

TIC

TANTALUM-NIOBIUM

INTERNATIONAL STUDY CENTER

Bulletin N° 172: January 2018

Announcing the Anders Gustaf Ekeberg Tantalum Prize



An artist's impression of the Prize medal, set against a background of tantalite ore.

Contents

President's Letter	2	Tantalum efficiency wins the markets	12
Director's Letter	3	The changing face of tantalum	16
The Anders Gustaf Ekeberg Tantalum Prize	4	Tantalum and niobium intellectual property	22
58th General Assembly and 2017 AGM report	6	59th General Assembly: CALL FOR PAPERS	23
Proposal for the T.I.C.'s statistics service	9	Member company and T.I.C. updates	23
Introduction to the EPRM	10	And finally... extra-terrestrial niobium	24

President's Letter

Dear Fellow Members,

As we enter the new year, I look back on 2017 as a year that has shown warnings of 'turbulence' in the supply chain. While 2018 undoubtedly promises improvement, I am reminded that efforts to tackle industry problems often take years to bear fruit. For example, the work done to expand the supply of sources in 2009 paid dividends in 2014 – 2017. It is clear that promoting tantalum and niobium, and protecting the reputation of these industries must be pursued continuously. The major goals for 2018 will be 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.



The T.I.C.'s 59th General Assembly will be held in the beautiful Great Lakes Region of central Africa, in October 2018.

(photo: Shutterstock)

The central African General Assembly has the exciting potential of attracting a host of African members who have not been able to attend conferences in other venues. The expanded African attendance should draw companies looking for new supply options. Locating the 59th General Assembly in central Africa will show our organization and industry's commitment to an increasingly valued supply region.

I would like to thank the Ministry of Mines in the Democratic Republic of the Congo and the Rwanda Mines, Petroleum & Gas Board for their willingness to meet so many times. I am excited about the concept of a central African steering committee comprised of participants from both key countries

and other regional producers including Ethiopia, who I am sure will develop a template that ensures pan-African support for this conference.

To improve our statistics service, the Statistics Subteam has recommended adopting a less confusing reporting format and the augmentation of member statistics with world wide import and export data (discussion of the proposal is included in this Bulletin, see page 9). The new statistics report is intended to provide more useful information for our members by clearly and accurately showing changes in industry demand and supply. Improved statistics will also allow the T.I.C. to measure the effectiveness of the Association's efforts at promotion of tantalum and niobium.

At the end of last year, I had the pleasure of attending conferences with Roland and David, as well as visiting Emma in the Brussels office. There has been a real need to clarify the roles and job descriptions of the team, and to put in place reasonable policies to assure best practices for the Association.

I have been very impressed with the ability and dedication Roland, Emma and David bring to the T.I.C. and feel improvements in the organizational structure will help everyone work together to achieve the ambitious but attainable goals set by the Executive Committee.

Sincerely yours,

John Crawley

President



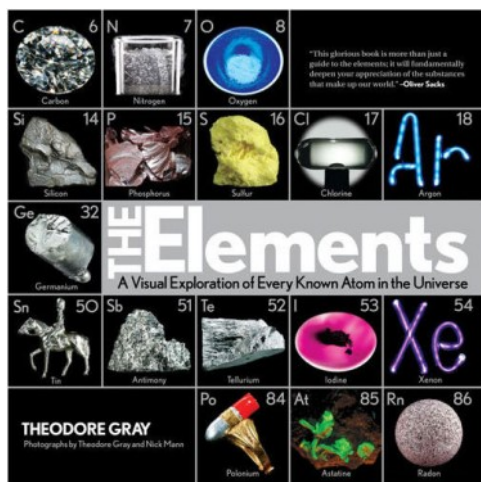
The T.I.C.'s office in Lasne, Brussels, Belgium

(photo: Google Earth)

Dear T.I.C. Members and stakeholders,

It was wonderful to catch up with so many of you at our conference in Vancouver and I hope you found the presentations as interesting as I did. The 58th General Assembly was a great success and my sincere thanks to all members who participated in the annual general meeting, providing the T.I.C. with guidance and the mandate for the busy year ahead. A report from Vancouver can be found on pages 6 to 8.

For the first time at a General Assembly, this year we held a light-hearted vote that asked delegates to chose which presentations they had found most technical and most entertaining. We received a lot of feedback and the large number of votes cast for all the presentations underlines the high quality of the plenary sessions.



The prize for the presentations as voted by delegates to the 58th General Assembly (photo: periodictable.com)

Voting was very close, but once voting was complete the winning presentations were:

- Most technical: **Tantalum efficiency wins the markets**

Written by Y. Freeman, P. Lessner, J. Poltorak, C. Guerrero, S. Hussey and C. Stolarski, and presented by Dr Yuri Freeman (KEMET Electronics Corporation).

- Most entertaining: **The mysterious life of the tantalum atom**

Written and presented by Ms Kokoro Katayama (Metal Do Co. Ltd) and Mr Joel Nields (Exotech, Inc.).

Their prize will be a copy of "The Elements" by Theodore Gray, a stunning illustrated guide to the periodic table. Dr Freeman's presentation is on pages 12-15 of this newsletter and members are reminded that the presentations from Vancouver, including *The mysterious life of the tantalum atom*, are available in the members' section at www.TaNb.org, under the "PUBLICATIONS" tab.

If you are interested in giving a presentation at the 59th General Assembly in October 2018 please contact Emma Wickens at info@tanb.org to receive an abstract submission form before the end of March.

Recognising excellence in tantalum

There are many powerful, positive messages to tell about both the elements we represent. However, while for almost forty years developments in niobium have been recognised by the Charles Hatchett Award, sponsored by CBMM, until now developments in tantalum have not had a similar recognition.

This is why the T.I.C. has agreed to sponsor a new international honour dedicated to recognising excellence in tantalum research and development. It is called the Anders Gustaf Ekeberg Tantalum Prize and I hope you will share our enthusiasm for this flagship project to promote tantalum (details are on pages 4 - 5).

Out and about

The fourth quarter of 2017 saw the T.I.C. team on the road more than ever before, clocking up thousands of airmiles and meeting hundreds of members and other stakeholders. Next month T.I.C. will be attending the Mining Indaba in Cape Town, South Africa, and if you know of other events that are relevant for the Association to attend, then please let us know. We are ready to promote tantalum, niobium and members' interests wherever and whenever necessary.

Best wishes,

Roland Chavasse,

Director



Giving a presentation at the CRU-Ryan's Notes conference in Arizona, USA, in October 2017.

(photo: CRU Publishing)

Announcing the Anders Gustaf Ekeberg Tantalum Prize

The Anders Gustaf Ekeberg Tantalum Prize (the Prize) is a new annual award established by the Tantalum-Niobium International Study Centre (T.I.C.) to recognise excellence in published tantalum research*. The Prize will increase awareness of the many unique properties of tantalum products and the applications in which they excel.

The Prize has been named after the discoverer of tantalum and will be awarded to the lead author(s) of the published paper or patent that is judged by an independent panel of experts to have made the greatest contribution to understanding the processing, properties or applications of tantalum. The prize is sponsored by the T.I.C. and is central to its efforts to publicise the many exceptional benefits afforded by this element.



An artist's impression of how the Prize medal could look.

The long-term future of the tantalum market will depend on technology-driven innovations and winners of the Anders Gustaf Ekeberg Tantalum Prize will be acknowledged as true leaders in this field. The lead author(s) will be invited to give a presentation on their work at a General Assembly, where they will also receive a medal made of tantalum and a certificate of award presented by the T.I.C. President. They will also be interviewed in this magazine.

Who was Anders Gustaf Ekeberg?

Born in 1767, Anders Gustaf Ekeberg was a Swedish scientist, mathematician, and poet. He became a professor at Uppsala University in 1794 and initially made his name by developing advanced analytical techniques and by proposing Swedish names for the common chemical elements according to the principles set out by the "father of modern chemistry" Antoine-Laurent de Lavoisier.

Ekeberg discovered the oxide of tantalum in 1802, isolating it from samples of two different minerals, specifically, tantalite from Kimito, Finland and yttrotantalite from Ytterby, Sweden.

According to Ekeberg's friend, the chemist Jacob Berzelius, Ekeberg chose the name 'tantalum' partly to reflect the difficulties that he had experienced in reacting the new element with common acids and partly out of his passion for ancient Greek literature. Tantalus was a demi-god who killed and cooked his son, Pelops, and as punishment was condemned to stand in a pool of water beneath a fruit tree with low branches, with the fruit ever eluding his grasp, and the water always receding before he could take a drink.

Ekeberg suffered from poor health in later years and in February 1813 he died, unmarried, at the age of 46.



A sample of yttrotantalite (dark) from Skuleboda, Västergötland, Sweden
(photo: e-rocks.com)

How will the Prize be granted?

The Prize is open to any published paper or patent that is judged to advance knowledge and understanding of tantalum. To be eligible for consideration the publication must be in English and be made between 24 and 6 months before the award ceremony at a T.I.C. General Assembly. Therefore, to be eligible for the October 2018 Prize a publication must be dated between October 2016 and April 2018.

Should you wish to submit or recommend a publication for consideration for the 2018 Award, then please contact info@tanb.org or any member of the Executive Committee (see page 6) by March 31st 2018.

