Bentonite

What is Bentonite?

The term Bentonite was first used for a plastic clay found in about 1890 in upper cretaceous tuff near Fort Benton, Wyoming. The main constituent, which is the determinant factor in the clay's properties, is the clay mineral montmorillonite. This in turn, derives its name from a deposit at Montmorillon, in Southern France.

Bentonite is a plastic clay generated frequently from the alteration of volcanic ash, consisting predominantly of smectite minerals, usually montmorillonite.

Other smectite group minerals include hectorite, saponite, beidelite and nontronite. Smectites are clay minerals, i.e. they consist of individual crystallites the majority of which are $<2\mu m$ in largest dimension. Smectite crystallites themselves are three-layer clay minerals. They consist of two tetrahedral layers and one octahedral layer. In montmorillonite tetrahedral layers consisting of $[SiO_4]$-tetrahedrons enclose the $[M(O_5,OH)]$-octahedron layer (M = and mainly Al, Mg, but Fe is also often found).

The silicate layers have a slight negative charge that is compensated by exchangeable ions in the intercrystallite region. The charge is so weak that the cations (in natural form, predominantly Ca^{2+}, Mg^{2+} or Na^{+} ions) can be adsorbed in this region with their hydrate shell. The extent of hydration produces intercrystalline swelling.

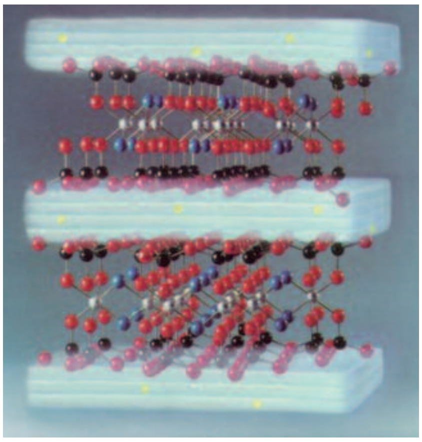
Depending on the nature of their genesis, bentonites contain a variety of accessory minerals in addition to montmorillonite. These minerals may include quartz, feldspar, calcite and gypsum. The presence of these minerals could impact the industrial value of the deposit, reducing or increasing its value depending on the application.

Bentonite presents strong colloidal properties and its volume increases several times when coming into contact with water, creating a gelatinous and viscous fluid. The special properties of bentonite (hydration, swelling, water absorption, viscosity, thixotropy) make it a valuable material for a wide range of uses and applications.

Bentonite deposits are normally exploited by quarrying. Extracted bentonite is distinctly solid, even with a moisture content of approximately 30%. The material is initially crushed and, if necessary, activated with the addition of soda ash (Na_2CO_3). Bentonite is subsequently dried (air and/or forced drying) to reach a moisture content of approximately 15%. According to the final application, bentonite is either sieved (granular form) or milled (into powder and superfine powder form). For special applications, bentonite is purified by removing the associated gangue minerals, or treated with acids to produce acid activated bentonite (bleaching earths), or treated with organics to produce organoclays.

Multiple properties – manifold uses

- **Foundry:** Bentonite is used as a bonding material in the preparation of moulding sand for the production of iron, steel and non-ferrous casting. The unique properties of bentonite yield green sand moulds with good flowability, compactability and thermal stability for the production of high quality castings.
- **Pelletising:** Bentonite is used as a binding agent in the production of iron ore pellets. Through this process, iron ore fines are converted into spherical pellets, suitable as feed material in blast furnaces for pig iron production, or in the production of direct reduction iron (DRI).
- **Construction and Civil Engineering:** Bentonite in civil engineering applications is traditionally used as a thixotropic, support and lubricant agent in diaphragm walls and foundations, in tunnelling, in horizontal directional drilling (HDD) and pipe jacking. Bentonite, due to its viscosity and plasticity, is also used in Portland cement and mortars.



- **Environmental Markets:** Bentonite's adsorption / absorption properties are very useful for wastewater purification.

  EU directives recommend low permeability soils, which naturally should contain bentonite, as a sealing material in the construction and rehabilitation of landfills to ensure the protection of groundwater from the pollutants. Bentonite is the active protective layer of the Geosynthetic Clay Liners.

- **Drilling:** Another conventional use of bentonite is as a mud constituent for oil- and water- well drilling. Its role is mainly to seal the borehole walls, to remove drill cuttings and to lubricate the cutting head.

- **Oils / Food Markets:** Bentonite is utilised in the removal of impurities in oils where its adsorptive properties are crucial in the processing edible oils and fats (Soya / palm / canola oil). In drinks such as beer, wine and mineral water and in products like sugar or honey, bentonite is used as a clarification agent.

- **Agriculture:** Bentonite is used as an animal feed supplement, as a pelletising aid in the production of the animal feed pellets, as well as a flowability aid for unconsolidated feed ingredients such as soy meal. It is also used as an ion exchanger for improvement and conditioning of the soil. When thermally treated, it can be used as a porous ceramic carrier for various herbicides and pesticides.

- **Pharmaceuticals, Cosmetics and Medical Markets:** Bentonite is used as filler in pharmaceuticals and due to its absorption/adsorption functions, allows paste formation. Such applications include industrial protective creams, calamine lotion, wet compresses, and anti-irritants for eczema. In medicine, bentonite is used as an antidote in heavy metal poisoning. Personal care products such as mud packs, sunburn paint, baby and face powders, and face creams may all contain bentonite.

- **Detergents:** Laundry detergents and liquid hand cleansers/soaps rely on the inclusion of bentonite, in order to remove the impurities in solvents and to soften the fabrics.

- **Paints, Dyes and Polishes:** Due to its thixotropic properties, bentonite and organoclays function as a thickening and/or suspension agent in varnishes, and in water and solvent paints. Its adsorption properties is appreciated for the finishing of indigo dying cloth and in dyes (lacquers for paints & wallpapers).

- **Cat Litter:** Bentonite is used for cat litter due to its advantage of absorbing refuse by forming clumps (which can be easily removed) leaving the remaining product intact for further use.

- **Paper:** Bentonite is crucial to paper making, where it is used in pitch control, i.e. absorption of wood resins that tend to obstruct the machines and to improve the efficiency of the conversion of pulp into paper as well as to improve the quality of the paper. Bentonite also offers useful de-inking properties for paper recycling. In addition, acid activated bentonite is used as the active component in the manufacture of carbonless copy paper.

- **Catalyst:** Chemically modified clay catalysts find application in a diverse range of duties where acid catalysis is a key mechanism. Most particularly they are employed in the alkylation processes to produce fuel additives.

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IMA Europe

Borates

What are borates?

Borates are naturally-occurring minerals containing boron, the fifth element on the Periodic Table. Trace amounts exist in rock, soil and water. Plants need them to grow. People need borates, too, as an important part of a healthy diet and an essential ingredient in many products necessary for an acceptable standard of living.

The element boron does not exist by itself in nature. Rather, boron combines with oxygen and other elements to form boric acid, or inorganic salts called borates. Despite the millions of tons of industrial borates mined, processed and distributed around the world every year, far larger quantities of boron are transferred around the planet by way of natural forces. Rain, volcanic activity, condensation and other atmospheric activities redistribute at least twice as much boron as all commercial practices combined.

Multiple properties – manifold uses

The key to the borate industry's strength also lies in nature: specifically, the nature of borates' structural and bonding characteristics. In living systems, these characteristics make borates vital to metabolism – the fundamental way in which organisms translate food into energy. Borates abound in industrial systems as well, for two reasons.

First, they're safe. Used for centuries, borates pose no risk to people, animals or the environment under normal handling and use. Even those who handle borates every day have experienced no adverse health effects. Second, they're versatile. In some applications, there is simply no substitute for borates. In other products and processes, their natural functions impart a wide range of performance, cost, environmental health and safety advantages.

Metabolising Effects – In certain organisms, borates can inhibit metabolic processes. This makes them useful in controlling insects, bacteria and fungi in everything from construction timbers to cosmetics.

Bleaching Effects – Another key chemical effect comes into play in laundry detergents and other cleaning products, where borates are important components in bleaching and stain removal.

Buffering Effects – The chemical properties of borates serve to balance acidity and alkalinity in many applications. Detergents, fireworks and film processing solutions all rely on borates for a stable pH.

Dispersing Effects – Borates are able to bond with other particles to keep different ingredients dispersed evenly and are used to control viscosity in paints, adhesives and cosmetics.

Vitrifying Effects – Borates modify the structure of glass to make it resistant to heat or chemical attack. In the same way, they facilitate the production of ultra-thin LCD screens, functional fiberglass and beautiful ceramic tiles and glazes.

Inhibiting Effects – Borates interact with surfaces containing iron to form a coating which protects the metal from corrosion. They are important additives in products as diverse as antifreeze and aerosol cans.

Flame-Proofing Effects – Combined with zinc, borates are used to retard flames and suppress smoke in polymers. Borates also act as a flame retardant in cellulose insulation.

Neutron-Absorbing Effects – Borates absorb neutrons in applications ranging from nuclear containment shields to treatments for cancer.

