BENTONITE - A Versatile Natural Product

We would like to introduce to you to a natural resource, which is used by modifications in many working and living areas. Let us take this path together that started about 14 million years ago.

Bentonite is a clay mineral, whose name goes back to the American geologist Knight. Around the year 1890 he explored in Wyoming (USA) near Fort Benton a clay deposit. After the place of discovery this material was named bentonite. Decisive for the versatile properties is the montmorillonite, a clay mineral named after its deposit at Montmorillon in Southern France. Bentonite is the name given to an industrial mineral that can contain besides the main component montmorillonite also accompanying minerals such as quartz, feldspar, mica, or calcite.

Important bentonite deposits are found not only in the United States, but worldwide. In Europe it is mined around the Mediterranean, for example in Sardinia, Spain, Greek Islands, Turkey and Morocco. In Germany there are economically interesting bentonite deposits in Bavaria right and left of the river Isar, in the region of Mainburg, Moosburg and Landshut.

In 2007 the bentonite production has been 5.1 million tons in the United States, 3.1 million tons in China, 1 million tons each in Turkey and Greece.

Formation of bentonite - using the example of the Bavarian deposit

The Bavarian bentonites are weathered materials of acidic volcanic glass tuffs. These glass tuffs originate from a massive volcanic activity in the Carpathian arc about 14 million years ago. By soil drifts the volcanic ashes were transported over a distance of about 3,000 kilometres to Bavaria. Here several hundreds of meters of huge sedimentations in river depressions were formed by ash drifts. Due to the influence of water they were quickly covered by sand and marl.

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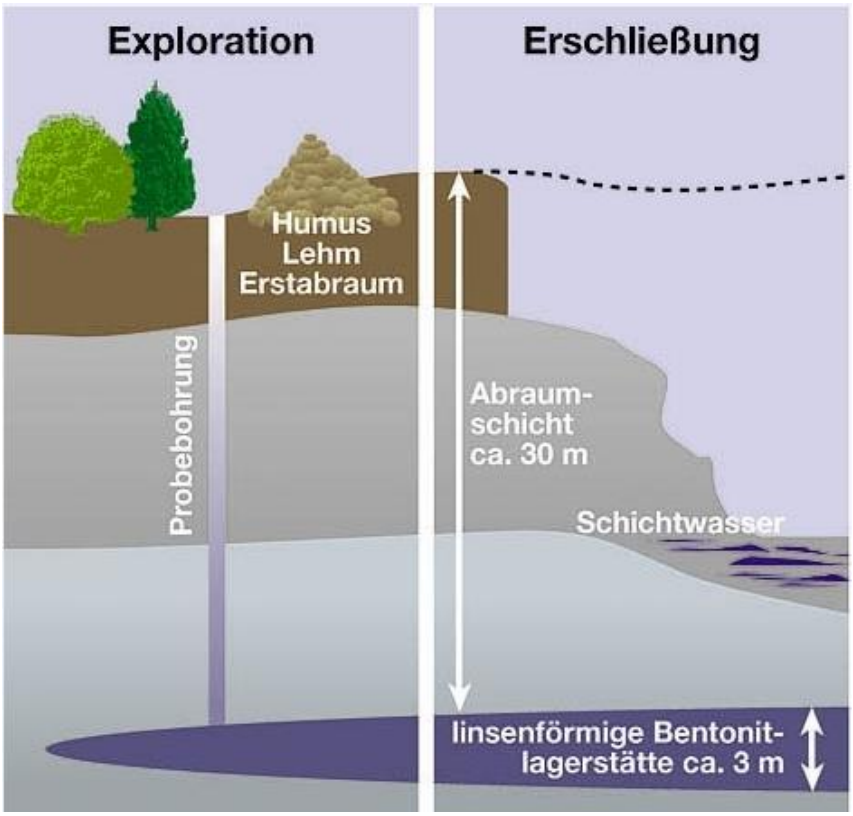
Bentonite extraction is carried out in surface mining. The resulting pits are cultivated and returned to landowners.



In the course of time under appropriate hydrothermal conditions, i.e. under the influence of water and temperature bentonite was formed. For a successful bentonite extraction exploratory drilling has to be carried out to find the mostly lenticular enclosed bentonite. The clay mineral is extracted in surface mining. After the closure of mines the resulted pits are recultivated. The countryside destroyed by mining is restored to its original state and returned to its owners. The new area again can be used for forestry and agriculture.

