'Sunbeams from cucumbers': an early twentieth-century gold-from-seawater extraction scheme in northern New South Wales

BRETT J. STUBBS[1]

Worldwide interest developed in the late nineteenth century in devising practical means of extracting the minute amounts of gold that were by then known to be present in seawater. Of the many schemes devised, only two are known to have resulted in the construction and operation of plant on a commercial scale: one at Hayling Island, in southern England, and one at Broken Head, in northern New South Wales. This paper is an historical and archaeological survey of the latter operation which is interpreted in the context of the international gold-from-seawater fervour of which it was a product.

INTRODUCTION

The possibility that seawater might contain dissolved gold was speculated and experimented upon widely by scientists in the latter half of the nineteenth century. The eventual measurement of small amounts of the precious metal in seawater from various parts of the world inspired fortune-seekers to devise means of harvesting it. Although the concentrations were minute, the enormous volume of the world's oceans potentially could supply an immense amount of gold if an economical method could be devised to extract it.

In an address to the American Association for the Advancement of Science in 1866, Henry Wurtz suggested that the oceans 'may contain more than two hundred and fifty million times more gold than the total present wealth of mankind in this metal', despite its presence in concentrations that were so small as to be 'beyond the limits of our present… modes of chemical detection' (Wurtz 1868). The earliest attempts to measure the amount of gold in seawater were probably those of Edward Sonstadt, who reported his results in 1872. Many years earlier, Malaguti et al. (1850 a, b, c) had demonstrated the existence in seawater of silver, copper and lead, but not of gold.

Sonstadt experimented with samples of seawater from the coast of the Isle of Man, and concluded that they contained gold, but in a proportion 'certainly less than one grain in the ton' (one grain being equivalent to about 65 mg). He went as far as to suggest, however, that one of his methods 'might be practically applied to the exploitation of the gold in sea-water, which might be received at high water in large tanks, and emptied at low water' (Sonstadt 1872). Sonstadt emphasised in 1892 that the amount of gold in seawater was 'far less than one grain per ton' (Sonstadt 1892).

Despite Sonstadt's experiments, the President of the Society of Chemical Industry, Edward C. C. Stanford, stated in 1894 that 'the presence of gold [in seawater] has not been satisfactorily proved' (Stanford 1894). Perhaps taking Stanford's remark as a challenge, Archibald Liversidge, Professor of Chemistry at the University of Sydney, late in 1894 commenced testing seawater from the coast of New South Wales. His results, presented to the Royal Society of New South Wales in October 1895, and later published in London in *Chemical News*, were 'in favour of gold being present…in the proportion of about .5 to 1 grain per ton'. Although that represented an enormous amount for the whole ocean, Liversidge cautioned that 'at the present day it would probably not pay to extract the gold' (Liversidge 1895, 1896). Wurtz (1896) described Liversidge's results as 'the first positive confirmation of the discovery published in 1872 by Sonstadt of the presence of gold in solution in the water of the oceans'. A few years later, Pack, an assayer at the United States mint in San Francisco, found gold in the water of the Pacific Ocean in the proportion of about half a grain to the ton, confirming the results of Sonstadt and Liversidge (Anon. 1899; Pack 1898).

John Don of Otago, New Zealand, also investigated the matter. He applied one of Sonstadt's methods and one of his own to the measurement of the amount of gold in seawater, his several determinations giving an average content of 0.071 grains of gold per ton (Don 1897). Luther Wagoner of San Francisco reported in 1901 that he had succeeded in measuring the amount of gold in seawater; he extracted 12.6 mg of gold per metric tonne of water, equivalent to about 0.2 grains per ton, somewhere between the determinations of Liversidge and Don (Wagoner 1901).

After reviewing the work of Sonstadt, Liversidge and Pack, and conducting his own experiments, de Wilde, of the University of Brussels, concluded that there was a very great difference in the amount of gold in water from various localities, but if the concentration of gold was not less than 32 mg per tonne (0.5 grains per ton) it could be extracted easily and economically (de Wilde 1905).

The confirmation by Liversidge—and later by others—that gold was contained in seawater, stimulated the minds of inventors worldwide, and from the latter part of the 1890s, numerous patents were sought for various processes for its extraction. Of the many schemes that were devised, however, only two are known to have been put into commercial practice: one at Hayling Island, in southern England, and another (the subject of this paper) at Broken Head, New South Wales, both in the early twentieth century, in fact, almost simultaneously.

