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MINING・ENERGY・NATURAL RESOURCES
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Coltan (Niobium and Tantalum)

The two minerals which comprise coltan, columbite and tantalite, are the most important raw materials for niobium (chemical symbol Nb; atomic number 41) and tantalum (symbol Ta; atomic number 73). Niobium and tantalum based metallurgical products are essential in the downstream manufacture of many products used in high-tech industries.

Niobium is widely used in the steel industry to produce steel alloys and is contained in nickel, cobalt, iron based super alloys for high temperature applications such as in jet engines and rocket subassemblies. Niobium alloys are also used in the manufacture of superconducting magnets for magnetic resonance imaging (MRI) and nuclear magnetic resonance (NMR).

Regarding tantalum, the electronics industry accounts for about one-half of all consumption. Electronic capacitors are the leading end use owing to the ability of tantalum to store and release energy. Because of this components can be exceptionally small and are favored in space-sensitive applications such as in cell phones, hard drives, hearing aids and pacemakers. To date there are no effective substitutes for tantalum in electronic devices without loss of performance.

Niobium was first discovered in 1801 by an English chemist, Charles Hatchett. However, he called it columbium as the mineral sample he was analyzing came from America, also known as Columbia at the time. Tantalum was discovered one year later in 1802 by Swedish scientist Anders Ekberg. In 1846, Heinrich Rose, a German chemist, used the name niobium for an element he had found in a tantalite sample. By 1864 this was confirmed as the same element as columbium. However, it was only in 1950 that niobium was accepted as the official name by the International Union of Pure and Applied Chemistry.

In nature niobium and tantalum are almost always found together, both being transition metals and belonging to the same group in the Periodic Table. Thus, they have very similar physical and chemical properties. They are concentrated in a variety of relatively rare oxide and hydroxide minerals, as well as in a few rare silicate minerals. Columbite and tantalite share the same chemical formula, ($(Fe,Mn)(Nb,Ta)_2O_6$), with the mined ore taking the name (ie columbite or tantalite) of whichever of the elements has the highest concentration.

Niobium and tantalum are both considered critical minerals by the United States Geological Society (USGS) – commodities that have important uses and no viable substitutes. The sale of 'conflict coltan', attributed to rebel forces waging a civil war in Congo has highlighted the need for a transparent and traceable global supply that can exclude illegal coltan from the conventional market.

Coltan ore from artisanal miner *礦工手中的鈳鉭鐵礦*
Source: Australian Institute of International affairs

鈳鉭鐵礦 (鈮和鉭)

鈳鉭鐵礦石由鈮鐵礦和鉭鐵礦這兩種礦物組合而成，是鈮（化學符號 Nb ；原子序數 41）和鉭（符號 Ta ；原子序數 73）的最重要原料。鈮基和鉭基冶金產品對於許多高科技行業的下游製造至關重要。

鈮在鋼鐵工業中廣泛用於生產鋼合金及在鎳、鈷、鐵基超級合金中，應用於高溫環境，例如噴射發動機和火箭組件。鈮合金還用於製造用於磁共振成像（MRI）和核磁共振（NMR）的超導磁體。

電子工業約佔鉭一半的消耗量。由於鉭具有存儲和釋放能量的能力，因此電子電容器是主要的最終用途。由於這種組件非常小，因此特別適合對空間敏感的應用，例如手機、硬盤驅動器、助聽器和起搏器。 迄今為止，在不損失性能的情況下，沒有有效的鉭替代品。

鈮最早由英國化學家 Charles Hatchett 於 1801 年發現的。 當時，他稱其為鈳 (columbium) 是因為他正在分析的礦物樣品來自美國，當時也被稱為哥倫比亞 (Columbia)。 一年後的 1802 年，瑞典科學家 Anders Ekberg 發現了鉭。 1846 年德國化學家 Heinrich Rose 將鈮的名字用於他在鉭鐵礦樣品中發現的一種元素； 到 1864 年這種元素被確認與鈳相同。 然而直到 1950 年，鈮才被國際純粹與應用化學聯合會接受為正式名稱。

在自然界中鈮和鉭幾乎總是共生的。它們都是過渡金屬，在元素週期表中又屬於同一族，因此它們具有非常相似的物理和化學性質。它們集中在各種相對稀有的氧化物和氫氧化物礦物以及一些稀有的矽酸鹽礦物中。 鈮鐵礦和鉭鐵礦具有相同的化學式（$(Fe,Mn)(Nb,Ta)_2O_6$)），而開採出的礦石按較高元素濃度的命名（即鈮鐵礦或鉭鐵礦）。

