RECORDS OF ROCK TEMPERATURES AT SYDNEY HARBOUR COLLIERY, BIRTHDAY SHAFT, BALMAIN, SYDNEY, N. S. WALES.

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I. *Introduction.*—About seventeen years ago Professor J. D. Everett, F.R.S., Secretary to the Underground Temperature Committee of the British Association for the Advancement of Science, furnished one of us (Professor David) with two slow-action thermometers and one maximum thermometer for observing rock temperatures underground. The thermometers were made by Negretti and Zambra, and were tested at Kew Observatory. The Kew certificates were forwarded with them and the corrections applied in the table given later on in this paper are in accordance with these certificates.

The first opportunity for observing underground temperatures near Sydney was afforded by the diamond drill bores for coal, put down at Cremorne, Robertson's Point, Sydney Harbour. The second of these bores was completed in November 1893. The maximum thermometer, sent by Professor Everett, became mislaid in the interval between the completion of the first and second Cremorne bores, and when it became necessary to observe underground temperatures at the No. 2 Bore, Mr. H. C. Russell, B.A., C.M.G., F.R.S., Director of the Sydney Observatory, kindly lent maximum thermometers for the purpose, similar to the one sent by Professor Everett, but not protected by a thick, hermetically sealed outer glass casing. It was, accordingly, necessary to protect these thermometers against the water pressure at the bottom of the bore, and this was done efficiently, though the method is cumbrous, by enclosing the thermometers in a strong wrought iron pipe, hermetically sealed at both ends by means of screw cap pieces which were screwed on hot, with molten lead in the threads of the screws. The results of these observations have been recorded by two of us elsewhere.[1]

The results of these observations show that the rate of increase of rock temperature downwards at Cremorne is about 1° Fahr. for every eighty feet. Shortly after these observations were made at Cremorne, Professor Everett kindly sent another protected Negretti and Zambra maximum thermometer, as well as a protected Phillips maximum thermometer, for further observing of underground rock temperatures. The thermometers used on the present occasion were the two slow-action and the two maximum Negretti and Zambra thermometers sent by Professor Everett. Their numbers are 50452 and 50454 (slow-action) and 15888 and 65294 (maximum).

II. *Methods of Observing.*—The observations of underground temperatures at the Sydney Harbour Colliery, Balmain, Sydney, were obtained by the methods recommended by the Underground Temperature Committee of the British Association for the Advancement of Science. The sinking of the Birthday Shaft had reached a depth of 600 feet before the first observations were made, but since then, readings of the rock temperatures have been taken at intervals of practically 50 feet, and an opportunity will be afforded of making observations at less depth than 600 feet during the sinking of the Jubilee Shaft, which is situated at a distance of 168 feet from the Birthday Shaft (the distance given being from centre to centre of shafts) and has reached, at the present time, a depth of 225 feet.

From 600 feet down to 1,100 feet only the two slow-action thermometers were used, and the horizontal holes, which were drilled into the walls of the shaft for their reception, were put in a distance of 3 feet down to the 950 feet level, while from that

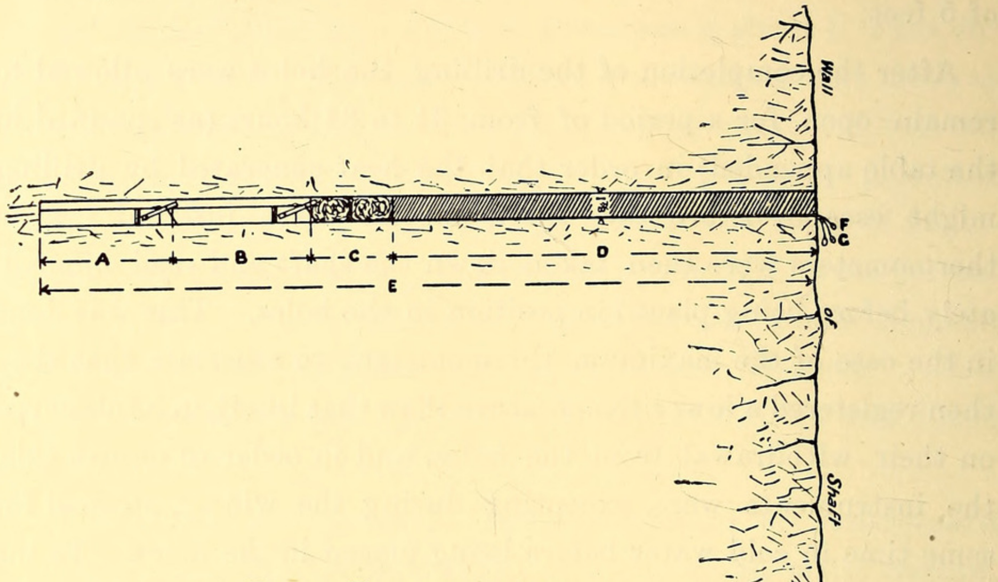
1 T. W. E. David and E. F. Pittman—Records Geol. Survey N. S. W., 1894, IV., pt. 1, p. 7; Proc. Roy. Soc. N. S. Wales, 1893, XXVII., pp. 460 - 465.

to the 1,150 feet level they were put in a distance of 4 feet in each case. Beginning at the 1,150 feet level the two maximum thermometers were used, in addition to the two slow-action instruments, and the practice has been to place one instrument of each type in each of the holes, which have been put in to a distance of 5 feet.

