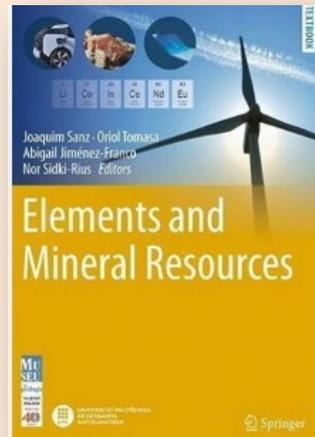


ELEMENTS and MINERAL RESOURCES: uses and recycling (slides to project in class)

**Authors: Joaquim Sanz, Nor Sidki Rius i Oriol Tomasa
Geological Museum Valentí Masachs (UPC)
2022**



Contents [\(interactive\)](#)

Aluminium – *bauxite*

Antimony

Barite

Beryllium

Boron - *borates*

Calcite – *limestone*

Chromium

Cobalt

Copper

Feldspars

Fluorine – *fluorite*

Gallium

Germanium

Gold

Graphite

Gypsum

Indium

Iron

Kaolinite

Lead

Lithium

Magnesium – *magnesite*

Manganese

Molybdenum

Nickel

Niobium

Phosphorus - *phosphorite*

Platinum (group)

Potassium – *sylvinite*

Quartz – *silica sand*

Rare Earths

Sepiolite

Silver

Sodium – *halite (salt)*

Talc

Tantalum

Tin

Titanium

Tungsten

Vanadium

Zeolites

Zinc

ALUMINIUM (Al) [Z=13] and *bauxite*

- The most abundant element in the Earth's crust.
- A good electrical conductor, malleable, ductile, soft and light.
- Provides a metal barrier that is impermeable to light, oxygen and bacteria.
- Obtained from bauxite. The EU considered it a strategic rock in 2020.

 The production of aluminium from recycled cans saves 95% electrical energy.

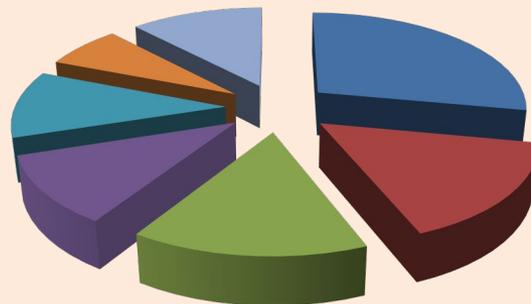
- *Bauxite, as a rock, is used directly as an additive in cements, in the manufacture of fire bricks and as an abrasive.*

Scandium, a highly appreciated metal, can be found in the red mud obtained as a residue after the treatment of bauxite <http://www.redmud.org>.



BAUXITE (rock formed from gibbsite, diaspore and boehmite) mix of aluminium hydroxides and oxides
Miralles (Anoia) Catalonia

USES



- construction 28%
- automotive 16%
- packaging 15%
- industrial 11%
- electrical/electronics 11%
- aerospace 7%
- other end user indust. 12%

Source: Mordor Intelligence 2021



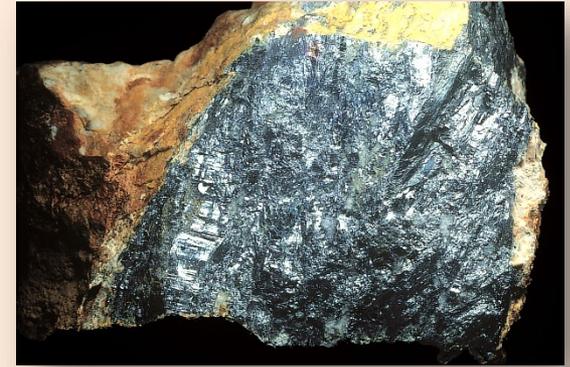
REFERENCES AND LINKS

GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009 QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007 SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022 STWERTKA, Albert, *A guide of the elements, 3rd*. Oxford University Press, Inc. 2012 <https://www.european-aluminium.eu/> <http://www.eurometaux.eu>
<https://www.usgs.gov/centers/national-minerals-information-center/aluminum-statistics-and-information>

ANTIMONY (Sb) [Z=51]

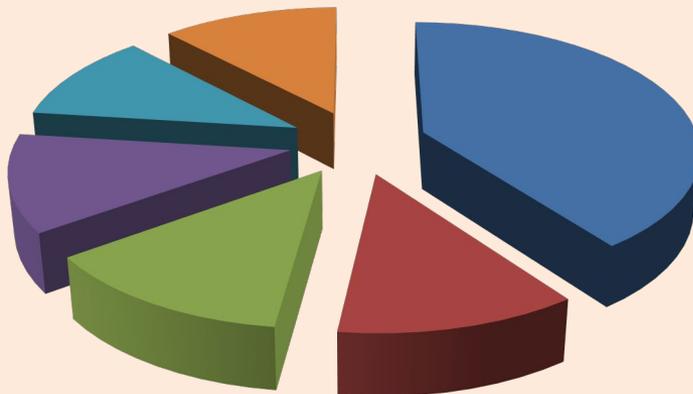
- A brittle metalloid with low hardness.
- Low thermal and electrical conductivity.
- Melts at low temperature (630°C) (with a lighter).
- The EU classified antimony as a strategic metal in 2017.
- Obtained from stibnite.

 This metal is recycled (28%) from exhausted lead batteries (SCREEN-UE) 2018



STIBNITE (antimony sulfide)
Abella (Ripollès) Catalonia

USES



- fiberglass composites 40%
- flame retardants 12%
- lead acid batteries 13%
- catalysts 12%
- alloy strengthening agent 11%
- others 12%

Source: Mordor Intelligence 2021

REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007

<http://www.eurometaux.eu> <http://www.antimony.com/>
<https://www.usgs.gov/centers/national-minerals-information-center/antimony-statistics-and-information>



BARITE

- A barium sulphate ($BaSO_4$)
- Has a high specific weight (4.5)
- Slightly soluble.
- Non-toxic, physically and chemically inert.
- Absorbs ionizing radiation and X rays (radiotherapy bunkers).
- The EU classified barite as a strategic mineral in 2017.



A considerable amount of barite is recovered from well-drilling mud.

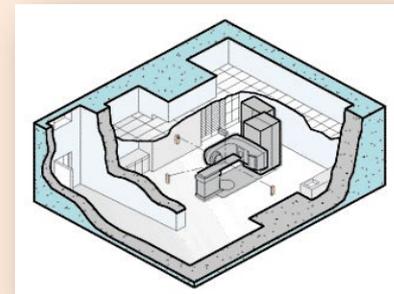


BARITE (barium sulphate)
Espinelles (Osona) Catalonia

USES



Source: Mordor Intelligence



REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <https://www.usgs.gov/centers/national-minerals-information-center/barite-statistics-and-information>
- <http://www.discoveriesinmedicine.com/Bar-Cod/Barium.html>

BERYLLIUM (Be) [Z=4]

- An alkaline earth metal, light and rare.
- Has a high melting point (1278°C) and a high heat capacity.
- High thermal conductivity and high toxicity.
- Obtained from beryl and found in emerald and aquamarine.
- The EU classified beryllium as a strategic metal in 2017.

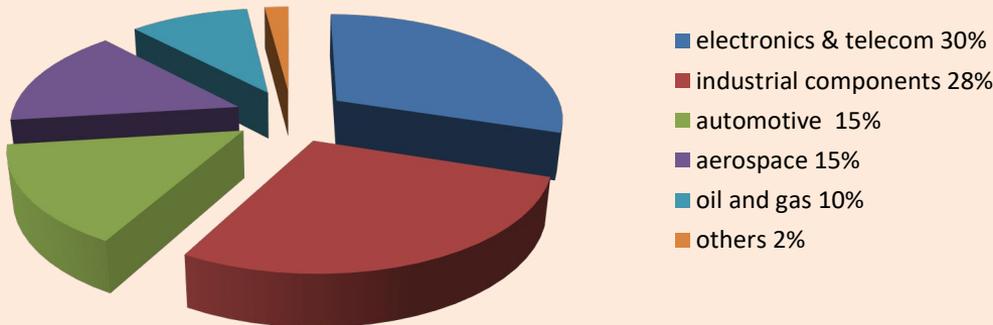


A total of 10% of the beryllium that is consumed is recycled from scrap metal obtained from the manufacture of products with this metal.



BERYL (beryllium aluminosilicate)
Mina Assunção, Ferreira de Aves (Portugal)

USES



Source: Mordor Intelligence 2021



REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <http://eurometaux.eu>
- <https://www.usgs.gov/centers/national-minerals-information-center/beryllium-statistics-and-information>

BORON (B) [Z=5] and *borates*

- A metalloid semiconductor.
- Very hard.
- Obtained from borax, ulexite, colemanite, and boron-rich brines.

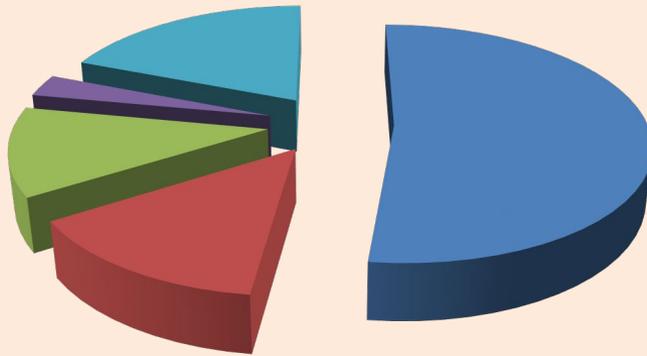


Only insignificant quantities of boron (and borates) are recycled.
The EU classified borates as a strategic minerals in 2017.



