INTRODUCTION TO BENTONITE & PERLITE MINERALS: KEY ATTRIBUTES & FUNCTIONALITIES
Group Presentation

MINERAL SOLUTIONS FOR A CHANGING WORLD

IMERYS
TRANSFORM TO PERFORM
Key figures 2015

- **€4.1Bn** Revenue
- **€538M** Current operating income
- **13.2%** Operating margin
- **16,130** Employees
- **250** Operating sites
- **50** Countries
- **8** R&D centers
- **#1 or #2** On most of our markets
- **€5.1Bn** Market capitalization
  - 54% of capital held by GBL

FTSE4Good

EURONEXT Vigeo Europe 120

MSCI 2015 Constituent MSCI Global Sustainability Indexes

May 2016 | Group presentation
Imerys offers high value-added functional solutions…

Imerys draws on its know-how

- Portfolio of high-quality mineral resources
- Knowledge of its customers’ applications
- Wide range of exclusive technologies and processes
- Materials science expertise

… to develop an offering based on:

- **Beneficiating mineral resources** (clay, bentonite, diatomite, feldspar, kaolin, mica, wollastonite etc.)

- **Developing formulations** (ceramic bodies, continuous casting fluxes for steel, monolithic refractories, etc.)

- **Producing synthetic minerals** (synthetic graphite, zirconia, etc.)
Revenue by geographic destination in 2015

- **Western Europe** 44% rev.
- **North America** 24% rev.
- **Emerging countries** 27% rev.
- **Japan / Australia** 5% rev.

Revenue by market in 2015

- **New construction** 13% rev.
- **Renovation** 13% rev.
- **Steel** 12% rev.
- **Automotive** 10% rev.
- **Energy** 7% rev.
- **Publishing** 6% rev.
- **Industrial equipment** 6% rev.
- **Magazines** 5% rev.
- **Consumer goods** 5% rev.
- **Food** 4% rev.
- **Packaging** 4% rev.
- **Infrastructure** 2% rev.
- **Office paper** 2% rev.
- **Markets < 2%**

The world leader in mineral-based specialties for consumer goods, industrial equipment and construction, with presence in **50 countries**
Imerys businesses are leaders in most of their markets.

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<thead>
<tr>
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<td>Monoilthic Refractories</td>
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<td>Refractory Minerals</td>
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A global presence
The Energy Solutions & Specialties business group manufactures and sells high-performance mineral solutions for various demanding industries: the consumer goods and paper sectors with Carbonates, high-temperature industries served by Monolithic Refractories, Graphite & Carbon applications linked to mobile energy, and oil and gas exploration served by the Oilfield Solutions division.

**Carbonates**
Natural (GCC) and Precipitated (PCC) Calcium Carbonates used as filling or coating pigment for paper production and functional additives for paints, rubber, plastics.

**Monolithic Refractories (Calderys)**
Unshaped refractory materials used to protect industrial equipment from high temperatures in heavy industries (steel, cement, power generation, petro-chemicals). Protection for furnaces, kilns, crucibles and incinerators.

**Graphite & Carbon**
High performance graphite powder for mobile energy, electronics and engineering, refractories for the transport and automotive markets.

**Oilfield Solutions**
Production of proppants and mineral solutions for non-conventional oil and gas exploration.
The Filtration & Performance Additives business group enjoys many high quality minerals and products (bentonite, diatomite, perlite, vermiculite, talc, wollastonite and steel casting fluxes) supplied to many industries including agriculture, food, beverages, steel, construction, horticulture, plastics, paints, rubber, catalysts, paper, pharmaceuticals, beauty and personal care.

- **Performance Additives**
  - The division addresses fast growing markets in which additional performance is key. The solutions offered consist of functional additives derived mostly from mica, talc, wollastonite, diatomite, perlite or vermiculite used for paints, plastics, polymers, rubbers, adhesives, sealants, pharma & personal care.

- **Minerals for Filtration**
  - Mainly diatomite and perlite used as filter aid for edible liquids (beer, wine, oil, fruit juice). The division is the world’s leading supplier of diatomite and expanded perlite-based products for filtration.

