

THE OCCURRENCE OF OPAL AT LIGHTNING RIDGE AND GRAWIN, WITH GEOLOGICAL NOTES ON COUNTY FINCH

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INTRODUCTION

A reconnaissance geological survey of County Finch and part of County Narran was carried out in conjunction with an examination of the occurrence of opal at Lightning Ridge.

The area, roughly triangular in shape, is bounded by the Barwon River on the east, the Narran River on the west, and the New South Wales-Queensland border on the north. A number of towns and villages are located through the area, viz.:—Walgett, Col-larenebri, Lightning Ridge, Angledool and Cum-borah.

Black soil plains consisting of Pleistocene to Recent alluvium cover the greater part of the area under review. These are broken by low ridges and hills, composed of sediments of probable Cretaceous age, which rise to a maximum height of 100 feet. Within these sediments precious opal has been won at a number of localities.

GEOLOGY

The area contains Cretaceous (?) sediments which have been subjected in part to silicification due to the movement of groundwater, and are overlain by some small Tertiary-Recent deposits. These sediments outcrop in low flat-topped ridges surrounded by extensive black soil plains, Pleistocene-Recent in age (see plate 1—B361).

Due to the paucity of outcrops it was impossible to determine structure of the Cretaceous (?) sediments. However, in the mined area, minor rolls and faulting are in evidence.

The stratigraphic sequence in the area is as follows:—

- Pleistocene-Recent: Alluvium—silt, sand, clay.
- Tertiary-Recent: Gravel, greybilly, laterite, conglomerate.
- Cretaceous (?): Sandstone, claystone, clayshale.

I. Cretaceous (?)

Sandstone and claystone which crop out over some of the area have been referred to the Cretaceous period by previous writers. However, during the present survey only indeterminate plant fossils were found and, although samples were submitted for micro-palaeontological examinations, no Foraminifera were present.

Work by Crespin (1946, 1956) shows that Lower Cretaceous microfossils are present in a number of bores sunk into the Great Artesian Basin in northern New South Wales, but two bores from the area under discussion, although sunk to depths of 3,303 feet and 3,781 feet, have failed to reveal any microfossils. She further states that "the foraminiferal assemblages suggest that the Lower Cretaceous deposits of the Great Artesian Basin were laid down in a near shore, shallow brackish water environment".

Whitehouse (1945) is of the opinion that "should further observations confirm this limiting range [of Lower Cretaceous Tambo and Roma Series fossils—J.W.W. & R.E.R.], it would indicate that the development in the south-east is different from the main part of the basin [Great Artesian Basin—J.W.W. & R.E.R.], lacustrine conditions beginning possibly earlier in that region".

David (1950) records the occurrence of *Unio*, *Ceratodus*, fragmental shells and the opalised teeth

and caudal vertebrae of a megalosaurian from Lightning Ridge, and is of the opinion that these beds are similar to White Cliffs for which he suggests estaurine or littoral conditions of deposition.

Etheridge (1917) describes *Trachysaurus rugosus* and *Crocodylus (Brotosaurus ?) selasophensis* from the Lightning Ridge field and assigns them to the Cretaceous period. In the same memoir he describes Cretaceous shelly fossils from White Cliffs. The Honorary Palaeontologist (H. O. Fletcher) has stated that a collection of fossils from Lightning Ridge has strong affinity with these forms.

Local miners report that at times opalised shell remains have been recovered from the claystones, but these are not prolific. Some samples of the claystone taken during this survey have revealed plant-stem remains, and it is considered that the sediments have been formed under either lacustrine or brackish-water conditions.

A generalised section of the Cretaceous (?) sediments as exposed at Lightning Ridge is as follows:—

Lightning Ridge Group—

Thickness: 0-12 feet Coocoran Claystone.

Thickness: 12-65 feet Wallangulla Sandstone.

Thickness: 4-20 feet Finch Claystone.

Coocoran Claystone

A fine-grained white to cream claystone is associated with sandstone throughout the area. Where it is exposed at the surface it has been hardened by the concentration of secondary chalcedony and opaline silica and is known locally as "shin-cracker". Microscopic examination shows that it is composed of clayey material crowded with quartz particles of silt grade. It has a blocky habit, with vertical jointing a common feature; it is not markedly stratified and has an even texture.

True thickness could not be determined for this member but at least twelve feet is in evidence at Dentists Hill along the main road from Walgett to New Angledool, and this thickness could be accounted for on the spoil dumps of the shafts at Coocoran. At Nobbies, fifteen feet of "shin-cracker" has been reported.

Wallangulla Sandstone

This sandstone has a very low quartz content and is defined as a fine-grained white, clayey variety which in some localities contains numerous rounded pellets of white claystone as inclusions. The sand grains, which make up 50 per cent. of the rock, are set in an almost opaque clayey base, and consist of quartz, chalcedony, altered felspar and possibly altered volcanic glass. Most of the grains are angular, only very few being well rounded.

At the surface secondary silicification has occurred as instanced by samples taken from a shaft near the Jungle Workings and described by H. F. Whitworth* in the appendix. This has taken the form of the development of fine-grained chalcedonic material both in the grains of claystone, which is the main constituent, and also in the clay cement.

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Ironstaining is common in the upper levels, and this accentuates the presence of the rounded pellets of clay-shale which have not been stained as much as the cementing material.

No true thickness could be ascertained for this sandstone, but thicknesses varying from 12 feet (Coocoran) to 65 feet (Cleared Line) and 60 feet (Grawin, Three and Mour Miles) have been sunk through, before the first opal level has been reached.

Current bedding is in evidence at an outcrop near Bangheet on the Lightning Ridge-Goodooga road.

Finch Clay-Shale

Beneath the Wallangulla Sandstone a grey to buff-coloured clay shale is formed. It is soft, free from grit, and it is within this horizon that most of the precious opal is found. It is commonly called "opal dirt". It absorbs water readily, becoming highly plastic and swelling slightly when wet, but cracks and disintegrates on drying. At the Nine Mile workings ironstaining has produced a red colouration in the clayshale.

Known thickness varies from 4-6 feet at the Three Mile, 9 feet at Hawk's Nest, 14-15 feet at Bald Hill to over 20 feet at Pony Fence. It occurs in a number of layers and precious opal is found in up to five levels at Bald Hill (although a shaft 100 feet deep in this locality is said to have eleven levels), four levels at the Three Mile, three levels at New Town and Dry Rush and two or three levels at the Angledool workings at Lightning Ridge. Andrews states that "these levels are not at all persistent, nor are they necessarily horizontal". This has been substantiated by the miners.

II. Tertiary—Recent

Gravel, greybilly, laterite and conglomerate overlie the abovementioned sediments in some localities.

Quartz gravel deposits are being quarried for road material on the western side of the Goodooga-Walgett road, 1½ miles south of Cumborah. A thickness of 10-12 feet is shown in the pit and a continuation of these deposits was noted on the eastern side of the main road in the same locality.

Other quartz gravels which have not been greatly ironstained, have been quarried from Parish Bangheet. Here, they are only 2-3 feet thick and overlie Cretaceous (?) sandstone.

Gravels have been worked also from the eastern margin of the Bald Hill workings at Lightning Ridge, and from near Collarenabri, New Angledool and Moongulla.

Ironstone gravels have been deposited over a large area of the Cretaceous sediments. Between Lightning Ridge and New Angledool they have been cemented and are of a blocky nature. Further east, in the Collarenabri-Mogul-Goondablui area they are rounded and approximately ¼-inch to ½-inch diameter. In places lateritic deposits have been formed which are in part consolidated.

The greatest concentration of greybilly was noted in the Weetaliba Tank area. Here, boulders up to 4 feet across are interspersed with smaller (6-inch) boulders. They are commonly flat-topped and vary in colour from light-grey to buff. Other areas where greybilly has been formed include the Goodooga-Walgett road north of Cumborah; Barney's Ridge near Wilby Wilby bore; the Narran River at Wammell Water Hole; in the Tertiary gravel quarry at Bangheet mentioned above; and near Goondablui.

In places as at Cumborah, Llanillo Station and on the Lightning Ridge—Angledool road, pebbles have been cemented together by iron to form a thinly bedded conglomerate.

III. Pleistocene-Recent

Deposits of sand have been formed into ridges along the eastern margin of Narran Lake. Towards the north end of the lake, Cretaceous(?) sediments crop out and it has been assumed they underlie the sand dunes. The sand is very fine grained, and possibly of aeolian origin.

Extensive deposits of Pleistocene to Recent alluvium are present in the greater part of the area. These consist mainly of silt and have been formed from infrequent flooding of the stream system which traverses the area. The resultant flood plain forms part of the "black soil plains" so common in the north-west sector of the State. This plain occurs at an elevation of approximately 450 feet above sea level whilst the surrounding hills are approximately 100 feet higher.

