18 NIOBIUM

18.1 Overview

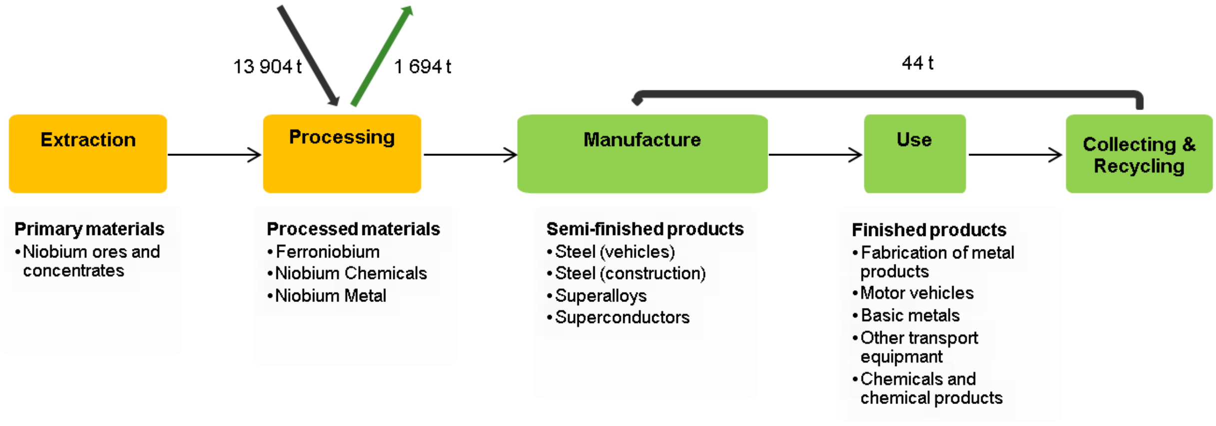

Figure 214: Simplified value chain for Niobium, data in tonnes of ferroniobium (2012-16 average).

Niobium (chemical symbol Nb) is grey in colour. It is a relatively hard, paramagnetic, refractory transition metal. It has a density of 8.57 g/cm^3 and a very high melting temperature (2,468°C). Niobium is also highly resistant to chemical attack and behaves as a superconductor at very low temperature. The upper-cristal abundance of niobium is 12 ppm (Rudnick and Gao, 2003), which is higher than some of the other refractory metals, but lower than many of the base metals. Niobium is not found as a free metal in nature, but chiefly occurs in minerals such as columbite and pyrochlore, the latter being the primary ore mineral. Some characteristics and properties are similar to other neighbouring elements on the periodic table. This is the case for tantalum, which is located just below niobium on the periodic table and often appears in the same deposits as niobium (Tercero et al. 2018).

Niobium was on the list of CRMs in 2011, 2014 and 2017.

Trade data for niobium ores and concentrates are not available, for this reason the criticality assessment for niobium is based on the production and trade of ferroniobium CN 72029 300 (Comext; Eurostat, 2019), which is the chief product that enters international trade. Primary extraction of niobium ores and concentrates does not take place in Europe, nor does the production of ferroniobium. Therefore, the EU is entirely reliant on imports of ferroniobium to meet its current demand.

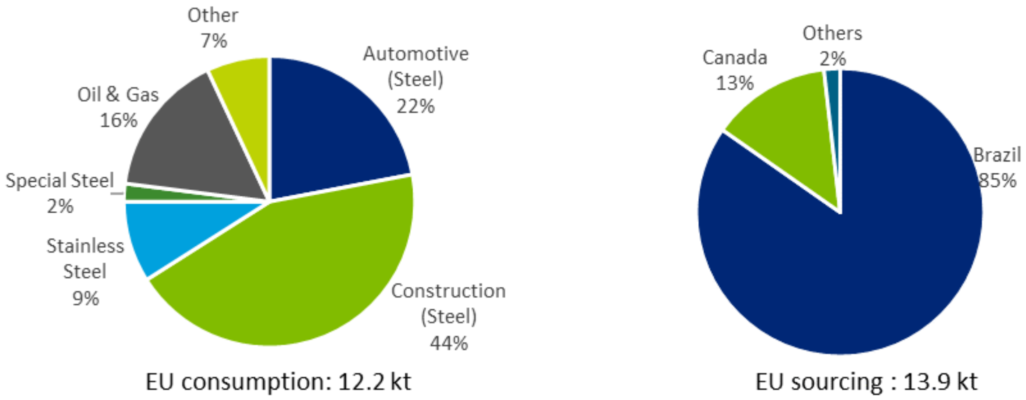

Figure 215: End uses (CBMM 2019) and EU sourcing of Ferroniobium (average 2012-16) (Comext; Eurostat, 2019).

Niobium market is small and applications are relatively new. Niobium only became available commercially in the 70's after the Araxa deposit, in Brazil was opened (CBMM, 2019). The global capacity is higher than the current demand. Ferroniobium is not openly traded on any metal exchange. Niobium concentrates (min 50% Nb_2O_5) price was 26.30 US$/kg in average on the period 2014-2018. Niobium pentaoxide (min 99.5%) price was 35.44 US$/kg in average on the period 2014-2018 (DERA, 2019).

