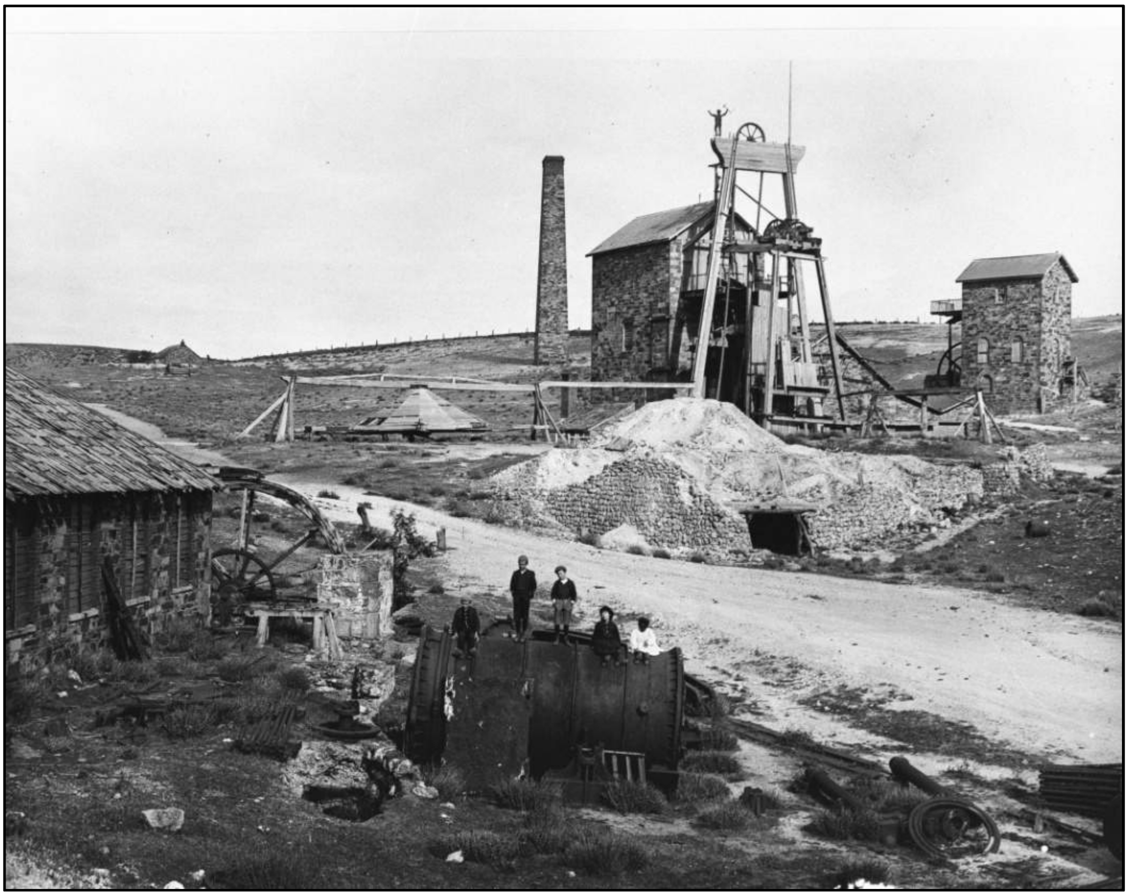
AUSTRALASIAN
MINING
HISTORY
ASSOCIATION

PROCEEDINGS
of the
26th ANNUAL CONFERENCE



Burra, South Australia
18-25 September 2022

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Morphetts Enginehouse and Windinghouse. ca. 1906.
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AUSTRALIAN MINING HISTORY ASSOCIATION

26th Annual Conference

Burra, South Australia

18-25 September 2022

Burra Mine ca.1867

We acknowledge that we are meeting on the Traditional Land of the Ngadjuri people and we pay our respects to their Elders past and present. The Australasian Mining History Association acknowledges the Traditional Custodians of country throughout Australia and their connections to land, sea and community and extends that respect to all Aboriginal and Torres Strait Islander peoples today.

A MESSAGE FROM THE MAYOR

I want to extend my warmest welcome to all of you attending the Australasian Mining History Association Conference here in Burra. It is our pleasure to be your host at this conference which I am sure will be rich with conversation, learnings and experiences.

In 1845 a history we know today began its journey, what unfolded between 1845 and 1877 was transformational for Burra, the State and our Nation.

The town of Burra began as a single company mining township that, by 1851, was a set of townships (company, private and government-owned) collectively known as "The Burra". The Burra mines supplied 89% of South Australia's and 5% of the world's copper for 15 years and the settlement has been credited (along with the mines at Kapunda) with saving the economy of the struggling new colony of South Australia. The Burra Burra Copper Mine was established in 1848 mining the copper deposit discovered in 1845. Miners and townspeople migrated to Burra primarily from Cornwall, Wales, Scotland and Germany. The mine first closed in 1877, briefly opened again early in the 20th century and for a last time from 1970 to 1981.

When the mine was exhausted and closed the population shrank dramatically and the townships, for the next 100 years, supported pastoral and agricultural activities. Today the town continues as a centre for its surrounding farming communities and, being one of the best-preserved towns of the Victorian era in Australia, as a historic tourist centre.

The Burra Charter, which outlines the best practice standard for cultural heritage management in Australia, is named for a conference held here in 1979 by Australia ICOMOS (International Council on Monuments and Sites) where the document was adopted.

Today, volunteers, Council and the National Trust all contribute to the ongoing upkeep of our mining heritage legacy for the benefit of future generations.

The Australian Cornish Mining Site: Burra and Moonta were listed as National Heritage on 9th May 2017, the Conservation Management Plan recently adopted by Council and endorsed by the National Heritage Council provides oversight and guidance to those who now manage, own or otherwise care for our mining heritage.

The timing of this conference could not be more perfect as the Regional Council of Goyder along with our community begin the process of a World Heritage journey, in association with the Copper Coast Council and National Trust Branch SA. Considerable work has been done in relation to the Outstanding Universal Values, which identify the nominated property as the most authentic and historically significant component of the Cornish Mining Landscape in Australia for the period 1845 to 1923 (Burra 1845-1877 & Moonta 1861-1923).

Once again welcome to Burra and please accept my best wishes for an informative and productive conference.

Sincerely,

Mayor Peter Mattey OAM

September 2022

AUSTRALASIAN MINING HISTORY ASSOCIATION BURRA CONFERENCE

President's Foreword

This conference at Burra is special for all of us. We can meet in person for the first time since Atherton in 2019. Bathurst and our initial attempt at a Burra conference had to be cancelled, but now we can at last renew old friendships, make new ones, and dive back into exploring mining history in the field.

Burra is a perfect place to do just that, being part of an historic copper mining area, and placed on the National Heritage list in 2017. We're holding the main conference activities in Burra Town hall, built in 1874 to replace the original 1857 Miners and Mechanics Institute. Not far from here, and a highlight of one of the field trips, is the 'Monster Mine', now part of an open air museum, which includes the reconstructed Morphetts Enginehouse (1858) and Windinghouse (1861), two other ruined Enginehouses (1868 and 1876), and the 1847 Powder Magazine.

Our two day post-conference tour is to the three 'Copper Triangle' towns of Kadina, Wallaroo and Moonta, all part of the copper bonanza of the mid-late C19th.

In 1849, gold fever was spreading across the globe from the Californian discoveries, then from those in eastern Australia, but South Australia, hosting very little gold, was extremely rich in copper. Australian mining history often features shepherds, sometimes assisted by a digging wombat, as the first to spot mineral outcrops, and this was probably true for discoveries at Kapunda (1842), Burra (1845), Wallaroo (1859) and Moonta (1861). By the 1870s, the largest copper producing region of the British Empire was South Australia, which had overtaken Cornwall. We look forward to exploring, and learning more of the history, of these historic areas.

I'd like to thank Mayor Peter Mattey OAM and Councillors of Goyder Regional Council, and other locals who have assisted our organising committee; and I give special thanks to Peter Bell, Ross Both and Geoff Hudson for keeping at it on the second time round, and enabling this 2022 conference of the Australasian Mining History Association to become a reality.

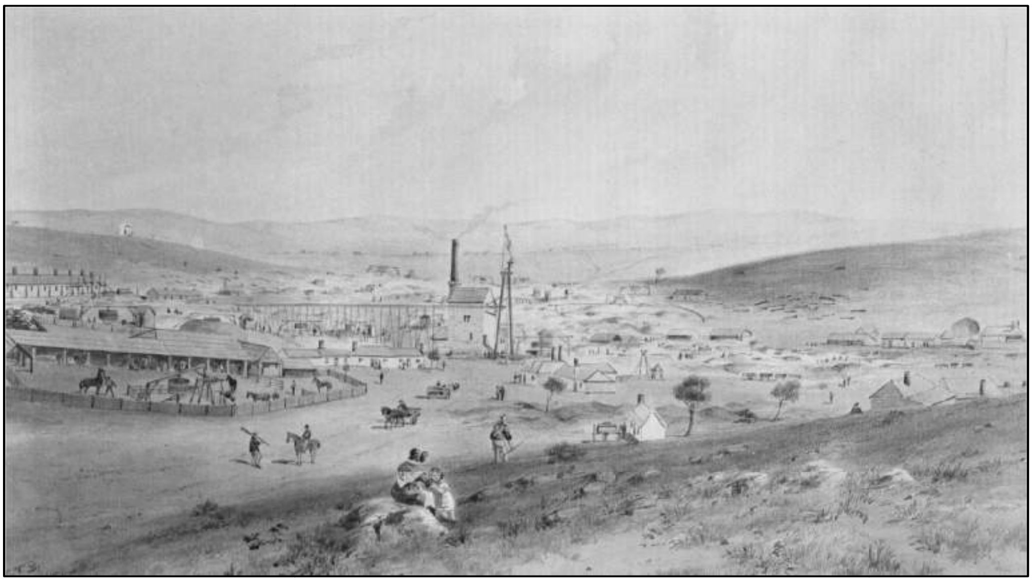
Nicola Williams
President

The Mining Industry in Burra

When a mining operation begins, the usual sequence of events is that someone discovers a valuable mineral, then someone else forms a company and raises capital, and mining commences. The beginnings of the Burra mine reversed that process; the South Australian Mining Association (SAMA) was formed in the young town of Adelaide in 1841, but they had no mineral assets. They sat around for several years as a hopeful syndicate in search of a mine and advertised in the newspapers for mineral samples. This unorthodox approach to prospecting paid off in July 1845 when someone walked into their office with a bright green specimen of malachite.

The Burra Burra copper deposit was discovered by Thomas Pickett, variously described as a shepherd or a bullock driver, 140 km north of Adelaide in mid-1845. It wasn't the first copper discovery in South Australia, but the most significant to that time. In that era before mining leases were invented, SAMA were horrified that the colonial government's land laws required them to buy 10,000 acres of freehold land at £1 an acre before they could begin mining the copper! It was among the most profitable investments in Australian history. They made £90,000 profit in the first eighteen months. The mine eventually paid them £800,000 in dividends; for the eighteen consecutive years from 1847 to 1864 it returned shareholders between 200 percent and 800 percent of their initial investment in every year. Pickett was rewarded with a £10 note.

The source of this wealth was a geological freak, a 'bubble of copper' unlike anything else found in Australia. There was no frustrating period of development and uncertainty; Burra was rich from the very first day of mining. The exposed orebody consisted of oxidised copper carbonate ore with negligible sulphide content, averaging from 40 to 50 percent copper with patches up to 70 percent, outcropping as a great shallow mass. It was easy to mine and easy to treat. If a Cornish miner and a Welsh smelter hand were asked to design a copper deposit ideal for both mining and smelting, the result would be very like Burra.



S.T. Gill 1850, Burra Mine

Although no plans of the underground workings at Burra survive (and quite possibly never existed), we have a better record of what they looked like than we do of most other historic Australian mines. In 1847, SAMA commissioned Adelaide artist S.T. Gill to do a series of paintings of the surface and underground workings at Burra. His watercolours form a remarkable record of their appearance. The ground at Burra seems to have been extraordinarily accommodating, for Gill depicted enormous underground spaces with almost nothing supporting the roof. His paintings show little evidence of structures such as shafts, drives, stopes or timbering; the miners seem to be intent on hauling out the richest ore wherever they found it, and leaving irregularly-shaped cavities behind.

There was an influx of about five thousand people in Burra's first five years; in 1850 it was the largest inland town in Australia. The majority of the workforce and their families were housed in makeshift accommodation in close proximity to the mine, frequently in shelters they had built themselves. The company provided basic materials, and correspondence between the mine and Adelaide regularly referred to materials such as 'palings for temporary huts' to be supplied to the builder-occupants.

The housing problem and the traditional skills of the miners combined to produce an unorthodox solution. A large proportion of the town's population - probably approaching two thousand people - lived in burrows or dugouts excavated in the banks of Burra Creek for a distance of several kilometres above and below the township. At the end of 1850, William Cawthorne visited Burra, and left both pictorial and written descriptions of the dugouts:

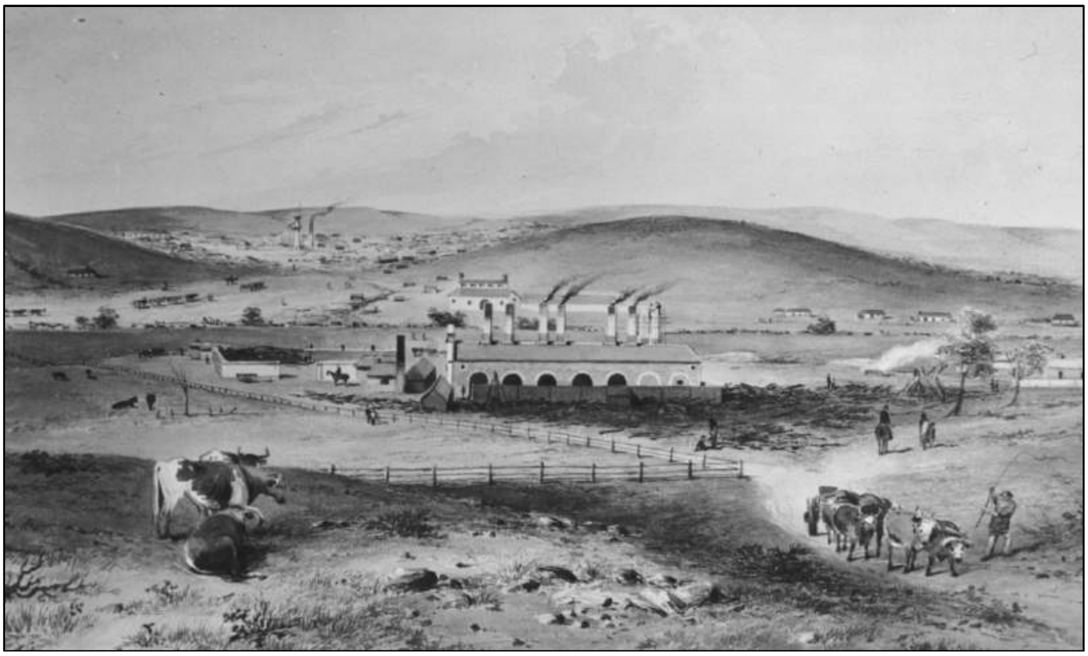
> In passing over the bridge leading to the Smelting Works, a picturesque feature struck upon my astonished gaze, viz., the "creek habitations"; which are nothing more or less than excavations of a small size in the banks of a rivulet, at the present time supplied with water from the engines of the mine. As far as the eye can reach down the creek, these human wombat holes are to be seen - one long hole for a door, and a small square or round one for a window; a perfect street, with above 1500 residents. Such is the force of habit, that the miner never thought of building a house, but mining one, and accordingly the Burra Creek is riddled like a honeycomb ...

Although initially popular, this experiment in housing was short-lived for obvious reasons; the dugouts were plagued by floods, and their occupation was prohibited by SAMA after catastrophic storms in June 1851, although a few individuals were reported to be still living in the creek as late as 1860.

The first copper smelter in Burra (and Australia) was built in 1846 by Georg Ludwig Dreyer and his son, experienced smelter builders from the Harz Mountains. The smelter was built at a cost of about £1,000, and tested early the following year. It stood near the entrance to the mine, within what is now a walled enclosure called the mine storeyard. Construction was underway in early 1846, and the company called tenders for 25,000 bushels (over 600 tonnes) of charcoal fuel. It was described as a hot blast furnace, its air provided by bellows made by an Adelaide organ-builder and powered by a two-horse whim. The Dreyers' smelter was a failure; it produced a quarter of a ton of copper, but at greater cost than freighting the ore to Europe for smelting. The air blast was insufficient, so a larger blowing machine was ordered in March 1847 and fitted to a new furnace. Still the trials dragged on for months. About 230 kg of copper matte were produced eventually, but it would have been cheaper and quicker to freight the ore to Swansea. In October 1847 the Superintendent drew up a plan for a new smelter with its blower powered by a steam engine, but the directors had heard enough about blast furnaces. The experiment was over.

When their first smelter failed, SAMA did not persevere in the smelting business, but entered into an agreement with the Patent Copper Company of Swansea who started building a Welsh reverberatory plant close to the mine in 1848. It was a good choice, for the rich carbonates of Burra would prove to be ideally suited to Welsh smelting methods. The Burra company's subsequent smelting record was confused by their indecision over the economics of smelting at the mine or at other sites. In the 32-year history of the Burra mine, its ore was smelted at the mine, at Apoinga 30 km away where there was a good firewood supply, at the Port and

Yatala smelters in Adelaide, in Newcastle and in Swansea. For most of the 1850s, mule teams carried coke to Burra for smelting the lower grade ore, and back-loaded richer ore to the coast for shipping.



S.T. Gill 1850, Burra Smelting Works

The heyday of the new works was brief, from 1854 to about 1862. In that year, the company had completed its new smelters at Port Adelaide and the railway was advancing toward Burra. Less and less ore was smelted at the mine until in 1869 the Burra smelters closed, and all ore was railed to Port Adelaide. The smelters the company erected at Port Adelaide and Newcastle were also orthodox reverberatories, reflecting their faith in Swansea technology.

The company kept the Burra smelting works standing for many years, although there are records of bricks and other materials being sold off as time passed, and the quantities involved suggest that the reverberatories themselves were being dismantled. A new company was formed to crush and treat slag on the site in the early twentieth century, and the site of one of their small cylindrical waterjacket furnaces can be seen today. The stone shell of the smelter buildings stood until about 1920, and then disappeared from photographs, most likely cannibalised for their building materials. The great red brick stack of 1853 stood alone in a sheep paddock until as recently as 1956. Then it was dynamited by the local Council because they believed it was dangerous, presumably to the sheep. Fragments of the furnaces remain on the site, which is publicly accessible and interpreted for visitors.

In 1870 the Burra mine went over to open cut production. The remaining years were relatively uneventful, simply quarrying ore and railing it to Port Adelaide. There was little development at the mine except the steady expansion of the open cut. Production was steadily winding down, and SAMA was selling off redundant machinery and other equipment to other mining companies. The mine was closed in 1877 by a worldwide copper price fall.