- **Performance Additives for Metallurgy**
  - Serves the metallurgy market along the whole metal production chain, from raw materials through to the casting of the final products.
  - Includes Steel Casting Fluxes, Bentonite & Perlite Intermediates, and Metalcasting Performance Additives.
Bentonite: a Smectitic Clay with hundreds of applications
Bentonite mineralogy and attributes
Bentonite’s Structure

- Bentonite is a volcanic rock composed dominantly of clay minerals belonging to Smectite group.
  - Consists of 3-layer platelets: an octahedral layer comprising of Mg, Fe, Al and OH-groups, sandwiched between two tetrahedral layers with Si-O tetrahedrons.
  - One smectite mineral is the di-octahedral Montmorillonite (part of Al$^{+3}$ is replaced by Mg$^{+2}$ and Fe$^{+2}$ while Si$^{+4}$ is replaced by Al$^{+3}$)
  - Due to isomorphic substitution, all layers are electrically charged and this is counterbalanced by hydrated “exchangeable” cations occupying the space between platelets
  - All key-properties are attributed to this “charged-layer/cations” couple. i.e. H$_2$O Absorption, Swelling, Thixotropy, Thickening

Swelling of Ca- Bentonite vs. Swelling of Na-Bentonite

The preference of Na$_2$CO$_3$ for Activation (Cation Exchange):
Montmorillonite’s performance is due to its ability to:
1. disperse in colloidal particles («easy cleavage» vs. other clays like e.g. kaolinite)
2. absorb and immobilize big amounts of \( \mathrm{H}_2\mathrm{O} \) and ions
3. form thixotropic slurries and thick pastes

Montmorillonite’s performance in \( \mathrm{H}_2\mathrm{O} \) systems is maximized by exchanging \( \mathrm{Ca}^{+2} \) by \( 2\mathrm{Na}^{+1} \) (e.g. \( \mathrm{Na}_2\mathrm{CO}_3 \) treatment, called Activation), Electrolytes and Polymers addition

Montmorillonite’s performance in non-\( \mathrm{H}_2\mathrm{O} \) systems (e.g. crude oil, resins, organic solvents, edible oils and fats) requires treatment with other molecules and compounds (e.g. quaternary amines, partial acid leaching with mineral acids, etc.)
General Functionalities of Montmorillonite in H$_2$O environment

Application wise ("mineral" with 1,000 uses") Montmorillonite can be seen as:

1. Binder
2. Thixotropic agent (gelling, sealing, thickening)
3. Absorbent
4. Functional additive
How key-attributes relate to Applications
Bentonite in Foundry application

- Bentonite is used as a binder for the making of moulds.
- Mechanism: Wetted bentonite powder is mixed with Quartz sand grains. Hydrated Smectite platelets are delaminated and cover the sand particles. Bonding takes place through adhesion and cohesion based on the surface properties of the wet clay platelets attached to the quartz surface.
- It is economic and environmentally friendly since the majority of the sand and binder is reused in a cyclic system.
- Key specs for bentonite are:
  - rich in Montmorillonite content
  - High thermal durability at 550°C
Bentonite in Iron Ore pelleting (Balling)

- Bentonite’s binding properties are utilized for the pelleting of fine iron ore concentrates. Bentonite powder is mixed with wet fine beneficiated iron ore. After mixing, tumbling (in Discs or Drums) results in green (“plastic”) pellets formation.
- Mechanism: Hydrated Smectite platelets are delaminated and interconnect the iron ore particles (bridging). Bonding takes through weak chemical bonds between the surface and the edges of the clay platelets and Fe2O3 surface.
- In addition, bentonite provides a secondary binding (slag bonding = “hardening”) at >850 °C.
- Pellets are used as feed to Blast furnace operations (pig iron), and often to Direct Reduction Reactors (sponge iron for mini mills).
Civil Engineering and Oil Drilling muds (Thixotropic Slurries application)

- **Civil engineering**: provides thixotropy/gelling for supporting the trench-front and keeping cuttings in suspension in diaphragm walls, foundations, tunneling operations, horizontal directional drilling (HDD) and pipe jacking.
- **Drilling industry**: is used in the oil and water drilling industry as a mud constituent. It seals borehole walls, removes cuttings and provides lubrication to the cutting head.
Bentonite in Paper manufacturing

Bentonite yields a huge number of **electrically charged platelets** in water environment, thus, improving the **sieve retention** on the paper machine and the **binding of impurities** as resin conglomerates. Also it performs well in process **Water treatment** and purification:

1. **Retention**: Bentonite and Polymers connect paper fibers and fillers forming a better fiber web and resulting in less loss through the sieve. Yield (Retention) and Dewatering are increased (machine’s throughput).

