Global Resources & Reserves

Security of long-term tin supply

2020 Update

Contents

Global Resources and Reserves 3
Summary 3
The Risk: Critical Materials 3
Resources and Reserves 4
Tin resources and reserves calculation 5
ITA's estimate of global tin resources and reserves 6
Resources and Reserves by Region 8
North America 8
South America 9
Africa 10
Europe 11
Australia 12
South East Asia 12
Middle East and India 13
China 13
Analysis 14
Limitations of resource and reserve estimates 14
USGS studies on tin resources and reserves 16
Outlook for tin supply 17
References 19

Global Resources and Reserves

Summary

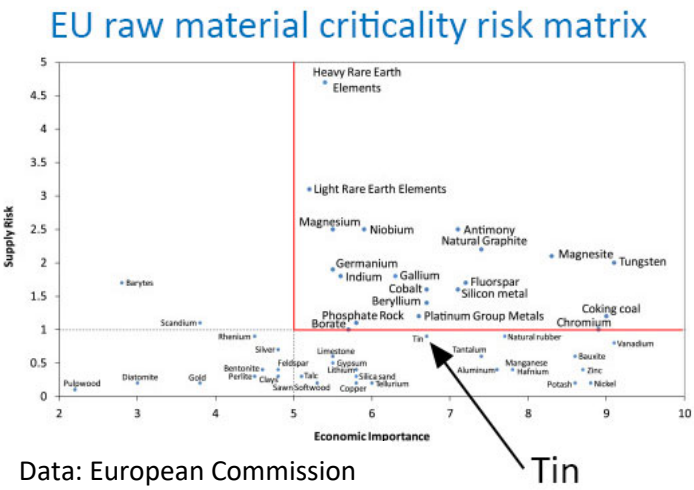
- According to ITA calculations, the world's reported tin resources at the end of 2019 totalled some 15.4 Mt, including some 5.5 Mt of reserves. Of this, some 39% (6.0 Mt) of resources and 29% (1.6 Mt) of reserves were compliant with CRIRSCO standards.
- The top five countries as a proportion of global compliant resources were Russia (29%), Australia (15%), Peru (9%), DR Congo (9%) and Brazil (8%). When non-compliant resources are included, the top five countries become China (38%), Russia (11%), Australia (7%), Indonesia (7%) and Bolivia (4%).
- When considering just the defined tin resources, current demand levels can be supported for another 50 years. However, the potential of unreported and undiscovered tin worldwide is enough to support demand long into the future. However, many defined tin resources will require higher tin prices or more efficient extraction technologies to become economic for development.
- The current low tin price represents a risk to short-term supply due to reduced investment in tin projects. However, it is important to clarify that this is unrelated to the amount of metal in the ground.

The Risk: Critical Materials

The long-term supply of any material is a top priority for downstream users and policy makers. The perception that a material is "running out" can lead to researchers looking to alternatives for new technologies, companies replacing the material with more abundant options, and policy makers labelling it as "critical" which can lead to legislation to limit consumption.

All three possibilities threaten tin use. Tinplate packing is already being replaced by aluminium and plastic. Tin remains on the edge of criticality in Europe but is already a critical metal in China and the US. Lithium-ion batteries, which represent a significant new market for tin, are still in research and development; if long-term supply is limited, researchers may look elsewhere.

Different countries have different definitions of critical materials, but they are generally assessed on their supply risk and economic importance. Materials that have a significant supply risk in one country may have a much lower risk in the country that supplies them. In the European Union's criticality matrix, tin's low supply risk means it falls just outside of the critical zone. However, if this supply risk is interpreted differently, or the threshold values change, the result could differ. Indeed, in China and the United States, tin is already labelled as critical.



Data: European Commission

China and the US are aiming to reduce their reliance on imports of critical materials, or to improve their access. The US gets much of its tin supply from South

America, with some coming from the recycling of solder production wastes. While part of the country's critical materials strategy includes domestic mineral exploration, the report also calls for the government to develop alternatives to critical minerals. As previously mentioned, this could be detrimental to tin use – although tin's main use, solder, has relatively few replacements.

Nevertheless, the move by the world's two largest economies to label tin as a critical material is worrying. In general, the ITA believes that tin's supply risk is overstated. To assess this, the ITA has compiled information of global resources and reserves to demonstrate the security of long-term supply.

Resources and Reserves

There is a plethora of different terms for defining the size of a geological deposit. These are often confusing for those outside the mining industry, but the most common terms are "resource" and "reserve".

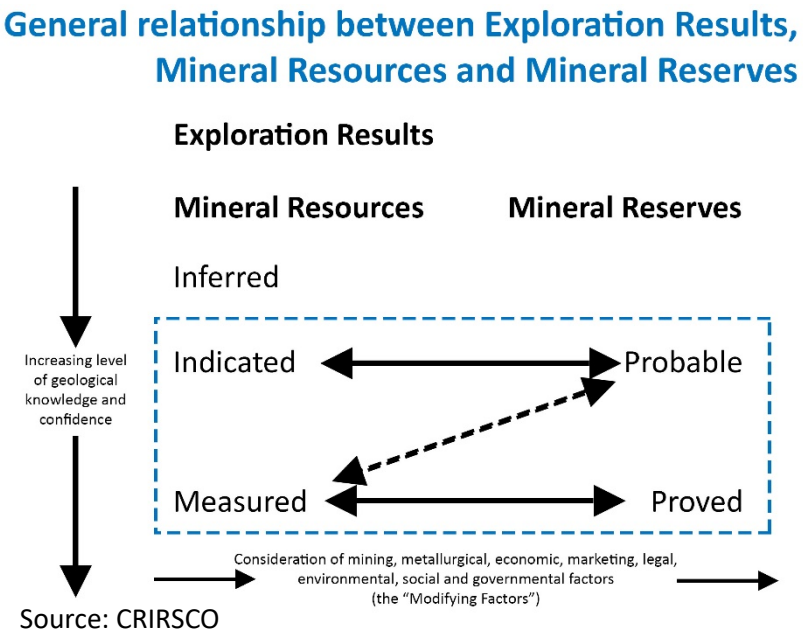
Reporting the resource and reserve of a new mineral deposit is an important part of attracting investment. However, these reports are commonly tailored to the country where the deposit is located, or where the company is registered. The Committee for Mineral Reserves International Reporting Standards (CRIRSCO) is an inter-organisational body that brings together international reporting standards around the globe. Australasia, Canada, Chile, Europe, Mongolia, Russia, South Africa, and the United States of America have been members for some time, while India and Kazakhstan have recently joined. China and Turkey are looking to join in the future.