ECONOMIC GEOLOGY

I. Opals

(a) History

Departmental records of production of opals from the Lightning Ridge Field date back to 1904, but J. B. Jaquet, then Chief Inspector of Mines, stated in the Annual Report of the Department of 1905 that "opal has been known to occur in the locality for the last ten to twelve years, or even longer, and from time to time pieces of the precious stones have been picked up on the surface. About two years ago a syndicate was formed, systematic prospecting commenced, and opal found *in situ*".

The latter part of the above statement possibly refers to a find by Charlie Nettleton in 1902 in the Six Mile area as referred to by Knight (1953). Knight gives Nettleton the credit for discovering black opal at Lightning Ridge.

On the other hand, E. C. Andrews (1924) says that opal had been recorded "possibly as much as forty years ago according to statements of reliable residents, but the stone was not recognised then as of commercial value". This would place the discovery around the 1880's.

The first attempt at marketing black opal by Charlie Nettleton was unsuccessful with Sydney buyers refusing his parcel, and a well-known London dealer expressing doubt as to whether the gems were natural stones (Knight, 1953). However, in 1904 £1,000 worth of opals from the area had been sold, and the amount gradually increased to a peak £46,200 worth in 1910. Production of the order of £10-20,000 was maintained until 1925, but since then it has fallen to the present £1-2,000 a year. The total recorded production from the Lightning Ridge field to the end of 1957 amounts to £482,792.

In 1904 twenty-six miners were employed on the field, while 500-800 men were estimated to be working during 1909. From then until 1934 estimates vary from 95 to 290. Figures were not kept from 1934 until 1950 since when an average of about 25 men have been constantly employed.

The first production appears to have been from Lightning Ridge which was situated 5 miles westerly from Wallangulla township, now known as Lightning Ridge. From here, prospecting spread out in every direction. The first areas to be named as such appear to be the Three Mile in which the majority

of the early opal was won; the Four and Five Mile in a southerly direction, and the Six Mile in a westerly direction were started in 1910.

As early as 1907 prospecting was carried out on Boorooma Station and Grawin South, and again in 1908 in the parishes of Mein and Morendah and at Grawin. In 1915 there was a new rush north of the township of Lightning Ridge. This is presumed to be at Bald Hill, as, in 1919 this area, together with the Telephone Line and Three Mile workings, produced all the opal from the field.

In 1926 there was a new rush to an area at Grawin adjoining the old South Grawin field, and £4,948 worth of opal was won.

In 1927 a new rush started in an area adjoining Bald Hill (Potch Point?), and in 1928 finds were made at Glengarry near Grawin, and "New Angledool" on the Lightning Ridge field.

In 1930 there is a record of a little opal of poor quality being found at Glenogy near Angledool. Angledool paddock or Meehi itself was found with assistance from the Prospecting Vote in 1924, but it was not until 1932-34 that an appreciable amount of marketable opal was recovered. In 1934 there were approximately ten miners on this field (Harper, 1934).

(b) Occurrence of Opal

Precious opal occurs within the Finch Claystone, usually at or near its junction with the overlying Wallangulla Sandstone and underneath the "steel-band" which is sometimes formed at this junction. This "steel-band" is a thin (up to one foot) layer of hard siliceous sandstone.

Opal either occurs as nodules (known locally as "nobbies") or in seams or thin layers. The nodules are elliptical in shape and some of these have small protruberances on one side to form "tear drops".

Seams are formed along joint planes within the clayshale, either horizontally or vertically. In some instances silica has replaced both organic and inorganic material (calcium carbonate from bivalves and crinoid stems, clay nodules, gypsum? and plant remains), to form opal.

Opal has replaced shells and animal bones; Smith (1924) states:

"Very fine replacements of shells and animal or reptilian bones have been found which are either sent out of the country or broken up for any precious opal they may contain. The writer has seen the complete opalised skeleton of an animal as large as a cat brought up from underground in a miner's cap. In this case the opal was rose in colour and translucent, but apparently contained little, if any, play of colours". Other reports of opalised shells, etc., have been recorded earlier in this report.

Potch has been formed along concentric joints in small pieces of porcellanite which have been developed within the clayshale. These have been locally termed "angel-stones" and "walnut-stones" by the miners. They are very hard and usually semi-spherical or ellipsoidal in shape.

(c) Mining Areas

The following notes on the different workings were collected from some of the miners, the areas mentioned being shown on the attached plan E121 (Fig. 1) Lightning Ridge Opal Diggings and plan B361 (Plate 1) the Geology of the County of Finch.

Lightning Ridge

Potch Point.—This locality, so called because of the inordinate amount of "potch" found, was worked to depths of 50 feet. On top of the hill the first level was encountered at 30 feet and the second at 40 feet, whilst towards the base of the hill opal dirt was struck at a depth of 17 feet.

Towards the New Chum Claim only one level was met with and that at a depth of 50 feet.

Opal to the value of a few thousand pounds was won.

New Chum.—Average sinking here was from 20 to 35 feet although on one margin the level occurred in shallow ground 4 to 5 feet from the surface.

Opal to the value of £1,500 was won.

This was the first locality on the field where a £100 stone was found. This was a stone of 100 carats.

Old Chum.—Opal was found in gravels on the side of the hill and the deepest workings were at a depth of 10 feet.

Bald Hill.—Here a true level trending in the same direction as the hill was encountered at 45 feet.

Most of the opals were won in an area 400 feet long by 100 feet wide.

The opals were deep in the levels which showed 14 feet to 15 feet of opal dirt separated by bands of sandstone.

In the main workings there were five levels, but one shaft 100 feet deep had eleven levels with traces of opal on each one.

Canfell's Hill.—Opal was worked in the gravel around the base of the hill and the chief workings were 4 to 6 feet in depth, but on the crest of the hill the sinking was approximately 20 feet.

The main level ran true and some good opal was obtained.

Angledool.—On this claim the sinking varied between 2 feet 6 inches and 30 feet and opal was obtained at times in the sandstone. In the deeper ground two and three levels were encountered and here the levels also were continuous for some distance.

From these diggings some named stones were won, chief among which was "Pandora" which had dimension of 4½ inches by 2½ inches, weighed about six ounces, and £1,000 was refused by the owner during the depression days.

Sim's Hill.—This is one of the oldest diggings on the field and the workings vary in depth from 4 feet near the base of the hill to 80 feet at its crest.

The seams are thick in comparison with the rest of the field and some large pieces of potch were found. Some bars of opal were up to one-half inch in thickness.

Telephone Line.—Depth of workings on this claim was 40 feet and there were no shallow diggings. The level was continuous over a considerable distance.

Pony Fence.—All workings in this area were shallow but the claim was characterised by the thickness of opal dirt which was over 20 feet.

New Town.—The levels in these diggings (which varied in depth from 32 to 45 feet deep on the crest, 28 feet lower down the slope, down to 4 feet near the base of the hill) were very rich in opal. Three levels were encountered.

Cleared Line.—On this claim the sinking was 60 feet deep on the crest of the hill, but down the slope towards Lightning Ridge the depth to opal dirt was 65 feet. Cleared Line was characterised by the presence of a "steel-band" 1 foot in thickness and nobbies were found as big as fists.

Dry Rush.—Only four claims found opal in these diggings. Three levels were worked, the deepest being 40 feet.

Nobby's.—Said to be the first claim on the field and opal was found in the gravel. A considerable amount of opal was found at a depth of 20 feet. However, the ground is extremely hard and dusty and difficult to work; even the opal dirt is much harder than on the rest of the field.

Bullock's Head.—The levels in these diggings were discontinuous due probably to faulting and very little opal was recovered.

The Flat.—These workings were shallow and adjacent to the Three Mile, the depth of sinking varying between 12 and 20 feet. Plenty of good opals were won, both black and light varieties.

Three Mile.—These were the biggest workings on the field and at one time 1,000 men were engaged in opal mining. The opal won from this area was greater than that from the rest of the field. The depth of the main level varied from 20 to 60 feet and was continuous over a wide area.

There were four levels worked in one part between 52 and 84 feet. The opal dirt was four feet in thickness, being sandy in places. Evidently the second level produced the greatest amount of opal whilst on one of the 80-foot levels the opal was in seams and badly crazed. On the western fall there was only one level.

On Three Mile Hill the area was stoped more than elsewhere and is practically worked out.

Frog Hollow.—The diggings here are shallow, varying from 6 to 20 feet, and have remained wet since the floods of 1949-50. Encouraging traces of opal were found but the production of good opal was small.

Hawk's Nest.—Sinking here varied between 4 and 30 feet, and 9 feet of opal dirt was encountered. Some very good opal was produced.

