

1953

—  
WESTERN AUSTRALIA

---

REPORT  
*of the*  
Geological Survey  
*for the year*  
1950

(Extract from the Mines Department Annual Report)

---

PERTH :

By Authority: WILLIAM H. WYATT, Government Printer.

—  
1953.

ANNUAL PROGRESS REPORT OF THE GEOLOGICAL SURVEY BRANCH OF THE MINES  
DEPARTMENT FOR THE YEAR, 1950.

## Contents

	Page
Letter of Transmittal .....	5
Administration—	
Staff .....	5
Field Work .....	5
Publications .....	5
Reports—	
Report on Domestic Water Supply "Timoni" Gold Mine, Mt. Ida, North Coolgardie Gold Field .....	6
A Reconnaissance Survey of the Cue and Day Dawn Districts, Murchison Goldfield, W.A. ....	7
Report on Progress of a Geological Survey of the Metropolitan Area as at 31st December, 1950 .....	13
Report on the Great Fingall Exploration Venture, 1949-50 .....	23
Progress Report on Diamond Drilling, Collie Mineral Field, W.A. Bore No. 1—Site C—Mineral Lease 415, North-East of Shotts .....	27
Progress Report on Diamond Drilling, Collie Mineral Field, W.A. Bore No. 2—Site L—Mineral Lease 152, 2½ miles South of Collie Townsite .....	31
Progress Report on Diamond Drilling, Collie Mineral Field, W.A. Bore No. 3—Site E—Mineral Lease 328, 4 miles East of Collie Townsite .....	33
Shallow Drilling for Open-Cut Coal on a Portion of Mineral Leases 82, 129 and 130, East Collie Burn, Collie Mineral Field, W.A. ....	34
Report on the South-West Iron Reconnaissance .....	36
Summary Report on South-West Limestone Reconnaissance .....	39
Report on Testing a Limestone Deposit, 3 miles North-West of Capel, South-West Division .....	40
Report on Survey of the Limestone Deposits of the South-West Division of W.A. Within a Radius of 50 miles from Bunbury .....	40
Report on Survey of Limestone Deposits between Harvey River Diversion Channel and Mandurah, South-West Division .....	42



## List of Plates

Plate No.	Title.	To Face Page
I.	Reconnaissance Structural Map of Cue-Day Dawn District, Murchison Goldfield. Scale : 40 chains to an inch	8
II.	Diamond Drilling Machine in Operation at Collie Mineral Field	29
III.	Contour Plan and Sections of Portion of Mining Leases 82, 129 and 130, showing Position of Boreholes and Details of Coal Intersected, East Collie Burn, Collie Mineral Field. Scale : 4 chains to an inch	35
IV.	Isopach and Structure Contour Plans of Portion of Mining Leases 82, 129 and 130, East Collie Burn, Collie Mineral Field. Scale : 4 chains to an inch	36
V.	Map of Portion of the South-West Division, Western Australia, within 50 mile radius of Bunbury, showing Localities Investigated during Iron and Limestone Reconnaissances of the Area. Scale : 4 miles to an inch	37
VI.	Geological Map of Portion of the Stirling Estate, 3 miles N.W. of Capel, South-West Division, showing Limestone Outcrop Area. Scale : 10 chains to an inch	39

## List of Figures

Figure No.	Title.	To Face Page.
1.	Domestic Water Supply Timoni Goldmine, Mt. Ida, North Coolgardie Goldfield. Scale : 40 chains to an inch	6
2.	Creep Study of Great Fingall Diamond Drill Hole, No. 1. Scale : 10 feet to an inch	25
3.	Condition Diagrams of Great Fingall Diamond Drill Holes, Nos. 1 and 2. Scale : 200 feet to an inch	25
4.	Diamond Drill Hole, No. 1—Site C—(Collie Mineral Field)—Percentage Core Recovery	29
5.	Position of Diamond Drill Hole, No. 1—Site C—C.M.L. 415—Collie. Scale : 40 chains to an inch	29
6.	Columnar Section Diamond Drill Hole, No. 1—Site C—C.M.L. 415—Collie	29
7.	Diamond Drill Hole, No. 2—Site L—(Collie Mineral Field) Percentage Core Recovery	32
8.	Position of Diamond Drill Hole, No. 2—Site L—C.M.L. 152—Collie. Scale : 40 chains to an inch	32
9.	Columnar Section Diamond Drill Hole, No. 2—Site L—C.M.L. 152—Collie	32
10.	Diamond Drill Hole, No. 3—Site E—(Collie Mineral Field) Percentage Core Recovery	33
11.	Position of Diamond Drill Hole, No. 3—Site E—C.M.L. 328—Collie. Scale : 40 chains to an inch	33
12.	Columnar Section Diamond Drill Hole, No. 3—Site E—C.M.L. 328—Collie	33

## Annual Progress Report of the Geological Survey of Western Australia for the Year ended 31st December, 1950.

*The Under Secretary for Mines,*

I have the honour to submit, for the information of the Honourable the Minister for Mines, my report on the operations and progress of the Geological Survey for the year ended 31st December, 1950.

The work of the Geological Survey was carried out by 11 classified officers consisting of the Government Geologist, 6 geologists and 4 office staff.

### *Availability of Geologists.*

Period.	No. of Geologists available, including Government Geologist.	Area of State.	Square Miles per Geologist.	Population.
1950.		sq. miles.		
		975,920	....	558,000
Jan.-Feb. ....	8	....	121,900	....
March ....	7	....	139,410	....
April-May ....	6	....	162,650	....
June-Dec. ....	7	....	139,410	....

### FIELD WORK.

*Major Field Work completed during the Year and in Progress as at December, 31*

(1) A geological reconnaissance of the Cue-Day Dawn area in which particular attention was paid to the regional structure and the occurrence of gold, was completed.

(2) A systematic search for deposits of ironstone and limestone of commercial grade and size was carried out over an area situated within a 50 mile radius of Bunbury, most of this work was carried out in thickly timbered, hilly country and yielded negative results for a great deal of physical effort. The Department of Industrial Development had assured representatives of Brasserts Ltd., who had been approached in the matter of establishing a steel industry based on Bunbury and using Collie coal and S.W. iron ore and limestone, that there were unlimited resources of both ironstone and limestone of suitable grade for a steel industry. This was done without prior reference to the Geological Survey.

The result of the work done by this Branch in conjunction with analytical work done by the Mineral Section of the Government Chemical Laboratory was that no deposits of iron ore or limestone of suitable grade and size occurred within a radius of 40 miles of Bunbury.

(3) Field work was commenced in August by 5 geologists on a detailed economic geological survey of an area of approximately 2,000 square miles of country surrounding the city of Perth. This is at present in progress and is referred to elsewhere as the geological survey of the Metropolitan Area. The principal aim is the location and valuation of industrial minerals and rocks.

(4) Supervision of deep drilling and shallow percussion drilling on the Collie Coal field.

### PUBLICATIONS.

#### *Issued during 1950.*

Annual Progress Report of the Geological Survey of Western Australia for 1947.

Bulletin No. 102: The Greenbushes Mineral Field, by R.A. Hobson, B.Sc. (Hons.) and R.S. Matheson, B.Sc.

Bulletin No. 104: Some Economic Aspects of the Principal Tantalum Bearing Deposits of the Pilbara Goldfield, by H. A. Ellis, B.Sc., A.O.S.M.

Bulletin No. 106: A Geological Reconnaissance of Portion of the Yalgoo, Peak Hill and Gascoyne Goldfields, by W. Johnson, B.Sc. (Hons.).

Atlas of Maps to accompany Bulletin No. 101. (Bull. 101 issued 1947.)

#### *In the Press.*

Annual Progress Report of the Geological Survey of Western Australia for 1948.

Annual Progress Report of the Geological Survey of Western Australia for 1949.

Bulletin No. 103: Geology of Portion of the Mt. Margaret Goldfield, by R. A. Hobson, B.Sc. (Hons.) and K. R. Miles, D.Sc., with two atlases of maps.

Mineral Resources of Western Australia Bulletin No. 5: Moulding Sands of Western Australia, by K. R. Miles, D.Sc. and H. A. Stephens, B.Sc.

Bulletin No. 95 (1st Reprint): The Physiography of Western Australia, by J. T. Jutson, B.Sc., LL.B.

Geological Sketch Map of Western Australia, Scale 40 miles=1 inch.

#### *Compiled and Awaiting Authority to Print.*

Bulletin No. 107: A Re-Survey of the Coolgardie District, W.A., by J. C. McMath, B.Sc. (Hons. Lond.), F.G.S., M.Aust.I.M.M. and N. M. Gray, B.Sc.

Mineral Resources of Western Australia Bulletin No. 6: Silver, Lead and Zinc, by W. Johnson, B.Sc. (Hons.).

Mineral Resources of Western Australia Bulletin No. 7: Vermiculite, Talc and Soapstone, Fuller's Earth, Bentonite, and Diatomite, by W. Johnson, B.Sc. (Hons.).

Bulletin No. 108: The Geology of the Irwin River and Eradu Coal Basins, by W. Johnson, B.Sc. (Hons.), J. S. Gleeson, B.Sc. and L. E. de la Hunty, B.Sc.

#### *In Course of Preparation.*

Bulletin No. 105: The Collie Mineral Field, Part I, by J. H. Lord, B.Sc., F.G.S.

A large amount of field and office work has been done during the year, and my thanks are due to those responsible for a satisfactory combined effort.

H. A. ELLIS,  
Government Geologist.

January, 25, 1951.

REPORT ON DOMESTIC WATER SUPPLY  
"TIMONI" GOLD MINE. MT. IDA. NORTH  
COOLGARDIE G. F.

By H. A. Ellis, B.Sc., A.O.S.M., Government  
Geologist.

*Locality.*

The "Timoni" Gold Mine is situated 62 miles by road north-west of Menzies. It is the only operating mine in the district and is owned and operated by Goldfields Australian Development Coy. Ltd., of 39 Boulder Road, Kalgoorlie. The inspection on which this report is based was made on May 15, 1950.

*Development.*

During the last three years the company has spent approximately £250,000 in mine development, treatment plant erection, and housing. The mine is fully developed to a depth of 600 feet, and has proved ore reserves sufficient to keep the mill operating for seven years as from May 1950.

The last level driven, No. 6, at a vertical depth of 600 feet, is the best level in the mine, and the future prospects in depth are very good.

*Population.*

Population as at May 1950 consisted of 150 persons all told, living in mine-owned houses and huts on the company's leases. There is no recognised township established yet. It is estimated that soon this number will be increased to 200.

*Present Sources of Water Supply.*

(a) Treatment water.

Water for milling purposes will be obtained from mine workings.

(b) Ablution water—mine showers.

Mine water is not suitable, and water has to be carted for this purpose.

(c) Domestic water.

This is obtained from two sources.

1. Rain water tanks attached to buildings.
2. Carted from well supplies over distances up to five miles.

*The Immediate Water Supply Problem.  
Treatment Water.*

In 1948 the Geological Survey examined the mine, and among other things made recommendations aimed at ensuring the best exploration for further supplies of underground water from sources within the area being developed by the company at present.

No immediate problem exists with regard to this type of supply. (May 1950.)

*Domestic Water.*

At present (May 1950) the company is carting 20,000 gallons per week from two sources, viz., the Government well on water reserve No. 12922, situated about 1½ miles north of the mine, and from the tank at the Mt. Ida State Battery under a "Gentleman's agreement" with the lessee of the battery, Mr. A. E. Grey. The company provides petrol for the engine operating the State Battery pumping plant on their well located about 1½ miles north-east of the battery on water reserve No. 12353, and in return is permitted to draw water from the battery tank.

The overall consumption of water for mine ablution and domestic purposes averages around 19 gallons per head per day. This is not a generous allowance, and does not permit of the use of water on gardens or lawns, which naturally do not exist at Mt. Ida at present.

The capacity of the Government well on reserve No. 12922 situated about 1½ miles north of the mine is about 4,000 gallons per day. That of the well supplying the State Battery tanks is reported to be 19,000 gallons per day.

The company has tested all existing old wells within a radius of eight miles of the mine and finds that the maximum yield of any one of them is 1,000 gallons per day.

The only existing reliable sources of supply then are those mentioned above, and they cannot be controlled by the company because they are Government property. In any case these two sources can supply only the bare domestic needs of the existing population, and make no provision for what could be called "amenity water," i.e., water for gardens and lawns, so necessary in this part of the country.

*Prospects of Obtaining Additional Supplies of Domestic Water.*

Usable ground water could occur in three different types of geological structures in the Mt. Ida district, all confined to the granitic terrain north and north-east of the mine. The greenstone country will not provide potable ground water. These structures are:—

- (a) In decomposed granite in or close to the margins of existing drainage channels, e.g., the Government well 1½ miles north of the mine. This class of structure has only a very thin development of alluvium which is not important as an aquifer.
- (b) In drainage channels in which there is a thick development of alluvium overlying decomposed granite, e.g., Sharman's well, situated approximately four miles by track north of the mine.
- (c) In wide alluviated basins or flats in which there is no defined drainage system, e.g., the Government State Battery well on water reserve No. 12352 situated about eight miles north-east of the mine.

The immediate problem is to locate a source of underground water suitable for development as a permanent supply in reliable quantities by means of wells and a pipe line to the mine area.

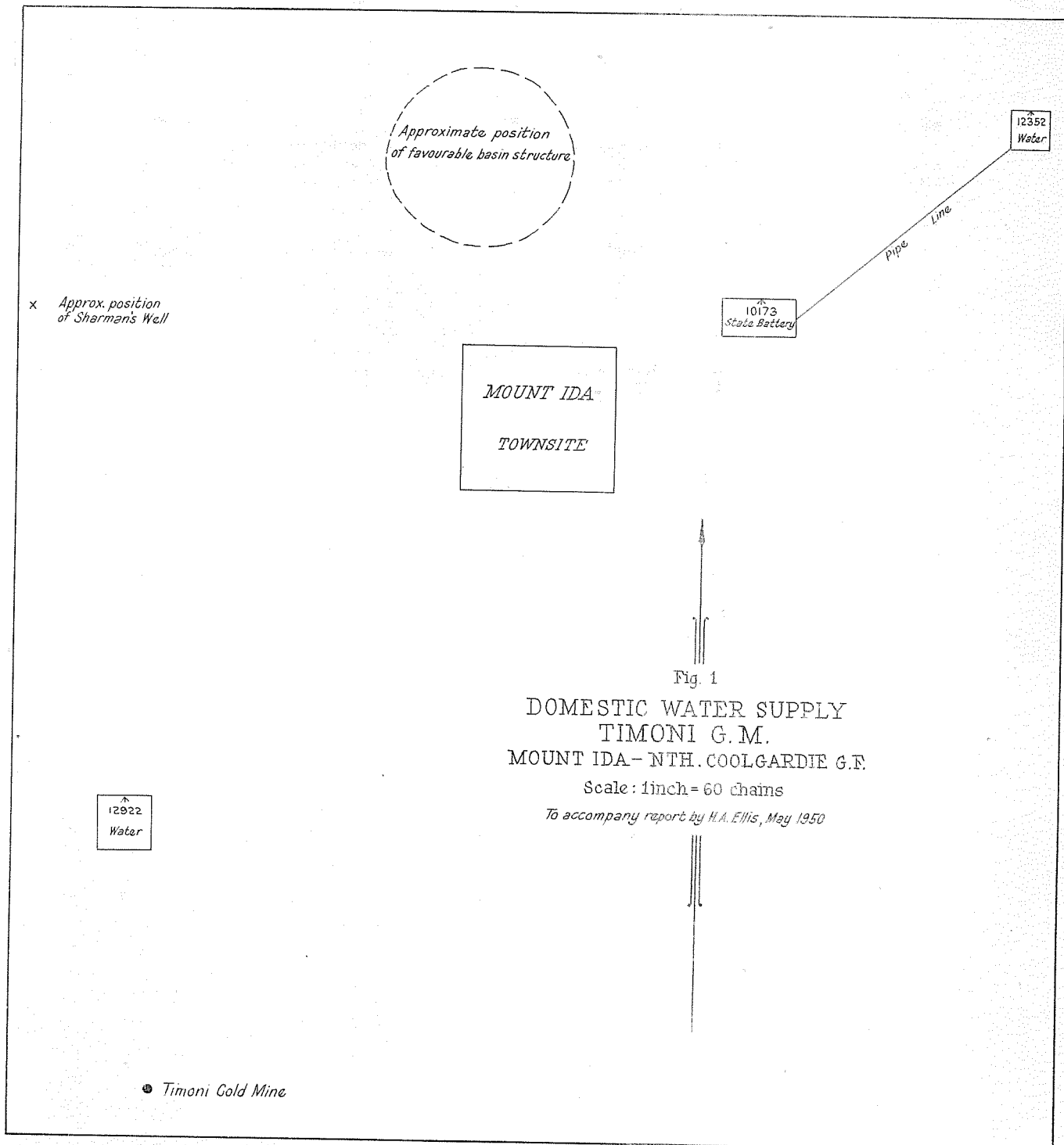
Wells located in structures similar to (a) above have no prospect of yielding large quantities of underground water. We are not so much concerned with finding water; bores almost anywhere in the granitic terrain except on solid outcrop granite, will yield some water. We are concerned with quantity and quality, and the other two classes of structures (b) and (c) are the types capable of holding and yielding large amounts of water.

In Sharman's well there is about 50 feet of rather poorly sorted alluvium overlying a very decomposed kaolinised granite. The alluvium did not contain water—the decomposed granite below the alluvium yielded about 1,000 gallons per day.

The well is in a wide, flat, irregular drainage channel which has been filled with alluvium. What is the maximum depth of this alluvium, and where is its deepest point? This apparently flat area overlies a buried stream bed, and in its deepest part this alluvium could contain large quantities of water.

A series of exploratory bores across this alluviated area would adequately answer the questions raised above. Bores should be sunk to hard granite.





The other type of favourable structure, (c), has been exploited in the well on reserve No. 12352 from which the State Battery draws its water, and undoubtedly other wells of similar capacity could be located in this area.

This favourable locality is eight miles away and it is thought that another and closer area situated about  $1\frac{1}{2}$  miles north of Mt. Ida Townsite may have the characteristics of an alluviated basin. This locality is perhaps the best prospect and should be the first one prospected by bores to solid granite.

A pipe line about four miles long would be needed to bring the water from either the Sharman well locality or from this locality to the mine area, should either area prove satisfactory.

Failing the successful development of either of these localities then the area in the vicinity of the State Battery well—reserve No. 12352—would have to be relied upon to provide the necessary quantity of water. This would mean at least eight miles of pipe line unless arrangements could be made to use the existing  $1\frac{1}{2}$  miles of pipe line from the State Battery well to the State Battery tank at the State Battery, when over six miles of pipe line would have to be provided by the company.

#### *Arrangements for Exploratory Drilling.*

The writer visited the Mt. Ida district and conferred with the local mine manager at the mine and with the general manager of the company in Kalgoorlie.

It was learned that a contract had been let by the company to a drilling contractor from the wheat belt, to undertake the exploratory drilling at a price of £1 per foot. The contractor demanded a guaranteed minimum footage of 1,000 feet, so that should the first hole drilled be successful then it would cost the company £1,000. A depth of 150 feet is likely to be the maximum depth of any drill hole in this district.

The likely areas were examined with the mine manager, and further reconnaissance examinations were made by the writer alone. The geological problems and the best methods of attacking the water supply problem were discussed with and outlined to the mine manager.

The company is now in a position to go ahead with the water-boring exploration, and intends to do so.

The writer was asked, rather naturally, he thought, whether the Goldfields Water Supply Branch of the Public Works Department would be willing to help the company in its water supply problems. Subsequent inquiry by the writer from the Engineer in Charge, Goldfields Water Supply Department, indicates that this Branch of the Public Works Department regards it as the function of the mine to provide water for its employees, and that it is not interested in this particular problem.

#### **A RECONNAISSANCE SURVEY OF THE CUE AND DAY DAWN DISTRICTS, MURCHISON GOLDFIELD, W.A.**

*By J. C. McMath, B.Sc. (Hons. Lond.), F.G.S., M.A.I.M.M.*

#### **INTRODUCTION.**

In the light of regional structural work in the Yilgarn and Coolgardie Goldfields<sup>1</sup> and subsequent recognition of some general relations of gold mineralisation to regional geological structure, a reconnaissance geological survey of approximately 600 square miles in the Cue District (Murchison Goldfield) was undertaken between September, 1949, and April, 1950. This region, hereinafter termed the "Area," ranges between Cue Town, on the north, southwards to Moyagee Siding. A glance at the accompanying map will give a rapid appreciation of the detailed boundaries.

A structural appreciation of the Area has been made together with a more detailed stratigraphical picture than has hitherto been available<sup>2</sup>. Unfortunately no clear and unequivocal picture of the relation of gold mineralisation to geological structure was to be had in detail, though broad loci of mineralisation in relation to structure were apparent. It must be borne in mind that detailed large scale mapping and investigation of mining groups would be necessary to amplify the picture now presented—such work could legitimately form an aspect of exploration programmes of mining companies.

#### *General Information.*

##### *Location.*

Cue (the administrative centre of the Murchison G.F.) lies approximately 400 miles north of Perth and 300 miles east of Geraldton—the nearest port.

##### *Reference Maps.*

- 3 { Lands & Surveys Dept. Lithograph 54/300  
Topographical Series—10 miles = 1 inch.  
Geraldton.

##### *Communications.*

- (a) *Railway.*—Cue lies on the Meekatharra-Wiluna Branch of the Western Australian Government Railways. It is the junction for Big Bell; Geraldton is reached via Mullewa.
- (b) *Road.*—Cue lies some 400 miles north of Perth on the Northern Highway and approximately 300 miles east of Geraldton via Mt. Magnet and Yalgoo.
- (c) *Air.*—An air service connects Cue with Perth, Geraldton, Kalgoorlie, and points north.

##### *Commonwealth and State Facilities.*

- (a) *Commonwealth.*—Post and Telegraph Office.
- (b) *State.*—Warden and Resident Magistrate's Office, Mining Registrar's Office, State Battery, Inspection of Mines Office, and office of the Goldfields Water Supply.

##### *Other Facilities.*

Consist of a branch of the Bank of New South Wales, together with three hotels and modest shopping facilities. There is a hospital, but the nearest doctor is at Big Bell.

##### *Water Supply.*

The town has a reticulated water supply drawn from wells at Nallan, 12 miles north. The water is exceedingly hard and saline.

##### *Mining Timber and Fuel.*

No useful mining timber is to be had in this "mulga" country—though small prospectors usually contrive to "make do". Wood for fuel is scarce in the vicinity of the town but is available within reasonable range.

##### *Acknowledgements.*

No type of survey can be executed without the co-operation of many organisations and individuals. The author is happy to record his indebtedness for diverse assistance rendered by officials of the Mines Department, Goldfields Water Supply, mine owners, prospectors, and many others too numerous for individual acknowledgement.

<sup>1</sup>Bull. 97, G.S.W.A., 1939, H. A. Ellis. Bull. 107, G.S.W.A. (awaiting publication), J. C. McMath.

<sup>2</sup>Ref. brief bibliography.

<sup>3</sup>Obtainable from Lands and Surveys Department, Perth.

### Mining Activity and Production Statistics.

Cue is one of the oldest mining centres in the State, owing its discovery to—and taking its name from—Tom Cue who found alluvial gold in 1891 on an area subsequently known as "The Patch". "The Patch" lies on the northern boundary of the present town.

By 1893 the character of the gold winning had changed from that of alluvial diggings to that of "hard rock" mining.

With the exception of the well known Great Fingall Mine (shut down shortly after World War I), the general history of the area is one of small and short lived ventures. The Great Fingall Mine was originally known as the Day Dawn (discovered in 1891) from which the town takes its name.

At the time of writing (1950) prospecting is virtually moribund with the exception of the drilling operations of the Great Fingall Exploration Company who are carrying out deep prospecting operations for a possible repetition in depth of the Great Fingall orebody. Within the area surveyed mining is mainly limited to "gouging" of old shows, the major exception being the Mountain View Mine at Day Dawn.

Total production of the area to the end of 1949 is as under:—

District.	Ore Treated.	Gold Therefrom.	Average Grade.
	long tons.	fine ozs.	dwts.
Cue ....	4,843,754·24	1,121,047·1	4·6
Day Dawn....	2,025,932·63	1,369,391·73	13·5
Totals ....	6,869,686·87	2,490,438·83	7·3

### Brief Bibliography.

Bull. No 7, G.S.W.A.—1903—Auriferous Reefs of Cue and Day Dawn—W. D. Campbell.

Bull. No. 8, G.S.W.A.—1903—Murchison Gold-field—C. G. Gibson.

Bull. No. 29, G.S.W.A.—1907—A report upon the Geology, together with a description of the Productive Mines of the Cue and Day Dawn Districts, Murchison G.F. Pt. I.—H. P. Woodward.

Annual Report, G.S.W.A. 1906—Day Dawn and Cuddingwarra—H. P. Woodward.

Annual Report, G.S.W.A. 1898—Cue and Lake Way Traverse—T. Blatchford.

Mining Handbook, 1919—Cue and Day Dawn Gold Deposits—A. G. Maitland.

### GEOLOGICAL NOTES.

#### Introduction.

The Area consists, in the main, of Pre-Cambrian folded rocks together with granites, granite-gneisses (largely the product of "granitisation" processes be what they may) and some younger basic intrusives. Apart from detailed mining investigations and some diamond drilling of certain leases<sup>4</sup> geological work has been confined to the broad general work carried out in the early years of this century. This work was, of necessity, incomplete (as is also the present work), yielding only the very general stratigraphic outline and but little conception of regional structure. It was to expand this knowledge in terms of current structural and stratigraphic advances, correlating these aspects with gold mineralisation (if possible) that the present work was undertaken.

#### Geomorphology.

The Area lies on the north-western boundary of "Salina-land"<sup>5</sup> and is, with its general mulga scrub vegetation, alluviated and eluviated terrains (comprising some 60 per cent. to 70 per cent. of the Area), isolated ridges of Pre-Cambrian rocks, "breakways," and "dry" lakes (Lake Austin and

its ramifications), quite typical of this physiographic division.

Major Positive Relief Elements consists of the following:—

- (i) Sharp (almost knife-edged) ridges of steeply dipping jaspilites which occupy the Area south of, and including, Mainland.
- (ii) Equally high, but more rounded and dissected, ridges of "Greenstones" as at Cue, Day Dawn, Cuddingwarra, and on the east and west flanks of the jaspilites at Moyagee in the south of the Area.
- (iii) The occasional granite "rocks"—as in the "Garden Granites" to the east of Cue on the Sandstone road.
- (iv) The "breakways," mesas, and buttes of "granitised" greenstones, granite-gneiss, etc. which form so prominent a part of the topography on the north side of the town. (Bull. 95—G.S.W.A. 1934—pages 234, 238 give good illustrations of these features).

These features have a general accordancy of summits (though they are dominated by Trenton Hill (approx. 1,620 ft. a.s.l.) and Cue Hill (approx. 1,653 ft. a.s.l.) and form part of the "Old Plateau" of Western Australia<sup>6</sup>.

Minor Positive Relief Elements consist of the following:—

- (i) Low rounded hills, rising very little above the general level, which largely consist of schistose greenstones or basic meta-sedimentary rocks. These are usually lateritised to lesser or greater degree. The country to the east of Cue and adjacent to the railway is typical as also are some localities between Day Dawn and Cuddingwarra.
- (ii) Occasional igneous intrusives of dyke form—e.g. the syenitic dyke intruded into the flat terrain of Pinnacles granite gneiss—which are so prominent in eluviated and alluviated landscapes. Quartz "blows," such as those to be seen north of the town, come into this category.
- (iii) "Island" residuals of doleritic intrusives usually taking a conical form) which rise above the alluvium as in Lake Austin and at Cuddingwarra to the north of the Big Bell railway spur line. These features are also well illustrated in the Bulletin previously cited.
- (iv) Sand dunes, vegetated and, otherwise about Lake Austin.

These features form intermediate steps between the "Old" Plateau and the "New" Plateau of the present cycle of erosion.

Negative Relief Elements consists of the following:—

- (i) The "dry" or "salt" Lake Austin and its ramifications.
- (ii) Wide flat alluviated and eluviated valleys—e.g. the country between Day Dawn and Cuddingwarra (especially about Austin Downs Homestead). These flat terrains may show pavements of granite-gneiss or meta-sedimentary rocks.

These features constitute the "New" Plateau under construction in the present cycle of erosion.

#### Drainage.

Drainage within the Area is internal, the focus being Lake Austin, and ephemeral. Creeks, with few exceptions debouch upon alluviated flats although all drainage ultimately finds its ways to the Lake; sheet flooding and sheet erosion are features. Few well defined drainage courses are to be found, although two major ones exist:—

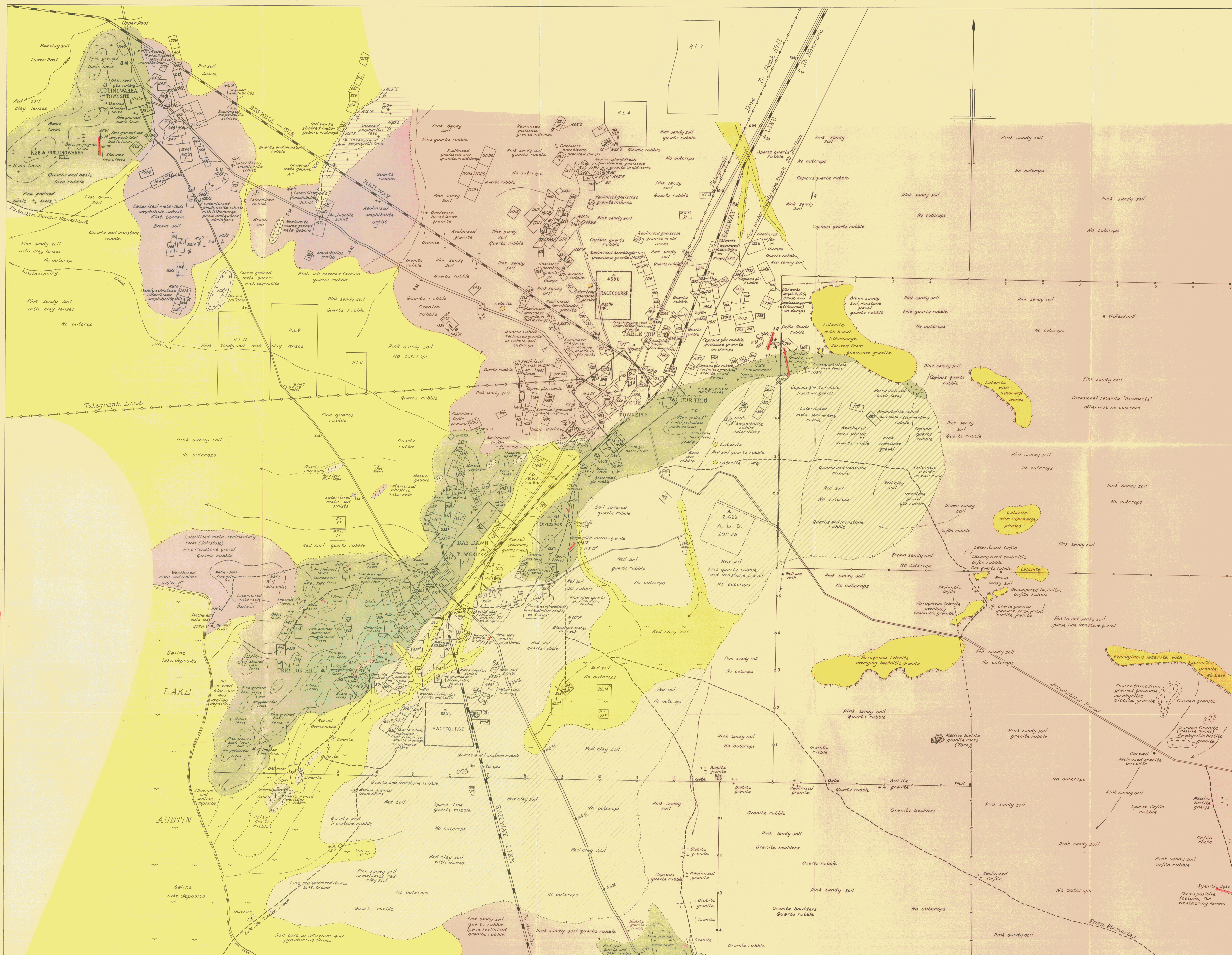
- (a) That which drains from Cue past Day Dawn to Lake Austin.

