# The UK's Green Future and Mining in the South West

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***Climate Change and Mining***

To meet emissions targets and keep within +1.5°C of global warming the world is increasingly turning to green technologies, such as solar panels, wind turbines, electric vehicles (EVs) and large-scale battery storage.

These green technologies require vast amounts of raw materials, i.e. metals, concrete and steel etc. For example, a solar panel requires 16 different mineral and metals. To meet growing demand production of raw materials will need to increase through mining. Production of certain minerals, such as graphite, lithium and cobalt are predicted to increase by almost 500% by 2050. To minimise the social and environmental cost of these raw materials mining will need to be responsible and sustainable, dubbed Climate Smart Mining by the World Bank.

***The UK's Green Industrial Revolution and Raw Materials***

The UK governments Ten Point Plan for a Green Industrial Revolution hinges on the development of green technologies with seven of the ten points dependent on raw materials. Sourcing the raw materials needed, produced to high environmental, social and governance (ESG) standards, may be the largest hurdle facing the successful implementation of the plan and the UK's efforts to be Net Zero by 2050.

For example, meeting the target of offshore wind powering every home by 2030 will require a capacity of 40 gigawatts. A 300% increase from current capacity. This requires that, on average, a new wind turbine is built every day until 2030. With a single 3 megawatt wind turbine requiring 4.3 tonnes of copper, 2 tonnes of neodymium, 300 tonnes of steel, 1100 tonnes of concrete and 2.7 tonnes of aluminium alongside other materials including zinc, molybdenum and cobalt this target alone represents a huge demand for raw materials.

**METALS TESLA NEEDS TO BUILD 20M CARS A YEAR**

| Tesla Production @ 20m | Material Required (t) | Production 2019 (t) | % of Production |
|---|---|---|---|
| Graphite | 1,028,775 | 1,100,000 | 94% |
| Nickel | 750,410 | 2,460,000 | 31% |
| Lithium | 127,302 | 77,000 | 165% |
| Copper (vehicle) | 1,820,000 | 21,000,000 | 9% |
| Manganese | 20,811 | 19,000,000 | +0% |
| Cobalt | 68,315 | 122,000 | 56% |
| Aluminum (battery) | 16,544 | 64,000,000 | +0% |
| Aluminum (vehicle) | 3,380,000 | 64,000,000 | 5% |
| MagREO (NdPr, Dy, Tb) | 18,000 | 46,000 | 39% |

Battery graphite, nickel, cobalt, lithium, manganese, MagREO (NdPr, Dy, Tb): Adamas Intelligence
Production: USGS, BMO, Morgan Stanley, BP. Fitch, Excl. synthetic graphite
Copper, aluminum (vehicle): UBS estimates of Chevy Volt

MINING.COM EVMETAL INDEX

Figure 1: Material required by Tesla to build 20 million cars a year (predicted output by 2030) in tonnes, with tonnes produced in 2019 globally, and amount required in 2030 as a percentage of global 2019 production. Taken from MINING.COM.

However, as a central part of the Ten Point Plan, it is with EVs and lithium-ion batteries that arguably the biggest challenge is faced. The ban on new petrol and diesel vehicle sales from 2030 means EV production and sales look to increase at nearly exponential rates. As an example of future production and raw materials

demand, Tesla alone is predicted to be producing 20 million EVs by 2030, which will not only require a vast amount, but also a variety of metals (Figure 1).

Recycling and a move towards a Circular Economy will help provide some of the materials needed, but won't be able to provide nearly enough. Estimates show that by 2030 global production of lithium will be in deficit to the tune of 1.4 million tonnes a year, with similar predictions for graphite (8 million tonnes), cobalt (800,000 tonnes) and nickel (400,000 tonnes).

***Sourcing Raw Materials & UK EVs***

Currently, many of the materials needed for green technologies are imported from abroad where mining can have high environmental and social costs. There are also concerns about the security of supply. The first debate in UK Parliament dedicated to critical minerals, held in March 2021, highlighted that China hosts >75% of global Li-ion parts manufacturers and produces >72% of Li-ion batteries and 45% of all EVs.

