

Cangai copper: History of ‘a good little earner’

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Key Words: Copper, gold, mining, Grafton, Clarence Valley, NSW.

The Cangai copper mine, located northwest of Grafton in northern New South Wales, was one of the most successful mining operations in the state during the early 1900s. Following discovery in 1901 and initial mining by syndicates, the mine was operated by the Grafton Copper Mining Company from 1905 until 1917 and produced approximately 5,000 tonnes of copper, as well as significant gold and silver, from an estimated 76,940 tonnes of mined ore.

Discovery of the Cangai copper deposit was relatively late amongst the mineral discoveries in the Clarence River region. Most deposits in this area were found between 1860 and 1880, with gold generally the first metal discovered as prospectors worked their way along the rivers. The reasons for such a late discovery were related to the rugged and heavily forested terrain, relatively remote location and prospecting focus on gold.

The Cangai deposit had some advantages for low-cost mining. The physiography of the area meant that the lode outcropped on each side of a steep spur and could be worked by horizontal adits into the spur from the northwest and southeast. The elevation of the mine also meant that a cable tramway could use gravity to transport the ore part way to the on-site smelter. There was a good local water supply and abundant wood fuel for the smelter. The main drawbacks related to transport, including transporting the copper matte product to Copmanhurst, the nearest river port on the Clarence River, obtaining supplies and collecting the wood fuel.

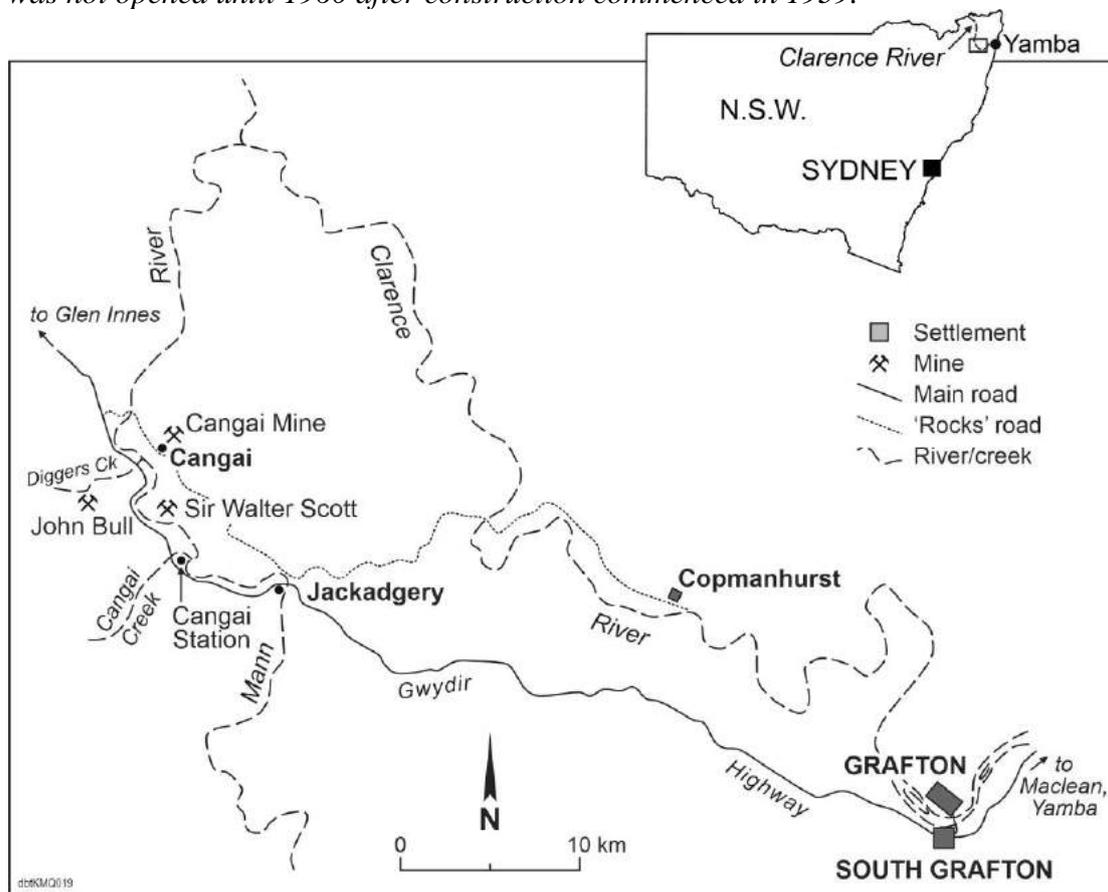
A notable feature of the Cangai copper mine was that it required virtually no capital outlay. Through low-cost mining and smelting of high-grade ore, the deposit funded its own development. The Grafton Copper Mining Company was able to pay healthy dividends and through its activities and expenditure make a significant contribution to the development of the local region.

Early mining in the Cangai area

Cangai or Cangi was the name of a pastoral run situated along the Mann River, 46 km northwest of Grafton in the Northern Rivers region of New South Wales (Fig. 1). The run was taken up by Brisco Ray in about 1845.¹ Following the first gold rushes to central New South Wales in 1851, attention turned to the New England region in the north of the colony. Working their way along the river systems, prospectors made a succession of alluvial gold discoveries from south to north, including along the Peel River, near Tamworth, the Rocky River, south of Armidale, and at the head of the Timbarra River, east of Tenterfield.² Between 1857 and 1859 gold was discovered at Toloom and Pretty Gully, in the northern headwaters of the Clarence River.³ The search along other remote and rugged tributaries of the Clarence was intensified.

In early 1861, respected prospector Peter Hansen, commonly known as Norwegian Peter, discovered alluvial gold near Cangai along the Mann River (then also variously named the South Arm or the Mitchell River), a southwest tributary of the Clarence River.⁴ In September 1861 there were about 60 miners on the Cangai field and by December the first gold-bearing quartz reef was discovered.⁵ Most miners preferred to continue mining the alluvial gold, earning from £4 to £5 per week, but by 1868 other reef deposits had been found and attention turned to reef mining.⁶ One of the first reefs worked was the John Bull, in the area of Diggers Creek, initially taken up by Paulo Marcolino, T. McTaggart and Jack Hart in June 1872 (Fig. 1). Within a month there were 16 claims

Figure 1: Map showing the location of the Cangai copper mine, the town of Cangai and some of the early gold mines. Also shown is the 'Rocks' road constructed in 1908 for transport between Cangai and Copmanhurst. The Gwydir Highway to Glen Innes was not opened until 1960 after construction commenced in 1939.



Source: Map constructed by the author using Google Earth as a topographic base.

along this reef, some with patches of rich quartz showing visible gold.⁷ By March 1873, Marcolino had installed a small crushing battery at the John Bull mine, the first on the field, and a substantial hotel was under construction.⁸ The battery was launched on the 3rd June before a party of 60 guests and officially named the 'Clara Machine' after Miss Clara Bassetti, who broke the customary bottle of champagne on the flywheel.⁹ With limited ore to crush, the battery operated sporadically until about 1876, when reef mining appears to have stalled.¹⁰ Alluvial mining continued in the area, including successful surface sluicing around the John Bull reef.¹¹

A second important reef was the Sir Walter Scott, located 3 km southeast of the John Bull, on the other side of the Mann River (Fig. 1).¹² This reef was discovered in September 1872 by an aboriginal prospector and taken up by William Ross, T. Bawden and T. Fisher.¹³ This group attempted to develop the reef and conducted some small-scale mining before abandoning the prospect, rather than risk the large amount of capital required for machinery and further development. Joseph Adams then erected a crude hand operated 'dolly' to crush the stone and, with a mate assisting, made a small wage before also giving up. Next, two old diggers, Cornish Bill and Barry the Doctor, worked the reef in a desultory fashion, using the existing crushing apparatus to make 'tucker' and the occasional 'spree'.¹⁴ Other leases were taken out along the reef, but with little mining.¹⁵ The Sir Walter Scott reef then lay unworked for some time awaiting capital for proper development.¹⁶

There was resurgent interest in reef mining at Cangai around 1887, the result of increased awareness of the field and greater availability of capital.¹⁷ Two prospectors, Robert E. Wilson and James Robson, with Jack Hart, acquired the Sir Walter Scott reef in August 1889 and commenced extensive prospecting and testing. In August the following year they managed to sell the prospect to a syndicate of miners and investors, with a plan to float it into a company.¹⁸ Following an inspection and a favourable report on the reef by Thomas Walsh, mine manager of the Enmore Gold Mining Company, near Armidale, the Sir Walter Scott Gold Mining Company NL was floated on 19th September 1890 in Armidale.¹⁹ The new company had a nominal capital of £100,000 in £1 shares and an 'ingenious' financing approach, whereby: 15,500 fully paid shares and £500 cash were allocated to the original syndicate owners; 20,000 shares given to a 'machine' syndicate to set up a 10 head stamp battery and plant, with additional payment of 25% of the gross gold output; 2,000 shares given to Walsh for his report on the mine; 60,000 shares taken by the promoters; and 3,000 shares held in reserve for sale, to provide working capital. All shares apart from those to the original owners were considered paid up to 17s 6d.²⁰ The majority of directors were selected from local shareholders and included Samuel See, a prominent Grafton businessman and his elder brother, John See MLA. Thomas Walsh was appointed manager of the mine.²¹ Work commenced in earnest with further mine development and preparations for installing the battery at a site previously selected by Walsh, close to the Mann River for easy supply of water. This location would later prove to be problematic.

Machinery for the stamp battery at the Sir Walter Scott mine arrived in December 1890 and by February the following year the full plant was ready for operation. The official opening on 22 March 1891 was a grand event with 150 guests, including the Mayor of Grafton and many visitors from Copmanhurst and Grafton. Samuel See, now chairman of the board of directors, officiated at the event and personally 'christened' the battery the 'Mary', after both his wife and eldest daughter. The ceremony was followed by a sumptuous lunch and a plethora of toasts and speeches, all on an optimistic note.²² Interestingly, at about this time there were attempts to re-open the John Bull workings and the John Bull Gold-mining Company N.L was floated, with many of the same

shareholders and a similar financing scheme to the Sir Walter Scott.²³ During 1891 parcels of John Bull ore were treated at the Sir Walter Scott battery, but the John Bull Company failed to flourish and by 1897 had disappeared.