2. **Deposit control**: Tacky substances come from wood or wastepaper (stickers, binders, glue...) and form agglomerates which disturb the process and the quality of the paper. Bentonite **binds** such substances to the fibers before agglomeration.

3. **Water treatment – Effluent control and water recycling**: In water treatment **microflotation** is applied to separate particles and fibres from water by using air. Bentonite and Polymer flocculate these particles and make flotation more effective. Bentonite also adsorbs very fine particles improving the water clarity.
Bentonite in Paints, Plasters and similar pastes

- **Viscosity and plasticity** of bentonite improve thixotropic and pseudo plastic flow behavior. Bentonite works in:
  1. Water-borne paints & coatings
  2. Plasters, sealants
  3. Ceramic masses

- Bentonite’s performance is enhanced through soda overactivation and additional treatment with PEO, MgO, polymers and inorganic salts:
  - High gel strength / High yield point
  - Thixotropic & pseudoplastic flow behavior
  - Anti-settling properties
  - Inhibits running or sag
  - Synergy effect with organic thickeners
  - Can produce a surfactant free emulsion (interfacial barrier that allows for the formation of isolated water droplets)
  - Improved mechanical stability of coatings

- Key properties: 1) strong rheological behavior, 2) high whiteness, 3) ultra-fine particle size 4) stability against electrolytes

- Organoclay and (synthetic) hectorite dominate the clay additives subsegment in P&C market
Bentonite as Animal Feed additive

Smectitic Clay is used:

1. As binder for Animal Feed pellets (group: binders, anticaking agents, substances for control of radionuclide contamination, EC Reg.No: 1m558i)
2. Additionally, as an additive for the absorption of harmful aflatoxin (group: substances for reduction of the contamination of feed by aflatoxin B1, Reg.No 1m558)

Bentonite’s performance as binder and active ingredient:

1. Lamellar structure and surface chemistry contribute to binding, anti-caking and flowing agent properties during pellet processing and conservation
2. By its swelling action slows down the intestinal tract and increases the absorption of nutrients (proteins, lipids)
3. Better environment by livestock manure management
   - Animal waste management by water absorption
   - Management of odor emissions by absorption of ammonia
4. Buffering capacity of clay leads to reduction of acidosis hazard for ruminants.

Bentonite’s performance as Mycotoxins absorber: Bentonite containing >70% dioctahedral smectite is added to the feed to:

1. decrease mycotoxins bioavailability, reduce mycotoxins uptake,
2. reduce distribution to the blood and target organs,
3. prevent future contamination

Flatoxins are produced by fungi. Various absorption mechanisms have been proposed. The most probable ones:

A. Ion-dipole interactions and coordination between exchange cations and carbonyl groups
B. Water bridging effect - H bonding between carbonyl groups and H$_2$O in hydration shells of exchange cations
Bentonite as Pet Litter absorbent

- Granular bentonite is used for the formation of cohesive Clumps (when in contact with pet’s urine)
  - Cat’s urine creates tight clumps which are then scooped and removed
- Recently bentonite along with expanded perlite were used for the development of a new lightweight PL
  - Expanded perlite granules are used as core material, which is coated through balling process with a layer of a bentonite powder
  - Lightweight PL (patented by Nestle) offers the strength of traditional clumping litters at almost
New Applications under consideration (NPD projects)