As well as having better control of the environmental, social and security aspects of the supply chain, producing the materials we need domestically may also be key to ensuring the future of the UK automotive industry.

The UK automotive industry employs 800,000 people and produced >1.3 million cars and 2.5 million engines in 2019, adding £18.6 billion to the economy. It is also one of the UK's largest exporters with 8 out of 10 cars exported, predominantly to the EU (55% of car exports in 2019).

The EU-UK Trade and Cooperation Agreement means UK-EU car trade is tariff and quota-free as long as cars meet 'rules of origin' i.e. a certain % of the car's value must be sourced either from the UK or EU. There will be a six-year phase-in period for EVs and batteries but from 2027, 55% of EVs must be sourced from the UK or EU and they must have an 'originating' battery pack. To be classed as an originating pack either 65% of the battery cell or 70% of the total battery pack must be sourced from within the UK or EU. Failure to meet these 'rules of origin' will result in 10% tariffs, which would pose a serious threat to the export-dependent UK automotive industry.

Furthermore, because batteries are expensive and somewhat hazardous to transport, especially over long distances, car manufacturers will look to be located close to battery production. In turn, battery manufacturers will require a dependable, sufficient and sustainable supply of raw materials. This coupled with the 'rules of origins' means the UK needs a domestic source of both batteries and the raw materials needed to build them.

However, the UK is yet to attract a top-tier battery producer to build a gigafactory (large-scale battery production plants that produce ~20 GWh of batteries a year). In contrast, in 2020 China announced 38 new gigafactories, the USA 3, and Europe 2.

Benchmark Mineral Intelligence estimates that to meet future demand the UK needs at least 4 gigafactories, to be built in the next 6 years (costing ~$20 billion), operating at a combined capacity of 175 GWh by 2035. Other estimates paint a similar picture, even before the Ten Point Plan was announced the Faraday Institution wanted £12 billion invested and up to 7 gigafactories to meet demand by 2040. While the UK does have a battery facility in Sunderland it is relatively small, producing only ~2 GWh per year, and so far there are only plans for one gigafactory in Northumberland from the start-up, Britishvolt.

While the UK may be a hub of battery and automotive expertise, the Li-ion battery was even invented in Oxford, the battery and EV supply chain is currently ill-prepared, especially when it comes to domestic sources of raw materials. Benchmark Mineral Intelligence estimate the 175 GWh of capacity needed by 2035 will require 155,000 tonnes of lithium, 210,000 tonnes of graphite anode, 18,000 tonnes of cobalt, and 140,000 tonnes of nickel. This is just for EV production alone.

Currently none of the metals needed for the Green Industrial Revolution are mined within the UK. Forecasts for many of the necessary metals show supply deficits by the mid-2020s with supply bottlenecks predicted to intensify, especially for non-producing countries.

The problem has started to be recognised by the UK Government and one of the priority actions of the recently released Integrated Review is 'to explore opportunities in domestic extraction of critical minerals, as well as their recovery, recycling and reuse for a circular economy'. While this is a step in the right direction, there is an aspect of better late than never to it.

Geologically speaking the UK does have some of the raw materials needed, but not in the quantities required to 'fuel' the Green Industrial Revolution. The UK will need to aim to produce as much as possible domestically while also creating agreements to source raw materials from elsewhere.

So where are we going to find these all-important domestic sources?

***A Historic Mining Region Revisited***

Mining in Cornwall and West Devon stretches back to ~2150 BC, possibly having a key role in the European Bronze Age. In the 18th century, Cornwall and Devon were the centre of the mining world, producing more copper and tin than anywhere else in the world. It was during this time the region became a hotbed of innovation, driven by the mining industry, and globally significant inventions including the first steam-powered engine by Richard Trevithick originated here.

Cornwall and Devon continued to dominate until the turn of the 20th century when lower prices and increased international competition meant the industry started to decline. This led to mass emigration of Cornish miners around the world including Mexico, New Zealand, South Africa, North America, Australia and South America, taking their culture and technology with them. The significance of the regions mining heritage is recognised in the form of the Cornwall and West Devon Mining Landscape UNESCO World Heritage Site.

