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Key information

Market: Private/pre-IPO
Sector: Mining

This report is an investigation into kaolin and the opportunity of developing an additional revenue stream at Mining Licence ML 100008 at InterGroup's Brilliant Brumby Project.

Business

Gold mining and exploration in Queensland, Australia. The Company has a 100% stake in the Brilliant Brumby Project which is a fast-expanding major gold project in Northern Queensland. The Brumby Project covers more than 100km² of highly prospective ground in an underexplored gold district lying within the Charters Towers Gold Province.

InterGroup Mining Limited is an unlisted Australian Public Company registered in Queensland under ACN 163 989 553.

Website

www.igmining.com

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Kaolin opportunity

Potential additional revenue stream from simultaneously mining kaolin which has fast-growing high-tech applications

- ❖ **Tier 1 gold asset in the making in the legendary Charters Towers Gold Province.** InterGroup Mining's (IGM) Brilliant Brumby Project covers a vast area of highly prospective ground in this rich gold province in NE Queensland, Australia, where over the years more than 20Moz of high-grade gold has been mined. Work on the ground is fast pointing to a potentially large scale near surface deposit of high-grade gold coupled with relatively straight forward mineral processing which could well suggest a Tier 1 status over the coming years.
- ❖ **Potentially c100 million tons of kaolin available to mine.** Work on the ground is beginning to suggest an additional revenue stream. Already a kaolin sample has been sent for analysis to ascertain its purity and brightness in order to assess whether a potentially saleable product can be mined at Brumby. Kaolin could be excavated along with the gold-bearing quartz veins and would therefore represent an additional revenue stream if the product has the right characteristics. Initial test results will determine future work on this kaolin opportunity.
- ❖ **Kaolin has a wide range of industrial applications and a ready market in Asia.** Demand is dominated by the paper industry which accounts for more than 40% of market share in terms of volume where kaolin acts as both as a filler to reduce costs as well as improving printing characteristics. The second biggest market is in the manufacture of whiteware ceramics where kaolin makes ceramics whiter. However, it's the rapidly developing high-tech applications with big growth stories, such as being a battery mineral, that have begun to attract attention.
- ❖ **Disruptive technologies allow kaolin to be processed into HPA which is a key ingredient of the modern world.** High Purity Alumina (HPA) is highly versatile with a myriad of uses in new age industries such as LEDs, coating cathode and anode electrode separator sheets in the lithium-ion battery. HPA produced from kaolin is less expensive as its less energy intensive than the traditional processing route which uses bauxite as the feedstock material. World demand for HPA has gained incredible traction with the product fetching prices around US\$6,000 to 35,000/t (3N – 6N) on increasing purity, when aluminium was trading at US\$2,200/t.
- ❖ **A kaolin play of such a scale could well become a world class asset.** The c100 million tons currently estimated would equate to a sizeable resource in the kaolin world. It could easily open the doors to a whole raft of opportunities stemming from the Company's proprietary production with value-adding processes, off-take agreements and deals with leading channel distributors. All depends on the results of laboratory testing at this stage, but ultimately, IGM could be well positioned geographically to supply kaolin to key commercial end users globally for a wide range of industrial applications.

KAOLIN

Kaolin is a fine soft white clay which results from the natural decomposition of other clays or feldspar. It is also known as china clay and used for making porcelain and china, as a filler in paper and textiles, and in medicinal products which exploit the material's absorbent properties.

Kaolin mostly consists of the clay mineral called kaolinite which has the chemical composition $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$ and termed a hydrous aluminium silicate. The kaolinite content of processed kaolin is generally within a range of 75-94%. Different deposits around the world have markedly different properties which includes minor amounts of mica, feldspar, traces of quartz and, depending on the origin, organic substances and/or heavy minerals.

Physical properties include high brightness, being non-abrasive, having naturally fine particles, remaining white after calcination (heating at a high temperature), being a weak conductor of both heat and electricity and being chemically inert. Kaolin is also hydrophilic making it easily dispersed in water. Historically the commercial value is based on the minerals' whiteness and its fine controllable particle size which can be optimised during processing.



Kaolin. Source: Mindatnh.org

Uses

Kaolin has a range of industrial applications, but the major markets are paper, ceramics and other speciality uses. Demand is dominated by the paper industry which accounts for more than 40% of market share in terms of volume where kaolin acts as both as a filler to reduce costs as well as improving printing characteristics which is important in the manufacturing of high-quality paper for promotional material. Lightweight coated papers can contain up to 35-40% kaolin.

