2. Historie využívání zdrojů

…a intenzity využívání, od náhodných sběrů až k těžebnímu průmyslu v souvislosti s narůstajícími druhy materiálů, poznání a v závislosti na rostoucí komplexitě lidské společnosti

Potřeba zdrojů v závislosti na poznání a rozvoji technologií – od kamene k …

- 1. Initial or First Era - Using things as found or with slight adaptation
  8000 BC Hammered copper
  6000 BC Silk production
- 2. Second Era - Changing things with heat or chemicals to improve properties
  5000 BC Glass making
  3500 BC Bronze Age
  1000 BC Iron Age
- 3. Third or Final Era - Understanding, making new materials

https://www.researchgate.net/publication/255203410_Materials_Science_and_Technology_Teachers_Handbook

Materials Footnotes Through History

8000 Hammered copper
7000 Clay pottery
6000 Silk production
5000 Glass making
4000 Smelted copper
4000-3000 Bronze Age
3200 Linen cloth
2500 Wall plaster
2500 Papyrus
1000 Iron Age
300 Glass blowing
20 Brass alloy
105 Paper
600-900 Porcelain
1540 Foundry operation
late-1500s Magnetization of iron demonstrated
1729 Electrical conductivity of metals demonstrated
1774 Crude steel
1789 Discovery of titanium
1789 Identification of uranium
1800 Volta's electric pile (battery)
1824 Portland cement
1839 Vulcanization of rubber
1850 Porcelain insulators
1850s Reinforced concrete
1856 Bessemer steelmaking
1866 Microstructure of steel discovered
1866 Discovery of polymeric compounds
1868 Commercial steel alloy
1870 Celluloid
1871 Periodic table of the elements
1875 Open-hearth steelmaking
1880 Selenium photovoltaic cells
1884 Nitrocellulose (first man-made fiber)
1886 Electrolytic process for aluminum
1889 Nickel-steel alloy
1891 Silicon carbide (first artificial abrasive)
1896 Discovery of radioactivity
1906 Triode vacuum tube
1910 Electric furnace steelmaking
1913 Hydrogenation to liquefy coal
1914 X-ray diffraction introduced
1914 Chromium stainless steels
1923 Tungsten carbide cutting materials
1930 Beginnings of semiconductor theory
1930 Fiberglass
1934 Discovery of amorphous metallic alloys
1937 Nylon
1940s Synthetic polymers
1947 Germanium transistor
1950 Commercial production of titanium
1952 Oxygen furnace for steelmaking
1950s Silicon photovoltaic cells
1950s Transmission electron microscope
mid-1950s Silicon transistor
1957 First supercritical U.S. coal plant
1958 Ruby-crystal laser
1959 Integrated circuit
1960 Production of amorphous metal alloy
1960 Artificial diamond production
1960s Microalloyed steels
1960s Scanning electron microscope
1966 Fiber optics
late-1970s Discovery of amorphous silicon
1984 Discovery of quasi-periodic crystals
1986 Discovery of high-temperature superconductors
1989 Buckyballs (Buckminsterfullerene)

Table 10: Transition Temperatures of Some High-T_c Superconductors

compound	T_c(K)
$Nd_{1.85}Ce_{0.15}CuO_4$	24
$La_{1.85}Sr_{0.15}CuO_4$	40
$YBa_2Cu_3O_7$	92
$Bi_2Sr_2Ca_2Cu_3O_{10}$	110
$Tl_2Ba_2Ca_2Cu_3O_{10}$	127
$Hg_2Ba_2Ca_2Cu_3O_8$	134

1. Horniny – náhodné ale i cílené sběry

The Stone Age marks a period of prehistory in which humans used primitive stone tools. Lasting roughly 2.5 million years, the Stone Age ended around 5,000 years ago when humans in the Near East began working with metal and making tools and weapons from bronze.

https://www.history.com/topics/pre-history/stone-age

Humans weren't the first to make or use stone tools. That honor appears to belong to the ancient species that lived on the shores of Lake Turkana, in Kenya, some 3.3 million years ago. First discovered in 2011, these more primitive tools were created some 700,000 years before the earliest members of the Homo genus emerged.

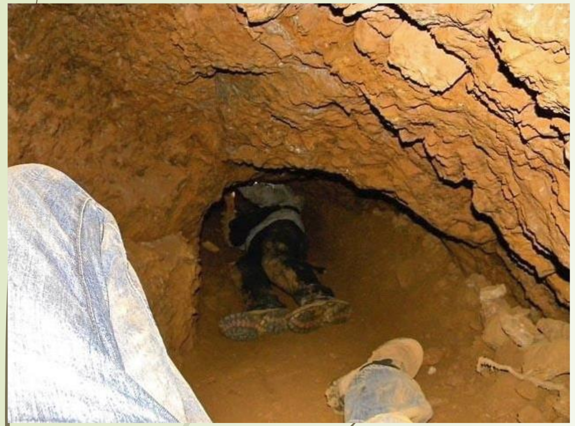
One of the earliest examples of stone tools found in Ethiopia. Sharpened stones (Oldowan tools): 2.6 million years ago

Paleolithic Art in the Roucadour cave, Themines, Quercy, Lot, France.
The paintings and engravings in the Roucadour cave, France, are attributed to the oldest phase of Paleolithic Art in Quercy, between 28,000 and 24,000 years BP.

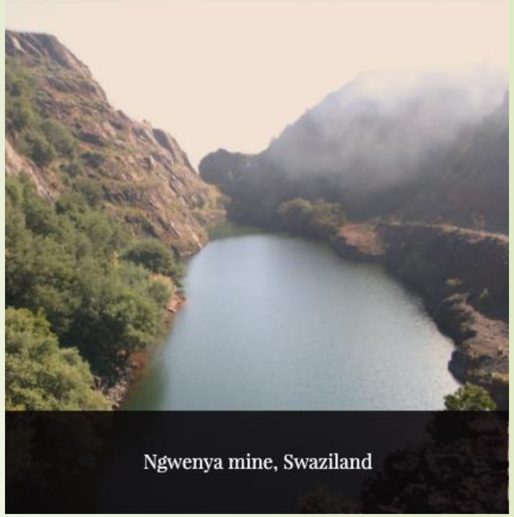
Jadeite axes from the Neolithic Period in central Europe.
Vzácnější materiál i místo výskytu – rozsáhlejší těžba na místě a obchod

Oldowan stone chopper from Olduvai Gorge, Tanzania
Částečně zaoblený – možná původní valoun

Nejstarší systematická těžba



Based on archaeological records, the world's oldest mine is the Lion Caves located in Swaziland, South Africa. Once tested radiokarbon, the old mine came from 43,000 years ago. One of the interesting things about Lion Caves is that the mine is a pigment mine. Mining of red ocher, pigments by primitive people as body paint for their rituals. The amount of material moved is quite impressive. Approximately 50-100 tons are regularly mined.

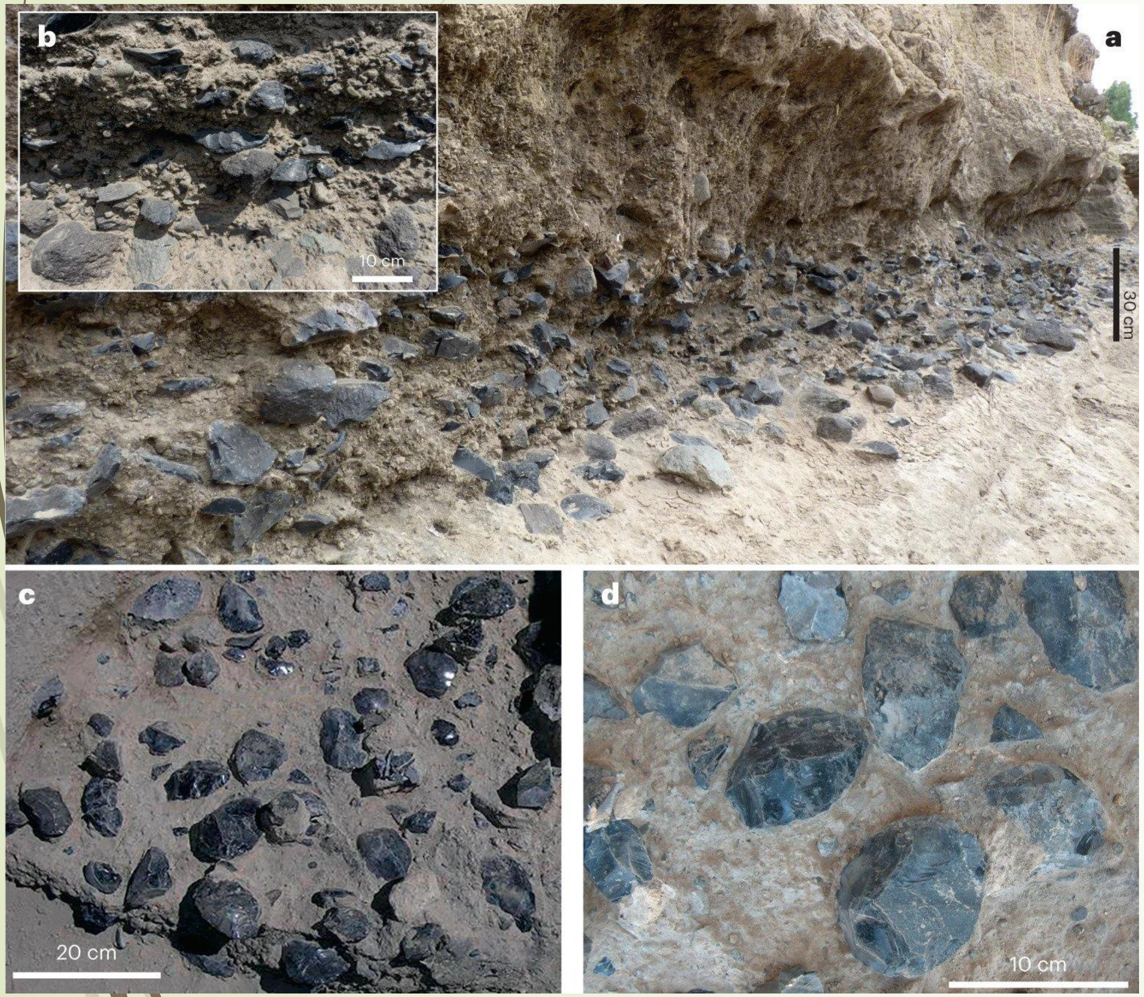


Ngwenya mine, Swaziland

Multiple-block extraction on descending platforms in the New Kingdom (1500 BC) to Late Period part of the el-Sawayta limestone quarry near Samalut and Minya, Egypt. Photo by JAMES HARRELL.

