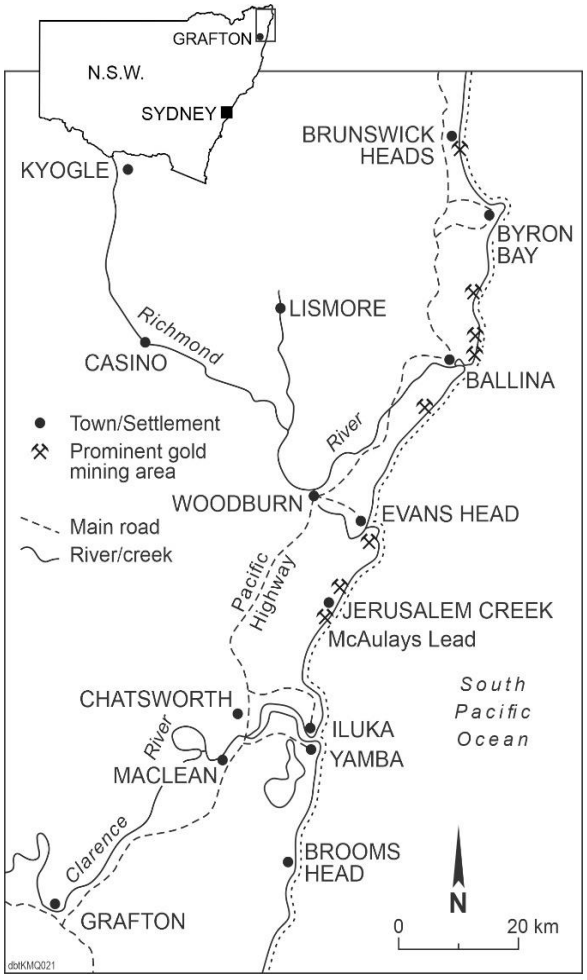
The golden sands of Jerusalem Creek: Early beach placer mining on the north coast of New South Wales

By KEN MCQUEEN
University of Canberra

Key Words: McAulay's Lead, heavy mineral sands, gold, platinum.

The history of gold mining on beaches and back-beach areas along the east coast of Australia is not widely known. Between 1870 and 1935 something in excess of 30,000 oz of gold was produced from these deposits, found between Currumbin in southern Queensland and inland of Bermagui on the New South Wales south coast.[1] One of the largest producing areas was around Jerusalem Creek, between Iluka and Evans Head on the north coast of New South Wales (Fig. 1).

Figure 1: *Map of the north coast region of New South Wales showing key beach gold mining sites, including the area of Jerusalem Creek and McAulay's Lead.*



Source: Map by author using Google Maps as a base.

Early beach placer mining used simple equipment, mostly cradles, sluice boxes, shovels and wheelbarrows, and the fields were worked as 'poor man's' diggings for gold and minor platinum (Fig. 2). Mining was commonly intermittent or seasonal, often by local farmers and part-time workers in the sugar industry. From 1904 there were attempts at larger scale mining, particularly using various types of dredges, but these attempts were largely unsuccessful.

The demand for titanium and zirconium minerals through the twentieth century, focused attention on the possibility of mining the associated and extensive black sand placer deposits for the contained rutile and zircon. Improvements in dredging and mineral processing technologies allowed this concept to successfully develop on a large scale. The early beach gold mining was thus the forerunner of the heavy mineral sands industry, which flourished from the 1950s through to the 1970s on the same beaches and back-beach areas.

Gold on the beaches

The first discovery of payable gold on the beaches of New South Wales was made near the north head of the Richmond River at Ballina in March 1870 (Fig. 1). At this site, on the beach of Shaws Bay, John Sinclair observed gold in exposed black sand and over two weeks was able to recover 12 oz.[2] Soon after this discovery the Richmond River district was subjected to a period of severe storms, heavy rain and floods and it was not until fine weather returned in June that the discovery was followed up by further prospecting. The storms and rough seas had cut into the beaches and produced large exposures of heavy black sands, referred to by the prospectors as 'sniggers'. Additional discoveries were made north and south of the Richmond River mouth and a small gold rush ensued.[3] By August there were fifty claims taken out and by October about 300 miners working on the beaches, doubling the population of Ballina. The local police officer, Senior-Constable John Henderson had run out of miners' rights, so the miners had to be content with a receipt to show they had paid the fee and amongst themselves agreed to take out claims of 50 sq. feet. The 'sniggers' were variously worked using cradles, and sluices, with some trials of G.M. Stephen's patent amalgamating cradle. Reliable estimates suggested that the miners were earning between £2-5 per man, per week.[4]

Figure 2: *Beach miners using a sluice box to recover gold, Ballina ca. 1890.*

Source: Richmond River Historical Society, Lismore, NSW.

Among the attracted diggers were beach sand miners from New Zealand, where in September 1865, gold had been discovered and worked in black sand on the beaches south of Greymouth on the west coast of the South Island.[5] The New Zealand miners introduced methods of mining and gold extraction they had developed through their previous experience in black sand mining.[6] This involved the use of portable sluice boxes with a hopper, mercury coated copper plate and a small tail sluice or table lined with carpet or corduroy to catch the very fine gold. The black sand was shovelled directly into the hopper or transported by wheelbarrow. Water was supplied by a hand pump from seepage into a hole dug in the sand. This relatively cheap and effective technology was quickly adopted by most of the miners, who typically worked in parties of three to five men. In May 1871, a group of New Zealanders found a rich patch of gold south of Evans Head

on a small beach, later named New Zealand Beach. It was reported that they were producing up to 140-360 oz of amalgam per week.[7] Large numbers of miners were quickly attracted to this area.

Over the next seven years gold deposits were found on beaches between southern Queensland and Port Macquarie. In June 1878 a prospecting party, including a New Zealander known as 'West Coast Bill' discovered gold near Currumbin, ironically on what was later to become known as the 'Gold Coast', but for different reasons.[8] This find proved to be a 'wages only' proposition, and at the time 'West Coast Bill' would not advise anyone 'to leave a decent living to go there'.[9] The beach prospecting and mining were intermittent activities and typically restricted to periods after heavy storms and strong south-easterly gales. During these storms the high seas disturbed the adjacent dunes to expose and rework the underlying seams of black sand onto the fresh beaches.[10]

A prominent beach miner at this time was Captain Thomas Paddon. Paddon was born in Devon in 1841 and had worked in the merchant marine, travelling to Australia and New Zealand. He also joined the New Zealand west coast gold rush before coming to Ballina in about 1874 to take up a position with the coastal shipping trade. After marrying, he retired from the sea and in 1877 took up a selection at Evans Head, where he soon became involved in the beach mining. He continued intermittently in this activity for the next 20 years, as well as setting up a hotel in Evans Head and pioneering oyster farming in the nearby Evans River.[11]

Gold behind the beaches

Some of the early beach miners had suspected that there were gold-bearing black sand deposits in the nearby back-beach areas, but these were hard to prospect due to the dune cover and thick coastal heath. There had been some indication of such deposits behind the beaches around Ballina and in September 1880 gold was found in a similar situation near Wallaga Lake, north of Bermagui on the south coast. This latter discovery was proclaimed as the Montreal Goldfield in 1880 and worked until 1883.[12] The back-beach deposits were essentially in fossil beaches developed during periods of higher sea level. Fossil beach deposits were also known on the west coast of New Zealand, where they extended inland for up to 12 km and at elevations up to 300 m, although here they were largely the result of tectonic uplift of the land.[13].

During the 1890s there was resurgent interest in beach gold mining on the north coast due to the economic depression, exacerbated by prevailing drought conditions. Many local farmers and rural workers were keen to supplement their dwindling incomes and the government was also keen to promote gold mining for the unemployed.[14] In 1890 there were about 250 miners working between Clarence Heads and Byron Bay with at least 1,200 oz of gold won.[15] Other areas were also being worked, but by this time many of the exploitable beach deposits had been worked out and greater attention turned to the back-beach areas.[16]

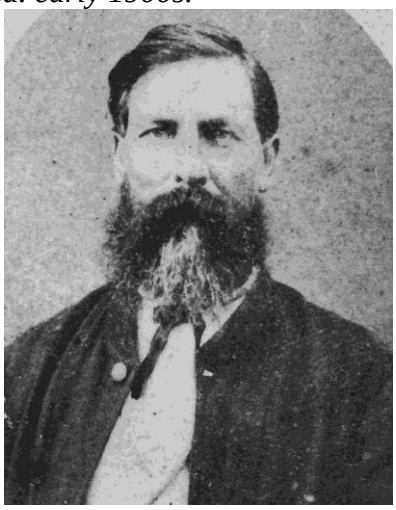
In August 1893 James McGeary and his prospecting mate Nobbs discovered alluvial gold in black sand 1 km inland from the coast at Ghostly Creek, about 5 km south of Evans Head. The site appeared to be an old beach 'terrace' in a flat swampy area with up to 6 m of covering sand. The auriferous sand layer was about 30 m wide and 1 m

thick.[17] This discovery and subsequent reporting focussed attention on this style of gold occurrence in the surrounding Jerusalem Creek area. By 1894 it was recognised that gold could be found in three types of deposit: on the present beaches; in slightly raised positions in the immediate back-beach dunes; and inland in old, so called, 'terrace' deposits partly covered by dunes.[18]