- Bleaching clays: used for edible oils purification. Bentonites are acid treated at T=80-120°C. Smectite is attacked (selective leaching) in order to increase porosity / surface area. Classification: HPBE (Acid Activated Bentonite), SMBE (Acid treated Attapulgite), NBE (Attapulgite or other).
- OrganoClays: Na⁺ or Ca²⁺ ions are replaced by long chained organic cations, particularly quaternary ammonium salts (“Quats”). Organoclays are used in Oil drilling Muds, Solvent based paints, waxes, etc.
- Geosynthetic Clay Liners (GCLs): develop resistant bentonites to high alkalinity and high conductivity effluents.
- Nuclear Waste sealing: Highly compacted bentonite products (rings, pellets or bricks) ensuring their sealing properties for 100s of years for radioactive wastes permanent disposal. Aflatoxin absorbent (in animal feed): Na-Mont adsorbs aflatoxins and thus reduces or eliminates toxicity of the mycotoxins to animals and humans.
- Seed Growth: seeds are coated with a bentonite slurry which provides the water to promote rapid sprouting of the seed when planted (gardens and greenhouses).
- NanoClays: bentonite is purified and platelets are dispersed in the size of nanometers. By organophilization Nanoclays are produced suitable as resin fillers, e.g. for reinforcing PP and Nylon 6 composites.
- Cosmetics: Na-activated, organoclays, and white bentonite are used in cosmetic formulations. Small quantities provide thixotropic and suspension aids.

Future(?): 1) Catalysts: Ca-Monts’ and Acid Activated provide catalytic activity and are used in Petrochemical industry. Acid-treated Monts are used for dimerization reactions of unsaturated fatty acids, etc. 2) Pillared Clays: Monts pillared with inorganic cations (e.g. Al hydrated Complexes) are used as catalysts, selective sorbents, membranes. 3) Pesticides Carrier: pesticides are absorbed on the granular particle which is incorporated in fertilizers or spread directly on the ground. Calcination is sometimes required.
Perlite: an expandable Volcanic glass
Key Perlite and Volcanic glasses attributes

**Perlite** is:

- A Volcanic glass containing **70-76% amorphous silica**. It is a **solid solution** of Alkalis (K, Na) in SiO2 matrix.
- **Expands 5-30 times** its original volume, when rapidly heated to its softening temperature range (>870 °C), due to the presence of 2-5% “combined” H2O and Alkalis (6-10%).
- “Combined” H2O is exists mainly the form of **Silanol groups [SiOH]** Also present: OH-, H2O absorbed by few exchangeable ions, H2O bound through Hydrogen bonding.

**Unexpanded perlite (milled, graded)** is used in industry due to its: 1) amorphous SiO2 (70-76%), which is **chemically very reactive** against certain chemical solutions, 2) abrasiveness.

**Expanded perlite** has exceptional physical properties, making it appropriate for numerous applications in **Construction and Building**: 1) **Light weight** (apparent density: 30-150 kg/m³), 2) **Low thermal conductivity** (0.035-0.06 W/m×K at 24°C), 3) **Multi-Cellular structure**

**Functionality of Perlite in BCMs Applications:**

1. Reduction of the end-product weight (**“Lightweight”**) 
2. Enhancement of **acoustical** and **thermal insulation** properties (high porosity) 
3. Improved **flow characteristics** and **workability** of bulk products (mortars, plasters) 
4. Chemically **inertness** 
5. **Economically** attractive
Established applications of perlite

- **Construction industry**
  - Thermal-acoustical insulation tiles
  - Lightweight concrete, plasters, mortars
  - Loose fill insulation in masonry constructions

- **Food and Fertilizers industry**
  - Filter-aids
  - $\text{H}_3\text{PO}_4$ production

- **Industrial insulation, heat and high temperature Resistance**
  - Cryogenics and low temperature insulation
  - Preformed perlite-silicate products for insulation
  - Steel and foundry industry
  - Other high temperature applications

- **Horticulture**
  - Hydroponics
  - Growing media
Acoustical ceiling tiles are manufactured from mineral wool, cellulose fibers, starch, clay, fiberglass and expanded perlite. The raw graded perlite is expanded and the added proportion in the formulation can vary tremendously (from 10 to 75 w/w%) depending on the required properties of the finished product.

- Expanded Perlite is added to increase the porosity of the tile, to enhance their acoustical properties as well as to provide bulk volume in order to reduce tile weight.
Expanded Perlite in Lightweight concrete (LWC), plasters (LWP) and mortars (LWM)

Perlite improves physical properties when added to construction mixes. Primarily reduces the density of the product and enhances thermal insulation characteristics.