Conference Program 18-25 September, 2022

Sunday 18th September

4.00 pm	Registration in Town Hall
6.00 pm	**Regional Council of Goyder Reception**

Monday 19th September

8.30 am	Registration
9.00 am	Acknowledgement to Traditional Land Owners and President's Welcome
9.15 am	**Session 1. Chair: Nick Williams** **Copper Mining in South Australia**
	Peter Bell, *Burra's place in Early Australian Mining History*
9.55 am	Ross A. Both, *The Burra Mine Story post-1877*
10.30 am	**Morning Tea**
11.00 am	**Session 2. Chair: Peter Bell**
	Christopher J. Davey, *Cornish Timber Support Technology used in the Burra Burra Mine*
11.30 am	**Keynote Address**: **Darren Peacock, *Mining Heritage for the Twenty-first Century***
12.20 pm	Ken McQueen, *Sidwell the Bal Maiden: from Burra to Cobar* (Poster)
12.30 pm	**Lunch**
1.30 pm	**Session 3. Chair: Nic Haygarth** **Geotourism- Celebrating Mining Heritage**
	Angus M. Robinson, *Geotourism: Conserving Heritage and Generating Post-Mining Economies for Communities*
2.00 pm	Patrick R James, *Celebration of Mining History in UNESCO Global Geoparks*
2.30 pm	Colin Conor, *Yorke Peninsula, South Australia – IOCGs - where it all Began*
3.00 pm	**Afternoon Tea**
3.30 pm	**Session 4. Chair: Angus M. Robinson** **Geotourism- Celebrating Mining Heritage (cont.)**
	Susan Pearl, *Keeping History Alive at the Blinman Heritage Mine*
4.00 pm	Peter Waggitt and Mark Asendorf, *Northern Territory Heritage: Update on the Pine Creek Miners' Park and a Proposed Geotrail*
4.30 pm	Ian D. Lewis, *A Proposed Goyder Geotrail Centred on Burra, South Australia: Bringing Geology and Mining to the Public's Appreciation*

Tuesday 20th September

	Bus and walking tour of Burra
9.00 am	Depart Burra Town Hall
	Mine and town lookouts, Morphetts Enginehouse and Museum, and Redruth Gaol
1.00 pm	Purchase lunch at cafes. Self-guided walking tour of town in vicinity of Market Square
2.30 pm	Depart Market Square
	Visit Smelts and Dugouts
5.00 pm	Return to Market Square

Wednesday 21st September

9.00 am	**Session 5. Chair: Geoff Hudson**
	Presentation on 2023 AMHA Conference to be held in Reefton, NZ
9.10 am	**Keynote Address: Jason Shute,** ***Ayers and the Burra: "Australia's mining giant", Politician and Serial Premier – the Man and the Myths***
10.00 am	Sharon Burnell, *Surgeons and Medical Practice at Burra, 1848-1852*
10.30 am	**Morning Tea**
11.00 am	**Session 6: Chair: Gordon Boyce**
	Mel Davies, "*Unbridled Benevolence?": the South Australian Mining Association in the Age of Laissez Faire*
11.30 am	James A. Lerk, *Bendigo's Central Nell Gwynne Mine: Born out of the Great Depression*
12.00	Nick Langsford, *Pitwork at the Tasmania Gold Mine, Beaconsfield*
12.30 pm	**Lunch**
1.30 pm	**Session 7. Chair: Ruth Kerr** **Mining Personalities**
	Christopher J. Davey, *Henry Roach: the Burra Burra Mine Captain*
2.00 pm	Geoffrey Randall, *The Life and Career of Uriah Dudley: Mining Engineer, Inventor and Freemason*
2.30 pm	Judy M. Fander, *Lionel CE Gee SM: Gold Warden and Senior Public Servant: his Contribution to South Australia's Mining Industry 1882-1924*
3.00 pm	**Afternoon Tea**
3.30 pm	**Session 8. Chair: David Carment**
	Gordon H. Boyce, *"Cory Out, Dreyfus Home": Cory Brothers' Coal Merchant Business, 1888-1914*
4.00 pm	Susan Arthure, *The Occupation of Baker's Flat, an Unusual Nineteenth-century Irish Settlement near Kapunda*
4.30 pm	**AMHA Annual General Meeting followed by General Meeting**

Thursday 22nd September

Excursion to Kapunda

9.00 am	Depart Burra Town Hall
	Walking tour of Kapunda mine site and visit to Envirocopper In-Situ Recovery Copper and Gold project
1.00 pm	Purchase lunch at cafes. Self-guided walking tour of town in vicinity of Main Street
2.30 pm	Kapunda Historical Society Museum
3.30 pm	Depart Kapunda
5.00 pm	Return to Burra
6.00 pm	**Advisory Committee Meeting**

Friday 23rd September

9.00 am	**Session 9. Chair: Mel Davies** **Mineral Exploration Case Histories** Aert Driessen, *Grassroots Copper Exploration in the Flinders Ranges in the 1960s*
9.30 am	Geoff Hudson, *The Discovery of Olympic Dam - Revisiting the Record*
10.00 am	Joseph Ogierman, *The Angas Deposit, South Australia: a Tale of Discovery 150 years in the Making*
10.30 am	**Morning Tea**
11.00 am	**Session 10. Chair: Ross Both** **Workshop: *Researching and Writing Mining History*** Ken McQueen, *How I write mining histories*
	Ruth Kerr, *Archival sources*
	Peter Bell, *Government publications*
12.30 pm	**Lunch**
1.30 pm	**Session 11: Chair: Greg Maiden** Janette Lange, *German Miners in South Australian Mining History*
2.00 pm	Anne Both, *Invisible People: Muleteers in South Australia, 1850s and Beyond*
2.30 pm	Gordon H. Boyce, *East and West of Aden: The Aden Coal Co., 1881-1910*
3.00 pm	**Afternoon Tea**
3.30 pm	**Session 12: Wendy Carter** Roger Kellaway, *The Bishop of Tasmania's Yacht and the California Gold Rush*
4.00 pm	Nick Haygarth, *"Over hill and dale with an aching back": the History of the Adamsfield Track, South-western Tasmania*
4.30 pm	Heather Nimmo, *Putting the Personal into Writing Mining History*
6.30 for 7.00 pm	**Conference Dinner at the Burra Hotel**

Saturday 24th September

9.00 am	Minibus for Adelaide departs Burra Market Square. ETA Adelaide approx. 11.00 am. Drop-off in CBD and Airport.

Post-conference tour to Wallaroo and Moonta

Saturday 24th September

8.30 am	Coach departs Burra Market Square
10.15 am	Participants travelling independently to Kadina join coach outside Kadina Gateway Motel
10.45 am	Hughes Enginehouse, Richmans Enginehouse, Moonta Mines Methodist Church
1.00 pm	Purchase lunch at cafes
2.00 pm	Moonta Mines Museum and Tourist Train
4.00 pm	Part of Moonta heritage trail by bus
5.00 pm	Return to Kadina Gateway Motel

Sunday 25th September

9.00 am	Depart Kadina Gateway Motel Drive past abandoned Wallaroo mine sites
10.00 am	Wallaroo Smelters walking trail
12.30 pm	Purchase lunch at Coopers Ale House Wallaroo
2.00 pm	Departure from Wallaroo of bus to Burra and minibus to Adelaide ETA Burra approx 3.45 pm. ETA Adelaide approx 4.00 pm. Drop-off in CBD and Airport

Burra Hotel (formerly Miners Arms Hotel)

Confirmed as a State Heritage Place 8 November 1984

The Burra Hotel was originally built in 1847 as the single-storey Miners Arms Hotel. Located in the hub of the main road system in Kooringa, the hotel became a focus of after-work celebrations by the miners. Free ginger beer was supplied for miners who competed in regular wrestling matches in the hotel's stable yards, and a whole bullock was often roasted. Many of these contests continued throughout the night and were known to last up to three days during Christmas holiday breaks. The hotel also provided refreshments and accommodation for coach travellers. One of its more famous visitors was the explorer John McDouall Stuart, who stayed overnight on 16 December 1862, as he returned from his successful crossing of Australia from south to north. In 1878, the same year as the railway extension from Burra to Hallett was opened, the hotel was badly damaged by fire. In 1880, after it was rebuilt, it became the Burra Hotel. A second storey was added in 1912, and the verandah in 1920.

Conference Dinner Friday 23rd September 2022
$50 per person

MENU

Entrée

Cheese and Dips & Pita & Garlic Bread

Mains

Barramundi with Hollandaise Sauce

Pork Spare Ribs with a Tangy BBQ and Honey, Garlic Sauce

Chicken Breast with Camembert, Spinach and Creamy Pesto Dressing

Vegetable Stack with Napoleon Sauce, Sticky Balsamic Glaze and Sesame Seeds

Dessert

Lemon Meringue Pie served with Ice-cream and whipped Cream

or

Apple and Rhubarb Crumble

Served with Ice-cream and Whipped Cream

Thank you for choosing to dine @theburrahotel

The Occupation of Baker's Flat, an Unusual Nineteenth-century Irish Settlement near Kapunda

Susan Arthure

College of Humanities, Arts and Social Sciences, Flinders University, Adelaide, South Australia

For nineteenth century South Australia, the mining town of Kapunda was critically important. It had the first successful metal mine in the country, its rich copper ore saved the fledgling colony from bankruptcy and many of its men went on to do 'great things'. But what about the men and women of Baker's Flat, a long-lived Irish settlement on the outskirts of town that provided much of the labour for the mine?

Part of a mural at Kapunda (now in storage) depicting the women of Baker's Flat repelling bailiffs and legal officers using brooms, sticks and boiling water. Photo: Susan Arthure.

The Baker's Flat settlement was located on contested land, with the Irish residents proclaiming their rights to it as vehemently as the legal landowners. Mostly, the Irish are remembered in general terms as feisty and rebellious, agitating for their rights to the land through direct action. The women were at the forefront of this resistance, with newspaper accounts detailing how they jumped in postholes to prevent the land being fenced, or used sticks, brooms and pots of boiling water to repel legal officers. Archaeological fieldwork at Baker's Flat has identified it as a *clachan*, a traditional Irish settlement pattern characterised by clusters of houses and co-operative farming. This is the first clachan to be recognised in Australia to date. The presence of a clachan in early South Australia, combined with the land rights activism of its residents, makes this a most unusual settlement. This presentation provides an historical and archaeological overview of Baker's Flat, explaining how the clachan operated, and putting names to the key families and activists.

Burra's Place in Early Australian Mining History

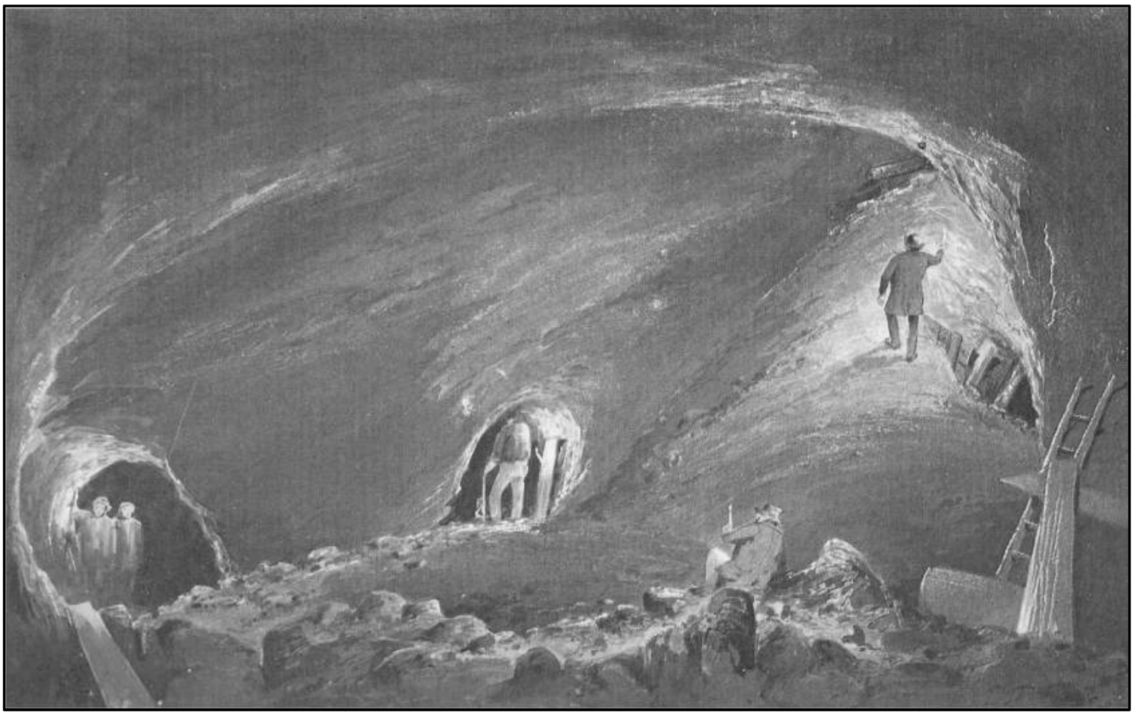
Peter Bell

Adjunct Senior Research Fellow, Flinders University, Adelaide, South Australia

Copper ore was discovered at Burra in 1845, and the mine opened shortly afterward. By 1850, a town of 5,000 people had grown up beside the mine, the largest inland town in Australia. By 1856 it was important enough to have its own gaol, the only one north of Adelaide. The orebody proved to be very rich, paying dividends by 1847, and financed multiple shafts with Cornish pumphouses and winding engines.

Underground illustrations by S.T. Gill show it was worked very unsystematically, with miners simply gouging out rich patches of the orebody. A smelter was built in 1849 and extended in 1853. By the 1860s returns were falling, and the directors adopted open cut extraction in 1870, believing it would be more economical. In 1872 a railway arrived in Burra from Kapunda, and from that time the smelters were abandoned and ore was railed to Port Adelaide for smelting.

In 1877 the worldwide copper price crashed, and Burra was among the many mines forced to close. A second episode of mining would follow a century later. The town survived; it was well-established as the centre of a prosperous Merino grazing region and a railway hub. The railway is gone now, but Merinos and tourists support the local economy.



Interior Scene in the Burra Mine, S.T. Gill, 1847

Invisible People: Muleteers in South Australia, 1850s and Beyond

Anne Both

Burnside Historical Society

Who were the muleteers whose presence is rarely mentioned in Australian mining literature? Few traces of them can be found, even in official records, beyond references such as those found in shipping lists, e.g. '14 muleteers and 2 families with children'.

What brought them to South Australia? The first group arrived from Montevideo, Uruguay, on the *Malacca* on 18th July, 1853. The Patent Copper Co at Burra was faced with increasing costs and unreliability of transport for copper and fuel, with bullocks proving unsatisfactory, poor or non-existent roads, and labour in short supply. E.K. Horne was sent to South America to arrange purchase of mules for the company's transport need. Mules were the ideal animals: sturdy, requiring less feed and overall operations would be cheaper even with the requirement for drivers.

Six muleteers accompanied 70 mules, the number remaining from a shipment of 180, the rest having perished during a rough passage. In 1856 the muleteers in SA were described thus: 'The Chilean drivers - fine dark fellows some wearing picturesque costumes and tremendous spurs with long rowels'. Much of what appeared in the press of the day or later reminiscences shows a tendency to comment on the exotic aspects of these men who were frequently referred to as Spaniards.

The first group of muleteers to arrive were named in the shipping list but the subsequent two groups were simply noted as so many mules and muleteers. To know personal details of their life after arrival it is necessary to seek them in official records, but anglicising of names in some cases renders this difficult. Using genealogy records, newspaper archives such as Trove, local and family histories, diaries, letters etc., some part of the story of these muleteers can be gleaned and not all remain faceless and nameless. This paper will attempt to put a face to some of the muleteers whose labour contributed to the development of Burra and who appear to have been lost to mining history. At least some remained in Australia and when mine worked finished mule teams were used in station work.

Ten-mule team hitched to a wagon at Mutooroo Station, South Australia, ca. 1912. SLSA PRG18/3/2/64

The Burra Mine Story post-1877

Ross A. Both

23 Windsor Street, Fullarton, SA, 5063

From 1845 to 1877 the South Australian Mining Association produced 234,648 tons of dressed ore from the Burra Mine, with the average grade estimated to have been approximately 22 % copper.[1] This unusually high grade was the result of oxidation and enrichment of (probably) low grade primary mineralisation. The ore consisted almost entirely of the secondary minerals malachite, azurite and chrysocolla, with only trace amounts of primary and secondary copper sulphides. The ore is located in a steep east-dipping sheared and crushed zone between two faults in the Late Precambrian Skillogalee Dolomite.

From 1887 to 1913 small parcels of ore were periodically won by tributers working above water level. A plant erected in 1891 to retreat slag from the old smelter was reported to have operated profitably for several years. Two deep diamond drill holes in 1898-89 to explore for sulphide ore intersected only low grade mineralisation. In 1889 the South Australian Mining Association announced the sale of the mine to a syndicate registered in London but a crash in the price of copper from about £75/ton to £40/ton led to the sale falling through.

The Burra Burra Copper Co. was formed in 1901 with the intention of retreating dumps of waste and tailings and at the same time prospecting for further ore bodies. Treatment of the dumps was sublet to a separate company involving Elder Smith & Co and Mr F.H. Snow who attempted to employ an electro-magnetic separation process with a plant purchased from Germany. The process was unsuccessful and the venture failed. After installing a pumping plant the Burra Burra Copper Co. carried out underground exploration, reporting that ‘now and again valuable ore is met but not in large quantities’. By 1906 finances were almost exhausted and the Company was looking to sell the mine. In 1907 the Kooringa Prospecting Syndicate took out an option to purchase the mine, but after drilling two more holes decided not to proceed. The Burra Burra Copper Co. was wound up in 1917.

As part of investigations during World War II to discover further supplies of copper for munitions and industrial use, S.B. Dickinson of SA Mines Department carried out a detailed study of the mine area, but concluded that further work was not warranted.

During the early 1960s a Mines Department program of geological mapping, geopyhysical and geochemical surveys, and drilling indicated an oxidised ore reserve of 1.2 mt averaging 1.44% copper. Further work in 1966-1969 by MEPL (a consortium of mining companies) increased the ore reserve to 3.02 mt averaging 1.7% copper but relinquished the lease after metallurgical work failed to find a method of economically treating the ore. Samin Ltd took over lease, solved the metallurgical problem and began mining by open cut in 1969. A processing plant to produce copper oxide (CuO) was constructed. Mining ceased in 1981 having produced 1.89 mt at an average grade of 1.71% copper. The processing plant, now operated by Adchem (Australia) Pty Ltd, has not only continued but expanded and sources a variety of copper-bearing raw materials.

A South Australia Sesquicentenary Grant in1986 enabled restoration of Morphetts Enginehouse for use as a mining museum and Burra was declared a State Heritage Area in 1994. In 2017 Burra, along with Moonta Mines, was included in the National Heritage List as Australian Cornish Mining Sites.

[1] S.B. Dickinson, ‘The structural control of ore deposition in some South Australian copper fields’, *Geological Survey of South Australia*, Bulletin No. 20, p.66.

"Cory Out, …": Cory Brothers' Coal Merchant Business, 1888-1914[1]

Gordon H. Boyce

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On the eve of World War I, Britain exported about 100 million tons of coal annually. These shipments fuelled much of the global economy, and thereby supported the spread of industrial and economic development in advanced countries, regions of recent settlement, and emerging areas.[2] The coal export trade provided British shipowners with a vital outbound cargo that complemented imports from all around the world, thereby generating vital two-way operations. Outbound coal carrying lowered the cost of Britain's imports, contributed to the nation's invisible earnings, and thereby helped to maintain its healthy balance of payments surplus.[3]

Cory Brothers of Cardiff ranked as one of the nation's premier coal trading houses (shipping roughly 5 million tons annually) to the extent that tramp owners used the phrase "Cory Out, Dreyfus Home" to refer to the invaluable trade comprising coal exports and grain imports. (Louis Dreyfus & Co. held a salient position in Britain's grain import trade.) Despite its importance, Cory Brothers has been overlooked by British business historians, and the present study seeks to redress this situation.

On its formation as a private limited liability company with a capital of £880,000 in 1888, Cory Brothers owned several Welsh collieries, held substantial investments in shipping and some 7,000 railway wagons, held interests in 35 overseas bunkering stations, and conducted a very substantial coal export business.

The first part of the presentation begins with an overview of the Cory enterprise which consisted of a string of 'vertically-aligned' operations that were not subjected to systematic co-ordination. This structure was quite typical of similar British businesses at the time, and the rationale for its application is explored with a view to explaining the underlying logic in the hope that it may contribute to a wider understanding of the nation's corporate organisation during the pre-1914 era.

The following sections consider in turn: 1. the mechanics of Cory's coal export operations, which comprised very large purchasing and sales contracts (100,000 tons or more p.a.), 2. the role that the family's coal mining interests played within the overall operation, 3. the brothers' investments in shipping and railway wagons, and finally, 4. the organisation, administration and expansion of the firm's overseas bunkering depots which numbered 118 by 1913.