However, the mining industry never completely left Cornwall and the china clay industry has continued to form a large part of the economy. The region certainly hasn't lost its expertise and global influence, alongside the Camborne School of Mines, a world-class mining education and research centre, over 100 consultancies and SMEs (Small and Medium-sized Enterprises) now form the Cornwall Mining Alliance. The members of which have, and continue to, work in over 150 countries worldwide.

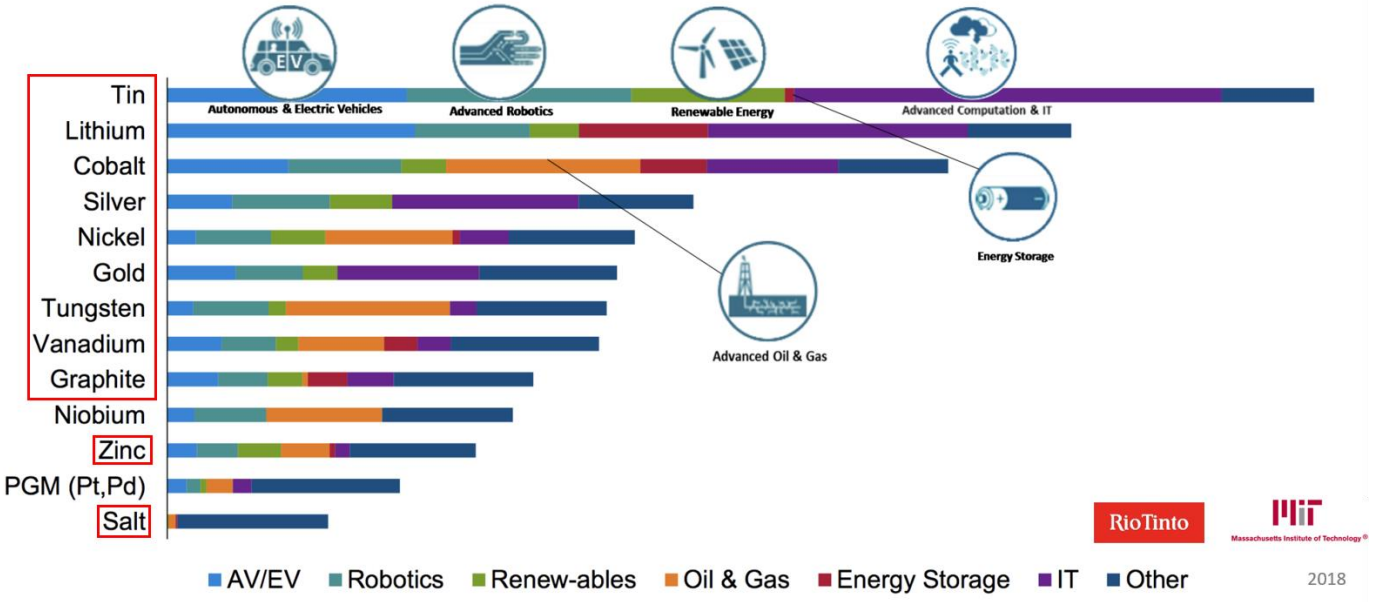


Figure 2: Metals and minerals that will be most positively impacted by future technologies in a study by Rio Tinto and MIT in 2018. Highlighted metals are those that can be found in Devon and Cornwall. The metals and minerals were assessed on 3 criteria: 1) Ease of substitution (including dematerialisation trends), 2) Likelihood of market disruption due to technology, 3) Potential size change of commodity demand compared to current market size.

Metals that are predicted to see increased demand from green and future technologies, i.e. those needed for the Green Industrial Revolution, aligns well with those that can be found in Cornwall and Devon (Figure 2). Alongside increasing demand, new exploration technologies and methods, and an ever-increasing desire for metals produced to high ESG standards the region has become attractive for mining once again and there are now several new projects (Figure 3).

