

KAOLIN

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Kaolin, also known as china clay, is white commercial clay consisting predominantly of the mineral kaolinite, a hydrated aluminosilicate. Kaolinite, $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$ is triclinic, the other associated kaolin group minerals (halloysite, nacrite and dickite) being monoclinic. Kaolinite and halloysite are the most commonly found members of the kaolin group whilst nacrite and dickite are considered rare. However, with the progress made in infrared spectroscopy techniques, nacrite and dickite are being found commonly in association with kaolinite in many deposits. The levels of nacrite and dickite are used as a guide by the oil industry as an indication of depth of burial of sediments, the levels of the two minerals increasing with higher temperatures and pressures at depth. The presence of nacrite and dickite has even been recognised in the recently-developed Amazon sedimentary deposits of the Rio Capim.

The name 'kaolin' is derived from the village of Gaoling in Jiangxi province, China, where the white clay was mined. The nearby Jingdezhen potteries used the kaolin to create their fine white porcelain. Europeans identified the composition of Chinese porcelain in the 18th Century and deposits of kaolin were sought in Europe. This led to the discovery of the kaolin deposits in Cornwall, southwest England, which were named china clay.

Deposits

Kaolin deposits are encountered throughout the world and new deposits are still being discovered. Kaolin deposits may be classified as primary or sedimentary. Primary, or residual deposits, were formed by the alteration in situ of the parent rocks, which may have been igneous, metamorphic or volcanic in origin, by hydrothermal and weathering processes. Sedimentary, or secondary, kaolin is derived from the erosion of pre-existing rocks and the subsequent transport and deposition of the clay.

In Cornwall and Devon, the kaolinite is derived from the late-stage magmatic or hydrothermal decomposition of feldspar within granite. It is separated from the host granite by washing it out with high-pressure water hoses, a process known as monitoring. The kaolin content rarely exceeds 20% of the altered granite, but the depth of kaolinisation extends in many places down to 300 m. In Western Australia, vast tracts of granitic rock have been weathered down to 50 m, and the kaolin content often exceeds 40%. The best-known sedimentary kaolin deposits are from Georgia in the US and the Amazon Basin in Brazil. The deposits of kaolin were formed from the erosion of deeply weathered crystalline rocks in plateau areas, which were then transported and deposited as sedimentary sequences. Here, the kaolin is found in lenses, often between 5-20 m thick, and with a high percentage of kaolinite, around 80-95%, which is dry mined.

Production

Kaolin is found in many countries but it is just the beneficiated, or refined clays that will be considered in this report. Worldwide production is estimated by the US Geological Society (USGS) to be in excess of 40 Mt/y. However, this value includes 13.5 Mt/y from Colombia and Uzbekistan, which distort the figures, as the majority of these clays are low grade, and not processed. The estimated production figures of beneficiated kaolin from 30 countries are shown in Table 1 for 2001-2003.

North America is still the most important area, with 32% of production, followed by Europe, with 27%. However, both the US and the UK are decreasing their production, mainly as a result of Brazilian competition. The share of South America has risen from 4% to 9% in the past five years, solely as a result of the production of high-quality coating clay from Brazil. Four countries, the US, the UK, Brazil and China each produce more than 2.0 Mt/y of kaolin (total of the four is 14.1 Mt/y) and account for 56% of the world's total.

The leading producing kaolin companies are shown in Table 2, with estimated production levels for 2003.

The eleven leading producing companies account for 54% of the total. Comparisons with previous years are not relevant as there has been so much restructuring of the industry by a combination of acquisitions, closure of some unprofitable plants and switching of grades from one operation to another.

Imerys

Imerys, with headquarters in France, has kaolin operations in the US, Brazil, the UK, Portugal, Thailand, Australia, Ukraine and New Zealand, and accounts for almost one-quarter of the world's production. In January 2003, Imerys reorganised its business into Paper and Speciality Groups. The creation of a new global 'Pigments for Paper' business group was effective from January 1, 2003. This new group encompasses existing Paper Divisions in Europe, North America, Brazil and Asia. Imerys is the only kaolin company with deposits and production in the three major zones of high-quality kaolin for paper coating – Brazil (Amazonas), Georgia (US) and Cornwall (UK). These deposits give the following characteristics:

- Brazil's coating kaolins offer high brightness and opacity due to their range of particle size and shape.
- Georgia's reserves are used for all coating applications for the North American paper industry and its calcined clays are used worldwide for their opacifying effect.
- Cornwall provides filler and coating kaolins that are well suited to the European supercalendered (SC) paper and lightweight coated (LWC) paper markets.

