

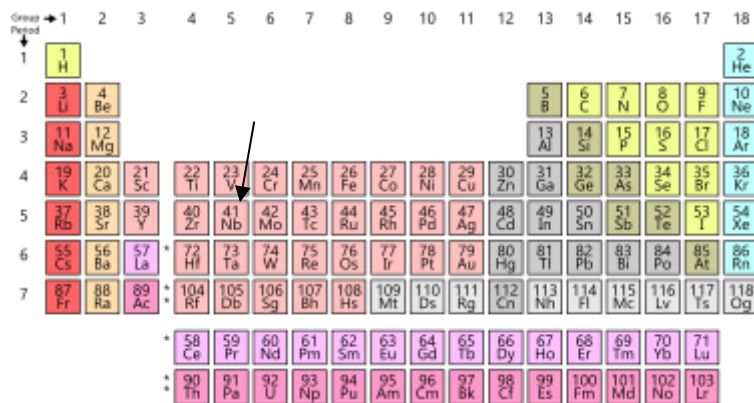
Niobium: A Strategic Metal

eResearch Corporation is pleased to provide its overview of the niobium industry.

NIOBIUM



The chemical element, niobium, has the symbol “Nb” and atomic number “41”.



Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Period 1	1 H																	2 He	
Period 2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
Period 3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
Period 4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
Period 5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
Period 6	55 Cs	56 Ba	57 La	* 72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	
Period 7	87 Fr	88 Ra	89 Ac	* 104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og	
			* 58 Ce 59 Pr 60 Nd 61 Pm 62 Sm 63 Eu 64 Gd 65 Tb 66 Dy 67 Ho 68 Er 69 Tm 70 Yb 71 Lu																
			* 90 Th 91 Pa 92 U 93 Np 94 Pu 95 Am 96 Cm 97 Bk 98 Cf 99 Es 100 Fm 101 Md 102 No 103 Lr																

OVERVIEW

Niobium used to be known as columbium. Niobium was officially adopted as the name of the element in 1950, but the name columbium remains in current use in metallurgy in the United States.

Niobium and tantalum are nearly always found together in nature.

It was not until the early 20th century that niobium was first used commercially.

Niobium is used mostly in alloys, the largest part in special steel such as that used in gas pipelines. Although these alloys contain a maximum of 0.1%, the small percentage of niobium enhances the strength of the steel. The temperature stability of niobium-containing super-alloys is important for its use in jet and rocket engines.

Niobium is used in various super-conducting materials. These super-conducting alloys, also containing titanium and tin, are widely used in the super-conducting magnets of MRI scanners.

Other applications of niobium include welding, nuclear industries, electronics, optics, coins, and jewellery.

NIOBIUM FACTS

Niobium is a shiny, white metal that typically forms a film on its surface when exposed to air, turning shades of blue, green, or yellow. It has a wide range of uses including hypo-allergenic jewellery to jet engines to super-conducting magnets.

Niobium is considered a technology-critical element.

While some compounds of niobium dust can cause eye and skin irritation, there are no known cases of any serious effects of working with niobium. There are also no known environmental effects of niobium.

ATTRIBUTES OF NIOBIUM

Niobium is a soft, grey, crystalline, ductile metal often found in the minerals pyrochlore and columbite.

Pyrochlore is a mineral group of the niobium end member of the pyrochlore super-group. Pyrochlores are an important class of materials with diverse technological applications, such as in luminescence, ionic conductivity, nuclear waste immobilization, high temperature thermal barrier coatings, automobile exhaust gas control, catalysts, solid oxide fuel cell, and ionic/electric conductors.

Columbite is a black mineral group that is an ore of niobium.

PHYSICAL ATTRIBUTES

Niobium is a lustrous, grey, ductile, paramagnetic metal. It becomes a super-conductor at very low temperatures. At atmospheric pressure, it has the highest critical temperature of the elemental super-conductors.

Niobium has the greatest magnetic penetration depth of any element. The super-conductive properties are strongly dependent on the purity of the niobium metal. When very pure, it is comparatively soft and ductile, but impurities make it harder.

The metal is used in the nuclear industries where neutron transparent structures are required.

