Gypsum is one of the mineral resources in Switzerland which have a good long-term availability. Nevertheless around 50% of gypsum products are imported and thus most of the value creation is generated abroad. The reason for this is, that products such as plasterboard are produced in large mass production, low labour costs are particularly crucial in order to be competitive in the world market. This condition is not fulfilled in Switzerland.

On the other hand, due to a high growth in stock there is more and more gypsum waste. This wastage ends up in the inert material landfills, where the sulphate can be washed out and can enter the groundwater or the landfill waste water. In addition, the available landfill volume should be conserved where possible. Given its physical and chemical properties, gypsum can in principle be managed as a sustainable resource.

Especially nowadays, that sustainable building has become the current trend, the gypsum industry should make better use of the recycling potential. Plasterboard can be recycled to a high degree, which could be a major societal selling point over other wall materials that have a much lower potential for being recycled.

Due to the high percentage of imports, it will become more and more difficult to reuse all of the future gypsum waste in Switzerland.

In addition to the production of gypsum wallboard, the cement plants are, first and foremost, the major targets processes for the recycling of gypsum. In theory this would represent a consumer market of around 260,000 t/y. In the longer term, however, the Swiss gypsum waste collection and processing capacities must be increased and the future waste material purchasing markets have to be developed abroad. This could mean that society must formulate the conditions such that, for example, the companies producing abroad will have to back a certain percentage of waste gypsum and use it in their production on a long-term basis. Alternatively Switzerland could consider an increase of own recycling and production capacities, coupled with a reduction of imports.

Other measures and courses of action that lead to a prevention of environmental impacts and a more sustainable use of gypsum must be discussed and driven forwards in cooperation with the gypsum and cement industries, as well as with the importers of gypsum products. As a forward-looking stakeholders, the public sector should moderate and assist the process development towards attaining a sustainable resource management in the gypsum industry.

8. Resource management: The overall situation at a glance

In global terms, around 50% of the gypsum is used for the production of cement, 35% for the production of plaster and stucco (which also includes wallboards) and around 10% in agriculture (Fig. 1). Due to its low price (Fig. 2) and gypsum products are not usually transported over long distances, which in the past prevented the recycling of gypsum waste. During the past few years better technologies were developed for the increased recycling of gypsum. In regions where there are coal-fired power plants, these recycled products have to compete with cheap fly-ash desulfurization (FGD) gypsum (Chap. 3).

In Switzerland, which corresponds to slightly less than 3 t of gypsum per capita. Be- tween 2000 and 2012, the use of gypsum has increased by almost 50%, while in Germany it is around 2.8 m²/(per capita/year) and in France 3.5 m²/(per capita/year). The use of gypsum in Switzerland today is still at a moderate level: approx. 4,000 t/yr.

Within Switzerland, around 600,000 t (~73 kg/per capita) are used for gypsum wall materials today in Switzerland, which corresponds to slightly more than 3 t of gypsum per capita. Between 2000 and 2012, the use of gypsum has increased by almost 50%. This trend is likely to continue due to increased gypsum use in drywall construction. The demand for gypsum wall materials today in Switzerland is in the range of 1.7 m³/(per capita/year), while in Germany it is around 2.8 m³/(per capita/year) and in France 3.5 m³/(per capita/year). On this premise, the stock of gypsum in Switzerland could grow to over 45 million tonnes by 2035. The recycling potential in Switzerland today is still at a modest level: approx. 4,000 t/yr.

The world production of gypsum is in range of 140–160 million tonnes (Fig. 2). Gypsum and anhydrite occur all over the world and are usually easy to exploit.

3. Validation of the model for describing the gypsum flows in Switzerland

The world production of gypsum is in range of 140–160 million tonnes (Fig. 2). Gypsum and anhydrite occur all over the world and are usually easy to exploit.

Gypsum is one of the oldest known minerals used in basic and construction materials. As far back as 7000 BC, gypsum was already used as a base for frescoes in the town of Qasr al-Hayr in As-Suwayda. Gypsum was also used in its natural form for sculptures and building blocks, as plaster and in the mortars of world-famous buildings such as the pyramids of Jericho, the Great Pyramid of Cheops or the Palace of Knossos.

The Romans knew about the advantageous properties of gypsum and spread the knowledge of its preparation to the area north of the Alps. Much of this knowledge about the processing of gypsum was lost during the Migration Period (400–700 AD).

It was not until the architectural style of Romanism that gypsum returned to the scene as a building material. Gypsum technology was further developed during the period of industrialisation in the 19th century, which provided a clear distinction between gypsum dihydrate, hemihydrate and completely dehydrated anhydrite and the importance of different firing temperatures (Chap. 5, Tab. 1).

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3. Primary/secondary raw materials

Switzerland has large geogenic deposits of gypsum that are found mainly in the Triassic deposits of the Jura and the Marne. The gypsum rock is currently being mined in Bern (VD), Granges (VS), Les CH (BE) and Kernen/Melbach (OW) in open-pit mines.6

After extraction the gypsum rock is treated (Les CH and Granges) and ends up either in the cement factories or is processed into hemihydrate and anhydrite using the single-, double- or triple-effect dewatering method. The product is then manufactured into wallboard (at Les CH and Granges) or gypsum plasters and mortars (at Kernen/Melbach, Bern and Granges).7

As byproducts of industrial processes large quantities of gypsum are mainly produced abroad by means of flue-gas desulphurisation (FGD gypsum) in coal-fired power plants. In Germany alone, the production of primary gypsum was produced in 2003.8

FGD gypsum is powdery and has a residual moisture content of 10%.9 Natural gypsum and FGD gypsum have the same chemical composition (except Hg and Se).