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[1] Based on records held at the Glamorgan Archives, Cardiff, series DCB. This study forms part of the author's four volume study, *A History of British Tramp Shipping, 1870-1914,* forthcoming from the University of Liverpool Press.

[2] Roy A. Church, *The History of the British Coal Industry,* Vol. 3 (OUP, 1986).

[3] The importance of British coal exports has been a subject of debate. See, C. Knick Harley, 'Coal Exports and British Shipping, 1850-1913', *Explorations in Economic History,* 26, (1989), 111-38, Sarah Palmer, 'The British Coal Export Trade, 1850-1913,' in D. Alexander and R. Ommer (eds), *Volumes not Values,* (St. John's: UFP, 1979), and G. H. Boyce, 'Edward Bates & Sons, 1897-1915," *International Journal of Maritime History,* 23, No. 1 (2011), 13-50.

East and West of Aden: The Aden Coal Co., 1881-1910

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The world-wide network of bunkering stations that developed after 1870 constituted vital infrastructure for steam-powered maritime transport. This presentation provides a unique 'inside view' of bunker depot operations in the pre-1914 era using the records of the Aden Coal Co., an affiliate of Cory Brothers.[1] The run of Directors' Minutes begins in 1881, when the business was founded as a joint venture with outside parties, until 1910 when Corys absorbed the business and separate records were no longer compiled.

The bunker supply business was subject to 'double-derived' demand conditions. The volume of fuel requirements reflected demand for shipping services which in turn depended on consumption trends within the global trading system. These conditions produced volatile cyclical oscillations in freight rates and coal prices. After 1870, when the international cable system began to expand, rapid communication ensured that information regarding changing conditions was quickly transmitted to businesses across an ever-greater part of the globe. Located along the major East-West trading corridor, the managers of Aden Coal developed highly responsive capabilities and an anticipatory 'feel' for shifting business currents. Upon its formation the enterprise's fixed capital amounted to about £38,000 in addition to which the value of its coal stocks must have been significant. During the period, the depot sold between 32,000 and 64,000 tons per annum making it a fairly sizeable undertaking.

The presentation examines operations under three sets of conditions:

1. First, the study replicates operating equations that reflected supply- and demand-side prices and costs that were relevant during times of 'normal' trade. The analysis reveals the parameters for managerial responses when 'typical' cyclical conditions prevailed.
2. Sudden shocks temporarily disturbed the usual operating parameters and required more decisive managerial action. Examples include the outbreak of cholera in India, harvest failures in Asia, coalminer's strikes in Britain, and war in Egypt and South Africa. In most instances, dislocation lasted for about one year.
3. More fundamentally, gradually unfolding structural changes threatened the bunkering business, particularly in the Suez region. The formation of new depots disturbed the structure of the local industry and intensified local competition. The growth of foreign rivalry in world shipping reduced demand for Aden's services. The arrival of substitute coal from India, and to a lesser extent Australia, across Asia and within the Suez area undermined demand for the British product. The managers of Aden Coal responded quite effectively to these emerging circumstances; they began supplying Indian coal at the depot and developed several new supply-related services: the firm paid an attractive average dividend of nearly 13% p.a. across this 29 year period.

[1] Glamorgan Archives, Cardiff, series DCB 3.

Surgeons and Medical Practice at Burra, 1848-1852

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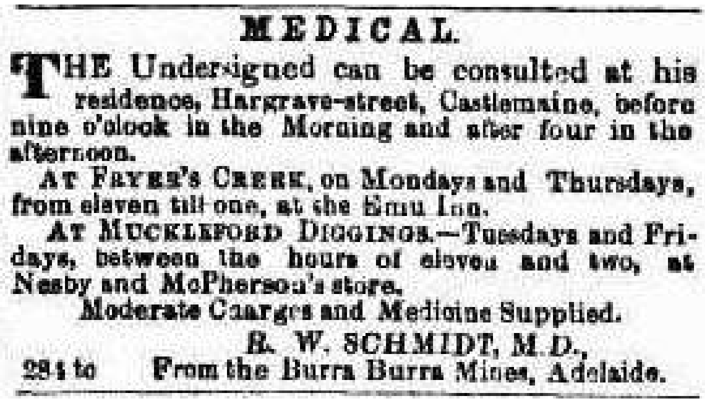
This paper identifies and profiles the Anglo and German ship-surgeons working in Burra from 1848 through to the end of 1852 using a range of contemporary sources. These include records of the South Australian (SA) Mining Association archived in the State Library of SA, correspondence and inquest reports held by State Records of SA, death entries for the District of Murray held by Genealogy SA, and newspaper articles found using TROVE.

These surgeons were generally university-qualified medical practitioners with a range of professional experiences. They were highly mobile, moving on when needs be, often to other mining towns, such as Kapunda and Moonta Mines. Several of these surgeons travelled to the Victorian and New Zealand goldfields to work. Of particular interest to the author is Dr Richard Wilhelm Schmidt who arrived in Adelaide from Hamburg in 1849 as ship surgeon on the *Wilhelmina Marie*. Although the author has not found any evidence that Dr Schmidt was directly employed by the SA Mining Association,he later advertised the fact that he had been at the Burra Burra mines (Fig. 1).

Figure 1: Advertisement placed by Dr R.W. Schmidt while living in Castlemaine,Victoria.



Source: *Mount Alexander Mail*, Friday 27 July 1855, page 3.

The question of who employed these surgeons in Burra, and how miners were able to pay for their services, is examined. An analysis of the people dying in Burra and their 'causes of death' will be provided to illustrate the types of conditions and injuries dealt with by the surgeons, and the limitations of the data identified. The operation of the SA Mining Association's Club Fund and the Independent Order of Odd-Fellows will be discussed, and questions raised for further research.

Yorke Peninsula, South Australia: IOCGs - where it all began

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The Copper Triangle is the name given to the copper-gold mining district of northern Yorke Peninsula: the apices of the triangle are the mining towns of Kadina and Moonta and the smelter and port of Wallaroo. All three towns owe their origins to the 1859 discovery of the Wallaroo lodes by James Boor, a shepherd, who recognised green copper carbonate in the spoil of wombat burrows on the Wallaroo pastoral lease of Walter Hughes and John Duncan. The discovery of Moonta followed two years later. One hundred and fifteen years later (i.e. in 1975), WMC (Western Mining Corporation) stepped north from Yorke Peninsula to spud OD1 into what was to become the Olympic Dam Iron Oxide Copper-Gold-Uranium-REE orebody. This was a previously unknown type of mineral deposit, however subsequent research has recognised deposits sharing similar characteristics elsewhere: Kiruna in Sweden, the Werneke Mountains in Canada, Candelaria in Chile, and Eloise in Cloncurry are notable examples, however there are a host of lesser copper-gold deposits with sulphides co-existing with iron oxides. The discovery of Olympic Dam caused all these to be drawn together into the world renowned IOCG family. From a more local perspective the Yorke Peninsula-Olympic Dam association paved the way to recognition of the Olympic Copper-Gold Domain, which contains all the major IOCG deposits along the eastern flank of the Gawler Craton. Olympic Dam contains the world’s largest uranium resource and the fourth largest copper resource.

Being the historic origin of the IOCG concept, the Yorke Peninsula mines, together with some natural outcrops, continue to provide valuable information,both historic and scientific. The Wallaroo Mines, the nearby New Cornwall-Wandilta Mines, the Moonta Mines and the Harts and Hillside Mines (including the newly discovered Hillside deposit) all present distinctly different styles of mineralisation. Mine exposures provide examples of each of the four styles of mineralisation: Moonta-style at the Poona open-cut, Wallaroo-style at the Kurilla Mine, New Cornwall on private property east of Kadina, and Harts Mine in the east coast cliffs. These are critical teaching sites routinely visited by economic geologists from South Australia, interstate and overseas. Mining history for tourism is provided by Moonta, but for science the historically rich Wallaroo Mines area at Kadina has been disregarded. Unfortunately, burgeoning cultural development, together with a disappointingly low level of interest in their history has put the sites under threat, surprisingly so in view of the region being proudly named ‘The Copper Coast’, and with all three towns of the Copper Triangle owing their origins to the Wallaroo and Moonta Mines. The Wallaroo Mines are of equal historic significance to those at Moonta, which currently have been singled out to represent the history of mining in the Copper Triangle. Much evidence of mining still tenuously survives along the Wallaroo Mines line of lode , but it has suffered neglect. The remains of mining constitute a valuable resource for Kadina, and so deserve to be both preserved and promoted. An expanded heritage trail highlighting the evidence for mining along the once extraordinary line of lode would be of great value, not only to Kadina and the Copper Coast, but also to South Australia.

Cornish Timber Support Technology used in the Burra Burra Mine

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Mine timber support was introduced to the Burra Burra Mine in 1847 by Captain Henry Roach.[1] In 1990 the author measured up the dressed timber pieces that had been removed from the Burra Burra underground mine during the 1970s open-cut mining operation and were yet to be burnt as firewood.[2] As the underground mine closed in 1867 the timber legs, caps and shaft plate drawings represent mid-nineteenth century Cornish mine support technology.

The paper will reconstruct the underground timber structures and, where possible, make comparisons with photographs and drawings of mines elsewhere that followed Cornish tradition. It will also comment on the subsequent development of timber support and the system known as square-set stoping used in Australia until 1980s.[3]

Figure 1: Mine timber from the Burra Burra Mine.

Source: C.J. Davey 1990.

[1] Ian Auhl, *The Story of the 'Monster Mine': The Burra Burra Mine 1845 – 1877.* Investigator Press, Adelaide, 1986, 288 pp.
[2] A brief unrefereed paper on this subject was delivered at the 1993 Centenary Conference of the Australasian Institute of Mining and Metallurgy held in Adelaide. It contained no analysis or discussion.
[3] The author worked in timber stopes at Broken Hill in 1960s, while qualifying as a Registered First Class Mine Manager in NSW.

Henry Roach: the Burra Burra Mine Captain

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Henry Roach (1808–1889) was chief mine captain at the Burra Burra Mine from 1848 until the underground mine closed twenty years later. Unlike Captain Hancock at Moonta, Roach has had no biographer. The paper will trace Roach's life as sources allow, and add to the narrative of his life as it is found in Auhl.[1] Roach was born into an extensive mining family, some of whom also migrated to South Australia between 1847 and 1857.[2] However, it appears to have been the relatives in Cornwall with whom he maintained relations to assist with mining equipment assignments and family business. The paper will consider his early employment at Tresavean Mine, near Redruth, then at the Bolivar Mine, which is now in Venezuela, and finally at the Burra Burra Mine. He developed the Burra Burra Mine equipment and underground mine support while navigating many awkward situations and gaining much respect.

Figure 1: A memorial-tombstone erected at the entrance of the Towednack Parish Church by Henry Roach after 1867 for his grandmother, Jane Roach, nee Dunstone (1757–1847). It records Henry's international career and affection for his grandmother.

Source: C.J. Davey 2019.

[1] Ian Auhl, *The Story of the 'Monster Mine': The Burra Burra Mine 1845 – 1877.* Investigator Press, Adelaide, 1986, pp. 237-248.
[2] Henry Roach's great grandparents are also the authors great x5 grandparents.

"Unbridled Benevolence?": the South Australian Mining Association in the Age of Laissez Faire

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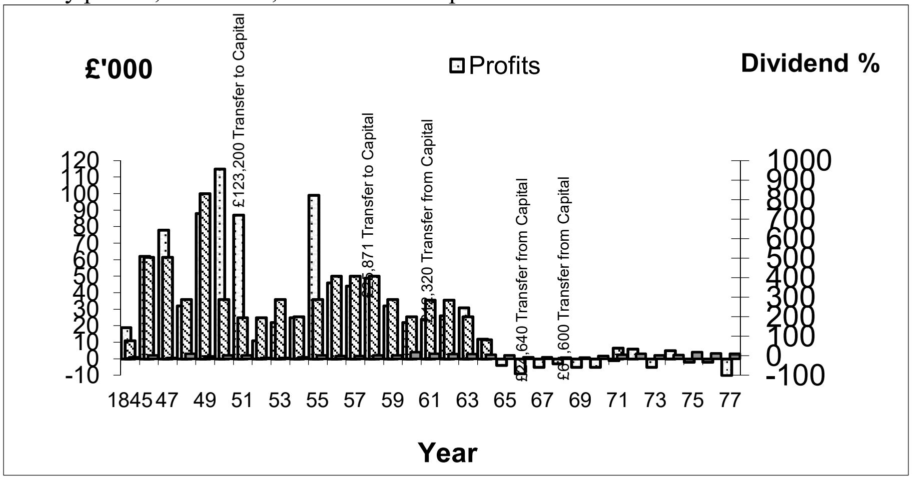
Much has been said in historical literature on the paternalistic and magnanimous nature of the South Australian Mining Association [SAMA]. However, such statements as: "In an age of laissez faire Burra was the most benevolent company in the land…" must be questioned, for while the appearance at a macro level supports such opinion, a close inspection at the micro level reveals a far less generous picture.

Using secondary and primary sources, the latter mainly from the voluminous records of SAMA in the South Australian Archive, the paper will examine the approaches of the Directors of the Company to matters associated with welfare and wellbeing of the miners and wider community. The focus will be related to the areas of health, housing, infrastructure, wage systems, attitudes to welfare, impositions associated with supply of mining supplies to workers, etc. The conclusion is that the greatest concern by SAMA's Directors was profit rather than welfare maximisation, whereby the interests of shareholders were the maxim by which they operated during the life of the Mine.

Of note is that the mine in its early period of production was seen as the richest copper mine in the world. Original £5 shares rose in the early period to over £250 while dividends over the first 21 years of production averaged 300 percent. In the early periods of the mine, production was claimed to be more like quarrying than conventional mining. For example, in 1850, a report from Captain Henry Roach spoke of miners driving 15 fathoms at the 30 fathom level through a "magnificent lode, eight fathoms wide producing malachite, red oxide and native copper varying from forty-six to sixty per cent", and this was but one of many such finds. With such bounty, it would be expected that a supposedly enlightened liberal elite in South Australia would have promoted their ideal of a more progressive society. Many colonists, and this was true of the Directors, were disciples of Jeremy Bentham and his Utilitarian associates who preached that the benefits of laissez faire worked to the benefit of 'the greatest number'. In the case of SAMA, however, it appears that the benefits were weighted heavily in favour of the very few.

Yearly profits, dividends, and rental receipts SAMA 1845-1877.



Grassroots Copper Exploration in the Flinders Ranges in the 1960s

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In so far as copper goes, 'The Flinders' is 'elephant country' and so in the mid-1960s, London-based Selection Trust formed an Australian subsidiary, Australian Selection Pty Ltd, to find a copper deposit like the those it was mining in the geological province then known as the Rhodesian Copper Belt (RCB, now in Zambia and the Congo). These deposits are large, near-shore sediment-hosted, stratiform deposits of late Pre-Cambrian to early Cambrian age. The sedimentary sequences comprising the Flinders Ranges match these depositional environments and geological age criteria.

Our exploration model rested entirely on our studies of the Blinman diapir as previously mapped by the Geological Survey of South Australia. A diapir is a large volume of rock that is able to pierce (intrude) the strata above it, partly because its specific gravity is less than that of overlying strata, and in the right circumstance is squeezed upwards. Many salt domes are balloon-shaped diapiric structures. The composition of the Blinman diapir is mainly dolomitic and calcareous in nature, some 10 km in diameter, and contains 'rafts' of sedimentary strata, some 100 m long, which it engulfed on its upward journey. One such raft was mined for copper near Blinman. By our reckoning, the copper mineralisation was pre-diapiric, stratiform, and generally consistent with the aforesaid RCB characteristics, and of Willouran (late Pre-Cambrian to early Cambrian) age. We therefore positioned our exploration tenements to cover *in-situ* Willouran-age sedimentary strata.

Our orientation studies quickly showed that we should begin with a regional stream sediment sampling program targeting the minus 80 mesh[1] (about 180 µm) fraction for analysis. Areas shown to be anomalous would then be followed upstream to locate sources, and tested by follow-up soil sampling, again directed at the minus 80 mesh sample fraction. Anomalous soil zones were tested by shallow percussion drilling to a depth of 50 feet, and the results of this phase indicated a need for two 700 ft diamond drill holes, both of which drained the exploration budget and yielded naught of interest. Such outcomes are common to many grassroots exploration programs.

I do not know if a modern exploration program looking for the type of deposit that we were looking for then, in the type of country we were exploring, would do it any differently today, but I doubt it. I say that with confidence because our geological model was sound, our exploration strategy rational, and our techniques validated by orientation studies. Notwithstanding, our efforts bore no fruit, meaning that we didn't find a copper deposit, let alone a world-class deposit large enough to sustain production for at least 10 years. Indeed, our experience only confirmed that grassroots exploration is very costly and fails to find its target in over 95% of cases, all of which could collectively be regarded as technical successes but economic failures. Far easier and cheaper to extend the boundaries of known mineralisation of an economic deposit to secure future production, but that is not always possible.

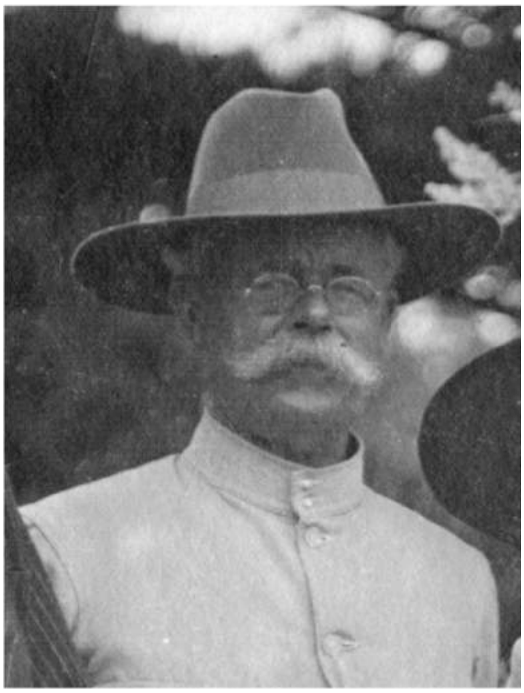
[1] I have stayed with units of measurement of the British Imperial System as they were in use at that time.

Lionel CE Gee SM: Gold Warden and Senior Public Servant - his Contribution to South Australia's Mining Industry, 1882-1924

Judy M Fander, PHA (SA)

Lionel Gee (1854-1936) made a minor but significant contribution to the mining industry of early South Australia. Within the Department of Mines, he became the unofficial expert on the subject of mining acts and the regulations of the day. His skill in administration gained on the goldfields where he had served as warden led naturally to other administrative work such as writing, compiling and editing the Record of the Mines of South Australia 1908. A classic of its time, it remains a valuable reference.

Figure 1: Lionel CE Gee



Source: SLSA PRG 326/4/17/7

When Gee entered the public service as a survey cadet in 1870, G.W. Goyder was Surveyor-General of South Australia and Gee became a government surveyor. In 1882, the renowned geologist Henry Yorke Lyall Brown was appointed government geologist. Warden Gee worked closely with Brown until the geologist retired. During the Teetulpa rush in 1886, Gee began to make his name as warden of goldfields. Brown later chose Gee to be his assistant on a government expedition to the Northern Territory in 1905.

Gee became Chief Registrar and Recorder of the Mines Department following a restructuring of the Department in 1911. Retiring in 1924 after 54 years, he had become an "identity" of the service, an authority on matters of gold mining, and a repository of stories and reminiscences of the early days. 'Bush Tracks and Gold fields',[1] published in 1926, brought together a selection of these reminiscences.

Initially appointed assistant warden of goldfields to Warden Hack in the Goldfields Office in 1882, he spent time in the Adelaide Hills area, visiting goldfields at Echunga and Woodside. With the Teetulpa gold rush beginning in October 1886, the tempo changed. Gee promoted to warden, later assumed the senior role previously held by Hack. After his time at Teetulpa, Gee was warden at the Worturpa (1899), Tarcoola (1900-1902), Arltunga (1903) and Tanami goldfields (1909-1910).

