SCRREEN2

This project has received funding from the European

Union's Horizon 2020 research and innovation programme

under grant agreement No 958211.

Start date: 2020-11-01 Duration: 36 Months

FACTSHEETS UPDATES **BASED ON THE EU FACTSHEETS 2020**

LIMESTONE

AUTHOR(S):

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LIMESTONE

OVERVIEW

Limestones are rocks of sedimentary origin that are composed mainly of calcium carbonate (CaCO3). With an increasing content of magnesium carbonate (MgCO3), limestone grades into dolomite [CaMg(CO3)2]. Chalk is a type of very fine-grained limestone, easily pulverized, white-to-grayish variety of limestone. Chalk is composed of the shells of marine organisms. The purest chalk contains up to 99% CaCO3. Chalk is extremely porous, permeable, soft and friable.

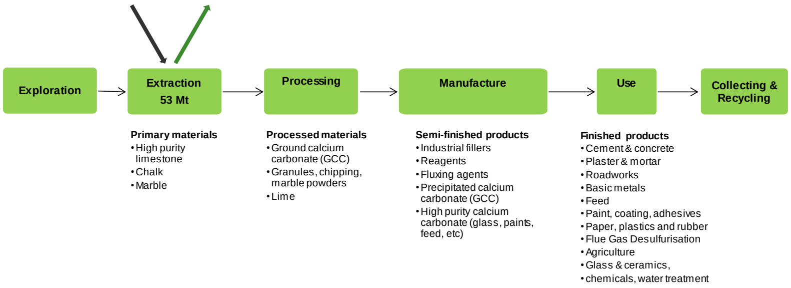

Figure 1. Simplified value chain for limestone in the EU[1]

Table 1. Limestone supply and demand in metric tonnes, 2016-2020 average

Global production	Global Producers	EU consumption	EU Share	EU Suppliers	Import reliance
No data	No data	22 Mtonnes		Norway 86% UK 12% Bosnia 2%	

Prices: In 2020, limestone production was reduced as consequence of the temporarily closing plants during COVID-19 (Garside, 2021, USGS, 2021). However, this event did not affect significantly the average annual prices, which remains stable between 2018 and 2020.

Primary supply: No data is available about the world production of limestone, chalk or granules, chipping and powder of marble, thus only estimates can be used. It is mentioned that Turkey has 40% of the world marble potential.

Secondary supply: Limestone and sub-types of limestone can be obtained from secondary sources. For instance, granules, chipping and marble powder may be recovered as by-products or waste rock from

[1] JRC elaboration on multiple sources (see next sections)

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ornamental stone quarrying. At end-of-life, products in which limestone is used (e.g chalk and marble powder) are often recycled (IMA-Europe (2018).

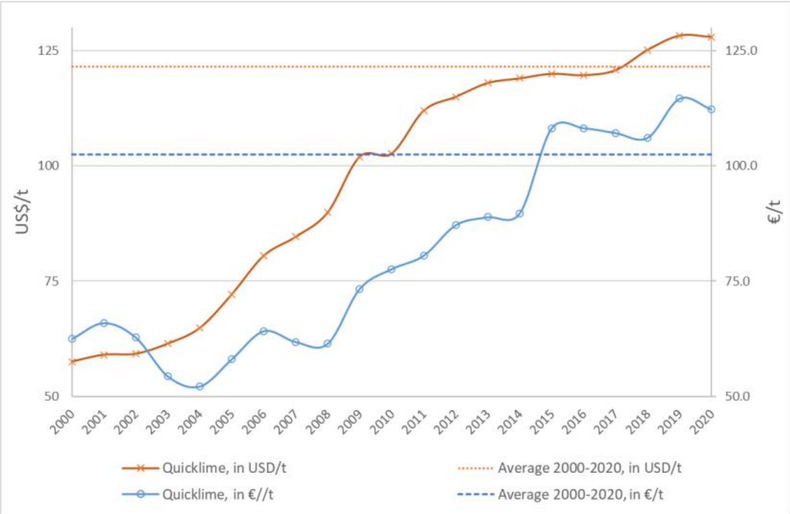

Figure 2. Annual average price of limestone between 2000 and 2020 (USGS, 2021)[2].

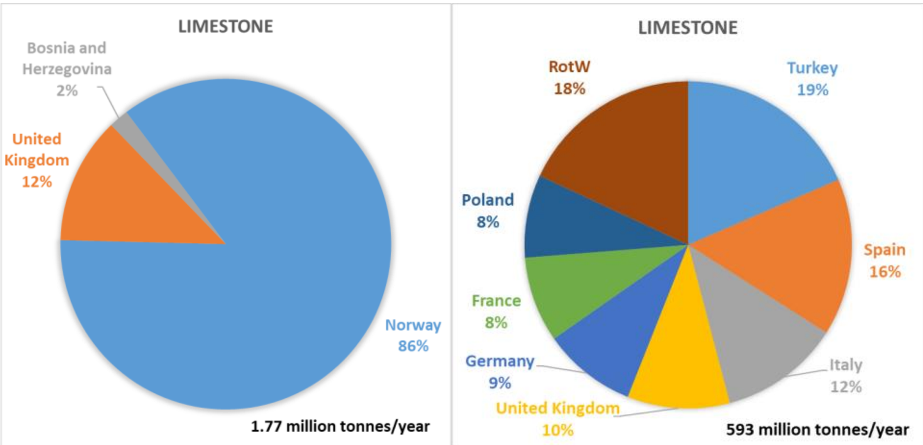

Figure 3. EU sourcing of limestone and European (at large) production (average 2016-2020)

[2] Values in €/kg are converted from original data in US$/kg by using the annual average Euro foreign exchange reference rates from the European Central Bank (https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

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Uses: According to IMA-Europe, the main uses of limestone are cement and concrete (31%) and paper, plastic and rubber (31%).

Substitution: There are no quantified 'market sub-shares' for the identified substitutes of chalk and granules, chippings and powder of marble based on global figures. In most cases the uses are based on hypotheses made through expert consultation and literature findings (SCRREEN workshops, 2019 and 2021).