CRIRSCO produced a set of agreed standard definitions for the reporting of Exploration Results, Mineral Resources and Mineral Reserves (CRIRSCO, 2019). These definitions can be found below:

*"A **'Mineral Resource'** is a concentration or occurrence of material of economic interest in or on the Earth's crust in such form, quality and quantity that there are reasonable prospects for eventual economic extraction. The location, quantity, grade, continuity and other geological characteristics of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge, including sampling. Mineral Resources are subdivided, in order of increasing geological confidence into Inferred, Indicated and Measured categories."*

*"A **'Mineral Reserve'** is the economically mineable part of a Measured and/or Indicated Mineral Resource. It includes diluting materials and allowances for losses, which may occur when the material is mined or extracted and is defined by studies at Pre-Feasibility or Feasibility level as appropriate that*

include application of Modifying Factors. Such studies demonstrate that, at the time of reporting, extraction could reasonably be justified."



To summarise, reserves require that a deposit can be shown to be profitably mined at the time of reporting, whereas resources refer to material considered a reasonable prospect for profitable extraction at some point in the future.

Tin resources and reserves calculation

This report aims to provide a reliable, minimum estimation of available global tin resources and reserves. Therefore, the contained data uses the most up-to-date reported resource and reserve estimates for 338 deposits and mining districts or regions. Data sources include information publicly reported by companies, in scientific papers, and from national geological surveys.

While every effort was made to maximise the coverage of this study, there will be many more economic occurrences of tin which did not have any publicly available information or that weren't fully assessed at the time of publication.

Reserve and resource data are split into CRIRSCO and non-CRIRSCO groupings based on the specific reporting standards and quality of sources in each case. Figures reported that do not adhere to the CRIRSCO template are less reliable but must be included in our analysis because current tin production globally is heavily weighted towards countries which are not part of CRIRSCO, such as China and Indonesia. To illustrate this point further, 56% of 2019 mined tin production came from countries with CRIRSCO-compliant tin resources and only 29% where the CRIRSCO resource is significant (the resource exceeds the production of tin from the country during the year). However, this rises to 100% and 98% of production in each instance respectively when non-CRIRSCO resources are included.

Where estimates for existing or recently closed mines are out of date and production data between the resource year and the end of 2019 exists, the latter was subtracted from the former, with reserves depleted first. Potential undiscovered and speculative resources are not included in the ITA estimates but are discussed within the report.

ITA's estimate of global tin resources and reserves

Tin resources globally, as calculated by ITA, totalled 15.4 Mt at the end of 2019, of which 6.0 Mt (38.9%) was CRIRSCO-compliant. Global tin reserves, a subset of the aforementioned figure, totalled 5.5 Mt, of which less than one third (1.6 Mt) was reported to CRIRSCO standards. The proportion of CRIRSCO-compliant resources and reserves should increase dramatically in the next few years once China become part of the reporting group.

Based on 2019 tin mine production of 305.8 kt, present global tin reserves will last a minimum of 18.0 years, while resources will last a minimum of 50.4 years. Geographically, the majority of CRIRSCO-compliant resources and reserves come from Europe, Australia and South America, whereas most non-complaint resources are found in Central and Eastern Asia.

World tin reserves and resources

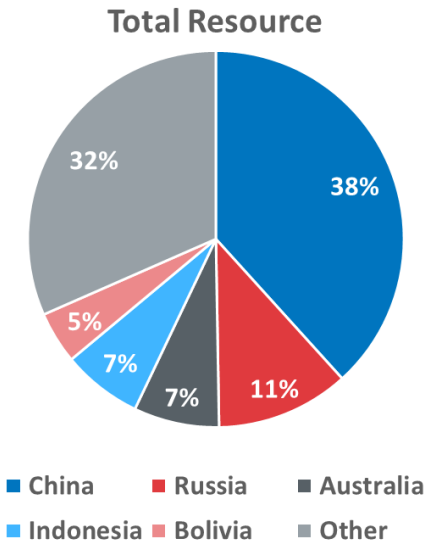
'000 tonnes of contained tin

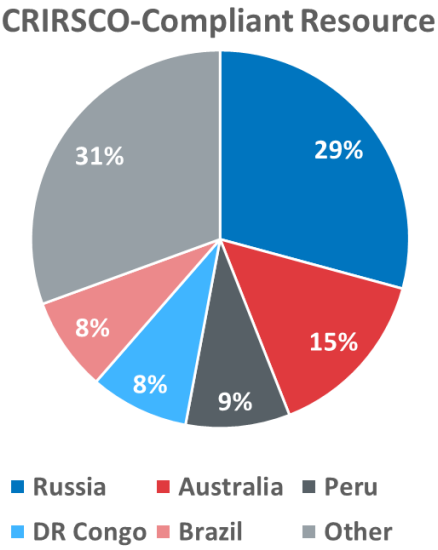
		CRIRSCO		Non-CRIRSCO		Total	
Country	**2019 mine production**	**Resources***	**Reserves**	**Resources***	**Reserves**	**Resources***	**Reserves**
Afghanistan	0	0	0	18	0	18	0
China	80	0	0	5,988	2,160	5,988	2,160
India	0	0	0	102	1	102	1
Indonesia	78	32	16	1,044	415	1,075	431
Kazakhstan	0	351	0	0	0	351	0
Kyrgyzstan	0	0	0	205	0	205	0
Laos	2	0	0	81	46	81	46
Malaysia	4	51	11	0	0	51	11
Mongolia	0	7	0	99	6	106	6
Myanmar	46	0	0	113	113	113	113
Tajikistan	0	0	0	45	0	45	0
Thailand	0	0	0	64	0	64	0
Vietnam	5	0	0	48	11	48	11
Asia total	**215**	**441**	**27**	**7,808**	**2,753**	**8,249**	**2,779**
Bolivia	18	76	20	623	228	700	248
Brazil	20	493	325	80	80	573	405
Canada	0	110	0	7	0	117	0
Peru	19	546	218	91	0	638	218
USA	0	0	0	72	0	72	0
Argentina	0	0	0	0	3	0	3
Americas total	**57**	**1,226**	**563**	**873**	**308**	**2,099**	**871**
Czech Republic	0	263	0	32	0	295	0
Germany	0	309	0	207	0	516	0
Portugal	0	26	3	13	0	39	3
Russia	2	1,791	588	0	340	1,791	928
Spain	0	69	0	0	0	69	0
UK	0	264	0	0	0	264	0
Europe total	**3**	**2,721**	**591**	**253**	**340**	**2,974**	**931**
Australia	**8**	**908**	**228**	**243**	**0**	**1,151**	**228**
DR Congo	13	519	167	0	0	519	167
Egypt	0	40	0	0	415	40	415
Morocco	0	131	57	0	0	131	57
Nigeria	6	0	0	75	0	75	0
Rwanda	4	23	6	91	8	114	14
Other Africa	0	0	0	0	0	0	0
Africa total	**24**	**713**	**231**	**166**	**423**	**879**	**653**
World Total	**306**	**6,000**	**1,600**	**9,300**	**3,800**	**15,400**	**5,500**