After the completion of the drilling, the holes were allowed to remain open for a period of from 34 to 84 hours (as specified in the table appended) in order that the heat generated by drilling might escape before the thermometers were inserted. The thermometers were then taken down the shaft and read immediately before being placed in position in the holes. This was done in the case of the maximum thermometers, to ascertain that they then registered a lower temperature than that likely to be observed on their withdrawal from the holes, and in order to ensure this, the instruments were, excepting during the winter, steeped for some time in cold water before being placed in the holes. To the copper cases enclosing the thermometers, strong pieces of string were attached to facilitate their subsequent withdrawal from the holes, and when the instruments were in position 'end on' to one another at the back of the holes, the strings extended from the cases to a little beyond the mouths of the holes. The plugging of the holes consisted, in each case, of about six inches of greasy cotton waste, placed next to the thermometers and gently rammed against the outer instrument case with a wooden rammer, the remainder of the hole being filled up with plastic clay, rammed into the hole. Attached to the cotton waste, in each hole, was a piece of pliable wire, by means of which the plugging could be quickly withdrawn after the clay tamping was removed by a scraper.

After being left in the holes for a period of from 37 hours upwards (as specified in the table appended) the clay tamping and cotton waste plugging were removed from the holes, and the thermometers pulled out by means of the strings and read immediately. In the case of the slow-action thermometers the thick layer of paraffin wax around their bulbs prevented any appreciable alteration in the height of the mercury column taking place before the records were taken.

The following diagram shows, to scale, the arrangement of thermometers in the holes :—



ROCK TEMPERATURES
AT
SYDNEY HARBOUR COLLIERY
Sketch showing arrangement of Thermometers in holes

On one occasion (at the 951 feet level) the thermometers were left in the holes for almost nine days, and on another occasion (at the 606 feet level) for eighteen days. This was during the time occupied in putting in a section of brick walling in the shaft, immediately above the level where the thermometers were placed, it being impracticable to remove the thermometers whilst this work was going on. The whole of this part of the work was done by one of us (Mr. Rae the manager of the Sydney Harbour Colliery) assisted by the contractor for the sinking of the shaft (Mr. T. Cater).

III. *Section of strata passed through in sinking the Birthday Shaft, Sydney Harbour Colliery, Balmain.*—The following section was taken by Mr. W. S. Dun, Palæontologist to the Geological Survey of N. S. Wales, and one of us (Mr. Rae):—

BIRTHDAY SHAFT, SYDNEY HARBOUR COLLIERY.

Strata.	Thickness ′	Thickness ″	Depth from Surface. ′	Depth from Surface. ″
Brickwork	7	0	7	0
Yellowish-red, gritty, thick bedded ferruginous sandstone	32	2	39	2
Grey shaly sandstone	4	0	43	2
Shale parting	0	1	43	3
Rather hard thick-bedded grey sandstone	49	8	92	11
Dark bluish-grey sandy shale	5	5	98	4
Rather fine grained greyish sandstone ...	1	9	100	1
Bluish-grey sandy shale	8	4	108	5
Rather fine light grey sandstone with narrow bands of nodular carbonate of iron ...	15	0	123	5
Shale parting	0	0½	123	5½
Greyish-white sandstone with mica streaks	42	6	165	11½
Shale, horizontally bedded...	4	6	170	5½
Greyish-white sandstone with mica streaks	24	3	194	8½
Shale parting	0	1	194	9½
Greyish-white sandstone, false-bedded with streaks of mica	15	8	210	5½
Fine grained greyish-white sandstone ...	10	9	221	2½
Grey sandstone, horizontally bedded with shale bands	18	8	239	10½
Greyish-white sandstone, false-bedded ...	5	6	245	4½
Sandstone with pebbles of shale	13	0	258	4½
Shale band	0	3	258	7½
Greyish-white sandstone with balls of shale	12	9	271	4½
Fine grey sandstone with mica	19	8	291	0½
Greyish-white sandstone with a little fine conglomerate	12	7	303	7½
Shale band	0	3	303	10½
Coarse sandstone, false-bedded	9	6	313	4½
Grey sandstone with pipes of shale ...	7	0	320	4½
Clay parting	0	0½	320	5
White sandstone	10	0	330	5
Hard grey sandstone with dark streaks false-bedded in places...	23	10½	354	3½
Clay parting	0	2	354	5½
Hard grey sandstone with dark streaks, carbonate of iron nodules	1	3½	355	9
Hard grey streaky sandstone, shewing current bedding	35	11	391	8
Fine conglomerate passing into gritty sandstone with occasional nodules of carbonate of iron...	9	2	400	10

