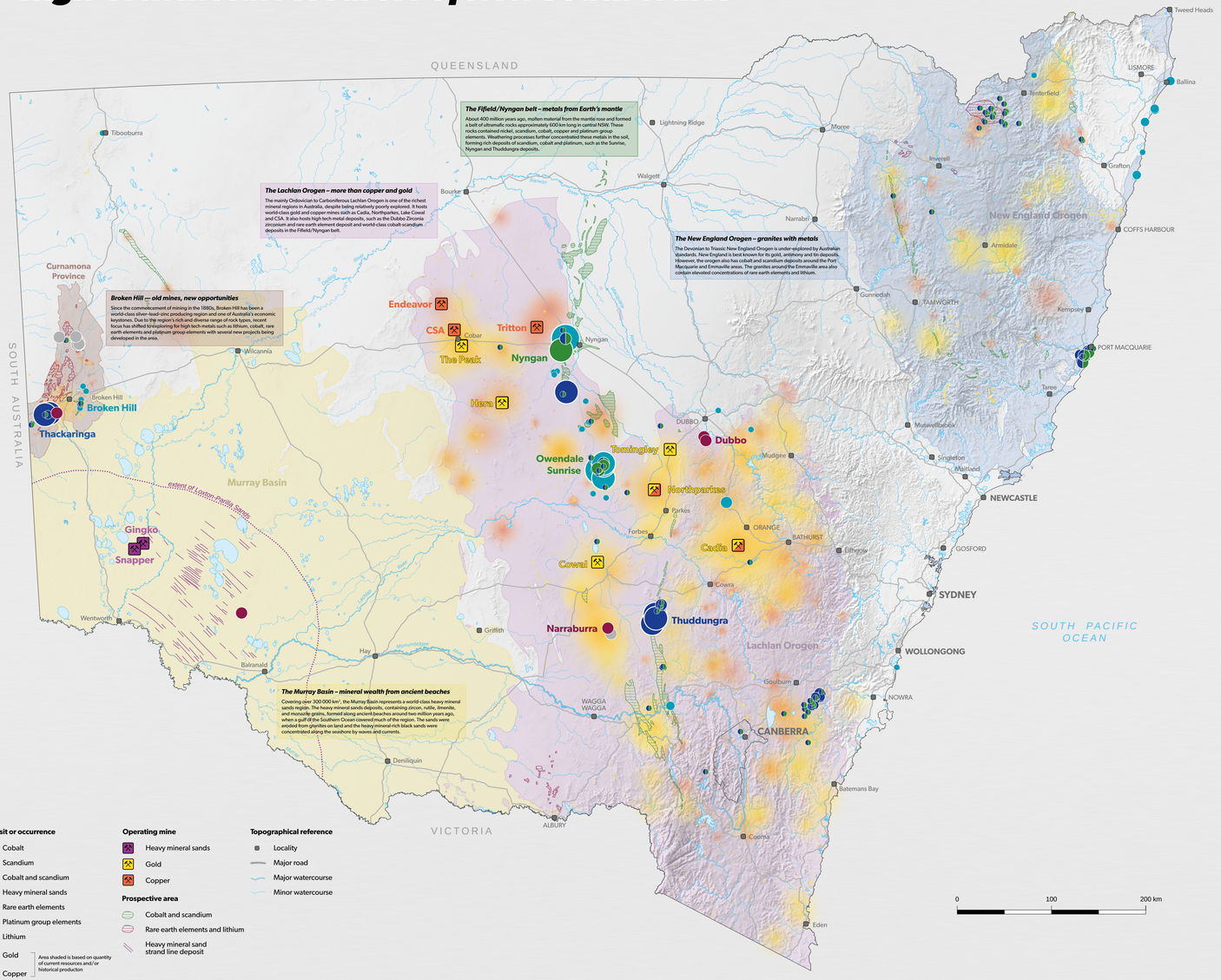
High-tech metal resources of New South Wales



What are high-tech metals?

High-tech metals are those metals that support the rapidly growing high-technology industries, which are fuelled by consumer demand for a high-tech, environmentally sustainable future. High-tech metals are often very expensive as they may be hard to find, difficult to extract in economic quantities, or have unique properties that make them difficult to substitute with lower cost metals.

New South Wales (NSW) has a very proud exploration and mining heritage, due to having significant endowment, world-class mineral systems and stable governance. NSW is a world-class exploration destination for traditional commodities such as gold, copper, and base metals, with world-class mines such as Cadia. For example, since commercial production commenced in 1999, Cadia has produced over 9 million ounces (>255 000 kilograms) of gold. In fact, approximately 1000 tonnes (t) of gold and 4 million tonnes (Mt) of copper have historically been produced in NSW.

