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Article · January 2006

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Hidden Copper: The Early History of the Cornish, Scottish and Australian (C.S.A.) Mine, Cobar, NSW

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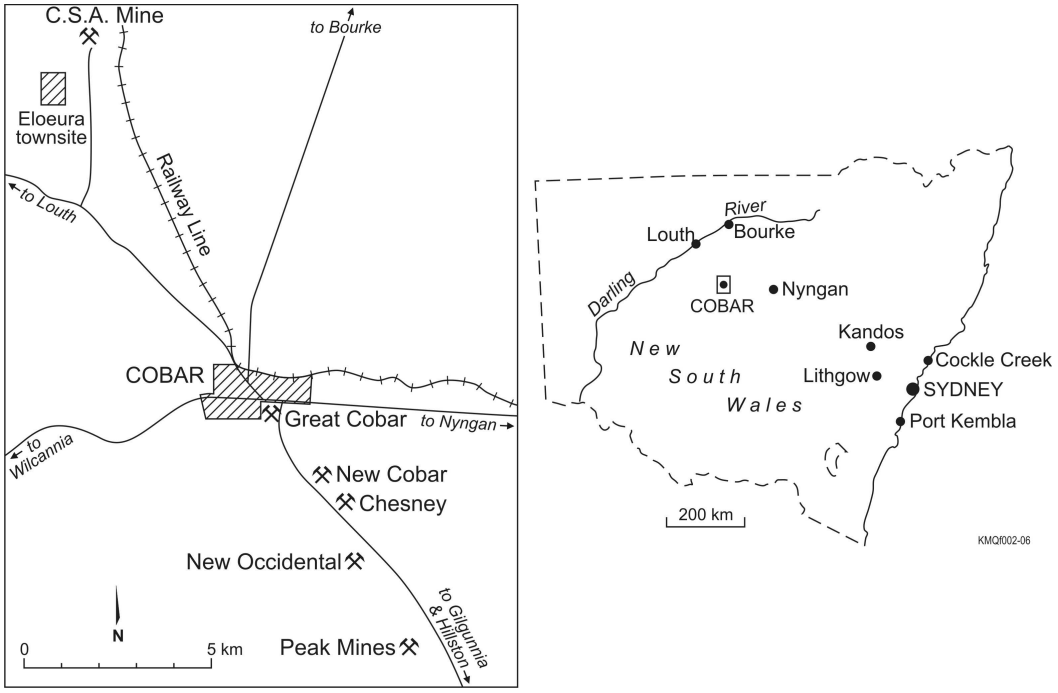
The Cornish, Scottish and Australian mine north of Cobar in western New South Wales had an inauspicious beginning. After discovery of the outcropping gossan and initial speculative optimism during the copper boom of 1872 there was a long and disappointing period of testing and exploration by a number of groups before commercial mineralisation was finally located in 1905. This was rich secondary lead and silver-bearing ore and its discovery sparked another exploration boom in the region[1]. It was not until 1910 that the first significant copper ore was discovered. By this time more than £100,000 had been expended on exploration and development with no return to shareholders. Successful copper mining followed, until a disastrous underground fire closed the mine in 1920. Exploration and deep drilling from 1947 to 1960 finally showed the full potential of the C.S.A. deposit.

Figure 1: *Location of the C.S.A. mine in relation to Cobar and some other historic mines. State map shows the locations of some other sites referred to in this article.*



Redevelopment and persistent near mine exploration from the 1960s through to the present has led to the discovery of further hidden ore bodies. The C.S.A. is now recognised as the largest copper deposit in the Cobar region, containing an estimated 1.6 million tonnes of copper metal.[2] Between 1965 and 1996 the C.S.A. mine contributed more than 50 percent of the total copper production of NSW and up to 2005 had produced a total of 596,250 tonnes of copper.[3] This is the first detailed account of the history of discovery and early development of this major ore deposit and illustrates the trials and tribulations that were encountered by the various prospectors and companies when chasing the lodes.

Discovery

In the spring of 1870 copper was discovered at 'Kubbur', an aboriginal water hole on the dusty plains between the Darling and Lachlan Rivers.[4] Three contract tank sinkers, Charles Campbell (true name Ferdinand Emilius Kempf), Thomas Alfred Hartman (true name Jens Arnholdt Gottfred Albrecht Hartmann) and George Samson Gibb, had been led to the water at this site by their aboriginal guides Frank and Boney, while travelling from Louth on the Darling River to Priory and Gilgunia. The party camped overnight at the water hole and noticed bright green and blue staining in the kaolin and 'raddle' on the walls of the rock hole. In the early 1860s the three contractors had tried their luck on the Victorian goldfields and were sufficiently curious to collect samples of the brightly coloured mineralisation.[5] The next day as they continued south they met Henry and Sidwell Kruge and showed them the specimens. Mrs Kruge (nee Woolcock) had worked as a 'bal girl' in the Cornish copper mines and was probably also familiar with the copper ores of Burra in South Australia.[6] She immediately identified the samples as copper ore. Campbell, Hartman and Gibb returned to Bourke, and on the 6th of October 1870 in partnership with local postmaster and businessman Joseph Becker, they took up a mineral conditional purchase of 40 acres.[7] They then returned to the Kubbur water hole to evaluate their find. A three ton sample was sent to Louth by bullock dray and then to Adelaide by river boat for testing. Joseph Becker also despatched samples to Sydney for analysis. The assays from the sample sent to Adelaide were received in February 1871 and showed 33 percent fine copper. The Cobar Mining Company was formed in late 1871 with 200 shares issued at a price of £10 per share.[8] The original owners were the three tank sinkers and four leading men of Bourke, Joseph Becker, William Bradley, Russell Barton and James Smith. Becker's accountant, Alexander

Ogilve was appointed company secretary. Captain Thomas Lean, an experienced mine manager, was appointed to supervise mining and arrived at Cobar with six Cornish miners on the 4th November 1871. Captain Lean had worked at the Steiglitz gold mines in Victoria and in various copper mines and operations in South Australia including at Moonta-Wallaroo.[9] On the 1st July of the following year the Cobar Copper Mining Company Ltd was registered with 74 shareholders and nominal capital of £20,000 in 20,000 £1 shares.[10] Hartman and Campbell sold their shares to Joseph Becker, but Gibb, Smith and Barton retained shares, while Bradley and Becker became major shareholders.[11] This company was to become the Great Cobar Copper Mining Company (Limited) following merger with the adjacent South Cobar mine in 1876.[12]

The discovery of rich copper ore at Cobar led to the search for similar deposits in the district. Joseph Becker with others took out claims around the initial discovery in 1871.[13] In late 1871 or early 1872 Thomas O'Brien discovered a large boat-shaped gossan of brick-red iron oxides on a low rise (later called Elouera Hill) 11km north of Cobar (Figure 1). After some searching he picked up a small piece of copper carbonate.[14] O'Brien appears to have approached or been a member of a prospecting party set up and funded by George Gibb in late 1871 to explore for additional copper in the region.[15] George Gibb and his partner John Connelly (sometimes spelt Connolly) examined the find and decided it was worth claiming. It was said that they departed for Bourke very quietly in the hope of securing the ground without opposition, even muffling the hoofs of their horses with bags so that their movements might not be heard in the clear night air.[16] The party did not have sufficient cash to pay the required £20 deposit for a 40 acre lease, but two Bourke businessmen, Henry William Nancarrow and his younger brother Richard, were able to help them out in return for an interest. The claim was lodged on the 1st of February 1872.[17] On the 27th of February a well-equipped party including Henry Nancarrow and John Connelly revisited the discovery to further evaluate the find. They returned to Bourke around the 21st of April with fine specimens of grey and ruby oxide of copper.[18] The four lease holders decided to put the venture into 1,000 shares and call the mine the Cornish, Scottish and Australian copper mine after their respective nationalities, Nancarrow (Cornish), Gibb (Scottish) and Connelly (Australian). They issued scrip and many started buying, although enthusiasm was dampened when Captain Lean from Cobar, visited the site but declined to pass judgement on the discovery.[19] The prospecting party had suffered great hardship,

including shortage of water and food, and decided to wait for rain before commencing operations.[20]

An early description of the C.S.A. mine was not particularly encouraging. In June 1872 Augustus Becker (brother of Joseph Becker) inspected the site on his return to Bourke from a visit to Cobar. He reported:

> On returning, the road being heavy and wet, I visited the Cornish, Scottish and Australian copper mine, which is situated about seven miles north-west of the Cobar. There was no person on the ground. The mine is a recent discovery. A small quantity of ore, some of it of good percentage, lies on the ground. Only one blast has been put in the lode. I traced the 'back' of it for some distance. The country has some resemblance to Cobar. Those who have knowledge of copper mining speak favourably of it, but I don't profess to speak authoritatively myself on such matters and regretted that no one was on the ground to guide me as to its probable extent. Two practical men have been sent out to open the mine. All desirous of correct information concerning either this mine or the Cobar will obtain it from the recognised agent, Mr W. Webb, Bourke.[21]

Early Optimism, Speculation and Disappointment

In 1872 the copper price (see Appx. Fig. 1) was at a dramatic high and the discoveries around Cobar sparked a local land-pegging boom from June to August.[22] On the 6th of July the Bourke correspondent for the Town and Country Journal noted: 'The copper mania is fast upon us but nothing positively can be said of any of the mines save Cobar'.[23] The following week he may have succumbed to the mania himself, reporting: 'The specimens brought in from the C.S.A. mine, or where the mine is to be, are rich and great are the expectations there'.[24]

In late July the Cornish, Scottish and Australian Copper Mining Company Limited was formed with a nominal capital of £40,000 in £1 shares, with power to increase to £60,000. Two hundred and sixty acres of land were taken up and two men were engaged in developing the prospect.[25] In early August the number of miners was increased to six and a few shares in the new company sold at auction in Bourke for £18.5s.[26] Also in July a group holding the northern half of the hill at C.S.A. formed the North Cornish, Scottish and Australian Copper Mining Company.[27] On the 7th of August the Bourke correspondent for the Town and Country Journal reported on the copper mining activities in the Cobar area as follows:

> There are some fine specimens of copper ore on view from the C.S.A. Company and there is no doubt if the directors do their duty to the shareholders in an intelligent, energetic manner, there will be nothing to complain of. It is regarded

> by the majority of scrip holders that a mistake was made in the issue of 40,000 shares instead of 20,000. 640 acres taken up last Thursday, and tomorrow there will be another rush. The cartage of copper ore will commence directly from Cobar, many teams being put on at the C.S.A. There are six miners at work, while four times that number is needed. The lack of miners is a great drawback to the various enterprises. The work goes on too slow.[28]

A report from the C.S.A. mine in early September 1872 indicated that a shaft had been sunk 27 feet and black 'sulphate' of copper intersected.[29] The lode at both ends of the shaft was reported to be about 2.5 feet wide. C.S.A. shares were quoted at £13.10s.[30] Later in the month the leading miner reported that the shaft was down 38 feet in rich lode material and a specimen sent to a Mr Twemlow of Sydney assayed 11 percent copper. However, the water supply was beginning to fail.[31] By this time a number of parties had pegged ground around the C.S.A. mine and a proposal was put to amalgamate these properties with the existing company. This appears to have been misrepresented to shareholders in Sydney as a forced amalgamation, necessitating a public meeting of Bourke shareholders on the 18th of September to resolve the issue.[32] A number of shareholders were unhappy with the management and development of the property, with local complaints that there was not enough 'brain and muscle on the ground'. In October the company was handed over to the Sydney shareholders, with Messrs G.S. Gibb, H. Collis and W.W. Davis chosen to represent the Bourke interests. In early 1873 a new mine captain was appointed to properly develop the mine,[33] though, a subsequent report in the press on the 24th May gives a hint of the speculative approach of management.

> The Captain of the C.S.A. has arrived at the mine but has not had sufficient time for more than a cursory inspection. From this however he has formed a most favourable opinion of the Company's property. The manager and some of the local directors propose visiting the mines after the races in order to confer with the Captain as to carrying on the work. The shaft is at present down 73 feet.[34]

In June it was reported that Captain Tonkin with a few miners was sinking at the C.S.A. and doing other necessary work, such as making a ground tank for water and constructing a few huts.[35] Progress appears to have been slow and no significant lode was discovered. In March 1874 the shaft was down to 150 feet and the Captain was 'positive that the mine will be profitable'.[36] After this time little was reported from the mine and it appears to have been abandoned by 1876 when the lease lapsed.[37] During this initial period of exploration many shallow diggings were put into the gossan, but

unlike the Cobar mine, no significant body of rich copper ore was found in the near surface oxide zone. Many of the shareholders and Bourke entrepreneurs were also clearly more interested in making money from speculation than from mining.

In 1882 a new group under I.J.K. Cohn started prospecting at the C.S.A. and attempted to develop it as the Scottish and Australian mine.[38] Lack of water in 1883 forced the company to suspend operations for that year and continuing dry conditions and low copper prices during 1884 and 1885 meant that copper mining in the whole Cobar district was in a very depressed state.[39] Eventually in 1886 the C.S.A. lease was forfeited. The Great Cobar Copper Mining Company then took up the property and under the management of Captain R.N. Williams began further shaft sinking and prospecting.[40] Encouraging prospects were obtained from the gossan in 1887. By 1888, two new shafts had been sunk on narrow veins of copper ore to depths of 100 and 120 feet respectively, and drives had been put in from the old shaft but with limited results. Work was again hampered by a lack of water, there being only 6 inches of rain in 1888. On the 3rd of August 1889 the Great Cobar mine was closed following a drop in the copper price due to the failure of the Société de Metaux to corner the copper market. Prospecting operations at the C.S.A were also suspended.[41]

From 1895 to 1899 the C.S.A. lease was held by Henry Cornish and party. Henry was a well known Cobar identity who had held shares in the original company as well as a number of other Cobar mining ventures. He had lost his investment in the C.S.A. but obviously not his faith. By this stage the main shaft into the large gossan had been sunk to 250 feet. The gossanous lode at this level was very wide and carried a little gold all through, with occasional veins of lead carbonate. Henry's group received Government aid to deepen the main shaft a further 100 feet and to cross-cut 50 feet at that level. After carrying the shaft down to 332 feet and completing some driving, operations were abandoned, no payable ore being discovered in the still persistent porous gossan.[42]

Discovery of the zone of secondary enrichment

In early 1905 George Blakemore set up the C.S.A. Development Syndicate in yet another attempt to prospect the C.S.A. property.[43] This syndicate was probably modelled on the Great Cobar Mining Syndicate, which very successfully redeveloped the Great Cobar mine from 1893 to 1906. Blakemore had been the Mine Manager of the Great Cobar mine from 1901 and in 1905 was appointed General Manager, a position he

still held while developing the C.S.A. mine. Blakemore's group was able to raise £2,000, in 40 £50 shares, although at the time many understandably considered the venture a gamble.[44] From his experience at the Great Cobar, Blakemore recognised the importance of testing deposits in the region to below the extensively leached and depleted upper part of the oxidised zone. In a letter to the Department of Mines in 1905 and as part of an application for prospecting aid he noted:

> No persistence was shown by the original prospectors, and they seem to have wasted their money in sinking a number of shafts and cutting costeans all over the hill, instead of starting in one shaft and sinking below the oxidised zone. The depth that oxidation has reached is notable.[45]

