BENTONITE PROMOTION DOCUMENT

OCCURRENCE OF BENTONITE IN ETHIOPIA

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2012
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1 INTRODUCTION

Bentonite is clay consisting of smectite minerals, in particular montmorillonite. Bentonite has exchangable Na, Ca, or Mg cations, and exhibits far greater ion-exchange worldwide capacity than any other mineral except for zeolite. Na-bentonite has high swelling capacity and Ca-bentonite has a relatively low swelling capacity.

Ca-bentonite has wide application as absorbent, animal feed, foundry sand, catalyst (oil refining), waterproofing and sealing, etc. In addition to these applications, Na-bentonite is also widely used for iron ore pelletizing, foundry sand, drilling mud, adhesive, paint, landfill, bonding, plasticizer, etc.

1.1 Physical and chemical properties
Bentonite feels greasy and soap-like to the touch (Bates & Jackson, 1987). Freshly exposed bentonite is white to pale green or blue and, with exposure, darkens in time to yellow, red, or brown (Parker, 1988). The special properties of bentonite are an ability to form thixotropic gels with water, an ability to absorb large quantities of water with an accompanying increase in volume of as much as 12–15 times its dry bulk, and a high cation exchange capacity. Substitutions of silicon by cations produce an excess of negative charges in the lattice, which is balanced by cations (Na+, K+, Mg2+, Ca2+) in the interlayer space. These cations are exchangeable due to their loose binding and, together with broken bonds (approximately 20% of exchange capacity), give montmorillonite a rather high (about 100 meq/100 g) cation exchange capacity, which is little affected by particle size. This cation exchange capacity allows the mineral to bind not only inorganic cations such as caesium but also organic cations such as the herbicides diquat, paraquat (Weber et al., 1965), and striazones (Weber, 1970), and even bio-organic particles such as rheoviruses (Lipson & Stotzky, 1983) and proteins (Potter & Stollerman, 1961), which appear to act as cations.

Variation in exchangeable cations affects the maximum amount of water uptake and swelling. These are greatest with sodium and least with potassium and magnesium.

Interstitial water held in the clay mineral lattice is an additional major factor controlling the plastic, bonding, compaction, suspension, and other properties of montmorillonite-group clay minerals. Within each crystal, the water layer appears
to be an integral number of molecules in thickness.

Physical characteristics of bentonite are affected by whether the montmorillonite composing it has water layers of uniform thickness or whether it is a mixture of hydrates with water layers of more than one thickness. Loss of absorbed water from between the silicate sheets takes place at relatively low temperatures (100–200 °C). Loss of structural water (i.e., the hydroxyls) begins at 450–500 °C and is complete at 600–750 °C. Further heating to 800–900 °C disintegrates the crystal lattice and produces a variety of phases, such as mullite, cristobalite, and cordierite, depending on initial composition and structure. The ability of montmorillonite to rapidly take up water and expand is lost after heating to a critical temperature, which ranges from 105 to 390 °C, depending on the composition of the exchangeable cations. The ability to take up water affects the utilization and commercial value of bentonite (Grim, 1968; Parker, 1988).

Montmorillonite clay minerals occur as minute particles, which, under electron microscopy, appear as aggregates of irregular or hexagonal flakes or, less commonly, of thin laths (Grim, 1968).

Differences in substitution affect and in some cases control morphology.

1.2 Natural occurrence
Bentonite derived from ash falls tends to be in beds of uniform thickness (from a few millimetres to 15 m) and extensive over large areas (Parker, 1988). Bentonite from ash falls and other sources occurs worldwide in strata spanning a broad range of ages, but is most abundant in Cretaceous or younger rocks. Bentonite is a widely distributed material. Accordingly, its major component, montmorillonite, occurs abundantly as dust at and near surface deposits of bentonite and is dispersed widely by air and moving water. Montmorillonite is thus ubiquitous in low concentrations worldwide in soil, in the sediment load of natural waters, and in airborne dust. Biodegradation appears minimal, if it occurs at all, and there is no evidence of or reason to suspect accumulation in the foodchain. Abiotic degradation of bentonite into other minerals takes place only on a geological time scale (Parker, 1988).
2 PROPERTIES AND APPLICATIONS

Bentonite is a 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 <2µm in largest dimension. Smectite crystallites themselves are three-layer clay minerals.