NSW also provides exciting opportunities for high-tech metals. There are many highly prospective areas, some buried at shallow to moderate depths, which have undergone very little exploration.

The high-tech metals that NSW currently produces, or has the potential to produce include:

- copper and gold
- rare earth elements (REEs), including scandium
- platinum group elements (PGEs)
- cobalt, lithium, titanium, zirconium.

The periodic table of elements

H HYDROGEN 1																	He HELIUM 2
Li LITHIUM 3	Be BERYLLIUM 4											B BORON 5	C CARBON 6	N NITROGEN 7	O OXYGEN 8	F FLUORINE 9	Ne NEON 10
Na SODIUM 11	Mg MAGNESIUM 12											Al ALUMINIUM 13	Si SILICON 14	P PHOSPHORUS 15	S SULFUR 16	Cl CHLORINE 17	Ar ARGON 18
K POTASSIUM 19	Ca CALCIUM 20	Sc SCANDIUM 21	Ti TITANIUM 22	V VANADIUM 23	Cr CHROMIUM 24	Mn MANGANESE 25	Fe IRON 26	Co COBALT 27	Ni NICKEL 28	Cu COPPER 29	Zn ZINC 30	Ga GALLIUM 31	Ge GERMANIUM 32	As ARSENIC 33	Se SELENIUM 34	Br BROMINE 35	Kr KRYPTON 36
Rb RUBIDIUM 37	Sr STRONTIUM 38	Y YTTRIUM 39	Zr ZIRCONIUM 40	Nb NIOBIUM 41	Mo MOLYBDENUM 42	Tc TECHNETIUM 43	Ru RUTHENIUM 44	Rh RHODIUM 45	Pd PALLADIUM 46	Ag SILVER 47	Cd CADMIUM 48	In INDIUM 49	Sn TIN 50	Sb ANTIMONY 51	Te TELLURIUM 52	I IODINE 53	Xe XENON 54
Cs CAESIUM 55	Ba BARIUM 56	* 57–71	Hf HAFNIUM 72	Ta TANTALUM 73	W TUNGSTEN 74	Re RHENIUM 75	Os OSMIUM 76	Ir IRIDIUM 77	Pt PLATINUM 78	Au GOLD 79	Hg MERCURY 80	Tl THALLIUM 81	Pb LEAD 82	Bi BISMUTH 83	Po POLONIUM 84	At ASTATINE 85	Rn RADON 86
Fr FRANCIUM 87	Ra RADIUM 88	** 89–103	Rf RUTHERFORDIUM 104	Db DUBNIUM 105	Sg SEABORGIUM 106	Bh BOHRIUM 107	Hs HASSIUM 108	Mt MEITNERIUM 109	Ds DARMSTADTIUM 110	Rg ROENTGENIUM 111	Cn COPERNICIUM 112	Nh NIHONIUM 113	Fl FLEROVIUM 114	Mc MOSCOVIUM 115	Lv LIVERMORIUM 116	Ts TENNESSINE 117	Og OGANESSON 118

* LANTHANIDES	La LANTHANUM 57	Ce CERIUM 58	Pr PRASEODYMIUM 59	Nd NEODYMIUM 60	Pm PROMETHIUM 61	Sm SAMARIUM 62	Eu EUROPIUM 63	Gd GADOLINIUM 64	Tb TERBIUM 65	Dy DYSPROSIUM 66	Ho HOLMIUM 67	Er ERBIUM 68	Tm THULIUM 69	Yb YTTERBIUM 70	Lu LUTETIUM 71
** ACTINIDES	Ac ACTINIUM 89	Th THORIUM 90	Pa PROTACTINIUM 91	U URANIUM 92	Np NEPTUNIUM 93	Pu PLUTONIUM 94	Am AMERICIUM 95	Cm CURIUM 96	Bk BERKELIUM 97	Cf CALIFORNIUM 98	Es EINSTEINIUM 99	Fm FERMIUM 100	Md MENDELEVIUM 101	No NOBELIUM 102	Lr LAWRENCIUM 103

ATOMIC NUMBER
Symbol
NAME

The high-tech world needs metals

In the past 20 years, the world has seen the emergence and rapid growth of high-tech applications in industries such as:

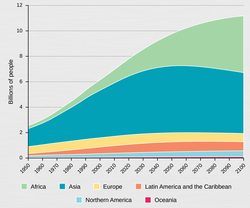
- consumer electronics (mobile phones, tablets)
- transportation (electric vehicles and advanced, fuel-efficient aircraft)
- aerospace (satellites)
- renewable energy (solar technologies, wind turbines and battery power storage).

