TIC
TANTALUM-NIOBIUM
INTERNATIONAL STUDY CENTER
Bulletin N° 177: April 2019

Earth's treasures

The minerals of tantalum and niobium

(see page 4)

Fergusonite, Columbite, Latrappite, Wodginite, Betafite, Pyrochlore

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President's Letter

Dear Fellow Members,

As we enter the new year, I look back on my letter laying out our goals of 2018 where we were determined to have a truly exceptional central African conference, to increase our Association's influence in shaping the conversation about tantalum and niobium, and to improve the accuracy and usefulness of our statistics. As we take stock of how the T.I.C. has done, I feel we have all made substantial progress in achieving our goals. As a member, I would like to thank the staff and the members of the Executive Committee (EXCOM) for all of the work done in 2018.

Hong Kong was selected for our 60th General Assembly (GA60) in part as it is an ideal transportation hub with friendly visa formalities enabling many first time attendees from the very successful GA59 in Africa to attend GA60. In our outreach efforts in Asia, recently EXCOM members Candy, Dan, Kokoro and I, together with Roland, our Director, all attended the MIRU Japanese tantalum conference in Tokyo. The T.I.C. strongly supports the development of the MIRU tantalum conference due to the many tantalum innovations commercialized in Japan. We are hopeful that our outreach, as well as the very desirable location, will contribute to outstanding attendance in Hong Kong where it will be an exciting location for manufacturers to meet potential suppliers.

Attending the MIRU tantalum conference in Japan (photo: MIRU)

The T.I.C., our staff, EXCOM, and leadership are working to expand our influence in shaping the conversation about tantalum and niobium. The T.I.C. is heavily involved in the European Partnership for Responsible Minerals (EPRM) where we are represented on the sub-teams for the knowledge portal and the advisory committee by Roland. The T.I.C. has also been collaboratively engaged in the Responsible Minerals Initiative (RMI) program development, where David Gussack, Frank Habig, Joel Sherman are working together with Roland and I on the RMI-T.I.C. Technical Working Group. Roland is also involved representing tantalum on the OECD multi-stakeholder group. Importantly Roland will publish a Compliance Newsletter bi-annually to keep membership updated about how the tantalum and niobium industries are moving to being involved in all key areas of compliance that affect our members' businesses.

It is nearly a year since we developed our augmented statistics policy and started to use import-export data to assure that we have the best and most representative statistics available. A year ago our EXCOM approved a policy to absolutely protect member privacy, while enabling us to publish accurate data, checked with multiple independent sources. Interestingly our statistics differ in key ways from other published data, our statistics sub-team has carefully compared our information with others and believes the T.I.C. offers the most accurate and unbiased data for our industry. This data should assist our members, as well as provide the basis for the T.I.C. to measure its own efforts at promotion of tantalum and niobium.

I look forward to seeing everyone in my home town of Hong Kong, the weather in October is usually the best all year, it is a wonderful place to hold GA 60!

With best regards,

John Crawley, President

T.I.C.'s 60th General Assembly

Hong Kong, October 13th to 16th 2019

"early bird" booking opens May 1st.

Members and non-members can book tickets at special discounted rates from May 1st. Full details will be circulated shortly and also posted on our website at www.TaNb.org/events-list.

Director's Letter

Tokyo, Japan

Dear T.I.C. Members,

I write this from inside a Boeing 787 'Dreamliner', waiting for it to take off and fly back to Europe after a successful trip to Japan, meeting T.I.C. members and being introduced to many potential new members.

The Boeing 787 'Dreamliner'; made possible by tantalum and niobium (Picture: Boeing)

Modern passenger aircraft are true marvels of engineering, the result of millions of hours of development. However, what always makes me smile when I fly, is the knowledge that it is only possible thanks to tantalum and niobium (something my seat neighbours often also come to appreciate during the flight!).

As with the development of passenger aircraft, so too this Association has undergone great development since 1974, when it was founded. For many years this Association has worked diligently and frugally, building up resources and supporting members' interests.

In 2013/2014 the Executive Committee decided a more proactive approach would be taken and during the last five years the Association has invested heavily in expanding existing core competencies and developing additional capabilities, all to improve the value proposition offered to members.

Since 2014 some highlights of the T.I.C.'s growth include:

- Developing a deeper, more effective and more respected industry body to promote members' interests
- Greatly increasing our stakeholder engagement, especially with governments and international organisations
- Overhauling the quarterly statistics report to include international trade data
- Developing NORM transport guidance in multiple languages (see page 7)
- Increasing T.I.C. staff from 1.5 to 2.4 equivalent full time positions
- Launching an international science prize, the Anders Gustaf Ekeberg Tantalum Prize (see page 24)
- Redeveloping the Bulletin newsletter to become the flagship journal of this industry
- Giving more presentations promoting tantalum and niobium at more conferences than ever before
- Creating a new and expanded website.

Today the T.I.C. offers greatly increased value to its members, but the Executive Committee knows that we can achieve even more and develop additional services (perhaps even a resolution service for members' commercial disputes?). With your support the T.I.C. will continue to grow and work to promote members' interests.

With best wishes,

Roland Chavasse, Director

Columbite, tantalite and other minerals

Neither tantalum nor niobium occurs in a free state as native elements, but in the form of complex oxides and other minerals. Minerals have a discrete chemical composition, physical properties and crystal structure. Whilst there are many minerals containing tantalum and/or niobium most of them are only of mineralogical interest. The key economically recovered minerals are tantalite-columbite, microlite, pyrochlore, wodginite, and strüverite.

Tantalite-columbite and microlite are the most common minerals, being present to a greater or lesser extent in almost all tantalum orebodies. They occur mainly in pegmatites, because niobium and tantalum do not readily enter the structure of the commoner minerals that crystallise early in the consolidation of magmas. Rare-earth elements behave similarly and thus become essential constituents of some niobates and tantalates.

- **Tantalite-columbite** is an isomorphous series, where tantalum and niobium may substitute each other; tantalite is the tantalum-rich end of the series and columbite is the niobium-rich end. Common ratios between the two elements are from 3:1 to 1:3: hence the mineral is often referred to as tantalocolumbite or (more often) columbotantalite.
- **Microlite** is the end member of the microlite-pyrochlore series, but there are very few cases of pyrochlore deposits with less than a 10:1 niobium:tantalum ratio, or indeed microlite with significant quantities of contained niobium.
- **Wodginite** is less common, but was the primary tantalum mineral found in the original Wodgina deposit in Australia (from which it gained its name) and also at the Tanco mine in Canada.
- **Strüverite**, a variation of rutile, is a low grade source of tantalum predominantly associated with cassiterite (tin ore) in south-east Asia.

Tantalum and niobium minerals may not sparkle like a diamond, but here at T.I.C. we see in their crystalline beauty an undeniable value and sense of gravitas. Here are some of our favourite samples from around the world.

Columbite

Chemistry: $(Mn,Fe)_4(Nb,Ta)_8O_{24}$

Crystal: orthorhombic

Source: Raade, Norway

Collection: Natural History Museum, UK

Source: Haddam, CT, USA

Collection: Museum für Naturkunde, Germany

Source: Picuí, Paríba, Brazil

Collection: Natural History Museum, UK

Source: Governador Valadares, Minas Gerais, Brazil

Collection: Natural History Museum, UK

Source: Tellapad, Nellore district, India

Collection: Natural History Museum, UK

Source: Kenticha, Ethiopia
Collection: EMPBFC, Ethiopia

Tantalite

Chemistry: $(Mn,Fe)_4(Ta,Nb)_8O_{24}$

Crystal: orthorhombic

Source: Donkerhoek, Namibia
Collection: Museum für Naturkunde, Germany

Source: Afghanistan
Collection: Museum für Naturkunde, Germany

Source: (unknown)
Collection: GSG/AIST Geological Museum, Japan

Microlite

Chemistry: $(Na,Ca)_2Ta_2O_6(O,OH,F)$

Crystal: cubic

Source: Virginia, USA
Collection: Museum of Natural Sciences, Belgium

Source: Rutherford, VA, USA
Collection: Natural History Museum, UK

Pyrochlore

Chemistry: $(Na,Ca)_2Nb_2O_6(O,OH,F)$

Crystal: cubic

Source: Tatarski Massive, Sakha Republic, Russia
Collection: Museum für Naturkunde, Germany

Source: Oka, Deux Montagnes Co., QC, Canada
Collection: Natural History Museum, UK

Wodginite

Chemistry: $Mn_4(Sn>Ta,Ti,Fe)_4(Ta>Nb)_8O_{32}$

Crystal: monoclinic

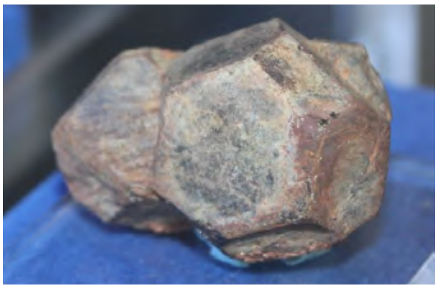
Source: Minas Gerais, Brazil; Collection: Natural History Museum, UK