Suitable subjects may include, but are not limited to:

- 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)
- Innovative new applications for tantalum
- Processing of tantalum minerals, synthetic concentrates or other raw materials
- Recycling of tantalum-bearing scrap

The T.I.C. staff and Executive Committee, acting as secretariat to the Prize, will create a shortlist of approximately a dozen eligible publications for consideration by the independent panel of experts (the 'Panel') that will vote on the winner.

The Panel

The Panel is a group of between five and seven international experts selected from around the world to provide an impartial assessment on the technical merit of the shortlisted papers. Each will be asked to serve for up to three years to give continuity and stability to the decision-making process. Members of the T.I.C. Executive Committee and staff cannot sit on the Panel.

Work has already started to identify experts and invite them to join the Panel. Details of this esteemed group will be published in the next Bulletin (#173, April 2018). If you wish to be considered or would like to recommend someone as a panellist please contact info@tanb.org.

Schedule for the first Anders Gustaf Ekeberg Tantalum Prize

The initial Prize is planned to be awarded at the 59th General Assembly in October 2018. Full details of the Prize will be added to a dedicated section of our website in due course. **TIC**

The Anders Gustaf Ekeberg Tantalum Prize follows in a long tradition of awards for excellence in metals, chemicals and related scientific disciplines, including:



The Albert Einstein World Award of Science (science)



The Nobel Prizes (including physics and chemistry)



The Bessemer Gold Medal (steel)



The Charles Hatchett Award Prize (niobium)



The Gadolin Medal of the Society of Finnish Chemists (chemistry)

* Although the T.I.C. represents and supports both tantalum and niobium equally, the Anders Gustaf Ekeberg Tantalum Prize will focus only on tantalum, but this is only because CBMM's Charles Hatchett Award (www.charles-hatchett.com) already does an excellent job of recognising niobium published research.

Fifty-eighth General Assembly and 2017 AGM report

The Fifty-eighth General Assembly and 2017 annual general meeting (AGM) was held on October 15th - 18th 2017, at the Fairmont Waterfront Hotel in Vancouver, Canada. The event was attended by leading tantalum and niobium participants from around the world and was generously sponsored by KEMET Electronics Corp., A&R Merchants Inc., Exotech, Inc., and Krome Commodities Ltd.

During the AGM on October 16th, members passed motions including approving the minutes from the Fifty-seventh General Assembly, membership applications and the budget for 2018 financial year.

Also noteworthy was that the annual membership subscription has been frozen until December 2018. All documents pertaining to the General Assembly and AGM, together with the presentations and photos from the event, are currently available on the members' area of the Association's website.

Executive Committee elections

During the meeting Mr David Henderson (Rittenhouse International Resources LLC), Mr Marc Hüppeler (H.C. Starck Tantalum and Niobium GmbH) and Mr David O'Brock (formerly at NPM Silmet AS) stepped down from the Executive Committee. In the subsequent elections all other committee members were re-elected and Mr Janny Jiang (Jiujiang Jinxin Non-ferrous Metals Co. Ltd) and Mr Ben Mwangachuchu (Société Minière de Bisunzu (SMB)) were elected, bringing the total to eleven out of a possible twelve positions.

The Executive Committee is (alphabetical by surname):

Conor Broughton	conor@amgroup.uk.com
John Crawley (President)	jcrawley@rmmc.com.hk
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-rc@tokin.com
Alexey Tsorayev	tsorayevaa@ulba.kz

Of these eleven, Mr John Crawley was elected President of the T.I.C. until the next AGM, replacing Mr David Henderson who stepped down after three highly productive years in the role. During his time as President Mr Henderson instigated many initiatives which have contributed to the ongoing growth and success of this Association, and his pertinent contributions to the Executive Committee will be missed. As always, the T.I.C. asks that Executive Committee members serve as individuals, not in their corporate roles.

Looking ahead, the 59th General Assembly will be held in Kigali, Rwanda, on October 14th to 17th. If you are interested in giving a presentation or sponsoring at this event please contact Emma Wickens on info@tanb.org.

New members

At the AGM six new corporate members and one new associate member were elected.

Corporate membership of the T.I.C. is open to organisations actively involved in any aspect of the niobium and tantalum industries, from explorers to miners, traders and processors, through to end users and suppliers of goods and services to the industry.

Associate membership is available to organisations that are not commercially involved in our industries, such as academia, associations, government bodies and civil society.



The new corporate members are:

Mining Mineral Resources Sarl



Address: 7721 Avenue Kisambi, Quartier Lido-Golf, Lubumbashi, Haut-Katanga, DRC

Website: -

Delegate: Mr Geoffrey Levy

Email: geoffrey@somika.com

Standard Die International



Address: 12980 Wayne Road, Livonia, Michigan 48150, United States

Website: www.standarddie.com

Delegate: Ms Jill Krol

Email: jkrol@standarddie.com

Mitsubishi Corporation RtM Japan Ltd



Address: 7-2, Marunouchi 2-chome, Chiyoda-ku, Tokyo 100-7027, Japan

Website: www.mitsubishicorprtm.com

Delegate: Mr Takemi Okamoto

Email: takemi.okamoto@rtm.mitsubishicorp.com

Tantalex Resources Corporation



Address: 333 Bay Street, Suite 630, Toronto, Ontario, M5H 2R2, Canada

Website: www.tantalex.ca

Delegate: Mr Samuel Boudaux

Email: sb@tantalex.ca

Pilbara Minerals Ltd



Address: Level 2, 88 Colin Street, West Perth, Western Australia, Australia

Website: www.pilbaraminerals.com.au

Delegate: Mr Ken Brinsden

Email: cmarks@pilbaraminerals.com.au

ThreeArc Mining LLC



Address: Narodnogo Opolchenia 2A, St. Petersburg, Russia

Website: www.threearc.ru

Delegate: Mr Oleg Anikin

Email: oanikin@zaoict.ru

The new associate member is:

International Conference on the Great Lakes Region (ICGLR)



Address: Boulevard du Japon 38, B.P. 7076, Bujumbura, Burundi

Website: www.icglr.org

Delegate: Ambassador Ambeyi Ligabo

Email: secretariat@icglr.org

A selection of photos from the Fifty-eighth General Assembly





Facing page: Presenters and panellists at the General Assembly.
Above: Welcome Reception sponsored by Krome Commodities.
Below: the tour for accompanying persons and delegates exploring the local culture (photos courtesy of Joy Krause and Samantha Fife).

Many more photos are available at www.TaNb.org. **TIC**



Taking the T.I.C.'s statistics service to the next level

The Association's statistics service is over 40 years old and is mandated by our Charter (Article 3.2). It has seen several iterations in that time as members' requirements and the markets have developed and changed. In recent years we have moved from a fax-based collection system to the secure online database, but the last comprehensive overhaul of categories and rules was in 1983, since which time both the Association and the tantalum and niobium markets have changed considerably.



Under the proposed changes members' data will continue to be collected by Miller Roskell, the 100% independent certified accountant that has collected members' data since 2015.

Following extensive consultation with T.I.C. member companies throughout 2017 the Statistics Subteam wishes to propose that a complete reworking of the statistics service is needed. The membership statistics questionnaire in February 2017 found that the majority of members value the statistics service. What was also clear was the level of support for augmenting the members' data with third-party data, such as international trade statistics.

While the current T.I.C. statistics report format is well received, the Statistics Subteam is committed to improving the usefulness of the report. The focus for this initiative is on the more complex tantalum market since it is widely held that the niobium statistics are already of high quality and reliability.

The Statistics Subteam, supported by the Executive Committee, proposes the following changes:

1) Re-working the current quarterly statistics report

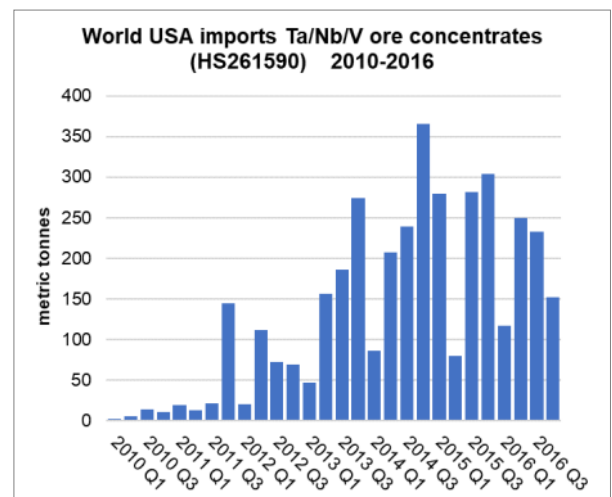
The Subteam is investigating ways to improve two key aspects of the current tantalum statistics system:

- Reporting rules: Feedback from members suggests strongly that the current reporting rules that exclude business with other members (in order to avoid double-counting) are overly complex. The current rules also fail to capture intra-company shipments by vertically integrated companies and pay insufficient attention to complex scrap flows, two aspects of the market that have changed greatly since the early 1980s.
- Reporting categories: The four most important points in the tantalum supply chain are i) when the ore is mined, ii) when the ore is refined to K-salt (K_2TaF_7) or other intermediate chemical, iii) when intermediate chemicals are transformed to a metal powder (of any grade) or a specialist chemical product, and iv) the activity of specialist scrap processors. Therefore the statistics should focus on these points in the supply chain.