<sup>4</sup> Bull. 48, G.S.W.A., 1912, H. P. Woodward.

<sup>5</sup> Bull. 95, G.S.W.A., 1934, J. T. Jutson.

<sup>6</sup> J. T. JUTSON, op. cit.





LEGEND

- Laterite
- Alluvium
- Soil-covered areas (The nature of the underlying rocks cannot be inferred with any degree of certainty)
- PRE-CAMBRIAN
- Relationship obscure
- Metamorphosed sediments (consisting of siltstone, phyllite, mica schists, thin bands of gneiss with a development of acid porphyritic lavas)
- Metamorphosed basic lavas (fine to medium grained basic lavas, and pillow lavas and thin siltites (probably metamorphosed tuffs))
- Relationship obscure
- Metamorphosed sediments (Dominant type: siltstone, mica schists, thin bands of gneiss)
- Granite, Granite-gneiss and allied rocks
- Acid porphyritic minor intrusives
- Quartz reefs

REFERENCE TO SIGNS

- Observed geological boundary
- Approximate geological boundary
- Assumed geological boundary
- Faults
- Strike and dip of schistosity
- Strike of vertical schistosity
- Strike of schistosity with no observed dip
- Strike and dip of bedding
- Strike and dip of foliation
- Strike of vertical foliation
- Outcrops with no observed strike or dip
- Form lines
- Bluffs and breakaways
- Watercourses (Normally dry)
- Wells
- Fences
- Tracks
- Railways

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

RECONNAISSANCE STRUCTURAL MAP OF THE CUE-DAY DAWN DISTRICT

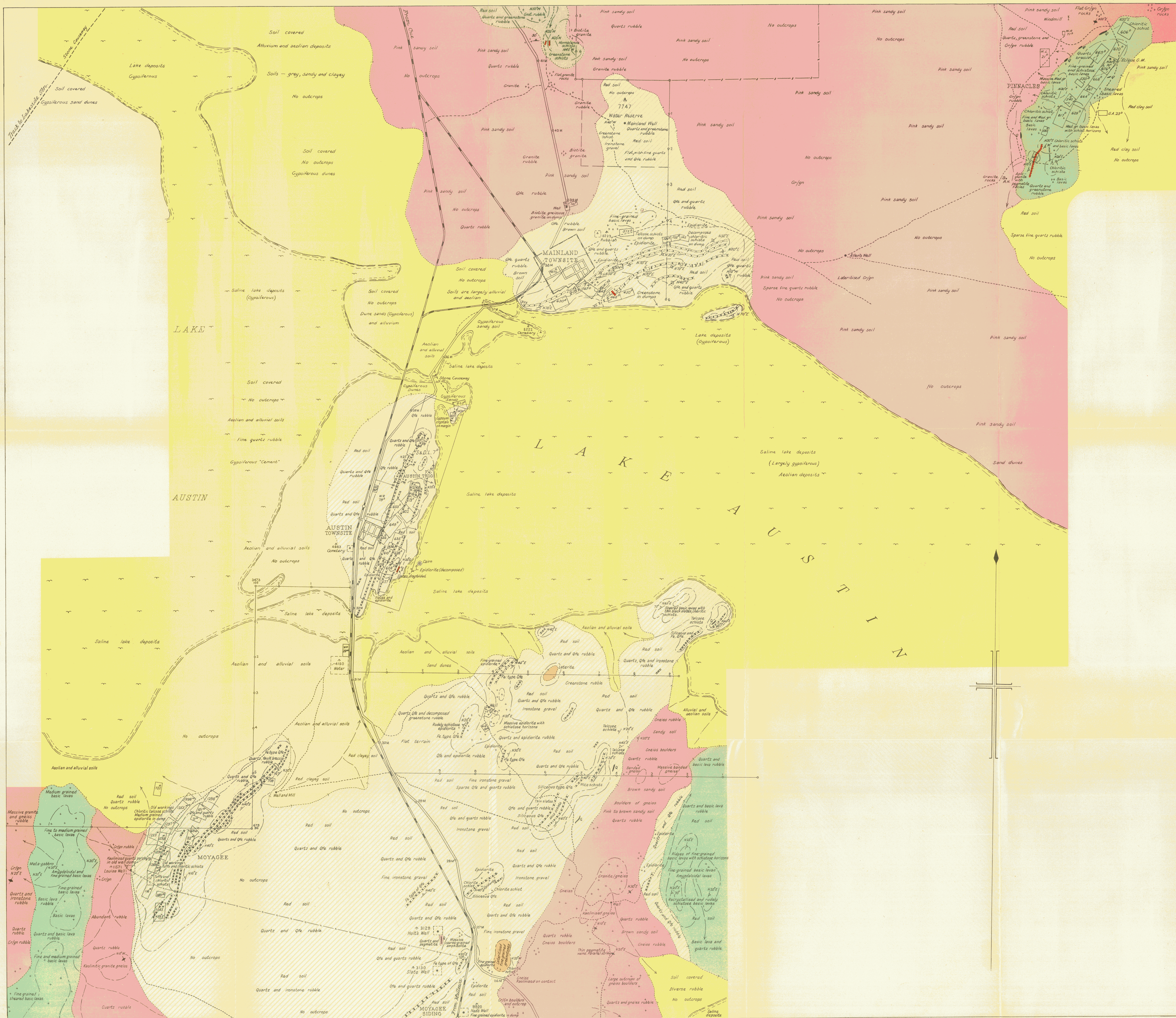
MURCHISON GOLDFIELD

SHEET 1

Scale: 40 chains = 1 inch

Geology by, J.C. Math, B.Sc., F.G.S. 1949-1950





**LEGEND**

Laterite  
 Alluvium  
 Soil-covered areas (The nature of the underlying rocks cannot be inferred with any degree of certainty)

**PRE-CAMBRIAN**

Relationship obscure  
 Metamorphosed basic lavas (Fine to medium grained basic lavas, amphibolites and pillow lavas and thin siltites (probably metamorphosed tuffs))  
 Metagabbro (Medium to coarse grained hornblende and hornblende - felsic rocks (minor intrusives))

Relationship obscure  
 Metamorphosed sediments (Dominant type: siltstone, mica schists, thin bands of gneiss)  
 Siltites

**SUBVOLCANIC ROCKS (Pre-Cambrian)**

Granite, Granite-gneiss and allied rocks  
 Acid porphyritic minor intrusives  
 Quartz reefs

**REFERENCE TO SIGNS**

Observed geological boundary  
 Approximate geological boundary  
 Assumed geological boundary  
 Faults  
 Strike and dip of schistosity  
 Strike of vertical schistosity  
 Strike of schistosity with no observed dip  
 Strike and dip of bedding  
 Strike and dip of foliation  
 Strike of vertical foliation  
 Outcrops with no observed strike or dip  
 Strike and plunge of dragfold  
 Rock Hole  
 Watercourses (Normally dry)  
 Wells  
 Fences  
 Tracks  
 Railways  
 Form lines  
 Bluffs and breakaways



- (b) The "Water Supply River" which drains from Cue to Lake Austin on the western side of the Trenton group of hills.

Otherwise drainage channels are better thought of as "trends."

Reference to the accompanying map shows that a very large measure of structural control is evident in the drainage pattern. This control is thought to be largely posthumous. Lake Austin, which might represent an original depression on an uplifted surface, shows in its ramifications a certain parallelism to regional structures. The main body of the lake, however, cuts across these structures at a large angle. The question of origin remains open.

The sand dunes about Lake Austin remain for comment.

Two types are distinguished:—

- (a) Yellow, fine grained, non-vegetated, gypsiferous dunes. These may carry a cap of gypsum bearing sandstone and, owing to proximity to road and railway, may be of future economic interest. They are Recent in age.
- (b) Fine grained, red to purple, vegetated dunes which are relics of a previous erosion cycle.

#### *The Folded Pre-Cambrian Rocks.*

Within the Area are rocks which have undergone folding on a regional scale, subsequent igneous intrusion, and "granitisation" in varying degree. The following elements, in their stratigraphic order, are distinguished:—

- (a) *Meta-sedimentary* rocks showing jaspilites as their most prominent topographic expression. They carry occasional thin amphibolite schist horizons and have been intruded by minor meta-doleritic rocks (also folded).
- (b) *Basic lavas* with very subordinate schistose meta-sedimentary horizons.
- (c) *Meta-sedimentary* rocks with developments of acid lavas, occasional thin amphibolite schists.
- (d) *Meta-gabbro* and dolerite minor intrusives.
- (e) Occasional small quartz-porphyry dykes and/or sills.

The development of the meta-sedimentary rocks with jaspilites is confined to the Moyagee-Austin-Mainland area. The jaspilites comprise the bulk of the outcrop (excepting granitic gneiss). These jaspilites vary from siliceous cherty to ferruginous types; are, in places, highly contorted and drag-folded, and show, in the Moyagee locality, a gradation to granitised equivalents and thence to granitic gneiss which may preserve original structures.

The basic lavas, which are stratigraphically younger than the jaspilitic meta-sediments, may be seen in juxtaposition with them in the Moyagee area. These lavas range in type from fine grained basalts and amygdaloidal lavas to porphyritic and pillow types. The Porphyritic lavas usually have feldspar as phenocrysts. Tuffaceous horizons, now slates, occur. As a whole the lavas present a fresh appearance although some re-crystallisation has taken place and the development of chlorite is to be noted in places. These lavas have their maximum occurrence in the Trenton and Cue groups of hills.

Neither base nor top of these two units have been recognised, although the Moyagee granitic gneiss represents in part the lower portion of the jaspilitic meta-sediments. Also, the relation between these meta-sediments and the basic lavas is not to be seen. It may be conformable or unconformable. Paucity of outcrop has necessitated inferred boundaries between the two units.

West of Trenton Hill and ranging as far as Cuddingwarra (and southwards to Lake Austin) are thin quartzites, amphibolitic and mica schists. In the centre of this area is a development of acid lavas, ranging in texture from felsitic to porphy-

ritic. Flow tops are to be seen. From structural evidence these meta-sediments are younger than the basic lavas. Again, due to paucity of outcrop, the relation between these rocks and the basic lavas is nowhere to be seen. It may be conformable or unconformable. Nowhere has either base or top been seen. These rocks furnish but minor topographic elements and are characterised by deep weathering, a tendency to be kaolinised to some depth, and a varying degree of lateritisation.

In the foregoing are gabbroic and doleritic minor intrusives which have also undergone regional folding. Soil cover largely obscures the relations of these two younger meta-sedimentary rocks. It is, however, in the basic lavas that it can best be seen that they have undergone regional folding.

These meta gabbros are medium to coarse and equigranular in texture; they may be blocky or rudely schistose. In mineral composition they vary between approximately equal proportions of amphibole and feldspar to a type in which amphibole predominates. The amphibole may be clustered in knots giving a porphyritic look to the rock. Quartz is present in minor amount. Pegmatoid phases have been noted.

The most interesting of these bodies is a sill form, intruded into the basic lavas (in which pillow lavas predominate) of Day Dawn. This body extends from the Strathmore Mine (G.M.L. 592D, abandoned) in the south, northwards through the Trenton Mine (G.M.L. 148D, abandoned) and the Pingall Leases. This sill is intimately connected with the Pingall ore bodies over whose distribution it exercises a structural control. More detailed work should prove of value to the local mining community.

Associated with both the jaspilitic meta-sedimentary rocks, the basic lavas, and the Day Dawn-Cuddingwarra meta-sediments are occasional quartz-porphyry sills and/or dykes which show the same structures as have been imposed upon the folded rocks. They largely appear to be concordant intrusives and may be seen, for example, in the vicinity of G.M.L. 425D, at Day Dawn. They have not been noted in relation to the later meta-gabbros and dolerites.

#### *Post-Folding Rocks.*

Associated with the folded-Pre-Cambrian rocks are major and minor acid igneous intrusives and a few small basic dykes. There is no field evidence as to their mutual relations in time. As far as observable—gold quartz reefs come into this category. These rocks then are:—

- (i) *Magmatic granites* (previously referred to) together with minor acid intrusives associated with them. These minor acid intrusives are dominantly quartz-porphyrines, though micro-granites occur. In no case was any minor intrusives seen directly as an apophysis of a major granite though their general proximity to granites makes this inference valid. These rocks, on available evidence, are post-folding and post "granitisation" in age.
- (ii) A *massively jointed*, coarse and equiangular grained syenitic dyke of approximate east-west trend intruded into the granitic gneiss of the north Pinnacles area. This rock carries very subordinate quartz, and about approximately equal quantities of pyroxene and feldspar. There is some secondary amphibole. In age this rock can only be rated as "post-granitisation."
- (iii) *Small doleritic dykes*, usually showing chilled margins. These are known from old workings in the hybrid gneissose granite to the west-north-west of Cue, (e.g. G.M.L. 1296). They are post magmatic granite and post gold mineralisation in age.
- (iv) *Gold-quartz veins*—these occur in all members of the folded Pre-Cambrian Rocks and in the hybrid gneissose granites; hence they are post-magmatic and pre-dolerite in age.



### Recent Deposits.

Some 60% to 70% of the Area is covered by Tertiary-Recent deposits. These deposits comprise:—

- (i) *Laterites (incl. "cements")*. The broad distribution of laterites is confined to traces of the "Old" and "New" Plateaux of Jutson<sup>7</sup> where they form the spectacular "breakaways," buttes, and mesas to the north of Cue and the "breakaways" bordering Lake Austin in the south-west corner of the area respectively. Thus they are associated with the granitic gneisses and meta-sedimentary rocks respectively and, accordingly, are dominantly alumina and iron rich in type. Of interest is the development of a considerable kaolinitic basal phase, especially in those laterites associated with the Day Dawn-Cuddingwarra meta-sediments. Between the "Old" and "New" Plateaux are to be found "cements." These occur on both granitic and greenstone terrains and may be of considerable thickness.

- (ii) *Lacustrine Deposits and Alluvium*. The former are confined to Lake Austin and its ramifications. Of very variable thickness, they are heavily saline with calcium sulphate appearing preponderant.

Alluvium is confined to the major drainage trends and ranges between a few inches up to about 30 ft. in maximum thickness.

- (iii) *Aeolian Deposits* are of two types—one largely non-vegetated and gypsiferous and the other red to liver coloured and vegetated. Both are associated with Lake Austin. They have been referred to previously.

- (iv) *Soils (residual)*. Residual soils within the Area rarely achieve a depth of more than 10ft. Their characteristics are dependent upon the nature of the underlying rock. The following main types are distinguished:—

- Brick red* clayey soils derived from basic lavas.
- Red soils*, lighter in colour than the above, associated with argillaceous meta-sedimentary rocks.
- Pink sandy soils* associated with granites and granitic-gneisses.
- Brown to grey soils* associated with the metagabbros and dolerites. These may have a green tinge due to undecomposed amphibole.
- Light yellow-grey* sandy soils associated with quartz porphyries and highly siliceous metasedimentary rocks. Their distribution is limited.

### Sequence of Rock Types and Events.

From the foregoing the following sequence of rock types and events is given for the Area. It cannot be regarded as final and must remain open for revision resulting from any future work:—

Age.	Description.	Remarks.
Recent ....	Soils—lake deposits and sand dunes in part	Various types.
Tertiary to Recent	Alluvial, lake deposits, sand dunes in part	These deposits may be younger or older than the laterites. Probably deposits of both ages occur. The "red" dunes are older than the yellow gypsiferous dunes.

<sup>7</sup> Op. cit.

Age.	Description.	Remarks.
Tertiary ....	Laterites, ferruginous and otherwise, and "cement" deposits	W.A. laterites are generally rated as of Tertiary age.
Pre-Cambrian ? Proterozoic	Doleritic minor intrusives and one syenitic dyke	Great Unconformity. Beyond being post "granitisation" and granite plutons, their stratigraphic position is unknown.
Pre-Cambrian Archeozoic	Small granite plutons—some acid minor intrusives, "Garden" granites, etc.	Contact ----- Granites are biotitic types and may be porphyritic. Acid minor intrusives range from microgranites to quartz-porphyrites. Small pegmatite phases may occur. Period of gold mineralisation. Post "granitisation" and folding.
	----- Igneous Contact -----	
	Granitic gneisses of Moyagee, Cue, Pinnacles	Period of "granitisation" affected folded rock some measure
	Period of Earth Movements. Meta-gabbro and dolerite dykes and sills	May show pegmatite phases. Have folded.
	----- Igneous Contact -----	
	Meta-sediments and acid lavas of Day Dawn - Cuddingwarra area. Quartz porphyry minor intrusives	Lie in synclinal younger than basic lavas. Folded rock
	----- Relationship Unknown. -----	
	Basic lavas—including pillow, amygdaloidal, porphyritic types. Quartz porphyry minor intrusives Schistose tuffs	Folded rocks.
	----- Relationship Unknown -----	
	Meta-sediments including jaspilites of Austin-Moyagee areas	Folded rocks.
	Granitic gneisses of Moyagee	Represent granitised jaspilitic meta-sediments lower in succession than above.

The sequence of Pre-Cambrian events and rock types of the Area bear considerable resemblance to those of the Yilgarn and Coolgardie Goldfields, but there being as yet no direct evidence of close connection in time (beyond the regional folding) and space with these latter Goldfields, and since such lithologic sequences tend to be common throughout various periods in the Pre-Cambrian terrains elsewhere in the world, it is considered that correlation of these ancient folded and non-folded rocks with those elsewhere is at present premature. Equating by lithological analogy over the distance involved is dangerous, however tempting. The folded rocks may or may not be equivalent to the Yilgarn-Kalgoorlie System.

### Metamorphism.

Within the Area all folded Pre-Cambrian rocks have, in greater or lesser degree, been metamorphosed. The following types of metamorphism are recognised:—

- Regional Metamorphism.
- Metamorphism by "granitisation" processes.
- Contact metamorphism.

The above is the observed order of relative magnitude. Chronologically, regionally, regional metamorphism preceded "granitisation". Contact metamorphic effects were seen to be limited in nature

and degree but are associated with both pre- and post-folding minor intrusives.

(a) *Regional Metamorphism* is, generally, of low grade—the effects usually being some re-crystallisation of rocks together with the formation of chlorite. These effects are best seen in the basic lavas and the folded meta-gabbroic rocks which are more resistant to weathering and present a remarkably fresh appearance. No metamorphic “highs”, such as are seen in analogous rocks of the Coolgardie District, were noted. The events leading to regional metamorphism have impressed a very constant schistosity (varying but few degrees east and west of north) upon the folded rocks. Such schistosity swings in the vicinity of minor “cross-flexures” (which may ultimately prove to be major drag-folds) as in the locality of G.M.Ls. 652D and 511D in the Day Dawn District.

(b) *Granitisation*.—The fact that solid rocks have been converted to rocks of granitic character is indisputable—it is not proposed to enter into controversy as to processes, effectiveness, or scale of operation. Sufficient body of field evidence exists to demonstrate that complete granitisation of solid rocks in situ may be effected, together with the preservation of pre-existing structures. Reference may be made to the following:—

- (i) Granitisation and Associated Processes—A. C. Macgregor and G. Wilson—Geol. Mag. Vol. 76—1939.
- (ii) Origin of Granite—Memoir 23—1943—Geological Society of America.
- (iii) Evolution of Metamorphic Rocks—Memoir 30—1945—Geological Society of America.

The author regards the problem of granitisation as falling within the province of metamorphic geology.

The following main elements are seen in the Area:—

- (i) Granites of undoubted magmatic origin.
- (ii) The granitic gneiss areas.
- (iii) The areas of highly kaolinised and quartzose rocks (usually metasediments) which may occupy significant positions with regard to the major structures of the basic lavas and jaspilite metasediments.

Poor outcrop conditions have necessitated that, in large part, geological boundaries be “inferred” or “approximate”. It has not proven possible, for the same reason, to differentiate granites and granitic gneisses in the northern part of the Area. Accordingly they have been mapped as “Granite-Gneiss”.

I.—Granites of magmatic origin include the “Garden Granites” to the east of Cue and that exposed at the 393 Mile on the Northern Highway. They are biotitic granites with a dominant potash feldspar. Some portions are porphyritic. No clear-cut contacts either with the folded rocks or gneisses were seen. They may be regarded as apices of a sub-jacent body of batholithic dimensions. Exposure of these granites occur both as “rocks” and flat pavements—as also do exposures of the granitic gneisses.

II.—Granite Gneisses occur in both the basic lava and jaspilite horizons of the folded rocks as well as in the Day Dawn-Cuddingwarra metasediments. This location with regard to regional structures is of interest and will receive comment later. The following broad division can be made in the field:—

- (a) Those granitic gneisses arising from granitisation of the metasediments in the lower portion of the folded rocks. These are best exposed and examined in the eastern portion of the Moyagee locality; again to the south of the Louise Well (Moyagee); and, in less satisfactory manner, on the northern end of the Pinnacle hills. They consist of banded gneisses, the banding

of which may consist of either melanocratic and leucocratic minerals or of leucocratic banding only. These granitic gneisses may be porphyroblastic and show fine pegmatitic developments parallel to the gneissosity or to the jointing. The gneissosity has the regional strike, and many of the structures of the adjacent meta-sedimentary rocks have been preserved. Transition zones between meta-sedimentary rocks and the granitic gneisses are apt to be characterised by quartz “blows” as in the east Moyagee area and again at Pinnacles and elsewhere.

In the northern section of the east Moyagee area a very clear transition from meta-sedimentary rocks to granitic gneiss can be seen—the transition is distinguished by the bleaching of the jaspilites and the development of a fine grained saccharoidal texture, finally merging into the granitic gneiss. Such fine grained bleached residuals were noted in the granitic gneiss north of Pinnacles and give the appearance of flat plates of fine grained quartzite.

The structural environment of this broad division, whose major development is around Moyagee, is as follows:—

- (a) *East Moyagee*—in core of regional anticlinorial.
- (b) *West Moyagee*—in a metasedimentary horizon on the western limb of the abovementioned structure. Southwards towards Wandari and Mt. Magnet the terrain is occupied by granitic gneisses in which small residuals of regionally trending jaspilites have been noted.

III.—Granitic gneisses arising from granitisation of the basic lava component of the folded rocks. These are particularly in evidence to the north of Cue where the process may be seen along a fairly sharply defined transition zone in the vicinity of G.M.L. 809.

These rocks give the appearance of being coarse grained and gneissose hornblende granites. They constitute the “gneissic granites” of the older writers.

Along the transition zone between basic lavas and this amphibole granitic gneiss the following phenomena have been noted:—

- (a) Granitisation qua granitisation in the vicinity of G.M.L. 809. This has received mention.
- (b) Westwards, through Cue toward Cuddingwarra, the process seems to have become magmatically active and the coarse grained gneissose granite carries basic lava xenoliths in varying stages of digestion. This is particularly evident from material from mine dumps in the area.
- (c) Northwards from Cue these gneissose granites tend to become finer in grain; amphibole may diminish almost to zero; biotite may become more prominent except in the vicinity of large relicts of basic lavas remaining unassimilated. These relicts have, in the past, been regarded as later intrusions. They are exposed in mines, now inaccessible, such as the Light of Asia and the dumps thereof. Later basic intrusions do, however, occur, e.g. that of G.M.L. 1296, but chilled margins occur.

IV.—Certain horizons, largely tuffaceous and meta-sedimentary, of the basic lavas—e.g. those to the east and west of Day

Dawn—show a tendency to be kaolinised to considerable depth. Such kaolinisation may be associated with lateritisation but the vertical distribution of this tendency suggests that it may coincide with a vertical limit of granitisation and that this latter process has impressed upon the rocks a pre-disposition to weathering of this type. This is purely speculative and the question must, for the present, remain open.

Granitisation is intimately bound up in space and time with regional metamorphism and with what is regarded as normal igneous activity, and it is difficult to consider these effects as divorced and unrelated phenomena. Of the scale of granitisation within the Area—it is remarked that the granitic gneiss greatly predominates in area over the intrusive granites.

The sequence, if sequence it be, of what may be termed "igneometamorphic" events appears to be:—

- I. Granitisation affecting both basic lavas and metasediments—the effects being apparently at a minimum, as far as observed, in the Day Dawn-Cuddingwarra metasediments—i.e., there appears to be an upper or vertical limit.
- II. Magmatic phase during which granitic magma (? mobile phase of granitisation) has intruded granitised rocks (the granitic gneisses in the Mainland and Garden Granite localities) and basic lavas, assimilating the latter in part.

Current "granitisation" thought as exemplified by Read and Reynolds<sup>8</sup> requires a "basic front". Where is—or what has become of—this "front" within the Area?

The distribution of the granitic gneisses within the Area does not seem entirely fortuitous. The core of the broad regional anticlinorial structure from Moyagee northwards to Cue is occupied by these rocks—which also breach (replace?) the eastern limb in part. A suspected major anticlinorial cross flexure, whose axial zone is about Nallan, is almost entirely represented by gneisses, though the Day Dawn-Cuddingwarra metasediments together with younger doleritic and gabbroidal intrusives are to be seen a mile or two north of the Big Bell road between Cue and Cuddingwarra.

In relation to adjacent territory to the west, the Area shows the same broad igneous and metamorphic features. The recent work of Messrs. Hobson and Johnson<sup>9</sup> has effectively demonstrated the existence of a major batholithic body fringed by granitic gneisses and residuals of folded Pre-Cambrian rocks. The rocks of the Area form portion of the fringe on the eastern flank of this batholith which presents many of the features of the "mantled gneiss domes" of Eskola.<sup>10</sup>

#### *Regional Structure.*

Regional folding has affected the older Pre-Cambrian rocks of the Area—the jaspilite, basic lava, and younger metasedimentary series.

Elucidation of the broad structure hinges upon the distribution and attitudes of:—

- (a) The jaspilitic series of meta-sediments.
- (b) The basic lavas series.

The jaspilitic series are confined to the area south of Mainland whilst the basic lavas occur to the north and extend as far as Cue. They also have a minor development in the Moyagee area.

The jaspilitic series of Mainland and Moyagee demonstrate an anticlinorial structure whose axial zone (which is occupied by replacement gneiss) trends approximately north-south. Of this structure only the western limb and nose (comprised

of the Mainland jaspilites) is complete. The eastern limb consists of the east Moyagee jaspilites which are flanked by basic lavas on the east. Southwards the structure becomes lost in the replacement gneiss, though the western limb may be traced as small pendants of jaspilite in the gneiss for some seven miles southwards. From drag-folding in the jaspilites the structure has a steep northerly plunge. Briefly, south of Mainland an anticlinorial structure, with a steep northerly plunge, exists. On both limbs it is flanked by basic lavas, and its axial zone, together with a horizon on the western limb, have been granitised. No evidence of isoclinal or overturned folds was seen—evidence from elsewhere in the area suggests that subsidiary folding may be relatively gentle. Minor structures may sometimes be seen preserved in the replacement gneiss.

Northwards from Mainland the outcrops of the Day Dawn and Cue basic lavas conform in symmetry with the Moyagee anticlinorium. Consideration of bedding-schistosity relations, regional schist dips and strikes, together with pillow lava facings (not clear-cut) point to these lavas being part of the Moyagee anticlinorium. As in the latter structure, the basic lavas present a reasonably complete western limb and nose, whilst the eastern limb is only represented by the Pinnacles basic lava pendant—the remainder of the structure being lost in replacement gneiss. The same steep northerly plunge is evident. Again, the axial zone between Mainland and Cue is occupied by replacement gneiss. Until evidence to the contrary is forthcoming the jaspilite metasediments and the basic lavas are regarded as integral parts of the same north plunging anticlinorium. A problem of scale of development of this portion of the Pre-Cambrian arises since there is a gap, occupied by gneisses, of some ten miles between the nose of jaspilites at Mainland and that of basic lavas at Cue. This gap would represent the disappearance of some 50,000ft. of lavas and sediments. How much of this thickness is due to repetition by internal folding of the anticlinorium? Or, despite general evidence, are the jaspilites and basic lavas portions of different structures? The general stratigraphic relations do not support this possibility—but it remains a possibility, even if remote.

Symmetry considerations of this anticlinorial structure would demand a complementary synclinorium in the Day Dawn-Cuddingwarra area. The basic lavas of Cuddingwarra and Day Dawn together with the meta-sedimentary rocks in between show in their bedding and schistosity relations, pillow lava facings, and general schist dip and strike detail, that the area is synclinorial. Of interest is that some meta-sediments on the shores of Lake Austin in the south-west of the Area show bedding with a northerly dip of 30°.

"Cross-folding" as seen in the Yilgarn and Coolgardie Goldfields, is not apparent in the Area. In the vicinity of the Creme-d'Or Mine and Great Fingall (Day Dawn) there is a suggestion of a "cross-flexure," which could be a major drag-fold on the western limb of the anticlinorium. It is of interest in relation to the Fingall ore bodies.

Rapid, reconnaissance northwards of Cue to Tuckanarra suggests that what can now be called the "Cue Anticlinorium" may be reflected in this locality. Should this prove to be the case, then the Nallan greenstones may mark a "cross-fold" axial zone. Further work is necessary to prove or disprove this suggestion. A detailed study of the following in this possible "cross-fold" zone might prove of economic interest:—

- (a) The broad structural venue of gold deposition at Tuckanarra.
- (b) The broad structural venue of the above compared with the Cue structure.
- (c) The relation of this possible "cross-fold" to the Big Bell gold deposition.

#### *Gold Mineralisation and Regional Structure.*

Within the Area gold deposition takes the form of auriferous quartz reefs and lodes. Both modes may occur separately or in association. "No quartz, no gold," as in the Yilgarn and Coolgardie Goldfields, was found to be applicable.

<sup>8</sup> D. L. REYNOLDS, Q.J.G.S., Vol. CII, Pt. 3, 1946.

<sup>9</sup> A.P.R., G.S.W.A., 1943, "Progress Report on the Geology of portion of the North-West Division"—W. Johnson.

<sup>10</sup> "The Problem of Mantled Gneiss Domes," P. E. Eskola (Q.J.G.S., Vol. CIV—1949.).



The distribution of past and present mining leases which have a production record, shows that the major occurrences of gold are largely confined to the Cue anticlinorial structure. Within this major structure further restrictions are noted:—

- (i) Major concentration of ore bodies is confined to the nose and western limb of the structure.
- (ii) Ore bodies decline in number, size, and grade southwards along the western limb.
- (iii) Significant gold mineralisation is confined to:—
  - (a) the jaspilitic meta-sediments of the Mainland-Moyagee locality;
  - (b) the meta-sedimentary horizons underlying the basic lavas in the Cue-Day Dawn area;
  - (c) the granitic gneisses (granitised folded rocks) with associated unassimilated relicts of basic lavas and younger folded meta-dolerites which occur immediately to the north of the north plunging nose at Cue. In the distribution and attitude of these ore bodies there is no suggestion that they favour a stratigraphic horizon now granitised, but rather that they result from control of mineralisation by shears developed in the anticlinorial nose and parallel to the axis thereof;
  - (d) the margin of the folded meta-gabbro sill at Day-Dawn.
- (iv) Significant gold deposition on the eastern limb is confined to the basic lavas of the Pinnacles where it is associated with minor acid intrusives with lode material as the dominant mode of occurrence. At the Moyagee end of this limb, no ore bodies have been located, although a very small amount of alluvial gold has been obtained.
- (v) The virtual absence of any significant gold deposition in the meta-sediments of the Day Dawn-Cuddingwarra synclinorial.

It would seem, within the Area, that:—

- (i) Two favourable broad horizons for gold deposition exist.
- (ii) Major deposition is confined to the western limb and north plunging nose of the anticlinorium.
- (iii) There is an upper limit of gold deposition as indicated by the virtual barrenness of the Day Dawn-Cuddingwarra meta-sediments.