But the possibility of mining in the Nile River Valley is older. There are four old mining sites reported around the Nile, Qena and Nazlet Safaha that have existed since 50,000 years ago, while Nazlet Khater and Beit Allam, have existed since 60,000 years ago. All the old mining sites are stone quarries .

1,2 mil. let stará „továrna“ - Etiopie



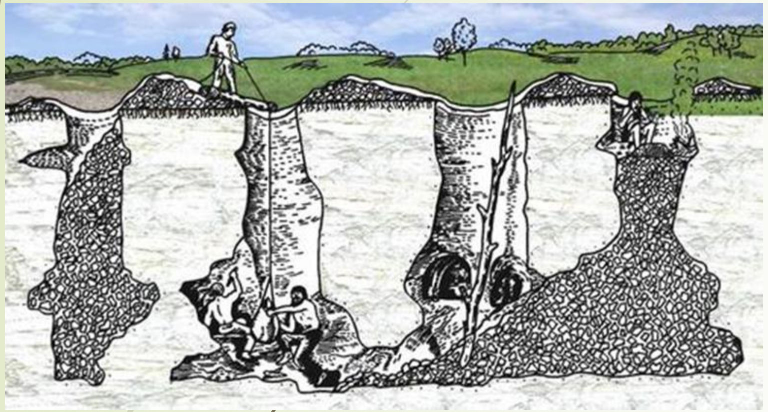
Bylo nalezeno 575 ručních seker

(publikováno na začátku r.2023, Nature)
…Simbiro III level C, in the upper Awash valley of Ethiopia, allows us to test this assumption in its assemblage of stone tools made only with obsidian, dated to more than 1.2 million years (Myr) old. Here we first reconstruct the palaeoenvironment, showing that the landscape was seasonally flooded. Following the deposition of an accumulation of obsidian cobbles by a meandering river, hominins began to exploit these in new ways, producing large tools with sharp cutting edges. We show through statistical analysis that this was a focused activity, that very standardized handaxes were produced and that this was a stone-tool workshop.…

https://www.nature.com/articles/s41559-022-01970-1

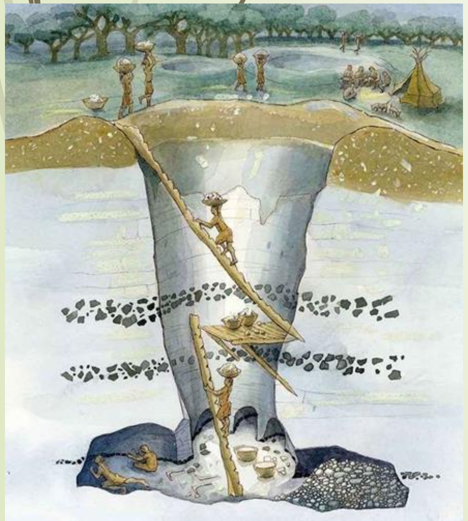
Těžba silicitů, pazourku – „průmysl“

highly organised flint mining is being studied in Belarus.



Neolithic Flint Mines at Spiennes (Mons)

Spiennes, minière du Camp-à-Cayaux
© SPW



Grime's Graves: A Neolithic Flint Mine, Norfolk, UK
Beginning around 5,000 years ago, and continuing for an entire millennium, Stone Age peoples mined 'floorstone' flint beneath more than 10 meters of chalk.

Grimes Graves is one of a series of mines dug in prehistoric sussex following a rich seam of flint bearing chalk. Other shafts were dug before at nearby harrow hill and a further 200 shafts were dug at cissbury.

Silica forms silicic acid (H_4SiO_4) in solution, which can then dissociate through a series of reactions, e.g.,
$H_4SiO_4 \leftrightharpoons H_3SiO_4^- + H^+$
$H_3SiO_4^- \leftrightharpoons H_2SiO_4^{2-} + H^+$ ...

…dodnes horniny využíváme a těžíme

- hrubý kámen
- leštěné desky,…
- drcené kamenivo
- …umění

…a provází nás až do konce života

Zdroje kamene:

Marble quarry near Orosei. Sardinia. Italy, Foto de Stock, Imagen Derechos Protegidos Pic. C46-1127464 | agefotostock

Povrchová těžba v lomu i hlubinná těžba kamene – např. břidlicový důl Staré Oldřůvky (pokrývačské břidlice, Nízký Jeseník

Bronz - doba bronzová - zdroje



malachit $Cu_2(CO_3)(OH)_2$
azurit $Cu_3(CO_3)_2(OH)_2$

malachit:

Copper	57.48 %	Cu	71.95 % CuO
Hydrogen	0.91 %	H	8.15 % H2O
Carbon	5.43 %	C	19.90 % CO2
Oxygen	36.18 %	O	
	100.00 %		100.00 % = TOTAL OXIDE

Great Orme on the north Welsh coast was an exception, becoming the first industrially worked copper mine, dominating production from 1500 to 1200 BC. Copper is mined from green malachite and it is estimated that in the Bronze Age over 40,000 tonnes of ore-bearing rock were removed from the site of the underground mine and the opencast surface mine. This could have produced around 1,700 tonnes of copper ore, enough to make 10 million bronze axes.

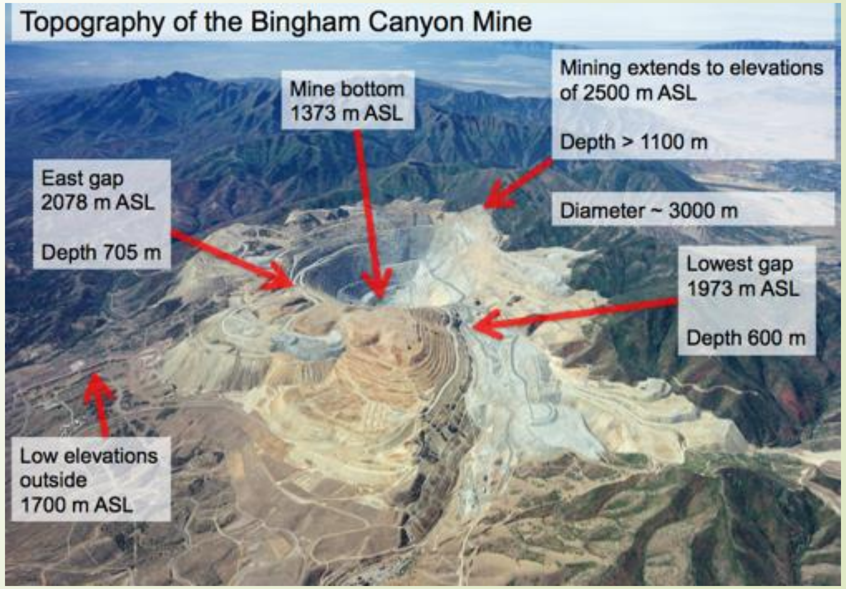
Timberlake offers 2100 BC as a date for the beginning of tin extraction in Cornwall - alluvial tin – casiterite (gold extraction as well!) (Timberlake 2017).

Kasiterit SnO_2

Příklad současné těžby Cu-rud, Montana, USA hlavní ruda: chalkopyrit – $CuFeS_2$

CuFeS2
Composition:

Iron	30.43 %	Fe
Copper	34.63 %	Cu
Sulfur	34.94 %	S
	100.00 %	



Železo - doba železná

...above 1,250 °C

(copper 1,085 °C … 6000 BC … 900 °C)

A smelting furnace from the Late Iron Age/Middle Ages, Norway

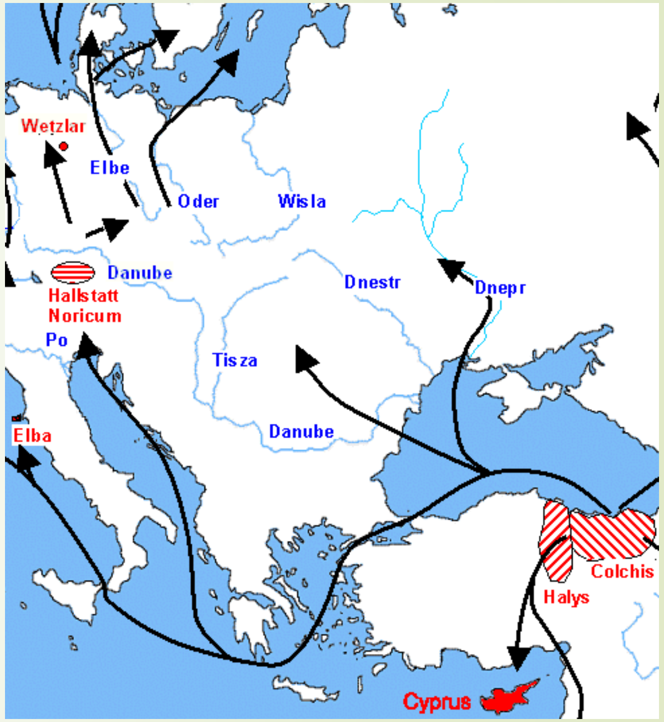
Modern archaeological evidence identifies the start of large-scale iron production in around 1200 BC, marking the end of the Bronze Age. Between 1200 BC and 1000 BC diffusion in the understanding of iron metallurgy and the use of iron objects was fast and far-flung. Anthony Snodgrass suggests that a shortage of tin, as a part of the Bronze Age Collapse and trade disruptions in the Mediterranean around 1300 BC, forced metalworkers to seek an alternative to bronze.

