

White gold

Michael Schwartz reports on kaolin, a clay mineral lending itself to an array of applications, most notably, in construction where its make-up can help reduce the sector's carbon footprint.

As one of the world's most versatile minerals, kaolin's use ranges from everyday items such as ceramics and coated paper, through to highly specialised refractory applications. In the case of ceramics, kaolin features in the manufacture of whiteware products such as household pottery goods, not least because of its moulding properties and the strength and smooth surfaces it offers the finished product.

A spokesperson at the United States Geological Survey (USGS) defines kaolin as "a clay formed by the weathering of granite. As such, it is a hydrated aluminosilicate with a platy crystalline structure.

"The heating of kaolin to approximately 600-800°C drives off the water in the kaolin structure, and this causes the crystalline structure to break down, creating an amorphous, fine particle aluminosilicate. Kaolin is a relatively inert mineral and this, together with its normally fine particle size and white colour, lends itself well as a filler across many applications from paper, paint, plastics, etc."

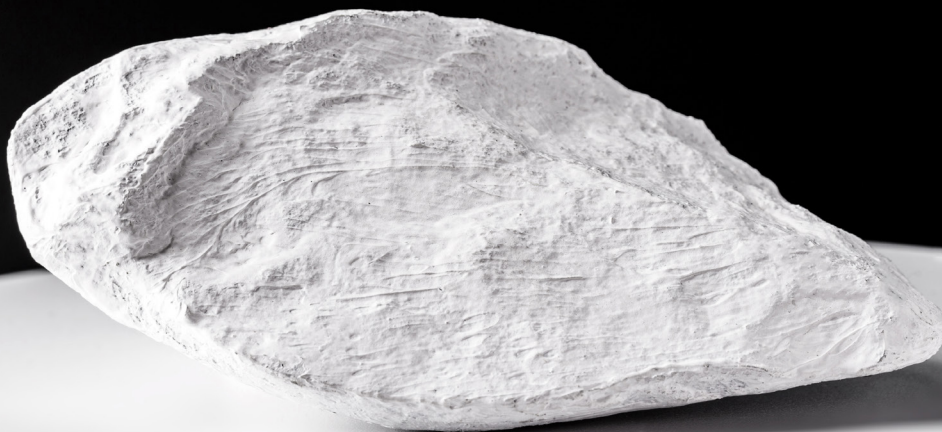
However, there are two factors that can hinder its application potential. The first is that naturally occurring

kaolin usually contains varying amounts of other minerals such as quartz and feldspar. Secondly, kaolin in its crude state is often stained yellow by iron hydroxide pigments, meaning it must be bleached to remove the pigment and then washed to bring it up to commercially acceptable standards.

The USGS classifies kaolin and five other mineral commodities as clays, further breaking them down by their final applications, including:

- Ball clay for sanitaryware and ceramic tiles
- Bentonite for absorbents, drilling mud, a foundry sand bonding agent and iron ore pelletising
- Common clay for bricks, lightweight aggregates and Portland cement clinker
- Fire clay for refractories
- Fuller's earth for absorbents
- Kaolin for the paper and refractory markets

Other attributes used to classify clay minerals are their composition, plasticity, colour, absorption qualities, firing characteristics and clarification properties.



Ceramic growth

Several market research reports have been published regarding kaolin, including last September's study from US-based Grand View Research. The report on kaolin market size, share and trends analysis anticipates a compound annual growth rate in the market of 3.5% from 2020-27. Here, the study confirms ceramics applications are emerging as an influential factor for growth.

The research notes that kaolin's exceptional suspension capabilities help prevent particles such as silica and feldspar from settling during manufacturing, something which has played its part in the mineral's steady growth over the last decade.

However, much of 2019's US kaolin production has been exported not only for the paper and ceramic sectors but also as an extender in rubber products and for paint fillers. Few countries received the kaolin – China, Japan and Mexico according to USGS figures for 2020. Then again, what exactly China's role as a customer will be for the future is somewhat uncertain, due to major tensions between that country and the USA.

While definitive production figures for 2021 are not yet available, the USGS has recently published estimates. In the 2022 issue of its annual *Mineral Commodity Summaries*, total production of all aforementioned six clays came to an estimated 25Mt valued at US\$1.5bln and produced by around 120 companies across 38 US States. There is differentiation in the production statistics for the six clays since 2017. Bentonite, ball clay and common clay have undergone marginal decreases, while fire clay and fuller's earth experienced increases. Kaolin recorded a substantial decrease.

Export figures also showed different outcomes, but this time with kaolin showing a marked growth from 2020-21, returning to the level of production in 2017-2019. Kaolin prices per tonne have been almost unchanged since 2017.

Kristi Simmons, a Mineral Commodity Specialist for clays, perlite and vermiculite, who compiled the USGS statistics, confirms an estimated production of 4.1Mt of kaolin mainly from Georgia and South Carolina, with 2.3Mt exported.

Responding to the question of whether kaolin is a critical mineral, Simmons cites the US Energy Act of 2020, which "defined critical minerals as those which are essential to the economic or national security of the United States; have a supply chain that is vulnerable to disruption; and serve an essential function in the manufacturing of a product, the absence of which would have significant consequences for the economic or national security. The Act further specifies that critical materials do not include fuel minerals, water, ice or snow, or common varieties of sand, gravel, stone, pumice, cinders and clay. Kaolin is produced in the US in sufficient quantities – it is not on the US critical mineral list."