Formation of the new group underlines Imerys' commitment to serve the global paper industry with an emphasis on multinational paper customers. The new Speciality Group will cover markets for both ceramics and speciality minerals (paint, rubber, plastics).

United States

The main production of kaolin in the US is in Georgia and South Carolina, and is based on a large number of deposits. It is estimated by the USGS that there are 1,400 Mt of kaolin resources remaining. The China Clay Producers Association (CCPA) of Mid-Georgia, whose members include Engelhard Corp, Imerys, JM Huber Corp and Thiele Kaolin Co, announced in June 2003 that the industry posted a net profit of US\$36 million in 2002, which represents a return of 4.2% on the net investment.

The CCPA announced on June 29, 2004, the composite earnings for the four major kaolin producers in the state of Georgia for 2003. The industry posted a net profit of only US\$4.6 million, representing a return of 0.5% on the investment.

"One of the major issues is continued over-capacity/turmoil in our major served markets, the paper industry. In addition, the Georgia kaolin industry is struggling from increasing foreign competition, other competing minerals, and higher energy prices," said Lee Lemke, executive vice president of the CCPA. "This industry has had a dismal five years. Profitability has averaged a negative 0.76% for a five-year period, with significant losses reported in 2000 and 2001."

"As a mature industry, the Georgia kaolin companies have experienced major restructuring and continue to reduce payroll and expenses," said Lemke. Direct employment in the industry now stands at 2,917, down from its peak of 4,500. Restructuring has resulted in a shutdown of older unprofitable assets, which has reduced the net investment by almost 32% for the four CCPA member companies. The industry's investment in Georgia now stands at US\$823 million.

"Unfortunately, the kaolin industry in Georgia is not seeing the reinvestment in capital, as assets are shifting to more profitable areas. This redeployment of assets will continue until income numbers reflect an acceptable return on investment," reported Lemke.

Imerys announced cutbacks in its capacity in Georgia and, in 2002, 30% of production was shut down and manufacturing was concentrated on higher value-added products. Production from Imerys' Dry Branch operations was largely cut and this process continued in 2003. Also, other producers such as Engelhard have continued to concentrate on their higher value-added calcined clays rather than investing more in the lower-quality commodity grades. With this policy of cutting capacity, overall sales of kaolin from the US have decreased significantly from 8.1 Mt/y in 2001 to an estimated 7.45 Mt/y

for 2003. This trend is expected to continue over the next few years, with increasing imports of paper coating kaolin from the Amazon Basin in Brazil and the switch to utilising ground calcium carbonate (GCC) and precipitated calcium carbonate (PCC).

The Georgia kaolin belt continues to be an important supplier to the paper industry in the US with supplies mainly being by rail in slurry form. Calcined clay capacity is 1.1 Mt/y and is sold to the paper industry as a partial replacement for the more expensive titania dioxide in paper and paint. Some of the kaolin can also be processed dry by air flotation, and various grades of kaolin are sold to the ceramics, paint, rubber and adhesives sectors. A split of grades of kaolin from Georgia from 2001-2003 is shown in Table 3 and indicates a significant decrease from 6.84 Mt in 2001 to 6.38 Mt in 2003, a decrease of 6.7% in two years. The main loss has been the #2 Coating Clays, with an overall drop in hydrous clays from 6.03 Mt in 2001 to 5.50 Mt in 2003, a decrease of 8.8% over two years. Calcined clay production in Georgia increased from 0.80 Mt in 2001 to 0.88 Mt in 2003, up 9% over the two years.

In Canada, where up to 1.0 Mt/y of kaolin is imported from the US and UK, investigations continue by Black Bull Resources Inc on the kaolinised granite of the Yarmouth area, Nova Scotia. Here, the kaolin shows the potential to be delaminated and is suitable for supercalendered (SC) paper. Port Hawkesbury at present produces SC paper and imports up to 150,000 t/y from Imerys in Cornwall. The kaolin project is now being revitalised following the granting of environmental and mining permits for the associated quartz.