The EU demand of ferroniobium was on average 12.2 kt between 2012 and 2016. EU is 100% import dependent of ferroniobium. Brazil is the main exporting country to the EU accounting with 85% of the EU imports averaged over 2012-216.

Niobium is mostly consumed in the production of ferroniobium (containing around 65% niobium), which is an important component in high strength low alloy (HSLA) steels used to make car bodies, gas pipelines and ship hulls. It is also used in the manufacture of superconducting magnets, carbide-based cutting tools, high-performance glass coatings and superalloys. Metals such as vanadium, molybdenum, tantalum and titanium may substitute for niobium in the production of HSLA steel and superalloys.

Global Niobium resources are about 83,861 kt, but its production occurs almost exclusively in Brazil, which currently accounts for about 96 % of all global resources. Ten members states are known to have niobium resources.

Global extraction of niobium ores and concentrates takes place in eleven countries; more than 92 % of world production taking place in Brazil, followed by Canada 6 %, Russia, Burundi, Democratic Republic of Congo, Madagascar, Nigeria, Rwanda, and China which account for the remaining 1 % of worlds production (WMD, 2019). Average global production of ferroniobium during the 2012-2016 period was almost 42.5 kt per annum (average 2012 to 2016). Ferroniobium production only took place in three countries, Brazil (91.7 %), Canada (8.3 %) and Russia (less than 0.1%). Functional recycling of Niobium is very minor. The EOL-RIR was estimated at 0.3% (BIO Intelligence Service 2015).

No trade restrictions exist for ferroniobium. In its native form niobium is fairly inert and poses few, if any, environmental or human health issues.

18.2 Market analysis, trade and prices

18.2.1 Global market analysis and outlook

Niobium only became available commercially in the 70's after the Araxa deposit, in Brazil was opened. The capacity is higher than the demand, plus CBMM has created stockpiled amounts in the EU to prevent shortages (CBMM 2019).

The use of ferroniobium in the production of HSLA steel means that future demand is likely to be driven by the construction and automotive sectors, particularly in rapidly developing countries such as China and India. Ferroniobium production is likely to remain concentrated in Brazil; however, the Araxá niobium deposit, owned by CBMM, has a history of increasing production to meet long-term market demand (Linnen, et al., 2014). Global resources of niobium are estimated as 83,861 kt, therefore significant potential exists for supply to become diversified if advanced projects (Table 97) in other parts of the world e.g. in Australia come to fruition.

Table 97: Qualitative forecast of supply and demand of niobium

Materials	Criticality in 2020		Demand forecast			Supply forecast		
	Yes	No	5 years	10 years	20 years	5 years	10 years	20 years
Niobium	x		+	+	+	+	+	+

Even if several sources (Tercero et al., 2018) pointed out an increase in the demand of Niobium, in particular in the transportation sector, there are however contradictory estimates showing the decrease of Niobium demand in the EU. SCRREEN deliverable D2.3 refers that if there will be no substitution of different high strength steel alloys with niobium high strength alloys the development of niobium is mostly influenced by a reduction in the use of fossil fuels, in the EU. This will reduce the demand of niobium in gas turbines, gas pipelines and internal combustion engines (Tercero et al., 2018).

18.2.2EU trade

Niobium is not traded in the form of ores and concentrates, but rather processed materials such as ferroniobium or niobium metal. According to BIO Intelligence Service (2015), ferroniobium is not produced in the EU. During the period 2012–2016, the EU is entirely reliant on imports for its supply, with an average net import of about 11.3 kt per annum during the period 2012–2016 (Eurostat 2019b).

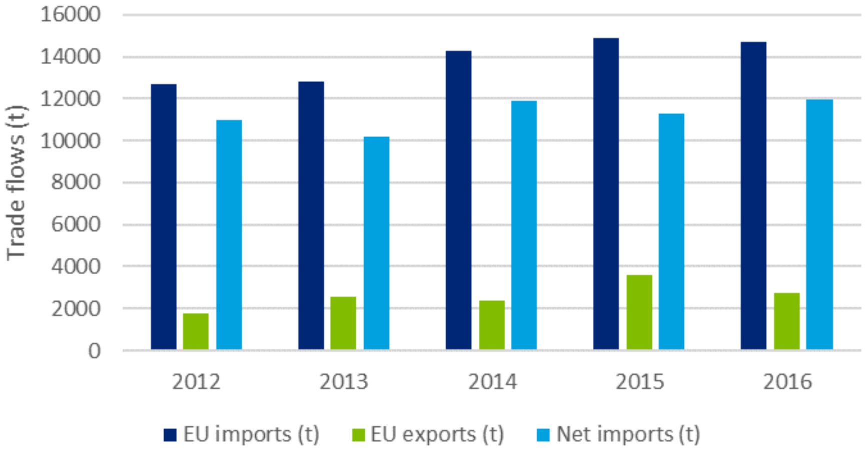

Figure 216: EU trade flows for ferroniobium, data from (Eurostat 2019b).