The opportunity mining offers in Cornwall has been highlighted in the Georesources Cornwall working paper and recognised by the Cornwall & Isles of Scilly Local Enterprise Partnership who have listed geo-resources as a Distinct Opportunity in the draft Local Industrial Strategy. Any new modern mines will be almost unrecognisable from that of the region's past; and while mining could help bring a much-needed economic boost to Cornwall, one of the poorest regions in Europe, any future mining will need to fit into and contribute to the economic, environmental and social future of Cornwall.

*Box 1: Where did the mineral deposits in Devon & Cornwall come from?*

The geological evolution of the South West is unique to the rest of the country, and it's mineral deposits potential for geothermal energy and can largely be attributed to the regions granites.

In the Carboniferous, the South West was involved in a continental collision event known as the Variscan Orogeny, creating mountains and a thicker and heavier crust. Eventually this heavy and thick crust started to thin, generating heat leading to melting and ultimately the creation of magma. This magma formed a vast mass of granite called the Cornubian Batholith which underlies the entire South West (Figure 3).

The intense heat from the granites caused hot water to circulate within cracks in the granite and surrounding rocks. This hot water, enriched in metals such as copper, tin, tungsten and other metals, started to cool forming mineral deposits in both the granites and surrounding rocks around 270 million years ago. While there were multiple mineralisation events, some not related to the granites, this was the most significant.

The granites are also enriched in lithium, forming one of only five large-scale lithium enriched granite bodies in the world. This lithium is found in the form of Li-bearing micas (mica is a mineral known for easily breaking into flakes and common in Cornish granites) and also in geothermal waters.

More information about the geology of the region can be found on the Variscan Coast website and South West England Geology Overview map.