BORON-RICH BRINES
Salar de Uyuni (Bolivia)

USES



- glass 52%
- agriculture 14%
- ceramics 12%
- detergents 3%
- others 19%

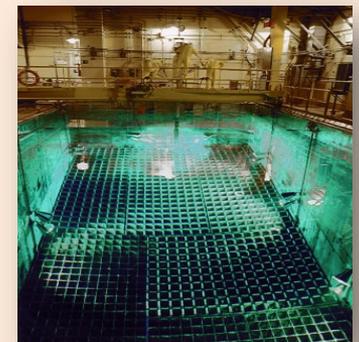


Source: Merchant Research 2021

REFERENCES AND LINKS

GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
 QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
 SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
 STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012

<https://www.usgs.gov/centers/national-minerals-information-center/boron-statistics-and-information>



CALCITE and limestone

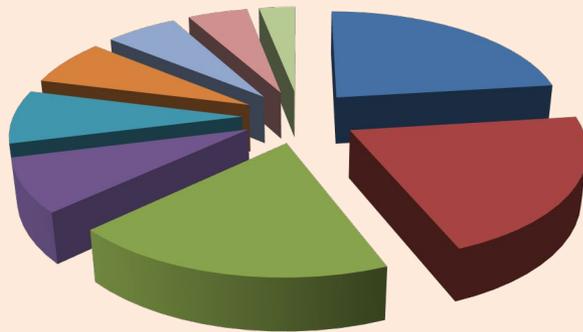
- A calcium carbonate; brittle and not very hard.
- Reacts with acids and effervesces.
- A mineral that forms rocks such as limestones and marbles.

Calcium oxide (lime) is recycled in the paper industry, treatment plants and carbide production. Many marble quarries transform waste into gravel for gardens or use as a filler agent. Recycling or reuse of paper, plastics, helps reduce the consumption of limestone.



CALCITE (calcium carbonate)
Illes Medes (Baix Empordà) Catalonia

USES OF LIMESTONE



- iron & steel 23%
- paper 21%
- construction 19%
- water/gas treatment 8%
- agriculture/poultry raising 8%
- paints 7%
- chemical industry 6%
- plastics/rubbers 5%
- others 3%

Source: IMA Europe



REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012

<http://www.ima-europe.eu>

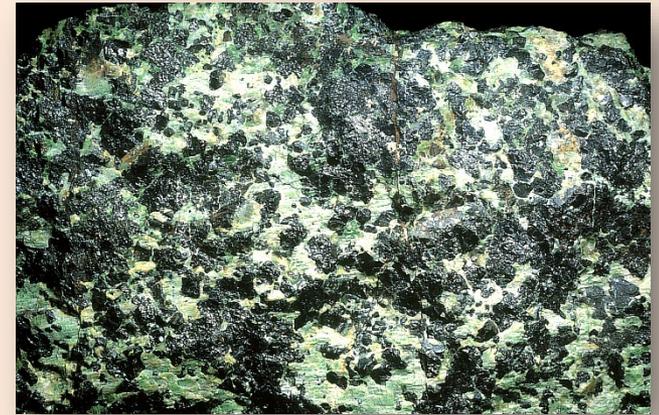
http://www.reverteminerals.com/index_en.php

CHROMIUM (Cr) [Z=24]

- A very hard metal.
- Has a high melting temperature.
- Does not oxidise.
- Resistant to heat and friction.
- Can be very highly polished (mirrored surface).
- Obtained from chromite.

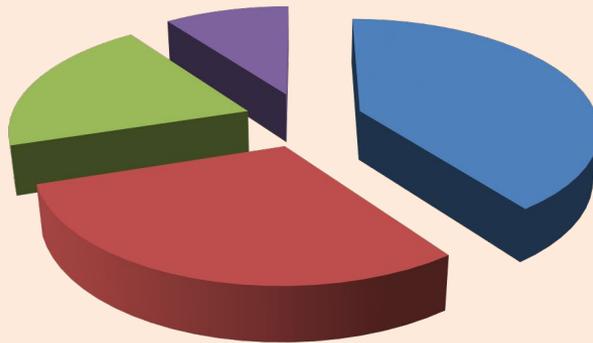


- In 2021, recycled chromium made up 20% of total chromium, and was obtained from the recycling of stainless steels that contain this metal (USGS)



CHROMITE (chromium oxide)
Turkey

USES



- stainless steel 40%
- electroplating and chemicals 30%
- refractory materials (chromite) 20%
- others 10%

Source: Mordor Intelligence 2019

REFERENCES AND LINKS

GRAY, Theodore; MANN, Nick. *Els elements*. Barcelona: IEC/UAB/PUV, 2011
SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022

<http://www.eurometaux.eu>

<https://www.usgs.gov/centers/national-minerals-information-center/chromium-statistics-and-information>

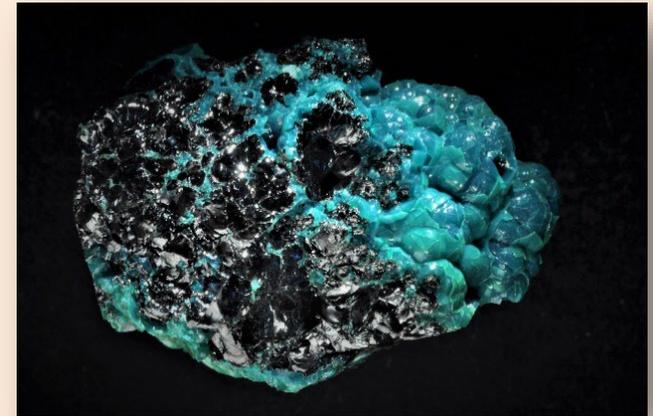


COBALT (Co) [Z=27]

- A metal with magnetic properties.
- High melting point (1500 °C).
- Heavy.
- The EU considered that it was a strategic metal in 2017.
- Obtained from nickel and cobalt sulphides, and from laterites rich in these metals, but also from cobalt hydroxides such as heterogenite.

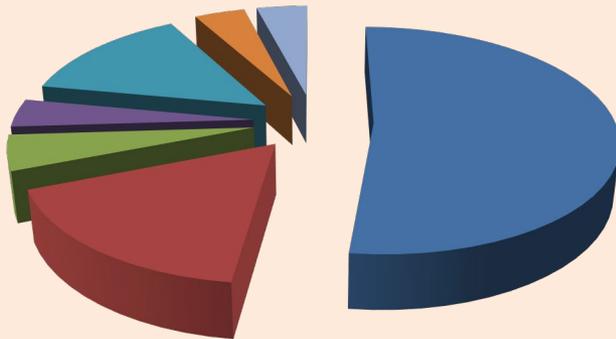


Cobalt is recycled from scrap metal generated during the manufacture of products that contain this metal and from cathodes for lithium batteries.



HETEROGENITE (cobalt hydroxide)
Lubumbashi (DRC)

USES



Source: Cobalt Institute 2021

- batteries 52%
- superalloys 17%
- hard metals 5%
- ceramics/pigments 4%
- catalysts 14%
- magnets 4%
- others 4%



REFERENCES AND LINKS

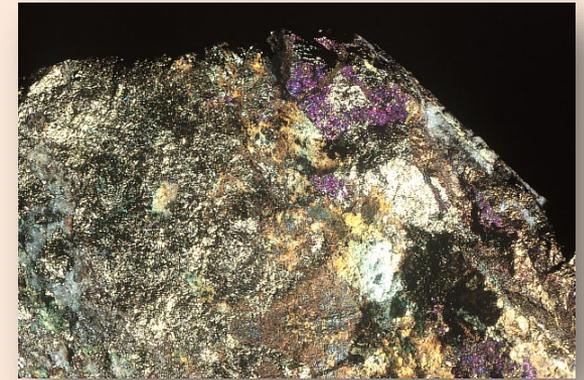
GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
 QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
 SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
 SWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012

<https://www.cobaltinstitute.org> <https://www.ecobalt.com/>
<https://www.usgs.gov/centers/national-minerals-information-center/cobalt-statistics-and-information>



COOPER (Cu) [Z=29]

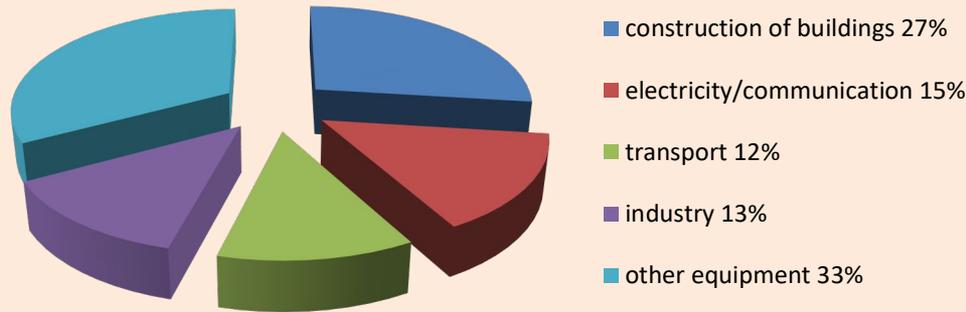
- A metal, a very good electrical and thermal conductor.
- Malleable, ductile and dense. Resistant to rusting.
- Has antimicrobial properties.
- Obtained from chalcopyrite, bornite, chalcocite and oxidised minerals such as brochantite and antlerite.



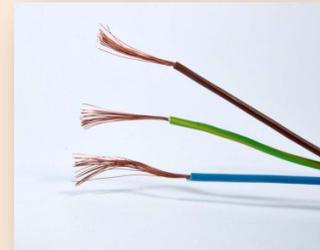
CHALCOPIRITE (cooper and iron sulfide)
El Brull (Osona) Catalonia

- 100% recyclable, with no loss of quality.
- Recycling copper reduces SO₂ emissions by 86%, CO₂ emissions by 94%, and the generation of solid waste by 99%. Sixty per cent less energy is consumed, and 98% less water.