Strüverite

Chemistry: $(Ti,Ta,Nb<Fe)_2O_6$

Crystal: tetragonal

Source: Tongafeno, Madagascar
Collection: Museum für Naturkunde, Germany



Betafite

$U_4+(Nb,Ti)_2O_6OH$

Source: Husting, ON, Canada

Collection: AIST Geological Museum, Japan

Euxenite

$(Y,Ca)(Nb,Ti)_2O_6$

Source: Lista, Vest-Agder, Norway

Collection: Museum für Naturkunde, Germany

Fergusonite

$(Yt,Er)(Nb,Ta)O_4$

Source: Ambohi, Madagascar

Collection: Natural History Museum, UK

Kobeite

$(Yt,Fe,U)(Ti,Nb,Ta)_2(O,OOH)_6$

Source: Ushio Mine, Kyoto, Japan

Collection: Museum of Natural Sciences, Belgium

Lueshite

$NaNbO_3$

Source: Lueshe, Nord-Kivu, DRC

Collection: Museum für Naturkunde, Germany

Labuntsovite

$(K,Ba,Na)(Ti,Nb)(Si,Al)_2(O,OH)_7.H_2O$

Source: Mont St. Hilaire, QC, Canada

Collection: Natural History Museum, UK

Manganotantalite

$(Mn,Fe)(Ta,Nb)_2O_6$

Source: Pr. Paraiba, Brazil

Collection: Museum of Natural Sciences, Belgium

Niocalite

$Ca_4NbS_{12}O_{10}(OH,F)$

Source: Oka, QC, Canada

Collection: Natural History Museum, UK

Romeite

$(Ca,Fe,Mn,Na)_2(Sb,Ti)_2O_6(O,OH,F)$

Source: Miguel Burnier, Brazil

Collection: Natural History Museum, UK

Simpsonite

$Al_4Ta_3O_{13}(OH)$

Source: site TBC, Brazil

Collection: Museum of Natural Sciences, Belgium

Stibiotantalite

$SbTaO_4$

Source: Mesa Grande, CA, USA

Collection: Museum of Natural Sciences, Belgium

Tapiolite

$Fe(Ta,Nb)_2O_6$

Source: Frey Martinho, Brazil

Collection: Natural History Museum, UK

This is just a small selection of the photos in our collection that we are in the process of adding to our website. If you have tantalum/niobium mineral photos please get in touch as we would be very interested to see them.

Our sincere thanks to Dr Ralf-Thomas Schmitt at the Museum für Naturkunde, Marleen De Ceukelaire at the Royal Belgian Institute of Natural Sciences, Richard Burt and Ulric Schwela for their kind help and advice on this project. All photographs are copyright T.I.C. 2019 unless otherwise stated.

Transporting NORM: gamma radiation measurement best practice

The T.I.C.'s Transport Policy is that members strive to comply with international, national and local regulations governing the safe and secure transport of radioactive materials.

To assist members, the T.I.C. publishes guidance in 8 languages (available at https://www.tanb.org/view/transport-of-norm) and has now commissioned additional guidance from Calytrix Consulting (http://www.calytrix.biz/) concerning the best practice in measurements of gamma radiation from NORM in transport and much else (the full report will be shared with members shortly). This article is for general information purposes only and no liability whatsoever is accepted by the T.I.C. in connection with this article.

T.I.C.'s simplified guide is now also in German.

Introduction

Raising the awareness of the safe transport of Naturally Occurring Radioactive Materials (NORM) with both industry and the public, while keeping potential risks in context, is an important part of any NORM transport strategy. Niobium and tantalum minerals generally contain such low levels of naturally occurring thorium (Th) and uranium (U) as to be below the exemption levels for transport and so are not of regulatory concern for this activity.

However, in those instances where this is not the case, the material is subject to a number of regulatory requirements (Regulations) for the transport, and companies have a legal duty of care to their workers and the general public to comply with these requirements.

A company wishing to arrange a shipment of radioactive material may experience a lack of carriers willing to quote for the transport required, or receive quotes that exceed the general freight rate by much more than a factor of ten. It is also important to note that a ship's captain, a plane's pilot and a port's harbour master each have the legitimate right to decline carriage or passage to any package they personally deem unsafe (whether or not that package is actually unsafe).

It is important to note that even if a material is exempt from the Regulations and the associated signposting, the concentrations of radionuclides in niobium and tantalum minerals and concentrates will, almost always, cause elevated gamma radiation levels outside the containers that are easily detectable by the equipment that is commonly used at border crossings and in ports worldwide. This article describes best practice for undertaking measurements of gamma radiation from a container containing NORM.

The need for gamma radiation measurements

The measurement of gamma radiation levels from the container with niobium or tantalum concentrate or slag is always advisable:

1) If the concentrations of radionuclides confirm that the material is not classified as 'radioactive' for transport it is always useful to have this data, as almost all containers are currently scanned for gamma radiation levels at border crossings and the values obtained at a distance of 1 meter from the container can be presented to the relevant authority if required.

   Additionally, the measured levels can be used to determine the extent of the radiation protection program associated with the transport of a certain mineral – as all niobium and tantalum minerals emit gamma radiation at levels higher than natural background levels.

2) If the concentrations of radionuclides are expected to be above the limits given in regulations by only a relatively small margin, there is a possibility that the container may be classified as 'excepted package' (meaning all regulations are applicable, except signposting), the measurements of gamma radiation from the surface of the container will be required.

A typical Geiger counter (geigercounters.com)

In our industry cross-border container shipments are commonplace (photo: shutterstock)

For example, if an assay of the mineral indicates that the radioactivity concentration of uranium and thorium (U+Th) is around 12-15 Bq/g (so the regulations would be applicable), but the surface gamma radiation readings from the surface of the 'package' (container, truck, etc.) are all below 5 microSv/hour, then the package can be classified as 'excepted' and the sign stating that the material is radioactive is placed on the *inside* of the package.

3) If it is determined that the material in the container is classified as radioactive, the measurements at 1 meter distance are required to determine the transport index for the consignment.

<u>The procedure for the measurements</u>

No special qualifications are required to operate a simple gamma radiation meter. There is a vast variety of different monitors and the following simple rules must be observed:

a) The equipment must be properly calibrated in the locally authorised laboratory*, each monitor must have a 'calibration sticker' attached – showing that it was calibrated less than 12 months prior to the date of the measurement;

b) The equipment manual must be thoroughly studied by the operator before the commencement of any measurements – for example, some monitors will provide almost instant (under 5 seconds) reading, others will require accumulation of data for 30 or 60 seconds and provide the average reading after this time period;

c) Particular attention needs to be paid to the equipment technical characteristics – for example some monitors may fail when used at extreme temperatures (above +40^{o} and/or below –30^{o} Celsius);

d) The batteries must be in good order and all applicable functions of the instrument need to be checked prior to the measurements;

e) Some monitors are also supplied with 'check sources' (usually caesium-137 or radium-226), which emit gamma radiation at the known level and performing this check confirms that the equipment will provide an accurate reading;

f) All results must be properly documented in accordance with locally applicable requirements.

There are three types of gamma radiation measurements:

A. At the surface of the truck/container (figures 1 and 2);

B. At the distance of 1 meter from the truck/container (figure 3):

C. Walking away from the truck container in different directions until such time when the level of gamma radiation is the same as background level (figures 4, 5 and 6)

* Many national authorities only recognize the readings obtained by the equipment calibrated in their country. For example, readings obtained by a gamma monitor calibrated in Australia may not be acceptable in the USA and vice versa.

There are also three purposes for which the monitoring is undertaken and those are linked with the points A, B and C above, as follows:

To determine if the ‘package’ can be shipped as ‘excepted’	A
To determine • The transport index (TI) for the consignment, if the material is classified as ‘radioactive’ • The levels that will be measured by a gate radiation detector at a border crossing	B
To establish if a radiation protection programme will be required for the shipment of the material and to determine the extent of this program	A,B,C

Illustrations

The illustrations of the monitoring and the obtained results are provided in figures 1 to 6. All readings were done for the containers with NORM mineral concentrates with activity concentrations of U+Th in the order of 4 – 11 Bq/g, at different unspecified mining and mineral processing sites.

