Are you missing something?

Exploring the full diversity of white mineral filler options

By

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Filler grades only part of the demand

Mineral	World production Million Tonnes	Percent for polymer fillers	Use in polymers Tonnes
Ground Calcium Carbonate	28	40	11,200,000
Kaolin	42	5	2,100,000
Precipitated Silica	3	50	1,500,000
Talc	6	17	1,020,000
Alumina Trihydrate (ATH)	6.5	13	845,000
Barytes (Barite)	9	4	360,000
Silica	300	0.1	300,000
Precipitated Calcium Carbonate	4	7	280,000
Bentonite	25	1	250,000
Dolomite	200	0.1	200,000
Wollastonite	1	15	150,000
Perlite	4	2	80,000
Mica	0.7	10	70,000
Diatomite	2.3	3	69,000
Brucite/hydromagnesite	0.4	15	60,000
Magnesium Hydroxide (MDH)	1.1	5.5	60,000
Pumice	21	0.1	21,000
Pyrophyllite	1.9	1	19,000
Halloysite	0.2	5	10,000
Phlogopite	0.1	10	10,000
Feldspar	30	0.03	9,000
Hectorite	0.1	5	5,000
Nepheline Syenite	2	0.2	4,000
Vermiculite	0.4	1	4,000
Kyanite	0.1	1	1,000
Anorthosite	0.8	0.05	400
Total	*690*		*18,627,400*

Multiple uses for minerals

- Multiple grades of the minerals and only some grades produced for filler applications
- For some only a very small proportion for polymer fillers
- Ground calcium carbonate primarily for filler with ~40% in polymers but large amounts also in paint and paper
- Kaolin large volume production but only 5% for polymer fillers. Paper fillers/coatings larger percentage but also large volumes for ceramics, glass fibre and refractories
- Many others less than 1% of demand in polymer fillers or fillers in general and other applications are the main focus of the producers

Not all resources equal

- Mineral resources are inherently variable
- There are vast quantities of limestone, chalk and marble but few that can meet the specifications for filler applications on colour, impurities such as silica etc.
- However, availability is widespread
- Kaolin is also common but filler grade resources concentrated in countries such as USA, Brazil, Australia and the UK
- Some others have production restricted to only a few operations worldwide

The million tonne+ minerals

Mineral	World production Million Tonnes	Percent for polymer fillers	Use in polymers Tonnes
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The million tonne+ minerals -- $CaCO_3$

- Out of an estimated 18-19 million tonnes of total consumption of fillers in polymers, only 4 materials are used in volumes of more than 1 million tonnes annually
- Ground calcium carbonate is by far the leading material used
- It is available on a worldwide basis in many grades depending on properties such as grind sizes even down to sub micron, various degrees of colour, and with added coatings in some cases
- Apart from grinding, sizing and coating there tends to be little upgrading with deposits selected for their natural suitability and some selective mining to achieve the required grades
- Markets tend to be regional, especially for standard lower value grades
- Dolomite separate and slightly harder mineral so much smaller use

The million tonne+ minerals -- kaolin

- Kaolin resources widespread, but high quality filler grades less so.
- Large operations in the US state of Georgia, Brazil, Australia, UK plus a number of other countries and considerable international trade.
- Use in polymers is only a small fraction of 42 million tonnes total production. Paper filling and coating plus ceramic grades are larger markets for kaolin.
- Considerable processing common to reduce iron content and manufacture delaminated grades and some grades calcined before use.

The million tonne+ minerals -- talc

- World talc production much smaller than that of calcium carbonate or kaolin
- Resources widespread in North America, Europe, Australia, but almost 50% from SE Asia most notably China but also India, Japan, North Korea and more recently Pakistan
- Generally require degree of processing including flotation to separate talc from host rock to produce good clean white talc
- Much used in ceramics as well as in paper both as a pitch controller and for filling and coating
- A few deposits linked to asbestos cases

The million tonne+ minerals - Precipitated silica

- A manufactured product
- Plentiful supply of most raw materials silica sand, soda ash and caustic soda, although caustic soda supply has been tight in recent years
- Properties can be manipulated during the manufacturing process to supply multiple grades
- Relatively expensive compared to natural minerals but competitive with carbon black
- Most used in rubber compounds

Other clay minerals

Mineral	World production Million Tonnes	Percent for polymer fillers	Use in polymers Tonnes
Bentonite	25	1	250,000
Halloysite	0.2	5	10,000
Hectorite	0.1	5	5,000

Other clay minerals

- Bentonite including other common clays such as attapulgite and sepiolite.
  - Primarily used for other applications such as drilling muds foundry sands and cat litter
- Hectorite is a lithium bearing clay with very limited production concentrated in Nevada.
  - Considerable exploration for new deposits as a source of lithium and some synthetic production from other clays
- Halloysite of high grade until recently primarily produced in New Zealand for ceramic use but newer developments in USA
  - Promoted for having high aspect ratio “nanotubes” for enhanced properties in polymers combined with flame retardancy because of water in crystal

Other platy minerals

Mineral	World production Million Tonnes	Percent for polymer fillers	Use in polymers Tonnes
Mica	0.7	10	70,000
Pyrophyllite	1.9	1	19,000
Phlogopite	0.1	10	10,000
Vermiculite	0.4	1	4,000