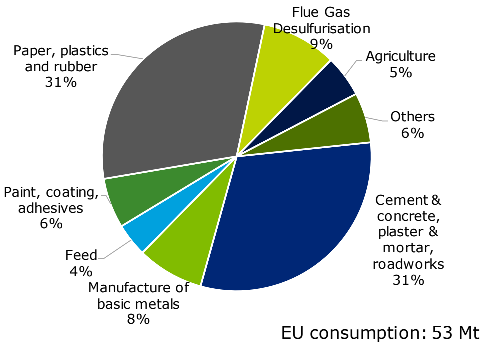

Figure 4: EU uses of limestone

Table 2. Uses and possible substitutes

Use	Percentage*	Substitutes	Sub share	Cost	Performance
Manufacture of basic metals	20%	Fluorspar	5%	Slightly higher costs (up to 2 times)	Similar
Paints, coatings, adhesives	6%	Kaolin	5%	Similar or lower costs	Similar
Paints, coatings, adhesives	6%	Talc	5%	Slightly higher costs (up to 2 times)	Similar
Paints, coatings, adhesives	6%	Wollastonite	2%	Very high costs (more than 2 times)	Similar
Paints, coatings, adhesives	6%	Feldspar	2%	Similar or lower costs	Similar
Paints, coatings, adhesives	6%	Mica	2%	Slightly higher costs (up to 2 times)	Similar
Paints, coatings, adhesives	6%	Pyrophyllite	1%	Similar or lower costs	Reduced
Paints, coatings, adhesives	6%	Silica	1%	Similar or lower costs	Reduced
Paints, coatings, adhesives	6%	Diatomite	1%	Similar or lower costs	Reduced
Paints, coatings, adhesives	6%	Bentonite	1%	Similar or lower costs	Reduced

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Paper	2%	Talc	8%	Slightly higher costs (up to 2 times)	Similar
Paper	2%	Kaolin	30%	Similar or lower costs	Similar
Paper	2%	Zeolites	1%	Similar or lower costs	Reduced
Paper	2%	Diatomite	1%	Similar or lower costs	Reduced
Plastics and rubber	6%	Kaolin	6%	Similar or lower costs	Similar
Plastics and rubber	6%	Talc	6%	Similar or lower costs	Similar
Plastics and rubber	6%	Wollastonite	3%	Similar or lower costs	Similar
Plastics and rubber	6%	Bentonite	2%	Similar or lower costs	Similar
Plastics and rubber	6%	Mica	1%	Similar or lower costs	Similar
Plastics and rubber	6%	Pyrophyllite	1%	Similar or lower costs	Similar
Plastics and rubber	6%	Silica	1%	Similar or lower costs	Similar
Plastics and rubber	6%	Baryte	1%	Slightly higher costs (up to 2 times)	Similar

*** EU27 estimated end uses of limestone for 2020 (Updated following SCRREEN expert validation workshops 2022, personal estimate from M.Dondi)**

Other issues:

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MARKET ANALYSIS, TRADE AND PRICES

GLOBAL MARKET

Table 3. Limestone supply and demand in million metric tonnes, 2016-2020 average

Global production	Global Producers	EU consumption	EU Share	EU Suppliers	Import reliance
No data	No data	22 Mtonnes		Norway 86% UK 12% Bosnia 2%	

Limestone is obtained from the rock by blasting or mechanical excavation depending on the hardness of the rock (Nordkalk, 2021). Then, limestone is processed into ground limestone, concentrated calcite, and quick and slaked lime (Nordkalk, 2021). Global market size for limestone was around 780 million metric tonnes in 2020 (Research and Market, 2021)

In 2020, the three major lime producers were China, United States, and India, where production volumes were 300 million metric tonnes, 16 million metric tonnes, and 16 million metric tonnes, respectively (Garside, 2021). For the pulp and paper industries, lime is internally regenerated to be re-used in paper mills (NLA, 2021; USGS, 2021). Furthermore, quicklime is regenerated from waste hydrated lime in carbide production (USGS, 2021).

EU TRADE

For this assessment, limestone is evaluated at both extraction and processing stage.

Table 4. Relevant Eurostat CN trade codes for limestone

Mining		Processing/refining	
CN trade code	**title**	**CN trade code**	**title**
2517 10 20	Limestone, dolomite and other calcareous stone, broken or crushed	2521 00 00	Limestone flux; limestone and other calcareous stone, of a kind used for the manufacture of lime or cement

Figure 5 and Figure 6 show the EU trade of limestone between 2000 and 2021. Over the whole period, the EU was a net importer of limestone (CN 2517 10 20), and net exporter of limestone flux (CN 2521 00 00). The imports of limestone (CN 2517 10 20) varied from 30,246 t to 962,293 t, while exports ranged between 66,071 t and 488,112 t. For limestone flux (CN 2521 00 00), EU imports fluctuated between 83,368 and 576,828 t, while exports ranged from 17,053 to 216,361.

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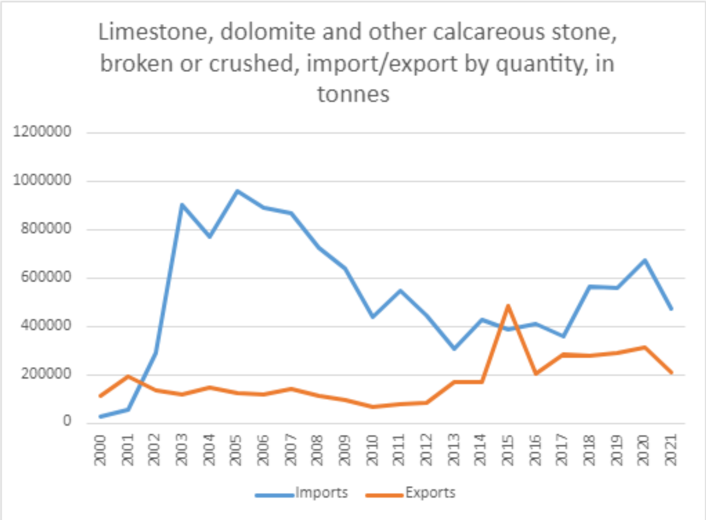

Figure 5. EU trade flows of limestone (CN 2517 10 20) from 2000 to 2021 (Eurostat, 2022)

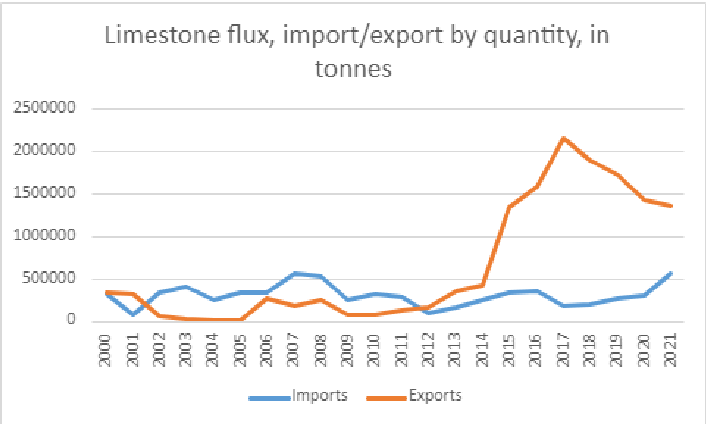

Figure 6. EU trade flows of limestone flux (CN 2521 00 00) from 2000 to 2021 (Eurostat, 2022)

Figure 7 and Figure 8 show the average EU imports of limestone by country for the period 2000-2021. The major EU supplier of limestone was Bosnia and Herzegovina, which corresponds to 42% of the EU's limestone imports in the period. The UK, and Norway followed with 15%, and 9% of the total limestone imports, respectively. For limestone flux, the main supplier was the UK, which represents 28% of the total EU's imports in the period, followed by Bosnia and Herzegovina (18%), Norway (13%), and Canada (7%).