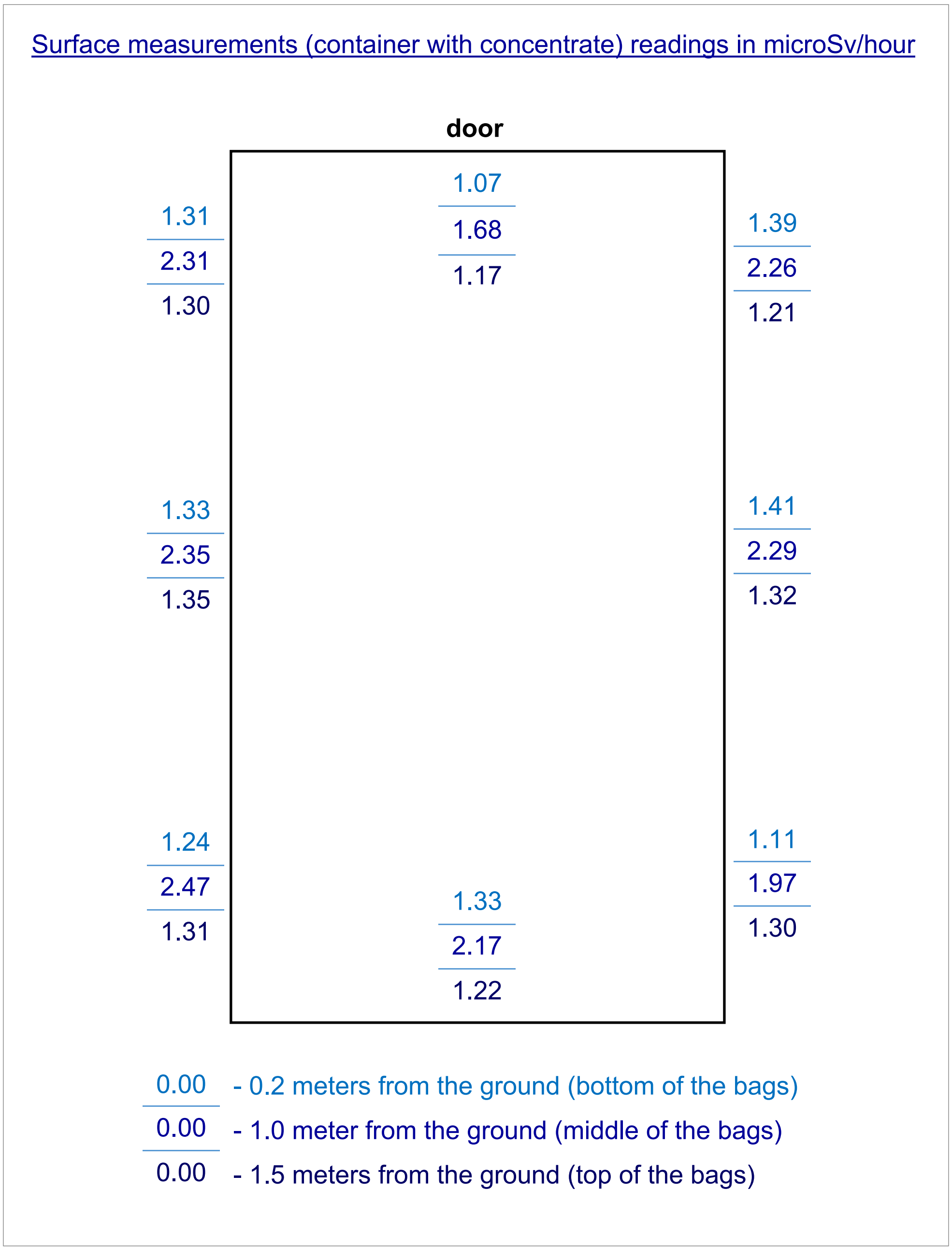


Figure 1: Gamma radiation measurements from the surface of the container with NORM, U+Th ~6 Bq/g

Figure 2: Taking comparative gamma readings from a container, U+Th ~4 Bq/g

Figure 3: Taking gamma readings at a distance of 1 meter from the container

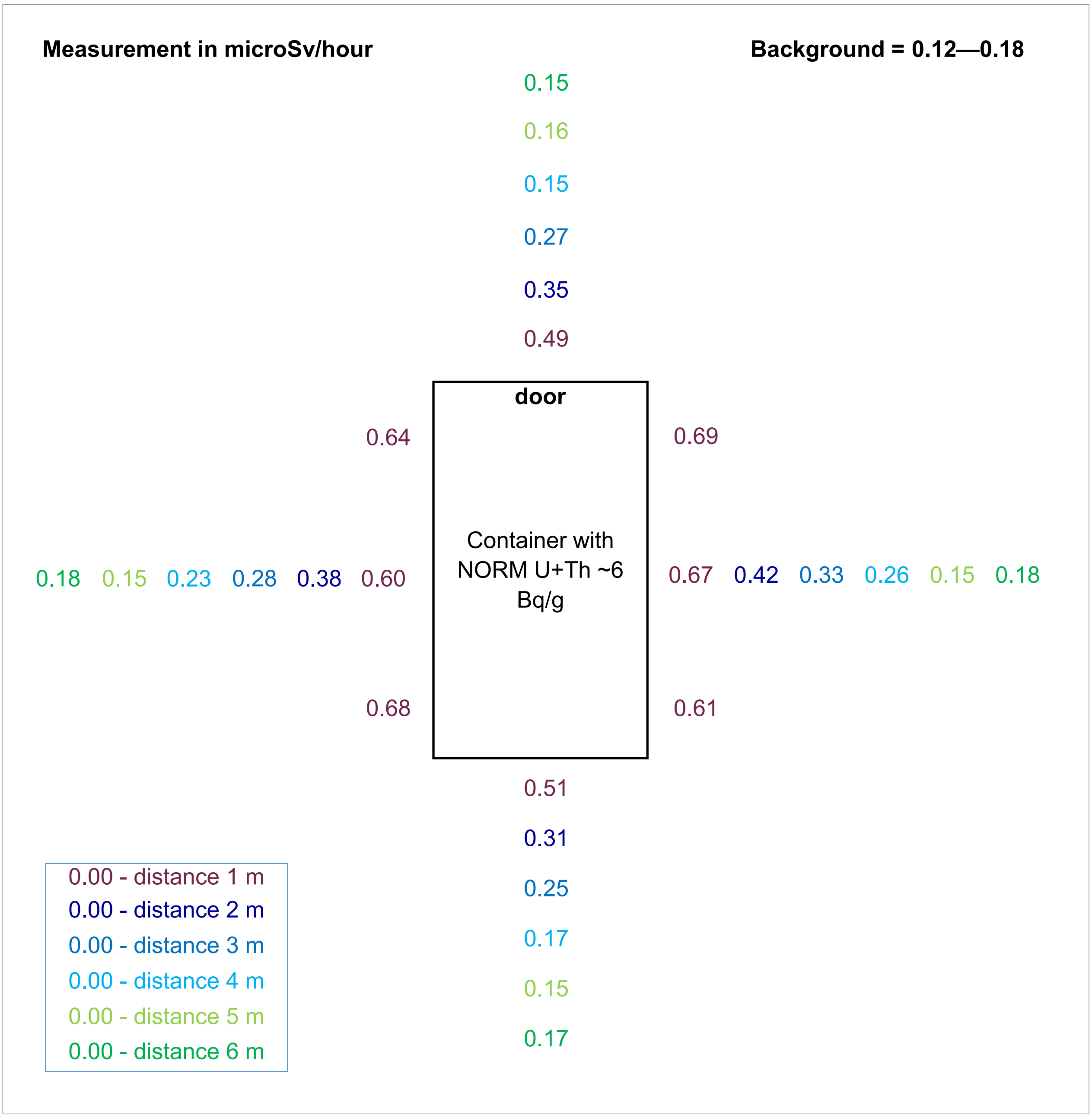


Figure 4: Gamma radiation measurements around the container with NORM, U+Th ~6 Bq/g

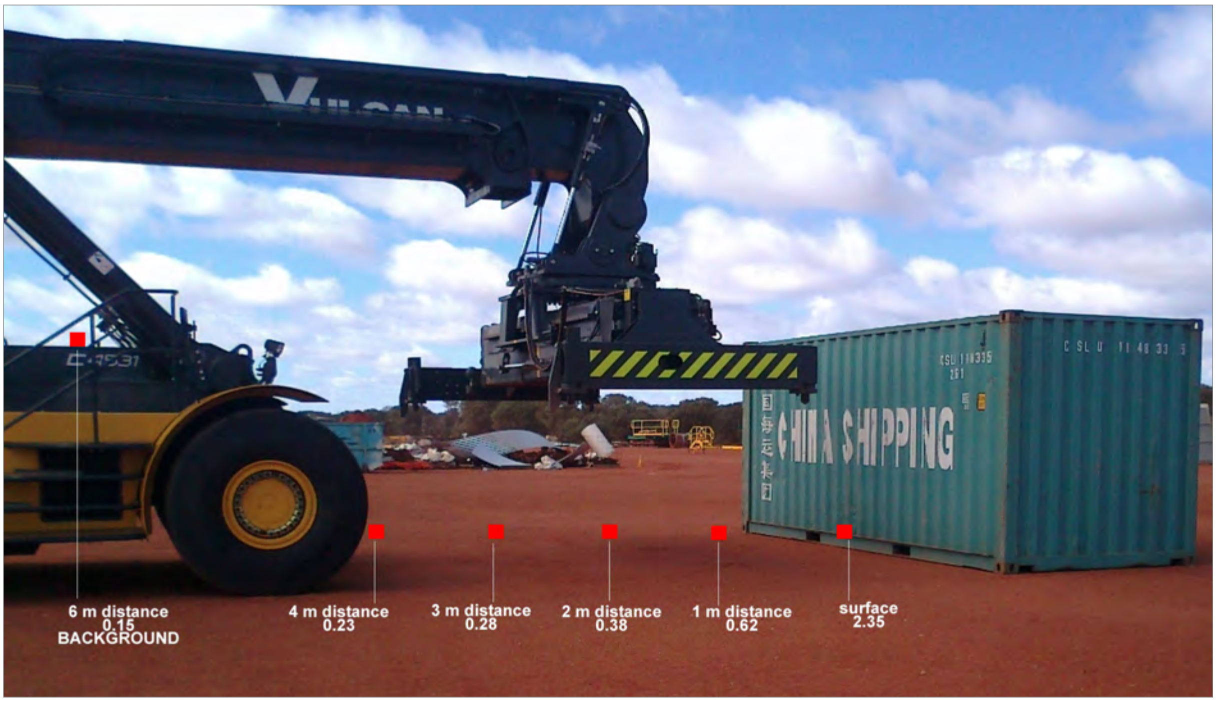


Figure 5: Visual representation of gamma radiation monitoring for a container with material containing uranium and thorium at ~11 Bq/g (classified as radioactive – Class 7)

Figure 6: Visual representation of gamma radiation monitoring for a container with material containing uranium and thorium at ~11 Bq/g (classified as radioactive – Class 7, but can be transported as 'excepted package', without "radioactive" signs on the container, as surface gamma levels are below 5 micro-Sieverts per hour)

T.I.C.'s 60th General Assembly: "early bird" booking opens May 1st

Hong Kong, October 13th to 16th 2019

Topics to be discussed include:

- Primary processing and refining
- Secondary processing and metallurgy
- Capacitors, superalloys, HSLA steel and other key applications
- Research and development on new applications for tantalum and niobium

The program is managed by the Executive Committee and will be published soon. Abstract submissions and other questions should be sent to info@tanb.org.

