BENTONITE E06

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IDENTIFICATION

SYNONYMS: Sodium and calcium montmorillonites, montmorillonite clay, smectite clay, volcanic clay, soap clay, mineral soap. Other terms for sodium montmorillonites are sodium bentonite, swelling bentonite, Wyoming or Western bentonite, while calcium montmorillonites are referred to as calcium bentonites, non-swelling bentonite, Southern bentonite or fuller's earth, sub-bentonite.

COMMODITY: Bentonite (many different grades for a variety of applications and end uses).

EXAMPLES (British Columbia (MINFILE #)- *Canada/International*): Hat Creek (0921NW084), Princeton (092HSE151), Quilchena (0921SE138), French Bar (0920099); *Rosalind (Alberta, Canada), Truax (Saskatchewan, Canada) Morden (Manitoba, Canada), Black Hills District, Big Horn Basin (Wyoming, USA), Gonzales and Lafayette Counties (Texas, USA), Iwambaand and Monroe Counties (Mississippi, USA), Milos (Greece), Landshut (Germany), Sardinia (Italy), Annalka (Japan), Campina Grande (Brazil).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Montmorillonite-rich clay beds intercalated with shales, sandstones and marls which are part of shallow marine or lacustrine environment deposits.

TECTONIC SETTINGS: Virtually all continental or continental platform settings; also common in island arcs.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Bentonite deposits form when volcanic ash is deposited in a variety of freshwater (sometimes alkaline lakes) and marine basins characterized by low energy depositional environments and temperate climatic conditions.

AGE OF MINERALIZATION: Mostly Cretaceous to Miocene age, but are known to be as old as Jurassic and as recent as Pleistocene.

HOST/ASSOCIATED ROCK TYPES: Bentonites are hosted by and associated with argillite, mudstone, siltstone, sandstone, tuff, agglomerate, ignimbrites, marl, shale, zeolite beds and coal.

DEPOSIT FORM: Beds range in thickness from several centimeters to tens of meters and can extend hundreds of kilometres. In island arc environment, bentonite can also occur as lens-shaped bodies with a limited lateral extent.

TEXTURE/STRUCTURE: Bentonite is bedded, with a soapy texture and waxy appearance. It ranges in colour from white to yellow to olive green to brown to blue. In outcrop, bentonite has a distinctive "popcorn" texture.

ORE MINERALOGY [Principal and *subordinate*]: Montmorillonite, *beidellite, illite.*

GANGUE MINERALOGY [Principal and *subordinate*]: Mica, feldspar, quartz, calcite, zeolites, gypsum, *opaline silica, cristobalite, unaltered volcanic glass.* These minerals rarely constitute more than 10% of a commercially viable deposit.

ALTERATION MINERALOGY: Alteration consists of devitrification of the volcanic ash with hydration and crystallization of the smectite mineral. In some instances there is evidence of a loss of alkalies during the alteration. Also, silicification of beds underlying some bentonites indicates downward migration of silica. There is also sometimes an increase in magnesium content compared to parent material. Besides smectite minerals, other alteration products in the volcanic ash include cristobalite, opaline silica, zeolites, calcite, selenite and various iron sulphate minerals.

WEATHERING: Yellow colouration (the result of oxidized iron ions) may improve the colloidal properties of bentonite. Also, weathering may decrease exchangeable calcium and increase exchangeable sodium. Some soluble impurities like calcite, iron sulphates or selenite may be removed by weathering process.

ORE CONTROLS: The regional extent of bentonite deposits is controlled by the limit of the regional deposition environment, paleogeography and distribution of the volcanic pyroclastic unit. Porosity of the host rocks may be important for the alteration process. Deposits in the continental and continental platform settings are the largest.

GENETIC MODELS: Volcanic pyroclastic material is ejected and deposited in shallow marine or lacustrine setting. Bentonite is a product of alteration of the glass component of ashes and agglomerates. Alteration of the glassy pyroclastic material possibly starts when the ash contacts the water or may occur soon after the ash reaches the seafloor or lake bottom. Wyoming bentonites, however, were altered after burial by reaction with diagenetic seawater pore fluids

ASSOCIATED DEPOSIT TYPES: Other clays, zeolite (D01, D02), lignite coal (A02), sepiolite, palygorskite (F05).

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Nil

GEOPHYSICAL SIGNATURE: Apparent resistivity and refraction seismic survey may help to interpret the lithology.

OTHER EXPLORATION GUIDES: Sedimentary basins with volcanic ash layers. In some locations bentonite layers can form a plane of weakness that results in landslides. Montmorillonite displays popcorn texture on the dry surface.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE: Montmorillonite content is usually more than 80%. Other properties depend on specifications for particular applications. Published data on individual deposits are very scarce. Typically, commercial beds in Wyoming are 0.9 to 1.5 metres thick. Individual bentonite beds are continuous for several kilometres. The Wilcox mine in Saskatchewan has three bentonite seams - 61, 46 and 30 centimetres thick within a 6 metre thick sequence of shale. In Manitoba, another mine has 6 beds which have a cumulative thickness of about 76 centimetres within a 1 meter sequence.

ECONOMIC LIMITATIONS: Value of the product depends on the type of impurities, colour, size of clay particles, cation exchange capability, rheological properties and structures of the clay. Sodium bentonites are of more interest because of swelling properties and in general higher cation exchange capacity. Calcium bentonites are frequently activated by acids or soda ash to provide better performing product. Economic viability is often determined by the thickness of the overlying strata and overburden. The Wyoming deposits are mined with up to 12 metres of overburden. The 1997 quoted price for Wyoming bentonite is from US$25 to 40 a short ton.

END USES: Main uses for bentonite are in foundry sands, drilling muds, iron ore pelletizing and absorbents. Important applications are also in civil engineering for a variety of composite liners and as a food additive for poultry and domestic animals. (Special uses include filtration in food processing, cosmetics and pharmaceuticals.)

IMPORTANCE: Bentonite is an important industrial mineral; about 6 million tonnes are produced annually in North America. Declining markets in drilling mud and pelletizing will likely be easily offset by increasing use in environmental applications like liners and sealers.

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