International Forum of ceramic tile manufacturers' associations

Sevastopol
Ukraine
29th June 2012
Who are Sibelco?

- Founded: 1872
- Production sites: 228
- Countries: 41
- Continents: 5
- Turnover: €2bn
- Employees: 10,000
Who are Sibelco?

Five decentralised yet co-ordinated operating regions
Who are Sibelco?

Products

123 plants

Silica
Calcium
Feldspar
Olivine

Clay & Kaolin
Mineral Sands
Recycled Materials

Other Minerals
Other Products
What do we do?

- Commercial
- Electronic
- Construction & Engineering
- Functional fillers
- Metals/Castings
- Energy
- Industrial
- Glass
- Ceramics

Markets
What do we do?

- Silica sand and flour
- Crisotbalite
- Frac sand & resin coated sand
- High purity quartz (HPQ)
- Clay & Kaolin
- Feldspar & Nepheline
- Lime & Limestone
- GCC & PCC
- Olivine
- Glass cullet
- Mineral sands
- Barytes
- Wollastonite
- Manganese dioxide
- Chromite
- Aluminium hydroxide
What do we do?
What do we do?

Ceramics
- Silica sand and flour
- Plastic Clay & Kaolin
- Feldspar & nepheline
- Mineral sands
- Chromite
- Manganese dioxide
- Wollastonite
Who do we do it for?

- SAINT-GOBAIN
- Pilkington
- Ideal
- Halliburton
- BASF
- corus
- Roca
- AkzoNobel
- ArcelorMittal
- Functional fillers
- Metals/Castings
- Construction & Engineering
- Industrial
- Ceramics
- Energy

SIBELCO

Who do we do it for?
What does Sibelco Ukraine do?

Core Applications
- Ceramics
- Glass
- Foundry
- Functional Fillers

Core Minerals
- Plastic Clays
- Silicas
- Ceramic Bodies/ Composites
- + Group Portfolio

400 K Tonnes silica
1 200 K Tonnes Plastic Clay
300 Customers
21 Destinations
€ 45 M Turnover
Where do our products come from?

Silica: Our Novoselovsky silica plant is located near Kharkiv

Plastic Clay & Prepared Body: Body plants is located in Slavyansk with our composite located in Mertsalovo

Geology of Ukraine plastic clay deposits for tiles:
- The highest quality deposits are limited to the Donetsk Oblast (region)
- They are from the Miocene age (~12 million years old)
- Clay sequence is from 1.5 to 5m thick and consists of 4 or 5 seams or layers and extends over an area of 60km x 25km
- Total Sibelco reserves and resources of clay 46 million t
Why Sibelco clays for Tiles?
At Sibelco, product quality is taken very seriously,
- control starts whilst the minerals are still in the ground
- extensive geological mapping and resource planning pre extraction
- Planned operating to ensure longevity and consistent supply can be maintained
Ukrainian Plastic Clay Production

High Reserves & global resources

- Total reserves & resources of plastic clay @ 46 Million t
- Total reserves & resources of sand > 23.% Million t
Ukrainian Plastic Clay Production

Exploration & evaluation of mineral quality

- Extensive geological surveys map the quality of the minerals before & during extraction
  - Improves selection & blending
  - Maximises end product quality
Ukrainian Plastic Clay Production

Controlled mineral extraction

- Excavator’s are used to carefully extract each seam or clay selection
- The key clay selection criteria are $\text{Al}_2\text{O}_3$ and $\text{Fe}_2\text{O}_3$ content
- Up to 10 different selections are extracted & stored separately at Mertsalovo (16km from quarries)
- The clay benches are regularly sampled for chemical analysis to determine the quality of the clay selections
Ukrainian Plastic Clay Production

Blending and storage

- Quality assurance continues throughout the various blending and processing stages
Plastic Clay Analysis & Selection

Routine Quality Control

Why have good mineral QC?
- Materials effect end manufacturing process efficiency
  - Preparation
  - Forming
  - Drying & Firing
  - Finished product quality

Fired Properties
- Rheology
- XRF
- > 125µm

Quality Assurance
- XRD
- PSA
- Surface Area
- Carbon
- Strength

Quality Product

Yield

Productivity

Product Quality
Sibelco has a culture of innovation and actively uses customer collaboration to develop new ways of working
Industrial Mega Trends

We actively identify future mega trends and develop new solutions to address them
More For Less

Continuous Improvement

Yield Improvement

Cost Reduction

Best Quality
Recycling
Environment
Linked to Resources
Local Solutions
Recycling
Carbon Dioxide Emissions
Linked to Resources
Reduction in Carbon Dioxide

Reduction in Use

Reduction in Cost

Energy
Examples of Addressing the Mega Trends Using Ukrainian Clay

Resources
- Case Study 1: Yield Improvement
- Case Study 2: Improved Environment
- Case Study 3: Reduced Energy

More for Less
- Case Study 1: Yield Improvement
- Case Study 2: Improved Environment
- Case Study 3: Reduced Energy

Environment
- Case Study 1: Yield Improvement
- Case Study 2: Improved Environment
- Case Study 3: Reduced Energy