An earlier and much better known gold-from-seawater scheme, that of the Electrolytic Marine Salts Company at North Lubec, Maine, was nothing other than an elaborate hoax. Its story has already been well told (Hallett 1955, Mason 1965, Railton 1986, Plazak 2006:208–214), so it is mentioned here only briefly. This scheme was devised by Prescott Ford Jernegan (1866–1942), a Baptist minister in Connecticut and Florida, who had heard of the work of Sonstadt. Jernegan announced in 1896 that the means of extracting gold from seawater had been revealed to him in a dream. Rather than patent the process, he kept it a secret, then sold millions of shares in his Electrolytic Marine Salts Company to gullible

1. School of Environmental Science and Management, Southern Cross University, PO Box 157, Lismore NSW 2480.

New Englanders. A plant at North Lubec was built in an abandoned grist mill, which had been set up to harness tidal currents. The mill building was fitted out with a bank of 'accumulators', devices that purportedly extracted gold and silver from seawater that passed through them. Instead, gold and silver from jewellery and other sources was secreted into the factory, then presented as having been extracted from the ocean. The company began shipping bullion in March 1898, but the swindle was exposed later the same year.

The first apparently genuine gold-from-seawater scheme was instigated in southern England several years after the exposure of Jernegan's hoax. A company was formed in London early in 1904 under the title Industrial and Engineering Trust Limited to develop a process invented by the English engineer Henry James Snell (1842–1927). The company, which included some eminent capitalists among its shareholders, retained one of Britain's most distinguished scientists, Sir William Ramsay, to investigate Snell's process. After carrying out trials with a small plant erected at Hayling Island, near Portsmouth, and capable of dealing with 40–50 tons of seawater at a time, Ramsay concluded that 'there is no doubt but that Mr Snell has proved that gold can be profitably obtained from sea water on a large scale' (Anon. 1905b). Coming from the man who had recently been awarded the Nobel Prize for Chemistry, no better recommendation of Snell's process could be wanted.

By October 1905, Industrial and Engineering Trust Limited had quietly disappeared, the *Australian Mining Standard* surmising that it had 'gone the way of the Electrolytic Marine Salts…Company' (Anon. 1905c). Perhaps unsurprisingly, there is no mention of Ramsay's involvement in this venture in either of his biographies by Tilden (1918) and Travers (1956).

Before the advent of Industrial and Engineering Trust Limited, Snell licensed an earlier version of his process to the brothers Umberto and Henry Charles Ciantar, who undertook to establish a gold-from-seawater factory on the Mediterranean island of Malta. Instead of erecting a factory, the Ciantars took out a patent for the process, and sold it to Atomised Gold Recovery Limited. Snell took legal action against the Ciantars for revealing his secret process, and they against him to recover money lent in connection with its development. In the former matter, the jury returned a verdict for Snell, but, taking into account that the process had never produced a profit and was considered unlikely to be a commercial success, only one farthing damages was awarded (*Times*, London, 8 and 9 March 1907). Indeed, the whole scheme reminded Justice Darling of the savant in Swift's *Gulliver's Travels* who had been working for eight years on a process for extracting the sunbeams from cucumbers (they were to be put in hermetically sealed phials, and let out to warm the air in inclement weather).

THE BROKEN HEAD SCHEME

The second of the two known, apparently genuine gold-from-seawater schemes began to appear late in 1904 at Broken Head (lat. 28° 44' S, long. 153° 37' E), between Cape Byron and Lennox Head on the northern coast of New South Wales (Fig. 1). It was the creation of Australian mining engineer Alfred Argles (c.1851–1938), who used his own money to fund this venture, a fact taken by the *Australian Mining Standard* as evidence of his bona fides (Anon. 1904b).

Excavations for a reservoir at the northern end of Seven Mile Beach, abutting Broken Head, had commenced by the end of 1904, and two 12 inch (300 mm) diameter iron pipes had been installed on the sea side of the reservoir, to fill and empty it. 'Nine or ten' men were employed on the construction at that time (although its operation when complete was expected to employ only two to four men). Early in 1905, Argles took out a mining lease over 5 acres (2.5 ha) of land encompassing his construction site. Further machinery, pipes and vats were landed at the port of Byron Bay in February 1905. Local newspapers carried detailed reports of the almost complete project in January 1906, and the annual report of the New South Wales Department of Mines for the year 1905 recorded that Argles had 'erected a plant with the avowed object of recovering gold from sea-water' (Anon. 1904a, b, 1905a, 1906a, b).

Before proceeding, it must be pointed out that the remains at this site were located and briefly described, but incorrectly explained in a 1990 archaeological study of Broken Head

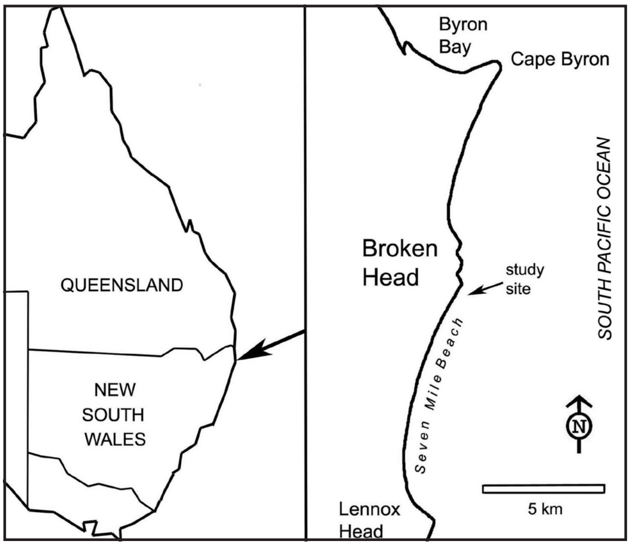

Figure 1: Location plan.

