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ENVIRONMENT AND RAW MATERIAL COMMITTEE

Factsheet on:

What is Gypsum?

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I. Natural Gypsum

A. Introduction

The mineral Gypsum precipitated some 100 to 200 million years ago when sea water evaporated. From a chemical point of view it is Calcium Sulphate Dihydrate (**$CaSO_4.2H_2O$**) deposited in sedimentary layers on the sea bed. Under high pressure and temperature Gypsum turns into Anhydrite (**$CaSO_4$**).

In nature, Gypsum and Anyhdrite occur as beds or nodular masses up to a few metres thick. Gypsum is formed by the hydration of Anhydrite. The depth of hydration can range from the surface of the deposit down to three hundred metres, depending on temperature and pressure, topography and the structure of the deposit. Anhydrite is often mined in conjunction with Gypsum, but is comparatively limited in its technical applications. The content of Gypsum in sedimentary rock varies from 75% to 95%, the rest being clay and chalk.

B. Extracting Natural Gypsum

Gypsum/Anhydrite are produced from open-cast mines, or underground mines using pillar and stall mining methods, that give extraction rates of up to 75%.

Gypsum is normally only screened to remove 'fines' (mainly mudstones), then crushed and finely ground. Gypsum/Anhydrite for cement manufacture is supplied in crushed form for further fine grinding with cement clinker.

C. Processing Natural Gypsum

When Gypsum (**$CaSO_4,2H_2O$**) is ground to a powder and heated at 150° to 165° C, three-quarters of its combined water is removed producing hemi-hydrate plaster (**$CaSO_4,1/2H_2O$**), commonly known as the 'Plaster of Paris'. When this powder is mixed with water the resulting paste sets hard as the water recombines to produce Gypsum again. This process can be repeated almost indefinitely, with important implications for recycling.

II. Synthetic Gypsum

A. Introduction

The Gypsum Industry is working towards building value for society by offering safe, economic and recyclable products for the home owner using **substitutes** to natural Gypsum whenever possible, in order to reduce the pressure on natural resources.

B. FGD Gypsum

An intelligent alternative is Gypsum that comes from the flue gas desulphurisation plant (FGD) of the power station industry. This FGD Gypsum is the end product of a wet purification procedure with natural lime, that essentially forms according to the same laws as natural Gypsum – but in a speeded-up process taking only a few hours.

FGD Gypsum is an important supplement to the supply of natural Gypsum. This synthetic Gypsum has a higher purity (Gypsum content of 96%) than most natural Gypsum (80%). This means that lower quality Gypsum can be blended with high purity Desulphogypsum, allowing material that would not have been mined in the past to be classified as exploitable reserves.

Processing FGD Gypsum

Of the flue gas desulphurisation processes available, limestone-based scrubbing processes have proved the most popular. The desulphurisation process takes place in scrubbing towers in which the flue gases are brought into contact with an aqueous suspension containing powdered limestone or slaked quicklime as its alkaline component. The SO_2 is washed out by the water, oxidised to Sulphates SO_3 in the aqueous solution, and precipitated with Calcium from the limestone/quicklime into Dihydrous Calcium Sulphate (**$CaSO_4,2H_2O$)**, Gypsum. The Gypsum crystals are separated out of the suspension as a moist, fine crystalline powder with the aid of centrifuges or filters.

C. Phosphogypsum,Titanogypsum and Citrogypsum

1. Phosphogypsum

Phosphoric Acid is a commodity chemical of which large quantities are used in the production of fertilisers and detergents. It is obtained by processes based on the decomposition of Phosphate minerals with Sulphuric Acid. Tricalcium Phosphate reacts with Sulphuric Acid to form Phosphoric Acid and Calcium Sulphate. Most usually, the less soluble Calcium Sulphate is separated from the Phosphoric Acid by filtration. The Calcium Sulphate appears generally as Hemihydrate or Dihydrate, depending on process temperature conditions and the Sulphuric and Phosphoric Acid concentrations.

The limiting factors for a more extensive use by the Gypsum industry are rest impurities, deviant crystal shape of the Gypsum and quality fluctuations, which can lead to a behaviour not compatible with Gypsum processing, and the **higher level of natural radioactivity**, depending on the phosphoric rock, especially when compared to other Gypsum sources, which creates a psychological barrier to its use.

The psychological and subjective barriers to the public acceptance of this Phosphogypsum may be a much stronger brake to development than the technical factors.

2. Titanogypsum

Titanium Dioxide is a white pigment and is, by far, the most important pigment in terms of quantity. World production of Titanium Dioxide is approximately 4 mio tonnes/year, of which about one-half is produced by the Sulphate process, the other half by the Chloride process. Only the Sulphate process outputs Gypsum, of which a maximum of about 50%, is the so called 'White Gypsum', which can be considered for use by the Gypsum industry.

