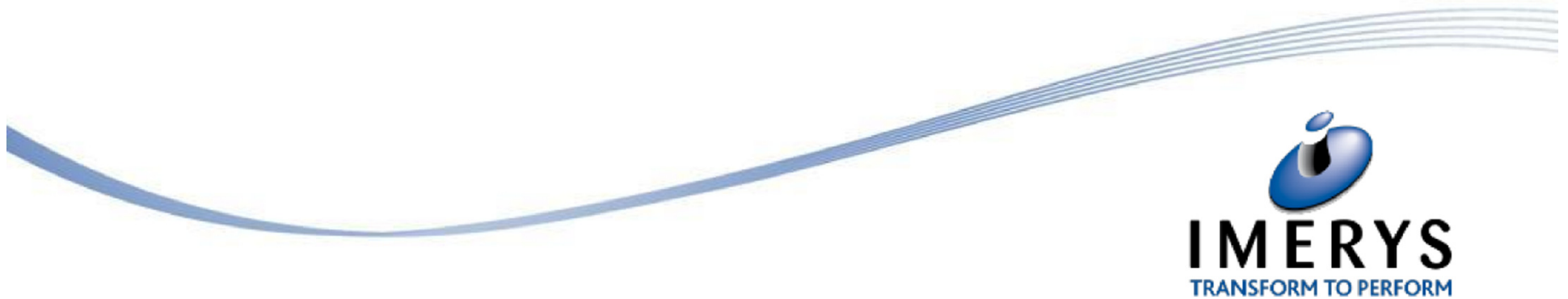


INTRODUCTION TO BENTONITE & PERLITE MINERALS: KEY ATTRIBUTES & FUNCTIONALITIES



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



FTSE4Good



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



2015 Constituent
MSCI Global
Sustainability Indexes

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.)





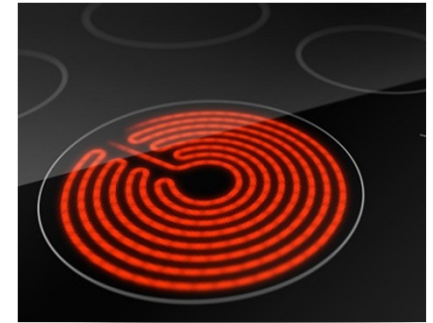
Filtration of edible liquids



Gloss and opacity for paint



Lifespan of lithium-ion batteries to improve electric vehicle autonomy



Conductivity of ceramic hobs



Strength and **lightness** of vehicle bumpers



Protection of crops

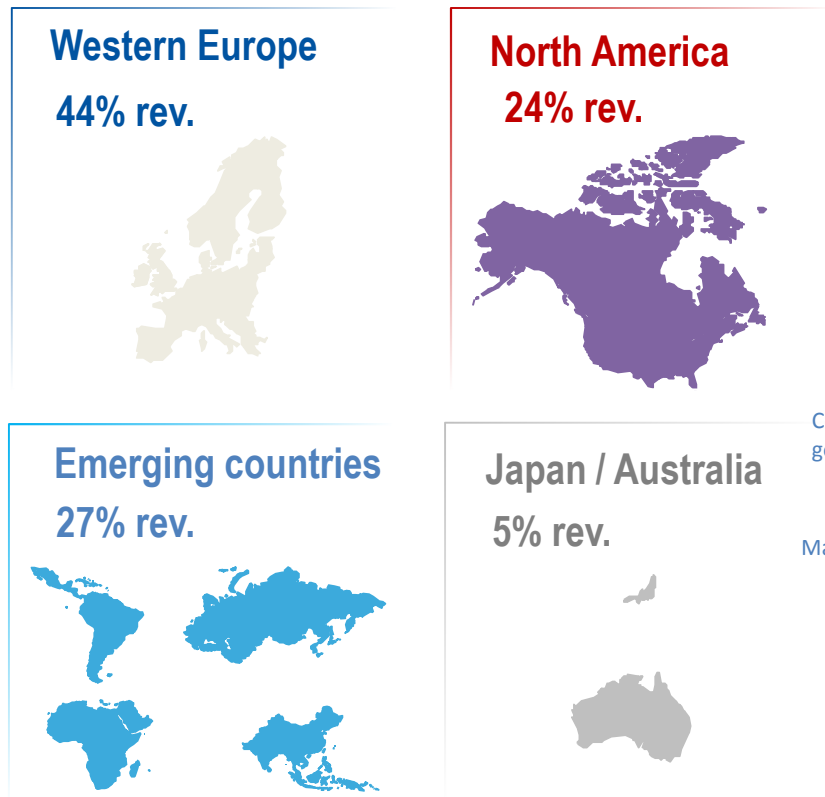


Watertightness and **insulation** of roofs

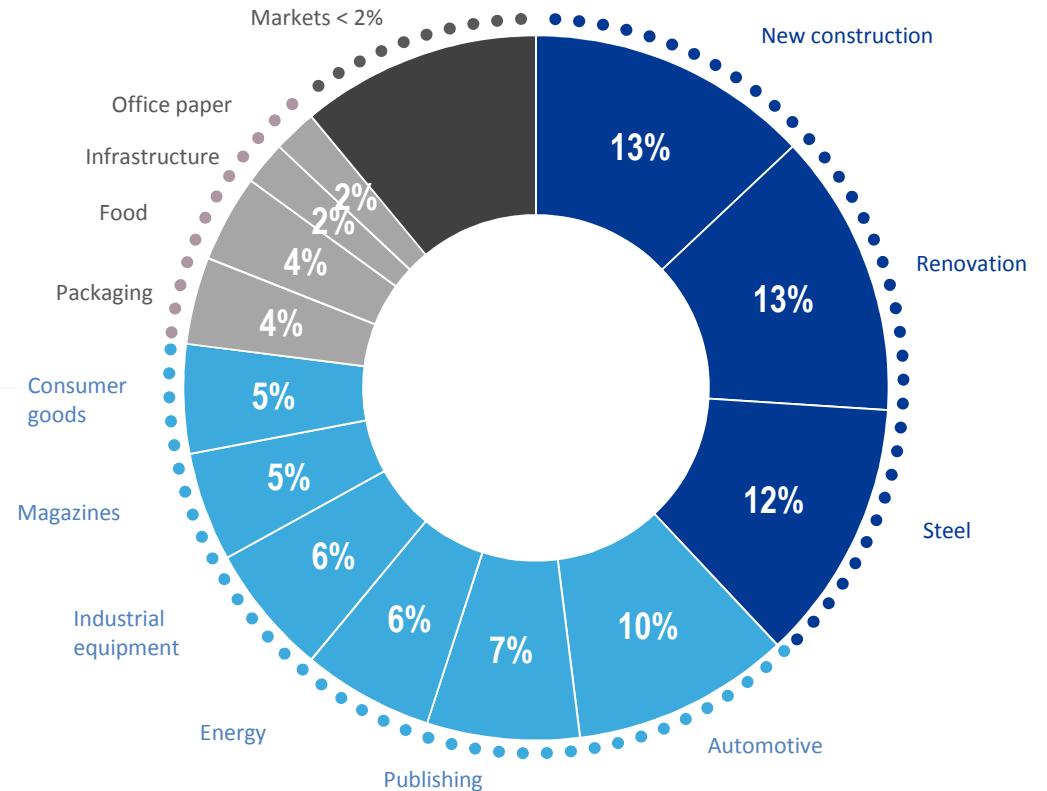


Whiteness and **toughness** of sanitaryware

Revenue by geographic destination in 2015



Revenue by market in 2015

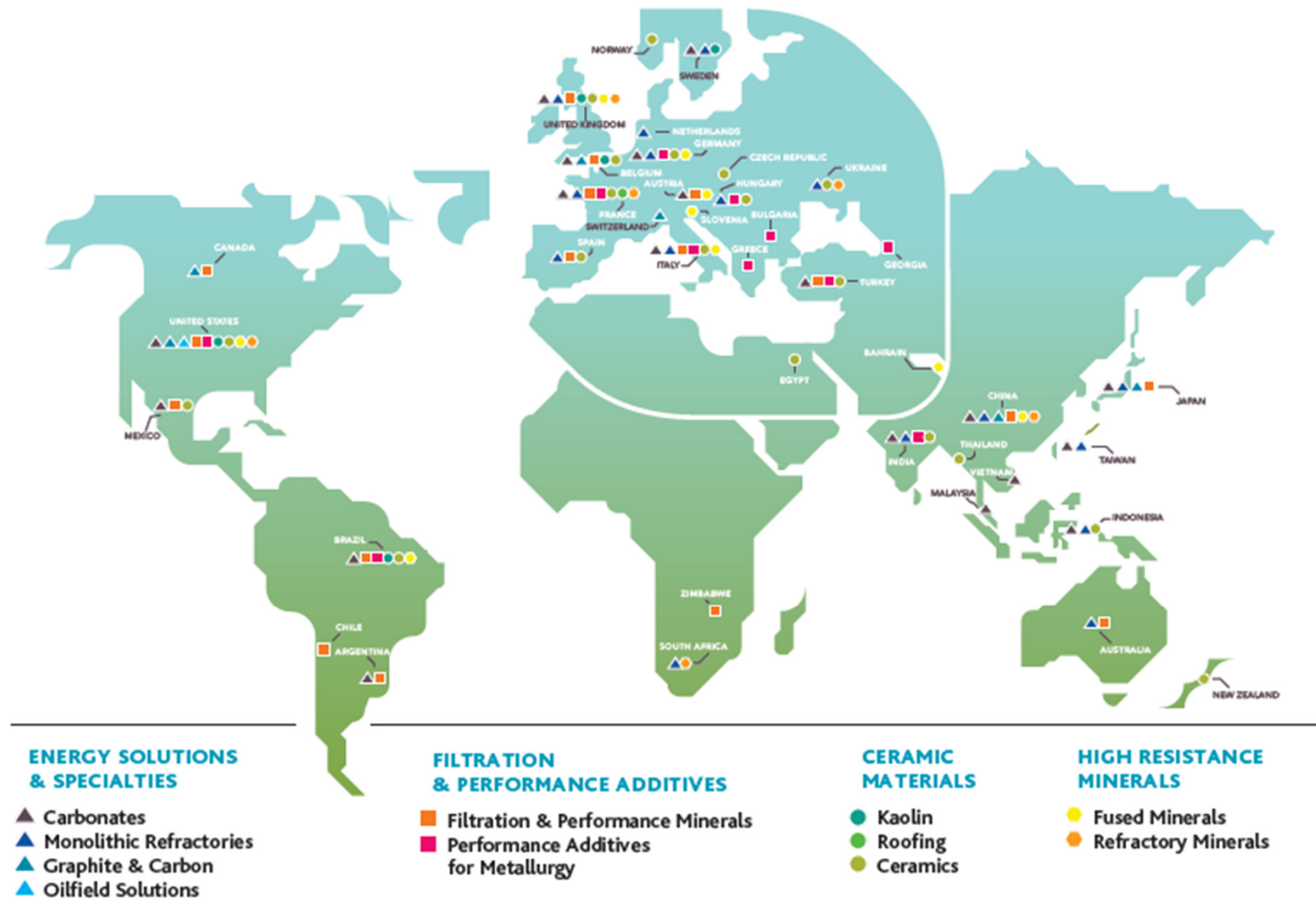


The world leader in mineral-based specialties for consumer goods, industrial equipment and construction, with presence in **50** countries

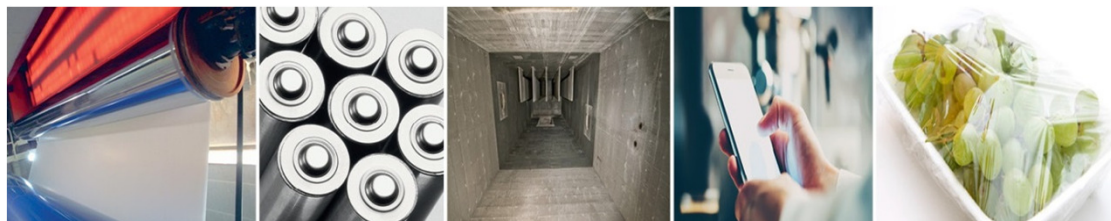
Energy businesses are leaders in most of their markets

Energy Solutions & Specialties	▪ Carbonates ▪ Monolithic Refractories ▪ Graphite & Carbon ▪ Oilfield Solutions	Revenue 1,253 M€
Filtration & Performance Additives	▪ Performance Minerals ▪ Minerals for Filtration ▪ Performance Additives for Metallurgy	Revenue 1,082 M€
Ceramic Materials	▪ Kaolin ▪ Ceramics ▪ Roofing	Revenue 1,172 M€
High Resistance Minerals	▪ Fused Minerals ▪ Refractory Minerals	Revenue 630 M€

A global presence



Energy Solutions & Specialties



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.