The first crushings of selected high-grade ore at the Sir Walter Scott mine gave an average yield of just over 1oz of gold per ton from 620 tons,²⁴ but as mining progressed deeper the ore became more refractory and gold recovery dropped dramatically. It was found that much of the gold was bound up in sulphide mineralisation consisting of pyrite, arsenopyrite, chalcopyrite, sphalerite and galena, with some associated silver. Assays of this material indicated that it commonly contained around 3.5ozs of gold per ton, but only 11dwt could be extracted by the plant.²⁵ By March 1892 the company was in financial difficulties and there was some reluctance by the contributing shareholders to pay calls to cover the debts.²⁶ To make matters worse, the location of the battery in a steep area near the river meant that it was difficult to stockpile the growing volume of gold-bearing tailings for separate treatment, and much of this material was subsequently washed away in floods.²⁷

In June 1892, a sample of refractory ore was sent to Uralla for testing by a Goddard patent, fine grinder and amalgamator, with some success.²⁸ In August, further enquiries were made about methods to improve gold recovery and the Reverend Joseph Campbell, consulting geologist and mineralogist, appeared on the scene. This somewhat eccentric and self-promoting, theological geologist visited the mine and arranged for a one-ton sample to be tested by the Lockwood-Chappell patent process in Sydney.²⁹ The test appeared successful, at least at the laboratory scale, and the company was persuaded to install a full-scale plant at the Sir Walter Scott battery at a cost of £1,000. From October 1892 the Reverend Campbell, assisted by Alfred Lockwood, spent four months supervising construction of the plant, incorporating his own modified version of the Lockwood-Chappell patent, which he referred to as the 'Thermo-Hyperphoric' process.³⁰ After many trials and tribulations related to problems with the weather, difficulties with getting material to the remote site and faults with some of the equipment, the works were completed and tested in January 1893. The plant, the first of its kind to use this process, consisted of two cast iron retorts in which steam was reacted with white hot charcoal to produce water gas (hydrogen and carbon monoxide). The gas was conducted to six air-tight, fireclay retorts, in which ore crushed to about walnut size was roasted at a temperature of around 1,200°F (649°C). The hydrogen and carbon monoxide supposedly permeated and reduced the complex sulphide-arsenide minerals, removing the sulphur and arsenic and releasing the trapped gold so that it would be available for mercury amalgamation. After 6-8 hours the treated ore was processed in two fine-grinding and amalgamation pans and one concentrator-amalgamator using the Lockwood-Nicholson patent.³¹ Campbell predicted that the plant could treat 40 tons of ore per week at a cost of £2 per ton, including mining of the ore. His payment for the work appears to have been a parcel of shares in the company, as he was later described as a large shareholder.³² Just before the Reverend departed for Sydney in early February, there was a great flood and the Mann River rose 15 m, engulfing part of the battery and threatening to submerge the retorts. To avoid an explosion of the hot retorts the fires were reduced, but at the last moment the water receded – possibly a case of divine intervention, but with a warning.³³

After a short delay to repair the plant, operations resumed under the management of J.F. Heighway, 'late of the Thames goldfield in New Zealand'.³⁴

The 'Thermo-Hyperphoric' process appeared to work well, but in June there was an even greater flood, which damaged the retorts and threatened to wash away the whole plant. The Reverend Campbell returned to organise repairs, supervise bailing water from the lower parts of the mine and survey the course of a proposed tunnel to assist dewatering of the mine and provide easier access to ore in the lower levels.³⁵ The setbacks appear to have dismayed the shareholders, but mining eventually resumed and Campbell remained optimistic and upbeat about his process. By early 1894 there were 36 men employed at the mine and the tunnel to the lower part of the reef was completed.³⁶ However, over the previous year the plant had only produced 42 ozs of gold from 25 tons of ore.³⁷ To this point about £4,000 had been spent on the mine. In March the company applied for three months suspension of labour conditions to erect additional machinery.³⁸ A key problem at this stage appeared to be the scale of the plant, which limited the ore throughput to the point where the whole operation was unprofitable. In December 1894, 10 tons of refractory ore were sent to the Queensland Smelting works in Maryborough for treatment, suggesting that the company was also not entirely happy with the 'Thermo-Hyperphoric' process and investigating other methods to treat the ore.³⁹

During 1895, operations at the Sir Walter Scott were retarded by a water shortage and gold production to the end of the year from mid-1894 was limited to 317ozs. Subsequent developments, including an improved water supply and tramline to the battery, prompted optimistic predictions by the directors of a better future, but the optimism was premature.⁴⁰ There was no production during 1896 and in 1897 the company attempted to dispose of the property.⁴¹ The mine and plant were eventually sold at auction in January 1898 to pay the mortgagees and the equity of redemption sold for £60. The mine leases were cancelled in September for non-payment of rent. Some of the former owners re-applied for three leases with the intention of working on a smaller scale with the existing plant.⁴² Total gold production by the Sir Walter Scott Gold-mining Company was 1,790ozs (55.68kg) from 2,203 tons of ore, giving an income of around £5,500.⁴³ More than 70% of this production was in the first year of operation. Total expenditure on the mine was in the order of £9,000. At best this was a misadventure for the local directors and investors, but with some lessons learnt.

A late discovery and initial copper mining

In August 1901, Cangai resident John Seller was hunting koalas for their skins and stopped for lunch in the saddle of a high mountain spur.⁴⁴ While resting he noticed a prominent outcrop with bright green and blue staining and broke off a piece to reveal copper carbonates. Seller described his find to Thomas Harps and William Volkhardt, two miners who had worked at the Sir Walter Scott gold mine, and the three men pegged a 40-acre mineral lease (M.L. 1).⁴⁵ To raise funds to register the claim the prospectors approached Samuel See in Grafton, who agreed to provide the £10 needed, in exchange for a quarter share in the property. Work commenced with two shafts, the deepest to 12m, and 4 tons of oxidised ore were sent to the English and Australian Copper Smelting Co.

at Waratah, near Newcastle, for testing. This material returned 22% copper, 2dwt of gold and 13dwt silver per ton.⁴⁶ After the lease was issued, 80 tons of ore were raised and shipped for custom smelting, yielding 22-34% copper per ton. The ore was taken by dray to Copmanhurst at the head of navigation on the Clarence River and then shipped by riverboat and coastal steamer to Newcastle and Waratah.

Following the initial discovery other prospectors were attracted to the area and a party consisting of Archibald McLean, Joseph Adams and Bertrand Dessieu (aka Napoleon⁴⁷), discovered the western continuation of the lode. This group also sought funding in Grafton and after some misunderstandings, obtained support from Peter Kritsch and brothers Michael and William Zietsch.⁴⁸ A claim, known as No. 1 West (M.L. 2), was taken out adjacent to the original Prospectors claim, and in March 1903 a trial shipment of 10.5 tons of ore was sent to Dapto, for a yield of 29% copper.⁴⁹ Subsequently a third group including D. Corrie, S. Everingham and C. Cumberland took up the eastern extension of the lode zone as M.L. 3 (Fig. 2). This eastern lease was sold to Melbourne investors under the title of the Cangai Copper Syndicate. A parcel of 5 tons of ore was extracted for test treatment in June 1902.⁵⁰

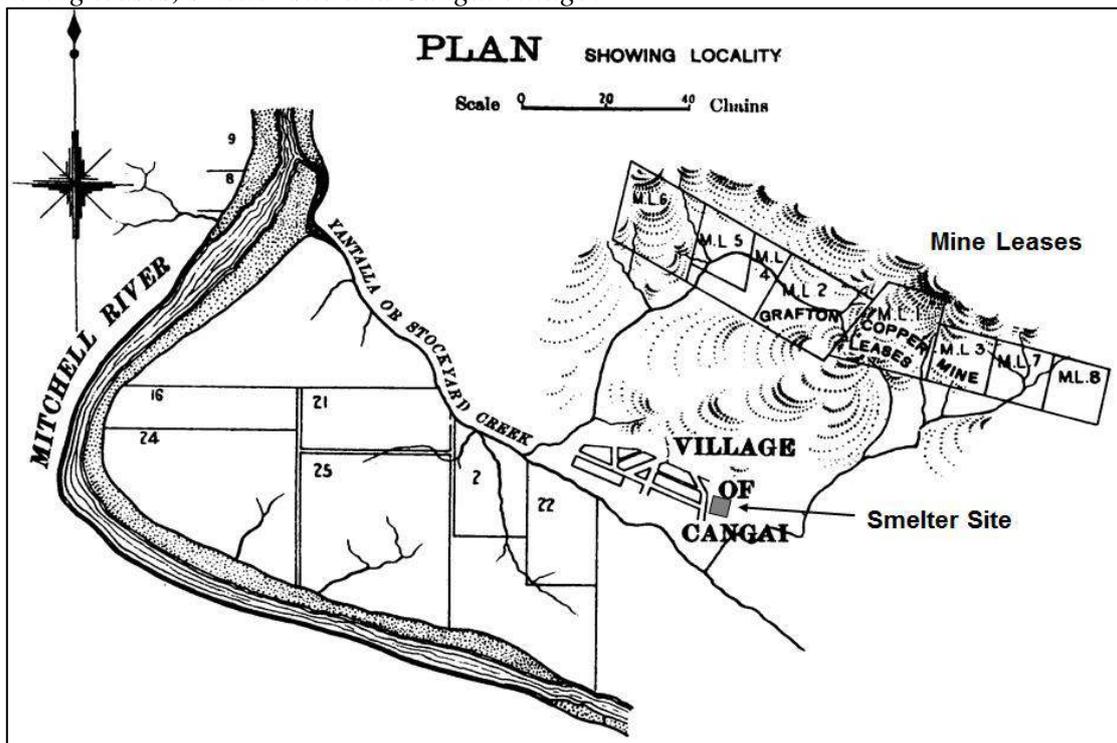
For a time, the three groups worked the Cangai deposit as separate syndicates, but during 1903 an agreement was made between the No. 1 West and Prospectors syndicates to form a joint company. Samuel See was given two months to float the company on a share and cash basis and travelled to Sydney to float the two leases into a no-liability company with 80,000 £1 shares. This attempt failed, as after a month, insufficient subscriptions had been raised, probably due to the prevailing low price of copper and resulting disinterest in new copper mining companies.⁵¹ A second attempt by See to float the company locally in Grafton also failed. At the end of the allocated two months the agreement between the two syndicates lapsed and their properties continued to be worked independently.⁵² In February 1903 the Cangai Copper Syndicate, intermittently working the eastern section of the lode, was successfully floated in Melbourne as the Cangai Copper-mining Company NL with nominal capital of £25,000.⁵³

