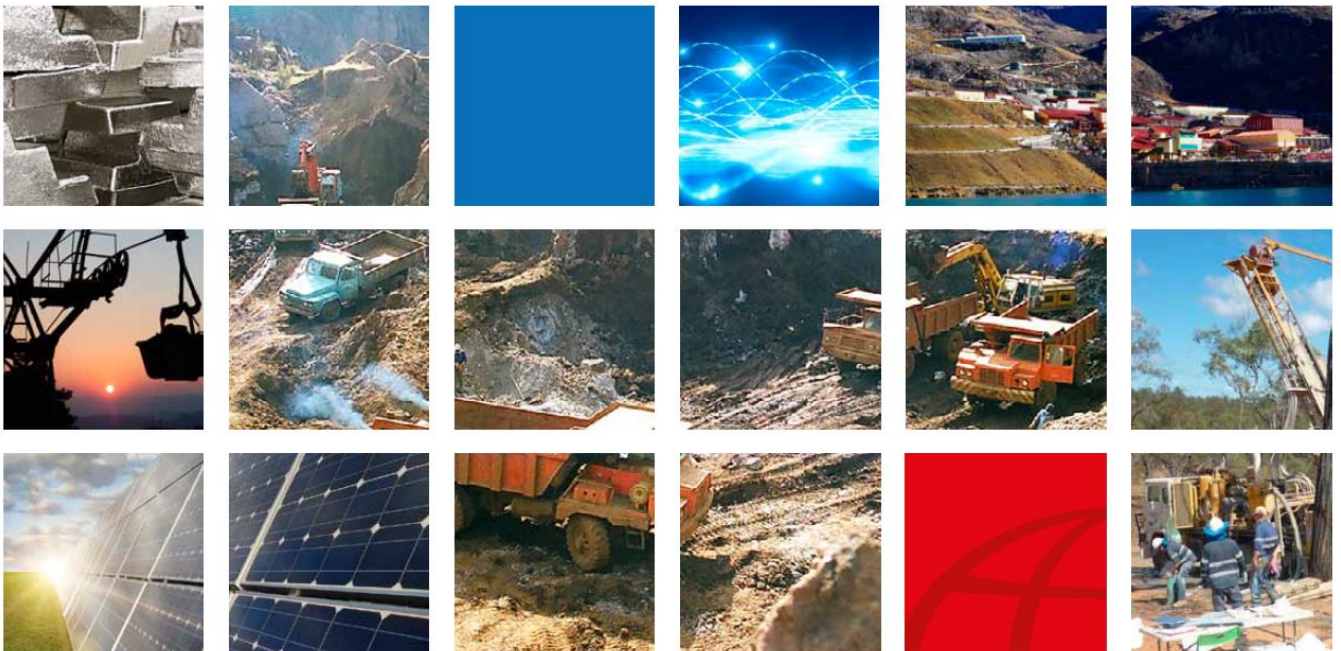


2016 Report on Global Tin Resources & Reserves



Security of long-term tin supply

Security of long-term tin supply

This report presents ITRI's estimate of global tin resources and reserves at the end of 2015, with commentary and outlook for the important tin producing regions of the present, and potentially the future.

Acknowledgements

ITRI is grateful to all members who provided feedback on this report and would also like to extend special thanks to Dr Harald Elsner, Choo Mun Keong and John Sykes for their constructive comments.

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Summary

- As calculated by ITRI, the world's reported tin resources at the end of 2015 totalled some 11.7 Mt, including 2.2 Mt of reserves. 3.4 Mt of resources (29%) and 0.6 Mt of reserves (27%) were compliant with the CRIRSCO reporting standard.
- The top 5 countries as a proportion of compliant global resources were Australia (24%), Brazil (16%), Kazakhstan (14%), Germany (8%) and Peru (8%). When non-compliant resources are included, the top 5 countries change to China (35%), Russia (12%), Australia (8%), Indonesia (7%) and Brazil (6%).
- When considering these defined tin resources and the potential of unreported and undiscovered tin worldwide, it is clear that there is enough of the metal to satisfy global demand long into the future. However, many defined tin resources will require higher tin prices or more efficient extraction technologies to be economic for development.
- The current low tin price is a risk to tin supply over the next 5 years due to reduced investment in tin projects. It is important to clarify that this short term supply risk results from a stalled project pipeline and not the long term availability of the metal in the ground.

The threat: Tin criticality

Availability of raw materials is of huge importance to policy makers and downstream users. A perception that a material is “running out” can destroy demand through substitution to other materials, economisation, or introduction of legislation to limit consumption.

Notable examples for tin include substitution of tinplate with aluminium in production of beverage cans and economisation in solder use in electronics due to miniaturisation and more efficient soldering methods and component mounting technologies.

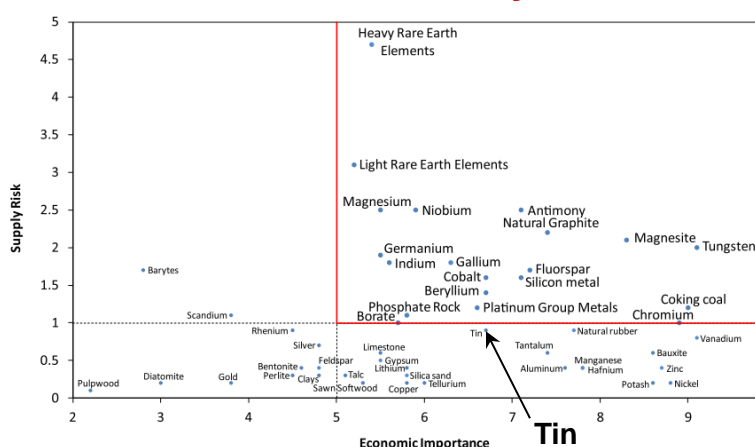
Pictured on the right is a risk matrix from a 2014 paper on criticality commissioned by EU for a range of raw materials ^[1]. The risk matrix balances the economic importance of the raw material against the risk of supply shortages. Whilst a low supply risk means tin falls just outside the critical zone of the matrix, any difference in interpretation of supply risk or adjustment of the criticality threshold could have a different result and indeed this has been the case in alternative studies ^[2]. A transparent up-to-date analysis of long term tin supply is critical to ensuring supply risk in these studies is not overstated.

ITRI’s objective with this report is to reassure all those concerned about tin supply by providing a fresh estimate of global tin resources and reserves. It is also important to point out the limitations and potential pitfalls of resource reporting, not just in tin but across the wider mining industry, to help ensure that these figures are not over-interpreted.

Defining resources and reserves

There is a fundamental difference between mineral resources and mineral reserves, a distinction that is often confused by those outside the mining industry. It is likely that past use of the terms “reserve base” and “geological reserves”^[3] to refer to resources, including sub-economic resources, has added to the confusion.