Other platy minerals

- Mica is a common mineral and often a by-product of other mineral production with muscovite variety preferred because of colour
  - Platy nature offers reinforcing properties in polymers but also extensively in construction products such as cement boards
- Pyrophyllite is commonly linked to talc in statistics but it is aluminium silicate rather than the magnesium silicate formula of talc
  - Primarily used as a refractory or ceramic raw material but some grade as a reinforcing platy high aspect ration filler and for anti-block fillers in thin film polymers
- Phlogopite production limited primarily to Canada, Finland and Russia
  - Imparts increased stiffness and heat resisting properties as well as improved electrical insulation so used in automotive and some electronic applications. It is not white so only used in non-colour sensitive applications
- Vermiculite
  - Know for its insulating and flame resistant properties once expanded from the natural mineral with expansion factors of x15 or more. Small use in polymers

Silica minerals

Mineral	World production Million Tonnes	Percent for polymer fillers	Use in polymers Tonnes
Silica	300	0.1	300,000
Perlite	4	2	80,000
Diatomite	2.3	3	69,000
Pumice	21	0.1	21,000

Silica minerals

- While precipitated silica in widely used especially in rubber there is also use of natural silica minerals
- Silica sand is hard quartz and used in applications where the hardness and optical properties desirable
- Diatomite a lightweight filler used in applications such as antiblock fillers for thin film polymers
- Pumice natural lightweight filler, with little current use in polymers, although is used in some asphalt formulations
- Perlite a volcanic silica glass that expands on heating to for lightweight aggregates. Has some use as a lightweight filler in synthetic stone products with resin binder.

Silica replacements

Mineral	World production Million Tonnes	Percent for polymer fillers	Use in polymers Tonnes
Feldspar	30	0.03	9,000
Nepheline Syenite	2	0.2	4,000
Anorthosite	0.8	0.05	400

Silica replacements

- Nepheline Syenite Only two deposits (and one company) supplies commercial quantities to market -- no free silica
  - Glass and ceramics by far the largest markets fillers small proportion but could be increased if demand required
- Feldspar common mineral produced in many countries for glass and ceramics – low or very low free silica.
  - Mainly for glass and ceramics but small market in fillers where a hard or abrasive resistant material required
- Anorthosite production limited from deposits that are white so little or no filler production until recently.
  - Two new deposits in Greenland, one in production, primarily marketed for glass fibre production but also a fine ground filler grade the other at pre-feasibility stage.

Flame retardants

Mineral	World production Million Tonnes	Percent for polymer fillers	Use in polymers Tonnes
Alumina Trihydrate (ATH)	6.5	13	845,000
Brucite/hydromagnesite	0.4	15	60,000
Magnesium Hydroxide (MDH)	1.1	5.5	60,000

Flame retardants

- ATH many sources for Bayer hydrate but few can meet colour specifications for ground hydrates.
  - Re-precipitated grades for higher end applications using wet hydrate feedstock
  - Can only withstand plastic processing temperatures of up to maximum of 200°C Monohydrate Boehmite developments to withstand higher temperature up to over 300°C
- MDH few plants in the world producing high specification magnesium hydroxide from brines. One operation producing from serpentinite
  - More expensive than ATH but can withstand higher temperature plastic processing up to about 310°C
- Brucite/hydromagnesite/huntite Natural minerals produced in Greece, Turkey, Russia and USA
  - Brucite is natural magnesium hydroxide, a hydromagnesite/huntite natural mix is sold as a flame retardant with water released at about 220°C CO2 at 330°C and then a char formed at about 560°C

Needle shaped minerals

Mineral	World production Million Tonnes	Percent for polymer fillers	Use in polymers Tonnes
Wollastonite	**1**	**15**	**150,000**
Kyanite	**0.1**	**1**	**1,000**

Needle shaped minerals

- Wollastonite limited number of producing sies in USA, Mexico, Finland, India and China
  - Much of it used in ceramics and continuous casting fluxes. Needs careful grinding to retain the needle shape of the natural crystals
- Kyanite Not normally considered as a filler with almost all consumption used in refractories and foundry sands. One major producer in USA with lesser production in India, China and Ukraine
  - Has been trialled as a filler to replace wollastonite in some polymer compounds

Other minerals

Mineral	World production Million Tonnes	Percent for polymer fillers	Use in polymers Tonnes
Barytes (Barite)	9	4	360,000
Precipitated Calcium Carbonate	4	7	280,000

Other minerals

- Barytes (barite in North America) is a heavy mineral. Used where weight, x-ray visibility or sound dampening are required. Large quantities used in oil well drilling with polymer usage a small proportion of demand
- Precipitated Calcium Carbonate is a manufactured purified calcium carbonate with added control of crystal size. More expensive than ground calcium carbonate, but with enhanced properties for many uses.
- Gypsum not included in the table of minerals but has potential for use in polymers, although will react to loose water of crystallisation at low temperatures. Huge world production for construction applications of the order of 150 million tonnes and large additional quantities of by-product from processes such as phosphate rock manufacture and flue gas desulphurisation

Summary

- 26 minerals or mineral products listed
- Very large production in the hundreds of millions of tonnes.
- Use in polymers for some is limited
- Opportunities for collaborative efforts between mineral producers and fillers consumers for development of new grades of fillers
- Considerable untapped potential to engineer minerals to provide desired properties
- There are hard and soft minerals heavy and lightweight, different refractive indices, abrasion resistance, reinforcing properties, colours etc.

Thank you for listening

If you have any questions I am happy to answer in this session if possible.

Otherwise please feel free to send them to me at the contact details below

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