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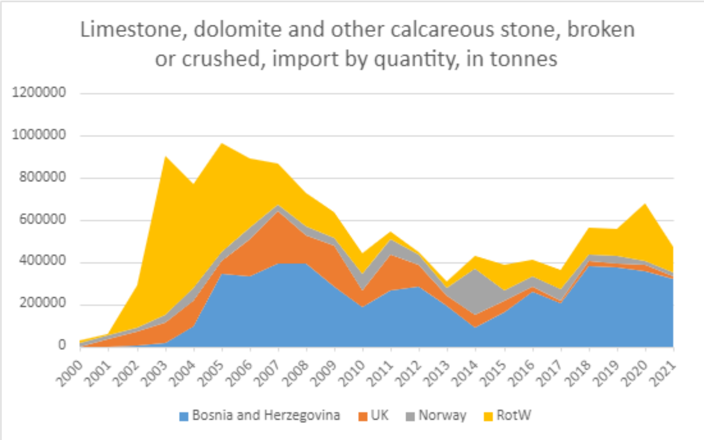

Figure 7. EU imports of (CN 2517 10 20) by country from 2000 to 2021 (Eurostat, 2022)

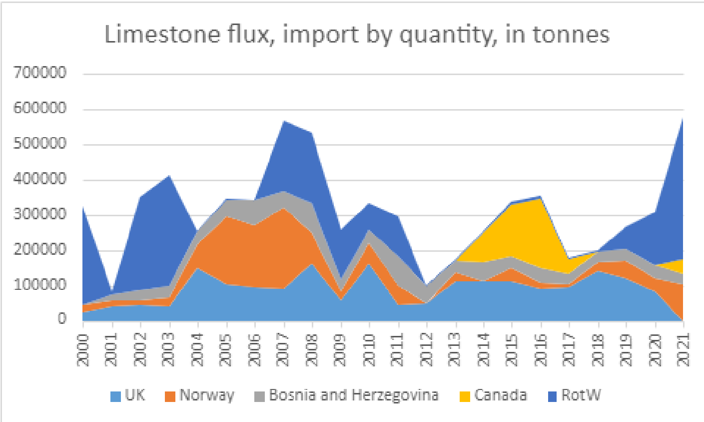

Figure 8. EU imports of limestone flux (CN 2521 00 00) from 2000 to 2021 (Eurostat, 2022)

Commenté [W(1]: I think there is a source missing in the references.

Commenté [GAH2R1]: Thank your for comment. There was a mistake in the reference list. We have changed 'Eurostat (2021)' for 'Eurostat (2022)' in references

PRICE AND PRICE VOLATILITY

In 2020, limestone production was reduced as consequence of the temporarily closing plants during COVID-19 (Garside, 2021, USGS, 2021). However, this event did not affect significantly the average annual prices, which remains stable between 2018 and 2020. Quicklime price volatility was around 2% between 2016 and 2020. In this period, price volatility was mostly disturbed by the price changes from € 107/t in 2017 to € 116/t in 2019. After 2019, the price volatility of quicklime between 2018 - 2020 remains lower than the 2016-2020 period.

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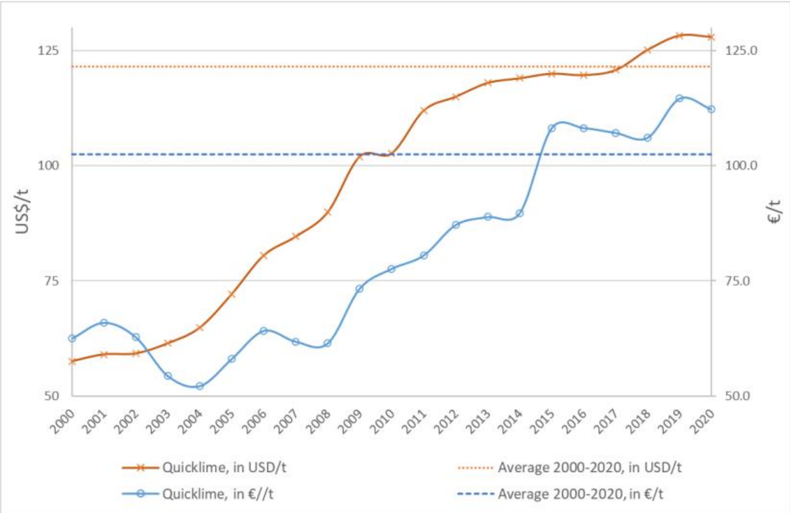

Figure 9. Annual average price of quicklime between 2000 and 2020, in US$/t and €/t[3]. Dash lines indicate average prices for 2000-2020 (USGS, 2021)

OUTLOOK FOR SUPPLY AND DEMAND

The global market of limestone is expected to increase more than 3% between 2021 and 2026 (Research and Market, 2021). This is because the rise of construction demand together with increases in the steel sector worldwide. Nevertheless, this forecast is affected by the decrease of construction and steel production during 2020 as result of the COVID-19 pandemic, where lime production was reduced in the major producer countries. For example, in the United States, lime production went down by 5% in 2020 compared to the 2019 production (USGS, 2021). For high grade limestone demand, it is expected an increase in production in the following years, however, this will depend on the state of economies of certain countries and regions including China, the United States, and Europe (European Commission, 2020).

DEMAND

GLOBAL AND EU DEMAND AND CONSUMPTION

The EU apparent consumption of high-grade limestone over the period 2012-2016 was 53 Mt per year (including chalk 9.7 Mt/y and granules, chipping and powder of marble 6.2 Mt/y). Most of the domestic

[3] Values in €/kg are converted from original data in US$/kg by using the annual average Euro foreign exchange reference rates from the European Central Bank (https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

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production is consumed within Europe, and it can satisfy the EU industry demand with no import reliance issues.

Limestone extraction stage EU consumption is presented by HS codes CN 08113010 Chalk and CN 20134340 Calcium carbonate. Import and export data is extracted from Eurostat Prodcom (2021b). Production data is extracted from Eurostat Prodcom (2021a) using PRCCODE 8113010 Chalk and PRCCODE 283650 Calcium carbonate.

Between 2016-2020, the annual average import and export quantities of limestone at extraction stage have been 520,000 and 360,000 tonnes which are small in comparison to 17.6 and 17.8 Mt in production and demand.