A.M. Snodgrass (1966), "Arms and Armour of the Greeks" (Thames & Hudson, London)

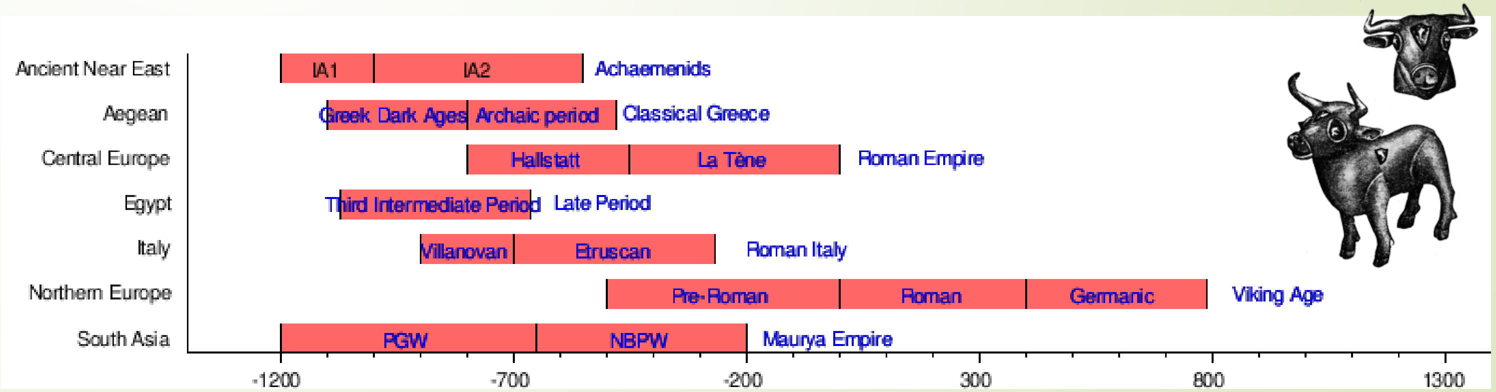
A.M. Snodgrass (1971), "The Dark Age of Greece" (Edinburgh University Press, Edinburgh).

Theodore Wertime & J.D. Muhly, eds. The Coming of the Age of Iron (New Haven, 1979).

The spreading of iron technology after 1200 BC

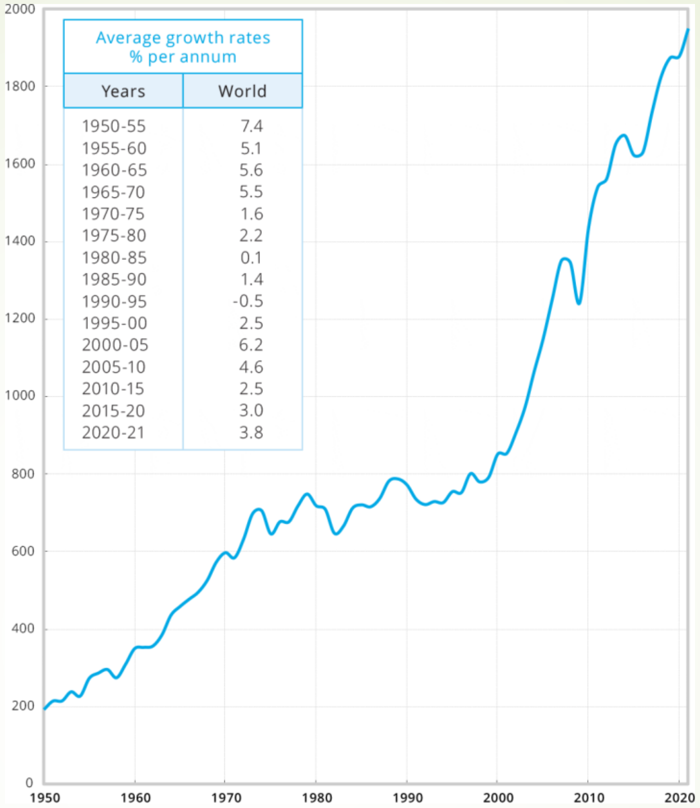


Železná houba (současná) ze železářské pece a nálezy hotových výkovků



…až ocel

1751 Sheffield, …a další pokroky v metalurgii



Country	2021		2020	
	Rank	Tonnage	Rank	Tonnage
China	1	1 032.8	1	1 064.7
India	2	118.2	2	100.3
Japan	3	96.3	3	83.2
United States	4	85.8	4	72.7
Russia	5	75.6	5	71.6
South Korea	6	70.4	6	67.1
Turkey	7	40.4	7	35.8
Germany	8	40.1	8	35.7
Brazil	9	36.2	9	31.4
Iran (e)	10	28.5	10	29.0
Italy	11	24.4	13	20.4
Taiwan, China	12	23.2	11	21.0
Vietnam	13	23.0	14	19.9
Ukraine	14	21.4	12	20.6
Mexico	15	18.5	15	16.8
Indonesia	16	14.3	16	12.9
Spain	17	14.2	18	11.0
France	18	13.9	17	11.6
Canada	19	13.0	19	11.0
Egypt	20	10.3	20	8.2
Saudi Arabia	21	8.7	22	7.8
Poland	22	8.5	21	7.9
Austria	23	7.9	24	6.8
United Kingdom	24	7.2	23	7.1
Belgium	25	6.9	26	6.1
Malaysia (e)	26	6.9	25	6.6
Netherlands	27	6.6	27	6.1
Australia	28	5.8	29	5.5
Bangladesh (e)	29	5.5	28	5.5
Thailand	30	5.5	30	4.5
Pakistan	31	5.3	35	3.8
South Africa (e)	32	5.0	34	3.9
Argentina	33	4.9	36	3.7
Slovakia	34	4.9	38	3.4
Czechia	35	4.8	31	4.5
Sweden	36	4.7	32	4.4
Kazakhstan (e)	37	4.4	33	3.9
Finland	38	4.3	37	3.5
Algeria	39	3.5	39	3.0
Romania	40	3.4	40	2.8
United Arab Emirates	41	3.0	41	2.7
Belarus (e)	42	2.4	42	2.5
Luxembourg	43	2.1	45	1.9
Oman (e)	44	2.0	44	2.0
Portugal	45	2.0	43	2.2
Serbia	46	1.7	47	1.5
Greece	47	1.5	48	1.4
Colombia	48	1.3	54	1.1
Chile	49	1.3	53	1.2
Kuwait (e)	50	1.3	49	1.3
Others		17.7		16.2
World		1 951.2		1 879.4

(e) = estimate

https://worldsteel.org/steel-topics/statistics/world-steel-in-figures-2022/

Ocel: …slitiny železa s nižším obsahem uhlíku… a dodání legujících prvků, např. manganu, silikonu-křemíku a dalších: Cr, Mo, W, Ni, Co…., Ti….

Zdroje železa

Limonite staining laterite soil: A profile of laterite soil heavily stained by limonite from Parque Nacional la Mensura, Cuba. USGS photo by Paul Golightly.

„bog iron“ – FeO(OH)

Banded iron formation in Barberton Mountain Land the Barberton Greenstone Belt in Barberton Mountain Land, South Africa.

Carajas Iron Ore Mine, Para, Brazil

A modern open-pit mine in Australia.

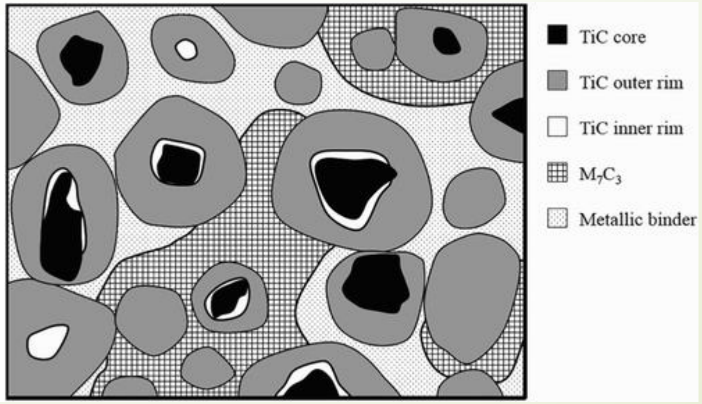
Pottery - keramika

ceramic remains in a cave in China's Hunan province that are from 15,400 to 18,300 years old.