EU raw material criticality risk matrix



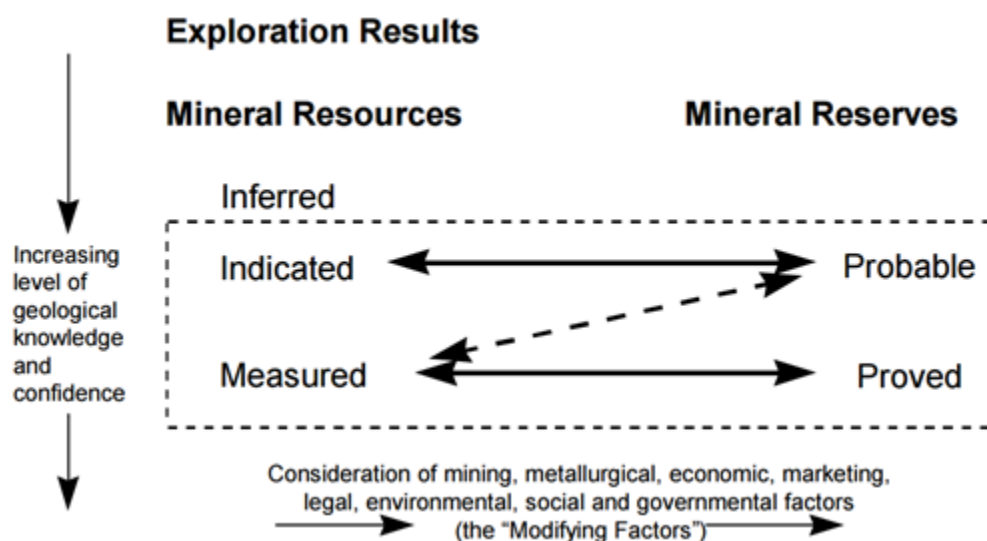
The Committee for Mineral Reserves International Reporting Standards (CRIRSCO) is an inter-organisational body bringing together national and regional mineral reporting committees. CRIRSCO was established to create a set of agreed standard international definitions for the public reporting of Exploration Results, Mineral Resources and Mineral Reserves. Current members of the group include JORC (Australasia), CIM (Canada), Comision Minera (Chile), PERC (Europe), MPIGM (Mongolia), NAEN (Russia), SAMCODES (South Africa) and SME (United States of America).

We provide the 2013 CRIRSCO definitions^[3] of Mineral Resources and Mineral Reserves 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."

General relationship between Exploration Results, Mineral Resources and Mineral Reserves



Source: CRIRSCO^[3]

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 method

This report takes a minimum case, highest confidence approach to the calculation of global resources and reserves. The overall and intended result is that all reported figures should represent, as much as possible, a reliable minimum estimation of tin resources and reserves, rather than speculative estimations with wide positive and negative margins of error. In this study 235 deposits, mining districts and regions were identified. While every effort was made to maximise the coverage of this study, there will be many more economic occurrences of tin for which quantitative information on resources or reserves does not exist or which were unknown to ITRI at the time of data collation.

Figures for tin resources and reserves were retrieved from numerous data sources including USGS^[4] and DERA reports^[5], company press releases and presentations, national data and private communication with ITRI. The total tin resources and reserves for each country were calculated from Mineral Resource statements or estimates from individual deposits or mining regions, with the exception of Brazil and China, which utilised nationally reported figures.

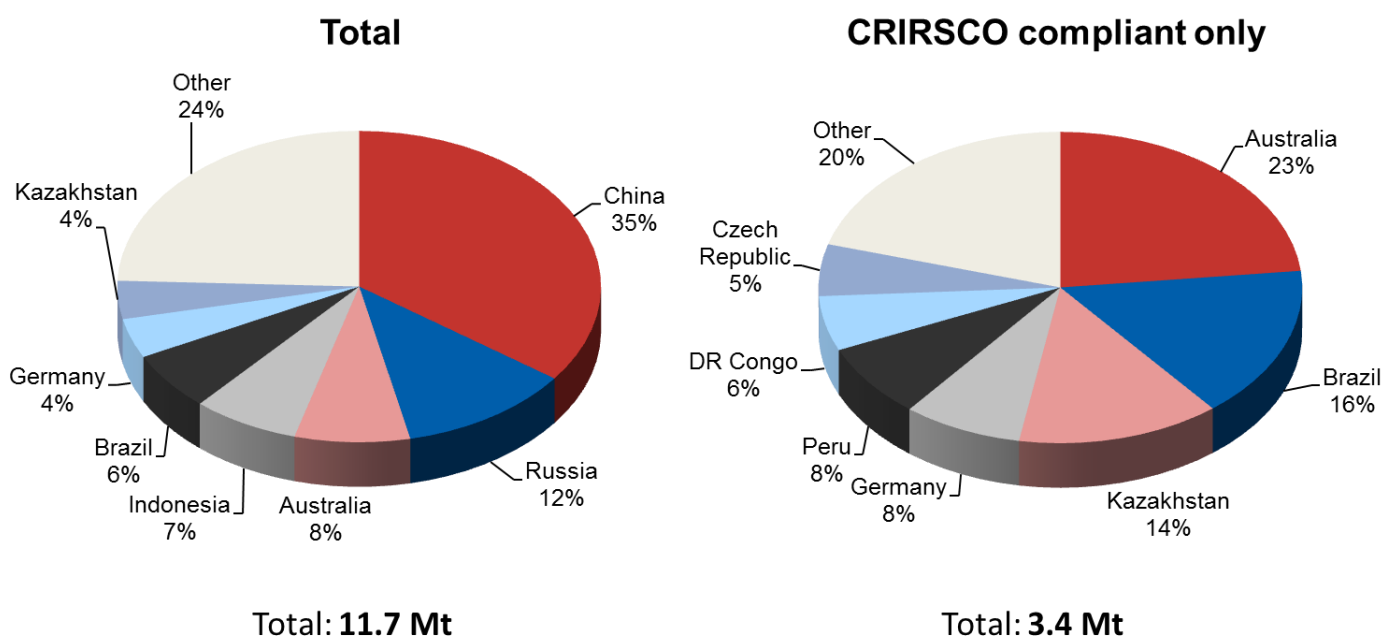
Reserve and resource data is split into CRIRSCO and non-CRIRSCO groupings based on the specific reporting standards and quality of sources in each case. Figures reported that do not adhere to the CRIRSCO template are less reliable, but must be included in our analysis because current tin production globally is heavily weighted towards countries which are not part of CRIRSCO, such as China and Indonesia. To illustrate this point further, only 52% of 2014 mined tin production came from countries with CRIRSCO-compliant tin resources and only 23% where the CRIRSCO resource is significant i.e. it exceeds the production of tin from the country during the year. However, this rises to 99% of production in both instances 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 2015 exists, the latter was subtracted from the former, with reserves depleted first. Potential undiscovered and speculative resources are not included in the ITRI estimates but are discussed within the report.

ITRI's estimate of global tin resources and reserves

Tin resources globally, as calculated by ITRI, totalled 11.7 Mt of contained tin at the end of 2015, of which 3.3 Mt, or 29%, was reported according to CRIRSCO standards. Global tin reserves, a subset of the aforementioned resource figures, totalled 2.2 Mt, of which 0.6 Mt, or 27%, was CRIRSCO-compliant. Based on 2014 tin mine production of 306 kt, present global tin reserves will last a minimum of 7 years and resources a minimum of 36 years. When looking at the distribution of resources globally, the majority of CRIRSCO compliant resources can be found in Europe, Australia and South America, with some in Africa, whereas the majority of non-compliant resources are found in Central and Eastern Asia.