2) Augmenting members' data with international trade data

All physical international trade is recorded according to categories that are defined by the Harmonized System (HS) set out by the World Customs Organization (WCO). Almost all countries participate in this system and use the HS codes to determine their tariff schedules. This system generates a vast quantity of data and by analysing it one can identify changes in patterns of international trade over time.

The Association proposes to purchase the data that is relevant to shipments of tantalum and niobium and use it to generate charts and analysis that will be presented to T.I.C. members in a new, second chapter to the quarterly statistics report.



An example of a chart created using trade data (© GTT)

Looking ahead

Please share your feedback on this proposal with our Technical Officer, David Knudson (david.knudson@tanb.org).

The Statistics Subteam's work on this issue is expected to continue until early March 2018 and the new reporting system is proposed to be in place for the first quarter of 2018 collection period (starting on April 1st 2018).

The updated reporting rules will be designed to be compliant with the World Customs Organization (WCO)'s new Harmonized System (HS) codes. **TIC**

The European Partnership for Responsible Minerals (EPRM)

In Bulletin #171 (October 2017) it was mentioned that the T.I.C. had applied for membership of the European Partnership for Responsible Minerals (EPRM, europeanpartnership-responsibleminerals.eu) which has since been confirmed. The EPRM is a multi-stakeholder partnership established to support the implementation of the OECD Due Diligence Guidance in Europe and promote responsible mining practices in Conflict and High Risk Areas (CAHRAs). Here the EPRM explains more about its structure, how it operates and its work.

The European Partnership for Responsible Minerals (EPRM) is a multi-stakeholder partnership which was set up in November 2016. Its main goal is aiming to increase the proportion of responsibly-produced minerals from conflict-affected and high-risk areas and to support the socially responsible extraction of minerals that contributes to local development. EPRM focuses on four conflict minerals: tin, tantalum, tungsten and gold (3T+G).



European
Partnership
for Responsible
Minerals

Why EPRM?

A number of regions in the world that are endowed with these minerals, for example Africa's Great Lakes Region and Colombia, are experiencing prolonged violent conflicts and severe human rights abuses. International trade in minerals can play a significant role in financing and perpetuating human rights violations in these conflict regions. It is therefore imperative to break the link between mineral extraction and conflict.

Responsible mineral supply chains require cooperation throughout the chain, from sourcing to the assembly of end products. The OECD Due Diligence Guidance is a key point of departure but further multi-stakeholder dialogue and cooperation are required to successfully implement it. The EPRM fulfils an important role in facilitating information-sharing and learning, both along the supply chain and across different sectors that make use of 3TG. Large downstream companies rely on the entire chain to meet their responsibility and can play an important role in educating and supporting SME suppliers.

In addition, EPRM provides an excellent way to support the implementation of the OECD Due Diligence Guidance in Europe itself. This includes backing up the European Commission's proposed legislation with action by both public and private actors. EU Commission, Parliament and Member States have noted the need for such initiatives. However, progress at the EU is not a precondition for the development of EPRM, which has a worldwide scope.

What kind of activities?

EPRM supports activities to improve the conditions in mining areas in conflict affected and high-risk areas. EPRM will also serve as a knowledge platform where organisations can share knowledge on due diligence. For instance, it provides support for the implementation of the OECD Due Diligence Guidance in Europe and will promote knowledge-sharing and cooperation between supply chain actors.



Artisanally produced 3T minerals
(photo: EPRM)

A key bottleneck in the responsible mineral supply chain is that mines lack the necessary skills, regulations and financial capability to implement good mining practices.

The role of the EPRM is to create partnerships with stakeholders such as international organisations, civil society organisations, and local governmental agencies to increase financial and technical resources and coordinate strategies to support better mining practices on a larger number of mines in targeted countries. The main objective is to bring better social and economic conditions for mine workers and local communities. The pilot projects are currently being implemented in Colombia, DRC and Indonesia. For more information visit <https://europeanpartnership-responsibleminerals.eu/projects>.

Who can contribute?

EPRM encourages companies, civil society organizations and governments to join the EPRM. From SMEs to large companies, the EPRM enables all supply chain actors to make progress in the field of responsible minerals not only by jointly tackling issues regarding responsible mineral sourcing, but also by supporting companies and SMEs in conducting due diligence and by creating a platform for sharing knowledge, best practices and lessons learned.

The EPRM supports capacity-building of upstream actors as well as public institutions on the ground in conflict-affected and high-risk areas and helps to foster stronger linkages between downstream and upstream partners throughout the entire supply chain.

Current EPRM board members are:

Supply chain actors:

- Intel
- RMI (formerly CFSI)
- Valcambi

Civil Society:

- Solidaridad
- IPIS
- Diakonia

Governmental institutions

- Dutch Ministry of Foreign Affairs
- UK Foreign & Commonwealth Office
- Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (BMZ)



Washing coarse minerals (photo: EPRM)

The secretariat of EPRM is hosted by The Netherlands Enterprise Agency (RVO.nl, english.rvo.nl).

Case studies of EPRM projects

The following case studies are EPRM projects that are currently being implemented in Colombia and the DRC. A third project is underway in Indonesia, promoting responsible tin mining.

1. IMPACT – AFECOR in DRC

The Artisanal Mining Women’s Empowerment Credit & Savings project (AFECOR) supports women and men in artisanal gold mining communities to access savings and credit in an effort to promote entrepreneurship and economic security. Women and men participating in Democratic Republic of Congo’s Ituri Province are supported by AFECOR to establish village savings and loans associations. By participating in the AFECOR project, artisanal miners and community members decrease their reliance on informal credit networks that characterize the “gold economy”, where gold is used as currency to cover basic needs, small businesses and mine site operations, often with unfavourable conditions. The AFECOR project promotes women’s leadership and economic empowerment in their homes, at artisanal mine sites, and in the wider community.

2. CAPAZ – Passport to Markets programme in Colombia

The CAPAZ programme has two main goals. Firstly, to develop an open-source and worldwide Market Entry Standard for commercial engagement with artisanal and small-scale gold mining, especially in Conflict Affected and High Risk Areas. This standard will ensure compliance with the OECD Due Diligence Guidance framework and other key requirements. It provides a ‘passport to markets’ for artisanal miners and it brings efficiency and confidence for downstream companies and refiners seeking to engage with these artisanal miners. Secondly, pilots will promote local development in the communities surrounding the pilots. Supply chain actors and other key stakeholders in Colombia will be engaged to raise awareness of the (little-known) conflict-free minerals regulations. Practical case studies and solutions will help prepare the Colombian ASM sector to comply with OECD Due Diligence requirements, and to seize opportunities to engage with legitimate markets.

For further information about EPRM, its work and how to join visit europeanpartnership-responsibleminerals.eu.

Tantalum efficiency wins the markets

Paper written by Y. Freeman, P. Lessner, J. Poltorak, C. Guerrero, S. Hussey, and C. Stolarski, KEMET Electronics Corp., and presented by Dr Yuri Freeman on October 16th 2017, as part of the Fifty-eighth General Assembly in Vancouver, Canada. All views and opinions in this article are those of the authors and not the T.I.C.

P.O. Box 5928, Greenville SC 29606, United States

questions@kemet.com, www.kemet.com

Introduction

This presentation was largely taken from the book 'Tantalum and Niobium-Based Capacitors' by Dr Freeman which was published by Springer in October 2017. It is the first book to be dedicated to this subject and details appear at the end of this article.

The key message of this presentation is that nothing is simple in the applications for tantalum and niobium. In nature there are many significant obstacles in tantalum and niobium thermodynamics, but these obstacles, if understood, can be used to make products with unparalleled efficiency and reliability that far exceed the performance of alternatives.

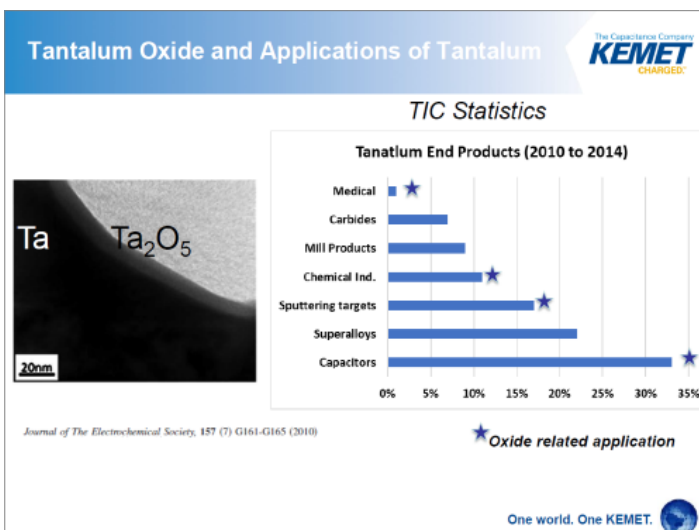


A brief history of tantalum

Tantalum was discovered in 1802 by the Swedish analytical chemist Anders Ekeberg in mineral samples, including from Ytterby in Sweden. The minerals from Ytterby are rich in several rare elements and yttrium was also first identified there. The name 'tantalum' comes from the ancient Greek myth of Tantalus, a powerful hero who challenged the gods, lost, and was punished by eternal thirst and hunger.