Brazil

Over the past 20 years there has been a tremendous amount of exploration for kaolin carried out in the Amazon Basin, particularly in the vicinity of the Jari and Capim rivers. Proved reserves in the Amazon Basin are estimated at more than 500 Mt, although this is being increased with current exploration. In the Capim River Basin there are two operating mines and 15 undeveloped deposits (13 controlled by CVRD and two by CPRM). The mines exploit high-quality sedimentary seams of kaolin which exhibit high brightness, fine particle size, fine particle size distribution and particle shape, and good rheology which make the kaolin very suitable for the paper coating market. There are currently two companies producing coating kaolin in the Amazon Basin – CVRD now controls Cadam (formerly Caulim da Amazonia SA) based on the Jari deposit, and PPSA (Pará Pigmentos SA) and RCC (Rio Capim Caulim SA, Imerys) based on the Capim deposits. Capacity and sales for coating kaolin for 2002 are shown in Table 4.

PPSA was created in 1994 to explore the kaolin deposits in the Capim River area. In 1996 a US\$200 million plant was commissioned and the first kaolin shipment made to Europe. In 2003, sales of kaolin were 420,000 t and budgeted sales for 2004 are 510,000 t. Since the commencement of operations over 2.0 Mt have been sold to Europe, Asia and Latin America.

Current plans are for Cadam to increase its capacity to 1.2 Mt/y and PPSA to 1.0 Mt/y in the next few years. Meanwhile, RCC (Imerys) is just completing its expansion to 850,000 t/y, so that, overall, Brazilian capacity will increase to 3.05 Mt/y.

Coating kaolin demand in the world is at present around 8.0 Mt/y split between North America (31%), Europe (35%), Asia (9%), Japan (15%), South America (3%) and others (8%). Coating kaolin production capacity is now 10 Mt/y with Brazil accounting for 22%. With the majority of Brazilian coating kaolin destined for the export market its share of the world trade is an impressive 43% of global exports with 21% of global sales.

The Brazilian producers are extremely competitive, based on their high-quality ore deposits and good mine-to-port logistics. The Jari deposit and plant is adjacent to the ocean-going port of Munguba, whilst both of the Capim plants (PPSA and RCC) send their processed ore by a 180 km pipeline to Barcarena (near Belem) where the slurry is spray dried and loaded directly onto ocean-going vessels. Imerys Rio Capim Caulim commissioned its 160 km pipeline from the mine site to Barcarena in May 2002. Following the capacity increase from 450,000 t/y to 600,000 t/y in 2001, a further expansion to 850,000 t/y was begun at the plant in 2002 and was completed in the first quarter of 2003. The spray-dried kaolin, at just 4 - 6% moisture content, is delivered to specially designed facilities in ports such as Antwerp where further processing (slurrying, bagging) takes place.

Imerys, as the world's largest kaolin producer now controls Imerys Rio Capim Caulim SA (formerly RCC) with 100% of the shares. CVRD, the world's leading exporter of iron ore from Brazil, has now acquired Caemi. Following approval by regulatory authorities, CVRD now controls 100% of Caemi which, in turn, controls 100% of Cadam and 80% of the voting shares of PPSA and, importantly, 100% of the Capim mineral rights. This control establishes CVRD as a major player in the kaolin market, second only to Imerys.

United Kingdom

The main producing country in Europe remains the UK, with the French group Imerys now controlling the majority of deposits in Cornwall and Devon. Sales have remained fairly static for the past few years at 2.2 – 2.3 Mt/y, way below the heights reached in the late 1980s when up to 3.3 Mt/y was produced. Apart from Imerys, other producers are Goonvean, a privately-owned company with a capacity of 250,000 t/y (sales currently at 200,000 t/y) based on the St Austell granite, and WBB Minerals (formerly Watts Blake & Bearne, now renamed WBB Minerals and fully owned by Sibelco, the Belgium group) with 150,000 t/y.

Goonvean is thus the only remaining English china-clay producer, and the company specialises in the filler and ceramic markets. Kaolin from Devon and Cornwall is characterised by very low titania that makes it suitable for high-quality ceramics, particularly porcelain and tableware.

The iron level is also of importance and this can be controlled by selective mining and by utilising super-conducting magnets.

Goonvean has developed new products for high-quality ceramics over the past four years. A new product called Diamond Star is now being sold for use in high-quality tableware and porcelain, and is competing with Imerys' 'Super Standard Porcelain' and New Zealand's China Clay 'Premium'. Diamond Star has low iron and titania, which gives rise to good-fired whiteness and translucency in tableware (in both oxidative and reductive firing conditions). In 2003 a new product, Astra, with low potash, very high plasticity and fired colour has been introduced as a top range kaolin for porcelain and is gaining acceptance in the market. Goonvean is currently working with EU Committees in Brussels in agreeing limits for additives in kaolin for use in animal feed stuffs. Goonvean intends to be well prepared for this legislation and will supply kaolin within the limits of heavy metals, dioxins and other additives.

