

18TH OCTOBER, 1900.

THE DEEP SINKING OF SHAFTS AT
THE SYDNEY HARBOUR COLLIERY,
BALMAIN, SYDNEY, NEW SOUTH
WALES.

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Before describing the various operations and appliances connected with the carrying out of the deep sinkings at the Sydney Harbour Colliery, it may interest the members of this Association to learn something of the circumstances and events which had a bearing on the inception of the important mining work now in hand.

It was known that as far back as the year 1847, the late Rev. W. B. Clarke believed in the existence of coal underneath Sydney, for in the same year he gave evidence to that effect before the Select Committee of the Legislative Council on "Coal Inquiry." In his evidence Mr. Clarke was reported to have said: "If we take a dip of only one degree from Newcastle to the south, and from Illawarra to the north, the synclinal curve will meet at the entrance to Broken Bay, which is exactly half way (the extremity, probably, of the minor axis) at a depth of 4680ft., the depth of the coal seams, if continuous."

Again, about the year 1850, in conversation with Mr. R. D. Adams, the late Mr. Clarke referred to the probable existence of coal under Sydney, and the possibility of mining for coal, under the harbour, appealed so much to the mind of Mr. Adams that he never lost sight of the question, and finally, in the year 1874, applied for the mining rights under the whole of Port Jackson.

Further, in the year 1866, in a lecture delivered in Sydney by Mr. J. Mackenzie (late Examiner of Coal Fields), reference was also made by him to the probable existence of coal under Sydney.

Subsequent to these years, the question of the probable occurrence of coal, at a workable depth, underneath Sydney, received the attention, from time to time, of local geologists and mining engineers, but it was not until the year 1878 that any real attempt was made to verify the assumptions which had been made. In that year a diamond drill bore was put down at Newington, on the Parramatta River, but was abandoned, at a depth of 1312ft., without having reached coal. Subsequently, bores were put down at Botany (Holt-Sutherland No. 1 bore) to a depth of 2193ft., in the year 1879; at Moore

Park (at a point about half a mile southerly from the southern end of Bourke-street) to a depth of 1860ft., in the year 1880; at Narrabeen (to the west of the lagoon there, and about seven miles north of Manly) to a depth of 1985ft., in the year 1883; and on the Cooper Estate, at Rose Bay, Sydney Harbour, to a depth of 1700ft., in the year 1888; but for various reasons (chief amongst which, perhaps, was the blocking of the bores by broken boring tools, which the appliances of the day could not recover), these bores were also abandoned before reaching a depth at which coal could be expected, at least according to subsequent events.

However, bores put down at Camp Creek (near the site of the Metropolitan Colliery at Helensburgh) in the year 1884; at Heathcote (near Waterfall station, on the Illawarra Railway) in the year 1886; at Holt-Sutherland No. 3 bore (Dent's Creek) in the year 1887; and on the Moorebank Estate, Liverpool, in the year 1890, were successful in reaching coal at the following depths:—

A seam of coal, 12 feet thick, was struck at a depth of 846 feet. The height of the site above sea level was 336 feet.

Two seams of coal were struck, the upper seam (4ft. 8½in. thick) at a depth of 1513ft., and the lower seam (6ft. 1in. thick) at a depth of 1577ft. 9in. from the sur-

face. This bore was carried down to a depth of 1586ft. The height of the site above sea level was 467ft. 6in.

Two seams of coal were struck, the upper seam (4ft. 2in. thick) at a depth of 2228ft., and the lower seam (5ft. 3in. thick) at a depth of 2229ft. 0in., from the surface. The site of this bore was 132ft. above sea level, and the total depth bored was 2307ft. from the surface.

Three seams of coal were struck, the upper seam (1ft. 5in. thick) at a depth of 2493ft. 6in., the second seam (1ft. 4in. thick) at a depth of 2507ft. 7in., and the lowest seam (6ft. 6½in. thick) at a depth of 2583ft. 4in. from the surface. The site of this bore was about 40ft. above sea level, and the total depth bored was 2601ft. 6in. from the surface.