Based on my biography of Gee, this paper describes the living conditions on the goldfields where Gee was warden. It reviews the range of the warden's official administrative duties and the extra responsibilities he assumed. How effective was he? Life was arduous on the field. However, Sunday was a day of rest. Some recreational activities of these communities are considered.

[1] Gee, LCE, *Bush tracks and gold fields: Reminiscences of Australia's 'Back of beyond'*. FW Preece & Sons, Adelaide, 1926.

"Over hill and dale with an aching back"[1]: the History of the Adamsfield Track, south-western Tasmania

Nic Haygarth

The Adamsfield Track was cut as a pack-track to facilitate surveying of the Great Western Railway, a farcical private land grab based on the idea of winning Hobart the trade of the Mount Lyell Copper Mine. After the railway scheme failed in the early 1900s the track and associated huts were re-used by prospectors and hunters. In 1925 the section of track through the Florentine Valley was reinvented as the main access route for Adamsfield, the shanty town at the centre of an osmiridium[2] mining rush.[3] A stable of one of the Great Western Railway huts became a sly-grog shop to fuel the diggers on their march to the field. One of the hazards for the sozzled was dodging the unburdened pack-horses galloping home from Adamsfield. Since there was no feed along the 40 km route the animals were very keen to see the home pastures.[4]

Over the next two decades the track surface was beaten into submission. Injured, sick and pregnant Adamsfielders were stretchered out to hospital by teams of bearers, who sank in the bogs and split their boots on the corded timber floor. However, that was nothing compared to the feats of packer Arthur Fleming who lugged loads into Adamsfield that would sink a pack-horse. No amount of track maintenance could quell complaints about its condition. During the Great Depression from 1929 Adamsfield's 'poet laureate' Mulga Mick O'Reilly saw the track as a divide between the parasitic rich of Hobart and the virtuous mining poor.[5] In the 1930s, even as the osmiridium grew scarce, a primitive, dangerous, horse-drawn wagonette service known as the Adamsfield Express bumped passengers, post and freight to the mining field. In the late 1940s the track was upgraded again by forester Australian Newsprint Mills as a slow road for high-slung cars into Adamsfield. Stan 'the Count' Gerny, the wizened Adamsfield postmaster, came out that way to die in the New Norfolk Hospital in 1962.[6] The town of Adamsfield was dead, although small-scale mining continued for decades.

Today the Adamsfield Track is a multi-layered archaeological zone, the bones of stores, hunting huts, track workers' camps and even the legend of the last Tasmanian tiger being mixed among its overgrown cuttings, fallen bridges and bottle dumps.

[1] This is a paraphrase of 'Mulga Mick' O'Reilly's poem 'The Adams River Rush', in his book *The Pinnacle Road and Other Verses*, the author, Hobart, 1935, pp. 45–46.

[2] Osmiridium is a natural alloy of osmium and iridium

[3] See Nic Haygarth, *On the Ossie: Tasmanian Osmiridium and the Fountain Pen Industry*, Forty South Publishing, Hobart, 2017.

[4] Former Adamsfield resident Lily Gresson, quoted by Fred A. Murfet, *Sherwood Reflections*, self-published, 1987, p. 190.

[5] 'Mulga Mick' O'Reilly, 'Stealing the Children's Bread: Lesson of the Adamsfield Track', *Mercury*, 2 September 1932, p. 8.

[6] Bill Mollison, *Travel in Dreams: an Autobiography*, Tagari Publications, Tyalgum, N.S.W., 1996, pp. 66–68.

The Discovery of Olympic Dam: Revisiting the Record

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The death of Roy Woodall in February 2021 rekindled memories of WMC's glory days of discovery under his guidance and prompted reflection on the discovery of the Olympic Dam deposit.

Woodall[1] noted that Jim Lalor *wrote a very important report on the discovery based solely on the written record (WMC K Report 2792). Jim's thesis was, "If it was not written down it didn't happen."* Unfortunately, this report was not published and later descriptions of the discovery history of the Olympic Dam deposit relied very heavily on recollections.

RDD1 (later called RD1), the discovery drill hole, was completed in late July 1975 to test the stratigraphy based on a model that the alteration of basalts would release copper in solution that could precipitate in proximal, low energy, reduced sediments. The unusual rocks intersected in the basement in RD1 were initially identified as hematite-altered basalt as in the model, but rather than copper depletion, analysis indicated 38m at 1.05% Cu. The nature of the basement rocks and copper mineralisation was a matter of great conjecture for several months with hematite-altered volcanic rocks being preferred, but there was no positive identification of the copper mineralisation.

Drill core samples from RD1 were sent the WMC Geological Research Laboratory in Kalgoorlie for petrological examination. Hudson[2] concluded:

The mineralised rocks in RDD1 are quartz- and hematite-rich, apparently fragmental and hydrothermally altered. The nature of the parent rock remains obscure but appears to have been derived from acid to intermediate plutonic rocks. Hydrothermal alteration is extreme, and the mineral assemblage produced has some similarities to that seen in high level breccia pipes in Chile.

Copper mineralisation occurs as disseminated bornite-chalcocite-digenite disseminated through the sericite- and hematite-rich groundmass of the rocks. In some instances, the sulphides are obviously open space fillings that have subsequently been infilled by fluorite.

The identification of brecciated granite and the comparison to Chilean high-level breccia pipes was the first description of what was to become the new class of IOCG ore deposits and gave context to ongoing exploration at Olympic Dam. No mention of this was made by either Haynes[3] or Upton[4] in their publications on the discovery of the Olympic Dam deposit.

The last word belongs to Roy Woodall[5], who stated in 2008: *It was Geoff who had said, 'I'm sorry, Douglas, this is not a hematite-altered basalt or dolerite; this is a brecciated granite!*

[1] Roy Woodall, "Australian Geologist, 1953 to 1995: Success in Exploration for Gold, Nickel, Copper, Uranium, and Petroleum," an oral history conducted by Eleanor Swent in 2004, Regional Oral History Office, The Bancroft Library, University of California, Berkeley, 2006. https://ethw.org/Oral-History:Roy_Woodall#Further_Reading.

[2] Geoff Hudson, 1975, Memorandum XK75/94 16/10/75 to JH Lalor, "Andamooka Samples-RDD1. Unpublished.

[3] Douglas Haynes, 'The Olympic Dam Ore Deposit Discovery- A Personal View', *Society of Economic Geologists Newsletter*, Number 66, July 2006, pp. 7-15.

[4] David Upton, *The Olympic Dam Story- How Western Mining defied the odds to discover and develop the world's largest mineral deposit*, UPTON Financial PR, PO Box 8430, Armidale, Victoria, 3143, 2010, pp. 180.

[5] Roy Woodall, 2008, Australian Academy of Science, https://www.science.org.au/learning/general-audience/history/interviews-australian-scientists/dr-roy-woodall-earth-scientist#11.

Celebration of Mining History in UNESCO Global Geoparks

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Australia offers an enormous wealth of mining history and geoheritage potential. This is being developed in many regional and rural settings for the benefit of local populations often in great need of support. Mine closures, changed mining operations (e.g. FIFO) and other challenges such as current and ongoing economic, social and health (i.e. COVID) crises suggest that wider investigation of current global activity in this area is warranted.

Many other countries (not including Australia, unfortunately) have joined the relatively modern (less that 20 year) explosion of investment in establishing geopark geotourism destinations, some of which are accepted by UNESCO under the banner of the Global Geoparks Network. Such Global Geoparks are recognised as unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education and sustainable development; thus they are defined areas of significant geological or landscape attributes which are established, developed and promoted for visitors or geotourists, specifically to improve the sustainability of both the area, planet and importantly the local population.

As well as many types of themed Geoparks based around particular geologic/geomorphologic features like caves, mountains, coasts, fossils etc, there are a large number of Global Geoparks which have based their development and promotion on a history of mining and quarrying. From the Copper Coast Geopark in Ireland to the Mining Geopark of Tuscany and from recently closed Canadian coal mines, UNESCO Global Geoparks have helped to reinvigorate languishing communities and also to provide a more sustainable vision for our mining geoheritage.

Figure 1: Mining Heritage from Copper Coast Geopark

https://coppercoastgeopark.com/

Figure 2: Etruscan mining tool from the 8th century BC

https://parcocollinemetallifere.it/storia-e-cultura/

Figure 3: Quintette mine closed Tumbler Ridge BC.

Figure 4: Tumbler Ridge Geopark-logo and dinosaur prints

https://www.tumblerridgegeopark.ca/

The Bishop of Tasmania's Yacht and the California Gold Rush

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At eight o'clock on the evening of 20 February 1849, the *Psyche*, a yacht owned by the Anglican Bishop of Tasmania, was used by four convicts to escape from the penal colony of Van Diemen's Land. Popular opinion on the Hobart waterfront the following day was that the escape had been prompted by the news that gold had been discovered in California and that the objective of the absconders was to take the boat to San Francisco. There are two totally contradictory theories about the fate of the Bishop's yacht. One is that it was wrecked near Percy Island in the Great Barrier Reef leading to the recapture of two of the escapees. The other theory involves reports received from Tasmanian emigrants to California that the yacht had arrived and the convicts had gone to the goldfields. These reports were partly inspired by a recently arrived Vandiemonian merchant who wished to purchase the *Psyche* for use on the river route between San Francisco and Stockton.

This paper argues that it is possible to separate the two stranded sailors on Little Percy Island from the *Psyche*. Their claim, that they were survivors of the *Bona Vista*, a boat from New Zealand en route to the Torres Strait to fish for *beche-de-mer*, may have been true. The other two men, John Hill and Rees Griffiths, then could have sailed the *Psyche* to California. However, there are more important historical questions involved than the fate of these men. One concerns the reasons why the crowd on the waterfront on 21 February were unanimously of the opinion that Californian gold had prompted men with good conduct records to escape. The second involves the reasons why the enthusiasm so evident in January and February faded away so that the rush from Hobart only begins in June 1849. The third and most important issue involves the impact that gold rushes to California, Victoria and New Zealand had on the population structure of Tasmania by hollowing out the number of younger working age males and widening the gap between the upper and lower rungs of society.

California is seen as the least significant of the three gold rushes. Whilst true, historians have underestimated the number of gold rush emigrants by focusing only on the 17 ships that left for California in 1849. More people actually went on the fifty ships that sailed in 1850. They may have also misunderstood the structure of this emigration. The conventional thesis argues that the typical forty-niner was a young man who had done well by their own efforts or had the backing of well-off parents to afford the high cost of a trip to California. These were arguably the most likely persons to return. Analysis of the backgrounds of 1,371 persons who took ship for San Francisco from Hobart and Launceston is currently under way and shows that while the thesis is supported by many case studies, the statistical data suggest that the emigrants seem to be more varied than previously believed. The current paper will consider these issues largely with respect to persons involved in the story of *Psyche*. The convicts Hill and Griffiths are not included in the database. If they were, they would be emigrants number 3 and 4. Robert Swanston, the merchant who wanted to buy the *Psyche* in San Francisco, would then be emigrant number 6 being the first name on the passenger list of the *Harriet Nathan* which sailed from Hobart on 2 June 1849.

German Miners in South Australian Mining History

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When one thinks of mining in Colonial South Australia, it is usually the Cornish miners who come to mind. But German miners also played an influential and significant role in the early years of mining in South Australia.

Their influence dates from the 1837 arrival of Johann Menge, hired by the South Australian Company to act as mineralogist, geologist and quarrying adviser, and accompanied by four Harz miners to assist him. After officially opening the Kapunda mine in 1844, Menge stayed on for a while, assisting the Cornish men in ore-sorting and advising the mine owners, Bagot and Dutton. Menge's expertise was such that he has come to be considered the 'Father of SA mineralogy'.

But it was from the Harz area in the Kingdom of Hanover (now in central northern Germany) that most of South Australia's German miners and smeltermen hailed. Between 1845 and 1854, around 1400 Harz emigrants (mainly miners, allied workers and their families) came specifically to take up opportunities in South Australia's mining and smelting industries. The first of these were induced to emigrate by Menge's 1845 report about South Australian mining, and they found immediate employment at the Burra Burra mine: August Ey as mine captain and Dreyer and son in setting up the first smelting operations.

German leadership of the Burra Burra mine was short-lived and the mine was then run as a Cornish mine. Despite that, there were still significant numbers of Germans involved; in 1851, almost 20% of the miners were German. From 1848 onwards, a significant number of Harz ore sorters and dressers came to SA, their emigration no doubt made possible by financial assistance from the Hanoverian government, and they readily found work at the Burra Burra mine and elsewhere. Numerous Germans, like H.W.C. Fuss, also worked in the smelting works.

But German miners weren't only to be found at Burra. Wheal Gawler at Glen Osmond was for a time worked as a German mine. Harz miners found work at Kanmantoo and Callington from the mid-1840s into the 1860s, as well as at Moonta, Balhannah and on Eyre Peninsula. Some remained long-term in mining, with a small percentage holding the positions of mine superintendents.

Despite bringing significant mining expertise to South Australia and their involvement over several decades, one often needs to read 'between the lines' of mining history and interpretive signs to find the German contribution.

This presentation will consider the push and pull factors in the immigration of German miners to South Australia, the mining expertise they brought with them, and their participation in mining and leadership here in South Australia.

Pitwork at the Tasmania Gold Mine, Beaconsfield

Nick Langsford

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In 1903 the Tasmania Gold Mine at Beaconsfield was taken over by a London-based company directed by John Taylor and Sons. They installed three large pumping units with 20-inch plunger pumps driven by compound horizontal differential steam engines constructed by Hathorn Davey of Leeds. Two were installed at the 1500 foot deep Grubb's shaft and one at Hart's shaft pumping from 1370 feet.

The plunger pumps were driven by long strings of wooden rods, each weighing 180 tons, with in-shaft balance bobs. After closure of the mine in 1914, the permanent plunger pumps were removed from Hart's shaft. Reclaiming of the collapsed Hart's shaft in the period 1982-1998 allowed for recovery of almost all the remaining pump rods, fittings and temporary plunger pumps from the shaft.

As a consequence, the Beaconsfield Mine and Heritage Centre has an unrivalled collection of wooden pump rods of three different sizes with strapping plates, connectors and other fittings. Parts of the balance bobs and attachments, and the temporary plunger pumps were also recovered.

As well as the displayed artefacts there are many photographs taken during the shaft reclamation and recovery of the pumps. These allow a detailed reconstruction of the arrangement of the pump rods and attachments and how these massive items were put together and installed. Conference participants will be invited to consider the difficulties of doing this with very few mechanical aids and by candlelight.

Remaining parts of four pump rods in the collapsed Grubb shaft. Heavy steel plates were attached to the ends of the rocking quadrants driven by huge compound steam engines. Shaft was 1539 feet (460m) deep. Uppermost wooden pump rods are 22 inches square. Author photo.

Bendigo's Central Nell Gwynne Mine, Born out of the Great Depression

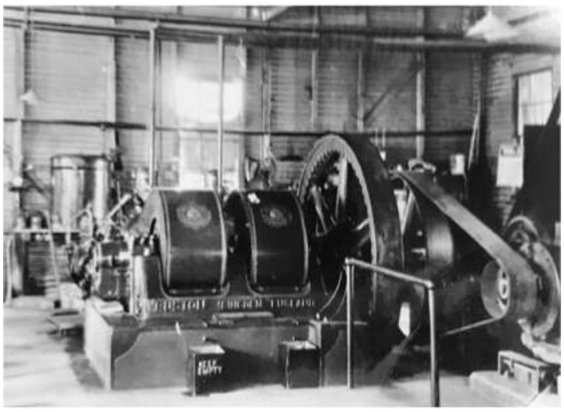
James A. Lerk

The indigenous Dja Dja Wurrung people had known about the existence of gold on their land for millennia, having carried small nuggets to distant myrniongs.[1] The European 'discovery' of gold at what became Bendigo took place in September 1851, but was not publicised for almost three months. Alluvial gold production that followed the rush to Bendigo Creek took some years to decline, but it was to be the quartz reefs that made Bendigo Goldfield famous and the richest in Eastern Australia.

One of the Bendigo reefs was named Nell Gwynne, after one of Charles the Second's mistresses. The Nell Gwynne Reef was the focus of mining attention at the turn of the twentieth century, however it was not until the Great Depression that a mine known as the Central Nell Gwynne was identified by a number of geologists as having potential for development and that it should receive priority in helping to provide a stimulus for a gold mining revival. Devaluation of the Australian Pound meant that the relative price of gold rose accordingly.

Some 70 companies were floated and operated on the Bendigo Goldfield during the period immediately following the Great Depression. Central Nell Gwynne was to be one of the more successful out of this number. The Company installed a modest plant at first, and when a large ore body was uncovered much new machinery and equipment were installed at the site; some of this equipment was to be requisitioned by the Commonwealth Government during World War II. During the war the mine was kept on a care and maintenance basis. In the post-war period reopening of the mine faced the challenges of rapidly rising costs and material shortages, along with a relatively stable gold price. The Central Nell Gwynne was forced to close in December 1949, after having produced almost two tonnes of gold.

View of Central Gwynne Mine showing the 21.1 m high poppet head, the tramway leading to the No.3 gyratory Jaques primary crusher and the enclosed conveyors to the ore bins in the battery house, with the engine room facing the photographer.
Fred Smith photograph, copyright James A. Lerk



Portion of interior of Central Gwynne Mine engine room showing a British-made twin cylinder crude oil engine on its massive cast iron bedplate. The engines were purchased through the Melbourne agent of Ruston Hornsby.
Fred Smith photograph, copyright James A. Lerk

[1] Myrniongs are camping places often associated with fire mounds.

A Proposed Goyder Geotrail Centred on Burra, South Australia: Bringing Geology and Mining to the Public's Appreciation

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Geology and Mining are vital activities contributing directly to an improved quality of life for all societies. Unfortunately, elements of the Environmental Movement are stigmatising these industries as merely exploitative. 'Geo' means 'World', not just 'Rocks'! One important tool in mitigating and improving the public image of these activities is the introduction of **Geotourism** with the aim of widening appreciation of these activities by a greater public audience. UNESCO designate certain geologically unique areas across the world as **Geoparks**. Important sites are designated or nominated for increased protection as **Geoheritage Sites**.

In Australia, the former Australian National Landscapes are now being re-evaluated for presentation as **Geo-Regions** with their particular, outstanding landscape attributes. Australia had one UNESCO Geopark, the Kanawinka Geopark, covering the Newer Volcanic Field from near Ballarat in central Victoria across the western volcanic plains to Mount Gambier and Mount Burr volcanic complexes in South Australia. For many reasons but also due to its sheer size (400 x 150 km) Kanawinka was unable to sustain itself through local community support alone and was deregistered after four years (2008-2012). Opposition from National Parks and Mining interests mistakenly assumed that a Geopark would (a) draw funding away from National Parks and (b) prevent mining and exploration activity. Reflections on these issues, particularly in Australia, have led to a different approach for the positive promotion of geology, mining and landscape tourism – the innovation of **Geotrails**.

The advantage of these are multiple –

- They are an instantly recognisable concept which appeals to local bodies, e.g. LGAs.
- They link landscape features and activities into a coherent story followed by travellers.
- They can include Abiotic, Biotic and Cultural elements (ABC) derived from the geology.
- They incorporate local history of land use including mining and associated activities.
- They can link Indigenous stories of landscapes alongside modern geological science.
- They connect local communities along the Geotrail, proud of their natural local assets.
- They can promote but protect special geosites.

Geotrails can be a single line, multiple strands or in loop form. The loop form allows a central regional tourism focus to be developed as a primary attraction to promote tourism.

The **Goyder Regional Council** has been developing a Geotrail concept for their region along the eastern edge of the Mount Lofty and Southern Flinders Ranges - the Adelaide Rift Complex. At its centre is the mining and historical complex of Burra – the location where the ICOMOS **Burra Charter** was inaugurated. The Geotrail is named after George Goyder, SA Surveyor General from 1861-1894 who assigned **Goyder's Line** along the 12 inch (30 cm) rainfall line beyond which cropping was risky. Many thousands of early farmers challenged this to their ruin and the evidence is still scattered across the landscape. The Goyder Geotrail incorporates regional geology, Burra's mining heritage and small regional mines, Goyder's Line itself, the stories of indigenous traditions and of settlers building a new colony and State. The Geotrail is expected to be a loop trail about 300 km long with Apps for smartphones etc. and signage of recyclable 'wipeable' plastics produced by a charity. The Goyder Geotrail can set new standards for exploring a large rural region with central themes and the elevation of geology and mining in the minds of our nation and its communities.