Front profile of the statuette. Credit: Petr Novák, Wikipedia, 29,000-year old Venus of Dolní Věstonice, the oldest known ceramic artifact

A cermet is a composite material composed of ceramic particles including titanium carbide (TiC), titanium nitride (TiN), and titanium carbonitride (TiCN) bonded with metal. The name "cermet" combines the words ceramic (cer) and metal (met). They are most successfully used for finishing and light roughing applications.

Cermet a jeho struktura



moderní keramika

600 CE Chinese introduce porcelain

Porcelán - Porcelain

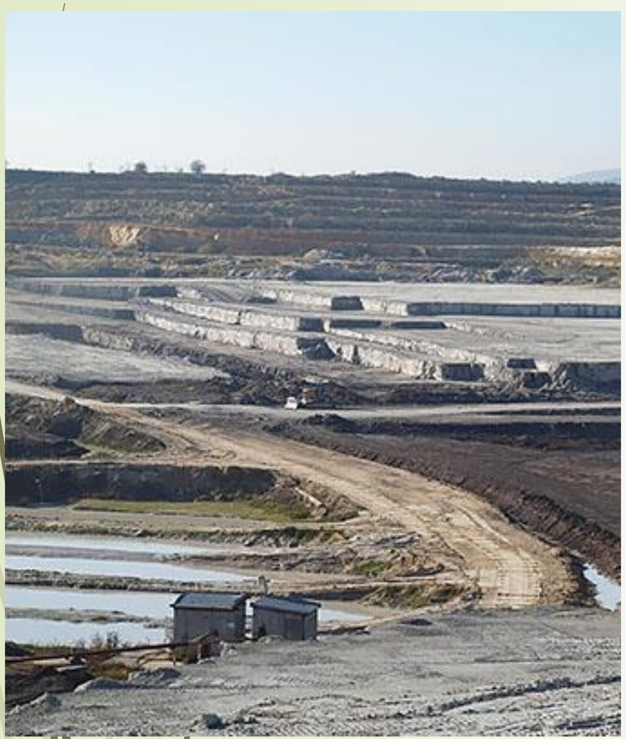
Základem je surovina kaolín, s minerálem kaolinitem ($Al_2Si_2O_5(OH)_4$, patří do skupiny jílových minerálů)

1200-1400 °C, vzniká mulit (křemičitan – obsahují skupinu SiO_4^{4-}) – spolu se vznikajícím sklem zajišťuje průsvitnost porcelánu, mullite - $Al_{(4+2x)}Si_{(2-2x)}O_{(10-x)}$ where x =0.17 to 0.59

Song dynasty celadon porcelain with a fenghuang spout, 10th century, China

současné předměty

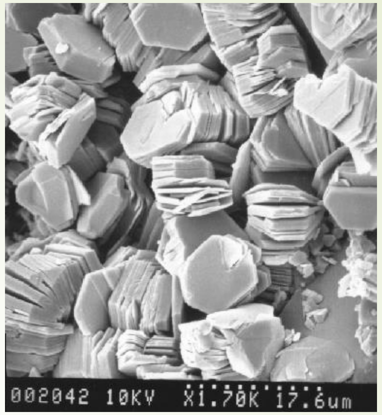
Zdroje jílu a kaolínu

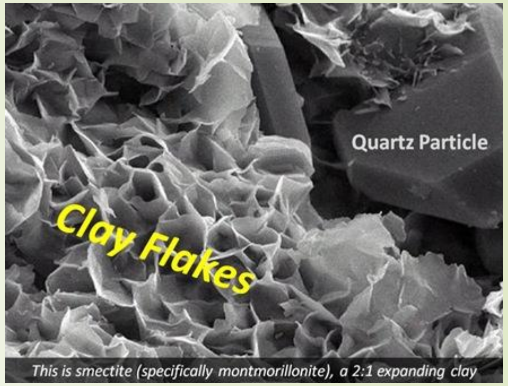


Keramické jíly, Chebská pánev

Zdrojem pro keramiku jsou jílovité horniny - sedimenty (směs jílových minerálů), jílový minerál je i kaolinit - porcelán

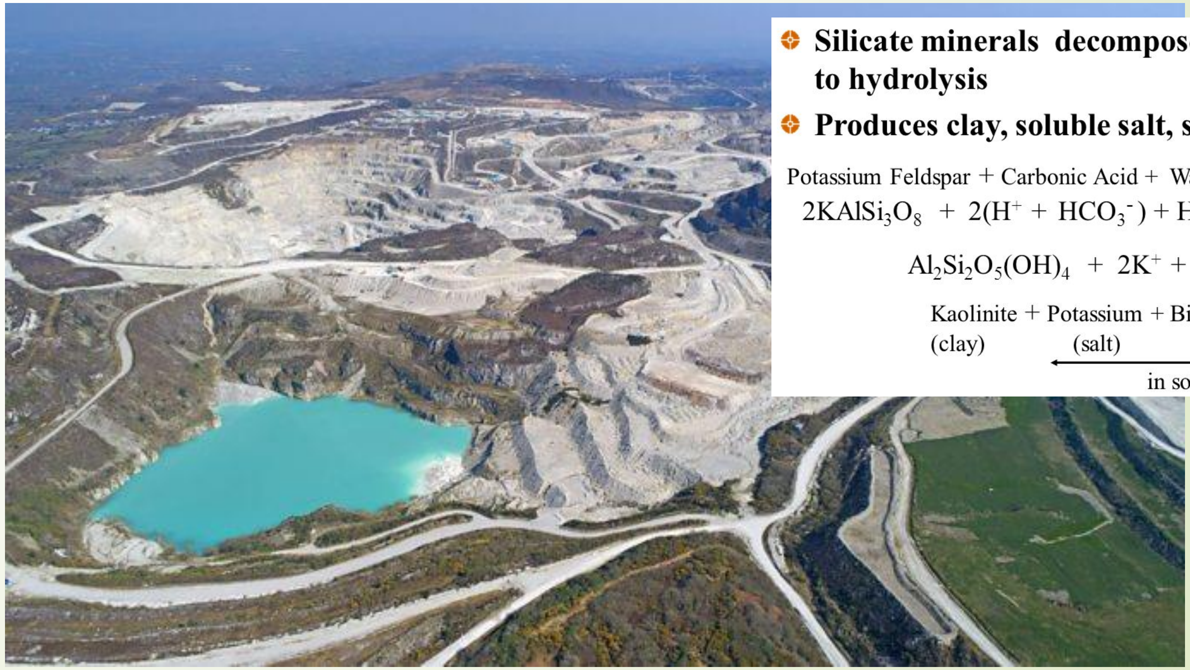
Kaolinit v elektronovém mikroskopu





Použití jílů je spojeno se strukturou jílových minerálů, která určuje jejich vlastnosti

Ložisko kaolínu (často zvětralé žuly – minerály živce se mění na kaolinit



- **Silicate minerals decomposed by water due to hydrolysis**
- **Produces clay, soluble salt, silica**

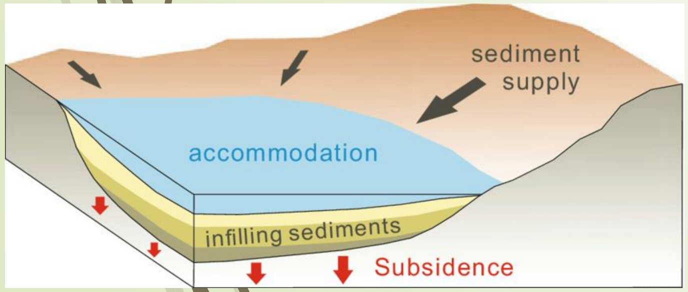
Potassium Feldspar + Carbonic Acid + Water

$$2KAlSi_3O_8 + 2(H^+ + HCO_3^-) + H_2O \longrightarrow$$

$$Al_2Si_2O_5(OH)_4 + 2K^+ + 2HCO_3^-) + 4SiO_2$$

Kaolinite (clay) + Potassium (salt) + Bicarbonate + Silica

in solution

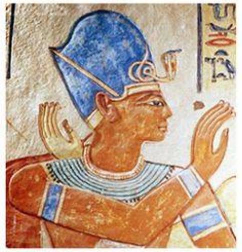


Model sedimentární pánve

Egyptská fajáns a modř (3250 BC…?)

Egyptská modř – první syntetický pigment, pasta: písek + natron + oxid Cu?(nebo malachit?, zbytky bronzu?) a pak 900°C

A faience vase fabricated in part from natron, dating to the New Kingdom of Egypt (c. 1450–1350 BC)



Egyptian faience ushabti of Lady Sati. New Kingdom, Dynasty XVIII, reign of Amenhotep III, c. 1390–1352 BC. Possibly from Saqqara.

natron ($Na_2CO_3 \cdot 10H_2O$), přírodní sůl – směs uhličitanů Na, soda

Wadi El Natrun is a depression in northern Egypt that is located 23 m below sea level and 38 m below the Nile River level. The valley contains several alkaline lakes, natron-rich salt deposits, salt marshes and freshwater marshes.

dnešní těžba solných jezer
Salt Lake Uyuni, Salar de Uyuni, Bolivia

Sklo

These two cobalt-blue glass beads, found in 3,400-year-old graves in Denmark, came from ancient Egypt, probably via extensive European trade routes, according to new research. A. MIKKELSEN, NATIONAL MUSEUM OF DENMARK

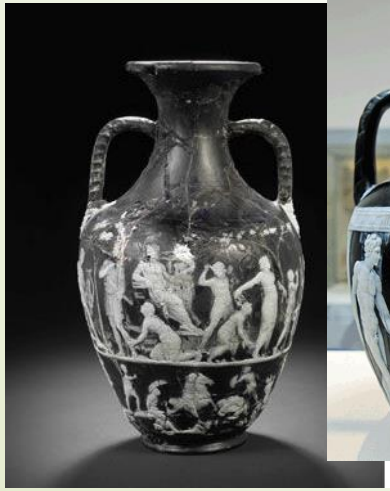
https://www.sciencenews.org/article/ancient-egyptian-blue-glass-beads-reached-scandinavia

Glass as an independent object (mostly as beads) dates back to about 2500 BC. It originated perhaps in Mesopotamia and was brought later to Egypt. Vessels of glass appeared about 1450 BC, during the reign of Thutmose III, a pharaoh of the 18th dynasty of Egypt. A glass bottle bearing Thutmose's hieroglyph is in the British Museum in London. From Mesopotamia and Egypt, glassmaking using the basic soda-lime-silica composition traveled to Phoenicia, along the coast of present-day Lebanon.