Data: ITA, BGR, NBSC, Various company data

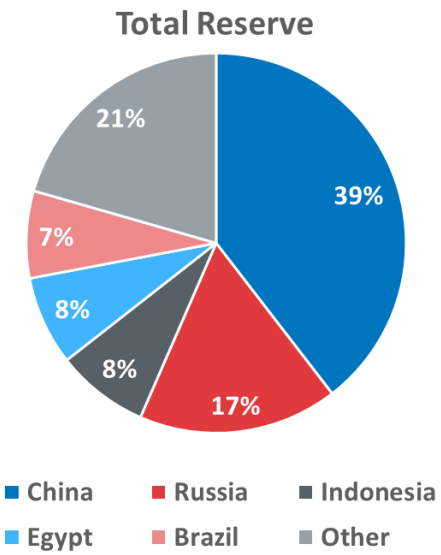
*All resource figures are inclusive of reserves, world totals rounded excluding production

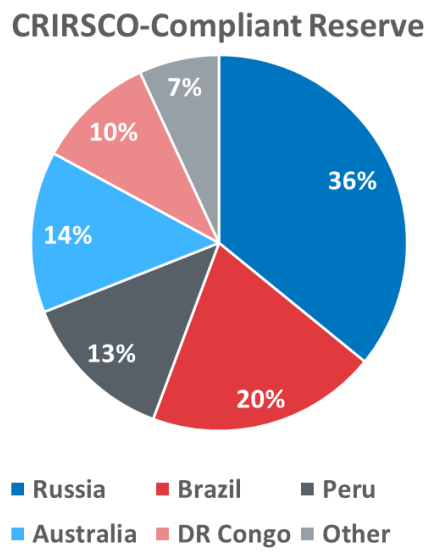
2019 Global Tin Resources





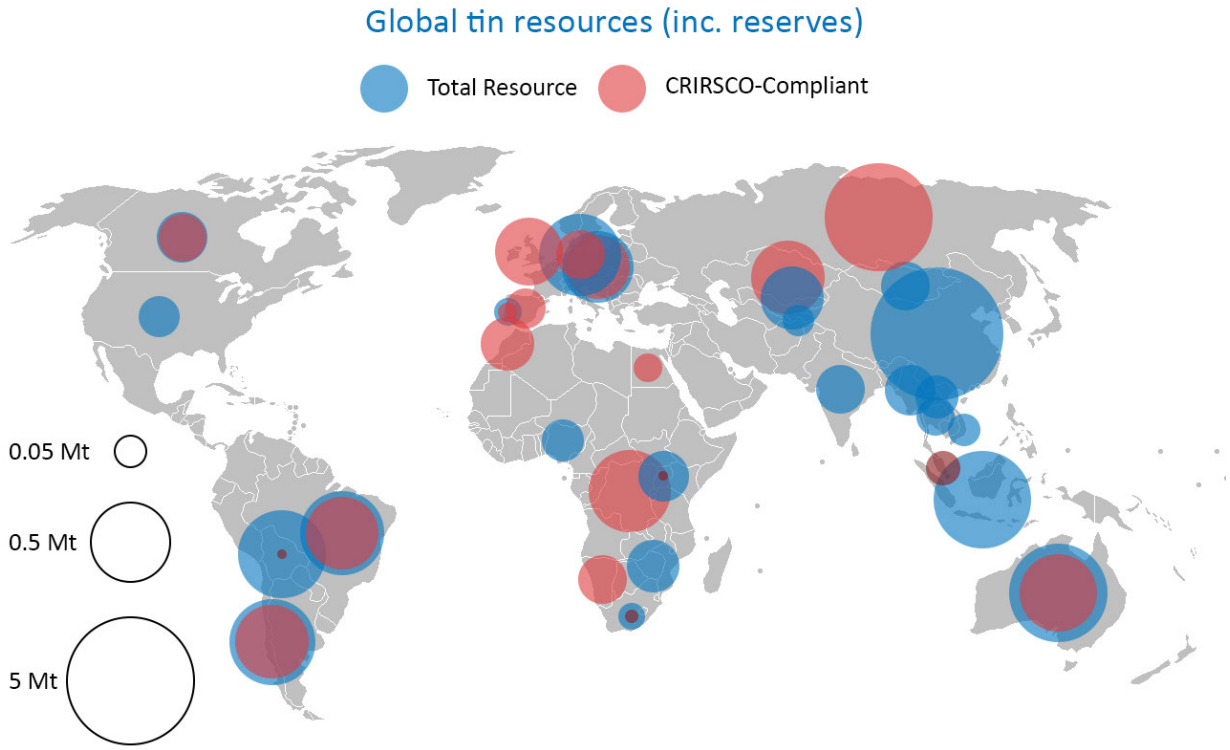
2019 Global Tin Reserves





Resources and Reserves by Region

While global tin reserves and resources indicate around 18 and 50 years of remaining consumption, there is a significant regional difference. For example, in Europe, known resources would last over 1,000 years at current mining rates. Below we explore this variation in more detail, with emphasis on up-and-coming projects or important existing mines.



North America

North America currently has no active mines and has almost no exploration has taken place in recent years. Apart from the East Kemptville project in Canada, there are no other mines in development. However, the prospects for future supply are good, with the Appalachian mountain belt, Alaska and the Carolina Tin-Spodumene Belt being the standout areas for future exploration. Tin is now labelled as a critical material in the United States, and this could bring more activity in the near future.

United States

There is currently no tin mining in United States of America. It has only two named deposits: Kougarok and Sleitat Mountain, both of which are in the state of Alaska. Neither has a CRIRSCO-compliant resource, although historical estimates place their combined resource at some 85.6 kt. Only that of Sleitat Mountain has been included however, as the resource for Kougarok is speculative. Despite the lack of known deposits, the North American geology is favourable for tin deposits. The USGS Mineral Resources Data System (USGS, n.d.) lists nearly 1,500 individual tin occurrences, prospects and closed mines in the US alone. Many of these are clustered in the Carolina Tin Belt – an area currently being developed for lithium mining – or in Alaska. This is a good example of an area with huge potential for tin resources in a tin-poor region of the world and is therefore a good analogue for the vast potential for additional unreported or unknown tin deposits worldwide.

Canada

Canada, like the US, currently has no active tin mines, although exploration and development is on-going at the East Kemptville mine in Nova Scotia. Avalon Advanced Materials, which owns the project, will begin construction within 16 months of project financing, with the goal to start in 2020 (Avalon Advanced Materials, 2019). There are two additional prospects in the country, JC Smart and Mount Pleasant. Combined, the three projects have a resource of over 115 kt tonnes, with 95% CRIRSCO-compliant.

South America

South American production of tin concentrates peaked in 1989 at over 75 kt of contained tin. However, since 2000, production from the continent has been falling as grades at historical mines decline. Tin exploration has been fairly limited, with only established producers increasing known resources and reserves. Recently, however, new junior mining companies have begun work across the continent.