Filtration & Performance Additives



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



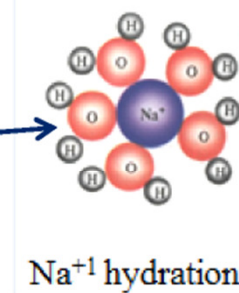
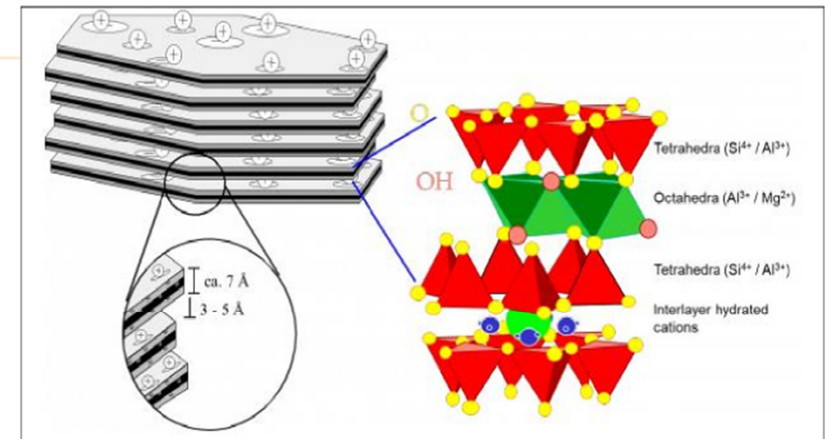
Bentonite mineralogy and attributes



Bentonite's Structure

□ Bentonite is a volcanic **rock** composed dominantly of clay minerals belonging to Smectite group.

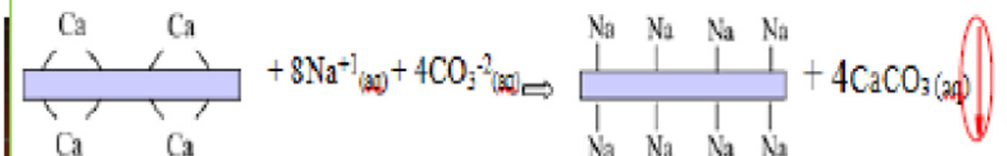
- Consists of 3-layer platelets: an octahedral layer comprising of Mg, Fe, Al and OH-groups, sandwiched between two tetrahedral layers with Si-O tetrahedrons.
- One smectite mineral is the di-octahedral Montmorillonite (part of Al^{+3} is replaced by Mg^{+2} and Fe^{+2} while Si^{+4} is replaced by Al^{+3})
- Due to isomorphous 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_2O Absorption, Swelling, Thixotropy, Thickening



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



The preference of Na_2CO_3 for Activation (Cation Exchange):



Bentonite's (Montmorillonite's) behavior in aquatic environment

- Montmorillonite's performance is due to its ability to:
 - disperse in colloidal particles («easy cleavage» vs. other clays like e.g. kaolinite)
 - absorb and immobilize big amounts of H_2O and ions
 - form thixotropic slurries and thick pastes
- Montmorillonite's performance in H_2O systems is maximized
 - by Exchanging Ca^{+2} by $2Na^{+1}$ (e.g. Na_2CO_3 treatment, called Activation),
 - Electrolytes and Polymers addition
- Montmorillonite's performance in non- H_2O 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.)

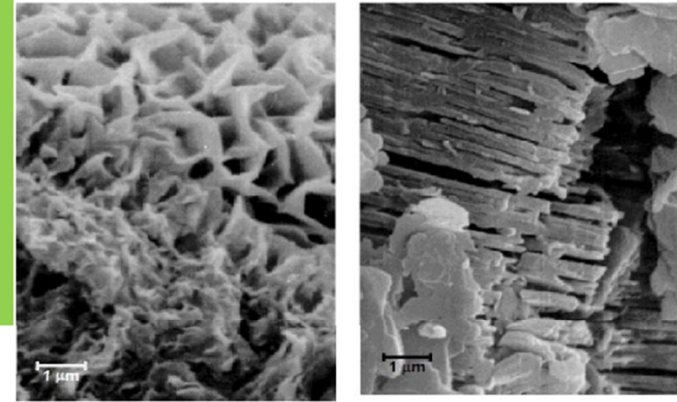
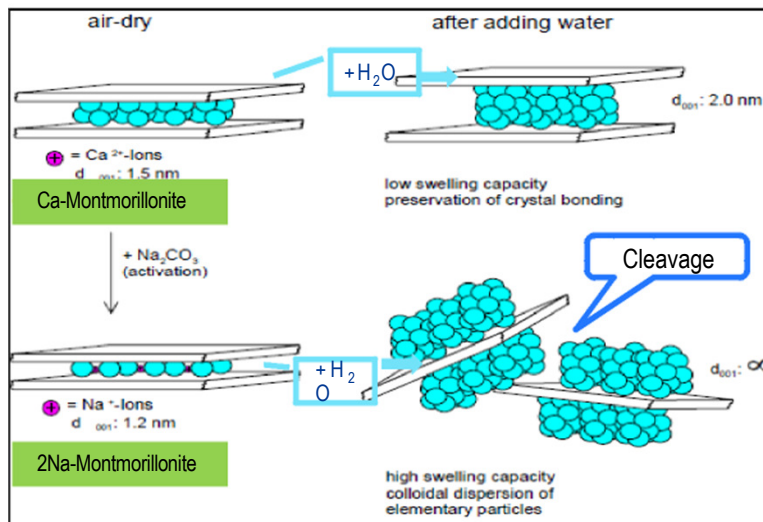
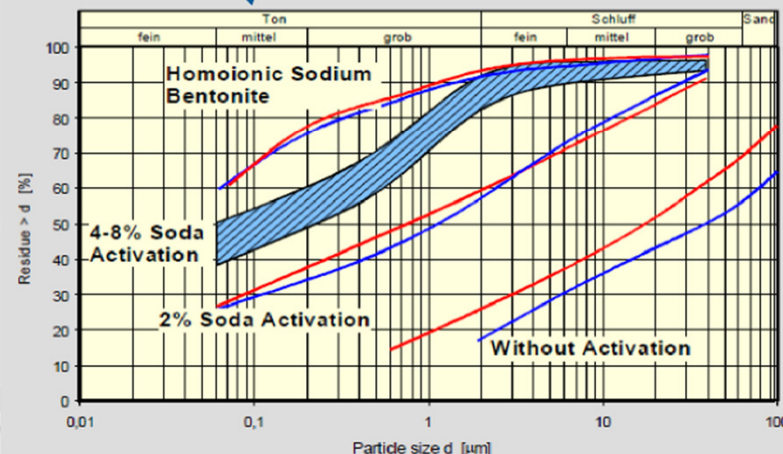


Fig. 2: Smectite and kaolinite under the electronic microscope

Montmorillonite	50-120 m ² /gm (external surface)
	700-840 m ² /gm (including the interlayer surface)
Illite	65-100 m ² /gm
Kaolinite	10-20 m ² /gm



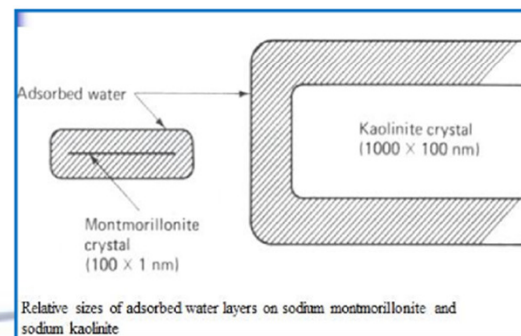
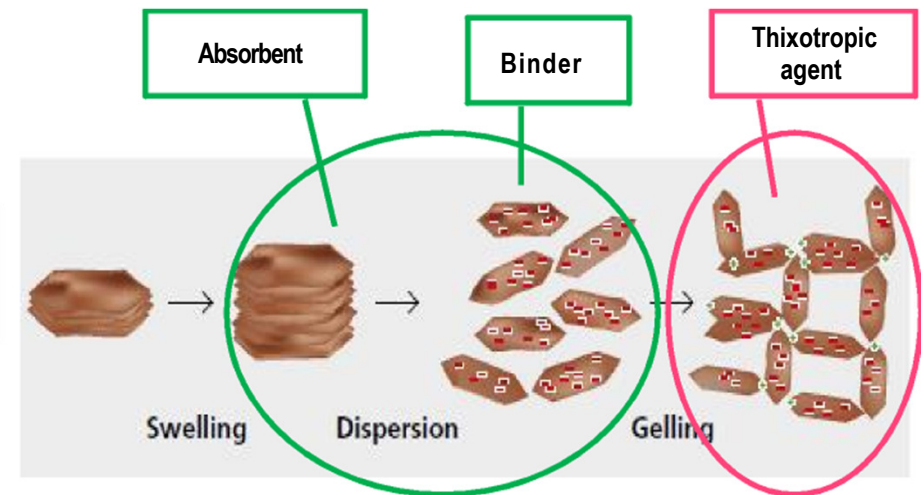
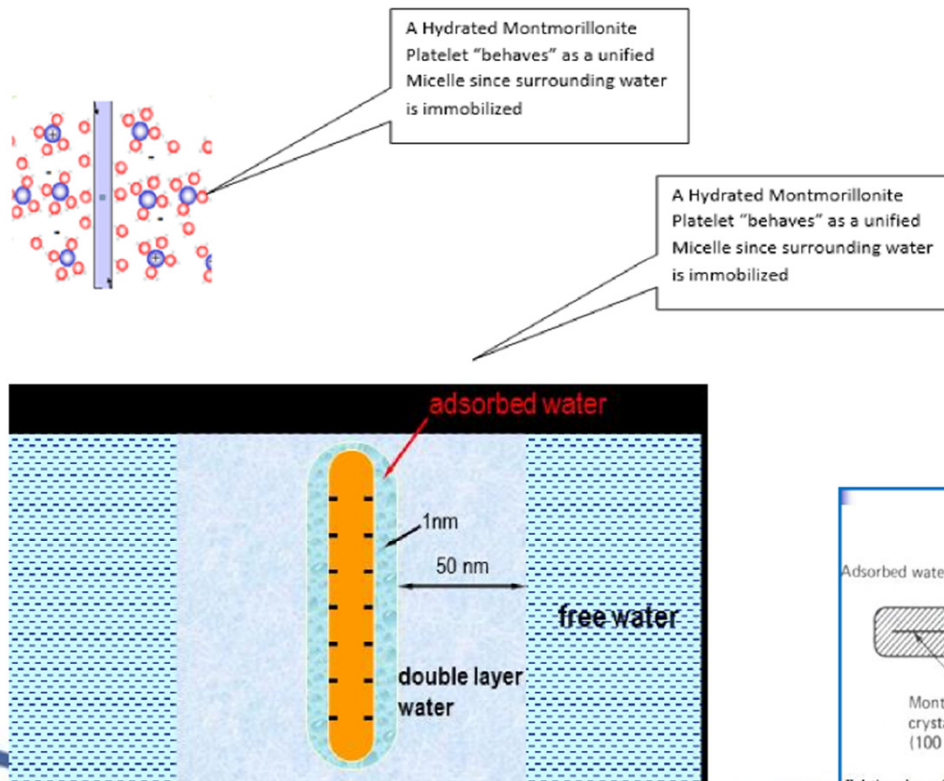
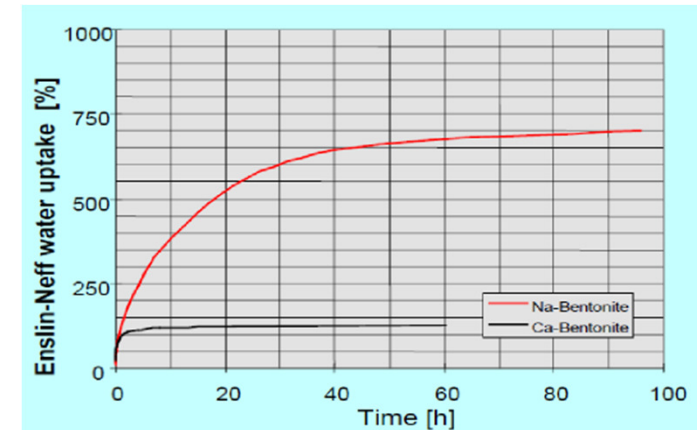
Grainsize distribution (Sedimentation)