NIOBIUM AS A RARE METAL

Niobium is quite rare. It is estimated to be the 34th most common element in the Earth's crust. Its abundance on Earth could be much greater, such that the element's high density could be concentrated in the Earth's core.

The free element is not found in nature. However, niobium occurs in combination with other elements in minerals. Minerals that contain niobium often also contain tantalum.

NIOBIUM AS A STRATEGIC METAL

Niobium has been declared a “strategic metal” by the U.S. government, with stockpiling recommended for niobium along with other strategic metals.

WORLD RESOURCES

World resources of niobium are more than adequate to supply projected needs. Most of the world’s identified resources of niobium occur as pyrochlore in deposits of carbonatite (igneous rocks that contain more than 50% by volume of carbonate minerals).

World Mine Production & Reserves

	** Mine Production**		Reserves
	2017	2018E	2018
Brazil	60,700	60,000	7,300,000
Canada	6,980	7,000	1,600,000
United States	0	0	180,000
Other Countries	<u>1,410</u>	<u>1,000</u>	<u>N/A</u>
TOTAL	69,090	68,000	9,080,000

Source: U.S. Geological Survey, Mineral Commodity Summaries, February 2019

USES FOR NIOBIUM

Niobium is primarily used by the steel industry to increase strength, toughness, corrosion resistance, as well as reduce the weight of alloy products.

Niobium is used by the aerospace industry in nickel-, cobalt-, and iron-based super alloys. Niobium-geranium, niobium-tin, and niobium-titanium alloys are used in super-conducting magnets for magnetic resonance imaging instruments and in particle accelerators.

Other promising uses for niobium at an early stage of development and discovery include significantly increasing the recharging speed of lithium-ion batteries, and in developing the field of quantum computing.

APPLICATIONS

An estimated 90% of world production of niobium is used in high-grade structural steel.

The second largest application is super-alloys. However, niobium alloy super-conductors and electronic components account for a very small amount of world production.

STEEL PRODUCTION

Niobium is an effective micro-alloying element for steel. Within steel, it forms niobium carbide and niobium nitride, and these compounds improve the grain refining, as well as retard recrystallization and precipitation hardening. These effects, in turn, increase its toughness, strength, and corrosion-resistance, as well as its ability to be formed and welded.

Within micro-alloyed stainless steels, the amount of niobium is a small but it is an important addition to high-strength low-alloy steels that are widely used structurally in modern automobiles.

Niobium is sometimes used in considerably higher quantities for highly wear-resistant machine components and knives. These same niobium alloys are often used in pipeline construction.

SUPER-ALLOYS

Niobium is used in nickel-, cobalt-, and iron-based super-alloys, in proportions as great as 6.5%, for such applications as jet engine components, gas turbines, rocket sub-assemblies, turbo charger systems, and heat resisting and combustion equipment.

OTHER USES

Niobium is used in other applications in addition to the two main uses described above.

Gas Pipelines

Niobium plays an important role in the production of oil and gas transmission pipelines. Transporting oil and gas to market from rugged and remote locations requires transmission pipelines to operate at high pressures and with improved toughness over a variety of temperature ranges. The need for specialized steel tubing to meet the growing demand for energy resources has put additional focus on niobium for its ability to retard recrystallization at elevated temperatures. This ability has added a new form of processing of cylindrical tubing to meet American Petroleum Institute (API) standards for pipe called High Temperature Processing or HTP. The benefits of using a HTP niobium micro-alloy approach includes reduced operating cost per ton, ease of rolling and welding, excellent low temperature toughness properties, and high strength.

Electro-Ceramics

Lithium niobate is used extensively in mobile telephones and optical modulators. Niobium is added to glass to obtain a higher refractive index, which allows for the manufacture of thinner and lighter corrective eye-glasses.

Medicine and Jewellery

Niobium and some niobium alloys are functionally inert and hypo-allergenic and, therefore, niobium is used in prosthetics and implant devices, such as pacemakers.

Because niobium oxidizes in the Earth's atmosphere very slowly, it is used in jewellery as a hypo-allergenic alternative to nickel. Niobium is highly prized in the jewellery business as it can be heated to produce a wide array of iridescent colours.

Numismatics

Niobium is used as a precious metal in commemorative coins, often with silver or gold. In 2011, the Royal Canadian Mint started production of a \$5 sterling silver and niobium coin named *Hunter's Moon* in which the niobium was selectively oxidized, thus creating unique finishes where no two coins were exactly alike.