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While borate applications number in the thousands, chief among them are:

- **Agriculture:** Boron is an essential micronutrient for plants, vital to their growth and development. Without sufficient boron, plant fertilisation, seeding and fruiting are not possible. On every continent of the world, crop yields and food quality are diminished due to insufficient boron concentrations in the soil. These deficiencies can be corrected with borate fertilisers. In areas of acute deficiency, borates can increase crop yields by 30 to 40 percent.

- **Ceramics:** Borates have been an essential ingredient in ceramic and enamel glazes for centuries, integral to affixing glazes or enamels, and enhancing their durability and lustre. Borates are now gaining acceptance as an essential ingredient in ceramic tile bodies, allowing manufacturers to use a wider range of clays, heightening productivity and decreasing energy usage.

- **Detergents and Personal Care Products:** Borates enhance stain removal and bleaching, stabilise enzymes, provide alkaline buffering, soften water and boost surfactant performance in detergents and cleaners. Their biostatic properties control bacteria and fungi in personal care products. New trials demonstrate that adding borates to laundry soap bars significantly improves their cleaning action and reduce levels of dirt redeposition.

- **Diet:** Not surprisingly, people get the boron they need by eating plant-derived food. Studies indicate that people in a wide variety of cultures consume one to three milligrams of boron per day through a combination of foods and drinking water in their local diets. Although it has not yet been proved that humans need boron to live, there is almost universal agreement in the scientific community that boron is nutritionally important to maintain optimal health.

- **Fibreglass:** Borates are an important ingredient in both insulation fibreglass – which represents the largest single use of borates worldwide – and textile fibreglass, used in everything from circuit boards to surfboards. In both products, borates act as a powerful flux and lower glass batch melting temperatures. They also control the relationship between temperature, viscosity and surface tension to create optimal glass fiberisation.

- **Glass:** Borosilicate glass is the foundation for all heat-resistant glass applications and the myriad products they make possible – from cathode ray tubes to Pyrex® cookware. Borates increase the mechanical strength of glass, as well as their resistance to thermal shock, chemicals and water.

- **Polymer Additives:** Zinc borates are used primarily as a fire retardant synergist in plastics and rubber applications. They can also function as smoke and afterglow suppressants, anti-tracking agents, and can be used in polymers requiring high processing temperatures. Zinc borates can be found in polymers ranging from electrical parts and automobile interiors to wall coverings and carpeting.

- **Wood Treatments:** Borate treated wood is on the rise as a safe and long-lasting method to protect homes and other structures from wood-destroying organisms. Borate-based preservatives can be used to treat solid wood, engineered wood composites and other building materials like studs, plywood, joists and rafters. Borates prevent fungal decay and are deadly to termites, carpenter ants and cockroaches – but are safe for people, pets and the environment.

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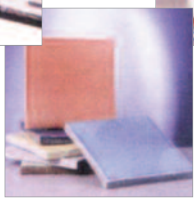
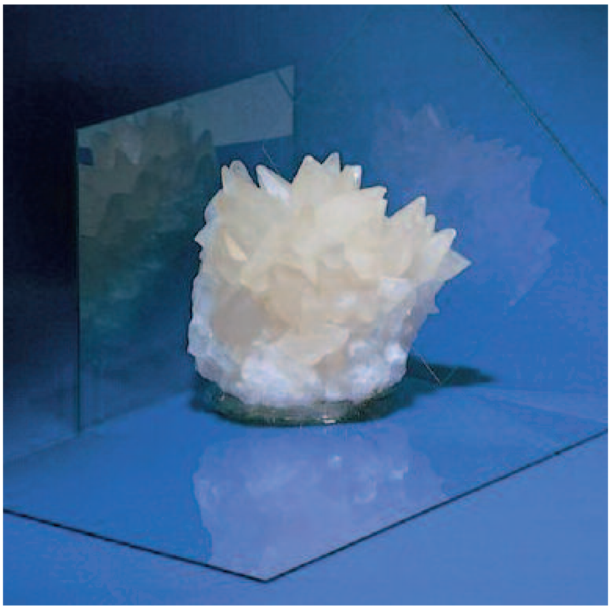


IMA Europe

Calcium Carbonate

What is Calcium Carbonate?

Calcium Carbonate is an exceptional mineral. The chemical formula $CaCO_3$ covers a raw material, which is widespread throughout nature, whether dissolved in rivers and oceans, in molten form as "cold" carbonatite-lava, or solid as a mineral in the form of stalactites, stalagmites or as the major constituent of whole mountain ranges. Plants and animals need calcium carbonate to form their skeletons and shells. In fact, when considering our lives, modern mankind could hardly imagine existing without calcium carbonate. Almost every product in our daily lives either contains calcium carbonate or has some association with the mineral during its production.



The Earth's crust contains more than 4% calcium carbonate. As a result, the three calcium carbonate minerals - calcite, aragonite and vaterite - are among the most important rock-forming minerals. Rocks are not the only calcium carbonate deposits in nature, most stretches of water and countless plants and animals contain huge amounts of calcium carbonate. The link between these natural resources is the calcium carbonate cycle.

Plants and animals absorb calcium carbonate from water - where it exists, in most cases, in the dissolved form of calcium hydrogen carbonate $Ca(HCO_3)_2$ - and use it to build up their skeletons and shells. After their death, crustacea, coccoliths, algae and corals form sedimentary deposits on sea-beds, thus the rock forming process is put in motion.

The first stage is the sedimentation process from which chalk and limestone originate. Chalk is a poorly compacted sedimentary calcium carbonate rock, whose diagenesis is incomplete. When the sedimentation process is completed this results in the formation of limestone. If the sedimentation process takes place in magnesium containing water a dolomitisation may occur. Part of the calcium ions in the crystal lattice are replaced by magnesium ions, a fact that leads to the formation of dolomite $CaMg[CO_3]_2$. Marble is a metamorphic rock, which is the result of a recrystallisation process of limestone, under conditions of high pressure and temperature. The carbonate rocks, chalk, limestone, dolomite and marble rocks are subject to erosion, under the influence of wind, temperature and water they dissolve, and the cycle may start again.

Multiple properties – manifold uses

Calcium carbonate rocks are spread throughout the world, which is why they have been among the most widely used raw materials for more than 5000 years. Long ago, the Egyptians built their pyramids with limestone, and today we still use hundred of millions of tonnes of calcium carbonate in the building industry alone. However, although the deposits are plentiful, only a few are of sufficiently high quality to be worked and even a fewer number of deposits will provide raw materials for industrial and agricultural uses other than the construction and roads building industry. Only if the purity, degree of whiteness, thickness and homogeneity are acceptable is commercial extraction worthwhile. After quarrying, further treatment is required to process natural calcium carbonates of the highest quality, known generically as Ground Calcium Carbonate (GCC). Precipitated Calcium Carbonate (PCC) is a synthetic calcium carbonate produced industrially by means of a recarbonisation process.

Both GCC or PCC can be used in a wide range of applications. For each end use there exists a tailor-made product, where fineness and particle size distribution are optimally balanced to meet the technical demands of that particular requirement.

- **Paper:** Over the last 30 years, the use of calcium carbonate has grown significantly as technology in the paper industry has moved from acid to neutral sizing. Today, calcium carbonate is the most widely used mineral in paper-making. GCC and PCC are used both as a filler and a coating pigment, and help produce papers with high whiteness and gloss and good printing properties.

- **Plastics:** Calcium carbonate is by far the most important mineral for compounding with polymers. By weight it accounts for more than 60% of the filler and reinforcements market. Main applications include plasticised and rigid PVC, unsaturated polyesters, polypropylene and polyethylene. Other important areas of use include rubber, foamed latex carpet-backings, sealants and adhesives.

  Calcium carbonate is not only a filler added to reduce costs and extend petroleum based resources, many properties of the plastic can be influenced by the use of calcium carbonate. Breathable PE-films for hygiene products and the building industry, for example, can only be produced with the incorporation of a filler such as calcium carbonate.

- **Coatings:** In paints and coatings, calcium carbonate has established itself as the main extender. Fineness and particle-size distribution can contribute to the opacity of coatings. Moreover, calcium carbonate can offer improvements in weather resistance, anti-corrosion and rheological properties, coupled with low abrasiveness, low electrolyte content, and a pH stabilising effect. In water-based systems calcium carbonate reduces the drying time.

- **Environment:** As a natural product, calcium carbonate is perfect for environmental protection applications. For example, flue gas desulphurisation, drinking water treatment, waste water treatment and forest and lake liming for the neutralisation of acid rain, are all growth areas for the use of calcium carbonate. It has a natural buffer-effect and works as a pollution-filter. These properties, likewise, apply to the derivative products.

- **Agriculture:** Calcium fertilisers were one of the first to be widely used. The Greeks and Romans were aware of their attributes. Their use guarantees an adequate supply of calcium to plants and stabilises the pH-value of the soil. These characteristics make calcium carbonate an important fertiliser for the agriculture and forestry sectors. Every year, in Europe alone, more than 4.5 million tonnes are supplied to this market. Other agricultural-related uses of calcium carbonate include its use as a calcium supplement in animal feed compounds.

- **Construction/Architecture:** Calcium carbonate has found an innovative application in the concrete market. It is increasingly used as a quality filler in concrete applications, such as concrete wares (paving-stones, tubes, sewage-tanks), ready-mixed concrete and prefabricated elements. It improves the concrete density, pre-stability and durability. Its stable colour quality increases the aesthetics which make it very suitable for architectural applications.