Sidwell the Bal Maiden: from Burra to Cobar

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Sidwell Woolcock was born in 1827 at Nancekuke Gate, northeast of Illogan, Cornwall. She was one of seven children born to Ephraim and Elizabeth Woolcock (nee Willoughby). When Sidwell was 8 years old her mother died during pregnancy. Her father remarried two years later. Probably in her mid-teens, Sidwell became involved with the Cornish mines. By 1851 aged 24, she was living independently with her youngest sister Mary Ann, at Illogan Downs and both were working as bal maidens at the local copper mines. Bal maidens were integral to the Cornish mining industry, undertaking the necessary ore dressing tasks.

After Marry Ann married a miner in 1854, Sidwell decided to emigrate to South Australia to assist her older sister Emma, who had emigrated to Kooringa (Burra) and married John Trevillian. Arriving in Burra in 1855, Sidwell lived with the Trevillians, helping her sister with a growing household. The famous Burra copper mine was in full swing and although it is unlikely that Sidwell worked at the mine it would have been a topic of household interest and discussion. At some point before 1858 Sidwell met Henrik (Henry) Kruge, a Norwegian sailor from Sanderfjord, and on 19 June that year the pair married at St Barnabas Church in Clare. The young couple purchased a wagon to set up as travelling hawkers. They worked around the Clare Valley before travelling to the Riverina region of southern New South Wales in about 1861.

Figure 1: Sidwell 1889.

In 1870 the Kruges settled on Priory Station northeast of Hillston, where Henry undertook contract work. In September that year they met three tank sinkers travelling south from an aboriginal water and ochre hole. The trio (two Danes and a Scot) had collected brightly coloured samples from this site which Sidwell immediately recognised as rich copper ore. Sidwell's advice that this was a significant discovery persuaded the tank sinkers to return to the locality and take out an MCP claim, the initial step in development of the Great Cobar Copper Mine. Without the fortuitous meeting and Sidwell's identification it is likely that the tank sinkers would have ridden on and not taken up the find. The discovery sparked a copper prospecting boom in the surrounding area and other deposits were found.

The following year Henry and Sidwell set up a store and 'shanty' at Gilgunnia on the route between Hillston and the new settlement of Cobar. In 1873 they built the Gilgunnia Hotel on a 160 acre selection and it soon became renowned for cheerful, courteous and efficient service under Sidwell's management. When gold was discovered at Gilgunnia, Henry also became involved in prospecting. Henry died in 1888 aged 54. Sidwell continued operating the hotel assisted by Hans Monkerud. In July 1889 Sidwell remarried and the hotel licence was transferred to her new husband, James William Dean. The marriage turned very unhappy: Dean squandered Sidwell's assets and physically abused her. When she refused to live with him in 1892, he stopped supporting her, forcing her to eke a living renting out two small miner's cottages. In 1905 she sued Dean for support, but the magistrate found that Dean, who had offered to support her if she returned to him, had insufficient means to do so. Sidwell lived with her sister Mary Ann who had emigrated to Australia and moved to Cobar. Sidwell died there on 17 April 1913.

Sidwell's role in the Cobar copper discovery was widely acknowledged and in gratitude the tank sinkers presented her with a gold pendant. However, no great financial rewards accrued to her.

Putting the Personal into Writing Mining History

Heather Nimmo

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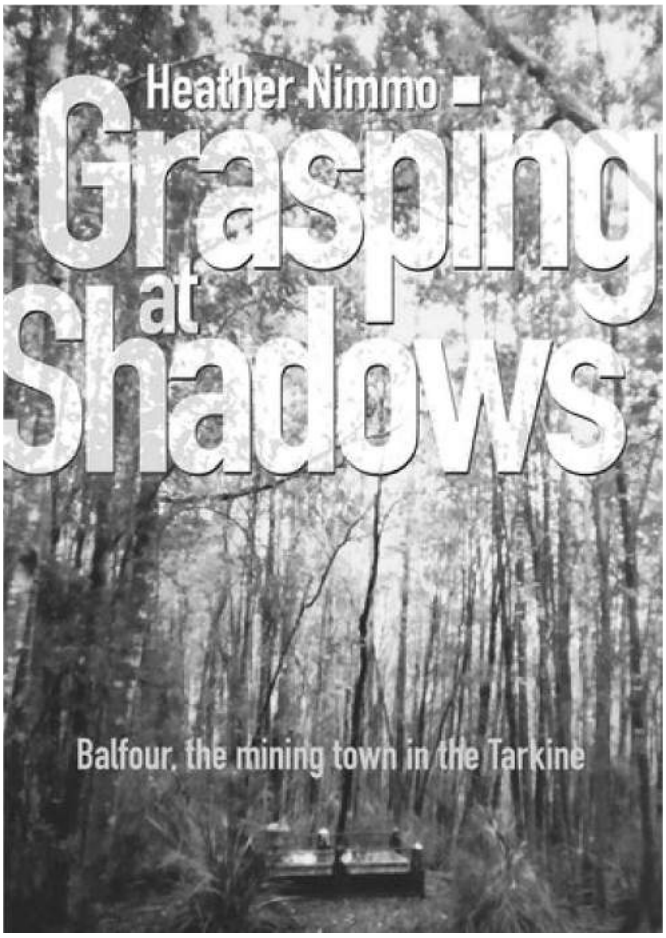
I shall use what I learned from writing my book, *Grasping at Shadows: Balfour, the mining town in the Tarkine*,[1] to discuss how to engage and entertain those readers who do not yet enjoy mining history, through creating distinctive voice(s), characters and dramatic structure.

In October 1975 I fell in love with a geologist. In May 1976 I resigned from my job teaching at an Adelaide high school to follow Nick to the abandoned Tasmanian mining town of Balfour. My fellow teachers presented me with a copy of *Autobiography of a Yogi* and fifty HB pencils. I wanted to write but at 23 I had nothing of interest to say, so I decided to tell the story of Balfour and its people. This is both a personal story of my life at Balfour between 1975 and 1981 and an imaginative account, based on research of the largely forgotten mining town and district lying in what is now the Tarkine.



Always a tin scratchers' field, Balfour (in Tasmania's remote northwest) became a copper mining boom town between 1906 and 1914, attracting such mining luminaries as T.B. Moore, Robert Carl Sticht, the mining journalist Randolph Bedford, and the Broken 'Hillionaires' and Mount Lyell investors, Bowes and Aloysius Kelly. There was much speculation, an 'old boys' last throw of the dice, and some mining. The Murray brothers, gentlemen sons of an Anglican priest, worked their Reward lease, but when the rich surface ore failed at depth and the miners couldn't be paid, William Murray shot himself, and his brother Thomas became a broken man. Stitch's sons attempted to recoup some of their father's unprofitable investment in Murrays Reward by extracting copper from the mine dumps by flotation using eucalyptus oil, and when that failed, turned to large-scale tin scratching, until they too, with their mother and her maid, abandoned the field. The town lingered on until the 1930s but there were substantial exploration efforts in the area, BHP looking for tin and ACI for copper in the late 60s and early 70s.

[1] Heather Nimmo, *Grasping at Shadows: Balfour, the mining town in the Tarkine*. Forty South Publishing, Hobart, 2021, pp 212.

The Angas Deposit, South Australia: a Tale of Discovery 150 years in the Making

Joseph Ogierman

Consulting Geologist

South Australia has a somewhat unusual mining industry compared with other Australian states; it is blessed with several 'giant' deposits such as Olympic Dam and Carapateena and a plethora of small to very small deposits, mostly worked in the 19th Century. There have been very few mid-sized mines with Moonta, Kanmantoo and the Angas near Strathalbyn being among the exceptions. The 3Mt Angas Pb-Zn Mine was opened in 2007 but is has a much longer history, with the orebody actually discovered in 1869 during later stages of the state's first mining boom. Unfortunately, the discovery was not developed and what followed was nearly 140 years of it being missed and dismissed by prospectors, farmers, miners and geologists before its true potential was realised in the early 21st Century.

The story of the Angas deposit and mines in the surrounding Strathalbyn district in the late 19th Century has many parallels with the mining industry in the 20th and 21st Centuries; there are tales of unscrupulous mining promoters, stockmarket booms and crashes, unsupportive land owners and metallurgical challenges – a case of 'everything old is new again'.

Ultimately, successful development of Angas in the 21st Century relied on the "3 Ps" – patience, persistence and perspective and, ironically in a world of modern exploration techniques, detailed mining records from the 19th Century. Angas is a great example of the importance of preserving old data and having that data widely available to everyone, something with which the South Australian Department of Mines has been very proficient.

What has Angas taught us? That if it took 140 years to find a 3 Mt deposit which outcrops in cultivated farm land, only 50 km from a city of 1 million people and which had been walked and driven over by hundreds if not thousands of people. What does it imply about the prospectivity of the rest of the state where outcrop is poor or non-existent, population density is low and exploration data mostly restricted to large-scale, open-source geophysical surveys?

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Aerial view of Angas Mine and treatment plant

Mining Heritage for the Twenty-first Century

Dr Darren Peacock

Chief Executive Officer, National Trust of South Australia

The year 2023 marks the centenary of the closure of the original Moonta Mines on the Yorke Peninsula in South Australia. Over a sixty-year period from 1862, Moonta became one of the most advanced hard rock mining sites in the world, utilising and advancing the techniques that originated in the tin and copper mines of Cornwall. It also was the heart of a Cornish cultural community that survives to this day.

One hundred years from the closure of the mine, the National Trust will be re-opening the Moonta Mines site as a cultural and tourism destination following a significant Commonwealth Government investment in conservation and interpretation works at the site.

Moonta, alongside Burra, was added to the list of National Heritage Places in 2017. The national listing of these pre-eminent Australian Cornish Mining sites is a precursor to nomination for world heritage listing in conjunction with the original Cornish mining sites inscribed on the world heritage list in 2006. The National Trust, in conjunction with the Goyder and Copper Coast Councils, are advancing the case for world heritage listing for the Australian sites. That process requires the preparation of detailed nomination documentation including evidence of how the site is protected and managed.

Conserving and interpreting the site as a place of global significance and with relevance and resonance for today's visitors is a complex challenge. The world of the Cornish miners at Moonta that ended abruptly in 1923 is now several generations distant from the culture and life experience of today's visitor to the Australian Cornish Mining sites in Burra and Moonta. This presentation will discuss how the National Trust is approaching the task of preserving and presenting the site as a cultural and industrial landscape and developing its potential as a community and tourism asset.

Conservation works at Hughes' Pump House (March- June 2022)

Keeping History Alive at the Blinman Heritage Mine

Susan Pearl

Manager, Blinman Heritage Mine, Blinman, South Australia 5730

Even today Blinman is considered remote. It still has an old-world charm of an untouched bygone era, except for the stream of cars arriving daily.

The Blinman Mine tour seeks to "transport people back into the 1860s" via "an underground theatrical experience" and it certainly does that according to many reviews and testimonials.

Blinman was named after Robert Blinman "Pegleg" who discovered the outcrop of copper in December 1859. The mine was worked by four companies in four distinct periods from 1862 to 1907; it was anticipated to be "a grand mineral prize"[1] but this aspiration was not achieved. Like most other Cornish mines there were substantial buildings, chimneys and mine infrastructure unfortunately dismantled and sold off in the Depression to build other things. Untouched in stable solid rock are drives, shafts and stopes dating back to the early 1860s.

With such a unique mine on its doorstep, members of the Blinman community considered the long-term viability of the town (population 20). Numerous discussions occurred to explore the viability to develop the mine into a tourist attraction, followed by a variety of meetings with government departments, geotechnical engineers, mining engineers, mining inspectors, historians, and creative people. The mission and vision of the Blinman Heritage Mine was set and work began in to earnest realise a dream.

Now some 20 years later, with tours running for just over 10 years, the name of Blinman is now known much more widely than Pegleg could ever have imagined!

This presentation will cover a brief history of the Blinman mining operation and the various considerations necessary to develop a popular, highly regarded and profitable geo-tourism product meeting a myriad of legislative and heritage requirements.

Table 1: Visitation numbers and tours 2011-2021

Year	Tours	Visitors
2011-12	265	2446
2012-13	604	3108
2013-14	676	4251
2014-15	733	4507
2015-16	891	6071
2016-17	1062	6766
2017-18	1108	6448
2018-19	1149	7023
2019-20	917	5867
2020-21	1385	8988

Figure 1: Blinman Mine 1907

Source: Blinman Archives

[1] N. Klassen, *The Northern Flinders Ranges: Mountains, Minerals and Mines*. Lutheran Publishing House, Adelaide, 1991, p.16.

The Life and Career of Uriah Dudley: Mining Engineer, Inventor and Freemason

Geoffrey Randall

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Shortly after Uriah Dudley was born in 1852 in Bedfordshire, his family emigrated to Australia, settling first of all in Geelong. The family moved to Gympie after the discovery of gold there in 1867. Uriah Dudley completed an apprenticeship as a mechanical engineer at John Walkers' Foundry in Maryborough (Qld) and in 1872 went to the Herberton tin field where he came under the influence of the United Grand Lodge of Good Templars which was promoted and sponsored by the mining entrepreneur John Moffatt. In 1879 he returned to Gympie as operator of an engineering company.

The early 1880s saw Dudley in Sydney where he studied mining engineering and geology through the Sydney Board of Technical Education. With the boom in mining activity in the Barrier Ranges in western NSW, he was appointed manager of the Sydney Rockwell Mine, one of a number of short-lived mines in the Broken Hill district. In 1889 he was appointed Operations Manager of the Umberumberka Mine near Silverton and became an active member of the Silverton community: he was Principal Instructor in physics, mathematics, mining, geology and chemistry at the Silverton Technical School, Mayor of Silverton in 1890-1892, Justice of the Peace, Chairman of the Licensing Court, a member of the Hospital Board, President of the Silverton Chess Club, and an early member of the Umberumberka Masonic Lodge.

With the decline of the Silverton field, Dudley moved to Broken Hill in 1893 as manager of the chloridising works of the BHP Co and was also an instructor in mining and mineralogy at the Broken Hill Mechanics Institute. As Secretary of the Broken Hill Mine Managers' Association he was a founding influence and Secretary of the Australasian Institute of Mining Engineers (which later became the Australasian Institute of Mining and Metallurgy).

In 1895 he left Broken Hill for Coolgardie where he managed the Golden Bar Mining Company and later a mine at Menzies. The turn of the century saw him in Denver City, Colorado, managing a mine, but in 1901 he returned to Western Australia to manage the Emperor Gold Mine in the Murchison field. In about 1907 he travelled to England to promote the Great Fingal Group of mines of the Murchison Field and became a member of a number of English mining and geological societies. After suffering a debilitating stroke in England he returned to Australia and died at Annandale in NSW in 1909.

Uriah Dudley. Source: Wikipedia.

Uriah Dudley was a gifted and versatile engineer who recognised the need for better education of those involved in the mining industry. He also had a number of inventions to his credit, mostly in the field of ore-processing,

Geotourism: Conserving Heritage and Generating Post-Mining Economies for Communities

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In launching a national strategy for geotourism development in April 2021, the peak body - the Australian Geoscience Council Inc (AGC) consulted with one of its key members, the Australasian Institute of Mining and Metallurgy (AusIMM) through the auspices of its Heritage Committee working with the Societies of Social and Environment, and Geoscience. The objective was to determine how best the development of geotourism throughout Australia can enhance the scope of regional development of mining areas during current mining activities and after mine closure. Geotourism adds considerable holistic content value to traditional nature-based tourism as well as cultural attributes (embracing both Aboriginal and post-European settlement) having regard to mining aspects and can be delivered through mechanisms such as geotrails and geoparks within defined 'GeoRegions'. By raising awareness of the importance of the area's geological heritage in society today, geotourism gives local people a sense of pride in their region and strengthens their identification with the area.

In recognition of these benefits, the National Geotourism Strategy embraces seven strategic goals that include Goal 5, i.e., 'to develop geotourism in regional mining communities with potential geoheritage and cultural heritage sites.'

Goal 5 identifies opportunities for geotourism in rural and regional Australian post (or active) mining communities, where their recreational, educational, and cultural values can be realised.

Goal 5 also aims to draw attention to the range of activities (including museum and geotrail development) that could be conducted in these places. By way of example, a national mining park has also been proposed for the Hunter Valley to celebrate the significant role mining has played in Australia's development since the first coal mining in Australia by Aboriginal people (on a small scale) prior to European arrival.

The AGC considers that Goal 5, where it is applied to mining activity, can be developed through collaboration between member professional societies and organisations researching mining and resource industry heritage. These include mining companies, geological and mining museums (e.g., the Australian Fossil and Minerals Museum, Bathurst) and historical societies (e.g. the Australasian Mining History Association (AMHA), the Eastern Goldfields Historical Society Inc., Boulder, Western Australia, and the Burra History Group, South Australia). Aboriginal cultural elements and landscapes cut across widely accepted, post-settlement landforms and landmarks, and have values specific to various groups and individuals. Therefore, there is potential to incorporate and/or communicate (with permission or via collaboration) creation stories and narratives of landscapes and features through geotourism.

The AusIMM has also identified several topics that could form the basis for incorporating this aspiration into Goal 5. This includes issues relating to the consequences of mine closure. The current emphasis is on environmental remediation (make safe, stable, and non-polluting). This needs to be broadened to preserve the mining heritage, including gossans and other geologically significant exposures, structures (e.g. buildings, workings, and equipment) and other artifacts (e.g. mining and personnel records). A mine site at Rosebery in Tasmania has agreed to participate in a geotourism focused, pilot project.

Ayers and the Burra: "Australia's first mining giant",[1] Politician and Serial Premier – the Man and the Myths

Jason Shute

Henry, photographed by Frith of Melbourne, c 1864

What tied this young migrant to the fortunes of the South Australian Mining Association through the good times and the bad for over 50 years? How was his 'safe pair of hands' reputation, fostered by that experience, capitalised upon through his political career in the colony's responsible-government era post-1857? How did the go-getting young mining Secretary transform into the reformist Premier of the 1870s, via a good dose of Unitarianism? Accolades came in the form of a knighthood for hastening the completion of the Telegraph Line and, simultaneously, the application of his name to Australia's central 'Rock'. As that association fades, in favour of Uluṟu, how accurately and, indeed, how much, is he remembered today, as a pioneer of either South Australian industry or its polity?

As late as the mid-1930s, his name could be invoked as an inspiration for younger South Australians facing the Depression. Since that period, however, it has slipped into the mists of time with even his Adelaide home – 'Ayers House' and its museum - recently in danger of disappearing from public view. It's high time to re-evaluate the career for which he had never been consciously prepared and yet could make his own.

ST Gill's Burra Mine, c 1850

[1] As referred to when Inaugural President of the Australasian Institute of Mining and Metallurgy at its 1894 meeting

Northern Territory Heritage: Update on the Pine Creek Miners' Park and a Proposed Geotrail

Peter Waggitt[1] and Mark Asendorf[2]

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The Northern Territory of Australia has a long and rich history of mining activities. Perhaps nowhere more so than around the famous Pine Creek Orogen (PCO), which was the focus of a gold rush in the 1880s that saw the town of Pine Creek become the centre of a significant gold mining industry that continues to this day. There are few dedicated memorials to this history, the most obvious is perhaps the Miners' Park set up in 1988 by a dedicated group of enthusiasts. This is a permanent collection of old mining machinery salvaged from historical workings in the PCO, and displayed as much as possible to show how they may have been used.

The management of the park is complex, with the site sitting within the heritage listed Historic Railway precinct containing buildings and a museum managed by the National Trust (NT). However, the low level of funding available means that care and maintenance of the grounds is almost the limit of activity. A new toilet block has been installed for use by visitors to the park and the museum. In 2018 the Darwin Branch of the AusIMM undertook the replacement of the information signs for much of the equipment and a similar plan of remedial action is underway this year (2021) to update some elements of the park, which will include a contribution from the National Trust.