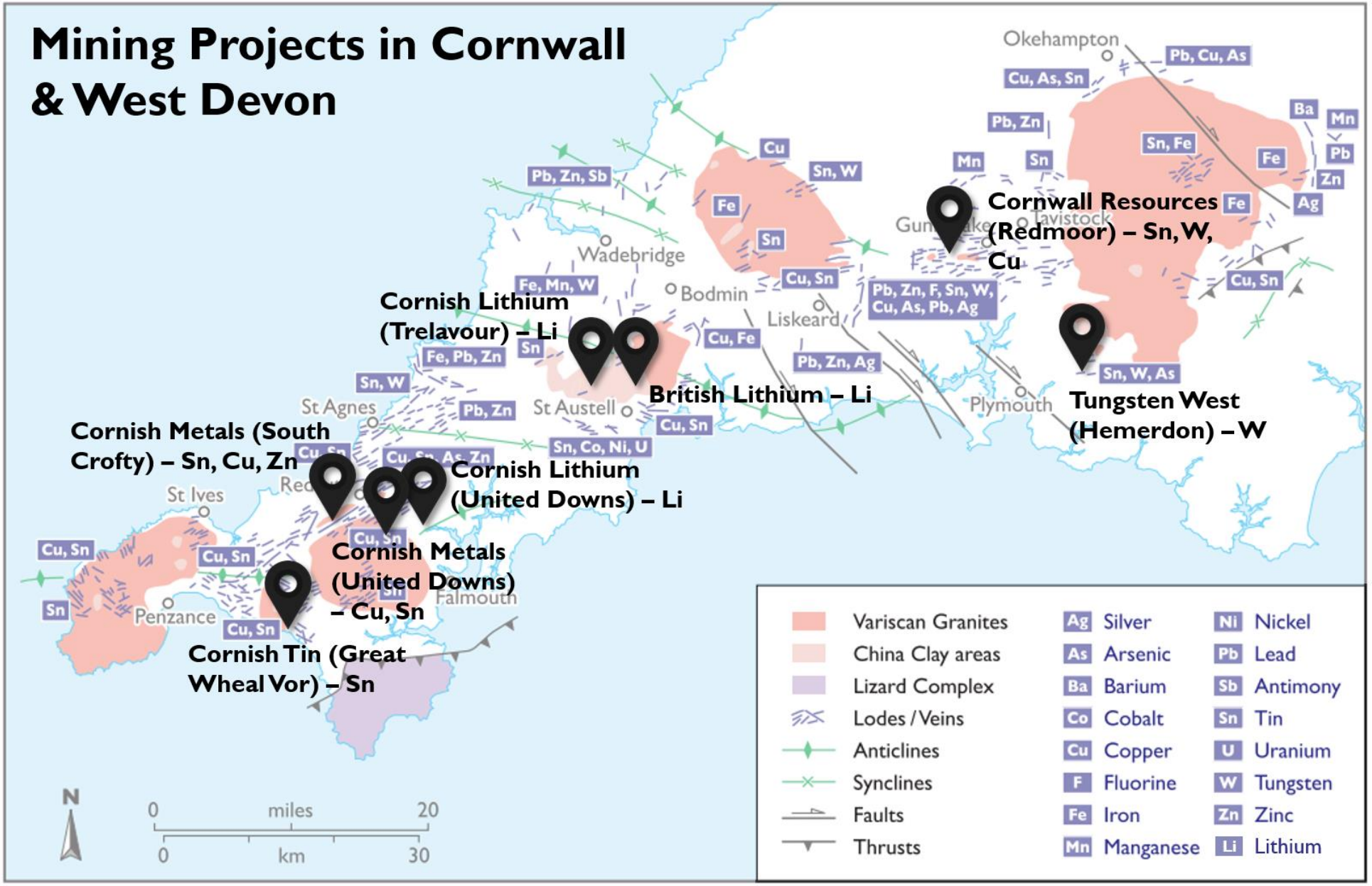


Figure 3: The location of current exploration and development projects in Cornwall and West Devon with company, project name and commodity indicated. The surface outcrops of the Cornubian Batholith (Variscan Granites) and mineralisation are also displayed. Base map modified from [Geological Hazards in the UK: Their Occurrence, Monitoring and Mitigation. Engineering Group Working Party Report. Chapter 13.]

The signs for a mining revival are promising. At the start of 2020 the Li4UK project, which includes Cornish Lithium and Wardell Armstrong (both based in Cornwall) as partners, produced the first lithium from UK sources, including Cornish Lithium's Trelavour site near St Austell.

The revival is not just based on lithium though.

Tin, the metal that first made Cornwall and Devon famous is making a comeback. Today tin is considered a strategic metal by many governments and has uses in lead-free solder, batteries and semiconductors. There is also increased interest in tungsten, considered a critical metal by Europe. Tungsten is not only the hardest metal but also has the highest melting point, making it crucial for drilling and manufacturing alongside uses in aeroplane engines and mobile phones. Meanwhile, copper has been dubbed 'the metal of the future' due to its widespread use in future and green technologies. It is predicted we will need to mine as much copper in the next 25 years as has been produced in the last 5000 years combined.

*Box 2: What are critical and strategic raw materials?*

While there is no universal definition, critical raw materials is generally refers to metals and minerals that have high importance to industry, have no or little substitution alternatives, and there is, or a risk of, supply shortage.

Strategic minerals are by and the large the same as critical minerals but have additional potential defence or military importance.

***Overview of Mining Companies in Devon & Cornwall***

*British Lithium*

Previously named MétAmpère, British Lithium began looking for lithium in 2016 and were the first to drill for lithium in the UK. Focussing on lithium bearing micas Li-micas. This is a new strategy with currently no lithium produced from Li-micas anywhere else in the world. They have also been the first to establish an official resource. They aim to produce enough lithium to support the production of ~350,000 EVs a year and recently received a £500,000 grant from Innovate UK, followed by a £3 million grant from the governments Sustainable Innovation Fund for work on their pilot processing plant.

*Cornish Lithium*

Cornish Lithium is looking to extract lithium from geothermal waters in Cornwall. They are investigating the potential to produce lithium with heat as a byproduct from shallow geothermal waters (<2 km deep) boreholes, as well as from deep ones. For the deep waters, they are collaborating with the United Downs Deep Geothermal Project to build a pilot lithium extraction plant, where the geothermal waters contain globally significant amounts of lithium. This geothermal lithium extraction operation aims to be carbon neutral and has received funding from the UK Government's 'Getting Building Fund' to build the £4 million pilot plant. In addition, they are exploring the potential to produce lithium from Li-micas at their Trelavour hard rock project near St Austell. They are a delivery partner for the 'Deep Digital Cornwall' project.