The rush to McAulay's Lead at Jerusalem Creek

In March 1895, Alexander and Angus McAulay discovered a rich 'run' of gold in the back-beach area 1.5 km south of Jerusalem Creek (Figs 3 and 4). For several months they had been prospecting the low-lying ground behind the beach using a 'sludger' or simple sand drill, finding colours of gold almost everywhere. This was an encouraging sign, but it was not until they tested an area on the east face of a narrow north-trending dune that they were able to find payable gold. The prospectors appear to have kept the richness of their find 'quiet', working the deposit with their two other brothers, John and Malcolm. The McAulay brothers were farmers and during the off-season periods prospected for gold in the Evans Head-Jerusalem Creek area. They had been persistent at this activity over some years without much success until they found the deposit that soon became known as McAulay's Lead.[19]

Figure 3: *Alexander MacAulay ca. early 1900s.*

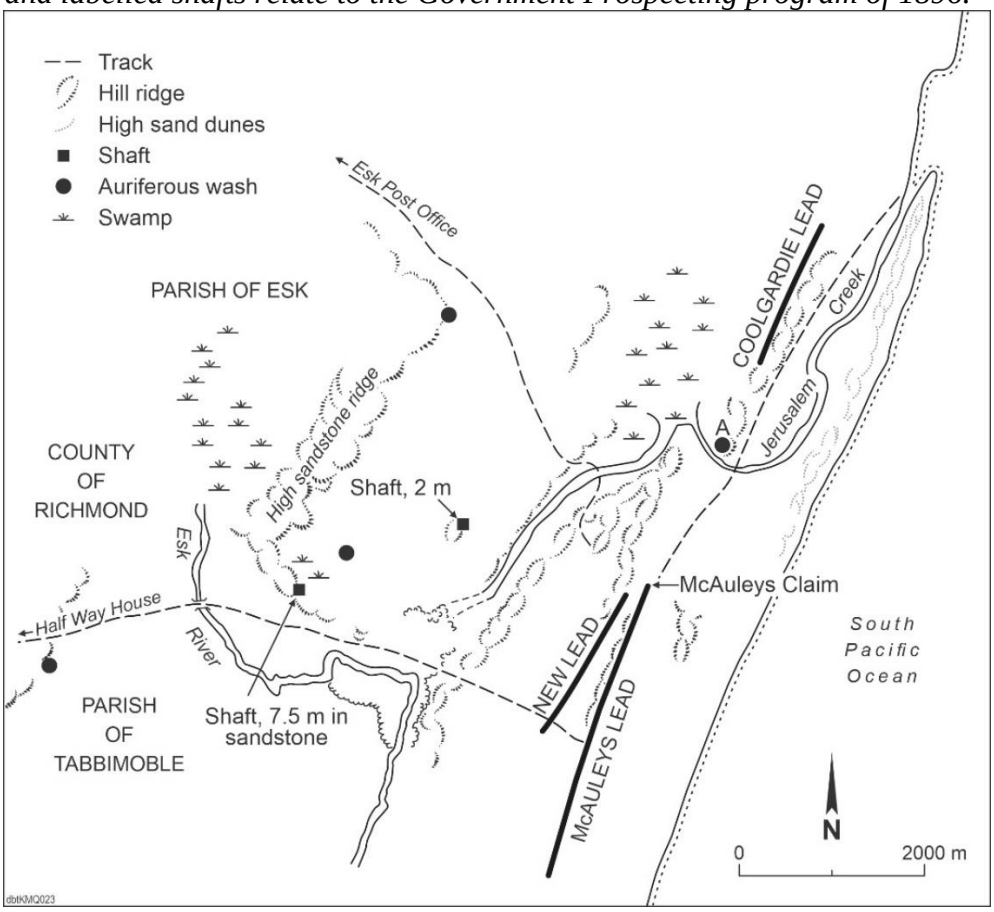


Source: Maclean District Historical Society.

Other beach miners in the vicinity became aware of the richness of the McAulays' discovery and this news quickly led to a rush. By early August there were 200 miners in the Jerusalem Creek area, most working claims along McAulay's Lead, with many reported to be making up to £5 per week per (about 1.3 oz of gold).[20] Miners also prospected the adjacent areas and during August a new discovery, named the Coolgardie Lead, was found to the northeast of the McAulay claim along the western side of Jerusalem Creek (Fig. 4).[21]

McAulay's Lead was a buried strip of concentrated black sand 4-9 m wide, dipping slightly to the east and extending for 3.2 km in a north-northeast direction. In vertical section it consisted of 2-5 m of white sand overlying compact black sand (referred to as the 'black rock'), which contained the rich gold-bearing layer (wash) at about 1.5 m below its top. Beneath the wash was a cemented reddish-brown sand, considered to be the 'bottom' (Figs 5 and 6). On the western edge of the lead the wash layer was very thin, defining the limit, and the richest gold lay well up on the east sloping bottom of the lead, similar to its position on the modern beach 'sniggers'. In several claims there were two layers of gold wash separated by about 20 cm of barren sand. Colours of gold were also found in some of the overlying white sand, but this material could not be economically worked. The Coolgardie Lead had similar features and was considered to be the northern extension of McAulay's Lead with an area between removed by later erosion.[22] The gold was very fine-grained, similar to the beach gold, but generally of a higher purity.[23]

Figure 4: *Map of the Jerusalem Creek area showing the location of McAulay's Lead, Coolgardie Lead and topographic features of interest. The marked areas of auriferous wash and labelled shafts relate to the Government Prospecting program of 1896.*



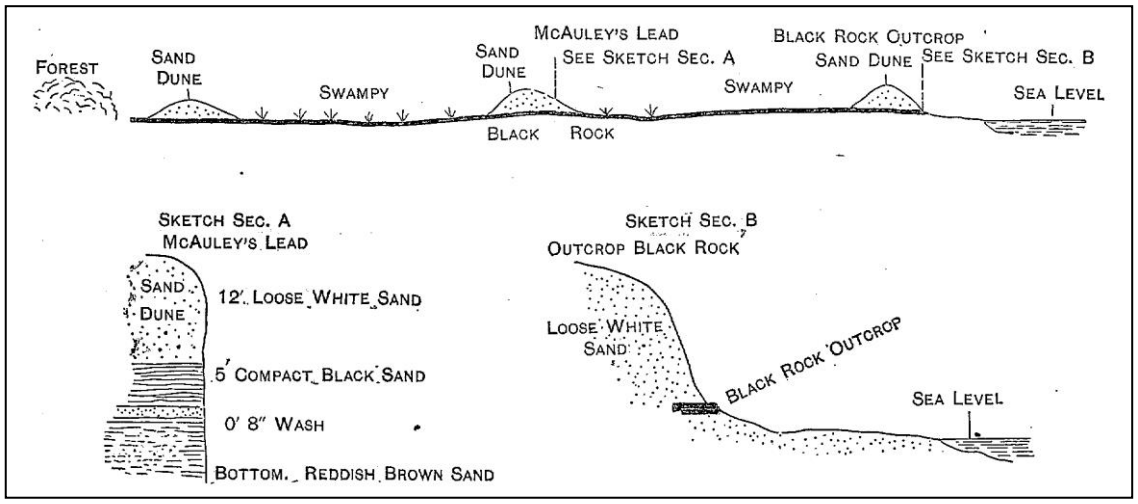
Source: Modified from plan by D.W. Munro 1897 prepared after the Government Prospecting program.

By October 1895 there were about 400 miners working on McAulay's Lead and the total population of Jerusalem Creek had grown to 500-600.[24] A significant settlement had developed, with most of the miners living in tents or huts close to their claims. A reporter for the *Richmond River Herald & Northern District Advertiser*, who visited the diggings in June 1896, provided a detailed account of some of the claims and methods of working (see below). He also described the settlement at McAulay's Lead, which at this stage included a school with 15 pupils, a good store owned by Mr J. Hunter, and two restaurants and accommodation houses operated by Messrs Richards and Blanch. He further noted that:

> The situation is remarkably healthy and very little sickness visits the tents and huts. The men all look healthy, the women buxom and comely, and the children's ruddy faces bespeak health, freedom and happiness.[25]

The miners were well supplied by the butchers, bakers and greengrocers who regularly visited Jerusalem Creek from the nearby towns of Woodburn and Chatsworth. They also had the luxury of a twice weekly mail service, with delivery direct to their claims by the obliging postmaster and mailman Mr R.C. Smith.[26] Additional facilities at various times included an oyster saloon, numerous 'pop up' beer stalls, an athletics oval and a cricket club, grandly titled the Pacific Club.[27]

Figure 5: *Schematic section across the Jerusalem Creek area from the ocean to the forest country showing the location of McAulay's Lead. Also shown are detailed cross sections of McAulay's Lead and the beach area (measurement in feet and inches).*



Source: J.E. Carne, *ARNSWDM* for 1895.