3. Citrogypsum

Citric Acid is a component found in almost all plant and animal species, and is pivotal in the energy cycle of living organisms. Large quantities of Citric Acid for use in food, pharmaceutical and detergent industries are produced by mycological fermentation of crude sugar solutions such as molasses. In order to free Citric Acid from impurities such as proteins and sugars, it is precipitated with lime to Calcium Citrate and washed. Pure Citric Acid is then recovered by acidification with Sulphuric Acid and filtering off from the formed Gypsum.

Technically, this Gypsum can be purified to a grade which can be processed by the Gypsum industry. Part of this Gypsum, however, is used as a filter aid to remove complex trace metals. It has a blue colour due to absorption of Ferric Hexacyanoferrate complexes which can only be removed by high temperature calcination producing Anhydrite (usable by the cement industry).

D. Fluoroanhydrite

For the production of Hydrofluoric Acid the mineral Fluorspar or Fluorite is heated with Sulphuric Acid. As the reaction is normally conducted in dry conditions at elevated temperatures, the resulting Calcium Sulphate is formed in the anhydrous form, Anhydrite.

E. Other Synthetic Gypsum

Small amounts of Gypsum are recovered by the production of some organic acids like Tartaric, Lactic, Formic and Oxalic Acid. For the production principle please refer to the Citric Acid paragraph (point II, C.3).

Additionally, all processes which end with the sub-product Sulphuric Acid are potential Gypsum producers. Neutralisation of acidic effluents with lime or limestone yields Gypsum, for which the potential usage depends on the impurities remaining. Titanogypsum here is the classic example. The removal of Sulphates from brines with the help of lime produces Gypsum - the high Magnesium content of this 'salt Gypsum' is one of the main obstacles to its use.

F. Conclusions

Natural Gypsum will continue to cover the basic raw material needs of the Gypsum industry, followed by FGD Gypsum.

The most important potential of other synthetic Gypsums than FGD Gypsum lies in the use of purified Phosphogypsum. Next to that is some potential in the use of purified Titanogypsum. In the past, both the Phosphoric Acid and the Titanium Dioxide industries have shown a systematic close down of production facilities in Europe. Investments in either the purification of the produced Gypsums, or in finding applications for the Gypsums produced, may be essential for the future viability of these sites.

III. Anhydrite Demand

Anhydrite has limited uses, although large quantities of a mixture of Anhydrite/Gypsum are blended with cement clinker and finely ground to produce Portland Cement. Addition of about 5% is used to control the initial rate of reaction with water and to retard the setting time of the cement.

IV. Gypsum Demand

Gypsum is used mainly in the manufacture of building products – plaster, plasterboards, Gypsum fibreboards and plaster blocks. Demand is principally driven by activity in the construction sector. The value of construction output continues to increase in real terms. Demand for new and refurbished housing is increasing and in conjunction with the need for new schools, hospitals, offices and shops, there is likely to be increasing demand for Gypsum building products for the foreseeable future.

V. Gypsum Applications

The most important applications of Gypsum are in the production of plaster, plasterboards, Gypsum fibreboard and Gypsum blocks. The mineral forms the basis of a large industry processing a wide range of building products. Synthetic Gypsum is now more widely used in the manufacture of plasterboard and Gypsum fibreboards. Natural Gypsum is especially suitable for the manufacture of building plasters because it contains clays that improve the workability of the plaster. High-purity natural Gypsum is also used to produce special plasters, for example for use as plaster moulds in the pottery industry and for surgical and dental work. Small quantities of high-purity Gypsum are also used in confectionary, food, the brewing industry, pharmaceuticals, in sugar beet refining, as cat litter and as an oil absorbent.

Last, but not least, Gypsum has been used for more than 200 years as a soil amendment and fertiliser. Indeed, it improves water penetration and workability of impermeable sodic ‘alkali’ soils; it softens soils with a high clay content; it helps neutralise soil acidity; and it adds plant nutrients: Calcium and Sulphur.

VI. Gypsum Recycling

Gypsum products are amongst the very few construction materials where “closed loop” recycling is possible, i.e. where the waste can be used to make the same product again and not merely recovered for use in other “down-cycling” applications, such as is the case with some other construction materials, e.g. waste concrete and bricks used for aggregates in road construction.

Furthermore, a major advantage of Gypsum is that it is eternally recyclable. Increasing recycling of Gypsum products waste is occurring from construction sites. Once collected, the plasterboards are broken down into a fine powder which is then re-introduced, in a controlled blend, into the manufacturing process. Tonnages derived from this source are increasing. Only a small quantity is currently recycled from demolition waste due to challenges surrounding contamination with other materials. This is an area of continuing research and development.