No studies of localisation of ore bodies could be made owing to the essentially reconnaissance nature of the work, but the known association of the Fingall ore bodies with the warping and folding of the Day Dawn meta-dolerite still may be a typical structural control on the limbs of the anticlinorium. On the steeply north plunging nose of the regional structure, localisation of ore bodies may be related to shear patterns consequent upon the regional folding. More detailed studies are required.

Gold, in the free milling state, occurs within the Area associated, sometimes strongly, with pyrites, arsenopyrites, chalcopyrites, and to a very small degree with bismuth bearing sulphides. The association of gold and arsenopyrite is usually indicative of increasing gold values. Of significance is the distribution of these associated metals, the gold-copper-arsenic association being confined to the western limb and nose of the structure in the broad horizon of the basic lavas. The gold-arsenic-bismuth suite appears confined to the Pinnacles portion of the eastern limb—again in the broad horizon. In addition to the foregoing minerals, the following have been recorded in the Area:—

Sphalerite.  
Galena.  
Pyrrhotite.  
Scheelite.

#### Recommendations.

The nature of the survey precludes any but very general recommendations. Accordingly it is suggested that further prospecting may be repaid in:—

- (i) The area between Day Dawn and Lake Austin along the zone of the meta-dolerite sill.
- (ii) The anticlinorial nose in the vicinity of the Mainland and Lake Austin, where the structure is breached by the Lake.

#### Water Supplies.

For the benefit of those interested in prospecting the following water points within the area are given:—

Well or Shaft.	Depth and Water Level.		Capacity.	Remarks.
	Depth Feet	W.L. Feet	G.p.h.	
Moyagee	80	30	?	
Holts Well	66	2	25	
Marchesi's Well	45	29	30	Good stock water.
State Well	84	48	80	Brackish.
Pinnacles Well	53	51	450	Fresh.
Mainland Well	60	31	40	Fresh.
Garden Granite	80	70	80	Fresh.
Louise Well	86	70	20	Good stock water.
Day Dawn Town Well	73	50	68	Fresh.
Sanitary Well	70	48	27	30 grs. salt.
Rose of England	175	118	100	70 grs. salt.
St. Albans	?	70	2,500	Salt, 150 grs.
H.L. 25	86	65	70	34 grs. salt.
Yarraquin Dairy Well	70	58	108	58 grs. salt.
Slaughter Yard Well	?	62	480	44 grs. salt.
Brewer's Well	?	?	1,000	28 grs. salt.

#### REPORT ON PROGRESS OF A GEOLOGICAL SURVEY

of the

METROPOLITAN AREA AS AT 31/12/50.

By J. C. McMath, B.Sc. (Hons. Lond.), F.G.S.,  
M.A.I.M.M., Senior Geologist.

#### CONTENTS.

	Page
Introduction	13
Industrial Liaison	14
Industrial Rocks and Minerals of the Area	14
Definition of the Area	14
Reference Maps	14
Sample and Locality References	14
Personnel	14
The Armadale Sub-Area	14
Communications	14
General Geological Outline	14
Brief Outline of Economic Results	15
Summary	16
Acknowledgments	16

#### APPENDIX I.

Results of Industrial Testing of Samples	16
--	----

#### Introduction.

Past work of the Geological Survey in the Metropolitan Area has largely centred about economic aspects of geology—usually related to specific problems, e.g. water supply, brickmaking materials, limestones, etc. Unofficial work has concerned itself with more academic aspects of local geology. Resulting from this work is a large and diverse literature, usually strictly localised in character. The Metropolitan Area, until the present work, has never been systematically investigated in its geological entirety—the sole geological map of the

Area being a compilation from the unpublished maps of the late H. P. Woodward (a former officer of the Geological survey).<sup>11</sup>

Economic pressures and the accelerated expansion of the metropolis in space and industrial activity emphasised the need for an overall knowledge of the fundamental geology and geological resources of the Area. To this end the present work was undertaken. Its objects are:—

- (i) Location and appraisal of industrial rocks and minerals within the Area.
- (ii) Indication to interested parties of possible sources of such raw materials as are in urgent demand and short supply.
- (iii) Reconnaissance investigation of the hydrogeology of the Area.
- (iv) A broad outline of contemporaneous land utilisation within the Area.

The achievement of these objects necessitated detailed geological mapping of the Area. This was started on 14th August, 1950.

#### *Industrial Liason.*

To relieve, as rapidly as possible, urgent demands upon local geological resources required rapid means of:—

- (i) Evaluation as to industrial suitability of materials sampled.
- (ii) Assessment of scale of use.
- (iii) Equitable distribution of information to interested parties.

This was achieved, more or less satisfactorily, through the Chamber of Manufactures of W.A. and its sub-organisations together with the State Brick Works and Western Australian Government Railways.

Evaluation as to suitability of materials was undertaken by:—

- (i) Brisbane & Wunderlich Ltd. with respect to ceramic materials—including tile clays.
- (ii) State Brick Works—with respect to brick earths and shales.
- (iii) Tomlinson Steel Pty. Ltd. and Western Australian Government Railways with respect to natural and synthetic foundry sands.
- (iv) Geological Survey of W.A.—approximate estimation of total carbonates in limestones.

Distribution of information takes the form of interim reports which are circulated to industry through the Chamber of Manufactures of W.A.

#### *Industrial Rocks and Minerals of the Area.*

The chief industrial rocks and minerals which may occur are:—

- Clays and Shales—brick, tile, pipe making.
- Clays—minor ceramic uses—cement.
- Sands—foundry uses, glass, filters, etc.
- Diatomaceous earths—filters, etc.
- Gravels—road surfacing—aggregate material.
- Limestone—chemical, industrial, and agricultural uses—dimension stone.
- Marls—agricultural uses, etc.
- Salt—industrial uses.
- Refractories other than clays and shales (possible in the Pre-Cambrian rocks).
- Igneous and Metamorphic Rocks—dimension stone and aggregate material.

#### *Definition of the Area.*

The maximum area authorised for investigation extends from the latitude of Muchea southwards to that of Safety Bay. The eastern boundary of the Area approximates that of Glen Forest.

For convenience of operation, determined by demand priorities of materials (clays, limestones, foundry sands), communications, and proximity to the city, the Area was sub-divided into areas

centred about Armadale, Bullsbrook, and the city of Perth. The foregoing considerations, together with existing geological information, determined the order of treatment—Armadale being first, followed by Bullsbrook, with the built up city area last.

A start was made on 14th August, 1950, in the Armadale area which was completed in mid-December. Some 500 square miles were mapped to a scale of 20 chains—1 inch, prospected, and sampled. Some 145 samples were taken and are in the course of evaluation for industrial suitability. Where testing of samples warranted, "follow-up" boring with hand equipment was carried out.

*Reference Maps* to the Metropolitan Area as defined for the purpose of this Survey are:—

Lands and Surveys Department Lithos:—

29/80—31/80, 341A/40, 341B/40, 341C/40, 341D/40.

Military Maps 1 inch=1 mile.

Mundaring	....	Zone I No. 309
Yanchep	....	Zone I No. 392
Toodyay	....	Zone I No. 393
Perth	....	Zone I No. 398
Fremantle	....	Zone I No. 404
Kelmscott	....	Zone I No. 405
Rockingham	....	Zone I No. 410
Jarrahdale	....	Zone I No. 411

*Sample and locality references* are, for convenience and brevity, given in terms of the military grid. This grid will be incorporated on the published geological map. For results of sample testing to date, reference may be made to Appendix I.

*Personnel.*—Six professional officers (including one temporary) were engaged upon this survey during the period. They were:—

Geologist.	Function.	Period.
J. C. McMath	In charge	14 Aug.—31 Dec., 1950
N. M. Gray	Field duties	14 Aug.—31 Dec., 1950
J. Sofoulis	Field duties	14 Aug.—31 Dec., 1950
L. E. de la Hunty	Field duties	14 Aug.—31 Dec., 1950
G. H. Low	Field duties	14 Aug.—31 Dec., 1950
A. Glance	Field duties	14 Aug.—18 Dec., 1950

#### *The Armadale Sub-area.*

##### *1.—Communications.*

Armadale is situated 18 miles south of Perth upon the Perth-Bunbury railway at the junction with the main line with a spur to Fremantle. Major north-south roads are:—

- (i) Perth-Bunbury road—which skirts the foot of the Darling Range.
- (ii) Fremantle-Mandurah road.
- (iii) Armadale-Fremantle road.

These major highways are connected by a plexus of dirt roads—road accessibility in the area can be rated as very good. South of Serpentine the east-west accessibility becomes poor.

##### *2.—General Geological Outline.*

From east to west the broad geological elements of the Armadale sub-area are:—

- (i) The Pre-Cambrian rocks of the Darling Range and scarp. These consist of granite gneisses and minor epidioritic intrusives. On their western margin they are flanked by the Pre-Cambrian meta-sedimentary Cardup Series—of economic interest by reason of the shales in the lower portion. The Cardup Series has been traced from Gosnells to Serpentine. Associated with these rocks are Recent residual deposits such as clays and laterites.

<sup>11</sup> Handbook Aust. Assoc. Adv. Sci.—Perth, 1926. "The Geology and Physiography of the Neighbourhood of Perth."—E. de C. Clarke.

(ii) A piedmont zone on the western slopes of the scarp consisting of residual deposits together with alluvial fan material. This zone is variable, though narrow, in width. The deposits of this zone are Recent in age.

(iii) Succeeding the abovementioned zone is one of vegetated siliceous sand dunes which are dissected by diverse, and interrupted, drainage systems. The major drainage systems are those of the Canning and Serpentine Rivers and the Wongong Brook. Clays and loams are confined to these drainage lines. Westwards these argillaceous deposits become estuarine in character and appear to underlie the vegetated siliceous dunes. At present these clays are considered late Tertiary in age; the siliceous dunes may be of a like age.

(iv) A coastal belt of calcareous sand-dunes which are vegetated. These dunes are fringed on the coast by "live" dunes deriving from the present beach. Between these calcareous sand-dunes, which form positive relief features, and the coast in the Rockingham-Safety Bay locality are a well defined series of old beach ridges paralleling the present coastline—these consist of highly calcareous sands and are vegetated. These calcareous sand-dunes and beach ridges overlie the marine element of the Coastal Limestone Formation. Present sampling indicates that these calcareous sands become less calcareous eastwards and southwards of Perth. "Cap Rock" areas become progressively more sparse southwards until they become obvious "pinnacles" of secondary enrichment controlled by vertical jointing. These calcareous sand-dunes and vegetated siliceous dunes are breached, in the south-west, by the Serpentine River.

(v) Westwards of, and fringing, the piedmont zone, and extending westwards to the coast, are a series of lakes some of which may be dry seasonally. They consist in part of portions of disconnected drainage systems, local slight depressions, and—in the case of White and Salt Lakes just to the east of Rockingham—former coastal lagoons. Their chief economic importance lies in their deposits which are "marls," sometimes with a total carbonate content of 90 per cent.

### 3.—Brief Outline of Economic Results.

Reconnaissance sampling of the Armadale sub-Area has been completed and some "follow up" boring carried out in the light of test results to hand. The materials sampled are:—ceramic materials, brick materials, limestones, and foundry sands.

(i) Ceramic and Brick Clays—materials, limited in extent and liable to lateral and vertical variation in quality, occur along the piedmont zone at the foot of the Darling Scarp and include poor grade kaolinitic materials. Kaolinitic clays from the Darling Range offer, upon levigation, possible pottery clays. Otherwise they may have uses as low grade refractories or for "fancy" bricks. The known extension of the shales of the Lower Cardup Series from Gosnells to Serpentine offers adequate reserves of this material.

The major prospects for ceramic and brick clays are confined to the Serpentine, Wongong, and Canning River Belts. The latter Belt, exploited from the early days of Perth, is becoming more and more encroached upon by urban development and is offering problems of land values and utilisation to the development of industries based upon clays and loams. The Serpentine and Wongong Belts, showing in their central and western portions depths of 18 feet of clays and loams, offer very adequate reserves of ceramic and brick clays of diverse suitability. It is anticipated that, owing to water logging, exploitation of these reserves would be seasonal.

(ii) Foundry Sands—(a) "Natural Sands.—All samples tested to date have been rejected on the score of coarseness and over high iron content. These "natural" sands are river loams (together with loams from the piedmont zone) and samples, generally representative, were on a reconnaissance basis. The results are not unexpected and emphasise the fact that acceptable "natural" sands have a very limited vertical and horizontal distribution.

In any one locality a deposit varies greatly in a short distance—e.g., the Guildford loams at present in use. Limited quantities of "natural" sands can only, then, be located by very close prospecting of loams mapped during the course of the survey. Their location becomes a special operation outside the province of the Geological Survey.

(b) Synthetic Sands.—Sources of synthetic sands—a silica sand to which a banding agent such as bentonite is added to produce a foundry sand to specification—are confined to the medium belt of siliceous and vegetated dunes. Within this belt location of a particular grade of sand is best attempted from a consideration of dune structures—top, fore, and bottom setting of materials—the top and bottom set sands being coarser than the fore set sands. Thus, for medium grade sands, the probability lies in their occurring on the eastern flanks of these siliceous dunes. Samples tested have not proven acceptable to the rigid specifications of the testing firm for use within their own foundry (steel) but offer possibilities to other users whose specifications are less rigid or whose work is of a different nature. For a particular foundry use demanding very rigid specifications, washing to a particular grade size range might prove practicable.

(iii) Limestones—(a) Chemical Limestones.—Industrial demand is for a  $\text{CaCO}_3$  content of 80 per cent. or more. This specification limits severely the use of the calcareous sand-dunes. The general distribution of calcium carbonate in these dunes has been remarked elsewhere and the recommendations for detailed prospecting (entailing a fair boring programme) of K. R. Miles<sup>12</sup> are repeated. Apart from prospects arising from such a boring programme, no reserves of "Cap Rock" commensurate with industrial demand can be seen with regard to these calcareous dunes.

Calcareous lacustrine deposits offer, as it appears at date of writing, better prospects. Two definite prospects, together with a third which remains to be sampled in more detail, exist. These are:—

(a) Wongong Brook (Location 31 and Adjacent Ground).—Some 130 acres are known of average depth 12ft., although depth is variable. Samples indicate, so far, approximately 80 per cent. total carbonates. The "marl" or soft limestone bottoms on a green-brown calcareous clay. The presence of the clay may be an asset from the cement manufacturing point of view. Further detailed work is required, but the occurrence—thought to be an old arm of Lake Jandakot—remains a major chemical lime prospect.

(b) White Lake, on Rockingham-Mandurah Road.—This was grid bored, when dry, in 1914. Sampling showed an average of 86 per cent. carbonates to an average depth of 15ft. over 1.75 square miles. Only 1.5 per cent.  $\text{SiO}_2$  was noted, the balance consisting of organic matter. This project offers 60-80 years reserves on a 200,000 ton per year production basis.

(c) Salt Lake, which lies just to the south of White Lake, and separated from it by a sand bar, has not been grid bored but sampling to date has indicated a general likeness to White Lake both in total carbonate content and possible reserves. Further work is required, when the lake is dry, to confirm these indications.

Both these prospects are situated on the Fremantle-Mandurah road some 18 miles south of Fremantle.

Other similar calcareous deposits are known of approximately the same tenor—e.g. Lake Coogee—but are very much more limited in extent and have problems of land utilisation and values attached.

(b) Dimension Stone—two types of dimension stone are obtained from the calcareous dunes of the Coastal Limestone Formation. The first is a

<sup>12</sup> Ann. Prog. Rept. G.S.W.A., 1944, p. 50.

fine grained, compact, sectile stone with a clay content. This stone, upon weathering, leaves as a residue a pink to red coloured terra rossa which is diagnostic. Largely confined to the Spearwood locality, this type grades southwards into the more arenaceous second type.

The second type gives rise to a lighter coloured more quartzose soil. South of the 12 Mile Peg on the Fremantle-Rockingham road, the stone becomes too siliceous for use as a good building stone. In detail, suitable stone is localised by dune structure and occurs on the westward, windward, side of the vegetated dunes. An economic eastward limit to quarrying operations is set by the crest-line of a particular dune and the incoming of the thin lenticular fore set beds. Building limestones should be prospected for accordingly.

(iv) Road Metals and Aggregates.—(a) Lateritic Gravels—are confined to the piedmont zone and the Darling Range. The piedmont zone offers the most accessible and largest reserves. The gravels of the Darling Range are limited in occurrence and extent and are largely confined to pockets, usually at the heads of gullies, along drainage lines.

(b) "Blue Metal"—is derived from the dolerite and epidiorite intrusives in the Pre-Cambrian granitic gneisses of the Darling Range. Adequate reserves exist.

(c) Sand—sand, as builder's sand, has a wide distribution in the zone of vegetated siliceous dunes and adequate reserves exist. Limited quantities of sharp, ill-sorted, silica sands occur on the Darling Range and contain varying amounts of kaolinitic fines.

(v) Silica—Occurs massive in two forms:—

- (a) Quartz reefs in the Pre-Cambrian complex of the Darling Range. The major body is that worked at Gosnells by White Rock Quarries. This body contains adequate reserves for all likely demands.
- (b) Quartzites occurring in the Lower Cardup Series—these quartzites could supplement the previously remarked reserves.
- (c) Silica sands of the vegetated siliceous dunes—whilst dominantly siliceous, there is a small but variable iron content.

#### Summary.

The geological survey of the Metropolitan Area—2,000 square miles centred about Perth—was undertaken to delineate the geology of the Area with particular reference to economic aspects. The necessity for this work, actually long overdue, arose by reason of social and economic pressures consequent upon World War II and long term development of the Area. To satisfy, where possible, urgent demands upon and shortages of industrial rocks and minerals rapid assessment of suitability of materials to industry and transmission of information to affected parties was necessary. This was done through liaison with the Chamber of Manufactures of W.A. and ancillary bodies.

Initial Field Mapping—to a scale of 20 chains to one inch—started on 14th August, 1950, and was centred about Armadale. Some 500 square miles were completed by 31st December, 1950.

Resulting from this work were the following points:—

- (i) The establishment of adequate clay reserves—the chief being the Wongong and Serpentine Belts—suited to general ceramic uses and brick making.
- (ii) The tracing of the Cardup Shales, of brickmaking and ceramic interest, from Gosnells southwards to Serpentine.
- (iii) The location and partial assessment of three major chemical limestone prospects—those of White and Salt Lakes (Rockingham) and Wongong Location 31, together with a more general appreciation of the lime potentialities of the Coastal

Limestone Formation. These potentialities are very limited and largely confined to the Naval Base locality and require demonstration by boring.

- (iv) The concrete realisation that "natural" foundry sands are limited in quantity and extremely variable in characteristics within any one particular locality. "Natural" foundry sands reserves of significance were not established. Of "synthetic" sands—i.e. silica sands—good potentialities were seen, some beneficiation with regard to grade to suit a particular type of foundry work might prove an economic possibility. Results of industrial testing of industrial rocks and minerals sampled are given in Appendix I. Field work during 1951, will be centred about Bullsbrook, and will finish with the mapping of Perth and its built up environs.

#### Acknowledgments.

The writer wishes to record his appreciation of the co-operation that he has received from both official and unofficial bodies and individuals too numerous for specific mention.

#### APPENDIX I.

##### CONTENTS.

	Page
Ceramic and Brick Materials ....	16
Limestones, Lime Sands, Marls ....	21
Moulding Sands ....	21

#### Broad Results of Sampling.

##### Notes.

1. Source of test results is indicated by the abbreviated titles of the organisations who carried out the tests. These organisations and abbreviations are:—

H. L. Brisbane & Wunderlich Ltd.—B.W.  
State Brick Works—S.B.W.  
Tomlinson's Steel Pty., Ltd.—T.  
Geological Survey of W.A.—G.S.W.A.  
Western Australian Government Railways—W.A.G.R.

2. Locations of samples are given, as they will be indicated in the completed work and maps, as a military grid reference to conform with the field-sheets. When possible, the approximate position of a sample will be referred to a Location Number (ref. L. & S. Lithos).

3. Owing to time lags only those sample results in hand are given.

#### Clays and Loams.

##### Notes.

1. For remarks on the Serpentine and Wongong Clay Belts, see page 52.

2. When tests have not been completed, preliminary results will be given.

Sample No. G.S.M. 7: Map reference 945078, 200 yards W. of N.W. corner of Cockburn Sound Location 271.

Drying Shrinkage	4.7
------------------	-----

##### Total Fired Shrinkage—

1112°C	4.7
1160°C	4.7

##### Fired absorption—

1120°C	17.1
1160°C	16.7

Colour—light brown—poor.

Salt Glaze—poor, body to porous and soft.

Could be used as minor constituent in red burning ware to improve drying and reduce firing shrinkage, but otherwise not generally suitable for ceramic purposes. (B.W.)

*Sample No. G.S.M. 10:* Map reference 947049, N.W. corner of Cockburn Sound Location 50.—A brown loamy clay with just fair elasticity. It has good drying characteristics and fairly good dry strength.

				%
Drying shrinkage	....	....	....	4.7
Total Fired shrinkage—				
1120°C	....	....	....	5.8
1160°C	....	....	....	7.1
Fired absorption—				
1120°C	....	....	....	15.6
1160°C	....	....	....	15.8

Colour—fairly good red.

Salt Glaze—good—darkens colour considerably.

Reasonably good for extruded brick and agricultural drain tile, but just a little soft for the best product. The discrepancy between shrinkage and absorption at the two firing temperatures is due to the difference in kiln atmosphere. This clay could also be used with a stronger clay for roofing tiles. (B.W.)

*Sample No. G.S.M. 12:* Map reference 984045, 300 yards S.E. of N.W. corner peg of Cockburn Sound Location 807.—A chocolate brown slightly loamy clay with fairly good plasticity. Drying characteristics are good, and dry strength is good.

				%
Drying shrinkage	....	....	....	5
Total Fired shrinkage—				
1120°C	....	....	....	9.0
1160°C	....	....	....	badly warped
Fired absorption—				
1120°C	....	....	....	14.5
1160°C	....	....	....	10.3

Colour—very dark red with black ironstone particles.

Salt Glaze—good—darkens colour.

This firing temperature is a little high for this clay.

Fired at a lower temperature (about 1050°C), this should be entirely suitable for extruded brick. Strength is good. Not satisfactory for other products. (B.W.)

*Sample No. G.S.M. 15:* Map reference 927118, 100 yards W. of S.W. corner peg Cockburn Location 245.—A dark grey, very plastic and tough clay, having excellent dry strength. Tends to warp in drying, but this is typical for these very plastic clays. Does not crack in drying, and in general drying characteristics are good.

				%
Drying shrinkage	....	....	....	9.6
Total Fired shrinkage—				
1120°C	....	....	....	11.4
1160°C	....	....	....	12.1
Fired absorption—				
1120°C	....	....	....	11.1
1160°C	....	....	....	11.2

Colour—pleasant medium red.

Salt Glaze—excellent with a very nice reddish brown colour.

Fired strength is good and surface very good. This clay would be suitable, mixed with a less plastic clay, for extruded brick, roofing tiles, sewer pipe and all other types of red burning ware. Altogether, a good clay. (B.W.)

*Sample No. G.S.M. 18:* Map reference 863068, 100 yards S.E. of N.W. corner Cockburn Sound Location 471.—A grey brown clay, slightly loamy but very plastic and tough. Warps slightly in drying but is all right. Good dry strength.

(2)—61225/53

				%
Drying shrinkage	....	....	....	8.7
Total Fired shrinkage—				
1120°C	....	....	....	11.3
1160°C	....	....	....	12.2
Fired absorption—				
1120°C	....	....	....	11.1
1160°C	....	....	....	11.0

Colour—light brownish red. Only fair colour.

Salt Glaze—Readily glazed, but gives surface cracking.

Very hard body, but rather poor surface. Will make quite a good extruded building brick, particularly if broken down with a less plastic clay or other material. Not preferred for other products. (B.W.)

*Sample No. G.S.M. 19:* Map reference 841069, S.W. corner Cockburn Sound Location 450.—A dark grey, almost black, clay very plastic and tough. Warps slightly in drying, but not more than expected for its plasticity and toughness. Otherwise it dries very well, and has very good dry strength.

				%
Drying shrinkage	....	....	....	9.2
Total Fired shrinkage—				
1120°C	....	....	....	11.4
1160°C	....	....	....	11.4
Fired absorption—				
1120°C	....	....	....	11.9
1160°C	....	....	....	12.0

Colour—fair medium light red.

Salt Glaze—Readily glazes, but causes surface cracking, colour pleasing, reddish brown. Very hard body, but fairly poor surface. Suitable for extruded brick. A mixture with a second less plastic clay will improve this clay. Not preferred for roofing tiles or sewer pipes, but could be used as one clay of a mixture. (B.W.)

*Sample No. G.S.M. 23:* Map reference 938080, S.E. corner of Cockburn Sound Location 266.—A medium light brown colour, plastic and tough, but only slightly fatty.

				%
Drying shrinkage	....	....	....	7.0
Total Fired shrinkage—				
1120°C	....	....	....	14.1
1160°C	....	....	....	15.2
Fired absorption—				
1120°C	....	....	....	10.7
1160°C	....	....	....	10.2

Colour—medium brownish red—fair.

Salt Glaze—Fair, darkens colour and causes fine surface cracking. Fired strength is good.

While the colour is only fair, it is satisfactory. Slight surface cracking, which can be overcome by blending with another clay, is the main fault. However, this clay can be used for roofing tiles, sewer pipe, or extruded brick. (B.W.)

*Sample No. G.S.M. 24:* Map reference 869055, seven chains S.W. of S.W. corner Cockburn Sound Location 473.—Grey brown colour, very plastic and tough and fairly fatty. Contains small amount of sand loam. Dries fairly well with good dry strength.

				%
Drying shrinkage	....	....	....	8.9
Total Fired shrinkage—				
1120°C	....	....	....	11.0
1160°C	....	....	....	11.3
Fired absorption—				
1120°C	....	....	....	12.0
1160°C	....	....	....	11.2

Colour—brownish red, not so good a red as G.S.M. 23 above.



Salt Glaze—readily glazed, darkens a little and causes slight surface cracking, but is good.

Fired strength is good. Warps some in fire. The colour is not a real good red, but otherwise this clay is suitable for roofing tiles, sewer pipe, and extruded bricks. (B.W.).

*Sample No. G.S.M. 26:* Map reference 829057, S.E. corner peg Cockburn Sound Location 508.—Very dark grey colour, almost black, plastic, tough and fatty. Contains small amount of sand. Dries fairly well with very good dry strength.

Drying shrinkage	....	....	....	%
Total Fired shrinkage—				
1120°C	....	....	....	13.6
1160°C	....	....	....	13.3
Fired absorption—				
1120°C	....	....	....	12.9
1160°C	....	....	....	13.1

Colour—a light red Terra Cotta, but very clean.

Salt glaze—Fair, changes colour to a medium brown and causes some fine surface cracking.

Fired strength is good. Warps slightly in fire. Colour is rather light, but this clay is suitable for manufacture of roofing tiles, sewer pipes and extruded bricks. (B.W.).

*Sample No. G.S.M. 27:* Map reference 853055, 20 chains N. of N.E. corner Cockburn Sound Location 560.—This clay is dark grey in colour, plastic, tough and fatty. It contains a small proportion of sand. Dries well with fairly good dry strength.

Drying shrinkage	....	....	....	%
Total Fired shrinkage—				
1120°C	....	....	....	12.8
1160°C	....	....	....	12.8
Fired absorption—				
1120°C	....	....	....	8.5
1160°C	....	....	....	8.5

Colour—fair brownish red.

Salt Glaze—glazes readily, darkens colour to red-dish brown. Surface cracking is pronounced.

Fired strength is very good.

This clay is suitable (with the addition of another clay to stop surface cracking) for the manufacture of roofing tile, sewer pipe, and extruded brick. Firing range, as shown by shrinkage and absorption figures, is particularly good. (B.W.).

*Sample No. G.S.M./G/50:* Map reference 827975, drain S.W. corner Cockburn Sound Location 1122.—A dark brown clay containing coarse non-plastics, mainly sand. Plasticity is good. Clay grain is fine and clay is sticky. Very difficult to dry and tends to warp badly.

Drying shrinkage	....	....	....	%
Total Fired shrinkage—				
1230°C	....	....	....	15.5
Fired absorption	....	....	....	10.3

Colour—deep red with darker iron staining.

Cracks badly but, except for cracks, is very strong.

No use alone, but could be used with a weak clay for bricks and possibly tiles. Further samples to be fired in salt glaze kiln. (B.W.).

*Sample No. G.S.M./G/52:* Map reference 832015, road junction S.W. corner Cockburn Sound Location 953.—A fairly dark brown coloured clay. Appears to be free of any appreciable quantity of sand or other non-plastics. It is coarse grained, slakes readily, only slightly plastic and sticky. Dries well and fair dry strength.

Drying shrinkage	....	....	....	%
Total Fired shrinkage—				
1230°C	....	....	....	16.5
Fired absorption	....	....	....	14.8

Colour—excellent red with small black specks.

Strength is good. There is no checking or cracking. Appears to be suitable for 1st quality face brick. Might be useful in roofing tile mixture. (B.W.).

*Sample No. G.S.M./G/53:* Map reference 820028, drain S.W. corner Cockburn Sound Location 924.—Very similar in properties to G.S.M./G/50.

Drying shrinkage	....	....	....	%
Total fired shrinkage—				
At 1230°C	....	....	....	14.9
Fired absorption—				
At 1230°C	....	....	....	8.0

Colour—deep red with dark iron staining.

Cracks very badly in fire. Hard and, except for cracks, is very strong.

No use alone but might be used with other weak clays for bricks or possibly tiles. Must be used with care. (B.W.).

*Sample No. G.S.M./G/54:* Map reference 855025, 1,000 feet E. of N.W. corner Cockburn Sound Location 1106.—This is a dark brown colour sample containing some sand. This is a low density material. A cube was pressed and fired to 1050°C to test heat insulation value.

Dry vol. of cube	....	....	....	Cubic cms.
Fired vol. of cube	....	....	....	54.0
Fired weight of cube	....	....	....	46.2
Apparent sp. gr. 0.94 or 58½lbs./cu. ft.				grams.
				43.5

This is too heavy for insulating material.

Clay slakes readily and is fairly plastic, but rather sticky and spongy.

Drying shrinkage	....	....	....	%
Total fired shrinkage—				
1230°C	....	....	....	3.5
Fired absorption—				
1230°C	....	....	....	9.4
				46.5

Colour—cream.

Only medium strength but good solid body, free from cracks. Should be useful as a second clay in roofing tiles or sewer pipes. (B.W.).

*Sample No. G.S.M./G/51:* Map reference 827995, drain S.W. corner Cockburn Sound Location 994.—Similar to G.S.M./G/50 and 53. The only difference is the colour being a little lighter in this sample.

Drying shrinkage	....	....	....	%
Total fired shrinkage—				
1220°C	....	....	....	10
Fired absorption—				
1220°C	....	....	....	12.5
				10.7

Colour—good deep red.

Some warp in firing. Fairly bad cracking. Body is hard. No use alone but might be used with a weak clay for bricks or tiles. Must be used with care. (B.W.).

*Sample No. G.S./H/1005:* Map reference 044150, Cockburn Sound Location 802, 10 chains S. of N.E. corner.—This is a very light greyish brown coloured ball clay or semi-ball clay. It is fairly difficult to deflocculate. Washing gave a non-plastic residue of 30.6%, consisting mainly of sand but with some unslaked or non-plastic clay substance which readily passed through a 100 mesh screen. The clay is quite tough and has fair plasticity. Good to press in moulds.

Drying shrinkage 6.3%. Good dry strength.

Drying shrinkage—				%
Good dry strength	....	....	....	6.3
Total fired shrinkage—				
1230°C	....	....	....	15.6
1400°C	....	....	....	18.7
Fired absorption—				
1230°C	....	....	....	8.6
1400°C	....	....	....	6.5

Colour—cream.