鈮和鉭都被美國地質學會視為重要礦物 — 具有重要用途且沒有可行替代品的商品。 由於剛果叛亂部隊發動內戰，導致了 "衝突鈳鉭鐵礦石" 的出售。這凸顯了全球供應對透明及可追溯的原料的需求，該供應可以將非法鈳鉭鐵礦石排除在常規市場之外。

地理分佈

大陸地殼中鈮和鉭的平均含量比較低，分別為 8.0ppm 和 0.7ppm。它們通常伴生於錫、鐵、錳和其他稀土元素附近。 它們的化學特性，例如小離子尺寸和高電場強度，顯著降低了被成岩礦物中更常見元素替代的可能性，因此其含量亦相對較低。

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Geological Deposition

The average abundance of niobium and tantalum in the continental crust is relatively low, 8.0ppm and 0.7ppm respectively, often occuring in proximity to tin, iron, manganese and other rare earths. Their chemical characteristics, such as small ionic size and high electronic field strength, significantly reduce the potential for these elements to substitute for more common elements in rock forming minerals, hence their comparatively low amounts.

There are two types of deposit containing these minerals :-

(i) as *Primary deposits* dispersed in igneous intrusive rocks with relatively uncommon chemical makeup or

(ii) as *Secondary deposits* present in laterites formed by the weathering in-situ of the Primary deposits or washed out and concentrated as placers within rivers.

The grade of coltan is measured by the presence of niobium pentoxide (Nb_2O_5) and tantalum pentoxide (Ta_2O_5) instead of their elemental forms. In mining commercially viable head grades of niobium generally range from 0.1% to 3.0% Nb_2O_5 of the total resource whilst tantalum ores tend to be in the range of 0.02% to 0.05% Ta_2O_5. Accordingly, a large amount of material must be mined to get the ore and therefore only the larger deposits have volumes great enough to be of economic interest. Furthermore, and as would be expected, the cost of mining *Secondary deposits* is significantly less compared to hard rock mining.

Mining and Processing

Most of the commercial extraction of niobium and tantalum is either by open pit, using common earth moving techniques, or through artisanal mining. However, there are some underground operations, but these are less common as costs are greater.

After extraction both niobium and tantalum ores are treated similarly, and are commonly crushed and ground before mineral separation. This may involve dry and wet gravity separation, dry screening, magnetic separation, flotation, acid leaching, and sometimes smelting, to remove impurities and concentrate the ore to higher percentages of niobium and tantalum for further processing.

At the mine site the level of concentration that can be achieved is limited and for the most part concentration to a higher purity is carried out in a factory environment by buyers of the mine concentrate.

On site, particular attention is given to the removal of any naturally occurring radioactive minerals (NORM) in granites - typically uranium and thorium minerals - which are often found within the ore. Shipping of concentrates with excessive radiation are considered 'Dangerous Goods' and require special shipping arrangements. Material below 10 Becquerels per gram is exempt from radioactive transport regulations.

Commercial practice is for tantalum ores to be concentrated to >15% Ta_2O_5 and >18% Nb_2O_5 while niobium ores should contain >20% Nb_2O_5 and >3% Ta_2O_5. The pricing practice of tantalum ore is to calculate the value of the shipment by taking only the value of the tantalum - the value of niobium being normally excluded. Conversely when valuing a shipment of niobium ore the price paid considers both the contained niobium and tantalum.

Brazil and Canada are by far the leading producers of niobium mineral ore and concentrates, respectively 89% and 9%. Rwanda and the Democratic Republic of Congo were the leading producers of global tantalum concentrates in Yr 2017 accounting for over 50%, followed by Nigeria, Brazil and China. Until 2009 Australia was a major producer but the high cost of extraction meant mining of the ore became no longer viable. In Yr 2019 USGS reported that global production of niobium was 74,000t,