2015 Global tin resources



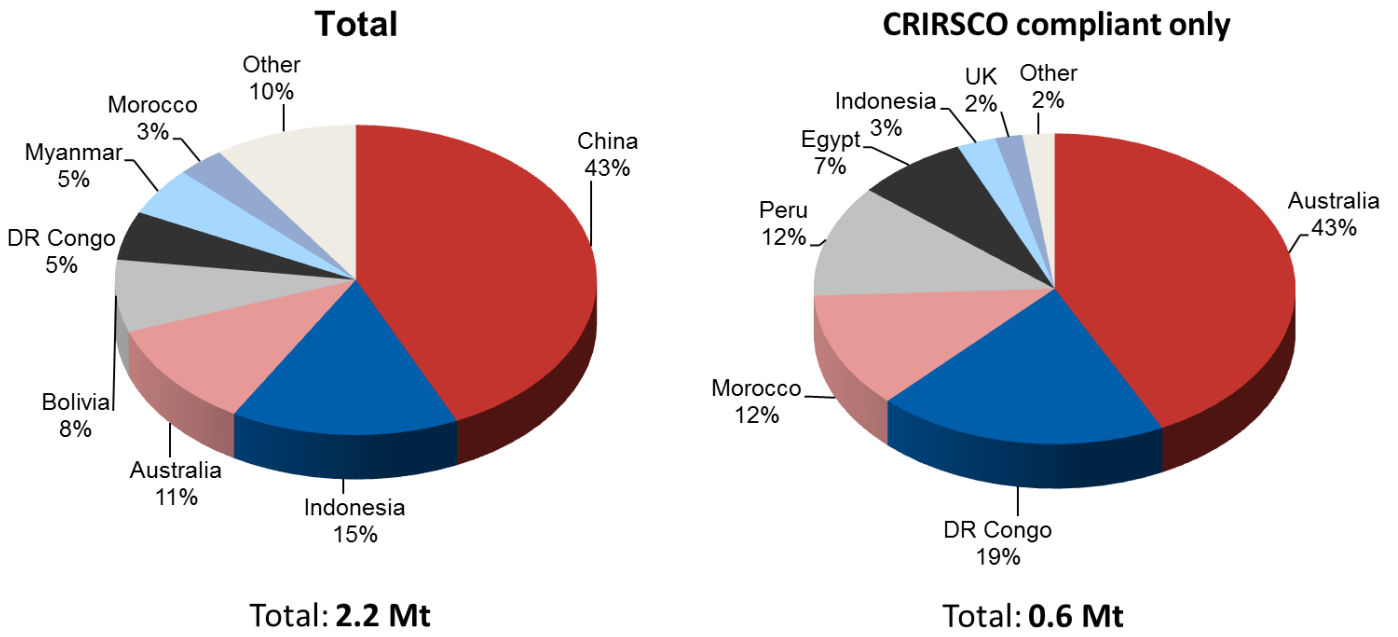
Data: ITRI

'000 tonnes of contained tin		CRIRSCO		Non-CRIRSCO		Total	
Country	2014 mine production	Resources*	Reserves	Resources*	Reserves	Resources*	Reserves
Afghanistan	0.0	0.0	0.0	18.0	0.0	18	0
China	103.4	0.0	0.0	4,096.1	968.3	4,096	968
India	0.1	0.0	0.0	102.3	1.1	102	1
Indonesia	88.3	31.1	15.4	801.9	328.4	833	344
Kazakhstan	0.0	463.1	0.0	0.0	0.0	463	0
Kyrgyzstan	0.0	0.0	0.0	215.9	0.0	216	0
Laos	0.8	0.0	0.0	37.3	0.0	37	0
Malaysia	3.8	33.2	0.0	0.0	0.0	33	0
Mongolia	0.1	7.4	0.0	104.6	5.5	112	6
Myanmar	30.0	0.0	0.0	113.4	113.4	113	113
Tajikistan	0.0	0.0	0.0	45.0	0.0	45	0
Thailand	0.1	0.0	0.0	64.3	0.0	64	0
Vietnam	5.4	0.0	0.0	48.2	10.7	48	11
Asia total	232.0	534.8	15.4	5,646.9	1,427.5	6,182	1,443
Bolivia	19.8	60.8	4.3	323.3	165.0	384	169
Brazil	12.1	540.8	0.0	170.9	67.3	712	67
Canada	0.0	113.2	0.0	6.8	0.0	120	0
Peru	23.1	262.4	68.4	0.0	0.0	262	68
USA	0.0	0.0	0.0	71.5	0.0	72	0
Americas total	55.0	977.1	72.6	572.5	232.3	1,550	305
Czech Republic	0.0	183.3	0.0	44.7	0.0	228	0
Germany	0.0	271.9	0.0	207.4	0.0	479	0
Portugal	0.1	4.6	0.0	12.9	0.0	17	0
Russia	0.2	115.0	8.3	1,234.7	0.0	1,350	8
Spain	0.0	69.1	0.0	0.0	0.0	69	0
UK	0.0	80.5	10.7	0.0	0.0	81	11
Europe total	0.3	724.5	19.0	1,499.7	0.0	2,224	19
Australia	6.9	794.0	249.7	106.5	0.0	900	250
DR Congo	5.1	194.2	114.4	265.1	0.0	459	114
Egypt	0.0	40.1	43.5	0.0	0.0	40	44
Morocco	0.0	131.4	71.0	0.0	0.0	131	71
Nigeria	2.5	0.0	0.0	51.8	0.0	52	0
Rwanda	4.0	0.0	0.0	0.0	0.0	0	0
Other Africa	0.2	18.4	0.0	134.1	0.0	153	0
Africa total	11.8	384.1	228.9	451.0	0.0	835	229
World total	306	3,400	600	8,300	1,700	11,700	2,200

Data: ITRI, DERA, NBSC, Various company data

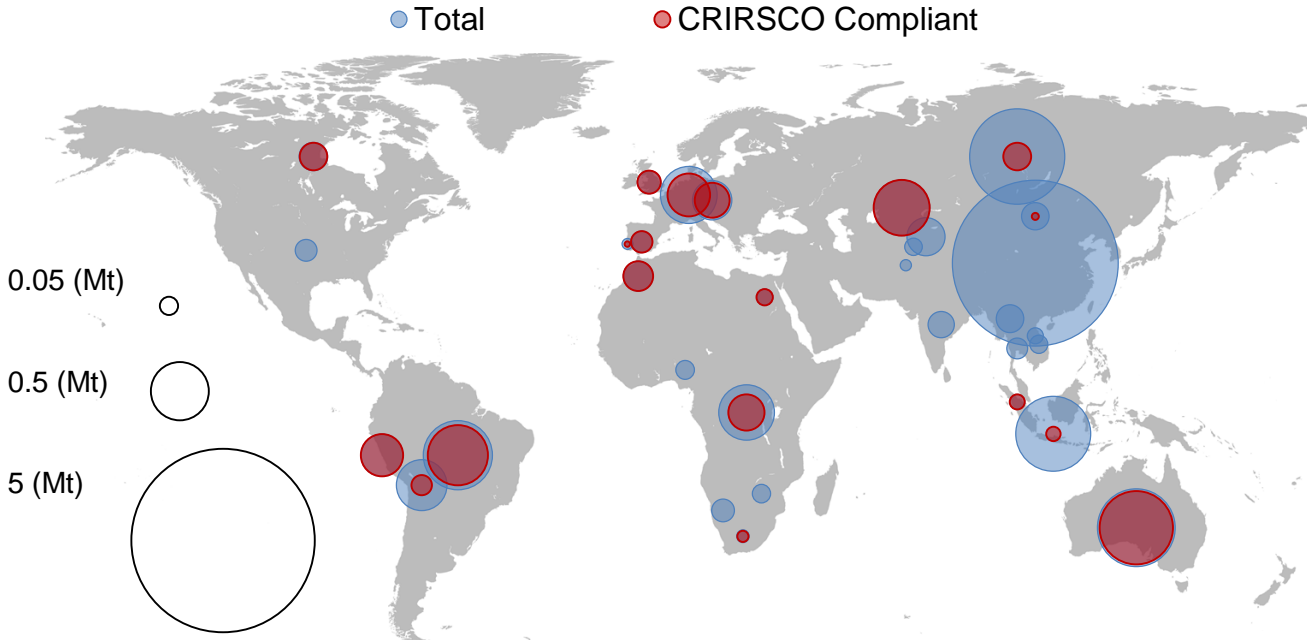
*Resources inc. reserves, world totals rounded, correct as of 31/12/2015