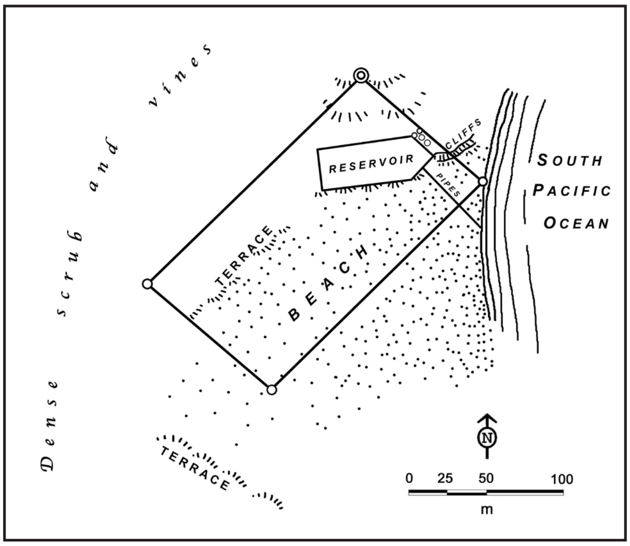

Figure 2: Plan of the Argles mining lease at Broken Head (Portion GL 17, Parish of Newrybar) based on NSW Department of Mines plan no. G16296 (surveyed July 1905).

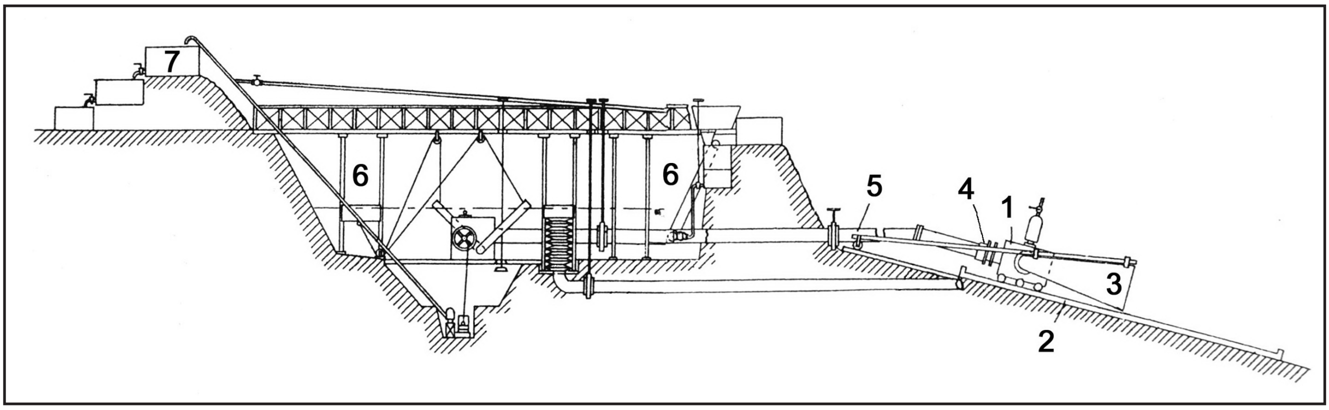

Figure 3: A sectional elevation of the Argles gold-from-seawater apparatus. Components include the wave motor (1) with flared openings or receivers (3), and running along inclined rails (2), telescopic pipe (4), intake pipe (5), reservoir (6) and sludge vat (7). Based on the detailed description and diagrams in Australian patent no. 2963/05.

undertaken for Byron Shire Council. The unresearched speculation identified the site as a seawater pump for a 1930s rutile-zircon sandmining operation (Collins 1990). Survey plans in connection with the Rutile Zircon Limited operation on Seven Mile Beach indicate, however, that the 'remains of old works' were present on the site even in 1935 (Department of Mines plans of ML2 and ML3, Parish of Newrybar).

Part of the Argles operation is depicted in a July 1905 survey plan, undertaken in connection with the granting of his mining lease over the site (Fig. 2). The best record, however, comes from a patent (Australian patent no. 2963/05) applied for by Argles in April of the same year for an 'improved process and apparatus for the extraction of gold from sea water'. A sectional elevation of the apparatus described in the patent is shown in Figure 3.

Central to the scheme was a wave motor (the subject of a separate Australian patent, no. 2380/05) to provide power for the process, thereby lessening its cost of operation. The wave motor (1) ran along inclined rails (2) and had flared openings or receivers (3) facing the sea. The energy of the waves, while driving the motor up the incline, forced the seawater through the motor and through a telescopic pipe (4) to an intake pipe (5) leading to the reservoir (6). Before reaching the reservoir, the seawater was dosed with a hot precipitating solution of lime and iron oxide, then was passed through and across various metallic pipes and silvered plates 'to assist in freeing the gold in a metallic form'.