Bolivia

Bolivia's estimated resources of 700 kt of contained tin, with reserves of nearly 250 kt, are a combination of the country's two state-run mines, Huanuni and Colquiri, as well as projects in Catavi. These projects are run by co-operatives near the historical Siglo XX mine. Additional speculative resources come from several tin tailings projects near Catavi, however much of this is an exploration target and little drilling has taken place to prove this resource. As such, these resources are not included in this summary.

Peru

Peru's tin industry has long been dominated by Minsur's San Rafael Mine, which began operating in 1975. As a result, much of the country's 550 kt resource belongs to the company and is CRIRSCO-compliant. The company's B2 project will reprocess the mine's extensive tailings; at more than 1% Sn, the grade is higher than most greenfield projects. B2 contains some 81.5 kt of tin as a resource, with some 96% classified as reserve (Minsur S.A., 2018).

Newcomer Tinka Resources is developing the Ayawilca project in the Pasco department towards the centre of the country. Although the resource is not yet CRIRSCO-compliant, the project is undergoing development – although the focus is currently on the areas of zinc mineralisation. It is estimated that the project has over 90 kt of tin as a resource (Ayawilca Polymetallic Project NI 43-101 Technical Report, 2019).

Brazil

The country has a CRIRSCO-complaint resource of 493 kt, 65% of which are classified as reserves. These reserves belong wholly to Taboca's Pitinga mine, meaning it has the largest CRIRSCO-compliant tin resource and reserve in the world. At current production rates, reserves would last for another 20 years. However, according to Minsur's 2018 annual report (Minsur S.A., 2018), the resources are estimated using an assumed tin price of nearly US$ 24,000; reserves use US$ 20,000. At current tin prices, some of this may no longer be economical.

Additional, non-compliant resources for other Brazilian projects – as estimated by the country's department of mineral production – of some 80 kt, are also included in ITA's estimate of Brazil's tin resource.

Argentina

Currently, Argentina has no CRIRSCO-compliant reserves, although estimates from junior mining company Alto Grande SA include a non-compliant reserve of 2.5 kt and additional speculative resources of 5.5 kt at its Vil Achay project (Buslaiman, 2018). Vil Achay was previously mined for tin between 1939 and 1984.

Africa

Africa has grown into the tin market in recent years, with a move away from traditional artisanal or small-scale mining (ASM) methods to more mechanised, large-scale mining. This has helped to almost double production of tin-in-concentrate from 2015. However, over half of African production is still extracted by ASM methods, which – due to the sectors informal nature – results in large year-on-year variations. These mine workings also have little in the way of resource estimates. It is therefore difficult to estimate exactly how long resources will last for, but it is likely to be greater than the 40-year estimate based on the available data.

Namibia

Namibia is one of the up-and-coming regions of Africa in terms of tin production, with the Uis project – operated by AfriTin Mining – producing its first concentrate in 2019. The mine has CRIRSCO-compliant resources totalling some 95 kt of tin (AfriTin Mining, 2019). This is expected to expand as the company explores the numerous likely tin-bearing pegmatites in the vicinity of the mine.

Uis was also a producing mine before the tin price collapse of the mid-1980s, and as such has a significant tailings dump. Montero Mining filed an Inferred NI 43-101 complaint Mineral Resource of 17.1 Mt at 0.05% Sn for these tailings in early 2019 (Montero Mining and Exploration, 2019).

DR Congo

In terms of CRIRSCO-complaint resources and reserves, the Democratic Republic of Congo has the third-largest resources and the second-largest reserves in the world, split between two major mine projects. The Bisie project has some 165 kt of tin in reserves (The MSA Group, 2017), primarily from the Mpama North section of the deposit. The southern part is expected to be comparable in size to the north but does not yet have a defined or estimated resource. The Manono lithium project has some 220 kt of contained tin as a resource (AVZ Minerals Ltd, 2019) and is expected to enter the market in 2021.

Other regions

South Africa was a historically important mining region, although there is little current production. The country holds over 18 kt of CRIRSCO-compliant resources, with no complaint reserves. The Bushveld Complex, once home to the Zaaiplaats mine, is the main potential source of tin, either from reprocessing tailings or from brownfield exploration.

Due to the mainly ASM-based production in the Rwanda, resource estimates are few and far between. However, junior mining company Piran Resources released a CRIRSCO-compliant resource of some 28.5 kt in 2019 (Piran Resources Ltd, 2019). This also included some 40 kt of non-compliant resources. Additional non-compliant resources (some 24 kt) come from the main producer in the country, Rutongo Mines.

Tin mining has been a staple in Nigeria for hundreds of years, but most of this is ASM. As such, there are no CRIRSCO-compliant resources or reserves in the country. Non-complaint resources total some

65 kt, although none can be classified as reserves. Some works estimate national reserves on the scale of 300 kt (Gyang, Nanle, & Chollom, 2010).

Both Egypt and Morocco are home to large tin projects – Abu Dabbab and Achmmach, respectively. However, only Achmmach is currently being developed. Both projects have CRIRCSCO-complaint resources (40 kt (Kinnaird, Nex, & Milani, 2016) and 127 kt (Kasbah Resources, 2018), respectively), while Achmmach has complaint reserves of 58 kt (Kasbah Resources, 2018). Proposed changes to the Egyptian mining laws could see exploration return to Abu Dabbab in the future.

Somalia and Burundi have some artisanal mining activity and minor reported resources of less than 2.7 kt. Zimbabwe's historical Kamativi Mine still holds over 120 kt of tin as a non-compliant resource (Zimbabwe Mining Development Corporation, 2017), both in the ground and in its tailings dumps.

Europe

Europe is home to several historical tin mining regions, including Cornwall in the UK, northwest Iberia (covering Spain and Portugal), and the Western Ore Mountains on the German-Czech Republic border. Some tin is being produced in Russia and as a by-product in Spain. Most tin resources in this region belong to projects attempting to revive historical operations, although there are some greenfield projects in Spain.

United Kingdom

Cornwall, UK is perhaps the most famous of all historical tin mining areas, but there has been little production since the South Crofty mine closed in 1998. Work is underway in Cornwall and at the recently closed Hemerdon to revive these older mines. The UK holds CRIRSCO-compliant tin resources of over 260 kt.

Russia

Current tin mining operations in Russia include Perevalnoye and Festivalnoye, both operated by Seligdar, and the Khingan Tailings project. Combined, these mines produce just 2.7 ktpa (Ministry of Natural Resources of Russia, 2019). However, Russia is one of the most prospective countries for tin and is number one for CRIRSCO-complaint resources and reserves with nearly 1.8 Mt of resources spread across 18 reporting projects. Russian tin mining is generally concentrated to the east of the country, along the Stanovoy Mountain Range and the border with China. The isolated nature of these mines makes them difficult investment propositions, however.