2015 Global tin reserves



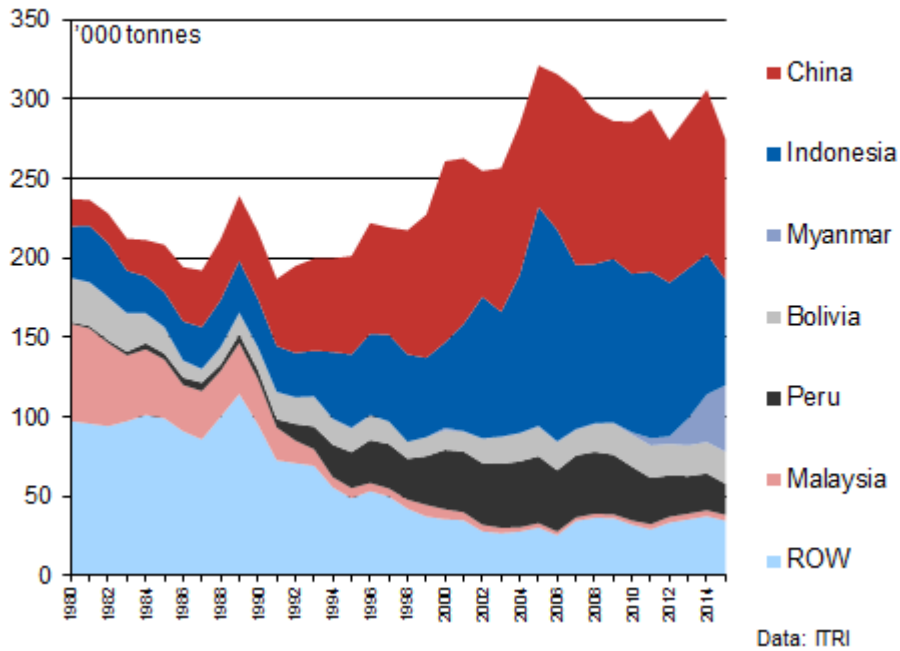
Data: ITRI

Global tin resources (inc. reserves)



* Resources are located by country. Specific deposit sites not represented

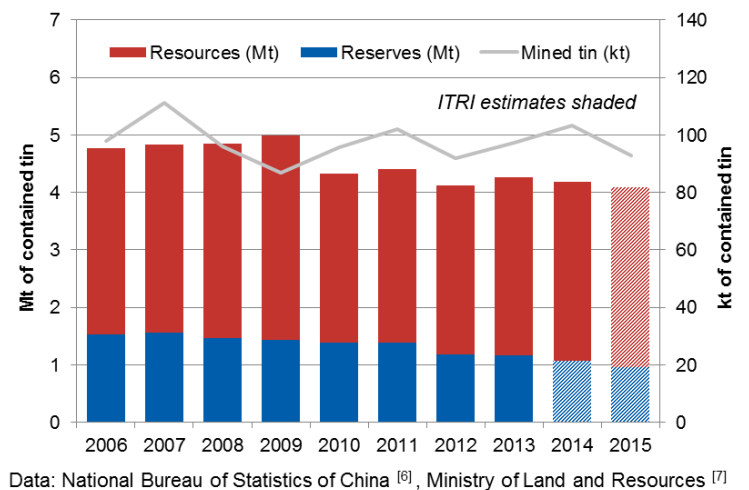
Shares in world mine output 1980 - 2015



China

For either total resources or reserves, China appears to have the greatest tin production potential of any country. The ITRI estimate uses the most recent official figures for China's national tin resources as reported in the online database of the National Bureau of Statistics of China^[6] and the 2015 China Mineral Resources Report^[7]. The report announced tin resources in 2014, including reserves, of 4.189 Mt of tin metal, down 1.6% from 2013, largely explained by a 98% fall in new tin discovered through exploration, from 130 kt in 2013 to 8.7 kt in 2014. China's tin reserves, calculated at 968 kt, are also significant and constitute 46% of global reserves. However, as the figures are reported nationally and the standards used are not clear, all estimates of tin in China are assumed to be non-compliant with the CRIRSCO mineral reporting standard.

China's Tin Resources & Reserves (2006 - 2015)



In recent years there has been a rationalisation of ownership in China, with a few large companies investing in modernisation and many small operations being shut down as environmental and safety regulations have been tightened. While the Chinese industry is becoming more efficient, resources and reserves have declined gradually over the last decade, largely due to tin production exceeding replenishment of tin stocks by exploration. While the tin potential of China and its position as the world's largest tin producer is not under threat any time soon, a decline in mined tin production is expected in line with increased regulation and depleting resources.

Indonesia

Indonesia remains the second largest tin producing country in the world, with an estimated 70,900 tonnes of tin mined in 2015 but has the 4th highest tin resource globally. Apart from a small, JORC-compliant, resource of some 31 kt, including 16 kt of reserves, from PT Koba Tin, which ceased production in 2013, publicly available tin resources and reserves exist only as non-CRIRSCO compliant figures reported by the state run company, PT Timah. The company's reserves in 2015 totalled 328,392 tonnes of tin, of which 276,772 tonnes (84%) are situated offshore.

However, a significant proportion of production in the country (over 60% in 2015) comes from private producers and informal miners for which no mineral estimates are available. The alluvial tin in Indonesia can be processed very cheaply using basic washing and gravity separation methods with most of the costs concentrated in the mining stage. However, producers have reported declining grades over the last decade which has resulted in rising costs and falling production.

Regardless, the offshore alluvial deposits, mainly around the islands of Bangka and Belitung, still show potential and there is still new open pit mining being developed. Significant deposits of tin are known to exist further offshore, but these have not proven to be amenable to the dredging method that has been so successful in the shallow waters over the last couple of decades. Several private Indonesian companies have been investigating whether borehole mining would be a practical and economically viable way of exploiting these deeper deposits.

Russia

Despite annual tin production in the hundreds of tonnes, Russia has the second largest total compliant and non-compliant tin resources after China of 1,350 kt, but with just 8 kt of reserves. Data for individual mining areas was collected from a 2014 national report^[8] and supplemented with additional ITRI and company data. While the Russian reporting committee, NAEN, is now a member of CRIRSCO, many of Russia's historically published resources and reserves use the USSR classification system. This system is not too dissimilar from CRIRSCO but often suffers from overlapping use of the terms reserve and resource, which can make it difficult to differentiate the two.

Although there are a number of defunct mines with potential, these mines require significant investment, which will not be forthcoming when considering the fragile domestic political and economic situation. The isolated, far east location of these operations also increases the difficulty of redevelopment.