Four Mile.—Five good claims were worked here during the depression. The sinking was 60 feet with no shallow ground in evidence. The opal was good and a fair production was maintained. The original discoverer (Otto Schroeder) sunk the first shaft on aid from the Department of Mines.

Belars.—The diggings on this claim varied in depth from 1 to 10 feet. Every nobby found was a replaced shell adhering to the roof of the opal dirt and extending into the overlying sandstone. Two claims recovered most of the opal and one stone was sold for £140.

Six Mile.—The depth to the opal dirt in this locality varied between 30 and 40 feet on the crest and was 6 feet at the base of the hill. The best of the opal was found in the deeper ground.

Thorley's Six Mile.—Only two good claims were worked, the depth varying between 20 and 35 feet. The opal dirt was very rich and characterised by the presence of much clear potch.

Rouse's Six Mile.—This was a rush on shallow ground, the depth varying between 6 and 16 feet. Only two claims produced opal in any quantity, characterised by big black nobbies.

Nine Mile.—Extensive workings which were 40 feet deep on the crest of the hill and extended on to the flat amongst the gravel. The opal dirt in this locality is red in colour, probably due to iron staining. Inordinate amounts of potch were found interspersed with the opal.

Eulan.—Only a few shallow holes were sunk in this locality and although some good colour was struck, the opal was of poor quality.

Grawin

The workings at Grawin are very extensive and a large amount of opal has been won. Sinking varied between 40 and 60 feet on the crest, but graded out to 4 to 6 feet on the flat. Opal occurred mainly in seams with very few nobbies. Although some black opal was found, in the main the opal is light-coloured with a greasy lustre (probably similar to that found at Andamooka in South Australia.) Big seams of potch were found in the workings, one mass weighing 27 pounds.

Coocoran

The Coocoran field was developed during the depression years when about ten shafts were sunk. Sinking varied between 12 and 50 feet depending on their location on the ridge. Although numerous fossils were said to have been encountered in the workings only plant stems were in evidence on the dumps. Only one good stone was recovered and the production was small.

Angledool or Meehi

This locality is one of the few in which denudation has proceeded far enough to expose the underlying sediments. Here soft sandstone crops out in cliff-like form. Miners have used this fact to drive adits into the hill presumably on opal dirt. Shafts to the depth of 30 feet have also been sunk from the crest of the hill. The production from the diggings was small, as the opal, although of good colour, had a tendency to craze and did not cut well.

No information is available concerning the diggings at Llanillo, Glengarry or Dentists' Hill shown on plan of Lightning Ridge Opal Diggings (Fig. 1).

(d) Mining Methods

The common method of mining is to sink a small shaft through the overlying sandstone to the level of the "opal dirt". This is tested at the base of the shaft and, if no opal or indication of opal in the form of potch is found, the shaft is then abandoned

and one dug nearby. It is only in areas where a large amount of opal has been won from the base of the shafts, or in short drives, that any amount of driving has been carried out. It appears anomalous to see the number of shafts on an opal field and realize the amount of sinking that has taken place, with only a relatively small amount of driving from the shaft. In only one area (the Three Mile) of the Lightning Ridge field has there been any great amount of driving. Here pillars which had been left by earlier miners have been extracted and roof falls have occurred.

Once the opal dirt is struck at the bottom of a shaft great care has to be taken that worthwhile gems are not broken by contact with a pick or shovel. The opal dirt is literally shaved with a pick until opal is encountered and the opal is then carefully removed from the matrix by means of some sharp tool, usually the "spider" or candleholder. This is a very tedious operation and little genuine mining is being carried out at the present time. The majority of the men on the field are culling over old mullock dumps and separating material by means of a machine which is locally termed a "dry puddler".

This is a machine by means of which opal dirt is broken down and sieved to give a concentrate of harder material consisting of "nobbies" and pieces of sandstone. The "nobby" is then snipped with a pair of pincers to see if any colour is showing. If colour shows it is then buffed on a polishing machine to determine the extent and value of the opal. Following is a description by J. H. Burford, Inspector of Mines, of a typical "dry puddler":—

"A cylindrical drum 25 inches diameter and 22 inches high is fabricated with $\frac{1}{8}$ inch mild steel plate sides and $\frac{1}{4}$ inch mild steel plate bottom. The bottom and the side, up to a height of 12 inches, is punched at 1 inch centres by $\frac{3}{8}$ inch diameter holes. A small door in the side near the bottom allows for removal of the concentrate. An A.I.A. Post Hole Borer, powered through V-belt drive from a 9 h.p. Southern Cross diesel engine and geared down to 120 revolutions per minute at the auger, provides the breaking medium.

A 12 inch auger is cut off to a length of 10 inches and two 2 inch x $\frac{1}{2}$ inch mild steel bar verticals welded to the auger screws. Another 2 inch x $\frac{1}{2}$ inch mild steel bar is welded across the squared-off auger end. The three bars are faced with strips of rubber conveyor belting to prevent excessive wear and two short lengths of chain welded at the extremities to clean out the corners. The machine is mounted at the back of a truck with the bottom of the drum about 18 inches above the ground and shifted from dump to dump when required. In practice the auger is lowered into the drum and set in motion. Dump material is shovelled into the top and the rotary motion of the screw and hammering of the paddles breaks it up and throws the fine material through the screen where it collects in a heap and is shovelled away."

(e) Production

The figures set out in the following table are only an estimation of the output from the field, and in most cases they are grossly understated, as prices received for many stones are not disclosed by the seller and, in many cases, miners leave the field before any record of production can be secured.

Production of Precious Opal

Annual Report	Lightning Ridge Value £	Grawin Value £
1904	1,000	..
1905	4,000 +	..
1906	6-7,000 (est.)	..
1907	13,000	..
1908	10,000	..
1909	40,000 (est.)	..
1910	46,200	..
1911	39,100	..
1912	26,180	..
1913	19,372	..
1914	21,636	..
1915	4,076	..
1916	20,610	..
1917	12,522	..
1918	20,000	..
1919	25,000	..
1920	20,000	..
1921	12,500	..
1922	15,000	..
1923	3,000	..
1924	10,500	..
1925	10,000	..
1926	6,525	4,948
1927	8,543	4,810
1928	11,000 (inc. Grawin)	..
1929	4,584	1,457
1930	3,250	2,250
1931	1,811	367
1932	1,011	142
1933	4,231 (inc. Grawin)	..
1934	2,908	350
1935	4,300	220
1936	5,500	600
1937	3,254	88
1938	4,132	50
1939	990	..
1940	900 (inc. Grawin)	..
1941	825	..
1942	800	..
1943	2,278	..
1944	3,000	..
1945	3,000	..
1946	3,500	..
1947	1,000	..
1948	400	..
1949	1,592	..
1950	610	..
1951	240	..
1952	515	..
1953	204	..
1954	661	..
1955	1,000	..
1956	2,750	..
1957	1,500	..
Total ..	467,510	15,282
Grawin ..	15,282	..
	482,792	..

II. Underground Water

Except for a small portion in the south-western corner of County Finch, the whole of the area is within the zone of flowing bores of the Great Artesian Basin.

Artesian water is used exclusively for stock-watering and bore drains convey water many miles throughout the countryside from the twenty-three bores which service some 4,000 square miles of grazing land.

As can be seen from the analyses, the water is typical artesian water, i.e., high sodium carbonate content and low sodium chloride, although the total salinity is relatively low. This high sodium carbonate content prevents the use of artesian water for irrigation and horticultural pursuits. Also of

note is the fact that when samples of water have been analysed after bores have been deepened, or after some period of time has elapsed since previous analysis, the total salinity shows a considerable decrease and the sodium chloride content in most cases decreases by more than fifty per cent.

Four bores registered flows of over one million gallons per day with the highest being Angledool No. 2 with a flow of 1,505,310 gallons per day. The smallest flow in the area is from Angledool No. 1 some 800 feet shallower than Angledool No. 2 with a flow of 42,425 gallons per day.

In common with other flowing bores in the Great Artesian Basin, a marked diminution in flow has occurred over the years the loss varying up to 90 per cent. of the original yield. This cannot be attributed entirely to bad drilling technique in the past or to the corrosion of casing restricting the flow. Gingie No. 2 sunk in 1956 and first gauged in 1957 showed a loss of 12,977 gallons per day when gauged in 1958. Release of pressure due to the increasing number of bores sunk could be the main contributing factor.