USES



Source: IWCC/ICA 2021



REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <https://erocopper.com/> <http://www.coppercouncil.org/>
- <https://www.lafarga.es/en/the-group/the-copper-museum/introduction> <http://eurometaux.eu>
- <https://www.usgs.gov/centers/national-minerals-information-center/copper-statistics-and-information>

FELDSPARS

These are potassium aluminium silicates: orthoclase (potassium feldspar), of sodium (albite) or calcium (anorthite).

- Very hard (6 on the Mohs scale).
- Highly resistant to abrasion.
- Low viscosity.

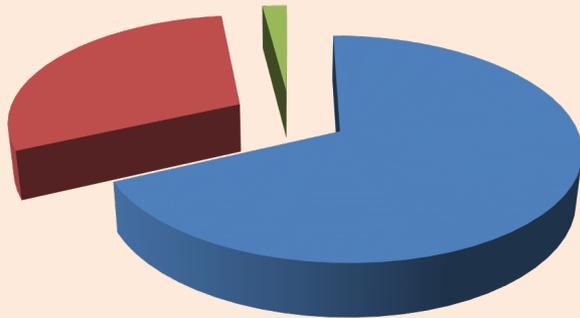


Feldspars is not known to be recycled. However, the recycling of glass reduces the consumption of feldspars.



FELDSPAR (orthoclase) potassium aluminium silicate
Montnegre (Maresme) Catalonia

USES



- glass 68%
- ceramics 30%
- fillers, abrasives 2%

Source: Grand view research 2019



REFERENCES AND LINKS

SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022

<http://www.llansasa.com> <https://www.imerys.com/minerals/feldspar>

<https://www.usgs.gov/centers/national-minerals-information-center/feldspar-statistics-and-information>

FLUORINE (F) [Z=9] and *fluorite*

- Fluorine is a highly reactive, corrosive, toxic gas.
- It reacts with humid air and water to produce hydrofluoric acid.
- It is the most electronegative element that is known.
- It is obtained from fluorite. In the EU it was considered a strategic mineral in 2017.

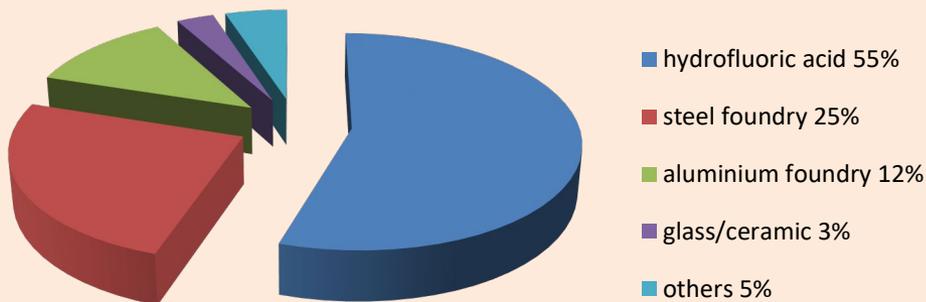


FLUORITE (calcium fluoride)
Sant Cugat del Vallès (Vallès Occidental) Catalonia



- Fluorine is not known to be recycled.
- Fluorite is only recycled in very small amounts
- The main uses of fluorite are in the extraction of hydrofluoric acid, in the iron and aluminium foundry, and in the manufacture of glass as a fluidising agent.

USES (fluorite)



Source: Mordor Intelligence 2021

REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <http://www.minersa.com>
- <https://www.usgs.gov/centers/national-minerals-information-center/fluorspar-statistics-and-information>



GALLIUM (Ga) [Z=31]

- A ductile, malleable metal.
- Liquid at a temperature of 30°C.
- A rare metal and a semiconductor.
- The EU considered it to be a strategic metal in 2017.
- Found in bauxite and sphalerite.

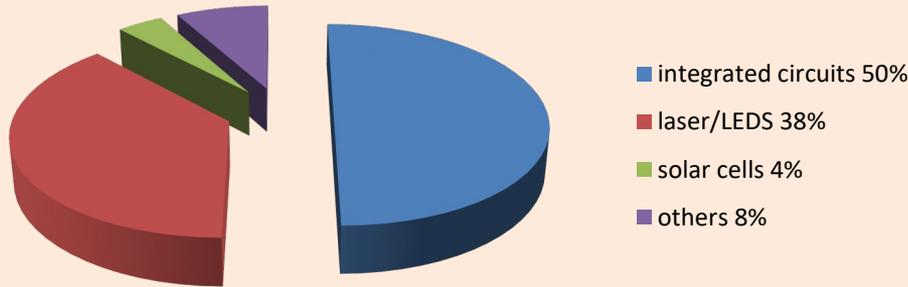


Scrap metal generated in the manufacture of electronic components made with gallium arsenide can be recycled.

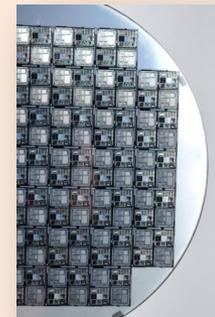


BAUXITE (aluminium hydroxides & oxides with gallium)
Fontespatlla (Matarranya)

USES



Source: Roskill 2014



REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <http://eurometaux.eu>
- <https://www.usgs.gov/centers/national-minerals-information-center/gallium-statistics-and-information>

GERMANIUM (Ge) [Z=32]

- A relatively rare metalloid semiconductor.
- Hard and brittle.
- Oxidises slowly in contact with air.
- The EU classified it as a strategic metal in 2017.
- Found in sphalerite.

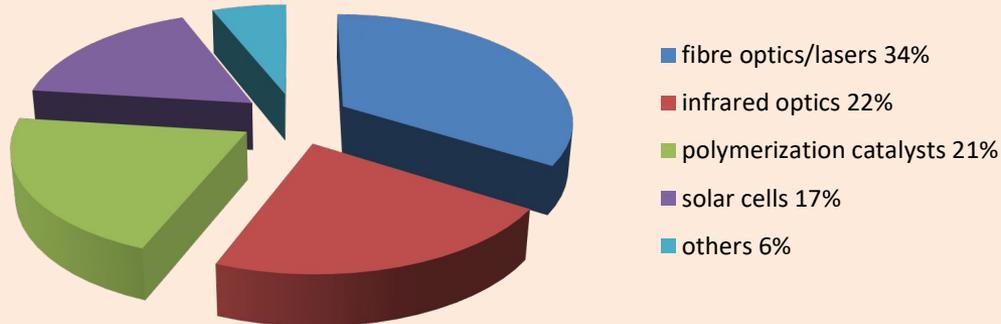


Approximately 30% of the germanium that is consumed worldwide is from recycled sources. In the process of manufacturing optical apparatus, over 60% of germanium is reused.



Caramelised SPHALERITE (zinc sulfide with germanium)
Picos de Europa (Santander)

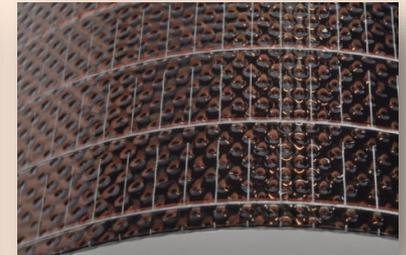
USES



Source: mcgroup 2021

REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <http://eurometaux.eu>
- <https://www.usgs.gov/centers/national-minerals-information-center/germanium-statistics-and-information>



GOLD (Au) [Z=79]

- A noble metal.
- This is the most ductile, malleable metal that is known.
- A very good reflector of heat and light.
- An excellent electrical conductor.
- Does not oxidise and is one of the most stable metals.
- Found in association with other minerals in primary deposits and alluvial deposits. In addition, it is obtained as a by-product of copper extraction.

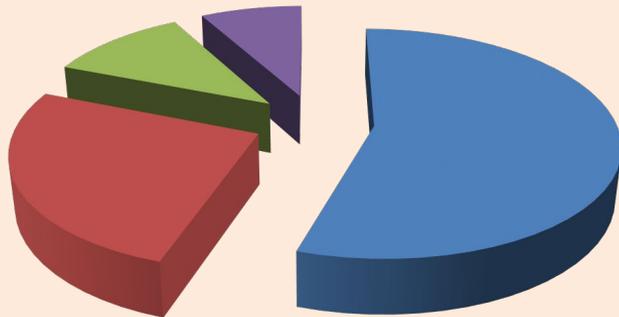


A total of 100% is reusable and the maximum amount possible is recovered from jewellery and old electronic equipment.

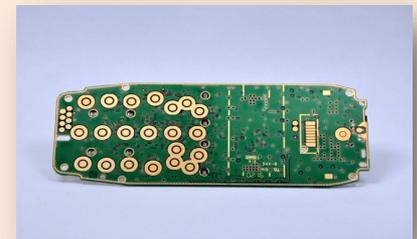


GOLD (native)
Nevada (USA)

USES



- jewellery 55%
- investment 26%
- central banks 11%
- technology 8%



Source: World Gold Council 2021

REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <https://www.gold.org/>
- <https://www.usgs.gov/centers/national-minerals-information-center/gold-statistics-and-information>



GRAPHITE (C) [Z=6]

- This is one of the allotropic forms of carbon.
- A soft material.
- A good solid lubricant.
- A low conductor of electrical current.
- Refractory, resistant to high temperature.
- The EU classified it as a strategic mineral in 2017.
- One of the sources of graphene and of carbon fibre composites.

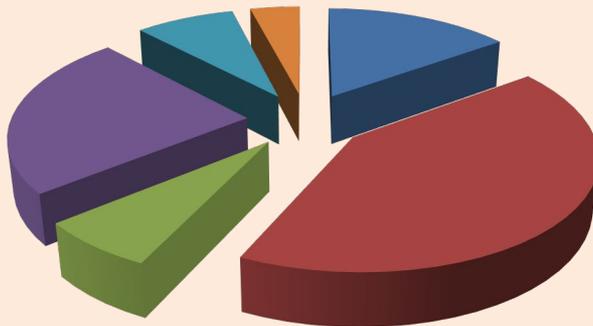


The market of refractory recycled graphite is growing.