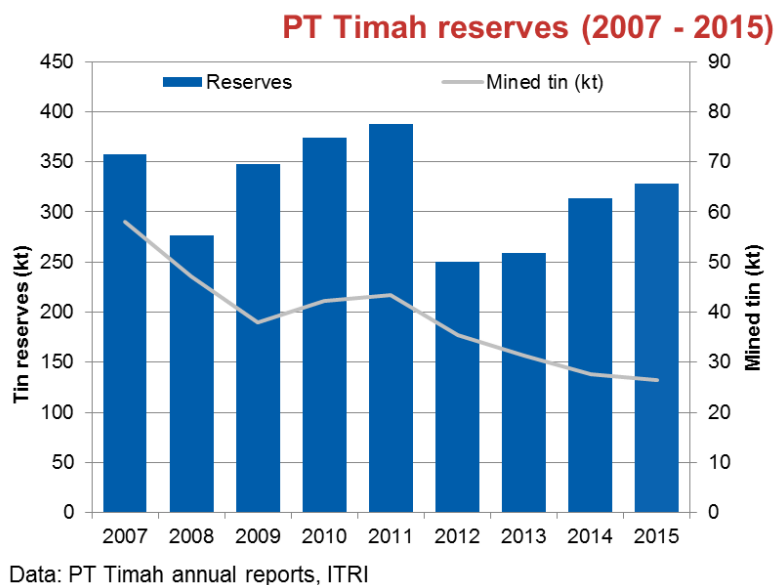
Australia

Australia has seen a flurry of tin exploration activity over the last few years, particularly in response to the US\$ 33,000 peak in tin prices in 2011. Due to the large number of publicly listed companies in the Australian tin exploration space, resource and reserve data is well reported, with 39 deposits identified with defined resources. Thus it is not surprising that Australia has the third highest reported tin resource globally at 900 kt, 88% of which is CRIRSCO-compliant.

At present, the Renison mine in Tasmania is the only significant producer of tin in Australia, with unaudited annual mine production of 6.9 kt in 2015, although increases in production are expected over the next few years. Whilst the recent drop in tin prices has stifled investment in tin projects and resulted in a lower activity, the outlook for Australian tin over the long term is bright, with 5 of the top 15 undeveloped CRIRSCO-compliant tin resources globally located in the country.

Brazil

Brazil has the fourth largest global resources, at 712 kt, including the sixth largest global reserves, at 67 kt. Like Australia, Brazil produces a modest quantity of tin annually, some 12 kt in 2014. Just under half of production was accounted for by the Pitinga mine, with the remainder produced by a number of smaller private producers and



co-operatives. While production from co-operatives has generally decreased in recent years, an integrated private miner and solder producer, White Solder, has communicated the possibility of increasing mine production.

The ITRI resource and reserve estimates for Brazil use nationally reported reserve figures from 2013^[9] minus production over the last two years and CRIRSCO compliant resources from the Pitinga mine, which are reported separately.

Minsur's 2014 annual report includes a JORC compliant, pit constrained resource of 545,259t of tin for Pitinga, the largest compliant resource reported for an individual operation globally. However, it is important to add that this resource estimate assumes tin prices of US\$ 24,000/ tonne, and so a large part may be uneconomical at current price lows. A subset of the resource is expected to be upgraded to an ore reserve in due course. The mine operated on a reduced capacity in 2015 due to emergency repairs on the dedicated hydroelectric dam, and it is expected that production will also be affected by repairs to some degree in 2016.

Bolivia

Bolivia's estimated resources of 384 kt, including reserves of 169 kt, are totals of resources from the two state run mines, Huanuni and Colquiri as well as tin projects in Catavi, near the historical Siglo XX mine, where co-operative miners continue to operate. 84% of the resources are non-compliant with CRIRSCO.

The country's production was 19.8 kt in 2014, 12 kt from the state mines and the remainder from co-operatives and smaller, private operations. The government has been trying to boost production with new mill capacity at Huanuni and a new Ausmelt furnace at the state run Vinto smelter, which refines the majority of the country's concentrates, but has seen limited success so far. Several of the tin projects near Catavi are considering tailings reprocessing, but some only have exploration targets estimated and as such are not included in the resource estimate, despite potential to be included in the future. Regardless, Bolivian tin projects are unlikely to move ahead at current tin prices.

Peru

Peru's only tin resources and reserves are reported for the world class San Rafael Mine, which began operating in 1975, and its associated tailings project, B2. Reported reserves at the mine declined over 85% between 2001 and 2011, but have remained broadly steady since and are now expected to rise, with owner Minsur reporting that reserve replenishment is now exceeding the rate of tin production. CRIRSCO compliant resources for the mine and tailings at the end of 2014 totalled 282 kt including 88 kt of reserves.

The additional resources and reserves defined in 2015 have not yet been reported and so ITRI's global estimate instead uses the 2014 figures adjusted for 2015 mine production. The mine has seen tin production fall steadily, from 39,037 tonnes in 2007 to 19,511 tonnes in 2015, due to falling tin grades, although mined head grades have almost reached the proven reserve grade of just under 2% Sn (2014) and so further falls in production should be limited. A new ore sorting plant under development for San Rafael should increase tin production from low grade ore stockpiles and the B2 project could potentially add over 6 kt of tin production annually.

Malaysia and Thailand

In the early 1980s Malaysia and Thailand were the world's top two tin mining countries with annual production of some 60 kt and 30 kt respectively. Production in both countries declined rapidly throughout the 80s and 90s due to depleting tin resources and low tin prices following the crash of 1985. Since then annual mined tin production has remained at low levels of a few thousand tonnes in Malaysia and few hundred tonnes in Thailand, although combined annual refined tin production from both countries exceeded 40 kt in 2015, based on custom smelting of imported ore.

33 kt of tin in Malaysia from the Rahman Hydraulic mine and 64 kt of offshore tin deposits in the Andaman Sea in Thailand constitute the entirety of reported mineral resources in the two countries. Environmental issues with local fisherman and nearby tourism are also a barrier to mining in the Andaman Sea. However, the Perak government in has an active interest in developing an exploration programme in Malaysia, focussing on the Pengkalan Hulu region in the state, to restore the tin resources and reserves and encourage investment, but a recovery in tin prices will most likely be required to justify the necessary level of investment in programme. Deep alluvial tin deposits are also known to exist at Kuala Langat in Malaysia, with speculative tin resources estimated at 85,000 tonnes of contained tin.

Myanmar

Myanmar has been the big story in tin over the last few years with mine production estimated by ITRI at some 45 kt tonnes of contained tin in 2015 from less than 1 kt in 2009. The surge in production has come from a new mining area, known as Man Maw, or Nuoba, in the east of the country on the border with China. While it lacks a resource estimate and there is limited geological data available, the deposit is known to be hard rock, polymetallic and, based on the similarity of mineralisation to mines in Geiju in China and Renison Bell in Australia, resources could be anywhere from 0.1 Mt to 1 Mt of contained tin. However, in ITRI's global summary, the only reported resources are 113 kt of tin from historical operations in the south of the country, where production totals a few thousand tonnes of tin per year.

The discovery of a deposit of this size in eastern Myanmar only emphasizes the untapped potential of underexplored regions of the world. Revision of the onerous mining laws in the country could also lead to a revival of the tin industry in south of the country in the future.