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 can impact the industrial value of a 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 (Na₂CO₃). 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 super fine 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.

The main application of natural bentonite includes:

**Foundry:** Bentonite is used as a bonding material in the preparation of molding sand for the production of iron, steel and non-ferrous casting.

**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.
**Pelletizing:** 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 used traditionally as a thixotropic, support and lubricant agent in diaphragm walls and foundations, in tunnelling, in horizontal directional drilling and pipe jacking. Bentonite, due to its viscosity and plasticity, also is used in Portland cement and mortars.

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

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

**Oils/Food Markets:** Bentonite is utilized in the removal of impurities in oils where its adsorptive properties are crucial in the processing of 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 pelletizing aid in the production of animal feed pellets, as well as a flowability aid for unconsolidated feed ingredients such as soy meal. It also is 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, it allows paste formation. Such applications include industrial protective creams, calamine lotion, wet compresses, and antiirritants 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 are appreciated for the finishing of indigo dying cloth, and in dyes (lacquers for paints & wallpapers).

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 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.

3 BENTONITE OCCURRENCES IN ETHIOPIA
Bentonitic clay resources are found in the Afar and oromia regions. They are easily accessible, as they are located near the main road. The main occurrences in afar are located at Ledi, Gewane, Hadar and Warseiso. The bentonitic beds are part of a thick sequence of lacustrine sediments, which consists of clays, silts, sands, calcareous grits, gravels, conglomerates, basaltic flows, and ashes. These sediments were deposited near the western margin of the central part of the Afar depression, which throughout the Tertiary and Quaternary was an area of subsidence and intermittent volcanism. The bentonitic clays are probably the result of alteration of glassy igneous materials (Mengistu, 1987). The total resource in the Afar region is estimated to be 170 million ton. The bentonitic beds are well exposed and the overburden consists of loamy gravel and sandy clay. Tests conducted so far confirm that some beds could be used for the preparation of drilling mud and iron ore pelletization, and if upgraded, may have foundry application as well.

The Gidicho Island in Lake Abaya in the rift valley is another source of
bentonitic clay. This occurrence is of Pleistocene lacustrine origin and occurs in association with diatomite, silt and diatomaceous earth. The preliminary resource estimate is 5 million ton of material suitable, after upgrading, for the preparation of drilling mud (Knot, 1983).

3.1 Warseiso Bentonite

The bentonite occurrence lies between 700m and 3000m north of the Desie-Assab highway between the badona river and warseiso with a geographic coordinates of $11^\circ 22'20''N$ and $40^\circ 39'00''E$ (fig1).

The area is covered with range of hills dominated by coarsely bedded rhyolite and massive basalt. Sloping down from the hills to the southwest is flat plain of gravel conglomerate, Silt and volcanic ash with rare remnants of soil. Along badana river the
underlying sediments which are bedded close to the horizontal and of unknown thickness have been exposed by erosion in a strip roughly 1-2km wide and 6km long. These beds found to contain beds of bentonitic clay which improved in quality towards the volcanic hills and graded into brown sandy silts to the south west (Tibebe, 1983). Five blocks of bentonite were identified, separated from each other by erosional gullies filled with recent sand and gravel. All the blocks consist of grey or green grey bentonitic clay with a low sand content and only rare beds of contaminant material (Megistu, 1987). The result of physical and chemical analysis indicated that the warseisso bentonite can be used for different industrial purposes by upgrading with chemical treatments (Saba et al., 2002). The total reserve of bentonite in the area is estimated to be about 7006660 m³.