Quite a little surface checking extending into body. Shrinkage is higher than normal and this with the surface checking is bad.

#### Washed Clay.

	%
Drying shrinkage	44.7
Total fired shrinkage—	
1250°C	200.2
Total fired absorption	1.2

Colour—grey cream.

Pottery Glaze Behaviour—good with no crazing in autoclave accelerated crazing test.

Not white enough for white dinner ware but good for coloured art ware. Must be washed with consequent loss of 30 per cent. material in washing. (B.W.)

*Sample No. G.S./H/1006:* Map reference 037160, Canning Location 716, three chains S.E. of N.W. corner of location 716.—A light grey coloured clay with some iron staining. It is a semi-ball clay, only moderately plastic, but very fatty. Good dry strength.

	%
Drying shrinkage	5.6
Total Fired shrinkage—	
Small bars—1250°	16.1
Large bars—1400°C	15.6
Fired absorption—	
1250°C	10.9
1400°C	9.6

Colour—1250°C light cream, 1400°C—light grey.

Pottery glaze fairly good and no crazing. Surface is fairly rough and badly checked. Some of the cracks extend into the body. Body is strong but is not a generally useful clay, because of the surface cracking. (B.W.)

*Sample No. G.S./S/2002:* Map reference 015295, Canning Location 30A.—This clay is a medium yellow-brown in colour, very plastic, tough and fatty. Contains no appreciable sand or loam. Dries fairly well with good dry strength.

Fired absorption—	
Drying shrinkage	10.75
Total Fired shrinkage—	
1120°C—Sample broken	
1160°C	17.5
Fired absorption—	
1120°C	3.7
1160°C	3.3

Colour—dark reddish brown with black un-oxidised case. Overfired for best colour.

Salt Glaze—excellent.

Fired strength is very good with no cracking or warping.

The clay is overfired at 1120°C.

This is a fine grained clay somewhat similar to clay from the Pyrtan Estate, Guildford. It is suitable for the manufacture of roofing tiles and extruded brick with the addition of a second clay to open it up and reduce shrinkage. It is probably too fine grained for sewer pipes.

*Sample No. G.S./S/2004A (Top Sample):* Map reference 004295, Canning Location 30, W. side of highway.—Grey colour, fairly plastic, tough and fatty. Contains a considerable proportion of sand. Dries very well, but dry strength is only fair.

Drying shrinkage	5.5
Total Fired shrinkage—	
1120°C	6.5
1160°C Sample lost.	

#### Fired absorption—

1120°C	16.3
--------	------

Colour—very light brown, very slight surface seam.

Salt Glaze—Poor at this temperature. Too soft and porous.

Fired strength—poor.

Not suitable for roofing tiles, sewer pipes or bricks. May be a good refractory bond clay or medium grade refractory. (B.W.).

*Sample No. G.S./S/2004B (Bottom Sample):* Lighter colour than sample G.S./S/2004A, and the sand content is finer grained. Otherwise similar. Fairly plastic, tough and fatty, dries well but with only fair dry strength.

Drying shrinkage	6.3
Total Fired shrinkage—	
1120°C	7.8
1160°C Sample broken.	

#### Fired absorption—

1120°C	18.0
1160°C	17.6

Colour—dirty cream.

Salt Glaze—poor at this temperature. Too soft and porous.

Fired strength—very poor at this temperature.

Remarks—same as G.S./S/2004A. (B.W.)

*Sample No. G.S./L/3001:* Map reference 005348, Canning Location 15.—It is a light grey colour, and is very plastic and tough. It contains approximately 60 per cent. clay substance and 40 per cent. non-plastic, mainly silica.

Sample fired to 1400°C.

	%
Total shrinkage	13.4
Fired absorption	5.8

Colour—light warm brown.

Strength—very good.

A little too refractory for true stoneware. Would be useful as a bond clay in medium grade refractories. (B.W.)

*Sample No. G.S./L/3001:* Supplementary report.

	%
Drying shrinkage	5.6
Total Fired shrinkage—1240°C	13.9
Fired absorption—1240°C	6.4

Colour—very light brown.

Glaze behaviour using standard pottery glaze is fairly without crazing.

Very hard body.

As this clay was first considered as a pottery clay, a portion was washed. Sixty per cent. was retained as clay substance, and after removing excess water was pressed into bars, dried, and fired. The non-plastic portion is highly siliceous.

#### Washed Clay.

Is a plastic tough clay, slightly sticky, but with finish very smooth with knife or palette. Good drying characteristics and good dry strength. Colour is light brown.

	%
Drying shrinkage	7.7
Total Fired shrinkage—1240°C	19.1
Total fired absorption—1240°C	0.45

Colour—brownish grey.

Glaze behaviour with standard pottery glaze—excellent with no craze.

Best possibility for this clay is for vitreous stoneware. It will require firing to at least 1300°C. It is a very good clay for this purpose, but not quite as smooth as the ideal. (B.W.)

*Sample No. G.S./L/3002:* Map reference 982348, Canning Location 16.—A dark reddish brown clay containing a little loam. Plasticity and dry strength are very good. There is a tendency to crack in drying, and a second good drying clay would have to be used with this to make a reasonably safe drying body.

Drying shrinkage	....	....	....	%	7.3
Total Fired shrinkage—					
1120°C	....	....	....		13.3
1160°C	....	....	....		14.8
Fired absorption—					
1120°C	....	....	....		13.5
1160°C	....	....	....		11.7

Colour—dull brownish red.

Salt Glaze—very good, colour very dark.

Fires very hard with good smooth surface. Shrinkage is rather high and drying without cracks is difficult. Mixed with a clay having less shrinkage and better drying characteristics, this clay would be useful for extruded bricks, agricultural drain pipes and possibly for roofing tiles and sewer pipes, but is not preferred. (B.W.)

*Sample No. G.S./L/3004:* Map reference 961374, Canning Location 3.—A medium red clay, fairly loamy but with good plasticity and dry strength. There is a tendency to crack in drying, and must be dried with care.

Drying shrinkage	....	....	....	%	6.8
Total fired shrinkage—					
1120°C	....	....	....		10.2
1160°C	....	....	....		9.5
Fired absorption—					
1120°C	....	....	....		15.7
1160°C	....	....	....		14.8

Colour—dark reddish brown, poor.

Salt Glaze—fairly good, colour very dark.

Fairly hard body and good surface. Mixed with a clay having better drying characteristics this would be suitable for extruded brick and will not require firing to quite as high a temperature. Lower firing temperature will also brighten and improve the red colour. Discrepancy in shrinkage of the higher fired sample is due to some cracking occurring. (B.W.)

*Sample No. G.S./L/3019:* Map reference 051363, Canning Location 313.—A fairly white china clay, with a slightly shaley texture. It slakes readily, is fairly plastic, fine grained and fatty. A good clay to work. Washing gives 84.4 per cent. plastic and 15.6 per cent. of non-plastic material. Drying characteristics are fairly good and dry strength is good.

Whole Clay—

Drying shrinkage	....	....	....	%	6.7
Total Fired shrinkage—					
1250°C	....	....	....		17.6
Fired absorption	....	....	....		14.1
Colour—cream with small brown specks.					
Glaze—very good, no craze, strength good.					

Washed sample—good dry strength—

Drying shrinkage	....	....	....	%	5.7
Total Fired shrinkage—					
1250°C	....	....	....		19.2
Fired absorption—					
1250°C	....	....	....		7.6

Colour—cream.

Glaze—very good, with no craze. Very faint brown specks showing under the glaze.

This is a clay which is worth further testing for use in pottery and dinnerware body. It seems reasonably good. (B.W.)

*Sample No. G.S./L/3021:* Map reference 108331, Canning Location 164.—This is a light grey sandy clay. Plasticity is poor but can be washed all right. Drying is good and clay strength is good.

Drying shrinkage	....	....	....	%	6.6
Total Fired shrinkage—					
1120°C	....	....	....		8.0
1400°C	....	....	....		11.8
Fired absorption—					
1120°C	....	....	....		32.2
1400°C	....	....	....		23.8

Colour—fairly white.

Salt Glaze—1120°C—nil—slight surface checking.

Strength—poor at 1120°C and only fair at 1400°C.

This clay is too sandy but might be useful in roofing tiles or bricks to improve drying of a stronger clay. (B.W.)

*Sample No. G.S./L/3012:* Map reference 977359, Canning Location 13.—A dark yellow brown clay with good plasticity. Contains a small quantity laterite pebbles up to  $\frac{1}{4}$  in. Dries well with very good strength.

Drying shrinkage	....	....	....	%	9.7
Total Fired shrinkage—					
1120°C	....	....	....		20.0
1160°C—sample lost.					
Fired absorption—					
1120°C	....	....	....		5.9

Colour—good red with dark spots from laterite pebbles.

Salt Glaze—fair.

Very slight warp but excellent strength. Shrinkage is very high. Will make good bricks fired at a lower temperature. (B.W.)

*Sample No. G.S./L/3011:* Map reference 983369, Canning Location 13.—Yellow brown clay with only fair plasticity but good working properties. Contains some quartz up to  $\frac{1}{16}$  inch. Dries well with very good dry strength. Dries almost like cement.

Drying shrinkage	....	....	....	%	5.7
Total Fired shrinkage—					
1120°C	....	....	....		7.1
1160°C	....	....	....		7.4
Fired absorption—					
1120°C	....	....	....		14.7
1160°C	....	....	....		13.9

Colour—excellent red.

Salt Glaze—only fair.

A very slight warp. At these temperatures is rather soft for bricks. Might be all right fired harder. (B.W.).

*Sample No. G.S./L/3006:* Map reference 009338, Canning Location 52.—A reddish brown or chocolate coloured clay containing laterite pebbles up to  $\frac{1}{2}$  inch. It is very sandy and plasticity is only fair. Dries well with medium dry strength.

Drying shrinkage	....	....	....	%	6.7
Total Fired shrinkage—					
1120°C	....	....	....		6.7
1160°C	....	....	....		6.7
Fired absorption—					
1120°C	....	....	....		20.0
1160°C	....	....	....		19.7

Colour—good dark red.

Salt Glaze—poor (too porous).

Weak sandy body. No use alone but possibly could be used with one of the more plastic clays to improve drying and colour. (B.W.)

#### Non-plastic Content of Some Clays Tested by Working Away Clay Substance.

Sample No. G.S./G/25—52.9 per cent. non-plastic—coarse white sand.

Sample No. G.S./G/26—56.6 per cent. non-plastic—coarse white sand.

Sample No. G.S./G/27—41.0 per cent. non-plastic—coarse white sand.

Sample No. G.S./S/2004B—57.0 per cent. non-plastic—coarse sharp white sand.  
Sample No. G.S./L/3012—67.6 per cent. non-plastic—fine loam, angular quartz, ironstone.  
Sample No. G.S./G/12—65 per cent. non-plastic—sand and some ironstone.  
Sample No. G.S./G/15—47 per cent. non-plastic—coarse sand.  
Sample No. G.S./G/18—55.5 per cent. non-plastic—coarse sand.  
Sample No. G.S./G/19—58.3 per cent. non-plastic—white sand. (B.W.).

Notes.

- (i) Total carbonate determination by G.S.W.A.
- (ii) High assays of cap rock only indicate a very general distribution. In general it is not expected that detailed work will prove reserves commensurate with anticipated demand.
- (iii) Lower assays—which may prove of interest—again indicate only a general distribution, but it is expected that detailed work may show large reserves.
- (iv) Marls are limited in thickness and extent and confined to the “lake” system. Lake Coogee and Wongong offer possibilities of quantity.
- (v) The lime sands offer possibilities of quantity.
- (vi) Based upon these investigations, interested parties can carry out detailed work.

MOULDING SANDS.

Natural and Synthetic.

Locations of Samples Treated and Considered of some Utility.

Sample No.	Military Grid Co-ordinates.	Approx. Location.
G.S./M/G/5	000060	300 ft. N. of S.W. corner Co. Sd. Location 408.
G.S./M/G/6	970118	S.E. corner Co. Sd. Location 239.
G.S./M/G/8	987094	700 ft. N.N.E. of N.E. corner Co. Sd. Location 212.
G.S./M/H/1003	014189	Canning Location 186—5 chns. S.E. intersection Bunbury Highway and Wongong Brook.
G.S./M/L 3005	968314	Canning Location 16.
G.S./M/L 3015	896365	1½ miles N. of N. corner Canning Location 103.
G.S./M/G 44	885027	½ mile N.W. of Bridge in Co. Sd. Location 16.
G.S./M/G 46	878958	100 ft. W. of N.W. corner Co. Sd. Location 403.
G.S./M/G 47	917025	300 yds. W. of S.W. corner Co. Sd. Location 728.
G.S./M/G 48	972968	400 yds. N. of S.W. corner Co. Sd. Location 92.
G.S./M/G 49	948004	N.W. corner Co. Sd. Location 594.

SAND TESTS FOR GEOLOGICAL SURVEY.  
(W.A.G.R.)

A series of tests on sands submitted by the Geological Survey are listed below. The tests were performed with a view to determining suitability of the sands for foundry purposes.

Series A.

Markings: GS/M/L 3016, GS/M/L 3017, GS/M/L 3018, GS/M/L 3019.  
Lab. No.: MO 30\*.

10 Mesh	0.20
20 "	12.70
30 "	24.0
40 "	16.86
50 "	16.30
70 "	8.60
100 "	7.22
120 "	2.64
— 120 "	11.40

\* Not suitable for foundry purposes.

These sands were visually examined in conjunction with the foundry foreman, in order to obviate unnecessary testing of sands which were definitely unsuitable for moulding.

The sand selected for testing is a coarse grained silica sand. This sand contains an undue percentage of fines but could be used as a base for a synthetic moulding sand.

Series B.

Markings:	44	FRS 46	AM 47	MO 5 48	FRI 49
Lab. No.	MO 31	MO 32	MO 33	MO 34	MO 35
Colour	Brown	Grey	White	Yellow	Yellow
Percentage retained on:					
10 Mesh	0.64	2.70	8.70	0.44	1.58
20 "	1.50	52.54	42.88	10.60	15.56
30 "	1.30	20.53	16.16	14.20	16.90
40 "	0.84	9.42	11.14	18.12	20.68
50 "	1.88	3.14	2.0	7.30	14.26
70 "	3.14	2.34	3.74	14.80	6.58
100 "	6.0	3.22	1.20	1.08	4.60
120 "	3.22	34.24	9.6	22.90	20.48
A.F. 8 Clay	47.30				

Sample No. GS/M/G 44 is a brown loam and can be considered as more suitable than the red Guildford loam for non ferrous work. It is higher in the A.F.S. clay content than samples of Guildford loam. The proportion passing through the 120 mesh screen is below that of the red loam which has been tested in this laboratory. (It is assumed, of course, that the clay content is not extremely fine silt). This sample is worthy of further trial.

The silica sands contained undue amounts of vegetable material. They are not of outstanding quality for moulding sands. The two yellow sands are high in fines. The two white sands are coarse grained and would be suitable for backing sands when bonded.

14/2/51.

W. Hoffman.

Material.	Sample No.	Military Map Co-ords.	Approx. Location No.	Total Carbonates. Per cent.	Remarks.
Limestones, Lime Sands, Marls.	G.S./29	814058	3 chns. south-east of N.W. peg Co. Sd. Loc. 294	89	Old quarry
	G.S./30	780123	N.E. corner Co. Sd. Loc. 17	84	Cap rock very limited
	G.S./31	760103	5 chns. south-west of N.E. peg Co. Sd. Loc. 130	50	Calcareous sandstone
	G.S./32	768121	20 chns. north-west of S.E. peg Co. Sd. Loc. 427	69	Calcareous sand
	G.S./34	808082	5 chns. north of S.E. peg Co. Sd. Loc. 610	91	Capstone—limited
	G.S./2015	780240		68	Coarse calcareous sandstone
	G.S./2005	749308		41	Lime sand
	G.S./2006	773252	S.E. corner Lake Coogee	98	Marl—4 ft. thick

Material.	Sample No.	Military Map Co-ords.	Approx. Location No.	Total Carbonates. Per cent.	Remarks.
Limestones, Lime Sands, Marls— <i>continued</i>	G.S./2008	958234	Canning Loc. 75      ....      ....      ....	92	Marl—a prospect
	G.S./2010	963235	Canning Loc. 75      ....      ....      ....	96	Marl—a prospect
	G.S./35	714051	Near Safety Bay      ....      ....      ....	90	Lime sands
	G.S./36	745112	Near Safety Bay      ....      ....      ....	61	Lime sands
	G.S./37	747089	Near Safety Bay      ....      ....      ....	41	Lime sands
	G.S./4066	738089	Beach Ridges	58	Lime Sand—old beach ridges
	G.S./4067	753094	Rockingham-	37	Lime sand
	G.S./4068	743097	Safety Bay	41	Lime sand
	G.S./4069	755101	Area.	47	Lime sand
	G.S./4070	744022		53	Lime sand
	G.S./4871	743014		58	Lime sand
	G.S./4072	738004		51	Lime sand
	G.S./4073	734035		72	Lime sand
	G.S./1008	784133	3 chns. north-east of S.W. corner Canning Location 617	58	Quarry—limestone
	G.S./1009	819134	130 chns. east of S.E. corner Canning Loc. 617	75	Quarry—limestone
	G.S./1010	780151	8 chns. east of N.E. corner Canning Loc. 359	83	Quarry—limestone
	G.S./1011	772182	22 chns. east of N.E. corner Canning Loc. 508	86	Outcrop limestone
	G.S./1012	770189	S.W. corner Canning Loc. 435      ....	63	Limestone in road cutting
	G.S./1013	796175	30 chns. south of N.E. corner Canning Loc. 635	86	Limestone—caprock
	G.S./1014	768197	7 chns. north-east of S.W. corner Canning Loc. 382	92	Quarry—limestone
	G.S./1015	762220	2 chns. east of N.W. corner Canning Loc. 14	85	Limestone
	G.S./1016	765211	22 chns. north of N.W. corner Canning Loc. 510	93	Quarry—limestone
	G.S./1017	786197	3 chns. south-east of N.W. corner Canning Loc. 654	91	Quarry—limestone
	G.S./1018	794213	10 chns. south of S.W. corner Canning Loc. 226	91	Quarry—limestone
	G.S./55	718975	2,700 ft. north of N.E. corner Co. Sd. Loc. 682	88	Lime sand dune
	G.S./56	755974	Rd. Junction 2 miles east of S.E. corner Co. Sd. Loc. 682	51	Lime sand dune
	G.S./57	764962	1,000 yards north-west of Stale Hill	63	Lime sand dune
	G.S./60	767961	1,000 yds. north of Stale Hill      ....	83	Limestone
	G.S./61	771974		88	Limestone
	G.S./62	779009	1.3 miles north of Karnup Road      ....	88	Limestone
	G.S./63	781013		88	Limestone
	G.S./64	783032		88	Limestone
	G.S./65	787060	100 ft. north of N.W. peg Co. Sd. Loc. 302	76	Limestone
	G.S./66	795106	800 yds. north-east of N.W. corner Co. Sd. Loc. 302	87	Limestone
	G.S./67	788077		87	Limestone
	G.S./68	776106	100 yds. east of N.W. corner Co. Sd. Loc. 20	64	Limestone
	G.S./69	814117	300 yds. north of N.E. corner Co. Sd. Loc. 620	79	Limestone

TOMLINSON STEEL PROPRIETARY, LIMITED.

Sample No.	Colour.	Grain Class.	Organic Material.	A.F.A. Clay per cent.	A.F.A. Grain Size.	Screen.										
						10	20	30	40	50	70	100	140	200	270	Pan.
G.S. M/G/5	Fawn	Sub-angular	Small amount	1.36	45	0.04	0.27	7.81	32.5	23.54	25.29	3.14	3.33	1.08	0.49	0.86
G.S. M/G/6	White	Sub-angular	Small amount	1.19	57	0.0	0.34	4.43	16.89	18.56	35.77	9.58	7.25	3.29	1.21	1.36
G.S. M/G/8	White	Sub-angular to angular	Small amount	0.46	42	0.0	0.04	7.27	33.66	29.61	21.94	3.33	1.93	0.78	0.24	0.54
G.S. M/H/1003	Light brown	Angular	Small amount	14.56	88	1.08	3.94	7.02	8.46	4.43	18.16	12.05	12.12	6.6	3.66	7.44
G.S. M/L/3005	Dirty white	Sub-angular to angular	Trace	.40	43	0.0	0.04	2.94	20.50	33.41	38.26	2.70	1.32	0.14	0.0	.06
G.S. M/L/3015	White	Sub-angular	Small amount	Nil	52	0.0	0.0	1.4	13.0	17.6	47.6	12.6	6.6	0.8	0.1	0.1

REPORT ON THE GREAT FINGALL VENTURE  
1949-50.

By J. C. McMath, B.Sc. (Hons. Lond.), F.G.S.,  
M. Aust., I.M.M.

Introduction.

The Great Fingall Mine, operated by Messrs. Bewick Moreing & Co. from 1897 to 1918, when it closed down, is situated at Day Dawn, Murchison Goldfield, some 400 and 525 miles north of Perth by road and rail respectively. Over the period of its life the mine produced 1,875,365 tons of ore for a recovery of 1,216,579 fine ounces of gold from the Great Fingall Reef.

Brief Geological Background.

The ore-bodies, quartz reefs, occur in a series of folded Pre-Cambrian basic lavas and meta-sediments which have been intruded by one major dolerite sill together with sundry minor, and apparently concordant, doleritic bodies. These intrusive dolerites are pre-folding in age. The series has a high westerly dip and forms the western limb of a north plunging regional anticlinorium whose nose lies just north of Cue. The relevant rock succession, from east to west, is:—

- Major dolerite sill.
- Slates.
- Basic lavas (with thin slate horizons and pillow lavas).

The payable reefs occur as quartz filling of tension fractures in the dolerite sill together with quartz replacement of the dolerite along these tension fractures. The sill strikes N.35°E. and has a westerly dip of 60°. Within the sill the payable ore-bodies strike approximately north-west and dip westwards at 60°. Gold mineralisation is post-folding in age and is localised by tension strains set up by warping of the major dolerite sill. These warps show some degree of correlation with slight "cross flexuring" in the regional structure<sup>1</sup>.

Initiation of the Venture.

Ore search and the future life of the known goldfields of Western Australia now depend increasingly upon the large scale (and costly) application of advanced geological and geophysical techniques followed by diamond drilling of prospects so brought to light. There are two broad fields of such ore search—

- (a) the close investigation of past major producing ore-bodies for the possibilities of repetition in depth;
- (b) the close investigation of auriferous areas on a regional basis for favourable environments for the localisation of major ore-bodies.

These broad fields may—and often do—merge. The first field offers the more immediate prospects and, generally speaking, is the major field of present day activity.

In 1935 the Western Mining Corporation, Ltd. carried out such an investigation of the Day Dawn prospect, and their Chief Geologist—H. J. C. Conolly, A.R.S.M., B.Sc.—published brief results of his detailed analysis of structure and gold distribution in the Fingall ore-body together with deductions as to probable repetition of this ore-body in depth<sup>2</sup>.

On 21st March, 1946, a formal request was made to the Under Secretary for Mines by Mr. Conolly (now in private practice as a consulting geologist) applying for "a temporary reserve of 300 acres or more covering, to a depth of 5,000 feet, the Great Fingall reef and also the three reef formations crossing the Great Fingall dyke to the south-west of this mine."<sup>3</sup>

This Day Dawn area was one of four abandoned mining districts which Mr. Conolly wished to explore. He stated tentative plans for financing these explorations—"£20,000 was earmarked as necessary for the Great Fingall test. Mr. Conolly emphasised that long range efficient and economical diamond drilling which had made deeper exploration practicable in U.S.A. and Canada was necessary with regard to the Great Fingall and other deeper prospects. Without this efficient and economic drilling performance nothing could be done."<sup>4</sup>

The Government Geologist, well knowing the need for encouraging deep exploration in the Gold-fields, the need for structural geology in relation to ore search, the need for geological data from depth in critical locations of broad regional structure, and the high degree of geological probability for the repetition of the Fingall ore-body in depth, advised that this request be favourably considered by the Mines Department. The application was granted.

The introduction to Australia of the long range, etc., diamond drilling was effected through the organisation of a drilling company—under the style of Australian Drillers Pty., Ltd.—by a group of interested Eastern States mining companies. The purpose of this drilling company was to provide the modern equipment and expert drilling personnel necessary for this type of exploration.

The Great Fingall Exploration Company Ltd.

The situation at this stage is—

- (a) a valid prospect of the repetition of the Fingall ore-body in depth;
- (b) the creation of a temporary reserve protecting the prospect;
- (c) the existence of Australian Drillers Pty. Ltd. to supply the drilling equipment, expert personnel and technique, without which such deep exploration was considered impracticable.

<sup>2</sup> "A Contour Method of Revealing Some Ore Structures"—H. J. C. Conolly.  
Econ. Geol., Vol. XXXI., No. 3, 1936.

<sup>3</sup> G.S.W.A. File 39/1946. "Boring Great Fingall and Three Reefs to South-West, Day Dawn"—letter H. J. C. Conolly to Under Secretary for Mines—21/3/1946.

<sup>4</sup> Op. cit.

<sup>1</sup> Ann. Prog. Rept. G.S.W.A., 1950—J. C. McMath.



It remained to finance the exploration. Accordingly, the Great Fingall Exploration Company Ltd.<sup>5</sup> was incorporated in W.A. under the Companies Act, 1943-47, on 18/2/1949. The main object of the company was to explore in depth the Great Fingall prospect recommended by its consulting geologist (and director) H. J. C. Conolly. This prospect was covered by Temporary Reserves 1231H and 1232H together with G.M.L. 672D—totalling 488 acres.

The financial structure of this company was as follows:—

1. Nominal capital, £500,000 in 2,000,000 shares of 5s. each.

2. Actual available fund—

- (a) £16,000 from public subscription;
- (b) £14,000 from Anglo-Westralian Mining Pty. Ltd.;
- (c) £10,000 loan from State Government.

It should be noted that the Government loan was repayable in full only in the event of payable ore-bodies being found. In the event of failure, on a liquidation of the company, Government could claim ten fortieths of the company's assets.

This loan was recommended to the Government by the Government Geologist for the reasons already set out, and was only so recommended by virtue of his firm belief in the availability of modern and efficient diamond drilling services through Australian Drillers Pty. Ltd. Again, it is emphasised, high calibre and economical deep drilling could only make the venture practicable. Briefly, the venture was sponsored<sup>6</sup> by the Government upon the recommendation of the Government Geologist in order to—

- (a) demonstrate ore search in depth from the geological aspect;
- (b) demonstrate modern drilling practice in deep exploration;
- (c) encourage the search for potential ore bodies in existing gold-fields and thus prolong the lives of those fields and lend stability to the mining population;
- (d) geological data from depth in a critical location on a broad regional structure.

The Government was not represented on the board of directors although, by invitation of the Company, the Government Geologist attended board meetings.

Anglo-Westralian Mining Pty. Ltd. were appointed managers of the project, and held the controlling interest in the project.

The operation, as per Prospectus, was to be carried out by four or more diamond drill holes planned by its consulting geologist. The drilling was to be carried out under contract with equipment and experienced personnel by Australian Drillers Pty. Ltd. To effect this, Great Fingall Exploration Company Ltd., through a £10,000 subscription, became a member of Australian Drillers Pty. Ltd. This left £25,000 of available funds allocated to actual exploration work.

State Government Assistance was rendered to the venture both in its gestatory and operational stages. The assistance took two forms:—

- (a) Financial—the £10,000 loan has been previously remarked.
- (b) Practical—i.e. Departmental work and facilities rendered were as follows:—
  - (i) Preparations of a detailed geological plan, 1 inch = 100 ft.) of the relevant reserves together with the necessary field work by Mr. N. M. Gray of the Geological Survey.
  - (ii) Preparations of gold contour plans of the Fingall Reef by Mr. Gray, under the direction of H. J. C. Conolly.
  - (iii) Facilities offered in the preparation and reproduction of the above plans by the Mines Draughting Office.

- (iv) The secondment, on a part time basis, of the author to act as local geologist to the venture under the direction of and responsible to the Company's consulting geologist.

Operational Phase.—The situation of the venture was, then, at March, 1949, as follows:—

- (i) Successful promotion of the Great Fingall Exploration Co. Ltd. to explore by diamond drilling, laid out by its consulting geologist, the Fingall Prospect.
- (ii) Anglo-Westralian Mining Pty. Ltd. with headquarters at Big Bell, W.A., were appointed managers to the exploration company (in which they held a controlling interest) and undertook to render technical assistance and facilities in the field as occasion arose.
- (iii) Australian Drillers Pty. Ltd., by virtue of a £10,000 subscription from the exploration company, were to provide modern equipment, experienced Canadian practitioners of up to date diamond drilling techniques (including directional drilling), and to carry out the drilling. The specific reason for the formation of this drilling organisation was to introduce efficient and economical deep diamond drilling techniques to Australia.

The Drilling Plan.—The prospect of repetition of the Fingall ore-body was estimated by H. J. C. Conolly to occur on the Company's Reserves within the vertical limits of 3000 and 3400 feet, with an overall target area approximately 950 ft. x 250 ft., the larger axis trending north-west.

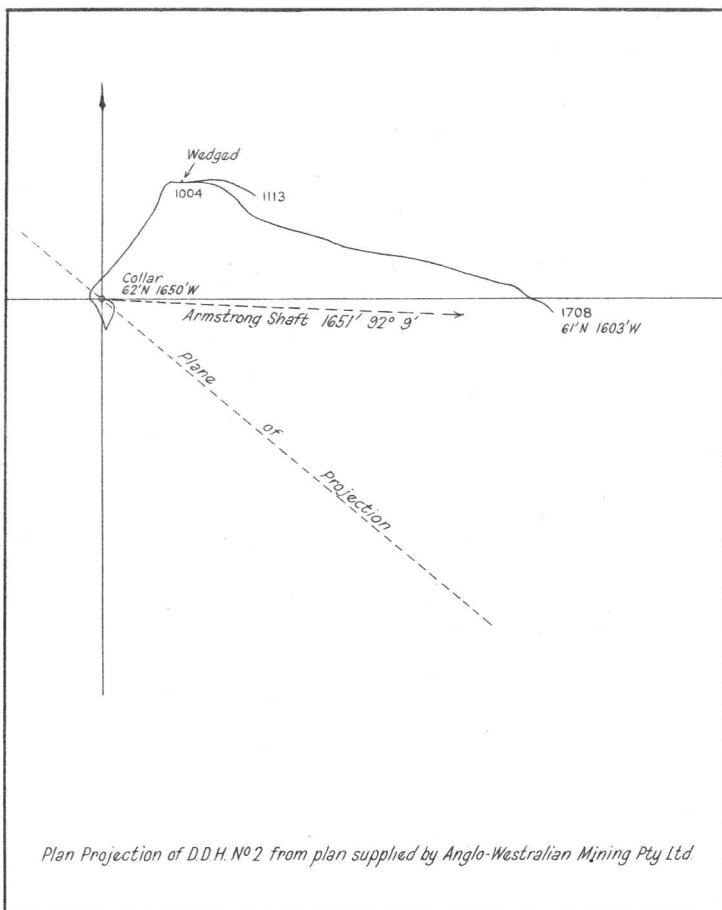
It was proposed, vide Prospectus of the Great Fingall Exploration Company, to explore this prospect with "four or more diamond drill holes". Final planning of the exploration was made in February, 1949, and the "four or more diamond drill holes" concept was changed to two diamond drill holes now considered sufficient to cover the range of possibilities. After discussion with the Field Superintendent of Australian Drillers Pty. Ltd. (an expert practitioner of controlled diamond drilling)—the Fingall Exploration Company's consulting geologist decided that the exploration be initiated by a diamond drill hole controlled to vertical from which subsequent directional diversions would be made. The depth to the target lay between 3000 and 3400 ft. vertically and the order of magnitude of allowable creep of such a controlled vertical hole was given as an ellipse 100 ft. long by 70 ft. across. In accordance with the location of the target, creep consideration, etc., No. 1 Diamond Drill Hole was sited N 85° 15'30" W. and 1465 ft. distant from the Armstrong Shaft. This shaft is the origin of the co-ordinate system used by the Geological Survey in the preparation of the detailed plans of the prospect. With reference to this origin, the co-ordinates of No. 1 D.D.H. were 121 ft. South, 1460 W.