The evidence afforded by these bores, as well as by the abandoned ones, as to the thickness of the Hawkesbury sandstones, depth and thickness of the chocolate shales and copper-bearing shales and rate and direction of dip of strata, more especially of the coal seams themselves, led to the conclusion that the existence of coal, at a workable depth, under Sydney was practically a certainty. Indeed, it might be said that the only matter requiring to be solved was the exact depth at which the coal lay.

The late Mr. C. S. Wilkinson (Government Geologist) and Professor T. W. E. David, B.A., F.R.S., F.G.S. (Professor of Geology at the University of Sydney, but at that time Government Geological Surveyor), devoted special attention to the question, and the latter gentleman—than whom there was no higher geological authority on the coal measures of this colony—predicted with wonderful accuracy the depth at which coal would be found under Sydney.

In the year 1890 a syndicate, called "The Sydney and Port Hacking Coal Company, Limited," was formed for the purpose of putting down bores to prove the depth at which the coal lay under the mining authorities in Sydney Harbour, which had been granted to Mr. R. D. Adams in the year 1878.

The use of a diamond drill having been secured from the Government, boring operations were begun in September, 1890, at Cremorne, Robertson's Point, Sydney Harbour. The site of the first bore was 54ft. above sea level, and it was carried down to a depth of 3005ft. from the surface. At a depth of 2801ft. 9in. from the surface, a seam of coal, which proved to be 7ft. 3½in. thick, was reached. The coal, however, was found to have been charred, or partly converted into coke owing to the intrusion of two dolerite dykes. Previous to reaching the coal seam the bore penetrated two masses of dolerite, and subsequent examination of the ground, in the vicinity of the bore, disclosed the course of the two dykes at the surface, thus showing that the site of the bore had been unfortunately chosen.

Nothing daunted by the only partial success of their first bore—which at least had shown that a thick seam of coal did exist—and holding the opinion that it only required further boring to prove that good coal did exist in the immediate vicinity, the Syndicate requested that a report might be obtained on the subject from Mr. T. W. E. David, B.A., F.R.S., F.G.S., at that time a geological surveyor of the Department of Mines, and now Professor of Geology at the University of Sydney. Mr. David's report being favourable, the Syndicate made arrangements for the putting down of a second bore, and with a view of avoiding the dykes in the new bore (the area of the land available for bore sites being limited) wisely applied for a geological survey of the neighbourhood, in order that the exact trend of the dykes might be determined.

After a careful geological examination, the site of the second site was selected by Mr. E. F. Pittman, A.R.S.M., Government Geologist, and boring operations were begun in July, 1892. The diameter of the bore was 5 inches to a depth of 2400 feet, and thence downward it was 4 inches. The site of the bore was distant about 40 chains in a direction N. 46deg. W. from the first bore, and its height was 139 feet 7½ inches above low water mark in Sydney Harbour. On the 8th No-

vember, 1893, at a depth of 2917 feet from the surface, the top of the Bulli Coal Seam was struck, and after 24 hours' continuous boring, lowering and raising of rods and core-barrel, the seam level, 10 feet 3 inches thick, was bored through, and an additional thickness of 1 foot 9 inches of rock, thus making the total depth of the bore 2929 feet.

The following is a descending section of the seam, proved by the bore:—

	ft.	in.
Roof—Clay Shale.		
Coaly Clay Shale	0	1
Splint Coal, somewhat inferior, with minute veins of calcite	0	8
Coal, splint and bituminous, of good quality	2	10
Band, dark brown clay shale, adhering firmly to coal	0	0½
Coal, splint and bituminous, of good quality, the last three inches rather soft and bituminous	6	4½
Coal, soft, bituminous, a trifle clayey . .	0	3½
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	10	3

Floor—Black carbonaceous clay shales.

Six samples of the core of coal, recovered from the bore, were submitted for analysis to Mr. J. H. Mingaye, F.C.S., Analyst and Assayer to the Department of Mines, and the mean, of the six analysis made, gives the average composition of the whole seam as follows:—

Hygroscopic moisture66	Coke	81.77 p.c.
Volatile hydrocarbons	17.57	Coke	81.77 p.c.
Fixed Carbon	71.09	Coke	81.77 p.c.
Ash	10.68	Coke	81.77 p.c.
	<hr/>	Coke	81.77 p.c.
	100.00	Coke	81.77 p.c.
Mean percentage of sulphur724		
Mean specific gravity	1.346		
Mean calorimetric value	13.00		

Mr. Mingaye also reported that "the samples are good descriptions of coals for household purposes, the percentage of ash being low, as compared with the average ash present in the Bulli and Wollongong coals." He added that "they may be described as excellent steaming coals, and that they yield an excellent coke, having all the principal properties of the Southern coke, i.e., Bulli and Wollongong, which are well suited for metallurgical purposes."