The main route to the Jerusalem Creek diggings was a 9.6 km track from the Halfway House Hotel, located about halfway between Chatsworth, on the Clarence River, and Woodburn, on the Richmond River (Figs 1 and 4).[28] Another route, more convenient for the northern part of the Jerusalem Creek area, was from Esk, at McKinnons Flat 17 km south of Woodburn.[29] There was also a beach track from Evans Head. No gold escort was provided for the miners, who were individually responsible for the security of their gold and transport to the banks and shops in Maclean or Woodburn.

There were no police stationed at Jerusalem Creek, but the constabulary from Maclean and Woodburn made regular visits. This was mainly to attend local events, such as the athletics or cricket matches, or respond to minor breaches of the peace, cases of abusive and indecent language and the occasional theft, including of gold, concentrates and tailings.

Disputes over claim boundaries and the parcelling out of gold winnings after the split-up of mining parties were not uncommon. Some of the latter embroiled the police in complicated scenarios, probably best handled by the mining warden, rather than the criminal courts. As an example, in a purported case of gold theft (as unprocessed amalgam) John Franklin was accused by Henry Chapman of having stolen 38 oz of amalgam that the former had in his possession. The amalgam had been seized by Senior-Constable Brown of Maclean during a search of Franklin's premises. Chapman had previously been in partnership with John Franklin and his brother Leonard Franklin. The case went to the Maclean Court, but the bench was persuaded that the grievance was a mining dispute and that it be transferred to the Mining Warden's Court in Ballina. An application by Constable Brown to retain the amalgam as evidence was however granted. The mining warden, Mr E. Jones P.M., determined that he had no jurisdiction, as it was still a criminal charge, and referred it back to Maclean. At the subsequent hearing the Franklin brothers proceeded against Constable Brown for detaining without just cause the 38 oz of amalgam, even though he had been directed to do so by the court. It also

transpired that Chapman had previously been entrusted with taking a parcel of gold to Woodburn for sale and on his return had become indisposed at the Halfway House Hotel. Two friends seeing him in this state took the money they found on him (which was short £3 4s) and handed it to the Franklins. Chapman then went to the Dalmorton goldfield and informed a friend that he was not returning. After some time, Chapman did return to McAulay's Lead and demanded his share of the latest production. When informed he was no longer a partner, he instigated proceedings through the police by means of a search warrant. The Franklins then suggested that the amalgam, when retorted, be credited to Mr Septimus Dowling their legal representative, to be held on trust in the Bank of N.S.W. at Maclean in order to avoid criminal proceedings. The case was then referred again to the Mining Warden's Court for a decision and the criminal proceedings quashed. After a lengthy sitting the warden found that the Franklins were entitled to two thirds of the amalgam and to be paid £5 for the cost of winning the gold. Chapman was entitled to one third of the amalgam from which he would be required to pay the legal costs of £31 4s, probably more than the value of his share. The case created much interest and entertainment for the diggers at McAulay's Lead.

Methods of mining and processing

Joseph Carne, Geological Surveyor for the NSW Geological Survey, visited the Jerusalem Creek diggings in late 1895. His report completed in January 1896 gives a detailed account of the methods used by the miners to mine and extract the gold.[30] At this stage, most of the overburden stripping and mining was done by manual labour with shovel and barrow. A few horse-drawn tip trays were employed and on one claim a derrick and scoop worked by horse-power was in operation. Stripping the loose, white sand overburden (up to 5 m thick) and pumping out the water seepage in the pits were laborious tasks, and the field soon became known as a 'poor man's, but not a lazy man's diggings. Fortunately, the discovery of McAulay's Lead coincided with a dry period, resulting in a lower water table and reduced chance of flooding of the workings from heavy rains.[31]

Figure 6: '*Black rock' (cemented-humate) outcrop at Black Rock Beach, near Jerusalem Creek, Bundjalung National Park.*

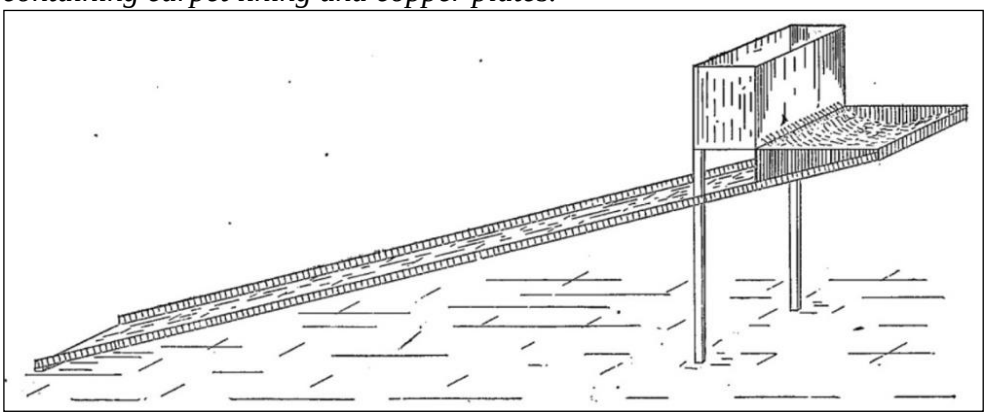
Source: Photo by the author, May 2019.

The general method of mining was to remove the white sand overburden in large benches, to get down to the compact black sand ('black rock') and the associated gold-bearing sand. To the casual observer the adjoining workings along the lead appeared like a large trench or canal under construction.[32] After removing the 'black rock' the gold-bearing material could be

excavated, in some cases after breaking up with large wooden mallets, and then processed to extract the gold. The worked-out benches were used sequentially to stow the 'black rock' waste or provide a sump for drainage of the water.

Initially, the gold extraction process was similar to that used by the beach miners, but it was progressively modified and improved to overcome problems related to the particular characteristics of the back-beach gold. One of the best processing plants was that of Henry Hammond and party who, specialising in innovative improvisation, made important advances in the treatment methods. The disaggregated auriferous wash was passed through a plasterer's quarter inch (6.4 mm) screen and the oversize placed on a wooden floor and rolled with an iron garden roller to break it up until all material passed the screen. The screened material was then fed slowly into a perforated hopper over a sloping box or table lined with carpet. Water pumped from the workings with a jigger pump was distributed over the table via a wooden box with a line of holes drilled in the bottom (Fig. 7). The heavier particles were trapped by the rough surface of the carpet as they washed down the table and this concentrate periodically collected.

Figure 7: *Sketch of typical sluice system used at McAulay's Lead in 1895. Note perforated hopper at right, water feed tank and sloping table (4.3 m long) containing carpet lining and copper plates.*



Source: J.E. Carne, *ARNSWDM* for 1895.

In the early stages of mining, the concentrates collected were washed over mercury coated copper plates, substituted for the carpet in the table, and the gold recovered by amalgamation. However, assays of the wash and tailings revealed that a significant portion of the gold was being lost due to a brown organic-iron oxide coating, as well as some likely loss of amalgam from the plates.[33] Through experimentation it was found that pre-washing the concentrates in a solution of washing soda (sodium carbonate) improved the recovery, by 'cleaning' the gold.[34] This treatment was quickly adopted across the field, but further experiments by another group, H. Allen and party, discovered that a 1% solution of caustic soda (sodium hydroxide) worked much better.[35] The method then developed, and widely applied, involved preparing a boiling caustic soda solution in 200 gallon (900 litre) ships tanks and releasing this into a long, iron-lined wooden shoot with a fine sieve of battery grating at the lower end. The gold-bearing wash was shovelled into the shoot to react with and be thoroughly permeated by the caustic soda solution, assisted by stirring and raking. The cleaned gold and other fines would then pass through the

battery sieve to be collected and dried before passing over mercury coated copper plates. Using this method, it was possible to effectively treat the gold-bearing wash directly, without the need to pre-concentrate on carpet. It was also possible to re-treat some of the tailings from earlier processing and recover more gold. The Hammond party re-treated some tailings from the old carpet concentrate method, which had yielded 200 oz of gold, and were able to recover an additional 100 oz. Claims considered worked out and abandoned were taken up again and the old tailings re-treated. In many cases these tailings had been used to fill in mined areas, so groups were engaged in searching for these buried tailings.[36] The result was a brief revival in mining activity and gold production.

Other heavy minerals in the sand

The black sand in which the gold was concentrated contained a range of other heavy minerals, the major ones being rutile (ca. 31% of the heavy mineral fraction), zircon (ca. 36%), ilmenite (ca. 16.5%) and monazite (ca. 1%).[37] The minor minerals were gold, cassiterite, platinum, other platinoid minerals and garnet.[38] During the early gold mining period there was essentially no market for the major heavy mineral constituents and these were discarded. There were some fitful attempts to recover the platinum, particularly from 1901, but the miners found the effort and time required rendered their gold recovery operations uneconomic. This was due to the rather primitive methods employed in mineral processing and the very fine grainsize of the platinum.[39] A plan for a concentrate processing plant at the government metallurgical works at Granville in Sydney (see below) was partly prompted by the possibility of recovering the platinum in combined parcels of concentrates from the induvial mining parties. Small parcels of tin (cassiterite) were recovered by a few miners, but again this was hardly worth their while.