During this early period of mining, high-grade, carbonate-oxide ore (20-40% copper) was transported 39 km to Copmanhurst by bullock dray. Each dray could carry 4.5 tons of bagged ore and in 1904 there were six teams operating.⁵⁴ The road was rough and difficult, involving five river crossings, which were impassable during floods. Even after a small rise or 'fresh' the river crossings could be dangerous. Initially a number of bullocks were drowned until a new method of crossing was devised, which involved unyoking the bullocks and swimming them across, hitching them to a wire or rope and pulling the dray across the river like a tethered submarine.⁵⁵ The round trip to Copmanhurst typically took at least two weeks and this section of transport was the main difficulty for the Cangai miners in getting their ore to market. From Copmanhurst the ore, and later, copper matte, could be taken by drogher down the Clarence River to Grafton for loading onto ocean-going ships.⁵⁶

In September 1904, well known theological geologist Father John Milne Curran was invited to inspect the Cangai workings and provide advice on their potential commercial development, as well as select a suitable site for a smelter. He returned to Sydney in early October laden with specimens and samples for exhibition and detailed

testing.⁵⁷ His report on the property was positive, professing great faith in the future of the mine and supporting another attempt by the Prospectors and No. 1 West syndicates to float a company. Initially a no-liability company was proposed, but when the key investors discovered that this would require a percentage of contributing shares they opted instead for a limited liability company with local ownership.⁵⁸ This decision may have been influenced by the previous experience of some shareholders who had been involved in the Sir Walter Scott Gold-mining Company NL, where it had been difficult to raise calls from speculating shareholders with contributing shares. From the first ore shipment in March 1903 until November 1904 the two syndicates had sent 350 tons of copper ore to Waratah, Dapto and Lithgow for smelting and a return of £4,660.⁵⁹ The Cangai Copper Company had produced an additional 300 tons of ore. By this stage most of the early prospectors in the syndicates, including John Seller, Thomas Harps, Joseph Adams and Archibald McLean, had sold out their interests. Seller took a job as a miner on wages, working in the mine that he had discovered, and later, he set up as a teamster hauling the copper to Copmanhurst.⁶⁰

Figure 2: Plan of the Cangai area in 1907, showing the location of the Cangai lode mining leases, smelter site and Cangai village.



Source: Modified from J.E. Carne, *The Copper Mining Industry and Distribution of Copper Ores in New South Wales* (2nd Ed.), 1908.

The Grafton Copper Mining Company Ltd

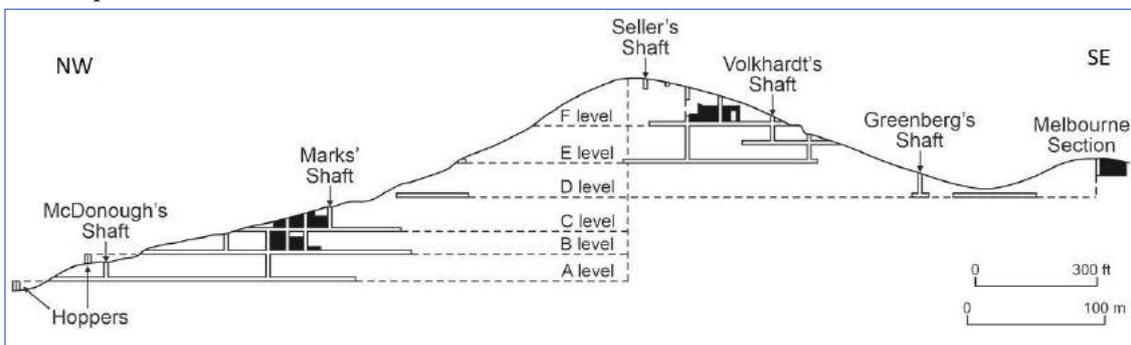
The Grafton Copper Mining Company Limited was successfully floated in late November 1904 with nominal capital of £80,000 in £1 shares. Shares were divided amongst the members of the two amalgamating syndicates, with no shares being offered to the public.⁶¹ The listed shareholders were Samuel See, William Zietsch, Peter Kritsch, George H. Varley, William Volkhardt, Michael Zietsch, Bertrand Dessieu and the

Official Assignee of the Estate of the Rev. Father Curran.⁶² Curran received 5,000 shares as payment for his geological advice and help in setting up the company. However, his shares had to be held by an assignee due to Curran's bankruptcy, related to property and mining investment transactions and a resulting court decision.⁶³ Samuel See was elected chairman of directors and William Zietsch took on the role of managing director. Father Curran was listed as a geological consultant, but quickly disappeared from the scene.

The new company acquired the leases and equipment of the Sir Walter Scott gold mine, with a view to treating the refractory ore by smelting to recover the gold, silver and minor copper.⁶⁴ Subsequently the property of the Melbourne-based Cangai Copper Company was also purchased for the small sum of £400, to secure a total of 100 acres of leases along the Cangai copper deposit.⁶⁵ William (Bill) J. Mulligan, an experienced and very practical mine manager, was appointed to oversee development of the mine and construction of a smelting plant. By the end of 1904 more than 20 men, including brick-makers, were employed at the mine and it was hoped to have a reverberatory furnace erected by the following February.⁶⁶ However, furnace construction was delayed until September, when the company acquired a 20 year lease over a suitable site 1 km southwest of the mine at the base of the mountain and close to water.

There was vigorous development of the mine during 1905 with much of this work in ore, so that the company was able to ship 291 tons for custom smelting to realise £4,806.⁶⁷ This approach of producing ore, while developing access to the orebody was to continue, allowing the mine to provide its own development capital. The first furnace was completed by the end of the year and smelting commenced in early 1906 to produce a 25% copper matte for shipment and further refining at Waratah. By May a second furnace was completed allowing second-stage matte roasting to produce a 50% copper matte and by the end of the year a third furnace was under construction. Smelting operations were directed by George Simon, late of Lithgow.⁶⁸ During 1906, 2,183 tons of ore were smelted and matte shipped, equal to 208 tons of copper metal worth £16,000. At the second annual general meeting of the company in January 1907 the directors recommended a maiden dividend of 6d per share (2.5% of the share value).⁶⁹ This positive result, combined with the rising copper price (up to £100 per ton), spurred a copper prospecting boom in the region and several other small deposits were discovered.⁷⁰

Figure 3: Longitudinal section of the Cangai copper mine workings in 1907, showing the stoped areas in black.

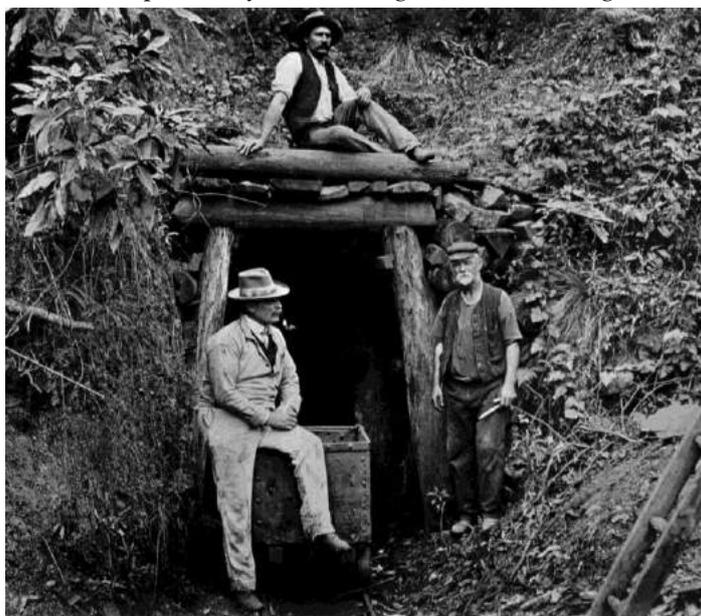


Source: Modified from J.E Carne, *The Copper Mining Industry and Distribution of Copper Ores in New South Wales*, 2nd Edition, 1908.

Extensive developments during 1907 led to a clearer picture of the Cangai deposit and great optimism for its future mining.⁷¹ The almost east-west trending lode had been traced down both sides of the mountain spur and accessed by adits or tunnels on six levels from both sides (Fig. 3). Winzes were constructed to provide internal access between levels, explore the lode and assist ventilation. The main A Level adit on the western side (Fig. 4) was 158m below the top of the spur and the original discovery outcrop. With this type of development, it was possible to remove ore via this lowest adit with the aid of ore chutes and gravity, avoiding the need for shafts and winding equipment. On the eastern side, ore could be removed from the upper levels via the Volkhardt adit (F Level) and lowered 152 m to the valley using an inclined reciprocating tramway, again with the aid of gravity.