General Functionalities of Montmorillonite in H₂O 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



and Perlite Attributes



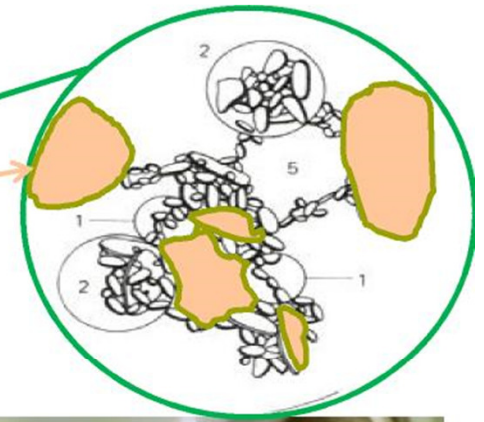


How key-attributes relate to Applications



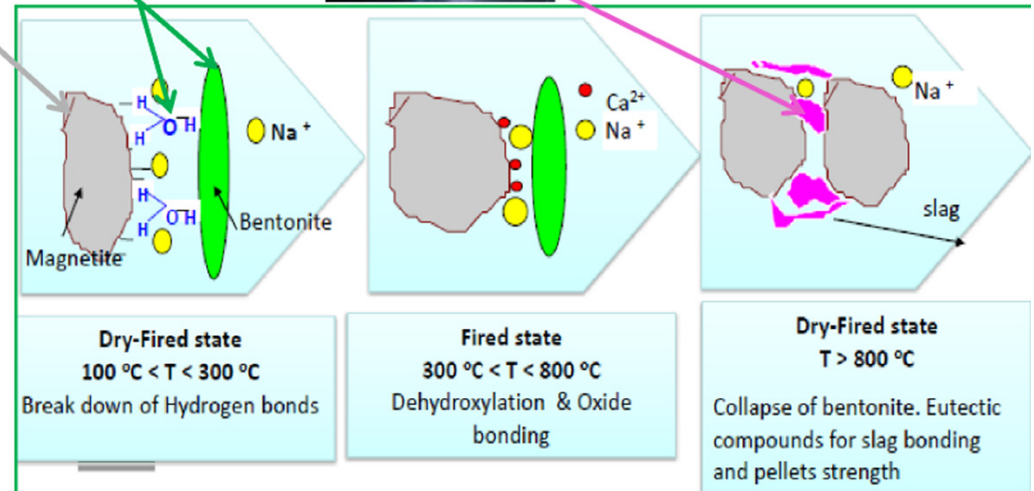
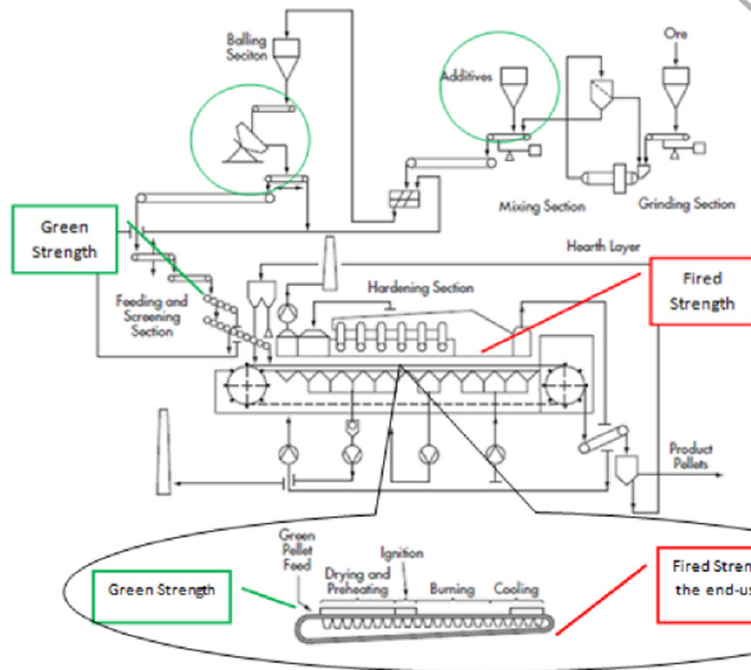
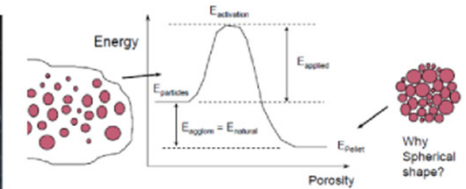
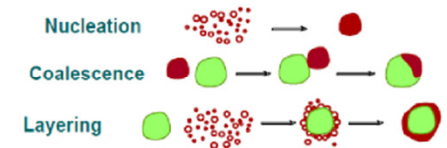
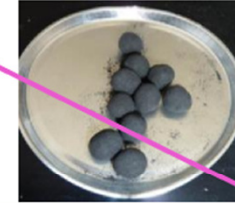
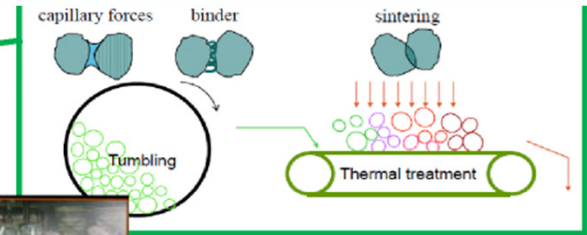
Bentonite in Foundry application

- Bentonite is used as a **green 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 pelletizing (Balling)

- Bentonite's **binding** properties are utilized for the **pelletizing** 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

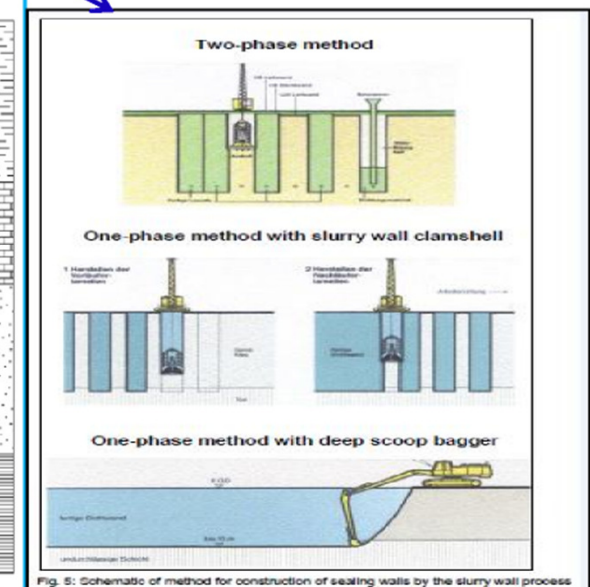
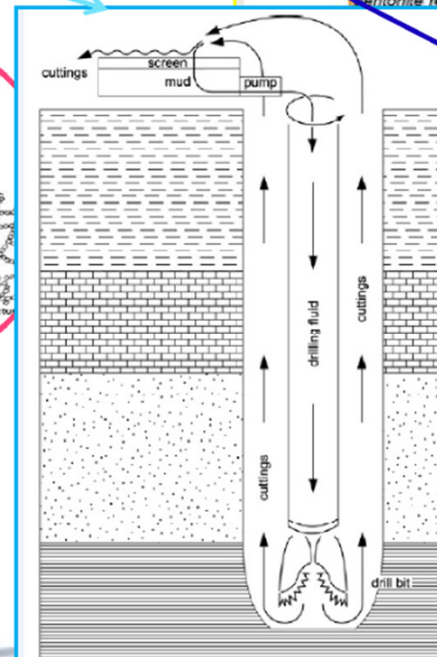
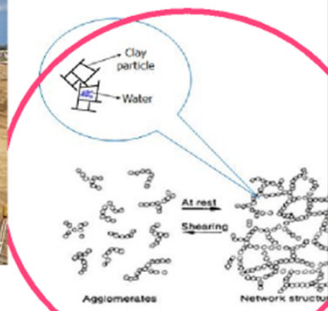
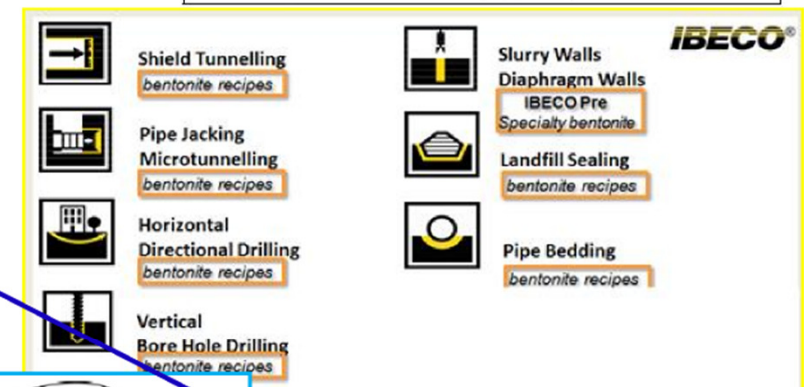
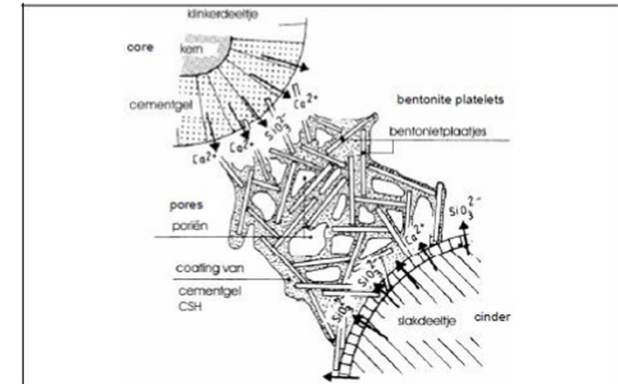
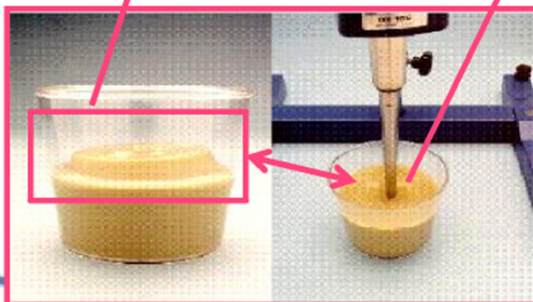


Fig. 63. Schematic showing drilling mud flow in an oil well.