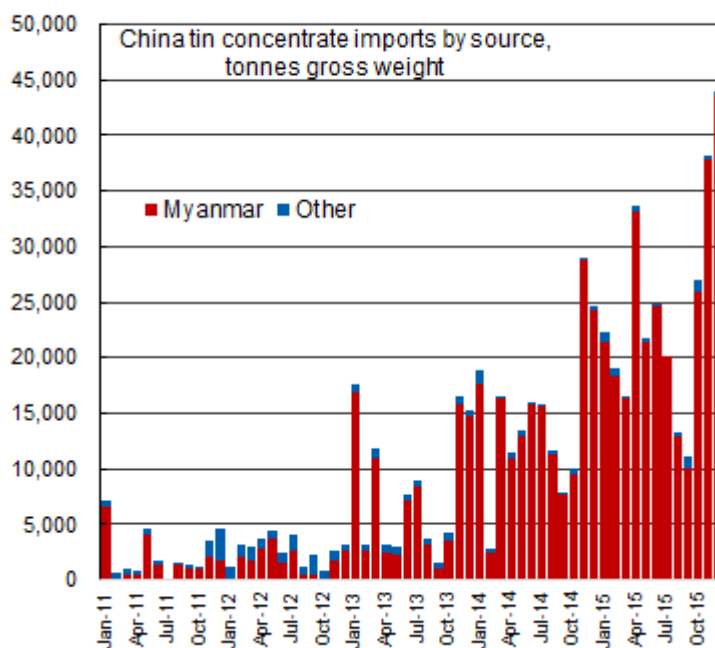
Africa

Despite mine production of almost 12,000 tonnes of tin in 2014, the majority of which originated in Rwanda, DR Congo and Nigeria, Africa has the second lowest tin resource by continent, at 835 kt, after North America. This is because of the dominantly artisanal nature of tin mining where resources are rarely defined or reported.

Widespread artisanal mining activity indicates that Africa is likely to have significant tin potential and over the long term it would not be surprising if it became a larger producer, driven in part by the potential development of one of two leading tin projects; The Bisie tin project in DR Congo and Achmmach project in Morocco have yielded CRIRSCO-compliant tin resources and reserves that constitute around 40% of the tin resource in Africa. Both these projects are at an advanced stage but will find it more difficult to raise sufficient capital for mine construction at current tin price lows. While a lower cost, small start option is being considered at Achmmach in response to the depressed tin market, the Bisie project's high tin grades mean it should be economic to develop even at current prices, with security risks and poor infrastructure in DR Congo being the project's main obstacles. A DFS has recently been completed at Bisie, which included an upgrade of part of the resource to a probable reserve, containing 3.04 Mt at 3.76% Sn, or 114,366 tonnes of contained tin.

The Manono mining area, Katanga, DRC has seen relatively little tin production in recent years, but non-compliant resources total 265 kt and contribute significantly to the continent total. The Abu Dabbab tantalum-tin project in Egypt

China tin concentrate imports



contributed 43.5 kt of JORC-compliant tin reserves, but an ownership disagreement has stalled its development. The Kamativi mine in Zimbabwe was recently auctioned off to a Chinese bidder and is at a very early stage of development. Resources are also reported for Namibia, Nigeria and South Africa

Europe

Europe is home to a number of historical, but now defunct, tin mining regions including Cornwall in the UK, Northwest Iberia and the Western Ore Mountains on the border between southern Germany and the Czech Republic. Some tin is produced on a very small scale in Portugal and the UK as a by-product of tungsten mining. Tin resources in all these regions total 874 kt, including 11 kt of reserves, all from projects attempting to revive historical tin operations.

North America

North America does not undertake any tin mining at present, but tin resources of 192 Mt were calculated from totals for a number of tin projects. These included 3 reported tin resources in Canada, including the old East Kemptville mine in Nova Scotia and Mount Pleasant in New Brunswick. With defined resources of 58 and 56 kt of contained tin respectively, these two projects are in the top 15 of CRIRSCO-compliant tin resources worldwide.

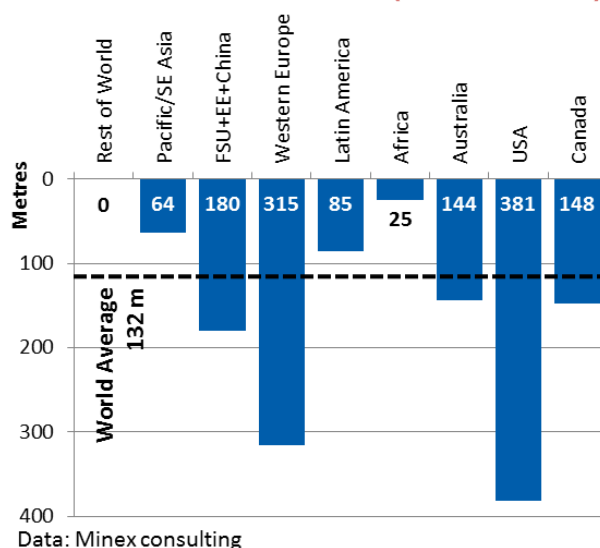
Apart from a resource estimate for the Sleitat Mountain tin deposit, the US has no published tin resources. However, the USGS Mineral Resources Data System (MRDS) lists 567 known unexploited tin occurrences and prospects in the United States alone^[8]. This is a good example of the potential of undiscovered tin resources in a tin-poor region of the world and therefore the vast potential for additional tin in unreported or unknown deposits worldwide.

The limitations of resource and reserve estimates

General issues

The most damaging misconception regarding estimates of resources and reserves across all metals is that they are a finite pool that is depleted by mine production over time. Firstly resources and reserves only refer to known deposits, which can be considered relatively few when compared to the vast potential for undiscovered mineral deposits. Even today, large areas of the earth's surface have not been thoroughly explored due to lack of transport infrastructure, inhospitable terrain, weather conditions, wars etc., although the cost and difficulty of doing so means these areas are unlikely to lead to new deposits in the short or medium term. There is also significant undiscovered mineral potential at depth, particularly in regions like Africa where the majority of base metal exploration and discoveries have been at surface level over the last decade^[11]. Most base metal mining exploration continues to be focussed in traditionally safe, large resource rich areas such as North America and Australia, although higher prices can encourage activity in the higher risk regions such as Africa and the former Soviet Union.

Average depth of cover for base metal discoveries (2005 - 2013)



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 also technical innovation in exploration methods and extraction, processing

and exploration technologies. More complex ores of lower grades will become viable for economic extraction and this will also increase the quantity globally that we know is available to us.