The deposit was found to consist of a series of west-plunging ore lenses developed along a well-defined fissure or shear. The lenses varied in thickness from 0.3 to 3.5 m, typically with one wall of the massive chalcopyrite-rich ore in sharp contact with the host

Figure 4: *Entrance to A Level adit. Man sitting on the ore cart is probably Bill Mulligan, mine manager.*



Source: Photograph - Frozen in Time Gallery, www.frozentime.com.au.

rocks and the other with a more irregular boundary showing alteration and lower grade ore. The main lens beneath the discovery site was found to extend up to 122 m along strike and to the full depth of the workings. The host rocks consisted of volcanic tuffs (also referred to as felsite) and the ore contained significant amounts of calcite, important for self-fluxing during smelting.⁷² Enriched carbonate-oxide ore (up to 45% copper) extended to a depth of 20 m below the surface with a transitional zone of black (supergene) ore and then the primary sulphide ore. Mining in the sulphide zone was mainly of the high-grade ore (typically around 12% copper) plus some of the lower-grade ore to provide sufficient silica and calcite to produce a fluid slag during smelting. All the ore was direct smelted without any concentration. During the year a major parallel lode was discovered south of the main lode channel. This new lode, varying in width from 1 to 3.3 m, was intersected in the upper two levels (E and D) and contained high-grade copper sulphides.⁷³

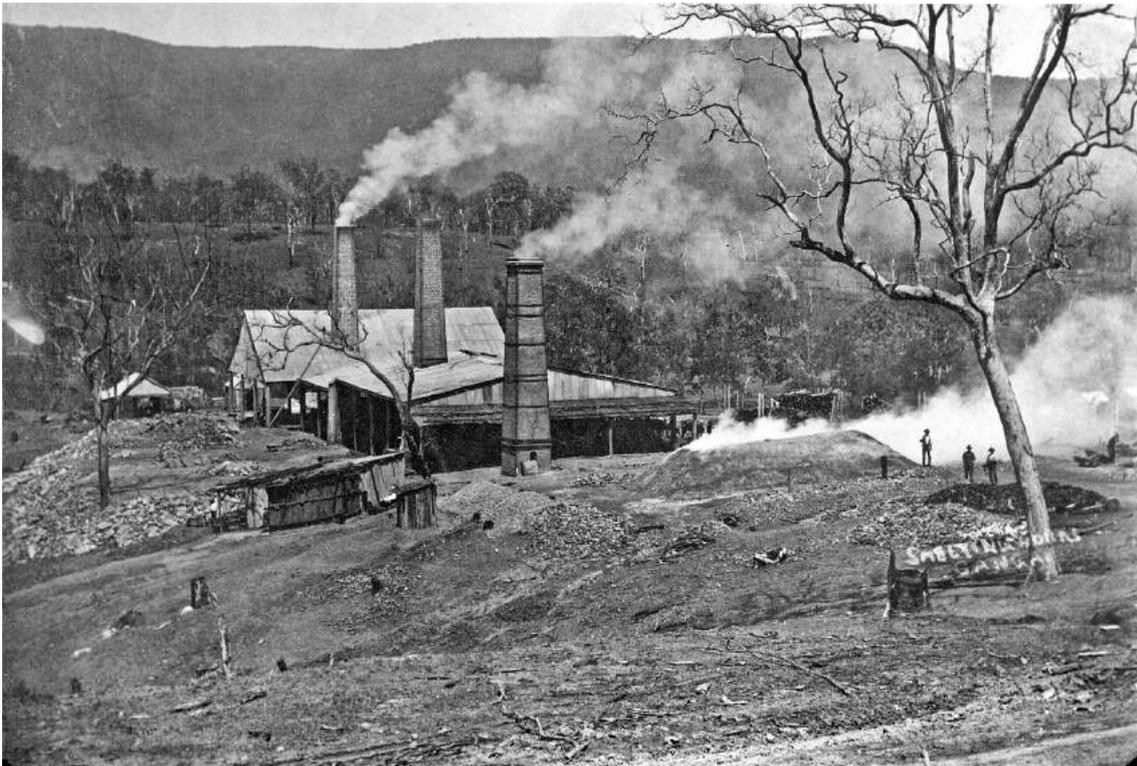
At the smelting works the third furnace was completed during 1907 with material readied for a fourth (Fig. 5). The directors were also considering electrifying the mine and expanding the works to include a concentrating plant and water jacket furnace to

allow pyritic smelting of the lower grade ores.⁷⁴ Construction had started on an improved road along the northeast side of the Mann River (referred to as the 'Rocks' road, Fig. 1). This road would negate the four river crossings on the Mann River and shorten the route to Copmanhurst by 9.7 km.⁷⁵

Ore production for 1907 from both development and stope mining totalled 7,665 tons with 3,535 tons smelted to produce 505 tons of matte containing 353.5 tons of copper, 176 ozs of gold and 946 ozs of silver. Ore reserves blocked out totalled 112,177 tons, comprising 17,713 tons at 10% copper, 23,612 at 6% and 70,852 at 3.5%. Profit for the year after expenditure was £14,251, which together with £3,615 brought forward from the previous year allowed £11,000 to be paid in dividends.⁷⁶ The annual report of the NSW Department of Mines for 1907 noted that:

The developments at the Cangai Mine in the Grafton District were of an especially promising nature and the indications point to this mine soon ranking among the large producing mines of this state.⁷⁷

Figure 5: *Smelting furnaces and calcining (roasting) heaps at right, Cangai copper mine 1907. View to southwest.*



Source: J.E. Carne, *The Copper Mining Industry and Distribution of Copper Ores in New South Wales*, 2nd edition, 1908.

Bill Mulligan had been so successful in developing the mine that at the end of the year he decided he should probably obtain his mine manager's certificate. This required undertaking a 'severe' examination, which he passed, with additional compliments from the Chief Inspector of Mines on the work he had done at Cangai.⁷⁸

In the following year, development and production continued apace with the mine supporting more than 300 workers, including miners, smeltermen, woodcutters and teamsters.⁷⁹ Underground development was at a reduced level, but still sufficient to keep

ore supply and reserves well ahead of the smelting. The ore reserve was increased to 25,000 tons of 11% copper and 6,000 tons were mined, with 4,885 tons smelted for 1,311 tons of matte containing 513 tons of copper, 240 ozs of gold and 3,994 ozs of silver. Despite the low copper price, financial results for the company were satisfactory due to the low cost of production. However, the directors (Fig. 6) decided not to pay a dividend,

Figure 6: *The Grafton Copper Mining Co. Directors ca. 1910, L to R - Peter Kritsch, William Zietsch, George Varley and Samuel See.*



Source: T. Kass, *Jacaranda City on the Clarence. a history*, Clarence Valley Council, Grafton 2009.

but to invest the profit back into the mine. The fourth reverberatory furnace was completed and No. 1 and 2 furnaces dismantled and enlarged to give a total production capacity of 700 tons of copper matte per month. A more efficient water service was laid on to the furnaces, reducing the fire risk. A new sawmill was erected to supply mine timbers at reduced cost, and also provide building material to the local residents. The new 'Rocks' road was completed at a cost of £1,250, which improved transport to Copmanhurst, although this

was still one of the more difficult and expensive aspects of the whole operation. It was hoped that the local council would 'come to the party' to further improve transport by constructing a bridge at the remaining river crossing on the Clarence River near Lilydale.⁸⁰

Second largest copper producer in New South Wales

In 1909 the Cangai copper mine produced 1,141 tons of high-grade matte plus 28 tons of blister copper, making it the second largest producer in the state after the Great Cobar mine. The year was not a good one for copper production across New South Wales due to the continuing low copper price (ca. £58 15s per ton), which was near or below the cost of production for many mines working low-grade ore. There were also additional problems at some mines. In the Cobar region the Nymagee, Mount Hope and Girilambone mines were closed down and at the Great Cobar a strike at the smelters in November, and a shortage of fuel due to a coal miners' strike, reduced output.⁸¹ Fortunately the Grafton Copper Mining Company was working high-grade ore (>7% copper), had low production costs and was using wood fuel for the smelters. There was a brief strike by the miners on the 21 May, but this was quickly settled.⁸² C.A. Sussmilch from Sydney Technical College, who had inspected the mine in January, assessed from his geological interpretation that mineralisation should extend to a depth similar to the strike length of

1.5 km, suggesting significant ore reserves. He also recommended installation of a water jacket furnace to treat the lower grade ore.⁸³

Further improvements were made to the smelting plant at Cangai, including lining the furnaces with chromite to increase their durability and reduce down-time and maintenance costs. Four furnaces were now operating and the company had commenced producing blister copper, as well as matte. Responsibility for the 'Rocks' road was transferred to the Dorriggo Shire Council and several travelling stock reserves were set up by the government to provide fodder for the bullock teams. Up to 45 teams of 22 bullocks each were now employed transporting matte, goods and wood fuel, so keeping the bullocks fed was a significant preoccupation for the bullockies (teamsters). These improvements helped with transport, but the trip to Copmanhurst was still fraught, particularly at the Lilydale river crossing, which was frequently closed during floods. The mine manager recommended that the company construct a wood-line tramway to improve the fuel supply and to consider installing air rock drills to reduce the cost of mining. He also proposed that a hydroelectric plant be built at the Dandahra Water Falls to electrify the mine, similar to the successful system recently installed at Hillgrove. Net profit for the year including a 5% dividend was £6,080.⁸⁴

Operations continued satisfactorily and profitably from 1910 to 1913. During 1910 the cost of fuel and labour significantly increased, and the local wood supply was largely depleted, requiring the wood cutters to travel further and into more difficult terrain. In periods of very wet weather it was often impossible for the teams to operate. The company paid a royalty to the government of 2s 6d per cord of wood and argued that it was effectively clearing the land for farming, without the waste of ring-barking or any support from the government.⁸⁵ Also in 1910 George Blakemore, a previous manager of the Great Cobar mine, was appointed consulting engineer, to assess the operations and future of the mine. His subsequent report verified the forecasts of the mine manager, Bill Mulligan, and supported the latter's recommendations for further development.⁸⁶

Figure 7: *Locomotive and train loaded with wood on the tramway, 1911.*



Source: Photograph - Frozen in Time Gallery, www.frozentime.com.au.