Germany

Most resources in Germany are held in historical mines. Many of these are being reassessed for their lithium potential, including Sadisdorf and Zinnwald, and the country has a large CRIRSCO-compliant tin resource totalling some 308 kt. However, none of the tin can be classified as a reserve. Non-compliant resources total an additional 207 kt, while the country is also host to significant speculative tin resources totalling some 390 kt.

Czech Republic

Like Germany, interest in lithium has seen the economic potential of many older mines reassessed. The major tin-containing project is Cinovec, which is currently in development. This mine holds over 260 kt of CRIRSCO-compliant tin resources (European Metals, 2019). There are thought to be over 100 kt of additional tin resources in the country, although these are purely speculative.

Spain and Portugal

Spain has CRIRSCO-compliant resources of nearly 70kt, with additional speculative resources of over 100 kt. Elementos, a junior mining company, is looking to begin mining at the Oropesa project in 2021. This project holds some 67 kt of tin as a CRIRSCO-compliant resource (Elementos Ltd, 2019).

Portugal is home to several historical mines, including Panasqueira, which now produces tungsten. In total, the country holds over 25 kt of CRIRSCO-compliant tin resources, 3.5 kt of which can be classified as reserves.

Australia

Australia remains a globally significant producer of tin concentrates, with Renison Bell and other minor producers contributing 7.7 kt to the global market in 2019. The country is highly prospective for tin, boasting nearly 90 different named prospects or deposits. Most of the active exploration and development is confined to the structures along the Federal-Bassett Fault in Tasmania. This is the main structural control on the mineralisation at Renison Bell, and many of the junior companies are hopeful that mineralisation can be found further along the fault.

Of the discovered deposits, Renison Bell and its associated tailings project, Rentails, hold the greatest reserve of tin at a combined 180 kt – 70% of the country's CRIRSCO-compliant reserve (Metals X Ltd, 2019). The country also holds another 240 kt of tin in non-compliant resources. Many of the projects that comprise this additional resource are no longer actively explored, although some could be medium-sized mines if developed.

South East Asia

Myanmar

Myanmar became the world's third-largest producer of tin concentrates in 2013, but due to the small-scale nature of mining activity in the country, hosts very little in terms of tin reserves and resources. Much of the country's production comes from the Man Maw mining district in the east of the country, along the border with China. Not much is known about this deposit, although it has similarities with mines in Gejiu, China and Tasmania, Australia. If similar to Renison Bell, Tasmania, resources could be anywhere between 0.1 Mt and 1 Mt. However, in this summary, only 113 kt of resources are reported, primarily from mines in the south of the country.

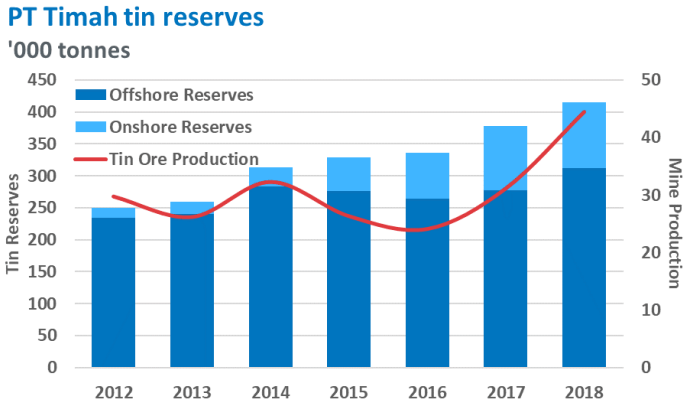
Malaysia and Thailand

While both countries were major producers in the early 1980s, production declined rapidly throughout the following two decades due to depleting resources and the low prices that followed the 1985 tin price crash.

The Rahman Hydraulic tin mine in Malaysia and resources offshore of Thailand in the Andaman Sea comprise the totality of the reported resources for the two countries, totalling some 100 kt. However, Elementos holds an interest in the Temengor mine, which operated until the mid-1930's (Elementos Ltd, 2019), while Malaysia Smelting Corporation (owner of Rahman Hydraulic) plans to expand its mining activities to Sungai Lembing, Pahang (Malaysia Smelting Corporation, 2018). Neither of these new mines have a defined resource yet, although the geology at the Temengor project is thought to bear similarities to the Rahman Hydraulic mine, and so may hold similar levels of resources.

Indonesia

Indonesia remains the second largest producer of tin globally, mining an estimated 77.5 kt of tin in 2019. Although the country hosts many private smelters, most of the tin resources (around 96% according to local sources) are held by the state-run company, PT Timah. In 2018, the company's reserves totalled some 415 kt, with a resource of over 1 Mt (Albar, 2019). Advances in extraction technology, as well as onshore exploration, have increased total reserves by 23% from 2017.



Other Regions

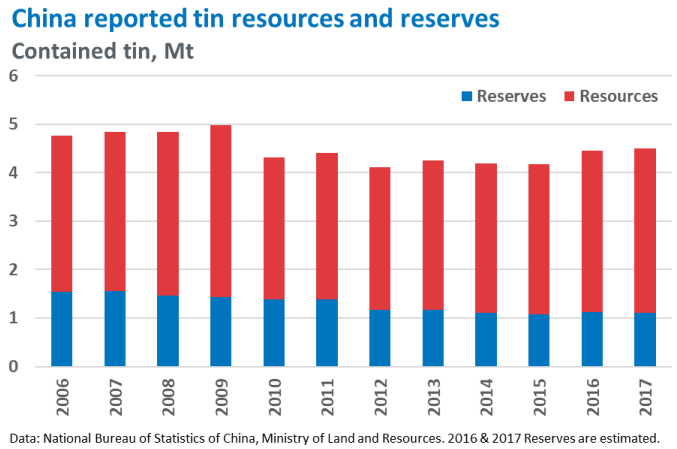
Other areas in South East Asia, namely Vietnam, Laos and Mongolia, have very little tin mining activity. This is primarily ASM, and as such as little in the way of CRIRSCO-complaint resources. Only the Narsiin Khundlen deposit in Mongolia has a complaint resource, but this is only 7 kt. The three countries have a combined total resource of 228 kt and a reserve of 62.5 kt.

Middle East and India

This area of the world has had little historical tin production but remains highly prospective. Only the Syrymbet project in Kazakhstan has CRIRSCO-complaint resources, but these are almost equal to total resources elsewhere in the region (351 kt vs 370 kt). Afghanistan has been extensively explored, with many deposits identified. However, no resources have been publically reported for the majority; only the Taghawlor Field has a resource, totalling some 17.5 kt (Peters, 2011). Three prospective areas have been identified in India, with a combined non-compliant resource of over 100 kt. In Kyrgyszstan, the combination of the Trudovoe and Uchkoshkon deposits is thought to hold over 200 kt of tin (Rogalsky, 2019).

