

Go west

Tungsten West Limited

Pictured: The Hemerdon tungsten mine, near Plymouth, Devon, UK

Michael Schwartz looks at recent ambitious plans for mining in Cornwall and Devon in the South West of England.

Britain's last deep coal mine closed in 2015. Coal mining is so deeply embedded in the British conscience that it is all too often regarded as the 'be-all and end-all' of English mining. But mining is alive and well in England – and it is not just coal-based.

One English county where coal was never dominant is Cornwall. For years, Cornwall was a leading global tin producer, and even when tin mining ceased, Cornish miners took their mining skills and dedication to operations throughout the world.

Documented tin mining around the towns of Pool and Camborne goes back to 1592, and intermittent tin mining in the region lasted until 1998 – the years 1700 to 1998 yielded at least 450,000t of tin.

Almost half of global tin consumption is attributed to the high-tech electronics industry in the form of lead-free solder. Cornish Metals is a Vancouver-headquartered associate company of Osisko Gold Royalties. Aiming to build its portfolio of strategic metals, it describes itself as, "well positioned to capitalise on the growing demand from end-users for 'clean tin' and on projections for higher prices for tin as the tin market experiences a growing supply deficit".

In this respect, 'clean tin' means that companies are under increasing scrutiny to show that the extraction is not supporting conflict, contributing to environmental damage, or exploiting children in the workforce.

Cornish harvest

South Crofty in Pool is Cornish Metals' fully permitted flagship project, with an underground permission (mining licence) until 2071, planning permission to construct a new process plant, and a permit from the Environment Agency to dewater the mine after successfully completing a four-month water treatment trial between November 2016 and March 2017. Cornish Metals plans to complete a feasibility study and to bring the project to a production decision.

The company has also acquired South Crofty, United Downs copper/tin project, 8km east of South Crofty, and other minerals rights in 2016 – the latter totalling around 15,000ha.

At South Crofty, the underground section of the permission area covers 1,490ha and includes 26 former producing mines. South Crofty mineralisation occurs in laterally extensive lode structures, with some over 4km long and extending to a vertical depth of at least 1,000m. Current infrastructure on the property includes four usable vertical shafts previously preserved and a 300m decline.

Cornish Metals has completed and published maiden NI 43-101 mineral resources for South Crofty using the vast archive of historical production data and more recent drilling completed between 2007 and 2013. In 2017, Cornish Metals completed a *Preliminary Economic Assessment* that demonstrated the economic viability of re-opening the mine.

Following the extensive pilot-scale water treatment trials, the company engaged Siltbuster Process Solutions Ltd to undertake flow sheet design and optimisation work on a full-scale plant capable of treating 25,000 m³/day of mine water.

The pH of this mine water is neutral at 6.5. To remove dissolved metals from solution involves aeration (addition of hydrogen peroxide). This is followed by the addition of lime to increase the pH to precipitate metals from the water, by a flocculant to bind metals for recovery in a settling tank, and then by adding CO₂ to reduce the pH before the final

discharge of clean, treated water that meets Environment Agency water quality standards. The main metals recovered in the process are iron and manganese, plus lesser amounts of copper and arsenic.

Construction of the water treatment plant foundations has commenced. The dewatering pumps, variable speed drives and new high-voltage power supply have been delivered to the site.

Drilling down

In June 2020, the company ran a drill programme designed to demonstrate the ability to infill drill the current resource from surface, to intersect multiple lodes from single drill holes and to show the potential exists to materially increase the current resource.

The results confirmed the high-grade nature and persistence of the known mineralised structures within South Crofty – hole SDD20-001B intersected 2.60m grading 10.33% tin between 974.20m and 976.80m, including 0.46m grading 39.60% tin from 975.77m. In addition, all drill intercepts reported lie outside the current NI 43-101 mineral resource and five new mineralised lodes were discovered, between, and adjacent to, historically-mined lodes.

Richard Williams, Cornish Metals' CEO, says, "Equally important, the proof-of-concept programme has confirmed the suitability of directional and wedge drilling to safely intersect multiple lodes from a single surface or underground drill hole as a means to undertake resource definition drilling and a path to completion of a feasibility study."

As this article was being written, Cornish Metals also reported the results of drilling at United Downs in early 2020 by Cornish Lithium. Cornish Lithium's involvement reflects the potential of lithium in hot spring brines at Cornish Metals' extensive tenure holdings across Cornwall and co-operation between the two companies.