- **Others:** Glass, ceramics and blackboard chalk, together with cleaning, dental care and cosmetic products are produced by the wide range of industrial manufacturers who rely on calcium carbonate. As a natural mineral, calcium carbonate has a multitude of characteristics that make it an ideal raw material for widely differing uses. No one calcium carbonate is exactly like another, whichever property is needed a high grade product is there to meet the demand. Diverse requirements such as low iron oxide content for the production of high-quality glasses, the authorisation for uses in foodstuffs, good buffering-effect or low abrasion, can be met by an existing grade of calcium carbonate.

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IMA Europe

Diatomite

What is Diatomite?

Diatomite is a powdery, non-metallic mineral composed of the fossilised skeletal remains of microscopic single-celled aquatic plants called diatoms. Over 10,000 species of these microscopic algae have been recognised, each with its own distinct shape, ranging in size from under 5 microns to over 100 microns. Diatomite deposits are usually categorised based upon their fresh water or salt water origin. Both the chemical composition and the physical structure of diatomite make it of great commercial value for a wide spectrum of uses, including filter aids, functional fillers, carriers for active ingredients and diluents, and aggregates.

Diatoms have the unique ability to absorb water-soluble silica present in their natural environment to form a highly porous, yet rigid, skeletal framework of amorphous silica. To this day, living diatoms in bodies of water worldwide continue to serve as a source of food for marine animals and, by photosynthesis, as a major source of atmospheric oxygen. Over the eons, their remains settled and were joined by succeeding generations forming deep-bedded deposits on ocean and lake floors, some of which rose about fifteen million years ago to become part of our present land-mass. In a few regions the diatomite deposits formed in sufficient thickness and purity to be mined for many uses beneficial to mankind.

Uniqueness

Before the end of the 19th century, the diatomite deposits attracted attention as a potential industrial material. At that time the chemical and physical properties of diatomite as an insulation material were already recognised. It was not, however, until sometime later, that the mining and processing of diatomite could be called an industry with a predictable future.

The *unique* properties of diatomite including:

- Light weight
- High porosity
- High absorptivity
- High purity
- Multi-shaped
- Rigidity
- Inertness

make it industrially useful in a variety of ways such as in liquid filtration; as a multi-functional mineral additive; as a carrier for active ingredients and diluents; as an aggregate; and, as a source of silica to name just a few.

How is it manufactured?

During its early development period, diatomite was processed almost exclusively by hand. It was taken from the beds in blocks and dried, and subsequently shipped in this form. The first mill or plant for processing natural diatomite was constructed in the early 1900s.

Today, diatomite is typically mined by open-pit quarrying techniques using conventional, heavy duty earth moving equipment then transferred to a processing plant. At the plant, three different processes are used to manufacture the many different diatomite products depending on the desired characteristics.

Natural Grades:
The crude ore is milled, dried at relatively low temperatures and classified to remove extraneous matter and to produce a variety of different particle-size grades. These natural powders, consisting primarily of amorphous silica, are generally off-white in color.

Calcined Grades:
These products are produced from the natural material by calcination, or sintering, at higher temperatures usually in excess of 900° C in a rotary kiln. After calcination, the diatomite is further processed into products with selected particle size ranges that can include filter aids, multi-functional fillers and aggregates. During calcination any organics and volatiles are removed and the color typically changes from off-white to tan or pink.

Flux-calcined Grades:
These products are also produced from the natural material by calcining in a rotary kiln. Temperatures in excess of 900° C, are used in the presence of a flux such as soda ash (sodium carbonate). During flux-calcination the diatoms further increase in particle size though agglomeration, and in many instances become bright white in colour depending upon the conditions chosen. Further milling and air separation control the final particle size distribution to produce filter aids of relatively high permeability and fine white multi-functional fillers.

Multiple properties - manifold uses

Filter aids: Liquid filtration is the process by which solid particles are separated from a fluid through a permeable material. Because of its high degree of porosity combined with its low density and inertness, diatomite makes an excellent filtration medium, providing the ability to economically remove microscopically small suspended solids from large volumes of liquid. Diatomite is ideally suited for a wide variety of applications including: antibiotics, beer, chemicals, edible oils and fats, fruit juices, glucose, pharmaceuticals, solvents, sugar, vitamins, water, wine, and many, many others.
Diatomite filter aids are used with outstanding success to remove suspended particles as small as 0.1 micron in size. A variety of grades are manufactured using the highest standards of quality to meet the exacting demands of almost every industrial filtration in an efficient and economical manner.

Functional Mineral Additives: The versatility of diatomite as a functional filler, in part as a result of its unique particle shape, has led to its widespread use in a number of applications such as: paint, plastics, paper, insulating bricks, and dental moldings.

Modern industrial processing technology demands more than single-purpose fillers that provide only traditional bulking characteristics. In diatomite, processors will find a multi-functional mineral additive that provides a variety of benefits that include: anti-blocking, brightness, cost control, density control, high surface area, reinforcement, controlled absorption, precise abrasive properties, and gloss and sheen control.

Carriers for Active Ingredients and Diluents: The high porosity of diatomite combined with its strong and irregularly shaped diatom structure makes it exceptional as a carrier for active ingredients and diluents. Complementing these desirable characteristics are its inert nature, large surface area and high purity. Typical applications include: pesticide carriers and catalyst carriers.

Aggregates: High absorptivity, lightweight and its free-flowing nature are characteristic of diatomite aggregates. They are used as absorbents in a number of applications including floor sweeping, the cleanup of hazardous wastes, oil and grease absorbents, and soil amendments.

Packaging and Distribution
Diatomite is shipped in multi-wall paper or plastic bags, in FIBC's, in cardboard containers, or in bulk utilising rail hopper cars, box cars or tank trucks. It is available worldwide.

For more information, please contact :

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IMA Europe

Feldspar

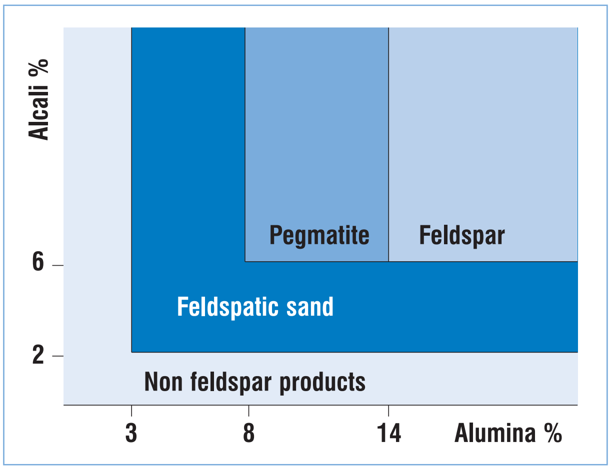
What is Feldspar ?

Feldspar is by far the most abundant group of minerals in the earth's crust, forming about 60% of terrestrial rocks. Most European deposits offer potassium feldspar as well as sodium feldspar and mixed feldspars. Feldspars are primarily used in industrial applications for their alumina and alkali content. The term feldspar encompasses a whole range of materials. Most of the products we use on a daily basis are made with feldspar: glass for drinking, glass for protection, glass wool for insulation, the floor tiles and shower basin in our bathroom, the tableware from which we eat, … Feldspar is part of our daily life.

Feldspar minerals are essential components in igneous, metamorphic and sedimentary rocks, to such an extent that the classification of a number of rocks is based on feldspar content. The mineralogical composition of most feldspars can be expressed in terms of the ternary system Orthoclase ($KAlSi_3O_8$), Albite ($NaAlSi_3O_8$) and Anorthite ($CaAl_2Si_2O_8$). Chemically, the feldspars are silicates of aluminium, containing sodium, potassium, iron, calcium, or barium or combinations of these elements.

The minerals of which the composition is comprised between Albite and Anorthite are known as the **plagioclase feldspars**, while those comprised between Albite and Orthoclase are called the **alkali feldspars**. The latter category is of particular interest in terms of industrial use of feldspars.

Amongst the numerous rocks in which they are present, feldspars are particularly abundant in igneous rocks like granite, which contains up to 50 or 70% of alkaline feldspar. Granite is however rarely used for its feldspatic content. Rather a whole range of rocks geologically connected to granite is used. Most often, commercial feldspar is mined from pegmatite or feldspatic sand deposits. Aplite, which is



a fine-grained igneous rock with the same mineralogical composition as granite is also frequently mined for its feldspar content.

Basically, the two properties which make feldspars useful for downstream industries are their alkali and alumina content. On those elements we can distinguish three families: Feldspatic sand, Pegmatite and Feldspar.

A further distinction can be made between sodium, potassium and mixed feldspars, depending on the type of alkali they contain.

Multiple properties – manifold uses

Feldspars play an important role as fluxing agents in ceramics and glass applications, and are also used as functional fillers in the paint, plastic, rubber and adhesive industries.

- **Ceramics:** In the manufacture of ceramics, feldspar is the second most important ingredient after clay.