包含這些礦物質的礦床有兩種

(i) 作為原生礦物散佈在火成侵入岩中，具有相對罕見的化學組成或

(ii) 作為次生礦物，由原生礦風化形成的紅土中，或經沖刷並沉積河中的砂礦。

鈳鉭鐵礦石的品位以五氧化二鈮（Nb_2O_5）和五氧化二鉭（Ta_2O_5）而非元素單位計算。在礦業中，商業上可行的鈮礦石品位通常為 0.1%至 3.0%Nb_2O_5，而鉭礦石則為 0.02%至 0.05%Ta_2O_5。因此必須大量的開採才能獲得足夠的礦石，所以只有較大的礦床才具有經濟效益。此外，可以預見的是，與原生岩礦開採相比，次生沉積的開採成本要低得多。

Mibra — Tantalum mine in Brazil
Mibra — 位於巴西的鉭礦

開採與加工

商業上大多數的鈮和鉭礦都是通過露天開採，利用常規的土方工程技術或通過人手採礦進行的。但也有少量地下開採的礦山，但是隨著成本增加，這種作業變得不那麼普遍了。

採出的鈮和鉭礦石均需要類似處理，通常在礦物分離之前進行粉碎和研磨，然後使用乾法和濕法重力分離、幹篩、磁選、浮選、酸浸、甚至冶煉等以去除雜質及濃縮鈮和鉭的含量成精礦以便進行下一步加工。

在礦山現場，可以達到的濃縮水平是有限的，大多數情況下，精礦的購買者會在工廠環境中進一步提純。

礦山的加工廠亦會注意去除花崗岩中的任何天然存在的放射性礦物（NORM）— 通常是鈾和釷礦物 — 常見於鈳鉭鐵礦石中。放射超量的精礦被視為"危險品"，需要特殊的運輸安排。每克 10 Becquerels 以下的材料不受放射性運輸法規的限制。

一般是將鉭礦石濃縮至 >15%Ta_2O_5 和 >18%Nb_2O_5，而鈮礦石則含 >20%Nb_2O_5 和 >3%Ta_2O_5。鉭礦石的貿易定價慣例是通過鉭的含量來計算價值 — 鈮的價值通常不包含在內，相反，在對一批鈮礦石進行估價時，所支付的價格同時考慮了所含的鈮和鉭。

迄今為止，巴西和加拿大是鈮礦產和精礦的主要生產國，分別佔 89%和 9%。盧旺達和剛果民主共和國是 2017 年全球鉭精礦的主要生產國，佔 50%以上，其次是尼日利亞，巴西和中國。在 2009 年之前，澳大利亞一直是主要生產國，但是高昂的開採成本意味著礦石的開採不再可行。美國地質學會 2019 年的報告稱，全球鈮產量為 74,000 噸，鉭為 1,800 噸。

已查明的鈮和鉭資源很大，估計足以滿足未來許多年的全球需求。但是有關全球儲備和資源的數據是零散的和不完整的。此外，儲量和資源量在地理上分佈不均。巴西佔目前已查明資源的大部分。

鉭總產量中約有一半來自開採的鉭礦，其餘來自錫渣和合成精礦。

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whilst tantalum was 1,800t.

Identified resources of niobium and tantalum are large and are estimated to be enough to meet global demand for many years to come. However, the data is fragmentary and incomplete on global reserves and resources. Furthermore, the reserves and resources are unevenly distributed geographically. Brazil accounts for most of the current identified resources.

About one half of all tantalum production comes from mined tantalite with the remainder from tin slag and synthetic concentrates. Niobium is mostly derived from mining of columbite.

Production of Niobium and Tantalum Products

There are three stages in the production of niobium and tantalum products. The first stage in this industry value chain is the Upstream process, which is the mining of the raw materials and the concentration of the pentoxide minerals.

The second stage is termed Midstream and it is here that the mined concentrates are further processed to a higher purity pentoxide product, (termed hydrometallurgical products — due to the metallurgical procedures involves solution leaching). By undergoing pyrometallurgical processes the pentoxides, are further processed into pyrometallurgical products including tantalum powder, tantalum carbide, niobium bars and niobium carbide. Further processing can produce bars, powder, ingots, metal materials, alloys and other industrial products for specified end uses as required by Downstream manufacturers.

The last stage is Downstream with manufacturers producing niobium and tantalum end products such as capacitors applied in consumer goods.

Market

The niobium and tantalum metallurgy industry has experienced rapid expansion since the early 1990s with market size normally measured by the volume of tantalum and niobium-based hydrometallurgical products (ie the high purity pentoxide) produced from the mined ore, slag and other raw materials. The drivers for growth are (i) growing demand from downstream industries (ii) technology upgrades and importantly (iii) strengthening stability in raw material supplies. With Congo and Rwanda providing the majority of global tantalum supply, and there being no other effective substitutes, this is a key risk item.