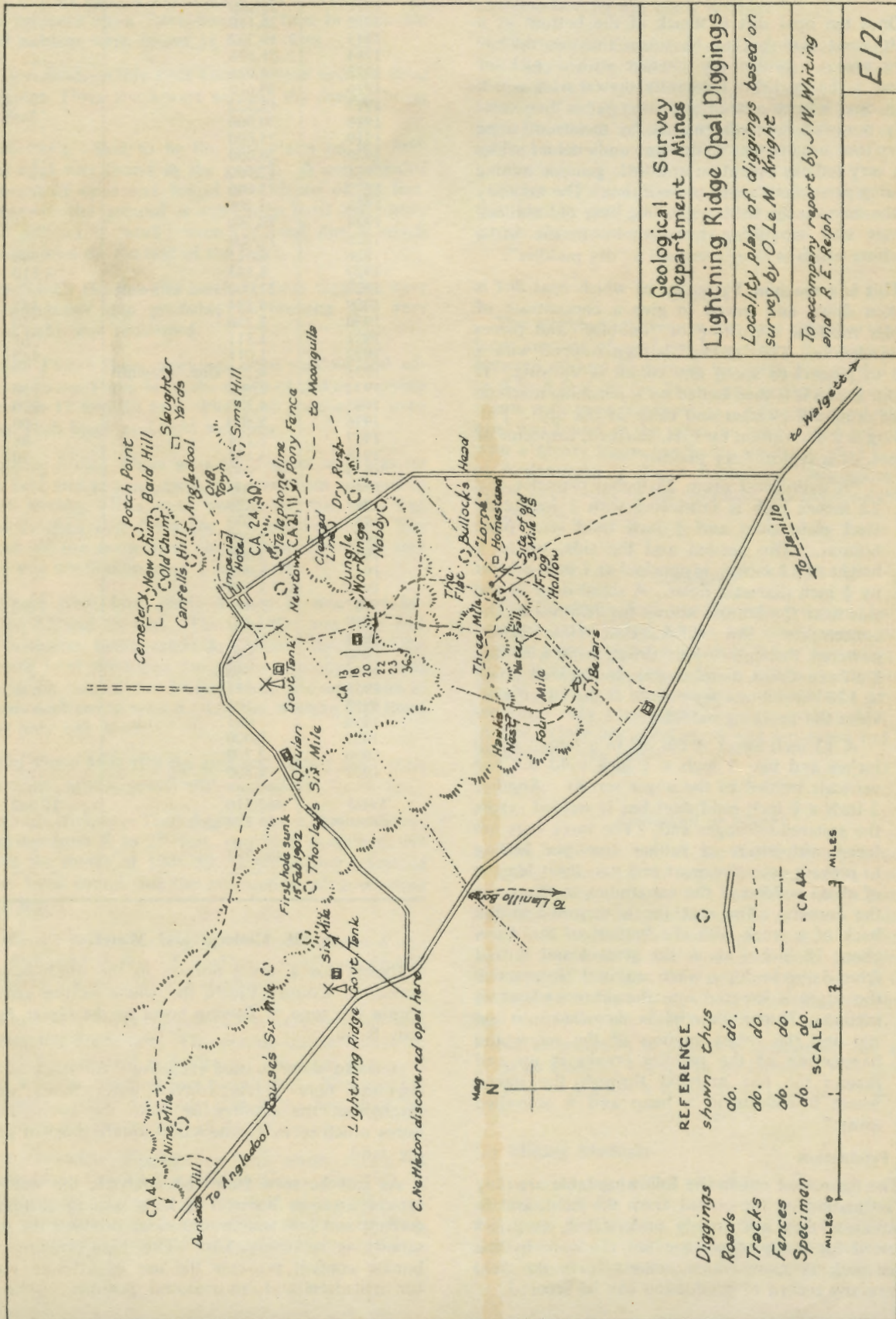


Figure 1

In the main, the artesian bores did not penetrate bedrock but Nullawa bore encountered granite at 3,010 feet and three other bores on the eastern portion of County Finch struck metamorphosed sediments at depth.

Underground water conditions in sub-artesian bores are similar to those which prevail throughout the whole of the Western Division.

All bores sunk on black soil plains encountered salt water at shallow depths, except where good drainage occurs, either on channels near the Barwon River as in Bore 14, or near the base of the mesa-like hills. At Cumborah, where Tertiary gravels overlie Cretaceous sediments, a number of bores have been sunk to depths up to 300 feet and good water intersected. One bore, No. 27, sunk to 960 feet, encountered salty water in the first aquifers and fresh water from 370 feet onwards.

These conditions are unusual, but the bore was sunk on a relatively low area, and the lower aquifers which are present in sandstone of high porosity and permeability are probably fed from high ground away from the immediate vicinity.

The yields of fresh water in the sub-artesian bores are low, rarely attaining more than 400 gallons per hour, but large supplies of salt water have been encountered. In the western part of County Finch useable supplies of water might be obtained by sinking in the sandhills; however, great care would have to be exercised to ensure that salt water underlying the fresh water did not enter the bore.

These conditions could apply on part of Boorooma station where a number of bores and wells have been sunk. Information about these is very meagre although the owners report that the majority of them are too saline for use. However, four of them are used, one having a very large supply.

"Opal dirt" has been recorded in the drilling logs from bores Nos. 26, 27, 28, 29, 30, 31 and 35, at depths varying from 7 to 90 feet. In all probability the claystone horizon in which opal occurs was penetrated in other bores but was not recognised because of the lack of knowledge of the driller. Appended is a list of bores, the numbers referable to those on the map (plate 1—B361).

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APPENDIX A

PETROLOGICAL REPORT ON ROCK SPECIMENS FROM LIGHTNING RIDGE

Collected by J. W. WHITING and R. E. RELPH. Sept. 1958

C.A. 11. 15959. From Ph. Walangulla, Co. Finch, Pony Fence, Lightning Ridge

A fine grained white clayey sandstone, containing numerous rounded masses of white claystone. On the weathered surfaces the sandstone is fairly heavily iron-stained whereas the claystone particles are not, which enables them to be clearly seen. On the unweathered portion of the stone, the claystone fragments are difficult to see, but they are readily seen by microscopic examination of thin sections.

The sandstone itself contains approximately 50 per cent. by volume of sand grains set in an almost opaque white clayey base. Approximately half the sand grains are quartz, the remainder being chalcedony, altered feldspar and what appear to be altered volcanic glass. Most of the grains are sharp and angular, very few being well rounded.

C.A. 55. 15990. From Bangheet crossing, Ph. Bangheet, Co. Finch

A pink, firmly cemented clayey sandstone, composed largely of grains of hardened claystone, chalcedonic material and relatively few grains of quartz set in an opaque ironstained clayey matrix. The clayey matrix appears to contain much opaline secondary silica, as, except for some tiny inclusions, it is isotropic.

C.A. 16. 15991. From Coocoran opal workings, Ph. Wannell, Co. Finch

A cream coloured hardened porcelain-like claystone, locally termed "shin cracker". It has a smooth, even texture and no marked stratification can be seen in it.

The microscope shows it to be composed of clayey material crowded with quartz particles of silt grade. The clay itself contains some secondary chalcedony and much opaline silica to which the hardness of the rock is due. There are many tiny curved or crescentic particles of siliceous material believed to be shards of devitrified pumiceous glass present. These do not necessarily indicate nearby vulcanism, as there is evidence that such particles, being largely chalcedonic in composition may persist through one or more complete cycles of erosion. Some tiny needle-shaped siliceous bodies believed to be spicules of siliceous sponges are also present.

C.A. 23. 15992. From shaft near Jungle workings, 1 mile S. of Lightning Ridge, Ph. Wallangulla, Co. Finch. Material from 3-ft. to 9-ft. depth

A fine grained white clayey sandstone similar to the specimen (C. A. 11) from Pony Fence but without the included masses of claystone. The clay cement of the rock has undergone considerable change, being no longer water absorbed and exhibiting no plasticity when wet. The microscope shows the development of fine grained chalcedonic material both in the grains of claystone of which the rock is largely composed and also in the clayey cement.

C.A. 20. 15993. From 9 feet to 15 feet deep in above shaft

This material is practically identical with the material from Pony Fence (C.A. 11) being essentially a fine grained clayey white sandstone, containing abundant rounded masses of white claystone varying from $\frac{1}{4}$ inch up to several inches in diameter.

C.A. 22. 15994. From 15 feet to 20 feet deep in the above shaft

A white clayey sandstone of medium grain size. Except for its somewhat coarser grain size, it is identical with the material from 3 feet to 9 feet deep. (C.A. 23.)

C.A. 13. 15995. *From a band at 17 feet deep in the above shaft*

A white clayey sandstone slightly finer in grain size than most of the material from 15 feet to 20 feet but otherwise identical with it.

C.A. 36. 15996. *From a band at 19 feet 4 inches in above shaft*

A loosely coherent ironstained clayey sandstone, containing rounded to angular masses of white claystone. In texture, the rock is similar to some of that from shallow depths between 9 feet and 15 feet but unlike it, its clay content absorbs water readily and becomes highly plastic when wet.

C.A. 18. 15997. *From 20 feet to 32 feet in above shaft*

A loosely coherent clayey sandstone of a pink colour with rounded masses of white clay. Essentially similar to some of the shallow material, but absorbs water readily and becomes highly plastic when wet.