Modifications of bentonite

Montmorillonite is a crystalline, layer-formed aluminium hydro silicate ($4SiO_2 * Al_2O_3 * H_2O + N * H_2O$). The silicate lamellae consist of three layers: a SiO4 tetrahedron, an aluminium hydrate octahedron and another SiO4 tetrahedron.

Each crystal consists of 15 to 20 silicate lamellae. By replacing trivalent aluminium in the octahedral layer by divalent ions (e.g. magnesium) the individual lamellae have negative excess charge, which is compensated by the incorporation of exchangeable cations such as calcium and/or sodium ions into the interlayer. The characteristics of the montmorillonite can be enhanced by chemical post-treatment.

Raw clay from the pit has a moisture content of 30 to 40%. If used as **natural bentonite** it will be dried to approximately 10 to 15% moisture content. With suitable crushing devices products with defined particle sizes are produced. Natural bentonites are commonly used in food, cosmetics and animal feed production. The **alkaline activation** is based on ion-exchange reaction, where the alkaline earth metals of montmoril

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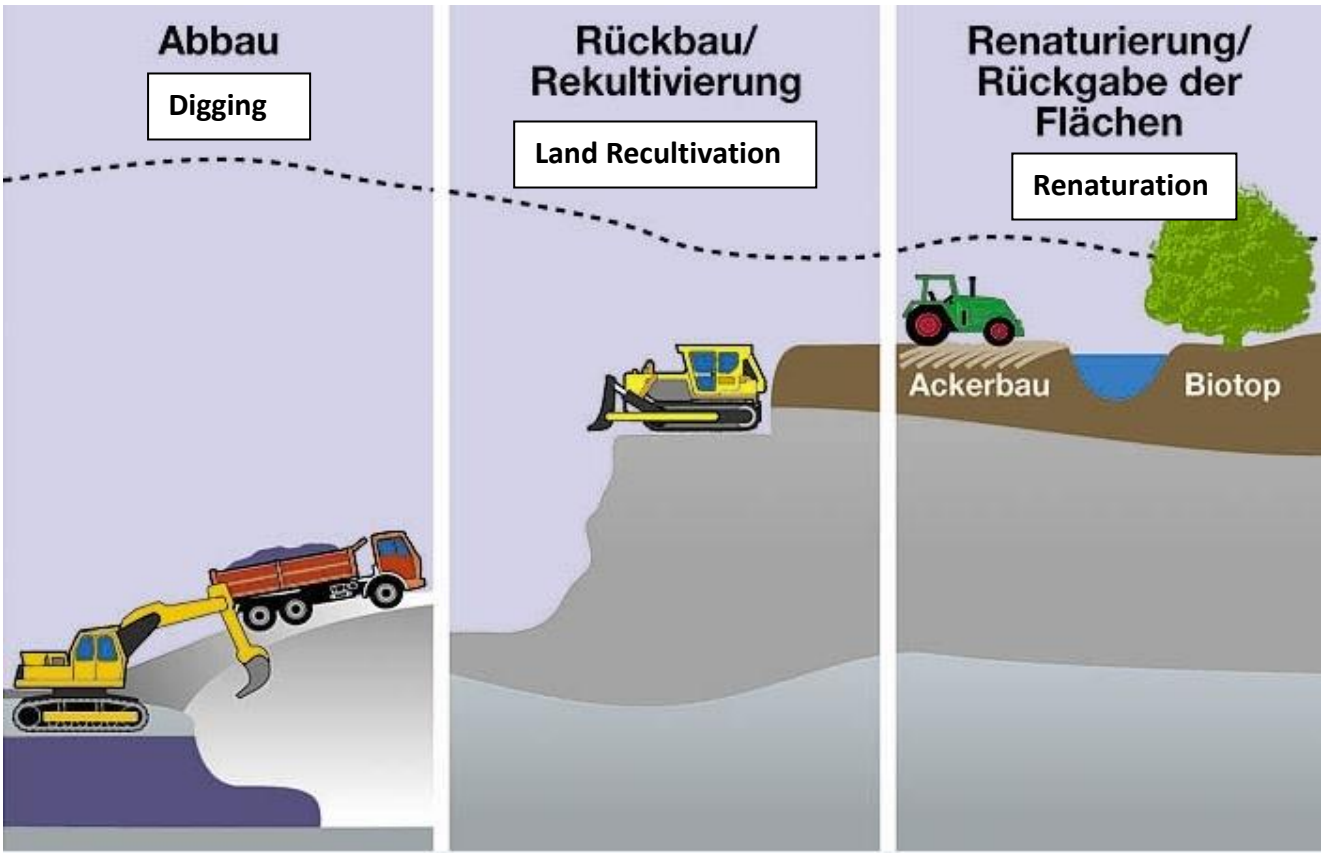
lonite are replaced by alkali metal ions. These particles are located at the edges and in the intermediate layers. In the presence of water they have a tendency to hydrate. This results in the incorporation of water between the layers and subsequently in strong expansion of interlayer distances. The intracrystalline swelling results in expansion of the interlayers which helps to explain the high adsorption and water retention.