This drilling has identified:

- Mineralisation over more than 750m depth
- Two drill holes intended to reveal lithium, but also discovering at least five new copper/tin zones with their own potential
- A 14.69m hole with 8.45% copper and 1.19% tin
- A 4.04m hole with 4.44% copper and 2.06% tin



"The world's ever-increasing demand for car-battery lithium is now focusing on Cornwall where lithium was first identified in 1864."

Williams continues, "When combined with our recent reported discovery of high-grade copper-tin mineralisation at the nearby United Downs project, the presence of many new, previously un-recorded, mineralised structures, in areas with little or no past drilling, once again demonstrates the exploration potential at both South Crofty and Cornish Metals' extensive tenure holdings across Cornwall."

On the charge

The world's ever-increasing demand for car-battery lithium is now focusing on Cornwall where lithium was first identified in 1864. Europe presently has no secure supply of lithium, and nearly all lithium comes from the Central Andes – the desert salars of Chile, Argentina and soon from Bolivia – or from Australia. In the Cornish context, recent technological advances mean that lithium could be economically extracted directly from the concentrations historically present within Cornwall's hot springs.

Four years ago, Jeremy Wrathall founded Cornish Lithium Ltd. Through Crowdfunder fundraising, he has raised £5.2m – £3.7m more than the original target. More funding has come from the Faraday Challenge Fund to determine the possibility of lithium processing in the UK. Cornish Lithium is now discussing with potential partners which method is best suited to extract lithium from those geothermal fluids.

Since August 2019, the company has:

- Identified very high lithium grades in the geothermal waters of the United Downs Deep Geothermal Project.
- Obtained government funding for a new Cornish Lithium pilot plant.
- Shown the potential of obtaining lithium from granite strata after drilling 41 boreholes in a disused china clay pit and drilled two shallow geothermal wells to test lithium-enriched waters up to 1,100m deep.

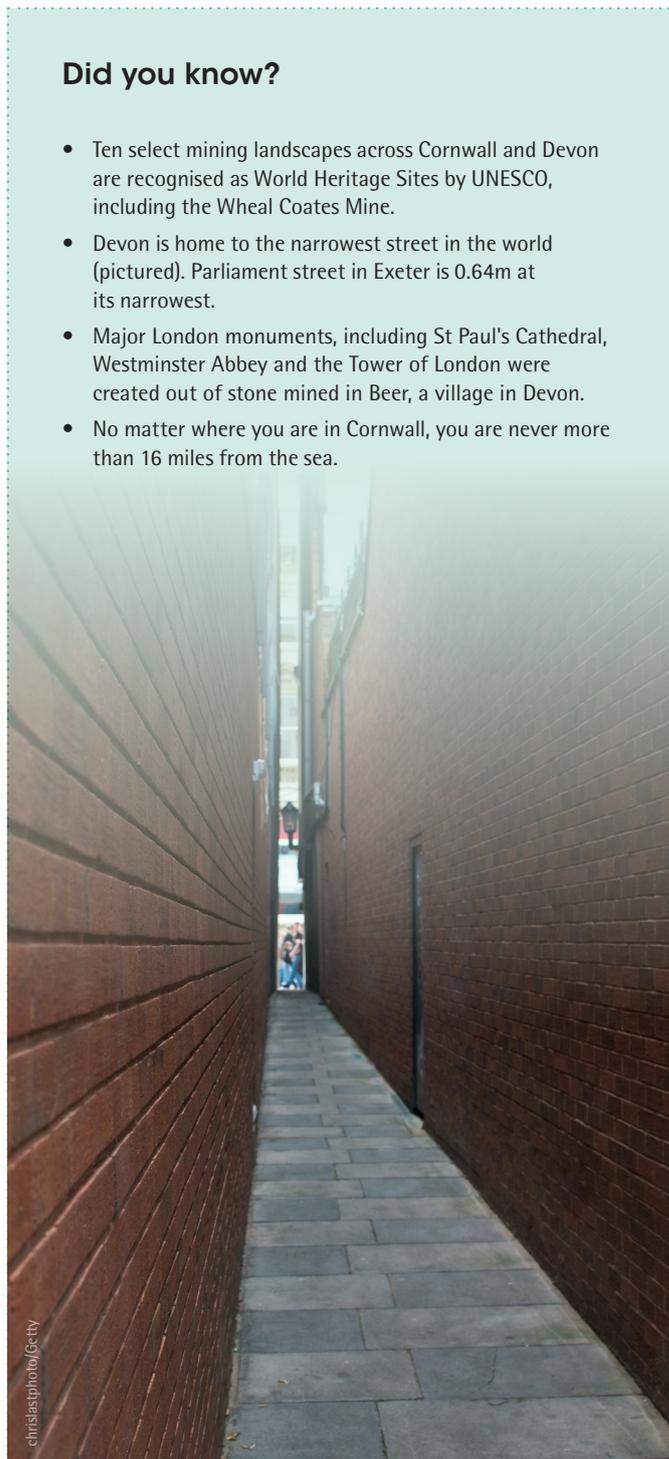
During the drilling, Cornish Lithium assessed the waters for lithium quantity. The company is much encouraged by its findings and will be able to determine whether lithium can be extracted in commercial quantities. Several exploration phases will, however, be necessary before extraction plants are constructed.