China

For either total resources or reserves, China appears to have the greatest potential in the world. The estimate in this report uses the country's official figures as reported by the National Bureau of Statistics of China and the China Mineral Resources Report (Ministry of Natural Resources, PRC, 2018). The 2018 report estimates that the country has a resource of over 4.5 Mt, of which 1.2 Mt are reserves. These totals have been boosted by an increase in exploration, with resources rising 1.1% between 2016 and 2017. This bucks the trend of slowly declining resources that have been seen over the past decade. However, these figures are reported nationally,



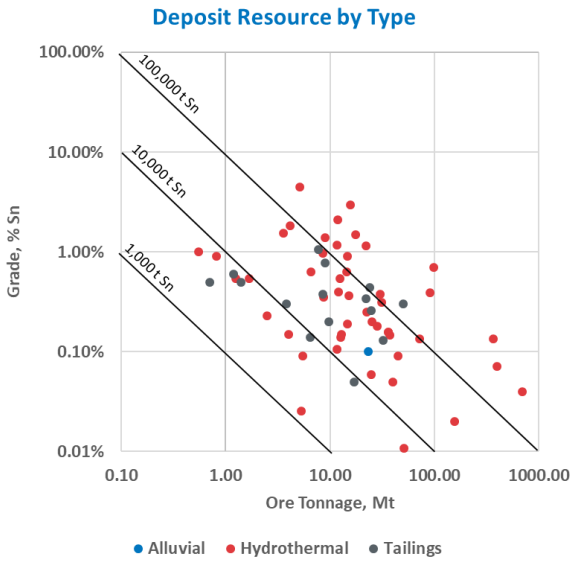
Data: National Bureau of Statistics of China, Ministry of Land and Resources. 2016 & 2017 Reserves are estimated.

and the standards are unclear, meaning that all estimates of tin in China are assumed to be non-compliant with CRIRSCO reporting standards.

Other sources of information for Chinese resources include the USGS and DERA. However, these numbers differ greatly. The USGS estimated that China held just 1.1 Mt of tin as a resource in 2019 (USGS, 2019), while the 2014 DERA report (Elsner, 2014) estimated 4.7 Mt.

Analysis

Compared to commercially viable deposits of other base metals, tin deposits are generally small. All deposits covered in this study fell within the range of 0.01 – 5% Sn, with ore tonnages less than 1,000 Mt. In terms of tin content, the largest single deposit contained less than 500 kt.



The figure (right) indicates one of the issues with resource and reserve estimates. Because the definition has an economic component, smaller deposits (~1 kt contained tin) are generally overlooked. Only one deposit falls close to this line on the figure. Most are clustered between the 10 kt – 100 kt contained tin lines. Larger areas (e.g. offshore Indonesia) did contain more tin but could not be classified as a singular deposit, and so are not included in the figure.

Limitations of resource and reserve estimates

General issues

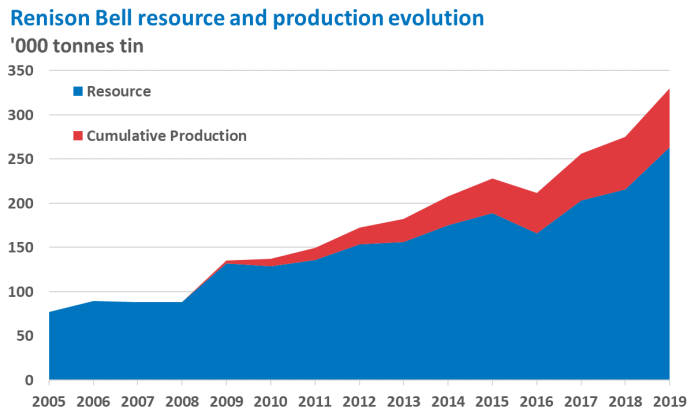
Resources and reserves suffer from the misconception that they are a limited pool of material that will deplete over time. Firstly, resources and reserves only refer to known deposits, which can be considered relatively few compared to the vast potential for new discoveries. Large regions of Earth have not been thoroughly explored due to their remote location, inhospitable terrain, or geopolitical climate. Furthermore, regions that have been explored may not have been explored at depth; African mining mainly takes place close to the surface, but mineralisation may extend deeper, potentially at higher grades. Moreover, most of the exploration is on land, although it is likely that there are considerable resources on, or below, the seafloor. This has been exploited in South East Asia, but nowhere else in the world. Most exploration continues to be focussed in traditionally safe jurisdictions, for example Australia. Higher prices may encourage activity in higher risk regions such as Africa and the former Soviet Union.

Secondly, resources and reserves are only estimated for deposits which are deemed to have short to medium term economic potential and where there is money to carry out the drilling and other activities required to define a resource or reserve according to the required standards. Over time, additional resources and reserves will be added due to additional results of exploration activity and technical innovation in extraction, processing and exploration technologies. More complex ores of lower grades will become viable and this will increase the known global quantity.

Resources and reserves are defined with an economic component. Resource and reserve statements will use a cut-off grade to represent the minimum concentrate of metal that is economical to extract. Only metal content within the assessed area above this concentration will be included. Higher metals prices and forecasts generally result in lower cut-off grades and larger reserve estimates, while other key variables such as by-product prices and input costs also affect this grade. This report will contain many estimates that use different cut-off grades and underlying assumptions, even when following the same reporting template. This can lead to both over- and under-estimations of resources and reserves. It is important to be aware that these error margins are unavoidable and are therefore present in this report.

Even when a deposit has been identified, the full production potential over the life of the mine remains unknown. Resource announcements will often comment that mineralisation is open along strike or at depth, meaning that the full extent is unknown. Following the commissioning of the mine, there is a better understanding of the geology, meaning potential mineralisation can be targeted more accurately and cheaply. Developed mine infrastructure and better access to utilities can reduce the cost of exploration, particularly in remote regions. Underground exploration is significantly cheaper when existing infrastructure can be utilised, rather than drilling directly from the surface.

Therefore, it is common for mines to operate for longer than their initial reserves would suggest. San Rafael in Peru and Renison Bell in Australia are prime examples of this. This reflects the evolving knowledge of the deposit as it is exploited and the fact that companies will only delineate resources and reserves as far into the future as business planning requires. Further drilling will then occur alongside mining to define additional resources and reserves to replace depleted ore.



Achieving environmental, social and political license to mine is also a critical hurdle for developing projects and the estimation of mineral reserves. Even for a world class deposit, if the potential environmental or social impacts of the mine are too great or political risks too high, development of the resource may be prevented. This can also be an issue for existing mines, an example being the dredging of offshore alluvial tin deposits in Indonesia. These operations are criticised as damaging to coral and sea life and have been the subject of protests by local fisherman. However, it is important to note that the same political, environmental and social factors that can make a resource unviable can also be reversed. Changes in government, improving local attitudes towards mining or a better understanding of the environmental impact of resource extraction and its mitigation can help change attitudes.

Tin-specific problems

The tin industry has several peculiarities that make accurate estimates of resources and reserves more difficult than other raw materials.