WBB Minerals mines the Dartmoor Granite at Lee Moor where it has two pits, Shaugh and Headon, and a plant at Headon. The markets served by WBB Minerals are paper (20%), ceramics (70%) and others (10%). WBB installed an Eriez magnet in 2002 to improve the fired brightness of the clay in ceramic clays by reducing the iron levels. Over 87% of the kaolin from Devon and Cornwall is exported.

Imerys still produces around 2.0 Mt/y, with sales destined mainly for the paper filler and paper coating markets (Table 5).

Although Devon and Cornwall produce a wide range of products for paper, based on the ability to offer a range of delaminated engineered clays, the competition from the Amazon Basin for the higher brightness coating pigments resulted in Imerys deciding to switch 150,000 t/y of such products to its Brazilian operation, RCC (Rio Capim Caulim). High brightness engineered pigments from the UK, such as Supratar and Suprapint, will be replaced by engineered pigments from Brazil such as Capim DG and GP. This switch of products to Brazil has now been completed. The kaolin market for tableware has suffered a little in 2003 as a result of increasing production from the Far East, especially Thailand and China.

Imerys has published a blueprint to map out the industry in Cornwall and Devon for the next 40 – 50 years based on the remaining mineable reserves of over 100 Mt. Despite facing significant competition since the early 1980s from other kaolin deposits, and other pigments such as PCC and GCC, it is envisaged that mining will continue at the 2 Mt/y level for the foreseeable future, and investment continues by Imerys to support the business.

Traditionally, mining of kaolin in Cornwall has been a wet process. However, some dry mining is now being carried out from the Dorothy, Great Longstones and Lower Longstones pits that give a tighter quality control for selected products.

Investment over the past few years has been at the US\$60 million level, being spent on the completion of a flash-calciner for 'Opacilite' (a new extender for paint and now selling well), streamlining refining facilities with pipe work replacement and upgrading centrifuges. Pit development has taken place, with new schemes for Blackpool and Wheal Martyn and expansion of the Littlejohns and Melbur pits. A further US\$12 million will be spent in 2004 in developing 'super-pits' (over the years, smaller pits have been amalgamated to form larger pits, generally covering over 125 ha) and completing the introduction of fluidised bed dryers.

Importantly, the problem of the waste rock and sand is being addressed (1 t of kaolin gives 9 t of waste, a mixture of hard rock and sand). From 500,000 t/y in 1999, approximately 2.5 Mt was sold in 2003. Imerys, local authorities and independent aggregate companies are currently exploring the important transport issues, including improving facilities at the port of Par to export secondary aggregates to both UK and European markets.

China

The market for kaolin continues to grow in China, with an estimated 2.1 Mt in 2002. Major markets of processed kaolin are ceramics (75%) and paper, paint and others (25%). Kaolin deposits are found in a wide range of geological settings both in the coastal and the inland provinces of southern China. The largest primary resources have been derived from the alteration of granitic rocks and their extrusive equivalents. A high-quality kaolin at Longyan in Fujian Province, suitable for high-quality tableware has attracted much interest from international kaolin companies but to date there is no joint venture. With large international paper companies now investing in China, imports of coating kaolin from the US and Brazil will continue to grow. Local Chinese companies are also being developed to compete in this market.

The Maoming Basin, in southwest Guangdong Province, consists mainly of arkosic sediments that have been deposited and subsequently kaolinised. Kaolin from Maoming is euhedral, has a high brightness of up to 90 ISO and good rheology, all suitable properties for paper coating. To date two companies, Maoming Kaolin Co and Yangdong International Kaolin Co, have established mining and processing facilities with good-quality coating products. The search for high-quality coating kaolin continues in China as the market is expected to increase from present levels of 200,000 t/y to 500,000 t/y within the next five years.

Also well known in China are the so-called hard kaolins that are greyish clays, often with low iron and titania, associated with coal measures in northern China. On calcination, these grey clays produce a high-quality, high-brightness calcined product suitable for paper and speciality markets.