Brazil: a large country of large niobium and tantalum reserves

Paper written by Breno Costa Rezende, an independent consultant based in Brazil. All views and opinions in this article are those of the author and not the T.I.C.

Introduction

Brazil is very big and diverse. At 8.5 million square kilometres it is the fifth largest country in the world and its vast territory includes a wide variety of climates, lanscapes and resources. Brazil is a major mining country (one state is even called "Minas Gerais" – literally General Mines) and a leading producer of iron ore, bauxite, manganese and tin.

However, in our industry, Brazil is famous for being the world's leading producer of niobium and among the big five producers of tantalum.

Niobium and tantalum geological occurrences and key mining areas

The large niobium and tantalum resources in Brazil are distributed differently along the country's wide territory and are currently exploited by miners and converters according to a series of feasibility factors. Figures 1 and 3 illustrate the main regions of occurrence and the key mining areas, respectively, and shall be followed along with the text.

The jewels in the crown lie near the centre of Brazil and together form the most important niobium deposits in the world. The Alto Paranaíba Alkaline Carbonatitic Province, from the Cretaceous period, is constituted by ultramafic metassomatized rocks, cut by carbonatites and phosphorites. Weathering had an important role on the carbonatites complexes, forming residual deposits of several elements such as barium, thorium, phosphorus, uranium, copper, titanium, rare earth elements, and, of course, niobium[1]. Mineralization of niobium usually occurs in the form of pyrochlore. It's within this region that the largest niobium-dedicated mining areas are located: in Araxá (Minas Gerais – **MG**), exploited by CBMM, and in Catalão (Goiás – **GO**), exploited by Niobras. In Tapira (**MG**), the niobium occurrences are currently not under exploitation, only the phosphate is[2].

Figure 1: Main regions of niobium and/or tantalum occurrences in Brazil (limits are approximate). Note: Brazilian states acronyms are in uppercase and bold. (Map credit: B. Rezende)

On the other hand, in the Amazonas state (**AM**), the Madeira and Água Boa Proterozoic granites at the *Mapuera Mineral Province* represent a remarkable polymetallic deposit of tin, niobium, tantalum and also zirconium (Zr), yttrium (Y), uranium (U), thorium (Th), heavy rare earth elements (HREE), lithium (Li) and rubidium (Rb)[3,4]. Located there is the Pitinga Mine, in Presidente Figueiredo (**AM**), where Mineração Taboca – a main Brazilian tin producer – recovers cassiterite and columbite from the albite-granite rocks of the major Brazilian reserves of tantalum.

At the far north of the country, still in Amazonas, there's the *Rio Negro Province*, where the Morro dos Seis Lagos region also contains pyrochlore from carbonatites as the primary source of niobium. It's an exceptional deposit of minerals, notably niobium, titanium and rare earths.

Top image: Shutterstock/B.Rezende

The heavy and frequent rains in the Amazon promoted a deep leaching of the more soluble elements from the carbonatites, destroying the pyrochlore and leaving the niobium available to form combined oxides, mainly with titanium and rare earths[1]. The large resources of "Seis Lagos" – as the region is usually known –, around the municipality of São Gabriel da Cachoeira (**AM**), are often regarded as "the largest niobium deposit in the world"[5,6]. However, not only does the area still lack proper quantification[7], it has never been commercially exploited because it is located inside indigenous sovereign territories and areas of environmental protection[8]. Unfortunately, this remote and forested region, where Brazil, Colombia and Venezuela meet, is said to suffer from illegal artisanal mining, sometimes exploiting indigenous labour and regulatory loop-holes[9,10]. Other niobium and also tantalum occurrences are reported within the *Rio Negro Province*, especially on the region known as "Cabeça do Cachorro" ("Dog's Head"), around the municipalities of São Gabriel da Cachoeira (**AM**), Santa Isabel do Rio Negro (**AM**) and Barcelos (**AM**)[8,11].

Figure 2: Bom Futuro mine in Rondônia (RO)

The *Mapuera* and the *Rio Negro* provinces form part of the "Guiana Shield" geological formation, which extends across the north-western border of Brazil into Guyana, Suriname, French Guiana, much of southern Venezuela and part of Colombia.

In the north there are occurrences of columbite-tantalite around Rorainópolis (Roraima – **RR**) and Porto Grande (Amapá – **AP**), but especially in pegmatites from *Rondônia Tin Province*, where most deposits are alluvial placers after weathering and erosion of primary rocks. From this area, some reasonable amounts of columbite are recovered as a valuable by-product of cassiterite production by tin companies (e.g. ERSA/CSN), small-scale miners and miners' cooperatives (e.g. COOPERSANTA at Bom Futuro mine), mainly in the region of Ariquemes (Rondônia – **RO**)[12,13].

Going to the southeast, the *Brazilian Eastern Pegmatitic Province* and, mainly, the *São João del Rei Tin District* present important deposits of tantalum minerals, especially from the columbite-tantalite series and also microlite. They are mainly formed within granitic pegmatite rocks and, at some important places, are associated with lithium minerals[14]. It's home to the country's largest tantalum mine: the Mibra Mine, in Nazareno (**MG**), close to São João del Rei (**MG**), owned and exploited by Advanced Metallurgical Group N.V. (AMG).

The *Borborema Pegmatitic Province*, in the northeast – and the poorest – region of Brazil, is a place where numerous small tantalum-bearing pegmatites form clusters, but it still lacks in-depth geological characterization. The zone known as "Seridó", especially in Juazeirinho (Paraíba – **PB**), is reported to be promising for the viable extraction of tantalum and niobium mineral resources[15]. Occurrences were also reported around Cachoeira do Sapo (Rio Grande do Norte – **RN**)[16] and Itapiúna (Ceará – **CE**)[17], but the related potential is still little known. The overall area was historically explored by small-scale mining "fluxes" induced mainly by high price cycles of metals. However, under current market conditions, most of the deposits are not large enough to warrant development on their own.

Occurrences of much less significance are reported in other locations in Minas Gerais (**MG**)[14] and Bahia (**BA**)[18].

Figure 3: Brazilian key niobium and tantalum mining areas and places of occurrence. Some location names were used due to their importance and/or for geographical localization. (Map credit: B. Rezende)

The big four niobium and tantalum producers

Brazil is a primary world supplier of niobium. According to the USGS[19], the country was responsible for about 90% of all niobium produced in the world over the last decade, mining it from its huge reserves that used to account for 95-98% of the world's reserves (last year, however, an update in Canadian reserves reduced this share). Regarding tantalum, destinations where there are issues surrounding conflict minerals or mine closures and re-openings often dominate the headlines but, outside of the media spotlight, Brazil has become a major and consistent supplier for companies around the world. According to the USGS[20], Brazil has tantalum reserves that account for approximately 31% of world reserves and, from 2014 to 2017, the country was the largest supplier of tantalum minerals to the US, accounting for 35% of its imports. Since 2008, when the Greenbushes and Wodgina mines in Australia were put on care-and-maintenance status, Brazil has been the leading tantalum producer outside Africa.

The majority of Brazilian production of niobium and tantalum has been shared among four companies, namely CBMM and Niobras (niobium), and Mineração Taboca and AMG (tantalum).

Companhia Brasileira de Metalurgia e Mineração (CBMM)

https://www.cbmm.com/

CBMM is by far the largest niobium producer in the world. Founded in 1955, it operates an open pit mine in Araxá (**MG**). The operating ore body is a deep weathered carbonatite, with 440 Mt of ore reserves at an average grade of 2.5% Nb_2O_5[21,22], which form the largest proven niobium reserves in the world. CBMM doesn't market any ore, but transforms all the concentrated pyrochlore into a wide range of products, after more than a dozen of industrial steps developed in house.

Ferroniobium (FeNb) is the main finished product, but the company also supplies vacuum grade alloys, niobium metal and a range of chemicals, including high-purity and optical grade niobium oxides and ammonium niobium oxalate.

In 2011, a Chinese group acquired a 15% stake in CBMM and a Japanese-South Korean consortium a further 15%. In 2017 FeNb production was over 68,000 t[22] and earlier this year the company announced that it would expand its capacity from the current level of about 100 ktpy FeNb (gross weight) to 150 ktpy by the end of 2020, with production anticipated at 110 kt in 2019 and 120 kt in 2020.

CBMM's operations: (a) open pit mine and (b) sintering unit at the ferroniobium plant
(Photos: Courtesy of CBMM)

Niobras Mineração Ltda

http://cmocbrasil.com/br/negocios/niobras

Niobras, the second largest niobium producer worldwide, extracts pyrochlore from a carbonatite deposit at its Boa Vista mine in Catalão (**GO**), which is in operation since 1973. The ore is processed at its industrial facility in Ouvidor (**GO**) to produce ferroniobium, which is sold to the steel industry in North America, Europe and Asia.

In 2012, the Boa Vista Fresh Rock Project was approved and, since then, production has increased from 4,500 t Nb in 2013 to 8,600 t Nb in 2017. In 2016, China Molybdenum Co., Ltd ("CMOC") bought the company from Anglo American.

The company's 2018 interim report to investors reported that at end December 2017 the niobium ore resources stood at 559 Mt with an average grade of 0.4%.