Energy
- Case Study 1: Yield Improvement
- Case Study 2: Improved Environment
- Case Study 3: Reduced Energy
We have an extensive network of Technical Centres in each of the key regions which we use for customer projects.
In most manufacturing industries, focus is given to reducing costs as a way to improving profits.
In the ceramics industry most factories have the opportunity to improve the yield which does have a greater impact on the manufacturing EBIT, but is quite often overlooked.
An Example from India

<table>
<thead>
<tr>
<th>Before</th>
<th>After Body Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>m2 produced</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Yield</td>
<td>79%</td>
</tr>
<tr>
<td>Saleable m2</td>
<td>790,000</td>
</tr>
<tr>
<td>Av. Selling Price/m2</td>
<td>$3.50</td>
</tr>
<tr>
<td>Sales Revenue</td>
<td>$2,765,000</td>
</tr>
<tr>
<td>Body Cost / Tonne</td>
<td>$60.00</td>
</tr>
<tr>
<td>Body Cost / Year</td>
<td>$1,320,000</td>
</tr>
<tr>
<td>Sales Revenue – Body Costs</td>
<td>$1,445,000</td>
</tr>
</tbody>
</table>

~10% Raw Material Cost Reduction

- m2 produced: 1,000,000
- Yield: 79%
- Saleable m2: 790,000
- Av. Selling Price/m2: $3.50
- Sales Revenue: $2,765,000
- Body Cost / Tonne: $54.00
- Body Cost / Year: $1,188,000
- Sales Revenue – Body Costs: $1,577,000

Financial Benefit: $132,000

Now Consider the Impact of Reducing ALL of The Body Raw Materials by Approximately 10%

- m2 produced: 1,000,000
- Yield: 90%
- Saleable m2: 900,000
- Av. Selling Price/m2: $3.50
- Sales Revenue: $3,150,000
- Body Cost / Tonne: $68.00
- Body Cost / Year: $1,496,000
- Sales Revenue – Body Costs: $1,654,000

Finally; Consider the Impact of Using High Quality Sibelco Materials to Optimise the Factory Yield – (With Increased Raw Material Costs)

By reformulating the customers body using a reasonably small amount of Ukrainian DBK-1, the yield was significantly improved.
Achieved By?

- Low impurities
- Batch to Batch Consistency
- Lower Shrinkage
- Stable Firing
- Improved Slip Rheology
- Improved Milling
- Better Spray-drying
- Consistent Pressing
Whilst the towards thinner format tiles has enabled tile producers to enter new markets; the technology also offers environmental benefits to the supply chain by reducing the amount of raw material required and the mass per square metre of product.
An Example from Europe

Toughness (T) is the ability of a material to absorb energy before rupturing.

By changing to Sibelco Ukraine DBY-4, the customer was able to produce high quality large format 3mm tile sheets due to improved plasticity.
Case Study 3 - ENERGY REDUCTION

The largest impact on manufacturing energy reduction can be achieved by focusing on Spray-Drying and Firing.

Energy Required to produce 1 kilogram of tile body / kJ/kg

- Milling: 3350; 52%
- Spray-drying: 1590; 25%
- Glazing: 200; 3%
- Drying: 21; 0%
- Firing: 1000; 15%
- Packaging: 313; 5%
Market example for Brazil

Example; Spray-dryer

Traditional Formulation
- Slip Density = 1.67 g/cm³
- Gas Consumption = 44.8 m³/t
- Cost per m² = 0.423$

Using Ukrainian Clay
- Slip Density = 1.75 g/cm³
- Gas Consumption = 35.7 m³/t
- Cost per m² = 0.337$

It might not appear to be significant, but the raw material costs were the same delivered and per year equates to a saving of 86,000$ for 1 million m³ production; before considering the other benefits of Ukrainian clay!
By Replacing the local bentonitic clay we were able to reduce the required heatwork, allowing for faster kiln throughput and increased production.
Achieved By?

Low impurities

Improved Slip Rheology

Batch to Batch Consistency

Improved Milling

Lower Shrinkage

More Efficient Spray-drying

Stable Firing

Higher Alkali Content
The Technical Bit!
- What Makes Ukrainian Clay Unique?
Traditionally:

UK used for sanitaryware with some tile

Germany used for tiles and structural

Ukraine used for tile
### Chemistry of the Samples

<table>
<thead>
<tr>
<th></th>
<th>SiO$_2$</th>
<th>Al$_2$O$_3$</th>
<th>Fe$_2$O$_3$</th>
<th>TiO$_2$</th>
<th>K$_2$O</th>
<th>Na$_2$O</th>
<th>L.O.I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indian Plastic Clay</td>
<td>54.0</td>
<td>30.5</td>
<td>1.3</td>
<td>1.4</td>
<td>0.4</td>
<td>0.6</td>
<td>11.3</td>
</tr>
<tr>
<td>UK (Premiere HV)</td>
<td>60.7</td>
<td>26.3</td>
<td>0.9</td>
<td>1.5</td>
<td>2.6</td>
<td>0.4</td>
<td>7.2</td>
</tr>
<tr>
<td>Germany (FT-1513)</td>
<td>64.8</td>
<td>22.8</td>
<td>1.0</td>
<td>1.4</td>
<td>2.0</td>
<td>0.3</td>
<td>7.1</td>
</tr>
<tr>
<td>Ukraine (DBK-0)</td>
<td>60.0</td>
<td>26.6</td>
<td>1.0</td>
<td>1.4</td>
<td>2.43</td>
<td>0.5</td>
<td>7.3</td>
</tr>
</tbody>
</table>

All of these four plastic clays have similar chemistries and all are used for tile manufacture.
Let us compare the four clay minerals using a technique known as X-Ray Diffraction to examine the structure.