Artisanal and small-scale mining constitutes around 40% of all tin mine production annually. Because of the informal nature of the mining, resources and reserves in these areas are typically not known and rarely reported. The history of the tin industry has been punctuated by surges of production from areas like these without well-defined tin reserves; Brazil, Indonesia and more recently Myanmar are all good examples.

Exploration activity typically follows a "boom and bust" pattern in reaction to mineral price cycles. Access to a potential area can also vary in line with geopolitical factors. Tin has been particularly affected by this "boom and bust" relationship. Between the tin price crash of 1985 and 2016, only 4 greenfield tin deposits were discovered, despite a peak in renewed exploration activity relating to the tin price spike of 2011. Although exploration is still stronger than in previous years, current low prices have stalled progress.

Putting aside tin's individual price performance, the metal is also commonly mined along metals such as tungsten, tantalum, copper, zinc, silver and increasingly lithium. A boom in prices across the wider industry, leading to an increase in general exploration activity, would also have a knock-on impact on discovery of tin resources. Indeed, in the last few years, many new projects have a by-product, or are producing tin as a by-product.

Ownership in the tin industry also presents a problem for resource reporting. The high proportion of state-owned and small private operations, the majority of which do not publish up-to-date resource estimates, means that there is a limited pool of public information. This means that resource and reserve estimates detailed in this report are likely lower than might be expected should the industry be fully transparent.

USGS studies on tin resources and reserves

Other organisations also attempt to estimate global tin reserves and resources. The most commonly referenced estimates are reported by the USGS on an annual basis. For tin, ITA estimated reserves are around 1 Mt higher than USGS estimates. The largest discrepancies come from South American and South East Asian countries, notably Indonesia, Malaysia, Thailand and Brazil, where the USGS reports far higher figures, and Bolivia and Peru, where USGS estimates are much lower.

USGS reported tin reserves of the last decade

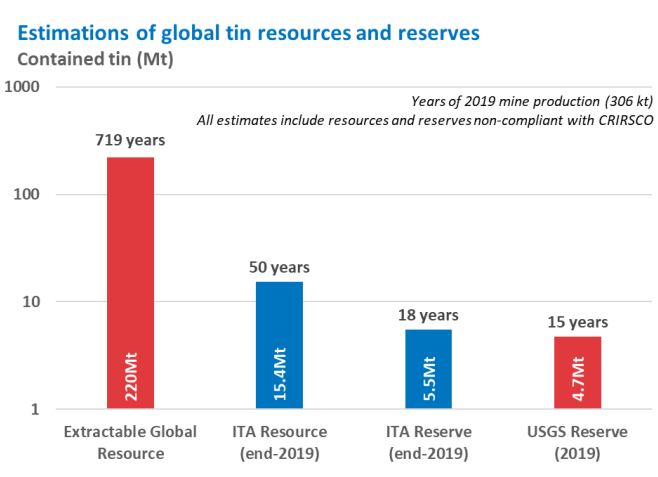
'000 tonnes

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Australia	150	150	180	180	240	240	370	370	370	490	370
Bolivia	450	450	400	400	400	400	400	400	400	400	400
Brazil	540	540	590	590	710	700	700	700	700	700	700
China	1700	1700	1500	1500	1500	1500	1500	1500	1100	1100	1100
Indonesia	800	800	800	800	800	800	800	800	800	800	800
Malaysia	1000	1000	1000	1000	500	500	250	250	250	250	250
Peru	710	710	710	310	310	91	80	130	100	105	110
Russia	300	300	350	350	350	350	350	350	350	350	350
Thailand	170	170	170	170	170	170	170	170	170	170	170
Other	270	270	250	250	250	180	180	180	410	450	450
World (rounded)	**6100**	**6100**	**6000**	**5600**	**5200**	**4900**	**4800**	**4900**	**4700**	**4800**	**4700**

Data: USGS

Outlook for tin supply

World tin production has been relatively stable for several years, with refined tin production between roughly 330 ktpa and 370 ktpa, and mine production between 270 kt and 310 kt. The difference between the two is filled by some 50ktpa – 70ktpa of secondary refined tin production.



Recycling will continue to play an important role in future tin supply and is likely to grow as demand rises. However, there has been limited investment into tin recycling technology, and it may be some years before the major tin resource of end-of-life electronics can be extracted efficiently.

Top 15 undeveloped CRIRSCO-compliant tin resources by tin content

Deposit	Country	Company	Ore (Mt)	% Sn	Sn (kt)
Syrymbet	Kazakhstan	TinOne Mining*	90.32	0.39%	351
Manono	DR Congo	AVZ Minerals	400.00	0.07%	288
Cinovec	Czech Republic	European Metals	695.90	0.04%	278
Deputatskoe	Russia	GOK Deputatsky CJSC	22.25	1.15%	256
Pyrkakaysky	Russia		91.69	0.26%	238
Tigrinoe	Russia		155.08	0.12%	186
Redmoor	UK	New Age Exploration	11.70	1.17%	137
Achmmach	Morocco	Kasbah Resources*	14.60	0.90%	131
Odinokoe	Russia		39.88	0.32%	128
Nazareth	Peru	Minsur**	9.00	1.38%	123
Tellerhauser	Germany	Anglo-Saxony Mining*	30.40	0.38%	116
Gottesburg	Germany	Anglo-Saxony Mining*	42.10	0.27%	112
Sherlovogorskaya	Russia		61.47	0.17%	105
Rentails	Australia	Bluestones Mines**	23.89	0.44%	104
Verkhneye	Russia		33.23	0.30%	100

*ITA Explorers and Developers Group Member **ITA Member

Top 5 undeveloped CRIRSCO-compliant tin reserves by tin content

Deposit	Country	Company	Ore (Mt)	% Sn	Sn (kt)
Deputatskoe	Russia	GOK Deputatsky CJSC	17.24	1.15%	198
Rentails	Australia	Metals X**	22.31	0.44%	99
Achmmach	Morocco	Kasbah Resources*	7.00	0.82%	57
Sherlovogorskaya	Russia		28.82	0.17%	49
Taronga	Australia	Aus Tin Mining*	22.00	0.16%	36

*ITA Explorers and Developers Group Member **ITA Member

With significant tin reserves and recycling likely to increase, there is no reason to suggest than the tin market cannot support a long-term upwards trend in tin demand in the future. Although it is clear than many tin mines and mining regions may be past their peak, there is reason to believe that increased tin prices will fuel exploration and fund the new generation of tin mines. It is expected that the resources and reserves of these promising projects will grow significantly over this period.

Only in the last few years have excess stocks been finally reduced to historically below-average levels, as supply has failed to keep up with demand. While there are short-term uncertainties relating mainly to global macro-economic conditions, the prospects for future tin demand are strong. As a result, ITA still believes that there is still a real need for new investment in modern, sustainable mine projects and that prices significantly higher than current levels are necessary to trigger this.