### Table 1 Estimated Bentonite resources

<table>
<thead>
<tr>
<th>ID</th>
<th>Location</th>
<th>X</th>
<th>Y</th>
<th>Overburden (m³)</th>
<th>Surface area (m²)</th>
<th>Thickness (m)</th>
<th>Reserve (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>warseisso</td>
<td>40.65</td>
<td>11.37</td>
<td>245116</td>
<td>1265155</td>
<td>5.58</td>
<td>7006660</td>
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<tr>
<td>2</td>
<td>Kada &amp; Ounda Hadar</td>
<td>40.61</td>
<td>11.12</td>
<td>50000000</td>
<td>647500</td>
<td>1.42</td>
<td>925450</td>
</tr>
<tr>
<td>3</td>
<td>Gewane</td>
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<td>10.25</td>
<td>14354313</td>
<td>6506874</td>
<td>11.83</td>
<td>77034611</td>
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<tr>
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<td>Ledi</td>
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<td>1200000</td>
<td>557500</td>
<td>3.2</td>
<td>1784000</td>
</tr>
<tr>
<td>5</td>
<td>Gidicho</td>
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<td>6.4</td>
<td>3462860</td>
<td></td>
<td></td>
<td>3462860</td>
</tr>
</tbody>
</table>

3.2 Hadar Bentonite

The bentonite beds outcrop in the Kada Hadar and Quada Hadar river valleys. Access to the area is through ascoma village via all weathered road 7km from the Dese-Assab highway. The Bentonite layers are associate with the sediments in Hadar the site of the famous Lucy, a hominid fossil of Quaternary age. The area is centered on lat11°07'30"N and 40°36'40"E (Fig2).

A sequence of Pliocene–pleistocene sediments about 110m thick (Taieb, 1974) is exposed in the cliff boarding the kada hadar and quanda hadar valleys. Generally the strike and dip of the bed is measured to be north-south and 5° east respectively.
The lacustrine sequence consists of poorly compacted various coloured clays, silts, sands, tuffaceous sands and cinerites, interbedded with compact layers of limestone, sandstone and calcareous flagstone (fig 4). The sequence is capped by conglomerates. Mammalian fossils are abundant and these include australopithicenes (Lucy (Dinknesh) and family).

Akilul assefa and R.F Ball traced the bentonite bed between 1.8 and 2.5 m thick. This bed is generally exposed only in a cliff face and covered in most places by tens of meters of overburden.

The reserve is estimated to be 925450m$^3$ with average thickness of bentonite is 4.2 , surface area 647500m$^3$ and the the volume of the overburden is found to be 925450m$^3$.

### 3.3 Ledi Bentonite

Bentonite sediment were noted on both sides of addis ababa assab road 20km south of desse junction with in 500m of Ledi river. The area is centered with geographic coordinates of 11$^0$9'30" N and 40$^0$41'E (fig2).

The lacustrine clays underlying the plain are exposed in river gullies and outliers. In ledi area 4 bentonite occurrence were identified,

- Horizontally bedded grey clay with a greasy luster contains interbeds of 1-2 cm thickness containing Iron, magnesium and gypsum is located to the south of ledi river.

- Extensive exposure of grey –green to brownish salty to sandy clay with indistinct horizontal bedding. the south of ledi river.