Fig. 5: Schematic of method for construction of sealing walls by the slurry wall process



Bentonite in Paper manufacturing

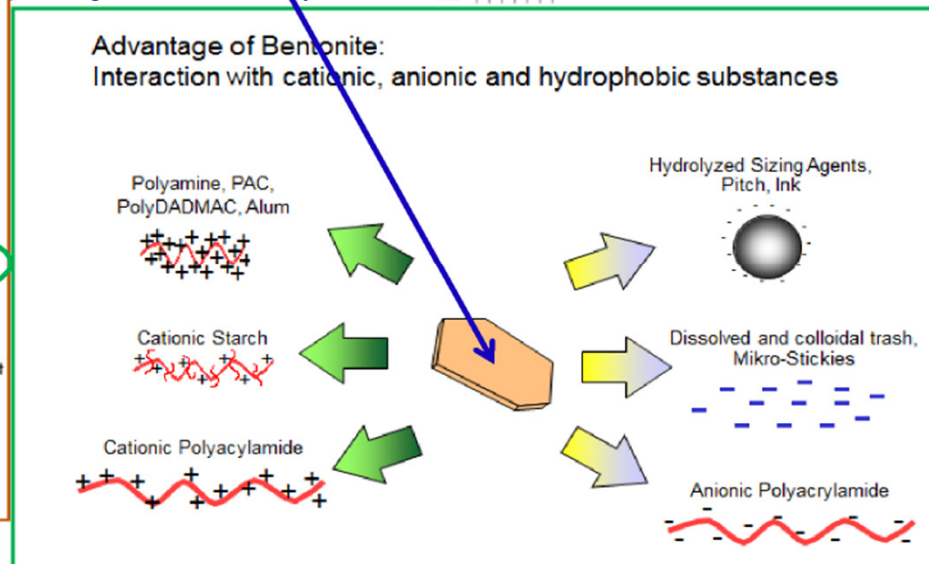
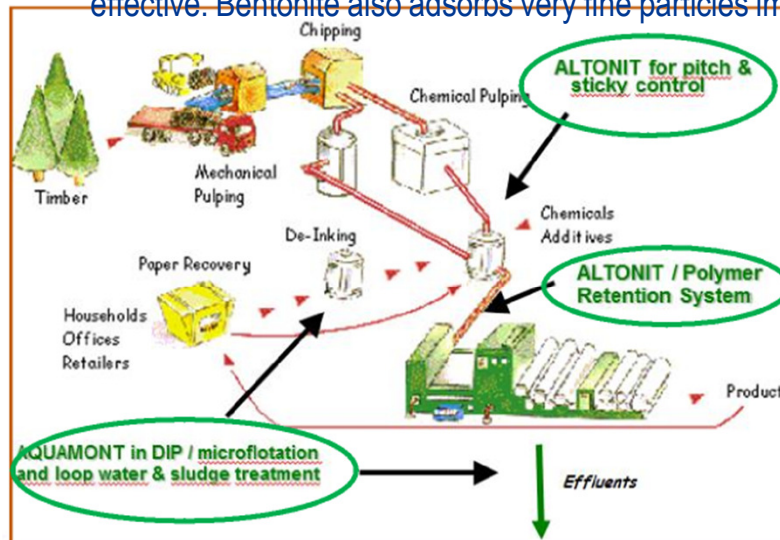
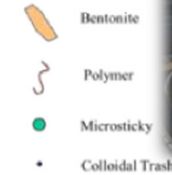
Bentonite yields a huge number of **electrically charged platelets** in water environment, thus, improving the **sieve retention** on the paper machine and the **binding of impurities** as resin conglomerates. Also it performs well in **process Water** treatment and purification:

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: Sticky 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:

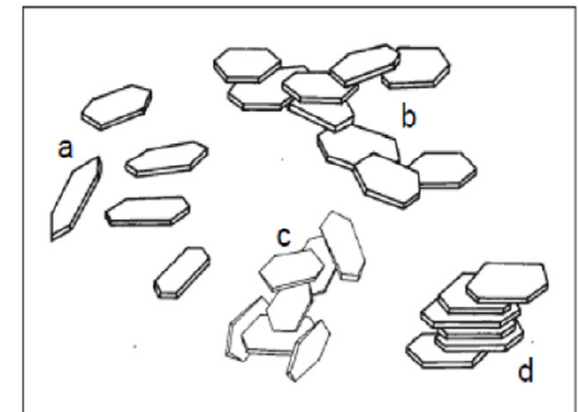
- High gel strength / High yield point
- Thixotropic & pseudoplastic flow behavior
- Anti-settling properties
- Inhibits running or sag
- Synergy effect with organic thickeners
- can produce a surfactant free emulsion (interfacial barrier that allows for the formation of isolated water droplets)
- Improved mechanical stability of coatings

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

• Organoclays and (synthetic) hectorite dominate the clay additives subsegment in P&C market



Rheology of Bentonite Dispersions



Model for Dispersions of Bentonite:

- a: sol - exfoliated particles
- b: 3-dimensional band-type gel
- c: 3-dimensional cardhouse-type gel
- d: aggregates (flocs)

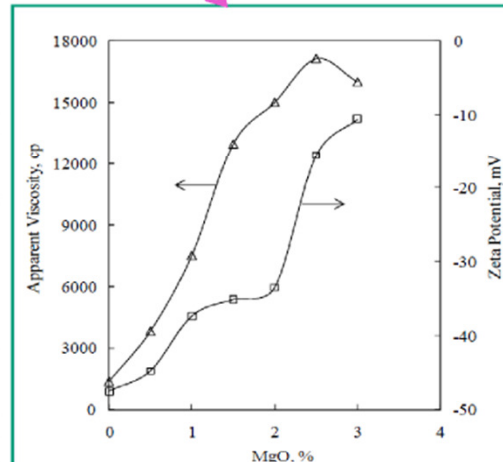
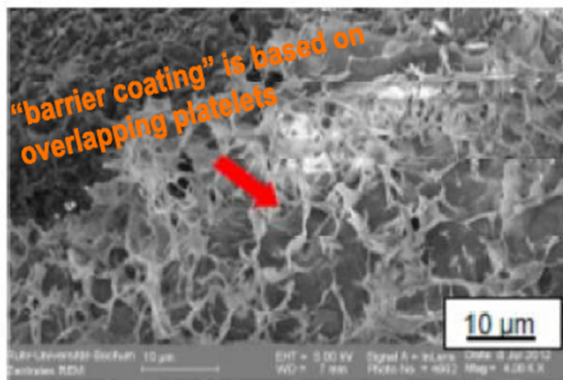


Fig. 3 Dependence of viscosity and zeta potentials on MgO dosage.

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)
 1. 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 H₂O in hydration shells of exchange cations

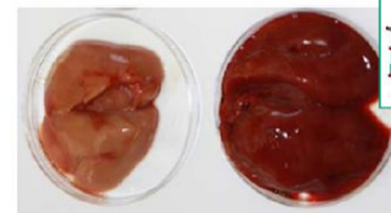
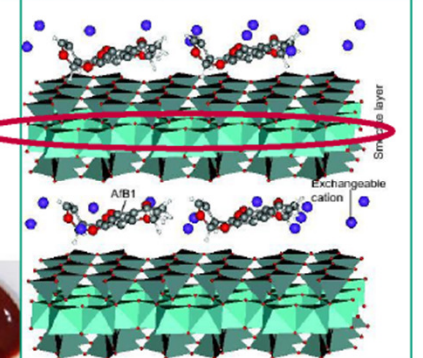
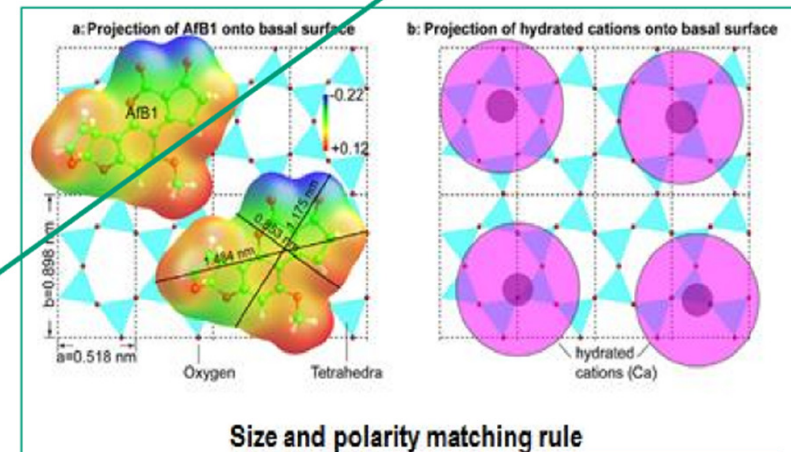
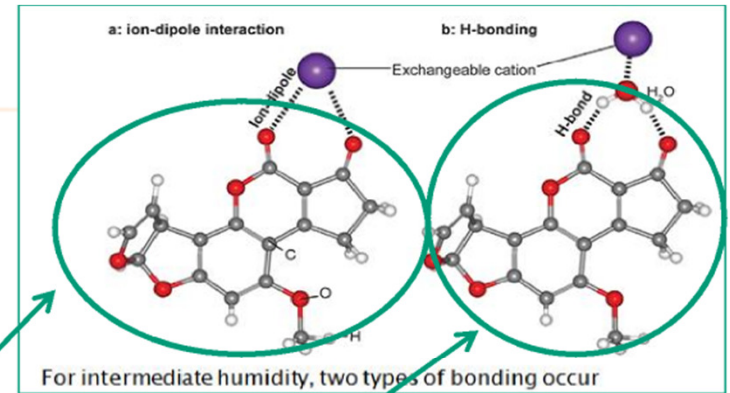
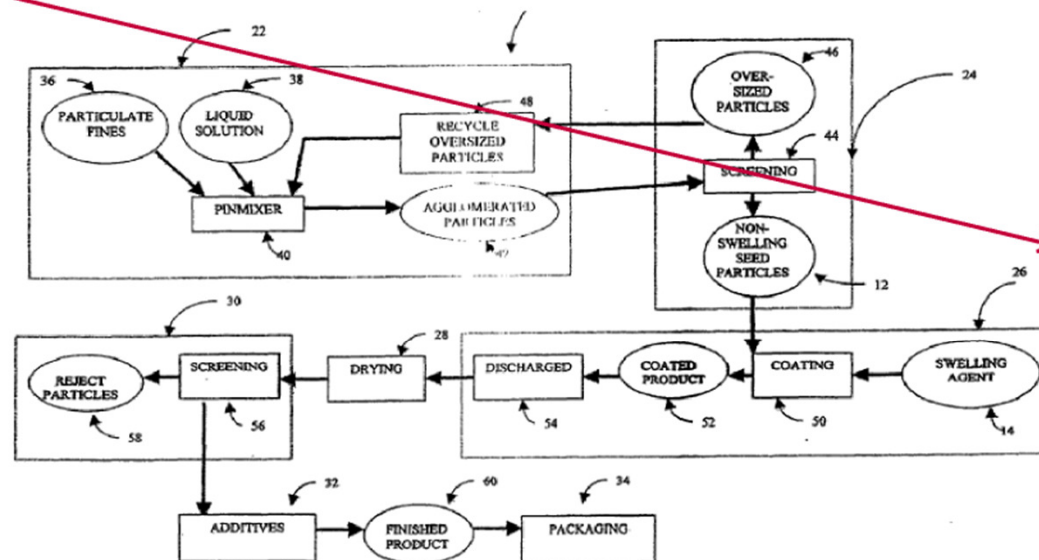
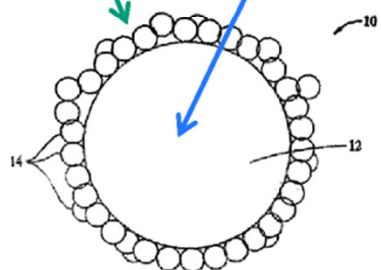
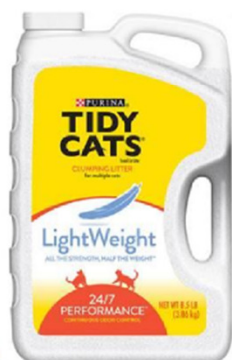


Fig. 5-6. Livers taken from 3-wk-old broilers fed either 1400 (left) or 0 (right) ppb aflatoxin.

