AMCOL Australia’s Gurulmundi mine
A leading supplier of high quality sodium bentonites

A
mcol International Corp said, it's acquiring the bentonite mining rights from Phoslock Water Solutions Ltd and the processing facility, that “these local bentonite mineral rights will not only strengthen our position in the metalcasting market, but will allow Volclay Pty Ltd the ability to grow in local construction markets and provide a valuable addition to Amcol’s bentonite resources in the Asian region.”

Since then, Amcol, an MTI company, the world’s largest bentonite company has been mining, processing and servicing a wide spectrum of markets from this high-quality reserve. Detailed exploration during this period has added significantly to the reserve base, which now stands at >1.3m short tonnes, secured by long-term mining leases ML 55007 and 55008.

As noted by Mr Les Bone, managing director of Amcol Australia, “Most recently we have been able to increase our exports due to the weakening of the Australian dollar, making the economics better for export. We have, over the last year, increased our export business based on the quality of our clay reserves, which has been aided by the weakening currency.”

According to Mr Hugh Parker, managing director, Amcol Asia, “Our global expertise in clay mining, blending and activation from all of our mine sites including Australia, China, Turkey and the US, continues to be the backbone of our global supply, as Amcol mines high quality products from our own mines across our market segments. The Queensland mine has allowed Amcol Business Units to provide options to our customers across the market space we operate in.”

Geological setting
Amcol Australia’s sodium bentonite mine, is located near Gurulmundi, 40km north of Miles, some 350km inland of Brisbane in Queensland, eastern Australia, in an area where bentonites were first reported in the 1960’s (e.g. Exon and Duff, 1968). Geologically, the bentonite deposits are hosted by the Orallo Formation of the Jurassic/Cretaceous Surat Basin, which straddles south east Queensland and northern New South Wales.

Sedimentary fill is believed to have been derived predominantly from volcanic rocks of the Cretaceous Whitsunday Volcanic Province and Graham Volcanics of the Maryborough Basin to the north east (Figure 1). Sandstones within the Surat Basin are dominantly volcanogenic and feldspar-lithic (average Q:F:Li ratio of 15:41:44), in which volcanic lithic grains represent more than 90% of the total lithic component (Bryan et al., 2012).

The Whitsunday Volcanic Province (recently described as a silicic Large Igneous Province, or LIP) is predominantly comprised of dacitic to rhyolitic lithic ignimbrites, with ignimbrite-dominated sequences exceeding 1 km in thickness. Pyroclastic deposits, subordinate basalt and rhyolitic lavas and coarse-grained volcanoclastic conglomerate and sandstone are interbedded with the ignimbrites (Bryan et al., 1997, 2000, 2012).

| Table 1. Representative whole-rock major-element chemistry (%) for bentonite beds intersected in boreholes from across the property. Analyses by Intertek Genalysis Perth, using lithium borate fusion / XRF. |
|-----------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| SiO₂ | Al₂O₃ | CaO | Fe₂O₃ | K₂O | MgO | Na₂O | SO₃ | TiO₂ | LOI | Total |
| 72.0 | 14.8 | 1.4 | 3.0 | 0.4 | 1.6 | 1.8 | 0.1 | 0.3 | 4.8 | 100.1 |
| 71.7 | 14.9 | 1.1 | 2.3 | 0.7 | 1.8 | 2.1 | 0.6 | 0.4 | 4.9 | 100.2 |
| 71.4 | 14.0 | 1.8 | 2.2 | 0.7 | 1.5 | 2.1 | 0.5 | 0.3 | 5.4 | 99.9 |
| 69.7 | 16.4 | 0.4 | 2.9 | 0.6 | 2.0 | 1.3 | 0.1 | 0.6 | 5.3 | 99.3 |
| 66.2 | 18.8 | 0.6 | 3.3 | 1.0 | 1.9 | 1.6 | 0.1 | 0.8 | 5.7 | 99.9 |
| 65.9 | 15.8 | 2.0 | 4.2 | 0.6 | 2.1 | 1.8 | 1.4 | 0.5 | 6.0 | 100.4 |
| 65.8 | 18.5 | 1.6 | 3.0 | 0.5 | 2.2 | 1.7 | 0.1 | 0.5 | 6.0 | 99.9 |
| 65.2 | 17.1 | 1.6 | 4.6 | 0.7 | 2.2 | 1.7 | 0.7 | 0.5 | 5.7 | 99.9 |
| 64.6 | 18.9 | 1.4 | 3.2 | 0.8 | 2.2 | 2.1 | 0.2 | 0.8 | 6.1 | 100.1 |
| 62.7 | 20.3 | 0.1 | 5.0 | 0.4 | 2.6 | 1.1 | 0.1 | 0.7 | 7.2 | 100.1 |

