Science L 4 Earth Systems
Chemistry and Society
Social Studies L4 How exploration and innovation create opportunities

An introduction to the Mine and Smelter

The mineral belt near Nelson had been used by Maori to extract argillite for tool making and became very attractive to prospectors beginning in the 1850s. The Champion Mine was developed in the 1880s, to mine Copper. Copper was selling for a high price partly because electricity had just come to New Zealand and lots of copper wire was needed.

The metal was in the rock and could be recognised by blue and green colours. There were also lumps of pure 'native' copper mixed up with a rock called serpentine. A layer of rock carrying the metals is called a 'lode' and the rock when it has been mined is called 'ore'.

The government subsidised the construction of the road up Aniseed Valley to the mine site. The Champion and United Companies could then bring in their heavy machinery by horse drawn drays (big carts) .

The mines were dug as shafts into the hill and the ore was brought by tramways to the smelter. It is dangerous to go into the old mines now because there is no support to hold the roof up any more.

What happened at the smelter

The smelter for producing the pure metals from the rock (ore) was on a flattish site that you get to from the Roding River. The ore arrived from the mine along a tramway and was put though a crusher and made into pieces about 2cm across. It was then mixed with limestone before it was roasted. The limestone was to help separate the metal from the ore.

The roasters were heated by wood fires and burnt for about 14 days. The smoke and fumes from the smelter went up the big brick chimney. The smell coming from the roasters was sulphury and hurt the back of your throat. After the roasting was finished and the roasters cooled, the ore was unloaded into barrows and taken to the mixing floor where limestone was mixed with it before it was taken to the smelter.

The smelter had to be much hotter than the roasters so it was heated by Greymouth coke. The coke was kept burning strongly by a blast of air from a blower driven by a water wheel in the river. The coke also supplied carbon to help separate the metal from the ore. The smelter roared loudly and showers of sparks came out of the chimney. One load of ore in the smelter was ready in about 8 hours.

The waste parts of the melted ore floated on the top and this substance is called slag. The slag was skimmed off through a door in the furnace and more ore and coke were added. The slag was poured down the bank and solidified there. After about a week the smelting process was complete and copper was poured into ingot moulds in the form of iron barrows. Each barrow contained 225 kg of copper matte filled at the rate of one every half hour. As the workers perfected their technique this rose to one barrow every five minutes. The cooled bars of copper were known as ingots.

There was only a small amount of ore prepared for smelting and after 52 tonnes had been processed smelting ceased, the furnace having operated for only two days. The existing stalls could only supply enough ore to keep it going for five days a month. Major modifications were necessary costing at least seven hundred pounds and the company had run out of money.

In 1890 the price of copper doubled and it seemed economic to start the mine again with improved smelting technologies for smelting. A second mining venture was started in 1903. It was originally called The Mineral Belt Copper Company but was taken over by a new group called the Maoriland Copper Company.

Working in the mine and the smelter

On the site was also a blacksmith's shop, sheds for storing coke, dynamite, stables for the horses, weigh bridges, weighing machines, carts and slag and ingot pots.

The mine manager's house had an assay room. There were a number of other buildings and a tent village on the flats.

Many men and boys worked at the smelter and down the mine;

38 at the smelter
30 making roads and tramways
37 down the Champion Mine
37 down the United Mine

These people needed somewhere to live, a shop to buy things at and people to look after the horses. There was a big stable with stable boys and blacksmiths. Some people lived in a boarding house and others in tents. The mine manager had a big house near the smelter.

At the shop you could buy;

2 oz (60g) tobacco for 2 shillings and 3 pence
Socks for one shilling and three pence.
Jam for six pence a jar
Matches for three and a half pence.
Dungarees (like overalls) for four shillings and six pence

The Science of the Champion Smelter (1)

The aim of this piece of work is to make a flow diagram that describes the process of extracting copper from its ore.

The mineral belt near Nelson had been used by Maori to extract pakohe (argillite) for tool making and became very attractive to prospectors beginning in the 1850s. Rocks containing the metals copper and chrome had been discovered. Mining companies were set up and mine shafts opened.

In some areas, including the Champion Mine, native copper was found. This is pure copper metal to which we give the symbol Cu. Most of the rock that contained copper was not so pure and it contained a lot of other substances such as iron and sulphur. The most common rock was copper pyrites and there was also some malachite .

Copper pyrites is mostly copper sulphide (chemical formula CuS). It is yellowish brown but it has some iron in it (Fe).

Malachite is mostly copper carbonate (chemical formula $CuCO_{3)}$. It is greenish.

Prospectors sent the ore to be assayed. This means that the ore was tested to see how much copper it would produce. The average from the Champion mine was $7^1/_2$%.

If you heat copper sulphide and copper carbonate until they are red hot they will start to give off some gases. This is what happened in the roasters at the smelter.

If there is lots of air available (remember air contains oxygen) copper sulphide will give off a smelly gas called sulphur dioxide.

This is the simplest way of looking at the process (we leave out the impurities)

Copper sulphide + oxygen ----- makes copper metal and sulphur dioxide

$CuS + O_2 \rightarrow Cu + SO_2$

If you heat copper carbonate until it is very hot it will give off carbon dioxide.

It works like this:

Copper carbonate makes copper oxide + carbon dioxide

$CuCO_3 \rightarrow CuO + CO_2$

The roasters weren't very efficient because the middle got hotter than the outside. In The middle the ore was changed to copper oxide and copper but on the outside the ore wasn't changed much. There was also still other impurities such as iron. There was less ore than they started with because some of it had been lost as sulphur dioxide and carbon dioxide.