When Ekeberg discovered tantalum, he needed to dissolve it to test its properties. However, all the common mineral acids could not dissolve it and when he eventually succeeded he named the new element after Tantalus, remembering his struggles.

According to the same ancient Greek myth Niobe was a daughter of Tantalus, and this was a fitting connection when niobium capacitors first started to be developed in Russia. That development was forced by a shortage of tantalum in Russia at that time. Eventually niobium capacitors were developed to be a reasonable alternative to tantalum capacitors and they are still manufactured in Russia today.



Tantalum oxide and applications of tantalum

Ekeberg's difficulty in dissolving tantalum was because tantalum is always covered by a thin film of tantalum pentoxide. It is a native oxide, forming naturally.

The oxide of tantalum has extreme resistance to acids and other chemicals. About half the applications of tantalum are not applications of pure elemental tantalum, but rather are using the thin film of tantalum oxide that forms over its surface.



Tantalum medical implants

Tantalum implants are totally biocompatible with human tissue. There has never been a rejection by the body of tantalum implants.

You can also make the structure porous, so that bone and blood vessels grow through the structure, locking it in place and preventing loosening over time. The porosity is also weight-saving.

Tantalum carbide (TaC) in cutting tools

Tantalum has a very high melting point, almost half the temperature of the surface of the sun.

But tantalum carbide melts at 900 degrees higher still. It is one of the highest melting points of any material that has ever been manufactured.

Tantalum carbide also has extremely high hardness and can even treat diamonds.

The slide is titled "Tantalum Carbide in Cutting Tools" and features the KEMET logo. It contains a table with the following data:

	Melting Point, °C	Hardness, kg/mm ²
Ta	2980	110
TaC	3880	1600-2000

Below the table is an image of cutting tools with yellow inserts. The text "Wikipedia" is at the bottom left and "One world. One KEMET." is at the bottom right.

The slide is titled "Tantalum in Chemical Industry and Coins" and features the KEMET logo. It contains two images: a person in a lab coat working with equipment and two coins. The text "Wikipedia" is at the bottom left and "One world. One KEMET." is at the bottom right.

Tantalum in the chemical industry and coins

In the chemical industry the tantalum pentoxide provides a highly resistant layer to protect equipment. The oxide layer is also used in coins produced by the Kazakhstan mint. The strong permanent colour is from the oxide film. But the oxide itself has no colour so how can this be?

The thickness of the oxide layer is exactly equal to the wavelength of blue light (in this example, although many other colours can be produced by varying the thickness of the layer).

Tantalum targets for MOSFET transistors

The third largest application comes from the use of tantalum in MOSFET transistors (MOSFET stands for metal-oxide-semiconductor field-effect transistor). Transistors form the basis of any electronic device by amplifying and switching the signal. Before the invention of semiconductor transistors, these were large vacuum tube transistors and one commonly used model was called a 'finger', due to its resemblance.

Tantalum Targets for MOSFET Transistors

The image shows two 3D electron density plots for SiO₂ and Ta₂O₅. The top plot for SiO₂ has a color scale from 1.9 to 2.1. The bottom plot for Ta₂O₅ has a color scale from 11 to 13. To the right is a cross-sectional diagram of a MOSFET gate stack. It shows a substrate with a gate stack consisting of a SiO₂ layer and a Ta₂O₅ layer. The text indicates that Ta₂O₅ is replacing SiO₂. Below the diagram, the dielectric constants are listed: SiO₂: k = 3.9 and Ta₂O₅: k = 26.5. The KEMET logo is in the top right corner.

Wikipedia

One world. One KEMET.

On an integrated circuit there are tens of thousands of transistors on a small chip. Individual transistors are now so small they cannot be seen with a naked human eye. Small transistors underpin the development of powerful small mobile phones, laptops and so forth.

Originally silicon dioxide was used as a dielectric in MOSFET transistors, but increasingly tantalum pentoxide is being used because the threshold voltage (V_{th}), for the switch is inversely proportional to the dielectric constant. Lower V_{th} means a more efficient product.

Nickel/TaC superalloy in turbine blades

The second largest application is the use of tantalum in superalloys. Last year the T.I.C. conference was in Toulouse, France, and we visited Airbus. This was because of the use of TaC in superalloys.

Creep deformation is a problem whereby the metal engine parts, under extremely high temperature and centrifugal forces, change shape. This can cause an engine to fail.

Adding TaC stabilises the superalloy because of its exceptional melting point. It sits on the crystalline grain boundaries and will not allow creep.

Ni/TaC Super Alloy in Turbine Blades

The image shows an Airbus A380 aircraft, a turbine blade, and a diagram of a Ni/TaC superalloy crystal structure. The turbine blade is labeled 'Nickel superalloy jet engine (RB199) turbine blade'. The diagram shows a central Ni atom surrounded by TaC atoms. The text indicates 'Secondary phase TaC' and 'Ni'. Below the diagram, the thermal creep deformation is listed: - dislocation motion and - grain boundaries motion. The KEMET logo is in the top right corner.

Wikipedia

One world. One KEMET.

Tantalum capacitors in cardio implants

Tantalum Capacitors in Cardio Implants

The image shows a diagram of a human chest with a cardioverter defibrillator (ICD) implanted. The ICD is a small device that is surgically inserted into the human chest. The diagram is labeled 'With permission from Medtronic Corporation'. To the right are two microscopic images of tantalum capacitors. The top image shows a large number of small, spherical capacitors. The bottom image shows a close-up of a single capacitor. The text indicates 'With permission from KEMET Dr. Javaid Qazi' and 'One world. One KEMET.' The KEMET logo is in the top right corner.

Wikipedia

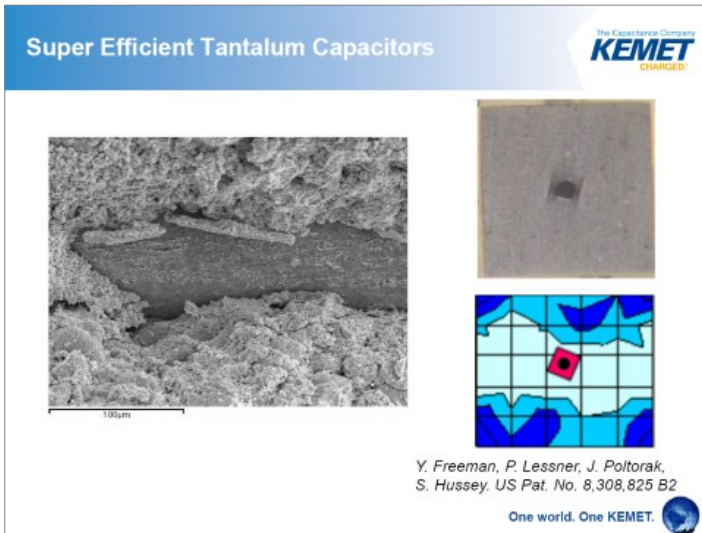
One world. One KEMET.

The most important tantalum application, representing some 30% of consumption, is that of tantalum capacitors.

Tantalum capacitors have record high efficiency CV/cc thanks to the design of the tantalum anodes sintered with tantalum powder, which provides a vast surface area in a minute space, and a very thin dielectric in the region of 20 to 400 nm thick, and exceptional reliability and durability.

The uses of tantalum capacitors are many and varied, but one that stands out for its contribution to human health is the implantable cardioverter defibrillator (ICDs).

There is limited room in a human chest to insert chunky aluminium capacitors and historically the alternative was to use external defibrillators that would have to be carried everywhere by a patient at risk. Tantalum capacitors allow an ICD to be small enough to be surgically inserted in the human chest, and yet still deliver 750 volts, enough to be effective on even the largest human body.



Super-efficient tantalum capacitors

High volumetric efficiency is the key selling point of tantalum capacitors that allows for continued miniaturization of the capacitor and the end electronic device. Historically, improvements in tantalum capacitors were achieved by using ever finer powder particles that have a higher surface area to volume ratio. However, the finest powders must be sintered at low temperature if they are not to be over sintered (i.e. be compressed to the point that their surface area reduces). This created a major obstacle since at low sintering temperatures the fine powder does not bond well with the small tantalum lead wire that connects the capacitor to the circuit board. If one used a higher temperature

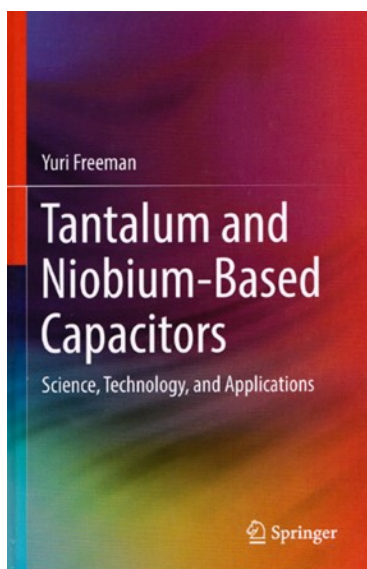
sintering process it would ensure a strong bond between lead wire and powder, but the powder would become compacted, lose surface area and therefore lose efficiency.

One solution developed by KEMET is to locally increase the press density around the lead wire. Thereby the wire-powder bond is improved without increasing the sintering temperature and causing capacitance to decrease.