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

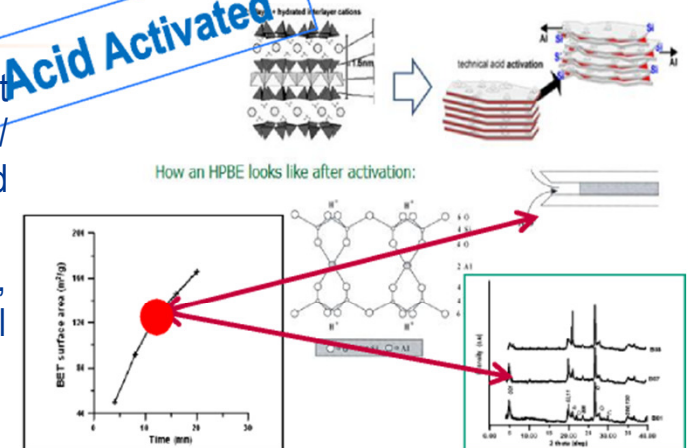


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New Applications under consideration (NPD projects)

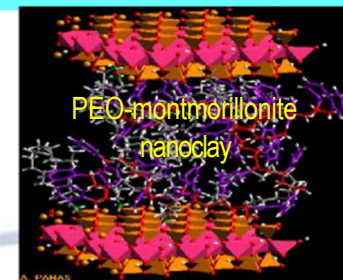
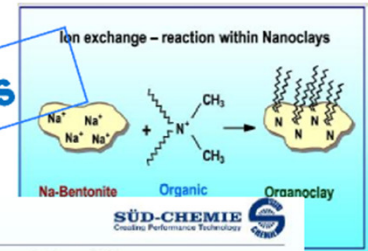
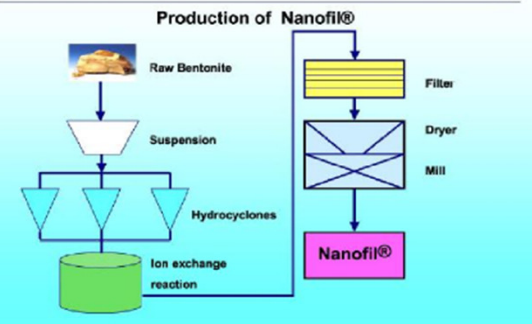
- Bleaching clays: used for edible oils purification. Bentonites are acid treated at $T=80-120^{\circ}\text{C}$. Smectite is attacked (selective leaching) in order to increase porosity / surface area. Classification: HPBE (Acid Activated Bentonite), SMBE (Acid treated Attapulgite), NBE (Attapulgite or other)
- OrganoClays: Na^+ or Ca^{2+} 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 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 Aflatoxine 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 cosmetics. Small quantities provide thixotropic and suspension aids

Acid Activated



OrganoClays

Nanoclay Production



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

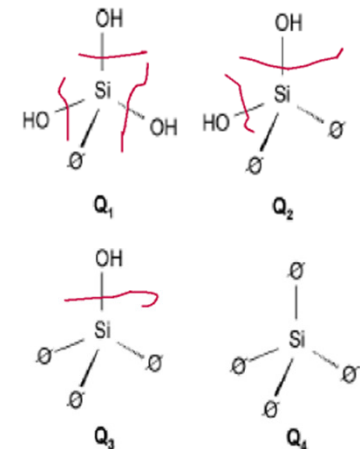
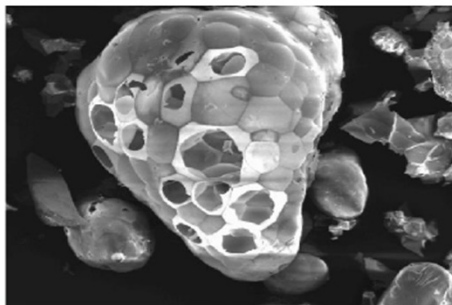
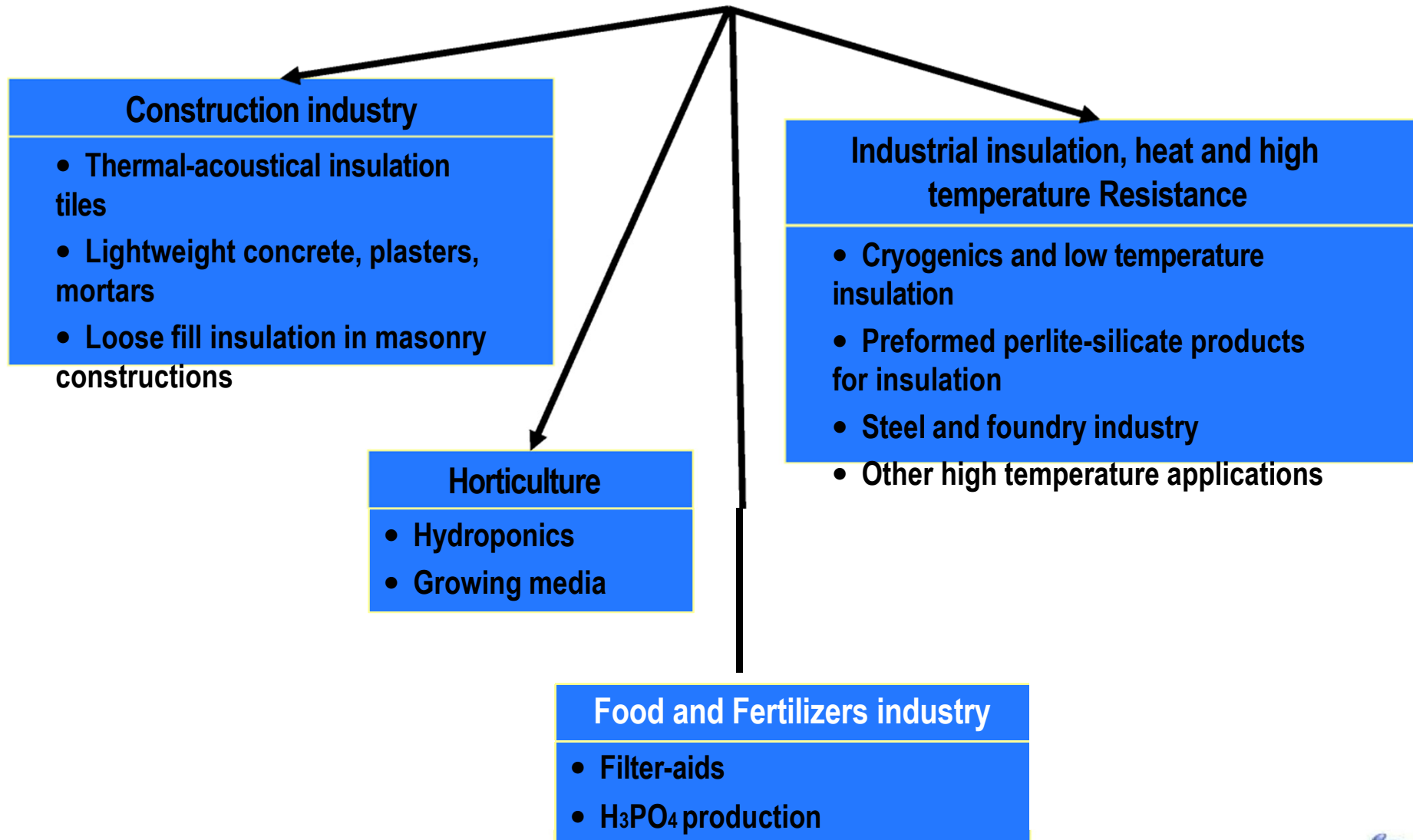


Fig. 1 Schematic structures of silicate tetrahedral units Q_n, with n denoting the number of oxygen atoms bridging two silicon centers (Ø = bridging oxygen atom)

Established applications of perlite



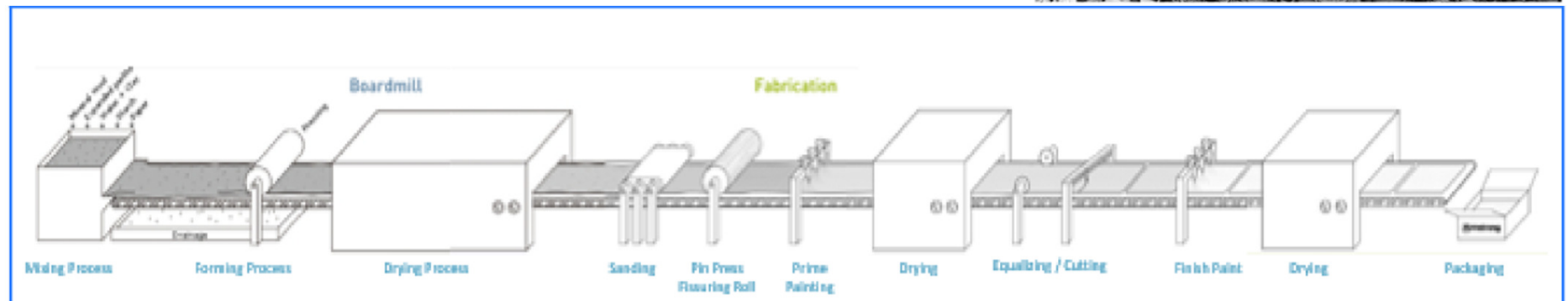
Expanded Perlite in Ceiling Tiles and Acoustical Boards

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



Cross-section of ceiling tile (SEM)



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.

Functionality:

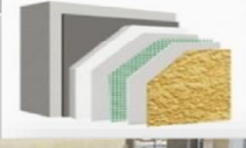
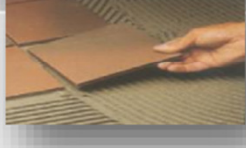
- **enhanced fluidity of the paste during pumping**
- **higher workability when pressing and compacting**
- **substantial increase of insulation properties**
- **smooth release of water during hardening (no cracking)**

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.



LWC application

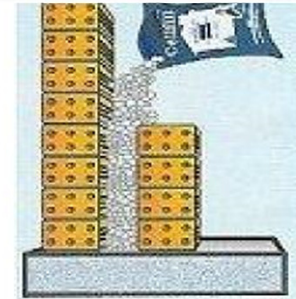
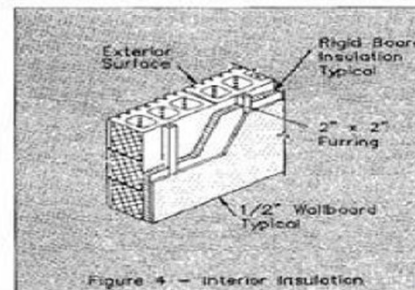
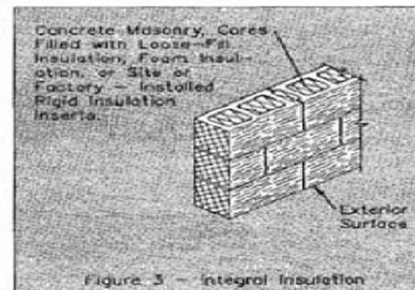
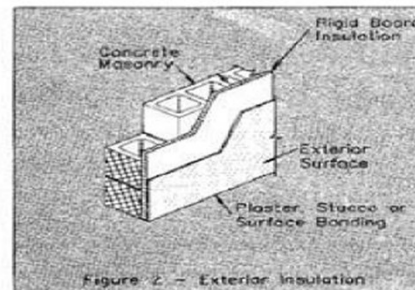
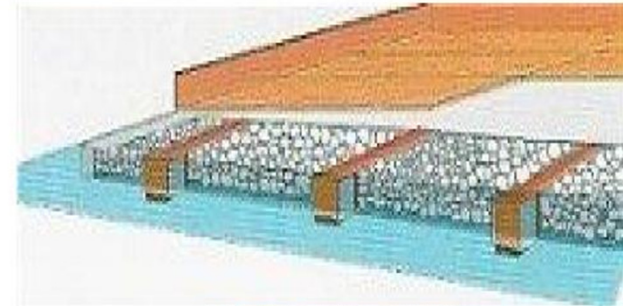


Type of end-product	Function
	Masonry Mortar : Bind materials together.
	Plaster : For leveling or smooth finish to the wall.
	Render: Protect against weathering (Monocouche for France)
	Insulating Render: Improve thermal insulation of walls.
	Screed: For leveling or smooth finish to the floor
	Tile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

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)
1. regulates drainage rate
1. has a reasonably stable pH (almost neutral)
2. is sterile (due to the high temperatures prevailing during expansion)
3. is weed-free
4. can be recycled



This garden had approximately 2 inches of fine grade perlite tilled 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.



Green house container growing

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



Green house production with perlite soil-less mixtures

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.