Increased demand for advanced technology is driven by the growth in world population, in particular the emerging middle class in Asia, and the need for environmental sustainability. However, this increased demand also creates challenges in the production and supply of the high-tech metals required for manufacture of these products.

Global middle class

Since the mid-1800s, the middle class has been a consumer class, driving the economies of countries that embraced the Industrial Revolution. It ushered in an age of mass development that swept the Western world in the 20th century and is now spreading to emerging economies, especially in Asia and Latin America.

Total population by region



Today, growth of the middle class across the world is one of the primary forces sustaining the global economy. At the end of 2016, the global middle class numbered about 3.2 billion people who spent $US35 trillion. This spending is forecast to reach $US64 trillion by 2030, accounting for roughly one-third of the global economy (Kharas 2017). This increase in spending will drive demand for consumer electronics, as well as services including tourism, entertainment, health, education and transport.

Environmental sustainability

Population growth and modernisation have led to increased global concerns about pollution, carbon emissions and climate change. These concerns are shaping government policies and the development of new technologies for cleaner energy and transportation.

Renewable energy and storage

As wind and solar power have an intermittent supply, large-capacity grid storage batteries, such as those recently installed in South Australia and planned for Victoria, will be essential if clean energy generation and distribution is to dominate future electricity supply.

The Australian government has identified energy storage as a key to supporting an electricity system that is affordable, reliable and able to contribute to national emissions-reduction targets.

Electric vehicles

A recent International Energy Agency (IEA) report stated that electric vehicles (EVs) will be the basis of future sustainable transport systems.

The transition to electric road transport technologies is gaining momentum. In 2016 the number of electric vehicles doubled on the previous year, surpassing 2 million units. In the next 10 to 20 years, as the electric car market transitions from early deployment to mass market adoption, the number of electric cars is forecast to be between 9 and 20 million by 2020, and up to 70 million by 2025 (Organisation for Economic Co-operation and Development/IEA 2017).

The potential contribution of EVs towards the reduction of global carbon dioxide (CO_2) emissions could be substantial, but it will come with challenges, such as the need to increase vehicle travel range and to build the infrastructure required for charging. As demand for EVs grows, so will demand for high-tech metals such as lithium and cobalt, which are required by current and future battery technologies, and copper. With many high-tech metals facing supply challenges, battery reuse and material recycling will become increasingly important for EVs to be economically and environmentally sustainable.

Aviation

The International Air Transport Association (IATA) expects 7.2 billion air passengers to travel in 2035, nearly doubling the 3.8 billion who flew in 2016. However, this increase may result in commercial aviation being one of the fastest-growing sources of greenhouse gas emissions, with direct emissions from aviation currently accounting for about 2% of global CO_2 emissions (International Civil Aviation Organization (ICAO) 2016).

In 2013, the global aviation sector recognised the need to address the global challenge of climate change and adopted a set of ambitious targets to reduce CO_2 emissions from air transport (ICAO 2016):

- improve fuel efficiency by 2% per year until 2050
- cap net aviation CO_2 emissions at the 2020 level (carbon-neutral growth).

The achievement of these goals will require technological innovation in aerodynamics, propulsion, and light-weight materials technologies. This innovation won't be possible without high-tech metals such as lithium and scandium. These strong, lightweight metals are used to create aluminium alloys with improved strength, toughness and corrosion resistance in aerospace components.

Supply challenges

The increased global demand for high-tech metals creates serious supply challenges, including:

- scarcity of supply – many of these metals are rare, hard to find, and difficult or expensive to extract
- concentration of supply – some of these metals are sourced almost solely from one country (e.g. REEs from China and PGEs from South Africa), potentially leading to monopolies, market manipulation and volatility, and supply chain risks
- non-ethical supply – human rights organisations are demanding that companies secure their raw materials from ethical mining sources due to concerns over child labour and non-sustainable mining practices.

To overcome these challenges and increase the certainty of supply, some of the leading global car and battery manufacturers are starting to negotiate directly with mining companies for supply of their materials, and have bought shares in mines or new mine projects in order to secure a future supply from ethical sources.