Government prospecting

During 1895 the NSW Minister for Mines and Agriculture, Sydney Smith, decided that the Government should be doing more to support the mining industry, particularly given the bleak economic conditions. It was decided to hold a Mining Conference in Sydney the following year where representatives from the various mining fields could present and discuss initiatives to assist the industry. Meetings of miners elected their representatives towards the end of 1896 and Septimus W. Dowling was elected to represent the beach miners from Jerusalem Creek, McAulay's Lead, Evans Head and Ballina.[40] The visit and report by J.E. Carne on the Jerusalem Creek diggings, conducted in 1895, was also instigated by the Minister to ascertain the extent and potential of the north coast beach mining.[41] The Government was particularly interested in promoting this sector of the industry to assist the unemployed who possessed limited capital resources. In his report, Carne noted that several applications had been made to the government Prospecting Vote for assistance to develop individual claims. However, he recommended that the field needed 'systematic prospecting under efficient control'.[42]

The Mining Conference was held at St James Hall, Sydney from 5-13 February 1896 with broad ranging discussion and some important outcomes.[43] Septimus Dowling presented his paper overviewing the north coast beach diggings, in which he also made eleven suggestions to assist and encourage mining. His first suggestion was that a portion

of the Prospecting Vote be allocated to systematically test the back-beach areas around McAulay's Lead, the Evans River and Byron Bay and that this be under government supervision. As this was in line with the recommendation made by Carne, the Minister approved this suggestion recommending that the work start forthwith. Other suggestions by Dowling accepted by the Minister were that a Mining Warden's Court and Registrar's Office be set up at South Woodburn and that a facility to process beach sand concentrates to extract gold and platinum be included in the new government metallurgical works under construction at Granville.[44]

In late February, D.W. Munro was appointed to oversee the approved government funded prospecting operations, which were to commence in the Jerusalem Creek area. Duncan Munro was a local auctioneer and land agent with a long experience and extensive practical knowledge of the beach sand deposits and their mining on the north coast.[45] He arrived on site in March, ready to set up the project in April.[46] The plan was to lay out five east-west lines, approximately half a mile (800 m) apart, from the coast across the 'terraces' of the back-beach area. Along each line a team of three men would sink holes every 25 feet (7.6 m) using a 'sludger'. The men were to be paid £1 per week each from the Prospecting Vote with the right to take up a claim if their party struck gold. Once taking up a claim they were to cease as government employees and their positions offered to other men.[47] If successful it was also planned to extend this activity to other localities further north. In parallel there was also a scheme to collect samples of wash, concentrates and tailings to send to Sydney for testing to determine the best system of treatment.

Progress by the government funded prospectors was slow but systematic. By the end of 1896, 2,828 bore holes had been completed for a total of 45,632 feet (27,598 m) of drilling. The teams then moved to the Evans Head area.[48] The increased activity and interest at Jerusalem Creek led to several discoveries by independent prospectors including south of McAulay's Lead and at Chinaman's Beach just south of Evans Head.[49]

End of the rush

During the latter part of 1896 many claims on McAulay's Lead were nearing exhaustion. The McAulay brothers' claim was worked out in August, after which they did some prospecting around the lead using their 'sludger', but without success.[50] The Government funded prospecting scheme had also been largely unsuccessful. A new lead was found just to the east of McAulay's (Fig. 4) but proved to be low-grade and uneconomic. Hopes of developing a larger, longer-lived goldfield to help the unemployed were dashed.

At the end of 1896, the rush to McAulay's Lead was essentially over. Many of the miners, including Angus and Malcolm McAulay, headed for new gold diggings such as at Bucca Creek in the Coramba area south of Grafton.[51] By 1898 only a few hardy beach combers or 'black sanders' remained in the area. McAulay's Lead was described as a 'desolate almost uninhabited region visited only by mosquitoes in the day time and dingoes at night'.[52] The sparseness of population is well illustrated by the story of John Wilson, a beach miner who in early January 1898 was knocked unconscious while he was felling a tree to make a sluice box at McAulay's Lead. When he regained consciousness,

he staggered 15 km to the Esk Post Office and on enquiring as to the day of the week discovered he had lain unconscious and undiscovered for six days.[53]

The total gold production from the Jerusalem Creek area is not accurately known because many miners sold their gold privately and not always to the banks. During the period of the rush to McAulay's Lead, the NSW Mines Department recorded estimates and the local newspapers also reported some production figures. The official Mines Department estimates for the Ballina and Maclean mining divisions during 1895-1896 total 5,237 oz of gold, but this would include a small proportion from outside the Jerusalem Creek area.[54] Newspaper reports and information from the diary of Malcolm McAulay indicate a production of at least 3,080 oz for Jerusalem Creek, but only from the main producing parties.[55] Much of the production was locally recorded as the value of the gold, rather than the quantity. An estimate of the total value of gold produced from Jerusalem Creek during the main part of the rush from May 1895 until the end of June 1896 is reported as £14,000 to £20,000.[56] Using the average gold price at the time and the gold purity, £1 in value would equate to 0.25 oz of gold. This indicates a gold production of between 3,500 and 5,000 oz. For the whole period of gold mining at Jerusalem Creek, 5,000 oz would be a conservative estimate of the total gold production.

After the rush

Small-scale beach mining, generally referred to in the annual reports of the NSW Department of Mines as 'fossicking' by 'beach combers', continued in the Jerusalem Creek and other areas after the McAulay's Lead rush. Individuals and small groups were able to eke out a living or supplement their other income. Production was not recorded as most of the gold went to the storekeepers to pay for rations and was not reported.

Between 1898 and 1899 there were attempts to work the gold-bearing sands at Jerusalem Creek by cyanide treatment. In 1898, mining agent and engineer J.S.A. Taylor applied for a 16-acre lease at McAulay's Lead to work the abandoned ground using a large cyanide plant. It appears the plant was not built, possibly due to lack of sufficient capital, and the attempt abandoned. Two other existing claims at Jerusalem Creek were extended by another group, also for the purpose of working these with cyanide.[57] During 1899 Mr A. Raywood employed two men on a small cyanide plant to treat about 50 loads of sand. Gold production from this operation was not reported but was probably small.[58]

At the turn of the century, interest was sparked in the potential of some of the other minerals in the gold-bearing black sands. In January 1902 a Melbourne based syndicate headed by H.M. Porter applied to mine the sands for their contained monazite, as well as the gold, platinum, tin and supposedly diamonds. There was now an increased demand for monazite as a source of thorium and cerium oxide, used in the manufacture of gas light mantles.[59] The price of platinum had also risen significantly (to £4 7s 6d per oz).[60] Three leases were taken out, in the Jerusalem Creek area, including one north of the Evans River, which featured a blue-clay, thought to resemble the diamond-bearing wash of Kimberley in South Africa. A company was formed in Melbourne called the Grafton Diamond and Mineral Company with nominal capital of £1,800.[61] Mr J. Feldheim, described as an expert from South Africa, visited the leases and parcels of concentrate

were sent to Melbourne for testing by mineral buyers. Nothing further was reported, and the venture appears to have quickly fizzled out, with the leases abandoned.[62]

Subsequently a French syndicate, titled the Société Industrielle Francais des Sables Metalliferes, took an interest in the Jerusalem Creek area. This group was headed by Charles Poulot, who had previously managed large dredging plants in South America.[63] From 1905 Poulot set up an elaborate camp near McAulay's Lead where he conducted sampling and experimental treatment of the black sands.[64] In May 1909 the syndicate commenced operations with a pump dredge and plant built at a cost of £5,000.[65] Concentrates were sent to Europe for treatment, however it was found that the throughput from the plant was too small to be profitable. The group applied for suspension of labour conditions to enable construction of a much larger plant, estimated to cost £27,000, and Poulot applied for an additional 50 acres of dredging leases.[66] This upgrade did not go ahead and at the end of July 1911 it was reported that the syndicate had abandoned the project, with the existing plant moved to Maclean.[67]

Dredging entrepreneurs

From 1896, gold dredging technology was progressively introduced into Australia following its successful development in the alluvial goldfields of New Zealand during the 1880s.[68] Different dredging methods were applied to large-scale and systematic reworking of many gold-bearing rivers and alluvial flats in eastern Australia. In New Zealand, dredging had also been applied to beach sands and in 1904 it was suggested that the Jerusalem Creek area would be an ideal field for working with floating dredges.[69] Henry Hammond, with his wide experience in beach mining along the north coast including mining at McAulay's Lead, was engaged by a Melbourne-based prospecting group to advise on the potential of various sites for dredging. This group formed the Chatsworth Dredging and Sluicing Company with reported capital of £12,500, and during 1905 it took out dredging leases in the Jerusalem Creek area.[70] The same group also formed the Australian Monazite Dredging and Sluicing Company with leases in the Mororo area to the west of Jerusalem Creek.[71] This was a period of active promotion of dredging companies, particularly in Melbourne. The plan was to extract a range of minerals from the black sand, including gold, platinum, tin and monazite, and there was great optimism that this multi-commodity approach would result in great profits.[72] Apart from prospecting and sample testing, little work appears to have been done on the ground by either company, and in September 1907 both companies were wound up.[73] The following year the leases were cancelled.[74]