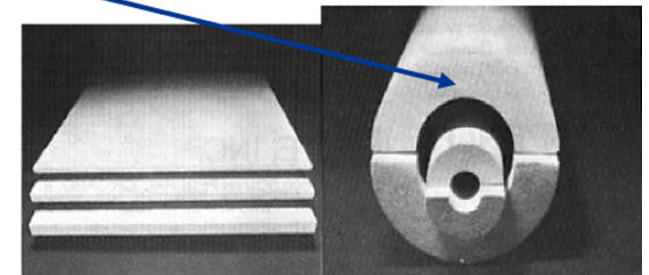
- “low temperature applications” : liquids at temperatures - 4°C down to -100°C
- “cryogenic applications” : liquids at temperatures lower than -100°C



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: H_3PO_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):



Main advantages of perlite addition:

1. Reduction in overall plant corrosion caused by HF ($6\text{HF} + \text{SiO}_2 \text{ (perlite)} \rightarrow \text{H}_2\text{SiF}_6 + 2\text{H}_2\text{O}$)
 H_2SiF_6 then precipitates as Na_2SiF_6 , KSiF_6 or NaKSiF_6 .
 - Target: to correct the active SiO_2/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 H_3PO_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 P_2O_5 residues left in the filtering cake

Volcanic glasses in Cement and Concrete

1. Pozzolane 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

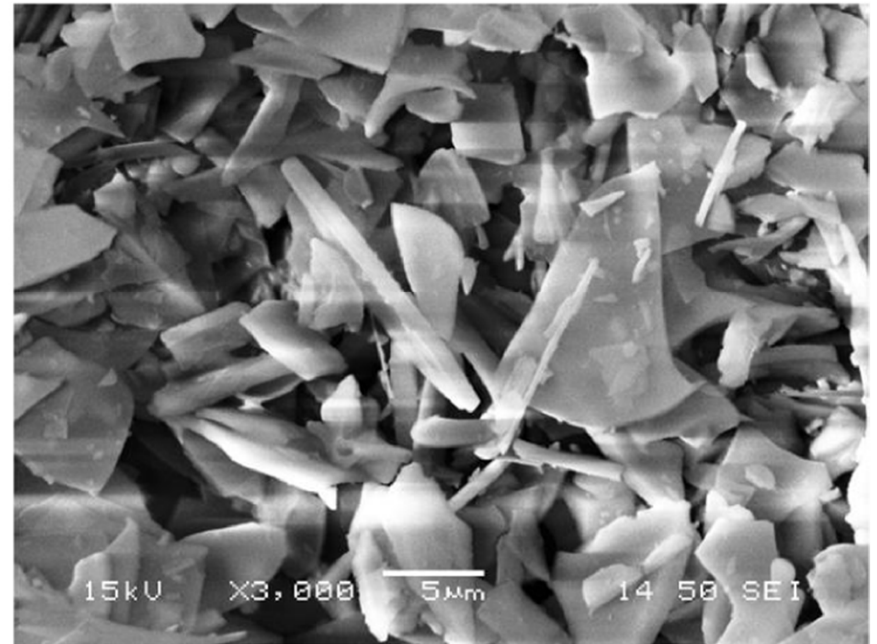
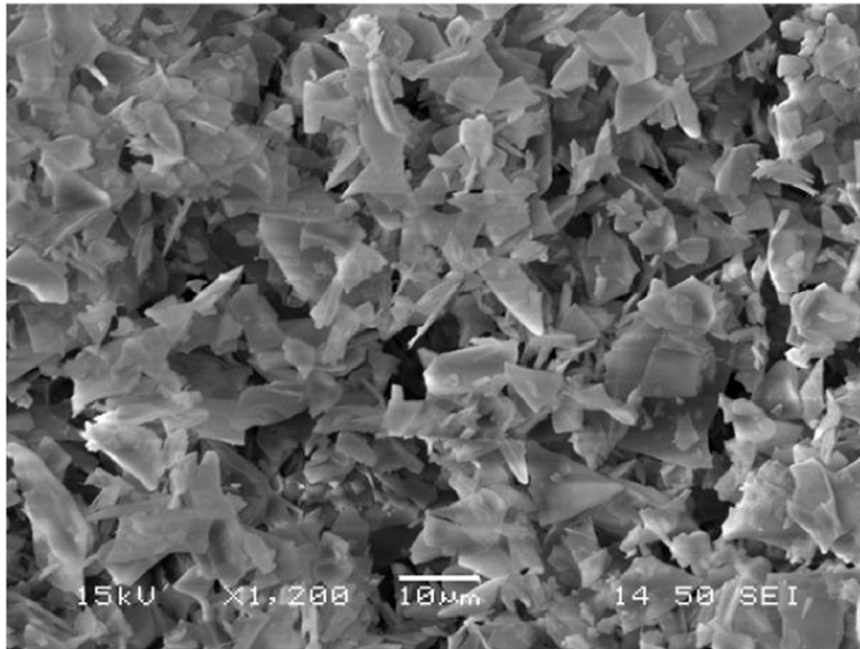
1. HPC Concrete

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

Projects in Pipeline: Micrasil

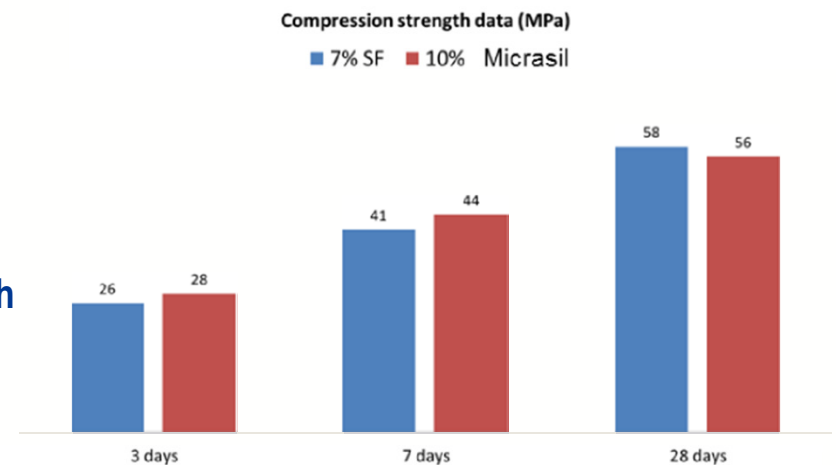


Micrasil is a highly performing **SCM**. It reacts with the free lime, by-produced during the **hydration of cement**, providing:

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^- , SO_4^{2-}), 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

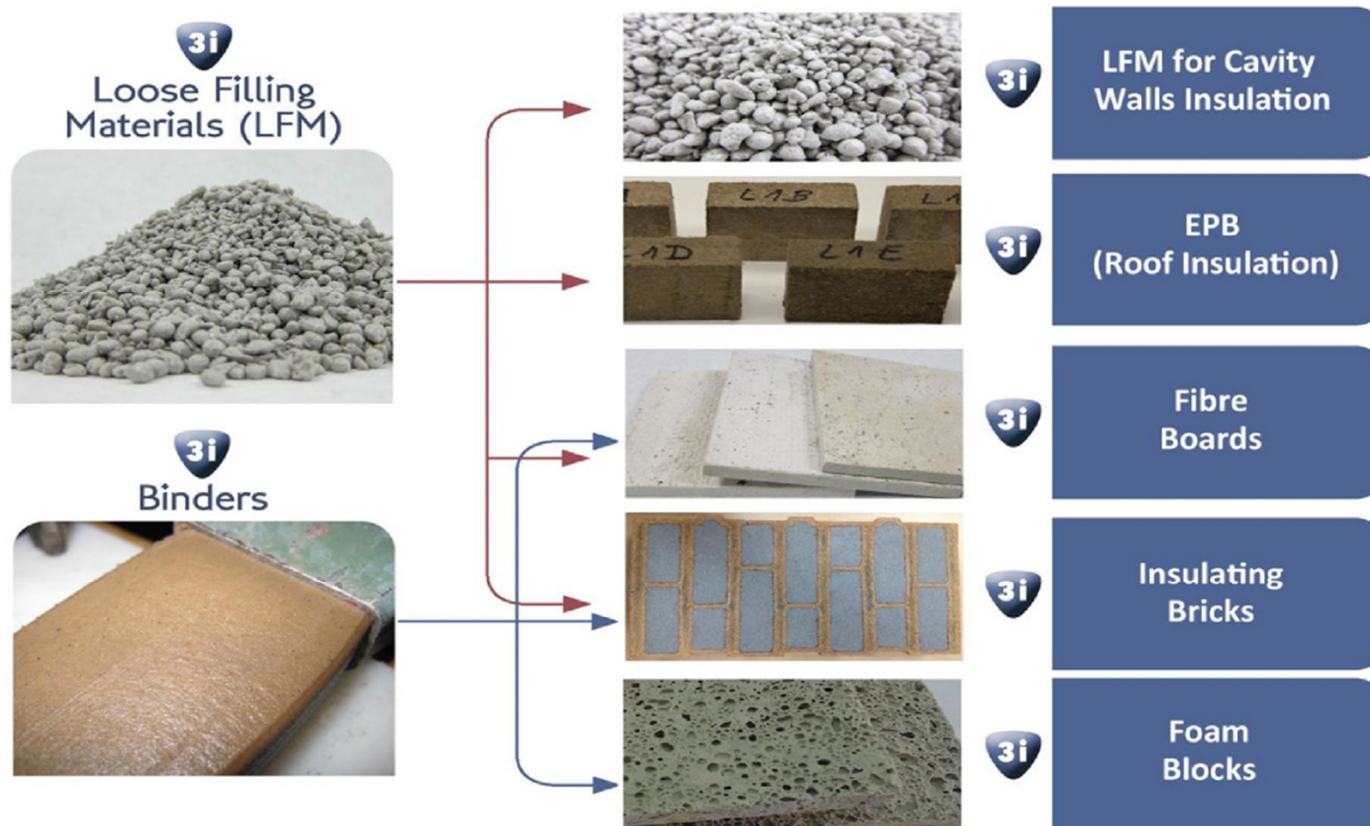


Projects in Pipeline: Geopolymers (based on perlite and/or clays)

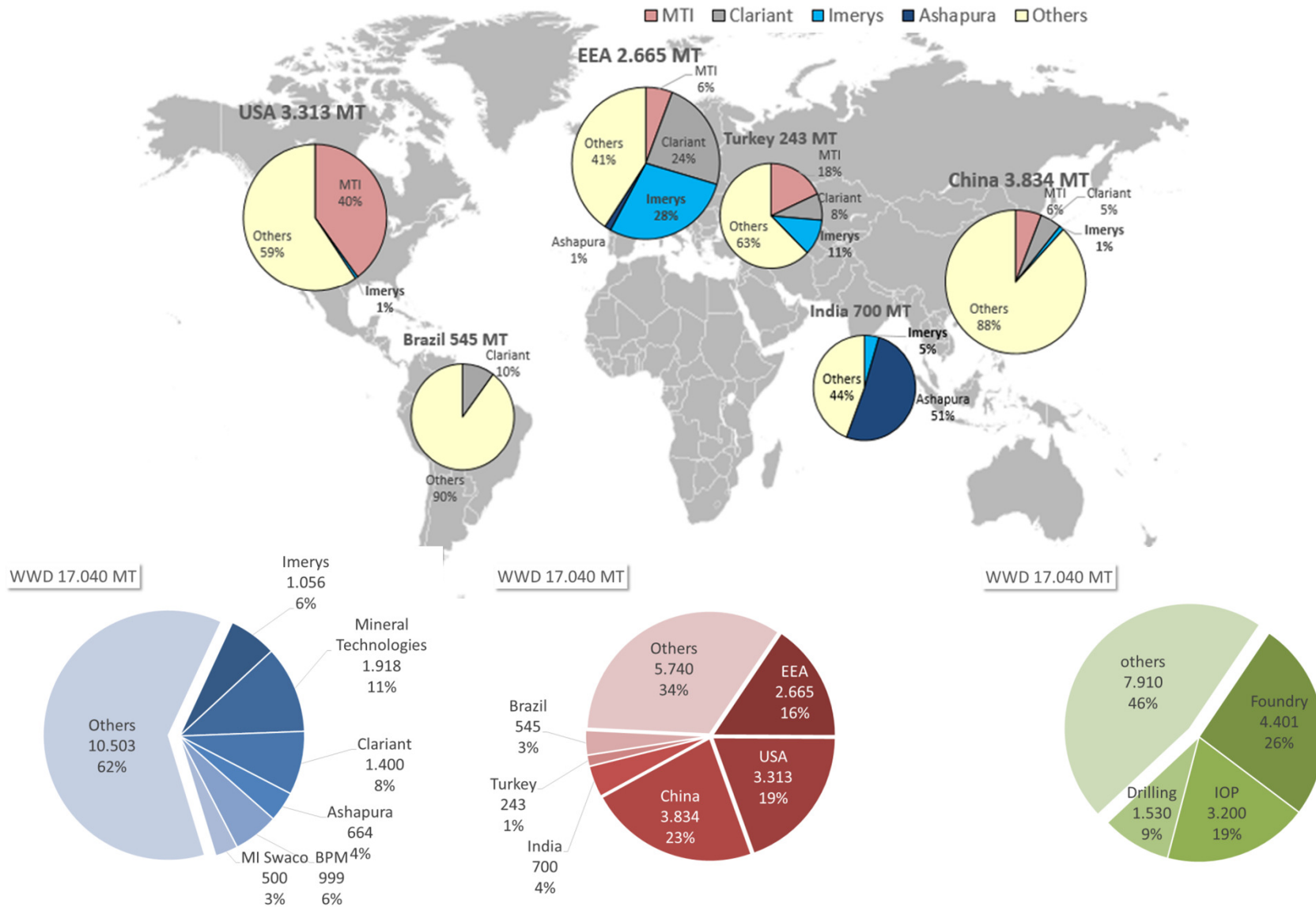
The **Challenges** for the construction industry are set under the “20-20-20 objective”