Niobras' operations: (a) Boa Vista mine and (b) FeNb final product
(Photos: Courtesy of Niobras)

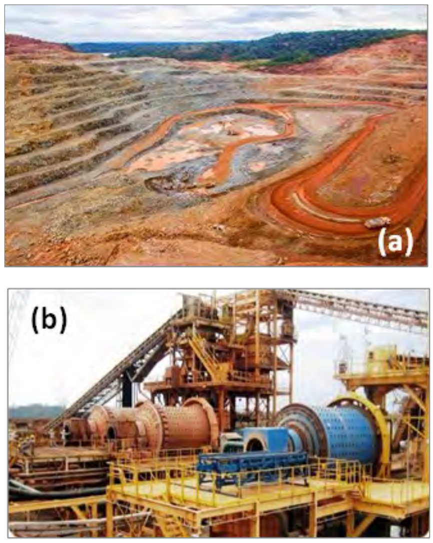
Mineração Taboca S.A.

http://www.mtaboca.com.br/Paginas/default.aspx

Mineração Taboca belongs to the Peruvian group Minsur S.A. and owns and operates the Pitinga Mine in Presidente Figueiredo (**AM**), home to the largest tantalum reserves in Brazil, mainly in the form of columbite. As of December 2016, measured plus indicated mineral resources were at 282.6 Mt grading 0.03% Ta_2O_5[23].

After concentration, the ore is submitted to metallurgical processing in order to separate the radioactive elements (U, Th), thus generating tantalum and niobium ferroalloys as main products – which are sold to the market as raw materials for the tantalum and niobium and the steel industries.

Mineração Taboca has recently concluded the expansion of its Pitinga Nb/ Ta operations, which allows the company to double the production of those ferroalloys and reach the target of 4,400 tpy.



Taboca's operations: (a) Pitinga mine and (b) concentration plant
(Photos: Courtesy of Mineração Taboca)

Advanced Metallurgical Group N.V. (AMG)

https://amg-nv.com/product/tantalum-niobium/

AMG operates the Mibra mine, its multi-mineral mine in Nazareno (**MG**), to recover tantalite and microlite as tantalum concentrates as well as cassiterite – converted into tin ingots – and a "mixed feldspar" that feeds the ceramic and glass industries. In 2017, the pegmatite ore body was reported to contain 20.3 Mt of measured plus indicated mineral resources with an average grade of 0.034% Ta_2O_5[24]. AMG also owns and operates a chemical plant in São João del Rei (**MG**), which produces tantalum and niobium oxides.

The group's subsidiary AMG Mineração, one of the largest certified tantalum concentrates producers in the world with a capacity of 135 tpy Ta_2O_5, has recently started the production of spodumene concentrates for the lithium industry, starting from tantalum tailings, at a new facility also built at Mibra.

AMG's operations: (a) Mibra mine and (b) new spodumene plant
(Photos: Courtesy of AMG)

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Niobium and niobium oxide capacitors overview

Paper written by Dr Tomas Zednicek of the European Passive Components Institute (EPCI). All views and opinions in this article are those of the author and not the T.I.C.

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Introduction

Niobium is a sister metal to tantalum, and shares many chemical characteristics with it, in addition to a few disadvantages and advantages of its own when used as a capacitor dielectric.

Niobium capacitor technology has existed for decades, but its limitation in maximum rated voltage, lower volumetric efficiency, incompatibility with low ESR polymer electrode, limited range and number of vendors keeps this technology as a niche line of the tantalum capacitor industry today. On the other hand, there are still some advantages (such as lower cost, safety and reliability) that are worth a closer look and consideration.

Brief History

Capacitor manufacturers have been evaluating niobium material for years every time the tantalum supply situation becomes unstable. Its lower cost base was also evaluated in order to replace low-voltage aluminium electrolytics.

Development of the first niobium capacitors started in former USSR already in 1960s motivated by shortage of tantalum there[1]. However, at that time, niobium powders were not available in appropriate low impurity, high quality level and the capacitor reliability was inferior to the tantalum capacitors.

Niobium-based material as easier to get and more abundant in nature captured the attention of most of the leading tantalum manufacturers especially after the tantalum shortage and supply chain issues around year 2000. Beside niobium metal powder, NbO material has been introduced with metal conductivity level by J.Fife[2] resulting in some advantage for capacitor application properties. Upon the new development and availability of low impurity Niobium/NbO powders within years 2001-2003, companies AVX, EPCOS (tantalum division acquired by Kemet in 2007), Hitachi (bought by Holy Stone in 2009, acquired by Vishay in 2014), Kemet, NEC and Vishay announced some early sampling and pre-production of niobium-based capacitors in 2002[3,4,5].

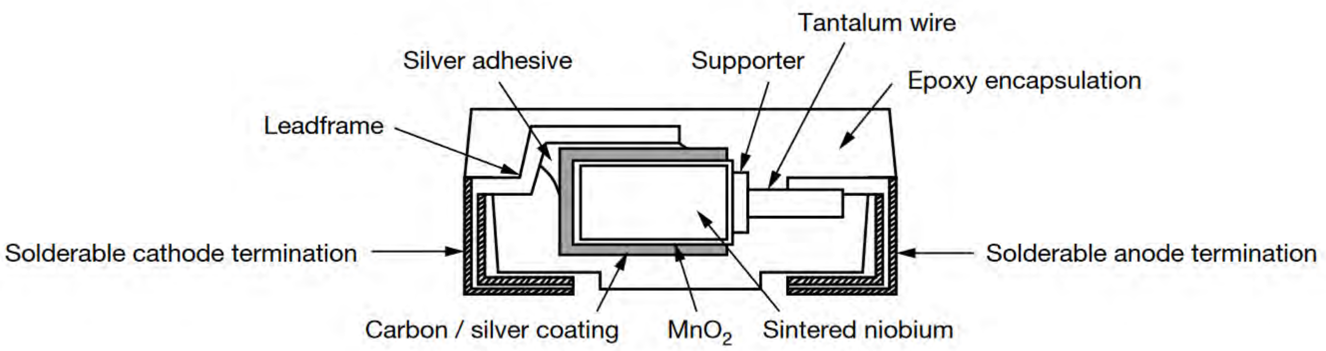

Figure 1: NMC series of niobium-based capacitor structure (source: Vishay[8])

Nevertheless, despite the very optimistic first results, niobium posed some early technical challenges that capacitor makers were struggling to overcome. The obstacles included high dc-leakage current (two to five times worse than for tantalum capacitors), increase of DCL with lifetime and susceptibility to damage by thermal shock during reflow manufacturing process. Low-CV capabilities have also been a problem because of the lack of high grade, high purity capacitor-grade powders at that time.

Tantalum supply chain has consolidated in further years and the urgency for niobium-based capacitor development dropped versus requirements for lower ESR tantalum capacitors with conductive polymer electrodes.

In co-incidence, conductive polymer junction to Nb_2O_5 dielectric is resulting in even higher DCL that practically disqualify its use with niobium-based capacitors. This next technical challenge would require additional development resources to address some basic physics issues related to potential development of polymer niobium-based capacitors. Hence, most of the manufacturers terminated further development effort, focusing their development power on other priorities and obsoleted their niobium-based capacitor lines.

Niobium-based capacitors with MnO_2 solid electrolyte are still on the market with high reliability versus cost unique value in certain applications. Vishay obsoleted its SMD chip niobium capacitors in 2017[8] and the major supplier of SMD NbO capacitors today is AVX Corporation[6] that dedicates its product to mainly automotive, aircraft, defence and high safety applications. Axial niobium capacitors are also still made in Russia by the company OJSC ELECOND[7] for industrial, defence and high reliability applications.

Niobium-based capacitor technology and features background

A) Volumetric efficiency

Niobium, as mentioned, is in many ways behaving very similarly to tantalum capacitors. Niobium or NbO material can be processed into a form of powder with a stable oxide Nb_2O_5 (versus Ta_2O_5 in case of tantalum) as a high dielectric constant insulation. Niobium pentoxide has a dielectric constant about twice as high as that of tantalum oxide, however the density of niobium is only half that of tantalum, resulting in similar or slightly lower volumetric efficiency compared to tantalum capacitors.

Anode material	**Dielectric**	**Relative permittivity**	**Oxide structure**	**Breakdown voltage (V/µm)**	**Dielectric layer thickness (nm/V)**
Tantalum	Tantalum pentoxide Ta_2O_5	27	Amorphous	625	1.6
Niobium or Niobium oxide	Niobium pentoxide Nb_2O_5	41	Amorphous	400	2.5

Table 1: Characteristics of the different tantalum and niobium oxide layers (source: AVX)

B) Abundance

An important advantage of niobium is the abundance of niobium ore in nature relative to tantalum ore; this relative abundance equates to lower cost and better availability within the capacitor marketplace.

C) Flame retardant

Niobium metal is behaving like tantalum capacitors. However, as one of its key advantages niobium oxide has a far higher ignition energy than tantalum which results in a significant reduction (up to 95%) of the ignition failure mode of niobium oxide capacitors when compared to conventional tantalum devices.

D) Sub-oxides stability

One of the “small” differences between niobium and tantalum that makes a big impact to capacitor features is that niobium sub-oxides are stable unlike tantalum. There are no long term stable suboxides between tantalum and the dielectric tantalum pentoxide (Ta_2O_5). There are at least two suboxides on niobium-based materials that are stable: NbO and NbO_2.

NbO is a material with metallic type of conductivity that can be processed and used as the main anode material in the same way as Nb or Ta metals (used by NbO capacitors as anode material). NbO_2 is an oxide with semiconductive behaviour that exists together with the “main” dielectric Nb_2O_5 on the junction with Nb/NbO anode. The NbO_2 oxide may grow with temperature (such as during the hot spot in dielectric failure site) and it’s responsible for the unique “self-arresting” mechanism.