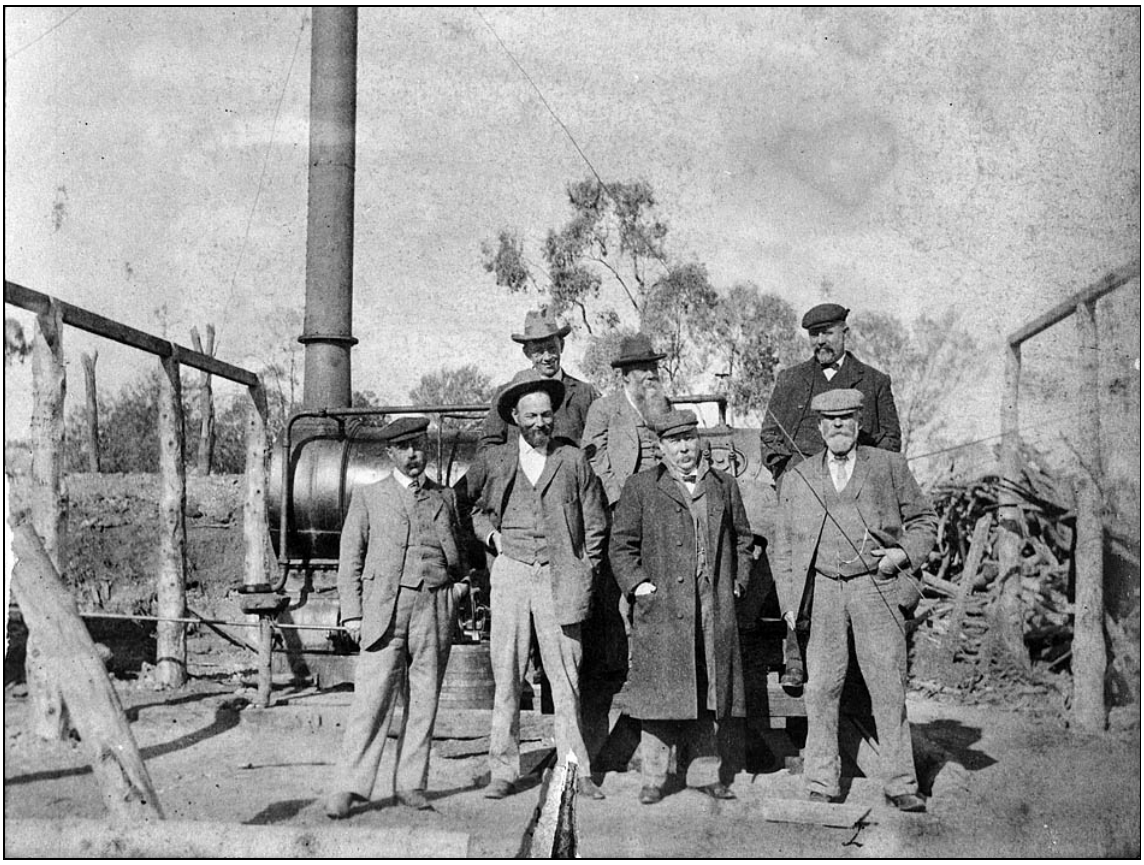
The C.S.A. Development Syndicate commenced work in March 1905 by cleaning out and re-timbering the old main shaft. An engine and boiler were borrowed from the Great Cobar Syndicate (Figure 2) and a poppet head erected over the shaft.[46] Prospecting aid was granted to deepen the shaft a further 150 feet to 482 feet, to get below the water table, and to explore by cross-cutting 75 feet east and 50 feet west.[47] By September, after sinking 125 feet, water was encountered in the shaft. A cross-cut was then started east, and after a few feet this intersected rich lead carbonate (cerussite) ore. This cross-cut was continued for 168 feet in ore. A bulk sample of ore over an eleven foot section assayed 52.5 percent lead, 11dwt of silver and 1dwt of gold. The C.S.A. Syndicate shares rose to £500 each.[48] Further development revealed a large body of secondary lead and silver-bearing ore with minor copper, the redeposited accumulation from 450 feet of leaching from the oxidised zone. Below the water table the change to lean sulphides of iron, lead and copper, was sudden. Inspector of Mines J. Polkinghorne reported:

> From the developments at the level, which consist of a cross-cut east 168 feet and west 50 feet, drive north 100 feet and south 50 feet – all in lode matter – it appears that this is destined to become a large productive mine. A winding and air compressing plant have been installed, and preparation made to install a diamond drilling plant to prove the ore body at greater depth.[49]

Two well-known mining experts, John Howell and A.T. Brown, visited the mine in November 1905 and are said to have agreed that 'it promises to be the biggest lead discovery since Broken Hill'.[50] Another land-pegging boom had ensued and during October, a total of 1,700 acres were claimed around the C.S.A. A number of groups keen to float companies took advantage of the excitement. In early October, the 'C.S.A.

North' with 32 £10 shares was floated at a meeting at Newberry's Hotel in Cobar and the 'South C.S.A. Development Syndicate' was also set up.[51]

Figure 2*: The C.S.A. mine site in early 1905 showing the newly installed steam engine borrowed from the Great Cobar mine. The mine captain Mathew Bryant is at the front right and Peter Snelson, local Director is front, second from the left.*



Courtesy: NSW Department of Primary Industries, Minerals Photo Collection

On the morning of 20th November 1905 an accident at the mine resulted in the death of Albert Barton, an engine driver, when he was crushed between the crown and pinion wheels of the winding engine. It appears that while attempting to oil the cogs his coat was caught and he was dragged in. Tiredness may have been a contributing factor as he had been up all the previous night nursing his sick wife.[52]

Following the discovery of rich secondary lead mineralisation, the C.S.A. Syndicate decided to float a company to further develop the mine. On the 5th December 1905 C.S.A. Mines Limited was formed with a nominal capital of 44,000 £1 shares, with 22,000 fully paid shares allotted to the original shareholders and 22,000 contributing shares issued with first right of purchase to the existing shareholders.

Directors of the Company were J.O. Armstrong, G.H. Blackemore, A.T. Brown, John T. Lemperiere, Dr R. Read and Peter Snelson, all of whom were members of the original syndicate (Figure 2).[53] By early 1906 the company held 210 acres of leases with 17 men working underground and 20 on the surface. Equipment included two boilers, a winding engine and air compressor. Captain Mathew Bryant was the mine manager and F.N. Yarwood the company secretary.[54] During 1906 a new three compartment main shaft was started at a position 240 feet NNW of the old main shaft. This new shaft was designed to test the sulphide zone well below the water table and to connect with the workings from the old shaft, improving access and ventilation. At the end of 1906 it was down to 250 feet. A new steam winding engine was installed at the new shaft. This was manufactured by Jas Martin and Co. of Gawler and featured 8 inch cylinders with a 16 inch stroke.[55] Exhaust steam was condensed in 20 foot high air condensers constructed from concentric double cylinders of galvanised iron (Figure 3). A large amount of driving was done from the old shaft and the system of square set timbering using imported Oregon pine was introduced for stope support. This was necessary because of the considerable width of the stopes and the very friable nature of the secondary ore being mined. [56] The ore produced and sold during 1906 amounted to 1,923 tons and realised £17,238. Production and smelting costs for this period averaged £3 2s 11d per ton. [57]

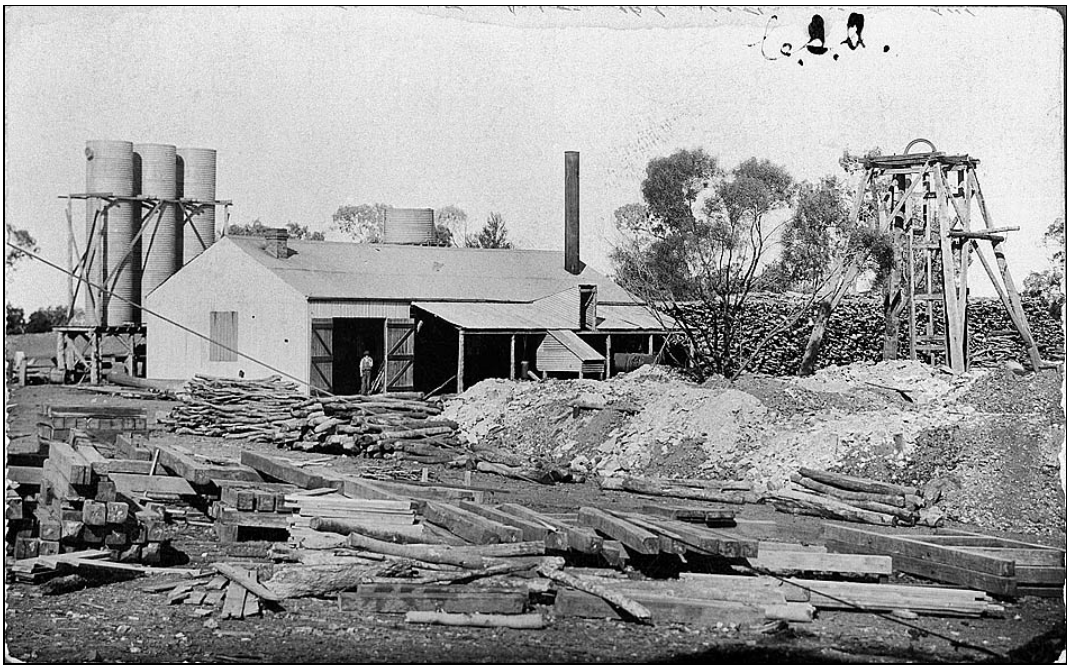
In 1907 L.J. Winton, an engineering graduate of the University of Sydney, took over management of the C.S.A. mine.[58] The adjoining C.S.A. Block 10 Mining Company was absorbed and the nominal capital of the company was increased to 60,000 £1 shares by the addition of a further 16,000 contributing shares.[59] Machinery to the value of £3,100 was added to the plant and the number of men employed was around 50, with 31 working underground and 19 above ground. At this stage there were 2 boilers, 2 winding engines, a three drill air compressor, oil engine and pump and other machinery in the course of erection. The main shaft was sunk to 595 feet and connected with the drive from the old shaft at the 450 feet level. Another level was developed at a depth of 560 feet. During the year, 1,367 tons of ore were raised, of which 1,024 tons were sold for a return of 355 tons of lead, 1,223 oz of silver and 87 oz of gold valued at £6,500.[60]

In the second edition of his classic treatise on the copper mining industry in New South Wales, Assistant Government Geologist Joseph Carne reported in 1908:

> The company, formed as a result of the rich lead strike, is now sinking the new main shaft well below the water level, for the purpose of testing the sulphide zone, the success of the mine depending upon the existence of sufficient copper sulphide to form matte in blast-furnace treatment.[61]

Further development during 1908 proved large bodies of low-grade mixed sulphides, but there was no recorded production. Up to this time C.S.A. Mines Limited had treated a total of 5,294 tons of ore for a yield of 1,350 tons of lead, 5,600 ozs of silver and 325 ozs of gold, worth £24,676. The company had expended £59,867 without a return to shareholders.[62]

Figure 3: *View looking southeast of the discovery shaft (original main shaft) and plant at the C.S.A. mine ca. 1908. Note the steam condensers at rear of engine house and timber for the underground workings.*



Courtesy: NSW Department of Primary Industries, Minerals Photo Collection.

