

A site visit with a difference

July 2023

There's a scene in the movie 'Journey to the Centre of the Earth' (the original 1959 film adaptation of Jules Verne's classic 19th century sci-fi novel starring James Mason) where a team of explorers, led by geologist Sir Oliver Lindenbrook, stumble upon a fantastic "crystal grotto" deep within the Earth after descending through an Icelandic volcano. The party is dazzled by this spectacular find but subsequently lose one of their number (student Alec McEwan, played by Pat Boone) who drops a lantern through a hole in the floor and becomes lost. He is discovered by the wicked Count Saksussemm, who proceeds to use him as a packhorse when his own maltreated manservant keels over dead from heat and exhaustion in a bid to reach the centre first.

What does this have to do with investing? Well, following a recent team discussion on lithium and resources in general, we decided to undertake our own Journey to the Centre of the Earth to learn more about our planet. We've all been on dusty mine site visits because they are invaluable for increasing our understanding of the mining industry. However, they can be hard to arrange, and we found a substitute in our own backyard.

So, we took ourselves off for a short walk across Hyde Park on a sunny Friday afternoon to the Australian Museum on College Street where we found our own crystal cave – the museum's Minerals Gallery, which houses a spectacular collection of all that is geologically weird and wonderful. No need to travel 3,000km to the centre of the Earth where it's more than 5,000°C (or Perth, which is about the same distance and almost as hot in summer). Our slightly easier excursion was only about a kilometre and at 22°C, in conditions a lot closer to the 1959 film than reality. Best of all, entry is free!!!

‘New materials’

This was really the genesis of our trip to the Gallery. Someone mentioned that the Museum had a couple of nice examples of spodumene (lithium), which has come to prominence only recently with the growth in electric vehicle sales. So, we thought we should look at the real thing.

Lithium is the third element of the periodic table and its lightest metal. It is also soft and a good conductor of both heat and electricity. The use of lithium in batteries is not new with some variants made commercially available in the 1970s. Batteries account for about two-thirds of

lithium demand with the rest winding up in less glamorous sectors like lubricants, glass and ceramics, and around 2% in pharmaceuticals.

Lithium is of particular interest for batteries because it is light and so has such a high charge-to-weight ratio. This results in faster charging and longer use. The power density makes it ideal for small applications, like phones, as well as bigger ones, like cars. Australia is currently the world’s second biggest producer of lithium (hard rock/spodumene in pegmatite) behind Argentina (brines/dissolved lithium).



Spodumene (left) and Lepidolite (right).

The pink/purple crystals in the image above (left) are examples of spodumene, whilst that on the right is spodumene’s poorer, plainer cousin, lepidolite. Lepidolite clays are potentially another important source of lithium, especially in China, where they

are reportedly plentiful but less desirable than spodumene. You’d be very lucky to find crystals of this size in the field but the largest reported spodumene crystal found, which was in the central US, was a whopping 14 meters long!

**Spodumene.
Know what I mean?**



Rare earths on display.

“New materials” also cover Rare Earths, a group of 17 heavy metals. These materials have really come into our consciousness over the past 15 years or so due to technological advancements in motor vehicles, renewables and military applications. 70% of these minerals are produced in China but there are important suppliers outside that country including Australia’s Lynas Rare Earths (~6%).

Rare earths are not particularly rare and can be found associated with thorium and uranium deposits. Their presence in uranium exploration was often overlooked in the past, such as during the last uranium boom in the first decade of this century. Rare earths are particularly useful in the manufacture of permanent magnets, motors, lasers and many other high-tech applications, and as the image above shows, are an important component in everyday mobile phones.

A lot of this ends up in your mobile.