The canvas-lined reservoir, which was situated about 100 m from the sea at low tide, had a capacity of about 10,000 cubic metres of water. It was constructed partly in the beach terrace and partly excavated out of the rocky base of the headland (which consists of hard Palaeozoic age meta-sedimentary rocks). The dimensions of the reservoir are uncertain, but assuming that the mining lease plan is accurately to scale, it was about 70 m long and 25 m wide. Published descriptions give its dimensions variously as 240 feet long by 150 feet wide (73 x 46 m) (Anon. 1904a, b, 1906a) and, more consistent with the survey plan, 200 feet by 100 feet (61 x 30 m) (Anon. 1906b).

When the reservoir was filled to a certain level, the contents were allowed to settle while the water was drawn off from the surface. The residue or sludge that settled at the bottom of the reservoir was pumped into a vat (7) and subjected to cyanide treatment to recover the gold. The wave motor, as well as filling the reservoir, provided the hydraulic power to elevate the sludge and to operate the subsequent treatment process. The cyanide process of gold extraction (the McArthur-Forrest process) was first patented in Great Britain in 1887, and came into use a few years later. In Australia its use increased rapidly from the late 1890s, and it soon replaced competing technologies, particularly the less efficient 'amalgamation' process, which involved the use of mercury to extract gold from crushed ore by the formation of a mercury-gold amalgam, followed by the application of heat to drive off the low boiling point mercury and leave the gold (Anon. 1897; Lougheed 1987). Amalgamation was the basis of Snell's Hayling Island scheme, and ostensibly of Jernegan's at North Lubec.

Argles planned to fill his reservoir twice, and treat about 20,000 tons of water, each day. Based on experiments that he had conducted on various parts of the English coast a few years earlier, he was confident of extracting at least half a grain of gold per ton of water, yielding at least 20 ounces (about 600 g) of gold per day 'with trifling expense'. The recovery of as little as one-tenth of a grain of gold per ton would give Argles 'a handsome profit' (Anon. 1906a, b).

No descriptive report is known of the Broken Head operation after that of the visiting journalists early in 1906. It is unknown precisely when and why it ceased operation, although it seems to have been remarkably short lived. The annual report of the New South Wales Department of Mines for the year 1906 reiterated that Argles had 'erected a plant at a stated cost of £3,500, with the avowed object of recovering gold from the sea water', and the value of this plant was included in the 'estimated value of [gold mining] machinery and plant' for the Ballina Mining Registrar's Division for that year. Similar entries do not appear in the Department's report for 1907, implying that Argles went out of business during that year. This is supported by evidence that Argles diverted his energies from 1907 into developing another of his inventions, a plant for recovering gold from a more conventional source—seams of heavy minerals in beach sand (Annual Reports of the New South Wales Department of Mines for the years 1909 and 1911). It seems probable that some of the original plant, including the wave motor, was used in connection with this later (also short-lived) development.

Archaeological Evidence

Very little remains in 2007–2008 of the Broken Head gold-from-seawater plant. Its position is revealed to the careful

Figure 4: Lengths of pipe (approx. 180 mm outside diameter) and rail (approx. 120 mm height) exposed after removal of sand by storm waves in Summer 2007–2008.

observer mainly by some rusted steel mounting bolts, cuttings in rock, concrete platforms or foundations, remnants of pipe cemented to rocks, and loose pieces of iron pipe and rail. Fortunately, heavy seas in late December 2007 and early January 2008 removed about 1.5 m of depth of sand from the site, exposing components, including the lengths of iron pipe and rail (Fig. 4), that were not visible when the initial field work was undertaken in the Spring of 2007. A survey of the site was undertaken in February 2008, and a plan was prepared showing the positions of all identifiable components.