The promise of copper

In April 1909 the C.S.A. mine was closed following exhaustion of the known secondary lead ore.[63] It was reopened in August 1910 and a search was made to the east of the main underground workings to test for possible copper bodies beneath gossans east of the main gossan. After driving a few feet from the No 1 east cross-cut from the old shaft on the 450 foot (No. 2) level a nice body of copper ore 8 to 10 feet wide was encountered. This was the first positive sign of the possible copper potential of the mine

and it provided considerable impetus for further copper exploration.[64] Between 1910 and 1911 the mine manager, Charles Mackenzie, focussed exploration in the area east of this discovery. The prospecting consisted of extending drives and cross-cuts from the 450 and 550 foot levels. As a result of this work a large body of siliceous copper ore was outlined.[65] In describing the work done on the 450 level, Mackenzie reported in December 1911:

> We drove along this body in from 5 to 6 percent ore for a distance of 100 feet, then came into a blank for 20 feet, then into a nice body of basic ore, very much like the Tinto ore. It is highly probable that this will continue to the Tinto workings.[66]

During 1905 a separate group had been prospecting to the south of the C.S.A. workings in an area known as Gardner's Block.[67] An underlay shaft was put down 200 feet on a gossan about 700 feet south of the main C.S.A. shaft. In 1906 this shaft was continued a further 100 feet, and below this a winze was extended an additional 118 feet making a total of 418 feet from the surface.[68] A cross-cut 52 feet west at the 418 feet level intersected a body of carbonate ore, similar to that found in the C.S.A. mine, and containing an average of 15 percent lead and 1.5 ozs of silver per ton.[69] In 1907 a vertical shaft was commenced east of this discovery and by 1908 reached a depth of 450 feet. At this depth a cross-cut was driven to the west, which after 25 feet intersected a lode carrying rich oxides and black sulphides of copper.[70] In March 1909 the property was floated into a company called the Cobar Tinto Copper Company NL and during the year a large body of copper oxides and sulphides were mined near the water table. In 1910 the main shaft was deepened a further 85 feet and intersected the east dipping lode, exposing primary sulphides. Driving commenced north and south at this level. During this development a mass of silicified slate with poor copper grades impeded progress and the mine was closed down. To this time a total of 5,129 tons of ore had been raised at the Cobar Tinto yielding 45 tons of lead, 582 ozs of silver, 112 ozs of gold and 244.5 tons of copper valued at £15,667.[71]

By the end of 1911 the C.S.A. mine had been developed on 4 levels between 330 and 660 feet below surface. Although significant bodies of copper-bearing ore had been found, the two largest veins were highly pyritic admixtures of lead, zinc and copper with a copper content too low to allow them to be worked as stand alone copper ores. However they had potential as a basic flux in copper smelting.[72] During 1912 a total of

414 feet of driving on ore was completed and further deposits of lead carbonate, some with high values of native silver, were discovered. A total of 2,519 tons of lead ore was raised and sent to Cockle Creek for treatment to produce 806 tons of lead and 10,078 ozs of silver, returning £14,185.[73] The company also completed 574 feet of horizontal diamond drilling from underground, and one hole to the east from the east cross-cut on the 660 foot level intersected three distinct copper ore bodies, 100, 15 and 10 feet wide respectively. These averaged 2-3 percent copper and gave great encouragement for the C.S.A. to be worked as a copper mine. Limited mining at the Tinto mine produced 60

Figure 4: *Directors of C.S.A. Mines Ltd in 1912. Back (L to R) P. Snelson, J.A. Armstrong, R. Breden. Front (L to R) J.O. Armstrong, G. H. Blakemore and A.T. Brown. All of these men except J.A. Armstrong and R. Breden had been members of the original C.S.A. Development Syndicate.*

Courtesy: Bicentennial Copying Project State Library of New South Wales

tons of ore grading about 8 percent copper.[74] It had previously been recognised that if the copper contents of the C.S.A. together with the Tinto deposits could be brought up to about 2.5 percent it would be possible to smelt them profitably on a large scale. However it was also realised that an extension of the railway from Cobar would be required to encourage sufficient investment to construct a proper plant. At this stage

C.S.A. Mines Limited employed 23 men and the total value of machinery was estimated at £6,889. In 1913 a total of 4,002 tons of lead ore were sold to the smelters for a return of £11,345.[75] The separate Cobar Tinto Mine employed eight men and in 1913 mined 505 tons of ore averaging 7.1 percent copper. This was sold to the Great Cobar Mine for £1,202. In August 1913 C.S.A. Mines Limited acquired the Cobar Tinto mine when it absorbed the Tinto Company.[76]

Extraction of the higher-grade lead ore was completed in 1914 and attention was then directed towards the copper ores.[77] Copper prices had dropped in early 1914 as a result of impending hostilities and the Great Cobar mine and associated smelters had closed in April, throwing many men out of work.[78] The outbreak of war in the latter part of the year meant that many of the Cobar mines were unable to sell their ore due to an export embargo and market uncertainty. At the C.S.A. mine operations continued throughout the year with the exception of two or three months pending an application for suspension of labour conditions. A total of 1,499 tons of ore was treated to produce 490 tons of lead and 101 tons of copper.[79]

The Great Cobar finally went into liquidation in 1915 and remained idle throughout the year while arrangements were made between the receivers, unions and NSW Government to finance and reorganise mining and smelting operations.[80] The increased demand for copper due to the war pushed the price to £86 per ton and mining at the C.S.A. was focussed on the copper ores. Total production for the year was 455 tons of copper from 4,350 tons of ore.[81] There was a firm proposal to extend the railway line from Cobar to the C.S.A. mine, but first it was necessary to establish that sufficient copper ore was available to justify this investment by the state Government. A special investigation conducted in 1916 by Inspector of Mines J.R. Godfrey, calculated the available copper resource as more than 200,000 tons at 5.5 percent Cu, giving a minimum mine life of 4 to 6 years. The railway connection was commenced in late 1916.[82]

An important aspect of the copper smelting activities at Cobar was the blending of different ore types. Ores with a high silica content were referred to as acid or siliceous ore, and ores with high iron content as basic ores. During smelting it was important to have the right mix of silica and iron to produce a good slag to remove the various non-copper components of the ore. Basic ores were particularly abundant at the Great Cobar mine and thus required the addition of siliceous ores from various local sources. Up until this time all of the C.S.A. ores had been sent away for processing and

the company had concentrated on the high grade supergene lead ore and the basic copper ores that were most in demand and most profitable. Large-scale mining and smelting on site would allow the mining of the abundant siliceous ores that surrounded the basic ore lenses and which carried surprisingly high values of copper.[83] It was also recognised that some sort of mineral separation, such as flotation or gravity separation could greatly benefit the processing of those C.S.A. ores that contained mixed metals. This would remove deleterious zinc and lead from the copper and also take advantage of the high zinc prices by producing a zinc concentrate. However such a process was not introduced, probably because of the complex nature of the ores (containing at least four different ore minerals) and the state of flotation technology at the time.[84]

The price of copper was abnormally high during 1916, ranging from £100 to £150 per ton, well above pre-war levels. However, in the Cobar district this very favourable price did not result in an increase in prospecting activity or the opening of new copper mines. This was apparently due to the inability of smaller mines to get their ores treated locally and the relatively high prices charged by custom smelters outside the district. Copper smelting had recommenced at the Great Cobar in January 1916 but industrial unrest and a lack of skilled labour hampered production. Operations on the mines were also considerably interrupted by an engine drivers strike, a coal strike and demands by local miners for increased wages and a 44 hour system similar to that granted to the Broken Hill miners.[85] At the C.S.A. mine a modern smelting plant capable of treating 100-150 tons per day was completed in August but was not started until early 1917.[86]