<table>
<thead>
<tr>
<th>ID</th>
<th>Area</th>
<th>X</th>
<th>Y</th>
<th>SiO$_2$</th>
<th>AlO$_3$</th>
<th>Fe$_2$O$_3$</th>
<th>TiO$_2$</th>
<th>CaO</th>
<th>MgO</th>
<th>Na$_2$O</th>
<th>K$_2$O</th>
<th>MnO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Warseisso</td>
<td>40° 39'</td>
<td>11° 22' 20&quot;</td>
<td>49</td>
<td>13.4</td>
<td>8.71</td>
<td>1.61</td>
<td>3.81</td>
<td>2.79</td>
<td>1.1</td>
<td>1.31</td>
<td>0.1</td>
</tr>
<tr>
<td>2</td>
<td>Kada Hadar</td>
<td>40° 36' 40&quot;</td>
<td>11° 07' 30&quot;</td>
<td>48.78</td>
<td>13.42</td>
<td>8.78</td>
<td>1.5</td>
<td>4.12</td>
<td>2.8</td>
<td>1.32</td>
<td>1.4</td>
<td>1.1</td>
</tr>
<tr>
<td>3</td>
<td>Ounda Hadar</td>
<td>40° 36' 40&quot;</td>
<td>11° 07' 30&quot;</td>
<td>54.23</td>
<td>12.9</td>
<td>9.1</td>
<td>1.4</td>
<td>1.9</td>
<td>2.5</td>
<td>1.76</td>
<td>1.1</td>
<td>0.1</td>
</tr>
<tr>
<td>4</td>
<td>Gewane</td>
<td>40° 35' 40&quot;</td>
<td>10° 14' 30&quot;</td>
<td>61.93</td>
<td>11.06</td>
<td>6.76</td>
<td>1.06</td>
<td>1.03</td>
<td>2.56</td>
<td>1.68</td>
<td>1.27</td>
<td>0.1</td>
</tr>
<tr>
<td>5</td>
<td>Ledi</td>
<td>40° 41'</td>
<td>11° 09' 30&quot;</td>
<td>54.23</td>
<td>12.65</td>
<td>7.75</td>
<td>1.35</td>
<td>3.15</td>
<td>2.8</td>
<td>1.85</td>
<td>1.35</td>
<td>0.1</td>
</tr>
<tr>
<td>6</td>
<td>Gudicho shigima</td>
<td>37° 34' 22&quot;</td>
<td>6° 21' 40&quot;</td>
<td>56.4</td>
<td>14.4</td>
<td>8.3</td>
<td>1.05</td>
<td>2</td>
<td>1.6</td>
<td>3</td>
<td>1.6</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>Arura</td>
<td>37° 56' 38&quot;</td>
<td>6° 25' 30&quot;</td>
<td>60.8</td>
<td>10.9</td>
<td>13.5</td>
<td>1.09</td>
<td>0.9</td>
<td>1.3</td>
<td>2.2</td>
<td>1.1</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>Biaso</td>
<td>59.4</td>
<td>16.4</td>
<td>8.7</td>
<td>1.04</td>
<td>0.9</td>
<td>1.4</td>
<td>2.4</td>
<td>1.5</td>
<td>0.16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
On the northern bank of Ledi river a grey–green bentonitic clay which is compact and massive containing minor salt and silt is exposed. In this area the bentonite outcrop is without an overburden and has 8.5 thickness.

5-6km west of the Gewane–Mille highway grayish to brownish bentonite clay is exposed in the Huana river valley. It has an average thickness of 7.5m.

In this area the reserve was estimated to be 1784000m$^3$ (table1) with an overburden of 1200000m$^3$. 
3.4 Gewane Bentonite

The area is located 15km north east of gewane town, afar region. The bentonite beds are outcrops in Kalhaitu, Ambule, Aburagarsa and Tathamatu valleys. It is bounded by latitude 10°14'30" and 10°21'10" N and longitude 40°35'40" and 40°40'30" E.

The area consists of a gently undulating plain plains covered by stratovolcanics.the plain is deeply dissected by river valley and gullies to revail the underlying fluvio-lacustrine sediments (fig 4).

The most important faults trend north east along the line of ambule, tannahmatu and kalhaitu rivers where considerable vertical displacement. The other prominent fault system in the area strikes NNE. It is associated with volcanism.

The underlying fluvo lacustrine sediments are inhomogeneously mixed and intercalated with beds of volcanic ash.

The bentonite bed sequences is exposed in the ambule river forms a thickness of 10-22m thickness .it is considered to be the most promising bentonite deposits in gewane area.

The reserve in the area is estimated to be 70,000,000m³ (Table1).

3.5 Gidicho Bentonite

Lake chamo and abaya are located in the southern part of the main Ethiopian rift valley. The tectonic activities of the area is part of the rift system. In tertiary uplifting of the basement due to the convection movement within the mantle caused the erection and outpouring of basaltic lava, followed by ignimbritic eruption magma there was a continental scale collapse giving rise to the rift valley.

In quaternary the graben (mostly south of Lake Abaya) was filled with ash fall giving rise to acid (rhyolite, ignimbrite, obsidian, pumice and ash) and basic outpourings alternatively. After the collapse in the pliestocene, the rift valley was filled by lacustrine sediments over 70m thick which includes diatomite, silt, volcanic ash, sand and bentonitic clay. The post rift volcanism took place in a lacustrine environment forming rocks of volcano- lacustrine facies.