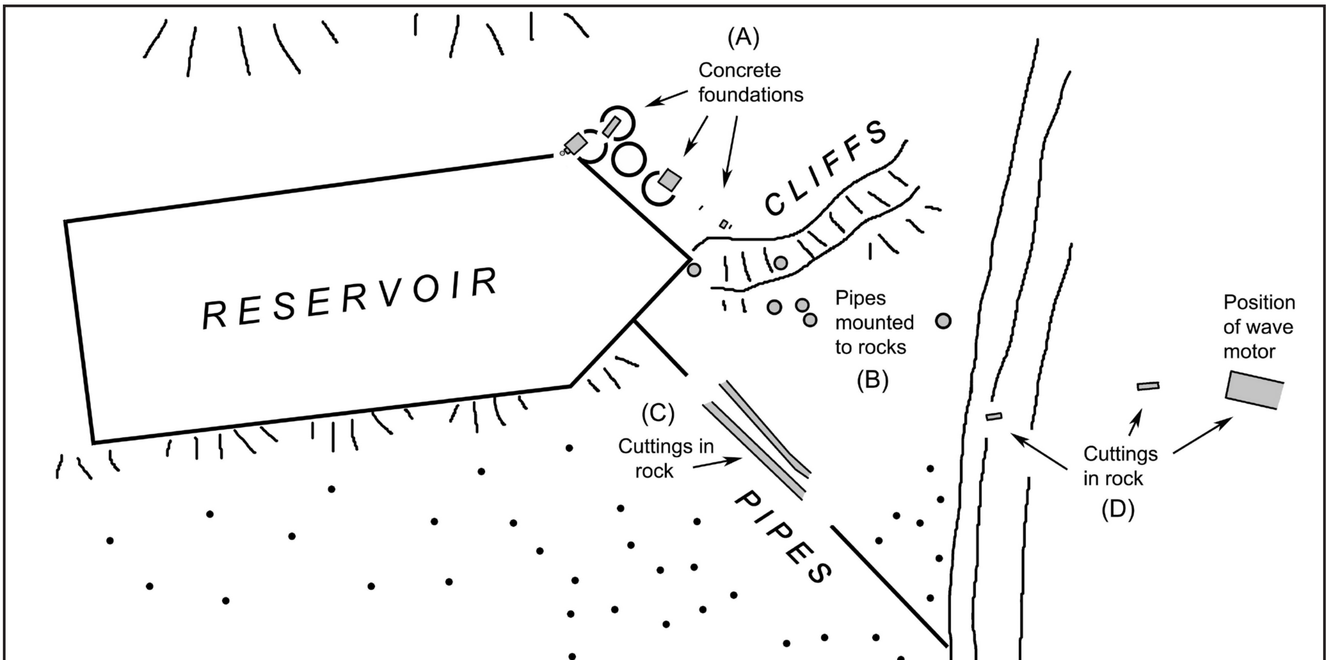

Figure 5: Plan showing reservoir, tanks and other features recorded in the 1905 survey of the Argles mining lease, together with various remnant features identified in 2007–2008 (distinguished by grey shading). Based on details on NSW Department of Mines plan no. G16296.

Some of these are shown in Figure 5 in relation to the features recorded in the 1905 mining lease survey, undertaken while the plant was still under construction. The extant components fall into four main categories (A–D in Fig. 5).

The most conspicuous remains are several concrete platforms (Figs 6, 7) which are situated on the side of the rocky headland at a range of elevations (A). These are associated with four circular tanks shown in the 1905 plan. These tanks are probably those described early in 1906 in the following terms: 'On two or three terraces like step above step one sees a number of circular wooden vats from 12 to 20 feet [3.5 to 6 m] in diameter connected by pipes with the [main] reservoir and with each other' (Anon. 1906b). The precipitated sludge from the reservoir underwent cyanide treament in these vats (Anon. 1904a).

With more careful examination of the headland it is possible to find several points at which pipes were cemented to the rocks (B). At some of these points, short lengths of rusted pipe (about 70 mm inside diameter) remain in position (Figure 8); at others, the cement that remains bears the imprint of the pipe which it formerly held in place. The larger size of imprint is consistent with the diameter (about 180 mm outside) of three loose lengths of pipe and one flange discovered at the site (all uncovered by the Summer storms). For both types the orientation of the pipe at each point was determined, but this is insufficient to reveal its function.

Further examination of the site at low tides revealed the presence of several cuttings, or channels, in the rocks. Two of these (C), each around 15 m long and about 1 m wide, coincide in position with 'pipes' indicated on the 1905 mining lease plan. These were the 12 inch diameter pipes through which the reservoir was filled and emptied (Anon. 1904a, b, 1906a); no remains of these have been found. A further set of cuttings (D) is associated with the wave motor and with the delivery of water to the main reservoir, and probably elsewhere. The most easterly of these (Fig. 9) is approximately 3 m wide, and on its gently seaward-sloping base can be discerned (despite an ample covering of cunjevoi and other intertidal marine fauna and flora) a pair of parallel grooves, spaced about 700 mm apart. These are presumed to mark the position of the rails which formerly bore the wave motor.

Therefore, it has been possible to establish the general layout of the site, including the positions of the wave motor and some pipework, and the general position of the main reservoir and associated tanks. A more detailed reconstruction is precluded by the dearth of archaeological evidence and the absence of any photographic record of the operation.

CONCLUSIONS

The precise fate of the Argles gold-from-seawater scheme is unknown, but it is likely that it was a failure. Had it been otherwise, it surely would have been celebrated, given the keen interest worldwide in the extraction of gold from seawater. As it is, no reports of the scheme have been found after those published early in 1906, and no mention of it has been found after that in the Department of Mines annual report for 1906. Even descendents of Alfred Argles who have lived all their lives in Byron Bay (not far from Broken Head) know little or nothing about it. Whether it was unsuccessful because it was inherently impractical or because some disaster befell it is unknown. That must remain a subject for further research. Nevertheless, it is worthy of some comment here.