To achieve maximum adsorption alkaline activated bentonites are mainly used in pre-dispersed, extended form.

This product group is characterized by thixotropic behaviour. This means: when products containing these additives are shaken or stirred they change from gelatinous to liquid state. At rest again gel is formed.

In the case of **acid activation** bentonites are treated with mineral acids (hydrochloric or sulphuric acid). The exchangeable cations are replaced by hydrogen ions. Depending on reaction conditions aluminium and magnesium ions are also dissolved out of the octahedron layers. The voluminous silicic acid remains, which is connected via SiO_4 tetrahedrons to the unaffected montmorillonite. The acid treatment leads to the loose of crystal structure and to a strong increase of the specific surface area (m^2 /g).



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After dispersing in water the crystal structure remains intact with a stable pore structure and a high content of macro pores.

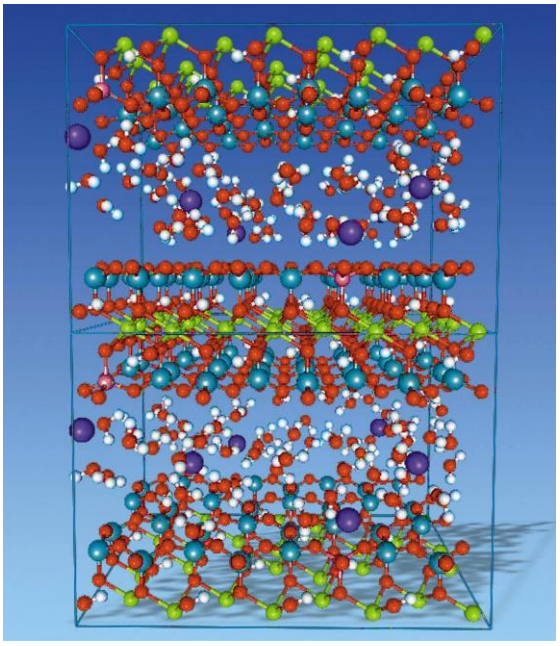
For the production of **organophilic bentonites** quaternary alkyl ammonium compounds are used. The exchange of interlayer cations results in products, which are used to modify rheology (thixotropic) of organic solvents, oils, fats, ointments and plastics.

By the organic modification the polarity of the bentonite surface is reversed.

The originally hydrophilic bentonite surface is made hydrophobic. This will allow the complete dispersion of silicate platelets in organic solvents.

Bentonite for the application in paper industry

Carbonless multiple form sets contain sheets of paper with different coatings: The coated back paper (top sheet) has a releasing layer and the coated front paper (final sheet) has a receiving layer. By pressing the top sheet the dye capsules on the back are destroyed. The colourless pre-stage is adsorbed by the absorbent receiving layer. The acid activated bentonite within the receiver layer reacts as a colour developer to a coloured final stage.



Structure of a montmorillonite crystal - a crystalline layered aluminium hydro silicate.

Even small quantities of coating-bentonites provide a good coverage of paper surface. In coating formulations binder content can be reduced and the production of paper qualities for various printing methods is possible.

Fast running paper machines require micro particle systems in order to set the following parameters: retention, drainage and formation. Combined with synthetic and natural polymers alkaline activated bentonites provide the desired solutions.

The closure of water and stock loops and the increasing load of impurities from raw materials lead inevitably to a build-up of stickies. Bentonite is used for the passivation of sticky components.

In peroxide bleaching heavy metals are bonded to bentonite and the bleaching agent is destroyed in an environmentally friendly manner.