E) Self-arresting mechanism

In addition to the self-healing known on conventional tantalum MnO_2 capacitors, the NbO capacitors are featuring one more feature when exposed to local breakdown, the NbO_2 layer on dielectric will grow as a “second” insulation thus protecting the part from a short circuit mode. Such part then continues in normal operation even in occasion of the main Nb_2O_5 dielectric breakdown. Under specified operating conditions, NbO capacitors are thus one of the safest capacitor technologies on the market.

F) Operating temperature

Another difference to tantalum capacitors is that Nb_2O_5 dielectric is more sensitive to higher temperature operation above 85°C. Reliability up to 85°C may be considered as better, about equal at 105°C and inferior at 125°C requiring higher derating compare to tantalum capacitors. The natural high reliability performance of niobium-based capacitors up to 85°C (including safety margin) makes them suitable for high performance industrial, automotive, defence, medical support, aerospace applications even for safety critical applications.

G) Rated voltage

As mentioned, the density of niobium is only half that of tantalum, so twice as much material is needed per unit volume to provide the same charge. The Nb_2O_5 dielectric constant is higher, but you must form a thicker niobium oxide dielectric for the same voltage. That is good to reduce further the electrical field stress to the dielectric (and achieve better reliability) on one side, but there is a certain limitation in maximum dielectric thickness / maximum rated voltage, driven by powder impurities and formation techniques on the other site. As a result, niobium-based capacitors are featuring significantly lower maximum rated voltage compare to tantalum capacitors.

Applications: where niobium capacitors bring benefits

High reliability, long term operation, safety circuits, with "standard ESR requirements" up to 8V application voltage operating in environment up to 85°C safety (105°C qualification) with a little more space on board needed compared to tantalum capacitors (still smaller then aluminium electrolytics). The parts show high mechanical robustness against shocks and vibrations and stable electrical performance (over MLCC class II capacitors).

There is a wide range of applications were niobium-based capacitors can bring benefits in low cost for high safety and reliability standards. Applications with benefits from downsizing of aluminium electrolytic capacitors include consumer items such as home theatres, game controllers, white goods controllers.

Applications with benefits from high value in lower cost versus safety and reliability include industrial applications with enhanced safety features such as smoke detectors, security electronics etc; automotive such as cabin electronics and telematics; and in aircraft, including the on-board entertainment system, telematics, and in defence (COTS+ version available).

Limitations

Limited sources and product range are the main current limitations of the technology apart from the technical borders discussed above. Case sizes, mounting guidelines etc of the niobium-based chip capacitors are however identical to tantalum and tantalum polymer capacitors, so they might be considered as drop-in alternatives on the same footprint to avoid single source issues. Thus, the niobium-based capacitors can be considered as additional options where tantalum capacitor designs are considered with enhanced safety feature.

Summary

Niobium-based capacitors are a niche capacitor market share within the tantalum capacitor industry. Nevertheless, some of their unique features, especially high safety, no short circuit failure mode under standard operating conditions and high reliability bring value to the end users to remain a viable capacitor solution in longer term future.

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[8] Vishay, "Solid Niobium Surface Mount Chip Capacitors" catalogue 2017, https://www.vishay.com/docs/40218/moldedguidepolytech.pdf. In addition note that Vishay obsoleted niobium capacitors in December 2017.

Trading Places: niobium and vanadium in steel applications

Between 2016 and 2018 imports of ferro-niobium (FeNb) into China increased considerably, after the standards for reinforcing bar (rebar) were amended. Here Willis Thomas, a consultant at CRU Consulting (willis.thomas@crugroup.com), considers the substitutability of ferro-vanadium (FeV) and FeNb. All views and opinions in this article are the author's and not of the T.I.C.

Introduction

There are multiple methods to increase the strength of steel, such as work hardening, precipitation hardening, alloying, and transformation hardening. These can be broadly listed as either process related refinements or ferroalloy additives, although they can and are often used together. Each method results in slightly different product strengths, though separate methods can be used to come to the same end product strength.

Two of the principal ferroalloy additives for increasing steel strength are niobium (Nb) and vanadium (V). While these elements have been shown to be used together in steel alloying, resulting in impressive strength profiles, there are many times when these ferroalloys compete directly for exclusive use in an alloy. Here we will compare and contrast them as exclusive elemental additives.

Vanadium overview

Vanadium is a soft, ductile, grey metal with characteristics that allow for its use in alloying steel and other metals as well as being used in chemical industries. Specifically, for steel and other alloys, the high strength to weight ratio of vanadium allows for harder ending alloys with lower weights than can be achieved in the absence of vanadium. Importantly, adding vanadium to steel does not require any changes to melting, rolling or finishing procedures as opposed to unalloyed steel. It does not occur in its native form, but as a component of polymetallic minerals and as an impurity found in hydrocarbons and bauxites. Nearly 90% of vanadium occurs in vanidiferous magnetite ores with the balance found in oil residues and shales.

Vanadium from nearly all sources of production is converted into either vanadium trioxide or pentoxide with most pentoxide being converted to one of the forms of ferrovanadium for use in alloying applications. Ferrovanadium (FeV) is an alloy of iron and vanadium (ranging from 35% to 85% V content). It is a universal hardener, strengthener and anti-corrosive additive for high-strength low-alloy (HSLA) steel (0.15-0.25% V), tool steels (1-5% V) and other ferrous products. With significant advantages over both iron and vanadium individually, FeV is used as an additive to improve corrosion resistance to alkaline reagents and sulphuric and hydrochloric acids, and to improve the tensile strength-to-weight ratio of the material.

FeV can be used in solid or crushed "ferrovanadium dust" forms. For these products, there is a limited spot market thus much of the material is traded on multi-year contracts designating volumes with prices set at a discount to published spot prices.

Is niobium a complete vanadium substitute?

Vanadium faces the potential substitution by other ferroalloys to increase hardness and strength of steels. The principal element which is substituted is niobium, used in the form of ferroniobium (FeNb) an alloy of 60–70% niobium with iron. Niobium is used mostly in high-strength, low-alloy (HSLA) and special steel such as that used in gas pipelines, construction and automobiles. These alloys contain a maximum of 0.1% which is sufficient to enhance the strength of the steel.

Historically, when FeV prices have risen to above half of the FeNb price, there is an economic incentive to replace vanadium by niobium. This becomes greater the further vanadium rises above this level, however, there are barriers beyond economics which keep vanadium and niobium from being easily interchangeable. Short term substitution from vanadium to niobium is not always practical or economical for steel producers due to:

- The end-pricing of vanadium-bearing steels shows some elasticity to allow for vanadium price swings to be absorbed at least partially in the final product.
- Niobium is technically more difficult to employ in the alloying process and it requires changes to the alloying, cooling, and rolling/finishing processes to be effectively substituted for vanadium. Niobium steel strengthening works through grain refinement and the end strength of the steel is less predictable than vanadium. Process related end-product quality generally leads to more variability in end-product strength.
- Along with the non-linear strengthening problems, the increased likelihood of bainite formation, embrittling the steel, is a barrier to the use of niobium in steels.
- Higher temperatures (1200^{o}C) are necessary to obtain solubility of niobium in steel, leaving some mills technically unable to use niobium as a substitute as on site furnaces top out below 1100^{o}C.
- High powered mills are required to achieve the 50% cross-section area on each mill pass as well as rolling at the low temperatures necessary for niobium usage. Niobium nitrides and carbides have relatively low solubilities and may precipitate out in the later stages of rolling. These high-powered mills are not installed at all plants, limiting niobium usage at the locations.
- As switching back and forth is difficult, producers who have not yet switched to niobium are unlikely to be incentivized to substitute until the pricing spread widens past historical peaks.

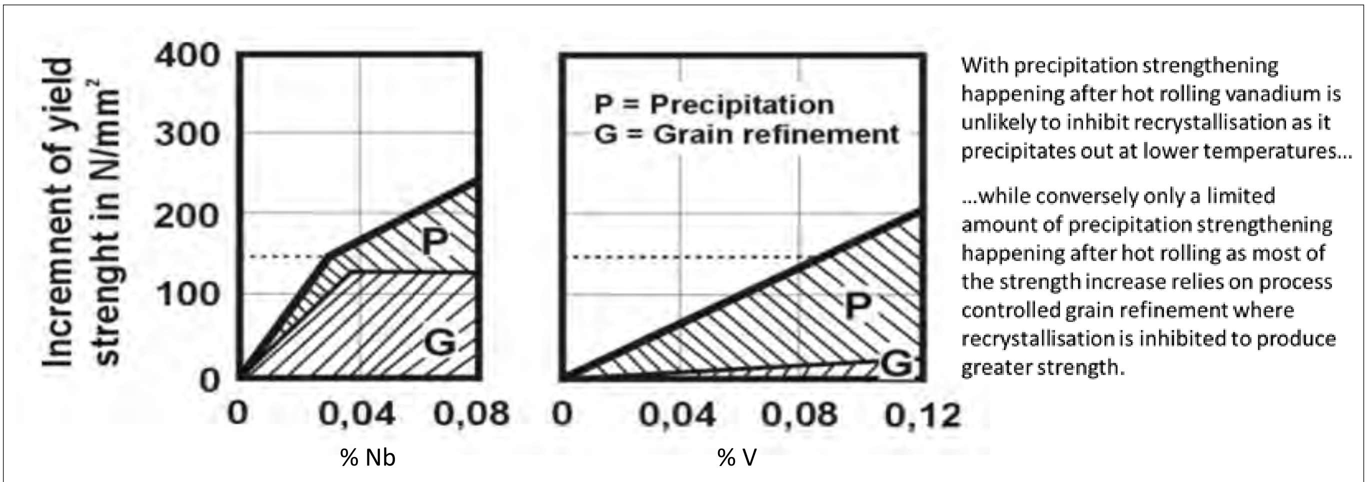

Figure 1: Strengthening by niobium (left) and vanadium (right)*

While substitution is normally not considered for short-term changes in market conditions, because of the considerable effort needed to implement the changes, expectations of prices staying higher for longer and the ability of niobium supply to respond to high prices and possibly offer long term contracts (which may provide improved price stability for steel plants) is likely to lead to some substitution, despite concerns over security of supply, the high degree of concentration and supplier pricing power.