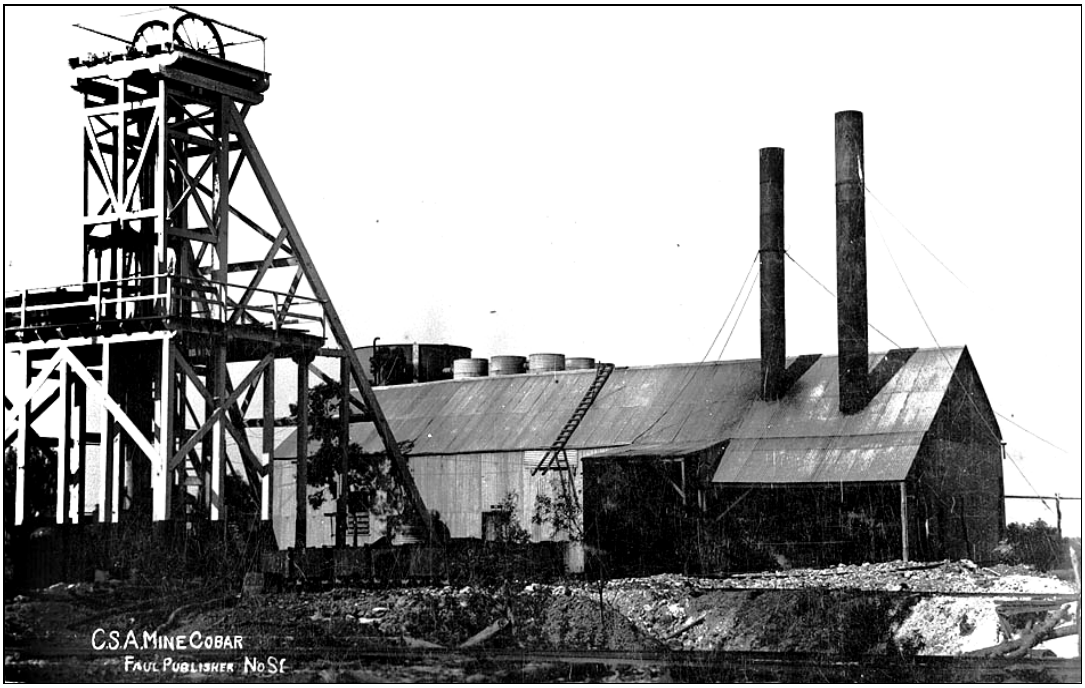
In September 1905 the C.S.A. Development Syndicate had applied to the NSW Forestry Department to reserve a belt of vegetation a mile wide around the mine site so that if a township developed it would not have the barren aspect typical of most mining settlements in western NSW. This far-sighted request was approved and an additional belt requested.[87] A small settlement known as Eleoura had gradually developed southwest of the C.S.A. mine where the company initially erected three houses for its staff and a large boarding house to accommodate 50 men. In 1917 it constructed 11 workmen's cottages and Eleoura had grown to small town with its own hotel and public school.[88]

The railway connection from Cobar to the C.S.A. mine was completed at the end of 1917 and officially opened in January 1918.[89] This considerably improved the economics of the C.S.A. operations. Until the railway was opened the first or low-grade

matte produced by the blast furnace was concentrated to a shipping grade of 45-50 percent copper and sold in that form. After the railway was opened, contracts were made with the Electrolytic Refining and Smelting (E.R. & S) Company at Port Kembla for the sale of the first matte for direct processing and refining. This contract would not have been profitable without the cheaper transport provided by the railway link. A second larger smelter commenced operations in January 1918.[90] From June 1917 to July 1918 the furnace plant smelted 26,118 tons of copper ore and 6,979 tons of basic pyritic ore to produce 1,343 tons of copper in the form of shipping matte. However, the Directors of the Company, particularly the Chairman George Blakemore, were not happy with the high processing and refining charges being levied by the refinery. Since the start of the war the Federal Government had prohibited the export of copper ore, copper matte or unrefined copper. This effectively gave the E.R. & S. Company a monopoly on treatment in New South Wales as they possessed the only electrolytic refinery. Blakemore devised a bold plan for the C.S.A. to build its own refinery and cut refining costs by 70 per cent, saving the company an estimated £20,000 per year. He also reasoned that this plant could service other copper produces in NSW and break the monopoly held by E.R.& S.. Blakemore's grand vision was not shared by all the Directors and shareholders, who felt that the required funds might be better directed towards dividends.[91] After some persuasion the decision was made to go ahead with the refinery and a suitable site was selected at Kandos on the railway near Mudgee. This was next to the New South Wales Cement, Lime and Coal Co., Ltd works and a contract was arranged with this company to lease suitable land and provide water, coal, limestone for flux and electricity at a cheap rate. Deposition tanks for the electrolytic plant were procured from the closed Great Cobar copper refinery at Lithgow. In May 1918, C.S.A. Mines Ltd commenced construction of a furnace plant and electrolytic refinery at Kandos capable of producing up to 50 tons of refined copper per week.[92] The plant cost about £32,000 and this capital expenditure also allowed the company to avoid paying War Profits Tax of 75 per cent on additional dividends above the 10 per cent profits allowed under the Federal Government's War Profits Bill. In October 1918 a blowing plant was also under construction at the C.S.A. mine site. This was designed to make full use of the fluxing qualities of the immense basic ore supplies available at the C.S.A. mine in smelting other siliceous ores of the Cobar district.[93] By the end of 1918 the C.S.A. plant had treated 55,028 tons of ore and produced 2,232 tons of copper, 60,294 ozs of silver and 558 ozs of gold, the largest annual production to that point.[94]

However, these positive developments all started to come unstuck with the end of World War I and the dramatically reduced market for copper.

Figure 5: *The C.S.A. main shaft headframe and engine house ca 1918, view looking northeast.*



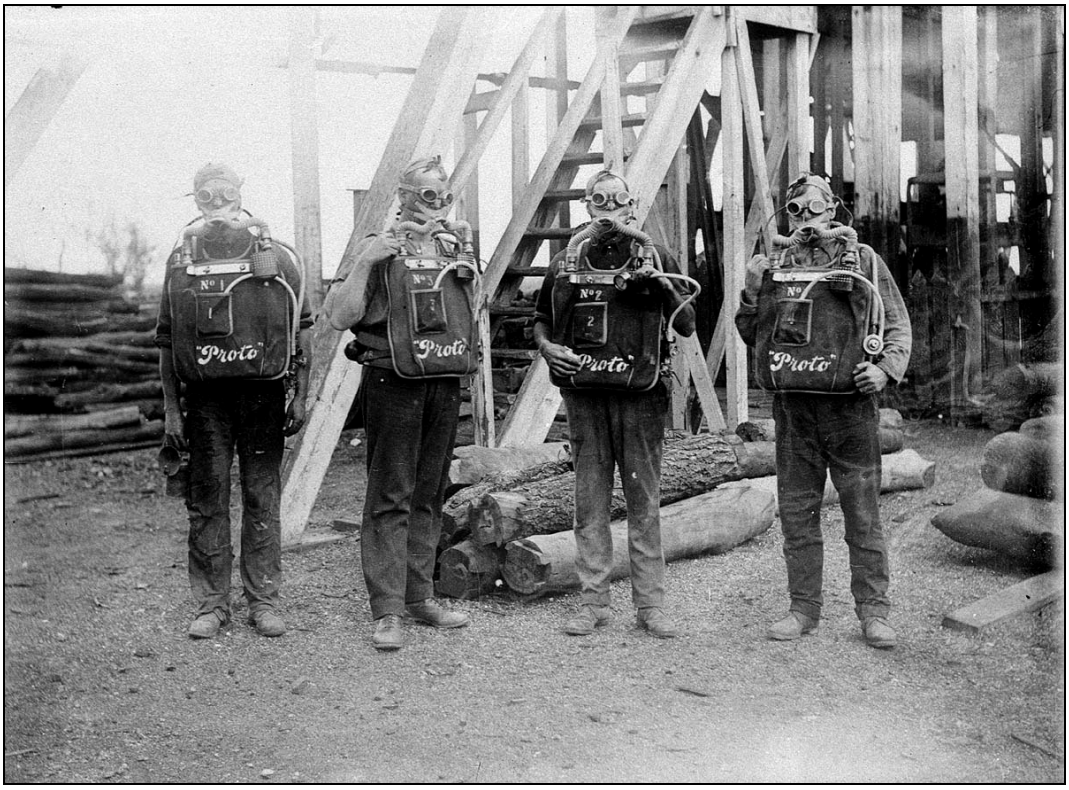
Courtesy: NSW Department of Primary Industries, Minerals Photo Collection.