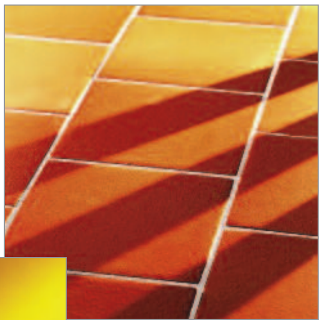
  Since feldspar does not have a strict melting point it melts gradually over a range of temperatures. This greatly facilitates the melting of quartz and clays and, through appropriate mixing, allows to modulate this important step of ceramic making. Feldspars are used as fluxing agents, to form a glassy phase at low temperatures, and as a source of alkalies and alumina in glazes. They improve the strength, toughness, and durability of the ceramic body and cement the crystalline phase of other ingredients, softening, melting and wetting other batch constituents.

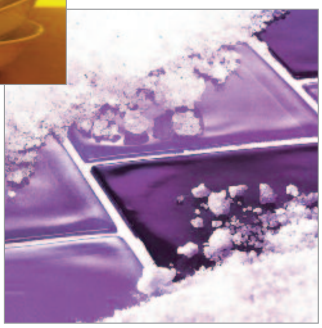
In the **flooring sector**, feldspar is the main constituent in the body composition. It is used as a flux, lowering the vitrifying temperature of a ceramic body during firing and forming a glassy phase. Surface tension pull the remaining solid particles together, giving a densification of the ceramic body. With rising temperature the alkalis become more active and first dissolve the clay particles and then the free silica.

In **tableware**, feldspar gives a good fusibility for a product without defects.

In the **sanitaryware** sector, the use of feldspar within vitreous ceramic bodies is used here to illustrate this optimisation process.

- **Glass:** Feldspar is an important ingredient in the manufacture of glass and an important raw material as well, because it acts as a fluxing agent, reducing the melting temperature of quartz and helping to control the viscosity of glass. The alkali content in feldspar acts as flux, lowering the glass batch melting temperature and thus reducing production costs. But feldspars are primarily added to glass batches for their alumina content, which improve hardness, durability, and resistance to chemical corrosion. The raw material for glass consists of silica sand, soda ash (sodium carbonate) and limestone (calcium carbonate).





Feldspar adds certain qualities to the process. Alumina provides hardness, workability, and strength, and makes glass more resistant to chemicals and more suitable for pressing. Fluxes reduce the melting temperature so that less energy is used and decrease the amount of soda ash needed.

Feldspars are used in the production of flat glass (windows, car glass…) but also container glass. They provide us with a clear view for our television and computer screens, car headlamps, fluorescent tubes, perfume bottles, soda bottles, pharmaceutical or laboratory glass…

- **Fillers:** Feldspars are also used as fillers and extenders in applications such as paints, plastics and rubber. Beneficial properties of feldspars include good dispersability, chemical inertness, stable pH, high resistance to abrasion, low viscosity at high filler loading, interesting refractive index and resistance to frosting. The products used in such applications are generally fine-milled grades.
- **Enamel frits and glazes:** Feldspar enters in the enamel composition, assuring the absence of defects and the neatness of the end product: enamel frits, ceramic glazes, ceramic tile glazes, sanitaryware, tableware, electrical porcelain and giftware to name just a few.
- **And many other end-uses:** in paint, in mild abrasives, urethane, welding electrodes (production of steel), latex foam, as a welding rod coating , road aggregate…

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Kaolin

What is kaolin?

Kaolinite is a mineral belonging to the group of alumino-silicates. It is commonly referred to as "China Clay" because it was first discovered at Kao-Lin, in China. The term kaolin is used to describe a group of relatively common clay minerals dominated by kaolinite and derived primarily from the alteration of alkali feldspar and micas. Kaolin is an industrial mineral used primarily as an inert filler and customers combine it with other raw materials in a wide variety of applications.

Kaolin is a white, soft, plastic clay mainly composed of fine-grained plate-like particles. Kaolin is formed when the anhydrous aluminium silicates which are found in feldspar-rich rocks, like granite, are altered by weathering or hydrothermal processes. The process which converted the hard granite into the soft matrix found in kaolin pits is known as "kaolinisation". The quartz and mica of the granite remain relatively unchanged whilst the feldspar is transformed into kaolinite. Smectite may also form in small quantities in some deposits. The refining and processing of the fine fraction of the kaolinised granite yields predominantly kaolinite with minor amounts of mica, feldspar, traces of quartz and, depending on the origin, organic substances and/or heavy minerals.

Individual kaolins vary in many physical aspects, which in turn influence their end use. Of particular commercial interest is the degree of crystallinity which influences the brightness, whiteness, opacity, gloss, film strength, and viscosity.

Multiple properties – manifold uses

Kaolin is part of our natural world. Its uses are multiple and diversified. Kaolin's whiteness and plasticity make it extremely suitable for its extensive use as a filler, extender, ceramic raw material and pigment. It is also an important raw material to refractories, and to catalyst, cement and fibre glass industries.

Kaolin is used in many applications. It is a unique industrial mineral, which remains chemically inert over a relatively wide pH range and it offers excellent covering when used as a pigment or extender in coated films and filling applications. In addition, it is soft and non-abrasive and has a low conductivity of heat and electricity.

The two largest applications of kaolin are the coating of paper to hide the pulp strands and the production of high-grade ceramic products. It is also used in many other industrial processes:

- **Paper:** In this industry, kaolin is used both as a filler in the bulk of the paper and to coat its surface. Kaolin's whiteness, opacity, large surface area and low abrasivity make it an ideal raw material for paper production. Its use allows a reduction in the amount of expensive wood pulp required, enhances the optical properties of the paper and improves its printing characteristics. When used as a coating on the surface of the paper, kaolin's whiteness improves paper brightness and opacity, whilst the size and the shape of the individual kaolin particles give the gloss and printed paper quality required for many different kinds of paper. Examples include papers for magazines and brochures, art paper, cartons and boxes etc.
- **Ceramics:** Kaolin converts to mullite and glass when fired to temperatures exceeding 1000° C. It is used in formulations described as **whitewares**, which consists of tableware, sanitaryware, and wall and floor tiles. It provides strength and plasticity in the shaping of these products and reduces the amount of pyroplastic deformation in the process of firing.

  In **tableware**, in addition to the strength and plastic qualities, it is essential to the achievement of high fired whiteness. This is because it contains a low content of colouring elements such as iron and titanium.

  For **sanitaryware**, the product is formed by casting (either in plaster, or resin moulds under pressure). Kaolin contributes the rheological properties that enables the casting slip to flow and drain after the cast formation. The cast pieces are relatively heavy and the kaolin must be strong to withstand the weight and retain the shape before the pieces enter the kiln.

- **Fillers:** When kaolin is used as a pigment, it is divided broadly into filler- and paper coating grade clays based on their brightness and viscosity. Its main properties, especially its whiteness or near whiteness, make it very suitable as a filler or pigment. In addition, it remains inert over a wide PH range, is nonabrasive, has a low heat and electrical conductivity and offers brightness and opacity.
- **Paint:** In its hydrous or calcined forms, kaolin can improve the optical, mechanical and rheological properties of a paint. Calcined kaolins are widely used in satin and matt paints where they can deliver increased opacity, whiteness and scrub resistance. Kaolin is particularly useful as a partial replacement for TiO_2 pigment.
- **Rubber:** Kaolin adds strength, abrasion resistance and rigidity to rubber. Calcined kaolin in particular, with or without a silane chemical surface treatment, finds extensive use in high value thermoplastic elastomers for a variety of applications and in rubber insulation on high voltage power lines.
- **Plastics:** Kaolin is used in plastics to provide smooth surfaces, dimensional stability and resistance to chemical attack, to conceal fibre reinforcement patterns and to reduce shrinkage and cracking during polymer compounding and shape forming. It is also used as a rheological modifier and a functional filler, in which capacity it is used to improve mechanical, electrical and thermal properties. A major application is in PVC cables where its main function is to improve electrical properties. Other important applications include specialty films where they impart anti-blocking or infra-red absorption characteristics. Chemically treated, calcined kaolins is one of the major additives used in the manufacture of automotive parts based on engineering thermoplastics.

- **Refractories:** Refractories are produced from natural materials, combinations of compounds and minerals, such as kaolin, which are used to build structures subjected to high temperatures, ranging from simple to sophisticated products, e.g. from fireplace brick linings to re-entry heat shields for the space shuttle. In industry, they are used to line boilers and furnaces of all types-reactors, ladles, stills, kilns and so forth.
- **Fibreglass:** The fibreglass which is used as a strengthener in a multitude of applications requires the use of kaolin for its manufacture. Kaolin allows for the strengthening of the fibres integrated into the material. It also improves the integration of fibres in products requiring strengthened plastics: cars, boats and marine products, sporting goods and recreation products, aviation and aerospace products, circuit board manufacturing, fibreglass insulation, fibreglass air filters, fibreglass tanks and pipes, corrosion resistant fibreglass products, fibreglass building and construction products, etc.
- **Cosmetics and pharmaceuticals:** 'British Pharmacopoeia Light Kaolin' (BPLK) and 'Heavy Kaolin' are manufactured according to the requirements of the British and European Pharmacopoeia respectively. BPLK is used in both human and veterinary medicinal products, for example to treat digestion problems and as a constituent of poultices. It can also be used as an excipient in personal care products including, for example, Thalasso therapy (bath and skin treatments) and in cosmetics. Additionally, BPKL is found in a number of dietary products, plasters, foot-powders and in the specialised treatment of some lung disorders.