Applications of tantalum capacitors

Today there are some extraordinary applications for tantalum capacitors. The fastest growing application is space. For more than fifty years it was believed that only wet tantalum capacitors can operate under the extreme conditions of space, but today there are advanced polymer capacitors which can meet the requirements, and do so more efficiently too.

Tantalum metal is ductile, it is malleable, and it also has remarkable properties, resistance to chemicals, dielectrics and much more. Tantalum may look gentle, like any other metal, but don't be fooled, it is an exceptional element with some truly remarkable properties.



Tantalum and Niobium-Based Capacitors

by Dr Yuri Freeman, 2017

ISBN 978-3-319-67870-2

Available to buy from <http://www.springer.com/gp/book/9783319678696>

This essential book provides an accessible yet comprehensive analysis of the science, technology, and applications of tantalum and niobium-based capacitors.

It focuses on polymer tantalum capacitors, with rapidly growing applications in special and commercial electronics. It discusses the fundamentals, focusing on thermodynamic stability, major degradation processes and conduction mechanisms in the basic structure. The major manufacturing steps from capacitor grade powder to the testing of finished capacitors are described. Applications are discussed and so too are theoretical models.

The changing face of tantalum

Paper written by Patrick Stratton, Jack Anderson and Robert Baylis, Roskill Information Services, for the Fifty-eighth General Assembly in Vancouver, Canada. All views and opinions in this article are those of the authors and not the T.I.C.

Roskill Information Services Ltd, 54 Russell Road, London SW19 1QL, United Kingdom

patrick@roskill.com, www.roskill.com

Introduction

The tantalum industry has seen many changes over the years. Prices have displayed a habit of volatility, often not based on supply/demand reality. The pattern of demand has altered. Relatively low-cost artisanal mining has made much of the conventional mining sector uneconomic and few new pure-play tantalum projects stand much chance of commercialization in the current price environment.



Supply

A lot can happen in a couple of decades and this is Roskill's estimate of new supply in 2016. Low-cost and increasingly "clean" supply has resulted in artisanal mining as the largest source of new tantalum, mostly originating in central Africa. This has come at the expense of conventional mining which has seen its market share fall from about 60% a decade ago to about 34% today (represented by the blue segment, below).

Looking further back the synthetic concentrates (syncons, the orange segment) would have been the most significant source of supply and tantalum was mainly a by-product.

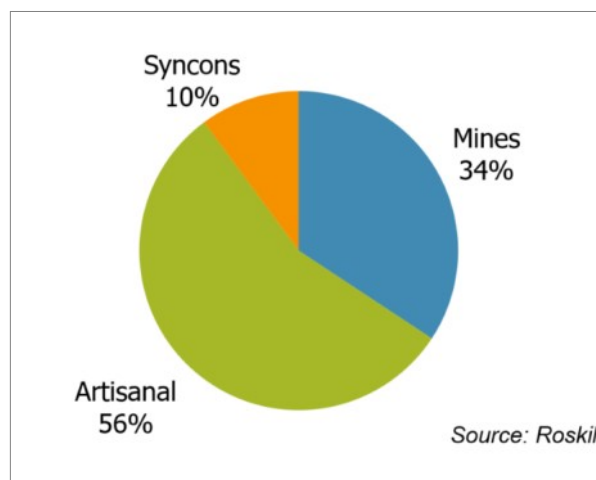


Figure 1: Estimated new tantalum supply, 2016
Total 1,778t Ta₂O₅

1 - Disclaimer:

The statements in this presentation represent the considered views of Roskill Information Services Ltd. It includes certain statements that may be deemed "forward-looking statements". All statements in this presentation, other than statements of historical facts, that address future market developments, government actions and events, are forward-looking statements. Although Roskill Information Services Ltd believes the outcomes expressed in such forward-looking statements are based on reasonable assumptions, such statements are not guarantees of future performance and actual results or developments may differ materially from those in forward-looking statements. Factors that could cause actual results to differ materially from those in forward-looking statements include changes in general economic, market or business conditions. While Roskill Information Services Ltd has made every reasonable effort to ensure the veracity of the information presented it cannot expressly guarantee the accuracy and reliability of the estimates, forecasts and conclusions contained herein. Accordingly, the statements in the presentation should be used for general guidance only.

By removing synthetic concentrates (syncons) from the picture the change in sources of estimated mine supply becomes clearer.

It is not surprising that most material comes from artisanal and some (semi-)industrialized mining in Africa, or from (mostly) industrial mining in South America. Chinese production is entirely consumed by the Chinese domestic market. Most significant is that since 2008 Australian production has fallen off the chart.

Looking ahead Roskill expects a steady increase in tantalum supply through the next decade, but the dynamics of supply could change considerably.

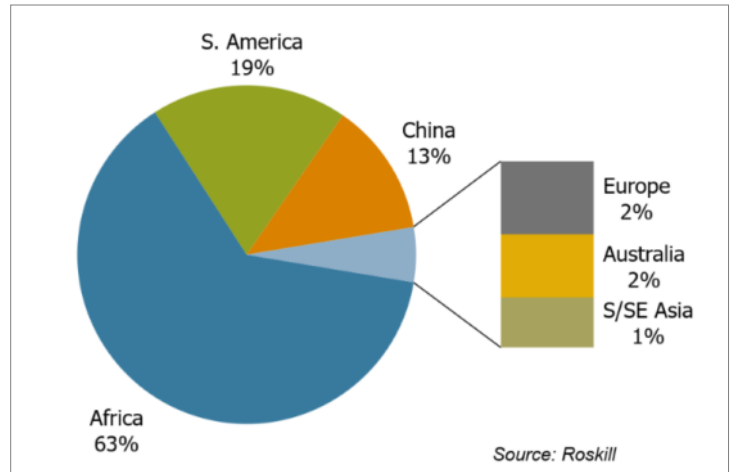


Figure 2: Estimated mine supply of tantalum minerals, 2016
Total 1,598t Ta₂O₅

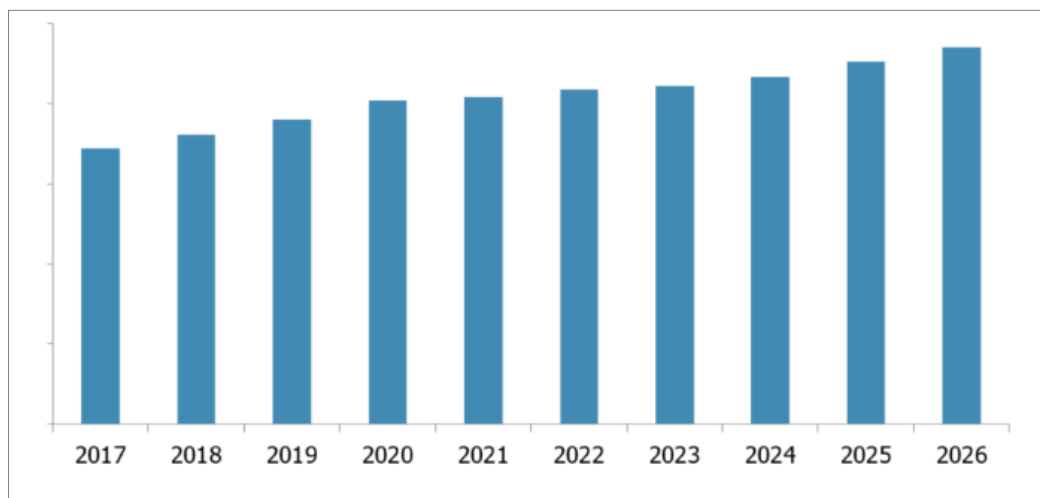


Figure 3: Forecast new tantalum supply (tonnes Ta₂O₅)

There is relatively little tantalum-focused mining left and the majority of potential tantalum and tantalum-niobium projects that were in development only a few years ago are now on hold.

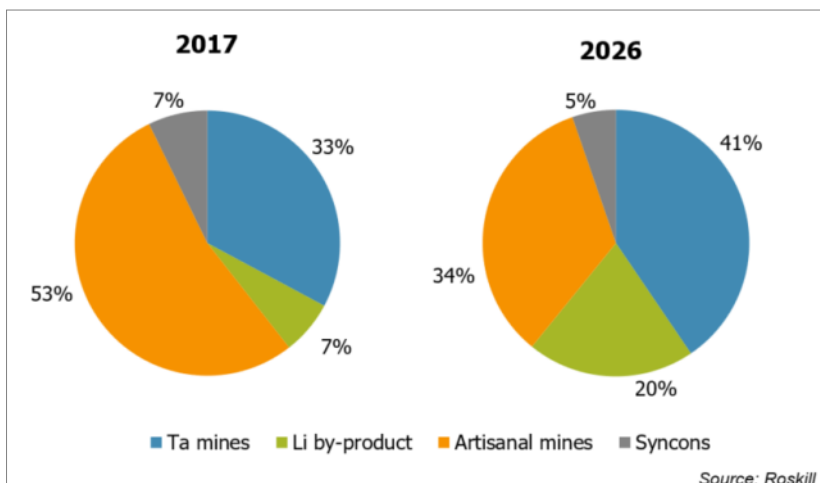


Figure 4: Forecast new tantalum supply (%)

The large and relatively accessible resources in Central Africa can probably supply all the tantalum that the world needs, but this is not necessarily a low-cost source and although the last decade has seen regional governments and traceability programmes make significant progress to resolve past conflict-related issues, it takes time to reassure the global market concerning supply chain transparency and supply stability. Nothing exciting is expected to happen in the tin market, so the quantity of tantalum won from processing tin-slugs is unlikely to change significantly.