In 1919 the price of copper plummeted. The Great Cobar mine closed in March and shortly after the C.S.A. ceased mining and remained idle throughout the winter except for exploration work. Operations commenced again in September when an assured market was found for the company's copper.[95] The new plant at Kandos had commenced smelting operations and some furnace refining, but the electrolytic refinery, although complete, was not used.[96] Total production for 1919 was 396 tons of copper, 8,791 ozs of silver and 43 ozs of gold from 15,626 tons of ore.[97]

Problems resulting from the low copper price were soon eclipsed by a much greater disaster. On Saturday 20th March 1920 at about 6pm after the end of shift, dense smoke was seen pouring from the Tinto shaft at the C.S.A. mine. Investigation revealed that a fierce fire was raging in the Oregon timbers of the old worked-out stopes on the 450 level. As there were no means of isolating the fire and there was great risk of it invading the forests of timber in the underlying producing stopes, it was decided to seal

the mine in the hope of smothering the fire. This was feasible given there were only five easily sealed connections to the surface. After this was done a steel smoke stack was erected over the Tinto shaft so that when the mine was reopened the hot smoke and gas would be drawn to this outlet, setting up a current of air in one direction. This would minimise the risk to anyone going below to investigate and fight the fire. Preparations were made for reopening the mine and a number of 'Proto' breathing apparatus were imported from Broken Hill. The shaft was reopened on the 3rd May and the workings investigated by a small team using the 'Proto' equipment (Figure 6). The fire appeared to be out but the mine was allowed to stand and ventilate for two days. On the second day the fire broke out again, but as the stack over the Tinto shaft was drawing well it was decided to leave the mine open and allow the fire to burn itself out in the old workings. Unfortunately a collapse in the stopes blocked the outlet to the Tinto shaft stopping the air current and causing the whole mine to fill with thick smoke. There was no option but to reseal the mine.[98]

Figure 6: *Fire investigation team wearing 'Proto' breathing apparatus at the C.S.A. mine in 1920. L to R: Fred Rue (miner) A.J. Julius (Mine Manager), Gwyder Whalen (surveyor), Bob Pivetta (underground foreman).*



Courtesy: Bicentennial Copying Project, State Library of New South Wales.

At the time and over the years, a number of conspiracy theories have been proposed, suggesting sabotage as the cause of the C.S.A. fire.[99] A more likely explanation relates to the oxidising characteristics of some of the C.S.A. ores. Self-combustion or heating of remnant sulphides or backfill in the old stopes could have ignited the dry Oregon timbers. In late 1917 when the smelter was idle, a large stockpile of ore on the surface had caught fire spontaneously and burned for some months.[100] Also in the 1960s when the mine was redeveloped, there were a number of local explosions and fires caused by ore dust igniting after blasting. These later incidents prompted detailed studies of the combustibility of the C.S.A. ores that resulted in special precautions being recommended to prevent further ignitions.[101]

The underground fire in 1920 put an end to mining and smelting operations at the C.S.A. and also resulted in the closure of some smaller mines that relied on the C.S.A. plant to process their ores. The fire burned until about 1936 and the mine remained closed apart for some very small-scale mining until 1962. From 1905 until 1920 a total of 113,559 tons of ore had been treated to produce 4,182.5 tons of copper, 3,978 tons of lead, 94,955 ozs of silver and 1,335 ozs of gold.[102] Most of this production occurred during a few short periods and the early history of the C.S.A. mine was greatly affected by the fluctuating copper price, droughts and world events (Figure 1, Appx. 1).

Drilling and deeper exploration reveal full potential

Copper mining across the whole Cobar field remained largely dormant from 1920 until World War II. During the 1930's there was renewed interest in gold mining and the Occidental mine south of Cobar was redeveloped by New Occidental Gold Mines N.L. (NOGM) as the New Occidental mine. The Cobar Gold Mine at Fort Bourke Hill (renamed New Cobar) was reopened by Cobar Gold Mines and this operation was absorbed by NOGM in 1935. Leases over the old Chesney and Young Australian mines were also acquired by NOGM. In 1942 NOGM was encouraged to turn attention to copper production to assist the war effort and in January 1943, with assistance from the Commonwealth Government, they reopened the Chesney mine for copper. However grades were low and this copper mining was not profitable, resulting in closure of the mine in 1944. Gold mining continued through the war. In July 1945 NOGM applied to the Federal Government for financial aid to carry out diamond drilling to test the Cobar area for new ore reserves. The Government was keen to rehabilitate the mining industry in Australia and had set up a Mining Industry Advisory Panel to examine such

proposals. The Bureau of Mineral Resources, Geology and Geophysics (BMR), and the New South Wales Geological Survey, were asked to prepare reports on the proposals for submission to the Panel. This led to a co-operative joint project between the BMR and NSW Geological Survey to assess the regional and mining geology of the whole Cobar field. Fieldwork for this project commenced in August 1946.[103] The Commonwealth Government was also persuaded to free up the official price of copper (but not gold) and the price rose from £95 to £130 per ton by May 1947 and to £160 by mid 1948.[104] As a result NOGM returned to mining copper at the Chesney mine. However, the profitability of their operations began to seriously decline, mainly due to rising costs in the post-war economic boom. A plan was put forward to switch strategy from developing the existing mines to exploration by deep drilling beneath these for larger low grade deposits of copper and gold.[105] Before this could be realised a combination of factors including a water shortage due to drought, decreasing ore grades and collapse of the hangingwall in the main production stope resulted in closure of the New Occidental mine in October 1952. The copper price was down again and the associated Chesney mine was also closed.[106] An approach was made to the Federal and State Governments for financial aid to reopen the two mines and pursue the plan to mine lower grade copper ores on a larger scale. This proposal was rejected and Cobar was left without any significant mining activity.

During this period geological studies by the BMR and NSW Geological Survey continued and the Broken Hill mining companies had become interested in the potential of the Cobar area. Enterprise Exploration Company Pty Ltd, a subsidiary of The Zinc Corporation (later Consolidated Zinc Pty Ltd. and then Conzinc Riotinto of Australia Ltd.), had started exploring the Cobar district in 1947.[107] In 1951 this company acquired the leases over the derelict C.S.A. mine. The workings were de-watered, the main headframe re-erected and the shaft re-timbered. Underground drilling was commenced and some copper precipitate produced from the mine waters. Exploration around the old workings established that there was at least 17 million tonnes of ore grading 1.3 percent Cu, 1.3 percent lead and 3.2 percent zinc between a depth of 492 and 1,600 feet and another 3.6 million tonnes of 3 percent copper, 1 percent lead and 3 percent zinc in a separate footwall lens. However a feasibility study indicated that this mineralisation could not be extracted economically and in 1958 the C.S.A. mine was placed on care and maintenance.[108]

In October 1955, Broken Hill South Ltd, through its subsidiary Mines Exploration Pty Ltd, had taken an option over the leases held by New Occidental Gold Mines Ltd. The following year they exercised their option and set up two companies, Cobar Mines Pty Ltd and Cobar South Pty Ltd, to develop the base metal and gold properties respectively.[109] This group began exploring the southern part of the Cobar field, pioneering the introduction of deep diamond drilling from surface, including at the Great Cobar and Chesney mines. In May 1960 Broken Hill South and Consolidated Zinc decided to merge their Cobar interests to better explore and develop the field. Agreement was reached whereby Broken Hill South Ltd. retained a 76 percent interest and Consolidated Zinc Pty Ltd. acquired a 23 percent interest in a joint Cobar project conducted through Cobar Mines Pty Ltd. and Cobar South Pty Ltd..[110] Cobar Mines commenced a major exploration program across the Cobar area, which included additional surface drilling at the C.S.A. mine. This drilling confirmed the continuity of the known ore to a depth of 3,100 feet and also identified a significant new zone of copper mineralisation (the Eastern Lode) to the east of the previously known lodes (Figure 2, Appx. 1).[111] The new concealed lode had been indicated by a magnetic survey in which the axis of a large magnetic high was offset 500 feet east of the known, steeply dipping Western Lodes. Initial diamond drilling proved that the magnetic anomaly correlated with pyrrhotite-chalcopyrite-pyrite mineralisation and deeper drilling confirmed its existence with four further ore intersections between depths of 1,700 and 2,500 feet.[112] As a result of these very encouraging discoveries it was decided in October 1961 to further investigate the orebodies by shaft sinking and pattern drilling prior to possible mining and production of 650,000 tons of copper concentrate per year.[113] Shaft-sinking commenced on the 13th February 1962 with collaring of the exploratory (later ventilation) shaft south of the old historic workings. Underground drilling showed the Eastern Lode to have a length of 550 feet and average width of 33 feet and the Western Lodes to be 1,120 feet long with an average width of 26 feet. Both these lodes were open at depth and reported to total 5,100 tons of ore per vertical foot, containing 1.3 percent copper, 6.3 percent zinc and a minor amount of lead. The first shaft was continued to a depth of 1,303 feet and a second production shaft sunk to 2,027 feet.[114]