During the progress of boring operations, additional mining rights were secured, on behalf of the Syndicate, which had meanwhile been re-named "Sydney Harbour Collieries, Limited."

The authorities to mine now extend over an area of 10,167 acres, and it is estimated that the quantity of coal, available for working, will be about 113,000,000 tons.

In the year 1895, a company, incorporated in England under the Companies Act, 1862-1893, was formed for the purpose of acquiring and developing the mining rights held by the Syndicate.

The concessions are held direct from the Crown, under the 28th section of the N.S.W. Mining Act, 1874; the tenure is subject to certain conditions, which are fair and reasonable both to the Government and the Company, and to a moderate annual rental, which will, however, merge into a Royalty of sixpence per ton on large coal, and threepence per ton on small coal.

The introduction to this paper has taken up more time and space than was the writer's intention, but it was felt that, before describing a class of work which, naturally, is new to Sydney, and which in point of magnitude is unequalled by anything of the same nature in the Southern Hemisphere, it might be of interest to, first, trace the various steps which led up to the enterprise.

In collecting the foregoing particulars, the writer has to express himself specially indebted to the valuable papers on the subject written by Professor T. W. E. David, B.A., F.R.S., F.G.S., to the "Notes on the Cremorne Bore," by him and Mr. E. F. Pittman, A.R.S.M.,

Government Geologist, read before the Royal Society of N.S.W. on December 6th, 1893, and to their joint paper "On the Discovery of Coal under Cremorne, Sydney Harbour," published in the records of the Geological Survey of N.S.W., Vol. iv., Part i., 1894. The reports of the several officials of the Mines Department, regarding depth of bores, etc., etc., as published in the Annual Mining Reports of the Department, have also been of much service.

Some difficulty was experienced in obtaining a suitable site for the surface works of the colliery. It must, however, be pointed out that the requirements were unique, as they embodied the following:—

- (a) Sufficient area, fronting the Harbour, for the accommodation of the necessary surface works.
- (b) Sufficient water frontage, together with reclamation rights, or wharfage lease, for the accommodation of large vessels and for the proposed shipping arrangements, generally.
- (c) Sufficient depth of water along the frontage—or natural facilities for acquiring the necessary depth at reasonable cost—to allow of the rapid and safe berthing of the largest vessels.
- (d) Position suitable for underground connection, from the shafts, with the areas to be mined under the Harbour.
- (e) Position suitable for the supply of city and local demand for coal, depending for its carriage on carts, etc., and other minor considerations.

Many sites were placed under offer, but, of those, few were really suitable, and, to add to the difficulty of choice, opposition was offered to the establishment of the colliery, from very unexpected quarters, notwithstanding the evident enormous importance, to the city of Sydney, of a local coal supply.

It was not until the latter half of 1896 that the site on which the colliery works are now being developed was secured, on the shores of Long Cove, Balmain. The site is freehold; it has an area of $4\frac{3}{4}$ acres (of which $3\frac{3}{4}$ acres represent the original area of the land, the re-

maining 1 acre having been reclaimed from the harbour since operations were begun), and it has a water frontage of 580 feet, besides having two street frontages and an entrance from the end of a third street.

The configuration of the site, in its natural condition, was that common to the unimproved shores of the harbour, steep cliffs rising from the water's edge, thence receding by rough rocky slopes carrying little or no soil. The original levels along the street boundary, opposite to the water frontage, varied from about 102ft. to about 113ft. above low watermark.

After careful consideration of the questions affecting the delivery of coal, both into vessels and to carts, it was decided that the level of the mouth of both pits should be 80ft. above low water mark, and that that should also be, as near as practicable, the level of the whole of the pit-bank and colliery yard, such level to be extended, in front of the pits, by made-up ground retained by massive rubble walls, allowance being made for the slight incline necessary for the gravitating of the full tubs of coal from the cages to the screening plant.