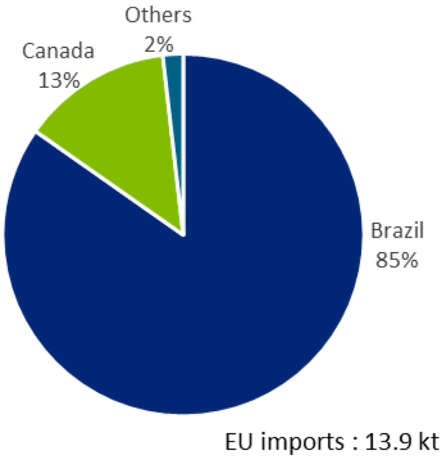

Figure 217: EU imports of ferroniobium, 2012-2016 (Eurostat 2019b).

Imports and export to and from the EU have fluctuated slightly during the 2012–2016 period, with a gently increasing trend observed since 2012. Almost 98% of all EU imports of ferroniobium come from only two countries, namely Brazil (84%) and Canada (13%).

Regarding trade agreements in 2019 the EU was the first major partner to strike a trade pact with Mercosur, a bloc comprising Argentina, Brazil Paraguay and Uruguay. In 2016 the EU signed also the EU-Canada Comprehensive Economic and Trade Agreement.

18.2.3Prices and price volatility

Ferroniobium is not openly traded on any metal exchange; contract prices are negotiated between buyer and seller and generally remain confidential (BGS, 2011). DERA reports prices for Niobium concentrates and Niobium pentaoxide (DERA, 2019), see Figure 218:

- Niobium concentrates (min 50% Nb_2O_5) price was 26.30 US$/kg in average on the period 2014-2018. From October 2018 to September 2019 the price average was 26.23 US$/kg;
- Niobium pentaoxide (min 99.5%) price was 35.44 US$/kg in average on the period 2014-2018. From October 2018 to September 2019 the price was average was 35.75 US$/kg.

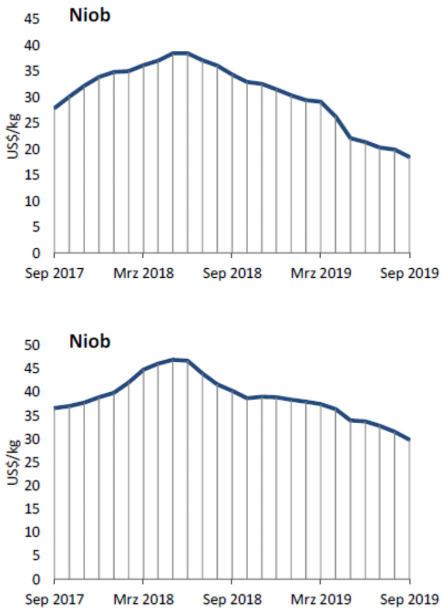

Figure 218: Price volatility of: top, Niobium concentrates (min 50% Nb_2O_5), botom, Niobium pentaoxide (min 99.5%) (DERA and BGR, 2019).

This shows a relatively stable period for Niobium prices contrasting the reported drop of more than 40% in 2015-2016 compared to the period 2011-2015 (European Commission 2017).

18.3 EU demand

18.3.1EU demand and consumption

Consumption of ferroniobium in the EU was about 12.2 kt per year during the period 2012–2016 (Eurostat, 2019b). None of this was produced within the EU. Therefore, the estimated import reliance is 100%.

18.3.2Uses and end-uses of niobium in the EU

Global and EU end-uses and of niobium are shown in Figure 219 and relevant industry sectors are described using the NACE sector codes in Table 98.

Globally about 90% of niobium (in the form of ferroniobium, in2017) is used in the production of HSLA steels. In the EU this amount accounts for 93% of the applications. Niobium is an important additive in steel for two reasons: (1) it increases strength by refining the microstructure and by forming nano-particle; and (2) the strength increases it gives allow weight savings in the final product. According to CBMM (CBMM, 2019) in the EU about 22% of niobium is used in the production of automotive vehicles, 18% used in the production of super alloys for gas and oil pipelines and turbines and 24% is used in steel for construction. However, it is not known how much of this niobium is used in high strength steel and which part of the niobium is used in super alloys in the exhaust systems.

Other uses include Niobium-bearing alloys and chemicals. These alloys may contain significant quantities of niobium and are typically used in high-performance, or specialised applications where traits such as corrosion resistance and high-strength at high operating temperatures are sought. These alloys are also used in the nuclear industry (e.g. reactor parts) and space industry. Other alloys of niobium include niobium-titanium and niobium-tin alloys, which are used to manufacture the superconducting magnets fund in MRI (Magnetic Resonance Imaging) scanners (BGS, 2011).

Niobium-based chemicals have unique optical, piezoelectric (i.e. the ability to generate an electric charge in response to mechanical stress) and pyroelectric (i.e. the ability to generate an electric charge in response to heating or cooling) properties that are sought after in several high-technology applications. For example, high-purity niobium oxide is used in the production of high-refractive index glass used in the manufacture of camera lenses. Compounds such as lithium niobate are used in the production of capacitors and surface acoustic wave filters, which are used in the manufacture of mobile phones and other touch screen devices. Niobium nitride is also used in the production of superconducting magnets found inside MRI scanners (T.I.C., 2019).