After this early aborted attempt at dredging around Jerusalem Creek and withdrawal of the French syndicate in 1911, attempts were made to introduce dredging to the beaches further north. Herbert J. Rose, described as a mining expert with experience on the Klondyke, in South Africa, New Zealand and Australia, applied for extensive gold mining leases along the coast from Ballina to Byron Bay.[75] During 1913 to early 1914 Rose tested several beaches and announced that they could be economically worked for gold by dredging. The Ballina Gold and Mineral Company Ltd was formed with Rose as managing director.[76] By May 1914 a 10 horsepower sluicing test plant was operating and a larger dredging plant was under construction at Sharpes Beach, north of Ballina.[77] The

large plant, costing £5,000 with components built by Thompson and Co. of Castlemaine, Victoria was completed and operational at the end of July 1915.[78] The plant, consisted of a floating pontoon built from Oregon pine, a steam-driven pump dredge with centrifugal nozzle pump and centrifugal gravel pump, and a concentrating plant with iron screens, 50 feet of amalgamation plates and a Harrison concentrator-amalgamator.[79] Rose professed great confidence in the plant and suggested that he was planning to order an additional five plants to operate on other beaches north of Ballina.[80] The first 'clean up' of the plant in mid-December resulted in 12 oz of gold and 10 oz of platinum. Touted as 'eminently satisfactory' this was in fact very disappointing after nearly five months work.[81] Operations continued sporadically into early 1915 and in July additional leases were applied for by Rose.[82] Investors began suspecting that the main dredging was in fact 'of their pockets'. The Company and Rose became involved in several legal claims and at an extraordinary meeting on the 25th July 1915 the Company was voluntarily wound up.[83] Rose was declared bankrupt in August.[84] The dredging plant was sold, probably for its components, as the ruins of the pontoons were still present on the beach at Ballina in 1934 - a sad reminder to investors of an ambitious, but fruitless scheme.[85]

During and after this time there were other attempts at dredging. In 1914 the North Coast Gold and Platinum Company was formed to work leases south of Yamba.[86] Reports in 1917 suggested that this company had successfully treated parcels of black sand for gold and platinum with the aid of cyanide solutions and were planning on treating several hundred tons per week. Larger scale operations proved unprofitable and the enterprise was abandoned the same year.[87]

A major difficulty encountered in the early attempts at large-scale mining by dredging was with separating the different minerals. Gold could be effectively extracted from black sand concentrates by amalgamation or cyanide treatment, but separating the other valuable minerals was not so easy. Existing gravity separation methods, such as the use of sluices and Wiffley tables did not work well, as some of the minerals, including the rutile and ilmenite, were of similar specific gravity. Furthermore, the processing methods used did not allow for a sufficiently rapid throughput to make the whole operation profitable from bulk, low-grade material. Well known metallurgist George Blakemore, boldly predicted at the time that this mineral separation problem would be 'a problem which science will solve as easily as it determined the most economic method of treatment to treat lead-zinc concentrates of the Broken Hill mines'.[88]

Subsequent black sand mining

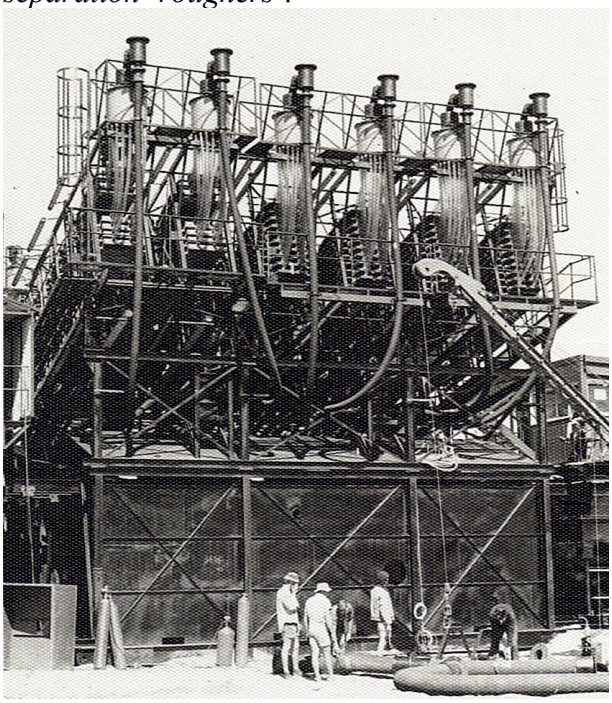
By the 1920s there was increased interest in the economic potential of the rutile, ilmenite and zircon that comprised most of the black sands along the north coast of New South Wales. The use of titanium dioxide as an alternative to toxic, lead carbonate for white paint pigment had been developed and there was demand for zircon as a refractory. To utilise these mixed minerals, it was still necessary to overcome the mineral separation problem. Partly for this reason, many of the early attempts to process these minerals involved exporting a mixed concentrate to plants overseas, particularly in the U.S.A.

One of the first entrepreneurs to mine and produce rutile and zircon was Cecil G. Cumberland who set up a small plant at Black Head, near Ballina in the early 1920s. With

a team of four young Englishmen, recruited through an advertisement offering 'colonial experience', together with members of the Ainsworth family from the nearby farm, he used carpet-lined sluice boxes to extract the black sand. The concentrate was shipped to the United Kingdom by Minerals Pty Ltd for treatment. Although a technical success, this early attempt at producing rutile and zircon was not profitable.

Cumberland remained in the Ballina area and during the early 1930s he and his wife spent much of their time prospecting and mining the black sand for gold while living in a tent behind the dunes. During this time, Cumberland came up with the idea of using selective flotation to extract zircon from the black sand concentrate. He developed and patented a method and was able to interest two Melbourne entrepreneurs, Ralph Randall and Frank Wright in testing it on a commercial scale. In June 1934, the Zircon Rutile Limited company was floated and commenced producing a mixed concentrate. The following year the company introduced the flotation process to produce a clean zircon concentrate and a mixed rutile-ilmenite concentrate. Other companies became interested and during 1935 the Titanium Alloy Manufacturing (T.A.M.) Company and Metal Recoveries Ltd began mining and producing a mixed concentrate. By 1937 T.A.M. Co. was extracting ilmenite by magnetic separation and exporting mixed rutile-zircon.[89]

Figure 8: *Part of the rutile-zircon concentrating plant of Cudgen-RZ at Iluka (Plant 7) ca. 1970. Photo shows the gravity separation 'roughers'.*



Source: Iluka History Group. Photo Andrew Brycker.

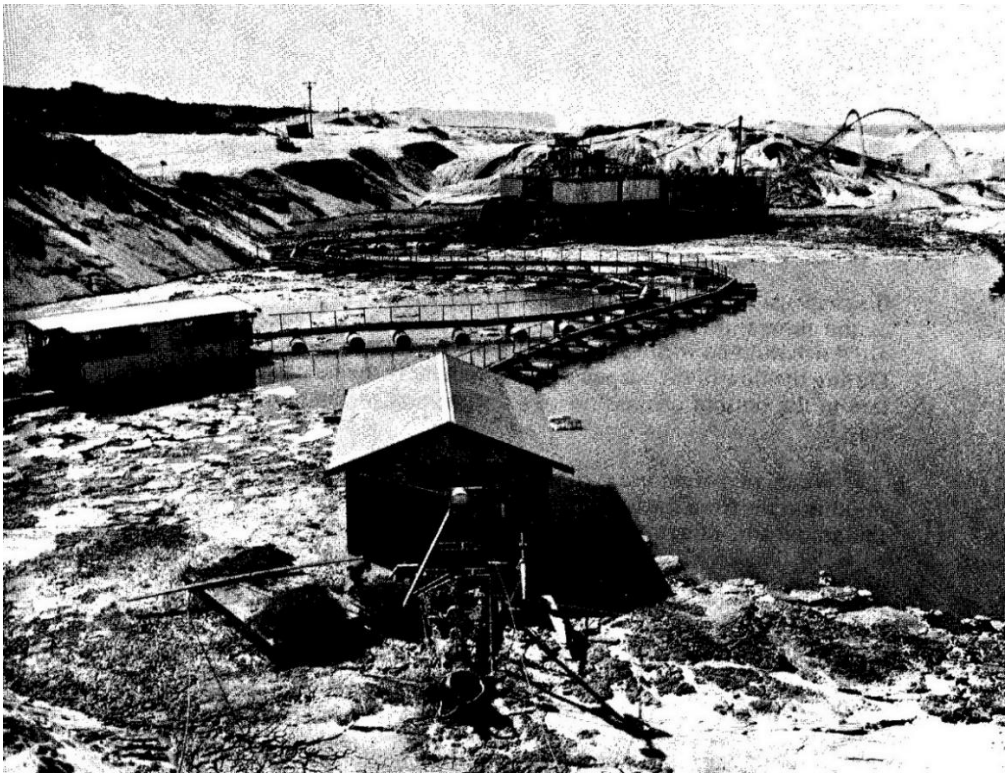
The demand for rutile increased sharply during WWII, mainly for use in welding rods and the manufacture of titanium tetrachloride for smoke screens. Towards the end of the war there was also renewed interest in monazite due to its thorium content and potential use of this element in atomic energy development.[90] In 1944 the Commonwealth Government introduced legislation through the Customs Act to prohibit the export of crude, mixed concentrates, allowing only high-grade concentrates of individual minerals. Enacted in 1950, this regulation together with improvements in separation technology, greatly stimulated development of the industry locally. The development of electro-magnetic and electro-static separators and the invention of spiral gravity concentrators provided an important breakthrough for the mineral sands industry. The Humphreys Spiral Concentrator developed in 1943 for the Oregon beach sands to extract chromite, appears to be the first example of this particular technology.[91] The new methods, which provided more selective separation and allowed rapid

processing of large volumes of heavy mineral sands, solved the former problems of mineral separation and insufficient throughput.