After lacustrine period, further volcanism and tectonic activities were followed and the lacustine sediments were overlain by volcanic rocks mostly pumiceous, pyroclastic, ignimbrite, rhyolite and minor basalts (fig 5).
Figure 5  Geological map of gidicho island  (After Million H et.al., 1991)
The oldest rock exposed in the island is the Pleistocene lacustrine sediments. These lacustrine sediments include diatomite, bentonitic clay and diatomaceous silt, which are exposed in the uplifted blocks within the island. The claybeds are mainly dominant in the lower most part of the lacustrine sequences with respect to the diatomite beds. (Million et al., 1991)

West of Arura village there are small outcrops of yellowish brown, massive silty limestone which is sandwiched between the lacustrine beds. In some places within the lacustrine beds (specially Shigima area) there are gypsum anhydrite, manganese nodules and some pistolites of carbonate origin. The upper part of the diatomite layer in Biaso area is partly covered by chert.

The underlying beds of the lacustrine formation are not exposed. The Pleistocene lacustrine sediments are overlain by volcanic rocks. Ignimbrite which is rhyolitic, greenish grey, fine grained and vesicular overlies the lacustrine beds. The ignimbrite in turn is overlain by dark grey, vesicular basalt and the vesicles filled with calcareous material.

There is a trachyte hill between Shigima and Arura village. Some exposure of grayish brown trachitic rock with abundant phenocrysts of feldspar are observed near the Shigima village lying on top of basalt. In some places this rock is slightly weathered.

Young Holocene lake sediments are exposed on the shore of the present lake while recent alluvium deposits are restricted at the mouth of some gullies within the island.

![Figure 6 Bentonite from Gewane area (geomuseum) photo. by mesfin](image)

The reserve in the area is estimated to be 3462860 m³ and the chemical composition of gidicho bentonite is almost comparable with the world bentonite producing countries (Table 4). In some areas slight variation also observed.

Tests conducted on Bentonite samples from these and Gidcho deposits have shown them to be suitable for iron–ore pelletization and drilling mud after proper beneficiation (Tibebe et al., 2002). Laboratory analysis of
gidich bentonite indicates that the clay has a good swelling property. The x-ray analysis showed that the dominant clay mineral is montmorillonite with subordinate amount of kaolinite, feldspar and quartz.

The drilling mud test indicates that gidicho bentonite competes well with Russia bentonite used by SPEE (soviet petroleum exploration expedition) and it does not fall quite far from the API (American petroleum institute) specification.

The mining condition of the deposits is favorable and it can easily be mined manually by open pit mining. Hobeles (local boats) are available in the area for transporting bentonite from the island to the shore.

### Table 3 Standards for chemical composition of Bentonite for different countries

<table>
<thead>
<tr>
<th>Country</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>Fe₂O₃</th>
<th>TiO₂</th>
<th>CaO</th>
<th>MgO</th>
<th>Na₂O</th>
<th>K₂O</th>
<th>LOI</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>55.6</td>
<td>18.1</td>
<td>3.6</td>
<td>0.1</td>
<td>1</td>
<td>1.9</td>
<td>1.6</td>
<td>0.4</td>
<td>8</td>
</tr>
<tr>
<td>UK</td>
<td>55.2</td>
<td>13.7</td>
<td>8.1</td>
<td>0.7</td>
<td>6.3</td>
<td>3.3</td>
<td>Trace</td>
<td>0.6</td>
<td>9.9</td>
</tr>
<tr>
<td>India</td>
<td>52</td>
<td>14</td>
<td>12</td>
<td>3.3</td>
<td></td>
<td></td>
<td>trace</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td>70.7</td>
<td>15.1</td>
<td>0.7</td>
<td>0.05</td>
<td>1.6</td>
<td>1.6</td>
<td>0.4</td>
<td>1.8</td>
<td>5</td>
</tr>
<tr>
<td>Turkey</td>
<td>57.6</td>
<td>19.3</td>
<td>3.3</td>
<td>0.3</td>
<td>4.2</td>
<td>2.2</td>
<td>2.6</td>
<td>1.9</td>
<td>7.4</td>
</tr>
</tbody>
</table>

The mining of natural deposits is favorable and it can easily be mined manually by open pit mining. Hobeles (local boats) are available in the area for transporting bentonite from the island to the shore.