The above specimens from this shaft are of interest as they show a progressive hardening near the surface. The deeper material is so soft and poorly consolidated that it disintegrates readily when rubbed with the fingers under water, whilst the material from the surface is much harder and its clay content is virtually unaffected by water. The hardening would appear to be due in part to de-hydration of the clay and partly to deposition of some opaline silica, derived from partial dissociation of the clay.

C.A. 30. 15998. *From Ph. Wallangulla, Co. Finch*

This material referred to as "Opal Dirt" is a buff coloured poorly stratified clay shale. It is practically free from grit, and absorbs water readily becoming highly plastic when wet. It swells slightly when wet, and cracks and disintegrates on drying.

C.A. 24. 15999. *From Ph. Wallangulla, Co. Finch*

An ironstained clayey sandstone with rounded masses of white claystone. Similar in all respects to the material from Pony Fence.

C.A. 44. 16001. *From N.W. of Lightning Ridge Tank*

A white clayey sandstone with lenses and rounded masses of white claystone. The rock is fairly porous, but hard and firmly cemented and does not become plastic when rubbed under water. Under the microscope it is similar to the other sandstones from near the surface, but shows a larger amount of opaline silica replacing the clayey cement and some development of chlorite around the fragments of claystone.

C.A. 21 16002. *From Pony Fence, Ph. Wallangulla, Co. Finch*

A cream coloured somewhat hardened claystone, containing regularly repeated thin layers of sandy material about $\frac{1}{4}$ -inch apart. The clayey portion of the rock is much like the so-called "Shin Cracker" in appearance. Under the microscope, it is almost opaque except for the small amount of silt-grade quartz present, and it contains an abundance of tiny crescentic and splintery particles which are isotropic or only very feebly doubly refracting and which closely resemble the numice shards in many fine grained acid tuffs. The rock is hard and shows no tendency to disintegrate or to become plastic when placed in water.

H. F. WHITWORTH, Curator,
Geological and Mining Museum,
28th October, 1958.

APPENDIX B

EXTRACTS FROM ANNUAL REPORTS OF THE DEPARTMENT OF MINES

1904.—Twenty-six miners were in employment on the field and opal realised up to £10 an ounce.

1905.—Two hundred men were employed at one period of the year, 75 in December. Opal value ranged from 9s. to £6 an ounce.

1906.—About 100 men steadily employed and at one stage (when shearing had been finished) 300 men were on the field. Water scarce. £6-7,000 of opal won.

1907.—"Black Opal" first found and brought to £40 an ounce. One hundred and twenty-five men constantly employed, at times 300 there. Prospecting was carried on near Lightning Ridge Tank, on Boorooma and Grawin South mines. Public school opened with 40 scholars.

1908, page 54.—The value of the precious opal disposed of from the Walgett Division during the year is estimated at £10,000 or £3,000 less than in the year 1907. This amount represents chiefly the returns obtained for the superior class of dark opal, known to the trade as "black opal", there being no sale during the greater part of the year for stone of medium or inferior quality, quantities of which are held by the miners pending a favourable market. It is difficult to determine the exact localities from which the gem stones disposed of were obtained, but, approximately it is estimated that £9,000 represents the value of the opal obtained in the vicinity of Wallangulla township; £900 that from Lightning Ridge, some 5 miles to the west; and £100 that from the Grawin, about 25 miles to the south, and in the vicinity of the parishes of Mein and Morendah. The average number of men on the whole of this field during the year is estimated at 350, representing a constantly floating population, so that in all probability only half of this number worked there for the full twelve months.

1909, page 54.—The value of the opal disposed of from the Walgett Division during the year is estimated at £40,000 or £30,000 in excess of that for the year 1908. This represents the output from the Lightning Ridge (Wallangulla) Opal field. The prices obtainable for the variety found on this field, known as "Black" opal, exceed that paid for any other class of opal, and consequently the quest for it is keen. The "black" opal, is, however, scarce. The bulk of the gemstone won is light in colour, and resembles that from White Cliffs, although it lacks the shape for cutting, the fire and play of colour, and is more faulty than the White Cliffs opal. The extent of country which has been proved to be opal-bearing points to Lightning Ridge being a permanent field. The Grawin, 31 miles from Lightning Ridge, has produced fair quantities of marketable opal, and at Nine-Mile good opal has been obtained, indicating that there is a large area of ground to be prospected. There were no new finds during the year of any importance. The main output has been furnished from the "Three-Mile". The population of the field is a floating one, the ranks of the experienced opal miners being augmented from time to time by station hands, and men from the cities and towns out to try their "luck". It is estimated that there were between 500 and 800 men on the field during the year, many of whom did well, while the places of those not so fortunate, and who left the field were filled by fresh arrivals.

1910, page 52.—The value of the precious opal won during 1910 is estimated at £66,200, as compared with £61,800 in the previous year—an increase of £4,400.

The output from the Lightning Ridge (Wallangulla) Opal Field is valued at £46,200 or £6,200 in excess of that of the previous year. Operations on this field extended over a much wider area than formerly and reached the "Four Mile" and "Five Mile" in a southerly direction, while marketable opal was being obtained at date from the Six Mile, west of the original field. There remains an extensive tract of country beyond the Six Mile as yet unprospected. The major portion of the output for the year, was however, obtained from the locality known as the "Three-Mile". Some fine gemstone was won at deeper levels than in former years, viz., 60 feet; but deep sinking is not vigorously pursued owing to the labour involved, and the hazardous prospects of recompense. The quality of the opal recovered was quite up to the standard of former years for colour, fire, and brilliancy, and some very high prices were recorded for individual gems. In one instance, £102 was paid for a stone weighing $6\frac{1}{2}$ carats of the good black variety for which this field is renowned. However, finds of this grade are infrequent, but they give stimulus to the development of the industry. The field generally has an aspect of stability, and although the population has not been augmented in numbers, it is apparently more settled. Then there are the casual workers, men of various occupations and callings, who visit the field, and who readily gain what knowledge is required to prosecute the search for the gemstone. No opal was won during the year from the field known as the "Grawin", and work has apparently been abandoned there.

1911, page 59.—The value of the precious opal won during 1911 is estimated at £57,300 as compared with £66,200 in the previous year, being a decrease of £8,900.

The output from the Lightning Ridge (Wallangulla) field is valued at £39,100 or £7,100 less than in the year 1910.

Operations were not conducted so actively as in former years, and owing to the lessened price rulings for the gemstone, and the hazardous prospects of recompense, a number of miners left the field to seek employment elsewhere.

During the year some rich finds were reported, and one stone weighing 5 oz., valued at £300, was recovered. The locality known as the "Three Mile" still continues to be the chief centre of production, operations being mostly confined to the neighbourhood of old workings, notwithstanding the vast area of unprospected land believed to be opal bearing in close proximity to the field.

The quality of the opal recovered was quite up to the standard of former years, and some of the prices recorded for individual gems were said to be very high.

The opal won during the year from the field known as the Grawin is estimated at £500.

1912, page 55.—The output from the Lightning Ridge (Wallangulla) field is valued at £26,180 as compared with £39,100 in 1911. Although most of the existing shallow workings are apparently exhausted, there yet remains a vast tract of untried country, and, as exemplifying the capricious nature of the occurrence of the gemstone, it is interesting to note that many of the rich finds recorded have been taken from claims which had been abandoned. Opal to the value of £1,000 was won, during a period of three months, by two men prospecting in an abandoned shaft sunk in new country; and experienced miners regard this discovery as one of the most promising developments for many years. Vigorous prospecting is going on in the locality although the deep sinking between 70 and 80 feet, entails a large amount of labour in hauling. The four adjoining claims are also producing good stone.

There is a ready demand for opal of all grades, the good black variety commanding the highest price.

The majority of the men engaged in the industry are experienced miners who have followed the pursuit for years; but this field, being in the centre of a large pastoral district, offers splendid opportunities for men who follow rural occupations to try their luck at opal digging whilst waiting for the season to commence.

No opal was won during the period under review from the field known as the Grawin.

1913, page 59.—The value of the precious opal won during 1913 is estimated at £29,493 as compared with £35,008 in the previous year, being a decrease of £5,515.

The output from the Lightning Ridge (Wallangulla) field is valued at £19,372, or £6,808 less than in the year 1912. Operations were not conducted so actively as in former years, and the future prospects of the field depend largely on whether there is a sufficient output of the right quality of opal. It is estimated that 280 men were employed on this field during the period under review.

1914, page 60.—Two hundred and ninety men on the field. War injured the market for opal to a large extent, a number of men left the field.

Very little new country was prospected, operations being confined mainly to existing workings.

1915, page 15.—The value of the opal won during 1915 is estimated at £6,403, being a decrease of £20,101 on that obtained during the previous year.