Of this change from "four or more diamond drill holes" to one controlled to vertical with subsequent directional diversions, it is supposed that formal acceptance and ratification of this departure from the drilling proposal as set out in the Prospectus is to be found in the minutes of the Great Fingall Exploration Co.

Controlled Diamond Drilling.—The basic principle is that the direction and inclination of a diamond drill hole can be controlled by positioning a deflecting wedge (whipstock) in the hole. The technique, developed and perfected in oil-well drilling, has been extensively applied in Canada and America to Pre-Cambrian metaliferous ore-search. The success of the technique said to be achieved in Canada is at variance with the results of the Fingall venture. Australian Drillers Pty. Ltd. imported drilling experts, and it was understood experts in wedging, for the purpose of the Fingall operation. The detail of this wedging technique followed by this drilling company is given in a paper presented to the Annual Meeting of the Canadian Diamond Drilling Association by H. M. Brownall—Resident Geologist,

<sup>5</sup> Prospectus of the Great Fingall Exploration Co. Ltd.—18/2/49.

<sup>6</sup> vide Prospectus of Company.



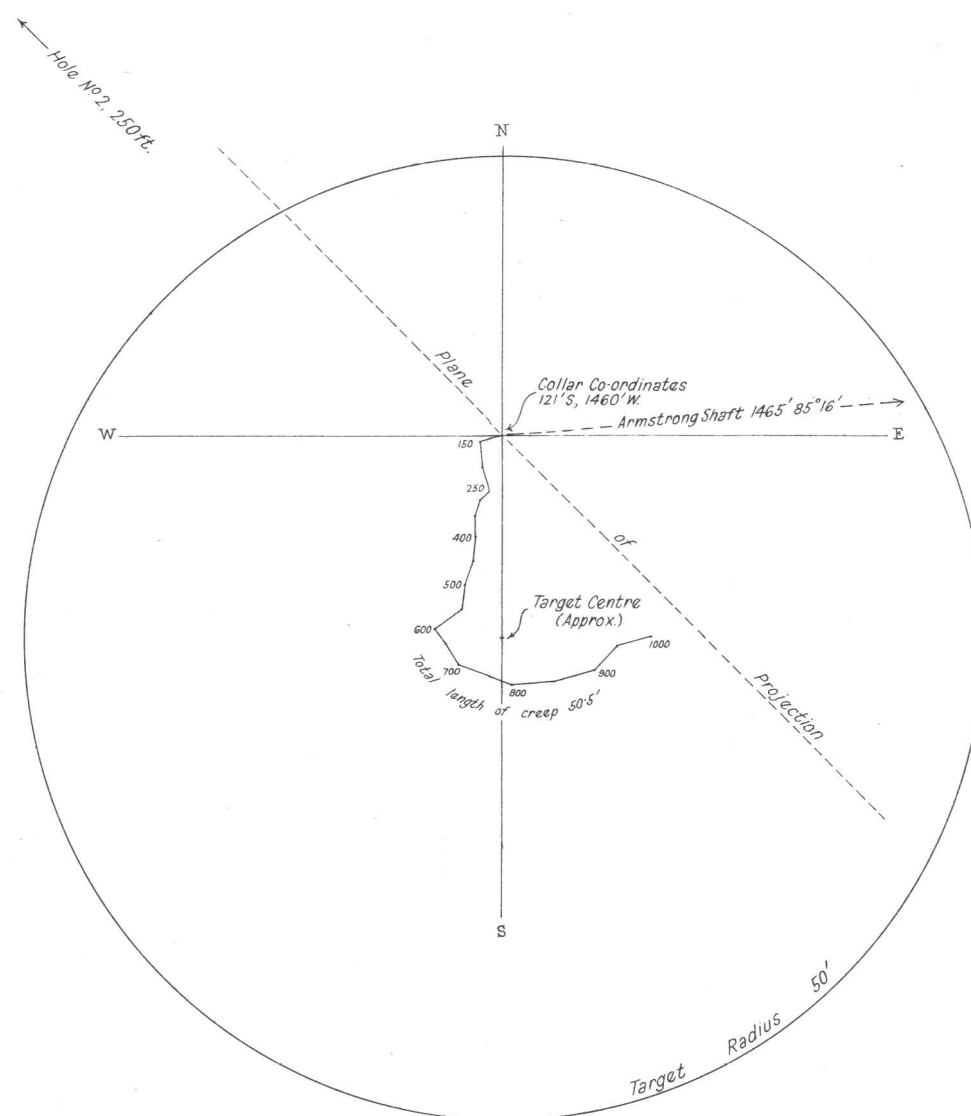
"EX" TROPARI SURVEY ANALYSES

DEPTH	INCLINATION	DEPARTURE OR CREEP	PROGRESSIVE CREEP	AZIMUTH
0-50'	29 1/2°	0.4'	0.4'	
50-100	29°	0.9	1.3	S 81° W
100-150	28 1/2°	1.3	2.6	S 87° W
150-200	27°	2.6	5.2	S 6° E
200-250	27°	2.6	7.8	S 17° E
250-300	28 1/2°	1.3	9.1	S 48° W
300-350	28°	1.7	10.8	S 20° W
350-400	27 1/2°	2.2	13.0	S 5° E
400-450	27°	2.6	15.6	S 7° W
450-500	27°	2.6	18.2	S 20° W
500-550	27°	2.6	20.8	S 6° W
550-600	26°	3.5	24.3	S 54° W
600-650	26°	1.7	26.0	S 39° E
650-700	27°	2.6	28.6	S 34° E
700-750	26°	3.5	32.1	S 71° E
750-800	27°	2.6	34.7	S 71° E
800-850	25°	4.4	39.1	N 87 1/2° E
850-900	25°	4.4	43.5	N 75° E
900-950	26 1/2°	3.5	47.0	N 43° E
950-1000	26°	3.5	50.5	N 74° E

Based on "Ex" Tropari surveys by Anglo-Westralian

D.D.H. No 1 AT 800'  
 R.L. depth 799.2'  
 Co-ordinates of hole 121°S 1460'W  
 $\begin{matrix} +25.6 \\ 1466'S \end{matrix}$  1459'W  
 Creep tendency S 2° E  
 Average rate of creep per 100 ft. depth = 4.3 ft

D.D.H. No 1 AT 1000'  
 R.L. depth 998.7'  
 Co-ordinates of hole 121°S 1460'W  
 $\begin{matrix} +20.8 \\ 1418'S \end{matrix}$  1444'W  
 Creep tendency S 37° E  
 Average rate of creep per 100 ft. = 5 ft.



Co-ordinates of Collar  
 121°S 1460'W

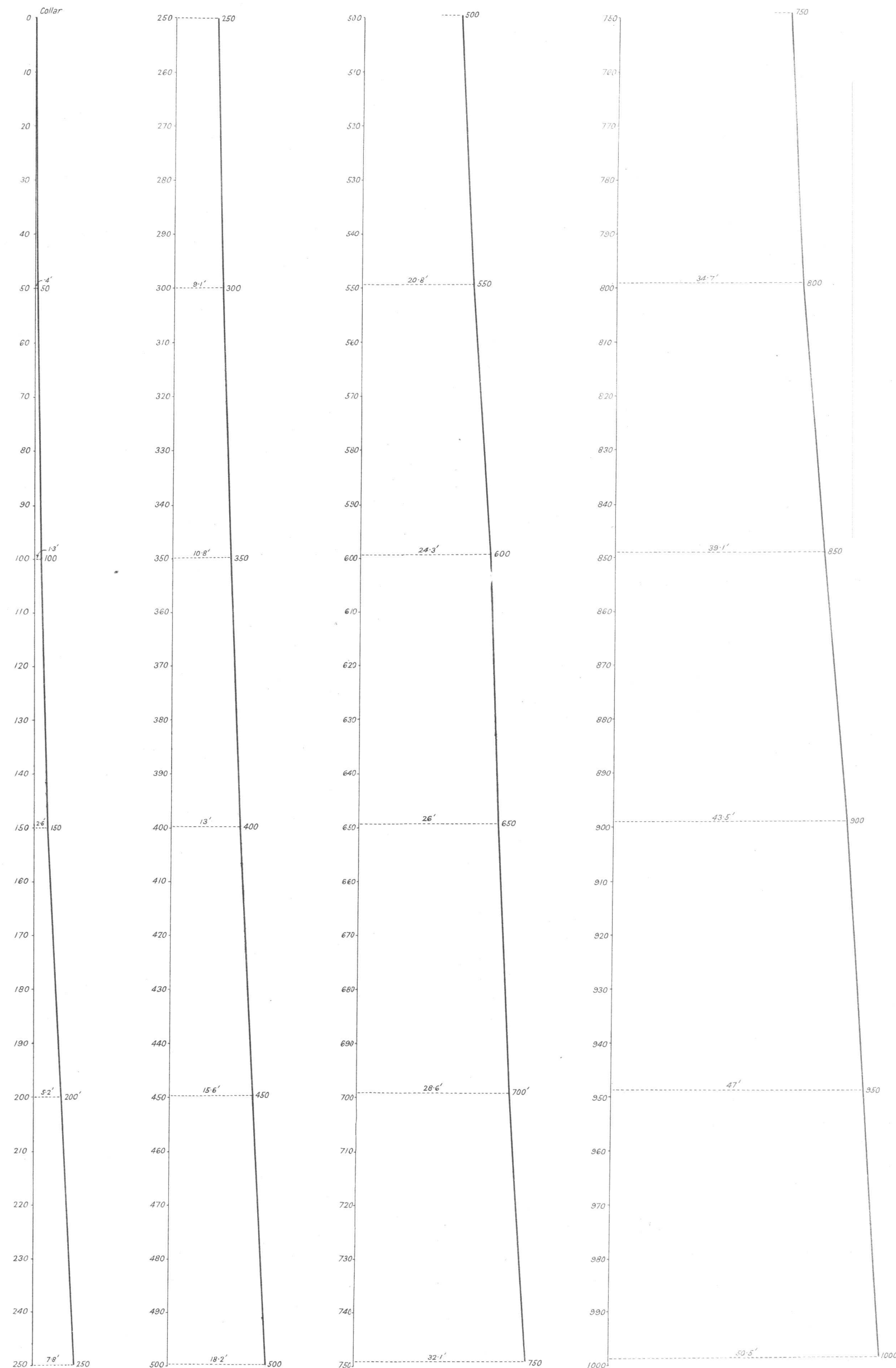


FIGURE 2  
 CREEP STUDY  
 of  
 GREAT FINGALL D.D.H. No 1  
 Scale 1 inch = 20 feet  
 Compiled by J.C. McMath, Dec. 1950

# FIGURE 3

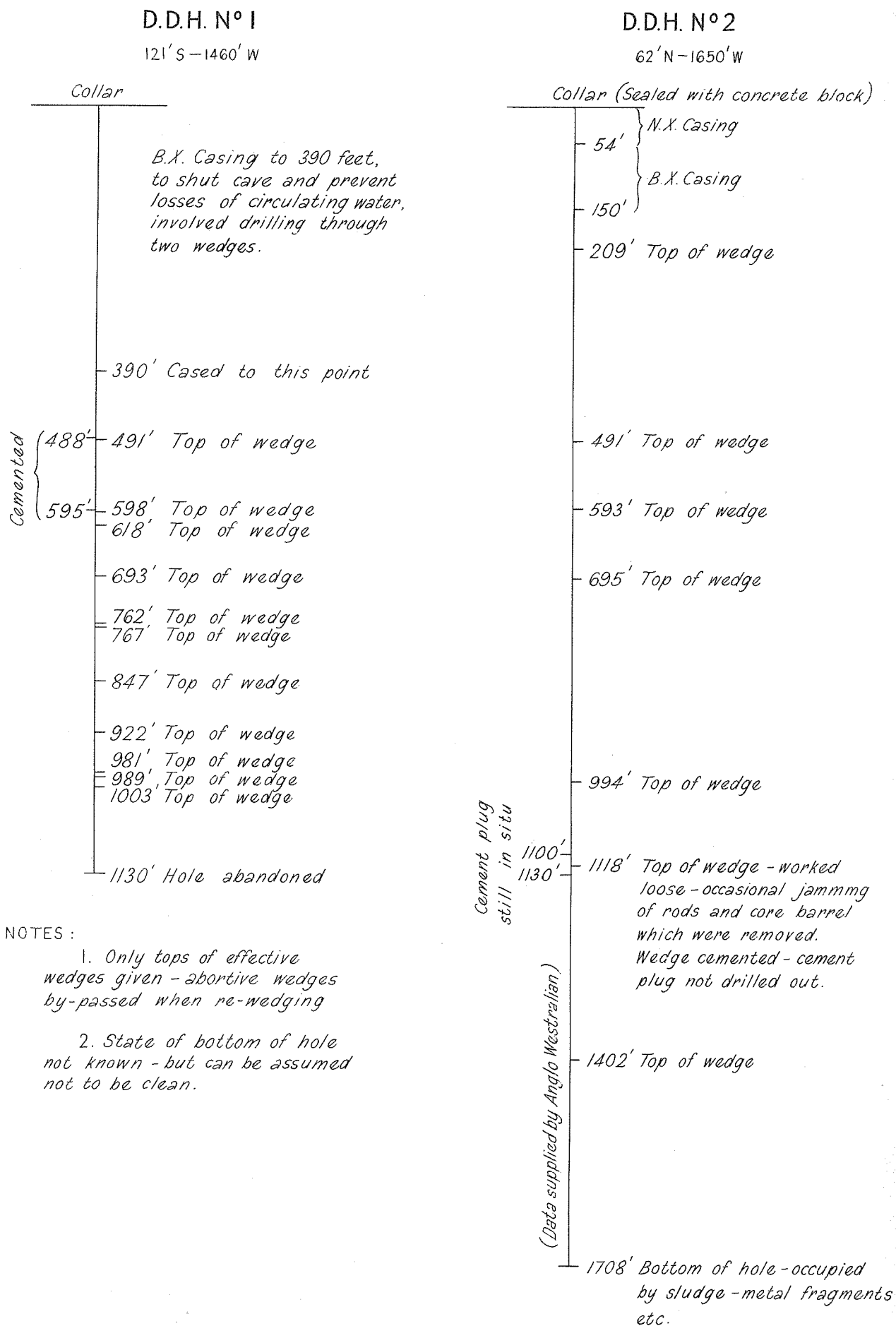
## CONDITION DIAGRAM OF D.D.H. N<sup>o</sup>s 1 & 2

Co-ordinate Origin - Armstrong Shaft

Core Size - B.X. = 1 5/8"

Direction - Vertical

Scale: 200 feet to an Inch



### NOTES :

1. Only tops of effective wedges given - abortive wedges by-passed when re-wedging
2. State of bottom of hole not known - but can be assumed not to be clean.

Frood Mine (International Nickel Company of Canada). The paper is entitled "Controlling Dip and Direction of Drill Holes by the Hall-Rowe Wedging Method". The paper was read in June, 1949.

Directional wedging of a hole entails—

- (i) survey of hole;
- (ii) orientation and positioning of wedge in the hole;
- (iii) check survey to ensure effectiveness of wedging operation.

The wedges employed in the Hall-Rowe Method are of brass or steel and remain fixed in the hole. Controlling a hole to vertical entails the same stages as above but is, theoretically more simple—orientation of the wedge being automatically determined by the drillers' use of the acid clinometer. It is remarked that, on the Fingall operation, a meniscus correction chart was supplied to the drillers. No accurate goniometer for reading the angle of inclination of the etched line was supplied. This was done with a home-made piece of apparatus of debatable value. In view of this the uses of the correction chart remain unknown.

For an accurate appreciation of the course of the hole survey both in azimuth and inclination the Trotter-Pajari Compass (supplied by Australian Drillers Pty. Ltd.) was used. Some comments on the three instruments used at various times are not out of place. Both sizes of instrument—BX/NX and EX/AX—were used and found unsatisfactory. Briefly, the instrument is ideal in concept. It is, however, liable to certain operational difficulties which can vary. These are largely attributed to unsound standards of manufacture and are centred about—

- (i) imperfections in timing gear leading to premature withdrawal of the instrument from the hole;
- (ii) uncertainty of effectiveness of locking device operated by timing gear under rod vibration, etc. during withdrawal of instrument from the hole.

Two BX/NX Troparis were found at fault and unserviceable. The EX/AX Tropari was found in error in time calibration but otherwise serviceable. Even if perfect, these instruments do not obviate the hazards of bore-hole survey since determination of azimuth is dependent upon a magnetic needle. The course of D.D.H. No. 1 hole was plotted in plan projection and creep studies made—reference Appendix I. Creep studies were also made of D.D.H. No. 2—reference Appendix I.

*Plant and Equipment.*—The drill supplied for the job was a Boyles Bros. B.B.S. No. 4, powered by a G.M.C. 248 truck engine with five speed transmission. Maximum performance with B rods 5,000'—with N rods 4,000'. The machine had chuck jaws modified to take B rods.

The tower used consisted of Cyclone Tubular Steel Scaffolding of overall height 80 ft.—78 ft. to distributing beam. Total weight was approximately three tons.

Circulating water was drawn from the St. Alban's Shaft.

*Personnel.*—Two Canadian driller-runners and two Australian helpers (trainee runners). Work was, for the greater part of the time on D.D.H. No. 1, on a three shift per 24 hour basis and a five day drilling week. The Field Superintendent, Mr. McCabe, was present at the start of drilling. The dates of his subsequent visits are not known to the author.

#### Diamond Drill Hole No. 1.

Co-ordinates (origin Armstrong Shaft) of collar were 121 ft. S., 1460 ft. W. Direction of hole was to be vertical and maximum permissible inclination before wedging back to vertical was laid down as 3°. The corrective value of a wedge was 1½°. Size of Core—BX = 1½ inches.

Drilling started on 12th December, 1949, and continued until the abandonment of the hole on 6th July, 1950, at a vertical depth of 1130 ft. The abandonment of the hole—which had become

mechanically unsound as a result of loosened wedges, dog-legging, and rod whip, was forced on the Company's Consultant by the failure of the drillers to pull the existing casing preparatory to re-casing to 1,000 ft. approximately. Until this point, completion of the hole considered practicable if the casing could be carried to 1,000 ft.

This mechanical condition of the hole existed in March, 1950, when the Company's Consultant visited the site. Thus, the overall drilling performance was of the order of 160ft. per month. It is remarked that the Consulting Geologist in a report to the Great Fingall Exploration Company dated 8th March, 1950 (after his visit to the site) said "it is reasonable therefore to look for, in the controlled drilling at Fingall, speeds in the order of 400ft. per month down to a depth of 2,000ft. Below 2,000ft. the rate will be progressively retarded to say 200ft. per month." At the time of this report, the drilling speed had been of the order of 300ft. per month.

This overall performance, not in accord with initial estimates of time and cost, was occasioned by the following factors:—

- (i) Initial equipment difficulties, time spent "fudging a course" whilst awaiting arrival of items, and the need for modification or re-machining of accessories supplied.
- (ii) Failure of wedging operations through "turning" of the wedge during setting. Turning of wedges was ascribed to—
  - (a) rising off collar of wedge with worn rising bits;
  - (b) an unsound wedging base due to accumulation of sludge, cuttings, and caved material in the bottom of the hole. (A clean base is essential to successful wedging).

In the case of such abortive wedges, it was necessary to back up the hole and re-wedge, resulting in lost footage and time.

- (iii) Losses of circulating water and consequent build up of sludge, etc. in the bottom of the hole. It was necessary to cement the horizons at which these losses occurred.
- (iv) Salinity of water accumulating in the hole leading to failure of cement, experimentation with cement mixtures—Cement Fondu and Portland—with a cartridge of Cement Fondu and bentonite finally giving a measure of success. A water analysis by the Government Chemical Laboratory showed that water at 750 ft. had a salinity of over 7,000 grains per gallon and that considerable calcium and magnesium ions were present. To overcome this, casing was carried down to 390ft.

So much for the general history of the drilling operations. In all 18 wedges were set, nine proving abortive for various reasons, of which "turning" was the chief. This was followed, in order, by the failure of wedges (though correctly positioned) to materially reduce the creep. Lastly two wedges jammed whilst lowering.

On 24th May, the Boyle Bros. B.B.S. No. 4 Drill was withdrawn by Australian Drillers Pty. Ltd. from Fingall and shipped to the Eastern States for service on a further Conolly prospect. Its place was taken by a Longyear Master Straightline Drill hired from the Commonwealth Government. The rating of this machine was 4,250ft. with A rods and 3,250ft. with B rods. It was said that this Longyear machine was suited to Fingall requirements.

Throughout the operation core recovery was high (approx. 98 per cent.) Reference may be made to Appendix II for the core record. A diagram showing the present condition of the hole constitutes Appendix III.

The author, by reason of urgent geological commitments elsewhere, was withdrawn from the venture on 4th May, 1950, by the Mines Department.

### Prelude to Diamond Drill Hole No. 2.

The foregoing operations had made inroads into the available funds of the Great Fingall Exploration Company. After visiting the site in early July, 1950, the Company's Consultant in a report to the Company (dated 9th July, 1950) remarks—"The project has been well nigh wrecked by the failure of the drillers to put down, under Australian conditions, a controlled hole. It has become necessary to abandon the hole preparatory to setting up on a second hole which must, without fail—

(a) hit the target;

(b) be completed with the money that is left.

After summarising his reasons, he recommended a second hole—again controlled to vertical but making allowance for the overall residual creep experienced in D.D.H. No. 1. The length of the hole was to approximate 3,500ft. at a total cost of £15,000. He adds "Mr. McCabe (Field Superintendent, Australian Drillers Pty. Ltd.) has assured the Great Fingall Co. the Longyear machine will do the job as indeed it will by its rated capacity."

### Diamond Drill Hole No. 2.

Co-ordinates were (Armstrong Shaft origin) 62ft. N. 1,650ft. west—i.e. 250ft. north-west of D.D.H. No. 1.

Direction of hole was to be vertical with maximum permissible inclination before wedging of 2° and a minimum wedge interval of 100ft.

The target was substantially that of D.D.H. No. 1.

Drilling was started on 24th July, 1950, and finally suspended at a depth of 1,708ft. on 13th November, 1950, due to the financial straits of the Great Fingall Exploration Company. The overall drilling rate was of the order of 400ft. per month—a very marked difference from performance on D.D.H. No. 1. Apart from poor mechanical performance of the Longyear machine and ancillary units, the history of the hole is uneventful apart from normal drilling "grief"—no water troubles were encountered, the Tropari Compass and container were dropped down the hole accidentally, the bit jammed against a loose wedge at 1,118ft. Eight wedges in all were set, one only proving abortive due to not seating properly. The wedge at 1,129ft. became loose and the latter part of operations was centred about this trouble. The condition of the hole at the close down on 13th November, 1950, was that the hole had been cemented from 1,100ft.-1,130ft. to secure the loose wedge seated at 1,129ft. The cement plug was left in the hole. The bottom of the hole was not cleaned of sludge, metal cuttings, etc. The collar of the hole was securely covered by a cement block. Local supervision of operations was carried out by Anglo-Westralian Mining Pty. Ltd.

Core recovery and log was substantially the same as for D.D.H. No. 1 (Ref. Appendix III). The creep study, by courtesy of Anglo-Westralian Mining Pty. Ltd., appears together with that for D.D.H. No. 1 in Appendix I. A diagram showing the present condition of D.D.H. No. 2 appears in Appendix II.

### Financial Exhaustion of Venture.

At a General Public Meeting of the Great Fingall Exploration Company on 21st September, 1950, the financial position as given by the Secretary was that, with all cash resources marshalled, including the full £10,000 loan from the Mines Department, they had £6,300. The estimate for the completion of the second hole to the first intersection was £17,000 approximately. Drilling was suspended temporarily pending arrangement for the provision of further capital. Approaches for temporary assistance were made to Australian Drillers Pty. Ltd., but such accommodation was not forthcoming. At a meeting of directors held on 28th September, 1950, a further proposal was advanced and, pending its finalisation, it was agreed that drilling be continued until the first week in November, when a further meeting would be held to review the position.

A further meeting of directors of Great Fingall Exploration Company was held on 3rd November, 1950. It then appeared that the proposed financial arrangement adumbrated at the meeting of 28th September, had fallen through completely for reasons appreciated by all concerned. It appeared, also, that the Company's Consulting Geologist was now uncertain, in the light of experience at Cobar and Mt. Lyell as well as at Fingall, whether deep drilling, practicable in Sudbury, was impracticable in Australia. It was decided to suspend drilling at Fingall and continue to endeavour to obtain additional finance. Accordingly, drilling was stopped, machine and rig dismantled, crew dispersed, the hole left sealed and the Great Fingall project reduced to suspended animation.

No comment on the history of the venture is necessary beyond that the repetition of the Fingall ore-body in depth remains a very legitimate prospect awaiting a more advanced drilling technique and financial appreciation than those used in the first approach to the problem.

### References.

- Bull. No. 7, G.S.W.A. 1903—Auriferous Reefs of Cue and Day Dawn.—W. D. Campbell.
- Bull. No. 29, G.S.W.A.—1907—A Report upon the Geology, together with a description of the Productive Mines of the Cue and Day Dawn Districts, Murchison G.F. Pt. 1.—H. P. Woodward.
- Ann. Prog. Rept. G.S.W.A. 1950—A Reconnaissance Survey of the Cue-Day Dawn Districts, Murchison G.F.—J. C. McMath.
- Econ. Geology Vol. XXXI. No. 3, 1936, "A Contour Method of Revealing Some Ore Structures."—H. J. C. Conolly.
- G.S.W.A. File 39/446, "Boring Great Fingall and three reefs to South-West, Day Dawn."—H. J. C. Conolly.
- G.S.W.A. File 14/1949—Great Fingall Exploration Co.—General.

### APPENDIX.

#### GREAT FINGALL VENTURE.

##### Logs of D.D.H. No. 1 and D.D.H. No. 2.

##### D.D.H. No. 1.

Depth (feet)	Remarks.
0 - 2	"Cement" and red clay.
2 - 55	Fine grained basic lavas—small quartz veinlets—a fracture system inclined approx. 30° to core axis. Varying degrees of weathering to approx. 40ft., thereafter fresh, dark green coloured basic lavas with some decomposition along fractured planes. Occasional small cavities infilled with limonite—? pseudomorphous after sulphide. Interval 53'-55' shows basic lavas with amphibole phenocrysts—? flow top.
55 - 56	Bleached compact ? tuff band.
56 - 128	Compact fine grained basic lavas with previous characteristics. Limonite and a little calcite on joint planes. Occasional limonite pseudomorphs after pyrite.
128 - 133	Fine grained basic lavas with quartz veinlets, following fractures at 30° to core axis. Basic lavas are slightly silicified.
133 - 134	White quartz at 30° to core axis—carrying xenoliths of fine grained basic lavas. Walls show dilation veinlets of quartz.
134 - 135	Fine grained basic lavas, slightly silicified. Slight amount of sulphide—? pyrrhotite.
135 - 139½	White quartz with basic lava xenoliths. No visible mineral in quartz.

## D.D.H. No. 1.

Depth (feet)

## Remarks.

139½- 250	Fine grained basic lavas—disseminated and sparse sulphide. Quartz stringers (at 30° to core axis) show slight sulphide. Basic lavas closely jointed with thin quartz films in joint planes. Quartz stringers tend to anastomose, the master veins being at 30° to core axis. Occasional vesicular and brecciated bands sub-parallel to core axis—? selvages of pillows.
250 - 273	Medium grained basic lavas—sparse sulphides—quartz veinlets at 30° to core axis. Some silicification. Possibly a doleritic minor intrusive. Sludges 250'-260' gave 0.5 dwts.—260'-270' gave 0.3 dwts.
273 - 293	Fine grained basic lavas with quartz veins at 30° to axis of core, also to plane of core diameter.
294 - 324	Medium grained basic lavas with quartz veinlets—possible doleritic minor intrusives. Sludges from 310'-320' assayed 0.3 dwts.
324 - 376	Fine grained basic lavas—slightly silicified—quartz veinlets at 30° to core axis. Sparse sulphides, with a heavier concentration at 329'. Some brecciation and "pillow" selva features. Some selva features show glassy tendency. These lavas become carbonated at 372' and break in blocky fashion.
376 - 467	Medium grained basic lavas. Quartz veins at 30° to core axis. Sparse sulphides.
467 - 557½	Fine grained basic lavas with pillow selva features, quartz veinlets, sparse sulphides.
557½- 558	Quartz vein at 30° to core axis.
558 - 570½	Fine grained basic lavas—sparse sulphides—quartz veinlets at 30° to core axis cut by later set at 20° to core axis.
570½- 571½	Quartz vein at 30° to core axis.
571½- 573½	Fine grained, compact basic lavas.
573½- 574	Quartz vein at 30° to core axis.
574 - 579½	Fine to medium grained basic lavas—with quartz veinlets.
579½- 581½	Quartz vein in fine grained basic lavas.
581½- 606½	Fine grained basic lavas—quartz veinlets to 30° to core axis—cleaved at 30° core axis. Sparse sulphide.
606½- 609	Quartz vein and brecciated fine grained basic lavas.
609 - 613½	Compact fine grained basic lavas.
613½- 614	Quartz at 30° core axis.
614 - 808	Fine grained basic lavas—sparse sulphides—quartz veinlets at 30° to axis of core. Cleavage 30° to axis of core. Occasional fine brecciation and pillow selva features. Quartz veinlets occasionally show megascopic sulphide. Shearing of lavas becoming more pronounced at 763'. Increase of sulphide from 763'-808'.
808 - 808½	Quartz vein at 30° to core axis—carries schlieren of slate.
808½- 810½	Black slates—sparse sulphides—quartz veinlets—cleavage is 30° to core axis.
810½- 814½	Quartz reef at 30° to core axis—sparse sulphides—slate inclusions.
814½- 817	Fine grained, silicified, basic lavas—sheared, with quartz veinlets, at 30° to core axis. Sparse sulphides,

## D.D.H. No. 1.

Depth (feet)

## Remarks.

817 - 824	Black slates, sparse sulphides, quartz veinlets. Cleavage is 30° to axis of core.
824 - 839	Silicified fine grained basic lavas—sparse sulphides—sheared at 30° core axis. Quartz shows sulphides.
839 - 841	Quartz with slate inclusions—megascopic sulphide.
841 - 845	Black, brecciated slate and quartz—sulphides present.
845 - 854	Fine grained basic lavas—quartz veinlets at 30° to core axis. Sparse sulphides.
854 - 863	Black slates, showing bedding of dip approx. 65°. Quartz veinlets and sparse sulphides.
863 - 866	Fine grained basic lavas with quartz veinlets.
866 - 878	Black slates—silicified—bedding shown. Quartz veinlets and sparse sulphides.
878 -1130	Fine grained basic lavas, quartz veinlets, sparse sulphides (arsenopyrite)—fractures at 30° to core axis.
Note.—Dips seen on surface are 70° approx. at N.62°W.	

## D.D.H. No. 2.

0 -1170

Substantially the same as for D.D.H. No. 1.

1170 -1300	Fine grained basic to intermediate lavas, with minor quartz stringers.
1300 -1499	Fine to medium grained lavas.
1499 -1505	Sheared lavas and black slate bands, 1502'-1505', banding inclined at 30°-45° to core axis.
1505 -1628	Fine to medium grained lavas.
1628 -1665	Medium to coarse grained lavas.
1665 -1676	Sheared lavas and thin bands of black slate, inclined 30°-45° to core axis.
1676 -1708	Fine to medium grained lavas.

PROGRESS REPORT ON DIAMOND DRILLING,  
COLLIE MINERAL FIELD, W.A.

No. 1. Site C—M.L. 415, North East of Shotts.

By J. H. Lord, B.Sc., F.G.S.