Perlite is a vital ingredient in lightweight gypsum plasters or mortars (LWP, LWM), which are specially formulated to be mechanically sprayed on the wall.

- **Masonry Mortar**: Bind materials together.
- **Plaster**: For leveling or smooth finish to the wall.
- **Render**: Protect against weathering (Monocouche for France)
- **Insulating Render**: Improve thermal insulation of walls.
- **Screed**: For leveling or smooth finish to the floor
- **Tile Adhesive**: Binding materials together
- **Dry Concrete**: Pre-packed & Ready-mix concrete for DIY
- **Colored Render**: Decorative coatings mainly to historical buildings (renovation)

**Type of end-product**

**Function**

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**LWC application**

Lightweight concretes (LWC) are used in roofing decks to reduce the weight that has to be supported by load-bearing structures. At the same time, thermal insulation ability is improved and transmission of noise reduced. Perlite also improves flow characteristics of cement or concrete and so is used in self-leveling floor screeds. LWCs are also used to insulate spaces around heating, steam, coolant pipes or bases for ovens, furnaces and cold storage tanks.
Expanded perlite for Loose fill insulation in masonry construction

Expanded perlite is used as loose fill insulation material:

- in cavity walls
- for filling the hollow cores of masonry blocks
- in fire doors
- to improve thermal insulation and fire resistance
Horticulture applications (1)

Expanded perlite increases the production yield and improves the quality of agricultural products as it:

1. provides good aeration and optimum moisture retention for plant growth (due to high porosity)
2. regulates drainage rate
3. has a reasonably stable pH (almost neutral)
4. is sterile (due to the high temperatures prevailing during expansion)
5. is weed-free
6. can be recycled

This garden had approximately 2 inches of fine grade perlite filled into the soil early in the growing season. The results after an extremely dry summer with almost no watering!
Horticulture applications (2): Hydroponics and Growing media

Hydroponic cultivation: growing of plants in a non-soil, supporting media

- Allows delivery of controlled amounts of water and specific nutrients to the plants.
- Either in greenhouses, or in the open air with plants in grow bags filled with perlite.

Perlite advantages:

- Strong capillary action while retaining good drainage: plants draw up water and nutrients at the needed rate
- It can be recycled
- It retains more air than the other materials, optimising root development

Typical “soil-less mix” with perlite (20-40% by volume):

- pH 5.9-6.7
- Moisture content 11-45%
- Apparent density 95-130 kg/m³ (0.09-0.13 g/ml)
- Sieve size < 9.5 mm
- “Soil-less mix” provides a growing medium for plant propagation, eliminating the risk of contamination by disease, insects and herbicide residues
Expanded Perlite in Cryogenics, Low Temperature Insulation and Special Industrial Insulation

A. Expanded Perlite insulates Low temperature and Cryogenic vessels used for the transportation or storage of very cold liquids. Storage tanks are double walled: the space between the inner and outer wall is evacuated (only for special cryogenic service) and simultaneously filled with fine expanded perlite. Perlite is ideal because of its free flowing nature.

- **“low temperature applications”**: liquids at temperatures -4°C down to -100°C
- **“cryogenic applications”**: liquids at temperatures lower than -100°C

B. Preformed expanded perlite-silicate Products for Special Industrial Insulation

Expanded perlite granules are bonded with the use of a suitable binder (Liquid sodium silicate or potassium silicate) to form rigid shapes for a wide range of insulating applications. The produced shapes (“Sproules”) are usually provided in the form of half shells for pipe insulation or in blocks:

1. are water resistant (<10% WA), do not corrode (“corrosion inhibitors”) the item to be enclosed
2. are thermally efficient (0.058 W/m.K at 120 DC)
3. fire resistant and stable (up to 650°C) throughout their temperature range of performance.
Chemical industry: \( \text{H}_3\text{PO}_4 \) production for Fertilizers

Medium-fine raw graded perlite (<0,8 mm) is used as modifier in the production of phosphoric acid with the “Wet” process (Wet process Phosphoric Acid-WPA):

\[
\text{Ca}_{10}(\text{PO}_4)_6\text{F}_2 + 10\text{H}_2\text{SO}_4 \rightarrow 10\text{CaSO}_4 + 6\text{H}_3\text{PO}_4 + 2\text{HF}
\]