Bentonite for the application in detergents

The extremely soft and thin silicate platelets are deposited on textile fibre surfaces and ensure soft hand of fabrics.

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They offer an environmentally friendly alternative to organic fabric softeners.

In agglomerate form bentonites are used as a substrate for different detergent additives (optical brighteners, dyes, surfactants).

Use of bentonite as cat litter

Usually cat litter consists of clay minerals (e.g. bentonite). Due to their porous structure they are able to absorb a lot of moisture. The advantage of a clumping cat litter is that the litter can be sieved and therefore sparingly used.

Bentonite for the application in iron ore industry

In iron ore industry bentonite is used as a binder in ore pelletisation. In the processing very fine-grained ore is produced, which has to be pelletized for further processing in the blast furnace. This is done with a drum process by adding water and bentonite.

Bentonites for the application in foundry industry

Anyone who has ever built a sand castle on the beach knows that it breaks down, when the sun dries the sand. By adding only small quantities of bentonite the castle is preserved, because bentonite binds water and this ensures sufficient cohesion of sand grains.

To produce foundry moulds from quartz sand and water for the liquid metal bentonite must be added to the mixture. The silica grains are bonded and well integrated. The moulding sand become sufficiently plastic and receives the necessary stability to withstand the temperature of the molten metals.

Bentonite for the application in building industry and drilling

Bentonite suspensions are used to stabilize drill holes and to transport the drilled material. This feature enables a wide variety of works, from cable laying in horizontal drilling up to the construction of tunnels. Bentonite suspensions support the excavated slots of slot-off walls and make additional boardings redundant.

Bentonite for landfill sealing

When it is raining, at landfills there is always a danger that stored pollutants are leached out into the groundwater.

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Bentonite prevents this by swelling in contact with rainwater and forming a layer impermeable to water. These seals are extremely insensitive to temperature fluctuations. They cracks and leaks are not formed such as is the case of using asphalt.

Use of bentonite in bleaching clays

For refining of edible and mineral oils, fats and waxes, acid-activated bentonites (so-called bleaching clays) with a specific surface 200-400 m \ g are used.
By removing unwanted accompanying substances such as dyes and oxidation products besides brightening also taste stabilization is achieved.

Use of bentonite In beverage preparation

Bentonite adsorbs proteins and other impurities in wine, beer and fruit juices.
The improvement of durability and compatibility is called fining, stabilization and clarification. After clarification the bentonite is removed without any residue from the liquid.

Use of bentonite in soil improvement

Bentonite mixed with soil prevents premature drying and seeping away of rainwater into the ground. Nitrogen, phosphorus and calcium fertilizers, which are flushed out from the soil by the rain, are adsorbed by bentonite.

Use of bentonite for soil improvement

Instead of grass, fresh grains and field crops increasingly prepared feed is fed to farm animals.

Bentonite is a versatile natural product, which contributes to improve quality of life in many areas

Frequently animal feed is mould infested with so-called mycotoxins releasing dangerous toxic substances. Mycotoxin adsorbers are based on bentonite. They are added to the feed to bind the mycotoxins. Thus, mycotoxines do no longer affect the metabolism of the animals but they are excreted.

Use of bentonite in waste water treatment

In the activated sludge biology bentonite is used as a nursery area for bacteria. Thus, the purification capacity of the activated sludge is stabilized in regard to carbon and nitrogen degradation. Bentonite has a high adsorption and buffering capacity for cations (eg NH_4^+ - ions). The addition of bentonite improves sludge weighting and sludge thickening.

Use of bentonite in drying agents

Bentonites are used for the packaging of high-quality and sensitive goods. Despite adverse conditions it ensures that quality is maintained during storage and transportation. Bentonite adsorbs occurring moisture and the goods will remain dry and free flowing, even if fully loaded. The water vapour absorption capacity is approximately ten percent by weight in dry environment and up to 30 weight

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percent in humid environment.

Conclusion

Bentonite has a variety of properties: high adsorption and absorption capacity, high pore volume, high specific surface area, high intracrystalline swelling capacity, high water retention capacity, high aspect ratio, it contains small particles (nanoparticles), and is a charge carrier. Therefore, it is an extremely versatile natural product contributing to improve life quality in many areas, and, moreover, bentonite is an environmentally friendly product.