Strata.	Thickness ′	″	Depth from Surface. ′	″
Dark sandy shale	0	11½	401	9½
Hard grey sandstone	1	7½	403	5
Dark blue shale	0	3	403	8
Shaly sandstone	2	5	406	1
Clay shale parting	0	1	406	2
Grey streaky sandstone with occasional pebbles of shale	10	4½	416	6½
Very porous sandstone, loose, with boulders of harder sandstone and bands of clay. In this bed the water increased from 75 to 275 gallons per hour	22	1½	438	8
Hard greyish- white sandstone	7	3½	445	11½
Very hard greyish-white sandstone with dark bands, false-bedded	17	11	463	10½
Hard greyish-white sandstone	10	4	474	2½
Very hard ferruginous sandstone	0	4	474	6½
Hard greyish-white sandstone, dark bands	26	8½	501	3
Hard ferruginous sandstone	2	0	503	3
Hard greyish-white banded sandstone ...	7	0	510	3
Rather softer greyish-white sandstone ...	3	0	513	3
Very hard greyish-white sandstone, banded and shewing false-bedding in places...	20	7½	533	10½
Very hard ferruginous sandstone	0	11	534	9½
Hard greyish-white banded sandstone ...	8	6	543	3½
Bluish-grey shale	1	1½	544	5
Rather softer greyish-white sandstone ...	12	6	556	11
Dark bluish-grey sandstone, upper 2″ loose	10	3	567	2
Hard greyish-white sandstone	4	0	571	2
Dark bluish-grey shale	3	0	574	2
Fine grained greyish-white sandstone, false-bedded and friable	15	7½	589	9½
Hard greyish-white sandstone, false-bedded and very friable	20	2½	610	0
Clay shale, bluish-grey	7	0	617	0
Greyish-white sandstone	11	0	628	0
Alternate bands of clay shale and sandstone with impressions of *Equisetum* and fern fragments	6	0	634	0
Fine grained greyish-white sandstone, false-bedded and very friable	38	0	672	0
Clay shale, soft and jointed	1	0	673	0
Grey sandstone with nodules and pebbles of shale and quartz	3	0	676	0
Greyish-white sandstone, false-bedded and friable	43	10	719	10

Strata.	Thickness ′	Thickness ″	Depth from Surface. ′	Depth from Surface. ″
Coarse grained white sandstone	13	6	733	4
Dark blue shale (6″ - 12″ thick)	1	0	734	4
Fine grained white sandstone with micaceous bands	4	2	738	6
Fine grained white sandstone with shaly partings, becoming more frequent ...	14	5	752	11
Hard white sandstone	13	10	766	9
Two bands of dark blue shale with sandstone parting	1	0	767	9
Hard white sandstone	0	6	768	3
Dark blue shale with sandstone partings...	5	4	773	7
Hard fine grained sandstone with shaly streaks...	1	0	774	7
Dark blue shale	4	9	779	4
Coarse white sandstone with thin bands of micaceous shale	14	5	793	9
Dark blue shale with thin sandstone bands very hard, varying from 3″ – 5″ thick (At 825′ 830′ and 835′ bands of hard white sandstone). Bottom of this bed dipping N.N.E. about 1 in 16 ...	47	10	841	7
Hard white sandstone with current bedding strongly developed, very friable...	38	9	880	4
Dark blue shale with thin bands of dark sandstone (At 888′ impression of *Equisetum* or *Zeugophyllites* in grey shales; 890′ fine grained sandstone	9	10	890	2
Sandy shale with dark shale bands (At 919′ thin parting with calcite crystals, 925′ hard fine grained sandstone bands, 930′ dark shale with abundant *Equisetum*, 932′ band of brownish-black shale) ...	63	8	953	10
Hard white sandstone with nodules of shale	10	0	963	4
Dark blue shale with thin sandstone bands (975′ dark shale with *Alethopteris?* 980′ dark shale with *Thinnfeldia?* 986′ calcite, 992′ concretionary markings)...	30	0	993	10
Light greyish shale...	4	6	998	4
Dark blue shale, plants *Thinnfeldia*, *Equisetum*, &c., (1,000′ coalpipes)... ...	6	3	1,004	7
Light grey shale (1,010′ 10″ band of very hard grey sandstone 1,022′ 7″ coalpipes [In this bed were found *Thinnfeldia odontopteroides*, Morris; *T. narrabeenensis*, nov. sp.; *Alethopteris*, nov. sp.; *Tæniopteris*, nov. sp.; *Equisetum*, Fructification (*cf. Sphæreda* and *Beania*)—all of Triassic Age.]	20	2	1,024	9