- 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



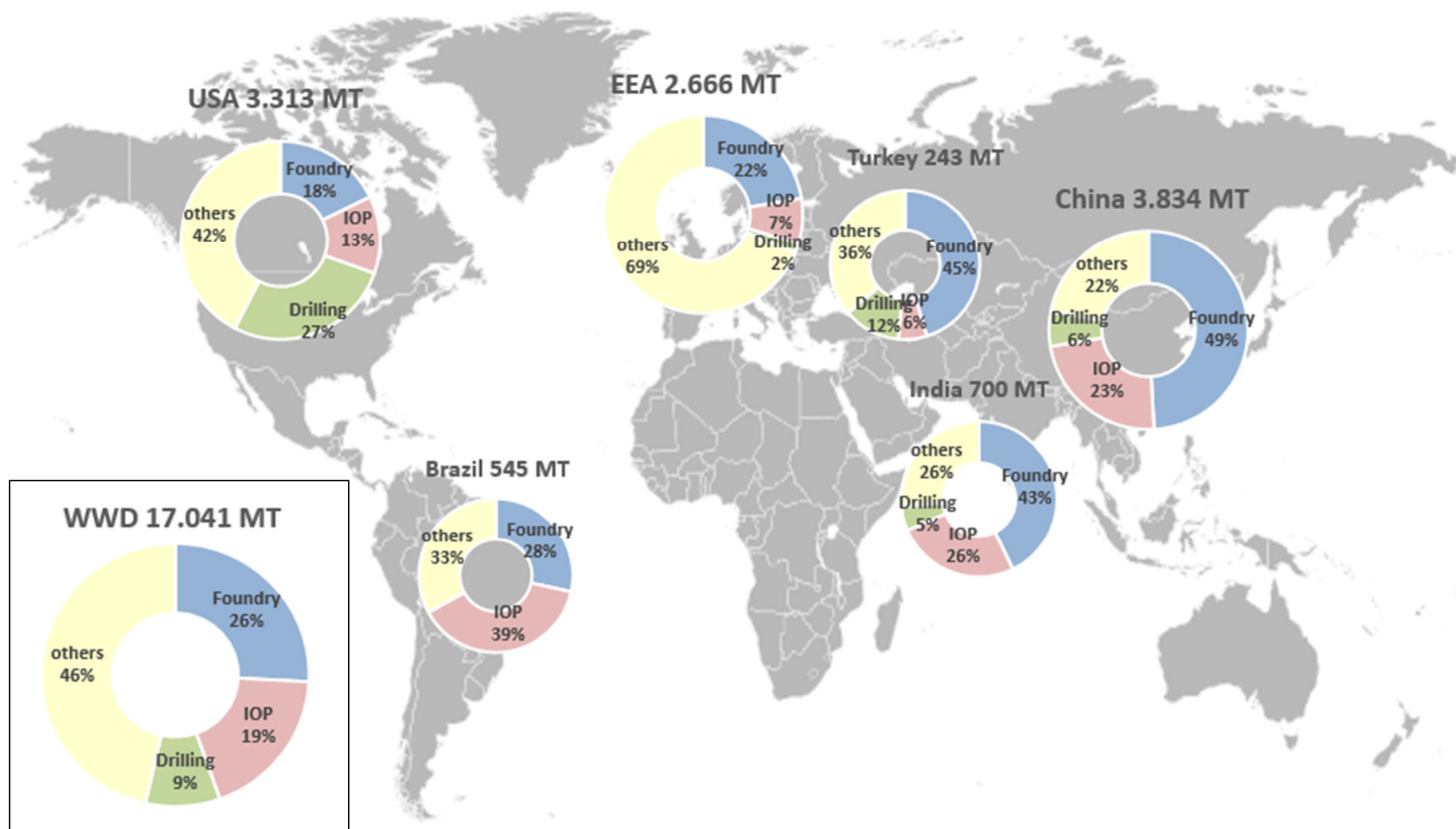
Imerys represents 6% of global and 28% of EU bentonite production



sources: Annual Reports, 10-K reports, Roskill 2015, Imerys market intelligence

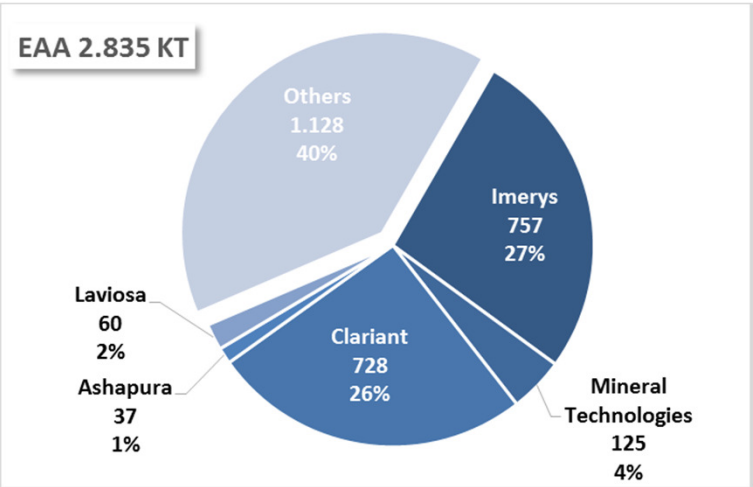
Leading position in almost all major bentonite applications, particularly foundry and iron ore pelletizing (IOP)

■ Foundry ■ IOP ■ Drilling ■ others

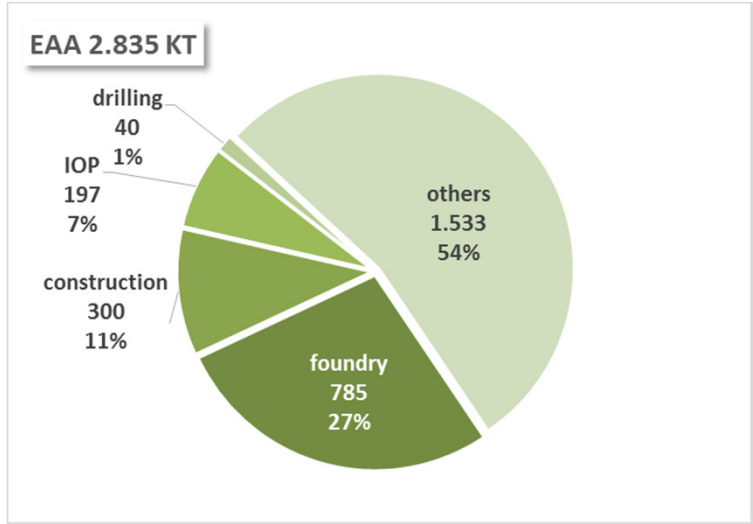


sources: Annual Reports, 10-K reports, Roskill 2015, databases with import/export data, Imerys market intelligence

EAA Bentonite consumed at a glance

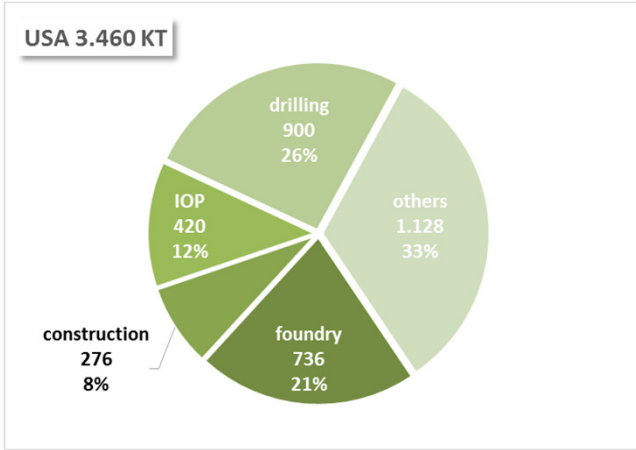
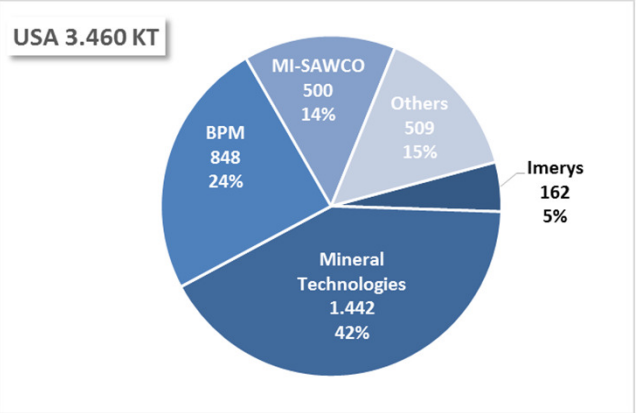


	Germany		France		Italy	
	kT	MS%	kT	MS%	kT	MS%
Imerys	301	33%	59	27%	67	31%
Mineral Technologies	0	0%	0	0%	0	0%
Clariant	361	39%	113	52%	24	11%
Huettenes Albertus	26	3%	8	4%		
Ashapura	25	3%			12	1%
Laviosa			5	2%	69	32%
Others	211	23%	32	15%	55,5	26%
Total market	924	100%	217	100%	215	100%