Another important use of niobium is in the production of niobium carbides. These are extremely-hard, ceramic substances which are produced by sintering niobium powder with carbon at high-temperature. They are resistant to wear and high-temperature and are therefore used to produce hard cutting tools (e.g. industrial high-speed cutting tools) and refractory coatings that are used in nuclear reactors and industrial furnaces (BGS, 2011).

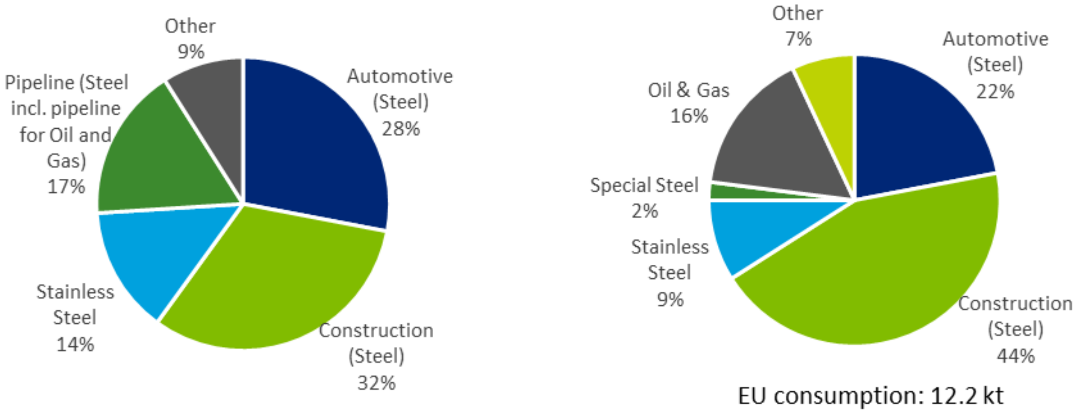

Figure 219: Global end uses in 2017 (left, (CBMM, 208)) and EU end uses (right, (CBMM, 2019)) of niobium, averaged over 2012-2016.

Producers are still researching new applications for this metal. Future uses include also the application of niobium in battery applications and a new application of niobium in aluminium alloys as a grain refiner (here Al-TiB alloys will be replaced).

The calculation of economic importance is based on the use of the NACE 2-digit codes and the value added at factor cost for the identified sectors (Table 98).

Table 98: Niobium applications, 2-digit NACE sectors, associated 4-digit NACE sectors, and value added per sector (Data from (Eurostat, 2019a)).

Applications	**2-digit NACE sector**	**4-digit NACE sector**	**Value added of sector (millions €)**
Automotive (Steel)	C29 - Manufacture of motor vehicles, trailers and semi-trailers	C2910 Manufacture of motor vehicles	160 603
Construction (Steel)	C25 - Manufacture of fabricated metal products, except machinery and equipment	C2511 Manufacture of metal structures and parts of structures	148 351
Oil & Gas	C24 - Manufacture of basic metals	C2420 Manufacture of tubes, pipes, hollow profiles and related fittings, of steel.	55 426
Stainless steel	C24 - Manufacture of basic metals	C2420 Manufacture of tubes, pipes, hollow profiles and related fittings, of steel.	55 426
Special steel	C30 - Manufacture of other transport equipment	C3030 Manufacture of air and spacecraft and related machinery	44 304
Superconductors[178]			

18.3.3Substitution

The main use of niobium is in steel alloys because niobium enhances the steels' mechanical strength, toughness, high temperature strength, and corrosion resistance. These characteristics make niobium an important material in the production of steel for automotive, construction and energy industries. According with different sources several materials can be substituted for niobium in the production of HSLA steel and superalloys: vanadium, molybdenum, tantalum, titanium, tungsten, ceramic matrix composites and gallium alloys ((USGS, 2019), (Tercero et al., 2018), (CRM_InnoNet, 2013)). However, assuming 1:1 substitution in alloys is overly simplistic, for the simple reason that the properties of a given alloy are not controlled by a single metal, but rather by several metals. In addition, each metal may produce a range of effects in the alloy. For example, niobium is used in combination with small amounts of several other metals, including, but not limited to chromium, nickel, copper, vanadium, molybdenum, titanium, calcium, rare earth elements and zirconium, in the production of HSLA steel. The interaction between these additions is complex, but they can be used to modify properties such as strength, toughness, corrosion resistance and formability (Beta Technology, 2016). Therefore, it cannot be reasonably assumed that the increased addition of one of these metals in the absence of niobium would produce a steel with the same properties.

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[178] Included in Others (7%) according to CBMM and redistributed among the other applications

Any substitution would be associated with a price and/or performance penalty. In general, there appears to be little economic or technical incentive to substitute niobium in its principal applications.

18.4 Supply

18.4.1 EU supply chain

Niobium ores and concentrates are not mined in the EU, nor are they traded within the EU. Ferroniobium is also not produced in the EU, meaning the EU is entirely reliant on ferroniobium imports to meet demand. However, specialist niobium-based alloys (e.g. superalloys) and chemicals (e.g. lithium niobate) are manufactured in Europe, although it is difficult to quantify how much ((BIO Intelligence Service, 2015), (Beta Technology, 2016)). NPM Silmet (Estonia) is a European refiner of niobium producing highly pure niobium. Figure 220 depicts the flows of niobium within the EU economy.