To address the fuel supply problem an 8 km tramway was constructed from mid-1910 to mid-1911 at a total cost of £10,000. The tramway extended from the smelter, southeast along the Stockyard Creek valley close to the 'Rocks' road (Figs 1 and 2). There was hope that it might eventually be continued all the way to Copmanhurst to provide a 'railway' connection to the outside world. The narrow gauge (762 mm) line with ten bridges, including an imposing trestle bridge across Smelter Creek, was completed and operating in July 1911 (Fig. 7). The rolling stock and a small steam locomotive, built by Orenstein and Koppel of Berlin, had been imported from Germany and the steel rails supplied by The Australian Metal Company.⁸⁷

The tramway was officially opened in October 1911 in a spirit of enthusiastic optimism, although at this point, wet conditions and a shortage of teams to bring sufficient wood to the line, meant the furnaces could still not operate continuously.⁸⁸ The company had already decided that to reduce fuel requirements it would cease producing blister copper and instead ship high-grade copper matte for final refining at custom treatment works. From 1906 sales contracts for matte had been to England, but in 1910 they were switched to Germany, probably because of a better price.⁸⁹ This would later prove to be a problem when WWI broke out. The plan to introduce a water jacket furnace was postponed, at least until there was better road transport to supply coke or coal, but a number of improvements were made to the existing plant. In 1911 a new stack was constructed for the Number 1 furnace, a new brick kiln completed and a brick-making yard prepared at the clay pit adjacent to the mine. The previous year, the company had built new office buildings in Cangai and acquired a telephone connection to Copmanhurst, greatly improving communications for the mine and local residents.⁹⁰

At the mine, there was significant development in the western part of the lode, particularly with extensions of the main adits on the A and C levels. During this work another new ore lens was intersected on A Level. An adit was developed into the far-eastern part of lode in the area known as the Melbourne section, where some very rich near-surface carbonate ore had been mined (this was the lease originally held by the Melbourne-based Cangai Copper Company (Fig. 3). The mine tramway was also extended to this area. The directors indicated that the Sir Walter Scott gold mine would receive more attention, as a source of siliceous ore to blend with the sulphide-rich 'basic' ore and to provide additional gold and silver to the matte.⁹¹

Ore production from Cangai for the period 1910-1912 was 28,626 tons with 3,663 tons of matte produced, for an estimated 2,292 tons of copper, 835 ozs of gold and 17,095 ozs of silver. Due to rising labour costs and the various problems related to smelting, production costs had increased from £18 17s to £26 12s per ton of copper. Approximately 250 workers were employed on a monthly wages bill of £2,200-2,400.⁹²

Industrial troubles

To improve ore production at Cangai and assist with mining below the A Level, the Grafton Copper Mining Company installed an air compressor plant, air-driven rock drills and an air hoist in August 1913. This had been recommended by the mine manager as early as 1909. Initially three drills were installed with a plan for four more, as demand determined. Up to this time miners had worked in pairs using traditional hammer and tap

drilling and blasting. The company agreed to keep two men on each drill, but to pay the offsider at labourer's rates. The company also wanted to change to a contract system, rather than day wages, and withhold 25% to ensure that the contracts were completed. This was deemed unsatisfactory by the machine miners, who also sought higher pay, arguing that as they were using machine drills, they were doing skilled work. As a compromise until their claim was considered, they offered to continue hammer and tap mining under the old conditions, but the company dismissed them. Although this only affected three drilling teams (six men) all the miners and hoist drivers went on strike on the 17 September, forcing the company to close the mine.⁹³ The strike was to last ten days.

The Amalgamated Miners Association (AMA), which had developed a strong presence at Cangai, after setting up a local branch in August 1910, vigorously prosecuted the miners' claims.⁹⁴ It was argued that the cost of living was higher in Cangai, due to the transport difficulties, and hence the miners should receive a general pay rise to 'Cobar rates'. The case was taken to the Wages Award Board, at which the Grafton Copper Mining Company was represented by Mr Nathan for the Mine Owners Association and the miners by Mr Wearmouth, president of the Cangai branch of the AMA. The Board found essentially in favour of the Company but decided the two machine miners should be paid the same rate and the contract conditions changed such that only 12.5% of the contract should be retained until completion, and only for sinking work and not driving or rising. If the contract was to be stopped the men would be found other mining work at award rates.⁹⁵ The smelter workers also went on strike, demanding double time for Sundays, but this claim was also decided in favour of the company.⁹⁶

Over the year, 8,282 tons of ore were mined for a production of 434 tons of copper, a 45% reduction on the previous year. Only one furnace was in operation and the copper price remained low, resulting in a return of £28,250.⁹⁷ Before the close of the year Bill Mulligan resigned as mine manager, possibly out of frustration. Samuel See also resigned as chairman of the board, due to ill health. William Zietsch took on the role of chairman. At the annual general meeting held in April 1914 the directors sought permission from the shareholders to seek a loan to pay off the company's liabilities and assist development work recommended by George Blakemore, consultant engineer.⁹⁸

During 1914 the labour situation at Cangai deteriorated further. Just before the 1913 Christmas holidays the company had announced a downsizing of the work force and that some miners would not be re-employed in the New Year. There was also persistent discontent amongst the miners with the contracting system. This resulted in a 44-day strike from the 3rd of January.⁹⁹ The company took the opportunity to make some alterations and improvements to the mine and engaged a new group of about 60 miners. Mining recommenced in mid-February. On the 21 May there was a second strike, which lasted six days. A deputation from the AMA informed management that the men had resolved to strike as there was a non-union man employed underground and a boy under 18 employed on the old labouring rate. They were also calling for the dismissal of the underground foreman, Frank Ross, allegedly because he used 'bad language'. It transpired that their real concern with Ross related to the way he allocated work and the requirement for each pair of miners to drill at least six feet (1.83 m) per shift. The mine

superintendent, William Hughes, refused to dismiss the foreman, clarified the work conditions and offered 3s per foot for any miner boring and firing holes, barring down and making the ground safe.¹⁰⁰ The strike was settled, but the difficulties with the machine miners meant that air drilling was never fully implemented at Cangai.¹⁰¹

Closure of the Cangai mine

Following the outbreak of WWI in August 1914, there was uncertainty about the copper market, particularly related to the ban on copper sales to Germany; and the directors of the Grafton Copper Mining Company decided to temporarily suspend operations. The company approached the NSW Government seeking advances on their copper if they kept producing, but this was deemed impractical. Application was then made to the Mining Warden's Court for suspension of labour conditions and this was granted for six months. During the year only 987 tons of ore were smelted to yield 73 tons of copper.¹⁰²

As the war continued the copper price began to rise and operations resumed at Cangai in March 1915 on the basis of one shift and 33 men employed. During the year 1,411 tons of ore were mined and 161 tons of matte produced to yield 100 tons of copper valued at £7,757, including the gold and silver credits.¹⁰³ This was an improvement on the previous year, but the ore reserve was rapidly diminishing, not helped by reduced development work. During 1916 there was very little mining and a small amount of unsuccessful underground prospecting. The smelter, which had been idle for some time, was restarted in July, but by October all the ore at hand had been treated. A mere 617 tons of ore had been mined and 75 tons of matte produced for 51 tons of copper.¹⁰⁴

A small amount of ore (197 tons) was produced in 1917 as the last gasp of mining.¹⁰⁵ The Cangai deposit was then widely considered mined out, even though there had been very little exploration below A Level and certainly no exploratory drilling. The Grafton Copper Mining Company continued to hold the mining leases until at least 1921, but eventually gave up the ghost.¹⁰⁶ Subsequently there were some abortive attempts to re-open the mine and the furnace bottoms at the smelter were blown up to recover the contained copper.¹⁰⁷ The chimneys survived, but were later demolished in 1974. Former mine manager, Bill Mulligan who had settled in Cangai as a pastoralist, prepared a report in 1937 for a plan to reopen the mine, but this did not eventuate.¹⁰⁸ In 1942 North Broken Hill Ltd assessed the Cangai mine for redevelopment, but Chief Geologist M.D. Garretty recommended against this based the limited ore reserves.¹⁰⁹

During the 1960-70s mining boom several groups investigated the Cangai area and Union Corporation (Australia) Pty Ltd completed two diamond drill holes under the mine in 1972.¹¹⁰ One of these holes intersected 2 m of sulphides with 1.9% copper, 84m below the deepest workings. Western Mining Corporation followed up this work in 1982-84, with detailed geochemical and geophysical surveys, leading to testing by two diamond drill holes targeted on geophysical anomalies. No significant mineralisation was intersected and the property was relinquished.¹¹¹ CRA Exploration conducted a more extensive, five-hole drilling programme in 1991, but also failed to find economic mineralisation.¹¹² Most recently, in 2017, the Cangai mine was acquired by Castillo Copper Ltd and this company has been undertaking extensive drilling aimed at defining a resource possibly suitable for modern mining.¹¹³

Cangai township

When the Grafton Copper Mining Company commenced full-scale mining at Cangai a village developed northwest of the smelting works. This started as a mining camp with some additional accommodation in the surrounding area, particularly related to the Sir Walter Scott mine. By 1906 the population had grown to more than 200 and in February that year the town site of Cangai was surveyed with allotments to be made available for purchase.¹¹⁴ A general store had already been set up by William Campbell and during the year a Mechanics Institute was established. A new building was under construction to house the school, which had been established in February 1905, with teacher Mr E.J. Buchan. An energetic Progress Association was actively pursuing the Postmaster-General's Department for a full postal service.¹¹⁵ Construction of the all-important hotel commenced in 1907 and was completed in December 1908 with Percy Neyle as the new licensee (Fig. 8).¹¹⁶

By 1911 there were more than 800 residents at Cangai and the town included the Cangai Hotel, school, police barracks, two general stores, two butcher shops, a bakery, several boarding houses, the mine house, offices and workshops and a public hall built by the Grafton Copper Mining Company. The hall was noted for its 'rustic style' and contained card and reading rooms and a fine dance hall. Hagney's four-horse coach operated a service to Copmanhurst twice a week. A full postal service and telephone connection had been achieved through the persistent lobbying by the Progress Association and the mining company.¹¹⁷

Figure 8: *View of Cangai Hotel and bullock teams unloading supplies with smelting furnaces and roasting heaps in background, ca. 1911. View to east.*



Source: T. Kass, *Jacaranda city on the Clarence: a history*, Clarence Valley Council, Grafton, 2009.