The success of the recently created Darwin City Geotrail (DCG) has led some local geoscientists and mining people to consider setting up a geotrail for the Pine Creek area, taking in the Miners' Park and some other local features, including the lookout over the former Enterprise mine pit.

The presentation describes the process and progress for the park update and the plans for the proposed geotrail. Initial work has begun on the form of this project. Further funding options are being considered over the next 6-18 months to enable completion of Stage 1. Further options for additional works in the Miners Park are also included in this presentation.

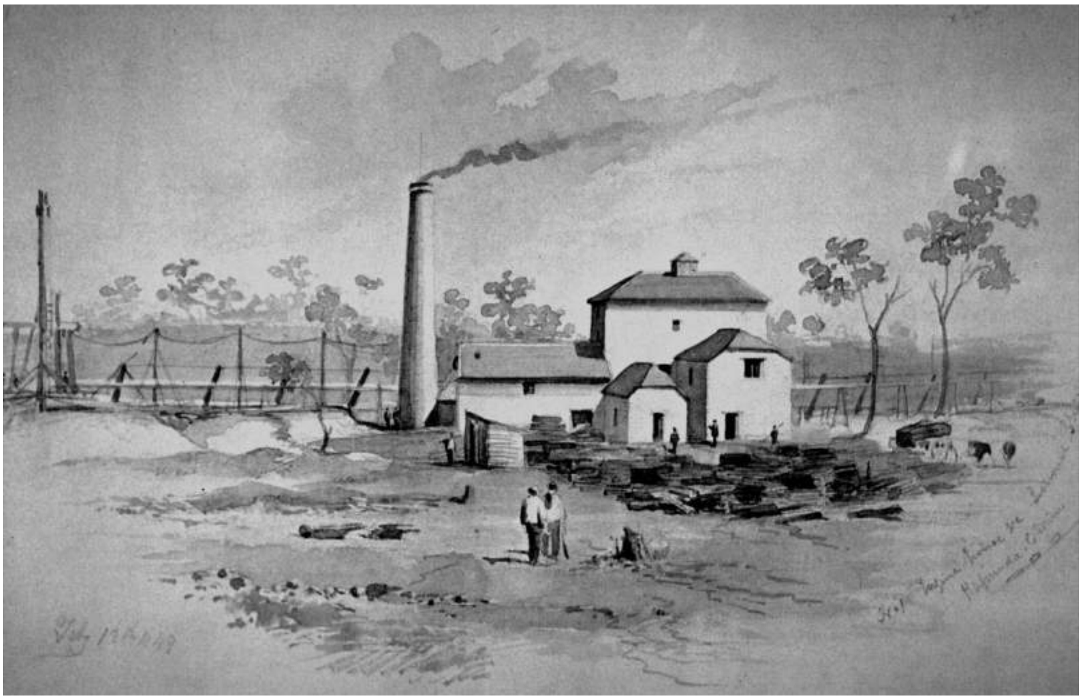
General view of the headframe and the Miners' Park

Example of a new sign at the Mine Lookout

The Kapunda Copper Mines

Copper ore was discovered on unoccupied land at Kapunda in 1842. Two neighbouring pastoralists formed a syndicate, bought the land and sent ore samples off to Swansea for assay. The results were encouraging, and in early 1844 they hired a team of experienced Cornish miners and started work. It was the first significant find of copper in Australia, and the first copper mine to go into production.

At first, surface ore was simply shovelled into drays and shipped to Swansea for treatment, but as the mine went deeper and struck water, technological assistance was required. In 1847 a Cornish engine was installed for pumping, and in 1849 the first reverberatory furnace was built. In 1865 a Scottish company took over the mines, and built a Henderson plant, which extracted copper from the ore by leaching and precipitation.



S.T. Gill 1849, Kapunda Mine. Draft Enginehouse showing winding rope and flat rods which transmitted drive to the shaft pump.

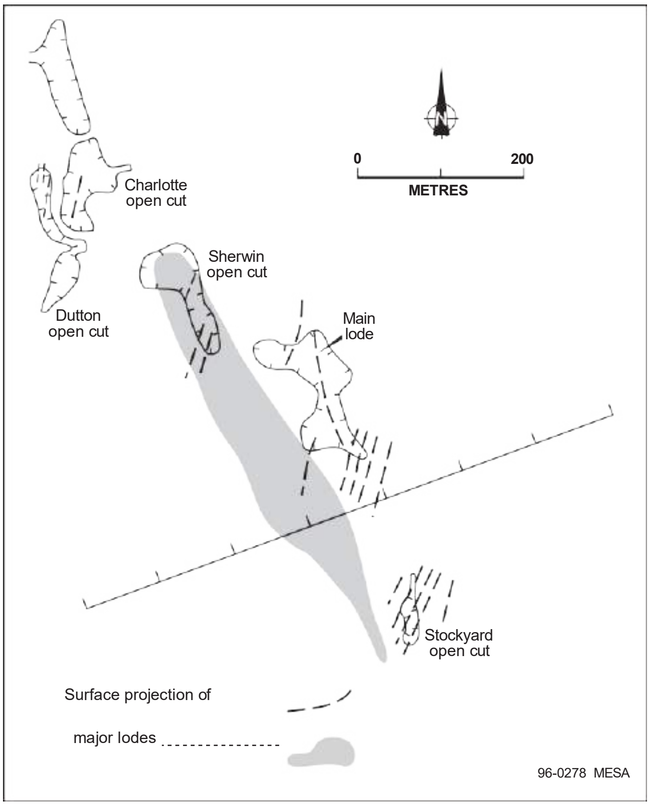
However, the operation was struggling financially, and about 1867 the underground workings were closed, and the mine went over to open cut extraction to reduce costs. In the following decade, the open cut obliterated all remains of the numerous shafts, diggings and machinery which had littered the mining landscape. The end came with the world-wide collapse of the copper price in 1877, which closed the Kapunda mines after a total recorded production of 69,000 t of ore. In the 1960s and 70s the land was acquired by the local Council with the intention of preserving it as a historic site.

Mine Geology[1]

The local geology consists of folded and faulted sediments of the Tapley Hill Formation. In the Kapunda Mine area, the local strike is to the north-northwest and dip is about 45º to the west-southwest. Most of the mineralisation itself occurs within what has been termed the "Kapunda Mine series" by Rowlands et al. (1978). This unit is 500-700 m thick, consisting mainly of massive to laminated siltstones that contain pyrite and pyrrhotite, and include two cupriferous units, dolomitic siltstone horizons, ranging from 50 to 300 m in thickness

(Lambert et al., 1980). The mineralised dolomitic units grade laterally into un-mineralised siltstone.
Primary mineralisation is in two main forms: 1) low-grade disseminated to bedded, 2) discordant to concordant chalcopyrite-pyrite-pyrrhotite-carbonate-quartz veins (Lambert et al., 1980). Chalcopyrite is the main copper-bearing mineral, and pyrite and pyrrhotite are also present. The veins mainly have sharp irregular contacts with the host rocks, and there is no associated alteration. The veins are interpreted as tensional structures by Lambert et al. (1980).

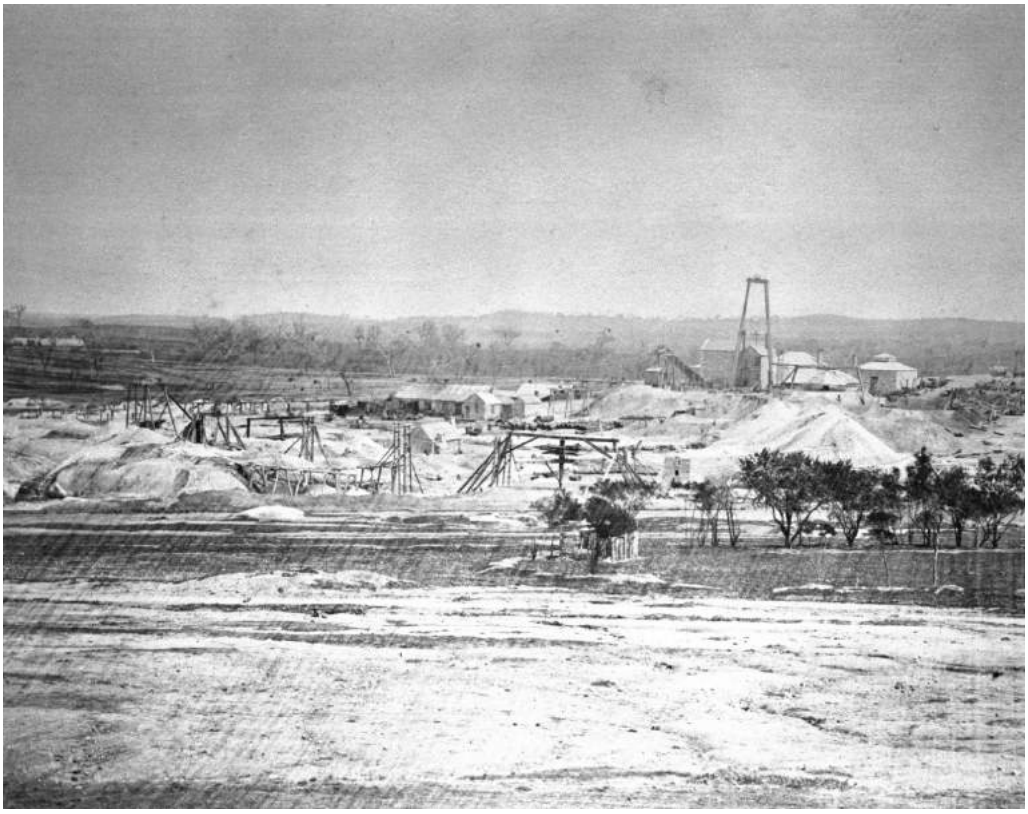
Mining was mainly of secondary ore, created by supergene enrichment of the vein mineralisation (Dickinson, 1953). The oxidised zone is characterised by leaching near the surface, with a south-plunging zone of enrichment, typically 75 m thick, below this. The vein mineralisation at Kapunda coincides with a northwest-trending zone of kaolinised sediments, about 150 m wide (Fig.18). Some mining of primary mineralisation occurred, but this was of substantially lower grade. The mineralised veins are sub-parallel, trending about 5-20° and dipping between 60 and 80° to the west. The "main lode" is an exception, trending 340350° and dipping at 30-45° to the west, parallel to bedding.

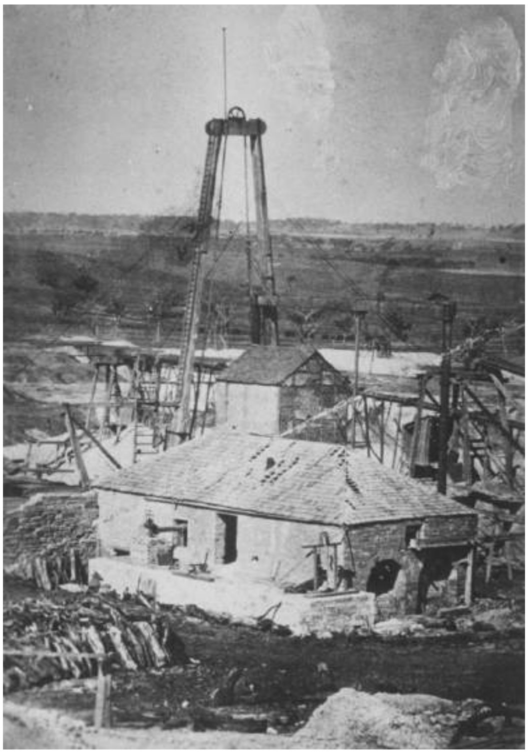


Simplified map of the Kapunda mine area showing surface projection of mineralisation and position of geophysical traverse (10N) in Figure 20. Geological data based on Dickinson (1953).

The locations of veins were thought by Dickinson (1953) to be joint-controlled, since evidence of displacement is rare. The mineralised veins define an en-echelon pattern and may be related to movements on a fracture zone trending north-northwest, parallel to a conjugate joint set. Within this zone three joint sets are observed, which lie parallel to the mineralised veins, the trend of the kaolinised zone and the bedding, respectively. However, Thomson (1963) interpreted the structural control to be the intersection of northwesterly dipping fractures and bedding planes. The orientation of the main lode shows that bedding did play some role in the localisation of mineralisation. Besides the main ore zones, low-grade disseminated mineralisation occurs in the "kaolin ore body". This mineralisation trends sub-parallel to the zone of supergene-enriched vein mineralisation, and has a shallow plunge to the southeast, closely corresponding in the vertical plane with the supergene-enrichment zone.

[1] Extracted from: Mike Dentith & Robert Stuart (2003) Sediment-hosted stratiform copper deposits in the Adelaide Geosyncline, South Australia: Geophysical responses of mineralisation and the mineralised environment, ASEG Extended Abstracts, 2003:3, 169-196, DOI: 10.1071/ ASEGSpec12_14





Kapunda Mine and Buhl Enginehouse c.1875

Post-conference tour to Wallaroo and Moonta

Introduction

Copper ore was discovered on grazing land at Wallaroo (modern Kadina) in 1859 and nearby Moonta in 1861. According to folklore, the Moonta ore was unearthed by a burrowing wombat. The Moonta ore deposits were vastly bigger than those of Burra or Kapunda, and the mines were profitable and self-funding from the outset. The mines, with their coastal smelter and port at Wallaroo, created three towns which became known as the Copper Triangle.

In 1876, Moonta became the first company in Australia to have paid its shareholders a million pounds in dividends. By 1900, the tailings accumulated at Moonta were estimated to contain 25,000 tons of copper metal. A leaching plant was set up by an expert from Rio Tinto in Spain, and extensive leaching and precipitation works were added to the mine landscape. By the First World War, the mines were down to nearly 800 metres depth, and production costs were high.

The post-war fall in the copper price could not be sustained, and in 1923 Moonta closed. The cheap leaching operation was still profitable, and operated until 1944. Over their lifetime, the Copper Triangle mines produced over 300,000 tons of copper metal, more than half of it from Moonta

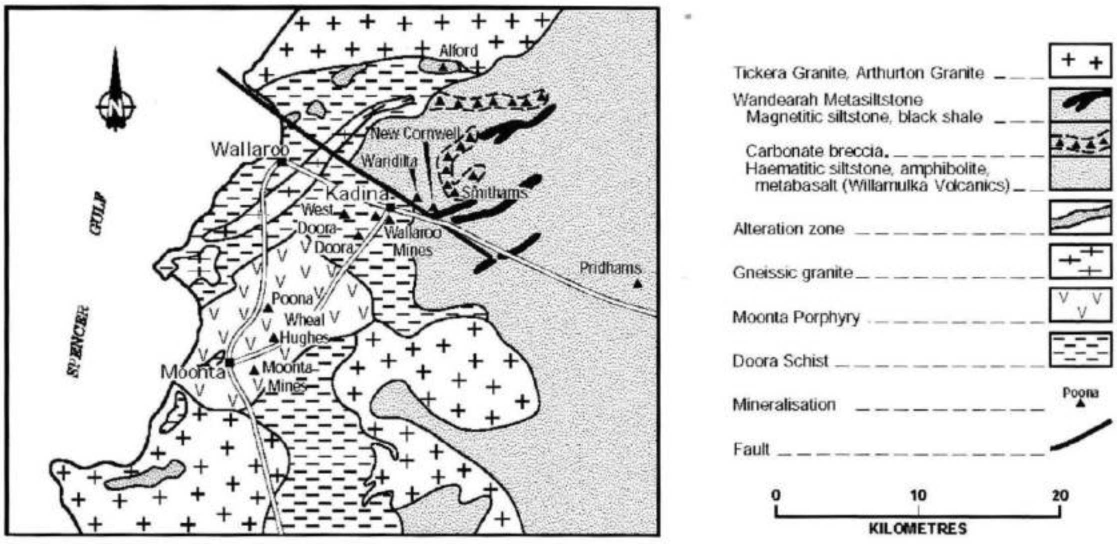
View of Elders Lode from Richmans Tailings Dump, Moonta Mine, c.1900

New discoveries at Poona and Wheal Hughes in the Moonta field led to development of open cut and underground operations by Moonta Mining Joint Venture, with a total production of 19,055 t of ore averaging about 5 % copper and 1 g/t gold between 1986 and 1994.

Geology of the Moonta-Wallaroo Mining District

The Moonta-Wallaroo Mining District is located in the eastern part of the Archaean-Proterozoic Gawler Craton. The Moonta and Wallaroo ore deposits are hosted by the Proterozoic Moonta Porphyry and Doora Schist, respectively, both of which are concealed beneath a thin cover of younger Proterozoic, Cambrian and Cainozoic sediments. The Moonta Porphyry is a fine-grained, metamorphosed volcanic rock which has been dated at 1740 Ma. The Doora Schist is in contact with the Moonta Porphyry in the Wallaroo field and consists of metamorphosed sedimentary rocks.

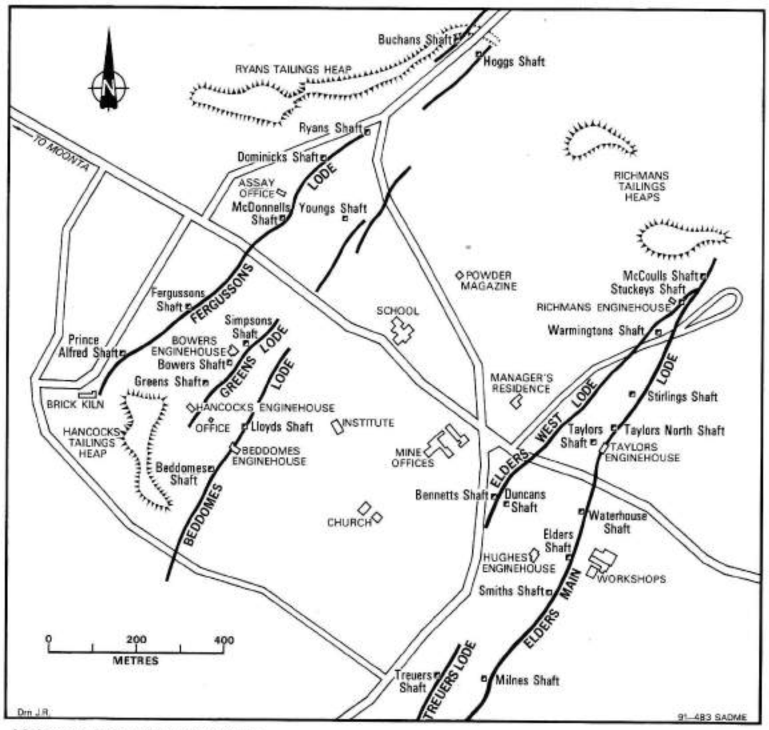
The Arthurton and Tickera Granites were emplaced following the 1850 to 1700 Ma Kimban Orogeny. These granites are equivalents of the Hiltaba Suite granites that are widespread in the Gawler Craton, and have ages in the range 1600-1585 Ma.