NIOBIUM RESEARCH

Niobium, due to its variety of properties, is used in several areas of research, including creating magnets. One of the strongest super-conducting magnets in the world uses niobium alloy wires, such as niobium-tin and niobium-titanium.

One such use for a super-conducting magnet is in magnetic resonance imaging (MRI) or spectroscopy (MRS). The super-conducting magnet uses niobium-titanium wire coils to create an initial magnetic field and additional coils of niobium-tin wire to create a secondary magnetic field. The two fields combine to create a stronger magnetic field than the more traditional niobium-titanium super-conducting magnet.

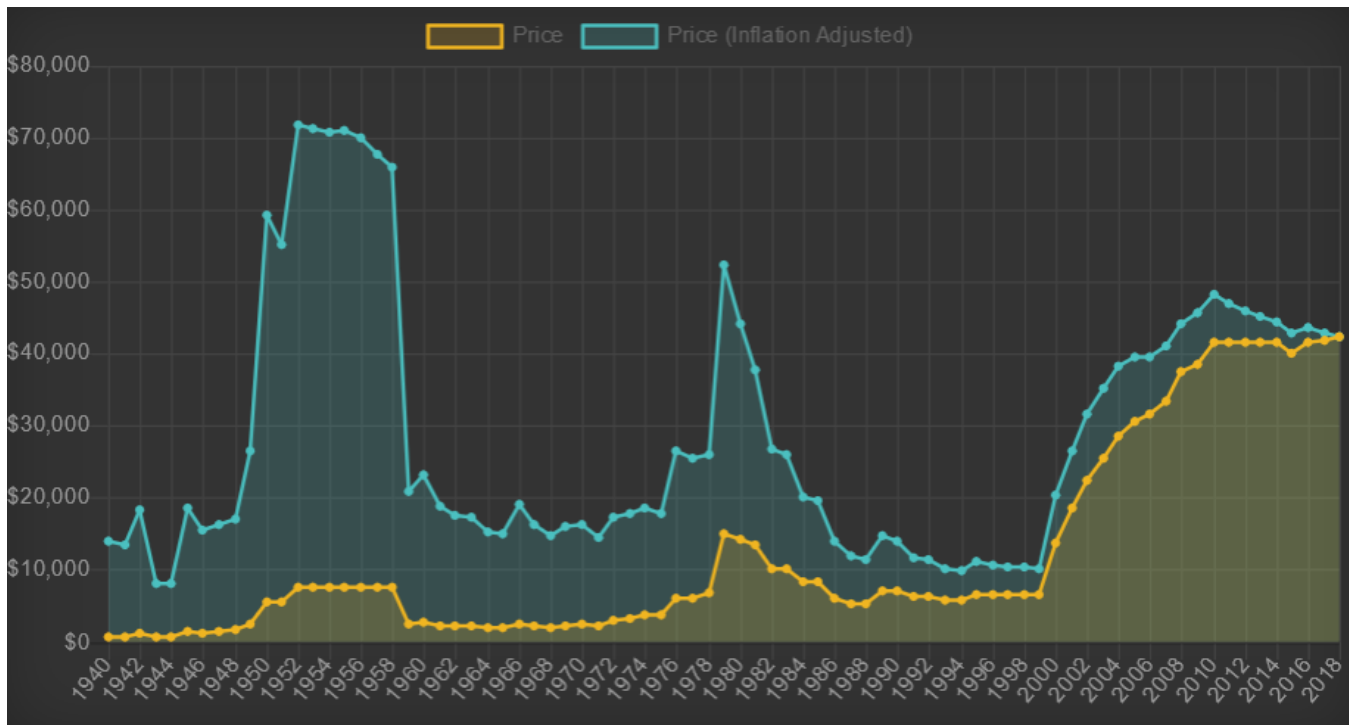
NIOBIUM PRICING

The primary use of niobium is in steelmaking, in particular, the production of high-grade structural steel and super-alloys. The steel industry accounts for an estimated 90% of niobium use globally. As a result, the trend for its consumption, and its price, will likely follow the trend in steel production. However, there is a caveat, which is that only about 10% of steel products use niobium and, therefore, it should not be assumed that consumption trends and price influence will automatically follow the trends in steel manufacturing.