It was also decided that the level of the boiler-house firing floor should be 75ft. above low water mark, that the level of the foundations for screening plant should be 58ft. above low water mark, and that a road, having an entrance from one street and an outlet to another, should pass right through the site, immediately in front of the screens and retaining walls, so that carts, requiring coal, could be quickly and conveniently loaded with either small or large coal.

Plans embodying these decisions having been prepared, the work of levelling the site was begun, in the end of December, 1896, and, as a result, the ground has been divided into a series of areas, having different elevations, suitable for the requirements of the various surface works.

The main upper level, on which the whole of the heavy machinery and permanent buildings are being erected, has an area of 2 acres 1 rood. The greater part of this area was excavated out of the solid rock, the remainder being formed ground, retained by rubble walls. The excavation amounted to 31,741 cubic yards and the

formed ground to 15,789 cubic yards, the latter containing 3135 cubic yards of retaining walls. The areas of the excavated and of the formed ground are 1 acre 1 rood 31 poles and 3 roods 9 poles respectively. The intermediate level for the site of the screening plant contains 977 cubic yards of formation, including 457 cubic yards of retaining walls. The excavations for the foundations of the various retaining walls, for machinery beds, and for a reservoir (formed partly by excavation and partly by concrete walls) amounted to a further quantity of 4115 cubic yards, and the walls supporting the boundary fences contain 539 cubic yards of rubble, the excavations for which amounted to 569 cubic yards.

Rack-a-Rock was the explosive used, the quantity being 3 tons 14 cwt.

The regulations applying to the reclamation and purchase of reclaimed land from the Crown, made it necessary that this work should be put in hand at once. The deposit of mud in the bottom of the harbour, fronting the site, was, of course, considerable, no dredging or work of any kind having ever been carried out to disturb the natural conditions.

It may be mentioned that, prior to purchasing the site, soundings were taken for the purpose of ascertaining, approximately, the amount of submarine work requiring to be carried out, to provide the necessary shipping facilities, and that such soundings showed that the thickness of mud varied from 3ft. to 17ft. A dredge was accordingly employed to remove this mud, in order to allow of soundings being taken to the rock. Altogether 1424 soundings were taken, and from these, cross and longitudinal sections were plotted. From these sections the plans of the quay-wall were prepared, and the amount of rock excavation (to give a depth of water of 25 feet at low tide immediately outside the wall) computed.

Preliminary operations connected with the quay-wall works were begun in May, 1897, and the construction of the concrete wall on 20th June, 1897. The wall was completed on 28th March, 1899, and the dredging of the rock excavated outside the wall was completed on 28th November, 1899. Where the rock had to be excavated outside the wall, to give a depth of water 25

feet at low tide, the face of the excavation was kept 2 feet clear of the projecting "toe" of the wall.

To give a full description of the carrying out of this work would prolong this paper beyond limit, but the following brief description of the method adopted in the construction of the wall may be of interest. The wall was built in lengths, or sections, of from 80 feet to 100 feet.

After the excavations for the foundations of a section of the wall were completed, a coffer-dam of corresponding length, and having an inside cross-section equal to the thickness of the wall throughout that length, was built. Before depositing the concrete in the coffer-dam the bottom was thoroughly cleaned, a high pressure hose being used for this purpose. This hosing operation was repeated between each layer of concrete put down. The stone used in the concrete was the sandstone excavated in levelling the site of the works and in sinking the shafts. It was broken in a 16-inch x 9-inch Baxter stone crusher, this operation also yielding "shivers" and sand of good quality, which were used as ingredients in the concrete.

The concrete was composed of 5 parts of broken stone ($2\frac{1}{2}$ inch gauge) and "shivers," $1\frac{1}{3}$ parts of sand (crushed from the stone), and one part of cement. It was mixed on a platform situated about the centre of the water frontage, and after being "turned" was filled into skips, containing each 1 cubic yard, which were run on rails parallel with and close to the coffer-dam. After being run to the required position, the body, or box, of the skip was raised, off the under frame and wheels, by a steam winch fixed on a punt conveniently moored outside of the coffer-dam. The box of concrete was then lowered through the water inside the coffer-dam, to the required position, indicated by the diver, who then gave the necessary signal for the door in the bottom of the skip to be opened, so as to allow the concrete to be deposited. The skip doors were opened by a "trigger," worked by a handline from the surface.