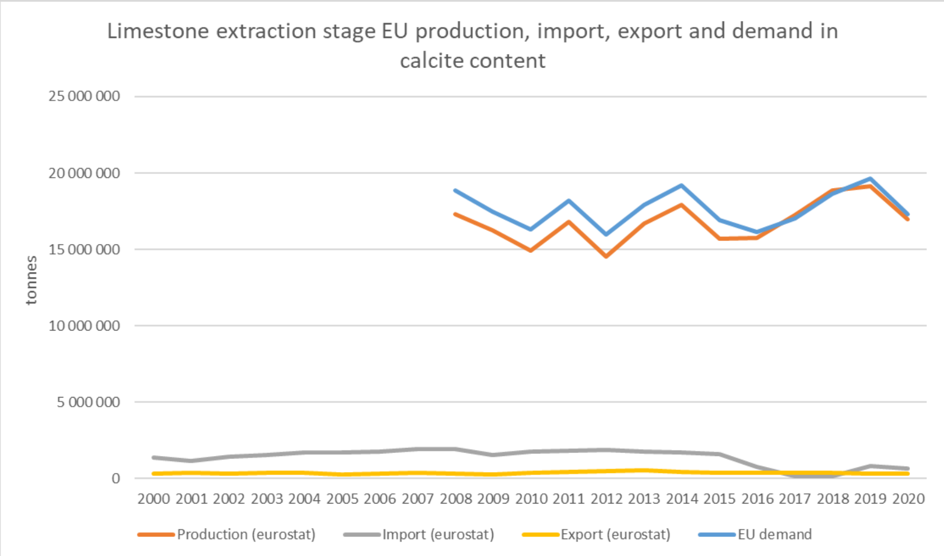

Figure 10. Limestone (08113010 Chalk, 20134340 Calcium carbonate) extraction stage apparent EU consumption. Production data for Chalk is available for 2008-2020 and for calcium carbonate for 2006-2020 from Eurostat Prodcom (2021a). Consumption is calculated in calcite content (EU production+import-export).

Based on Eurostat Prodcom (2021a and 2021b) average import reliance of limestone at extraction stage is 5.1 % for 2008-2020.

Limestone processing stage EU consumption is presented by HS code CN 251741 Granules, chippings and powders of marble. Import and export data is extracted from Eurostat Prodcom (2021b). Production data is extracted from Eurostat Prodcom (2021b) using PRCCODE 8121250 Granules, chippings and powders of marble.

Commenté [W(3]: Since Import and Export has small values compared to production and demand, maybe a logarithmic axis of tonnes would make sense/ make it easier to read.

Commenté [HJ4R3]: I tried logaritmic scale but makes it hard to estimate the production and demand. I added a sentences to give a clue about the level of import, export, production and demand.

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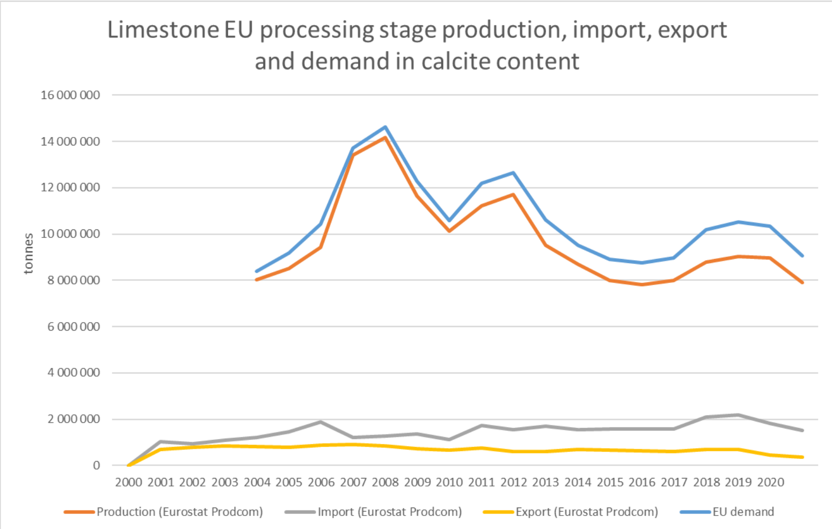

Figure 11. Limestone (CN 251741 Granules, chippings and powders of marble) processing stage apparent EU consumption. Production data from Eurostat Prodcom (2021b) is available for 2003-2020. Production data is represented by sold production (Eurostat Prodcom 2021b). Consumption is calculated in calcite content (EU production+import-export).

Based on Eurostat Prodcom (2021a and 2021b) average import reliance of limestone at processing stage is 8.9 % for 2003-2020.

EU USES AND END-USES

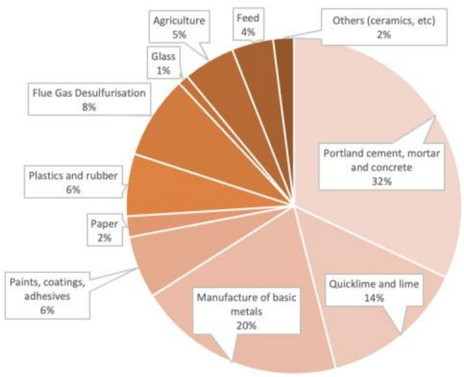

Figure 12: EU27 estimated end uses of limestone for 2020 (Updated following SCRREEN expert validation workshops 2022, personal estimate from M.Dondi)

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According to IMA-Europe, the biggest shares are allocated to the sectors in Figure 12: The relevant industry sectors are described using the NACE sector codes in Table 5

Table 5. Limestone applications (IMA-Europe, 2018), 2-digit and associated 4-digit NACE sectors (Eurostat, 2022).

Applications	2-digit NACE sector	Value added of sector (M €, 2019)	4-digit NACE sectors
Cement & concrete, plaster & mortar, roadworks	C23 - Manufacture of other non-metallic mineral products	72,396	23.61 23.62 23.63 23.64 23.69 23.52
Manufacture of basic metals	C24 - Manufacture of basic metals	63,700	
Feed	C10 - Manufacture of food products	251,015 (inc C11 & C12)	10.89 10.92
Paint, coating, adhesives	C20 - Manufacture of chemicals and chemical products	117,750*	20.30
Paper, plastics and rubber	C20 - Manufacture of chemicals and chemical products	117,750*	20.16 10.17
Flue Gas Desulphurisation	E39 - Remediation activities and other waste management services	1,000	39. 00
Agriculture	C20 - Manufacture of chemicals and chemical products	117,750*	20.15
Others (Glass & ceramics, chemicals, water treatment)	C23 - Manufacture of other non-metallic mineral products	72,396	36.00 23.52

Chalk as high-purity limestone is used in the production of lime and Portland cement, as well as fertiliser.

Finely ground and purified chalk, known as whiting, is used as filler, extender, or pigment in numerous materials, including ceramics, putty, cosmetics, crayons, plastics, rubber, paper, paints and linoleum.

The main use for chalk whiting is in making putty, to improve its plasticity, oil absorption and aging behaviour.

Marble can be heated in a kiln to remove carbon dioxide and produce calcium oxide (lime), which is used for acidity reduction in soils. When applied in combination with fertiliser, it may increase the yield of a soil.