GRAPHITE (carbon)
Huelma (Jaén)

USES (natural graphite)



- metal foundries 15%
- refractory products 42%
- lubricants 7%
- batteries 24%
- reinforced polymers 8%
- others 4%

Source: Wood Mackenzie 2021

REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <https://ecga.net/main-uses-of-graphite/>
- <https://www.usgs.gov/centers/national-minerals-information-center/graphite-statistics-and-information>



GYP SUM

- Hydrated calcium sulfate.
- A very soft mineral that is soluble in water.
- Not a good heat conductor (therefore a good insulator)
- Obtained from evaporite deposits, but recently, substantial amounts of gypsum have also been obtained from flue gas desulfuration (FGD).

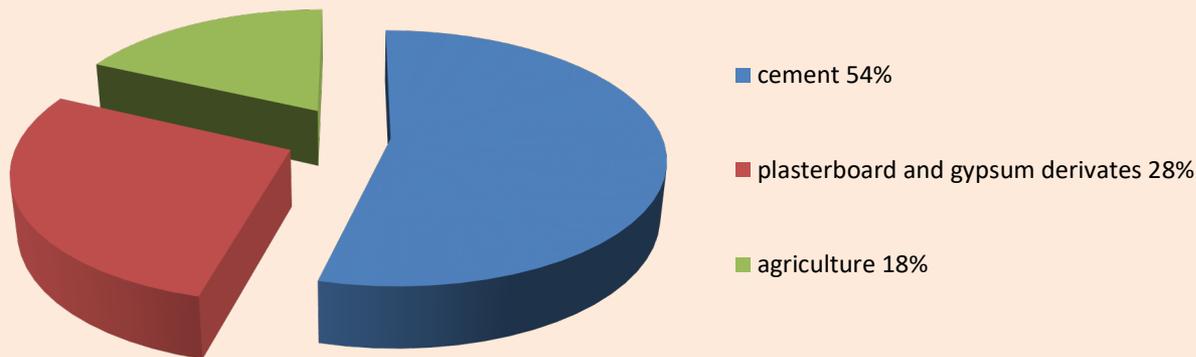


Gypsum is recycled from prefabricated gypsum products. Recycled gypsum is used mainly as a corrector of agricultural soils. It is reused in plasterwork, and in treatment of drinking water.



GYSUM (calcium sulfate)
Vinaixa (Les Garrigues) Catalonia

USES



Source: Data Intelo 2020



REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <http://www.knauf.es> <https://www.eurogypsum.org/>
<https://www.usgs.gov/centers/national-minerals-information-center/gypsum-statistics-and-information>



INDIUM (In) [Z=49]

- A relatively rare metal.
- Light, soft, ductile and malleable.
- A good electrical conductor.
- Melts at a low temperature (157°C).
- The EU classified it as a strategic metal in 2017.
- Found in sphalerite.



Indium is recovered from electronic equipment that contains indium-tin oxide (ITO) flat panel displays.



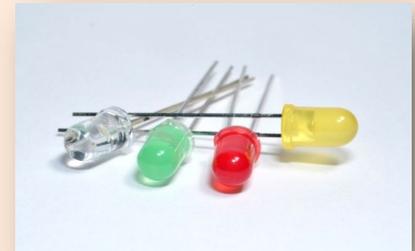
Caramelised SPHALERITE (zinc sulfide with indium)
Picos de Europa (Santander)

USES



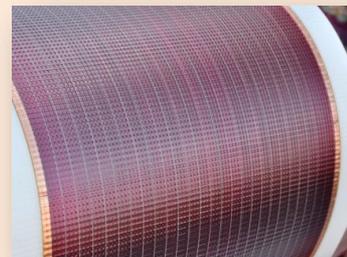
- flat screens (ITO) 70%
- solder and alloy 20%
- semiconductor 10%

Source: Gran View Research 2019



REFERENCES AND LINKS

GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
 QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
 SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
 STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
<https://www.indium.com>
<https://www.usgs.gov/centers/national-minerals-information-center/indium-statistics-and-information>

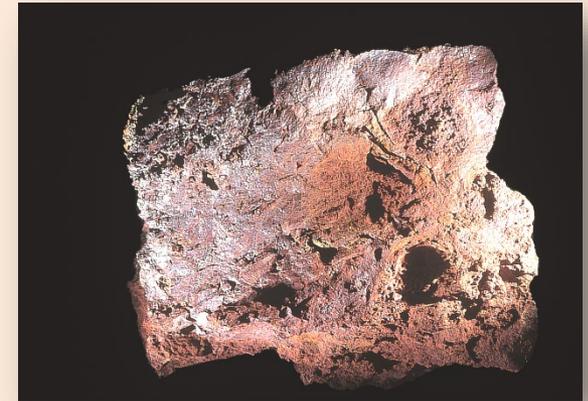


IRON (Fe) [Z=26]

- Essential for all living beings.
- The fourth most common element on the Earth's crust.
- Pure iron is soft and fragile.
- When carbon is added, it becomes harder and stronger.
- Obtained from hematite and magnetite.

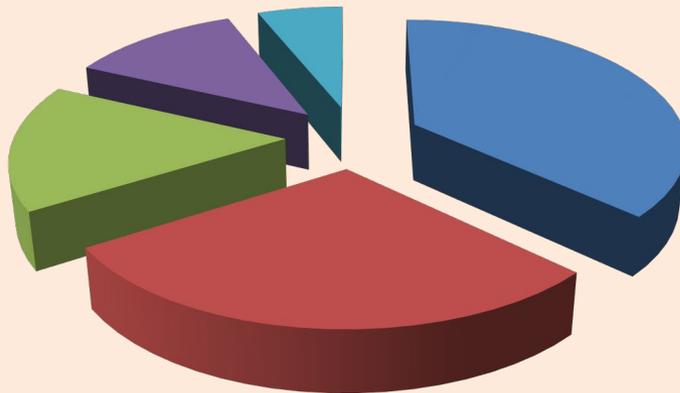


The main source of recycling of iron is scrap metal and steel, mainly from scrapping cars. A total of 62% of energy is saved compared to production with mineral iron.



HEMATITE (iron oxide)
Llucena (Alcalatén)

USES



- construction 37%
- machinery, metal ware 29%
- automotive 16%
- tubes 12%
- others 6%

Source: Eurofer 2021



REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <https://www.eurofer.eu/>

KAOLINITE

- Hydrated aluminium silicate.
- A basic component of many clays.
- White and soft to the touch.
- Gains plasticity in contact with water.
- Low thermal and electrical conductivity.

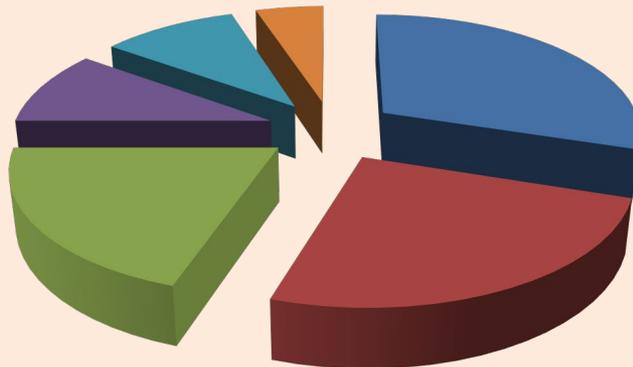


An insignificant amount is recycled directly, but kaolinite consumption can be reduced by recycling paper.



KAOLINITE (hydrated aluminium silicate)
Ares d'Alpont (Els Serrans) Catalonia

USES



- paper 30%
- ceramics 25%
- rubber 20%
- plastics 10%
- paintings 10%
- other 5%

Source: Mordor intelligence 2019



REFERENCES AND LINKS

SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022

<https://www.imerys-performance-minerals.com/>

<http://www.ima-europe.eu>

<https://roskill.com/market-report/kaolin/>



LEAD (Pb) [Z=82]

- A soft, ductile, malleable, extremely heavy metal.
- Highly resistant to corrosion.
- Absorbs sound and radioactivity well.
- Due to its toxicity, its use in certain applications is declining.
- Obtained from galena.

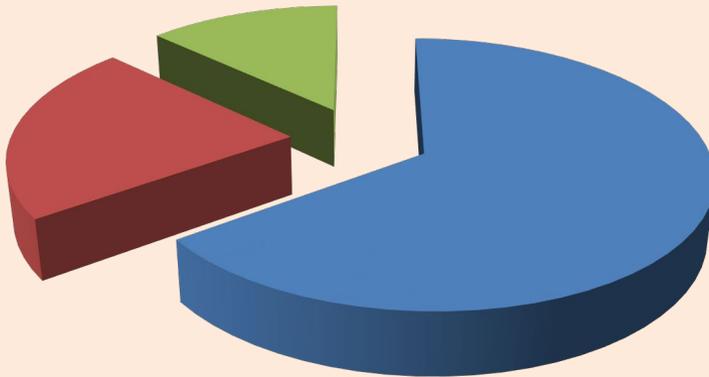


Around 88% is recycled, mainly from batteries.



GALENA (lead sulfide)
El Molar (Priorat) Catalonia

USES



- vehicle batteries 65%
- industrial batteries 22%
- (sound, radiation, muniton) 13%

Source: Wood MacKenzie 2021

REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCHR GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <http://www.ila-lead.org>
- <https://www.usgs.gov/centers/national-minerals-information-center/lead-statistics-and-information>



LITHIUM (Li) [Z=3]

- An alkali metal.
- This is the lightest metal that is known.
- It has a very high electrochemical potential.
- Its presence in the human body is essential for a person's mental equilibrium.
- Obtained from spodumene, lepidolite, petalite and lithium-rich brines.
- The EU classified lithium as a strategic metal in 2020.