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The Orallo Formation is located within the upper part of the Surat Basin and comprises clayey lithic sandstone, siltstone, minor mudstone and bentonite, deposited within a high energy fluvial/lacustrine to coastal plain and shallow marine environment. The contact between the Orallo Formation and the Mooga Sandstone is characterised by bentonite beds in the upper Orallo Formation, overlain by a laterally discontinuous polymictic conglomerate at the base of the Mooga Sandstone. Silicified fossil wood is fairly common in sandstones and conglomerates of the Orallo Formation above the bentonite. The rock strata strike NW and generally dip at 2 to 3° to the southwest.

At least ten bentonite beds of current and potential future economic interest have so far been identified on the property; these range up to ~ 4m in thickness and vary in colour from medium bluish gray through to olive gray and light olive-gray (Figure 2) to yellowish gray. Each bed is characterised by a distinctive mineralogical and chemical fingerprint, but in the main consist of dioctahedral smectite (montmorillonite) with lesser quantities of other constituents including feldspar, kaolinite, quartz and zoisite. The beds are capped by volcanoclastic rocks identified petrographically as other tuff or ignimbrite (Figures 3a & 3b) in addition to volcanoclastic sandstone which is often cross-bedded.

**Exploration, resource modelling and grade classification**

Exploration follows standard geological procedures, such as field mapping, of fine-grained volcanoclastic layers, sandstone and conglomerate marker beds followed by trenching and drilling. Drilling is by the rotary air blast (RAB) method at approximately 25m spacing for reserve definition and mine planning purposes, based on 0.5m sample intervals (Figure 4) which are sometimes split down to 0.25m according to lithologies. Clay colour is logged and coded according to Munell color chips such that, for example, light olive gray is coded as 5Y 6/1 and yellowish gray as 5Y 8/1.

**Figure 1.** Map of eastern Australia showing location of the Whitsunday Volcanic Province and Maryborough Basin/Graham Volcanics, relative to the Great Artesian Basin system. The Surat Basin is highlighted separately, with arrows indicating palaeocurrent direction from the volcanic sources. Miles town is about 40km south of AMCOL’s bentonite mine. Map modified after Bryan et al 1997, 2012.

**Figure 2.** Light olive-gray to olive gray SD bentonite of the transition zone, overlain by interbedded tuff/ignimbrite, shale and bentonite (SDHW) and volcanogenic sandstone. SD bentonite at this locality is 2m thick.

**Figure 3a.** Thin section of fine-grained volcanoclastic rock characterised by cuspatel volcanic shards, an elongate laminated autoclast and matrix-filled bubbles. Although the rock textures are almost perfectly preserved, the original glassy matrix and some of the shards have been replaced by clay minerals. Scale bar = 500 µm. Sample number AS4A.

**Figure 3b.** SEM images of sample AS4A illustrating a cuspatel shard with filled bubble (left hand image, scale bar = 100 µm) and part of a contorted autoclast (right hand image, scale bar = 500 µm).

**Figure 4.** Samples from RAB pit probe 12Q0003. Each sample represents 0.5m vertical thickness; note the light olive gray to olive gray samples of SD bentonite between 5 and 7 metres depth below pit floor (10 to 12 metres below original top surface). Borehole ID tag marks the collar.

**Figure 5.** Chip tray samples at 1m intervals from pit probe 12R0003. Note SD bentonite from 5 to 7m.
As part of accepted QAQC procedure required for public reporting, duplicates and standards are each inserted at a ratio of 1:20, both for control purposes and to verify lab accuracy and precision. Umpire samples are on occasion submitted to other in-house labs on a round-robin basis, to benchmark the Australian lab.

All exploration samples were photographed (Figure 4), sampled and sealed in plastic bags to retain 'in-situ' moisture for resource modelling purposes. Small samples representative of 1m intervals are retained in chip trays, photographed and stored for future reference as part of standard QAQC procedure (Figure 5). Closer spaced infill pit probes are drilled following overburden removal, for confirmation of grades.

In situ bulk density (ISBD) is a metric that in the author's opinion is often neglected by industrial minerals resource geologists and, as noted by Lipton & Horton, 2014, "There are three fundamental inputs to any mineral resource estimate; grade, volume and bulk density. The mining industry expends much time and effort on obtaining accurate estimates of the grade and volume of mineralised material.... unfortunately, there is often less attention paid to the third parameter, bulk density."