The population of Cangai was surprisingly multicultural. Residing in the town and surrounding area there were descendants of the indigenous people and the usual mix of English, Scottish and Irish settler descendants.¹¹⁸ There were the remnants of groups who had come to the Clarence district during the earlier gold mining period, including Italians and some French. A number of the personalities associated with the mine were of German background, including the Zietsch brothers, Peter Kritsch and William Volkhardt. In

February 1908, William Zietsch rescued a group of Bulgarian men who had been stranded in Sydney following an 'assisted immigration' scam, providing them with jobs at the Cangai mine and paying their travel costs. There was also a small group of Latvians, generally referred to as Russians, who had escaped from Russian controlled Latvia.¹¹⁹

After the mine closed, Cangai gradually declined as the workers and their families moved away, however it remained a small service centre for the local agricultural and timber industries well into the 1950s. In 1961 the population of the Cangai area was 57.¹²⁰ The post office finally closed in 1977 and the only building still standing from the former town is the Police Station house.¹²¹

Discussion and conclusions

The Cangai copper mine was a successful venture for the Grafton Copper Mining Company Ltd., producing 4,950 tonnes of copper, 52.7 kg of gold and 1,035 kg of silver.¹²² The mine paid for the capital expenditure and returned dividends to shareholders totalling £22,000. Total income from metal sales was approximately £261,000 and much of this found its way into the local Clarence Valley community through wages, contracts and supplies.¹²³ Such success was rare for New South Wales copper mines in the early part of the twentieth century and a number of factors contributed to this success.

The deposit was a well-defined lode with relatively high-grade ore (ca. 7% copper) that could be direct smelted. The ore was self-fluxing with available zones of siliceous and carbonate-rich, low-grade ore to blend with the 'basic' sulphide-rich ore. It also contained significant gold and silver credits. At the height of production, ore treatment consisted of calcining the bulk ore in open-air clamps (heaps), smelting by four reverberatory furnaces to produce a first-stage matte, followed by roasting in the furnaces to produce a high-grade matte with around 65% copper. For a time, blister copper was also produced, but it was found more economical to ship high-grade matte and save on the cost of wood fuel needed for the extra refining. The long-proposed water jacket blast furnace was never installed, largely due to closure of the mine before transport infrastructure to Cangai could allow for economic access to coke or coal.

The physiographic setting of the deposit allowed it to be worked from adits, using gravity to remove the ore and thus avoid the need for expensive shafts and winding equipment. The mine was self-draining, did not require any significant pumping, and once the workings were interconnected ventilation was good. Wood was available for the mine workings and to fuel the reverberatory furnaces. Water was also readily available from a nearby dam on Smelter Creek. These beneficial factors resulted in the lowest cost of production of any copper mine in NSW, and possibly Australia, during the period of operation. At no time did this cost exceed £37 per ton of copper and generally it was much less, allowing the mine to operate profitably through periods of low copper prices.

Good management by the board and the mine manager also contributed to the success of the Cangai copper mine. The ability to fund initial mine construction from early sales of rich surface ore, followed by the approach of extracting ore during ongoing development work, meant that the mine essentially provided its own capital. Cangai was

thus a good example of the 'bootstrap' model of mine development, whereby very little external funding was required.¹²⁴

The main disadvantage that the mine faced related to transport, both for shipping product and supplies, and collecting wood fuel. The mine was relatively close to cheap and efficient river and coastal shipping (Fig. 9), but due to the rugged terrain, connection to Copmanhurst at the head of navigation was persistently difficult. Even after improvement, the road was rough and during wet weather the bullock teams frequently bogged. Floods blocked the river crossings for weeks at a time. Teams bringing in wood fuel from the surrounding forest had similar problems under wet conditions, resulting in fuel shortages that required smelting to be curtailed or shut down. Rising costs, industrial troubles, a scarcity of skilled labour and uncertainty in the copper market became problems from 1913, which together with the apparent exhaustion of ore reserves, ultimately led to closure of the mine.

Figure 9: *S.S. Perseverance, near Copmanhurst on the Clarence River (ca. early 1900s). This was one of the droghers used to transport copper matte from Cangai and supplies to the Cangai mine.*



Source: Photograph - Frozen in Time Gallery, www.frozentime.com.au.

There were some interesting connections and parallels between the Cangai copper mine and earlier gold mining in the Cangai area, particularly with the Sir Walter Scott mine. Gold mining pioneered exploration and interest in mineral resources and provided a context and initial infrastructure for copper mining. Some of the key shareholders in the Grafton Copper Mining Company had been involved in the Sir Walter Scott gold mine, including Samuel See and William Volkhardt. This earlier experience may have guided development of the Cangai copper mine. (for example, the type of company floated, use of adits to access the ore and provide drainage, the application of gravity in the hilly terrain to help transport ore to the mill or smelter). The Sir Walter Scott mine was not a success, but it was subsequently acquired by the Grafton Copper Mining Company with the aim of extracting the refractory gold as part of the copper smelting. It is not clear from the records how much additional mining occurred at the Sir Walter Scott or how much additional gold was contributed.

In the case of both the Sir Walter Scott and Cangai mines, the directors sought expert advice from geologists and consultant engineers, even though this didn't always work out well. The board was generally cautious in its capital investment, particularly in the later development of the Cangai copper mine. Samuel See (Board Chairman of both mines) admitted that he had little knowledge and practical experience of mining, and his main motivation was to develop the resources of the Clarence region.¹²⁵ To an extent this was achieved at Cangai with mining 'opening up' the country for agricultural development and improving general access and infrastructure. More broadly, many local businesses, miners, teamsters, and shipping companies all benefitted from copper mining at Cangai. The earnings and success from Cangai copper were an important contribution to the mining and economic history of the Clarence Valley district of northern New South Wales.

Acknowledgements

The author acknowledges the National Library of Australia and the Geological Survey of New South Wales for access to information, particularly through their online services (including 'Trove' and 'Digs'). The late Lincoln McClatchie provided some information on the history of the John Bull gold mine. The author also thanks Russell Farmer, landowner at Cangai, who generously showed me around the Cangai mine and smelter site and provided useful information on the more recent history of the area. The article was improved by the helpful comments of two anonymous reviewers.

Glossary of some terms used in the text

Calcining – preliminary oxidation by heating or burning of sulphide ores to remove some of the sulphur as sulphur dioxide. Often conducted in open air on roasting heaps (stalls or clamps), or in calcining furnaces.

Chalcopyrite – the most common copper sulphide mineral (CuFeS₂).

Chromite – a chromium-iron oxide mineral with highly refractory properties.

Drogher – a small, shallow-draught paddle steamer.

Matte – the initial product of copper smelting, particularly of copper sulphide ores. The matte is essentially a copper-enriched, copper-iron-sulphide with the silica waste and some of the associated iron removed in the form of slag. Valuable trace metals such as gold and silver are retained in the matte.

Plunge – the linear direction of elongation of an ore body, as distinct from the dip, which is the angle of tilt of an ore lens from the horizontal.

Supergene – formed by descending waters during surface weathering.

Winze – a vertical opening excavated downwards to connect working levels in a mine.

Units

1 inch = 25.4 mm, 1 foot = 0.3048 m, 1 mile = 1.609 km, 1 acre = 0.4047 hectares.

1 troy oz (the standard measure of gold and silver) = 20 dwt = 31.10348 g; 1 dwt = 1.555 g.

1 pound (lb) = 0.454 kg, 1 ton (long) = 2,240 pounds (lbs) = 1.01604 tonnes.

1 (imperial) gallon = 4.4561 litres. 1 cord (of wood) = 3.625 cubic m.

Pre-decimal currency

£1 (pound) = 20s (shillings) and 1 shilling = 12d (pence).

Endnotes

¹ 'Clarence River Historical Society – Bawden Lectures', *Daily Examiner*, 6 March 1937, p. 10.

² K.G. McQueen, *New England Orogen 1:750 000 Metallogenic Map (back sheet notes)*, 2018, Geological Survey of New South Wales, Maitland, Australia.

³ I. Wilkinson, *Forgotten Country: the story of the Upper Clarence gold fields*, 3rd edition, Northern Rivers CAE, Lismore, p. 94; 'Important News from the Northern-Goldfields', *Armidale Express and New England General Advertiser*, 2 July 1859, p. 2. 'The Northern Goldfields - Tooloom', *ibid.*, 5 November 1859, p. 2.

⁴ 'Clarence River Gold Fields', *Maitland Mercury and Hunter River General Advertiser*, 3 October 1861, p. 2; 'Gold News', *Sydney Morning Herald*, 30 November 1861, p. 8; 'Gold Reward fund', *Bell's Life in Sydney and Sporting Chronicle*, 29 April 1865, p. 3.