Because it is not grainy like natural gypsum, FGD gypsum has to be dried and briquetted. This process requires 150 kWh/t for the drying and 10 kWh/t for the briquetting.9 Hardly any FGD gypsum is produced in Switzerland, however, some is imported from neighbouring countries to produce cement (Fig. 3).10

Dismantling and recycling activities of the building- and deconstruction industry produce large amounts of gypsum waste. Today, some 280 000 tonnes of are likely to occur every year in Switzerland, an amount which could almost double by 2035 (Fig. 4).11

From the recycling point of view, the gypsum industry receives a secondary raw material. Dewatering and dewatering particularly are of interest. They result in over half of the total gypsum waste (Fig. 4). In Switzerland a recycling system for waste gypsum has been operating for several years.12

The waste is first collected in various recycling centres and then sorted. From here it goes into the processing plant at the wallboard production site. The recycled gypsum is fed in the production process together with the primary material. Currently, the recycled content of the produced plasterboard is in the range of only 2%, a percentage that could be significantly increased. However, the total volume of wallboards produced in Switzerland is too small to accommodate all of the potentially recoverable waste gypsum, which currently amounts to around 230 000 t (Fig. 3). The cement industry in turn could be a promising buyer of recycled gypsum because it requires rather a lot of gypsum, approximately 200 000 t/y. Additionally, the cement manufacturing process specifically needs calcium sulphate dihydrate (Tab. 1). The mechanically prepared gypsum could therefore be used without further processing.

During the manufacturing, this process can be reversed by adding water. Four phases of the system CaSO4 / H2O are relevant for the production of gypsum (Tab. 1). When gypsum has not been thermally treated, it is used as a set regulator in the cement industry and as a sulphate carrier in the chemical industry. β-hemihydrate is used to produce gypsum plasterboard, gypsum wallboard and indoor plaster; plaster of Paris also contains anhydrite II. Screeds (un-dried) or plaster (dried) are divided into anhydrite and gypsum screeds. They contain, among other additives, anhydrite, β-hemihydrate or a mixture. Plaster for moulding and modelling is made from α- and β-hemihydrate.13

5. Technology

The preparation of various gypsum products can be defined as a gradual expulsion of the water bound in the gypsum rock (CaSO4·2H2O). Depending on what products are to be made, the gypsum is partially or completely dehydrated as follows:

Due to its chemical properties, gypsum is principally easy to recycle, because the hydrous gypsum fractions can be dehydrated by heating. However, the gypsum waste should not contain high levels of impurities (cf. supplement). Therefore, one could consider the recycling of wallplaster and plasterboard.14

The energy required for this process is relatively low because the material only has to be broken up and ground as in the primary production. The cardboard can be separated from the plasterboard by means of sieving.

6. Economy

In 2013, approximately 435 000 t of gypsum products were imported, but only small amounts were exported (Fig. 3).15 The largest share of the imports was made in wallboard with approximately 275 000 t, followed by building plaster at 105 000 t, whilst the raw (approx. 85%) and FGD gypsum (approx. 15%) for the cement industry accounted for an estimated 34 000 t. The remaining demand for gypsum of around 380 000 t is covered by mining and production in Switzerland. The domestic production processes are limited to wallboards, plaster, screeds and mortars as well as gypsum for cement production.

The current situation concerning recycling is as follows: There is around 230 000 t of waste gypsum in Switzerland that could be easily recycled.16 This amount corresponds to approximately 1% of the Swiss production of gypsum building materials. Currently, only a small portion of this is recycled.17 This relatively low recycling rate can be explained by the sufficient availability of raw gypsum in Switzerland and its neighbouring countries.

With estimated resource extraction costs of 10–15 CHF/t the conditions for the economically viable recycling of gypsum are not favourable (Tab. 3). In addition, the locally recycled gypsum competes with the FGD gypsum supplies from abroad. However, the largest quantities come from the brown coal power plants in eastern Germany, for which the transport costs of an export to Switzerland are likely to be too high. Thus, the competition with FGD gypsum is limited to power plants in the closer neighbouring countries.

In Switzerland the costs of landfilling gypsum waste are in the range of 50 CHF/t, although there are large regional differences. The costs for recycling gypsum waste fell from 25 CHF/t, which means that if less than 25 CHF/t are spent for sorting and waste collection logistics, recycling is more favourable than landfill disposal.

For cement production, the costs of the required gypsum are dependent, on the location, between 27 and 53 CHF/t, including transportation. If the gypsum recycling plants were operated in the vicinity of the cement plants, the raw material costs of the cement plants could probably be minimised. Therefore a great deal of potential can be seen in the recycling of gypsum from an economic point of view, especially since we can expect significantly increasing gypsum waste streams in the future.