### 4 MARKET AND TRADE

Bentonite and bentonite Fuller’s earth are mined worldwide. The USA is the major producer of bentonite Fuller’s earth (Table 3). Approximately 90% of world bentonite production is concentrated in 13 countries: the USA, Greece, the Commonwealth of Independent States, Turkey, Germany, Italy, Japan, Mexico, Ukraine, Bulgaria, Czech Republic, South Africa, and Australia (Table 1). The USA, Greece, and the Commonwealth of Independent States account for roughly 55% of the annual world production of 10 million tonnes.

Wyoming produces the bulk of bentonite mined in the USA (Ampian, 1985). In 2002, the bulk of US production was used domestically, and only a small fraction, 11%, was exported worldwide (Virta, 2002). In addition to the mining of natural deposits, small amounts of bentonite, mainly hectorite, are produced synthetically in both Europe and the USA for use as a catalyst. Most bentonite is mined by stripping methods from open pits after removing any overburden, although underground methods are used in a few places, such as the Combe Hay district in the United Kingdom (Patterson & Murray, 1983). Since deposits are often not uniform in composition,
bentonite from a single pit may be separated into several stockpiles, which subsequently are blended to obtain the desired composition. Bentonite is usually processed by breaking large pieces into smaller fragments, drying at low to moderate temperatures to remove water and other volatiles without altering the molecular structure of the

**OPPORTUNITIES**

Because of the large bentonite reserve tonnage in gewane, and excellent access to the area (like the warseiso bentonite) and a high swelling capacity of the lendi bentonite would be the prior choice for investment. In addition to this, because of proximity to the Djibouti port, afar bentonite is easy for export trade.

5 **ABOUT THE MINISTRY OF MINES**

In compliance with the market oriented economic policy of Ethiopia the parliament declared that it is the continuing policy of the Federal Government in the national interest to foster and encourage private enterprises in developing economically sound and stable mineral mining.

Accordingly the Federal Government’s Ministry of Mines is responsible to administer and supervise all large scale mining operations including to issue prospecting, exploration and mining licenses for foreign investors and to these in joint venture with Ethiopians as per the reform issued in 1998 on the Mining proclamation following the realization of previous shortcomings of earlier laws and policies.

The reform clearly stipulated the responsibility of National Regional Governments to issue licenses and administer all small scale mining operations owned by Ethiopians and collecting all fees in addition to issue prospecting and exploration licenses for national investors.

<table>
<thead>
<tr>
<th>Rank by state</th>
<th>Country</th>
<th>Bentonite production (Tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>United States</td>
<td>4,620,000</td>
</tr>
<tr>
<td>2</td>
<td>China</td>
<td>3,200,000</td>
</tr>
<tr>
<td>3</td>
<td>Greece</td>
<td>1,100,000</td>
</tr>
<tr>
<td>4</td>
<td>Turkey</td>
<td>600,000</td>
</tr>
<tr>
<td>5</td>
<td>Russia</td>
<td>500,000</td>
</tr>
<tr>
<td>6</td>
<td>Italy</td>
<td>470,000</td>
</tr>
<tr>
<td>7</td>
<td>Mexico</td>
<td>435,273</td>
</tr>
<tr>
<td>8</td>
<td>Brazil</td>
<td>419,214</td>
</tr>
<tr>
<td>9</td>
<td>Germany</td>
<td>363,998</td>
</tr>
<tr>
<td>10</td>
<td>Argentina</td>
<td>256,165</td>
</tr>
<tr>
<td>11</td>
<td>Czech Republic</td>
<td>220,000</td>
</tr>
<tr>
<td>12</td>
<td>Iran</td>
<td>186,323</td>
</tr>
<tr>
<td>13</td>
<td>Spain</td>
<td>160,000</td>
</tr>
<tr>
<td></td>
<td>World</td>
<td>14,600,000</td>
</tr>
</tbody>
</table>