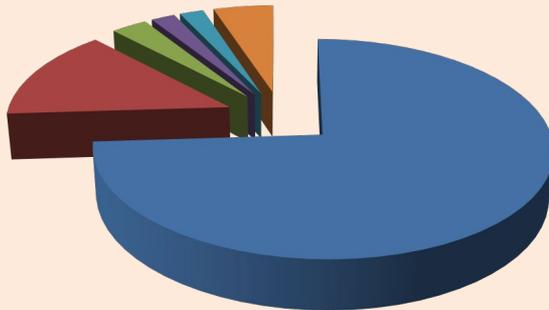


SPODUMENE (aluminium & lithium silicate)
Namibe (Angola)



Lithium battery recycling does not grow much due to low profitability. It does increase the reuse of lithium batteries used in vehicles to store domestic energy.

USES



Source: Statista 2021

- recharg. batteries 74%
- ceramic and glass 14%
- lubricants 3%
- casting mold powders 2%
- polymers production 2%
- others 5%



REFERENCES AND LINKS

GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
 QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
 SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
 STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
<https://europeanlithium.com/>
<https://www.usgs.gov/centers/national-minerals-information-center/lithium-statistics-and-information>

MAGNESIUM (Mg) [Z=12] and *magnesite*

- An alkaline earth metal.
- Lighter than aluminium, and highly resistant to corrosion.
- An essential element for the human body and for the chlorophyll of plants, which is vital in photosynthesis.
- Obtained mainly from magnesite, magnesium chloride from brine and seawater.
- The EU classified magnesium as a strategic metal in 2017.



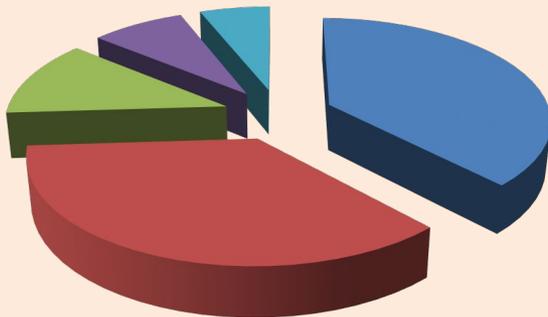
In the EU, 33% of magnesium is recycled. Recycling of magnesium has increased in recent years.

- Magnesite is magnesium carbonate that is used to manufacture refractory materials, in agriculture, livestock and construction.



MAGNESITE (magnesium carbonate)
Eugui (Navarra)

USES



- aluminium alloying 38%
- die casting 36%
- iron & steel 12%
- metal reduction 8%
- other 6%

Source: European Aluminium 2021

REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <http://www.roullier.com/en/>
- <https://www.usgs.gov/centers/national-minerals-information-center/magnesium-statistics-and-information>



MANGANESE (Mn) [Z=25]

- A very hard, brittle metal.
- Refractory and easily oxidised.
- Obtained from pyrolusite and other manganese oxides.

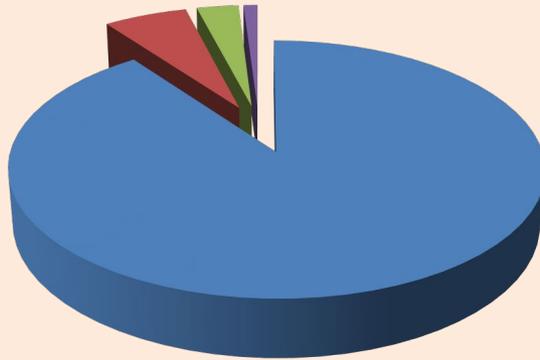


The main source of recovery of manganese is scrap metal produced during steel manufacture.



PYROLUSITE (manganese oxide)
Tosa d'Alp (Berguedà) Catalonia

USES



- iron/steels 90%
- aluminium alloys 6%
- batteries 3%
- others 1%

Source: Eramet

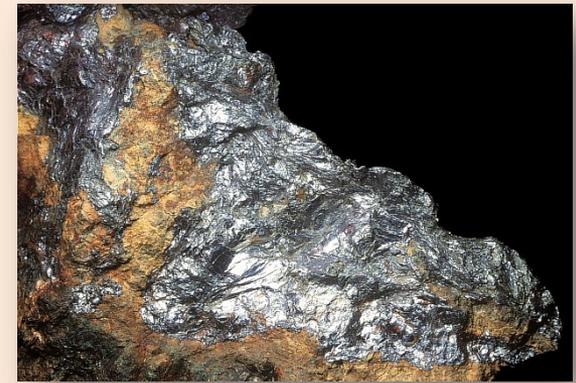


REFERENCES AND LINKS

GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
 QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
 SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
 STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
<http://eurometaux.eu> <http://eramet.com>
<https://www.usgs.gov/centers/national-minerals-information-center/manganese-statistics-and-information>

MOLYBDENUM (Mo) [Z=42]

- A metal that is a very good thermal and electrical conductor.
- Has a low expansion coefficient.
- Refractory (melts at 2625°C).
- Obtained from molybdenite.

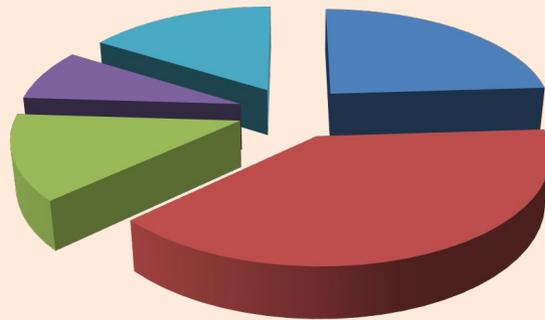


MOLYBDENITE (molybdenum sulfide)
Gualba (Vallès Oriental) Catalonia



Molybdenum is recycled from stainless steel and other steels. A total of 30% of the molybdenum that is consumed in the USA is recycled from scrap metal.

USES



- stainless steel 24%
- other steels 39%
- lubricants/catalysts 13%
- superalloys 8%
- others 16%

Source: IMO A 2021

REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <http://www.imoa.info/> <http://eurometaux.eu>
- <https://www.usgs.gov/centers/national-minerals-information-center/molybdenum-statistics-and-information>



NICKEL (Ni) [Z=28]

- A ductile, malleable metal.
- Slightly ferromagnetic at room temperature.
- Melts at 1455 °C.
- Resistant to corrosion, does not oxidise.
- Extracted from pentlandite, garnierite, and nickel-skutterudite.

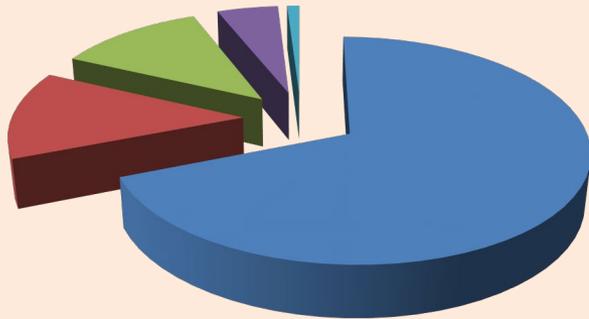


SKUTTERUDITE (cobalt arsenide with nickel)
Bou Azzer (Morocco)



Nickel is recycled from scrap metal of stainless steel and others steels that contain this metal. Stainless steel on the market contains an average of 65% of recycled nickel.

USES



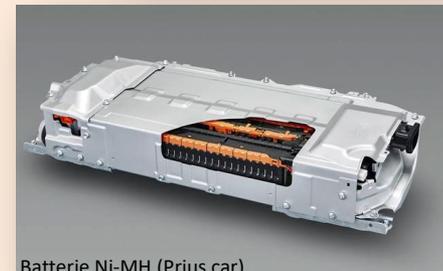
- stainless steel 69%
- batteries 13%
- alloys and superalloys 12%
- electroplating 5%
- others 1%



Source: Wood Mackenzie 2021

REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <http://www.nickelinstitute.org>
- <https://www.eurometaux.eu/>
- <https://www.usgs.gov/centers/national-minerals-information-center/nickel-statistics-and-information>



Batterie Ni-MH (Prius car)



NIOBIUM (Nb) [Z=41]

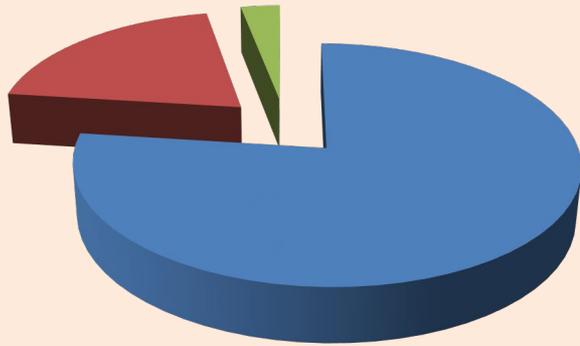
- A metal that is resistant to corrosion.
- Ductile and hard.
- A relatively rare metal.
- The EU classified it as a strategic metal in 2017.
- Found in columbite-tantalite (*coltan*), pyrochlore and euxenite.

 Niobium is recycled from steels and superconducting magnets.