The output from the Lightning Ridge (Wallangulla) field is valued at £4,076 as compared with £21,636 for the year 1914, or a marked decrease of £17,560.

The war has had a very depressing effect on the opal-mining industry. The markets of Germany, who were large buyers, are entirely closed, but America, France, and England are all opening up important markets, and several large and valuable parcels of opal on the field were withheld from sale, the owners preferring to wait for better prices which they consider must be offering when these markets develop.

The future prospects of the field itself are considered to be very promising. A new rush took place at a site north of the township, and the first ten claims bottomed struck payable opal. Most of the men are now prospecting in this locality, and it is likely that operations will be continued there for some considerable time.

The opal won is quite up to the standard of former years for colour, fire, and brilliancy.

One encouraging feature is the increasing demand for low-grade opal for the button trade. The supply of this class of opal, which was formerly cast aside as valueless, is large, and if the demand continues it should have a stimulating effect on the industry.

1919, page 50.—The output for 1919 is valued at £27,552 being an increase of £6,900 on that of the previous year.

The value of the opal sold during the year is estimated at £25,000. There were about 250 men engaged on the field including fossickers.

The price of opal has advanced considerably within the last twelve months. There is also a keen demand for all classes of the gem, particularly the black variety which commands high prices in the British and American markets, as much as £20 per carat having been offered for some stones on this field.

The opal won during the year is quite up to the standard of former years for colour, fire, and brilliancy.

Mining operations during the year have been confined chiefly to the Bald Hill, Telephone Line, and Three Mile workings. Rich finds have been won at each of the localities mentioned, and it is thought that active prospecting will be continued there for some time to come. There are about forty returned soldiers at present engaged in mining. Lightning Ridge opal fields offer many advantages to the returned soldier, especially those who receive a pension sufficient to keep them in provisions, because the work is not hard.

Those in delicate health need only work on the surface. Very often valuable gems are obtained from surface work, and there is always a good chance of making a substantial rise.

1920, page 32.—The total value of the opal produced and sold during the year is estimated at £20,000. In the early part of the year record prices were obtained on the field for all classes of opal, but during the past few months the prices have fallen to such an extent that there appears to be no demand except for the very best quality. Several new fields have been discovered during the year, and good quality opal won at each place. One very fine black opal was sold in the early part of the year for £600.

1920, page 54.—The Lightning Ridge field continues to yield gems of the finest quality, and there is abundant scope for further discoveries, not only in the localities already proved to be gem-bearing, but in other areas which are as yet quite untested. With a ready market and eager buyers, this class of mining offers considerable inducement to prospectors who can afford to carry on prospecting work for some time, which may result in little or no reward. Quite a number of men have been engaged in picking over the waste heaps on the surface, which had been raised at various times and thrown out while searching for the opal. The presence of the gem is not always known, and valuable stones might easily be overlooked; indeed, many have already been found in turning over these old heaps. Values have advanced considerably, especially for stone of superior quality; all qualities of opal, except the commonest kinds of potch, now seem to have a market value.

1921, page 48.—Lightning Ridge continues to produce some magnificent gemstones, but the trade in them is restricted owing to the difficulty of agreeing to the sale prices of the miners.

1921, page 33.—Opals valued at £12,500 were raised during the year. A discovery at the Nine Mile in June led to the employment of seventy men on this field, and very good gemstones were found.

1922, page 34.—Precious opals valued at £15,000 were raised during the year. Two new discoveries at the "Six Mile" and "Butterfly" gave a stimulus to prospecting and, with foreign buyers again operating, the prospects of the field appear brighter.

1922, page 54.—At Lightning Ridge, opal of the finest quality is being found in areas which were extensively worked and practically abandoned. This shows that the areas already worked and left are still capable of yielding values equal to anything in the past as the explorations are further extended into new ground. The depth at which most of this opal is being found is unusually shallow, rather under than over 20 feet from the surface. Though the chances of meeting with valuable stones are always against the prospector, there seem to be better prospects of success upon this field than upon many of those old fields which have been repeatedly tested.

1923, page 30.—The estimated value of the output for the year is £3,040, being a substantial decrease as compared with the previous year, viz., £15,150.

Practically the whole of the yield was obtained from the Lightning Ridge opal field. Work was seriously hampered by severe drought conditions, the local Government Tank, which is the field's water supply, becoming exhausted and remaining dry for about seven months. Black opal was almost unsaleable during the year, very few buyers operating. Little mining work was done, the greater part of the output being won by fossickers or "noodlers" operating on the dumps. At the close of the year about 100 men, chiefly old-age pensioners and war pensioners, were engaged in the industry. No new finds were made during the year.

1924, page 38.—The estimated value of the output for the year is £10,500, being an increase of £7,460 as compared with 1923.

The whole of the yield was obtained from the Lightning Ridge opal field, on which, at the end of December, about 200 miners were working. No new finds were located during 1924, but there still remains an area of 12,000 acres of opal-bearing country in the near vicinity of the town of Lightning Ridge, of which only a very small portion has been prospected. It is reported that the industry is now reaping the benefit of having a local representative at the British Exhibition, Wembley, practically the whole of the output for the year having been purchased and disposed of by Mr. H. Jenkins, miners' representative.

1925, page 31.—The estimated value of the output for the year is £10,030, as compared with £10,500 won during 1924.

Practically the whole of the output was obtained from Lightning Ridge opal field, on which, at the end of December, about 150 miners were working. No new finds were reported during 1925, but there still remains an area of 12,000 acres of opal-bearing country in the vicinity of Lightning Ridge, of which only a very small portion has been prospected. A grant of £200 was made from the Prospecting Vote during the year to assist in this work. Practically the whole of the opal won was disposed of.

1926, page 30.—The estimated value of the output for the year is £11,485, as compared with £10,030 won during 1925. Of this output, opal valued at £6,525 was obtained from the Lightning Ridge field, where about 100 miners were engaged at the end of the year.

A further grant of £250 was made from the Prospecting Vote during 1926 for the purpose of testing new areas in the locality. Very favourable indications were obtained at a site at the Six Mile, on Angledool Station.

The South Grawin opal field, about 30 miles from Lightning Ridge, gave employment to about eighty men during the latter part of the year, and was responsible for the production of opal valued at £4,948. Of this yield, opal valued at £1,596 was actually sold.

The area being worked adjoins the old South Grawin field, which was discovered many years ago.

1927, page 31.—The estimated value of the output for the year is £13,353, as compared with £11,485 won during 1926. Of this output, opal valued at £8,543 was obtained from the Lightning Ridge field, which furnished employment for approximately 120 miners.

During the year a further grant of £250 was made available for the purpose of testing untried portions of the field. The whole of the amount allotted had not been spent at the close of the year.

In October there was a rush to new country adjoining the old Bald Hill workings. The claims are as yet in the development stage, but it is estimated that about £1,000 worth of the best black opal has already been won. There is plenty of new ground surrounding the new workings, and it is not unlikely that it will improve into a big field.

There are about 40,000 acres of opal-bearing ground surrounding Lightning Ridge, of which only about 500 acres have been worked or partially worked. As there is a good demand for black opal in the world's markets, the future of the field seems assured.

1927, page 32.—Opal valued at £4,810 was won at the Grawin Field, about 35 miles from Lightning Ridge, and about 100 miners were engaged in prospecting during 1927. Apart from the original discovery, there have been no new fields opened up. There were several rushes within a radius of 10 miles of the old field, but apart from traces, there was no payable opal found. Some good dark opal was discovered at Grawin, but a large percentage is inferior to Lightning Ridge opal.

1928, page 30.—The production for 1928 is conservatively estimated at £11,000 and was wholly obtained at Lightning Ridge and Grawin. The actual value of the output cannot be ascertained, as the price realised for many valuable stones has not definitely been disclosed, and many miners, also buyers and collectors, leave the fields before a record of their production or purchases can be secured.

About 130 men were engaged at Lightning Ridge and Grawin, but, owing to the fact that the miners continually move from one place to the other, it cannot be stated definitely the number engaged on each field.

Of the production recorded a little more than half was obtained at Grawin.

Three notable finds of large stone have been made during the year, one at Lightning Ridge and two at Grawin. On 25th May, 1928, John MacNicoll, working at the 15-foot level on a claim at "New Angledool" Lightning Ridge field, unearthed a pocket of 15 stones. One of these stones, face and polished, measures 4½ inches by 2½ inches by about ½ of an inch thickness, and weighs 790 carats. This opal is very fine both in sun flash and shadow, fire and colours being very pronounced.

1928, page 31.—A magnificent stone, weighing 232 carats, was discovered at Grawin by W. Klein and K. Stevens, at a depth of about 15 feet. This opal has been sent to London and is reputed to be one of the best stones yet unearthed. It is genuine black patch, with a bar of blue and green colour and a very thin layer of red on top. The colouring is excellent and the pattern unique.