A recent example in NSW is the strategic partnership between Cobalt Blue Holdings and LG Corporation, based around the Thackaringa joint venture cobalt project, to provide high-purity, battery-grade, cobalt sulphate required to produce lithium-ion batteries.

Credits

Bibliographic reference
M.J. Armstrong, P.J. Carter, M.J. Drummond, G.D. Fleming, D.B. Forster & L.M. Talbot (compilers) 2018. High-tech metal resources of New South Wales. Geological Survey of New South Wales, Maitland.

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Project summaries

Broken Hill

PGE PLATINUM-GROUP ELEMENTS

Close to Broken Hill, this advanced exploration project includes very high-grade platinum, palladium, other very rare PGEs including osmium, iridium and ruthenium, along with gold, nickel and copper. Mineralisation is associated with ultramafic rocks which extend for many kilometres.

Cadia

Au 79 GOLD · Cu 29 COPPER

Modern mining commenced in the Cadia valley in 1997, first using open cut and now, underground methods. The deposits in the Cadia valley are among the largest gold- and copper-rich, porphyry-style deposits on Earth, containing over 1100 t of gold and 7.8 Mt of copper.

Cadia and other porphyry deposits in NSW, including Northparkes, also contain significant quantities of PGEs, which await a viable extraction method.

Cadia Valley control room. Image courtesy of Newcrest Mining Ltd.

Dubbo

Zr 40 ZIRCONIUM · REE RARE EARTH ELEMENTS

Located at Toongi, 25 km south of Dubbo in central west NSW, the Dubbo project is based on one of the world's largest in-ground resources of zirconium, hafnium, niobium, yttrium and rare earth oxides. This makes it a potential strategic and alternative global supply for a range of metals required for high-tech and sustainable technologies.

Once constructed, the mine is expected to process 1 Mt of ore per year with a potential life of at least 70 years. The project will create 300–400 jobs during the construction phase and 250 permanent jobs once operating.

Ginkgo and Snapper

HMS HEAVY MINERAL SANDS

The Ginkgo and Snapper mines collectively produce about 450 000 t of ilmenite, rutile and zircon per year, making NSW a world-class producer. Several new mines are in development, including the large Atlas and Campaspe deposits, and the smaller but extremely rich West Balranald deposit.

The basin contains over 115 Mt of high-quality zircon, rutile, ilmenite, and monazite mineral grains. From these grains titanium and zirconium are routinely extracted. There is also great potential for rare earth elements and thorium.

Narrabarra

Zr 40 ZIRCONIUM · REE RARE EARTH ELEMENTS · Li 3 LITHIUM

First discovered in 2007, Narrabarra REE deposit is one of Australia's largest zirconium- and rare earth element-rich resources. It also contains significant amounts of lithium.

Nyngan

Sc 21 SCANDIUM

Nyngan is set to have the world's first scandium-only mine, after receiving approval in 2017 from the NSW Government. Production of scandium oxide is expected to be approximately 38 t per year for more than 20 years. Exploration has also identified resources seven times greater than those for the current proposal, which could support higher production and a longer mine life.

Snapper mine. Image courtesy of Cristal Mining Australia.

Owendale

Sc 21 SCANDIUM

The Owendale project is another high-grade scandium project, which is hosted by the same deeply weathered laterite as found at the Sunrise project. If developed, the resources at Owendale could support scandium mining for up to 80 years.

Sunrise

Ni 28 NICKEL · Co 27 COBALT · Sc 21 SCANDIUM

The Sunrise cobalt, nickel and scandium deposit near Condobolin is one of the highest grade scandium deposits in the world and one of the largest and highest grade undeveloped nickel and cobalt resources outside Africa.

In May 2017, the Sunrise project received NSW Government approval to produce scandium oxide as a by-product of nickel and cobalt production. It is expected that 180 t of scandium oxide and 40 000 t of nickel and cobalt will be produced per annum for 21 years.

The project is collaborating with Airbus Group Innovations to develop and produce Scalmalloy®, a patented 3D printing aluminium–scandium powder and direct manufacturing concept used in the production of high strength components for Airbus' fleet of aircraft.

Thackaringa

Co 27 COBALT

Recent exploration west of Broken Hill at Thackaringa has identified three pyrite deposits: Pyrite Hill, Big Hill and Railway. Together these deposits contain over 60 000 t of cobalt and there are still several kilometres of cobalt-bearing rocks that are largely untested.

Battery ready cobalt sulphate from Thackaringa. Image courtesy of Cobalt Blue Holdings Limited.

Projected population growth 2015–2100