Mixtures of marble chips and powders with a binder of either cement, or resin can be used to produce blocks, which can be cut and processed, decorative tiles and mosaics (after mixing them with other materials), prefabricated products -mainly reinforced concrete structures- and urban furniture, pigments (using coloured marble powders), glues and stuccos, polymers reducing thus the need to use titanium dioxide, glass, ceramics, toothpaste, cosmetics, household detergents, sand-blasting and floral decorations (Ferrari Granulati Marbi sas, 2019).

Marble powder (and powdered limestone) is used to produce food supplements for animals - because they are softer than the animal's teeth, soluble and rich in calcium.

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Crushed and pulverized marble, in the form of granules, chipping and powder can be used to reduce the acidity of soils and aquatic streams, an acid-neutralizing agency in the chemical industry and to produce soft abrasives used in bathroom and kitchen surfaces (Ferrari Granulati Marbi sas, 2019).

SUBSTITUTION

Table 6. Uses and possible substitutes of limestone

Use	Percentage*	Substitutes	Sub share	Cost	Performance
Manufacture of basic metals	20%	Fluorspar	5%	Slightly higher costs (up to 2 times)	Similar
Paints, coatings, adhesives	6%	Kaolin	5%	Similar or lower costs	Similar
Paints, coatings, adhesives	6%	Talc	5%	Slightly higher costs (up to 2 times)	Similar
Paints, coatings, adhesives	6%	Wollastonite	2%	Very high costs (more than 2 times)	Similar
Paints, coatings, adhesives	6%	Feldspar	2%	Similar or lower costs	Similar
Paints, coatings, adhesives	6%	Mica	2%	Slightly higher costs (up to 2 times)	Similar
Paints, coatings, adhesives	6%	Pyrophyllite	1%	Similar or lower costs	Reduced
Paints, coatings, adhesives	6%	Silica	1%	Similar or lower costs	Reduced
Paints, coatings, adhesives	6%	Diatomite	1%	Similar or lower costs	Reduced
Paints, coatings, adhesives	6%	Bentonite	1%	Similar or lower costs	Reduced
Paper	2%	Talc	8%	Slightly higher costs (up to 2 times)	Similar
Paper	2%	Kaolin	30%	Similar or lower costs	Similar
Paper	2%	Zeolites	1%	Similar or lower costs	Reduced
Paper	2%	Diatomite	1%	Similar or lower costs	Reduced
Plastics and rubber	6%	Kaolin	6%	Similar or lower costs	Similar
Plastics and rubber	6%	Talc	6%	Similar or lower costs	Similar
Plastics and rubber	6%	Wollastonite	3%	Similar or lower costs	Similar
Plastics and rubber	6%	Bentonite	2%	Similar or lower costs	Similar
Plastics and rubber	6%	Mica	1%	Similar or lower costs	Similar
Plastics and rubber	6%	Pyrophyllite	1%	Similar or lower costs	Similar
Plastics and rubber	6%	Silica	1%	Similar or lower costs	Similar
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*** EU27 estimated end uses of limestone for 2020 (Updated following SCRREEN expert validation workshops 2022, personal estimate from M.Dondi)**

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There are no quantified 'market sub-shares' for the identified substitutes of chalk and granules, chippings and powder of marble based on global figures.

In most cases the uses are based on hypotheses made through expert consultation and literature findings (SCRREEN workshops, 2019 and 2021).

Research on substitutes has occurred but limestone will never be fully replaced because it is so widely used (SCRREEN Expert Workshop, October 2021).

PAPER, PLASTICS AND RUBBER

Possible substitutes in paper making include kaolin, talc and titanium dioxide, with kaolin the most widely used in this industry. Talc and titanium-dioxide are used in smaller quantities for special applications, where extreme whiteness and opacity, or pitch control are required. Titanium dioxide is more expensive than chalk (Natural Stone Institute, 2016).

Chalk substitutes within plastics and rubber applications include talc, kaolin, wollastonite, mica, silica and alumina hydrate (Natural Stone Institute, 2016).

CEMENT & CONCRETE, PLASTER & MORTAR, ROADWORKS

Limestone, dolomite, alumina trihydrate (ATH), slag, talc, silica, feldspar, kaolin, ball clay and dolomite are alternative materials that could be used as substitute for chalk or granules, chippings and marble powder.

PAINTS ADHESIVES & COATINGS

Multiple materials are potential substitutes, including clays, silica, feldspar, talc, mica, gypsum, barite and others.

Limestone is the primary extender and filler due to its low cost and good performance (Natural Stone Institute, 2016).

AGRICULTURE

Marble powder could be replaced by specific industrial by-products including calcite, lime, certain types of slag, paper mill sludge and flue dust.

OTHER APPLICATIONS: ENVIRONMENTAL APPLICATIONS

Marble powder may be used in water treatment. Lime and dolomitic lime are the primary materials used in these applications.

Alumina, bentonite, silica and several other mineral-derived chemicals could be used as alternatives (Natural Stone Institute, 2016).

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SUPPLY

EU SUPPLY CHAIN

EU production of circa 214 Mt per year in the reported period (2016-2020, PRCCODE 08112050) is much higher than net imports (12 Mt/y), which mainly originate from Norway and Turkey (7% and 2% of the EU sourcing, respectively). Imports from other non-EU countries is almost negligible (0.3%). Several EU countries produce chalk, the main producers being Poland, France, Germany, Spain and Denmark.

There are no trade restrictions to Europe on these commodities.

SUPPLY FROM PRIMARY MATERIALS

GEOLOGY, RESOURCES AND RESERVES

GEOLOGICAL OCCURRENCE

Limestones are rocks of sedimentary origin that are composed mainly of calcium carbonate (CaCO3). Chalk is a type of very fine-grained limestone. With an increasing content of magnesium carbonate (MgCO3), limestone grades into dolomite [CaMg(CO3)2]. Most limestones contain varying amounts of impurities in the form of sand, clay and iron-bearing materials.

Chalk is a soft, fine-grained, easily pulverized, white-to-grayish variety of limestone. Chalk is composed of the shells of marine organisms. The purest chalk contains up to 99% CaCO3. Chalk is extremely porous, permeable, soft and friable. It may contain small amounts of silica and small proportions of clay minerals, glauconite and calcium phosphate (**Gale, 2017; Eurostat, 2018**).

Extensive chalk deposits occur in Europe, south of Sweden, and in England. Other extensive deposits occur in the United States and in several other countries.

GLOBAL AND EU RESOURCES AND RESERVES

There is no single source of comprehensive evaluations for resources and reserves that apply the same criteria to deposits of high-grade limestone (including chalk or marble) in different geographic areas of the EU or globally. Individual companies may publish mineral resource and reserve reports, but reporting is done using a variety of systems depending on the location of their operation, their corporate identity and stock market requirements. In Europe, there is no complete and harmonised dataset that presents total EU resource and reserve estimates for neither limestone, nor chalk or marble. There are no global reserves figures, or country-specific figures published by any other data provider. Global reserves and resources figures are expected to be large and are distributed in several regions.