Production at the re-established C.S.A. Mine began in 1964, with ore coming from both the Western and Eastern Lodes. The modern processing plant commenced operations in May 1965 and the first shipment of copper concentrate was railed to the

Electrolytic Refining and Smelting Company in Port Kembla in the same year. Zinc and lead concentrates were also produced and these were stockpiled on site until 1967 when the zinc concentrates were sent to Port Kembla for sale overseas. In 1968 the lead concentrates were dispatched to Sulphide Corporation Pty Ltd at Cockle Creek.[115]

The new C.S.A. mine was officially opened on the 8th October 1966 by T.L. Lewis, the NSW State Minister for Lands and Mines. At the time it was the most modern underground mine in Australia, introducing such technological innovations as mechanised trackless cut and fill mining methods, incline access to working levels, concrete-lined shafts with a friction hoisting system using rope guides, autogenous grinding, automatic controls and closed circuit television monitoring of the process plant.[116] Large-scale development of the C.S.A. mine brought major benefits to Cobar, which grew dramatically in population from 2,200 to 4,000. As well as employment for 376 people, the project provided the catalyst to connect Cobar to the NSW State power grid and to construct a water pipeline from the Bogan River at Nyngan, 135 km to the east. [117] The 12-inch pipeline was completed in July 1965 and for the first time in its history, Cobar was virtually immune from severe water shortages due to drought. The capital cost of establishing the C.S.A. operation to mid October 1966 was $15 million, with a further $2 million spent on purchasing mining leaseholds and housing for employees. The parent Broken Hill companies had spent approximately $2 million up to February 1962 on exploration at Cobar. Cobar Mines also undertook long term financial obligations of approximately $4.2 million to the NSW Government and local government authorities for repayment of the capital cost of providing power, water and rail services.[118]

Since modern mining commenced at the C.S.A., ongoing near-mine exploration has identified further hidden mineralisation. A new zone of copper-zinc ore (the CZ system) was discovered between the Western and Eastern Lodes in the late 1960s. In 1976 a weak gravity geophysical anomaly east of the main orebodies was targeted by underground drilling, which intersected another zone of mineralisation called the QTS system (from Queenslander, Tasmanian and South Australian after the discoverers).[119] This system was found to have two components, the QTS North to the east of the known lodes and the QTS South, 500 m to the south. Both are covered by more than 600m of barren rock. Recently a further extension has been found below and to the south of the QTS South workings (QR1 lens).[120] Ore has now been proven down to 1.8km and is still open at depth. All the lodes plunge steeply and have large down-

plunge dimensions. The copper-rich QTS system is currently being mined 1.42km below surface, making the C.S.A. workings the second deepest in Australia after Mt Isa.

Conclusions

Like many of the ore deposits in the Cobar mineral field the C.S.A. ore system gave little surface indication of the great wealth that lay below. This was due to a combination of factors including the geometry and composition of the ore lenses (the exposed lode was a lead-zinc-copper body) and the intense, prolonged weathering that had leached most of the metals from the upper part of the deposit (Figure 2, Appx. 1). The Cobar polymetallic deposits typically occur as multiple lenses in steeply plunging pipe-like clusters. These pipe-like bodies have a very small surface area but great depth extension. The outcropping C.S.A. gossan covered an area of 400 by 10m, quite large by Cobar standards. However, the early prospectors found only small showings of copper and lead minerals. They were effectively beaten by the extent of the leaching. Thin veins of copper oxides and carbonates were found below 3m but it was not until the workings reached the water table and the zone of supergene enrichment that the true potential was indicated. George Blakemore deserves the credit for recognising the importance of sinking below the strongly leached oxidised zone. Mining of the rich secondary ores provided the capital and incentive to further explore the deeper parts of the deposit leading to the discovery of new blind ore lenses, particularly of copper. The history of the C.S.A. mine provides a lesson to modern explorers in the Cobar area, highlighting the need for very careful surface and near surface search and persistence in exploration at depth.

Much of the early exploration in the Cobar area was focussed on the search for solid iron-rich gossans, with little attention paid to the siliceous ‘blows’ occurring on the low residual hills, some of which later proved to be mineralised. The potential of these siliceous outcrops for gold was overlooked until well into the 1880s, also partly because of the belief that Cobar was ‘copper country’ and the two metals didn’t mix. The attention to gossans reflected the Cornish proverb: ‘There’s never a mine so rich and fat as that which wears the iron hat’.[121] The C.S.A. deposit certainly had a recognisable ‘iron hat’ but it took a long time and much persistence to find ‘the fat’.

Acknowledgments

My thanks to John Collins from the Great Cobar Heritage Centre, Cobar, staff of the Department of Primary Industries, Maitland, the National Library of Australia, Canberra and the State Library of New South Wales, Sydney for helping me locate information on the C.S.A. mine. David Barnes from the NSW Department of Primary Industries is thanked for providing copies of photographs held by the Geological Survey of N.S.W. in their Minerals Photo Collection. I thank Don Perkin for providing data on historic copper prices. The comments and suggestions of two anonymous reviewers helped improve the article.

Glossary of some terms used in the text

Costean – trench through soil or overburden to expose the underlying bedrock or lode. Cross-cut – a horizontal underground excavation commonly from a shaft towards or at right angles to the length of a lode or orebody (hence cross-cutting). Drive – a horizontal underground excavation parallel to or within a lode or orebody (hence driving). Flotation – a metallurgical process that separates and concentrates particular ore mineral particles by selectively causing them to adhere to rising air bubbles in an agitated solution. Gossan – the weathered and leached outcrop of an ore deposit (from a Cornish word for hat or wig). Chemical breakdown of iron-bearing minerals, typically sulphides, results in surface concentration of iron oxides and oxyhydroxides producing distinctive rusty and dense rocks (the iron hat). Kaolin – a common clay mineral (aluminium silicate). Incline – an inclined (gently sloping) underground excavation suitable for trackless rubber tyred equipment. Matte – impure metal sulphide alloy produced by smelting ore (requires further refining). Raddle – red ochre, typically clay stained with hematite (iron oxide). Secondary (supergene) ore – ore formed by re-precipitation at depth of elements leached by weathering from the upper part of an ore deposit. In many cases these ores contain a higher percentage of certain metals than the original primary ore. Stope – underground opening where the ore is removed. Sulphide – a mineral containing metal combined with sulphur. Iron sulphide (pyrite) is the most common sulphide. Important copper sulphides at the C.S.A. are chalcopyrite, cubanite (both copper iron sulphides) and chalcocite an enriched secondary copper sulphide. Winze – a vertical or near vertical opening within a mine excavated downwards and typically connecting different levels in the mine.

Units

1 troy oz (the standard measure of gold/silver) = 20 dwt = 31.10348 g; 1 dwt = 1.55 g; 1 lb = 0.454 kg;
1 (long) ton = 1.01605 tonnes; 1 foot = 0.3048 m; 1 mile = 1.609 km; 1 acre = 0.4047 hectares

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[11] Statement of shareholders, in Burgess, *The Great Cobar*.
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[71] Andrews, *Report on the Cobar, Part I*, pp. 169, 170.
[72] *Ibid*., *I*, p. 167 and Plan of Workings C.S.A. Mines Ltd Cobar.
[73] *Ibid.*, p. 201.
[74] *Ibid*., pp. 168, 202.
[75] ARNSWDM for 1913, p. 47; Mulholland and Rayner, Technical Reports, vol. 6, 1961, p. 44.
[76]*Ibid.*
[77] *Ibid.*, for 1914, p. 99.
[78] *Ibid.*, p. 25; C.L. Stegman, and T.M. Stegman, *Lodes of Gold*, Peak Gold Mines Pty Ltd, Cobar, 2002, p. 84.
[79] ARNSWDM for 1914, p. 52; Mulholland and Rayner, Technical Reports, vol. 6, 1961, p. 44.
[80] *Ibid.*, p. 25; Stegman and Stegman, *Lodes of Gold*, p. 25.
[81] Mulholland and Rayner, Technical Reports, vol. 6, 1961, p. 44.
[82] ARNSWDM for 1916, p. 104; Letter to Under Secretary of Mines from Office of the Chief Commissioner New South Government Railways and Tramways, 23 September 1915, in NSW Department of Mineral Resources file MR5056; Mulholland and Rayner, Technical Reports vol. 6, 1961, p. 25.
[83] ARNSWDM for 1916, p. 100.
[84]*Ibid.*, p. 104.
[85]*Ibid.*, p. 94.
[86] *Ibid.*, p. 96; G.H. Blakemore, 'Report of the Chairman's Speech, Eleventh Annual General Meeting of Shareholders, The C.S.A. Mines Limited 30 October 1918', p. 2, in NSW Department of Mineral Resources file MR5056.
[87] 'Mining', *Cobar Herald*, 30 September 1905 p. 4; *Ibid.*, 18 November 1905.