The buying and selling of niobium in the open market is somewhat sporadic. Over the last eight years, the average price of niobium (in FeNb) has been around US\$41.50 per kilogram, or US\$41,500 per gram.

The long-term price history of niobium has been extremely volatile, as would be expected for a rare metal without many large-scale uses.

The following chart, courtesy of Metalary, shows the price history for niobium since 1940. Despite the longer-term volatility, the niobium price has been very stable since 2010.



Source: www.metalary.com/niobium-price

NIOBIUM MINES

There are only three known mines in the world that are currently mining niobium as the primary ore. Two of these are in Brazil, which produces about 90% of world output, and the third is an underground mine in the Province of Québec.

These mines were founded in the 1950s, and they are still the major producers of niobium mineral concentrates.

1. Brazil

Together, the two large mines in Brazil produce about 88% of the world's supply. Brazil also has a large but still unexploited deposit in the state of Amazonas, as well as a few smaller deposits, notably in the state of Roraima.

2. Canada

The third largest producer of niobium is the carbonatite-hosted Niobec mine, near Chicoutimi, Quebec, which is owned by Magris Resources. It produces between 7% and 10% of the world's supply.

Magris Resources Inc. is a private company founded by ex Barrick Gold Corp. CEO Aaron Regent. Mr. Regent has some partners in his venture, which include Singapore's Temasek Holdings Private Limited ("Temasek") and Hong Kong-based CEF Holdings Ltd. Temasek is an investment holding company based in Singapore and owned by the Government of Singapore. CEF is an investment company 50% owned by Canadian Imperial Bank of Commerce and 50% by billionaire Li Ka-shing's Cheung Kong Holdings Ltd.

Magris Resources purchased the Niobec mine from IAMGOLD Corporation in 2015 for US\$530 million.

3. United States

In the United States, NioCorp Developments Ltd. is developing its Elk Creek project in south-east Nebraska with an underground mine and an associated manufacturing facility. NioCorp has completed a Feasibility Study and has obtained all required Federal permits. The mine life is estimated to be 36 years. Initial production is currently earmarked for April 2021. When operable, the project will be the only niobium mine and primary niobium processing facility in the United States.

COMPARABLES

Set out below is a select list of publicly-quoted niobium companies, ranked by market capitalization. A brief description of each company follows on the next page.

Selected Companies Engaged In Niobium Industry

<u>Company</u>	<u>Symbol</u>	<u>Recent Price</u>	<u>Shares O/S (million)</u>	<u>Market Cap (million)</u>	<u>200-Day Average Shares Traded</u>
Neo Performance Materials	TSX: NEO	\$11.18	39.1	\$437.1	59,720
NioCorp Developments	TSX: NB	\$0.78	231.5	\$180.6	89,060
Taseko Mines	TSX: TKO	\$0.56	221.8	\$124.2	159,430
Commerce Resources	TSXV: CCE	\$0.14	310.5	\$43.5	24,100
Niobay Metals	TSX: NBY	\$0.36	45.7	\$16.5	25,600
Plato Gold	TSX: PGC	\$0.02	204.4	\$4.1	62,150
Niocan Inc.	TSXV: NIO	\$0.13	26.0	\$3.4	3,000
Saville Resources	TSX: SRE	\$0.03	63.4	\$1.9	134,700

Source: eResearch and Companies

COMPANY DESCRIPTIONS

Neo Performance Materials Inc. is involved in the innovation and manufacturing of rare earth and rare metal-based functional materials, which are essential inputs to high technology, high growth, future-facing industries. The rare metal-based products produced include the following: niobium, tantalum, indium, gallium, rhenium, and hafnium. These specialty materials are used for numerous applications and include clean energy technologies, consumer electronics, energy efficient lightning, computer applications, advanced communications and satellites, and healthcare technologies.

NioCorp Developments Ltd. is developing the Elk Creek super-alloy materials project in southeast Nebraska that will produce niobium, scandium, and titanium. Niobium is used to produce super-alloys as well as high strength, low alloy ("HSLA") steel, which is a lighter, stronger steel used in automotive, structural, and pipeline applications. The Elk Creek Project is North America's only niobium / scandium / titanium project, and it is the highest-grade niobium project in North America. It is also one of the largest prospective producers of scandium in the world. Once in production, it will initiate the first production in the U.S. in decades of niobium and scandium. All three of the Project's proposed super-alloy metals have been designed as "critical minerals" by the U.S. Government.