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WORLD AND EU MINE PRODUCTION

No data is available about the world production of limestone, chalk or granules, chipping and powder of marble, thus only estimates can be used. It is mentioned that Turkey has 40% of the world marble potential. Turkey's visible reserves are 1.6 billion tonnes which means Turkey is able to meet the world's marble need for the next 80 years (Sezginmarble, 2019).

The EU production of limestone (PRCCODE 08112050) over the period 2008-2020 was 192 Mt. The major producers were Germany (28%), Poland (19%), Italy (13%) and Spain (7%).

The EU production of chalk (PCRCODE 08113010) over the period 2008-2020 was 11.7 Mt. The major producers were Poland (39%), France (27%), Germany (13%), Spain (8%) and Denmark (6%).

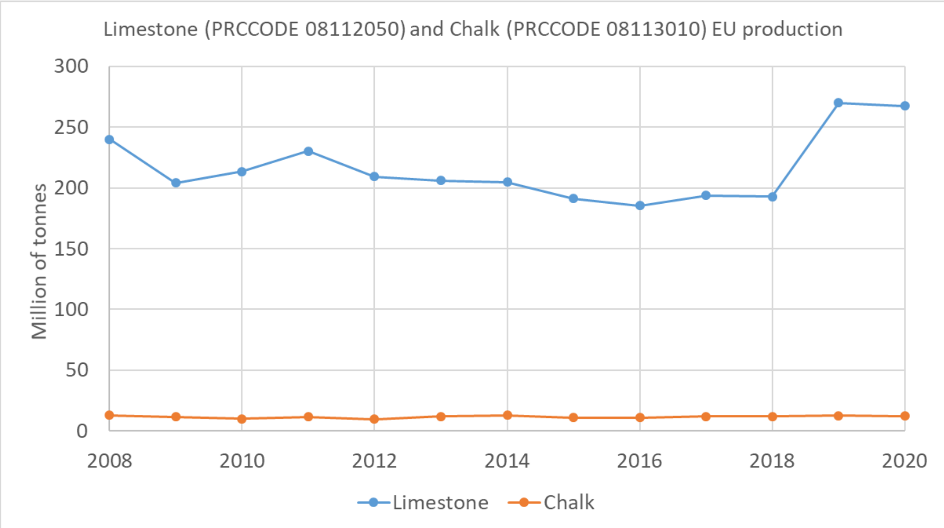

Figure 13. EU production of limestone and chalk, 2008-2020 (Eurostat, Prodcom 2022)

However, in general, it is almost impossible to gain consistent data on world (or EU) production of the calcium carbonate. One reason is the terminology – some reports contain aggregated data on limestone production or trade which includes also lime and aggregates (for instance USGS 2022 and BGS, 2021) while there is no subcategory for high quality calcium carbonate powders (which are the main interest for EU commission).

In high end calcium carbonate products is important to note difference between Ground Calcium Carbonate (GCC) and Precipitated Calcium Carbonate (PCC). However, data on production of these two products are not separated in reports.

Table 7 - Table 9 present the main EU exporters of calcium carbonate, calcium carbonate under aggregate form and chalk, respectively (worldbank.org). According to 2018 data, the European (EU-28) annual consumption of calcium carbonate was estimated at around 53 million tonnes (ima-europe.eu, 2018).

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According to the British Geological Survey, about 2.435 million tonnes of aggregates as sand, gravel and crushed rock used for concrete aggregates, roadstone and other construction uses, where produced in EU-UK in 2021 (BGS, 2021). European Minerals Yearbook presents historical data until 2018 concerning the sand, gravel and crushed aggregates. It is referred that the amount of aggregates imports and exports were 92.1 million tonnes and 100.1 million tonnes respectively (minerals4eu.brgm-rec.fr). However, these data provided by both the British and the French institutions do not specialize on calcium carbonate aggregates.

Table 7. Top-10 EU exporters of calcium carbonate in 2019 (HS Code 283650) (wits.worldbank.org).

EU country	Exports (tonnes x 1000)
Belgium	342.28
France	47.75
Netherlands	357.62
Germany	58.18
Spain	118.91
Italy	95.51
Portugal	58.85
Greece	76.26
Austria	14.47
Poland	8.62

Table 8. Top-10 EU exporters of marble, in granules, chippings and powder in 2019 (HS Code 251741) (wits.worldbank.org).

EU country	Exports (tonnes x 1000)
Austria	1133
Italy	709.56
Slovenia	712.8
Croatia	450.4
Greece	240.78
Czech republic	194.56
Germany	81.27
Spain	63.22
France	32.48
Romania	27.92

Table 9. Top-10 EU exporters of chalk in 2019 (HS Code 250900) (wits.worldbank.org).

EU country	Exports (tonnes x 1000)
France	266.44
Spain	85.1
Belgium	112.98
Germany	75.57
Netherlands	26.57

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Poland	34.43
Greece	31
Austria	17.76
Romania	6.51
Finland	2.73

SUPPLY FROM SECONDARY MATERIALS/RECYCLING

Limestone and sub-types of limestone can be obtained from secondary sources. For instance, granules, chipping and marble powder may be recovered as by-products or waste rock from ornamental stone quarrying. At end-of-life, products in which limestone is used (e.g chalk and marble powder) are often recycled (IMA-Europe (2018). However, only for a few applications recycling produces secondary materials with the same functions of natural limestone. During the validation workshops (SCRREEN workshops, 2019), it was estimated that the only functional recycling of limestone is in paper and plastic (mainly chalk). In summary: ~60% recycling times 31% share, gives an estimated EoL-RIR of 19%

As an example of non-functional recycling, if chalk is used for the production of lime or cement at the end of life of a building it ends up in contruction and demolition wastes, part of which are recycled. Again, interior and exterior paints which contain chalk are commonly used in buildings. At the end of a building's life, paint is found in construction and demolition waste, often recycled into secondary aggregates. When marble powder is used for the production of construction materials (e.g artificial stones, blocks, tiles, prefabricated products etc) at the end of life of buildings it ends up in C&DW, which is partially recycled.

Marble powder in container glass is recycled through the glass recycling process, however the market share is 2% only (IMA-Europe, 2018).

The Industrial Minerals Association – Europe has estimated the recycling rate of calcium carbonate used in various applications in terms of the recycling rate of each application and the recycled $CaCO_3$ amount (Table 10). For example: Spent cement, concrete, plaster and mortars can reused as aggregates used for other construction processes. In Europe, paper fibres are recycled 3.6 higher in comparison to the global average reaching 72.5% in 2016. End-of-life plastics containing calcium carbonate are either recycled or recovered for energy. Industrial film, PET bottles and PVC profiles are mainly recycled. Almost 3 million tonnes of Calcium Carbonate were used in agriculture in 2017. It can be considered that $CaCO_3$ in this application has a 100% recycling rate. Despite the high recycling rates of the above mentioned materials containing calcium carbonate, the actual recycling rate of $CaCO_3$ in terms of its recovery are relatively low (ima-europe.eu, 2018).