Within the global tantalum and niobium supply chain mined ore and concentrate is supplied to manufacturers of metallurgical products mostly located in China, Germany, USA and Thailand. After further processing to pyro-metallurgical products and other further downstream products the goods are then exported around the World to manufactures of end products.

The average market price in Yr 2019 for imported niobium and tantalum ores into China is estimated to have been respectively near RMB1.1 million/t and RMB180,000/t. Over the last five years the growth in prices have been small but consistent. In Yr 2018 China imported 7,200t of tantalum and niobium concentrates and ore to the value of US$185 million.

鈮主要來自鈮鐵礦。

鈮和鉭產品的生產

鈮和鉭的生產可分為三個階段。該產業價值鏈的第一階段是上游過程，即原材料的開採和五氧化二礦物的濃縮。

第二階段稱為中游階段，這裡是將精礦進一步加工成更高純度的五氧化二產物（即濕法冶金產品，由於冶金過程涉及溶液浸出）。通過進行火法冶金過程，將五氧化物進一步加工成火法冶金產品，包括鉭粉，碳化鉭，鈮棒和碳化鈮。根據下游製造商的要求，進一步加工可以生產用於特定最終用途的棒材，粉末，鋼錠，金屬材料，合金和其他工業產品。

Niobium & tantalum based super alloys are used in aero-engine turbine blade
鈮基及鉭基超合金均有用於航空發動機渦輪葉片

最後為下游階段，生產鈮基和鉭基成品，如電容，應用於消費商品。

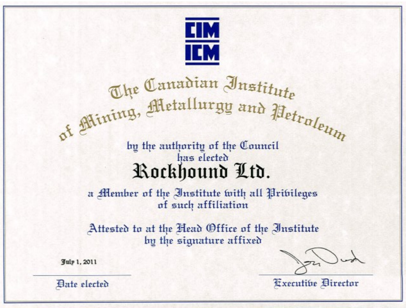
市場

鈮和鉭冶金工業自 1990 年代初以來已經經歷了快速發展，其市場規模通常由開採的礦石、礦渣和其他原材料生產的鉭和鈮基濕法冶金產品（即高純度五氧化二釩）的數量來衡量。增長的驅動力是（i）下游行業需求的增長（ii）技術升級以及重要的（iii）加強原材料供應的穩定性。剛果和盧旺達提供了鉭在全球範圍內的大部分供應，而且沒有其他有效的替代品，這是一個關鍵風險項目。

在全球鉭和鈮供應鏈中，礦產和精礦主要運往中國、德國、美國和泰國進行冶煉。在進一步加工成火法冶金產品和其他下游產品之後，這些貨物隨後銷往世界各地。

預計 2019 年進口鈮和鉭礦石的平均市場價格分別接近 110 萬元/噸和 18 萬元/噸。在過去的五年中，價格的增長很小，但一直保持穩定。2018 年，中國進口了 7,200 噸鉭和鈮精礦和礦石，價值 1.85 億美元。

Rockhound is a HK based company set up to serve the minerals industry in the Region. The company offers technical valuations and services in the natural resources sector.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Special Ed. 3 TOP INDUSTRIAL NEWS 鈳鉭鐵礦相關新聞 March 2020

Ximei Resources Holding Limited 稀美資源控股有限公司 (9936.HK)

Ximei Resources Holding Limited is primarily engaged in producing tantalum and niobium based metallurgical products in China. The Company recently listed on the Hong Kong Stock Exchange through an IPO. Despite the coronavirus outbreak impacting the global economy outlook, the Company attracted 14 times over-subscription and raised about HK$167M.

The Company is a midstream player and their major products are niobium pentoxide, tantalum pentoxide and heptafluorotantalate. They are the market leader with about 35% market share in China. Through this recent fund raising exercise, the Company plans to expand its business to further downstream products including tantalum powder and tantalum bars.

The demand for tantalum and niobium has grown in recent years and is forecast to remain upwards due to the special properties they possess, with no equally good substitution. This is positive for the Company.