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IMA Europe

Lime

What is Lime?

Lime is a generic term, but by strict definition it only embraces manufactured forms of lime – quicklime (CaO) and hydrated lime ($Ca(OH)_2$). It is, however, sometimes used to describe limestone products, which can be confusing.

The raw material for all lime-based products is a natural stone: limestone, which is composed almost exclusively of calcium carbonate ($CaCO_3$). When limestone contains a certain proportion of magnesium, it is called dolomite, or dolomitic limestone ($CaMg(CO_3)_2$). It is widely geographically available all over the world, (the Earth's crust contains more than 4% calcium carbonate,) and it is used for many different purposes.

In the lime or dolime production process the blocks of limestone or dolomite from the quarry are blasted, crushed and sorted by size in screening plants. At this stage part is used directly as aggregates for road construction, for concrete or other applications. Part is ground to lime fertiliser or pulverised into limestone powder, used in applications such as for cleaning flue gases, for animal feed or for fillers in many products (concrete, asphalt, carpet-backing etc.).

The rest of the high quality limestone, with a defined particle size, is calcined in a lime burning plant at a temperature of 900-1200°C, at which temperature it is decarbonised in either vertical shaft or horizontal rotary kilns fired by gas, oil, coal, coke or other fuels. During that process, carbonate is converted into oxide (CaO or $CaMgO_2$) and CO_2 is released. The combustion phase is essential for obtaining a quality of lime that satisfies the required characteristics. It is important to adjust the reactivity, because the various applications require reaction times (reaction of oxide with water) that can vary from a few seconds to more than thirty minutes. The products must possess precise physical and chemical characteristics for the different standards required for certain applications. The quicklime obtained can be used as such, or can be crushed, finely ground (even to micron size), depending on its intended use.

Quicklime can be hydrated, i.e. combined with water, in a hydrating plant. The quantity of water added is more than the amount required for the hydration reaction. The excess water is added to moderate the temperature generated by the heat of reaction by conversion to steam. The end product is hydrated lime or slaked lime ($Ca(OH)_2$) in the form of a very fine powder, suitable for a variety of applications.

Milk of lime and lime putty are produced by slaking of quicklime with excess water.

Slaking is done in both batch and continuous slakers. The term milk of lime is used to describe a fluid suspension of slaked lime in water. It may contain up to 40% by weight of solids. Milk of lime with a high solids content is sometimes called lime slurry. Lime putty is a thick dispersion of 55% to 70% by mass of slaked lime in water. Lime paste is sometimes used to describe a semi-fluid putty.

Multiple properties – many uses

Lime can be used for a wide range of purposes because of its different characteristics:

- alkaline reaction of lime with water (neutralization, coagulation, flocculation)
- forming of water insoluble calcium salts (precipitation of heavy metals and sulphates)
- re-carbonation reaction with CO_2 (hardening of plaster, increase of acid capacity)
- pozzolanic reaction with silicates (forming of calcium silicates)
- heat generation by contact of quicklime with water (drying, pasteurisation, disinfection)

While lime is one of the earliest industrial commodities known to man, its production and uses have grown with the times, and it continues to be one of the essential building blocks of modern industry.

- **Iron and steel:** Quicklime is used to form slag with the acidic impurities of ores and other raw materials. It purifies iron in the blast furnace and steel in the converter. Dolime addition to slag extends the life of (dolomitic) refractory linings in converters, protecting them from the aggressive effect of certain impurities present in the hot metal. Lime is used as well for hot metal desulphurisation and is also essential to producing metals other than steel, such as copper, aluminium and magnesium.

- **Flue gas treatment:** In power stations and industries, most sulphur dioxide (SO_2) emissions come from the combustion of fossil fuels (coal, lignite and petroleum products). Other processes, such as the incineration of household or industrial waste, generate SO_2 and other acid gases (HCl, HF) which, if they are not captured, contribute to an increase of acidity in the atmosphere and the formation of acid rain. Lime is used to capture SO_2 and other acid gas out of the flue gas

- **Water treatment:** The use of lime for *industrial waste water* to adjust pH levels can precipitate most heavy metals in the form of hydroxides, sulphates and phosphates as insoluble salts. For *municipal waste water,* lime increases the acid capacity, avoids the acidification of the biological process and stabilises the biocenosis. In *drinking water* and *process water* treatment lime eliminates undesirable organic matters and metallic trace elements. Lime is used for softening or re-mineralising drinking waters.

- **Sludge treatment:** Lime is widely used to coagulate and to stabilise industrial residual sludge or dredging sludge and for treating urban bio-solids before agricultural re-use or incineration. Lime is also used for sanitising sludge.

- **Civil engineering:** The addition of lime to clay containing soil improves soil properties (i.e. better densification). Its reaction with water enables it to dry out damp soils. Lime is increasingly used to recycle excavated material from sites in urban areas. Hydrated lime improves the performance of asphalt mixes used for road surfacing. It increases their resistance against stripping, and also against rutting and age-hardening. In tunnel construction, hydrated lime is used to improve the quality of mortars. Quicklime dries out the mud from the excavation and therefore improves its handling. It is also used in the deep soil stabilisation process (lime treated columns) to improve soft soils, reduce settlements and increase stability. Hydrated lime is one of the components used to produce injection binders.

- **Construction materials:** Builders have made use of the binding properties of lime. For example, lime-based mortars are often used in masonry and in plaster mixes for building facades. In addition, lime is being used increasingly in modern building materials, such as for aerated concrete blocks, for hemp-lime blocks and for sand-lime bricks. These materials are highly valued because they have excellent thermal and acoustic insulating properties and they are easy to use.

- **Agriculture:** Various mixtures of lime, limestone and dolomite are used in agriculture and forestry, both for correcting acidity in the soil and for adding nutrients which contain magnesium and calcium. These nutrients are essential for healthy plant growth and for increasing crop yield. In forestry, dolomite-based products stimulate photosynthesis and, by lowering the degree of acidity in the soil, ensure a better assimilation of nutrients, resulting in a significant increase in forest productivity.

- **Environment and soil protection:** Lime is used to combat acidification and control pH of soil, ground and surface waters. It is used for soil remediation i.e. treatment of soils polluted with hydrocarbons and heavy metals. Systematic liming of rivers and lakes (mainly in Scandinavia) has been carried out for more than 20 years to maintain their rich ecological system.

- **Food and feed additives, pharmaceuticals:** The human food, animal feed and pharmaceutical industries use lime as a neutralizing agent, to absorb excess moisture and carbon dioxide, as a preserving agent, as a filler, as an acidity regulator and as a source of calcium.

- **Others:** Lime is known as the most economical and most widely used alkaline reagent in the chemical industry. It is also used for the glass, leather, paper and sugar industries.

Lime is the only material that can perform so many functions. In most cases lime could only be replaced, if at all, by expensive synthetic materials. There is lime production in almost all EU countries which means that most users can find a nearby source, keeping transportation costs and also, therefore CO_2 emissions for transport, to a minimum.

Lime Standards

European standards exist for a number of lime products:

- EN 459, Parts 1, 2, 3 for building lime
- EN 1017 for half-burnt dolomite
- EN 12485 for test methods
- EN 12518 for calcium lime products used in drinking water treatment

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IMA Europe

Mica

What is Mica?

The word Mica is thought to derive from the Latin word "micare", meaning to shine, in reference to its glittering effect when exposed to light. The history of mica dates back to pre-historic times, as mica was known to the ancient Egyptian, Greek and Roman civilisations, and even in the Aztec civilization of the New World.

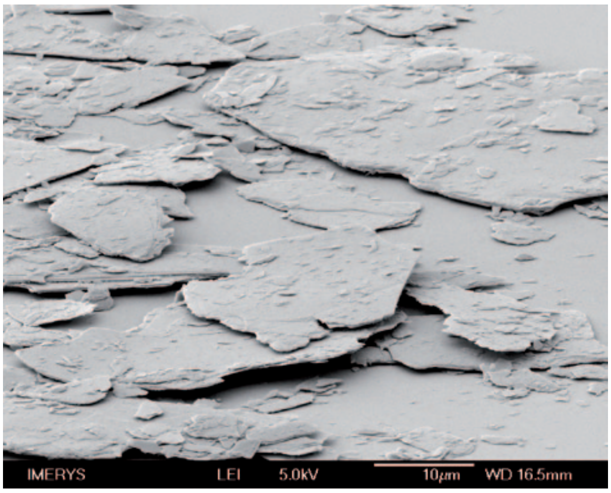
Mica is a phyllosilicate mineral that exhibits an almost perfect basal cleavage. Mica is a group comprising almost 30 members that differentiate from each other, primarily, by atom substitutions or vacancies in the crystal lattice. From an industrial standpoint, very few are mined: Muscovite, white mica, is by far the most common, Phlogopite - a dark brown mica - comes in second. To a lesser extent, lithium mica such as Lepidolite find some interesting applications in our industries.

Amongst platy minerals, micas are unique due to the broad range of particle sizes naturally available from microns up to several centimetres. Mica elementary crystals are three-layer platy minerals: they consist of two tetrahedral sheets and one octahedral sheet, so called Te-Oc-Te to describe the fact that 2 layers consisting of 3/4 [SiO4]- and 1/4 [AlO4]- tetrahedrons enclose the [M(O4,(OH)2)]-octahedron layer (M = Al for muscovite and Mg for phlogopite with the exception of a few substitutions, primarily Fe). This elementary sheet structure is approximately 10 angströms thick.