A flurry of beach mining activity ensued in the 1950s with numerous companies floated and large areas of dredging leases taken up along the north coast, including over the Jerusalem Creek area and McAulay's Lead. The deposits at Jerusalem Creek were described as amongst the largest in the world and in early 1953, Titanium Minerals Ltd established a dredging operation and processing plant at Jerusalem Creek.[92]

By 1961 export income from mineral sand mining, mostly in NSW, had reached over $10M (equiv.) annually. Companies that had already commenced manufacturing titanium pigment in Australia from imported ilmenite were also able to turn to abundant local supplies.[93] Mining and production of rutile, ilmenite and zircon became a well-established industry (Fig. 9). In 1976 Australia produced 390,000 t of rutile (95% of global production), as well as 420,000 t of zircon (80% of global production).[94] The history of the industry over the two decades from 1960 is beyond the scope of this article, and the reader is referred to the excellent account by Ian Morley in his book 'Black Sands'.[95]

Figure 9: *Heavy mineral sand mining on the NSW coast in the early 1970s. The photo shows a dredge pond (with low water level) and two floating suction pump dredges in foreground (showing cutting head), and at left. Treatment plant in background.*



Source: Rutile and Zircon Mines Ltd, *in* P.F. Cooper, *et al*. 1973 'Titanium, Zircon, Thorium'.

It is interesting to note that major processing of heavy mineral sands in some areas would have resulted in the recovery of gold as a minor by-product. This is supported by anecdotal evidence and discussions with former sand mining employees. However, there appears to be no record of this gold production.

Discussion

The discovery of gold in the black sand layers of the north coast beaches was an important step in the development of the broader mineral sands industry in Australia. Although short lived, the gold rush to McAulay's Lead at Jerusalem Creek drew significant official attention to the deposits. Much of the understanding of the black sands, particularly their distribution and mineralogy developed as a result of this interest.[96]

An important aspect of the beach gold deposits, and one that intrigued the early miners, was the origin of the deposits, particularly their formation and the source of the gold and associated minerals. The miners were aware from their observation of the modern beach 'sniggers' that wave action, particularly during storms was important in their formation. They had also noted that the deposits were more extensive or thicker at the northern end of the beaches, south of headlands. They concluded that the waves were acting like a natural panning process, concentrating the heavy minerals from the lighter quartz-rich sand. Careful observation of the wave activity by later investigators developed a plausible theory for the concentration process.[97] This theory can be summarised as follows. Breaking waves move sand into suspension and carry it up the beach with the incoming swash. As the swash velocity decreases the turbulent flow becomes laminar and the sand load is deposited. After the wave reaches its limit the flow reverses with increasing velocity. A surface layer of sand is disturbed and becomes a high particle density bed-flow in which the smaller and more dense particles migrate to the base. The thin basal heavy mineral layer has a covering of coarser sand which protects it from subsequent erosional stripping by the next incoming wave, allowing progressive development of a thicker black sand layer. During heavy storms the winds are typically from the southeast causing the waves to encroach from this direction and wash the sands toward the north and higher up the beaches. Here the black sands can build up and be preserved by windblown sand during calmer conditions.

Behind the beaches, sea level changes and wind activity were probably important in the formation and preservation of the black sand deposits.[98] Dunes are prominent in these areas and the early miners noted concentrations of heavy minerals near the foot of dunes, possibly due to winnowing of the lighter minerals by wind activity. The cemented sand layer below the 'black rock', as well as the 'black rock' itself, may also have played a role, particularly in the concentration of gold, acting as an impervious barrier or 'bottom' during water or wind reworking.

The primary source of the gold and other heavy minerals is not so clear. Joseph Carne suggested that the heavy minerals were transported by rivers to the coast from the granites and Palaeozoic basement rocks of the eroding New England region. Carne also raised the possibility that the gold was sourced from buried alluvial deposits or deep leads derived from these older rocks.[99] Rocks immediately adjacent to the beaches of this area are mostly Mesozoic sedimentary rocks of the Clarence-Moreton Basin, particularly the Gatton Sandstone unit, which contains old river channel deposits. The sediments in these rocks were derived from the New England region and other basement areas to the south and east and could represent an earlier concentration and subsequent source for the heavy minerals. Basalts, erupted from the Tweed Volcano, are prominent north from Ballina and originally extended to the area west of Jerusalem Creek (e.g. basalt caps of Mt Double

Duke). These basalts have also been suggested as a source of heavy minerals, although they are unlikely to have been a source for the gold, rutile, cassiterite and monazite. In 1888 it was reported that gold had been found in a scoria-agglomerate layer in the basalt at Black Head, north of Ballina, and a company was formed to prospect and mine it, the Black Rock Gold-mining Company.[100] However, later geological investigation suggested that this gold was probably beach gold emplaced in the basalt during eruption.[101]

Some of the early gold miners believed that the gold was derived directly from the sea, possibly as a precipitate from sea water. Alfred Argles was so firm in this belief that he built an extensive plant at Broken Head, south of Byron Bay, to extract gold directly from the sea water.[102] The plant proved unsuccessful and was ultimately washed away in a storm.[103] Although this idea was rather hopeful, given the known gold content of sea water (ca. 10 parts per trillion), the high chloride content of salty water and abundant organic compounds and micro-biota in swampy ground may have played a role in refining or remobilising the gold in the back-beach areas.[104] As mentioned previously the gold in these areas was found to be of a much higher purity than that on the beaches and much of it was coated with an organic-iron oxide layer.

Figure 10: *Area of McAulay's lead, near the McAulay claim (view to the southeast with fire trail in foreground).*

Source: Photo by the author, May 2019.

Conclusions

Although placer mining of gold on the north coast beaches of New South Wales did not result in a huge gold production, it was important for two reasons:

1. The industry was unusual in that many of the miners were local farmers and agricultural workers who mined the beaches and back-beaches intermittently, around their other activities. For the under-employed and the unemployed alike

the gold mining provided important supplementary income, particularly in times of economic stringency.

2. The discovery of gold in the beach sands and its subsequent mining laid the foundation for the heavy mineral sands industry. The gold mining involved techniques and ideas, many introduced from New Zealand, that ultimately led to the concept of using pump dredges and improved gravity separation to mine and process the black sands. It was a case of a 'poor man's' gold field transforming to a multi-million dollar export industry of high technology minerals.

Today, there is very little evidence of the early gold mining in the Jerusalem Creek area. This is following mining and back-filling of the diggers' claims, extensive heavy mineral sand mining, rehabilitation, conversion to a national park and ongoing natural modification by vegetation and wind. Without the historical record, visitors to the nearby Black Rock camping ground in Bundjalung National Park could imagine that the golden sands of Jerusalem Creek are a scarcely touched heathland wilderness (Fig. 10).

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'). I am grateful to the Richmond River Historical Society, Lismore, the Maclean District Historical Society and Janet Hauser from the Iluka History Group for kindly providing some photographs reproduced in the article. Robin McLachlan drew my attention to information on the fraudulent activities of Herbert J. Rose. The article was improved with useful comments from two anonymous reviewers.

Glossary of some terms used in the text
Cassiterite – tin oxide (SnO_2).
Ilmenite – iron titanium oxide ($FeTiO_3$).
Monazite – cerium phosphate ($CePO_4$) also containing other rare earth elements and thorium.
Prospecting Vote – a government funded scheme administered by the Department of Mines to assist prospectors.
Rutile – titanium dioxide (TiO_2).
Sludger – a simple sand coring device consisting of a short (60 cm) steel barrel (40-50 mm diameter) with a wooden or metal plug at the top end containing an escape air tube with a one-way valve. The barrel is inserted in a pipe liner and pushed into the sand with a long wooden rod. When the barrel is full it is pulled up and the core removed. As the hole progresses the pipe liner is rotated and pushed down the hole to support the walls.
Snigger – a mass of black sand on the beach after a storm, later (in 1935) also used to describe a thin seam of greyish sand, enriched in zircon, gold, platinum and cassiterite, within the thicker black sand layers. The term was peculiar to the beach mining of northern NSW.
Terrace – term used by the beach miners to describe the series of back-beach dunes behind the present beaches, not terraces in the normal sense.
Zircon – zirconium silicate ($ZrSiO_4$) generally contains trace hafnium, rare earth elements, uranium and thorium.