The Romans and Egyptians probably used sand mixed with ground seashells as raw materials for silica and lime and hardwood ash as the source of soda. They also showed astonishing skill in the way they used metallic oxides as colorizers. Very small differences in oxide content can drastically affect the final colour of a glass; yet colours and tints were reproduced time and again with remarkable consistency. Copper was used to make green and ruby-red glass; iron produced black, brown, and green; antimony, yellow; manganese was employed to make purple and amethyst glass. An opaque white glass, made by using tin, was important in glass cameo work, of which the famous Portland vase, made in 1st-century Rome, is an outstanding example.

Two different sources of alkali affected the composition of early glasses. On the Eastern Mediterranean littoral natron (hydrated Na_2CO_3) was usually the favored alkali, because it was available from northern Egypt. Further east, in Mesopotamia and Persia, the alkali was usually provided by plant ash that contained more K_2O (2%–4%) and MgO (2%–6%).

…dates from between late First Century B.C. to early First Century A.D and stands 13in (33.5cm) high, they are formed from two layers of glass – cobalt blue with a layer of white on top – which is cut down after cooling to create the cameo-style decoration



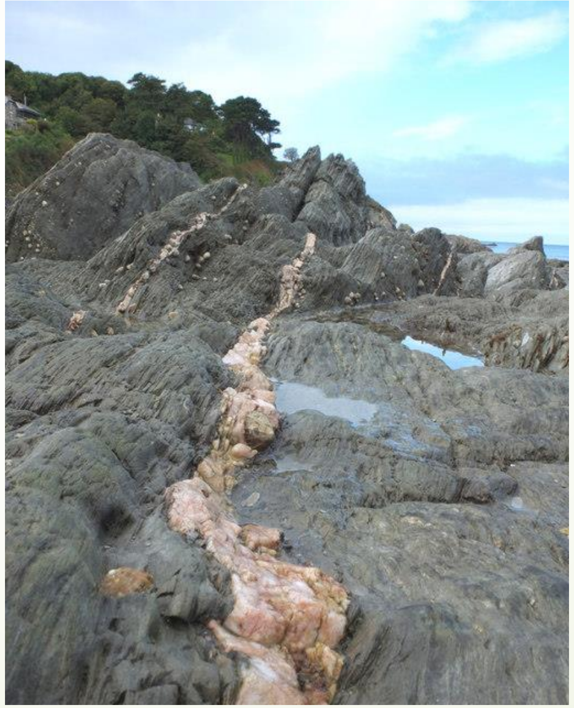
The Portland Vase is a Roman cameo glass vase, which dates between 1 A.D. and 25 A.D..

Potassium – pot+ash

Zdroje křemene

Dobře opracovaná, zaoblená písková zrna, světle šedé jsou křemeny

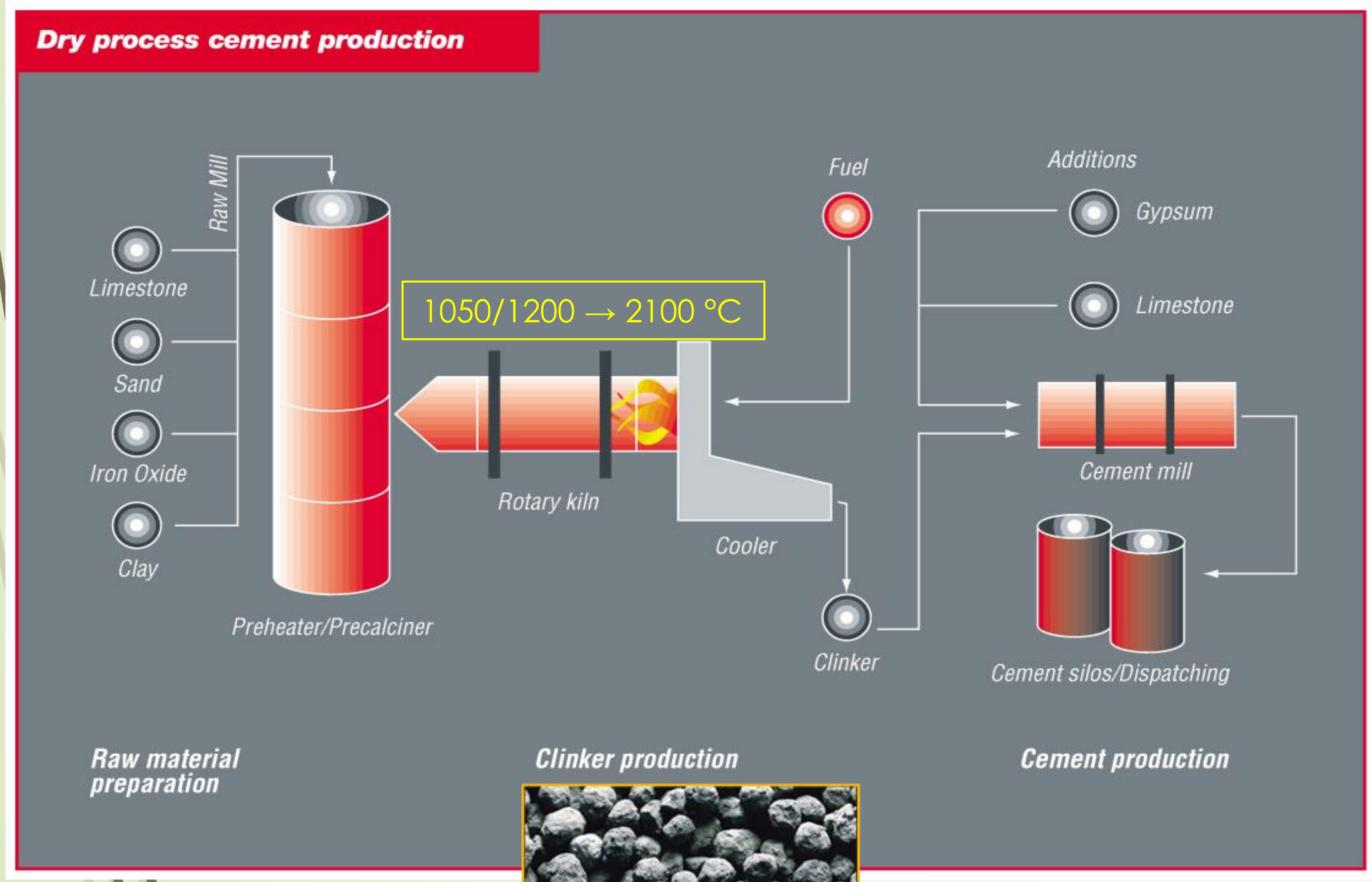
Současná těžba - Střeleč, velmi čisté písky, Česká křídová tabule, křída



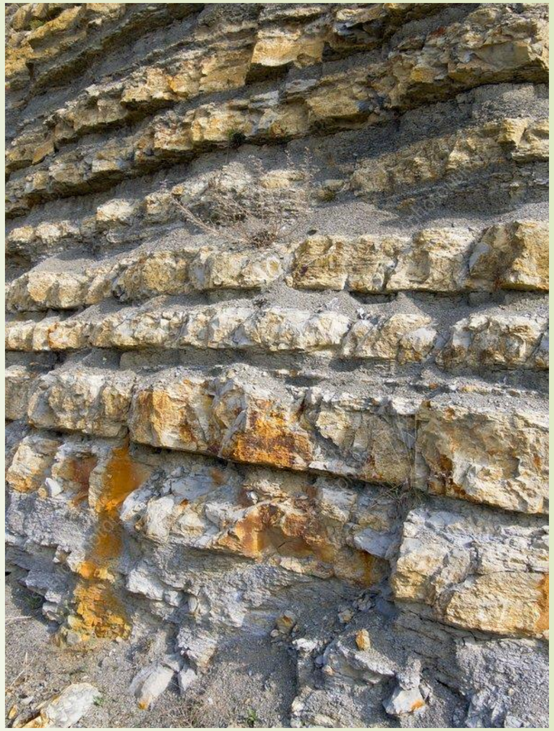
Pink quartz vein at Lee Bay

Štěrkopísky: zdroj křemene, živců, různé velikostní frakce

Cement, beton



Newly formed minerals Ca, Si, Fe, Al silikates (clinker - česky slínek)



sedimenty, vrstevnatý vápenec s břidlicemi, střídání vrstev

The origin of hydraulic cements goes back to ancient Greece and Rome. The materials used were lime and a volcanic ash that slowly reacted with it in the presence of water to form a hard mass. This formed the cementing material of the Roman mortars and concretes of more than 2,000 years ago and of subsequent construction work in western Europe. Volcanic ash mined near what is now the city of Pozzuoli, Italy, was particularly rich in essential aluminosilicate minerals, giving rise to the classic pozzolana cement of the Roman era.