Similar data, concerning the reducibility of calcium carbonate aggregates are described in the recent USGS factsheet (pubs.usgs.gov, 2022). Calcium carbonate used in road surfaces made of asphalt concrete and portland cement concrete surface layers, which contain crushed stone aggregate is recycled on a limited but increasing basis in most States. In 2021, asphalt and portland cement concrete road surfaces were recycled in all 50 states, however the recycling rate remains low. The total US calcium carbonate production in 2021 was 1500 million tonnes and the respective recycled amount 38 million tonnes.

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Table 10. Recyclability rate of calcium carbonate in respect of various industrial sectors (data between the years 2016-2018) (ima-europe.eu, 2018).

	$CaCO_3$ Markets	Application Recycling Rate	$CaCO_3$ Recycling Rate
Cement and Concrete, Plaster and Mortars	30%	50%	15%
Paper	25%	72%	18%
Flue Gas Treatment	9%	50%	4%
Paints, Coatings and Adhesives	7%	50%	3%
Plastics	7%	31%	2%
Agriculture (Liming Materials & Carrier)	5%	100%	5%
Glass	2%	54%	1%
Other uses	16%		
Total	100%		49%

LIMESTONE PROCESSING

Mining and processing: High purity limestone is extracted from surface quarries across Europe following conventional quarrying procedures. Processing of limestone includes crushing, grinding, sizing and possibly drying and storage prior to transportation. Depending on the intended end use, processing stages tend to vary accordingly. Ground calcium carbonate is produced in two ground forms, coarse to medium fillers for use in agriculture, animal feeds, asphalt fillers and elsewhere, and in fine to very fine fillers for use in paper, paints and coatings, plastics, food supplements and others. High purity limestone used in glass making, environmental protection applications, sugar refining and ceramics is commonly in crushed form.

Chalk is mined in quarries. The mined chalk is then taken to crushers where it is grounded and pulverized. Primary crushing involves the use of cone or jaw crushers, while secondary crushing involves the use of smaller crushers. Finally, grinding is carried out, mainly in rotating steel drums to remove impurities and produce a high quality fine final product. The resulting chalk is washed clean, dried and packaged.

Marble is also mined in quarries. Most marble is made into either crushed stone or dimension stone using a variety of equipment. Dimension stone is produced by sawing marble into pieces of specific dimensions.

OTHER CONSIDERATIONS

HEALTH AND SAFETY ISSUES RELATED TO THE LIMESTONE

Limestone is restricted by REACH as a component of Calcines, lead-zinc ore conc.[4]

[4] A thermally agglomerated substance formed by heating a mixture of metal sulfide concentrates, limestone, sand, furnace dross, miscellaneous zinc, lead and copper bearing materials, together with already roasted material to a temperature of 1000°C to 1200°C (538°F to 649°F).

According to the classification provided by companies to ECHA in CLP notifications, limestone causes skin irritation. However, Limestone is not subject to harmonized classification and labelling (ECHA 2023).

In terms of international threshold limits, the limit value (8 hours exposure) in EU countries such as Belgium, Hungary and Spain is 10 mg/m^3. In Japan the limit is 2 mg/m^3 while in the US OSHA it is 15 mg/m^3. (GESTIS 2023).

Limestone is not listed by MSHA, OSHA, or IARC as a carcinogen. However, this product may contain trace amounts of crystalline silica in the form of quartz or crystobalite, which has been classified by IARC as a Group I carcinogen to humans when inhaled. Inhalation of silica can also cause a chronic lung disorder, silicosis (Lhoist NA 2020).

(EFSA 2022) conducted a peer review of the pesticide risk assessment of the active substance limestone powder: "In the area of ecotoxicology, low risk to all non-target organisms was concluded based on the low exposure in the environment and relevant food items for non-target organisms. Limestone powder (calcium carbonate) does not meet the criteria for endocrine disruption for humans and non-target organisms according to points 3.6.5 and 3.8.2 of Annex II to Regulation (EC) No 1107/2009, as amended by Commission Regulation (EU) 2018/605".

ENVIRONMENTAL ISSUES

(Bendouma et al 2020) conducted a LCA to evaluate the environmental impact of limestone by collecting primary data in different five limestone quarries in Algeria: the results show that global warming potential (GWP) varies from 4,689 to 50,875 kg CO2-eq./ton and it is remarkably dominated by CO2 and N2O emissions. Primary energy use varies from 0.38 to 218.50 megajoules per ton. Other impacts are also mentioned in this study such as ecotoxicity and eutrophication which range from 2.17E-15 to 1.54E-11 and from 2.72E-17 to 1.61E-11 species/year, respectively.

The most widely adopted method of limestone mining is through opencast pits with bench formation. Limestone mining causes widespread disturbance in the environment. Myriad impacts are observed as changes in land use pattern, habitat loss, higher noise levels, dust emissions and changes in aquifer regimes (Ganapathi et al. 2020).

NORMATIVE REQUIREMENTS RELATED TO MINING/LIMESTONE PRODUCTION, USE AND PROCESSING OF THE MATERIAL

No specific regulations were found regarding limestone mining, production or processing.

The EuLA (European Lime Association), however, is carefully following standards on road materials, earthworks, soil treatment, masonry and mortar and drinking water, with the continuous objective to defend a correct treatment of lime in these standards – considering that lime is produced when limestone is subjected to extreme heat, changing calcium carbonate to calcium oxide (EuLa 2023).

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SOCIO-ECONOMIC AND ETHICAL ISSUES

ECONOMIC IMPORTANCE OF LIMESTONE FOR EXPORTING COUNTRIES

Table 11 lists the countries for which the economic value of exports of limestone represents more than 0.1 % of the total value of their exports.

Table 11: Countries with the highest economic shares of limestone exports in relation to their total exports.

Country	Export value (USD)	Share in total exports (%)
Jamaica	3,509,599	0.3
United Arab Emirates	252,614,673	0.1
Barbados	252,337	0.1

Source: COMTRADE (2022), based on data for 2020.

The countries for which this material has a higher economic importance related to its total exports are Jamaica, the United States of America, and Barbados.

SOCIAL AND ETHICAL ASPECTS

Social conflicts related to the extraction of limestone have been reported in Russia, specifically in the Southern Urals region, where in 2019 Bashkir Soda Company obtained the license to extract the material from Kushtau Hill. However, Kushtau Hill is considered a sacred site for local communities, who consequently fought against the workers and succeeded in blocking the project. In 2020, government representatives visited the site and promised to cease the excavations until an agreement was achieved between the local population and the Bashkir Soda Company (EJAtlas, 2020).