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.

Pre-decimal currency
£1 (pound) = 20s (shillings) and 1 shilling = 12d (pence).

Endnotes

[1] The exact amount of gold mined is not known as much production went unreported. The minimum estimate is based on incomplete official records of the Mining Wardens at Ballina, Woodburn and Maclean as recorded in the Annual Reports of the NSW Department of Mines for 1870-1935, supplemented by reports in the local newspapers for the period, including the *Richmond River Herald & Norther Districts Advertiser*, *Clarence and Richmond Examiner*, as well as the *Australian Town and Country Journal*, *Daily Telegraph*, *Evening New*s and *Sydney Mail*.

[2] J.E. Carne, 'Report on the auriferous beach sands of the Esk River and Jerusalem Creek in the Parish of Esk, County Richmond', *in Annual Report of the New South Wales Department of Mines* (here after *ARNSWDM*) for 1895, pp. 149-160.

[3] 'Ballina', *Clarence and Richmond Examiner & New England Advertise*,14 June 1870, p. 2; I.W. Morley, *Black Sands: A history of the minerals sand mining industry in Eastern Australia*, Univ. Queensland Press, St Lucia, 1981, pp. 18-21.

[4] 'Richmond River Heads', *Australian Town and Country Journal*, 27 August 1870, p. 15; 'The Richmond River Gold-Field', *Queenslander*, 15 October 1870, p. 9.

[5] J.H.M. Salmon, *A History of Goldmining in New Zealand*, Government Printer, Wellington, N.Z., 1963, p. 139.

[6] J.E. Carne, 'Report on the auriferous beach sands', *ARNSWDM* for 1895, p. 150.

[7] 'The Richmond Beach Gold Workings', *Australian Town and Country Journal*, 6 May 1871, p. 15.

[8] The name 'Gold Coast' was originally a nickname given to the coast south of Brisbane in the 1950s after development led to inflated prices for real estate, goods and services. It then became a convenient way to refer to the holiday/tourist strip from South Port to Coolangatta. 'Beaches now not so golden: Boom for land is ebbing', *Sunday Mail*, 29 October 1950, p. 4.

[9] 'Beenleigh', *The Brisbane Courier*, 8 June 1878, p. 7; 'The Tweed River Gold Discovery', *Clarence and Richmond Examiner & New England Advertiser*, 15 June 1878, p. 2.

[10] J.E. Carne, 'Report on the auriferous beach sands', *ARNSWDM* for 1895, p. 150.

[11] 'The Late Captain Paddon', *Richmond River Express & Casino Kyogle Advertiser*, 5 May 1914, p. 4: 'Death of Captain Thomas Paddon', *Mudgee Guardian & Western Representative*, 7 May 1914, p. 30.

[12] The Montreal Goldfield was worked up to 1883 and produced at least 7,673 oz (240 kg) of gold. *ARNSWDM* for 1880, pp. 130-131; *ibid*., for 1881, pp. 63-63; *ibid*., for 1882, p. 67; *ibid*., for 1883, p. 78.

[13] J.H.M. Salmon, *A History of Goldmining in New Zealand*, Government Printer, Wellington, N.Z., 1963, p. 139.

[14] 'Mining Matters – Jerusalem Creek', *Australian Star*, 7 August 1895, p. 3.

[15] 'Beach Mining', *Daily Telegraph*, 13 June 1890, p.7; *ARNSWDM* for 1893, p, 20.

[16] 'Auriferous Sea Beaches', *Maitland Mercury & Hunter River General Advertiser*, 5 June 1890, p. 2; 'Brief Mention', *Richmond River Herald & Northern Districts Advertiser*, 6 February 1891, p. 2.

[17]*ARNSWDM* for 1893, p, 20; G.A. Stonier, 'Report on alluvial gold deposits near the Evans River, Lismore District, 1894 Appendix R, *ARNSWDM* for 1894, pp. 129-131.

[18] *Ibid.*

[19] 'Mining Matters – Jerusalem Creek', *Australian Star*, 7 August 1895, p. 3; J.E. Carne, 'Report on the auriferous beach sands', *ARNSWDM* for 1895, p. 151.

[20] 'Mining Matters – Jerusalem Creek', *Australian Star*, 7 August 1895, p. 3.

[21] 'Jerusalem the Golden', *Richmond River & Northern Districts Advertiser*, 30 August 1895, p. 8; 'The Beach Mining', *Northern Star*, 23 October 1895, p. 2.

[22] 'Beach Mining', *Australian Town and Country Journal*, 26 October 1895, p. 18; J.E. Carne, 'Report on the auriferous beach sands', *ARNSWDM* for 1895, pp. 151-152.

[23] G.A. Stoner, 'Report on alluvial gold deposits near the Evans River, Lismore District' *in ARNSWDM* for 1894, pp. 129-131.

[24] 'Beach Mining', *Australian Town and Country Journal*, 26 October 1895, p. 18; 'The New Goldfield at Jerusalem Creek', *Clarence and Richmond Examiner*, 26 October 1875, p. 3.

[25] 'McAulay's Lead Goldfield', *Richmond River Herald &Northern Districts Advertiser*, 5 June 1896, p. 5.

[26] *Ibid*.; I.W. Morley, Notes and extracts from the diary of Malcolm McAulay related to goldmining at McAulay's Lead, Jerusalem Creek, NSW, 1895-1897, 1977, MLDOC2767, Mitchell Library, State Library of New South Wales (MLNSW), p. 4.

[27] 'McAulay's Lead Athletic Sports', *Richmond River Herald & Northern Districts Advertiser*, 29 May 1896, p. 8; I.W. Morley, Notes and extracts from the diary of Malcolm McAulay related to goldmining at McAulay's Lead, Jerusalem Creek, NSW, 1895-1897, 1977, MLDOC2767, MLNSW, p. 3.

[28] 'Beach Mining', *Australian Town and Country Journal*, 26 October 1895, p. 18.

[29] 'McAulay's Lead Goldfield', *Richmond River & Northern Rivers Advertiser*, 5 June 1896, p. 5.

[30] J.E. Carne, 'Report on the auriferous beach sands', *ARNSWDM* for 1895, pp. 149-158.