So, what could change?

The answer is quite simple: demand for lithium is growing very rapidly and many hard-rock lithium mines are expected to generate by-product tantalum.

The rechargeable lithium battery market has grown rapidly over the last two decades, boosted by smartphone, tablet and more recently (hybrid-)electric vehicle (xEV) demand. With a focus on emissions reduction, government mandates are forcing the automotive industry to electrify powertrains, and automotive companies are now making bold plans that could see the lithium-ion battery market increase 10-fold in a decade. Lithium supply will have to keep pace, albeit with technological advances steadily reducing intensity of use.

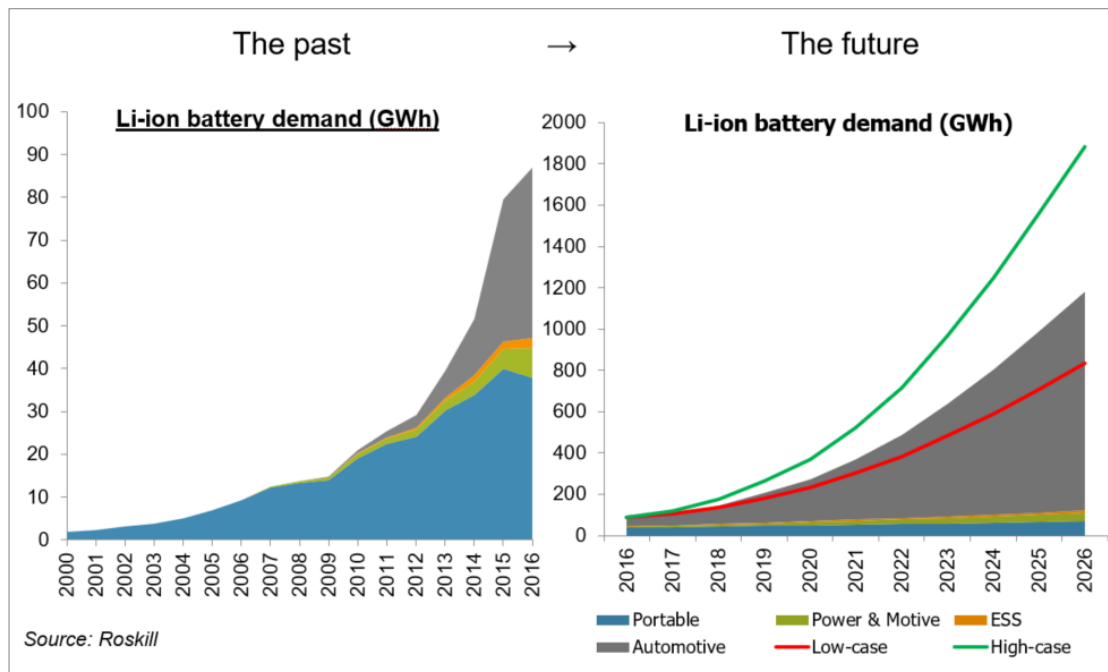


Figure 5: 10GWh to 100GWh in 10 years... 100GWh to 1TWh in another 10/15 years?

Currently primary lithium is won from brines or minerals in a roughly equal share. Brines in South America and China, like lithium clay deposits, do not produce any tantalum by-products. However, tantalum is found in many hard-rock (pegmatite) lithium deposits, including those in operation in Western Australia and China. Talison's Greenbushes mine is well known as a source of tantalum concentrate. Other common by-products in hard-rock lithium deposits include tin and tungsten. With hard-rock lithium deposits forecast to increase their market share of lithium supply alongside overall dramatic demand growth, there is potential for increased by-product tantalum output. Some current/past tantalum operations, such as AMG's Mibra mine, Tawana/AMA's Bald Hill mine and Mineral Resources' Wodgina mine are switching to a lithium focus.

How significant are tantalum by-products to lithium resources?

The majority of lithium hard-rock deposits contain tantalum, but not all, and at some it has not been reported or not analysed for. The majority of those where tantalum has been reported the grade is <0.03% Ta₂O₅. Applying a formula based on tantalum grade, recovery rate and tantalum concentrate prices, Mibra's lithium-equivalent grade rises to 2.82% LCE from 2.60%. At recently opened operations in Western Australia, the influence of tantalum is lower than Mibra but still significant with Mt Cattlin and Mt Marion rising by 0.15% LCE and Wodgina by 0.13%. The impact of by-products on lithium-equivalent grade is, however, minimal elsewhere with increases typically being less than 0.1% LCE, e.g. Pilgangoora's Pilbara project at 0.06% LCE.

While by-product influence on lithium-equivalent grades is relatively slight, the impact of by-product production on economics can be significant, as can the quantity of tantalum units generated. While Greenbushes, Mibra, and, more recently re-started, Mt Cattlin are already tantalum concentrate producers, other new lithium hard-rock mines could add to supply. And at capacity Pilgangoora mine, operated by Pilbara Minerals, could produce almost 150t Ta₂O₅.

Given the seemingly insatiable demand for lithium, and the requirement for hard-rock lithium supply, it is very likely that tantalum by-production will once again become a significant source of material over the next decade.

Table 1: Hard-rock lithium mineral resource estimates with by-product tantalum production/potential,
January 2018

Company	Deposit/operation	Location	LCE ¹ grade	Ta grade ²	Status
Xinjiang Non-Ferrous	Koktokay	China	NR	NR	Operational
Talison	Greenbushes	Australia	5.93%	0.03%	Operational
Galaxy	Mt Cattlin	Australia	2.68%	0.02%	Operational
Process Minerals Int.	Mt Marion	Australia	3.38%	0.01%	Operational
Yichun Tantalum	Yichun	China	NR	0.02%	Operational
Bikita Minerals	Bikita	Zimbabwe	NR	NR	Operational
Mineral Resources	Wodgina	Australia	3.18%	0.02%	Operational
Jilin Jien	Val d'Or	Canada	2.95%	NR	Recommissioning
AMG	Mibra	Brazil	2.60%	0.03%	Construction
Pilbara	Pilgangoora	Australia	3.08%	0.01%	Construction
Tawana	Bald Hill	Australia	2.91%	0.02%	Construction
Altura	Pilgangoora	Australia	2.46%	NR	Construction
Nemaska	Whabouchi	Canada	3.62%	NR	Financing
Keliber	Various	Finland	2.96%	0.01%	Feasibility
European Metals	Cinovec	Czech Republic	1.04%	NR	Feasibility
Critical Elements	Rose	Canada	2.34%	0.02%	Feasibility
Sayona	Authier	Canada	2.64%	NR	Feasibility
Rock Tech	Georgia Lake	Canada	2.55%	NR	Feasibility
Kidman/SQM	Earl Grey	Australia	3.55%	NR	Feasibility
Global Geoscience	Rhyolite Ridge	USA	0.87%	NR	Feasibility
Galaxy Resources	James Bay	Canada	3.09%	NR	Feasibility
Avalon	Separation Rapids	Canada	3.24%	0.01%	Feasibility
European Lithium	Wolfsburg	Austria	2.89%	NR	Feasibility
Prospect Resources	Arcadia	Zimbabwe	2.74%	0.01%	Feasibility
Birimian	Bougouni (Goulamina)	Mali	3.50%	NR	Feasibility
Premier African Mins	Zulu	Zimbabwe	2.62%	0.01%	Feasibility
Perilya	Moblan	Canada	3.48%	NR	Feasibility
Bacanora	Zinnwald	Germany	1.94%	NR	Feasibility
Novo Latio	Sepeda (Romano)	Portugal	2.47%	<0.01%	Feasibility
Ardiden	North Aubry	Canada	3.53%	NR	Feasibility
Lithium Australia	Sadisdorf	Germany	1.11%	NR	Feasibility
Lepidico	Alvarroes	Portugal	2.72%	NR	Feasibility
American Pacific	Fort Cady	USA	1.99%	NR	Feasibility
Plymouth Minerals	San Jose	Spain	1.45%	NR	Scoping
Savanah Resources	Mina de Barroso	Portugal	2.47%	NR	Exploration
Frontier	PAK	Canada	3.86%	0.01%	Feasibility

Source: Company information, Roskill

Notes:

1 – Lithium carbonate equivalent (contained Li X 5.323); 2 – Ta₂O₅ basis; NR – Not reported; DFS

Demand

Since 2008 the total demand for tantalum has increased by less than 0.7%py (per year). However, on a sector level the pattern of demand has changed quite significantly since 2008*.