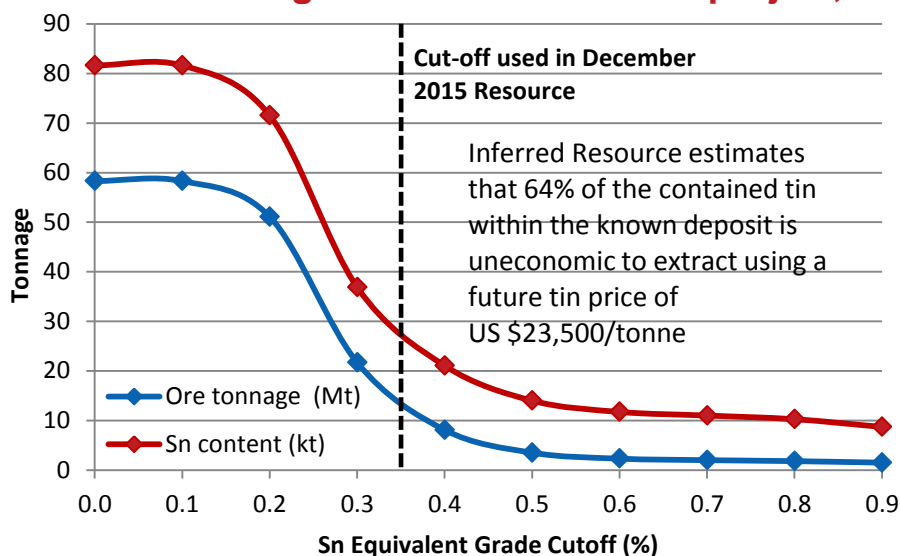
Any estimate of resources has an economic component and this is even truer of reserves. Resource and reserve statements will use a cut-off grade representing the minimum concentration of metal that is economical to extract and only metal content within the assessed area above this concentration will be included. Critically, higher metal prices and forecasts generally result in lower cut-off grades and a larger reserve estimate, with other key variables such as by-product prices and input costs having a similar effect. Tin explorer New Age Exploration's latest resource estimate for the Redmoor project is a good example of this^[10].

The mineral estimates of individual deposits included in global summaries of resources and reserves can differ significantly in their economic assumptions, even when following the same reporting template. Forecasting of tin price and selection of cut-off grades can differ significantly from project to project, particularly when comparing resources estimates of differing ages. This can lead to overestimations and underestimations of resources and reserves for any metal with changes in key economic variables. It is important to be aware that these margins of error are practically unavoidable and are therefore present in ITRI's estimates of global tin resources.

Even when a deposit has been identified, the full potential for production over the life of the mine remains unknown. Resource announcements by tin explorers will often comment that mineralisation is open at depth or along strike, but definition of the full potential for open mineralisation will often not take place until the mine has begun operating: Following commissioning of a mine there is a better understanding of the geology, meaning potential mineralisation can be targeted more accurately and cheaply. The existence of developed mine infrastructure and better access to utilities can also reduce the cost of exploration, particularly in remote regions. Underground exploration is also cheaper when underground mine infrastructure can be utilised rather than drilling directly from the surface.

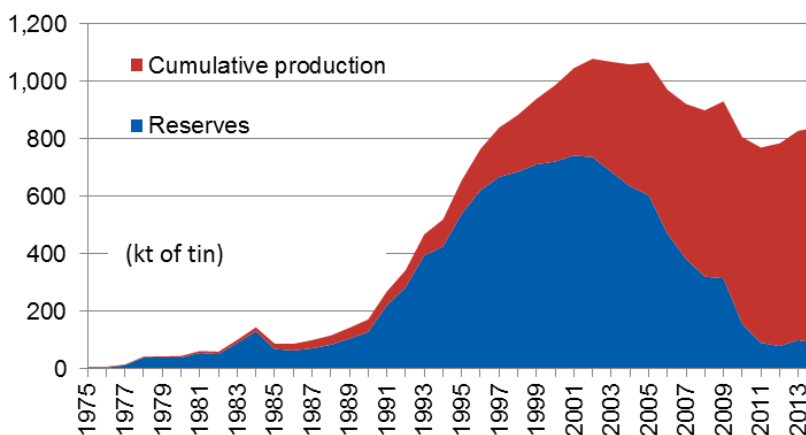
Therefore, it is common for mines to operate longer than their initial reserves would suggest, the San Rafael mine in Peru being a prime example. This reflects evolving knowledge of the deposit as it is exploited and also that companies will only delineate resources and reserves as far into the future as business planning requires. Further drilling will then occur alongside

2015 Sn resource based on varying cut-off grades at the Redmoor project, UK



Data: New Age Exploration (2015) ^[10]

San Rafael reserve and production evolution



Data: ITRI, Minsur

mining to define additional resources and reserves to replace ore that is mined.

Achieving environmental, social and political license to mine is also a critical hurdle for development 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, or the cost of mitigation may make an operation too costly to develop. This can also be an issue for existing mining, an example being the dredging of offshore alluvial tin deposits in Indonesia, where 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, such as by changes in government, improving local attitudes towards mining or a better understanding of the environmental impact of resource extraction and its mitigation.

Tin specific problems

The tin industry also has quirks that make accurate estimates of resources and reserves more difficult than other raw materials:

Artisanal and small scale mining constitutes almost half of all tin mine production annually. Because of the nature of the mining, resources and reserves in these areas are not typically known and are rarely reported. The history of tin production has been punctuated with surges of production from areas like these without well-defined tin reserves; Brazil, Indonesia and more recently Myanmar are all good examples. The Man Maw (also known as Nuoba) mining area in Myanmar, which ITRI estimates produced in excess of 40,000 tonnes of tin in 2015, has no defined geological resource, despite making the country the surprise 3rd largest mined tin producer after China and Indonesia.

Exploration activity typically follows a boom and bust pattern in reaction to cycles in mineral prices, with access to prospective areas also varying in line with political and other factors. Tin has been particularly affected by this boom and bust relationship. Since the tin price crash of 1985 only 4 greenfield tin deposits have been discovered, despite a peak in renewed exploration activity with the tin price spike of 2011. However, putting to the side tin's individual performance, the metal is also mined commonly alongside other metals such tungsten, tantalum, copper, zinc and silver. Therefore a boom in prices across the wider mining industry leading to a general increase in base metal exploration activity would also have a knock-on impact on discovery of tin resources.

The ownership of the tin industry also presents a problem for resource reporting. There are a high proportion of state-owned and small private operations, the majority of which do not publish reports detailing up-to-date resource estimates. This means there is a limited pool of publicly available information and therefore lower global resource and reserve estimates than might be expected with full data transparency across the industry.

USGS studies on tin resources and reserves

The most commonly referenced estimates of global tin resources and reserves are reported on an annual basis by the USGS ^[4]. When compared to ITRI reserve estimates for 2015 the largest discrepancies are between South East Asian countries, notably Indonesia, Malaysia and Thailand, and Russia, where the USGS report far higher figures.

These discrepancies can be attributed to a difference in calculating method; As shown in the table, the USGS figures for these countries are largely annual revisions based on past reserve estimates and represent broad estimations, whereas the ITRI method uses reported figures for individual deposits, but overlooks deposits where data is not readily available. However, for the purpose of addressing long term tin supply these differences are negligible, as both studies report similar global totals of reserves and resources equivalent to more than 15 yrs of 2014 tin consumption.