COLUMBITE-TANTALITE (*coltan*) (niobium&tantalum oxides)
Musaca (Rwanda)

USES



- ferroniobium (steels) 77%
- superalloys 20%
- electronics/magnets 3%

Source: USGS



REFERENCES AND LINKS

GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
 QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
 SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
 STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
<https://tanb.org/about-niobium>
<https://www.usgs.gov/centers/national-minerals-information-center/niobium-and-tantalum-statistics-and-information>

PHOSPHORUS (P) [Z=15] and *phosphorite*

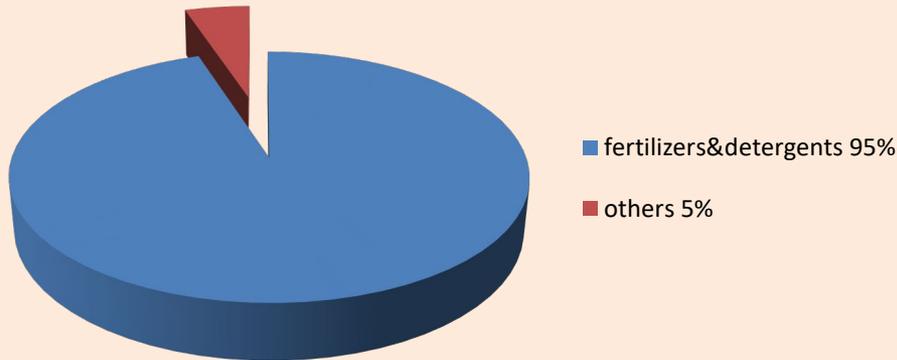
- A very reactive non-metal; it oxidises spontaneously in contact with oxygen and emits light (*phosphorescence*).
- Insoluble in water.
- An essential nutrient for plants.
- Adenosine triphosphate (ATP) is the cells' energy store.
- Phosphorus is obtained from *phosphorite* (cryptocrystalline variety of apatite).
- The EU classified *phosphorite* as a strategic rock in 2017.



Phosphorus and *phosphorite* are not known to be recycled.

PHOSPHORITE (calcium phosphate)
Logrosán (Cáceres)

USES



Source: USGS



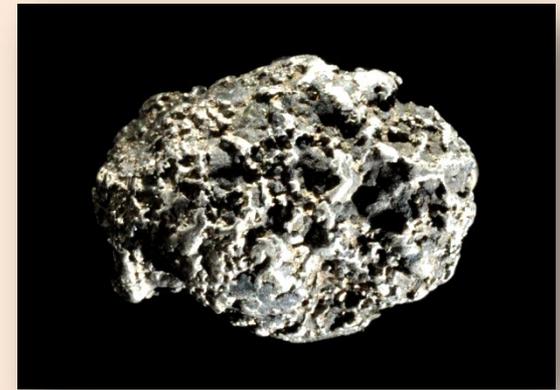
REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- www.phosphor-technology.com
- <https://www.usgs.gov/centers/national-minerals-information-center/phosphate-rock-statistics-and-information>



PLATINUM (group)

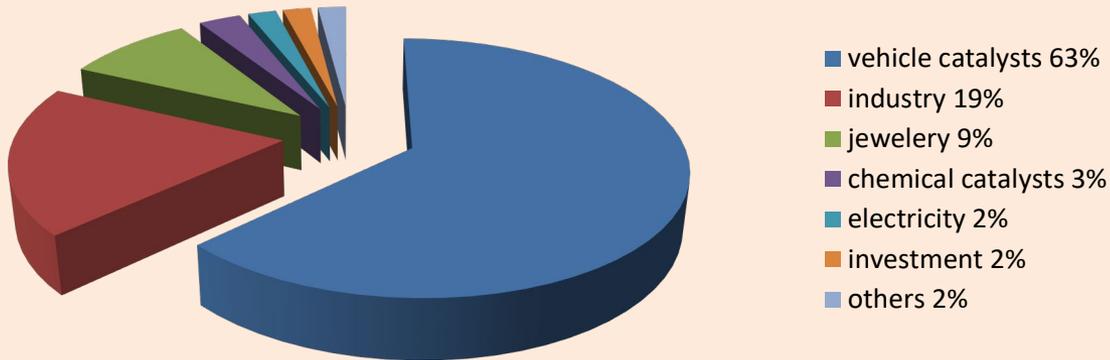
- The platinum group is comprised of iridium, osmium, platinum, palladium, rhodium and ruthenium.
- These are noble, dense, malleable metals.
- Resistant to corrosion and high temperatures.
- The EU classified them as strategic metals in 2017.
- Very good catalysts in reactions.
- Associated with each other in nickel and copper sulfides and related minerals such as sperrylite.



PLATINUM (native)
Chocó (Colombia)

 Most of the metals in the platinum group that are recycled are catalysts for vehicles, jewellery

USES



Source: Johnson Matthey 2021

REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <https://www.usgs.gov/centers/national-minerals-information-center/platinum-group-metals-statistics-and-information>
- <http://ipa-news.com/index/platinum-group-metals/the-six-metals>
- <https://matthey.com/>



POTASSIUM (K) [Z=19]

- An alkali metal.
- Reacts with water to produce hydrogen.
- Oxidises rapidly in air and vigorously in water, forming flames.
- An essential element in human, animal and plant life.
- Obtained from sylvinite and carnallite, and water from certain seas (the Dead Sea).

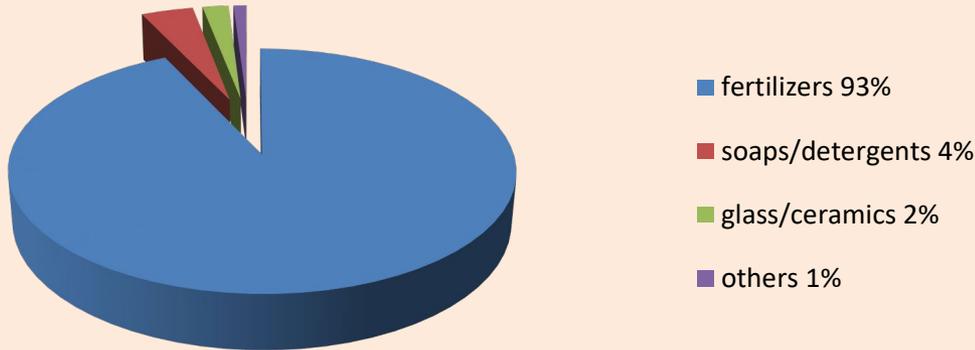


Not known to be recycled.



SILVINITE (potassium chloride)
Sallent (Bages) Catalonia

USES



Source: ICLiberia



REFERENCES AND LINKS

GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
 QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCHR GmbH & Co, 2007
 SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
 STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
<http://www.icliberia.com>

QUARTZ and silica sand

- This is a silicate (silicon oxide).
- It is hard (7 on the Mohs scale) and brittle.
- A very good abrasive.
- When a specific electrical current is applied between the ends of a quartz crystal, it vibrates at an exact frequency (resonant behaviour).
- It occurs in different forms with different uses:
 - *Macrocrystalline quartz: decoration, ferrosilicon, electronics.
 - *Cryptocrystalline quartz: manufacture of artificial stone (Silestone).
 - *Silica sand: manufacture of glass, abrasives, foundry moulds, carborundum.



- Recycled indirectly from glass recycling. The glass industry in Europe recycles 62% of silica sand.

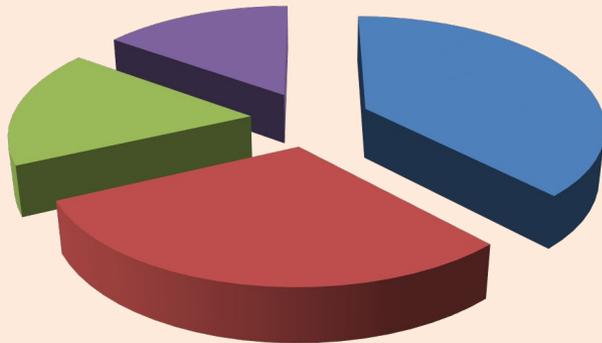


Hyaline QUARTZ (silicon oxide)
Chamonix (France)



Silica sand

USES of Silica Sand (Europe)



- glass 38%
- construction 30%
- foundry 17%
- abrasives/filters 15%



REFERENCES AND LINKS

GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
 QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCHR GmbH & Co, 2007
 SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
 STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
<https://www.sibelco.com/>
<http://www.ima-europe.eu>

RARE EARTHS

The following elements are known as the rare earths: lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb), lutetium (Lu), yttrium (Y) and scandium (Sc).

They have physical and chemical properties that make them very useful in the manufacture of small, permanent and very strong magnets, high performance batteries, catalysts, LEDs, LCD and plasma screens, low-energy light bulbs and lasers. The EU classified RARE EARTHS as a strategic metals in 2017.



Neodymium and dysprosium from wind turbines magnets, electric motors and hard disks are already being recycled, as lanthanum and nickel from Ni-MH batteries.



Clay impregnated with Rare Earths
(China)



Monazite
Minas Geraes (Brasil)

USES



Source: Roskill 2021

- catalysts 21%
- permanent magnets 29%
- polishes 13%
- glass 8%
- phosphors 1%
- ceramics 4%
- metallurgy 8%
- batteries 7%
- others 9%



REFERENCES AND LINKS

GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
 QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCHR GmbH & Co, 2007
 SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
 STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
<https://www.usgs.gov/centers/national-minerals-information-center/rare-earth-statistics-and-information>

SEPIOLITE

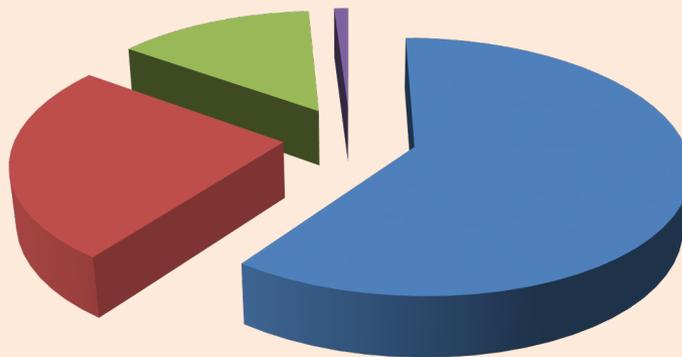
- Hydrated magnesium silicate.
- It is a special clay.
- Soft, light and porous.
- A good thermal insulator with a high capacity for absorption and adsorption.

 Sepiolite is not known to be recycled.