At Grawin, P. Burke also discovered a very fine stone, which was broken into three pieces when being got out. The largest piece weighs about 590 carats and the back is light grey patch, whilst the colour is dull red flash.

On the Grawin field a new find was made at Glen-garry, but the opal obtained was of poor quality.

There was a serious water shortage at Grawin during the year, and many miners left the field, whilst at Lightning Ridge a similar shortage was experienced on some of the workings.

Both on the Grawin and Lightning Ridge fields most of the work done has been concentrated on old ground. There are about 40,000 acres of opal-bearing ground surrounding Lightning Ridge, of which only about 500 acres have been worked or partially worked.

1928, page 45.—Interest in opal-mining has been maintained and prices obtained for stone of all qualities has been good. Two large and valuable stones were found at Lightning Ridge and Grawin respectively, the stone found at Grawin being the better of the two. Judging from developments about the Grawin, this field gives prospects of having a long life. The problem of a domestic water supply has not yet been solved and the question is a pressing one for those dependent on the field.

1929, page 29.—The value of the production for 1929 is estimated at £6,071. The actual value of the output cannot be ascertained, as the price realised for many stones has not been definitely disclosed, and many miners, also buyers and collectors, leave the fields before a record of their production or purchases can be secured.

The value of the production from Lightning Ridge was £4,584 and at the end of the year about 95 men were engaged. No large stones and no finds of any importance were made during the year. The opal market was not in a buoyant condition during the latter half of the year, and only good gem quality opal was saleable. Work was mainly confined to old ground.

Opal valued at £1,457 was obtained at Grawin, and about 45 men were at work on this field.

A good deal of prospecting has been done in this locality, and good traces of opal found in two places. A grant of £150 was made by the Department towards the close of the year for the purpose of testing untried portions of the field. Lack of water hampered operations during the year.

There are about 40,000 acres of opal-bearing ground surrounding Lightning Ridge of which only about 500 acres have been worked or partially worked.

Inspector H. F. Pearson

1929, *page 41*.—I recently visited the opal fields at Grawin-Lightning Ridge. The year has been a dry one and the water shortage is acute. The tank at Grawin is being cleaned out and provisions made for watering stock. Very little good opal has been found of late on either field.

1930, *page 28*.—The value of the production for 1930 is estimated at £5,500. The actual value of the output cannot be ascertained, as the price realised for many stones has not been definitely disclosed, and many miners, also buyers and collectors leave the fields before a record of their production or purchases can be secured.

The value of the production from Lightning Ridge was £3,250 and at the end of the year 132 men were engaged. Work was confined almost solely to old ground and very little prospecting was done in the large area of probable opal-bearing country surrounding Lightning Ridge. No finds of any importance were made during the year.

At Grawin, opal valued at £2,250 was won, and 59 men were engaged on the field at the end of the year. A grant of £150 from the Prospecting Vote was expended at Grawin early in the year, but no payable opal was discovered.

Prospecting operations were being carried out at Glengarry, near Grawin, during the latter part of the year.

A little opal of poor quality was obtained at Glen-ogy near Angledool.

1931, *page 30*.—The value of the production for 1931 is estimated at £2,178. The actual value of the output cannot be ascertained, as the price realised for many stones has not been definitely or accurately disclosed,

as many miners, also buyers and collectors leave the fields before a record of their production or purchases can be secured.

The Lightning Ridge field was responsible for the production value of £1,811, and at the end of the year 180 men were engaged in the industry. Operations were confined to fossicking in old ground, and no serious effort was made to prospect the large area of probable opal-bearing ground in the locality.

At Grawin, opal valued at £367 was won, and fifty-five men were at work on the field at the close of the year.

1932, *page 32*.—The value of the production which can be traced during the year is estimated at £1,233. The actual value of the output cannot be ascertained, as the price realised for many stones has not been definitely or accurately disclosed, and many miners, also buyers and collectors leave the fields before a record of their production or purchases can be secured.

The production from the Lightning Ridge field is set down at £1,011 and at the end of the year 110 men were engaged in the industry. At Grawin, thirty-four men were employed and opal valued at £142 is estimated to have been won. No discoveries of special merit have been notified.

1933, *page 28*.—The value of the production which has been reported is set down at £4,321.

The bulk of the production is reported as having been procured from the Lightning Ridge division. Only a comparatively small output is recorded from Grawin. The number of men who gained a livelihood in the division was stated to be 190.

Statements in the Annual Reports from 1934 to 1956 simply state the amount of opal won from the field and the fact that from 1950 an average of about twenty-five men have been employed.

APPENDIX C
UNDERGROUND WATER

Bore No.	Portion	Parish	County	Total Depth (feet)	Static Level (feet)	Supply g.p.d.	Aquifers (feet)	Total Solids grs./gal.	NaCl grs./gal.	Na ₂ CO ₃ grs./gal.	Quality	Remarks
1 ..	WLL515 ..	Townday ..	Finch ..	2,605	Flow ..	413,932	214 2,515 2,550	76-244	22-257	51-626	Good stock water	Brackish water struck at 214 feet, Sunk in 1901 gauging as shown. Last gauging 1957, 157,607 gallons, day.
2 ..	WL2,788 ..	Boorara ..	do ..	3,333	do ..	128,522	2,675 3,300	79-996	13-866	63-031	do do ..	Goondablui No. 2. Sunk in 1908 gauging as shown. Last gauging 1958, 117,777 gallons day.
3 ..	WLL1,931	do ..	do ..	3,542	do ..	793,000	3,313 3,412 3,445 3,480 3,520	(1) 87-248 (2) 52-528	19-153 7-403	65-441 41-999	do do ..	Goondablui No. 1. Sunk in 1890 to 2,723 feet when it flowed 334,011 per day; deepened in 1914 to 3,520 feet when the flow was 793,000 per day last gauging 1957 410,853. (1) analysis 1908; (2) analysis 1914.
4 ..	WLL9 ..	do ..	do ..	3,535	do ..	661,580	70 98 357 2,659 2,665 3,305 3,393 3,486 3,526 2,560	(1) 88-760 (2) 52-220	18-506 8-362	67-465 40-306	do do ..	Goondablui No. 4. Gauging in 1912 as shown. Last gauging 1958, 126,122 gallons/day. (1) analysis, 1911. (2) analysis, 1912.
5 ..	WLL2,493	Kennedy ..	do ..	2,560	do ..	371,977	2,560	83-188	21-447	59-019	do do ..	Goondablui No. 3. Gauging 1908 as shown. Last gauging 1958, 102,094 gallons/day.
6 ..	WLL751 ..	Keilmoi ..	do ..	3,828	do ..	1,279,820	99 2,297 2,606 3,050 3,277 3,395 3,408 3,457 3,661 3,676	....	..	..	do do ..	Yeranbah. At 99 feet very brackish water, did not flow until 2,606. Sunk 1926, (gauging as shown). Last gauging 1957, 858,240 gallons/day.
7 ..	TL231 ..	Mundadoo ..	do ..	2,755	do ..	207,410	50 2,558-66 2,706 2,721	(1) 77-308 (2) 59-220	15-931 7-357	52-564 48-129	do do ..	Dungle Ridge. (Public watering Place). 50 feet salt water. Sunk 1894, gauging 1906—shown last gauging 1958. 102,130 gallons/day. (1) analysis 1895. (2) analysis 1915.