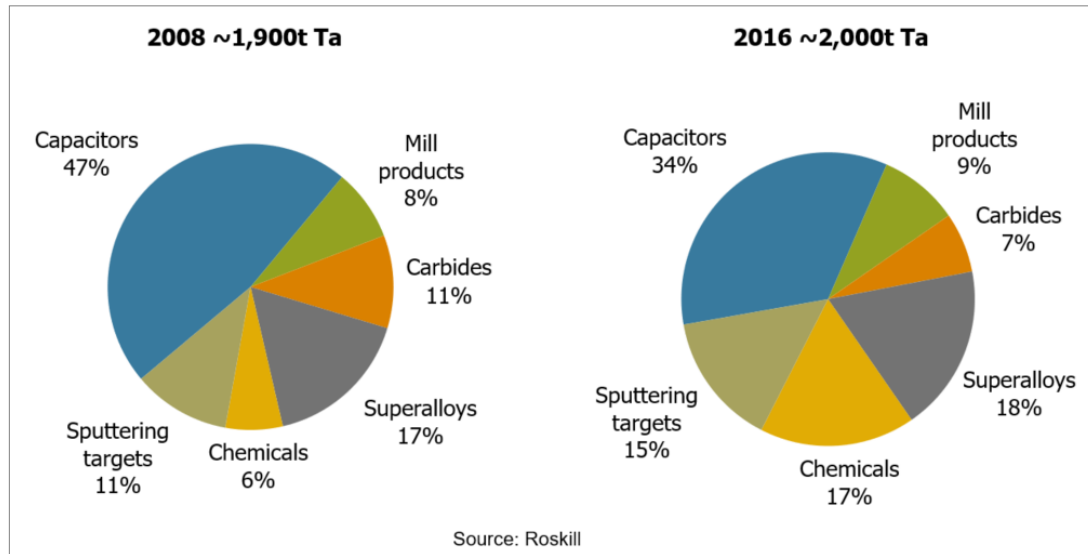


Figure 6: the pattern of demand has changed...

Capacitors:

Tantalum consumption in capacitors has fallen, although this is still the largest segment of demand. This is important because capacitor scrap makes up about 20% of the amount of recycled tantalum returning to the market (which is over 30% of consumption in any one year). There are several reasons for this. One is competition from other materials. Another is improved powder and wire technology (capacitors are getting smaller). Possibly the main factor has been the bundling of applications in smartphones (who still uses a small digital camera or separate sat-nav?).

The outlook for tantalum in capacitors is mixed. A more stable tantalum market has seen substitution ease and there are opportunities for increased use in data centres and vehicles. On the other hand, the electronics market has become saturated and replacement demand has taken over from new demand. Roskill's forecast for tantalum growth in capacitors is conservative, at 1.5%py.

Mill products:

Mill products represent one of the smaller markets for tantalum but benefit from a diverse range of applications. Roskill anticipates fairly healthy growth of 4%py.

Carbides:

The use of tantalum carbide (TaC) in tungsten and other carbides is the smallest market segment. Tantalum consumption has fallen because of the use of cheaper materials, new systems that require less TaC, greater recycling etc. Roskill sees demand continuing to decline, falling at about 2%py.

Superalloys:

Superalloys for aircraft engines and land-based turbines are the largest market for tantalum after capacitors. They are also a large and growing source of recycled tantalum. Future demand for tantalum in superalloys will be driven mainly by the aerospace industry. This industry is highly cyclical. Engine deliveries are forecast to fall from 3,370 units in 2017 to below 3,000 in both 2018 and 2019, before climbing back to nearly 4,000 by 2026. Roskill has thus forecast healthy growth for tantalum, at 4.6%py.

*Note: The T.I.C. is not able to provide a platform for third parties to discuss forecasts of tantalum prices.

Tantalum chemicals:

This is something of a catch-all category, and one that invites double-counting. To focus on two particular applications:

- The use of high-grade tantalum oxide in optical glass has been impacted by camera-enabled smartphones and subsequent decline in digital camera production. It is estimated that world production of digital cameras fell from 122M units in 2010 to just 22M units in 2015.
- Slowing growth in the smartphone market is also affecting demand for tantalum oxide for use in lithium tantalite, which goes into SAW filters. However, in this case, there is an upside. Despite contributing to a reduction in the tantalum market to date, smartphones are likely to benefit demand in future. Manufacturers are switching from 2G and 3G phones, with 13 and 29 bandwaves, respectively, to 4G and 5G, with 50+ bandwaves. Japan plans to have 5G in time for the 2020 Olympics. Each increase in bandwave results in more SAW filters being used per phone. Japanese companies are the largest producers of SAW filters and lithium tantalate capacity is rising to meet demand. Sumitomo Metal Mining raised production capacity for lithium tantalate/lithium niobate substrates from 120,000 units a month in December 2014 to 210,000 units a month in September 2016, and again to 300,000 units a month in October. Capacity was scheduled to rise further to 400,000 units a month by September 2017.

Roskill is bullish about future demand for tantalum chemicals, with growth in consumption forecast at 5%py.

Sputtering targets:

Sputtering targets are a significant and growing use for tantalum and used targets are possibly the largest single source of recycled tantalum. They are used in the manufacture of a variety of products, such as inkjet printer heads and magnetic storage media. Such diversity reduces exposure to individual markets. Roskill expects strong growth in demand for tantalum in sputtering targets, at 4.5%py. It could be higher, if “end of the aisle” (networked) inkjet printing replaces laser printing in organisations at a faster rate.

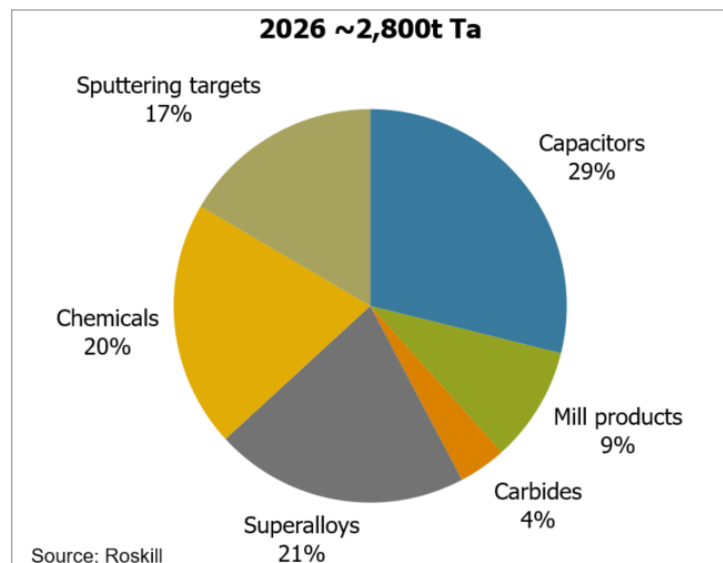


Figure 7: ...and will continue to change

Once these various markets and forecasts are combined, the overall picture is one of modest growth over the next decade. Capacitors will remain the single largest consumer for tantalum, increasing consumption even as their market share decreases slightly. Carbides will continue to lose market share too. Superalloys and chemicals will see their market shares increase most. In total the demand for tantalum is expected to reach 2,800t Ta by 2026, a growth rate of 3.42%py. With by-product supply from lithium production expected to outstrip this, and tantalum recycling also expected to grow, which existing sources of tantalum supply will make way for more by-product? Most likely it will be that from central Africa.

Note: All views and opinions in this article are those of the authors and not the T.I.C.

Tantalum and niobium intellectual property update

Historically the T.I.C. reported those patents and papers that were relevant to the tantalum and niobium industries (2000-2007, available in the members' area at www.TaNb.org). 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	Applicant(s)	Publication date
-------	--------------	------------------

TANTALUM

Tantalum capacitor with polymer cathode CN107077972 (A)	KEMET ELECTRONICS CORP [US]	2017-08-18
Thermal treatment method for tantalum powder CN107052329 (A)	F&X ELECTRO-MATERIALS LTD [CN]	2017-08-18
Processes for producing tantalum alloys and niobium alloys WO2017142884 (A1)	ATI PROPERTIES LLC [US]	2017-08-24
Method for manufacturing tantalum chloride KR20170097463 (A)	RES INST IND SCIENCE & TECH [KR]	2017-08-28
A tantalum powder and the method of its preparation and a sintered anode prepared from tantalum powder CZ20170250 (A3)	NINGXIA ORIENT TANTALUM IND CO LTD [CN]	2017-08-30
Method of joining titanium and titanium-based alloys to ferrous metals using tantalum EP3213861 (A1)	LAKE REGION MFG INC D/B/A LAKE REGION MEDICAL [US]	2017-09-06
Method for producing tantalum nitride (Ta ₃ N ₅) JP2017164732 (A)	TAIHEIYO CEMENT CORP [JP]	2017-09-21
Charging device for the thermal treatment of tantalum capacitors EP3221874 (A1)	PLANSEE SE [AT]	2017-09-27
Tantalum capacitor and method of fabricating the same KR20170118391 (A)	SAMSUNG ELECTRO-MECHANICS CO LTD [KR]	2017-10-25
Porous tantalum metal screw for fixing broken bone, and application thereof WO2017190437 (A1)	ZHAO DEWEI, WANG BENJIE, XIE HUI, LIU BAOYI, MA ZHIJIE, WANG WEI [CN]	2017-11-09
High performance and reliability solid electrolytic tantalum capacitors and screening method US2017345579 (A1)	VISHAY SPRAGUE INC [US]	2017-11-30
Material with multiple coatings of tantalum carbide and method for manufacturing same WO2017204536 (A1)	TOKAI CARBON KOREA CO LTD [KR]	2017-11-30