SEPIOLITE
Vallecas (Madrid)

USES



- animal litter 60%
- animal feeds 25%
- industrial uses 14%
- others 1%

Source: Sepiolsa



REFERENCES AND LINKS

SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022

<http://www.sepiolsa.com>

<http://www.tolsa.com>

<http://www.ima-europe.eu>

SILVER (Ag) [Z=47]

- A noble metal that is soft, ductile and malleable.
- It has the highest electrical and thermal conductivity of all metals.
- It is the whitest and most reflective metal.
- Many silver salts are light-sensitive.
- Obtained from argentite, from argentiferous galena, and as a by-product of copper extraction (anode sludges).

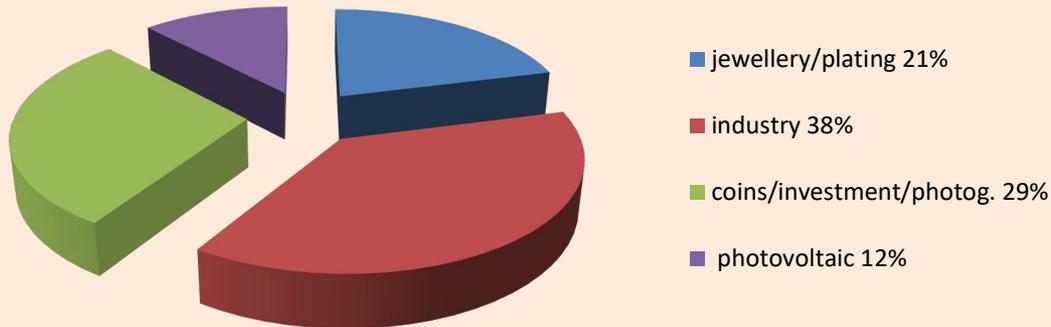


As much silver as possible is recycled. In the jewellery sector, 90% is recycled; in industry, between 40% and 50% is recycled.



SILVER (wires)
Poblet (Conca de Barberà) Catalonia

USES



Source: Silver Institute / Metal Focus 2021

REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <https://www.silverinstitute.org/>
- <https://www.usgs.gov/centers/national-minerals-information-center/silver-statistics-and-information>



SODIUM (Na) [Z=11] and *halite (salt)*

- An alkali metal.
- Reacts strongly with water and releases H₂.
- Oxidises rapidly in air.
- A basic element in human and animal diets.
- Obtained from halite.

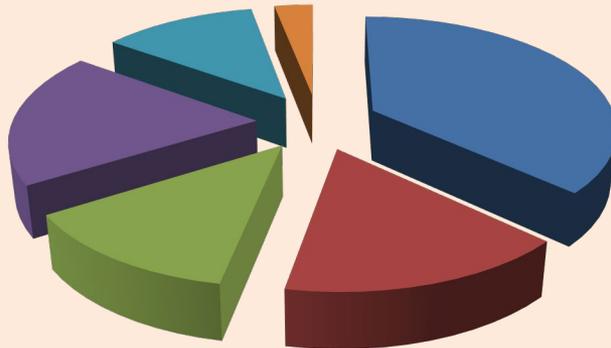


- The recycling of sodium and salt is insignificant.
- *Halite (common salt) is directly useful in food, water treatment and to prevent ice from forming on paths and roads.*



HALITE (sodium chloride)
Súria (Bages) Catalonia

USES of *halite*



- chlor-alkali 37%
- de-icing 16%
- food processing 13%
- soda ash 19%
- water treatment 12%
- pharmacy 3%

Source: Roskill

REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCHR GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <https://www.icliberia.com/>
- <https://eusal.com/>
- <https://www.usgs.gov/centers/national-minerals-information-center/salt-statistics-and-information>



TALC

- A hydrated magnesium silicate.
- An excellent mineral for filler (plastics (PP), ceramics....)
- White and greenish.
- Soft, smooth, light and hydrophobic.
- Resistant to temperatures of up to 1300°C.
- Low thermal and electrical conductivity.
- Found mainly in metamorphic rocks.

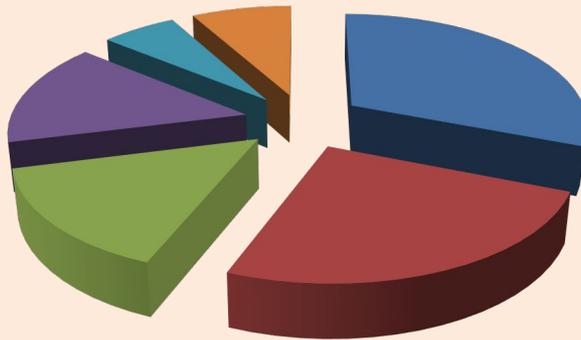


Talc is not known to be recycled, but recycling paper and plastics, we will reduce their consumption.



TALC (hidrated magnesium silicate)
Maçanet de Cabrenys (Alt Empordà) Catalonia

USES



- ceramics 31%
- plastics and rubber 25%
- paints and coatings 15%
- pulp and paper 15%
- personal care 6%
- others 8%

Source: Mordor Intelligence 2021

REFERENCES AND LINKS

SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022

<http://www.eurotalc.eu>

<https://www.usgs.gov/centers/national-minerals-information-center/talc-and-pyrophyllite-statistics-and-information>



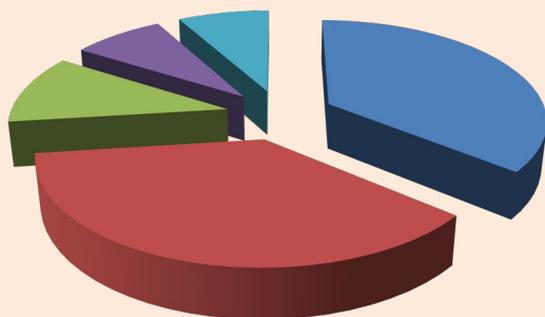
TANTALUM (Ta) [73]

- A relatively rare metal.
- Heavy, hard and resistant to corrosion.
- Has a high capacity to store electricity.
- Resistant to high temperatures (melts at 2996°C).
- The EU classified tantalum as a strategic metal in 2017.
- Found in columbite-tantalite (*coltan*) and tantalite.
- The main source of recycling of tantalum is the reuse of scrap metal created in the process of manufacturing capacitors, electronic components, tools and superalloys based on this metal.



COLUMBITA-TANTALITE (*coltan*) (niobium&tantalum oxides)
Musaca (Rwanda)

USES

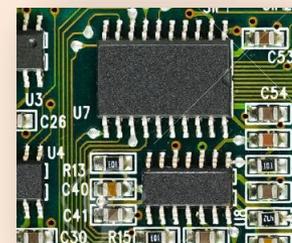


- capacitors 36%
- superalloys + carbides 37%
- sputtering targets 11%
- chemicals 8%
- others 8%

Source: CRU 2020

REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCHR GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <https://tanb.org/about-tantalum>
- <https://www.usgs.gov/centers/national-minerals-information-center/niobium-and-tantalum-statistics-and-information>

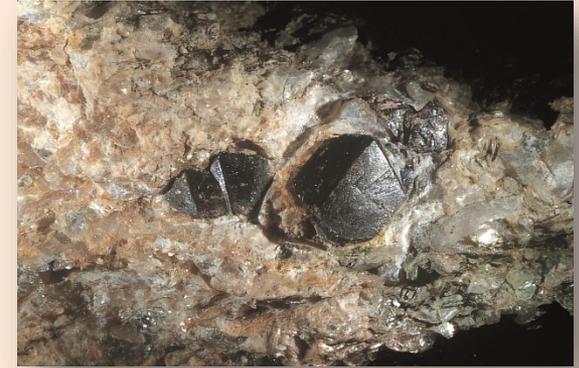


TIN (Sn) [Z=50]

- Malleable, ductile, a heavy metal.
- Does not react with oxygen or water; reacts with acids and bases.
- Melts at a low temperature (232 °C).
- Not a common metal.
- Can be found in cassiterite.

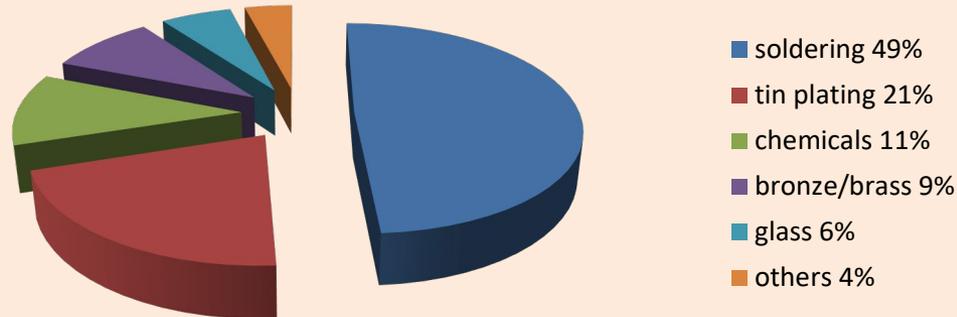


- In Europe, tin is recovered from printed circuit boards and tin cans.



CASSITERITE (tin oxide)
Alt Empordà (Catalonia)

USES



Source: Credence Reserarch 2021



REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York,2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCH GmbH & Co,2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*,3rd ed. Oxford University Press, Inc.2012
- <http://www.eurometaux.eu> <https://www.internationaltin.org/>
- <https://www.usgs.gov/centers/national-minerals-information-center/tin-statistics-and-information>



TITANIUM (Ti) [Z=22]

- A very hard metal that and highly resistant to corrosion.
- Lighter than steel and rust-proof.
- Has a high melting point (1668 °C).
- Titanium oxide, a white pigment, is used mainly in paints, cosmetics, plastics, paper, ceramics and food.
- The EU classified it as a strategic metal in 2020
- Obtained from ilmenite and rutile.

