



NSW DEPARTMENT OF
PRIMARY INDUSTRIES

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Photograph 2. Arumpo bentonite mine, Arumpo. The bentonite deposit (green–grey clay at base of photograph) contains high-purity sodium–magnesium bentonite formed during the alteration of volcanic ash deposited in the Pliocene Loxton-Parilla Sands. (Photographer J. Whitehouse)

Potential and Outlook

Bentonite clays (Photograph 2) are minerals of the montmorillonite (smectite) group. There is excellent potential for commercial bentonite deposits in the state, particularly in volcanogenic sedimentary rocks in Permian and younger sequences in eastern New South Wales, and in Cretaceous to Tertiary sequences in the western parts of the state (Figure 4).

Sodium bentonite forms in marine sedimentary basins adjacent to intermediate volcanic sources. There is a number of these settings in New South Wales, especially along the western margins of the highlands. For example, there are tuffaceous units derived from dacitic volcanoes within the Rylstone Volcanics east of Mudgee. Although Permian, these rocks have apparently never been deeply buried, and some are reportedly sodium-rich. Their location, however, is unknown.

Younger potential settings occur near volcanic complexes in Cretaceous–Tertiary basins near Canobolas (near Orange), Warrumbungle (near

Coonabarabran), and Kaputar (near Narrabri) (Figure 4). Areas east of these complexes may have greatest potential, because prevailing winds were probably westerly during the main volcanic activity.

The identification of the large, high-purity, sodium–magnesium Arumpo bentonite deposit in the Murray Basin indicates the strong possibility of other similar deposits in this region.

The widespread occurrence of bentonite globally and the development of new deposits overseas is progressively eroding international trade in the commodity. Also, flat or diminished demand in the major markets (foundry and iron ore pelletising and petroleum well-drilling muds) has, until recently, decreased the market stimulus for further developments.

There has been little systematic exploration for bentonite in the Murray Basin, except in areas of known discoveries that were originally located during exploration for mineral sands.



Figure 4. Bentonite occurrences in New South Wales

Nature and Occurrence

'Bentonite' and 'fullers earth' are terms used for any clay materials belonging to the smectite group, of which the most common mineral species is montmorillonite. Bentonite varieties are distinguished on the basis of their principal exchangeable cation, hence sodium-, calcium-, magnesium- (saponite), potassium- (meta-bentonite) and lithium- (hectorite) bentonite.

A general formula for montmorillonite is $(\frac{1}{2}\text{Ca}, \text{Na})_{0.7}(\text{Al}, \text{Mg}, \text{Fe})_4[(\text{Si}, \text{Al})_8\text{O}_{20}](\text{OH})_4 \cdot n\text{H}_2\text{O}$ (Deer et al. 1992).

Bentonite occurs in sedimentary or volcanic sequences where it forms in-situ by the alteration of volcanic ash or tuff. Alteration processes may include deuteritic alteration, hydrothermal alteration and sub-aqueous devitrification.

Most bentonite deposits form under marine conditions or, less commonly, in alkaline lakes. Andesitic to rhyolitic volcanic rocks are the most common primary source. The final chemical character of the bentonite

is dependent on the combined influences of the chemistry of the primary rock, the environment in which it was deposited and its post-formation history.

Bentonitic units are commonly laterally extensive strata within volcanogenic sedimentary sequences. They may vary in thickness from a few centimetres to tens of metres, and range from Permian to Pleistocene in age. The most economically important sodium-bentonites tend to be associated with Jurassic or younger volcanic rocks. This is because smectite clays are unstable at higher pressures, and bentonite is increasingly transformed into mixed illite-smectite with increasing depth of burial.

Total world output of all types of bentonite in 2004 was about 10.5 Mt (Virta 2005). The USA accounts for nearly one half of world production. Other major producers include the former Union of Soviet Socialist Republics (USSR), Greece, Germany, Turkey, Japan and Italy.

Deposit Types

The world's major bentonite deposits have been discussed by Harben and Bates (1990), Elzea and Murray (1994) Harben and Kužvart (1996).

The Cretaceous 'Wyoming' or 'western' bentonite deposits of the USA are the world's principal source of high-swelling capacity sodium-bentonite. Major mines are located in Wyoming, Montana and South Dakota. With the exception of a relatively small deposit of freshwater origin, these deposits are believed to have formed after the burial of volcanic ash beneath several hundreds of metres of marine sediment. They are intercalated with organic-rich marine shale.

Major calcium-bentonite deposits of Cretaceous to Miocene age are mined in Texas, Mississippi, Alabama, Oklahoma and Louisiana in the southern USA.

Tertiary and Cretaceous bentonite deposits occur in the former USSR, including the Ukraine, Azerbaijan, Kazakhstan, Georgia, Uzbekistan and Turkmenistan.