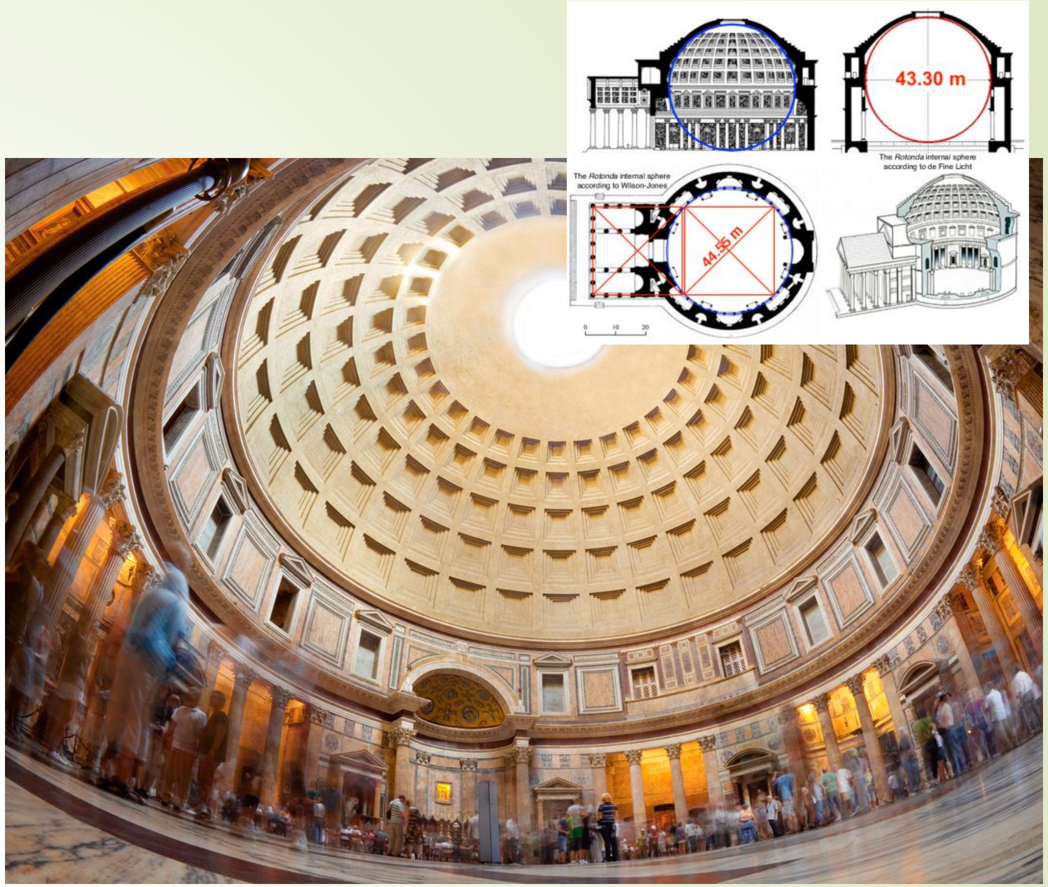
Portland cement is a successor to a hydraulic lime that was first developed by John Smeaton in 1756 when he was called in to erect the Eddystone Lighthouse off the coast of Plymouth, Devon, England. The invention of portland cement usually is attributed to Joseph Aspdin of Leeds, Yorkshire, England, who in 1824 took out a patent for a material that was produced from a synthetic mixture of limestone and clay.

Římský beton

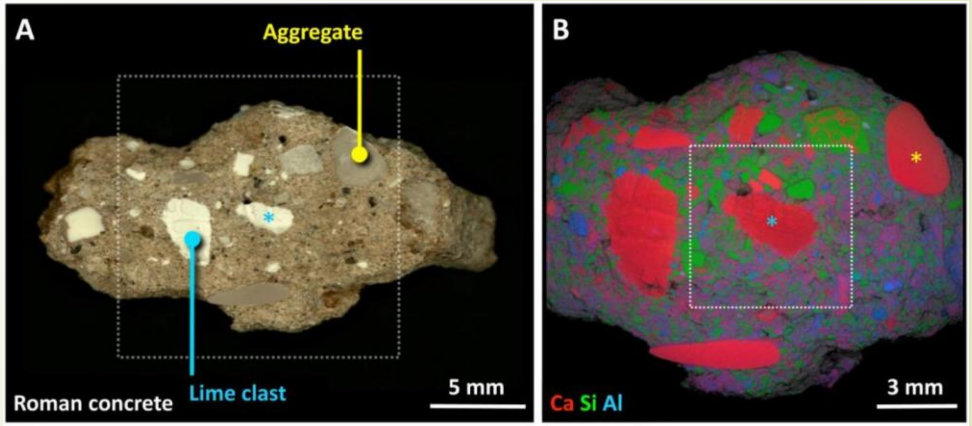
It was previously thought that the key to Roman concrete's durability was the introduction of pozzolanic ash, a natural siliceous or siliceous-aluminous material which reacts with calcium hydroxide in the presence of water at room temperature.
…A closer examination of ancient samples shows white mineral features referred to as "lime clasts," another key component in the concrete mix.
…Using high-resolution multiscale imaging and chemical mapping techniques, the researchers have determined that the white inclusions were, indeed, made out of various forms of calcium carbonate…

Puzzolano – hornina z vulkanického prostředí, bohatá na Si

https://www.heritagedaily.com/2023/01/secret-of-roman-concrete-solved/145758



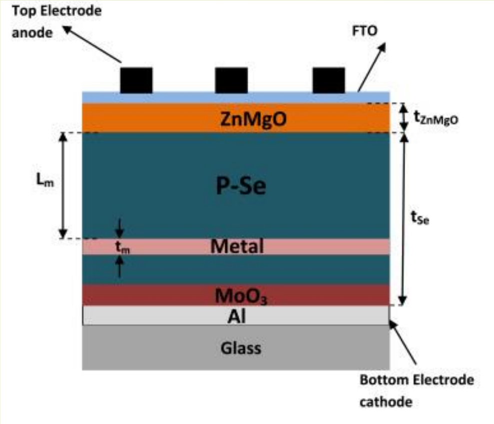
The Pantheon (completed around 126-128 A.D) in Rome features the world's largest unreinforced concrete dome.



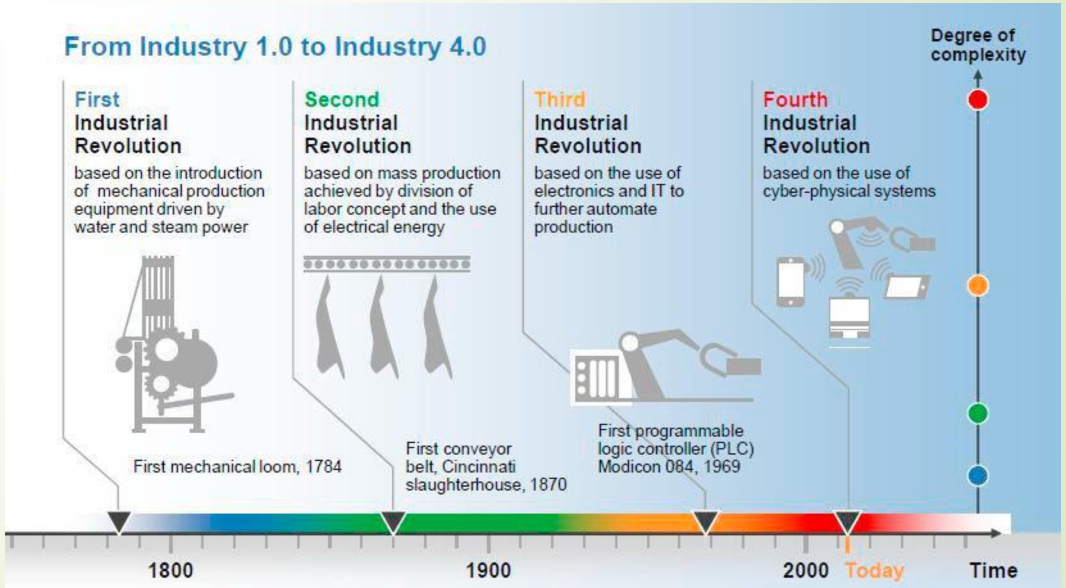
Průmyslové revoluce

Vzájemné ovlivňování nových znalostí, rozvoje průmyslových oborů, energetiky, technologií a jejich produktů….?

- 1. industrializace (1784 – tkalcovský stav…..)
- 2. elektrifikace (1870-80, …montážní linky…))
- 3. automatizace (1969, …malý počítač…)
- 4. internet (1987-1994,….) – komunikace, informace…, energie…?