Taseko Mines Limited acquires, develops, and operates mineral properties in Canada and the United States. The company explores for copper, molybdenum, gold, niobium, and silver deposits. It holds a 75% interest in the Gibraltar copper-molybdenum mine located in south-central British Columbia. The company also has interests in the Aley niobium, Harmony gold, and New Prosperity copper-gold projects situated in British Columbia; and the Florence copper project located in Arizona.

Commerce Resources Corp. is an exploration stage company that engages in acquisition, exploration, development, and evaluation of mineral resource properties in British Columbia and Quebec, Canada. Its primary focus is on its exploration activities with respect to tantalum and niobium. The company's Blue River Tantalum/Niobium Project is made up of three major anomalous deposits known as the Upper Fir, the Fir, and the Verity. The company's Carbo Claims consist of five mineral claims that are located approximately 80 kilometers northeast of Prince George, British Columbia, Canada. The Carbo Claims cover a series of niobium and rare earth element bearing, dike- or sill-like carbonatites, and syenites.

Niobay Metals Inc. acquires, explores for, and evaluates mineral properties in Canada. Its main exploration focus is on the "green critical metals" and, in particular, its search for niobium and tantalum deposits. The company holds a 100% interest in the James Bay Niobium property that covers an area of 2,530 hectares located in the James Bay Lowlands of Ontario. The Company received its exploration permit for this project in January 2019. The program consists of 8 holes of an average of 375-meters each. The objective is the program is to test the high-grade extension laterally and at depth. The company also holds an interest in the Crevier Niobium and Tantalum project, which include 83 contiguous concessions covering an area of 4,645 hectares located in the Lac Saint-Jean region of Québec.

Plato Gold Corp. is a junior mining exploration company. Its flagship property is the Good Hope Niobium Property near Marathon, Ontario where there is proximity to exceptional mining infrastructure, including road, rail, port, hydro, water, and a mining-experienced labour force. The property is located in northern Ontario approximately 45 km northwest of Marathon and 28 km north of Highway 17 (Trans-Canada Highway), and is in close proximity to the Hemlo gold mining camp. The property consists of a total of 254 claims and about 5,100 hectares. Drilling commenced on the Good Hope property in Q1/2018 and exploratory drill results from 9 completed holes encompassing 5,016 metres of drilling were announced in Q3/2018.

Niocan Inc. is engaged in the exploration and development of the Oka niobium property 40 km northwest of Montreal, Quebec. The company converts the niobium into ferro-niobium products. The Oka ore contains other minerals, including apatite, magnetite, calcite, and rare earths. The Oka project involves the development of a mining complex based on an underground mine, a concentrator and a converter to produce the ferro-niobium. The project has completed all exploration phases, including two drilling campaigns in 1995, 1996, and 1997 for a total of 22,204 meters, to define two resource ore bodies. Certain conducted tests allow for the development of an optimal pyrochlore recovery process. Pyrochlore is the niobium-bearing mineral.

Saville Resources Inc. is engaged in the acquisition, exploration, development, and mining of mineral properties. The Company's principal asset is the Niobium Claim Group Property, situated within the central Labrador Trough in Quebec. It is currently under an Earn-In Agreement from Commerce Resources Corp. for up to a 75% interest. The Property consists of 26 contiguous mineral claims, encompassing an area of approximately 1,223 hectares, and is considered highly prospective for niobium and tantalum. The Property includes portions of the high-priority, drill-ready Miranna Target, where prior boulder sampling in the area returned 5.9% Nb₂O₅.

INFORMATION SOURCES

Information for our niobium industry report was sourced from the following:

- United States Geological Survey:
<https://www.usgs.gov/centers/nmic/niobium-columbium-and-tantalum-statistics-and-information>
- Metalary:
<http://www.metalary.com/niobium-price>
- Wikipedia:
<https://en.wikipedia.org/wiki/niobium>
- Live Science:
<https://www.livescience.com>
- Company Websites

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