(Moheieldin et al., 2021) alleges that social conflicts related to the mining of limestone are affecting the society in Egypt given that in the last decades the country has been facing a transition from an agriculture-based economy to one based on the extraction and processing of several raw materials. Indeed, since the 1980s many emigrants which returned to their home villages in Middle Egypt after living during a period in Libyan quarries started mining limestone. This economic activity is mostly unpermitted, and workers hold informal contracts with their employers. Furthermore, the government does not have control over the mines and thus cannot collect fees and taxes for these activities. On top of political difficulties, long-standing ethnoreligious conflicts between Muslims and Copt Christians exacerbate the tension in this area, being the Copts who own and control most limestone quarries and their related commercialization activities in Middle Egypt. In conclusion, the mixture of rapid socio-economic transformations sustained by the mining industry, along with the ethnoreligious tensions and political instability could lead to social conflicts and exacerbate pre-existing problems.

RESEARCH AND DEVELOPMENT TRENDS

RESEARCH AND DEVELOPMENT TRENDS FOR LOW-CARBON AND GREEN TECHNOLOGIES

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- LEILAC - Low Emissions Intensity Lime and Cement (2016-2021, EU)[5]

LEILAC, Low Emissions Intensity Lime And Cement, will successfully pilot a breakthrough technology that will enable both Europe's cement and lime industries to reduce their emissions dramatically while retaining, or even increasing, international competitiveness. LEILAC will develop, build and operate a 240 tonne per day pilot plant demonstrating Direct Separation calcining technology which will capture over 95% of the process CO2 emissions (which is 60 % of total CO2 emissions) from both industries without significant energy or capital penalty.

Direct Separation technology uses indirect heating in which the process CO2 and furnace combustion gases do not mix, resulting in the simple capture of high-quality CO2. This innovation requires minimal changes to the conventional processes for cement, replacing the calciner in the Preheater-Calciner Tower. For lime there is no product contamination from the combustion gas. The technology can be used with alternative fuels and other capture technologies to achieve negative CO2 emissions. The project will also enable research into novel building materials with a reduced CO2 footprint, as well the upgrade of low value limestone fines and dust to high value lime applications.

- Towards greener ultra-highperformance concrete based on highly efficient utilization of calcined clay and limestone powder (Dong et al 2023)

In this study, greener ultra-highperformance concrete (UHPC) is designed and prepared based on calcined clay-limestone powder, aiming to increase the cement substitution level while ensuring the excellent mechanical properties of UHPC. Compressive strength tests, X-ray diffraction, thermal gravity-differential thermal gravity, isothermal calorimetry, and mercury porosimetry were used to characterize the mechanical properties, hydration and microstructure development of the samples, revealing the effect of the calcined clay and limestone powder on the performance of UHPC. The results show that when the substitution level is lower than 40%, the composition of raw materials has no obvious effect on the strength at the early stage, and the early mechanical properties decrease at the higher substitution level, but the mechanical properties at 28d are still comparable to or even higher than the reference sample. Especially, when the overall substitution level is 60% and the ratio of calcined clay to limestone powder is 2:1, the compressive strength exceeds that of the reference sample at 28d. Through this study, a feasible way for the design and preparation of greener UHPC is proposed based on calcined clay and limestone powder cementitious material system.

- Recycling of waste limestone powders for the cleaner production of epoxy coatings: Fundamental understanding of the mechanical and microstructural properties (Chowaniec-Michalak et al 2022)

Epoxy resins are very well suited for floor coatings, but their ingredients are harmful to the environment. Therefore, their content in coatings should be reduced, e.g. by adding a filler. In this paper, the fundamental understanding of the behavior of epoxy coatings modified with the addition of waste limestone powder was systematically assessed in terms of viscosity, mechanical properties (hardness, tensile strength, flexural strength, pull-off strength) and microstructure (powder distribution in the coating, porosity of the concrete substrate). The replacement ratio with limestone powder ranged from 0% to 29% of the mass of the epoxy

[5] https://cordis.europa.eu/project/id/654465

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resin. The following research methods were used: a flow cup, a Shore D durometer, a tensile and flexural testing machine, a pull-off tester, and a scanning electron microscope (SEM). It was observed that an increasing amount of waste limestone powder in the epoxy resin resulted in an increased viscosity of the liquid coating by 56%, an increased hardness of the cured epoxy coating by 10%, a decreased tensile and flexural strength by 62% and 59%, respectively, and a decreased pull-off strength of the coating by a maximum of 21%. Although the limestone powder caused a large increase in viscosity, the surface of the coating remained even, and the pull-off strength was still well above the standard minimum values.

OTHER RESEARCH AND DEVELOPMENT TRENDS

- Workability and strengths of ternary cementitious concrete incorporating calcined clay and limestone powder (Salman et al 2023)

Problems associated with the production and utilization of Portland cement have necessitated the use of alternative or supplementary binders in concrete production. This study investigated the use of two supplementary binders; calcined clay (CC) and limestone powder (LP) as substitutes for cement in the production of concrete. Both the calcined clay and limestone powder were characterized using X-ray diffraction (XRD), X-ray Fluorescence (XRF) and Scanning Electron Microscope (SEM).

- Numerical studies and analysis on reaction characteristics of limestone and dolomite in carbonate matrix acidizing (Wang et al 2023)

Carbonate reservoirs with abundant oil and gas resources are mainly composed of limestone and dolomite. As the acid-rock reaction progresses, limestone is gradually consumed and more acid gradually reacts with the slower dolomite. However, the existing acid rock-reaction models do not consider the competition between limestone and dolomite with acid, and cannot objectively describe the degree of contribution of limestone and dolomite to wormholes at each stage of acidizing. Here, an acidizing model was developed to study and analyze the effect of the reaction characteristics of limestone and dolomite on the carbonate acidizing. In this study, the probability of limestone and dolomite contact with acid is assumed to be related to the content of limestone and dolomite, and a new acid-rock reaction model is proposed by considering the reaction rate and reaction sequence of limestone and dolomite.

- Effect of limestone on engineering properties of alkali-activated concrete: A review (Lin Chan et al 2022)

Alkali-activated concrete (AAC) is a promising sustainable alternative to cementitious materials concerning its environmental benefits and satisfactory engineering properties. Given the growing use of limestone and other forms of calcium carbonate as an additive or supplementary precursor in AAC, this review summarises the effect of limestone on the engineering properties of AAC synthesised from various precursors such as fly ash, slag, metakaolin, and blends of them. Due to the underlying mechanisms including filler effect, additional nucleation and dilution effect, and chemical reaction of limestone, the incorporation of limestone with physical and chemical modifications into AAC can result in changes in reaction kinetics, microstructure, fresh properties, and hardened properties of AAC, which are quantitatively discussed and compared. In addition,

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the sustainability and environmental impact of AAC containing calcium carbonate are also assessed, whilst the research gap and opportunities for the future are identified.

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