[88] The C.S.A. Mines Limited, Report and Statement of Accounts 3 July 1918, in NSW Department of Mineral Resources file MR5056; N. Burgess, *The Great Cobar*, unpublished 2002 review of the book published in June 1995, p. 205.
[89] C.S.A. Report, 3 July 1918, NSW file MR5056; Blakemore, 'Report of the Chairman's Speech 1918', NSW file MR5056.
[90] *Ibid.*
[91] 'Cobar Future' (editorial), *Western Age*, 2 August 1918; 'C.S.A. Smelting Plant', *Ibid.*, 20 August 1918; Blakemore, 'Report of the Chairman's Speech 1918', NSW file MR5056.
[92] *Ibid.;* B.A. Fleming, *History of Kandos*. Brian Adrian Fleming, Bathurst, 1984, p. 43.
[93] Blakemore, 'Report of the Chairman's Speech 1918', NSW file MR5056.
[94] Mulholland and Rayner, Technical Reports, vol. 6, 1961, p. 44.
[95] ARNSWDM for 1919, pp. 43, 97.
[96] Fleming, *History of Kandos*, 1984, p. 43.
[97] Mulholland and Rayner, Technical Reports, vol. 6, 1961, p. 44.
[98] ARNSWDM for 1920, p. 50.
[99] Burgess, *The Great Cobar*, p. 211; Fleming, *History of Kandos*, 1984, p. 43.
[100] C.S.A. Report, 3 July 1918, NSW file MR5056.
[101] Letter to the Chief Inspector, Department of Mines from E.C. Myers, Registered Manager Cobar Mines Pty Ltd, 23 November 1965, NSW file MR5056.
[102] Mulholland and Rayner, Technical Reports, vol. 6, 1961, p. 44.
[103] *Ibid.*, p. 24.
[104] Stegman, and Stegman, *Lodes of Gold*, p. 98.
[105] Government Geologist, 'Life of the Cobar Mining Field' letter to the Under Secretary of Mines 13 December 1949, NSW Department of Mineral Resources file MR5056.
[106] Stegman, and Stegman, *Lodes of Gold*, pp. 120-21.
[107] R.T. Russell and R.R. Lewis, 'Copper and gold deposits of the Cobar district', in J. McAndrew (ed.), *Geology of Australian Ore Deposits, Eighth Commonwealth Mining and Metallurgical Congress, vol 1*, Australasian Institute of Mining and Metallurgy, Melbourne, 1965, p. 411.
[108] Stegman, and Stegman, *Lodes of Gold*, p. 128.
[109] *Ibid.*, p. 128; Russell and Lewis, 'Copper and gold', p. 411.
[110] W.J.L. Brooke, 'Cobar Mining Field', in C.L. Knight (ed.), *Economic Geology of Australia and Papua New Guinea 1 Metals*, Monograph Series no. 5, Australasian Institute of Mining and Metallurgy, Melbourne, p. 684.
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[112] *Ibid.*, p. 418.
[113] Mines Inspector's Report for 1961 cited in Stegman, and Stegman, *Lodes of Gold*, p. 129.
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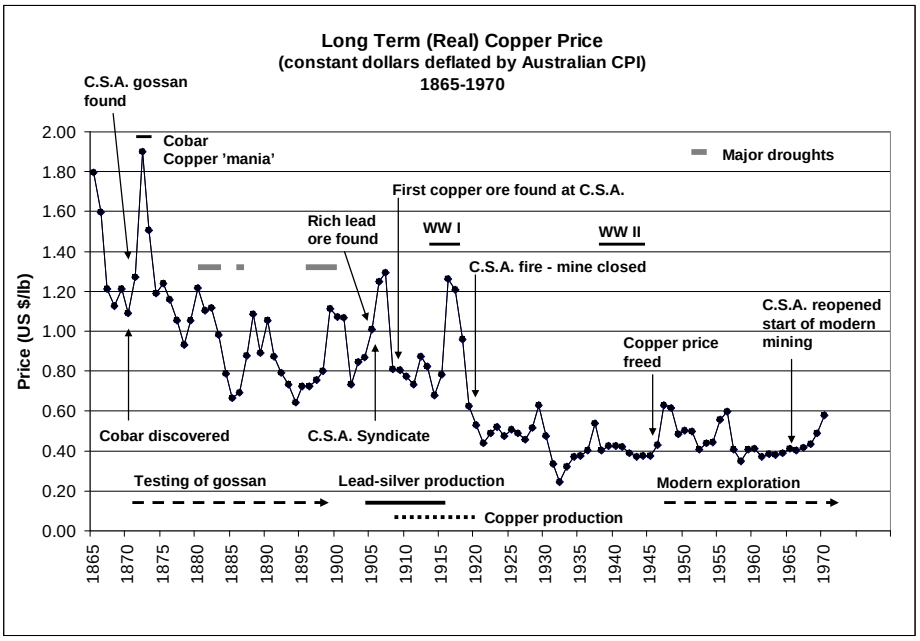
[115] Stegman, and Stegman, *Lodes of Gold*, p. 131.
[116] A. Parbo, *Down Under – Mineral Heritage in Australasia*, Australasian Institute of Mining and Metallurgy, Melbourne, 1992, p. 41; 'C.S.A.' *World Mining*, January 1967, p. 33.
[117] 'The Cobar Mines Story', *Australian Mining*, 16 May 1966, p. 58; 'Cobar Mines may install own power plant', *The Dubbo Liberal*, 29 November 1961, p. 1.
[118] 'C.S.A.', *World Mining*, January 1967, p. 36.
[119] *Ibid.*, p. 36; Stegman, and Stegman, *Lodes of Gold*, p. 132.
[120] I.R. Stockton, D. Webb and J. Hosken, 'CSA – 40 years old and enjoying a mid life renaissance!!!', Mines and Wines Conference, Extended Abstracts, 2006, p. 56; A detailed account of the recent (post 1965) history of the C.S.A. is available in Stegman and Stegman, *Lodes of Gold: A pictorial history of mining in the Cobar Goldfield'*, Peak Goldmines Pty Ltd, Cobar, 2002, 181 pp.
[121] Andrews, *Report on the Cobar, Part I*, p. 169; ARNSWDM for 1908, p. 17.

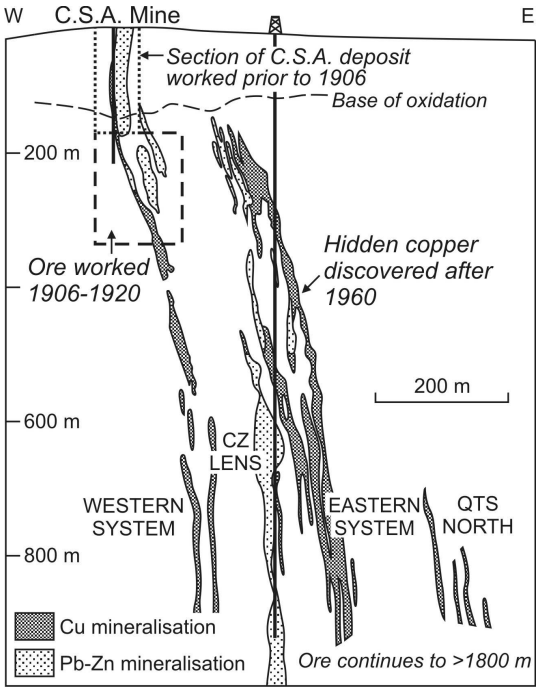
Appendix 1

Figure 1: *Copper prices ($US/lb) for the period 1865 to 1970 deflated by Australian CPI. Also shown are some events affecting the C.S.A. Mine.*



Source: Copper prices USGS, CPI from ABARE, courtesy Don Perkin, 2006.

Figure 2: *Cross section of the upper part of the C.S.A. ore system showing location of the early workings and the large hidden copper resources in the Eastern and QTS Systems. Most of the metal had been leached from the oxidised zone of the exposed Western System above the water table.*



Source: Cobar Management Pty Ltd.