- ⁵ 'Our Goldfields', *Sydney Morning Herald*, 30 September 1861, p. 4; 'Cangi Gold-Fields', *Sydney Mail*, 4 January 1862, p. 8. It is not clear exactly where Hansen found gold along the Mann River, but it was most likely downstream from or near a tributary later called Diggers Creek. This became the site of significant alluvial mining and subsequent discovery of gold reefs such as the John Bull.
- ⁶ 'Our Goldfields', *Sydney Mail*, 14 December 1861, p. 6; 'Mining Gazette', *ibid.*, 5 September 1868, p. 3.
- ⁷ 'Cangai Quartz Reefs' *Clarence and Richmond Examiner and New England Advertiser*, 9 July 1872, p. 2. Paulo Marcolino was a well known prospecting and mining identity, having previously worked on the Timbarra Goldfield. He also discovered and worked the Garibaldi Reef on the Solferino-Lionsville Goldfield, near Yugilbar on the Clarence River, before coming to the Cangai area.
- ⁸ 'Cangi-Gold-Field', *Clarence and Richmond Examiner and New England Advertiser*, 4 March 1873, p. 3.
- ⁹ *Ibid.*, 10 June 1873, p. 2.
- ¹⁰ 'The Goldfields in the Clarence District', *Australian Town and Country Journal*, 11 November 1876, p. 18.
- ¹¹ 'The Cangai Gold-Field', *Clarence and Richmond Examiner*, 5 October 1889, p. 8.
- ¹² 'Cangi Gold-Field', *Newcastle Chronicle*, 3 December 1872, p. 3.
- ¹³ 'Cangi Gold-Field', *Clarence and Richmond Examiner and New England Advertiser*, 1 October 1872, p. 2; 'History of the Sir Walter Scott Mine', *ibid.*, 28 March 1891, p. 3.
- ¹⁴ *Ibid.*
- ¹⁵ 'Notice to Application for Gold-Mining Leases', *Australian Town and Country Journal*, 18 March 1876, p. 6.
- ¹⁶ *Annual Report of the New South Wales Department of Mines* (hereafter ARNSWDM) for 1888, p. 114.
- ¹⁷ 'Mann River Reefs', *Glen Innes Examiner*, 28 June 1887, p. 2.
- ¹⁸ 'Cangi Goldfield', *Australian Star*, 28 August 1889, p. 8; 'Mining', *Clarence and Richmond Examiner*, 19 August 1890, p. 3.
- ¹⁹ 'Mining – Sir Walter Scott Mine', *Clarence and Richmond Examiner*, 20 September 1890, p. 8.
- ²⁰ 'The Grafton District – Sir Walter Scott and John Bull', *Evening News*, 20 May 1891, p. 7.
- ²¹ 'Mining – Sir Walter Scott Mine', *Clarence and Richmond Examiner*, 20 September 1890, p. 8.
- ²² 'The Sir Walter Scott Battery - Christening Ceremony', *Clarence and Richmond Examiner*, 24 March 1891, p. 2.
- ²³ 'Advertisement – Memorandum of Association of the John Bull Gold-mining Company', *Clarence and Richmond Examiner*, 24 March 1891, p. 1.
- ²⁴ 'The Sir Walter Scott Mine', *Armidale Express and New England General Advertiser*, 11 August 1891, p. 2.
- ²⁵ 'The Lockwood-Chappell Process', *Northern Miner*, 9 March 1893, p. 4.
- ²⁶ 'The Sir Walter Scott Gold-Mining Company', *Armidale Express and New England General Advertiser*, 15 March 1892, p. 5.
- ²⁷ 'The Sir Walter Scott Mine', *Clarence and Richmond Examiner*, 1 March 1892, p. 3; 'The Sir Walter Scott Mine', *ibid.*, 13 August 1892, p. 5.
- ²⁸ 'The Sir Walter Scott', *Clarence and Richmond Examiner*, 2 July 1892, p. 3. The Goddard patent was one of many developed around this time to treat refractory gold ores by finer grinding in various types of grinding and amalgamation pans. See, Ken McQueen, 'Early developments in treating pyritic and refractory gold ores in Australia', *Journal of Australasian Mining History*, vol. 10, 2012, pp. 88-102.
- ²⁹ 'The Sir Walter Scott Mine', *Clarence and Richmond Examiner*, 13 August 1892, p. 5; D.F. Branagan, 'Campbell, Joseph (1856-1933)', *Australian Dictionary of Biography*, National Centre of Biography, Australian National University; Philip Hart, 'Joseph Campbell and his thermo-hyperphoric process', *Te Aroha Mining District Working Papers No 110*, 2016, University of Waikato, 134 pp. Campbell had come in contact with shareholder, the Hon. John See, MLA, who invited him to visit and inspect the Sir Walter Scott mine and ore.
- ³⁰ ARNSWDM for 1892, p. 20; 'The Lockwood Chappell Process', *Northern Miner*, 9 March 1893, p. 4. Campbell chose the term 'thermo-hyperphoric' to indicate heat and mineralogical changes involving loss of some elements, as well as alluding to the supposed pre-eminence of the process.
- ³¹ 'Mining', *Clarence and Richmond Examiner*, 24 December 1892, p. 3; 'The Lockwood-Chappell Process', *Northern Miner*, 9 March 1893, p. 4; Hart, 'Joseph Campbell and his thermo-hyperphoric process', *Te Aroha Mining District Working Papers No 110*, 2016, p. 27.
- ³² 'Mining', *Clarence and Richmond Examiner*, 24 December 1892, p. 3.
- ³³ 'The Sir Walter Scott Mine – Success of the Lockwood-Chappell Patent', *ibid.*, 18 February 1893, p. 8.
- ³⁴ *Ibid.*; 'The Lockwood-Chappell Process', *Northern Miner*, 9 March, 1893, p. 4.
- ³⁵ 'The Sir Walter Scott Gold Mine', *Clarence and Richmond Examiner*, 20 June 1893, p. 5. The detailed chemistry of the 'Thermo-Hyperphoric' process was never fully understood or constrained and part of its

apparent success at the Sir Walter Scott Mine may have been due to the finer grinding by the Lockwood-Nicholson pans prior to amalgamation.

³⁶ 'The Sir Walter Scott Mine', *Sydney Mail and New South Wales Advertiser*, 20 January 1894, p. 148.

³⁷ 'By Telegraph – Grafton', *Sydney Morning Herald*, 18 February 1893, p. 11.

³⁸ 'Intercontinental Mining News – Grafton', *Australian Town and Country Journal*, 31 March 1894, p. 45.

³⁹ 'Grafton – Monday', *Sydney Morning Herald*, 4 December 1894, p. 7; ARNSWDM for 1894, p. 31.

⁴⁰ ARNSWDM for 1895, p. 29; 'Walter Scott G.M. Company', *Evening News*, 29 January 1896, p. 3.

⁴¹ ARNSWDM for 1897, p. 48.

⁴² *Ibid.*, for 1898, p. 52.

⁴³ Production figures calculated from ARNSWDM for years 1891 to 1897, cross checked and supplemented from Company annual reports published in newspapers.

⁴⁴ J.E. Carne, *The Copper Mining Industry and the Distribution of Copper Ores in New South Wales*, 2nd Edtn, New South Wales Department of Mines, Geological Survey, Mineral Resources No. 6, 1908, pp. 180-186. John Seller's surname is also given as Sellers or Sellars in some reports.

⁴⁵ 'Cangai Copper Mine – A Flourishing Concern', *Clarence and Richmond Examiner*, 17 November 1906, p. 2.

⁴⁶ ARNSWDM for 1901, p. 56.

⁴⁷ Dessieu was given the nickname Napoleon from his demeanour around the mines and his French background. He took an aboriginal wife, Annie Olive, who he later disowned, and their children adopted the surname Napoleon. Margaret Neyle, *A Dream Called Cangai*, M.R. Neyle, Baulkham Hills, NSW, 2013, pp. 26-27.

⁴⁸ There was an early disagreement over the exact proportion of ownership by Kritsch and the Zietsch brothers, resolved in their favour by the mining warden. See 'News Summary', *Clarence and Richmond Examiner*, 28 September 1901, p. 4; 'Warden's Court', *ibid.*, 11 October 1902, p. 5.

⁴⁹ 'Cangai Copper Mine', *ibid.*, 7 March 1903, p. 3; 'Cangai Copper Mine – A Flourishing Concern' *Ibid.*, 17 November 1906, p. 2.

⁵⁰ 'Mining Intelligence and Stock and Share Market', *Melbourne Argus*, 30 May 1902, p. 7; 'Copper Mining at Cangai', *Clarence and Richmond Examiner*, 21 June 1902, p. 5.

⁵¹ 'The Price of Copper', *West Australian*, 2 January 1902, p. 3. This decline in the copper price was largely the result of increased large-scale production from copper mining companies in the USA, including the large Amalgamated Copper Company and resulting competitive practices.

⁵² 'Cangai Copper Mine – A Flourishing Concern', *Clarence and Richmond Examiner* 17 November 1906, p. 2; 'Cangai – A Great Copper Mine', *Grafton Argus and Clarence River General Advertiser*, 6 October 1911, p. 4.

⁵³ 'Mining Meetings', *Melbourne Age*, 25 February 1903, p. 7.

⁵⁴ 'Cangai', *Grafton Argus and Clarence River General Advertiser*, 24 October 1904, p. 3.

⁵⁵ 'The Cangai Copper Field', *Northern Star*, 29 August 1907, p. 2.

⁵⁶ 'Cangai Copper Mine – Cheap and Effective Work', *Clarence and Richmond Examiner*, 31 August 1907, p. 10.

⁵⁷ 'Father Curran Visiting', *Grafton Argus and Clarence River General Advertiser*, 29 September 1904, p. 4; 'Father Curran's Visit', *Ibid.*, 3 October 1904, p. 3.

⁵⁸ 'Cangai', *Grafton Argus and Clarence River General Advertiser*, 24 October 1904; 'Copper Mining', *Clarence River Advocate*, 8 November 1904, p. 4; 'Cangai Copper Mine – A Flourishing Concern', *Clarence and Richmond Examiner*, 17 November 1906, p. 2.

⁵⁹ 'Grafton Copper Mining Company', *Clarence and Richmond Examiner*, 3 December 1904, p. 4; ARNSWDM for 1904, p. 47.

⁶⁰ 'The Cangai Copper Field', *Northern Star*, 29 August 1907; 'Accident near Copmanhurst', *Clarence and Richmond Examiner*, 23 April 1910, p. 4.

⁶¹ 'Grafton Copper Mining Company', *ibid.*, 3 December 1904, p. 4.

⁶² 'Cangai Copper Mine – A Flourishing Concern', *Clarence and Richmond Examiner*, 17 November 1906, p. 2.

⁶³ 'Special Messages – Father Curran's Bankruptcy', *Ibid.*, 17 December 1904, p. 5.

⁶⁴ ARNSWDM for 1904, p. 47; 'Grafton Copper Mining Company', *Clarence and Richmond Examiner*, 3 December 1904, p. 4.

⁶⁵ 'The Cangai Copper Field', *Northern Star*, 29 August 1907, p. 2.

⁶⁶ 'Cangai', *Grafton Argus and Clarence River General Advertiser*, 22 December 1904, p. 5; 'Northern Rivers Mining – The Cangai Copper Field', *Daily Telegraph*, 4 March 1908, p. 11.

⁶⁷ ARNSWDM for 1905, p. 46

⁶⁸ 'Grafton Copper Mining Co.', *Clarence and Richmond Examiner*, 29 May 1906, p. 4; 'Cangai Copper Mine', *ibid.*, 17 November 1906, p. 2.