The finished level of the top of the quay wall is 9ft. above low tide; it has a "batter" of 1 in 18 on the face, a thickness of 4ft. 3in. on the top, and is "stepped" at the back, each step increasing the thickness of the wall from

3ft. to 4ft. according to the height. The first step is 9ft. from the top of the wall and 4ft. wide, consequently the thickness of the wall, including the extra thickness due to the "batter" of its face, is 8ft. 9in. at low tide level. A considerable portion of the bottom section of the wall has a thickness of 14ft.

On the completion of the wall, the work of reclaiming the area behind it was carried out by tipping the ballast got from the shaft sinking. This was lowered in the same boxes as were used for the concrete, and emptied at the bottom and over the various steps on the back of the wall, until it had a width of at least 2ft. at the top of the wall and a natural slope shorewards. In this way 4763 cubic yards of ballast were tipped, after which the remainder of the reclamation area was filled up by emptying ballast from end-tipping skips.

In the construction of the quay-wall and reclamation, the quantities of work carried out were as follows:—

In the preliminary dredging before the detail soundings were taken over 20,000 tons of mud were removed. The excavations for the foundations of the wall amounted to $1744\frac{1}{2}$ cubic yards, the wall contains 6453 cubic yards of concrete, and the wall and reclamation contain some 24,000 cubic yards of material. Outside of the wall, the excavation, carried out to give the required depth of water, represented the cutting up of about 3400 solid cubic yards. Now that this work is completed, there is a shipping berth 580ft. long, with a depth of 26ft. of water at low tide, at which vessels can safely lie in any weather (the land providing shelter from the worst prevailing gales) within a hundred yards of the mouths of the pits.

The distance between the centres of the two shafts is 168ft. on a line at right angles to the southern boundary of the site. Both shafts are lined with brickwork, set in cement mortar, and have a diameter of 18ft. in the clear. The northern will be the main winding and "down-cast" shaft, whilst the southern will be "the up-cast" shaft. The latter is, however, being fitted up for coal winding, if required. The former is named the "Birthday" Shaft, and the latter the "Jubilee" Shaft, owing to the fact of opportunity having been taken to

fire the first shots at the surface—in the former on the Queen's Birthday, and in the latter on the Queen's Record Reign Celebration Day. Owing to the excavations connected with the levelling of the works site not being sufficiently advanced, it was, however, impossible to erect the shaft sinking machinery for some time after these dates.

The contour line, marking the natural level of 80ft. above low water mark (along which the excavations for levelling the surface began) passed close to the site of the Birthday Shaft, but in the case of the Jubilee Shaft the levelling had to be carried back for some distance from this contour line before the site of the shaft was bared.

In order that the sinking of the shafts might be begun—without the delay which, it was evident, must take place in waiting until the surface excavation work would allow of the proper machinery being erected—two steam cranes were hired and placed in working position, one close to the site of each shaft. The lifting capacity of the cranes was 5 tons and 7 tons respectively, that erected at the Jubilee Shaft being the more powerful of the two. The jibs of the cranes acted as head-gears over the shafts, and the work done by the cranes was satisfactory, considering that the speed of winding was comparatively slow, and that the limited width of the rope-barrels prevented the cranes being used beyond a depth equal to the length of rope which could be coiled on the barrel, single lap. To show that good work was done by the cranes, it may be mentioned that, in the Jubilee Shaft, a depth of 125ft. (i.e., from 29ft. to 154ft.) was sunk, through hard sand-stone, in four weeks. Sinking was begun in the Birthday Shaft on 9th June, 1897, and was carried to a depth of 149ft., the equivalent of the length of rope which the crane-barrel could hold. At a depth of 71ft. sinking was suspended, and the driving of a tunnel from the front, or harbour side, of the shaft was begun, and carried in a distance of about 20ft. It was driven 15ft. 6in. wide, by 12ft. 2in. high. The floor of this tunnel is on exactly the same level as the top of the quay-wall, and the driving of it will be completed from the outside. When