Ferroniobium is primarily used in the production of HSLA steels, with the majority (about 11,000 t) of EU imports going to only eight countries: Austria, Belgium, Germany, France, Finland, Italy, Spain and Sweden. Germany is the largest steel producer in Europe (World Steel Association, 2018) and therefore accounts for the greatest share of ferroniobium imports.

There are currently no export quotas placed on ferroniobium exported to the EU from other countries. However, ferroniobium exports from China entering the EU are subject to an export tax of between 25 and 75% (OECD, 2019).

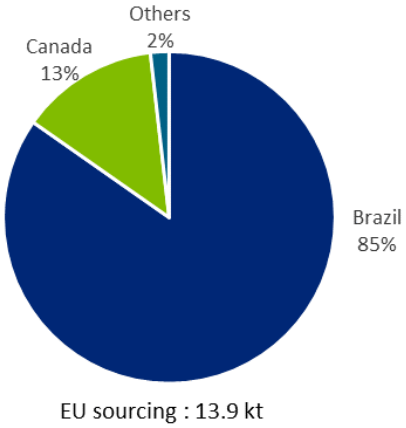

Figure 220: EU sourcing (domestic production + imports) of ferroniobium, average 2012-2016 (Eurostat, 2019b), (WMD 2018).

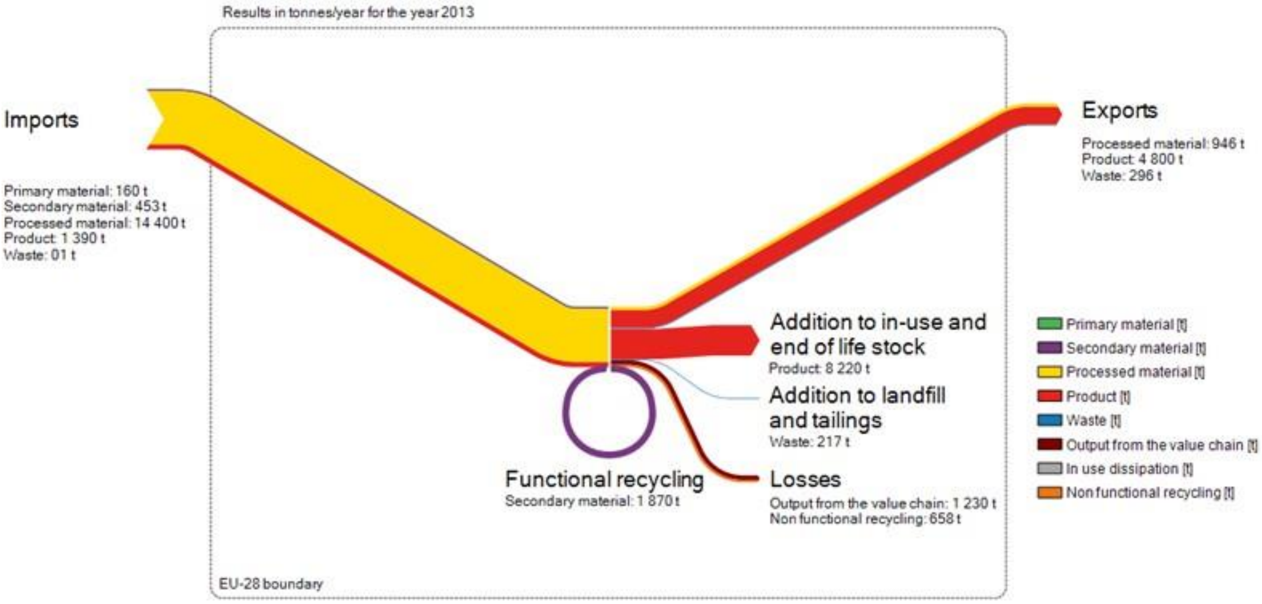

Figure 221: Sankey diagram showing the material flows of niobium in the EU economy in 2013 ((BIO Intelligence Service, 2015))

18.4.2Supply from primary materials

18.4.2.1 Geological occurrence/exploration

Niobium deposits are most commonly associated with peralkaline granites or syenites, and/or carbonatites (i.e. an igneous rock that consists of more than 50% primary carbonate minerals). Secondary deposits of niobium, such as laterites, and residual placers, typically form by the weathering of igneous deposits (Dill, 2010). An overview of these deposits is given in Table 99.

Niobium deposits associated with peralkaline granites and syenites are typically less than 100 Mt in size (BGS, 2011) and have ore grades of between 0.1 and 1 wt. % Nb_2O_5, contained in ore minerals such as columbite, eudialyte and loparite. Alkaline magmas responsible for the formation of these deposits are derived by melting of enriched sub-continental lithospheric mantle and are typically enriched in the High Field Strength Elements (HFSE) (i.e. niobium, zirconium and rare earth elements). These incompatible (i.e. elements that become concentrated in molten magma rather than early crystallising solid minerals) HFSE are further upgraded by magmatic (e.g. fractional crystallisation) and/or hydrothermal processes (BGS, 2011).