## CONTENTS.

	Page
Introduction .....	27
Drilling Procedure .....	28
Core Recovery and Log .....	29
Geology .....	29
Quality of Coal .....	29
Conclusion .....	30
Appendix—	
1. Summarised Log .....	31

## Introduction.

Although the deep drilling of the Collie Mineral Field has been recommended by various persons and bodies since 1905, it was not until the recommendation from the Geophysical and Geological Survey of Collie in 1946 and 1947 for deep holes at specified positions, that the Government decided to implement a deep drilling programme for the field.

The plant, which has been assembled by the Geological Survey of W.A., is being operated by Australian Drillers Pty. Ltd. as operating contractors using Canadian drill-runners.

Due to war-caused shortages, difficulties experienced in obtaining equipment from U.S.A. and lack of experienced drillers, it has taken considerable time to implement the project. Although the drill-



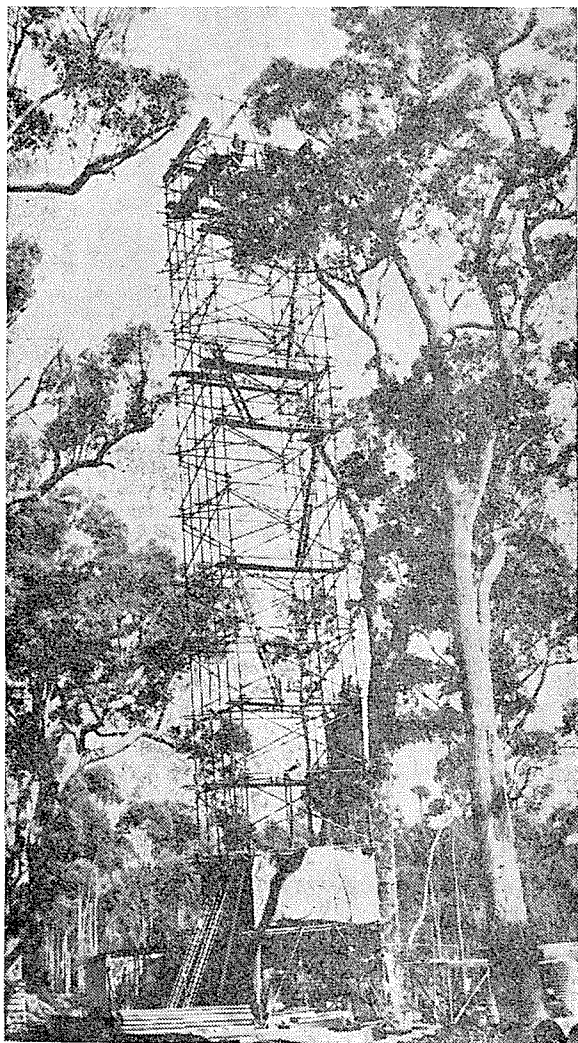
ing was authorised at the beginning of 1948, operations did not commence at Collie until 16th January, 1950.

This report details the results of the first hole drilled; a similar progress report omitting some general details will be prepared after the completion of each hole.

#### *Drilling Procedure.*

The drilling machine, which was purchased from Boyles Bros., Canada, is their BBS-4 model powered by a G.M.C. petrol motor and capable of drilling a hole, using NX equipment, to a depth of 4,000 feet. Although NX size rods, etc., are being used, the core barrels are of NM size (produces a 1 27/32 inch diameter core) to permit the circulation of the drilling mud.

After the plant was set on bed logs, a 82-foot tubular steel tower was erected which permits the drilling rods to be pulled and broken in 60-foot lengths and greatly speeds up the raising and lowering of the rods. The photograph (Plate II.) shows this tower rising through the jarrah trees.



Owing to the soft nature of the coal measures, the Canadian drillers recommended drilling with bentonite mud. The bentonite mud has the property of forming a gel when allowed to stand; in consequence mud circulated through the drill, instead of water, penetrates the soft walls of the hole, gels and holds up the wall and thus prevents loss by seepage and caving. Also the mud, due to its viscosity and gelling properties, removes the cuttings from the hole and retards any rapid settling if circulation stops.

At Collie the mud was mixed with a nozzle-type mixer, and normally 700 gallons were mixed in each batch and run into a small mud sump. The bore water used, with a pH of 5, was too acid to mix a good mud. It was found that a more satisfactory mud, which did not allow settling when the hole was left for a short period, was made by increasing the pH to 10, using soda ash.

Collie has always been noted for its hazardous casing conditions and in the majority of deep holes much casing was lost. In this hole 13 feet of 4-inch pipe and three 10-foot lengths of NX casing was inserted and then drilling continued with mud fluid. The only difficulty experienced with the hole occurred when the NX casing unscrewed, so to avoid a recurrence it was removed.

This is the first hole in Australia which has been drilled using mud throughout, and it proved entirely successful in solving the problem of casing at Collie.

Wyoming bentonite was used at the rate of 7.2 pounds per foot compared with the usual estimated rate of four pounds per foot, this being attributed to the soft nature of the strata and to the problem mentioned below which resulted in much mud being lost.

The high viscosity of the mud, which was necessary owing to the soft nature of the strata, produced a problem, as the cuttings would not settle out despite settling ditches. This accounted for nearly all the lost time. The sandy nature of the cuttings rapidly wore the working parts of the mud pump, causing the breakdown of the circulation.

A "Shale Shaker," used for separating the cuttings from the mud, has been ordered and may be available for the next hole.

No trouble was experienced at any stage with underground water.

Twelve diamond bits were used in the hole, that is, one bit per 156 feet of drilling. The sandy nature of the strata caused the setting holding the diamonds to wear away, while there was very little actual diamond wear.

Two shifts were worked until the last week of drilling, when the third shift commenced. When drilling, each shift consists of a Canadian drill-runner with an Australian helper. The following table (Table I) sets out the manner in which the shifts (regardless of number of men employed) and man-shifts were distributed over the various operations.

TABLE I.  
*Time Distribution at Site C.*

Operation.	Shifts.		Man-Shifts.	
	Number.	Percentage.	Number.	Percentage.
Drilling .....	124	71	254	59
Mud Mixing, breakdowns, etc. ....	23	13	55	13
Maintenance .....	8	5	24	5
Setting-up of Plant ....	20	11	101	23

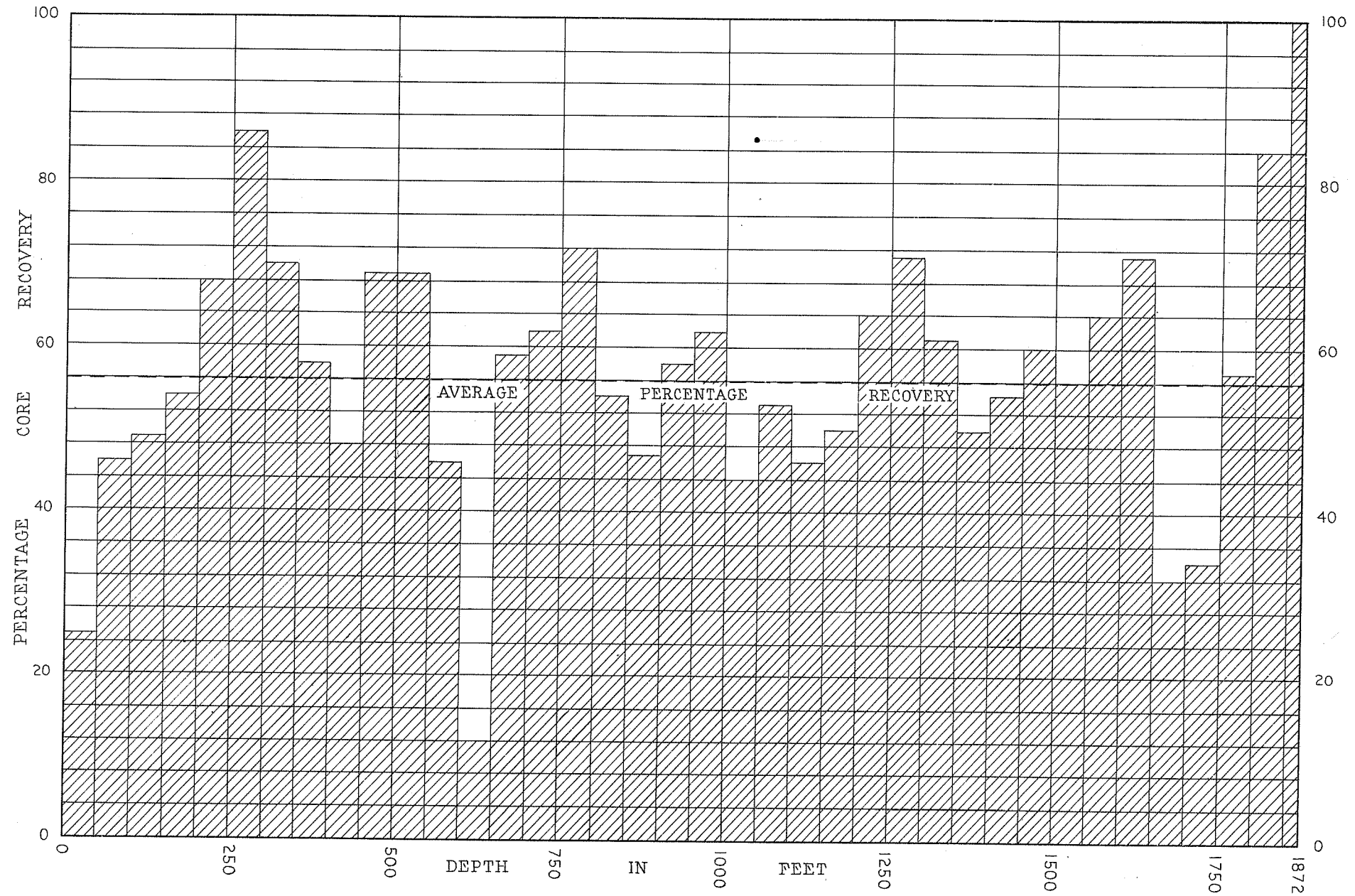
These figures show that a drill of this size should be used only on deep holes, because 23% of the man-shifts worked were in setting-up and preparing the drill site.

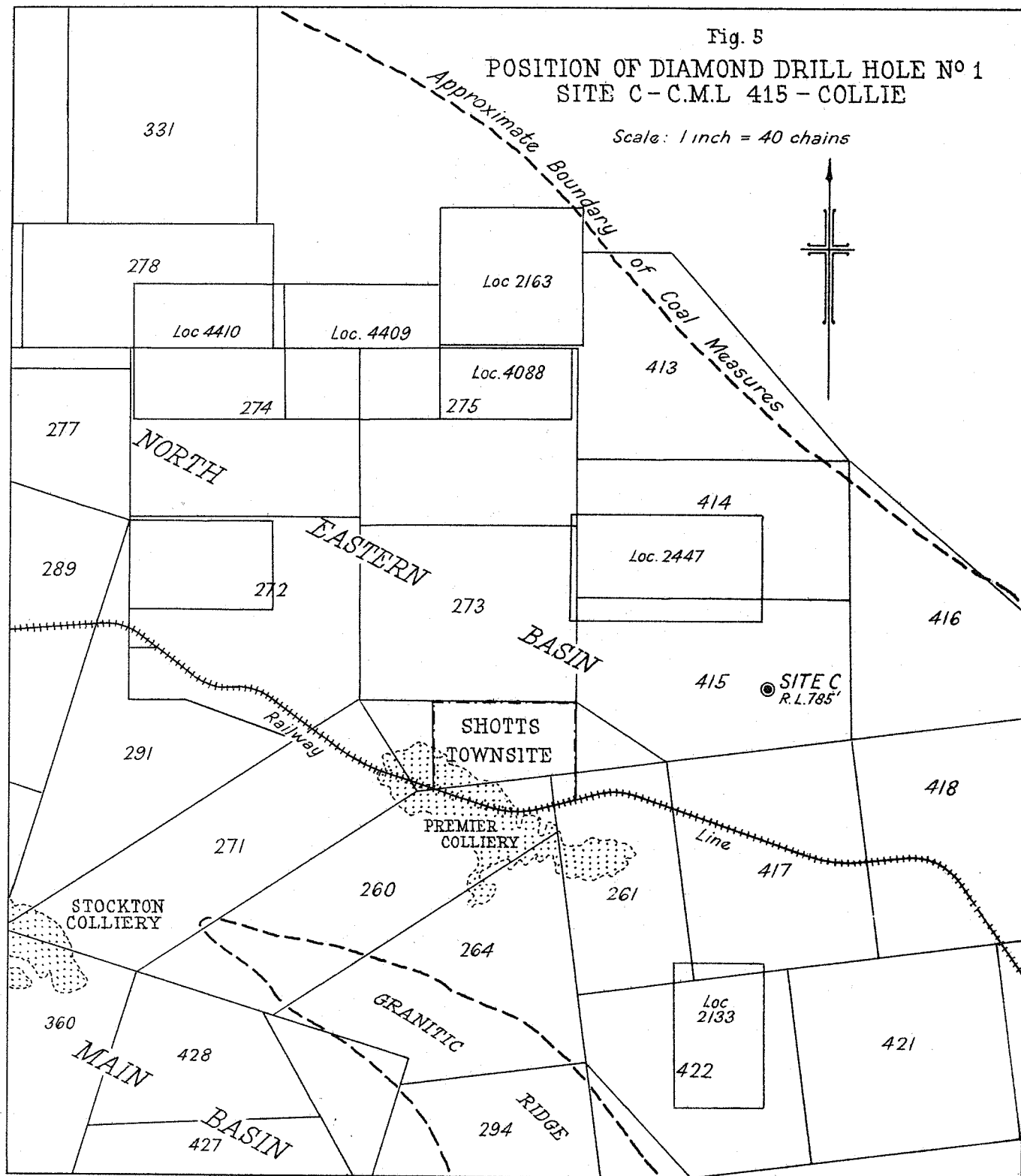
The following table (Table II) is a study of the operations on the shifts, when drilling took place.

TABLE II.  
*Time Distribution While Drilling and Core Recovery.*

Driller.	Number of Shifts Drilling.	Total Footage Drilled.	Core Re-covered.	Footage Drilled per Shifts.	Percentage Core covered.
Irwin ....	62	898	514	14.6	57
Koski ....	59	931	515	15.8	55
Miscellaneous	3	43	25	....	....
Total	124	1,872	1,054	15.1	56

Fig. 4 DIAMOND DRILL HOLE N°1 — SITE C  
PERCENTAGE CORE RECOVERY





GENERALISED DESCRIPTION	DEPTH IN FEET	COLLAR R.L. 785'	THICKNESS OF COAL	REMARKS
Lake Deposits	0			
Soft gray micaceous sandy shales	50		11"	
	64		2' 3"	PREMIER No 1
interbedded sandstones	100		4"	
with	150		3"	
interbedded sandstones	200		4' 7"	PREMIER No 2 Evidence of grinding, seam probably 5' 6" Shale roof and floor
Soft gray sandy shales	250		3"	
			4' 0"	PREMIER No 3 Evidence of grinding, seam probably 5' 6" Shale roof and floor
			7' 0"	PREMIER No 4 Shale roof and floor
with	300		5"	
interbedded sandstones	350		9"	
			10"	
			6"	
			10"	
	400		3' 4"	Sandstone roof and floor PREMIER No 5
Mainly			3' 10"	PREMIER No 6 Sandstone roof and shale floor.
sandstones	450			
	500		8"	

GENERALISED DESCRIPTION	DEPTH IN FEET	COLLAR R.L. 785'	THICKNESS OF COAL	REMARKS
Medium to coarse-grained sandstones	500		1' 5"	
with	550		1' 10"	
interbedded sandy shale	600			
	650		10"	
			7"	
Shales	700		4' 9"	Shale roof Sandstone floor
with	750		1' 1"	
interbedded sandstones	800		1' 5"	
			1' 0"	
			4"	
	850		3' 0"	Shale roof and floor with 4" shale band between
			2' 0"	
			1' 5"	
Gray shales	900		6"	
			1' 10"	
and			3' 2"	Sandstone roof Shale floor
			4"	
sandstones	950		2' 0"	
			1' 2"	
	1000		3"	

GENERALISED DESCRIPTION	DEPTH IN FEET	COLLAR R.L. 785'	THICKNESS OF COAL	REMARKS
Mainly coarse-grained sandstones	1000		3"	
	1050		4"	
with some	1100		7"	
interbedded shales	1150		6"	
	1200		10"	
			3"	
			9"	
Shales	1250		4' 3"	Roof: Shale? with sandstone above, (with 2' shale band) Floor: Sandstone 1" with shale below.
and	1300		8"	
sandstones	1350		9"	
Mainly	1400			
sandstones	1450			
			3' 4"	Roof: Sandstone Floor: Shale 8" with sandstone below.
			1' 0"	
	1500		3"	

GENERALISED DESCRIPTION	DEPTH IN FEET	COLLAR R.L. 785'	THICKNESS OF COAL	REMARKS
	1500		12' 9"	EWINGTON No 1 Black carbonaceous shale roof. Floor: 4' sandstone with shale below.
Sandstone	1550		2' 2"	
			4' 7"	EWINGTON No 2 Both seams show grinding probably 3' 6" Roof: Sandstone. Band of shale Floor: Black shale
	1600		8' 9"	EWINGTON No 3 Roof: Sandstone Floor: Shale
Mainly	1650		1' 5"	
sandstone	1700			
with occasional	1750			
interbedded shales	1800			
Shale	1850			
Granite	1857			
	1872			

Fig. 6  
COLUMNAR SECTION  
DIAMOND DRILL HOLE No 1  
SITE C - C.M.L 415 - COLLIE

The average rate of drilling was 15.1 feet per shift, but the rate per man-shift for the whole operation was only 4.3 feet.

The erection of the plant began at Collie on 16th January 1950, and the hole was completed on 30th May 1950.

This is the deepest hole (1,872 feet) drilled at Collie to date, the previous deepest being the Municipal water bore to 1,134 feet. The estimated depth of this hole published previously was 3,000 feet by Geophysical means<sup>19</sup> and 1,900 by Geological means<sup>20</sup>.

Core Recovery and Log.

As shown in Table II the overall total core recovery was 56 per cent. Fig. 4 shows the amount of core recovered for each 50 feet drilled. The only section where 100 per cent. core recovery was achieved was in the last 22 feet which was mainly granite.

In brief, it can be stated that coal and the darker shales cored reasonably well, but the soft sandy shales and soft sandstones were difficult to core. The graph of the core recovery (Fig. 4.) shows that there was only a very slight tendency for the sediments to become more consolidated with increase of depth.

Various methods of drilling were adopted to endeavour to obtain a better core recovery but none was successful. It is thought that, when the sandy cuttings can be taken out of the mud with the Shale Shaker, core recovery may improve.

Published with this report (Appendix I) is a summarised log showing sediments and coal (three inches in thickness and over) intersected. A full detailed log has also been prepared and is available at the Geological Survey. The core was logged shortly after it was recovered, and since drying out the shales in most cases have taken on a darker tone of grey. Also in the logging there is a very fine distinction between sandy shale and shaley sandstone; in fact all could be termed shaley sandstone.

Probably, the most noteworthy feature of the core from the coal measures is the violent current-bedding, which occurs at places throughout. Small faults and slumps can be seen and, in one piece of shale, the core had a vertical "sandstone dyke" half an inch wide in it.

The violent sudden changes, which must have taken place during sedimentation are another notable feature. Frequently a fraction of an inch of shale in coarse-grained sandstone is shown in the core, while abrupt changes from coarse-grained sandstone to shale and vice versa are common.

The log was a field determination and representative samples are being forwarded to the Bureau of Mineral Resources for a more detailed investigation.

Geology.

This hole on Lease 415 (Fig. 5.) was drilled on a site recommended by the Geophysical and Geological Survey as being near the centre of one of the two depressions in the floor of the North-East Basin. It is interesting to note that this site is in granite on plans of the coalfield issued before the above survey.

A columnar section (Fig. 6.) shows all coal seams (three inches and over) intersected. The first seams cut were those of the Premier Horizon as described previously by the writer<sup>21</sup>. The following Table III. shows the evidence for classifying these seams as the Premier Horizon.

Between the Premier Horizon, which may be considered to end below the No. 6 seam, that is, at 400 feet, and the next horizon, to be described below, at 1,500 feet there occurs only

TABLE III.  
Premier Horizon.

Stratigraphical Column.	Thickness in Diamond Drill at Site C.		Average Thickness in Percussion Holes on P.A. 53.		Thickness in Premier Caylx Bore.	
	ft. in.	ft.	ft. in.	ft.	ft. in.	ft.
No. 1 Seam .....	2	3	3	4	3	0
Sediments between No. 1 and 2 Seams .....	113		116		117	
No. 2 Seam .....	4	7(signs of grinding)	5	10	6	0
Sediments between No. 2 and 3 Seams .....	40		30		54	
No. 3 Seam .....	4	0(signs of intense grinding)	5	11	5	4
Sediments between No. 3 and 4 Seams .....	10		12		15	
No. 4 Seam .....	7	0	6	6	6	4
Sediments between No. 4 and 5 Seams .....	144		170		171	
No. 5 Seam .....	3	4	4	0	4	0
Sediments between No. 5 and 6 Seams .....	5		11		12	
No. 6 Seam .....	3	10	5	0	5	0

five seams, with a thickness greater than three feet. The thickest is 5 ft. 4 in. but has a four inch shale band three feet from the top.

It was in the above report on P.A. 53 that the writer suggested the possibility of intersecting the Ewington Horizon some 1,000 feet below the Premier Horizon. This proved to be approximately correct as three seams were intersected which are correlated with the Ewington Horizon, which in turn can be correlated with the Collie Horizon of the Main Basin. The seams were as follows:—

No. 1 (top) seam—12ft. 9in. of coal at 1,499 feet—equivalent to the Moira Seam of the Main Basin.

No. 2 (middle) seam—2ft. 2in. and 4ft. 7in. of coal separated by 1ft. 2in. of shale at 1,565½ feet—equivalent to the Dirty Seam of the Main Basin.

Note:—There was intense grinding in this coal and the seams were probably 3ft. and 6ft.

No. 3 (bottom) seam—8ft. 9in. of coal at 1,601¼ feet—equivalent to the Wallsend or Proprietary seam of the Main Basin.

The blind outcrop of these seams is in the vicinity of Lease 324 at Ewington some six miles to the west-North-west of this bore. The amount of coal available between this bore and the outcrop will approach a hundred million tons, but no estimate of tonnage will be made until the deep drilling programme at Collie is completed and the whole of the evidence can be considered.

The drill after passing through approximately 50 feet of grey shale (mudstone to be more accurate) containing in places some sand and granite pebbles, entered a coarse-grained granite at 1,857 feet. The drill continued 15 feet into the granite to ensure that it was not merely a boulder. There was no zone of weathering on the granite, the change being sharp from Permian mudstone to fresh granite.

Quality of the Coal.

The details of the analyses carried out on samples submitted to the W.A. Government Chemical Laboratories are shown on Table IV. The Laboratories intend to carry out further work on selected samples later.

The coal did not vary to any extent from the usual quality of the Collie coal. The deep coal is not a coking or gassing coal as was suggested previously by some persons.

<sup>19</sup> CHAMBERLAIN, N. G.: Preliminary Report on the Geophysical Survey of the Collie Coal Basin. Bureau of Mineral Resources, Geophysical Report No. 1, 1948, p. 5 (hole C).

<sup>20</sup> LORD, J. H.: Necessity for Deep Bores at Collie, W.A. G.S.W.A. Ann. Rept., 1947, p. 21 (hole No. 3).

<sup>21</sup> LORD, J. H.: Report on Prospecting Area 53 at Collie, W.A.

G.S.W.A. Ann. Rept., 1948.

TABLE IV.

PROXIMATE ANALYSIS OF THE THICKER SEAMS INTERSECTED IN BORE AT SITE C.

Chem. Lab. No.	Depth.	Thickness of Sample.	As Received.					Dry and Ash Free.		Ash on Dry Basis.	Colour of Ash.
			Moisture.	Ash.	Vol. Matter.	Fixed Carbon.	Calorific Value.	Vol. Matter.	Calorific Value.		
	Feet.		%	%	%	%	B.Th.U.				
2368/50	179	4 9	20.0	3.3	29.9	46.8	9,650	39.0	12,580	4.1	Red-brown
2367/50	220	4 0	20.0	5.05	29.2	45.75	9,560	38.95	12,760	6.3	Brown
2369/50	238	7 0	20.0	5.6	28.4	46.0	9,265	38.15	12,460	7.0	Chocolate
2385/50	389	3 4	20.0	3.5	27.9	48.6	9,640	35.5	12,610	4.4	Red-brown
2386/50	397	3 10	20.0	2.9	29.65	47.45	9,765	38.4	12,660	3.6	Red-brown
2687/50	501½	1 10	20.0	6.95	26.60	46.45	9,210	36.4	12,610	8.7	Fawn
3296/50	692	4 9	20.0	7.4	26.8	45.8	9,245	36.95	12,740	9.23	Light fawn
3297/50	817	3 0	20.0	7.0	26.45	46.55	9,235	36.25	12,650	8.75	Fawn
3298/50	820½	2 6	20.0	17.85	24.75	37.40	7,790	39.85	12,530	22.3	Buff
4087/50	896	2 0	20.0	8.20	24.85	46.95	9,170	34.65	12,760	10.25	Red-brown
4088/50	1,251½	4 4	20.0	12.60	23.75	43.65	8,535	35.25	12,660	15.75	Red-brown
4089/50	1,303	1 8	20.0	7.65	27.20	45.15	9,165	37.60	12,660	9.55	Red-brown
4635/50	1,477	3 4	20.0	10.60	23.95	45.45	8,750	34.5	12,600	13.25	Red-brown
4637/50	1,499	2 6	20.0	13.20	22.35	44.45	8,435	33.45	12,620	16.5	Dark brown
			*(18.28)								
4638/50		4 0	20.0	9.65	22.85	47.50	8,990	32.5	12,780	12.05	Brown
			(18.76)								
4639/50		3 0	20.0	7.90	24.10	48.00	9,285	33.40	12,880	9.85	Brown
			(19.36)								
4640/50		3 3	20.0	6.30	25.55	48.15	9,045	34.65	12,270	7.9	Red-brown
			(20.68)								
Weighted Mean											
1,499-1,511½		12 9	.....	9.08	.....	.....	8,980	.....	.....	.....	
1,501½-1,511½		10 6	.....	8.07	.....	.....	9,090	.....	.....	.....	
4920/50	1,565½	2 2	20.0	7.60	25.30	47.10	9,500	34.90	13,120	9.45	Brown
4921/50	1,569½	3 8	20.0	12.35	23.40	44.25	8,785	34.55	12,995	15.40	Light brown
4922/50		1 1	20.0	7.25	26.35	46.40	9,485	36.20	13,040	9.05	Light brown
4923/50	1,601½	2 8	20.0	6.05	22.65	51.30	9,660	30.60	13,065	7.55	Dark brown
			(22.04)								
4924/50		3 0	20.0	5.75	25.25	49.00	9,745	34.0	13,125	7.20	Dark brown
			(22.04)								
4925/50		3 0	20.0	6.25	26.45	47.30	9,790	35.85	13,275	7.80	Light brown
			(22.74)								
Weighted Mean											
1,601½-1,610		8 8	.....	6.02	.....	.....	9,730	.....	13,170	.....	
5352/50	1,634	1 5	20.00	8.95	27.0	44.05	9,675	38.0	13,620	11.2	Light brown

All moisture contents have been adjusted to 20 per cent.

\* Moisture content shown in brackets indicates as received value.

*Conclusion.*

The first hole of the Collie deep drilling programme was completed when it encountered granite at 1,857 feet. Mud drilling overcame the hazardous casing difficulties previously experienced at Collie, while the core recovery was 57 per cent.

The coal horizons cut included only those which had been previously anticipated by the geologist, the quality being similar to that shown by the seams elsewhere on the coalfield with no improvement due to increase of depth.

AUSTRALIAN DRILLERS D.D. HOLE No. 1—  
SITE 'C' M.L. 415 N.E. of SHOTTS.

Depth (feet)	Summarised Log.
0 - 39	Lake deposits.
39 - 47	Sediments.
47 - 48	Coal (11").
48 - 64	Sediments.
64 - 66½	Coal (2'3").
66½ - 128	Sediments.
128 - 128½	Coal (4").
128½ - 141	Sediments.
141 - 141½	Coal (3").
141½ - 179	Sediments.
179 - 183½	Coal (4'7")—evidence of grinding, seam probably 5'6".
183½ - 215	Sediments.
215 - 215½	Coal (3").
215½ - 224	Sediments.
224 - 228	Coal (4'0")—evidence of grinding, seam probably 5'6".
228 - 238½	Sediments.

238½ - 245½	Coal (7'0").
245½ - 252	Sediments.
252 - 252½	Coal (5").
252½ - 286½	Sediments.
286½ - 287½	Coal (9").
287½ - 295	Sediments.
295 - 296	Coal (10").
296 - 310½	Sediments.
310½ - 311	Coal (6").
311 - 322	Sediments.
322 - 323	Coal (10").
323 - 389	Sediments.
389 - 392½	Coal (3'4").
392½ - 397	Sediments.
397 - 401	Coal (3'10").
401 - 497½	Sediments.
497½ - 498	Coal (8" dirty).
498 - 501	Sediments.
501 - 501½	Coal (5").
501½ - 503½	Coal (1'10").
503½ - 665	Sediments.
665 - 666	Coal (10").
666 - 675	Sediments.
675 - 675½	Coal (7").
675½ - 692½	Sediments.
692½ - 697	Coal (4'9").
697 - 738	Sediments.
738 - 739	Coal (13").
739 - 764½	Sediments.
764½ - 765	Coal (5").
765 - 767	Sediments.
767 - 768	Coal (14").
768 - 768½	Sediments.
768½ - 769½	Coal (12").
769½ - 783½	Sediments.



Depth (feet)	Summarised Log.
783½- 783¾	Coal (4").
783¾- 817	Sediments.
817 - 820	Coal (3'0").
820 - 820½	Sediments.
820½- 822½	Coal (2'0").
822½- 828½	Sediments.
828½- 830	Coal (1'5").
830 - 882	Sediments.
882 - 882½	Coal (6").
882½- 888½	Sediments.
888½- 890½	Coal (1'10") (broken Core).
890½- 896	Sediments.
896 - 899	COAL (3'2").
899 - 909	Sediments.
909 - 909½	COAL (4").
909½- 928	Sediments.
928 - 930	COAL (2'0" dirty).
930 - 952	Sediments.
952 - 953	COAL (1'2" dirty).
953 - 955	Sediments.
955 - 955½	COAL (3").
955½-1040	Sediments (several bands of black shale containing coal).
1040 -1040½	COAL (3").
1040½-1058	Sediments.
1058 -1058½	COAL (4").
1058½-1092	Sediments.
1092 -1092½	COAL (7").
1092½-1127	Sediments.
1127 -1127½	COAL (6").
1127½-1194	Sediments.
1194 -1195	COAL (10").
1195 -1209	Sediments.
1209 -1209½	COAL (3").
1209½-1218½	Sediments.
1218½-1219½	COAL (9").
1219½-1251½	Sediments.
1251½-1255½	COAL (4'3").
1255½-1301½	Sediments.
1301½-1303	COAL (1'8").
1303 -1333	Sediments.
1333 -1333½	COAL (9").
1333½-1377	Sediments.
1477 -1480½	COAL (3'4").
1480½-1491½	Sediments.
1491½-1492½	COAL (1'0").
1492½-1492¾	Sediments.
1492¾-1493	COAL (3").
1493 -1499	Sediments.
1499 -1511½	COAL (12'9")
1511½-1565½	Sediments.
1565½-1567¾	COAL (2'2").
1567¾-1569½	Sediments.
1569½-1574	COAL (4'7") (Note: Severe grinding —this seam may be 6'0").
1574 -1589	Sediments.
1589 -1590	COAL (11").
1590 -1601½	Sediments.
1601½-1610	COAL (8'9").
1610 -1632½	Sediments.
1632½-1632¾	COAL (4").
1632¾-1634	Sediments.
1634 -1635½	COAL (1'5").
1635½-1857	Sediments.
1857 -1872	Granite.