In addition, the company has liaised with mineral rights holders in Cornwall to assess potential for lithium. Digital technology has combined historical data with geophysically and satellite-gained data to evaluate possibilities.

Left: Cornish Lithium's winter drilling at the United Downs Deep Geothermal Project, Cornwall, UK

Did you know?

- Ten select mining landscapes across Cornwall and Devon are recognised as World Heritage Sites by UNESCO, including the Wheal Coates Mine.
- Devon is home to the narrowest street in the world (pictured). Parliament street in Exeter is 0.64m at its narrowest.
- Major London monuments, including St Paul's Cathedral, Westminster Abbey and the Tower of London were created out of stone mined in Beer, a village in Devon.
- No matter where you are in Cornwall, you are never more than 16 miles from the sea.



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Wrathall adds, "The waste material from our brine processing operations will simply be the original brine, minus the lithium, and will be injected into the ground via a permitted injection well. Using Direct Lithium Extraction (DLE) technologies, there is no waste product – only the original brine stripped of lithium."

He notes that, "Initial interest has been expressed by both British and worldwide manufacturers. We would very much prefer to deal with manufacturers based in the UK given that this would capture more value added for UK plc. It will also lower the carbon footprint if materials are not shipped to far-flung destinations. [However,] we do not see any transport issues given the extensive rail, road and port network that exists in Cornwall. This is a significant advantage."

On the number of cars needing lithium batteries in the UK, Wrathall draws on an estimate by the Faraday Institute: "The UK will require over 30,000t of lithium carbonate equivalent by 2030 and over 58,000t by 2035 and that was before the recent changes to ban internal combustion engine cars by 2030 – which is likely to increase this number substantially. We believe that we can supply a significant portion of this from brine or hard rock projects – but cannot commit to exact numbers."

Local lithium

Cornish Lithium stresses its strong commitment to local communities and is very aware of its "social licence to operate". It meets local communities and supports local charities, maintains its offices in Cornwall and tries to source support services in the area.

Wrathall points out that Cornwall has rich and famous traditions of mining expertise. "Camborne School of Mines (CSM) is very involved with the project – hence we chose to locate our offices on the same campus. We actively collaborate on certain grant-funded projects and seek advice whenever necessary. I would describe CSM as an essential part of our project – and vision for Cornwall."

Tungsten time

Cornwall does not hold a monopoly of mining in south-west England. Located at Hemerdon, near Plymouth, Devon, Tungsten West Limited (TWL)'s resource is estimated to be the fourth largest tungsten reserve in the world, comprising 332Mt at 0.12% WO₃.

The main ore body is a granitic dyke that hosts a tungsten-bearing sheeted quartz vein system which has a measured and indicated grade of 0.18% WO₃. Mineralisation extends to the country rock grading at 0.11% WO₃, which was previously assumed to be waste.

The tungsten market has been dominated by Chinese production, controlling over 71% of the world's resource. Despite supplying 51% of tungsten supply worldwide in 2018, China remains a net importer of tungsten concentrates. This is why tungsten is high on the EU and US list of critical metals. Depletion of existing resources while demand continues constitutes another reason for its mining.

Mining tungsten in Devon has previously been difficult. TWL, a private UK company, purchased the Hemerdon mine in November 2019 for \$6.8m. The company spent the first half of 2020 studying the ore body and processing techniques to create an economically viable project. Given the success of the test work, TWL sees a promising route forward to restarting the project. The current focus is on finalising the definitive feasibility study to be published in the first quarter of 2021.

TWL's founding director and CEO Max Denning explains, "An over-generation of fines is going to be a major issue for any gravity separation plant – the finer the grain size, the more difficult it is to separate the minerals you want. Although we've found an additional processing technique that can mitigate against this issue, the over-generation of fines won't be as big a problem for TWL as the weathered portion of the ore body has been all but mined out [by the previous company] leaving us with fresh hard granite, which will respond far better metallurgically."