NIOBIUM

Method for nanoporous oxide formation on implant surface from powdered niobium RU2015155935 (A)	PETROZAVODSK STATE UNIVERSITY [RU]	2017-06-30
Processes for producing low nitrogen essentially nitride-free chromium and chromium plus niobium-containing nickel-based alloys... KR20170087867 (A)	CBMM SA [BR]	2017-07-31
Preparation method of niobium modified lithium titanate battery negative electrode material CN107069021 (A)	SHANDONG YUHUANG NEW ENERGY TECH CO LTD [CN]	2017-08-18
High-performance zinc-zirconium-niobium microwave dielectric ceramics CN107056295 (A)	UNIV TIANJIN [CN]	2017-08-18
Method for growing niobium oxynitride layer JP2017145498 (A)	PANASONIC IP MAN CORP [JP]	2017-08-24
Processes for producing tantalum alloys and niobium alloys WO2017142884 (A1)	ATI PROPERTIES LLC [US]	2017-08-24
Smelting method for niobium-containing inconel alloy WO2017157351 (A1)	ZHOU HAIBIN [CN]	2017-09-21
Pink and violet pigments comprising antimony and/or niobium oxide(s) that display heat stability, resistance to acidic conditions... WO2017192509 (A1)	SHEPHERD COLOR CO [US]	2017-11-09
Niobium and chromium low alloy carbon steel for high wear resistant automotive chain link plates WO2017196552 (A1)	BORGWARNER INC [US]	2017-11-16
Niobium-based alloy that is resistant to aqueous corrosion US9834829 (B1)	AIMONE PAUL, YANG MEI, H.C. STARCK INC [US]	2017-12-05

The Fifty-ninth General Assembly

The Fifty-ninth General Assembly will take place in Kigali, Rwanda, from Sunday October 14th to Wednesday October 17th 2018.

CALL FOR PAPERS

Papers on the following topics and other relevant subjects are sought from members and non-members:

- Raw Materials
- Supply Chain: transparency and traceability
- Services to the Industry
- Primary Processing and Refining
- Secondary Processing and Metallurgy
- Capacitor Production
- Applications



Rwanda is in the Great Lakes Region of Africa

Talks are to be given in English and the general length of presentations is 20-25 minutes. Please submit your proposals for papers for the technical sessions by March 31st 2018. The final program is decided by the T.I.C. Executive Committee and authors will be notified of the selection of their paper by the end of April 2018. Full papers must be submitted by September 15th 2018 for refereeing purposes.

All questions and requests for an abstract submission form should be sent to Emma Wickens at info@tanb.org.

Member company and T.I.C. updates

Transfers of membership

At the Fifty-eighth General Assembly the following membership transfers were approved:

- From **Anglo American Nióbio Brasil Ltda** to **Niobras Mineração Ltda**. The delegate is now Mr David Elliott, who can be contacted on delliott@cmocinternational.com. The new website is www.cmocbrasil.com.
- **H.C. Starck GmbH** to **H.C. Starck Tantalum & Niobium GmbH**. The delegate has changed to Ms Silvana Fehling, who can be contacted on silvana.fehling@hcstarck.com. Other contact details are unchanged.

Changes in member contact details

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

- The delegate for **ATI Specialty Alloys & Components** has changed from Mr Corey Smith to Mr Benjamin McKenzie. Mr McKenzie can be contacted at benjamin.mckenzie@atimetals.com.
- The delegate for **CBMM**, Mr Yuri Miranda, has a new email address yuri.miranda@cbmm.com.
- **Conflict-Free Sourcing Initiative (CFSI)**, an associate member, has changed its name to **Responsible Minerals Initiative (RMI)**. The website is now www.responsiblemineralsinitiative.org and the email of the delegate, Ms Leah Butler, has changed to lbutler@ResponsibleBusiness.org.
- **NAC Kazatomprom JSC**: Mr Galymzhan Pirmatov has become the official delegate, replacing Mr Askar Zhumagaliyev. The contact person has become Mr Abzal Beken, replacing Mr Talgat Nurtazayev. Mr Beken can be reached at abeken@kazatomprom.kz.

Resignations

The following corporate members have resigned from the Association since issue 171 of the Bulletin was published: Honeywell Specialty Chemicals Seelze GmbH and Rittenhouse International Resources LLC.

Termination

Yichun Jinyang New Materials Co Ltd has had its membership terminated for non-payment of membership dues.

And finally... extra-terrestrial niobium found in Scotland

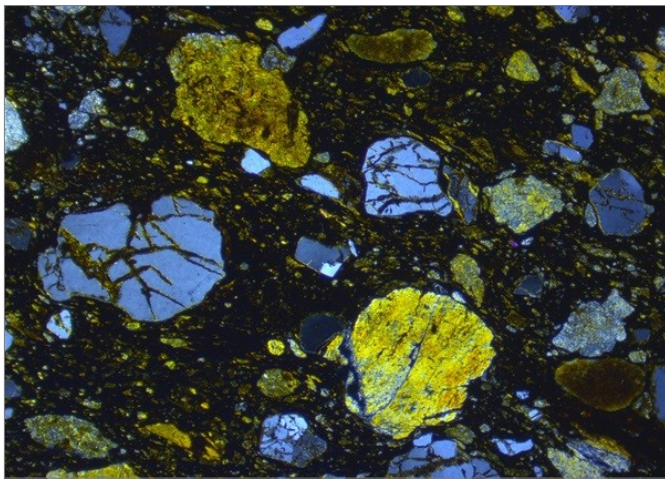
Geologists exploring the Isle of Skye, northwest Scotland, UK, have discovered extra-terrestrial niobium-containing minerals in a meteor impact crater that dates back around 61 million years.

Dr Simon Drake, from Birkbeck, University of London, made the finds at two sites on Skye with colleague Dr Andy Beard. Their discovery is reported in the latest journal of *GeoScienceWorld*.¹

The two rare minerals supporting their claim are a vanadium-rich osbornite (TiVN) and a niobium-rich osbornite (TiNbN). The former has never before been reported on Earth and until now had only ever been found in dust samples collected from the comet 81P/Wild 2 by NASA's Stardust mission in 2006. Niobium-rich osbornite has never previously been reported.



The Isle of Skye is known for its rugged landscapes, picturesque fishing villages, whisky and medieval castles. (photo: [avery ng](#) on wikicommons, map: Google Maps)



A thin section view of meteoritic ejecta containing extra-terrestrial niobium found on Skye (photo: Simon Drake)

An extra-terrestrial origin for these deposits is also supported by the presence of reidite (a high-pressure zircon polymorph), which is only found naturally at sites of meteorite impact.

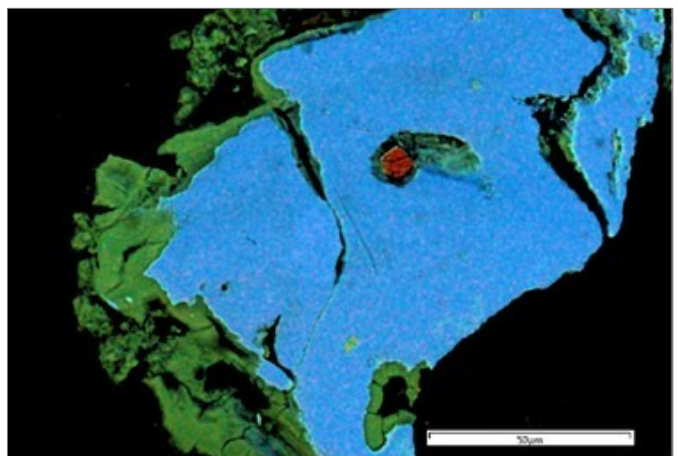
The Isle of Skye forms part of the British Palaeogene Igneous Province (BPIP), a region that was volcanically active around 61 to 54.5 million years ago. It has been well explored by geologists, and the team was surprised that the ejecta layer had not been identified before. The first site of discovery, Dr Drake explained, was steep, rough and very boggy, which may have deterred previous researchers from exploring the layer. The geologists will be returning to Skye later this year.

Although the niobium minerals found on Skye do not represent an economical deposit, this new discovery suggests that perhaps one day humans will mine meteors for niobium. **TIC**

The minerals were found unmelted beneath a thick layer of ancient lava and are believed to have come from original pieces of the meteorite. Dr Drake told the *Bulletin* "These are extremely hardy and highly unusual to find unmelted. Potentially they could have been located towards the rear of the impactor and broke up in a low pressure zone behind the bow wave and survived."

Such minerals are exceptionally rare and only one other unmelted impactor mineralogy has previously been recorded at the Chicxulub crater on the Yucatan Peninsula, Mexico.

At first the minerals were assumed to be a volcanic flow deposit called ignimbrite. However, it was when the samples were scanned by an electron microprobe that their true identity was discovered.



An elemental X-ray of a metallic microfragment from Skye revealing a TiNbN crystal 10 microns wide (red) enclosed within a Fe-Si metal (blue), surrounded by a layer of terrestrially weathered mantle of FeO (green). (photo: Simon Drake)

1 - "Discovery of a meteoritic ejecta layer containing unmelted impactor fragments at the base of Paleocene lavas, Isle of Skye, Scotland" is here: <https://pubs.geoscienceworld.org/gsa/geology/article/525169/discovery-of-a-%20%20meteoritic-ejecta-layer-containing%E2%80%AC>.