The second biggest market is for use in the manufacture of whiteware ceramics where kaolin makes ceramics whiter in anything from vitreous-china sanitary ware to tableware and wall tiles. Specialty applications include the use of kaolin as a filler in paint as well as being used in rubber, plastics and adhesives and sealants, pharmaceuticals, animal feed, white cement and glass fibre. Although, the associated minerals in kaolin do determine the suitability for a particular use.

Geology

Kaolin is formed over million years by the decomposition of other aluminous materials, especially feldspathic rocks like granite by weathering or hydrothermal (action of hot aqueous solutions or gases within the earth's crust) processes. Hard granite is converted into this soft matrix in a process called kaolinization, where the quartz and mica of the granite remain relatively unchanged whilst feldspar is transformed into kaolin. Such deposits can vary from being almost pure kaolinite to containing impurities that affect the characteristics of the clay. Kaolin deposits can be divided into two types - primary or residual kaolin which is developed in-situ by the alteration of existing feldspar-rich rocks; and secondary or redeposited kaolin deposits accumulated in stream, lake and basin environments as a product of eroded residual deposits.

Supply and Demand

World kaolin demand stands at something like 38 million tonnes per annum (tpa) which values the market at some US\$6 billion. Demand for kaolin is generally driven by the expansion of manufacturing activity in the developing countries. Advances will be constrained by a contraction in the paper markets of North America and Western Europe as the increasing digitisation of media reduces demand for kaolin-intensive coated paper products. Today, Imerys, Quazwerke (Sibelco) and BASF account for over 26% of global kaolin production. Market consolidation has occurred in recent years with key players acquiring assets from competitors with the world leader Imerys now having a 16% market share.

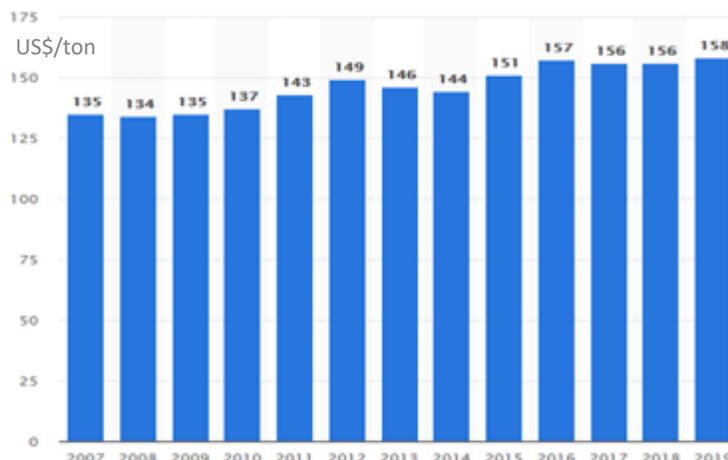
The largest producing country is the US where 60% of kaolin produced is used as paper coating and filling with 12% going into paint and 9% for catalysts. The US Geological Survey (USGS) reported that lightweight ceramic proppants for use in hydraulic fracturing are also a significant market for kaolin, but apparently insufficient data exists to estimate market size. The US exports around 2.5 million tons of kaolin mainly as a paper coating and filler, a component in ceramic bodies, and fillers/extenders in paint, plastic and rubber products, with China, Japan, and Mexico being the leading customers.

Europe is believed to be the largest consumer of kaolin. However, over the last decade the developing Asian markets have become increasingly important to global kaolin demand as these nations continue to drive most new demand led by China. Producers in Asia account for significant volumes, although this tends to be the lower quality material. The whole combined Asia Pacific region is now thought to account for around 38% of global volume share and materials science specialist publisher AZO Materials believes that out of a total of 3.4Mt of imports into the Asia, 1.8Mt are coming from USA and Brazil. Currently, Japan buys 26% of US exports which is estimated to be worth more than US\$264 million.