The stormy weather and heavy seas in December 2007 and January 2008 that conveniently exposed many hitherto buried components of the scheme raise the possibility that violent wave action during a storm may have destroyed or severely damaged the plant. A search was made in local newspapers for reports of storms in 1906 and 1907, but nothing was found to shed light on the matter. Much later, however, some clues were provided by an anonymous miner who had worked a claim on Seven Mile Beach, probably in the late 1920s. He had been advised then by an old gold prospector that 'only light, portable machinery was of any good, for the sea occasionally came sweeping in and removed everything within reach'; 'masses of old machinery, swinging in the wind' provided evidence that 'there's many a hope been borne out to sea on a rough night on the northern beaches' (P.M.H. 1930). Argles might conceivably have been the victim of such a heavy sea.

As for practicality, learned opinion (with some notable exceptions such as Ramsey and de Wilde) generally held such schemes to be futile. Judge Darling had likened the Hayling

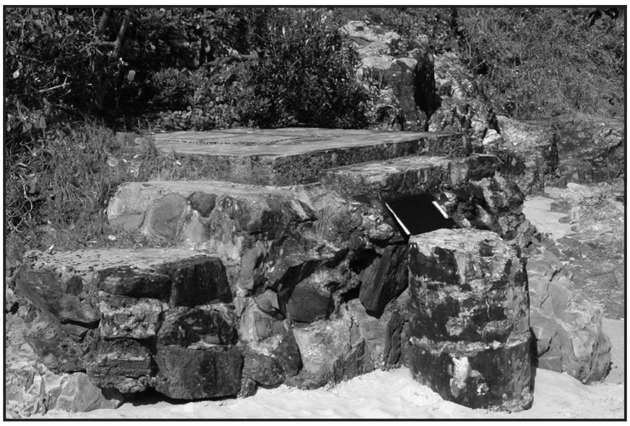

Figure 6: One of several concrete platforms constructed on the side of the headland to support vats for cyanide treatment; looking east. This is the lowest in elevation and is the westernmost of those depicted in Figure 5. Its upper level is approx. 1.5 m square; the circular column is approx 0.5 m in diameter (A4 folder gives scale).

Figure 7: View from above two concrete platforms, looking northwest. The far platform is that depicted in Figure 6. The near one is approx. 1.9 m square, and is approx. 2.5 m higher in elevation than the other.

Figure 8: Remnant of iron pipe (approx. 70 mm inside diameter) cemented to rock (camera lens cap gives scale), looking southeast.