Cross-sectional view of the proposed Se-based solar cell with intermediate ultrathin MLs



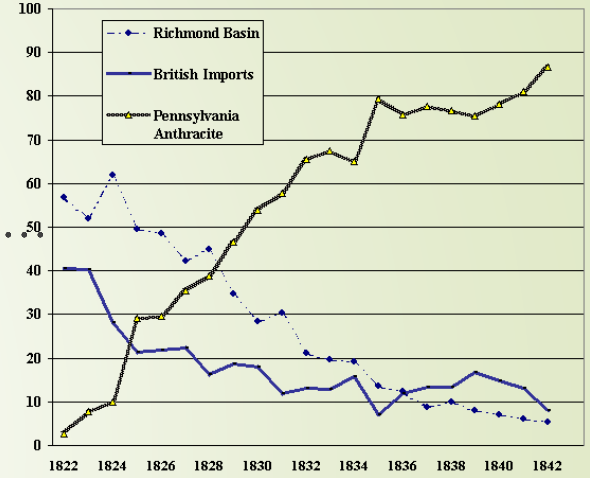
I. Průmyslová revoluce - industrializace

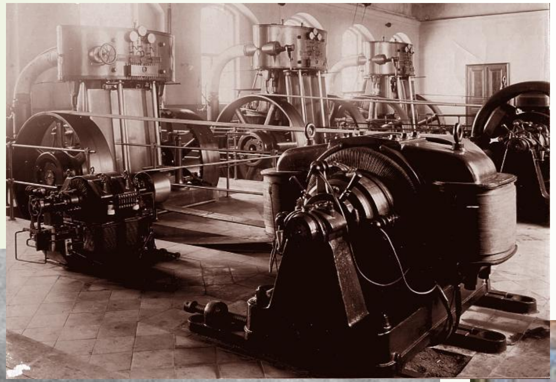
Industry 1.0: Production shifted from homemade to factories.

rudimentary steam engine was the aeolipile mentioned by Vitruvius between 30 and 15 BC

- Vynálezy: 1698, 1712 - parní stroj, 1824 – cement, beton,…
- Výroba strojů
- energetické zdroje a zdroje pro výrobu

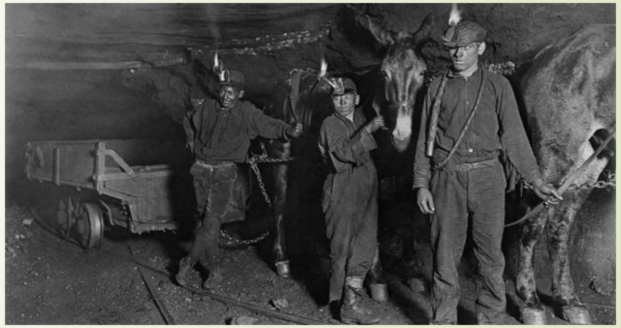
US coal





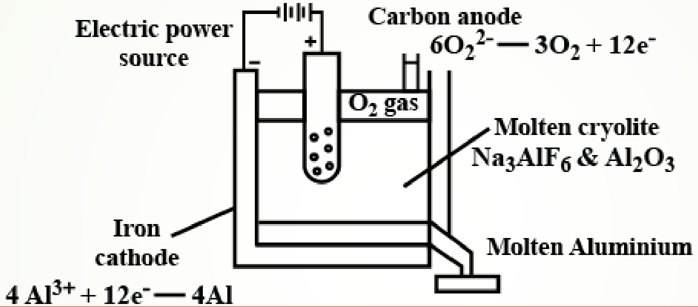
…Turbiny se stavějí do velikosti 100.000 i 200.000 koňských sil, tlaky parní přes 100 atm, s parou přehřátou, s kondensací obyčejně pak přímo spojeny jsou se strojem elektrickým vyrábějícím proud elektrický — generátorem — a tvoří s ním dvojici — turbogenerátor…

West Virginia coal miners



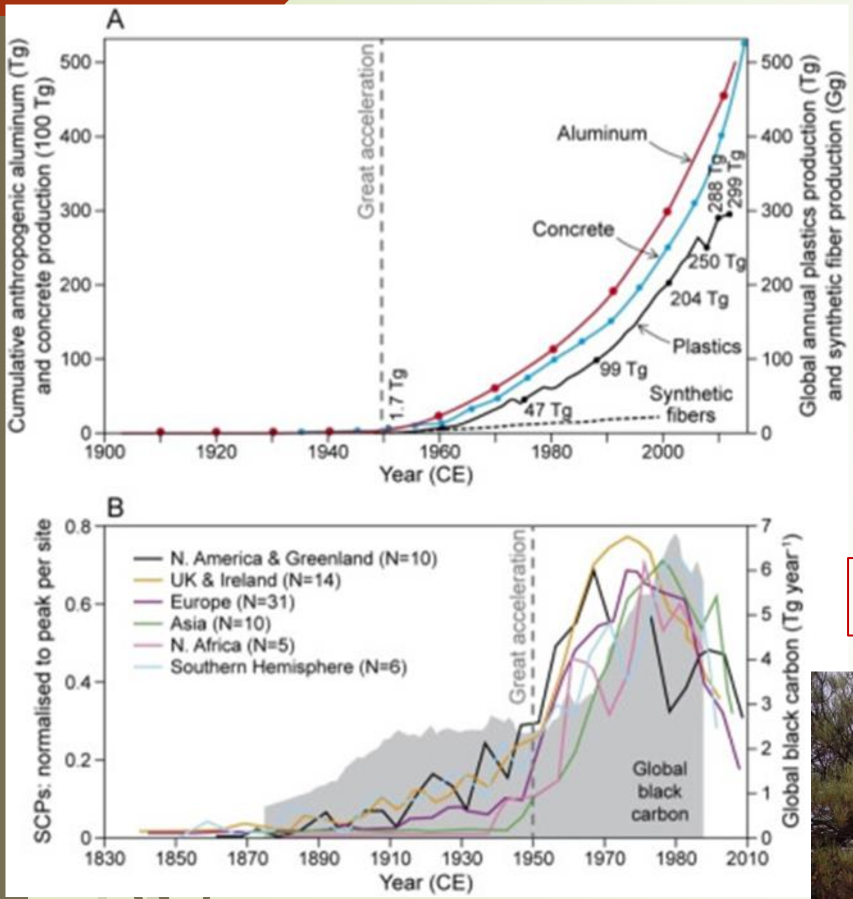
II. velkovýroba, elektrifikace

Industry 2.0: Powering of machines shifted from steam and water to electricity



1886 – elektrolytický proces Al

The Ford assembly line in 1913 (Henry Ford)



Arid Lands Roxby Downs, Australia

bauxit (Al-laterit)

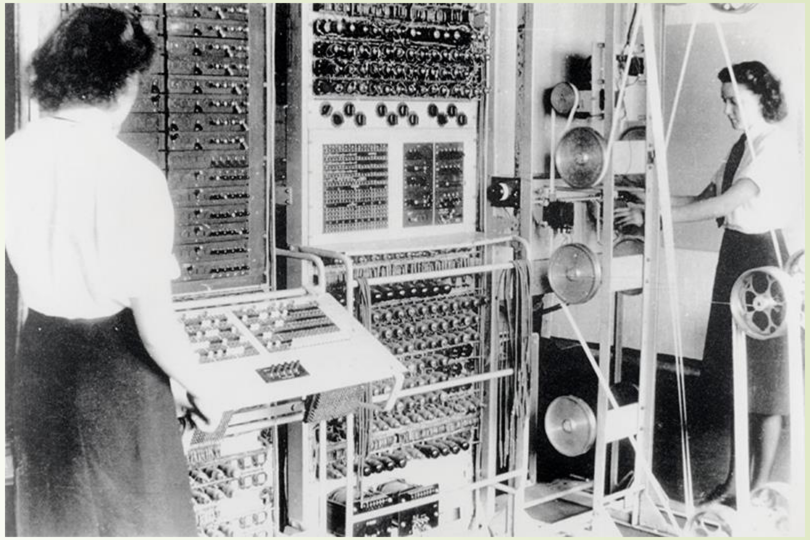
Různé typy kabelů na sloupu, Vietnam

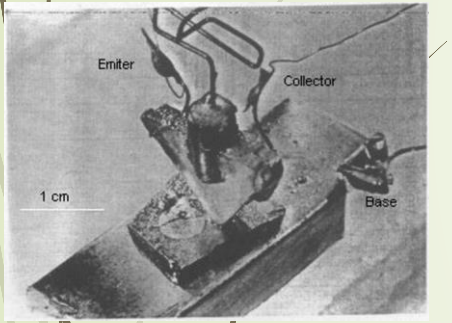
Al-laterit: hydrooxidy Fe a minerály např. bohmit, diaspor: $Al(OH)_3$

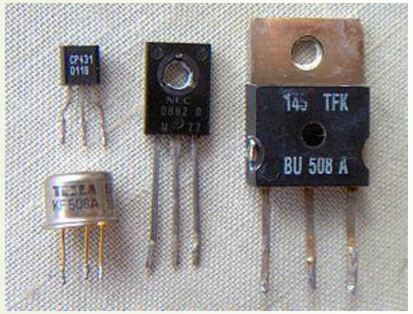
$H^+ + KAlSi_3O_8 + 7H_2O \rightarrow Al(OH)_3 + K^+ + 3H_4SiO_4$

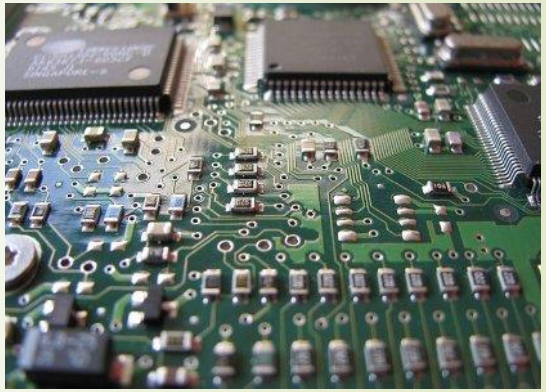
III. automatizace

Industry 3.0
Industry 3.0 was a huge upswing where the Industries are administered by the computes, electronic systems, information systems, and automation. This era was known for robotic because human tasks are highly performed by robotics but the involvement of humans was also there in automation. E.g., Use of Programmable Logic Controllers, Robots, ICTs (In-circuit test) electronics, etc.