General Geology of the Moonta-Wallaroo Mining District

Ore Deposits - Moonta District

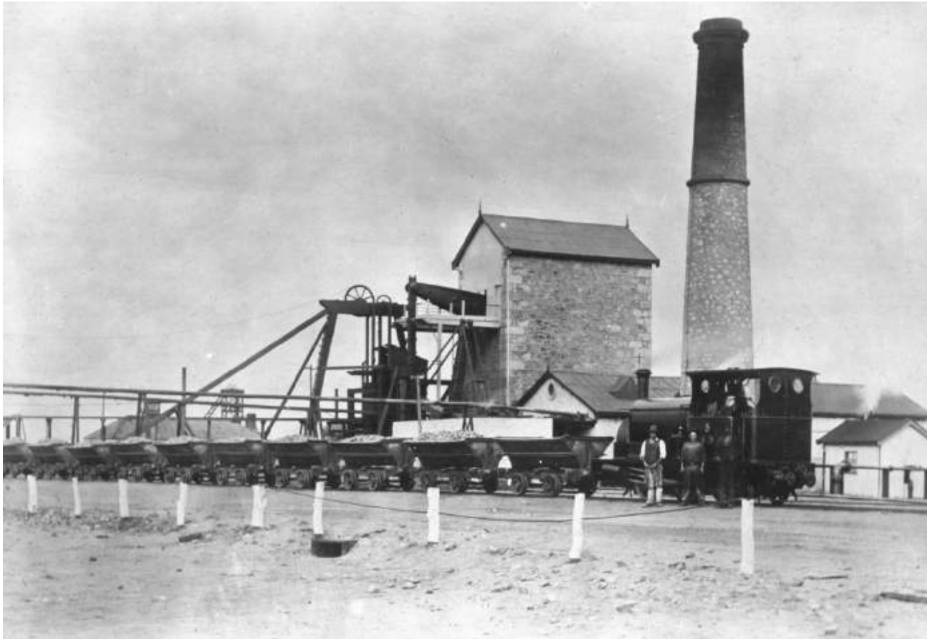
Ore bodies (lodes) in the Moonta district typically have the form of tabular veins within fractures and shear zones in the Moonta Porphyry. Veins up to 10 m wide and up to 1500 m long were mined to depths of almost 700 m. The majority of the veins are located in a series of concentric arcs trending from NNE to ENE. The largest veins (e.g. Taylor or Elder) are hosted by structures known as Main Lode Shears that dip 40º to 65º NW. West Lode Shears dip approximately 60º NW, but diverge in strike by about 15º from Main Lode Shears, and do not host major ore bodies, although high-grade ore shoots are located at the intersections with Main Lode Shears. The dominant primary minerals of the Moonta ores are chalcopyrite, bornite, pyrite, hematite, magnetite, quartz, tourmaline and chlorite.



Major ore lodes, Moonta Mines

Hughes Enginehouse

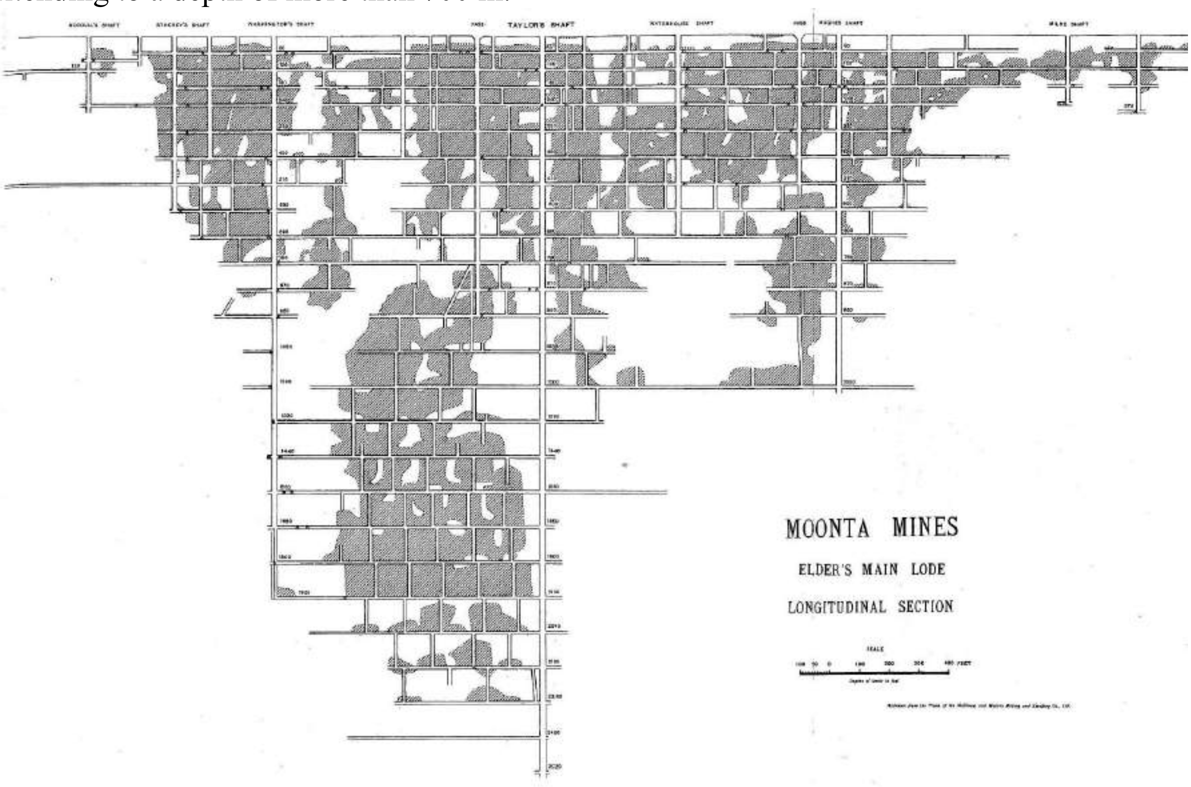
Hughes 60-inch Cornish pumping engine was erected in 1865 at Hughes Shaft, the principal pump shaft on Elders Lode. The shaft was sunk vertically to 128 m where it intersected Elders Lode which it followed on the underlay to the 365 m level. Flat rods connected to balance bob operated pumps in Taylors Shaft.



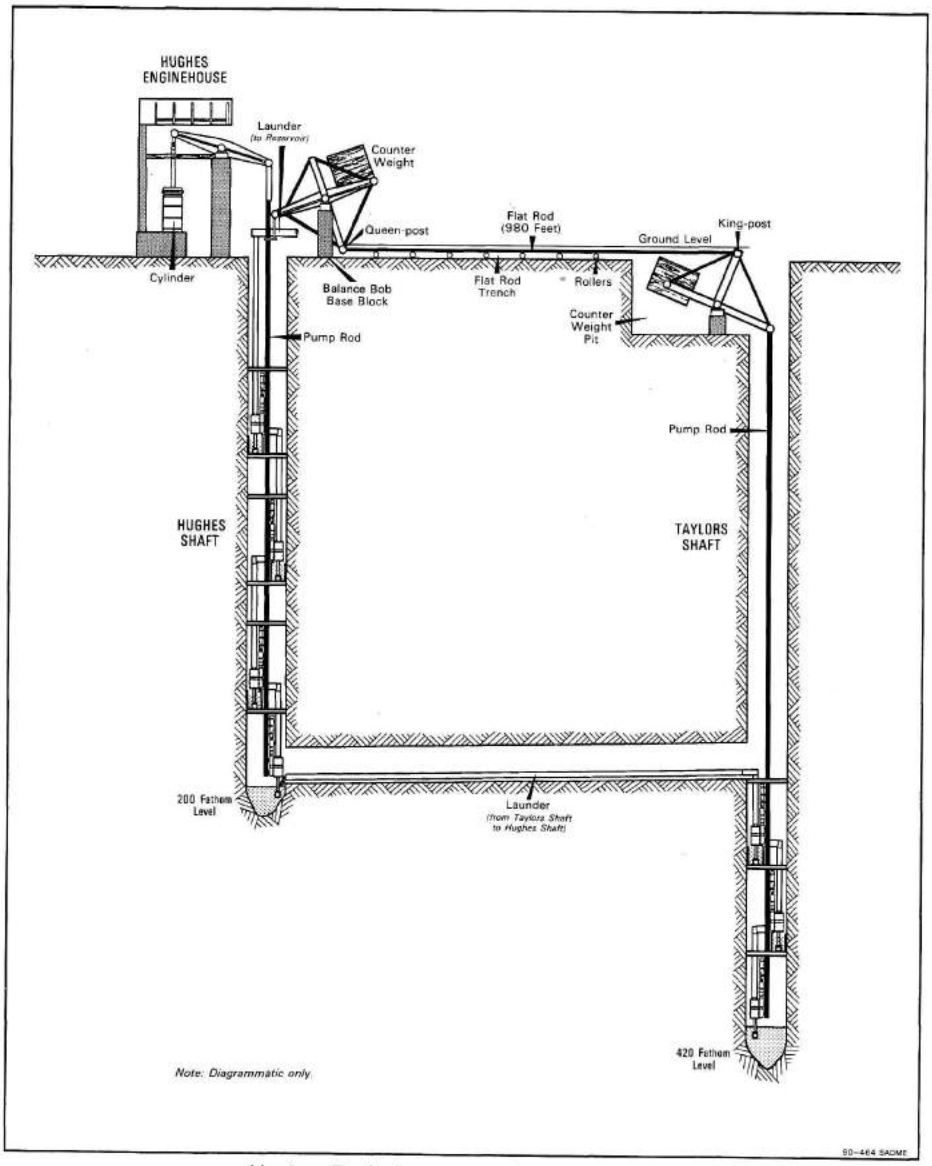
Hughes Enginehouse, c.1915

Elders Line of Lode

Elders Lode was the most persistent at Moonta, worked for a length of about 1000 m and extending to a depth of more than 700 m.



Taylors Shaft was the principal shaft on Elders Lode reaching a depth of 768 m. Hauling was originally undertaken by Prankerds Engine which was replaced in 1901 by Taylors horizontal winding engine. In 1868, pumps in Taylors Shaft were connected by flat rods to Hughes Engine 300 m to the south. Hughes Engine continued to operate those pumps until the mine closed in 1923.



Hughes Enginehouse pumping arrangement

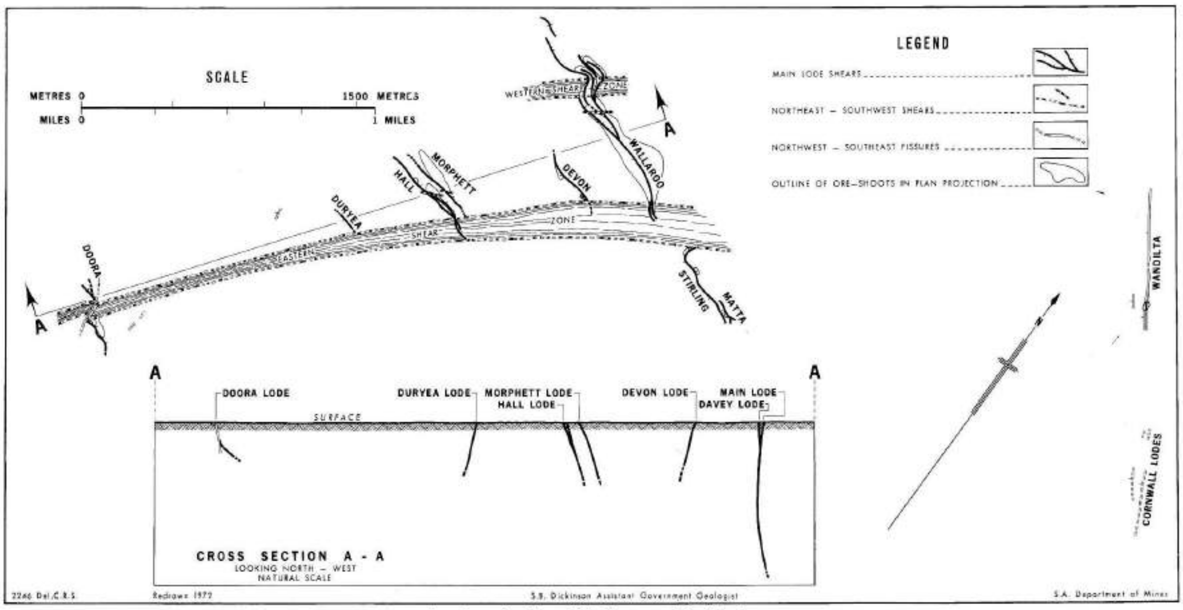
Richmans Enginehouse and Tailings Dump

Richmans 32 inch Cornish beam rotative engine was erected in 1860 to power crushing and concentrating machinery for treatment of low-grade ore. The coarse tailings were placed on the adjacent tailings heap. Buddles were added in 1875 to concentrate the fines from the process and the resultant slimes placed on large flat areas to the north and west.

Ore Deposits - Wallaroo District

The Wallaroo ore bodies were fewer in number compared to the Moonta district and occur within the Doora Schist. Most ore bodies are located in Main Lode shears which run approximately E-W and contain large and continuous ore bodies. The largest of these, the Wallaroo Main Lode, dipped steeply, varied in width from less than 1 m to more than 20 m and was mined over a distance of about 1000 m and to a depth of 850 m. It contained two productive shoots - Taylors and Youngs. Two major NE-SW shears have disrupted the Main Lode shears – the Western and Eastern shear zones.

The main minerals in the Wallaroo ores were chalcopyrite, pyrite, pyrrhotite, magnetite and minor galena and sphalerite in a matrix of quartz and carbonate minerals (calcite, dolomite, siderite and rhodocrosite). Bornite and hematite were much less abundant than in the Moonta ores.



Lodes in the Wallaroo District

Mining Methods at Moonta and Wallaroo

Shafts on both fields were sunk on the incline following the lodes, the deepest being Taylors Shaft, Wallaroo Mine, at more than 900 m. The Cornish system was used to drive horizontal tunnels or levels at regular intervals connecting shafts. These levels were initially at intervals of 10 fathoms (1 fathom = 1.83 metres) but were increased by Captain Hancock to 15 fathoms after 1870 and later to intervals of 20 fathoms.

Mining was carried out by overhand stoping, where miners worked upward from the upper part of one level towards the bottom of another. The resulting excavation or stope was therefore arranged so that broken ore fell to the level below and was trammed to a hauling shaft. A stope was worked by taking about one metre off the roof of the stope at one end, continuing to work towards the opposite end. Where the lode was wide and the ground weak, timber pillars known as styes, were erected to support the roof. As the roof was removed, the styes were increased in height and filled with crushed rock or attle which was conveyed by attle passes to the worked-out sections of the mine.

Gunpowder was used to break the rock and was placed in shot-holes drilled by hand, using a technique known as hammer and tap. After 1880, gunpowder was replaced by dynamite and, later, small rock drills worked by compressed air supplied from a central power plant were introduced.

History of Wallaroo Smelters

In 1861 the Wallaroo mining company built a smelter on the coast at Port Wallaroo, which treated ore from both mines. They relied on traditional Welsh smelting methods in reverberatory furnaces. Major technological re-development followed in the 1890s. A sulphuric acid plant was built, capturing sulphur fumes from flue gases. This led to a superphosphate fertiliser factory being built alongside by a separate company. A diesel powerhouse and an electrolytic refining plant were built.

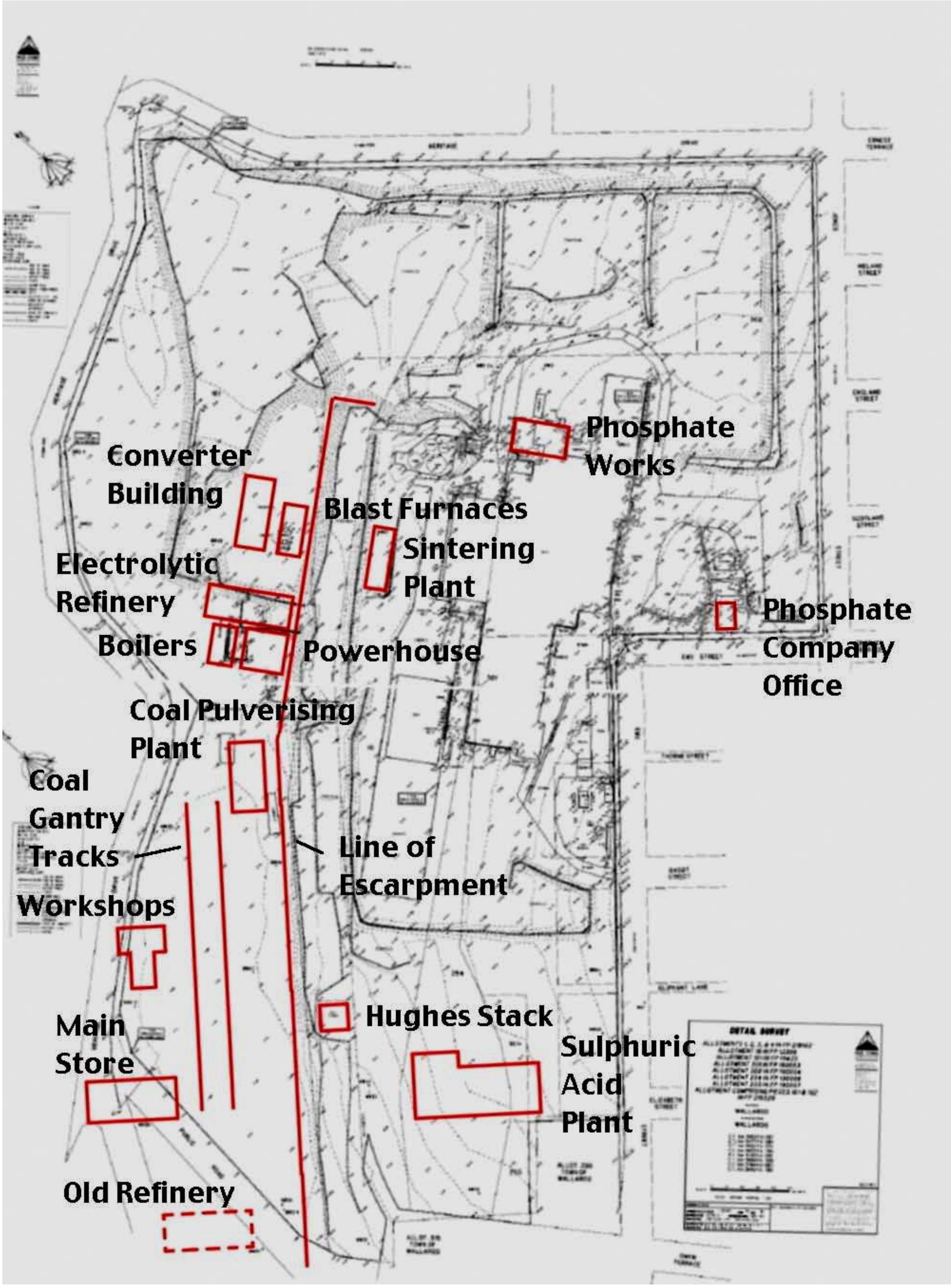
In 1899 the first waterjacket blast furnaces were installed, and came to dominate the smelting process, replacing the old Welsh methods with American and German technology. By the turn of the twentieth century, Wallaroo was being described as "the largest smelter in the world". In 1910 barrel converters were added to the flow diagram. By this time the old smelters of 1861 were abandoned and mostly demolished, and every new development moved the focus of the smelters further to the north.

What we see on the site today is mostly the remains of the new technology from 1899 onwards. The First World War brought a boom in copper prices for a while, followed by a bust as the war wound down. By 1919 the price of base metals had plunged, and mines were closing all over the world. The Moonta and Wallaroo mines struggled on until 1923, by which time the world price of copper no longer covered the costs of extraction and smelting. The smelters remained in operation for a while longer, treating ore stockpiles, but closed in 1926.

Total output of the smelters in 65 years was about 330,000 tons of refined copper. The demolition that followed was very thorough, destroying buildings and taking every piece of metal for its scrap value. For decades afterward the site was left open, and the citizens of Wallaroo took home any useful building materials they could find, so not much remains today.

If you would like to read a longer history of the Wallaroo smelters, you can download a report from
https://www.academia.edu/21680096/Wallaroo_Smelters_Site_Heritage_Assessment

Wallaroo Smelters ca.1900.



Plan or Wallaroo Smelters

The following pages are from Drew, G.J. and Connell, J.E., 1993: Cornish Beam Engines in South Australia. Department of Mines and Energy, South Australia, Special Publication No. 9.

THE FOUR LEVELS OF A BEAM PUMPING ENGINEHOUSE

The beam pumping enginehouse had four levels (or chambers), which allowed access for maintenance to the various engine components (Fig. 18).

The top chamber

At this level, the massive cast iron beam weighing 20 to 40 tons, was supported on the *bob wall*. The outdoor end of the beam was connected to the pump rod which extended down the shaft. The indoor end was connected to the piston rod via the loop and parallel motion.