She also explained the decline in US kaolin production. "Production of kaolin has been estimated to be declining for the past several years. Because 30% of kaolin used is for paper coalition and filling, it is thought that the decreased amount of hardcopy publications has had at least some effect towards that decline."

Did you know?

The name kaolin derives from the Chinese kao-ling and means high ridge – a reference to the hill in south-eastern China where the clay was originally discovered and used. The Chinese were the first to use kaolin to make porcelain in the 7th and 8th Centuries, however, it was not until centuries later that other parts of the world would duplicate the process.



Source: Industrial Minerals Association - North America and Britannica.com

Economy commodity

While the paper and ceramics industries have traditionally made great use of kaolin, a new use is leading kaolin to be described as a 'white gold' new economy commodity, capable of reducing carbon output across several industries once processed into metakaolin or high purity alumina (HPA).

HPA is in increasingly high demand for smartphones, LEDs and, most significantly, lithium-ion batteries. It can now be produced more economically from kaolin than from the traditional aluminium-based sources. It means an ever-growing interest in, and demand for, high-quality kaolin.

Kaolin explorer, InterGroup Mining (IGM) of Queensland, Australia, has stated that metakaolin prices delivered to the Australian market currently range between US\$530-840/t, while the untreated mineral can struggle to attract US\$20/t in bulk.

When defining the difference between kaolin and metakaolin, IGM notes the latter's reactionary properties, while acknowledging its credentials in reducing the carbon footprint of cement and concrete production. "By contrast metakaolin is reactive and in the presence of calcium hydroxide (released during the curing process of cement), it reacts to form calcium aluminosilicates which complement and add to the strengthening of cement to form mortar or concrete.

"The calcining/dehydrolysis process to produce metakaolin does not produce CO₂ and happens at a lower temperature than that required for clinker/cement. As a consequence, the replacement of clinker/cement by metakaolin reduces the carbon footprint of the resulting cement or mortar."

To be precise, metakaolin may enable the emissions derived from concrete production to be reduced by anything up to 40% – and less cement is required.

The pressure on the sector to decarbonise is placed into even sharper relief when carbon costs are taken into account. During 2021, prices on the EU Emissions Trading Scheme (ETS), for example, rose to 250% of their starting price and are expected to continue rising.



Left: At surface kaolin in the Surprise area of InterGroup's Brumby Project. The mineralisation extends over a 20km stretch

Opportunity down under

IGM is operating a mineral property within the Charters Towers region, in the north-east of Queensland, where it is currently developing a major gold and kaolin project, approximately 250km from the major seaport of Townsville. IGM has confirmed its commitment to explore for and to extract minerals under a net-zero agenda.

The company is currently at the exploration and planning stage but confirmed that when production commences it will “go down a green path” for the kaolin deposits, which lie at surface level.

As of February 2022, IGM has completed initial drilling at two areas of its Brilliant Brumby project, which is approximately 2% of the identified area of potential kaolinised mineralisation on the 2,630ha property.

The two areas, Surprise and Clydesdale, show an initial estimate of 9.2Mt kaolinised granite for 3.67Mt of contained kaolinite, with a comparative validation assessment for the wider 5% of the property that includes Surprise and Clydesdale indicating 47Mt kaolinised granite for 18.2Mt kaolin.

IGM's spokesperson comments, “For our Brumby Project, the kaolinite, as a proportion of the *in situ* weathered granite, is approximately 40%.” In addition to this, IGM has applied for a second kaolin exploration site in Queensland.

Regarding brightness, IGM says it is focused “on the processing of kaolin for the production of metakaolin and for this purpose high brightness kaolin is not a prerequisite.

“However, at Brilliant Brumby, the colour and grade of the kaolin varies across the deposit and, as such IGM, is also looking at the potential for direct shipping of some of the higher brightness *in situ* kaolin material, which in terms of natural whiteness is in line with some of the world's leading reserves.

The firm says, “Preparation of this material will require separation of silica from the kaolin, which may also involve some washing processes that may further improve brightness by removing impurities.”

IGM has also materially advanced its understanding of the potential for kaolin extraction and metakaolin production and commercialisation. The firm's spokesperson continues, “IGM is focused on the application of metakaolin as a high-performance additive to cement (reactivity, quality and consistency). As such, IGM has conducted extensive test work to assess the ability to convert its kaolin into metakaolin based on alternative processing technologies and alternative processing conditions.

“In addition, it has investigated the impact of alternative mixes of metakaolin with Ordinary Portland Cement to assess the impact of these on the strength and other performance characteristics of the resultant mortar and concrete.”

Has financial assistance and tax relief been offered to IGM for its exploration work? “Not yet, but as we move from exploration to production, we will certainly be looking to work closely with the relevant bodies of Queensland's Government as we seek to bring employment and new revenues to the Townsville region.”

Straddling sectors

It is unwise to assume that long-established minerals – and minerals used mainly in everyday applications – cannot be developed for more sophisticated products, in this case metakaolin. This is certainly the case with kaolin, where the decline in demand from the paper industry means that producers and marketers have to look to customers from other sectors. 🌐