The Te-Oc-Te structure has a slight negative charge that is compensated by inter-layered cations (in natural form, predominantly K+ ions) located in the intersheet region. The bonding strength between inter-layered cations and tetrahedral sheets, together with the steric effect, make the extraction of those cations almost impossible under standards conditions and gives all micas very high chemical and weathering stability. Under selected process routes, thorough delamination is achievable to the benefit of final applications where high levels of film reinforcement and/or barrier properties are expected.

Depending on the nature of their origin, micas contain a variety of accessory minerals in addition to muscovite/ phlogopite. These minerals may include quartz, feldspar, kaolin and pyroxene. The presence of these minerals in conjunction with the mica contained in the ore will impact upon both the industrial value of the deposit and the process complexity, reducing or increasing its value depending on the application.

Mica deposits are either mined for mica only, when matrix yield is high enough, or in association with other minerals such as kaolin/feldspar. When Mica is present in soft rock, it is beneficiated through wet processing, typically blunging, gravity separation and flotation. Mica is subsequently dried to attain a moisture content below 1%. In hard rocks, the preferred process is crushing, directly after drying, followed by sieving and magnetic separation. According to the final application, mica needs to be milled to the required particle size distribution and simultaneously delaminated to enhance its aspect ratio (particle diameter / thickness). This is obtained either through merely sieving (flakes form), or dry milling (into powder and micronised powder form) or wet milling for the most engineered grades with high smooth sheet surface and particle edges. Processor knowledge is critical in the balance of size reduction / delamination ratio. For special applications, mica can be further calcined or surface treated (grafted with organic functions or coated with iron oxide) in order to enhance specific attributes such as compatibility with polar polymer matrix.



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Varied properties – multiple uses

- **Automotive:** Micas in coarse and highly delaminated flakes are widely used in bitumen foils production that are attached onto the inner vehicle frame structures to dampen vibrations. They can be also applied in a spray form in less accessible areas.
- **Brake pads & Clutches:** Thanks to its high thermal resistance and platy structure, mica is added to frictional systems to impart better heat transfer in conjunction with noise reduction.
- **Decoratives:** Several niche markets highly appreciate mica for its glittering and aesthetic effects. Mica can be found in various products such as decorative paints, ceramics, decorative concrete, post cards, wall papers…
- **Drilling:** Another conventional use of mica is as a mud constituent for oil well drilling. Its main role is to seal the borehole walls to prevent leakage and pressure loss when the drill bit encounters fractured areas.
- **Fibre Cement:** Mica is used in high engineered fibre cement to impart dimensional stability either in moisturising conditions or in passive fire protection.
- **Fire extinguisher:** In this application, mica provides anti-caking & flowability. This is vital, ensuring the dry powder will be properly and quickly blown out of the extinguisher tank.
- **Foundry:** Mica is used for coatings in iron casting and to a limited extent in aluminium production casting. It provides several properties both in the coating preparation – e.g. rheology & stability - and once applied on the inner mould surface: mica provides a constant thickness layer on vertical walls, anti-veining effect, and provides a barrier between the sand mould and the molten iron.
- **Paints & Coatings:** An application where mica is widely used for its reinforcement properties, preventing cracks in particularly thick films as the drying process induces shrinkage. Thanks to its barrier properties, mica brings high value in external renderings and anti-corrosive paints.
- **Paper coatings:** High aspect ratio mica, with it's clean surface and smooth edges, imparts the highest barrier properties. This property is much appreciated in packaging products as it provides protection from the water or grease associated with the food. As a natural product, it offers an environmentally friendly solution versus the traditional organic binders.
- **Plastics:** Mica acts as a reinforcing additive and is mainly used in compounds further transformed in the packaging industry -mica reduces warpage in thin plastic frames - and in the automotive industry. Thanks to its low coefficient of thermal expansion, mica imparts dimensional stability in complex and long shape pieces.
- **Plasterboard & Joint compound:** Mica is used primarily as an anti-cracking and reinforcing additive. It provides good rheological properties and allows the smooth application of the joint paste.
- **Pearlescent pigments:** Mica is the only natural substrate that provides a pearlescent effect once it has been coated with TiO_2 or Fe_2O_3.
- **Rubber:** Due to its platy structure, mica is used either as a demoulding agent during the vulcanisation process, or as an anti-sticking powder when several rubber pieces are stacked together.
- **Welding rods:** Mica brings added value both during the rod manufacturing step (ease the extrusion) and the welding itself. During welding, the platy structure acts like a shield protecting the molten steel from ambient air oxidation and moisture.

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IMA Europe

Plastic Clay

What is Plastic Clay ?

Plastic clay is an extremely rare mineral found in very few places around the world. It is also sometimes referred to as 'ball' clay, a name which dates back to the early methods of mining when specialised hand tools were used to extract the clay in rough cube shapes of about 30cm. As the corners were knocked through handling and storage these cubes became rounded and 'ball' shaped.

Plastic clays are sedimentary in origin. Ancient rivers and streams washed kaolinite (formed from decomposed granite) from its parent rock. As the streams flowed from upland areas the kaolinite mixed with other clay minerals, sands, gravels and vegetation before settling in low-lying basins to form overlaying seams of plastic clay.

Plastic clays usually contain three dominant minerals: kaolinite, mica and quartz. In addition, there are other 'accessory' minerals and some carbonaceous material (derived from ancient plants) present. The wide variation both in mineral composition and in the size of the clay particles results in different characteristics for individual clay seams within a deposit.

Collecting different plastic clay samples from the quarry face.

Internationally, deposits of high quality plastic clay are much rarer than those of kaolin. The best deposits currently known and exploited commercially are found in South West England, the Westerwald area of Germany, several basins in France, eastern Ukraine around Donetsk and southern parts of the USA. Further important deposits have been identified in Thailand, Indonesia and China.

Extraction and Processing

Plastic clay is extracted using hydraulic 'back-hoe' excavators, working at 'benches' cut into the quarry to access the seams of clay. Individual raw clay selections are carefully blended according to pre-determined recipes to provide a product with a consistent and predictable range of characteristics and behaviour. The first stage in processing is then to shred (or 'kibble') the blended clay into smaller, more regular lumps about the size of a golf ball. Much blended clay is sold in this shredded form.

Further processing through drying and grinding yields powdered plastic clays and treatment by calcination produces chamotte. Ceramics manufacturers (particularly in the sanitaryware sector) have also benefited from the development of refined plastic clays and chamottes which offer improved performance and reduced manufacturing process costs. Refined clays are available in 'noodled' and slurried form.

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Multiple properties – uses

A vital material in ceramics

Plastic clays are used in many different industries, but in particular form a vital component in ceramic manufacturing. Used with kaolin, which has limited plastic properties, plastic clay provides the cohesion and workability necessary for the creation of ceramic parts.

As a result of their sedimentary origin, raw plastic clays have a wide range of colours. However, many of them are valued by the ceramics industry for their white-firing properties which are determined by the amount of metallic oxides within the clay. Ironically, many of the darker raw plastic clays from south west England have the whitest fired colour.

For refractory applications, plastic clays and chamottes with a high alumina content form the base composition for alumino silicate refractories.

- **Sanitaryware:** Sanitaryware typically includes chamotte and plastic clay as essential components, with the plastic clay providing plasticity and workability. In addition sanitaryware also includes kaolin, feldspar and quartz.
- **Tableware:** Ceramic tableware utilises plastic clay to provide high plasticity and a good white-fired colour, combined with Kaolin, feldspar and quartz.
- **Wall and floor tiles:** Again combined with feldspar, kaolin and quartz, plastic clays are utilised for their plasticity and bonding properties.
- **Glazes and engobes:** Plastic clays are also used in the production of coatings for ceramic products to ensure the perfect finish.
- **Refractory clays:** An ability to resist the effects of extremely high temperatures makes plastic clay and chamotte ideal for use in refractory products such as kiln insulation and furniture.
- **Construction ceramics:** Building materials such as bricks, clay pipes and roof tiles all contain plastic clay.
- **Electrical porcelain insulators:** You will find plastic clays in the electrical porcelain components that provide insulation from high voltage currents.
- **Chemical applications:** Plastic clays used as fine fillers and extenders in polymers, adhesives, plastics, fertilisers and insecticides.
- **Sealants:** Plastic clays are also widely used for lining landfill waste disposal sites, and for sealing over them once completed.

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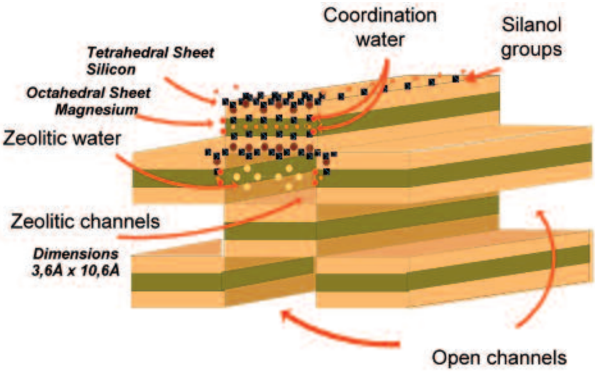
Sepiolite

What is Sepiolite?