Country	2018 Million tons	2019E Million tons
United States	5,530	5,500
Germany	4,300	4,300
India	4,000	4,000
Czechia	3,620 ¹	3,600 ¹
China	3,200	3,200
Ukraine	2,400	2,400
Brazil	1,800 ²	1,800 ²
Turkey	1,400	1,400
United Kingdom	1,000	1,000
Iran	790	790
Spain	450	450
Mexico	330	330
Rest of the World	13,400	13,000
World total	42,200	42,200

¹ - includes production of crude ore ² - beneficiated

World mine production of kaolin. Source: USGS Mineral Commodity Summaries. January 2020



Average price of kaolin in the US from 2007-19. Source: Statista

Outlook

Global demand has been forecast to grow by a compound annualised growth rate (CAGR) of 4.4% from 2017 to 2025 to reach 43.1 million tonnes by 2025. Although the main use of kaolin is in the manufacture of white paper, the industry faces strong competition from calcium carbonates. Research house Merchant Research & Consulting see ceramics as the fastest growing market and has also highlighted the expected growth to come from non-traditional markets such as plastics and pharmaceuticals. In addition, this researcher expects that market growth will be driven mainly by demand from the developing countries like China, India and Malaysia.

Further opportunities seem to be emerging as end users are really beginning to appreciate the improved product quality and brightness that inclusion of kaolin allows. At the same time, the powerful combination of a rapidly growing world population and rising living standards looks set to grow kaolin demand for ceramic products in both housing and construction. There is also seen to be exciting future demand for kaolin as an input into emerging technologies and products that are currently under development which includes acting as a feed stock for High Purity Alumina (HPA) production, which is a fast-evolving story.



Global HPA forecast 2016-24

On the supply side, pressure from regulators in China to improve environmental and safety standards has led to the closure of some kaolin producers and a tightening of supply; and last year the country increased the import tariff on US kaolin. Over the last twelve years the average price per tonne has risen by 17% to US\$158, but some forecasters are now expecting prices as the high as US\$213/t by 2025 (Source: Grand View Research report, Kaolin Market Analysis and Segment Forecasts to 2025).

NEW TECHNOLOGICAL APPLICATIONS

The use of kaolin in any industrial segment requires physical and chemical treatment to minimise the amounts of impurities below the level necessary for any such application. The market leaders like Imerys have substantial research budgets committed purely to kaolin which are focused on understanding the links between the chemical and physical properties and how they respond to processing as well as the influence on the performance of the end use applications. In this section we have focused on HPA and innovative solutions for smarter vehicles.

High Purity Alumina (HPA)

There are big benefits provided by high purity Al_2O_3 (>99.99%) are increasingly becoming better understood. HPA is highly versatile with a myriad of uses in new age industries such as the use in LEDs, coating cathode and anode electrode separator sheets in the lithium-ion battery. Lithium batteries generate a lot of heat which was well demonstrated by Samsung's Galaxy Note 7 smartphone catching fire. HPA coated separators improve the lithium battery's thermal stability and improve safety and efficiency; this comes from taking advantage of HPA being chemically inert with a very high melting point and not conducting electricity.



HPA has myriad of uses
Source: Fyi Resources

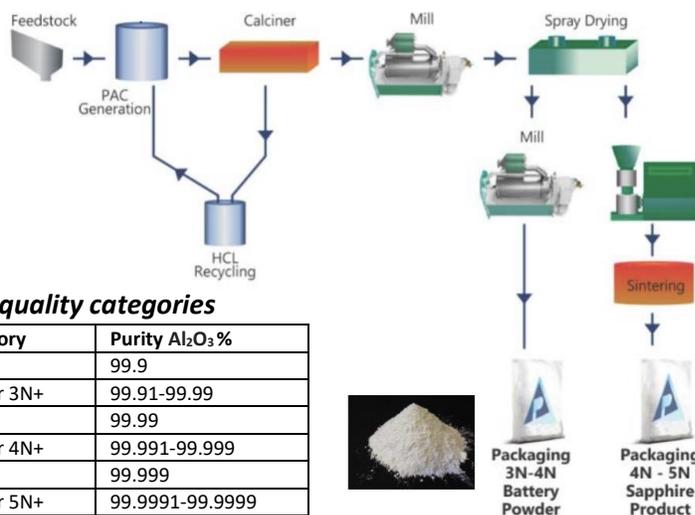
Traditionally HPA is produced on an industrial scale normally by either using the Bayer or the Hall-Heroult processes to convert bauxite into alumina which is then further processed to create HPA. These are expensive processes due to the energy required to firstly make aluminium and then processing it to become HPA. However, in recent times new technologies have emerged which produce HPA from kaolin which are less expensive and less energy intensive. Some of these competing technologies are discussed below.