USGS reported tin reserves of the last decade

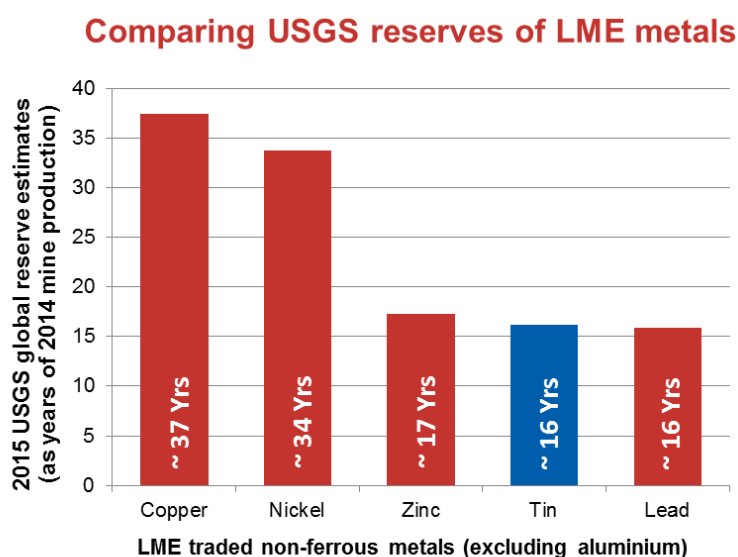
'000 tonnes	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Australia	110	145	150	150	150	150	180	180	240	240	370
Bolivia	450	450	450	450	450	450	400	400	400	400	400
Brazil	540	540	540	540	540	540	590	590	710	700	700
China	1,700	1,700	1,700	1,700	1,700	1,700	1,500	1,500	1,500	1,500	1,500
Indonesia	800	800	800	800	800	800	800	800	800	800	800
Malaysia	1,000	1,000	1,000	1,000	500	500	250	250	250	250	250
Peru	710	710	710	710	710	710	710	310	310	91	80
Russia	300	300	300	300	300	300	350	350	350	350	350
Thailand	170	170	170	170	170	170	170	170	170	170	170
Other Countries	270	270	250	250	250	180	180	180	180	180	180
World total (rounded)	6,100	6,100	6,100	6,100	5,600	5,600	5,200	4,800	4,900	4,700	4,800

Data: As reported in USGS annual commodity summaries

When comparing USGS reserve estimates across a range of non-ferrous metals we see that tin reserves reported as years of 2014 production are similar to those of zinc and lead, but less than half of copper and nickel.

For the reasons outlined earlier in this report, there is limited merit in comparison of these figures for the purpose of determining which metals may run out first. Each metal has bespoke factors affecting the quantity of reserves that have been defined. A good example is copper, where exploration at large porphyry deposits may be required to define mineralisation sufficient to justify construction of mines that can operate for a number of decades. In comparison,

many tin projects have targeted lifespans of less than 10 years, and thus many fewer years of resources or reserves will be needed to be defined to justify development of a mine that can be sustained for this shorter period



Data: USGS, ITRI

Outlook for tin supply

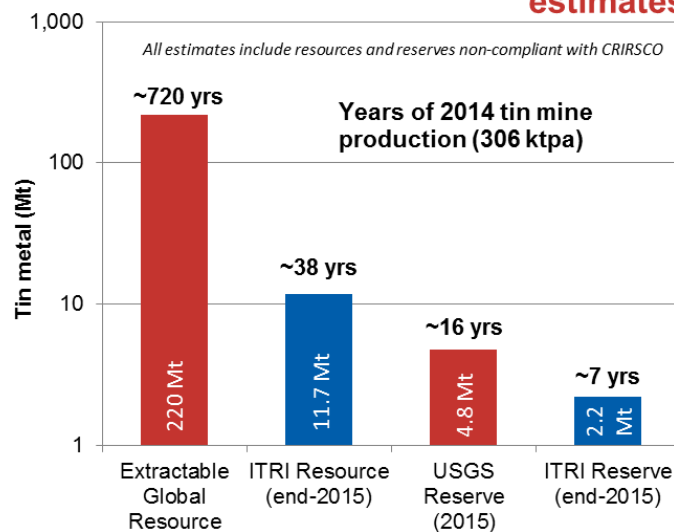
World tin production has been quite stable in recent years, with refined tin production between roughly 330,000 tpy and 370,000 tpy and mine production between 270,000 tpy and 310,000 tpy, the difference between the two filled by some 50,000 – 70,000 tpy of secondary refined tin production.

Tin recycling will continue to play a significant role in future tin supply. However, whether the market share of secondary refined tin will grow or decline will depend on the balance between improvements in tin recycling technology and economics versus the falling concentrations of tin found in end-of-life products as a result of economisation.

From this analysis, at a global level there is no reason to suggest that remaining tin deposits will be unable to sustain a long term, gradual upward trend in primary tin demand well into the future, although for many, a rise in tin prices or development of far more efficient exploration and mining technologies will likely be required to make the economic case for their development.

A 2011 paper^[13] published by the United Nations Environment Program (UNEP) estimated an Extractable Global Resource of 220 Mt of contained tin, based on 1% of upper crustal (top 1km) tin content. ITRI estimates of tin resources at the end of 2015 constitute ~5% and reserves ~1% of this theoretical global resource. Whilst the 220 Mt figure is subject to a large margin of error, the estimate suggests that, speculatively, over 90% of tin resources that may be economical to

Comparing global tin resource & reserve estimates



Data: USGS, UNEP, ITRI

Top 15 undeveloped CRIRSCO-compliant tin resources by tin content

Deposit	Country	Company	Ore (Mt)	%Sn	Sn (t)
Syrymbet	Kazakhstan	Syrymbet JSC*	94.5	0.490%	463,050
Bisie	DR Congo	Alphamin Resources*	4.8	4.063%	194,200
Cinovec	Czech Republic	European Metals	79.7	0.230%	183,310
Achmmach	Morocco	Kasbah Resources*	14.6	0.900%	131,400
Gottesburg	Germany	Tin International	42.1	0.267%	112,407
Pravourmiskoe	Russia	LLC Pravourmiyskoe	10.5	1.008%	106,046
Hammerlein-Tellerhäuser	Germany	Anglo Saxony Mining	22.1	0.460%	101,660
Rentails	Australia	Metals X**	21.8	0.450%	98,289
Heemskirk	Australia	Stellar Resources*	8.5	0.969%	82,365
B2	Peru	Minsur**	7.6	1.050%	79,937
Oropesa	Spain	Eurotin	12.5	0.553%	69,100
East Kemptville	Canada	Avalon Advanced Materials*	35.4	0.163%	57,586
Taronga	Australia	Aus Tin Mining*	36.3	0.158%	57,224
Mount Pleasant	Canada	Adex Mining	15.2	0.270%	55,600
Ardlethan	Australia	Australian Tin Resources	35.1	0.155%	54,505
		Total	455	0.393%	1,790,833

*ITRI Explorers and Developers Group Members

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extract in the future are currently unknown to us.

Top 5 undeveloped CRIRSCO-compliant tin reserves by tin content

Deposit	Country	Company	Ore (Mt)	%Sn	Sn (t)
Bisie	DR Congo	Alphamin Resources*	3.0	3.760%	114,366
Rentails	Australia	Metals X**	21.0	0.450%	94,343
Achmmach	Morocco	Kasbah Resources*	9.2	0.770%	70,986
Abu Dabbab	Egypt	Tantalum Egypt JSC	33.2	0.131%	43,530
Taronga	Australia	Aus Tin Mining*	22.0	0.160%	35,200

*ITRI Explorers and Developers Group Members

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However, it is clear that many existing tin mines and mining regions globally are past their peak and production is declining, albeit gradually in many cases. The need for a new generation of tin mines will grow over the next decade and it is expected that resources and reserves from promising projects will grow significantly over this period, particularly when a recovery in tin prices can renew investor interest in tin exploration and development.

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 and a recent surge in supply from Myanmar, ITRI 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 over the last three years. 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. However, it is vitally important for the image of tin, transparency and also 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 ITRI expects a shortage of tin mining capacity to develop over the next 5 years, 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.

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