Engelhard of the US is the first major foreign kaolin company to invest in China, acquiring in December 2003 the Shuozhou Anpeak Kaolin Co in Shanxi Province. Anpeak has a processing plant that was constructed in 2001 and is expected to have a capacity of 30,000 t/y of calcined clay by mid-2003.

Imerys has established a 100%-owned company in Cong Hua City, Guangdong Province, called Imerys Tableware Guangzhou Co Ltd. This is a new storage and blending facility for the processing of ceramic bodies and glazes for tableware, and will utilise both imported and local resources of clay.

Other areas

Europe

The Czech Republic is an important kaolin producer based on the sedimentary kaolinitic sands of Horni Briza and Kasnejov. Keramika Horni Briza (formerly ZKZ) is now controlled by the Austrian group, Lasselsberger. These clays are naturally platy and some are exported to Germany where they are blended with local clays for use on lightweight coated paper (magazine paper). Lasselsberger also now controls the Chlumcany deposit and plant. The kaolinised granites of the Karlovy Vary area produce the famous Zettlitz range of products for use in porcelain and tableware. WBB Minerals now controls the Hlubany plant and nearby kaolin pits for ceramic grades.

In France, Denain Anzin Minéraux (DAM), a subsidiary of the Swiss-based group Harwanne, controls all of the kaolin deposits, apart from those of Société Kaolinère Américaine (SOKA). AGS, the Dordogne-based chamotte producer used to be owned 40% by Imetal (now Imerys). As part of the acquisition of ECC it was necessary for Imerys to divest its share in AGS and the latter has now formed a partnership with SOKA, leaving DAM and AGS/SOKA as the sole kaolin producers in France. Ironically, Imerys, the largest kaolin-producing company in the world has no kaolin operations in France, but has plastic ball clays, ceramics clays and a body plant in Limoges.

In Germany, the main producer is AKW, with an estimated 900,000 t/y of capacity. Dorfner is another important producer, with production of 150,000 t/y of kaolin. Imerys Tableware recently acquired the body preparation plant in Kirchenlamitz, Germany, from the German ceramics producer Winterling Porzellan AG. The ten-year-old plant is a modern facility with capacity to produce 10,000 t/y.

In Spain, estimated kaolin reserves exceed 100 Mt with an annual production of 450,000 t. ECESA is the largest kaolin producer in Spain, with operations at Burela (Lugo) and Poveda de la Sierra (Guadalajara) producing 150,000 t/y. The Burela deposits are based on altered felsite dykes, which yield low iron-bearing clay suitable for porcelain, and also altered granites. In Poveda de la Sierra, kaolinitic sands are mined and processed for a range of products including coating clay. Caobar SA produces 75,000 t/y from its plant at Taracena (Guadalajara) fed from a quarry in Poveda de la Sierra. Caolines de Vimianzo (CAVISA), is now a subsidiary of an Italian paper producer (Veneta Mineraria Spa), and produces 60,000 t/y of a paper filler grade in Vimianzo, Galicia.

Production from Ukraine remains low at 350,000 t/y, compared with 750,000 t/y prior to the breakdown of the former Soviet Union. High-quality kaolin exists in many areas but investment has not been forthcoming. The joint venture to produce coating clays between Proskanaya and Engelhard, Dnipro Kaolin, has now been discontinued following difficulties. The plant in the Glukovsky area, near Kiev is undergoing some modernisation but production is still way down. Imerys (Speciality Minerals) has increased its share from 51% to 99.98% in Donbasskeramika (Ukraine), giving it access to high-quality kaolin for ceramics. In October 2003, Imerys created a 50:50 joint-venture company, Popasnianskiy Clay, with local partner Dobrobut, with a view to operating a local clay quarry.

Asia

In 2002, Imerys acquired the kiln furniture business of Siam Refractory Industry Co Ltd in Thailand. It also increased its stake in the Thai joint venture MRD-ECC (ball clays in Lampang) from 49% to 57.19%, simultaneously acquiring a 70% interest in Mineral Resources Development's (MRD) kaolin operation in Ranong. The Ranong kaolin operation produces 50,000 t/y mainly for use in sanitaryware as the clays show good casting properties.

The Skardon River project in Queensland, now under the ownership of Minerals Corp, is entering the market with both hydrous and calcined grades of clay for non-paper markets, to be followed by paper grades. However, the build-up to sales has been slow owing to production problems that are now said to be resolved.