**Braggs’ Law**

\[ d = \frac{n \cdot \lambda}{2 \cdot \sin \theta} \]
The traces produced from the instrument of the four clay blends appear to be very similar at first glance.
Fitting peaks to the patterns shows all four clay blends to compose of Quartz, kaolinite and Mica (Illite), and possibly feldspar.
Quartz and Feldspar - Introduction

Quartz – is an ancillary mineral, present from the initial silicate rock the plastic clay was formed from and not removed during subsequent geological or mineral processing.

None clay minerals found in plastic clay.

Feldspar – In general, the ‘clay’ minerals are produced by the geological weathering of feldspar. Some feldspar is not converted and therefore remains in the plastic clay.
Green = UK Plastic Clay Blend
Red = UA Plastic Clay Blend
Blue = DE Plastic Clay Blend
Orange = IN Plastic Clay

It can be seen that the Indian clay has less quartz than the German and Ukrainian, which all have similar quartz content, UK is in between
Kaolinite - Introduction

Kaolinite primarily forms during the hydrothermal alteration or weathering of feldspars under acid conditions.

Kaolinite typical of Plastic clay

Kaolinite stacks as found in primary natural deposits

Pure crystals of kaolinite
Kaolinite (1)

Green = UK Plastic Clay Blend
Red = UA Plastic Clay Blend
Blue = DE Plastic Clay Blend
Orange = IN Plastic Clay

Concentrating on the group of kaolinite peaks between 19 and 23 degrees 2 theta
The definition of the pattern and ‘loss’ of kaolinite peaks indicates the order of the kaolinite in the sample; edge damage, stack dislocation and size all affect the pattern. The UK clay is moderately disordered, whereas the Indian, German and Ukrainian clays are very disordered.
Muscovite and Illite have similar However, illite has on average slightly more Si, Mg, Fe, and water and slightly less tetrahedral Al and interlayer K than muscovite. The weaker interlayer forces caused by fewer interlayer cations in illite also allow for more variability in the manner of stacking and thus to different properties.

Illites form by the weathering of silicates (primarily feldspar), through the alteration of other clay minerals, and during the degradation of muscovite.
Green = UK Plastic Clay Blend
Red = UA Plastic Clay Blend
Blue = DE Plastic Clay Blend
Orange = IN Plastic Clay

The ratio of the mica peak area at 17.7 versus 8.9 gives an idea of how illitic the mica is.

Muscovite = 1:3.2, UK = 1:2.5, UA = 1:2.2, DE = 1:2.0
Smectites commonly result from the weathering of basic rocks and clays. Smectite formation is favoured by level to gently sloping terrains that are poorly drained, mildly alkaline, and have the high Si and Mg potentials.
Smectite

Green = UK Plastic Clay Blend
Red = UA Plastic Clay Blend
Blue = DE Plastic Clay Blend
Orange = IN Plastic Clay

Glycolating the samples and re-running the XRD at low angle reveals the presence of any expandable smectite.
On glycolation a small peak appears, showing that this clay blend contains a small amount of expandable smectite (montmorillonite):

It is the combination of this phase along with the moderately disordered kaolinite and moderately illitic mica that gives the UK clay some of its rheological properties.
A definite peak appears at 17 angstroms on glycolation revealing the presence of significant amounts of smectite.

It is predominantly this phase that is responsible for the rheological behavior and plasticity of this clay.
Possibly a small amount of smectite is present.

The main phases responsible for the rheological behavior and plasticity are the disordered kaolinite and illite content.
On glycolation the mica peak at 10 Angstroms sharpens and new peaks appear at 27 and 13.5 Angstroms. These peaks are thought to be the 001 and 002 reflections of a illite-smectite mixed layer mineral.
Along with the highly disordered kaolinite, it is this material that is responsible for the rheological properties and plastic nature of the Ukrainian clay.
Overview

Ordered Kaolinite  Disordered kaolinite  Illite  Mixed layer Illite-Smectite  Smectite

Increasing Fluidity

Increasing Strength/plasticity

Increasing Shrinkage

Sanitaryware  Structural Ceramics & Refractories  Tile
Most clay deposits have subtle differences in clay mineralogy, which give rise to unique properties. In the case of the Ukrainian plastic clay it is a mixed layer illite-smectite phase, coupled with disordered kaolinite and low iron which are responsible for its superior properties for vitreous tile manufacture:

- Highly Plastic

- Reasonable Shrinkage

- White Firing

- Good Vitrification
Thank You For Your Attention