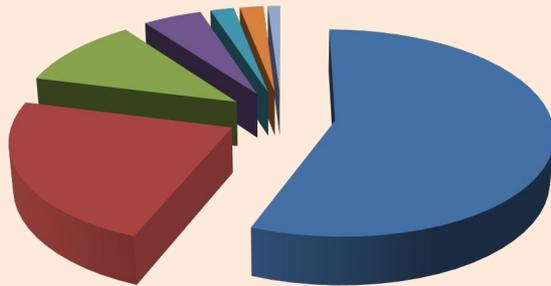


ILMENITE (titanium and iron oxide)
Sierra de l'Albarrana (Córdoba)



Titanium is recycled from off-cuts in processes such as stamping, and from metal that has already been used.

USES



- paints 56%
- plastics 23%
- paper 11%
- ceramics/catalysts 5%
- metallurgy 2%
- aviation 2%
- medicines/others 1%

Source: Roskill , USGS

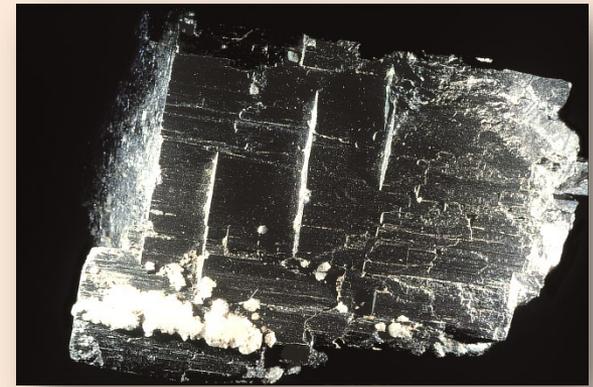


REFERENCES AND LINKS

GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
 QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCHR GmbH & Co, 2007
 SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
 STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
<https://titanium.org>
<https://www.usgs.gov/centers/national-minerals-information-center/titanium-statistics-and-information>

TUNGSTEN (W) [Z=74]

- Also known as *wolfram*.
- A metal with a very high melting point (3410 °C).
- Denser than mercury.
- A semiconductor.
- The EU classified it as a strategic metal in 2017.
- Obtained from wolframite, ferberite and scheelite.

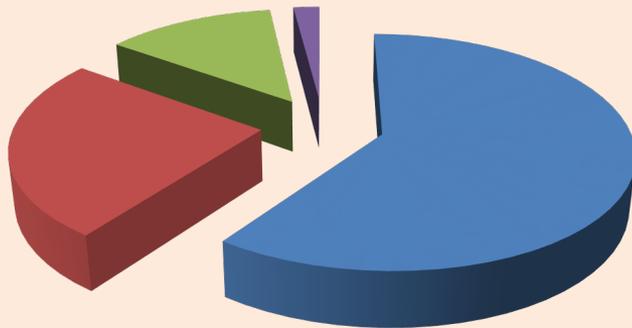


FERBERITE (iron and manganese wolframate)
Panasqueira (Portugal)



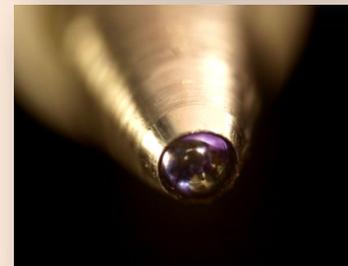
Large quantities are recycled from scrap metal and tungsten carbide (*widia*).

USES



- cemented carbides (*widia*) 60%
- steel alloys 25%
- mill products 13%
- chemicals 2%

Source: Merchant Research 2018



REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCHR GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <http://www.itia.info/applications.html>
- <https://www.usgs.gov/centers/national-minerals-information-center/tungsten-statistics-and-information>

VANADIUM (V) [Z=23]

- Ductile metal, resistant to oxidation.
- Very resistant to acids and bases.
- The EU classified it as a strategic metal in 2017.
- Obtained from magnetites rich in vanadium and carnotite.



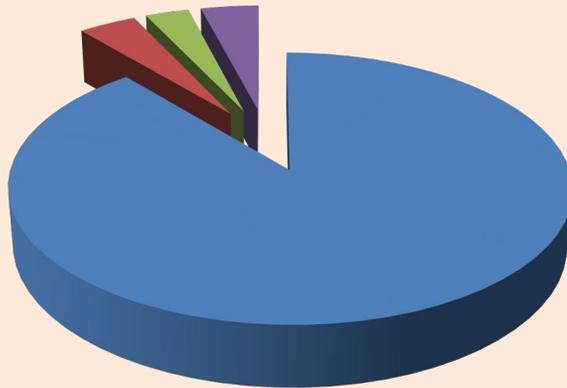
The quantity of vanadium recycled from spent chemical process catalysts is significant, and may compose as much as 40% of total vanadium catalysts.

Small percentage of vanadium steel scrap is recycled.



VANADINITE (chloro-vanadate of lead)
Mibladen (Morocco)

USES



- HSLA steels + others 89%
- non-ferrous alloys 4%
- chemical catalysts 3%
- redox batteries 4%

Source: TTP Squared Inc 2018

REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCHR GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <https://www.usgs.gov/centers/national-minerals-information-center/vanadium-statistics-and-information>



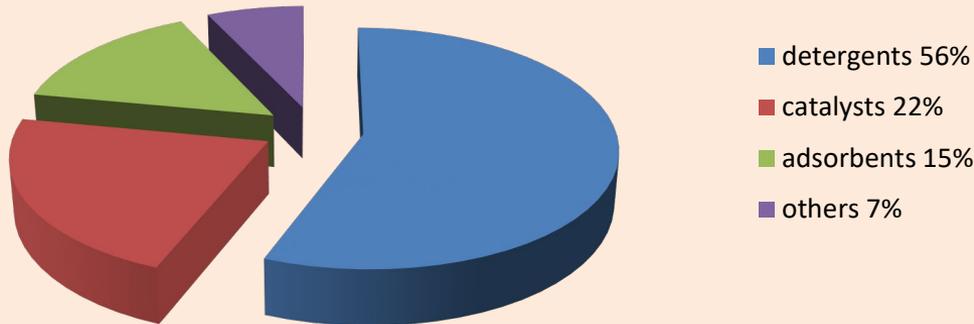
ZEOLITES

- A group of hydrated aluminosilicates with magnesium, potassium, calcium and sodium.
 - They are soft, light and porous.
 - Good thermal insulators and highly absorbent and adsorbent.
 - High ion-exchange capacity.
 - High affinity for ammonia (NH₃).
 - The main (natural) zeolites are clinoptilolite and chabazite, and the synthetics.
- Zeolites are not known to be recycled, although they are used as drying agents, gas absorbers, water treatment agents and can be reprocessed and reused.



CHABAZITE
Iceland

USES



Source: Expert Market Research 2021



REFERENCES AND LINKS

SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022

<http://www.zeolitanatural.com/english/agricandhort.htm>

<http://www.zeotechcorp.com>

<https://www.usgs.gov/centers/national-minerals-information-center/zeolites-statistics-and-information>

ZINC (Zn) [Z=30]

- A brittle metal.
- It has a low melting point (420°C).
- A fine layer of oxide protects the metal from further oxidation.
- Obtained mainly from sphalerite.

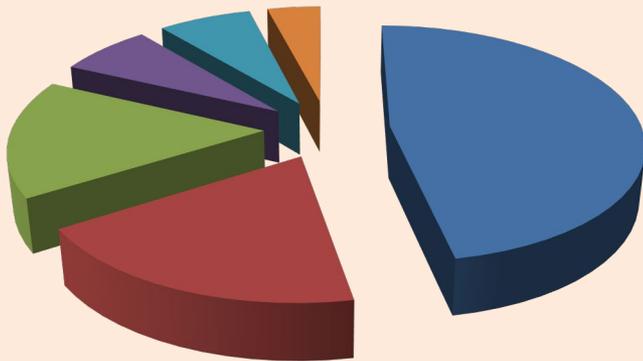


Caramelised SPHALERITE (zinc sulfide)
Picos de Europa(Santander)



Zinc is recycled from scrap metal, batteries, galvanisation waste, waste from the manufacture of pigments and other chemical products.

USES



- galvanizing 47%
- brass&bronze 19%
- diecasting 16%
- chemical industry 7%
- rolled zinc 7%
- others 4%

Source: ILZSG. 2021



REFERENCES AND LINKS

- GRAY, Theodore; MANN, Nick. *The elements*. New York, 2009
- QUADBECK – SEEGER, H-J, *Elements of the World*. WILEY- VCHR GmbH & Co, 2007
- SANZ et al., *Elements and Mineral Resources*. Springer Textbooks. Switzerland, 2022
- STWERTKA, Albert, *A guide of the elements*, 3rd ed. Oxford University Press, Inc. 2012
- <http://www.zinc.org>
- <http://www.ilzsg.org>
- <https://www.usgs.gov/centers/national-minerals-information-center/zinc-statistics-and-information>



Contributors

- **Photography's:**

Most of the photographs are by Joaquim Sanz i Balagué, except:

- **Aluminium file: RENFE (AVE train) and Grup Agbar (tower)**
- **Barite file : Raúl Osorio (drilling well)**
- **Boron file: Javier Castelo (spent fuel pool)**
- **Calcite file: Salvador Redó (road)**
- **Calcite file: Albert Prat Carné (soccer field)**
- **Cobalt and niobium : Carlos Domínguez (plane engine)**
- **Gypsum file: Pura Alfonso Abella (arm in plaster)**
- **Lithium file: Black&Decker (drill)**
- **Manganese file : Ferrocarrils de la Generalitat de Catalunya (train and rails)**
- **Niobium file: Fosters+Partners (bridge)**
- **Níquel file: Toyota (battery)**
- **Quartz file: Silestone – Consentino, SA (kitchen)**
- **Rare Earths file: Oliva Torras, SA (laser)**
- **Talc file : Stora Enso (paper spool)**
- **Tin file: Oleguer Serra (organ)**
- **Zinc file: Tube-mill (tubes)**