In Western Australia, the deposits evaluated in great detail by Rio Tinto in the Wickepin area, 180 km southeast of Perth, have been acquired by WA Holdings Pty Ltd. Detailed characterisation studies of the deposit have been carried out in UK and US laboratories, and the potential for a high brightness, glossy coating clay and calcined grades has been identified. A pilot-plant site has been purchased and trials will be carried out in late 2004 leading to a decision on whether a plant will be constructed. Resources of kaolin in Western Australia are reported to exceed 300 Mt.

In India, the main kaolin-producing company is English Indian Clays (EIC). This was originally a joint venture with English China Clays but the latter withdrew from the venture in the early 1990s. Over the past ten years, EIC has developed into a major kaolin-producing company, with a capacity of 120,000 t/y of coating and filler grades for paper and non-paper uses, and also produces calcined grades. The kaolin is mined from local sedimentary sequences in the Trivandrum area of Kerala State, southern India. Other deposits in the Kerala area are based on kaolinised granites.

Market

The consumption of kaolin is mainly for paper filler and coating, with paint, rubber, plastics, sealants, ceramics, refractories and fibreglass being of importance as shown in Table 6.

Kaolin competes with ground and precipitated calcium carbonate and talc in the paper, paint and plastics industries. In 1980, approximately 87% of the pigment use in paper was kaolin and this had reduced to 40% by 2002. Ground calcium carbonate (GCC), which was 9% of the market in 1980, has increased its share to 37%, and precipitated calcium carbonate (PCC), virtually unused in 1980, now has a 15% market share. This trend towards calcium carbonate has mainly been as a result of an alkaline papermaking system being introduced, and also because of the requirements of higher brightness pigments for wood-free pulp. Kaolin brightness for coating grades is between 86-90 ISO, whilst GCC and PCC can achieve over 95 ISO brightness.

However, kaolin has a platy morphology that is still required for a large number of paper applications, particularly in LWC (light-weight coated) papers. The trend in recent years has been for a combination of different minerals being used in the same coating formulation. GCC can be mixed with kaolin, GCC with PCC and more recently talc with GCC to obtain improved performance. Kaolin is widely used in paint as an extender and the calcined grades give higher opacity than a hydrous type. There are regional trends, with the US still relying dominantly on kaolin for coating, followed by PCC and GCC. In Europe and Asia the trend has been more towards the use of GCC, no doubt due to the proximity of high-quality marble deposits. It is necessary to use a crystalline limestone (marble) for high brightness as chalk and limestone rarely achieve brightness greater than 85-90 ISO.

Ceramics remains an important market for kaolin, with various grades for porcelain (low iron and titania), sanitaryware (good casting properties) and in refractories (controlled alkali levels).

Prices

List prices for various grades of kaolin produced in the US and UK are regularly quoted in *Industrial Minerals*, with *Chemical Marketing Reporter* quoting prices for US grades. The price of kaolin varies, depending on the degree of processing and in some cases the scarcity of a particular grade. The price of one grade can vary tremendously depending on the size of the order. Large papermakers taking bulk-delivery of 20,000 t in one shipment can expect to receive the same grade much more cheaply than a smaller customer.

In December 2002, Imerys announced price increases on all paper-grade kaolin by an average of 2% to 7% effective January 1, 2003. In February 2003, Imerys, Pigments for Paper Americas Division announced that, due to the significant increase in natural gas costs, a temporary energy surcharge would be implemented. Natural gas prices increased by up to 40% in early 2003, trading at prices as high as US\$10 per million Btu. From March 1, 2003, Imerys implemented surcharges of US\$4, US\$6, and US\$18 per dry short ton for hydrous slurry, hydrous clay and all calcined products, respectively. These surcharges will be reviewed monthly and will be based on the previous three months' rolling average of the NYMEX for natural gas.

They will remain in effect as long as the average quarterly price for natural gas remains above US\$4.50 per million Btu.

The prices quoted by Imerys in 2003 for hydrous kaolin were US\$100-250/t covering filler and coating grades. For calcined clay the price range is US\$325-375/t for calcined bulk, US\$65-75/t for sanitaryware grade (bagged) and US\$125/t for tableware grade (bagged). In Asia, the delivered price (cif basis) for kaolin varies from country to country but average prices are US\$210/t for #1 coating clay, US\$190/t for #2 coating clay and US\$420/t for calcined clay. The delivered price for #1 coating clay from Brazil is around the US\$200 - 210/t level. Filler clay from Indonesia is delivered in Asia for approximately US\$80 -100/t.