Main advantages of perlite addition:

1. **Reduction in overall plant corrosion caused by HF** (\( 6\text{HF} + \text{SiO}_2 \) (perlite) \( \rightarrow \) \( \text{H}_2\text{SiF}_6 + 2\text{H}_2\text{O} \))
   \( \text{H}_2\text{SiF}_6 \) then precipitates as \( \text{Na}_2\text{SiF}_6 \), \( \text{KSiF}_6 \) or \( \text{NaKSiF}_6 \).
   - Target: to correct the active \( \text{SiO}_2/\text{F} \) ratio to at least 0.53
   - adjust the \( \text{Al}_2\text{O}_3/\text{P}_2\text{O}_5 \) rate, to approx 0.020

1. **Reduction of the HF emission to the atmosphere**

1. **Increased efficiency in the filtration and washing stages of the \( \text{H}_3\text{PO}_4 \) production** (avoid Gypsum needles)
   - The gypsum crystal needle then changes from to a cluster-like shape whose specific surface area is significantly smaller

1. **Less \( \text{P}_2\text{O}_5 \) residues left in the filtering cake**
1. Puzzolane Cement

Natural pozzolans are used in the production of CEM II and CEM IV pozzolanic cements. Addition has a positive effect on: 1) heat of hydration, 2) alkali silica reaction, 3) permeability

- Perlite-based Pozzolans and super-Pozzolans are volcanic glasses
- high amorphous state, used in the production of pozzolanic cements

1. HPC Concrete

High-performance concrete (HPC) complies with properties that lead to long service life in severe environments: 1) strength, 2) water and chloride permeability, 3) resistance to alkali silica reaction

HPC is specified in the most of infrastructure projects such as bridges, airports, highways and in demanding projects like skyscrapers and high rising buildings.

- Micrasil is a new, effective, mineral based material of high consistency, being thus an attractive substitute of Supplementary Cementitious Material (SCM) like silica fume, natural pozzolans, fly ash or slag
Phyllomat: Reinforcing filler or Functional additive

- Phyllomat is jet-milled expanded perlite, lamellar-shaped and free of quartz (silane coated or uncoated)
- suitable to work as a functional filler in polymers and plastics and other formulations
- Morphology: platelets with aspect ratio of 10:1 – 20
Micrasil is a highly performing SCM. It reacts with the free lime, by-produced during the hydration of cement, providing:

1. Higher strength (due to additional hydraulic bonds)
2. Lower Porosity (due to the formation of calcium silicates in the interstitial spaces)
3. Enhanced Durability (lower chloride penetration, lower alkali-silica reactivity)
4. Improved Workability

In very demanding climate conditions (extreme heat & cold) and in aggressive soil (Cl⁻, SO₄²⁻), SCMs are inevitable component for construction in order to achieve concrete durability for more than 50 years.

- Typical SCMs used are silica fume, fly ash and GGBS and all of them are by products/ wastes of the silicon, coal energy or pig iron industry
- On the contrary, Micrasil is an industrial product with guaranteed physical and chemical profile and functionality
Projects in Pipeline: Geopolymers (based on perlite and/or clays)

The Challenges for the construction industry are set under the “20-20-20 objective”

- Embodied energy may account for 20% of the building’s energy use
- Building components with improved thermal properties

IMERYS’ Solution: Development of a new generation of inorganic, incombustible, insulation materials and building masonry components (“3I”) based on minerals with lower embodied energy (>50%), lower cost (15%) and upgraded properties compared to the commercial CBMs
Imerys represents 6% of global and 28% of EU bentonite production.

sources: Annual Reports, 10-K reports, Roskill 2015, Imerys market intelligence
Leading position in almost all major bentonite applications, particularly foundry and iron ore pelletizing (IOP)

sources: Annual Reports, 10-K reports, Roskill 2015, databases with import/export data, Imerys market intelligence
EEA Bentonite consumed at a glance