Poor estimates of density result in poor tonnage estimates and also make reconciliation difficult after mining. In situ bulk density (t/m³) is defined as 'the density of the material at natural water content', Lipton and Horton, 2014, which is the reason why AMCOL Australia takes care to seal drill samples in plastic bags to retain in-situ moisture as well as feasible.

AMCIL Australia has determined bulk density on several of the Gurumundi bentonites by core drilling and the 'callipier method' as described by Lipton & Horton, 2014. Accordingly, the ends of the core sample are cut with a saw perpendicular to the long axis of the core to create a regular cylindrical sample. The diameter of the core is determined with a pair of callipers at several points and the results averaged. The length of the core is determined with a ruler and the volume calculated. The mass of the solid is determined by weighing the core. Then by using weight/volume the ISBD is derived, which in the case of 5D light olive grey bentonite = 1.8 tonnes/m³ (112 lb/cu ft). This number has recently been validated by reconciling tonnes ‘hauled’ with in-situ tonnes modelled, over several mining campaigns.

In common with bentonite deposits elsewhere (e.g. Williams et al., 1953) weathering processes play a significant role in the development of different grades across the property. Taking the 5D bed as an example, there is a progressive change from bluish grey un-oxidised bentonite at depth, through an olive grey transition into pale grey and finally light brown clay near the outcrop (Figures 6 & 7). This is due to the oxidation of iron, as evidenced by iron-oxide stains on joints in the transition zone and we see a progressive change in basic characteristics and performance metrics from deep to shallow bentonite:

- 5D Bentonite of medium bluish grey colour generally has pH > 8.5, high fluid loss, low moisture content, low free swell and moderate plate water absorption.
- Intermediate to shallow light olive grey 5D bentonite from the transition zone often has iron staining on joints and is characterised by pH 6 to 8.5, slightly lower soluable Ca, together with low fluid loss and high free swell and plate water absorption. Carion exchange capacity (CEC) is the same as deeper blue-grey bentonite.
- Very shallow light brown to light brownish grey 5D bentonite has pH 4.5 to 6 and generally lower CEC and soluble Ca than deeper mineralisation, but highest moisture, free swell and plate water absorption.

Resource estimation is based on gridded seam models generated by software such as Carbon™ or GEOLIA Minex™, with grades classified according to parameters such as CEC, pH, soluble Ca & Mg, free swell, viscosity, fluid loss, plate water absorption and foundry bond strength, in accordance with AMCIL's global grading system. High MgO/CaO whole-rock geochemical ratios characterise the deposit, with some exceptions where minor gypsum is observed.
A notable feature is that most bentonites from this location display robust thermal durability eminently suitable for foundry applications (Figure 9).

**Mining, processing and markets**

In common with other industrial mineral deposits, selective mining and blending of bentonite is the key to providing tailored products of consistent quality to end-users. Therefore at the Gurulmundi operation the individual beds are mined by grade (Figure 10) and stockpiled separately on pads for sun drying to approximately 12% moisture (Figure 11).

Following appropriate blending and polymer and/or soda ash treatment for specific markets, the products are either shipped ‘dried and crushed’ in tipplers or containers, or milled into bags or bulk tankers. Amcol Australia’s Gurulmundi bentonites are supplied predominantly into the foundry, drilling, tunneling, civil engineering and cat litter markets in addition to a number of smaller specialized niche markets.

Given the unique mineralogy and physical characteristics of certain of the Gurulmundi bentonites, Amcol Australia is currently developing products for niche markets, as well playing an increasingly important role in offering options across the global bentonite market space.

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**Literature references**


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(Tables 1 and Figure 8). A notable feature is that most bentonites from this location display robust thermal durability eminently suitable for foundry applications (Figure 9).

**Figure 9.** AMCOL Queensland foundry-grade bentonites are characterised by high thermal durability, as exemplified by this example of 5D bentonite: note well-defined 695°C dehydroxylation peak.

**Figure 10.** Bentonite at the Gurulmundi operation is mined selectively according to bed and grade. This view illustrates premium-grade 5D bentonite exposed in the pit floor: overlain by SOHW brown shale / tuff / bentonite and a three metre thick bed of off-white SB / SC bentonite.

**Figure 11.** Aerial view of a drying pad next to the mill house at the Gurulmundi site. Crude 5D clay is being delivered by side tipper in preparation for solar drying.