For Cornwall, UK, free-on-truck prices quoted in July 2003 (per tonne), were £47-58/t for filler, £63-90/t for paper coating, £35-90/t for ceramic grade and £80-130/t for porcelain grade. In New Zealand, the ex-works price of Premium, the high-quality clay for use in porcelain was around US\$400/t ex-works, with a delivered price in the Asian region of around US\$500/t.

Tables 1-6 following pages.

Table 1**World Production of Kaolin ('000 t)¹**

	2001	2002	2003^e
Europe			
Austria	50	40	40
Bulgaria	150	170	170
Czech Republic	750	800	800
France	377	375	30
Germany	1,800	1,800	1,800
Poland	130	130	135
Portugal	170	170	170
Spain	440	450	450
Ukraine	300	350	350
UK ² (sales dry wt)	2,400	2,350	2,350
Uzbekistan	200	200	200
Europe			(27%)
Asia/Oceania			
Australia	230	230	240
China	2,000	2,100	2,100
India	500	600	600
Indonesia	500	500	500
Pakistan	70	70	70
South Korea	1,800	1,800	1,800
Malaysia	210	250	250
New Zealand	15	15	15
Thailand	250	260	270
Asia/Oceania			(23%)
South America			
Argentina	100	100	100
Brazil	1,800	2,100	2,200
Colombia	100	100	100
South America			(9%)
North America			
Mexico	400	400	400
US (sales)	8,110	7,450	7,450
North America			(32%)
Africa/Middle East			
Egypt	260	260	300
Iran	500	500	550
Nigeria	110	110	110
South Africa	140	140	140
Turkey	400	450	450
Africa/Middle East			(6%)
Others	870	880	800
			(3%)
Total	25,132	25,150	25,280

^e Estimated.¹ Sources: US Geological Survey and industry comments.² UK production figures, NERC and industry comments.

Table 2
Leading Producers, 2003

Company	Kt/y	%
Imerys, France	5,500	22.0
Engelhard, US	1,800	7.5
Huber, US	1,400	5.5
Thiele US	1,300	5.0
CVRD, Brazil (includes CADAM /Pará Pigmentos SA)	1,500	6.0
AKW, Germany	900	3.5
Lasselsberger (former Keramika HB), Czech Rep	400	1.5
Alter Abadi, Indonesia	300	1.0
DAM, France	270	1.0
Goonvean, UK	250	1.0
Others	11,660	46.0
Total	25,280	100

Table 3
Production of kaolin from Georgia, US (000't)

	2001	2002	2003
Product Types			
#1 @ >90 G.E. Brightness	742.2	757.3	738.8
#1 @ >86 G.E. Brightness	516.5	390.2	341.7
#2 @ >90 G.E. Brightness	168.9	147.5	151.3
#2 @ >86 G.E. Brightness	803.8	672.8	607.5
Delaminated Kaolin	1,206.8	1,179.1	1,250.2
East Georgia HiGloss	1,431.3	1,394.4	1,279.2
All Other	1,162.0	1,198.7	1,139.6
<i>Total Hydrous</i>	6,031.5	5,739.9	5,503.3
<i>Total Calcined Clays</i>	804.5	866.9	877.9
<i>Grand Total</i>	6,836.0	6,606.8	6,381.2

Source: China Clay Producers Association (CCPA), Figures do not include air float clays

Table 4
Brazilian Coating Kaolin 2003 (000't)

Company	Installed Capacity	Sales	Exports
CVRD - CADAM	900	720	650
- Pará Pigmentos SA	600	420	400
Imerys - Rio Capim Caulim	850	650	590
Total	2,350	1,790	1,640

Source: PPSA/CADAM/IMERYS

Table 5
Markets Served by Imerys UK Kaolin Products

Paper filler	37%
Paper coating	33%
<i>Total Paper</i>	<i>70%</i>
Sanitaryware	12%
Tableware	6%
Tiles	1%
Refractories	3%
<i>Total Ceramics</i>	<i>22%</i>
Paint	4%
Rubber	1.5%
Adhesives & Sealants	1.5%
Plastics	1%
<i>Total Performance Minerals</i>	<i>8%</i>

Table 6
Consumption of Kaolin

Industry	Share (%)
Paper	45
Paint, rubber, plastics, sealants	10
Ceramics	16
Refractories	15
Fibreglass	6
Others	8
Total	100