Greece is the third-largest producer of bentonite in the world. There are predominantly calcium-bentonite deposits on the Greek Aegean island of Milos, and much less important deposits on Mykonos and Kimolos. The bentonitic sequence on Milos is up to 30 m thick. Origins suggested for these deposits include the alteration of Pliocene volcanic ash deposited in a marine environment and the hydrothermal alteration of dacitic tuff.

The calcium-bentonite deposits of Bavaria in southern Germany support one of the largest bentonite mining industries in the world. The deposits occur in a sequence of late Miocene marine marls and tuffaceous sands, and probably formed through the in-situ lateritisation of felsic tuff.

Predominantly calcium-bentonite, but also some sodium-bentonite, occur in association with extensive Cretaceous volcanic rocks in southern and central Turkey.

Japan has volcanic-associated sodium- and hydrogen-montmorillonite deposits. Theories on the origin of the sodium-bentonite include: diagenetic alteration of rhyolitic ash which had originally been altered during deposition in a marine environment; hydrothermal alteration of rhyolite or rhyolitic tuff; and the alteration of rhyolitic ash and pumice in a marine environment.

The calcium-bentonite deposits of the Italian island of Sardinia formed by the hydrothermal alteration of trachyte and trachytic tuff. At Uri, a succession of 1 m to 2 m thick lenses of bentonite appears to have formed by the preferential deuteric alteration of pyroclastic lenses in a trachyandesite.

Main Australian Deposits

Bentonite is relatively common in eastern Australia, particularly in Queensland and New South Wales. Australia currently produces about 100 000 tpa of bentonite, mostly from Queensland. New South Wales produces about 25 000 tpa and there is minor production from Western Australia.

Bentonite has been mined at several sites in southeastern Queensland. The largest operation is that of Unimin Australia Ltd at Miles, southeast of Roma, where calcium-bentonite and sodium-bentonite occur in the Jurassic Orallo Formation.

In Western Australia, magnesium-rich bentonite (saponite) is mined from deposits of Cainozoic age in claypans near Moora, about 300 km north of Perth.

New South Wales Occurrences

There are 34 occurrences of bentonite recorded in the New South (Ray et al. 2003). A detailed study of the geology and occurrence of bentonite and fullers earth in New South Wales was undertaken in the early 1980s (Holmes 1983).

Most of the known deposits in New South Wales are calcium-bentonite, and are considerably older than the major overseas deposits. Deposits in the Hunter Valley are either Permian (derived from volcanic rocks in the coal measures) or Carboniferous (related to terrestrial volcanic rocks). They include deposits at Cressfield, Trida, Muswellbrook, Raymond Terrace, Boggabri and Eraring. The occurrences associated with the Permian coal measure sequences reputedly have very high swelling capacities and are likely to be sodium-bentonite. Bentonite also occurs in Tertiary volcanic sequences in the Inverell–Glen Innes area of New England (Holmes 1983).

The state's largest known bentonite resource is the Arumpe deposit (Photograph 2), 40 km southeast of Pooncarie. It contains 70 Mt of sodium–magnesium-bentonite (Browns Creek Gold NL 1993). The deposit consists of several bentonite layers with individual thicknesses of 5 m to 10 m or more. These are developed over a northwest-trending area about 1 km wide and several kilometres long and conformably overlie the Pliocene Loxton-Parilla Sands of the Cainozoic Murray Basin. They appear to have accumulated in a coastal back-barrier setting fed by several volcanic eruptions. Growth faulting played a major role in determining their thickness and saline groundwater may have had a significant influence on the formation of the bentonite (A. Mason pers. comm, 2004). Mineral sands mining and exploration over the past few years indicate that bentonite deposits are more common in the Murray Basin than previously recognised.

Although the Arumpo deposit is large by world standards, it is not comparable in size to the vast resources of sodium–bentonite in Wyoming (USA).

Applications

The special properties of bentonite, which include hydration, swelling, water absorption and viscosity, make it a valuable mineral for many applications. These properties vary according to the dominant cations present. Sodium (swelling) bentonite uses include drilling fluid (mud), water-softening, bonding or pelletising agent, foundry-moulding sand, and impermeable liner. Calcium (non-swelling) bentonite uses also include foundry-moulding sand as well as feed additives, pet product absorbents and detergents.

Economic Factors

Bentonite is produced in many countries and, in some, the industry is well-established, large-scale, and has a high profile (e.g. sodium-bentonite in the USA).

Consumption of bentonite is closely linked to global economic activity. Major markets include drilling muds (the demand for which is largely tied to activity in the oil and gas exploration industry); pelletising (where the main markets closely reflect demand for iron and steel, and are thus linked to demand for consumer durables); pet litter adsorbents (the demand for which is a function of consumer affluence and environmental awareness); and the construction and

pollution control industries (where a combination of economic expansion or contraction and legislative control exert significant influence).

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