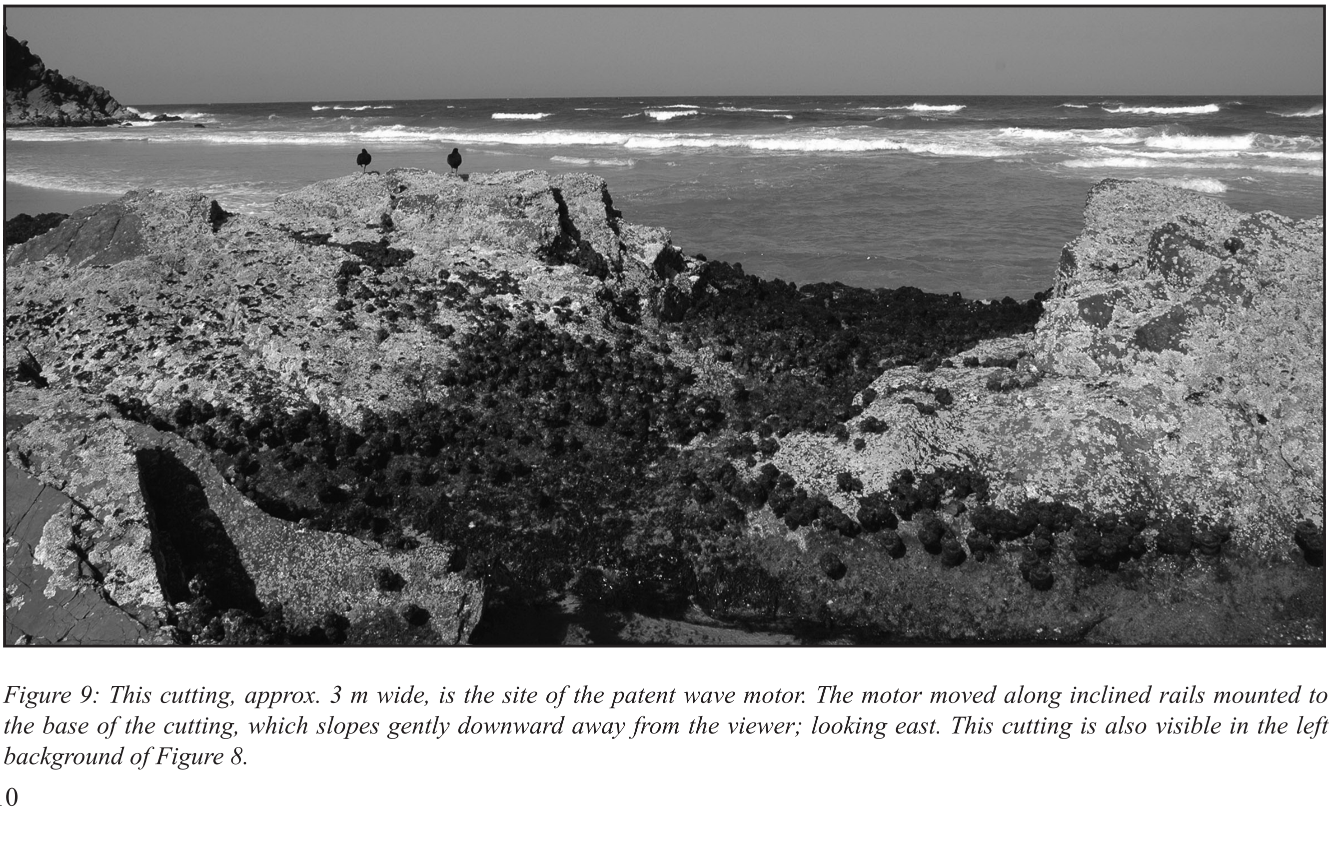

Figure 9: This cutting, approx. 3 m wide, is the site of the patent wave motor. The motor moved along inclined rails mounted to the base of the cutting, which slopes gently downward away from the viewer; looking east. This cutting is also visible in the left background of Figure 8.

Island variant to a fictional attempt to extract sunbeams from cucumbers, and others more expert in mining matters were no less sceptical. The subject was raised by George Beilby in his presidential address to the chemistry section of the British Association for the Advancement of Science meeting in Johannesburg in 1905. Beilby observed that the cyaniding expert, whose business was to extract gold from dilute solutions, could not profitably carry his extraction beyond a concentration of 2 or 3 grains per ton, 'even when the solution is already in his hand'. How, he asked, could it pay to extract gold from seawater, a solution 'one-half the richness'? Indeed, McArthur, the inventor of the cyanide process, had used it to attempt to extract 'the three quarters of a grain of gold that is contained in the average ton of sea-water' but without success (Anon. 1897). Beilby predicted that 'if ever the gold mines of the Transvaal are shut up it will *not* be owing to the competition of the gold resources of the ocean' (Beilby 1905). The Nobel Prize-winning chemist Fritz Haber, who later developed his own method for extracting gold from sea-water, came to the conclusion that the quantities were so small and the expense so great that the process could never be made profitable (Haber 1927).

On the face of it, the Argles scheme seems to have been superior to that of Snell and Industrial and Engineering Trust Limited in two ways. First, it employed the more modern and efficient cyanide process but this may not have mattered. More importantly, the use of a wave motor to provide power for the process, lessened its cost of operation and improved its chances of profitability. Nevertheless, it seems that the scheme produced nothing, becoming just 'another evidence of the inclination of human nature to follow up the impracticable, in the vain hope of a golden reward' (Anon. 1903).

ACKNOWLEDGEMENTS

The assistance of the following people is gratefully acknowledged. Kathy Buckley, librarian of the Queensland Museum, Brisbane, provided me with access to the museum's collection of Australian patents. Phil McMaster, of The Linneaus Estate, Broken Head, gave invaluable support by facilitating my access to the site and helping in many ways with field work. Chris Abbott and Simon Bailey of Chris Abbott Surveying, Ballina, surveyed the site and prepared a plan of the physical remains of the scheme. The document supply librarians at Southern Cross University, Lismore, attended promptly and efficiently to my many requests.

BIBLIOGRAPHY

ANON. 1897 'Interview with Mr McArthur (the inventor of the cyanide process for the extraction of gold)', *The Economic Journal* 7(25):119–122.

ANON. 1899 'L'extraction de l'or contenu dans l'eau de mer', *Revue Scientifique* I, 381.

ANON. 1903 Brief item re. new patent for extracting gold from sea-water, *Engineering and Mining Journal*, 15 August, p. 225.

ANON. 1904a 'Extracting gold from sea water', *Northern Star* (Lismore), 7 December, p. 4.

ANON. 1904b 'Gold from sea water', *Australian Mining Standard*, 29 December, p. 898.

ANON. 1905a 'District News—Byron Bay', *Northern Star* (Lismore), 25 February, p. 5.

ANON. 1905b 'Gold from sea water', *Australian Mining Standard*, 29 March, pp. 404–405.

ANON. 1905c 'Gold from sea water', *Australian Mining Standard*, 18 October, p. 371.

ANON. 1906a 'Gold from the sea', *Northern Star* (Lismore), 17 January, p. 3.

ANON. 1906b 'Gold from the sea', *Richmond River Times* (Ballina), 18 January, p. 2.

AUSTRALIA, DEPARTMENT OF PATENTS, 1905 *Specifications of Inventions*, vol. 12, no. 2380/05.