Strata.	Thickness		Depth from Surface.	
Dark chocolate shale (at 1,038′ three inch band of dark grey sandstone with coal-pipes; 1,072′ hard band of purplish-brown micaceous sandstone, with darker purple streaks, 4″ thick; 1,075′ six inch band of mottled chocolate and greenish grey shale)	′ 52	″ 3	′ 1,077	″ 0
Grey shale	1	3	1,078	3
Mottled chocolate shale	1	10	1,080	1
Dark chocolate shale	2	8	1,082	9
Mottled chocolate and grey shale... ...	12	10	1,095	7
Dark chocolate shale	6	4½	1,101	11½
Greenish glauconitic sandstone	0	1½	1,102	1
Dark chocolate shale	0	1	1,103	1
Mottled chocolate and grey shale	19	2	1,122	3
Dark chocolate shale	5	3	1,127	6
Mottled chocolate shale and greenish sandstone	0	5½	1,127	11½
Greenish-grey glauconitic sandstone ...	6	11½	1,134	11
Dark grey shale with *Equisetum*	6	5	1,141	4
Dark chocolate shale	2	9	1,144	1
Greenish glauconitic sandstone	5	1	1,149	2
Dark chocolate shale	23	10	1,173	0
Greenish glauconitic sandstone (coalpipes at 1,175′)	3	0	1,176	0
Mottled chocolate shale	6	6	1,182	6
Dark chocolate shale	2	2	1,184	8
Dark blue shale with *Equisetum* (shale ball near slip at 1,187′)	2	6	1,187	2
Very dark grey shale	0	3	1,187	5
Dark grey shale	2	7	1,190	0
Dark blue shale	0	9	1,190	9
Chocolate and grey shale, slip in shaft wall and very hard shale balls	0	7	1,191	4
Grey sandstone	0	8	1,192	0
Grey shale with dark sandy micaceous shale	0	10	1,192	10
Grey shaly sandstone with dark pebbles ..	0	2	1,193	0
Hard grey micaceous sandstone	1	0	1,194	0
Hard mottled chocolate shale, lighter near a slip	1	0	1,195	0
Dark chocolate shales, slightly mottled in places	1	5	1,196	5
Purplish gritty micaceous shale	1	3	1,197	8
Purple and green sandy shale (glauconitic)	2	0	1,199	8

Strata.	Thickness		Depth from Surface.	
	′	″	′	″
Dark purplish-green mottled shale (glauconitic)	1	0	1,200	8
Mottled shale, chocolate and grey... ...	2	7	1,203	3
Light grey sandy shale, glauconitic streaks	0	9	1,204	0
Dark blue shale	1	1	1,205	1
Hard light grey shale	4	9	1,209	10
Alternate streaks of light and dark shale...	0	3	1,210	3
Hard light grey shale with *Equisetum* ...	0	9	1,210	10
Alternate streaks of light and dark shale...	0	5	1,211	3
Hard light grey shale	1	1	1,212	4
Alternate streaks, hard light and dark shale	0	8	1,213	0
Very hard dark blue shale...	4	9	1,217	9
Very hard grey sandstone with dark streaks	1	2	1,218	11
Very hard dark micaceous sandstone ...	0	10	1,219	9
Very hard grey sandstone with dark micaceous streaks	4	3	1,224	0
Light grey micaceous shaly sandstone with streaks of dark shale (1,230′ bright bitumen coal pipe)	9	11	1,233	11
Hard dark blue shale (1,234′ *Thinnfeldia* n. sp.)	4	0	1,237	11
Hard grey shaly sandstone with bands of darker sandstone and blue shale ...	20	10	1,258	9
Dark blue shale with bands of shaly sandstone	7	6	1,266	3
Alternate bands, $1\frac{1}{2}''-2\frac{1}{2}''$ thick, of grey shaly sandstone and dark blue shale...	1	4	1,267	7
Grey shaly sandstone	1	4	1,268	11
Dark blue shale	0	10	1,269	9
Shaly sandstone with streaks of darker micaceous sandstone	0	6	1,270	3
Grey shaly sandstone	1	$0\frac{1}{2}$	1,271	$3\frac{1}{2}$
Alternate bands of grey shaly sandstone and dark blue shale, averaging $2\frac{1}{2}''$ thick	1	2	1,272	$5\frac{1}{2}$
Grey shaly sandstone	1	2	1,273	$7\frac{1}{2}$
Dark blue shale with streaks of shale, with *Thinnfeldia odontopteroides*, Morris ...	6	$10\frac{1}{2}$	1,280	6
Very hard grey shaly sandstone with streaks of darker sandstone	0	$7\frac{1}{2}$	1,281	$1\frac{1}{2}$
Alternate bands of dark shale and hard grey sandstone	2	0	1,283	$1\frac{1}{2}$
Blue sandy shale, fissile, micaceous with *Thinnfeldia odontopteroides*	8	$2\frac{1}{2}$	1,291	4
Mottled chocolate shale—dark chocolate and bluish-green	1	5	1,292	9

Strata.	Thickness		Depth from Surface.	
	'	"	'	"
Blue shale	1	0	1,293	9
Mottled chocolate shale	3	0	1,296	9
Bluish shale with *Thinnfeldia odontopteroides*	8	2	1,304	11
Bluish shale with dark bands and small patches of glauconitic sandstone ...	0	6	1,305	5
* Dark blue shale with coal pipe (½") ...	2	0½	1,307	5½
Carbonaceous shale, with coal pipes and *Equisetum*	0	1½	1,307	7
Dark blue micaceous shale with ½" coal-pipe	1	1	1,308	8
* These beds contain *Thinnfeldia odontopteroides*, Morris, *T. narrabeenensis*, sp. nov., and a *Thinnfeldia* with small pinnules, probably a new variety—Triassic.				
Mottled chocolate and green shale, micaceous	3	11	1,312	7
Bluish-grey shale with dark streaks jointed, coarse, with carbonaceous bands, *Thinnfeldia sp.* abundant	3	.4	1,315	11
Bluish-green sandy shale, *Thinnfeldia* ...	2	10	1,318	9
Grey sandy shale	1	7	1,320	4
Greenish-grey micaceous sandy shale with carbonaceous streaks, ⅜" coal pipe at bottom	1	5	1,321	9
Greenish-grey micaceous shale, glauconitic in parts, stained with chocolate, large *Thinnfeldia*	2	0	1,323	9
Greenish-grey micaceous sandy shale with tinges of chocolate in places	1	6	1,325	3
Greyish shale	0	2	1,325	5
Dark micaceous shale with patches of chocolate shale	3	7	1,329	0
Dark chocolate and green mottled shale, micaceous	2	0	1,331	0
Greenish-grey glauconitic sandstone ...	1	2	1,332	2
Mottled shale—grey and dark grey ...	0	3	1,332	5
Chocolate shale	1	4	1,333	9
Mottled chocolate shale	6	7	1,340	4
Bluish-grey shale	2	0	1,342	4
Very hard dark blue sandy shale, micaceous	4	6	1,346	10
Bluish-grey sandy shale	0	5½	1,347	3½
Dark blue shale	2	0	1,349	3½
Dark bluish-grey micaceous sandy shale, hard	3	10½	1,353	2
Bluish sandy shale	0	9½	1,353	11½
Hard fine grained bluish-green sandstone, coarse, dark streaks	0	6	1,354	5½