Grade	Smelter Grade Alumina (SGA) 95% Al_2O_3	Aluminium 99% Al (SA)	HPA (3N) 99.9% Al_2O_3	HPA (4N) 99.99% Al_2O_3	HPA (6N) 99.999% Al_2O_3
US\$/t	450	2,200	6,000	23,000	35,000

Illustration of the purity pricing scale when aluminium was trading at US\$2,200/t. Source: Fyi Resources Feb 2018

Polar Sapphire Limited

Toronto, Canada-based Polar Sapphire manufactures and sells HPA 3N-6N powders for various applications which includes making sapphire ingots to create substrates for LEDs which is the circuit board on which the LED chips are mounted. Other applications include high purity engineered ceramics, polishing and abrasion resistant coatings. Polar has an apparently a simple cheap process that reduces capex by having fewer processing stages coupled with a short lead time of just twelve months to commercial production and cashflow with a low scale up risk.



HPA quality categories

Category	Purity Al_2O_3 %
3N	99.9
3Nx or 3N+	99.91-99.99
4N	99.99
4Nx or 4N+	99.991-99.999
5N	99.999
5Nx or 5N+	99.9991-99.9999
6N	99.9999



Packaging
3N-4N
Battery
Powder



Packaging
4N - 5N
Sapphire
Product



Source: Industrial Minerals

Polar's HPA manufacturing process & processing facilities. Source: Polar Sapphire

Altech Chemicals Limited (ASX:ATC)

WA-based Altech Chemicals is aiming to become one of the world's leading suppliers of 99.99% (4N) HPA following the construction and operation of a 4,500tpa HPA processing plant in Malaysia, with the feedstock being sourced from the company's 100%-owned kaolin deposit in Meckering, WA. Altech's patent was granted in 2018 (originally filed in 2014) for kaolin to HPA production process which covers the production of alumina from all types aluminous clay including kaolin. In an eight-stage process, kaolin is first treated to reduce particle size and boost alumina content which is followed by calcination, leaching with hydrochloric acid, solid liquid separation, crystallisation, precipitation and dissolving. Before ultimately roasting and calcining the resultant aluminium chloride hexahydrate to produce alumina.

Lava Blue Limited

North Queensland sapphire miner Lava Blue discovered that the clays which hosted gem quality sapphires (which also has the chemical formula Al_2O_3) also contained up to 30% Al_2O_3 on its mining lease in 2017. The company has gone onto achieve its first HPA at 99.99% purity (4N) from its kaolin clays in a joint project with the Queensland University of Technology and the Innovative Manufacturing Cooperative Research Centre (IMCRC). Lava Blue is now perfecting the process of manufacturing 4N HPA from its extensive resources, building a pilot plant and conducting feasibility studies into the construction of a first commercial production train with a capacity of around 1,000tpa of 4N HPA. The investment in the pilot plant is expected to largely eliminate technical risk. Lava Blue intends to develop further productions trains and build total production capacity to at least 5,000tpa. Lava Blue's gem quality sapphires have now become a by-product.

Fyi Resources Limited (ASX:FYI)

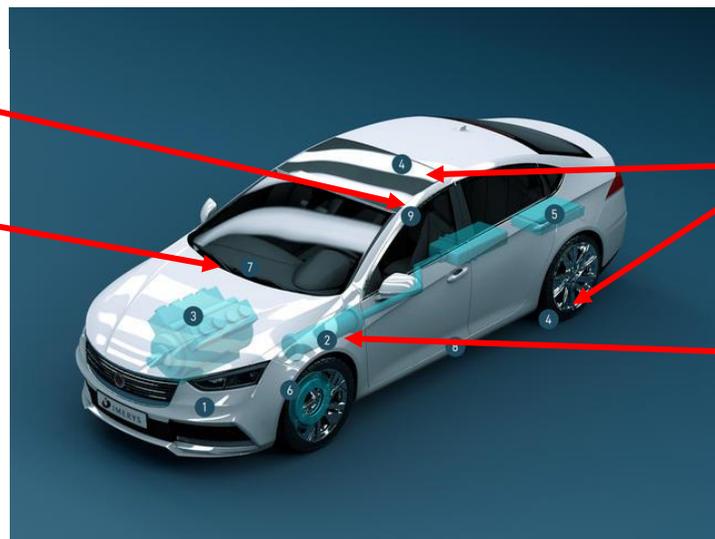
Also based in WA, Fyi Resources is developing a strategic HPA Cadoux Kaolin Project with the goal of becoming a leading producer. The company is developing a low industry capex and low opex process where the kaolin goes to a refinery where the material passes through a conversion furnace prior to a metakaolin (anhydrous calcined form of kaolinite) leach process which is followed by a 3-stage precipitation process adding HCL gas. The resulting metakaolin is finally subject to calcination. The pilot plant has successfully demonstrated high grade and excellent recoveries with metallurgical results exceeding 99.99% HPA targets; and has demonstrated a quality end product for real end users.