Table 4 List of bentonite producing countries in 2006 based on British Geological Survey.
5.1 Mining Legislation
In June 1993 new Mining and Mining Income Tax Proclamations were issued having considered knowledge-based experiences in some competitive countries and given the following;

Invite private investment in all kinds of mineral operations;

Provides a prospecting license for one year;

Provides an exploration license for an initial period of three years and renewed twice for one year each;

Provides a mining license for 20 years and renewed for 10 years unlimitedly;

Guarantee the licensee’s right to sell all the minerals locally or abroad giving marketing freedom;

Provides for exemptions from custom duties and taxes on equipment, machinery, vehicles and spare parts;

Gives securities of tenure;

Gives clear provisions on fiscal and other issues;

Considering taxation on repatriation of profits and capitals, a licensee shall pay a 2-5% royalty on ad Val Orem at production site, and a 35% income tax on taxable income. Taxable income is computed by subtracting from gross income for any accounting year all allowable revenue expenditure, a four years straight line depreciation, reinvestment deduction and permitted loses;

The mining proclamation guarantees the opening and operation of a foreign currency account in banks in Ethiopia, retention of portion of foreign currency earning and remittances of profits, dividends, principal and interest on a foreign loan etc. out of Ethiopia.

Of course this fiscal package is still subject to frequent reviews for we want to maintain a balance between the objective of the government and investors as is evident by a series of amendments of the 1993.

5.2 Investment Climate of Ethiopia
The Federal Democratic republic of Ethiopia has created a conducive investment environment to ensure, (promote) private investment play a leading role in the development of the national economy.

This favorable climate for foreign investment has been created as consequence of the solid foundation of political and economic reform, particularly the stably secured macroeconomic reforms which are
achieved by carefully managed sequential reforms coupled with faire fiscal and monetary policies. By virtues of Ethiopia’s unique and untapped natural resources, its proximity to middle eastern and European markets, its 60 million population, and huge labor force both disciplined and easily trainable are some of the comparative advantages worthy of consideration while investing in Ethiopia. This is further enhanced by specific incentives and efficient administrative procedures.

5.3 Mineral Investment
Between 1974 and 1991 private investments were not allowed in the mineral sector. The government was fully responsible for the exploration and development of the sector, before the advent of the new economic policy of Ethiopia. In compliance with the new market oriented economic policy of Ethiopia the parliament declares that it is continuing policy of the Federal Government in the national interest to foster and encourage private enterprises in developing economically sound and stable mineral mining.

For a successful implementation of the policy a number of steps have been taken aiming to boost the confidence of the private sector following the governments strong belief that rapid mineral development can only be realized when the private sector is given a full right of operating managing and owning mineral enterprises.

This is the underlined reason for the government’s active response to the concern of the International mining Companies. Accordingly it has restricted its role to basic mineral resources exploration, regulation and promotion only such as;

to avoid the fear of controlling a large tract of prospective land by state owned companies,

to avoid the fear of seeable high risk due to unexpected unfair competition with state owned enterprises.

In this connection a measure stick for such truck record of the government’s commitment is manifested by the privatized Lege Dembi Gold Mine, the only one government owned large scale gold mining, and the small scale Kenticha Tantalum Mine which is already in the pipeline for privatization. This includes the reform of the mining law which is taking place since 1993 and many changes that have happened justify the sincerity of the government.

Furthermore the commitment is much affirmed following the establishment of a
fair and clear cut mining legislation giving investors assurances of the fruits of their success. It constitutes a fair setup of efficient and effective licensing and mineral right administration system, a fair set of environmental laws, rules to monitor and mitigate and reclamation effects by mining operation, fair laws to regulate the safety and health of the work fore and securing of tenure. It also gives to license holders with a number of incentives including low royalty, exemption from custom duties and taxes on the equipment, machineries vehicles, and spare parts necessary for mineral operations with a 10 years provision to allow investors to carry forward losses.

REFERENCES


