and Recycling

The substitution of borates in applications such as detergents, enamels, insulation, and soaps are possible. Sodium percarbonate can replace borates in detergents; some enamels can use other glass-producing substances; insulation can be substituted by cellulose, foams, and mineral wools; and in soaps, sodium and potassium salts of fatty acids can act as cleaning and emulsifying agents³. There are however no substitution for borates in high-end applications and agriculture (fertilizer)¹.

Borate recycling within the European Commission and globally is insignificant^{3,20}.