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- ⁶⁹ 'Grafton Copper Company', *ibid.*, 2 February 1907, p. 3; ARNSWDM for 1906, pp. 48-49
- ⁷⁰ 'Revival of Mining', *Clarence and Richmond Examiner*, 17 November 1906, p. 4; ARNSWDM for 1906, p. 49. New copper discoveries included deposits at Pucka and Fine Flower.
- ⁷¹ 'Grafton Copper Mining Co.', *Clarence and Richmond Examiner*, 1 February 1908, p. 2.
- ⁷² W.J. Mulligan 'Report on the Cangai Copper Mine', 1937, in Geological Survey of N.S.W., Report File MR 0221, 10 pp.
- ⁷³ ARNSWDM for 1907, p. 55.
- ⁷⁴ It was proposed to install jigs for gravity separation, but later some experiments were also made on oil-acid and eucalyptus oil flotation. 'Grafton Copper Mine – An Experts Report'. *Sydney Morning Herald*, 21 June 1910.
- ⁷⁵ 'Grafton Copper Mining Co.', *Clarence and Richmond Examiner*, 1 February 1908, p. 2.
- ⁷⁶ ARNSWDM for 1907, p. 55.
- ⁷⁷ *Ibid.*, p. 48.
- ⁷⁸ 'Grafton Copper Mining Co.', *Clarence and Richmond Examiner*, 1 February 1908, p. 2; ARNSWDM for 1907, p. 72.
- ⁷⁹ 'Northern Rivers Mining – The Cangai Copper Field', *Daily Telegraph*, 2 March 1908, p. 11.
- ⁸⁰ ARNSWDM for 1908, pp. 49-50; 'Grafton Copper Mining Co.', *Clarence and Richmond Examiner*, 30 January 1909, p. 2. The Lilydale bridge was not constructed until 1934, 17 years after the Cangai copper mine was closed.
- ⁸¹ ARNSWDM for 1909, pp. 44-49..
- ⁸² 'Strike at Cangai', *Grafton Argus and Clarence River General Advertiser*, 24 May 1909, p. 2.
- ⁸³ 'Grafton Copper Mining Company', *ibid.*, 30 January 1909, p. 2; 'Cangai's Future', *Clarence and Richmond Examiner*, 2 January 1909, p. 9.
- ⁸⁴ 'Report of the Fifth General Meeting of the Grafton Copper Mining Company Limited', 31 January 1910, *Mine Record 221*, Geological Survey of New South Wales. ARNSWDM for 1909, p. 49. The teamsters mostly used bullocks, probably because it was cheaper to set up a team with bullocks than horses. Horses were used to haul ore in carts from the mine and inclined tramway to the smelter.
- ⁸⁵ 'Cangai – A Great Copper Mine', *Grafton Argus and Clarence River General Advertiser*, 6 October 1911, p. 4. The furnaces typically consumed more than 150 cords of wood per week (544 cubic meters).
- ⁸⁶ 'Grafton Copper Mine – An Experts Report', *Sydney Morning Herald*, 21 June 1910, p. 10; 'Report of the Sixth General Meeting of the Grafton Copper Mining Company Limited', 31 January 1911, *Mine Record 221*, Geological Survey of New South Wales.
- ⁸⁷ J.W. Shoebridge, 'The Cangai Railway: Grafton Copper Company Firewood Tramway', *Light Railways*, 134, pp. 3-18. In 1920 the locomotive and rolling stock were sold to the Tasmanian Timber and Tramway Company at Bridport.
- ⁸⁸ ARNSWDM for 1911, pp. 54-55.
- ⁸⁹ 'The Grafton Copper Mine', *Clarence and Richmond Examiner*, 25 January 1910, p. 7. Copper matte was sold under contract through Lohmann and Co., Sydney.
- ⁹⁰ ARNSWDM for 1910, p. 49; *ibid.*, for 1911, pp. 54-55; *ibid.*, for 1912, p. 51; 'Report of the Sixth General Meeting of the Grafton Copper Mining Company Limited', 31 January 1911, *Mine Record 221*, Geological Survey of New South Wales.
- ⁹¹ *Ibid.*
- ⁹² ARNSWDM for 1910, p. 49; *ibid.*, for 1911, pp. 54-55; *ibid.*, for 1912, p. 51.
- ⁹³ 'Cangai Copper Mine', *Brisbane Courier*, 18 September 1913, p. 7; 'Strike at Cangai', *Grafton Argus and Clarence River Advertiser*, 19 September 1913, p. 5; 'Cangai Dispute', *Sydney Morning Herald*, 22 September 1913, p. 6.
- ⁹⁴ 'Concentrates', *Cobar Herald*, 29 July 1910, p. 4; 'AM.A. Annual Conference', *ibid.*, 14 October 1910, p. 6.
- ⁹⁵ 'Cangai Strike Settled', *Clarence and Richmond Examiner*, 25 September 1913, p. 5.
- ⁹⁶ 'Grafton Copper Mining Company Ltd', *ibid.*, 2 April 1914, p. 2.
- ⁹⁷ ARNSWDM for 1913, p. 54.
- ⁹⁸ *Ibid.*, p. 54; 'Grafton Copper Mining Co. Ltd.', *Clarence and Richmond Examiner*, 9 April 1914, p. 2.
- ⁹⁹ 'Grafton Copper Mining Company Ltd', *ibid.*, 2 April 1914, p. 2; 'Cangai Copper Mine Closed', *Sydney Morning Herald*, 6 January 1914, p. 9.
- ¹⁰⁰ 'The Strike at Cangai', *Clarence and Richmond Examiner*, 26 May 1914, p. 5.
- ¹⁰¹ 'Strike Settled', *Sydney Morning Herald*, 30 May 1914, p. 25; W.J. Mulligan 'Report on the Cangai Copper Mine', 1937 in Geological Survey of N.S.W., Report File MR 0221, 10 pp.
- ¹⁰² ARNSWDM for 1914, p. 55.
- ¹⁰³ *Ibid.*, for 1915, p. 51.
- ¹⁰⁴ *Ibid.*, for 1916, p. 50.

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- ¹⁰⁵ *Ibid.*, for 1917, p. 43.
- ¹⁰⁶ ‘Wardens Court’, *Grafton Argus and Clarence River General Advertiser*, 23 April 1921, p. 2.
- ¹⁰⁷ Mulligan, ‘Report on the Cangai Copper Mine’, 10 pp.
- ¹⁰⁸ *Ibid.*
- ¹⁰⁹ M.D. Garretty, Report to North Broken Hill Ltd, 10 April 1932, in Geological Survey of NSW, Report File R00046195 (MR00221), 3 pp.
- ¹¹⁰ ‘Drilling aid, MLS 6243, 6244 and 6249, Cangai copper mine’, Geological Survey of NSW, 1972, Open File Report, R000245000 (GS1972/0910).
- ¹¹¹ ‘Final report on exploration, EL 1809 and 1811’, Geological Survey of NSW, Open File Report.R0009619 (GS1984/236).
- ¹¹² ‘Exploration Report EL 3665, Cangai, Stockdale area’, Geological Survey of NSW, 1992, Open File Report R0001693 (GS1992/038).
- ¹¹³ ‘Cangai Copper Project’, <https://www.castillocopper.com/project-cangai>. June 2019.
- ¹¹⁴ ‘Cangai Notes’, *Grafton Argus and Clarence River General Advertiser*, 22 February 1906, p. 4.
- ¹¹⁵ ‘Upper River Notes’, *ibid.*, 2 February 1905, p. 4; ‘Cangai Notes’, *ibid.*, 22 February 1906, p. 4; ‘Cangai Copper Mine’, *Clarence and Richmond Examiner*, 17 November 1906, p. 2.
- ¹¹⁶ Margaret Neyle, *A Dream Called Cangai*, M.R. Neyle, Baulkham Hills, NSW, 2013, pp. 42-43.
- ¹¹⁷ ‘Cangai’, *Grafton Argus and Clarence River General Advertiser*, 6 October 1911, p. 8; ‘A Visit to Cangai’, *Clarence and Richmond Examiner*, 7 October 1911, p. 2.
- ¹¹⁸ ‘Cangai Notes’, *Grafton Argus and Clarence River General Advertiser*, 22 February 1906, p. 4.
- ¹¹⁹ ‘Stranded Bulgarians’, *Clarence and Richmond Examiner*, 15 February 1908, p. 9; ‘A Grafton Tragedy – Young Russian’s Fate’, *Grafton Argus and Clarence River General Advertiser*, 22 June 1917, p. 2; Margaret Neyle, *A Dream Called Cangai*, M.R. Neyle, Baulkham Hills, NSW, 2013, pp. 38-39.
- ¹²⁰ Census of the Commonwealth of Australia for 1961, Vol 1 NSW, Part V, p. 16.
- ¹²¹ Neyle, *A Dream Called Cangai*, M.R. Neyle, Baulkham Hills, NSW, 2013, pp. 38-39.
- ¹²² ARNSWDM for years 1904 to 1917.
- ¹²³ ‘The Days of the Mining Boom’, *Grafton Daily Examiner*, 2 November 1938, p. 51.
- ¹²⁴ K. McQueen, ‘Approaches to mineral field discovery and development through history’. In Carpenter, L.J. and McQueen, K.G. (eds), *Rivers of Gold*, Proceedings of the 24th Annual Conference, AMHA, Cromwell, New Zealand, 7-13 October 2018, p. 27.
- ¹²⁵ ARNSWDM for 1889, p. 122; ‘The Sir Walter Scott Battery’, *Clarence and Richmond Examiner*, 24 March 1891, p. 2; ‘A Great Copper Mine’, *Grafton Argus and Clarence River Advertiser*, 6 October 1911, p. 4; ‘Death of Mr Sam See’, *Daily Examiner*, 25 October 1916, p. 5. As well as gold and copper mining Samuel See was involved in early attempts to mine coal in the Clarence region. He was an agent for the steamship company Nipper and See on the Clarence River and later the North Coast Steam Navigation Co. He became active in public life, tirelessly promoting the Clarence region, and serving as Mayor of both Maclean and Grafton for numerous terms. He died on 24th October 1916.