Strata.	Thickness		Depth from Surface.	
	′	″	′	″
Hard fine grained greenish sandstone, micaceous	0	4½	1,354	10
Greyish micaceous sandy shale	0	1	1,354	11
Fine grained sandstone with dark shaly streaks, micaceous	0	10	1,355	9
Bluish-grey micaceous sandy shale ...	0	1½	1,355	10½
Hard fine grained grey sandstone, micaceous fragments of shale and garnets (?)	3	11	1,359	9½
Alternate bands 2½″ - 4½″ thick of hard fine grained sandstone and bluish shale ...	1	2½	1,361	0
Hard fine grained grey sandstone with thin carbonaceous streaks	7	7	1,368	7
Dark grey sandy shale	0	2	1,368	9
Hard fine grained, light grey sandstone (garnets)	5	11	1,374	8
Dark grey sandy shale	0	2½	1,374	10½
Hard fine grained light grey micaceous sandstone	2	4	1,377	2½
Dark grey sandy shale	0	3½	1,377	6
Hard fine grained light grey sandstone ...	0	4	1,377	10
Dark grey sandy shale	0	0½	1,377	10½
Hard fine grained light grey sandstone ...	0	3½	1,378	2
Dark grey sandy shale	0	0½	1,378	2½
Hard fine grained light grey sandstone ...	0	6½	1,378	9
Dark grey sandy shale	0	3	1,379	0
Hard fine grained light grey sandstone ...	0	7	1,379	7
Dark grey sandy shale	0	5	1,380	0
Hard fine grained light grey sandstone ...	2	7	1,392	7
Dark greenish-grey shale, with chocolate...	1	6	1,394	1
Greenish-grey micaceous sandstone ...	4	8	1,398	9
Micaceous sandy shale	0	6	1,399	3
Greenish sandstone, fine grained, micaceous	3	9	1,403	0
Bluish-grey micaceous shale	1	6	1,404	6
Irregular fragments of bluish shale in grey micaceous sandstone	0	10½	1,405	4½
Light grey micaceous sandstone with included fragments of shale and red grains (garnets?)	1	0	1,406	4½
Dark bluish sandy shale	0	7½	1,407	0
Hard grey micaceous sandstone with pebbles of shale (included)	2	0	1,409	0
Bluish-grey micaceous sandy shale ...	0	8	1,409	8
Bluish-grey micaceous shale with *Equisetum*	0	1	1,409	9
Bluish-green sandstone, fine grained, hard	3	7	1,413	4
Bluish-grey micaceous sandy shale ...	0	1	1,413	5

Strata.	Thickness		Depth from Surface.	
	′	″	′	″
Hard fine grained light grey micaceous sandstone	4	1	1,417	6
Dark blue micaceous sandy shale	1	0	1,418	6
Hard fine grained bluish-grey micaceous sandstone	1	8	1,420	2
Hard fine grained light grey micaceous sandstone	3	11	1,424	1
Dark blue micaceous sandy shale	5	1	1,429	2
Hard fine grained bluish-grey micaceous sandstone	0	10½	1,430	0½
Bluish-grey micaceous sandy shale ...	3	1½	1,433	2
Hard fine grained light grey micaceous sandstone	0	9	1,433	11
Bluish-grey micaceous sandy shale ...	0	2½	1,434	1½
Hard fine grained bluish-grey micaceous sandstone	1	0½	1,435	2
Bluish-grey micaceous sandy shale ...	0	4	1,435	6
Hard fine grained bluish-grey micaceous sandstone	5	0	1,440	6
Dark blue micaceous sandy shale	2	1	1,442	7
Hard fine grained bluish-grey micaceous sandstone	0	1	1,442	8
Bluish-grey micaceous sandy shale ...	0	4½	1,443	0½
Hard fine grained bluish-grey micaceous sandstone	0	4	1,443	4½
Bluish-grey micaceous sandy shale ...	0	9½	1,444	2
Hard fine grained bluish-grey micaceous sandstone	1	2½	1,445	4½
Bluish-grey micaceous shaly sandstone ...	0	11½	1,446	4
Dark blue micaceous sandy shale	2	7	1,448	11
Hard fine grained bluish-grey micaceous sandstone	9	7	1,458	6
Bluish-grey micaceous sandy shale ...	4	3½	1,462	9½
Hard fine grained grey micaceous sandstone	6	6	1,469	3½
Hard fine grained bluish-grey micaceous sandstone	0	10	1,470	1½
Bluish-grey micaceous sandy shale ...	0	6	1,470	7½
Very hard fine grained bluish-grey micaceous sandstone	0	11½	1,471	7
Hard fine grained bluish-grey micaceous sandstone	0	8½	1,472	3½
Fine grained bluish-grey micaceous shaly sandstone	0	11	1,473	2½
Hard fine grained bluish-grey micaceous sandstone	7	8½	1,480	11