This view appears to be supported by recent changes in ferroniobium (FeNb) imports into China, which have risen sharply by 7,566t (~40%) between 2016 and 2017. The trend was further enforced through 2018 as vanadium prices reached 10-year highs and FeNb imports hit record levels in China in the 4th quarter. Although part of a trend of increasing imports since 2013 (and fundamental growth in FeNb consumption), the evidence points to higher vanadium prices spurring substitution.

How long this trend will continue is unclear, but analysts at CRU are forecasting further significant potential vanadium demand to be substituted over the 2018-2022 period, which is necessary to keep the market in balance (and to keep vanadium stocks above ~1-month worth of current demand).

* Zhang Yongqing, Guo Aimin and Yong Qilong, "Strengthening Effects of Niobium on High Strength Rebars" 2018.

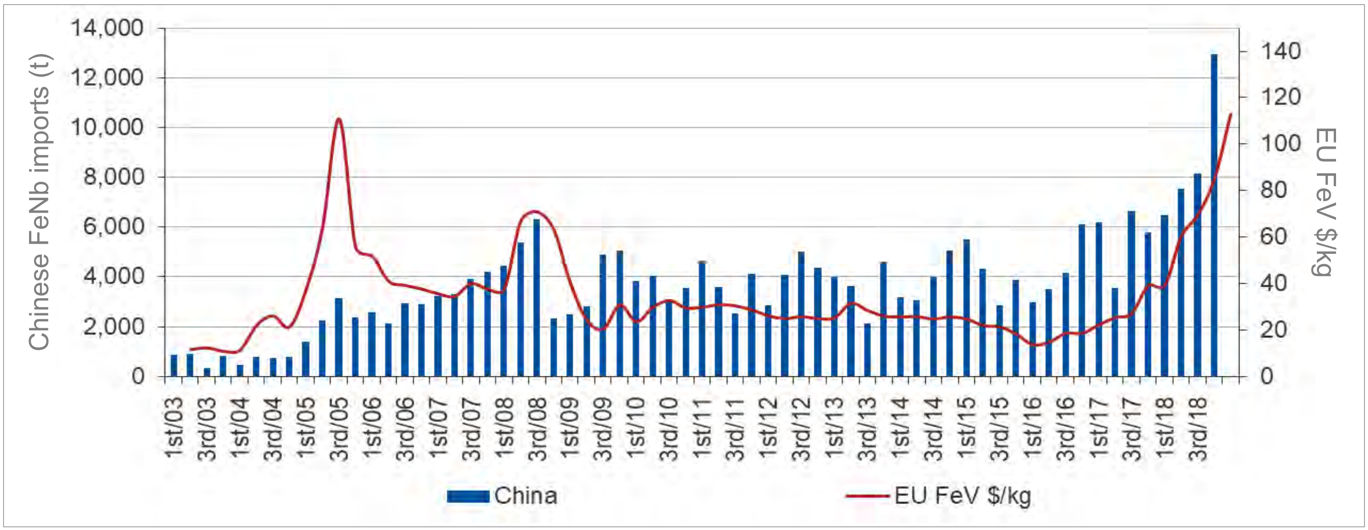

Figure 2: Quarterly Chinese FeNb imports and vanadium prices 2000-2018 (estimate) (Source: CRU, IHS)

Should FeV prices fall, then substitution is expected to be gradually reversed, although some of the substituted volumes are expected to be permanent for a combination of operational, commercial and broader strategic concerns. Such reverse substitution is more likely to come from Chinese users of ferroalloys than from non-Chinese users due to the recent history of substitution in these two regions. After the increase in vanadium prices, and lowering of availability of FeV from 2005-2008, FeNb intensity (in kg FeNb per tonne carbon crude steel) increased in both the world excluding China and in China. However, but for a blip in 2009, the world outside China remained at the elevated levels of niobium intensity, while Chinese intensity retreated significantly erasing half of the intensity gains. A similar pattern may be repeated in the future as recent Chinese intensity gains could retreat approximately from the gains of 2016-2018 if vanadium prices weaken in the medium to longer term.

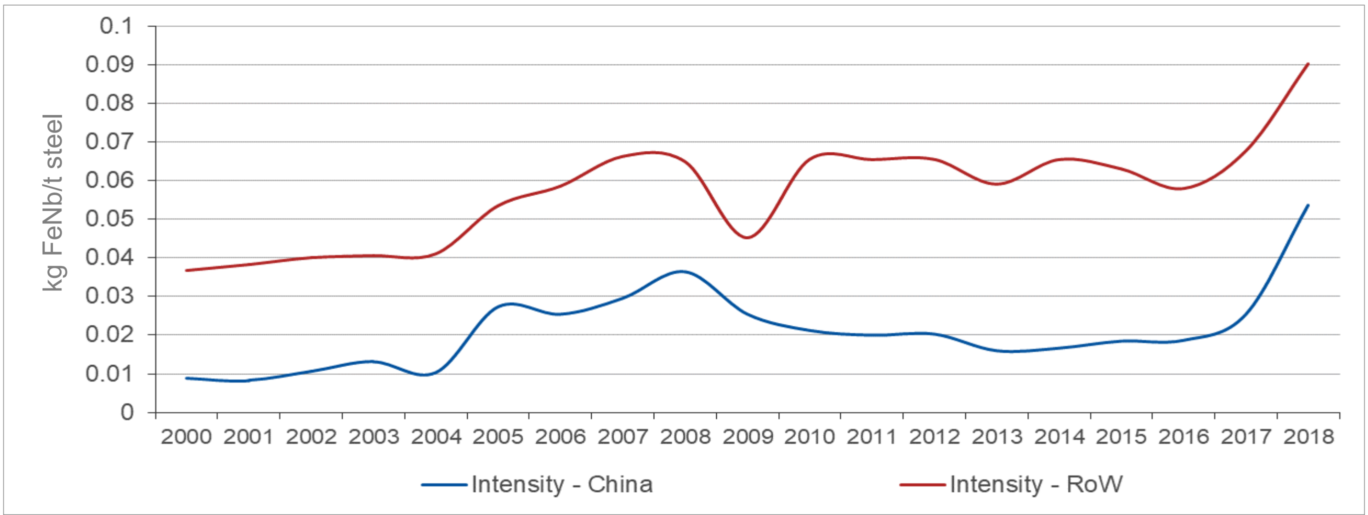

Figure 3: Niobium intensity in China and globally excluding China (Source: CRU, IHS)

Summary and conclusion: individual plant economics will drive substitution decisions

Each mill will have to look at substitution individually in relation to the economics of switching. The calculus for each mill will be unique as many factors such as customer base, technical ease of switching and many others will come into play for operators. In general, they must remember:

- Niobium and vanadium are not perfect substitutes as the strengthening of steel happens differently.
- Not all users of ferroalloys are able to technically substitute niobium for vanadium without processing changes requiring capital investment – raising the breakeven price difference for substituting.
- Not all consumers of steel can accept material with ferroalloys substituted for one another – no matter the final properties of the metal.
- Intensity gains are expected to be semi-permeant in China, with substitution being less likely to retreat in the world outside China.

Tantalum and niobium intellectual property update

Information here is taken from the European Patent Office (www.epo.org) and similar institutions. Patents listed here were chosen because they mention "tantalum" and/or "niobium". Some may be more relevant than others due to the practice by those filing patents of listing potential substitute materials. Note that European patent applications that are published with a search report are 'A1', while those without a search report are 'A2'. When a patent is granted, it is published as a B document. Disclaimer: This document is for general information only and no liability whatsoever is accepted. The T.I.C. makes no claim as to the accuracy or completeness of the information contained here.