Pictured: The fine gravity circuit at Hemerdon mine near Plymouth, in Devon, UK

"It would be far better if we took ownership of our own resource requirements so that we can ensure that these critical metals are extracted in a sustainable manner. Tungsten is a metal that most consumers don't know about but use every day."

"It is inevitable that consumers and businesses will push for transparency with regards to where their metals are sourced from."

This issue is then compounded by the lack of surge capacity and redundancy in the processing plant meaning that if one piece of equipment goes down, the whole plant had to be turned off.

One major tool identified by TWL is X-Ray Transmission (XRT) ore sorting so that materials can be recognised and separated based on their specific atomic density. Wolframite and ferberite – the two predominant tungsten bearing minerals – are some of the densest minerals of economic value.

Denning says, "The tungsten-bearing minerals are incredibly coarse and only found within the quartz veins of the granite ore body meaning that the mineralisation is very nuggety. These factors mean that this ore body is ripe for XRT ore sorting. We're able to reject all the barren granite rock prior to sending the material into the concentrator plant."

Gravity separation is also an important factor alongside Dense Media Separation (DMS), whereby 0.8mm - 8mm tungsten ore is introduced to a water/magnetite/ferro-silicon slurry. Minor modifications will optimise the process, including recommissioning the scavenger circuit.

The site is under care and maintenance at the time of writing, with the company having completed initial test work. Denning expects to attract finance as a result of the feasibility study, with a rebuild time of nine months. "The concentrator plant and ore dressing stages require very minor upgrades. However, the front end of the processing plant is not fit for purpose. We are changing out the primary and secondary crushing circuits as well as the screens. We're then adding into the processing plant several XRT ore sorting machines. The rebuild won't cost us more than \$53.3mIn, which is a relatively small investment for an asset that should generate significant returns."

Best foot forward

TWL has its core technical and production team in place and has brought back several of the former operator's employees.

"As projects commence production and ramp up, several issues and mistakes often occur," Denning says. "We have the advantage of re-engaging with the former employees and consultants to understand all of these issues and overcome them prior to commissioning."

The company is implementing several environmental policies and is targeting a carbon-neutral strategy by 2027. For example, power for the processing plant will come from new-build renewables generating 6.5MW, while the company is following the move away from diesel vehicles towards all-electric shovels and hydrogen and battery-powered haul-trucks.

Denning concludes, "The push for a more sustainable future is not a country-by-country issue but one of global importance. Developed economies such as the UK should not, in my view, outsource industries that could be deemed 'dirty'. It would be far better if we took ownership of our own resource requirements so that we can ensure that these critical metals are extracted in a sustainable manner. Tungsten is a metal that most consumers don't know about but use every day. It is inevitable that consumers and businesses will push for transparency with regards to where their metals are sourced from.

"Given Hemerdon's size and life of mine, we will be here for a while and we look forward to seeing the development of this side of the mining industry."

South Crofty, Cornwall

1,490ha

is the size of the underground area

26

former producing mines are included in the permitted area

4km & at least 1,000m

represent the length and vertical depth of the laterally extensive lode structures, respectively

5

new tin-bearing mineralised lodges have been discovered

25,000m³/day

of mine water will be treated in the full-scale plant, recovering iron and manganese, plus lesser amounts of copper and arsenic

United Downs, Cornwall

Over 750m

deep mineralisation

5

new copper/tin zones have been discovered

41

boreholes drilled, revealing potential for extracting lithium from granite strata

2

shallow geothermal wells have tested lithium-enriched waters up to 1,100m deep

£5.2mIn

raised by Cornish Lithium Founder Jeremy Wrathall through crowdfunding

Hemerdon mine, Devon

6.5MW

the amount of power that renewables will generate for the mine's processing plant. Alongside moving to electric trucks, the firm hopes it will be carbon-neutral by 2027

\$53.3mIn

is the maximum amount the mine's rebuild will cost, according to TWL's Founding Director and CEO Max Denning, "a relatively small investment for an asset that should generate significant returns."

4th

largest tungsten reserve in the world comprising 332Mt at 0.12% WO₃

0.8-8mm

of tungsten ore will be introduced to the water/magnetite/ferro-silicon slurry as part of the gravity separation process used alongside dense media separation

\$6.8mIn

was paid to purchase the Hemerdon mine in November 2019