Strata.	Thickness		Depth from Surface.	
	′	″	′	″
Bluish-grey micaceous sandy shale ...	0	6	1,481	5
Very hard fine grained bluish-grey micaceous sandstone	1	2½	1,482	7½
Greenish-grey micaceous sandy shale ...	3	0	1,485	7½
Hard fine grained dark bluish-grey micaceous sandy shale	0	8½	1,486	4
Bluish-grey micaceous sandy shale ...	2	11	1,489	3
Hard fine grained light grey micaceous sandstone	1	4½	1,490	7½
Bluish-grey micaceous sandy shale with light streaks	1	4½	1,492	0
Hard fine grained light grey micaceous sandstone	2	8	1,494	8
Bluish-grey micaceous sandy shale ...	0	4½	1,495	0½
Hard fine grained light grey micaceous sandstone			[1,500]	

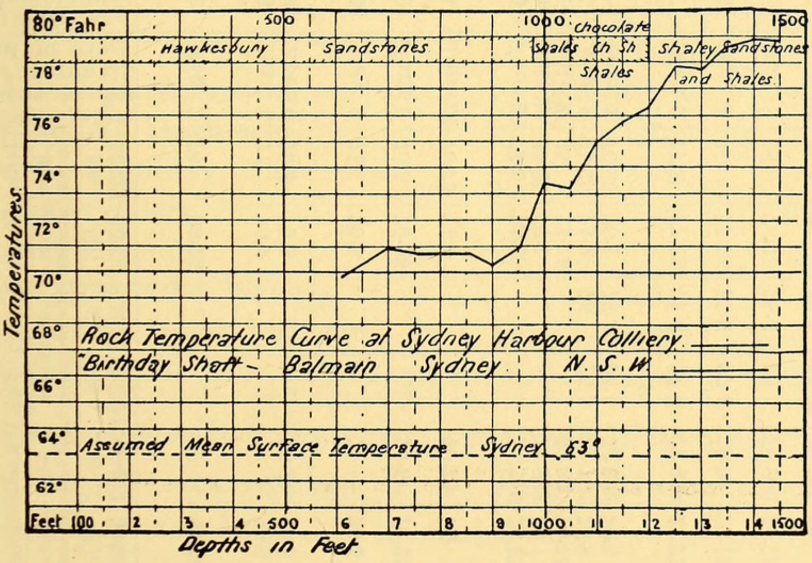
It may be mentioned that the Birthday Shaft bears S. 67° 15′ W. from the No. 2 Cremorne Bore, and is 260 chains distant. The original rock level at the Birthday Shaft was 73 feet above mean low tide level in Sydney Harbour, but the top of the brick walling in the shaft is now 80 feet above mean low tide, this being the finished level of the pit mouth. The distance from the shaft to the shore of the harbour at the nearest point is 70 yards.

With regard to features, connected with the geological section, which may have some modifying influence on rock temperature, it may be mentioned that very little gas has, as yet, been met with in the shaft, with the exception of a small blower at the 607 feet level. A bed of clay shale, having a thickness of 7 feet, was met with three feet below this level. For some distance above this, and for a considerably greater depth, the sandstone showed a tendency to burst off, in large flakes, from two sides of the shaft as though it were under considerable pressure. This necessitated the walls of the shaft being temporarily secured by close timbering, pending the putting in of the permanent brick walling.

As regards water circulating in the strata penetrated by the shaft, the following may be recorded :—The amount of water met with down to 416 feet 6½ inches was about 75 gallons per hour. Below this a bed of soft porous sandstone was passed through, having a thickness of 22 feet 1½ inches. The base of this bed was, therefore, at a depth of 438 feet 8 inches, and water made in the shaft at this level, at the rate of 200 gallons per hour, thus bringing the total inflow up to 275 gallons per hour. At a depth of 442 feet, where a "walling curb" was seated, a "water ring" or "garland" was also put in. In this all the water was collected and thence led down one side of the shaft in a 2″ diameter wrought iron pipe. The same amount of water, viz. 275 gallons per hour, continued to a depth of 607 feet, when in a bed of hard, greyish-white, false bedded, and very friable sandstone, a feeder of water accompanied by gas was met with, the inflow of water being at the rate of 170 gallons per hour, thus making the total inflow 445 gallons per hour. The gas, which evidently came from a bed of clay shale which was struck three feet below the feeder, took fire when a light was applied. At a depth of 672 feet, in a bed of clay shale, soft and jointed and one foot thick, another small feeder of water was struck which raised the total inflow to 463 gallons per hour. At a depth of 690 feet, the sinking being then in a thick bed of greyish-white sandstone, false bedded and friable, the water increased to 597 gallons per hour, and in the same bed of rock, at a depth of 700 feet, the total inflow still further increased to 654 gallons per hour. This bed of sandstone was 43 feet 10 inches thick, the top being 676 feet from the surface (top of brick walling) and the bottom 719 feet 10 inches. At a depth of 720 feet the water began to decrease, the total inflow being at the rate of 550 gallons per hour, and at the 750 feet level it had still further decreased to 511 gallons per hour. At the 768 feet level another "water ring" was put in, from which the whole of the water was led down the shaft in two inch diameter wrought iron pipes. When a depth of 774 feet was reached it was found that the inflow of water had still further decreased, the total amount being about 502 gallons per hour. Thence, down to the bottom of the shaft, the average inflow has ranged from 480 to 510 gallons per hour.