*Cornish Metals*

Previously known as Strongbow Exploration this company bought the South Crofty mine in 2016, the last tin mine to close in the UK in 1998, with a view to reopening it. South Crofty is classed as one of the highest grade (grade refers to the concentration of the desired material) tin resources in the world. Recently exploration work by Cornish Lithium near United Downs found significant amounts of tin and copper, which

Cornish Metals holds the rights to and their near term strategy is to focus on this mineralisation. At the start of 2021, they announced plans to list on the AIM (Alternative Investment Market) stock market to raise £5million to advance the United Downs Copper-Tin project and successfully beat that target raising £8.2 million.

*Cornwall Resources*

Cornwall Resources is developing the Redmoor project near Callington where they are exploring for tin, tungsten and copper. There has been extensive mining in the area from Roman times through to 1943. Cornwall Resources began exploring in January 2017 and on the basis of metal contained within the deposit, Redmoor ranks as one of the largest undeveloped tin-tungsten underground projects in the world. Cornwall Resources are currently working to advance the project towards development and recently received funding as a delivery partner on the new 'Deep Digital Cornwall' project.

*Cornish Tin*

Cornish Tin is the newest 'kid on the block' and is looking to start their exploration work at Great Wheal Vor, a group of former tin mines near Helston in 2021. In the mid-1800's it became the most productive tin mine in the world and copper was also produced. It closed in 1877 due to legal disputes between mineral owners, a lack of technology to extract the ore from depth and falls in the tin price. If mined today the Great Wheal Vor mines might be among the top three highest-grade tin mines in the world.

*Tungsten West*

Tungsten West brought the Hemerdon mine (previously named Drakelands when owned and operated by Wolf Minerals) for £2.8million in 2019. When Hemerdon previously opened under Wolf it was the first new metal mine to open in Great Britain for 45 years. Tungsten West are looking to produce both tin and tungsten and are currently studying the ore body and processing methods to restart production in 2022. The deposit at Hemerdon is classed as the 4$^{th}$ largest of its kind in the world and has the potential to make the UK the world's 3$^{rd}$ biggest tungsten producer.

***Closing Remarks***

During the Industrial Revolution, UK industry grew at a staggering rate and mining matched this growth to provide the coal and iron needed to fuel the revolution. To meet the targets of the Green Industrial Revolution and keep within +1.5$^{o}$C of warming we will need a similarly rapid transformation of industry and again mining will be called upon to provide the materials needed. Cornwall and West Devon will be key in providing these materials responsibly and sustainably for the UK.

***Selected References/Further Reading***

*Green technologies, raw materials demand and the UK*


BBC Future Planet Article: The new 'gold rush' for green lithium

Benchmark Mineral Intelligence Article: UK calls last orders on combustion engine, but needs to spend $20bn on four EV battery gigafactories by 2027

Guardian Article: UK carmakers have three years to source local electric car batteries

Minerals Engineering International Blog: Critical Metals and the UK's "Green Industrial Revolution"

MINING.COM Article: All the Mines Tesla Needs to Build 20 Million Cars a Year

Northwest Mining Association: Wind Power Needs Metals and Minerals

Proactive Investors: The great British mining revival is needed now more than ever

Visual Capitalist: Climate Smart Mining: Minerals for Climate Action

Visual Capitalist: The Raw Materials That Fuel The Green Revolution

World Bank: Climate Smart Mining: Minerals for Climate Action

*Cornwall and West Devon mining and geology*

Cornwall and West Devon Mining Landscape UNESCO World Heritage Site

Georesources Cornwall Working Paper

Project Ancient Tin: Did Britain's exceptionally rich tin deposits in Cornwall and Devon underpin the massive technological and cultural change from copper to full tin-bronze, and thus create the European Bronze Age?

South West England Geology Overview Map

Variscan Coast: A guide to interesting geological places across southwest England designed for students and / or geology enthusiasts or those who just want to learn more