### EEA 2.835 KT

- **Others**: 1.128 kT (40%)
  - **Imerys**: 797 kT (27%)
  - **Laviosa**: 60 kT (2%)
  - **Ashapura**: 37 kT (1%)
  - **Mineral Technologies**: 125 kT (4%)

### Sources:
- Annual Reports
- 10-K reports
- Roskill 2015
- Imerys market intelligence

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### EEA 2.835 KT

- **Foundry**: 785 kT (27%)
- **Construction**: 300 kT (11%)
- **IOPC**: 197 kT (7%)
- **Drilling**: 40 kT (1%)
- **Others**: 1,533 kT (54%)

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### Market Share by Country

- **Germany**: 301 kT (33%)
- **France**: 59 kT (27%)
- **Italy**: 67 kT (31%)

### Market Share by Producer

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<th>Producer</th>
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<th>France</th>
<th>Italy</th>
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<td><strong>Ashapura</strong></td>
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<td><strong>Laviosa</strong></td>
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<td><strong>Others</strong></td>
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### Total Market

- **Germany**: 924 kT (100%)
- **France**: 217 kT (100%)
- **Italy**: 215 kT (100%)
## USA Bentonite consumed at a glance

### Foundry Market

<table>
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<th>Company</th>
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<th>Construction</th>
<th>IOP</th>
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<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imerys*</td>
<td>162</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>162</td>
</tr>
<tr>
<td>Mineral Technologies</td>
<td>574</td>
<td>220</td>
<td>150</td>
<td>497.5</td>
<td>44%</td>
<td>1.442</td>
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<tr>
<td>Clariant</td>
<td>0</td>
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<tr>
<td>BPM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>848</td>
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<tr>
<td>MI-SWACO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>500</td>
</tr>
<tr>
<td>Others</td>
<td>56</td>
<td>70</td>
<td>150</td>
<td>233</td>
<td>21%</td>
<td>509</td>
</tr>
<tr>
<td>Total market</td>
<td>736</td>
<td>276</td>
<td>420</td>
<td>900</td>
<td>100%</td>
<td>3.460</td>
</tr>
</tbody>
</table>

### Construction Market

<table>
<thead>
<tr>
<th>Market</th>
<th>Foundry</th>
<th>Construction</th>
<th>IOP</th>
<th>Drilling</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>3.460</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.460</td>
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</tbody>
</table>

### Drill Market

<table>
<thead>
<tr>
<th>Market</th>
<th>Foundry</th>
<th>Construction</th>
<th>IOP</th>
<th>Drilling</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA 3.460 KT</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>3.460</td>
</tr>
</tbody>
</table>

### Other Markets

- Major player in US market is MTI (Minerals Technologies), having overall 42% market share.
- Imerys is purchasing bentonite from BPM and provides the US foundry market with a bentonite + coal blend (75%:25%).
- Other Wyoming bentonite producers in US are Black Hills (ca. 600 kT production) and Wyo-Ben (ca. 460 kT production).
- Other major applications are pet litter (ca. 950 kT) and animal feed (ca. 90 kT).
- Large quantities (350-450 kT) are exported from US to Canadian market.

Sources: Annual Reports, 10-K reports, Roskill 2015, Imerys market intelligence.
Imerys represents 25% of global and 45% of EEA perlite production.

*: British Geological Survey (BGS) estimate: Iran is producing around 1.1 mio MT pa (not included)
**: PERGEM is JV (50/50) of Imerys with IPM (Turkey)

sources: Annual Reports, 10-K reports, Roskill 2011, Imerys market intelligence
EEA Perlite consumed at a glance

EEA: EU- including TR + CIS

sources: Annual Reports, 10-K reports, Roskill 2011, Imerys market intelligence
North America Perlite consumed at a glance

The largest market in North America, with Imerys being the leading raw perlite supplier with 52% market share, followed by Dicalite/Grefco (24% share). The horticulture market is led by Cornerstone, having 41% share, with Imerys as the second largest player with 25% market share. The plaster and mortar (rather joint compounds related) business is equally split among Imerys and Dicalite/Grefco (46%). Lightweight cat litter business, recently developed by Nestle-Purina, was supported by Imerys in Bloomfield, MO.

Sources: Annual Reports, 10-K reports, Roskill 2011, Imerys market intelligence
Thank you for your attention