The water flowing into the shaft from between the "water rings" fixed at the 442 feet and 768 feet levels, is remarkably rich in lime, with distinct traces of barytes. So much lime is present that, in the space of a fortnight, the two inch pipe, leading the water down from the 768 feet level to the bottom of the shaft, became almost completely blocked with a solid fibrous, radial incrustation of barytic carbonate of lime. The iron pipes were consequently replaced with wooden boxes, three inches square, which can be taken to pieces when it is necessary to remove the incrustation. As the two inch wrought iron pipes from the " water ring " at the 442 feet level show no signs of lime incrustation, it is evident that it comes from somewhere between the 442 feet and 768 feet levels. Mr. H. G. Smith, F.C.S., and one of us (Professor David) have already noticed the occurrence of barytes in the Hawkesbury series, but this abundance of lime in the Hawkesbury Sandstone is quite exceptional.

IV. *Diagram showing Temperature Curve and Table of Records of Rock Temperatures.*—The following curve diagram and table give full particulars of the results of the observations made in the Birthday Shaft :—



RECORDS OF ROCK TEMPERATURES AT SYDNEY HARBOUR COLLIERY BIRTHDAY SHAFT, BALMAIN, SYDNEY, N.S.W.

Depth from surface, feet	Nature of Rock.	Date of first exposure of rock in sinking (1899)	Date of boring of holes for thermometers (1899).	No. of hours intervening between completion of holes and insertion of thermometers.	Depths of holes in which thermometers were placed in feet. (Diameter of holes 1 7/8 inches.)	Temperatures of thermometers at time of insertion in holes (° Fah.) Slow-action thermometers. No. 50452	No. 50454	Maximum thermometers. No. 15888	No. 65294	No. of hours thermometers were left in holes	Date of withdrawal and reading of thermometers (1899).	Temperatures of thermometers at time of withdrawal from holes (° Fah.) Slow-action thermometers. No. 50452	No. 50454	Maximum thermometers. No. 15888	No. 65294	Corrected temperatures of thermometers in accordance with Kew certificate (degrees Fah.) Slow-action thermometers. No. 50452	No. 50454	Maximum thermometers. No. 15888	No. 65294	Mean of corrected temperatures.
606	Hard greyish-white sandstone, current bedding strongly developed, very friable	Jan. 9	Jan. 12	84	3	...	...	...	...	432	Feb. 3	70	69·75	...	...	70	69·75	...	...	69·875
700	Hard greyish-white sandstone, current bedding strongly developed, very friable	Feb. 27	Feb. 28	39	3	...	...	...	...	140⅓	Mar. 8	71	70·9	...	...	71	70·9	...	...	70·95
758	Hard white sandstone	Mar. 28	Mar. 30	40½	3	...	...	...	...	129½	April 6	70·8	70·5	...	...	70·8	70·5	...	...	70·65
854	Hard white sandstone, current bedding strongly developed, very friable	May 1	May 3	48	3	...	...	...	...	76½	May 8	71	70·5	...	...	71	70·5	...	...	70·75
902	Sandy shale with occasional bands of dark shale	May 27	May 31	60¼	3	...	...	...	...	150	June 9	70·5	70·25	...	...	70·5	70·25	...	...	70·375
951	Sandy shale with occasional bands of dark shale	June 9	June 12	40¾	3	...	...	...	...	213¼	June 23	70·75	71	...	...	70·75	71	...	...	70·875
1000	Dark blue shale with numerous plants (*Thinnfeldia*, *Equisetum*, *Tæniopteris*) and coal pipes...	June 23	June 24	61	4	...	...	...	...	43½	June 28	73·5	73·25	...	...	73·515	73·25	...	...	73·382
1050	Dark chocolate shale	July 15	July 17	48	4	64	68·5	...	...	85½	July 23	73·25	73·1	...	...	73·262	73·1	...	...	73·181
1100	Dark chocolate shale	July 25	July 26	45	4	61·5	61·25	...	...	41¾	July 30	75	74·75	...	...	75·03	74·75	...	...	74·89
1150	Dark chocolate shale	Aug. 2	Aug. 3	57½	5	69·5	67	71	69	65½	Aug. 8	75·75	75·8	76	75·5	75·787	75·8	75·95	75·5	75·762
1200	Dark purple and green mottled shale	Aug. 23	Aug. 25	37¾	5	65	64·5	67·5	68	161¼	Sept. 2	76·25	76·1	76·25	76·4	76·292	76·1	76·208	76·4	76·25
1250	Hard grey shaly sandstone with bands of darker sandstone and blue shale	Sept. 5	Sept. 7	43⅚	5	74·5	73·3	74·5	75·5	37	Sept. 9	77·8	77·75	77·8	78	77·858	77·75	77·742	78	77·837
1300	Blue shale with plant impressions (*Thinnfeldia odontopteroides*) ...	Sept 23	Sept. 25	35⅙	5	74·25	70·25	75·5	73	113½	Oct. 1	78	77·75	77·6	77·6	78·06	77·75	77·544	77·6	77·738
1350	Hard, dark bluish-grey micaceous sandy shale	Oct. 3	Oct. 4	51⅓	5	74·25	75·25	76	76	38¼	Oct. 8	78·9	78·75	78·6	78·3	78·962	78·75	78·534	78·3	78·638
1400	Fine grained greenish-grey micaceous sandstone	Oct. 13	Oct. 15	34	5	78	72·75	72·5	74·75	49	Oct. 18	79·5	79	79·1	78·25	79·575	79	78·98	78·25	78·951
1449	Hard, fine grained bluish-grey micaceous sandstone	Nov. 21	Nov. 23	37½	5	73	73·75	75	74·5	146	Dec. 1	79	79	79	78·25	79·07	79	78·93	78·25	78·812