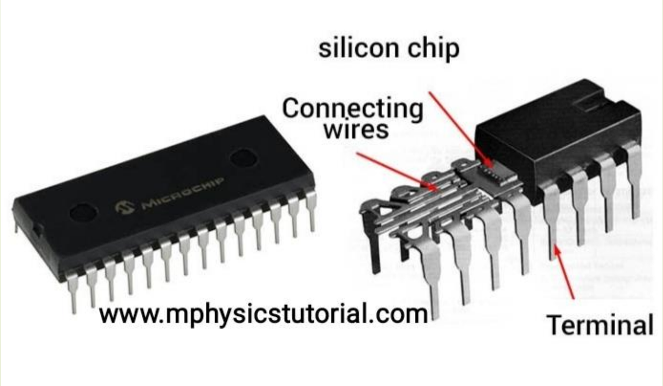




křemík, Ge, Sb, As, In, Ga, Al, … a jejich zdroje…?

Ge, Ga, max. X00 ppm, In prům. X0 ppm ve sfaleritu (ZnS) – zásoby sulfidických rud: hydrotermální polymetalická ložiska

Tranzistor je třívrstvá polovodičová součástka, kterou tvoří dvojice přechodů PN. Tranzistory jsou základní aktivní součástky, které se používají jako zesilovače, spínače a invertory. Jsou základem všech dnešních integrovaných obvodů, jako např. procesorů, pamětí. Tranzistorový jev (efekt) byl objeven a tranzistor vynalezen 16. prosince 1947 v Bellových laboratořích



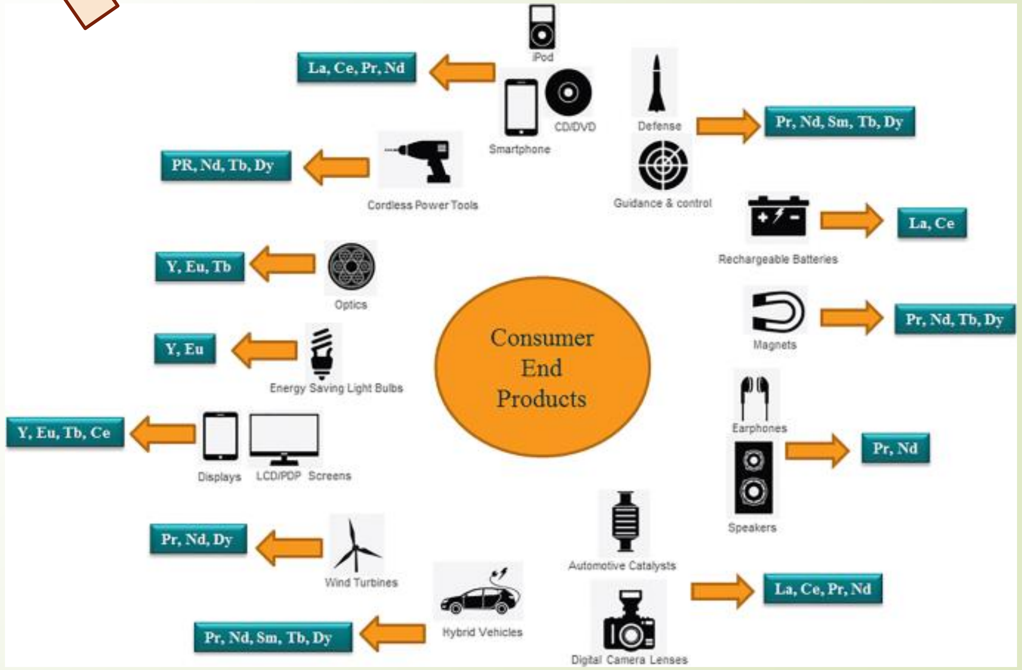
https://thefactoryscience.com/industry-3-0-vs-industry-4-0/

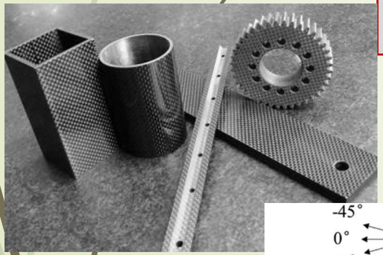
IV. Průmysl 4.0 – digitalizace,…?

Industry 4.0
Industry 4.0 is known as the digitization/digitized era, where the industries are transformed with smart machines/ assets, sensors, and smart data collection processes. The IIoT is leading this whole era with other technologies like Artificial intelligence, big data, cloud computing, and CPS (Cyber-physical system). It improves automation, connectivity, and achieving higher productivity, quality, and efficiency. With this industry 4.0, the smart factories have the ability to achieve some advancements like predicting failures before it occurs (in case of any machines/assets failures) and accomplish it autonomously and also even take a decision within minutes to hours based on real-time as well as achieve competitive advantage.

Industry 4.0 is revolutionizing the way companies manufacture, improve and distribute their products. Manufacturers are integrating new technologies, including Internet of Things (IoT), cloud computing and analytics, and AI and machine learning into their production facilities and throughout their operations.
This digital technologies lead to increased automation, predictive maintenance, self-optimization of process improvements and, above all, a new level of efficiencies and responsiveness to customers not previously possible.
Industry 4.0 concepts and technologies can be applied across all types of industrial companies, including discrete and process manufacturing, as well as oil and gas, mining and other industrial segments.

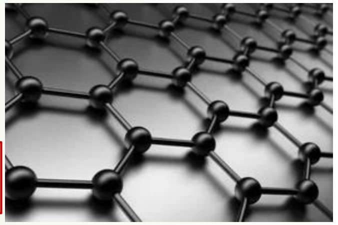
zdroje REE + …

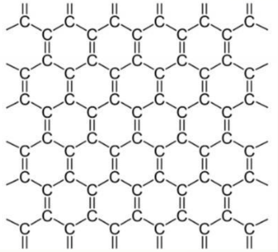




uhlík

grafen





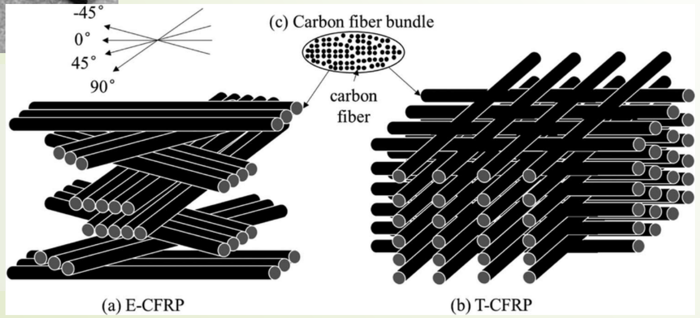
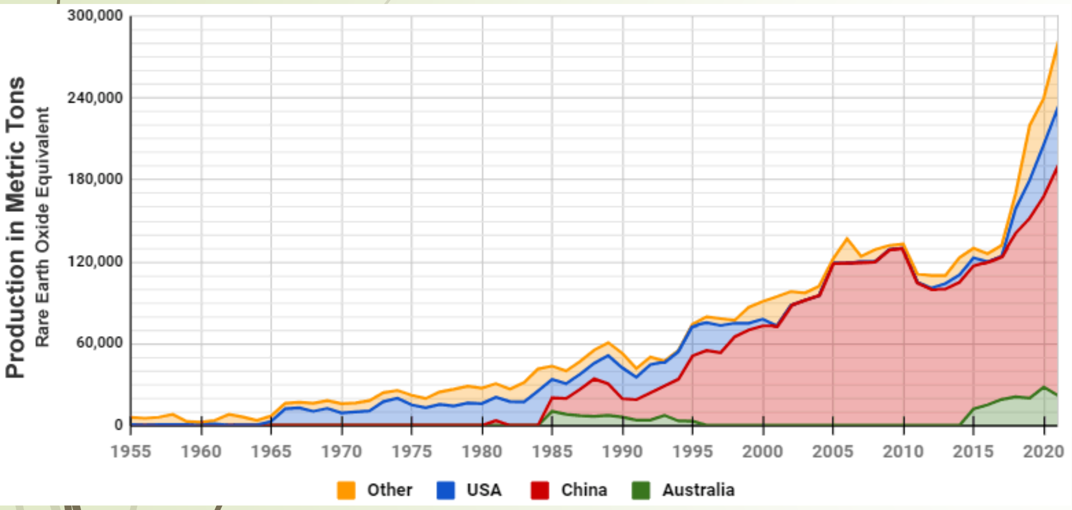


Illustration of the layered structures of (a) E-CFRP, (b) T-CFRP, and (c) the cross-section of a carbon fiber bundle containing carbon fiber lines.

https://thefactoryscience.com/industry-3-0-vs-industry-4-0/

Critical raw materials EU

EK: RMI – Raw Material Initiative 2018



Bayan Obo (China) is the world's largest known REE deposit. Reserves are estimated at more than 40 million tons of REE minerals grading at 3–5.4% REE (70% of world's known REE reserves), 1 million tons of Nb_2O_5 and 470 million tons of iron. The deposit also contains an estimated 130 million tons of fluorite….