Title		
Publication #	Applicant(s)	Publication date

TANTALUM

Perpendicular spin transfer torque memory (psttm) devices with a non-stoichiometric tantalum nitride bottom electrode and methods to form the same

WO2019005160 (A1)	INTEL CORP [US]; OUELLETTE DANIEL G [US]; WU STEPHEN Y [US]; BROCKMAN JUSTIN S [US]; WIEGAND CHRISTOPHER J [US]; GOLONZKA OLEG [US]; RAHMAN TOFIZUR [US]; SMITH ANGELINE K [US]; DOYLE BRIAN S [US]; ALZATE VINASCO JUAN G [US]; OBRIEN KEVIN P [US]; OGUZ KAAN [US]; DOCZY MARK L [US]	2019-01-03

Implant and method for manufacturing same

WO2019009428 (A1)	DAICEL POLYMER LTD [JP]	2019-01-10

Method of obtaining a given configuration of film resistors based on tantalum and compounds thereof

RU2017125408 (A); RU2017125408 (A3); RU2681521 (C2)	JOINT-STOCK COMPANY "OMSK SCIENTIFIC-RESEARCH INSTITUTE OF INSTRUMENT ENGINEERING" (ONIIP JSC) [RU]	2019-01-15

Heat-resistant alloy based on nickel for casting of working blades for gas turbines

RU2678352 (C1)	AKTSIONERNOE OBSHCHESTVO NAUCHNO PROIZVODSTVENNOE OBEDINENIE TSENTRALNYJ NAUCHNO ISSLEDOVATELSKIJ IN [RU]	2019-01-28

Semiconductor device, solid-state imaging device with tantalum oxide layer formed by diffusing a material of an electrode of necessity or a counter electrode

US2019035841 (A1)	SONY CORP [JP]	2019-01-31

Titanium aluminum and tantalum aluminum thin films

US2019043962 (A1)	ASM IP HOLDING BV [NL]	2019-02-07

Medical needle and method of maintaining sharpness of needle

EP3444391 (A1)	NATIONAL TAIWAN UNIV OF SCIENCE AND TECHNOLOGY [TW]	2019-02-20

Method of making a tantalum sputtering target with increased deposition rate

US2019055629 (A1)	TOSOH SMD INC [US]	2019-02-21

Ta method for manufacturing tantalum powder

KR20190019368 (A)	MTIG [KR]; FOUNDATION FOR RESEARCH AND BUSINESS SEOUL NATIONAL UNIV OF SCIENCE AND TECHNOLOGY [KR]; INST FOR ADVANCED ENGINEERING [KR]	2019-02-27

Method of fabricating tantalum nitride barrier layer and semiconductor device thereof

US2019067443 (A1)	TAIWAN SEMICONDUCTOR MFG CO LTD [TW]	2019-02-28

NIOBIUM

Processes for producing tantalum alloys and niobium alloys

EP3416772 (A1)	ATI PROPERTIES LLC [US]	2018-12-26

Process for manufacturing a titanium niobium zirconium (tnz) beta-alloy with a very low modulus of elasticity for biomedical applications and method for producing same by additive manufacturing

EP3416769 (A1)	DJEMAI ABDELMADJID [FR]	2018-12-26

Niobium-containing film forming compositions and vapor deposition of niobium-containing films

WO2019005433 (A1)	AIR LIQUIDE [FR]; LANSALOT MATRAS CLEMENT [US]; LEE JOOHO [KR]; NOH WONTAE [KR]	2019-01-03

Processes for refining niobium-based ferroalloys

US2019003011 (A1)	CBMM SA [BR]	2019-01-03

Austenitic stainless steel having niobium and manufacturing method of the same

KR101943591 (B1)	KOREA ADVANCED INST SCI & TECH [KR]	2019-01-30

Stainless steel alloys and turbocharger kinematic components formed from stainless steel alloys

US2019048441 (A1)	HONEYWELL INT INC [US]	2019-02-14

Nickel-base alloy, turbine blade, and method for producing injection molded article of nickel-base alloy

EP3444366 (A1)	MITSUBISHI HEAVY IND AERO ENGINES LTD [JP]	2019-02-20

Heat treatable coated article with niobium zirconium inclusive ir refelecting layer and method of making same

PL1667809 (T3)	GUARDIAN GLASS LLC [US]	2019-02-28

Sputtering targets and devices including mo, nb, and ta, and methods

US2019066987 (A1)	H C STARCK INC [US]	2019-02-28

Diary of forthcoming events to be attended by T.I.C. staff *

- MMTA's International Minor Metals Conference, Edinburgh, UK, April 9th to 11th 2019
- CMSE Components for Military & Space Electronics, Los Angeles, CA, USA, April 16th to 18th 2019
- OECD's 13th Forum on Responsible Mineral Supply Chains, Paris, France, April 23rd to 25th 2019
- IAEA's 38th TRANSSC meeting in Vienna, Austria, June 26th to 28th 2019
- **T.I.C.'s 60th General Assembly and AGM in Hong Kong, China, October 13th to 16th 2019**
- RMI's Annual Conference in Santa Clara, CA, USA, October 23rd to 25th 2019
- London Metals Week 2019 in London, UK, October 28th to 30th 2019
- EU Raw Materials Week, Brussels, Belgium, November 18th to 21st 2019
- FORMNEXT, Frankfurt, Germany, November 19th to 22nd 2019

* correct at time of print

Member company and T.I.C. updates

Changes in member contact details

Since the last edition of this newsletter the following changes have been made to delegate contact details:

- **Alliance Mineral Assets Ltd**: Ms Claire O'Brien has replaced Ms Pauline Gately as the nominated delegate. She can be reached at Claire.Obrien@allianceminerals.com.au.
- **H.C. Starck Inc./Fabricated Products**: Mr Mark Smolinsky has a new email: mark.smolinsky@hcsfpr.com.
- **Responsible Minerals Initiative (RMI)**: Ms Hillary Amster has replaced Ms Leah Butler as the nominated delegate. She can be contacted on hamster@responsiblebusiness.org.
- **Samwood NEO Inc.**: The delegate has a new email address satomi@sw-neo.com.
- **Standard Die International**: Mr Dave Waldeck has replaced Ms Jill Kroll as the nominated delegate. He can be reached at dwaldeck@standarddie.com.
- **ThreeArc Mining LLC**: Mr Sergey Grebenkin has replaced Mr Oleg Anikin as the delegate. He can be contacted on sgrebenkin@threearc.ru
- **United Spectrometer Technologies Pty Ltd**: The office address has changed to 26 Carbernet Street, Saxenburg Park 1, Blackheath, Cape Town, 7580, South Africa. All other details remain the same.

Members of the Executive Committee of the T.I.C. 2018-2019

The Executive Committee is drawn from the membership and committee members may be, but need not also be, the delegates to the T.I.C. of member companies. The Executive Committee that was approved by the T.I.C. members at the Fifty-ninth General Assembly consists of (alphabetical by surname):

Fabiano Costa	fcosta@amgmineracao.com.br
John Crawley (President)	jcrawley@rmmc.com.hk
Silvana Fehling	silvana.fehling@hcstarck.com
David Gussack	david@exotech.com
Jiang Bin	jiangb_nniec@otic.com.cn
Janny Jiang	jiujiang_jx@yahoo.com
Kokoro Katayama	kokoro@raremetal.co.jp
Raveentiran Krishnan	raveentiran@msmelt.com
Ben Mwangachuchu	bmwangaceo@smb-sarl.com
Candida Owens	owens.candida@cronimet.ch
Daniel Persico	danielpersico@kemet.com
Alexey Tsorayev	tsorayevaa@ulba.kz

Of these twelve, Mr John Crawley was elected President of the T.I.C. until October 2019. The T.I.C. currently has the following subteams (chaired by): Marketing (Daniel Persico), Meetings (Candida Owens), Statistics (Alexey Tsorayev) and Supply Chain (John Crawley). We are always looking for enthusiastic T.I.C. members to join the Executive Committee or one of our subteams. If you are interested in doing so please contact director@tanb.org.

The Anders Gustaf Ekeberg Tantalum Prize

The panel of experts 2019

The Ekeberg Prize is the leading science prize for published research on the element tantalum (Ta). The winner is chosen by an independent panel of tantalum experts drawn from industry and academia. We are delighted to announce two new members of the panel who will be considering the 2019 submissions:

Professor Toru Okabe of the Institute of Industrial Science, The University of Tokyo. Dr Okabe's doctorate examined the processing of reactive metals, such as titanium and niobium, and his subsequent career has included postdoctoral research with Professor Donald Sadoway at Massachusetts Institute of Technology (MIT), USA. Dr Okabe specialises in materials science, environmental science, resource circulation engineering and rare metal process engineering. Recently, in addition to the research on the innovative production technology, he has been working on new recycling and environmental technology of rare metals, such as niobium, tantalum, scandium, tungsten, rhenium, and precious metals.

Tomáš Zedníček Ph.D. is President of the European Passive Components Institute (EPCI). Dr Zedníček's doctorate examined tantalum capacitors and was awarded in 2000 from the Technical University of Brno in the Czech Republic. Prior to establishing EPCI in 2014, he worked for over 21 years at a major tantalum capacitor manufacturer, including 15 years as the worldwide technical marketing manager. He has authored over 60 technical papers and a US/international patent on tantalum and niobium capacitors. He regularly presented at the CARTS passive component conference and other leading events. Dr Zedníček has also contributed several articles for the T.I.C. Bulletin.

The 2019 panel of experts will be lead by Mr Richard Burt, a former President of the Association, ably assisted by Professor Elizabeth Dickey of North Carolina State University, USA; Dr Magnus Ericsson of Luleå University of Technology, Sweden; Dr Nedal Nassar of U.S. Geological Survey (USGS), USA; and Dr Axel Hoppe, a consultant and Chairman of the Board of Commerce Resources, Canada/Germany. Since 2018, Academician He Jilin of the China Academy of Engineering and Professor Animesh Jha of Leeds University, UK, have stepped down from the panel; the T.I.C. sincerely thanks them for their contribution.

Call for publications

The Ekeberg Prize is awarded for the published paper or patent that is judged by an independent panel of experts to make the greatest contribution to understanding the processing, properties or applications of tantalum (Ta).

Eligible publications must be in (or translated into) English and be dated between October 2017 and April 2019.

Suitable subjects may include, but are not limited to:

- Processing of tantalum minerals or other raw materials
- Tantalum used in capacitors or other electronic applications
- Tantalum metallurgy and mill products, including alloys
- The use of tantalum powder in additive manufacturing (3D printing) as pure metal or in an alloy
- Medical (including dental) applications of tantalum
- Recycling of tantalum-bearing scrap

To submit a publication please contact the T.I.C. office at info@tanb.org by May 31st 2019. The prizegiving ceremony will take place during the 60th General Assembly in Hong Kong, in October 2019.