PROGRESS REPORT ON DIAMOND DRILLING,  
COLLIE MINERAL FIELD, W.A. (2).

Bore No. 2—Site L—Mineral lease 152, 2½ miles  
South of Collie Townsite.

By J. H. Lord, B.Sc., F.G.S., Geological Survey of  
Western Australia.

CONTENTS.		Page
Drilling Procedure	.....	31
Core Recovery and Log	.....	32
Geology	.....	32
Quality of Coal	.....	32
Conclusion	.....	32

It is assumed that the reader is familiar with the information published in the first progress report, and only where there is any difference in procedure will comment be made in this report.

Drilling Procedure.

The drilling plant and rig was similar to that at Site C, except that a cement base was laid, onto which the plant and tower were erected.

The water for making the drilling mud was pumped from the river, some 1,200 yards distant. This water proved better chemically for the purpose than the bore water used in the previous hole.

The use of mud was again successful as only two lengths of NX casing were used. Bentonite was used at a rate of 3.0 pounds per foot as compared with 7.2 pounds per foot in No. 1 hole, the improvement probably being due to the better mixing properties of the water. No trouble was experienced from underground water or from the caving of the hole.

Seven diamond bits were used in the hole which means one bit per 191 feet of drilling as compared with one bit per 156 feet of drilling in No. 1 hole.

Three shifts were worked throughout the drilling of this hole.

A serious mishap occurred when drilling at a depth of 1,336 feet. A drilling rod broke at 676 feet below the collar of the hole. Apparently a "kink" which had developed in this rod caused it to revolve eccentrically thus causing excessive wear on one side, until eventually it wore through and the rod broke. This occurred on afternoon shift on 4th August. Fishing operations were commenced on day shift the following day.

First an outside tap was attached to the lost string of rods, but this tap broke when an attempt was made to pull. Later an inside tap was attached several times but the lost rods could not be moved, as apparently they were held fast by the cuttings and mud that had settled around them.

An attempt was made to drill over the lost rods with casing, without success.

The remaining possibility was to wedge the whole at 676 feet and drill on from there, but it was decided to abandon the hole because it was very doubtful whether a wedge would be successful.

Table 1 below sets out the manner in which the shifts (regardless of number of men employed) and man-shifts were distributed over the various operations, including the fourteen shifts lost while fishing for the lost rods.

TABLE I.  
Time Distribution on Site L.

Operation.	Shifts.		Man-Shifts.	
	Number.	Per-centage.	Number.	Per-centage.
Drilling	63	52	126	35
Mud-mixing, break-downs, fishing, etc.	36	30	120	34
Maintenance....	4½	4	14½	4
Setting-up and dismantling plant	17	14	97	27
Total	120½	....	357½	....

Drilling of 3.9 feet was done per man shift as compared with 4.3 in No. 1 hole, but if the time lost spent fishing is excluded the rate was 4.7 feet per man-shift.

The following table (Table II) is a study of the operations on shifts when drilling took place.

TABLE II.  
Time Distribution while Drilling and Core Recovery.

Driller.	Number of Shifts Drilling.	Total Footage Drilled.	Core Re-covered (Feet).	Average Footage Drilled per Shift.	Per-centage Core Re-covered.
Irvin ....	22½	414	246½	18.4	59.4
Koski ....	19½	459	253½	23.5	55.1*
Thompson	21	452	264½	21.5	58.4
Miscellaneous	....	11	....	....	....
Total....	63	1,336	764	....	57.2*

\* Allowance has been made for the 6 feet not pulled.

The average rate of drilling from the above table is 21.2 feet per shift as compared with 15.1 feet per shift on No. 1 hole. This illustrates the advantage of working three shifts although allowance must be made for the greater depth of No. 1 hole.

Core Recovery and Log.

As shown in Table II above, the overall total core recovery was 57%, just one per cent better than No. 1 hole. Figure 7 shows the percentage core recovered for each 50 feet drilled. It will be noticed that from the collar to a depth of 400 feet the core recovery was very poor being only 23%, whereas between 400 and 1,330 feet the average was 72%. Although the former was very disappointing as it included the Collie Burn horizon of coal seams, the latter improved core recovery was encouraging as much of the strata consisted of sandstones.

The lithology of the strata as shown in the core was similar to No. 1 hole and similar remarks apply to this log.

A summarised log (Appendix 1) is published with this report showing sediments and coal (three inches and above). A full detailed log has been prepared and is available at the Geological Survey.

Geology.

This hole on Lease 152 (Fig. 8) was drilled on a site recommended by the Geological Survey to test the Collie Burn horizon of coal seams between the Griffin Colliery and Collie Burn; and also to test the continuation of the Collie horizon of coal seams at depth in the main basin of the Collie Coalfield.

A columnar section (Fig. 9) shows all the coal seams (three inches and over) intersected. The first seams cut were those of the Collie Burn horizon which unfortunately, due to the poor core recovery, were difficult to identify. Below this horizon, that is below 500 feet, a great thickness of sandstone, shaley sandstone with occasional shale beds were encountered, but no coal of any importance. Due to the hole being lost at 1,336 feet, the depth where the Collie horizon was expected to be encountered was not reached.

It is considered that the 4ft. 3in. of coal recovered at 477 feet may be the No. 4 or Griffin seam of the Collie Burn horizon. The No. 3 and 2 seams could not be recognised due to poor core recovery and the No. 1 seam outcrops south of this site.

Quality of Coal.

The details of analyses carried out on samples submitted to the Government Chemical Laboratories are shown in Table III. The results of the proximate analyses of seams above 500 feet suggest that the seams are members of the Collie Burn horizon.

TABLE III.  
Proximate Analysis of the Thicker Seams Intersected in Bore at Site L.

Chem. Lab. No.	Depth (feet).	Thickness of Sample.	As Received.					Dry and Ash Free.		Ash Dry Basis.	Colour of Ash.
			Moisture.	Ash.	Volume Matter.	Fixed Carbon.	Calorific Value.	Volume Matter.	Calorific Value.		
		ft. in.	%	%	%	%	B.Th.U.	%	B.Th.U.	%	
6703/50	140	1 0	20	5.15	32.15	42.70	10,010	43.0	13,385	6.45	Pink-brown.
6704/50	261	3 11	20	3.95	31.40	44.65	9,850	41.30	12,950	4.95	Light brown.
6705/50	371½	2 8	20	19.40	23.85	36.75	7,920	39.30	13,065	24.30	Pink.
6706/50	422	3 3	20	7.15	28.80	44.05	9,505	39.50	13,055	8.95	Pink.
6707/50	465	1 0	20	7.75	26.40	45.85	9,425	36.55	13,040	9.65	Pink.
6708/50	477½	4 3	20	3.40	29.75	46.85	9,835	38.90	12,860	4.25	Red brown.
6830/50	718	1 8	20	2.60	27.25	50.15	9,605	35.25	12,420	3.30	Brown.
6974/50	801½	2 1	20	5.15	28.0	46.85	10,060	37.45	13,440	6.45	Red brown.
6975/50	960½	1 2	20	6.25	28.95	44.80	9,865	39.35	13,370	7.85	Light brown.

Conclusion.

The second hole (site L) of the Collie deep drilling programme was abandoned at 1,336 feet because of a drill rod breaking at 676 feet.

Mud drilling which was again successful made casing unnecessary, while the core recovery was 57%.

The Collie Burn horizon of coal seams was encountered although the core recovery in the seams was poor. The hole was lost before reaching the lower Collie horizon.

AUSTRALIAN DRILLERS D.D. HOLE No. 2—SITE 'L' M.L. 152—2½ MILES SOUTH OF COLLIE.

Depth (feet) Summarised Log.

0 - 103 Lake deposits.  
103 - 140 Sediments.  
140 - 141 COAL (12").  
141 - 186 Sediments.

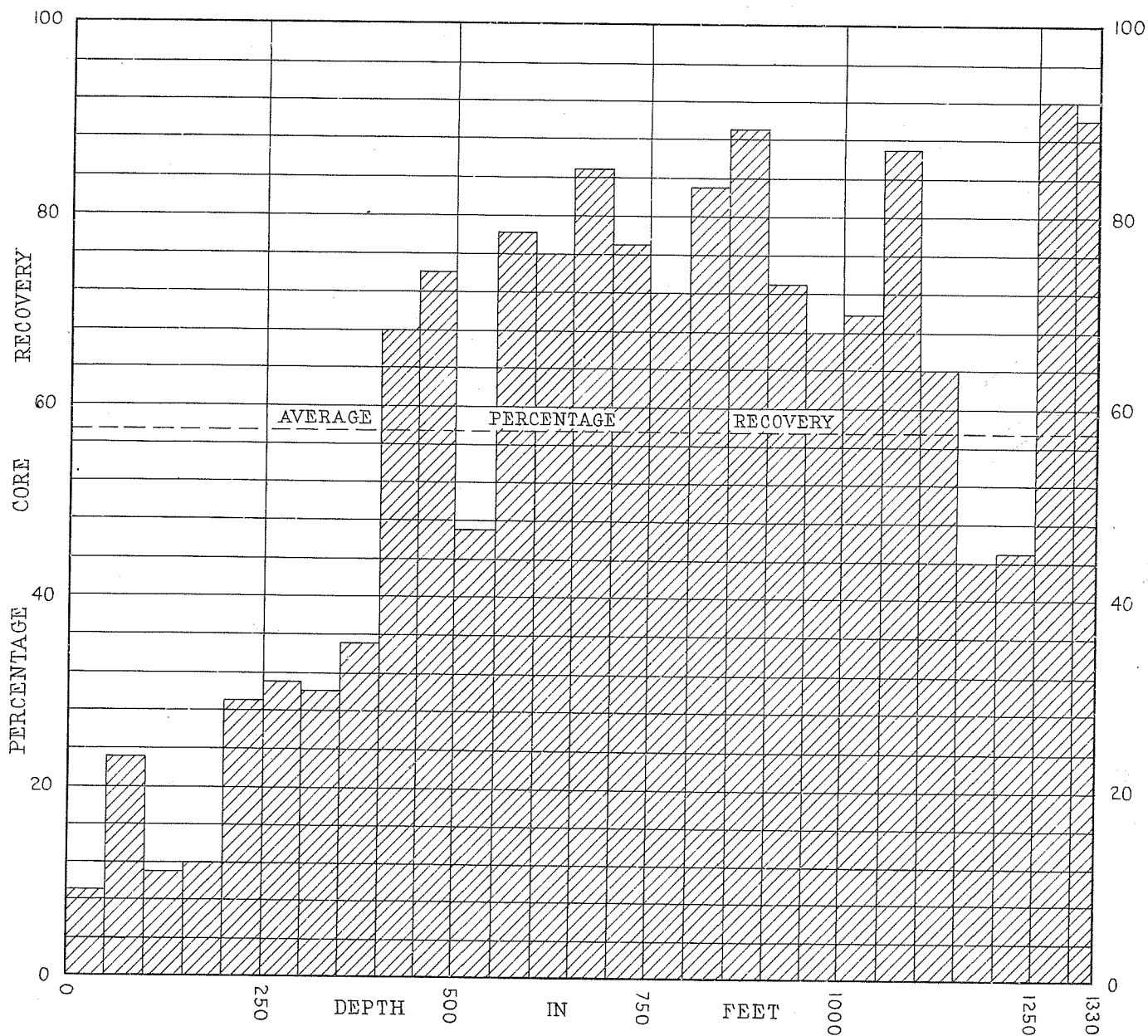
Depth (feet)

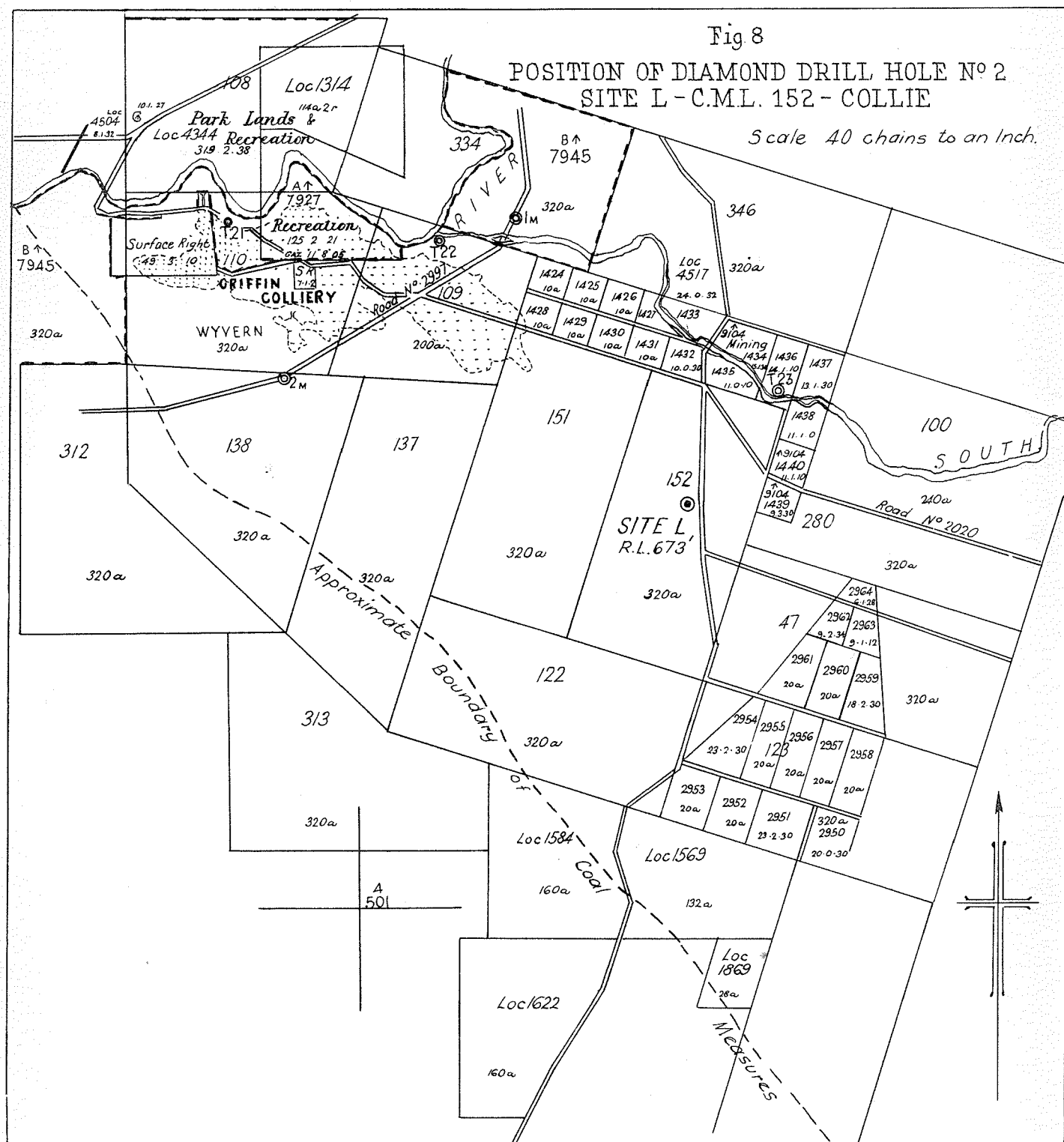
Summarised Log.

186 - 186½ COAL (8").  
186½- 191½ Sediments.  
191½- 192 COAL (3").  
192 - 261½ Sediments.  
261½- 265½ COAL (3' 11" of core but badly broken and worn).  
265½- 371½ Sediments.  
371½- 374 COAL (3'8" of core but badly broken and worn).  
374- 422 Sediments.  
422- 425½ COAL (3' 3" of core but badly broken).  
425½- 465 Sediments.  
465 - 466 COAL (12" broken core).  
466 - 477½ Sediments.  
477½- 482 COAL (4' 3" broken core).  
482 - 519 Sediments.

Fig. 7

DIAMOND DRILL HOLE N° 2 — SITE L  
PERCENTAGE CORE RECOVERY





GENERALISED DESCRIPTION	DEPTH IN FEET	COLLAR R.L. 673'	THICKNESS OF COAL	REMARKS
Lake Deposits	0			
Mainly clays	50			
	100			
Grey and black shales and fine to medium grained sandstones	150	1' 0"		HORIZON
	200	8" 3"		
	250	3' 11"		Sandstone roof shale floor
	300			COLLIEBURN
Fine to medium grained sandstones with interbedded grey and black shales	350	3' 8"		
	400	3' 3"		
	450	1' 0"		
	500	4' 3"		

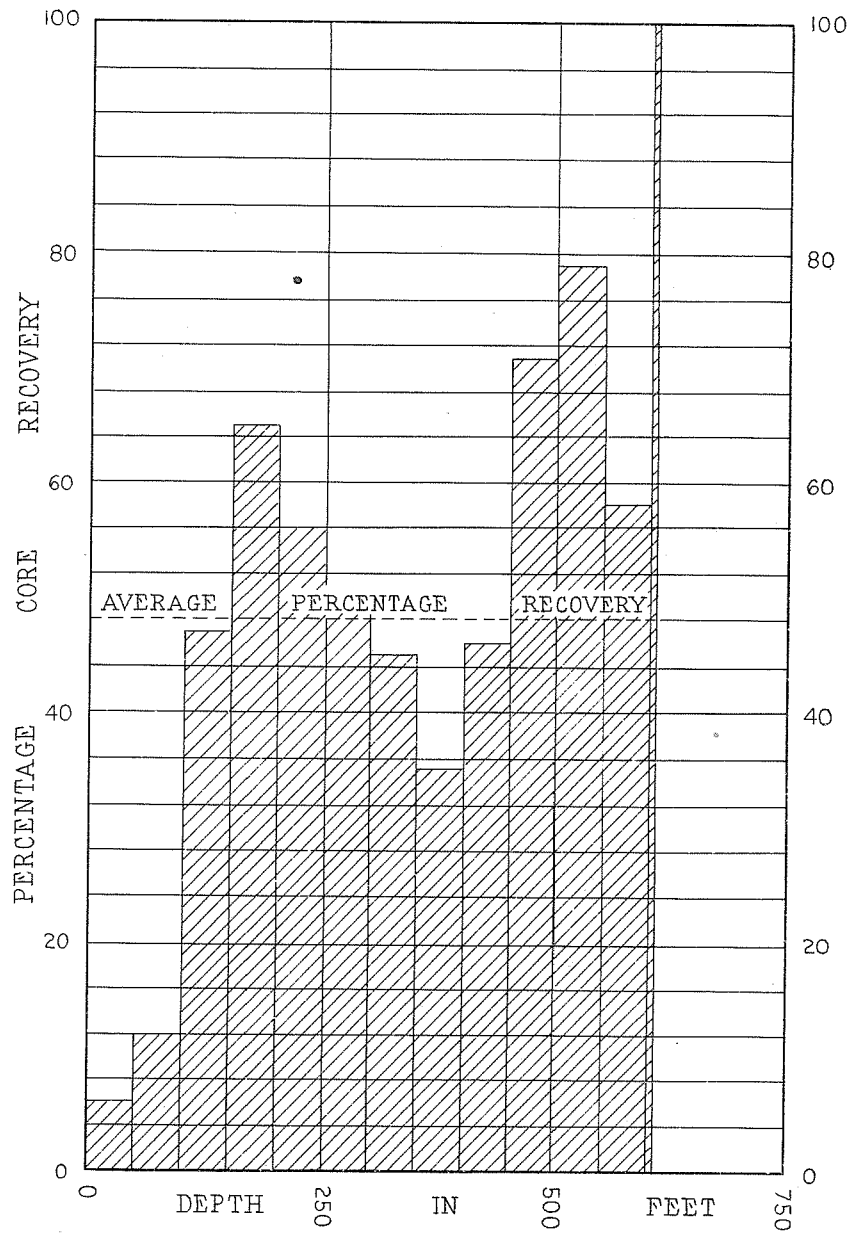
GENERALISED DESCRIPTION	DEPTH IN FEET	COLLAR R.L. 673'	THICKNESS OF COAL	REMARKS
Fine to coarse grained sandstones with interbedded grey to black shales	500		3"	
	550		3"	
	600		4"	
	650		1' 8"	
	700		3"	
	750		4"	
Medium to coarse grained sandstones with interbedded grey sandy shales	800	2' 1"	8"	
	850		9"	
	900		1' 2"	
	950			
	1000			

GENERALISED DESCRIPTION	DEPTH IN FEET	COLLAR R.L. 673'	THICKNESS OF COAL	REMARKS
Mainly medium to coarse grained sandstones with occasional shale bands.	1000		10"	
	1050		7"	
	1100			
	1150			
	1200			
	1250			
	1300		10"	
Gray and black shales and sandstones	1336			Hole Lost

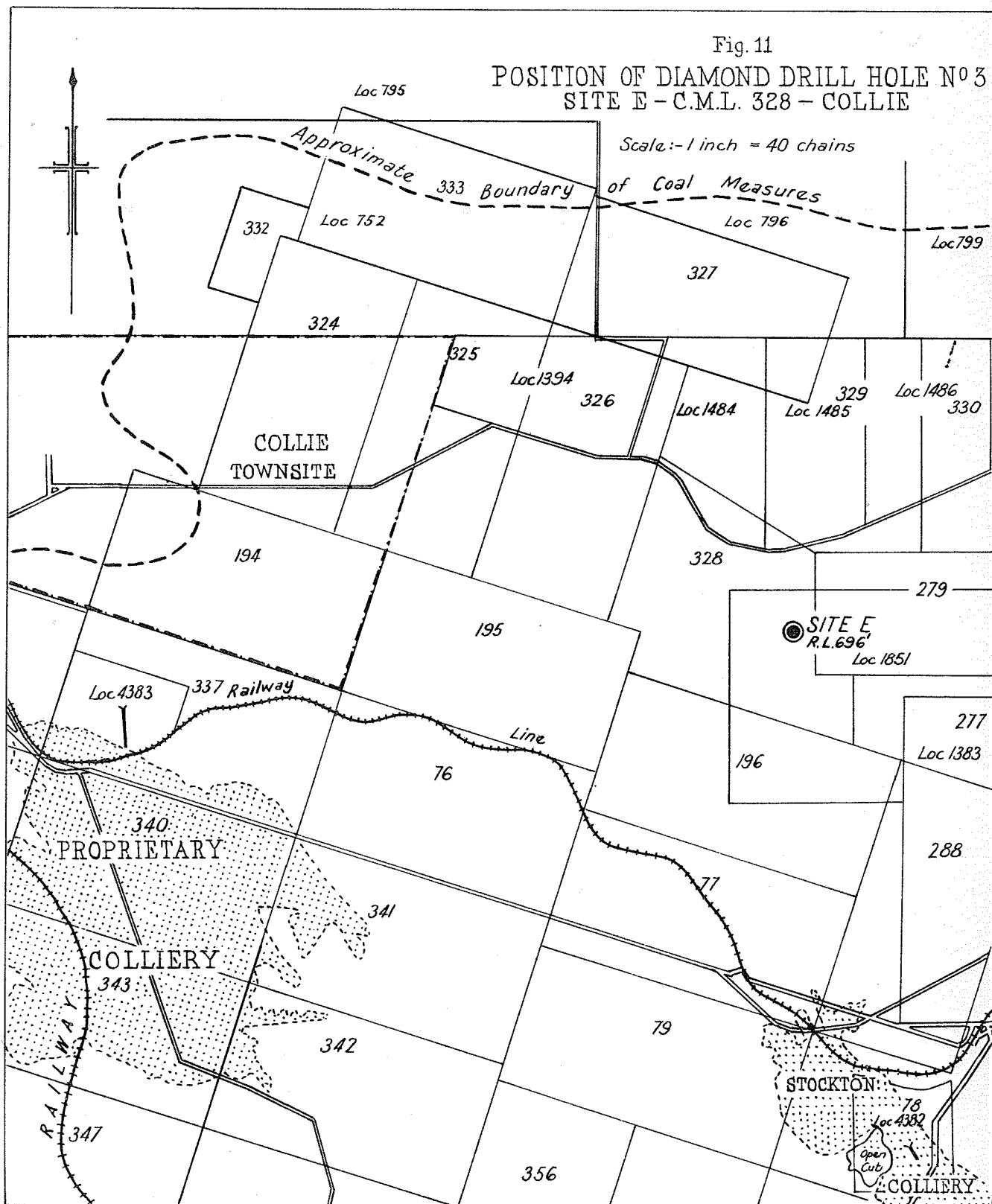
Fig. 9  
COLUMNAR SECTION  
DIAMOND DRILL HOLE N° 2  
SITE L - C.M.L. 152 - COLLIE

Fig. 10

DIAMOND DRILL HOLE N° 3 — SITE E  
PERCENTAGE CORE RECOVERY







GENERALISED DESCRIPTION	DEPTH IN FEET	COLLAR R.L. 696'	THICKNESS OF COAL	REMARKS
Lake Deposits	0			
Soft shaley sandstone with occasional shale	50		4" 8"	
Mainly shale	100		1' 5"	
and coal	150		11' 3" 1' 7" 3' 3" 10"	Appears to be the No 1 SEAM of the EWINGTON HORIZON Shale roof and floor
Sandstone with interbedded shales	200		1' 9" 3"	No 2 and 3 SEAMS OF EWINGTON HORIZON not encountered probably due to faulting
Mainly fine to medium grained shaley sandstones	300		6"	
Greenish-gray conglomerate with occasional	400		3"	
	450			
	500			

GENERALISED DESCRIPTION	DEPTH IN FEET	COLLAR R.L. 696'	THICKNESS OF COAL	REMARKS
shale and sandstone bands	500			
Granite	600 604			

Fig.12  
COLUMNAR SECTION  
DIAMOND DRILL HOLE No 3  
SITE E - C.M.L. 328 - COLLIE

519 - 519½	COAL (3" chips).
519½ - 564½	Sediments.
564½ - 564¾	COAL (3" chips).
564¾ - 636	Sediments.
636 - 636½	COAL (4").
636½ - 718	Sediments.
718 - 719¾	COAL (8").
719¾ - 749	Sediments.
749 - 749½	COAL (3").
749½ - 787	Sediments.
787 - 787½	COAL (4").
787½ - 801½	Sediments.
801½ - 803½	COAL (2' 1").
803½ - 816½	Sediments.
816½ - 817	COAL (8").
817 - 894¾	Sediments.
894¾ - 895	COAL (4").
895 - 895½	Sediments.
895½ - 896½	COAL (9").
896½ - 960½	Sediments.
960½ - 961¾	COAL (1' 2").
961¾ - 1011¾	Sediments.
1011¾ - 1012½	COAL (10").
1012½ - 1033	Sediments.
1033 - 1033½	COAL (7") (poor quality).
1033½ - 1303	Sediments.
1303 - 1304	COAL (10").
1304 - 1330	Sediments.
Hole lost.	

#### PROGRESS REPORT ON DIAMOND DRILLING. COLLIE MINERAL FIELD, W.A. (3).

Bore No. 3.—Site E.—Mineral Lease 328, four miles East of Collie Townsite.

By J. H. Lord, B.Sc., F.G.S., Geological Survey of Western Australia.

#### CONTENTS.

	Page
Drilling Procedure .....	33
Core Recovery and Log .....	33
Geology .....	33
Quality of Coal .....	34
Conclusion .....	34
Appendix I—Summarised Log .....	34

It is assumed that the reader is familiar with the information published in the first progress report, and only where there is any difference in procedure will comment be made in this report.

#### Drilling Procedure.

The drilling plant and rig was similar to that at Site C, except that the tower was 45 feet instead of 85 feet in height. This alteration was made because the depth of the hole was anticipated to be from 700 to 800 feet only, so it was decided to break the rods every 30 feet instead of every 60 feet.

The water for mixing the bentonite was pumped from a small hole in a nearby swamp. As this water had a pH value of 5, a measured quantity of soda ash was added to obtain a better mud.

The use of mud was again successful as only the usual two 10-foot length of NX casting were used. In this hole a considerable amount of soft sandstone was encountered in the first 100 feet necessitating the use of a very thick mud. Bentonite was used at the rate of 3.2 pounds per foot as compared with 7.2 and 3.0 pounds per foot in No. 1 and No. 2 holes respectively. No trouble was experienced from underground water or caving.

Three diamond bits were used in the hole which means one bit per 201 feet of drilling as compared with one bit per 156 and 191 feet in No. 1 and No. 2 holes respectively.

Three shifts were worked throughout the drilling of this hole. No mishaps or breakages occurred and bedrock was reached successfully.

Table I below sets out the manner in which the shifts (regardless of number of men employed) and man-shifts were distributed over the various operations.

(3)—61225/53

TABLE I.  
Time Distribution on Site E.

Operation.	Shifts.		Man-Shifts.	
	Number.	Percentage.	Number.	Percentage.
Drilling .....	29	69	58	45
Mud-mixing, break-downs, etc. ....	1	2	2	2
Maintenance.....	2	5	4	3
Setting-up and dismantling plant ....	10	24	64	50
Total .....	42	....	128	....

4.7 feet of drilling was done per man-shift as compared with 4.3 and 3.9 (4.7 if "fishing" time excluded) feet per man-shift in hole No. 1 and No. 2 respectively. It should be noted that on this site 50 per cent. of the man-shifts were spent in setting-up and dismantling the plant, showing that this type of drilling plant is unsuitable for shallow holes.

Table II below is a study of the operations on shifts when drilling took place.

TABLE II.

Time Distribution while Drilling and Core Recovery.

Driller.	Number of Shifts Drilling.	Total Footage Drilled.	Core Recovery (Feet).	Average Footage per Shift.	Percentage Core Recovery.
Irvin .....	9	189	91	21.0	48.1
Koski .....	9½	198	82	20.8	41.5
Thompson .....	10½	207	116	19.7	56.1
Miscellaneous .....	....	10	....	....	....
Total .....	29	604	289	20.8	47.9

The average rate of drilling from the above table is 20.8 feet per shift as compared with 15.1 and 21.2 feet per shift in hole No. 1 and No. 2 respectively.

#### Core Recovery and Log.

As shown in Table II above, the overall total core recovery was 48 per cent. Fig. 10 shows the percentage core recovery for each 50 feet drilled. The core recovery of 48 per cent. for this hole does not compare favourably with the recovery of 56 per cent. and 57 per cent. for hole No. 1 and No. 2 respectively, but it must be remembered that this hole was only 604 feet deep and the core recovery in hole No. 1 and No. 2 was 57 per cent. and 37 per cent. respectively to an equivalent depth.

The general lithology of the strata as shown in the core was similar to the previous holes, except that there was a greater development of the basal conglomerate in this hole.

A summarised log (Appendix 1) is published with this report showing sediments and coal seams (three inches and above). A full detailed log has been prepared and is available at the Geological Survey.

#### Geology.

This hole, situated on Lease 328, (Fig. 11) was drilled on a site recommended by the Geophysical Survey to test this particular portion of the North-Eastern Basin between Stockton and what is known as Hard Coals (Leases 324 and 328).

A columnar section (Fig. 12) shows all the coal seams (three inches and thicker) intersected. The only seam intersected which is of economic importance is the 12ft. 10in. at a depth of 138 feet. This seam has three inches and one inch of shale at 19 and 9 inches above the bottom respectively, which detracts from its value.

This seam is considered to be the No. 1 seam of the Ewington horizon, but the No. 2 and No. 3 seams of this horizon were not encountered as should be expected. The possible reason for this omission is either a fault, although no evidence has been seen in the core recovered, or, that the seams are lenticular in this portion of the basin. Although either may apply, it is recalled that diamond drilling on the Hard Coals leases some years ago produced results that could not be satisfactorily correlated; this therefore tends to favour the possible lenticular habit of the seams.

The basal conglomerate is worthy of note because of its association with greenish and occasionally reddish shales, indicating again the violent sudden changes in sedimentation. In places, the strata are contorted, indicating movement during consolidation of these sediments. The conglomerate carries pebbles and boulders of granite, quartzite and coarse-grained greenstone.