Carbonatite-hosted niobium deposits can be divided into primary and secondary deposit types. Primary deposits are generally in the tens of millions of tonnes size range and typically have ore grades of less than 1 wt. % Nb_2O_5. Carbonatites are found in areas of crustal extension or rifting and are thought to be derived from direct melting of the mantle. They are enriched in HFSE (e.g. niobium, zirconium and rare earth elements), but also barium, strontium, thorium and uranium. Important ore minerals in these rocks include perovskite and pyrochlore, and niobium-rich silicates such as titanite (BGS, 2011). Secondary niobium deposits are associated with deep, tropical weathering of carbonatites and are typically very large (up to 1 000 Mt) and have very high ore grades (up to 3 wt. % Nb_2O_5 in lateritic deposits, but as high as 12 wt. % Nb_2O_5 in some residual placers). Pyrochlore is the most common ore mineral in these secondary ore deposits (BGS, 2011).

Table 99: Summary of important niobium deposit types (BGS, 2011)

Deposit type	Brief description	Typical grades and tonnage	Major examples
Carbonatite-hosted primary deposits	Niobium deposits found within carbonatitic igneous rocks in alkaline igneous provinces	Niobec, proven & probable reserves: 23.5 Mt at 0.59% Nb_2O_5	Niobec, Canada; Oka, Canada
Carbonatite-sourced secondary deposits	Zones of intense weathering or sedimentary successions above carbonatite intrusions in which niobium ore minerals are concentrated	< 1 000 Mt at up to 3% Nb_2O_5 in lateritic deposits. Up to 12% Nb_2O_5 in placer deposit at Tomtor, tonnage not known	Araxá and Catalǎo, Brazil; Tomtor, Russia; Lueshe, DRC
Alkaline granite and syenite	Niobium and lesser tantalum deposits associated with silicic alkaline igneous rocks. Ore minerals may be concentrated by magmatic or hydrothermal processes	Generally < 100 Mt, at grades of 0.1 to 1% Nb_2O_5 and < 0.1% Ta_2O_5	Motzfeldt and Ilímaussaq, Greenland; Lovozero, Russia; Thor Lake and Strange Lake, Canada; Pitinga, Brazil; Ghurayyah, Saudi Arabia; Kanyika, Malawi

18.4.2.2 Resources and reserves

Global resources of niobium are about 84 Mt, but occur almost exclusively in Brazil (see Table 100), which currently accounts for about 96% of all global resources (Linnen et al., 2014). World resources of niobium are more than adequate to supply global projected needs (Padilla et al., 2019).

Known global reserves of niobium (as Nb) are estimated to be more than 9,100 kt (Table 100). There are no data about niobium reserves in Europe in the Minerals4EU (2019) website.

Table 100: Global resources in 2014 (measured and indicated*) (Linnen et al., 2014)and reserves (proven and probable) of niobium in 2018 (Padilla, 2019)

Country	Niobium(Nb_2O_5 content) Resources (kt)	Niobium(Nb content) Reserves (kt)
Brazil	78,133	7,300
Canada	3,005	1,600
Australia	165	N.A.
China	2,200	-
Egypt	4	-
Malawi	174	-
Mozambique	52	-
United States	129	180
*World total ***	*83,861*	*>9,100*

* Inferred resources are also reported in Brazil, Gabon, Kenya, Canada, Tanzania, Ethiopia, Saudi Arabia, Spain, Angola, Mozambique and the USA.

** Some deposits are omitted because no reliable reserve or resource data are available.

Table 101: Resource data for the EU compiled in the European project SCRREEN Deliverable 3.1 ((Lauri, 2018))

Country	Quantity (Mt of P_2O_5)	Location
Austria	No information	Occurrences associated with granitic pegmatites, which contain niobium
Czech Republic	No information	Occurrences mainly related to granitic pegmatites that contain Nb and Ta minerals
Finland	250 Mt of ore at 0.21 % Nb	Sokli P-Fe-Nb deposit
	8.15 Mt of ore with Nb oxide contents ranging from 0.12 % to 0.76 % and a calculated total amount of 13 000 t Nb_2O_5	Jokikangas, Katajakangas and Kontioaho
France	1 860 t of Nb_2O_5	Tréguennec deposit
	No information	There are other Nb and Ta-bearing mineral occurrences in France, which are mostly in granitic pegmatites
Germany	No information	Deposits and occurrences hosted by granitic and alkaline rocks
Italia	No information	There are over ten Nb-Ta occurrences in Italy that are hosted by granitic pegmatites.
Malta	No information	One sedimentary phosphorite occurrence
Netherlands	No information	Two sedimentary phosphorite occurrence
Portugal	350 t Nb_2O_5	Almendra deposit
Slovakia	No information	Four deposits with both niobium and tantalum as the main commodities, which are hosted by granitic pegmatites