There is a small but real possibility that a surge in production will occur due to the discovery of a world class tin deposit, such as has been seen in Myanmar between 2012 and 2015. The underexplored, vast mineral potential of South East Asia and Africa would make these likely locations, particularly if progress is made with development of infrastructure and channels for foreign investment. North America may see increased exploration soon, as the United States aims to reduce its reliance on imports of critical material.

However, it is vitally important for the image of tin, transparency and confidence in supply from downstream buyers, that the market share of sustainable, and transparent tin mining is maximised. It is likely that that small-scale and artisanal mining will continue to be prominent feature of the tin industry, so it is important that efforts to formalise artisanal mining and establish good practise are successful.

To summarise, while ITA expects a shortage of tin mining capacity to develop over the next 5 years, but this is unrelated to the quantity of remaining tin in the ground, and rather a symptom of low investment in tin projects in depressed market conditions.

References

AfriTin Mining. (2019, November). *AfriTin Mining Investor Presentation.* Retrieved January 21, 2020, from AfriTin Mining: https://afritinmining-my.sharepoint.com/personal/jeneth_ndlovu_afritinmining_com/_layouts/15/onedrive.aspx?id=%2Fpersonal%2Fjeneth%5Fndlovu%5Fafritinmining%5Fcom%2FDocuments%2FDesktop%2FPresentations%2F2019%2D11%2D22%20ATM%20Presentation%20November%202019

Albar, A. (2019). Indonesia Tin Outlook 2019. Xi'an: PT Timah.

Avalon Advanced Materials. (2019, November). *East Kemptville Tin Recovery & Site Remediation Project: Profitable rehabilitation of a closed mine site.* Retrieved 2019, from Avalon Advanced Materials: http://avalonadvancedmaterials.com/_resources/presentations/EastKemptville-Presentation.pdf

AVZ Minerals Ltd. (2019). *The Manono Lithium & Tin Project: The 'Escondida' of Lithium.* Retrieved November 12, 2019, from AVZ Minerals Ltd: http://asx.announcements.rozettatechnology.com/announcements/v1/documents/asx/AVZ/2019/11/12/pHd7pvogFomfpsBC03IPqwVYDJXnlauH71t4XWOQf7E/02171733.pdf

Ayawilca Polymetallic Project NI 43-101 Technical Report. (2019, July 2). Retrieved 2019, from Tinka Resourrces: https://www.tinkaresources.com/assets/docs/reports/Tinka%20Ayawilca%20TR%20Final.pdf

Buslaiman, L. E. (2018). *Vil Achay Exploration Project: Mining Prospect Discussion.* October.

CRIRSCO. (2019, November). *CRIRSCO International Reporting Template.* Retrieved from CRIRSCO: http://www.crirsco.com/templates/CRIRSCO_International_Reporting_Template_November_2019.pdf

Elementos Ltd. (2019, March). *Investor Presentation March 2019.* Retrieved from Elementos: https://www.asx.com.au/asxpdf/20190304/pdf/443655byjx3hm9.pdf

Elsner, H. (2014). *Zinn - Angebot und Nachfrage bis 2020.* Berlin: DERA-Rohstoffinformationen.

European Metals. (2019, July). *European Metals Investor Presentation.* Retrieved from European Metals: https://www.europeanmet.com/wp-content/uploads/2019/07/European-Metals-Presentation-July-19.pdf

Gyang, J., Nanle, N., & Chollom, S. (2010, March). An Overview of Mineral Resources Development in Nigeria: Problems and Prospects.

Kasbah Resources. (2018, July 16). *Achmmach Tin Project 2018 Definitive Feasbility Study.* Retrieved January 21, 2020, from Kasbah Resources: http://www.kasbahresources.com/site/PDF/1730_0/2018AchmmachTinProjectDefinitiveFeasibilityStudy

Kinnaird, J., Nex, P., & Milani, L. (2016). Tin in Africa. *39*(2).

Malaysia Smelting Corporation. (2018). *MSC 2018 Annual Report.* Retrieved from Malaysia Smelting Corporation: https://ir.chartnexus.com/msmelt/pdf/ar2018.pdf

Metals X Ltd. (2019, September). *September Quarterly Report.* Retrieved from Metals X: https://www.metalsx.com.au/system/announcements/1033/20190930_September_Qtrly_Report.pdf

Ministry of Natural Resources of Russia. (2019). *On the State and Use of Mineral Resources of the Russian Federation in 2018.* Ministry of Natural Resources of Russia.

Ministry of Natural Resources, PRC. (2018). *China Mineral Resources.*

Minsur S.A. (2018, 12 31). *Minsur Annual Report 2018.* Retrieved 2019, from Minsur S.A.: https://www.minsur.com/wp-content/uploads/pdf/Memoria%20Anual/ENG//Minsur_Memoria_Anual_2018_ENGLISH.pdf

Montero Mining and Exploration. (2019, September 30). *Management's Discussion and Analysis.* Retrieved January 21, 2020, from Montero Mining and Exploration: https://www.sedar.com/GetFile.do?lang=EN&docClass=7&issuerNo=00030660&issuerType=03&projectNo=02991671&docId=4629745

Peters, S. G. (2011). Summary of the Daykundi Tin, Tungsten, and Lithium Area of Interest. In T. V. Stephen G. Peters, *Summaries of Import Areas for Mineral INvestment and Production Opportunities of Nonfuel Minerals in Afghanistan.* USGS.

Piran Resources Ltd. (2019, September). *Tin, tantalum & lithium in Rwanda.* Retrieved December 16, 2019, from Piran Resources: https://piran-resources.com/wp-content/uploads/2019-09-13-Piran-Resources-Corporate-Presentation.pdf

Rogalsky, A. (2019). *Report on Classification of Energy and Mineral Resources and its Management in the Kyrgyz Republic.*

The MSA Group. (2017, March 23). *Bisie Tin Project NI 43-101 Technical Report.* Retrieved January 17, 2020, from Alphamin Resources: https://alphaminresources.com/wp-content/uploads/2019/11/Alphamin-NI-43-101-Technical-Report-Updated-Feasibility-Study-and-Control-Budget-Estimate-Report-23-Mar-2017.pdf

United States Department of the Interior. (2018). *Draft List of Critical Materials.* United States Department of the Interior.

USGS. (n.d.). (USGS) Retrieved 2019, from Mineral Resources Data System: https://mrdata.usgs.gov/mrds/map-commodity.html

USGS. (2019). *Mineral Commodity Summaries 2019.* USGS.

Zimbabwe Mining Development Corporation. (2017). *Mining Projects and Opportunities for Investment 2017.* Retrieved from http://www.sera.co.zw/wp-content/uploads/2018/01/ZMDC-Investment-Opportunity-Brochure-8.pdf

Unit 3, Curo Park
Frogmore
St. Albans
Hertfordshire
AL2 2DD
UK

Tel: +44 (0) 1727 875 544
Fax: +44 (0) 1727 871 341

Email:info@internationaltin.org
Web:www.internationaltin.org