sources: Annual Reports, 10-K reports, Roskill 2015, Imerys market intelligence

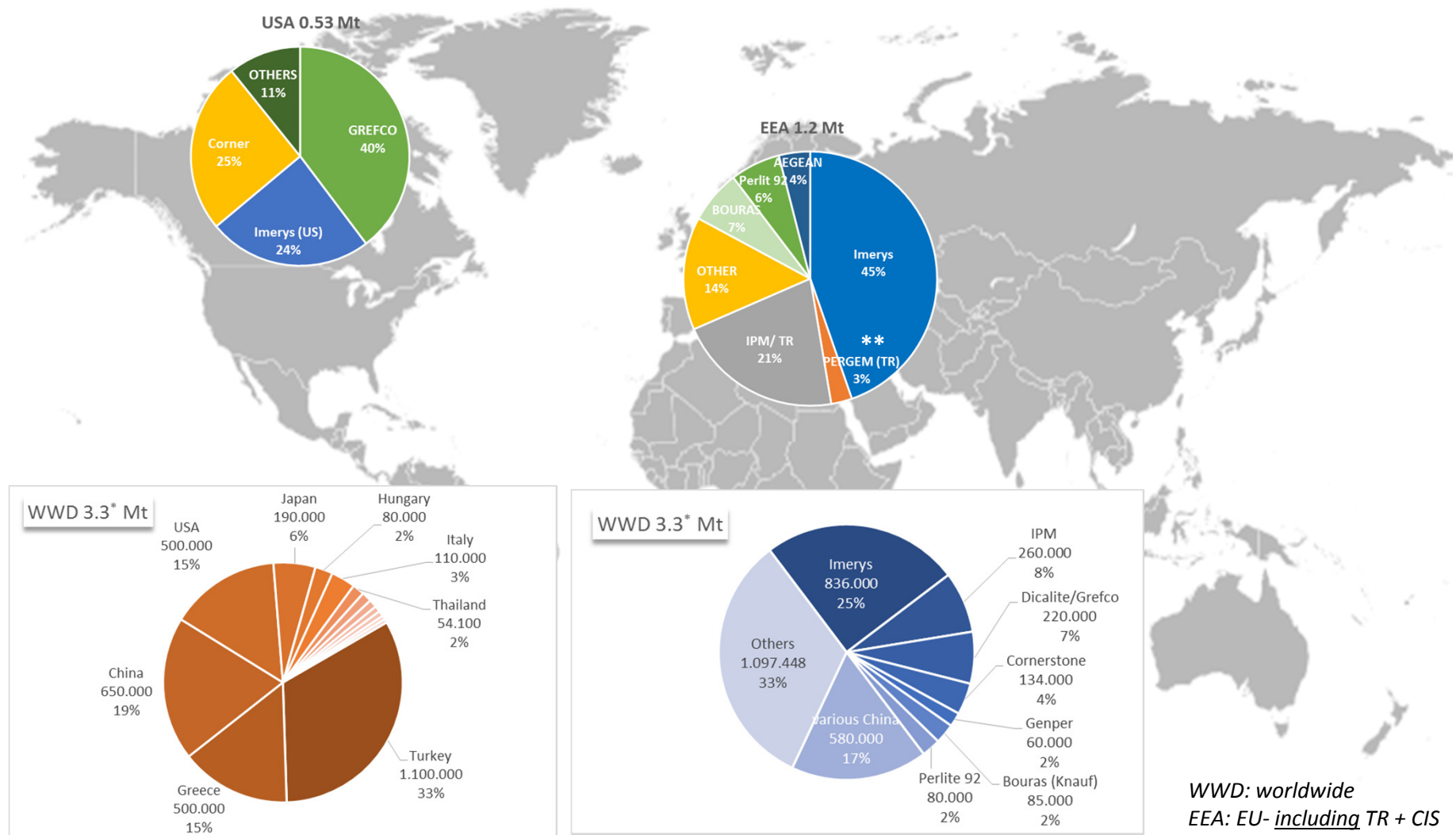
USA Bentonite consumed at a glance



	Foundry		Construction		IOP		Drilling		Others		Total
	kT	MS%	kT	MS%	kT	MS%	kT	MS%	kT	MS%	kT
Imerys*	162	22%									162
Mineral Technologies	574	78%	220	80%			150	17%	497,5	44%	1.442
Clariant											0
BPM					200	48%	250	28%	397,5	35%	848
MI-SWACO					150	36%	350	39%			500
Others			56	20%	70	17%	150	17%	233	21%	509
Total market	736	100%	276	100%	420	100%	900	100%	1.128	100%	3.460

sources: Annual Reports, 10-K reports, Roskill 2015, Imerys market intelligence

Imerys represents 25% of global and 45% of EEA perlite production

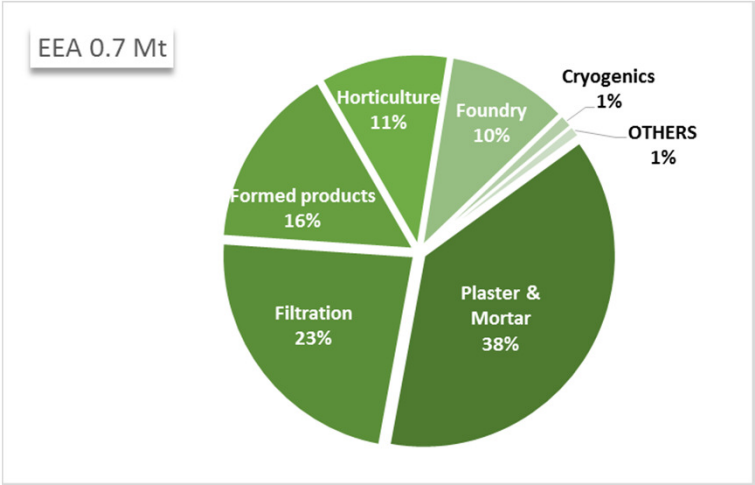
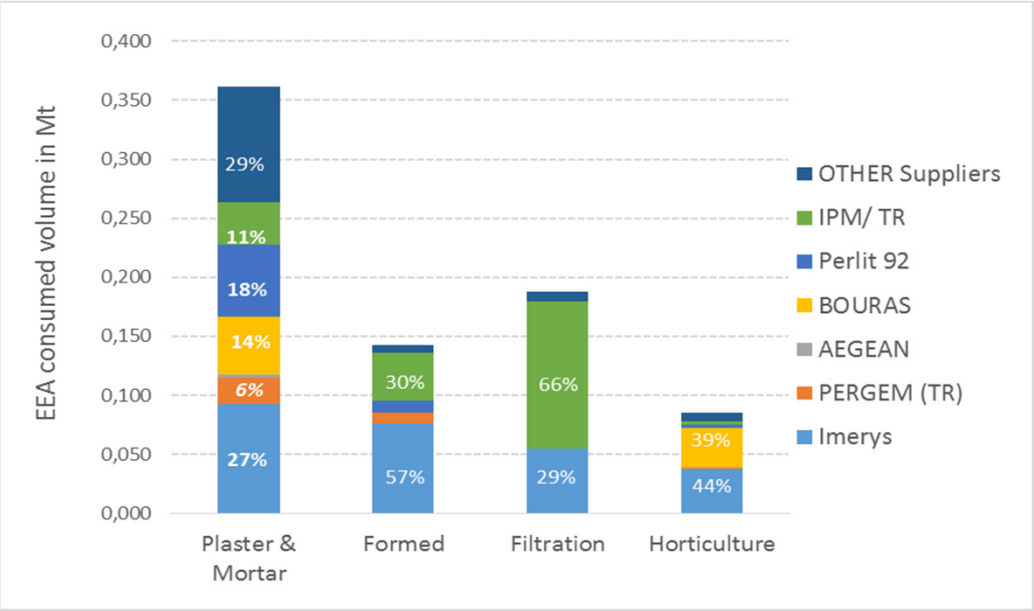
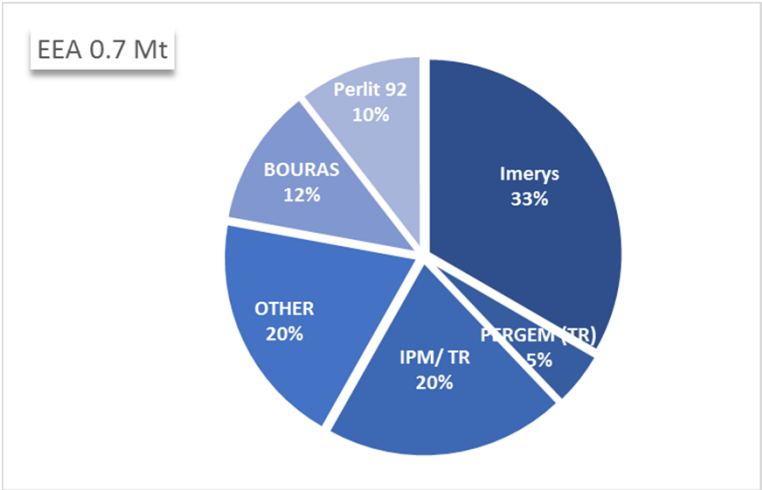


*:British Geological Survey (BGS) estimate: Iran is producing around 1.1 mio MT pa (not included)

** : PERGEM is JV (50/50) of Imerys with IPM (Turkey)

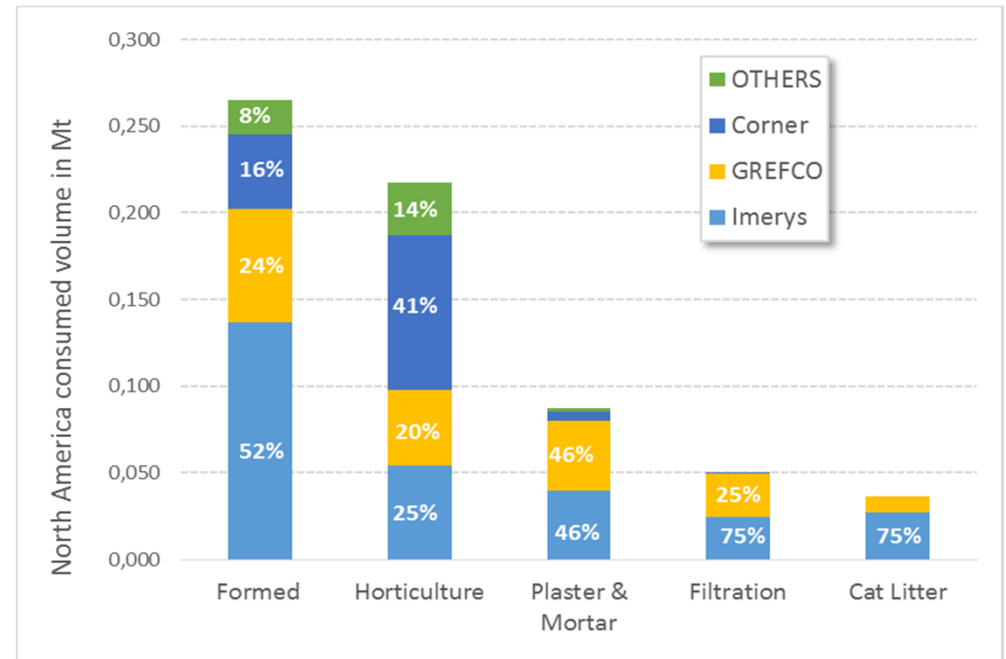
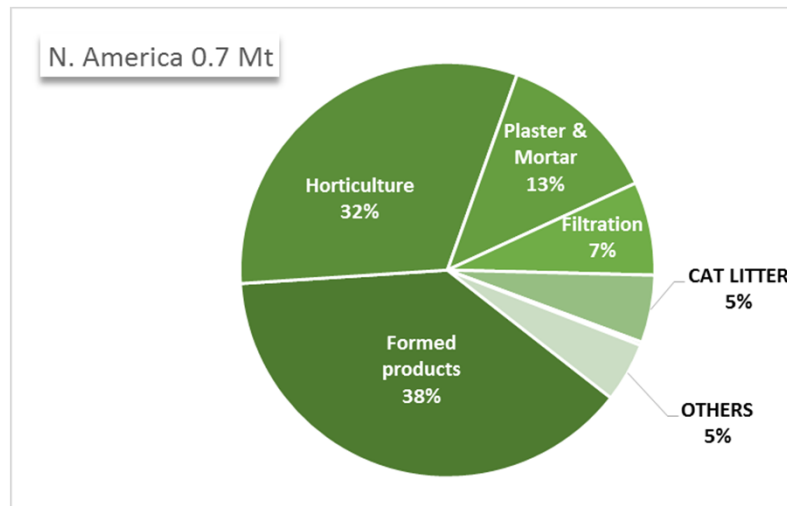
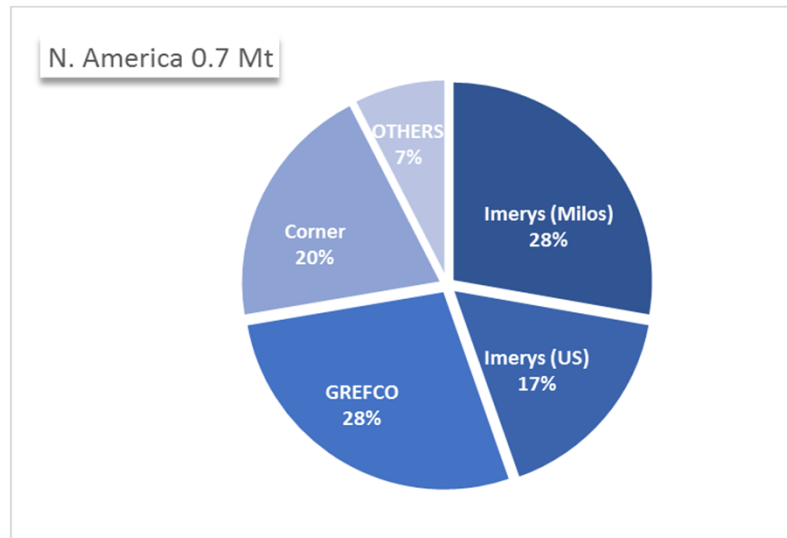
sources: Annual Reports, 10-K reports, Roskill 2011, Imerys market intelligence

EEA Perlite consumed at a glance



EEA: EU- including TR + CIS
sources: Annual Reports, 10-K reports, Roskill 2011, Imerys market intelligence

North America Fertile consumed at a glance



sources: Annual Reports, 10-K reports, Roskill 2011, Imerys market intelligence

Thank you for your attention