APPENDIX C—continued

Bore No.	Portion	Parish	County	Total Depth (feet)	Static Level (feet)	Supply g.p.d.	Aquifers (feet)	Total Solids grs./gal.	NaCl grs./gal.	Na ₂ CO ₃ grs./gal.	Quality	Remarks
8 ..	WLL631 ..	Mogil Mogil ..	Finch ..	3,708	do ..	577,930	2,718 3,057 3,103 to 3,675 (10 aquifers)	....	..	..	Good stock water	<i>Mogil.</i> Sunk 1922, flow as shown last gauging 1958—259,337 gallons/day. First flowed at 3,057 feet.
9 ..	PWP226 ..	Bukkulla ..	do ..	2,570	do ..	595,862	795 988 2,220-2 2,537-70	82.740	21.522	54.795	do do ..	<i>Moongulla Bore.</i> Public Watering Place. Sunk 1892, gauging as shown. Last gauging 1958—84,353 gallons/day. Small supply fresh water struck at 795 feet; salt at 988 feet. First flow 2,537 feet.
10 ..	WLL645 ..	Gooningeri ..	do ..	3,449	Flow ..	793,093	58 115 2,472 2,635 3,126 to 3,408	....	..	..	do do ..	<i>Dunumbral No. 2.</i> Sunk 1922, gauging then as shown. Last gauging 1958, 450,854 gallons/day at 58 and 115 small supplies of brackish water.
11 ..	5 ..	Campbell ..	do ..	3,303	do ..	992,943	60 100 2,372 2,876 3,090 to 3,277	....	..	..	do do ..	<i>Dungalear.</i> Sunk 1923, gauging as shown 1924, last gauging 1958—478,170 gallons/day. Soak fresh water at 60 feet, salt at 100 feet, first flow 2,876 feet.
12 ..	14 ..	Gordon ..	do ..	3,154	do ..	505,980	80 2,228 2,577 2,790 3,000	48.720	6.626	40.039	do do ..	<i>Gerongra.</i> Sunk 1912 when gauging as shown. Last gauging 1957—321,794 gallons/day. Large supply salt water at 80 feet. Bedrock—slate at 3,050 feet approximately.
13 ..	WLL5,541	Hungerford ..	do ..	276	..	large ..	56	....	..	..	Too saline for use	Sunk in alluvium.
14 ..	WLL8,140	Dungalear ..	do ..	88	55	300	55-70	....	..	..	Stock	Sunk in alluvium. Drawdown 60 feet.
15 ..	5 ..	Gingi ..	do ..	303	43	Large ..	43 65 100 150	....	..	..	Not used, too saline	Water encountered in alluvium.
16 ..	2 ..	Bon Bon ..	do ..	237	45	Large ..	45 65 147	....	..	..	do do ..	do do do
17 ..	HL1,137	Combadero ..	do ..	227	35	Large ..	55	....	..	..	do do ..	do do do
18 ..	TL306 ..	Moramina ..	do ..	2,272	do ..	1,069,920	70 275 370 1,740 1,956 2,110 2,250	54.852	7.395	45.355	Good stock water	<i>Moramina.</i> Gauging when sunk in 1897 as shown. Last gauging, 1958—139,500 gallons/day.

APPENDIX C—continued

Bore No.	Portion	Parish	County	Total Depth (feet)	Static Level (feet)	Supply g.p.d.	Aquifers (feet)	Total Solids grs./gal.	NaCl grs./gal.	Na ₂ CO ₃ grs./gal.	Quality	Remarks
19 ..	WLL4,610	Bogra	.. Finch ..	347	36	Large ..	40-50	1,117.0	995.0	..	Too saline for use	In alluvium.
20 ..	WLL350 ..	Telinebone	.. do ..	2,090	Flow ..	622,185	1,642 — 1,675 — 1,986 — 2,045 — 2,049 — 2,064 —	46.984	7.509	36.753	Good stock water	<i>Gingie No. 1.</i> Gauging 1908, as shown; last gauging 1958—187,805 gallons/day.
21 ..	LA242 ..	Durabeba	.. do ..	2,398	do ..	478,170	1,960 — 1,980 — 2,195 —	54.488	7.612	44.499	do do ..	<i>Llanillo.</i> Gauging 1908 as shown; last gauging 1958—148,520 gallons/day.
22 ..	WLL230 ..	Yamby	.. Narran ..	300	..	Large ..	....	....	..	..	Too saline for use	In alluvial drift.
23 ..	17 ..	Terewah	.. do ..	200	..	do ..	....	....	..	..	do do ..	do do do
24 ..	WL2,446 ..	Buddah	.. Finch ..	2,351	..	..	..	No Information				<i>Boorooma No. 2.</i> Sunk for artesian probably struck some shallow water.
25 ..	WL2,447 ..	do	.. do ..	1,493	..	..	..	No Information			Fresh	<i>Boorooma No. 1.</i> Sunk for artesian water. 0-1,284 feet fresh water, drifts every 50 feet.
26 ..	WLL553 ..	Cumborah	.. do ..	400	100	150 g.p.h.	360-362 390-394	....	..	..	Stock water ..	Sunk in an elevated position in Cretaceous sediments. Struck "opal dirt" between 60 and 80 feet.
27 ..	WLL553 ..	do	.. do ..	960	140	400 g.p.h.	200-215 300-305 370-380 500-510 750-755 900-920	....	..	..	Fresh, used for stock.	Sunk in Cretaceous sediments. "Opal dirt" encountered between 60 and 100 feet, first two aquifers saline.
28 ..	WLL4,127	Manning	.. do ..	850	105	400 g.p.h.	200-250	....	..	..	Stock water ..	<i>Mulga.</i> Sunk in Cretaceous sediments. "Opal dirt" encountered between 70 and 100 feet.
29 ..	WLL4,120	do	.. do ..	400	200	400 g.p.h.	200-250	....	..	..	Stock water ..	Sunk in Cretaceous sediments. "Opal dirt" encountered between 90 and 150 feet.
30 ..	WLL1,039	Blackwood	.. do ..	470	..	Large ..	93 111 200 470	....	..	..	Too saline for use	Sunk for Grawin opal field. First two aquifers 50 g.p.h., fresh, other saline. "Opal dirt" struck between 60 and 85 feet.
31 ..	WLL1,039	do	.. do ..	296	..	Large ..	45-100 283-296	....	..	..	do do ..	Sunk in Cretaceous sediments "Opal dirt" encountered between 31 and 43 feet. First aquifer 10 g.p.h. Salt, second aquifer large supply of salt water.

APPENDIX C—continued

Bore No.	Portion	Parish	County	Total Depth (feet)	Static Level (feet)	Supply g.p.d.	Aquifers (feet)	Total Solids	NaCl grs./gal.	Na ₂ CO ₃ grs./gal.	Quality	Remarks
32 ..	HL85/13 ..	Gurilly ..	Finch ..	2,151	flow ..	534,406	180 1,770-1,790 1,850-1,880 2,056-2,099	44-800	7-715	34-505	Good stock water	<i>Morendah.</i> First gauging, 1908 as shown; last gauging 1958; 232,594 gallons/day.
33 ..	TL362 ..	Wilby Wilby ..	do ..	2,162	do ..	1,114,800	72 153 1,750 1,940 2,160	44-966	7-246	35-638	do do ..	<i>Wilby Wilby.</i> First two aquifers salt. Gauging 1898, as shown; last gauging 1958—148,520 gallons/day.
34 ..	WLL77 ..	Morendah ..	do ..	2,415	do ..	682,760	72 2,036 2,167 2,388	43-400	7-882	33-20	do do ..	<i>Inglewood (Morella).</i> First aquifer salt. Gauging 1913 as shown; last gauging 1958—259,337 gallons/day.
35 ..	WLL384 ..	Imbergeee ..	do ..	350	120	220 g.p.h.	170 350	....	..	..	Slightly salt, good stock water.	"Opal stone" struck between 7 and 60 feet. "Opal dirt" between 60 and 90 feet.
36 ..	HL86/12 ..	Finch ..	do ..	7,640	Flow ..	793,093	1,900 2,485	45-668	7-395	35-994	do do ..	<i>Bangate No. 2.</i> First gauging 1908 as shown; last gauging 1957—252,552 gallons/day.
37 ..	AWL3 ..	Wooburrabebe ..	do ..	2,665	do ..	42,425	2,200 2,444 2,664	64-904	9-331	52-748	do do ..	<i>Angledool No. 1.</i> First gauging 1908 as shown. Last gauging 1957—9,163 gallons/day.
38 ..	WLL33 ..	Birrah ..	do ..	3,479	do ..	1,505,310	2,530 2,680 2,950 3,060 3,250 to 3,401 3,470 2,070	....	..	..	do do ..	<i>Angledool No. 2.</i> First gauging 1925 as shown. Last gauging 1958—777,117 gallons/day.
39 ..	WL440 ..	Barrangeel ..	do ..	2,480	..	300 g.p.h.	2,070	....	..	..	Fresh water ..	<i>Dunumbral No. 1.</i> Failure artesian water bore.
40 ..	WLL3,325	Bimber ..	do ..	236	43	Large ..	43 65 93 115 160	....	..	..	Too saline for use	Abandoned. Sunk in alluvium only salt water struck.
41 ..	WLL3,325	do ..	do ..	2,300	Flow ..	384,910	278 1,760 2,300	....	..	..	Good stock water	<i>Gingie No. 2.</i> First aquifer salt sunk 1956. First gauged 1957— as shown. Last gauging 1958—371,977 gallons/day.
42 ..	WLL4,114	Buggee ..	do ..	500	40	400 g.p.h.	88 211	1648-6	1265-7	..	Too saline for use	Sunk in alluvium to 190 feet then sandstone.
43 ..	WLL348 ..	Barlianbillian ..	Narran ..	3,020	Flow ..	505,980	72 147 1,270 2,554 2,602 to 2,675 2,998	50-148	6-923	40-265	Good stock water	<i>Nullawa.</i> First gauging 1909 as shown. Last gauging 1958—232,594 gallons/day. Bottomed in granite at 3,010 feet.