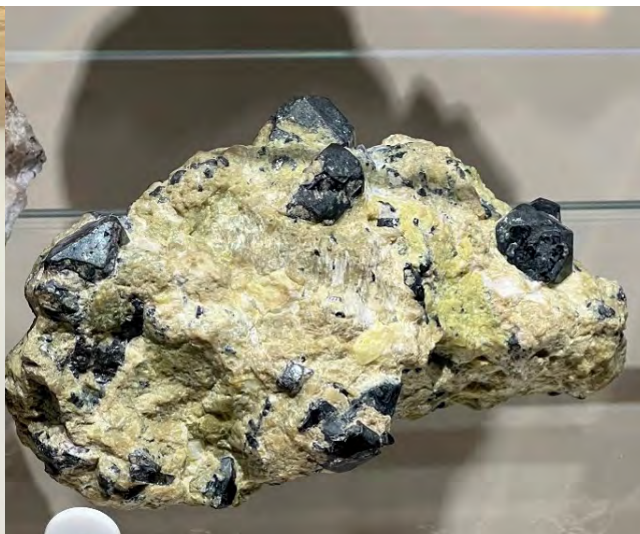
Mineral Sands

OK, the images below of rutile and ilmenite are not sand. Maybe under a lot of magnification they would look more like this. Both minerals, along with zircon and monazite, are usually extracted by either dredging (wet mining) or use of excavators (dry mining). The primary elements extracted from mineral sands are titanium (rutile and ilmenite) and zircon. Monazite is a minor

source of rare earth elements cerium, lanthanum and neodymium. Titanium is extracted as feedstocks for the paint/pigment industries or titanium metal, whereas zircon has uses in ceramics and as refractories for various industries like the nuclear power sector. Australia is the No.1 producer of both zircon and rutile and No.2 in ilmenite after South Africa.

Rare earths are usually not found in large quantities in mineral sands, but we note that Iluka Resources is in the process of establishing a rare earths facility in WA to extract the elements from its own monazite stockpiles. While volumes may

be comparatively small, they may have significance as parts of the world are attempting to move away from Chinese suppliers who overwhelmingly dominate the global rare earths market.



Ilmenite (left) and rutile (right). Slightly larger than normal.

Iron

No other metal is as widely used in our world, or is as important, as iron (Fe), accounting for about 95% of all metal use. From billions of faceless girders holding up office towers to the rebar buried in concrete beneath our feet, cars, trucks, tools, furniture, knives,

forks, spoons, the list is endless. The centre of our planet – the inner core – is mostly solid iron and the liquid outer core is largely a mix of iron and nickel. Convection in the outer core is thought to be the source of Earth's magnetic field.



Puny fund managers contemplate the enormity of 2.5bn years of Earth's history. A banded iron formation with alternating bands of iron oxide (hematite-magnetite, black), jasper (red) and tiger eye (golden).

Most iron ore was formed more than 2 billion years ago as banded iron formations (BIFs) when iron and silica-rich sediments were deposited in an oxygen-free atmosphere. The oxygenation of our atmosphere by organisms such as cyanobacteria altered our planet forever and ended the formation of BIFs.

These formations now provide most of the world's iron ore production, being composed of a minimum 15% Fe by weight. The 5cm-thick BIF slice shown in the first photo

above weighs 437kg and comes from the Hamersley in WA. It represents a 2.5 billion year old snapshot of our planet.



An exotic example of hematite (terrestrial, left) and a 617kg iron meteorite (right) recovered from the Nullarbor.

Did life come to Earth on one of these space travellers?

Not-so-boring-base

Outwardly, base metals are boring, but they are an integral part of our world – pipes (copper); wire (copper, aluminium); construction (aluminium, manganese); coatings and alloys (zinc, nickel, chromium); car batteries (lead, cobalt, manganese); etc. We focus here on copper (briefly) as it is arguably the most important of the base metals given its superior conductive qualities, corrosion resistance, malleability and ability

to alloy with other metals. These properties make it pervasive in electrical applications of all kinds. Only silver is a better conductor than copper, but is expensive and hence not practical for most electrical applications. Both are Group 11 elements – so-called ‘coinage’ metals because of their past and present use in currency – and are often found together in ore bodies.