Sepiolite, formerly known as Meerschaum (sea froth), is a non-swelling, lightweight, porous clay with a large specific surface area. Unlike other clays, the individual particles of sepiolite have a needle-like morphology. The high surface area and porosity, as well as the unusual particle shape of this clay account for its outstanding sorption capacity and colloidal properties that make it a valuable material for a wide range of applications.

Sepiolite is a very uncommon clay because of both its peculiar characteristics and scarce occurrence. There are very few commercial deposits in the world. Most of the world production of this clay comes from deposits of sedimentary origin located near Madrid, Spain.

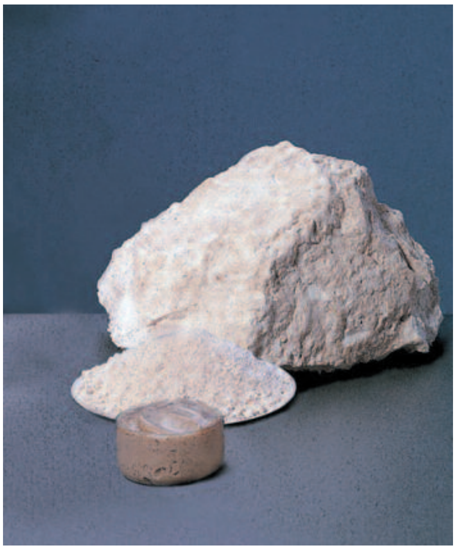
Chemically, sepiolite is a hydrated magnesium silicate with the ideal formula $Si_{12}Mg_8O_{30}(OH)_4(OH_2)_4.8H_2O$. Sepiolite, unlike other clays, is not a layered phyllosilicate. Its structure can be described as a quincunx (an arrangement of five objects, so placed that four occupy the corners and the fifth the centre of a square or rectangle) of talc-type sheets separated by parallel channels. This chain-like structure produces needle-like particles instead of plate-like particles like other clays.



Sepiolite has the highest surface area (BET, N_2) of all the clay minerals, about 300 m^2/g, with a high density of silanol groups (-SiOH) which explains the marked hydrophilicity of this clay. The silicate lattice has not a significant negative charge and therefore the cation exchange capacity of this clay is very low.

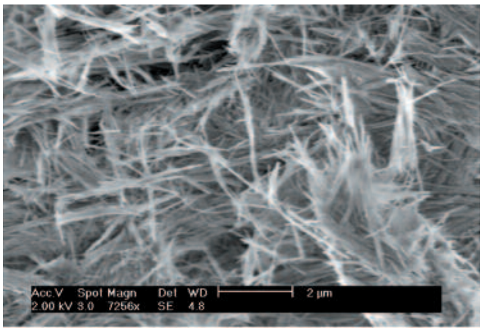
The tiny elongated particles of sepiolite have an average length of 1μm to 2 μm, a width of 0.01 μm; and contain open channels with dimensions of 3.6 Å x 10.6 Å running along the axis of the particle.

These particles are arranged forming loosely packed and porous aggregates with an extensive capillary network which explains the high porosity of sepiolite and its light weight because of the large void space.



The high surface area and porosity of sepiolite account for the remarkable adsorptive and absorptive properties of this clay. It adsorbs vapours and odours and can absorb approximately its own weight of water and other liquids.

Sepiolite is a non-swelling clay and its granules do not desintegrate even when saturated with liquids. Colloidal grades of sepiolite must be dispersed into water or other liquid systems using high-shear mixers. Once dispersed in the liquid, it forms a structure of randomly intermeshed elongated particles, which is maintained by physical interference and hydrogen bonding, and entraps the liquid, increasing the viscosity of the suspension. This structure is stable even in systems with high salt concentrations, conditions that produce the flocculation of other clay's suspensions, as bentonite.



The random network of sepiolite particles holds coarser particles in the liquid preventing their settling by gravity, acting as a suspending agent. Sepiolite provides to its suspensions a pseudoplastic and thixotropic behaviour which make it a valuable material in multiple applications to improve processability, application or handling of the final product.

A special clay with endless uses

The outstanding sorptive and colloidal properties of sepiolite provide specific solutions for a wide variety of industrial applications.

- **Cat and Pet litters:** The popularity of sepiolite pet litters is due to its light weight, high liquid absorption and odour control characteristics. Sepiolite absorbs pet urine and has a dehydrating effect on solid faeces which minimises bad odours and inhibits bacteria proliferation.
- **Industrial absorbents:** Sepiolite absorbs liquid spills and leaks keeping work and transit areas dry and safe. Sepiolite is a non-flammable material with high liquid absorbing capacity, suitable mechanical strength of the granules even in wet conditions, and chemical inertness which avoids reaction with absorbed liquids.
- **Waste treatment:** Sepiolite absorbs toxic and hazardous wastes in stabilization or inertisation treatments.
- **Carrier for chemicals:** Sepiolite absorbs active chemicals, as pesticides, remaining free-flowing and allowing an easy use and effective application of the product in the field.
- **Moisture control:** Sepiolite adsorbs excess humidity preventing condensation, corrosion, the proliferation of microorganisms and unpleasant odours.
- **Household Uses:** Sepiolite has numerous domestic applications such as moisture control, containment of accidental liquid spillages, and use in ashtrays to avoid smoke odour, control of liquid leakages and odours in dustbins, odour removal in refrigerators, etc.
- **Animal Feedstuffs:** Sepiolite is registered in the EU as a technological additive for animal feed (E-562). Sepiolite products are used as binders and anti-caking of free-flowing additives as well as excipient of supplements. Sepiolite-based rheological products are also used as suspending additives in liquid feeds for pigs and ruminants.
- **Fertilisers:** Sepiolite improves stability and components suspension of fluid fertilisers in spraying or fertirrigation applications.
- **Polymers and Elastomers:** The use of sepiolite fillers improve processing, dimensional stability, mechanical strength and thermal resistance.
- **Roof Panels:** Sepiolite improves binding of the components while increasing the fire resistance.
- **Construction additives:** Sepiolite provides thixotropy making for easier application, preventing sagging and providing a better quality finish in mortars, plasters and concrete. It is also used as a processing aid in the manufacture of fibre-reinforced cement products.
- **Bitumens:** Sepiolite allows controlling the rheological properties in heat application systems, improving fire resistance. It also improves the stability and the application in emulsions and asphalt in solvent products.
- **Rheological additives for aqueous systems:** Sepiolite provides stability, pseudoplasticity and thixotropy in different applications as paints, adhesives, mastics and sealants.
- **Rheological additives for organic systems:** Organically modified sepiolite allows controlling the rheological behaviour of different solvent-based systems as paints, greases, resins and inks enhancing their stability under a wide temperature range and making for easier application.

For more information, please contact:

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IMA Europe

Silica

What is silica?

Silica is the name given to a group of minerals composed of silicon and oxygen, the two most abundant elements in the earth's crust. In spite of its simple chemical formula, SiO_2, silica exists in many different forms. Silica is found commonly in the crystalline state but occurs also in an amorphous state resulting from weathering or plankton fossilisation.

Silica exists in ten different crystalline forms or polymorphs, quartz being by far the most common. Quartz is the second most common mineral on the earth's surface and it is found in almost every type of rock, i.e. igneous, metamorphic and sedimentary. Since it is so abundant, quartz is present in nearly all mining operations. It occurs in the host rock, in the ore being mined, as well as in the soil and surface materials above the bedrock, which are called the overburden.

Industry mainly uses the crystalline forms of silica, i.e. quartz and cristobalite. Both are sold as sand, which is a granular material with particles greater than 0.063 millimetres, or as flours that consist of finer particles.

Silica is hard, chemically inert and has a high melting point because of the strength of the bonds between the atoms. These are prized qualities in various industrial uses.

Quartz is usually colourless or white but is frequently coloured by impurities such as iron. Quartz may be transparent to translucent, hence its use in glassmaking, and has a vitreous lustre. Depending on how the silica sand was formed, quartz grains may be sharp and angular or rounded.

For industrial use, pure deposits of silica capable of yielding products of at least 98% SiO_2 are required. Silica sand may be produced from sandstone, quartzite and loosely cemented or unconsolidated sand deposits.

High grade silica is normally found in unconsolidated deposits below thin layers of overburden. It is also found as 'veins' of quartz within other rocks and these veins can be many metres thick.

Silica sand deposits are normally exploited by quarrying and the material extracted may undergo considerable processing before sale. The objectives of processing are to reduce impurities and increase the grade of silica present and to produce the optimum size distribution of the product depending upon end use.

After processing the sand may be sold in the moist state or it may be dried. Dry grinding in rotary mills, using beach pebbles or alumina balls as grinding media is the most common way to produce silica and cristobalite flour.

Since the natural resources of cristobalite are not sufficient for industrial use, it has to be synthetised by the conversion of quartz in a rotary kiln at high temperature (>1500°C) with the assistance of a catalyst.

Multiple properties – manifold uses

- **Paints and Plastics, Polymer Compounds, Rubber, Sealants and Adhesives:** Crystalline silica, as quartz and cristobalite, in its finest flour form is used as a reinforcing filler. Silica flour provides resistance against abrasive actions and chemical attack. Self-cleaning exterior wall coatings and heavy-duty offshore or marine paints are typical examples. The intrinsic properties of silica flour promote its use in plastics for encapsulating electronic components.