To prevent the engine going beyond its working distance on the indoor stroke and damaging the cylinder bottom, large timbers, called *spring beams*, were installed lengthwise in the enginehouse. Several pieces bolted together, known as the *main girder*, were laid transversely under the spring beams and bedded into the side walls of the enginehouse. An iron *catch wing* was fitted to the indoor end of the bob and in normal operation came down to within an inch or two of heavy striking blocks fixed to the spring beams. The main purpose of the catch wing was to warn the engine driver if the engine was over-stroking. A light warning rap indicated the piston was approaching too close to the bottom of the cylinder. The driver altered either the steam governor or the cut-off point to reduce the amount of steam allowed to enter the cylinder.

If this was not controlled, the piston could strike the bottom of the cylinder with disastrous results. The spring beams and girder often did little to save the engine in the event of a major failure, such as a broken pump rod, which might occur during the indoors stroke under steam pressure.

The middle chamber

The feature of this chamber was the *cylinder cover* and *nozzles* (or *valve chest*), containing the *governor, steam* and *equilibrium valves*. The *valve gear*, operated by the arbors and other gear in the chamber below, moved the links to open and close the valves at the right moment. The *piston rod*, moving in and out of the *cylinder gland*, was connected at its upper end to the loop of the *parallel motion*, to give its motion to the beam. The parallel motion linkage, anchored by a pair of links fixed to the massive timber cross girder, ensured that the piston rod moved in a vertical line without side thrust, while the end of the bob swung in its natural arc.

The bottom chamber

In the centre of this chamber was the steam-jacketed *cylinder* usually encased in polished wood for insulation. It sat on massive bedstones anchored to a large block of stonework by long bolts (two, four, five or six according to size and design) passing down to the bottom of the cockpit. In front of the cylinder was the *valve gear*.

The cockpit

The cockpit provided access to the *cylinder bolts* via *crow holes* and contained the *exhaust valve, eduction pipe, cataracts* and weights which operated the valve control arbors.

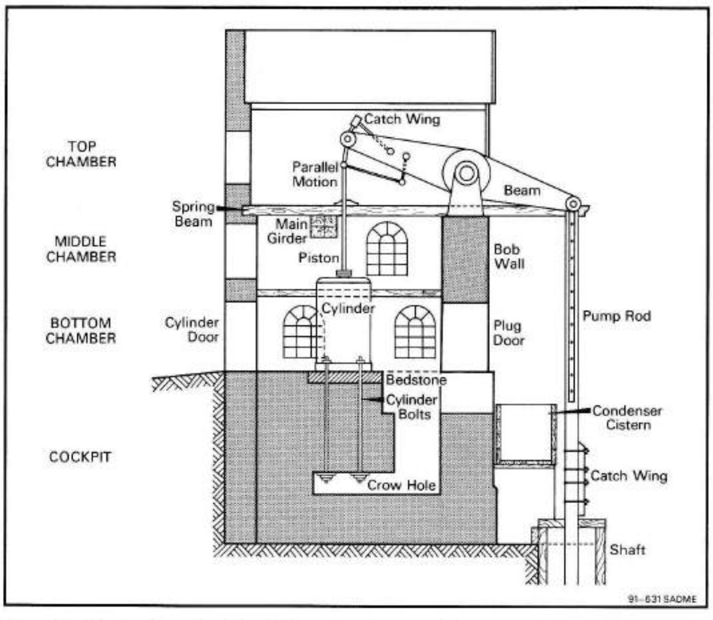


Figure 18. Section through a Cornish beam pumping enginehouse.

How a beam pumping engine works

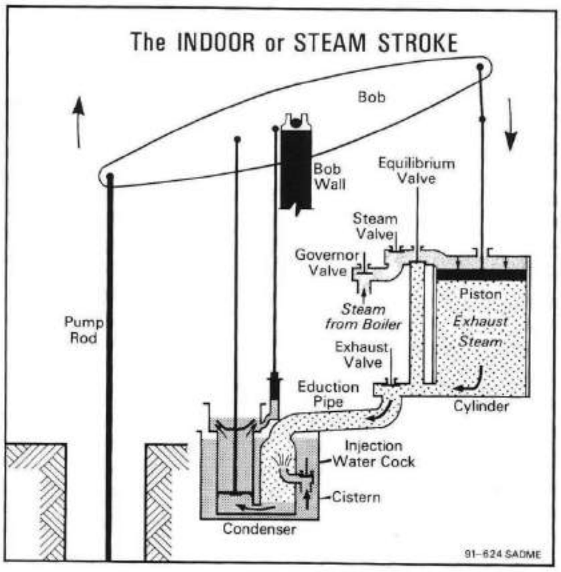
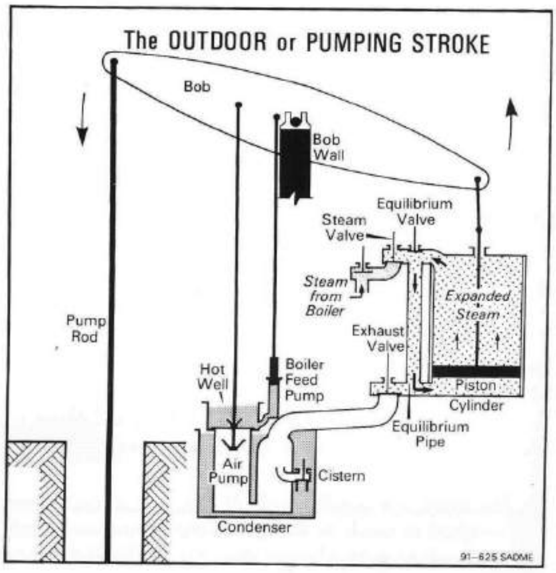


Figure 9a. The indoor or steam stroke.
At the start of the engine cycle, steam at 30 to 40 psi entered the valve chest or top nozzle high up in front of the cylinder via the hand-controlled throttle or governor valve. When the steam valve opened, steam entered above the piston, depressing it and raising the pump rod. This was known as the steam or indoor stroke. As the piston descended, steam remaining under it from the previous stroke expanded to the condenser beneath the floor via the eduction pipe and exhaust valve. The injection water cock let cooling water into the condenser from the surrounding cistern. This reduced pressure beneath the piston and assisted the live steam pushing on top of the piston. The steam valve shut at about one third of the stroke, the exact cut-off being selected by the driver. The piston continued to move by expansion of the steam helped by the vacuum below and the inertia of the beam, rods etc. until it reached the bottom of its travel when the exhaust valve and injection water cock closed. The controls caused the equilibrium valve to open, initiating the outdoor or pumping stroke.
Note: The governor valve was manually controlled by the engine driver but the steam, equilibrium and exhaust valves and injection water cock were operated automatically by the engine valve gear.

Figure 9b. The outdoor or pumping stroke.
The opening of the equilibrium valve allowed the expanded steam above the piston to pass down the equilibrium pipe, equalising the pressure on both sides of the piston and allowing the weight of the pump rod to take charge and displace the water in the pumps. Closure of the equilibrium valve as the piston approached the top of its stroke cushioned the descent of the pump rods in the shaft. The engine paused at the top of its stroke until a cataract or timing device in the cockpit allowed the steam valve to open and repeat the cycle.
All the time the engine was running, a mixture of cooling water and condensate from the exhaust steam settled in the condenser. The mixture had to be pumped out otherwise it would quickly accumulate and choke the engine. Any air entering through slight leaks at the glands or joints also had to be expelled. This scavenging was done by the air pump which was connected by a rod to the engine beam and lifted the water into the hotwell during the indoor stroke.
Water in the hotwell was not drawn back into the condenser at the end of the stroke because of a swimming cover which tended to be sucked down on to its seat by the vacuum. The air pump bucket had two bronze flap valves which opened on its return stroke. Some of the water in the hotwell was drawn into the feed pump and delivered back to the boiler, the rest overflowed to waste.



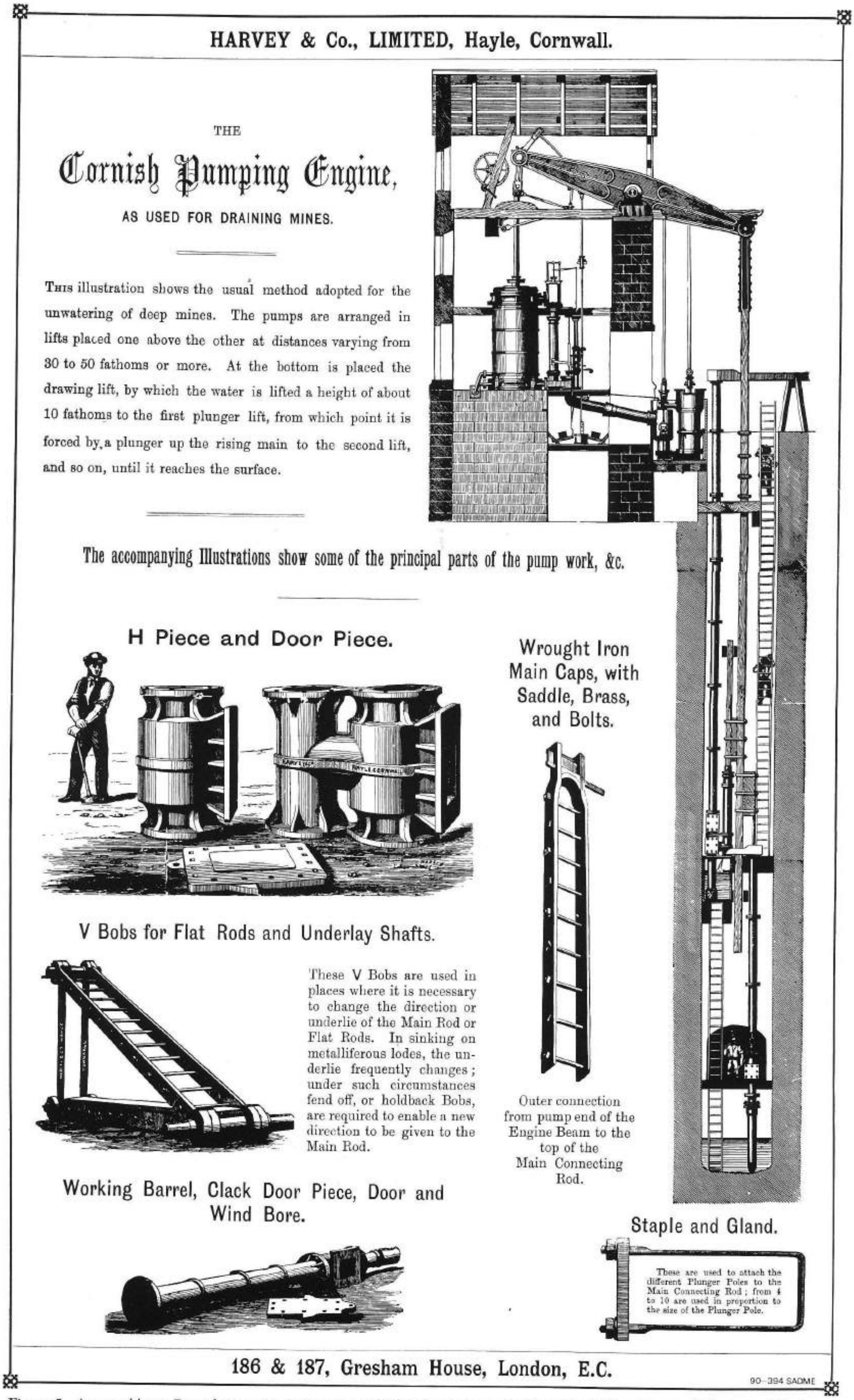


Figure 5. A typical large Cornish pumping engine as installed in South Australia (from the 1884 catalogue of Harvey and Co.).

BEAM ROTATIVE ENGINE

Engines to provide rotating motion had a variety of names. The term *rotary engine* is reserved for engines in which the driving parts rotate rather than reciprocate. James Watt had experimented with a rotary engine in which a blade intended to be driven round a central shaft was propelled by a steam jet[2]. This proposal was not developed and Watt successfully carried on experiments with the reciprocating engine. Today the term *rotary engine* can be correctly applied to the steam turbine and the Wankel rotary internal combustion motor.

The reciprocating engine, which provided rotary motion, was therefore given the generic classification of *rotative engine*. The early name was *fire whim* for engines used for mine hauling. Whim is the Cornish word for winding device, derived from the Icelandic *hvima*, meaning giddiness, folly, freak or caprice, and was used for the horse-driven winding device for hoisting ore from a mine. The early water-raising device of Thomas Savery of 1696 for *draining a mine* was patented as a *fire engine*, the use of fire seeming more important than any other feature of the device[3]. Hence a whim using steam, or more basically fire, became a *fire whim*.

Various names were applied according to the application of the rotative engine; winding, hauling, crushing or dressing were common classifications. The rotative engine was generally similar to the pumping engine in its main features (Fig. 11), but as the continuous rotating motion could operate the valves, it did not require cataracts. The engine, initially, was single-acting and similar to a pumping engine at the steam or indoors end. Although James Watt had built a double-acting engine by 1783[4], single-acting rotative engines continued to be made for many years.

Beam rotative engines were generally not more than 36 in. diameter with strokes of 6 to 7 ft and occasionally 9 ft maximum. The outdoor end of the beam was connected by a connecting (or sweep) rod to a crank to produce rotary motion. A flywheel, with a diameter of at least 12 ft, was required on large engines to keep the engine moving over the idling sections of the cycle. Early engines worked at about 20 rpm but, later, speeds of up to 30 rpm were common. Drive from the crankshaft was generally by clutch and gearing arranged to suit the required speed and power on multi-purpose engines.

Initially, the valves of the rotative engine were the same as those of the pumping engine, operated by the plug rods but without cataracts. Later it was found easier and better to operate the valves from a rod driven from a mitre gear on the crankshaft which in turn drove a camshaft to operate the valves by push rods. Alternatively, an eccentric on the crankshaft provided an oscillating motion to work the valves[5]. Two eccentrics were used to operate link mechanisms for reversing controls.

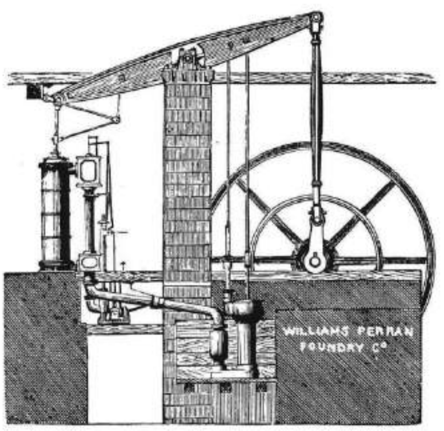
In 1797, William Murdock, James Watt's chief assistant, invented the D slide valve[6] (see Appendix B). This was used to a limited extent on beam rotative engines and was adopted as standard for the horizontal engines which were to follow 50 years later.

One further improvement made by Watt was to fit a speed governor[7]. This centrifugal device could be adjusted to run the engine at the desired speed. Should the engine

WHIM ENGINE,

WITH WINDING CAGE ATTACHED

The accompanying illustration represents a side elevation of a Whim Engine with Winding Cage attached. This is the ordinary Engine employed for raising the productions of the Mine, and is sometimes adapted for the threefold purposes of Winding, Crushing, and Pumping. These Engines are made in the best modern style and of any power required. Estimates for simple Winding Engines, for Engines adapted to other purposes, with pump, gearing, straps, and



boilers complete, furnished on application. These Engines are well finished and made in the most approved style and of any power required. For Winding, it is only necessary to state the height and daily tonnage of the lift. If for Crushing, state the number of tons and description of material required to be crushed in a given time; and if for Pumping, the depth of mine and quantity of water (in gallons) to be raised per hour.

90–397 SADME

Figure 11. Typical beam rotative engine, c.1866-1870 (from the 1870 catalogue of the Williams' Perran Foundry Co.).
The cylinder end appears much the same as on the Cornish pumping engine with typical valve gear and nozzles (but lacking plug rods), condenser, air pump and feed pump. The drive to the valve gear cannot be seen but it presumably came from the mitre gear or eccentrics on the crankshaft by a rod horizontally behind the engine bearing timber. The valve gear on rotative engines was subjected to many variations of design.

24

Bull Engine

Edward Bull had been an erector working for James Watt and saw advantages in eliminating the beam. Accordingly, he set up his own business, working in conjunction with Cornish engineer Richard Trevithick. Bull developed the engine which took his name and installed at least ten in the 1790s, before James Watt prosecuted him for infringement of patents. Harvey's Foundry paid more attention than others to Bull type engines, particularly for waterworks operation. One such waterworks engine made by Harvey and Co. in 1856 with a 70 in. diameter cylinder, is preserved at the Kew Bridge Steam Engine Museum near London and is operated at weekends.

The Bull engine had basic advantages in that it dispensed with the heavy and costly beam and required an enginehouse that was not nearly as large, heavy or costly. Despite these advantages, it was not popular as it was not adaptable to other than pumping. Since the cylinder covered much of the shaft, access was difficult and maintenance, such as simple packing of the piston rod gland, was dangerous, not to mention support of the weight and thrust of the engine over the shaft.

The Bull engine was generally more jerky in action than a beam engine, on which the inertia of the heavy beam tended to smooth the stroke action. The action of the valves or nozzles was similar to that of a beam engine and cut-off could be varied for expansive operation with steam economy. Lower fuel consumption was claimed for a direct acting engine as compared with an equivalent beam engine, but this is uncertain[11].

A special half beam was fitted to operate, via a plug rod, the valve gear, air pump and boiler feed pump, as for the Kapunda Bull engine. On some models the balance bob served this purpose, as for the Bull engine at North Rhine. The steam valve could be adjusted by the driver to cut off steam at about a third of the stroke to allow the rest of the stroke to be made by the expansion of the steam for greatest economy.

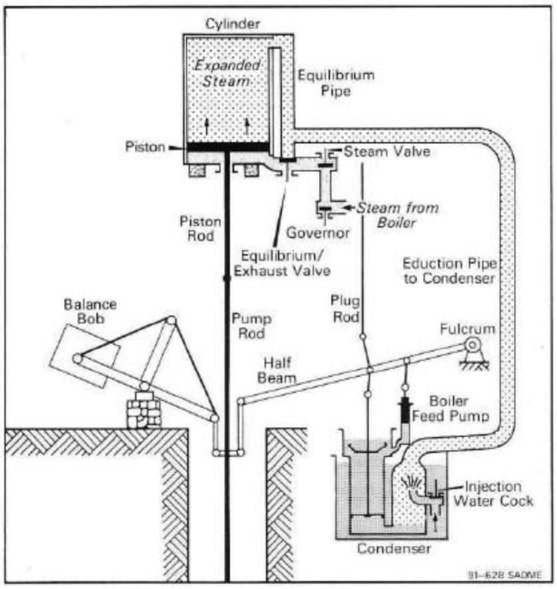


Figure 14. How a Bull pumping engine worked.
At the start of the pumping cycle with the piston at the bottom of the cylinder, steam at 30 to 40 psi entered the valve chest or bottom nozzle via the hand controlled governor valve. When the steam valve opened (as drawn) steam was admitted under the piston, which rose by reason of the steam pressure below and vacuum above. The pump rod rose with the piston, as did the balance bob. As the piston rose, steam remaining above it from the previous stroke passed to the condenser via the equilibrium and eduction pipes. The vacuum created in the condenser communicated directly with the top side of the cylinder thereby assisting the live steam to move the piston through its stroke.
At the end of the stroke, the equilibrium/exhaust valve opened and allowed steam pressure to equalise above and below the piston via the equilibrium pipe at the same time as steam passed to the condenser. The weight of the pump rod then prevailed and the pump rod and piston moved slowly down forcing the water up the rising main. The speed of descent could be restricted by limiting the opening of the equilibrium/exhaust valve.

Table 5. Bull engines in South Australia.

NAME OF ENGINE	MINE	CYLINDER DIAMETER (ins)	MAKER	DATE MADE	DATE STARTED	HP	STROKE (ft)
Ansteys[1]	Tungkillo	48	Harveys	1849	23/05/1850	70	8
Buhl	Kapunda	36	Harveys	1849	01/03/1851	36	8
Bingo	Bingo	50	-	1850(?)	1862	75	-

[1]Re-erected at North Rhine Mine in 1859 and at Wallaroo Mine in 1867

Notes

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