NOTE.—From 1,150 feet downwards, the thermometers were placed in the holes in pairs, one slow-action and one maximum thermometer being inserted in each hole, as follows :—

	No. 1 Hole. Thermometers—		No. 2 Hole. Thermometers—
At the 1150 feet level	Nos. 50452 and 65294	...	Nos. 50454 and 15888
„ 1200 „	„ 50452 „ 65294	...	„ 50454 „ 15888
„ 1250 „	„ 50452 „ 66294	...	„ 50454 „ 15888
„ 1300 „	„ 50452 „ 15888	...	„ 50454 „ 65294
„ 1350 „	„ 50452 „ 65294	...	„ 50454 „ 15888
„ 1400 „	„ 50452 „ 15888	...	„ 50454 „ 65294
„ 1449 „	„ 50452 „ 65294	...	„ 50454 „ 15888

In the observations of rock temperatures at the No. 2 Cremorne Bore (referred to in the introduction to this paper) the mean annual surface temperature at Sydney was taken as 63° Fahr. (this having been determined by Mr. H. C. Russell, F.R.S., Director of the Sydney Observatory), whilst the stratum of invariable temperature was assumed to be 15 feet below the surface. On this basis the average rate of increase of temperature downwards, in the Birthday Shaft will be found to be 1° Fahr. for every 90·7 feet.

V. *Rock temperatures, observed elsewhere, for comparison with the observations made in the Birthday Shaft, Sydney Harbour Colliery :—*

Place where observations were made.	Depth in feet.	Feet for 1° Fahr.
Schladebach Bore, Prussia...	5,735	65
Astley Colliery, Dukinfield...	2,700	72
Ashton Moss Colliery, Manchester	2,790	77
Dukenfield Colliery	2,055	83
St. Gothard Tunnel...	5,578	82
Lansell's Gold Mine, Victoria	3,250	111
Prizbam Silver Mines, Bohemia	1,930	126
Calumet and Hecla Lode, Lake Superior, U.S.A.	4,712	223

VI. *Conclusion.*—It is proposed to continue these observations to the full depth to be reached by the Sydney Harbour Colliery Shafts (nearly 3,000 feet), and it would, therefore be premature as yet, to comment on the temperature curve obtained from the observations made so far.

Our thanks are specially due to Mr. T. Cater (contractor for the sinking of the shafts) for his valuable co-operation in the work. We also desire to express our obligations to Professor J. D. Everett, F.R.S., for the use of the thermometers, and to Mr. W. S. Dun for the detailed section of the shaft and determination of the fossils.

NOTE ON THE EDIBLE EARTH FROM FIJI.

By the Hon. B. G. CORNEY, M.D., Professor DAVID, B.A., F.G.S., and F. B. GUTHRIE, F.C.S.

[*Read before the Royal Society of N. S. Wales, December 6, 1899.*]

THE sample of edible earth, which forms the subject of this note was collected by one of us (Dr. Corney), by whom it was presented to Professor T. P. Anderson Stuart, who in turn presented it to the Geological Department of the University of Sydney.

The earth occurs in several localities in the Fiji Islands. The specimen examined was collected near the northern coast of the large island called Vanua Levu, where the rocks are igneous. The natives, that is the women, eat small portions of it at times, and assert that it has some salutary influence over the later stages of pregnancy. It seems not unlikely that it may relieve some of the disagreeable or painful sensations incidental to that condition; and the practice may have arisen in consequence. The natives have no specific name for this earth, calling it merely *Qele kana*, which means 'edible earth.'

At Tavuki, on the north side of the island of Kadavu, it is met with in the solid, and the people cut it into brick-shaped blocks with which they face up the raised foundation mounds upon which their dwellings are constructed. The women there also eat it in small quantities.