18.4.2.3 World mine and refining production

Global extraction of niobium ores and concentrates takes place in 11 countries and averages 90.0 kt per annum over the period 2012-2016 and 81.7 kt in 2017. However, production is heavily concentrated, with about 92 % of world production taking place in Brazil. Canada accounts for about 6 % of the global total and nine countries, Russia, Democratic Republic of Congo, Rwanda, Nigeria, Burundi, China, Ethiopia, Mozambique and Uganda account for the remaining 2 % (WMD, 2019)

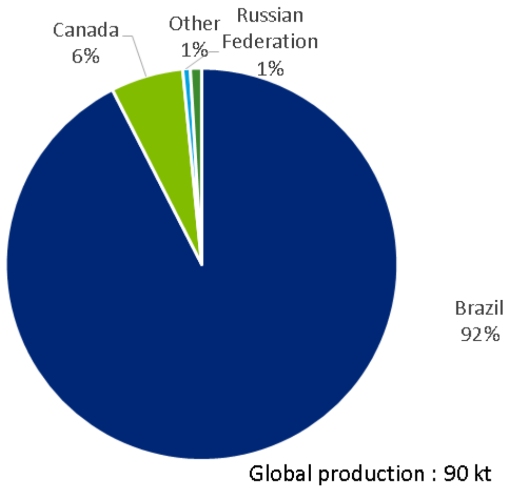

Figure 222: Global mining production of niobium, averaged over 2012-2016 (WMD, 2019).

With the exception of the African countries listed above, companies extracting niobium ores are typically integrated, meaning they also produce processed niobium products, such as niobium oxide, ferroniobium and niobium metal. Average global production of ferroniobium during the 2012-2016 period was almost 42.5 kt per annum (average 2012 to 2016). Figure 223 shows global ferroniobium production only took place in only two countries, Brazil and Canada.

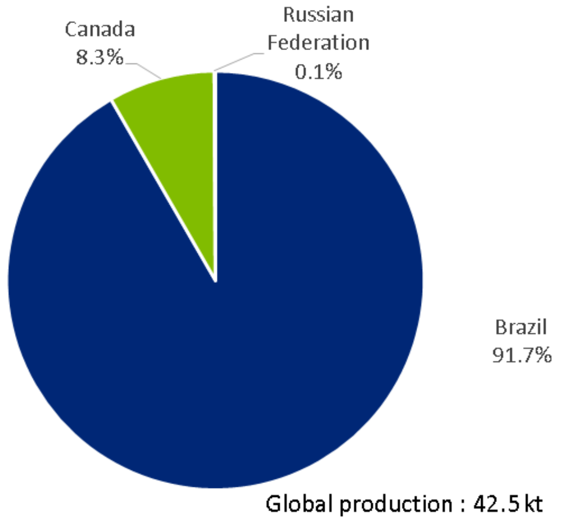

Figure 223: Global production of ferroniobium, averaged over 2012-2016 (BGS, 2019).

The main companies producing Niobium are reported in Table 102. It is important to highlight that the largest deposit in the world is located in Araxa (Brazil) and is owned by Companhia Brasileira de Metalurgia e Mineracao (CBMM).

Table 102: The tree largest world producers of niobium (TIC, 2019).

Company	Mine site (location)
Companhia Brasileira de Metalurgia e Mineração (CBMM)	Araxa, Brazil
China Molybdenum previously owned by Anglo American Niobio Brasil	Catalao, Goias state, Brazil
IAMGOLD Corp	Niobec Mine in Quebec, Canada

18.4.3Supply from secondary materials/recycling

According to the United Nations Environment Programme (UNEP) the End of Life (EoL) recycling input rate for niobium, chiefly as a constituent of ferrous (e.g. steel) scrap, is greater than 50% (Reuter, 2013). However, the amount of niobium physically recovered from scrap (i.e. functional recycling) is negligible, with estimates by BIO Intelligence Service (2015) by Deloitte given at less than 1%, i.e. 0.3% (Validation workshop 2019). In 2018, Strategic Minerals Spain (SMS) started the processing of tailings from waste-rock heaps and ponds of the old Penouta mine leading to the obtaining of tantalum and niobium minerals through a gravimetric separation process, without any chemical products or waste that is harmful to the environment. It is estimated that the mineral resources in the remaining original deposit amount to 95.5 Mt of Measured and Indicated Mineral Resources with average grades of 77 ppm Ta and 443 ppm Sn, and in the old tailing waste-rock heaps where the company has started operations 12 Mt of resources with average grades of 35 ppm Ta and 428 ppm Sn[179].

Table 103: Material flows relevant to the EOL-RIR of Niobium, data from 2012 (BIO Intelligence Service, 2015)

MSA Flow	Value (t)
B.1.1 Production of primary material as main product in EU sent to processing in EU	0.00
B.1.2 Production of primary material as by product in EU sent to processing in EU	0.00
C.1.3 Imports to EU of primary material	159974.00
C.1.4 Imports to EU of secondary material	452702.00
D.1.3 Imports to EU of processed material	14368682.00
E.1.6 Products at end of life in EU collected for treatment	757471.00
F.1.1 Exports from EU of manufactured products at end-of-life	1284.00
F.1.2 Imports to EU of manufactured products at end-of-life	543.00
G.1.1 Production of secondary material from post consumer functional recycling in EU sent to processing in EU	43896.00
G.1.2 Production of secondary material from post consumer functional recycling in EU sent to manufacture in EU	0.00

18.4.4Processing of Niobium

Niobium is mainly mined as the primary ore. Near-surface niobium deposits are typically exploited by open-pit mining methods, which commonly involve removing overburden, digging or blasting the ore, followed by removal of the ore by truck or conveyor belt for stockpiling prior to processing. Deeply buried niobium deposits are mined underground using conventional mining methods, such as room and pillar, where mining progresses in a horizontal direction by developing numerous stopes, or rooms, leaving pillars of material for roof support. Ore is blasted and then transported by rail, conveyor or dump truck to the processing plant.