Recently the World Health Organization has declared the coronavirus outbreak a global pandemic, which is likely to impact the global economy for quite some time; however, unlike iron and copper which have low-end applications and a demand highly dependent on the economic outlook, the major applications of coltan are for high-end electronics (including medical equipment) and the aerospace industry. Therefore the market of coltan is less likely to be significantly impacted.

US Funded Clean Minerals Project Raises Concerns in Congo (excerpt)

27 Sep 2019 <Reuters>

Democratic Republic of Congo plans to look into potential conflicts of interest in a U.S.-funded project to certify mines that produce minerals such as gold and tin responsibly, a Congolese official told Reuters.

The United States Agency for International Development (USAID) is using non-governmental organisation Pact to help the Congolese government identify which sites are free of human rights abuses, such as child labour, and don't fund conflicts.

Pact also works in Congo for ITSCI, the main private sector scheme monitoring mines for abuses, and the government is worried Pact's decisions on which sites are fit for purpose could be skewed by its relationship with ITSCI.

"We are going to look at whether there is a conflict of interest. We need to implement controls on the project to ensure that there is no conflict of interest regarding ITSCI and Pact," said Joseph Ikoli, secretary general of Congo's Ministry of Mines, adding that the government had not been involved in the selection of Pact.

Electronics firms such as Apple and Microsoft are under pressure to show minerals used in products from laptops to smartphones are sourced responsibly. Companies mostly rely on NGOs, auditing firms and certification schemes to give their supply chains a clean bill of health U.S. legislation passed in 2010 to stamp out "conflict minerals" requires U.S. firms to disclose if their products contain tantalum, tin, tungsten (3T) or gold from Congo - and perform due diligence. A similar EU rule will come into effect in 2021.

Congo Mine Deploys Digital Weapons in Fight Against Conflict Minerals (excerpt)

01 Oct 2019 <Reuters>

In a small shack overlooking muddy pits hewn out of eastern Congo's rolling green hills, a government official puts a barcoded tag on a sack of ore rich in tantalum, a rare metal widely used in smartphones. Coltan is a dull black metallic ore from which niobium and tantalum are extracted.

With a handheld device linked to a server in the cloud, the agent scans the barcode, uploading data including the sealed bag's weight, when it was tagged, and by whom.

The new system developed by RCS Global, a company in Berlin that audits supply chains, started in January at Societe Miniere de Bisunzu's (SMB) mine near Rubaya, Democratic Republic of Congo, which has some of Africa's largest deposits of coltan, a tantalum-rich ore.

"It allows purchasers of SMB material to be sure that it actually comes from that mine site and is not smuggled into the supply chain from other mines, as much as possible," said Ferdinand Maubrey, a managing director at RCS.

南方鉭鈮2月訂單額同比增長300%

2020年2月26日 <湖南日報>

鍛造、開坯、冷軋、熱處理、機加工、打磨入庫……25日，長沙南方鉭鈮有限責任公司生產車間一片繁忙，經過近20道工序，一根根稀有金屬鉭條"新鮮出爐" 。 2月，該公司出口訂單金額累計達到500萬美元，同比增長300% ，生產的鉭、鈮製品大量銷往美國、德國和中國台灣等地。

"公司2月3日已復工復產，一周前給美國霍尼韋爾公司緊急出貨近1噸鉭條，銷售額約60萬美元。"南方鉭鈮董事長蔣坤林介紹，公司已形成為客戶"量體裁衣"的定制生產能力，其生產的稀缺配件在軍工、化工等領域應用廣泛，合作夥伴包括美國霍尼韋爾、泰騰，德國西門子、美爾森、鉭泰克等多家世界500強企業。

南方鉭鈮是國內最大的異型材鉭鈮深加工生產企業。為防控疫情，公司推出系列實招：每天給員工煲中藥、測量體溫、發放口罩、食堂分餐、專人進行地面噴灑84消毒水、設置隔離區等，確保安全生產。面對源源不斷的合同訂單，南方鉭鈮生產線全部開足馬力，復工率超過90%，復產率100%。

南方鉭鈮主要生產鉭、鈮、鉭鎢合金類錠、棒、管、板、帶、箔、絲、靶材、坩堝以及其他非標製品，年加工能力達200餘噸，出口量居全國同行業首位。其創新生產的超長無縫鉭管、超寬幅鉭板、高純濺射鉭靶鈮靶、亞光細晶鉭帶等產品，均居國際領先水平。 2019年，該公司綜合營收2.48億元，出口創匯1.36億元人民幣。