Copper sulphide ores from Australia. On the right is a polished 2 billion year old example from Sandfire's DeGrussa mine in WA.

We are surrounded by copper and probably use it hundreds of times a day without realising it. It is thought to have been in use by people as long as 9,000 years ago (as jewellery), and certainly at least 5,000 years ago, as an important component of bronze (mainly copper and tin), for which the Bronze Age is named. The Bronze Age was superseded by the Iron Age about 3,000 years ago as furnace technology advanced and allowed for smelting of much more abundant iron. Whilst copper was readily available (in Cyprus, for example), tin was not - the world has not looked back since, Iron continues to dominate.

However, the “discovery” of electricity and electrical applications in the 18th and 19th

centuries ushered in a new era for copper where it retains a central place in our modern, digital society.

Geoscience Australia estimates that the average family home in this country contains 90kg of copper. Australia is a top 10 copper producer with output of about 800-900ktpa. It's a relative minnow compared to Chile, which produces more than 5Mtpa out of a global total of 22Mtpa. Approximately 18% of all the world's copper mines are in Australia though we only account for about 4% of global production. Our largest mine is BHP's Olympic Dam, which produces almost 140ktpa (~15% total Australia output), all of which tells us that there are a lot of small operations in this country.



Variety of samples (left) and copper ore (right).

More copper ore!

Space is too limited here to cover base metals in any detail so below are a few examples of the common types. The list is not exhaustive but gives a flavour for the variability of mineralisation in the Earth's crust.



Bauxite (aluminium, left) converted into a tinnie. Spectacular but less obviously useful is pyrite (iron sulphide, right), or Fools Gold, which is used to make iron sulphate for applications in agriculture.



Nickel ores from WA (left) and molybdenite from NSW (right). Both are common coating and alloying metals, and nickel is finding increasing application in battery technology.



Lead ore (galena, left) from USA and more copper ore! (right). Chalcopyrite this time, a sulphide.



Rhodochrosite (manganese, left), a carbonate and cassiterite, or tin ore (right), an oxide, for making a different kind of tinnie (bronze, perhaps).

The Precious

Given its reputation and central role as a store of wealth for thousands of years, it is hard to walk past the gold nuggets on display, even if the larger ones are (real size) replicas. The Welcome Stranger, the world's largest single alluvial nugget, would have a net face value of about \$6.6m at today's gold price* although you could argue someone would be willing to pay a premium for such an unusual specimen.

These alluvial nuggets are spectacular for their size, but most gold mining operations today revolve around much

lower concentrations of gold. Gold mining often requires huge material movements and extensive processing, sometimes very extensive processing, as is the case with refractory ores. Nuggety deposits do exist, for example around Ballarat in Victoria, and they can present their own challenges, like accurate resource estimation. Exploration drilling through coarse gold can lead to an overestimation of contained metal (it has happened in the past) and is not something you'd want to discover once mining had commenced.



Gold nuggets, larger ones are replicas.

You are gold!

Around 90% of gold is used as a store of wealth or jewellery. Jewellery accounts for about 47% of all gold consumption with bullion and coins making up a similar percentage. Most of the remainder, approximately 6%, goes into electronics. Gold, like copper and silver, is a Group 11 element and shares similar properties. It is,

for example, the third most conductive metal, highly malleable and corrosion resistant, and like copper and silver, found in nature as pure metal. Very small amounts are used in electronic devices like mobile phones and computers, and gold is an important element in satellites. Australia is the world's second biggest producer of gold behind China.

That was a brief stroll around the gallery and by no means an exhaustive commentary on what's on display. It didn't take much more effort than walking to the bus stop and yet it provided a very valuable, if different, insight into the world of resources. So, if you find yourself with a spare half hour, or a bit more, you could do a lot worse than spend it looking around a museum like the Minerals Gallery. We certainly learnt something new with risk no greater than crossing the road and at zero expense. Beats lowering yourself into a volcano any day.



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