Regardless of the mining method employed niobium ores are first crushed in jaw, cone or impact crushers and milled in rod or ball mills operating in closed circuits with vibrating screens and screw classifiers to liberate niobium mineral particles. The slurry containing niobium and waste rock is further concentrated to around 54% niobium oxide using a number of methods in multiple stages: gravity separation, froth flotation, magnetic and electrostatic separation, and acid leaching may be used, depending on the physical and chemical characteristics of the ore (BGS, 2011).

Typically, niobium ores from carbonatite-associated deposits are screened, classified, and deslimed (i.e. removal of very fine particles). Carbonate material is removed by froth flotation, followed by an additional desliming stage. Magnetite is removed by low-intensity magnetic separation, and sent to waste. The sought-after pyrochlore is collected by froth flotation. A final stage of froth flotation is used to remove sulphides, such as pyrite. Residual impurities may be leached by hydrochloric acid, leaving a final concentrate that contains about 54% niobium pentoxide ((IAMGOLD, 2019); (BGS, 2011)).

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[179] Blengini, G.A.; Mathieux, F., Mancini, L.; Nyberg, M.; Viegas, H.M. (Editors); Salminen, J.; Garbarino, E.; Orveillon, G.; Saveyn, H.; Mateos Aquilino, V.; Llorens González, T.; García Polonio, F.; Horckmans, L.; D'Hugues, P.; Balomenos, E.; Dino, G.; de la Feld, M.; Mádai, F.; Földessy, J.; Mucsi, G.; Gombkötő, I.; Calleja,I. Recovery of critical and other raw materials from mining waste and landfills: State of play on existing practices, EUR 29744 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-08568-3, doi:10.2760/600775, JRC116131.

Niobium concentrates are further refined by hydrometallurgical processes to produce niobium fluorides, oxides or chlorides. These compounds can then be converted to niobium metal by electrometallurgical (e.g. electrolysis) or pyrometallurgical (e.g. aluminothermic reaction) processes. Ferroniobium, containing 65–66% niobium, is also produced by aluminothermic reaction, but with the addition of iron oxide powder. Niobium carbide is produced by high temperature sintering of niobium oxide powder with carbon (Albrecht, 1989;BGS, 2011).

18.5 Other considerations

18.5.1 Environmental and health and safety issues

In its native form niobium is fairly inert and poses few, if any, environmental or human health. No environmental or social problems were found for the production of niobium.

18.6 Comparison with previous EU assessments

Niobium criticality was also assessed in 2011, 2014 and 2017. It was always found to be a critical raw material, because the applications where niobium is used are of high economic importance to the EU and the supply is highly concentrated in Brazil (92% of global production, averaged over 2012-2016). However, the available resources are more than sufficient to cover supply and according with CBMM (2019) stockpiles were created for EU industry consumers to avoid any problems of supply.

The 2020 assessment has been conducted using the same methodology as for the 2017 list. The results of this and earlier assessments are shown in Table 104.

Table 104: Economic importance and supply risk results for niobium in the assessments of 2011, 2014, 2017, 2020 (European Commission, 2011), (European Commission, 2014),(European Commission, 2017)

Assessment	2011			2014			2017			2020	
Indicator	EI	SR		EI	SR		EI	SR		EI	SR
Niobium	8.95	2.80		5.87	2.46		4.8	3.1		6.0	3.9

Although it appears that the economic importance (EI) of niobium has reduced between 2014 and 2017 this is a false impression created by the change in methodology. The value added in the 2017 criticality assessment corresponds to a 2-digit NACE sector rather than a ‘megasector’, which was used in the 2011 and 2014 assessments. The economic importance figure is therefore reduced. The supply risk (SR) score is higher compared to the previous assessments, which is due to the revised methodology and the way the supply risk is calculated. Therefore, differences between 2014 and 2017 assessments are largely due to changes in methodology (as outlined above) and the form of the commodity that has been assessed, that is the most recent assessment was based on the production and trade of ferroniobium. The 2020 results show an increase of the EI due to a redistribution of the end se sectors, which better represent the applications of niobium in the EU industry. The value for supply risk suffers a small increase due to updates on the substitutes of niobium in comparison with the values of 2017.

18.7 Data sources

Production data for ferroniobium was based on BGS World mineral statistics data (Beta Technology, 2016). EU trade data were taken from the Eurostat COMEXT online database (Eurostat, 2019b) using the Combined Nomenclature (CN) code 7202 9300 (ferroniobium). Data were averaged over the five-year period 2010–2014 inclusive.

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