When they got the ore out of the roaster they had to remix it before they put it into the smelter.

In the smelter the temperatures were much hotter. They mixed coal and coke with the ore because it burnt hotter and it provided carbon to help get the copper out. They also put in some limestone to help remove the iron. The iron impurities are called slag.

This is what happened:

Copper oxide and carbon produced copper metal and carbon dioxide

$2CuO + C \rightarrow 2Cu + CO_2$

Then they poured off the copper.

You can put this information on your diagram of the process at The Champion smelter or you can take the next page and read on and try to come to grips with the more complicated stuff. Your choice!

The Science of the Champion Smelter (2)

This is a more complicated way of looking at the process when we include the iron impurity.

This is what happens in the roasting chamber:

Copper pyrites (formula $CuFeS_2$) and oxygen from the air get heated up make red copper sulphide and iron sulphide and smelly sulphur dioxide.

$2CuFeS_2 + O_2 \rightarrow Cu_2S + 2FeS + SO_2$

When even more oxygen from the air is added, copper sulphide and ferrous sulphide and they give off even more smelly sulphur dioxide.

$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$

$2FeS + 3O_2 \rightarrow 2FeO + 2SO_2$

Then in the smelting furnace the roasted ore is mixed with coke and limestone.

As the furnace heats up iron oxide (FeO) is made into ferrous silicate (FeSiO3). The silica comes from impurites in the ore and from the limestone. We call this slag and it floats on top of the melted copper that is being made. It gets poured off before the copper is collected. There is a pile of it at the smelter site.

$FeO + SiO_2 \rightarrow FeSiO_3$

The cuprous oxide plus some oxygen and the carbon make copper and carbon dioxide

$2Cu_2O + O_2 + 2C \rightarrow 4Cu + 2CO_2$

Then they pour off the melted copper.

(All these chemical symbols look rather complicated but they get easier as you use them more often. They are like a new and exciting language. Chemists need these symbols to help them make calculations and to work out what is going on in chemical reactions.)

The remains today

At the caretaker's house at the beginning of the track there is a display of artefacts including the remains of a truck ore pot and an ingot mould.

At the smelter site:

Looking at the smelter from the creek side, from right to left.

Maoriland Company Smelter (1908)

Tram line coming from Champion Mine (a reasonably easy walk with several lengths of the metal capping on the track and further on at the limestone bluff the wooden rail and sleepers can be seen).

Below the line is another line with a shallow cutting probably a siding to store the emptied trucks before being towed back to the mine.

Below this siding, on the flat area was a sawmill.

At the end of the line are the remains of the crushing plant (long bolts and crushed fines to be seen).

Below this is the indentation of the chute where the crushed ore went to the roasting pots.

The roasting pots lie toppled with one roof on the furnace floor below. You can still see the grate in the bottom of the pots and the air vent that goes from the pivot point to the base of the pot.

Nothing remains of the aerial track that went to the furnace but directly below the roasting pots is the layered brick floor of the furnace.

On the furnace floor is an assortment of metal artefacts including the puddling stick used to mix the brick clay.

To the left and rising above the furnace is the brick lined flume that follows the hill to the chimney.

Below the furnace is the slag pile and fines.

Champion Copper Mine Company (1885-6).

Very little remains except the water jacket furnace re-erected on its original site. The top section seen in photos is in the bushes beside the toilet.

Beside the water jacket are concrete foundations possibly its original mount.

Above that is a brick lined chute that was used to feed the furnace.

Much of the stonework foundations would have been recycled from this original smelter.

The bricks used in the second smelter would have been recycled from the three-tiered chimney and the roasting ovens. Nothing remains of the first chimney but parts of the original roasting ovens can be found on a flat area to the left of the flume going to the second chimney.

Below the water jacket is the slag pile possibly the remains of the first two failed attempts to smelt the copper. Copper is present in the slag or matte.

*

Before the field trip:

1. Using the written resource

Report back from these questions.

> What metal did the Champion Mining Company hope to get?
> What three processes happened at the smelter site?
> What job would you have chosen if you were a boy working for the company?
> How much of your day's wage would it be if you bought a pair of socks. (There were 12 pennies in a shilling).

2. Find the area on a map (Laminated maps can be borrowed from Nelson Provincial Museum School Service.)

Start with a Nelson street map.

Find Aniseed Valley. Follow the road up to where it stops. The dotted lines that start there are tracks. What is the name of the river that the road follows?
In what direction does the last bit of the road go?

Find United Creek. The map covers too large an area for you to see much detail.

On the borrowed sheets there is an old geological map of copper and chrome deposits.

The lighter grey stripes indicate the mineral belt of rocks that the copper is found in. They are igneous rocks that have been squeezed up between layers of limestone and other sedimentary rocks as two continental plates rub against each other.

Find the United Mine and the Champion Mine.
Find United Creek and follow it down to where it joins the Roding River. This is where the smelter was.

3. Drawing a ‘sketch’ map.

Draw a frame 180mm x 180mm
Give your map a title : Location of Champion Smelter.

Draw a simple map that shows Richmond, Aniseed Valley Road, The Roding river, United Creek, Champion Creek, the smelter site, Champion and United mines.
To help you with an idea of scale, it is 10km in a straight line from Nelson Airport to the abandoned mines up Champion Creek

Give the map a scale and a key to any items you identify such as roads and rivers.