[31] 'McAulay's Lead Diggings', *Northern Star*, 6 May 1896, p. 2; J.E. Carne, 'Report on the auriferous beach sands', *ARNSWDM* for 1895, p. 153.
[32] 'Mining Matters – Jerusalem Creek', *Australian Star*, 7 August 1895, p. 3.
[33] Carne, 'Report on the auriferous beach sands', *ARNSWDM* for 1895, pp. 154-155.
[34] *Ibid*., pp. 153-154.
[35] 'McAulays Lead Goldfield', *Richmond River Herald & Northern Districts Advertiser*, 5 June 1896, p. 5.
[36] *Ibid*.
[37] J.B. McKellar, The Eastern Australian Rutile Province, *in* C.L. Knight, *Economic Geology of Australia and Papua New Guinea, Vol. 1 Metals*, Australasian Institute of Mining and Metallurgy, Melbourne, 1976, p. 1062.
[38] Carne, 'Report on the auriferous beach sands', *ARNSWDM* for 1895, pp. 154-156.
[39] *Ibid*., p. 156-157; G.A. Stoner, 'Report on alluvial gold deposits near the Evans River, Lismore District' *in ARNSWDM* for 1894, pp. 129-131; *ARNSWDM* for 1901, p. 32.
[40] 'Advertisement – Meeting of Miners', *Richmond River Herald & Northern Districts Advertiser*, 29 November 1895, p. 5.
[41] 'The Development of Beach Mining', *Clarence and Richmond Examiner*, 21 February 1896, p. 5.
[42] Carne, 'Report on the auriferous beach sands', *ARNSWDM* for 1895, p. 157.
[43] A major outcome was the Mining Laws Amendment Act of 1896, which among other changes clarified and provided easier access for prospecting and mining on private land. *ARNSMDM* for 1896, p. 2.
[44] 'Beach Mining in the North', *Richmond River Herald & Northern Districts Advertiser*, 21 February 1896, p. 2.
[45] 'Local and General News', *Northern Star*, 9 June 1888, p. 2; J.E. Carne, 'Report on the auriferous beach sands', *ARNSWDM* for 1895, p. 150.
[46] 'Mining', *Clarence and Richmond Examiner*, 28 March 1896, p. 8.
[47] 'Beach Mining', *Northern Star*, 26 February 1896, p. 3.
[48] *ARNSWDM* for 1896, p. 9.
[49] 'The Esk Diggings', *Richmond River Herald & Northern Districts Advertiser*, 21 February 1896, p. 5; 'Mining', *Clarence and Richmond Examiner*, 25 February, p. 8. The name Chinaman's Beach is interesting. Much later accounts ascribe this to a rush of over 300 Chinese miners to this site, e.g. 'When the Seas Spilled Gold on Evans Head Beach', *Northern Star*, 31 January 1939, p. 12. These numbers are probably exaggerated and there is no contemporary mention of any Chinese at this site during the rush.
[50] I.W. Morley, Notes and extracts from the diary of Malcolm McAulay related to goldmining at McAulay's Lead, Jerusalem Creek, NSW, 1895-1897, 1977, MLDOC2767, MLNSW, p. 10.
[51] *Ibid*., pp. 10-11.
[52] 'Maclean – Remarkable Escape', *Clarence and Richmond Examiner*, 11 January 1898, p. 4.
[53] *Ibid*.
[54] *ARNSWDM* for 1895, p. 59, *ibid*. for 1896, p. 36.
[55] I.W. Morley, Notes and extracts from the diary of Malcolm McAulay related to goldmining at McAulay's Lead, Jerusalem Creek, NSW, 1895-1897, 1977, MLDOC2767, MLNSW; Numerous newspaper items from the *Australian Town and Country Journal*, *Clarence and Richmond Examiner*, *Evening News*, *Maitland Weekly Mercury*, and *Richmond River Herald & Northern Districts Advertiser*.
[56] 'Jerusalem Creek', *Australian Town and Country Journal*, 20 June 1896, p. 16.
[57] *ARNSWDM* for 1898, p. 54.
[58] *ARNSWDM* for 1899, p. 46.
[59] The Welsbach gas lamp mantle used a mixture of thorium oxide, cerium oxide and magnesium oxide.
[60] 'Beach Mining', *Clarence and Richmond Examiner*, 11 January 1902, p. 8; 'McAulay's Lead Mining Field', *Clarence River Advocate*, 21 January 1902, p. 3.
[61] 'Beach Mining', *Clarence & Richmond Examiner*, 11 January 1902, p. 8.
[62] 'McAulay's Lead Mining Field', *Clarence River Advocate*, 21 January 1902, p. 3; 'News Summary', *Clarence River Advocate*, 6 May 1902, p. 2; *ARNSWDM* for 1902, p. 16.
[63] 'North Coast Beach Mining', *Richmond River Herald*, 9 April 1909, p. 9.
[64] 'McAulay's Lead Dredging', *Clarence River Advocate*, 4 August 1905, p. 8.
[65] 'District Mining', *Richmond River Express & Casino Kyogle Advertiser*', 18 June 1909, p. 3.
[66] 'Mining', *Clarence and Richmond Examiner*, 20 July 1909, p. 7; *ARNSWDM* for 1909, pp. 16, 26.
[67] 'French Mining Syndicate', *Northern Star*, 31 July 1911, p. 4.
[68] J.H.M. Salmon, *A History of Goldmining in New Zealand*, Government Printer, Wellington, N.Z., 1963, pp. 231-236.
[69] 'Dredging for Gold', *Richmond Rifer Express & Tweed Advertiser*, 25 October 1904, p. 3; *ARNSWDM* for 1904 p. 14.

[70] Mining in the North', *Sydney Morning Herald*, 16 March 1905, p. 4; 'Crown Lands', *Clarence and Richmond Examiner*, 10 September 1905, p. 3; *ibid*., 25 November 1905, p. 2; 'Beach Mining' *Richmond River Herald & Northern Districts Advertiser*, 1 December 1905, p. 2.
[71] 'Mining Meetings', *The Age*, 16 April 1907, p. 2.
[72] 'North Coast Beach Mining', *Richmond River Express & Casino Kyogle Advertiser*, 19 November 1907, p. 5.
[73] *ARNSWDM* for 1905, p. 13; *ibid*. for 1906, p. 20; *ibid*. for 1907, p. 23; 'Dredging Companies Wound Up', *The Age*, 21 September 1907, p. 15.
[74] 'Mining', *Clarence and Richmond Examiner*, 22 August 1908, p. 2.
[75] 'Beach Mining', *Clarence and Richmond Examiner*, 30 April 1914, p. 2. Rose was in fact a fraudster and as far as can be ascertained had no experience in South Africa, Western Australia, New Zealand or on the Klondyke. He also fraudulently claimed to be a geologist and mining engineer using the postnominals F.G.S. and M.E. (R. McLaughlin pers. comm., Trove fraudster list https://trove.nla.gov.au/list?id=130909).
[76] 'Beach Mining' *Richmond River Express & Casino Kyogle Advertiser*, 11 April 1913, p. 4; 'Mining', *Clarence and Richmond Examiner*, 2 May 1914, p. 9.
[77] 'Beach Mining', *Clarence and Richmond Examiner*, 30 April 1914, p. 2.
[78] 'Beach Sluicing', *Sydney Morning Herald*, 31 July 1914, p. 10.
[79] 'Gold Drifts', *Sunday Times*, 21 June 1914, p. 5.
[80] 'Beach Mining at Ballina', *Richmond River Express & Casino Kyogle Advertiser*, 8 May 1914, p. 6.
[81] 'Ballina Beach Mining' *Clarence and Richmond Examiner*' 26 December 1914, p. 14.
[82] 'Gold, Tin and Platinum Won from Sea Beach', *Sydney Morning Herald*, 2 April,1915, p. 9; 'North Coast News', *South Coast Times & Wollongong Argus*, 2 July 1915, p. 4.
[83] 'Ballina Mining Company', *Richmond Express & Casino Kyogle Advertiser*, 5 October 1915, p. 2.
[84] 'Bankruptcy', *Daily Telegraph*, 19 August 1915, p. 4.
[85] *ARNSWDM* for 1915, p. 21; I.W. Morley, *Black Sands*, 1981, p. 32.
[86] 'North Coast Gold', *Tweed Daily*. 16 July 1914, p. 2.
[87] 'Black Sands Successfully Treated', *Northern Star*, 4 April 1917, p. 4; *ARNSWDM* for 1917, p. 17.
[88] 'Golden Sands', *Sunday Times*, 7 June 1914, p. 5.
[89] I.W. Morley, *Black Sands*, 1981, pp. 40-55.
[90] P.F. Cooper, A. MacNevin and K. Winward, 'Titanium, Zircon, Thorium', *The Mineral Industry of New South Wales* Nos 40, 44 and 38, 1973, Geological Survey of New South Wales, pp. 49-50.
[91] B. A. Wills, J. A. Finch, 'Gravity Concentration' *in* B.A. Wills and J.A. Finch, Wills Mineral Processing Technology 2015 Elsevier, pp. 223-244.
[92] 'Mineral Sands Deposits Amongst World's Biggest', *Northern Star*, 12 January 1950, p. 4; 'Black Sand Mining Should Benefit Iluka', *Daily Examiner*, 21 April 1950, p. 5; *ARNSWDM* for 1952, p. 35; *ibid*., for 1953, p. 36.
[93] H.G. Raggatt, *Mountains of Ore: Mining and Minerals in Australia*, Lansdown Press, Melbourne, 1968, pp. 346-356.
[94] D.E. Moore, address to the Securities Institute of Australia, New South Wales Division, 28 March 1984, The Securities Institute Journal, No. 1, April 1984, pp. 20-25.
[95] IMorley, *Black Sands*, 1981, 278 pp.
[96] G.A. Stonier, 'Report on alluvial gold deposits near the Evans River'nAppendix R, *ARNSWDM* for 1894, pp. 129-131; Carne, 'Report on the auriferous beach sands', *ARNSWDM* for 1895, pp. 149-160.
[97] H. E. Clifton, 'Beach lamination: nature and origin'1969, *Marine Geology*, vol. 7, 1969, pp. 553-559; K. Winward, 'Quaternary coastal sediments', *in* N.L. Markham and H. Basden, (eds), *The Mineral Deposits of New South Wales*, NSW Geological Survey, Department of Mines, Sydney, 1974, pp. 597-621.
[98] *Ibid.*
[99] Carne, 'Report on the auriferous beach sands', *ARNSWDM* for 1895, pp. 149-160.
[100] 'Local and General News', *Northern Star*, 9 June 1888, p. 2; G.S. Wilkinson, 'Prospecting Board – Progress Reports' *in ARNSWDM* for 1889, p. 203.
[101] J.E. Carne, 'Report on the auriferous beach sands' *in* the Parish of Esk, County Richmond', *ARNSWDM* for 1895, pp. 149-160.
[102] 'Gold from the Sea', *Byron Bay Record*, 27 January 1906, p. 9.
[103] 'Black Sands of the Northern Beaches', *Sydney Morning Herald*, 11 December 1930, p. 10.
[104] S.K. Sanyai, J. Shuster and F. Reith, 'Cycling of biogenic elements drives biogeochemical gold cycling', *Earth Science Reviews*, Vol. 190, 2019, pp. 131-147.