AUSTRALIA, DEPARTMENT OF PATENTS, 1905 *Specifications of Inventions*, vol. 15, no. 2963/05.

BEILBY, G. T. 1905 'Presidential address, Section B, Chemistry', in *Report of the 75th meeting of the British Association for the Advancement of Science*, South Africa, pp. 351–363.

COLLINS, J. P. 1990 'Aboriginal and European heritage study, Broken Head, N.S.W.', unpublished report for Byron Shire Council.

DE WILDE, P., 1905 'Sur l'or contenu dans l'eau de la mer', *Archives des Sciences Physiques et Naturelles* 19:559–580.

DON, J. R. 1897 'The genesis of certain auriferous lodes', *Transactions of the American Institute of Mining Engineers* 27:564–668.

HABER, F. 1927 'Das Gold im Meerwasser', *Zeitschrift fur Angewandte Chemie* 40:303–314.

HALLETT, R. 1955 'The great Quoddy gold hoax: one of the greatest swindles of the age', *Down East* 1(5):18–20.

LIVERSIDGE, A. 1895 'On the amount of gold and silver in sea-water', *Journal and Proceedings of the Royal Society of New South Wales* 29:335–349.

LIVERSIDGE, A. 1896 'On the amount of gold and silver in sea-water', *Chemical News* 74:146–148, 160–161, 166–168.

LOUGHEED, A. 1987 'The cyanide process and gold extraction in Australia and New Zealand 1888–1913', *Australian Economic History Review* 27:44–60.

MALAGUTI, DUROCHER and SARZEAUD 1850a 'Sur la précence du plomb, du cuivre et de l'argent dans l'eau de la mer, et sur l'existence de ce dernier métal dans les plantes et les êtres organisés', *Annales de Chime et de Physique* 28, 129–157.

MALAGUTI, DUROCHER and SARZEAUD 1850b 'Researches on the presence of lead, copper, and silver, in sea-water, and on the existence of silver in organised beings', *The Chemist* 1(5), 205–206.

MALAGUTI, DUROCHER and SARZEAUD 1850c 'On the presence of lead, copper, and silver in sea-water, and on the existence of the latter in plants and animals', *Quarterly Journal of the Chemical Society* 3, 68–72.

MASON, J. 1965 'The great sea-water swindle', *Yankee*, February 1965, pp. 56–59, 110–112.

NEW SOUTH WALES, DEPARTMENT OF MINES, 1905 Plan of Portion GL17, Parish of Newrybar, Couty of Rous, plan no. G16296

NEW SOUTH WALES, DEPARTMENT OF MINES, 1906 *Annual Report…for the year 1905*

NEW SOUTH WALES, DEPARTMENT OF MINES, 1907 *Annual Report…for the year 1906*

NEW SOUTH WALES, DEPARTMENT OF MINES, 1910 *Annual Report…for the year 1909*

NEW SOUTH WALES, DEPARTMENT OF MINES, 1912 *Annual Report…for the year 1911*

NEW SOUTH WALES, DEPARTMENT OF MINES, 1935 Plan of Portion ML2, Parish of Newrybar, Couty of Rous, plan no. M19528

NEW SOUTH WALES, DEPARTMENT OF MINES, 1935 Plan of Portion ML3, Parish of Newrybar, County of Rous, plan no. M19529

PACK, J. W. 1898 'Gold from seawater', *Mining and Scientific Press* 77:154–155, 13 August.

PLAZAK, D. 2006 *A hole in the ground with a liar at the top: fraud and deceit in the golden age of American mining*, University of Utah Press, Salt Lake City.

'P.M.H.' 1930 'Black sands of the northern beaches', *Sydney Morning Herald*, 10 December, p. 12; 11 December, p. 10.

RAILTON, A. R. 1986 'Jared Jernegan's Second Family', *Dukes County Intelligencer* 28(2):51–94.

SONSTADT, E. 1872 'On the presence of gold in sea-water', *Chemical News*, vol. 26, no. 671, 4 October, pp. 159–161.

SONSTADT, E. 1892 'Gold in sea water', *Chemical News*, vol. 65, 11 March, p. 131.

STANFORD, E. C. C. 1894 'The President's Address', *Journal of the Society of Chemical Industry*, vol. 13, 31 July, pp. 694–700.

TILDEN, W. A. 1918 *Sir William Ramsay K.C.B, F.R.S. Memorials of his life and work*, Macmillan and Co., London.

Times (London), 8 and 9 March 1907.

TRAVERS, M. W. 1956 *The Life of Sir William Ramsay K.C.B, F.R.S.*, Edward Arnold, London.

WAGONER, L. 1901 'The detection and estimation of small quantities of gold and silver', *Transactions of the American Institute of Mining Engineers* 31:798–810.

WURTZ, H. 1868 'On a theory of gold genesis', *American Journal of Mining* 5:18.

WURTZ, H. 1896 'Oceanic Gold', *Engineering and Mining Journal,* vol. 62, 21 November, pp. 483–484.