Innovative solutions for smarter vehicles

The biggest player in the world kaolin market is Imerys which is at the forefront of developing innovative solutions for the automotive industry and the development of optimised cars with the target of creating lighter, cleaner and smarter vehicles. Today, there is mounting consumers pressure for auto manufacturers to reduce the environmental impact of vehicles. At the same time the advent of autonomous (self-driving) cars with connected vehicle technology does not seem that far off. Imerys has been using industrial minerals including kaolin for a variety of uses to produce better and lighter vehicles. Apparently, there are 30 minerals in the average car and by 2030 it is expected that 70% of the vehicle will be made up of lightweight materials. Plus, there are related applications in abrasives, mobile energy, ceramics and plastics.

Kaolin improves the durability of rubbers used in weatherstrip around the windshield and doors

Talc, wollastonite, treated kaolin and mica reinforce new and recycled plastics



Kaolin and talc strengthen tires and improve permeability

Honeycomb ceramic cordierite parts (containing kaolin and talc) are used in catalytic converters and particle filters and diatomite in gearboxes

Kaolin in cars. Source: Imerys

POTENTIAL ADDITIONAL REVENUE STREAM

IGM is a successful junior miner which continues to make high-grade gold discoveries across its vast licence area. The Brumby Project is rapidly growing scale as well as the potential for high-grade gold which continues to be demonstrated through painstaking exploration. Discoveries to date are fast suggesting the basis for establishing viable mining operations based on the gold veins of the Mt Stewart region. Investors may be beginning to get a glimpse of the potential true size of the prize at the Brumby. Truth is that the more that IGM explore, the more gold that seems to be discovered. The next round of drilling will not only target gaining an improved understanding of the potential of Brandy Creek but also start testing the growing possibility that all these identified isolated gold targets may connect underground.

Interestingly enough, the Brumby Project could be well on the road to rapidly developing a potential additional revenue stream from simultaneously mining kaolin with the gold ore. Currently IGM has sent an initial sample for testing but already believes that there is potentially approximately 100 million tons of kaolin available to mine following work on the ground. New technological applications for kaolin suggest an exciting outlook for this industrial mineral especially as a feedstock for HPA which looks like being a key ingredient for the modern world.

Advances in technology have given rise to a number of truly disruptive technologies which produce HPA directly from kaolin via a less costly process than the traditional bauxite feedstock route which involves first making aluminium, prior to processing the metal into HPA. Oregon-based Allied Market Research in its HPA report was able to comment that *"..world demand for high purity alumina has gained an incredible traction, owing to growing technological advancements and increasing demand from applications..."*. As with other battery minerals, new markets are rapidly opening for industrial minerals such as HPA propelled by the influx of high-tech industries emerging on the world stage, and it has all the makings of being a big growth story.

Such a sizeable resource if determined to JORC-compliant standards could probably be deemed a world class kaolin project provided that this material turns out to be high-grade premium kaolinized granite. A kaolin sample has been sent for analysis to ascertain its purity and brightness as a potential saleable product from the Brumby Mine. This material could be excavated along with the gold-bearing quartz veins and therefore could represent an additional revenue stream if the product has the necessary characteristics. Positive test results could open the door to opportunities stemming from the Company's proprietary production with value-adding processes, off-take agreements and leading channel distributors. IGM could be well positioned to supply product for a wide range of industrial applications and commercial end users globally.

About the author

Dr Michael Green is an independent analyst specialising in growth and resources companies. He gained a BSc Honours degree in Mining Engineering from Nottingham University, UK and PhD for a thesis that looked at the economic analysis of mining projects. Having been involved in consultancy work, Michael began working in the City in the 1980s as a Mining Analyst with stockbrokers Buckmaster & Moore and then HSBC-owned Greenwell Montagu Securities. Subsequently, he was involved in analysing a wide range of growth companies and became Head of Research at stockbroker Everett Financial which specialised in the small cap market. Since, 2006 Michael has been an independent analyst specialising in analysing companies in the resources sector and providing research for mining companies, stockbrokers, corporate finance houses, advisers and independent research firms. He was formerly a Non-Executive Director of Ascot Mining PLC, a quoted Central American gold mining company. In addition, Michael has also worked closely with resources companies on IR.

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