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- **Ceramics:** Typical everyday products such as tableware, sanitaryware, ornaments and wall and floor tiles but also high tech ceramics contain silica flour that has been ground to fine sizes to form a major constituent of ceramic glazes. Crystalline silica is a main component in the production of refractory bricks, ladle linings and fluxes.

- **Glass:** Silica is the major ingredient in virtually all types of glass. The principal glass products include containers (bottles and jars), flat glass (windows, mirrors, vehicle glass), tableware (drinking glasses, bowls, decanters), lighting glass (light bulbs, fluorescent tubes), TV tubes and screens (including flat screens), decorative glass optical glass, etc. The glass fibres, mainly used for composite reinforcing or in decorative textiles, are made from fine ground silica flour.

- **Foundry Casting:** Crystalline silica has a higher melting point than iron, copper and aluminium. This enables castings to be produced by pouring molten metal into moulds made out of silica sand and a binder. Castings form the basis of the engineering and manufacturing industries. Quartz and cristobalite flours are the main components in investment casting (also called precision casting) for the production of specialist products such as jewellery, dental bridges, aviation turbines and golf clubs.

- **Filtration:** Closely sized silica sand is the principal filtration medium used by the water industry to extract solids from wastewater.

- **Building Applications, Specialities and Commodities:** The construction industry is founded on silica sand and flours. There are a host of specialist applications including cement manufacture, silica and aerated concrete blocks, glues for roof and floor tiles, flooring and rendering compounds, white line markings, roofing felt and cement and resin injection systems.

- **Sports and Leisure:** Silica sand is used for equestrian surfaces, including the production of all weather horse racing tracks. It is also used in the production of root zones and drainage media for high specification football and other sports pitches and for golf courses. It is also used in play sand pits for the construction of sand castles!

- **Oil field application:** Special grades of silica sand that are of coarse size and have spherical particles are pumped down oil wells and into the oil-bearing strata to improve permeability and the flow of oil into the well.

- **Agriculture:** Silica is used in farming, market gardening, horticulture and forestry in applications such as soil conditioner or carrier for fertiliser and animal feed additives.

- **Chemicals:** Cristobalite sand and high purity quartz are used to produce a range of silicon chemicals including sodium silicate, silica gel, silicones, silicon tetrachloride, silanes and pure silicon. Pure silicon is used for silicon chips, the heart of the computer world. Silicon products are used in the production of detergents, pharmaceuticals and cosmetics.

- **Metallurgical Industry:** Quartz is the raw material for the production of silicon metal and ferrosilicon. Silicon metal is used in the production of alloys based on aluminium, copper and nickel. Ferrosilicon is a major alloying ingredient for iron and steel. Metal ores are purified in the furnace by silica sand that is transformed into metal slag.

For more information, please contact:

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IMA Europe

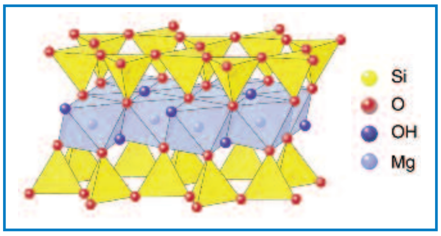
Talc

What is talc?

Talc is the world's softest mineral. Although all talc ores are soft, platy, water repellent and chemically inert, no two talcs are quite the same. Talc is a vital part of everyday life. The magazines we read, the polymers in our cars and houses, the paints we use and the tiles we walk on are just some of the products that talc enhances.

Talc is a hydrated magnesium sheet silicate with the chemical formula $Mg_3 Si_4 O_{10} (OH)_2$. The elementary sheet is composed of a layer of magnesium-oxygen/hydroxyl octahedra, sandwiched between two layers of silicon-oxygen tetrahedra. The main or basal surfaces of this elementary sheet do not contain hydroxyl groups or active ions, which explains talc's hydrophobicity and inertness.

Talc is practically insoluble in water and in weak acids and alkalis. It is neither explosive nor flammable. Although it has very little chemical reactivity, talc does have a marked affinity for certain organic chemicals, i.e. it is organophilic. Above 900°C, talc progressively loses its hydroxyl groups and above 1050°C, it re-crystallises into different forms of enstatite (anhydrous magnesium silicate). Talc's melting point is 1500°C.



Talc is a hydrated magnesium silicate with the chemical formula $Mg_3 Si_4 O_{10} (OH)_2$

Morphology

The size of an individual talc platelet (= a few thousand elementary sheets) can vary from approximately 1 micron to over 100 microns depending on the deposit. It is this individual platelet size that determines a talc's platyness or lamellarity. A highly lamellar talc has large individual platelets whereas a microcrystalline talc's platelets are much smaller.

The elementary sheets are stacked on top of each other, like flaky pastry, and, because the binding forces (known as Van der Waal's forces) linking one elementary sheet to its neighbours are very weak, the platelets slide apart at the slightest touch, giving talc its characteristic softness.

Related minerals

Talc ores also differ according to the type and proportion of associated minerals present. They can be divided into two main types of deposits: talc-chlorite and talc-carbonate. Talc-chlorite ore bodies consist mainly of talc (sometimes 100%) and chlorite, which is hydrated magnesium and aluminium silicate. Chlorite is lamellar, soft and organophilic like talc. It is however slightly less water repellent than talc. Talc-carbonate ore bodies are mainly composed of talc carbonate and traces of chlorite. Carbonate is typically magnesite (magnesium carbonate) or dolomite (magnesium and calcium carbonate). Talc-carbonate ores are processed to removed associated minerals and to produce pure talc concentrate.

Multiple properties – manifold uses

Talc's properties (platyness, softness, hydrophobicity, organophilicity and inertness) provide specific functions in many industries.

- **Agriculture and Food:** Talc is an effective anti-caking agent, dispersing agent and die lubricant and therefore contributes to more efficient functioning of animal feed and fertilizer plants. In premixes and agricultural chemicals, talc makes an ideal inert carrier.

  Talc is also used as an anti-stick coating agent in a number of popular food products and processes including chewing gum, boiled sweets, cured meats, and for rice polishing. In olive oil production, it increases yield and improves the clarity of the oil.

- **Ceramics:** Talc is a phyllosilicate which imparts a wide range of functions to floor and wall tiles, sanitary-ware, tableware, refractories and technical ceramics. In traditional building ceramics (tiles and sanitary-ware), it is used essentially as a flux, enabling firing temperatures and cycles to be reduced.

In refractory applications, chlorite-rich talcs are transformed into cordierite to improve thermal shock resistance. For steatite ceramics, microcrystalline talcs are the most appropriate. During firing, talc is transformed into enstatite, which possesses electro-insulating properties, while very low-iron-content talcs are particularly suitable for use in frit, engobe and glaze compositions.

- **Coatings:** Talcs confer a whole range of benefits to coatings. In interior and exterior decorative paints, they act as extenders to improve hiding power and titanium dioxide efficiency. Talc's lamellar platelets make paint easier to apply and improve cracking resistance and sagging. They also enhance matting. In anti-corrosion primers, talcs are used to improve corrosion resistance and paint adhesion. They also bring benefits to inks, jointing compounds, putties and adhesives.

- **Paper:** Talcs are used in both uncoated and coated rotogravure papers where they enhance printability and reduce surface friction, improving productivity at the paper mill and print house. They also improve mattness and reduce ink scuff in offset papers. Used as pitch control agents, talcs "clean" the papermaking process by adsorbing any sticky resinous particles in the pulp onto their platy surfaces, thereby preventing the agglomeration and deposit of these stickies on felts and calenders. As opposed to chemical pitch-control products that pollute the process water, talc is removed together with the pulp, enabling the papermaker to operate more easily in closed-circuit. In speciality papers, such as coloured papers or labels, talc helps to improve quality and productivity.

- **Personal Care:** As it is soft to the touch and inert, talc has been valued for centuries as a body powder. Today it also plays an important role in many cosmetic products, providing the silkiness in blushes, powder compacts and eye shadows, the transparency of foundations and the sheen of beauty creams. In pharmaceuticals, talc is an ideal excipient, used as a glidant, lubricant and diluent. Soap manufacturers also use talc to enhance skin care performance.

- **Plastics:** Talcs impart a variety of benefits to polypropylene, for instance higher stiffness and improved dimensional stability in automotive parts (under-the-hood/bonnet, dashboard, bumper interiors and exterior trim), household appliances and white goods. Advanced milling technology is required to obtain the finest talcs without diminishing the reinforcing power of their lamellar structure.

  Talcs are also used for linear low density polyethylene (LLDPE) antiblocking and as a nucleating agent in semi-crystalline polymers. In polypropylene food packaging applications, talc is a highly effective reinforcing filler.

- **Rubber:** Talcs reduce the viscosity of rubber compounds, thereby facilitating the processing of moulded parts. They also improve extrudate qualities, increasing production rates and enhancing UV radiation resistance of exterior parts such as automotive profiles. In sealants and gaskets, they provide good compression resistance, whilst in pharmaceutical stoppers, they create a barrier against liquids. In cables, talcs function as insulators and in tyre manufacture they make excellent processing aids.

For more information, please contact:

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