Quality of Coal.

The detailed analyses carried out on samples submitted to the Government Chemical Laboratories are shown in Table III.

TABLE III.  
Proximate Analysis of the Thicker Seams Intersected in Bore at Site E.

Chem. Lab. No.	(feet).	Thickness of Sample.	As Received.					Dry and Ash Free.		Ash Dry Basis.	Colour of Ash.	
			Moist- ture.	Ash.	Volume Matter.	Fixed Carbon.	Calorific Value.	Volume Matter.	Calorific Value.			
8547/50	138½	2 9	12'10" seam	20.0	12.15	20.25	47.60	B.Th.U. 8,815	29.85	B.Th.U. 12,990	15.2	Red-brown.
8548/50	141	3 0		20.0	9.8	20.95	49.25	9,230	29.85	13,150	12.25	Light red brown.
8549/50	144	3 10		20.0	10.7	20.75	48.55	9,000	29.95	12,990	13.35	Dark red brown.
8550/50	147½	1 6		20.0	17.4	19.3	43.3	8,145	30.80	13,020	21.75	Light red brown.
8551/50	149½	1 9		20.0	23.45	22.20	34.35	7,100	39.25	12,550	29.3	Light pink.
8552/50	156½	3 5		20.0	6.55	23.15	50.30	9,640	31.55	13,120	8.2	Fawn.
8848/50	221	1 0		20.0	10.05	23.70	46.25	9,350	33.90	13,370	12.55	Brown.

The 12ft. 10in. seam was analysed in five sections as shown. The quality of the seam as a whole is not good, having a calorific value of only 8,650 B.Th.U's. with an ash content of 13.3% as received. The top 2ft. 9in. and the bottom 3ft. 3in. have a calorific value below 9,000 B.Th.U's., but the remaining 6ft. 10in. is the best portion of the seam, with a calorific value of 9,100 B.Th.U's. and 10.3% of ash as received.

Carbonisation assays (0° to 600°C.) were carried out on a composite of sample No. 8548-51 mixed in ratio of the thicknesses of the samples.

Solid Residue	Per 100 gm.	Per Ton.	Therms.
Liquor—100°C.	63.7 gm.	12.7 cwt.	....
100°C.	20.0 gm.	44.8 gals.	....
Tar	4.92 gm.	11.0 gals.	....
Gas	2.68 gm.	6.0 gals.	....
	7,880 ml.	2,825 c. ft.	11.7
Analysis.	Percentage Air-free.	Yield cu. ft.	
CO <sub>2</sub>	38.5	1,087	
CnHm	1.6	44	
H <sub>2</sub>	23.5	664	
CO	9.7	275	
C <sub>2</sub> H <sub>4</sub>	3.1	88	
CH <sub>4</sub>	21.4	605	
N <sub>2</sub>	2.2	61	
Calorific Value:	3,950 K.Cal/M <sub>g</sub> , 413.6 B.Th.U/Cu. ft.		

Conclusion.

The third hole (Site E) of the Collie deep drilling programme encountered the granitic bedrock of the North-Eastern Basin at 593 feet. Mud drilling was again successful with a core recovery of 48%.

Only one significant seam was encountered which is considered to be the No. 1 seam of the Ewington horizon; the remainder of the horizon was absent due either to faulting or to the lenticular nature of the seams. The quality of the seam was not good.

AUSTRALIAN DRILLERS D.D. HOLE No. 3.  
Site E—M.L. 328—4 Miles East of Collie.

Depth (feet)	Summarised Log.
0 - 35	Lake deposits.
35 - 73½	Sediments.
73½ - 73¾	COAL (4").
73¾ - 74½	Sediments.
74½ - 75	COAL (8").
75 - 127½	Sediments.
127½ - 128¾	COAL (1'5").
128¾ - 138½	Sediments.
138½ - 149½	COAL (11'3").
149½ - 149¾	Sediments.
149¾ - 151½	COAL (1'7").
151½ - 166½	Sediments.
166½ - 169¾	COAL (3'3").

Depth (feet) Summarised Log.

169¾ - 176½	Sediments.
176½ - 177	COAL (10").
177 - 218	Sediments.
218 - 219	COAL (1'0").
219 - 221	Sediments.
221 - 221½	COAL (3").
221½ - 323½	Sediments.
323½ - 323¾	COAL (6").
323¾ - 416	Sediments.
416 - 416½	COAL (3").
416½ - 593	Sediments.
593 - 604	Granite.

SHALLOW DRILLING FOR OPEN-CUT COAL  
ON A PORTION OF MINERAL LEASES 82,  
129 AND 130, EAST COLLIE BURN, COLLIE  
MINERAL FIELD, W.A.

By J. H. Lord, B.Sc., F.G.S., Geological Survey  
of W.A.

	Page
General Information	34
Geology and Drilling Results	35
Quality of the Coal Seam	35
Coal Reserves	36
Costs	36
Conclusion	36

General Information.

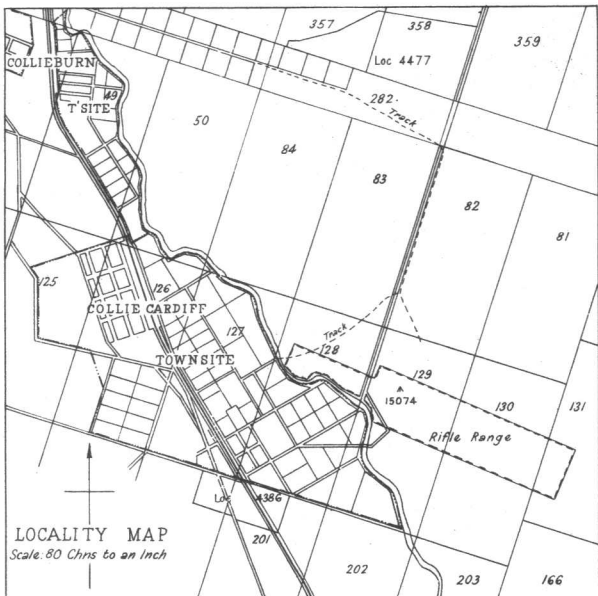
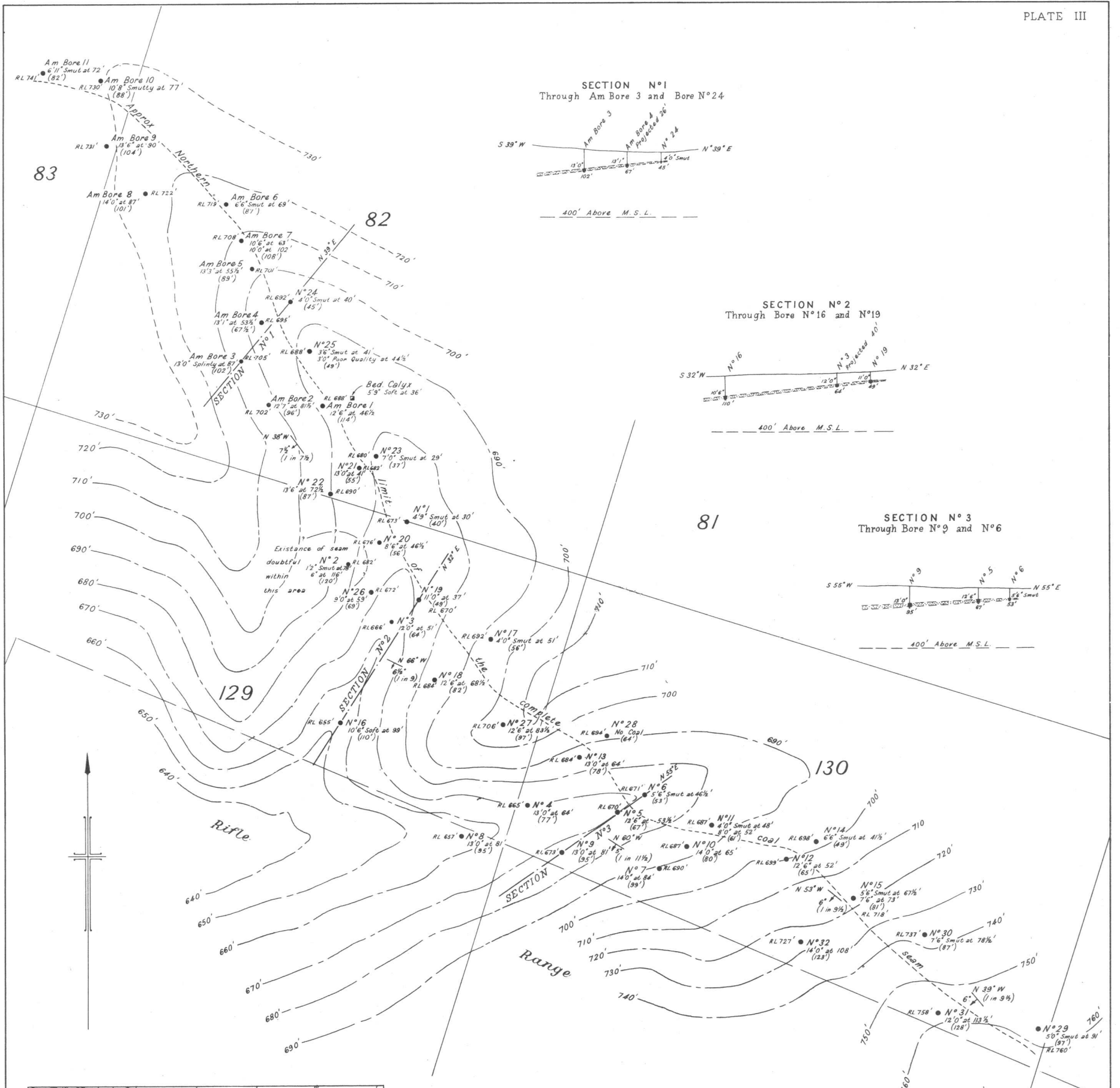
The area, which has been investigated for open-cut coal, is a portion of Mineral Leases 82, 129 and 130 (original numbers) approximately 2½ miles E.S.E. of Collie Burn siding, as shown on Plate III.

Access is gained to the area by crossing the river either to the north of Collie Burn or near Collie Cardiff, and by following old timber tracks as indicated on the locality plan (Plate III).

The area has a good coverage of vegetation consisting chiefly of jarrah and red gum with some banksia, blackboy and paper bark in the hollows.

The first hole, a calyx hole, was drilled on this area by Mr. Bedlington on Lease 82 at the end of 1901. Late in 1946 Amalgamated Collieries of W.A. Ltd. commenced a series of shallow holes near Bedlington's calyx hole, and worked westwards. There is no record of any other drilling or mining operations having been carried out on this area.

The writer recommended to the Mines Department that exploratory drilling be carried out eastwards from the calyx hole. A grant of money was made available and the drilling programme described below was carried out by Kent Bros., percussion drilling contractors.



REFERENCE TO SIGNS

- Borehole identification { Government Percussion Bore No. 25  
Amalg. Collieries Hand Bore Am Bore 3
- Borehole - showing identification (No. 9), reduced level { No. 9 • RL 673'  
(RL 673'), significant coal seam intersected { 13'0" at 81'  
(13'0" at 81'), and depth of borehole (95') (95')
- Lease boundary
- Contours (at 10' interval)
- Line of Section
- Strike and dip of coal seam from borehole data  
and gradient of coal seam
- Approximate position of coal seam in section

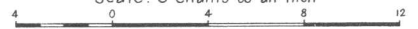
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA  
CONTOUR PLAN AND SECTIONS  
OF

**PORTION OF MINING LEASES 82, 129 & 130**

Showing Position of Boreholes and Details of Coal Intersected

**EAST COLLIEBURN  
COLLIE MINERAL FIELD**

Scale: 8 Chains to an Inch



Planetable and Telescopic Alidade survey. Reference M.S.L.  
Boreholes drilled and logged by Kent Bros. for G.S.W.A.  
Supervised and compiled by J.H. Lord, B.Sc., F.G.S. Jan to Sept 1950

Geology and Drilling Results.

Bedlington's calyx hole was drilled to 545ft. At a depth of 36ft, 5ft. 9in. of soft coal was encountered, but the only other seam of note was 5ft. 4in. at 130½ft. The seam of soft coal was actually a portion of the "blind" outcrop of the No. 1 (or top) seam of the Collie Burn horizon. Had the calyx hole been two chains further south, the complete 12ft. seam would have been encountered.

The Amalgamated hand bores followed the No. 1 seam westwards where it varied from 12 to 13ft. in thickness, but the depth of the blind outcrop increased in that direction to nearly 80ft. This increase in the thickness of overburden covering the blind outcrop as the topography rises, was found to be also the case as drilling was extended eastwards. Actually, this increase represents a thickening of the Pliocene lake deposits, which overlies the Permian coal measures unconformably. Hence open-cut possibilities hinge on the topography, which unfortunately is not even, resulting in fair to good open-cut prospects in the gullies, but poor prospects on the ridges.

This No. 1 seam of the Collie Burn horizon was followed across Leases 129 and 130 for nearly one mile, with the object of locating shallow coal. All the drilling was planned to intersect the coal near the outcrop with an occasional hole further down the dip. Of the 32 holes drilled the seam was only missed on one occasion.

Hole No. 2 showed only 1ft 6in. of smutty coal, where the seam was estimated to be, but included 4½ft. of "pink and white light friable clay" which is thought to be the remains of the seam after burning. Other holes drilled in the vicinity of this hole showed the existence of the seam, although it was not quite as thick as usual. This area has been discarded in all calculations.

The general strike and dip of the seam can be best visualised from the structure contour plan (Plate IV—Fig. 2). The seam strikes N.38°W. at the west end of the area drilled, and swings to N.66°W., moving eastwards, but it swings back to N.39°W. at the eastern end of the area. The dip to the south-west varies from 7½ to 6 degrees from west to east.

The thickness of the seam (see Table I), where it is not the weathered blind outcrop, varies from 12 to 14 feet, except in the vicinity of bore No. 2 where the thickness decreases to 8ft. 6 in. in bore No. 20. The average thickness of the seam where encountered below the blind outcrop is 12ft. 6in.

The overburden (the Pliocene lake deposits) consists mainly of clays and sandy clays with a

laterite capping on the ridges; the Permian coal measures consisting of sandstones and shales. There is no evidence of strata which would hinder the usual type of open-cut operations undertaken at Collie. The overburden is soft and would not require blasting.

TABLE I.  
SUMMARY OF BORE LOGS ON M.L.'s 82, 129 AND 130  
COLLIE MINERAL FIELD.

Govt. Percussion Bore No.	Reduced Level to M.S.L.	Depth of Seam Intersected.	Thick-ness of Seam.	Depth of Hole.	Depth to Water.	Remarks
	Feet.	Feet.	Ft. in.	Feet.	Feet.	
1	673	30	4 9	40	....	Smut. Blind outcrop.
2	682	77	1 6	120	71	Smut. Seam missing.
3	666	51	12 0	64	....	
4	665	64	13 0	77	39	
5	670	53½	12 6	67	47	
6	671	46½	5 6	53	No water	Smut.
7	690	34	14 0	99	73	
8	657	31	13 0	81	32	
9	673	31	13 0	95	45	
10	687	65	14 0	80	No water	
11	687	48	12 0	61	No water	Top 4' smut.
12	699	52	12 6	65	No water	
13	684	64	13 0	78	No water	
14	698	41½	6 6	49	No water	Smut.
15	718	67½	13 0	81	No water	Top 5½' smut
16	655	99	10 6	110	25	Some soft bands.
17	692	51	4 0	56	No water	
18	684	68½	12 6	82	59	
19	670	37	11 0	49	No water	
20	676	46½	8 6	56	No water	
21	682	41	13 0	55	No water	
22	690	72½	13 6	87	No water	
23	680	29	7 0	37	No water	Smut.
24	692	40	4 0	45	No water	Smut.
25	688	41	6 6	49	No water	Smut. and poor coal.
26	672	59	9 0	69	No water	Broken coal.
27	706	83½	12 6	97	77	
28	694	....	....	64	No water	No coal.
29	760	91	5 0	97	No water	Smut.
30	737	78½	7 6	87	No water	Smut.
31	758	113½	13 6	128	No water	
32	727	108	14 0	123	101	

Quality of the Coal Seam.

As the seam in this area is the continuation of the No. 1 seam of the Collie Burn horizon, as previously drilled on T.R. 1235H at Collie Burn,<sup>22</sup> the quality should be similar.

Twenty-four analyses were carried out by the Government Chemical Laboratories on samples supplied from this drilling campaign, and the results are tabulated in Table II.

<sup>22</sup> Shallow Drilling on a Portion of Mineral Leases 49 and 50 (Temp. Reserve 1235H) at Collie Burn for Open-cut Coal, by J. H. Lord. G.S.W.A. Annual Report, 1949.

TABLE II.  
ANALYSIS OF COAL FROM BORES ON M.L. 82, 129 AND 130, COLLIE, W.A.

Chem. Lab. No.	Bore No.	Depth.	Thick-ness of Sample.	As Received.					Dry and Ash Free.		Ash on Dry Basis.	Colour of Ash.
				Mois-ture.	Ash.	Vol. Matter.	Fixed Carbon.	Calorific Value.	Vol. Matter.	Calorific Value.		
		Feet.	ft. in.	%	%	%	%	B.Th.U.	%	B.Th.U.	%	
2365/50	3	51	4 0	20.0	3.8	27.25	48.95	9,495	35.80	12,460	4.75	White
2366/50	....	55	8 0	20.0	5.85	27.35	46.80	9,305	36.90	12,250	7.35	White
3294/50	7	84	5 6	20.0	4.85	29.15	46.00	9,585	38.85	12,750	6.05	Fawn
3295/50	....	89½	8 6	20.0	11.35	25.90	42.75	8,625	37.75	12,570	14.20	Fawn
3692/50	8	81	5 0	20.0	2.40	30.00	47.60	9,830	38.70	12,660	3.00	White
3693/50	....	86	8 0	20.0	5.60	27.80	46.60	9,335	37.37	12,540	7.00	Light fawn
3690/50	9	81	5 0	20.0	2.65	28.95	48.40	9,805	37.45	12,670	3.35	White
3691/50	....	86	8 0	20.0	3.50	28.50	48.00	9,630	37.25	12,590	4.40	White
4918/50	13	64	5 0	20.0	2.60	28.20	49.20	9,695	36.45	12,520	3.26	Light fawn
4919/50	....	69	8 0	20.0	3.20	29.25	47.55	9,480	38.10	12,345	4.00	Light fawn
4916/50	15	69½	5 6	20.0	2.90	29.50	47.60	9,320	38.25	12,100	3.60	Light fawn
4917/50	....	73	7 6	20.0	2.95	28.65	48.40	9,975	37.20	11,650	3.70	Light fawn
6709/50	16	99	10 6	20.0	3.60	29.20	47.20	9,580	38.25	12,540	4.50	Light fawn
6832/50	18	68½	12 6	20.0	2.75	29.40	47.85	9,680	38.05	12,525	3.45	White
6833/50	19	37	4 0	20.0	2.55	28.95	48.50	9,605	37.40	12,410	3.20	Light fawn
6834/50	....	41	7 0	20.0	4.55	28.65	46.80	9,470	38.00	12,560	5.70	Off white
6831/50	20	46½	4 6	20.0	3.05	29.35	47.70	9,715	38.00	12,640	3.85	White
6976/50	....	51	4 0	20.0	2.95	30.05	47.00	9,690	39.00	12,580	3.70	Light fawn
6977/50	21	41	4 0	20.0	6.36	28.50	45.15	8,610	38.65	11,695	7.95	Light fawn
6978/50	....	45	9 0	20.0	4.85	29.30	45.85	9,490	39.00	12,570	6.05	White
7526/50	26	59	4 6	20.0	3.75	26.40	49.85	10,100	34.65	13,250	4.70	Off white
7527/50	....	63½	4 6	20.0	3.25	31.40	45.35	9,245	40.95	12,050	4.05	Off white
8846/50	31	113½	4 0	20.0	3.65	27.20	49.15	9,775	35.65	12,800	4.55	Light fawn
8847/50	....	117½	9 6	20.0	4.10	28.55	47.35	9,655	37.65	12,720	5.10	Light fawn



The weighted mean analysis of the coal on a 20% moisture basis is 4.3% ash and a calorific value of 9,480 B.Th.U.'s/lb., which shows that the seam has improved in quality when compared with the results at Collie Burn of 8% ash and 9,300 B.Th.U.'s/lb. The dry ash-free value is lower than at Collie Burn.

The colour of the ash is white to light fawn, indicating an absence of iron and probably a high ash fusion point. The upper portion of the seam again analyses better than the lower portion.

The Laboratory also conducted Carbonisation Assays (0 to 600°C) on a composite sample of them (Lab. No. 4916-4919/50) for the following results on a 20% moisture basis at 110°C:—

	Per 100 gm.	Per Ton.	Therms.
Solid Residue ....	61.7 gm.	12.3 cwt.	....
Liquor—100°C. ....	20.0 gm.	44.8 gals.	....
100°C. ....	8.1 gm.	18.1 gals.	....
Tar ....	5.1 gm.	11.4 gals.	....
Gas ....	10,510 ml.	3,770 c. ft.	17.1
Analysis.	Percentage.	cu. ft./ton.	
CO <sub>2</sub> ....	32.9	1,240	
O <sub>2</sub> ....	1.7	65	
C <sub>2</sub> H <sub>6</sub> ....	12.6	475	
H <sub>2</sub> ....	25.3	955	
CO ....	3.4	130	
C <sub>2</sub> H <sub>4</sub> ....	23.2	875	
CH <sub>4</sub> ....	1.0	35	
N <sub>2</sub> ....			

Calorific Value : 4,340 K.Cal./M<sub>3</sub>, 454.0 B.Th.U./c. ft.

#### Coal Reserves.

This area is not an ideal open-cut site because of the irregular topography, which has the effect of making any open-cut long and narrow. The best ratio of overburden to coal is 3:1 in the gullies, and two small open-cuts could obtain a quantity of coal with an average ratio of 4½:1. However, since the cost of development, including roads etc., would probably not justify such action, the whole of the area is considered in the estimates below.

The northern limit of the open-cut has been fixed at the line which is considered to be the limit of the full thickness of the seam. Further north both the thickness and quality decreases rapidly, and the coal becomes smut. It may be possible to win a small tonnage from this area of lower overburden.

In all the estimates it is assumed that the seam averages 12 feet 6 inches in thickness and that 30 cubic feet of coal is equivalent to one ton. The estimates of overburden are approximate, and include an allowance for a 70 degree batter on the sides of the open-cut which is considerable, due to the narrow nature of the open-cut.

The areas considered are shown on the Isopach Plan (Plate IV.). This plan shows the contours joining points on the coal seam covered by equal thickness of overburden.

#### Ratio of 6 Overburden to 1 Coal.

Available Coal = 400,000 tons.

Overburden = 2,400,000 cubic yards.

Hence working to a depth of 74 feet of overburden to extract 12½ feet of coal, it will be necessary to remove approximately six cubic yards of overburden for every ton of coal.

#### Ratio of 8 Overburden to 1 Coal.

Available Coal = 900,000 tons.

Overburden = 6,600,000 cubic yards.

Hence working to a depth of 100 feet of overburden to extract 12½ feet of coal, it will be necessary to remove approximately 7.4 cubic yards of overburden for every ton of coal.

#### Costs.

The charge for this drilling was 12/6 per foot plus £5 for each hole less than 50 feet in depth. The total cost of the programme was £1,540 which is 0.41 pence per ton of coal located.

If geological and administrative expenses were added the cost would not exceed ½d. per ton.

#### Conclusion.

This open-cut site does not offer such good prospects as the existing open-cuts at Collie because of the larger amount of overburden to be removed. However, if it is not considered economical to extract the coal at present, the site provides a proven reserve for any national emergency.

Working to a maximum ratio of 6 of overburden to 1 of coal there is 400,000 tons of coal available, but if the ratio is increased to 8 to 1 there is 900,000 tons available.

The quality of the coal is better than at Collie Burn, having an average calorific value of 9,500 B.Th.U.'s/lb. with 4.3% ash on a 20% moisture basis.

#### REPORT ON THE SOUTH-WEST IRON RECONNAISSANCE.

By J. H. Lord, B.Sc., F.G.S.; N.M. Gray, B.Sc and J. Sofoulis, B.Sc.

	Page
Introduction ....	36
Method of Work ....	36
Physiography ....	37
Geology ....	37
Iron Deposits Located and/or Investigated ....	38
Conclusions ....	39

#### Introduction.

H. A. Brasserts & Co., who are investigating the possibility of establishing the steel industry at Bunbury, Western Australia, requested that a reconnaissance survey be made of the area within a radius of 50 miles of Bunbury, to determine if there were any deposits of ferruginous laterite, similar to that at Wundowie, suitable for supplying ore to the industry.

To be classified as ore, the ferruginous laterite must adhere rigidly to the following specifications:—It must contain 45 per cent. more iron (Fe), less than 1 per cent. titanium oxide (TiO<sub>2</sub>), and less than 10 per cent. silica (SiO<sub>2</sub>). The only permissible variation from these specifications is that laterite with 40 to 45 per cent. iron will be considered if it is in a large enough quantity but it must be within 30 miles of Bunbury.

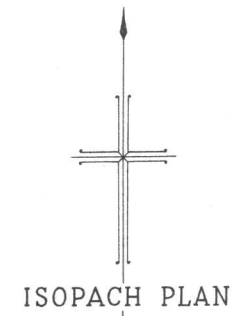
The quantity required is two million tons, in deposits of a minimum of 50,000 tons if within 10 miles of a railroad; otherwise the deposits must contain 100,000 tons to be of any use. For a rough guidance ore five feet thick must cover two acres to represent 50,000 tons.

Fieldwork for this survey was recommenced on 16th January, 1950 and completed on the 26 May, 1950. The field party consisted of the following geologists:—J. H. Lord (in charge), N. M. Gray, J. Sofoulis, L. de la Hunty (March to end) and J. Gleeson (beginning to March). This report incorporates the views of all concerned, and has been expanded considerably, as it may be read by persons outside of W.A. who are unfamiliar with the physiography and geology of this portion of W.A.

#### Method of Work.

The extent of this area can be seen on the plan showing the locality of samples (Plate V.). This area of approximately 4,000 square miles was covered by two methods (a) walking traverses at approximately one mile intervals. This method was used on the eastern portion of the area. (b) Traverses along forestry tracks, timber-haulers' tracks and fire-breaks by utility with short walks from the tracks where required. This method was used in the western portion of the area to the Darling Scarp (see Plate V.). If the latter method did not provide a close enough grid the former method was used to fill in the blanks.

Publicity in the local Press was given to this search, and anyone with information of deposits was asked to leave such with the local Road Boards. Later all Road Boards were visited and



ISOPACH PLAN

FIG I

isopach lines  
Borehole with identification and depth of overburden  
Explanation - The contours on this plan join points having the same thickness of overburden, overlying the coal seam

STRUCTURE CONTOUR PLAN

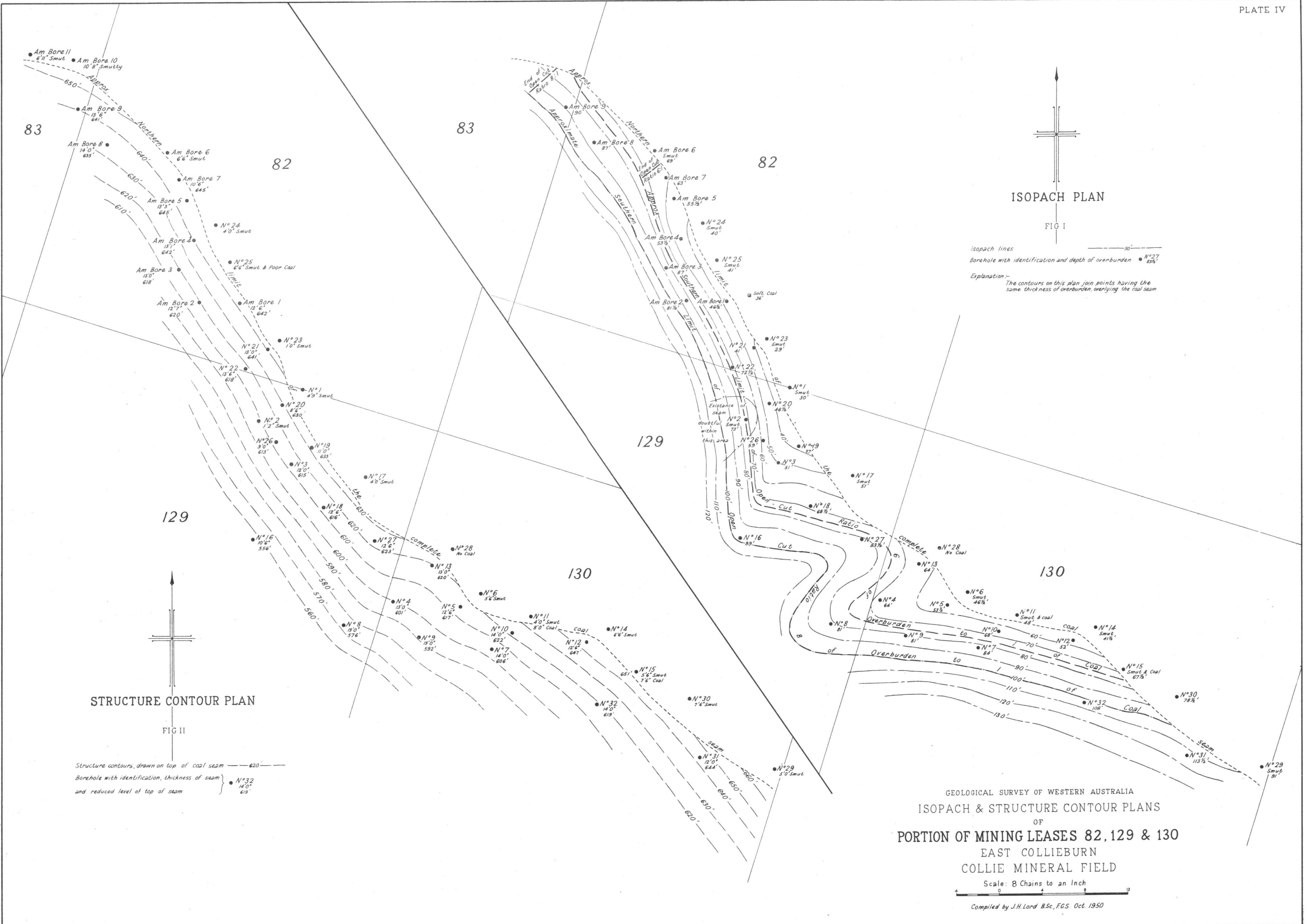
FIG II

Structure contours, drawn on top of coal seam  
Borehole with identification, thickness of seam  
and reduced level of top of seam

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA  
ISOPACH & STRUCTURE CONTOUR PLANS  
OF  
PORTION OF MINING LEASES 82, 129 & 130  
EAST COLLIEBURN  
COLLIE MINERAL FIELD

Scale: 8 Chains to an Inch

Compiled by J.H. Lord B.Sc. F.G.S. Oct. 1950



GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

— MAP OF —  
**PORTION OF SOUTH WEST DIVISION**  
**WESTERN AUSTRALIA**

WITHIN 50 MILES RADIUS OF BUNBURY  
 SHOWING  
 LOCALITIES INVESTIGATED DURING IRON AND LIMESTONE RECONNAISSANCES  
 OF THE AREA

SCALE: 1 INCH = 8 MILES

Locality and sample number mentioned in Iron report ● 5  
 Approximate position of major faults ———  
 West Australian Government Railways ———  
 Formed roads ———  
 Area in which outcrops of limestone occur, occasionally with a high-grade capping up to 2 feet thick. [Hatched area symbol]



all reports investigated. The assistance of the Road Boards and Forestry officers is gratefully acknowledged.

As this was a reconnaissance survey no detailed mapping was done, but general geological information was noted on a set of 40-chain to an inch Lands Department Lithographs which are on a file at the Geological Survey's office.

Samples collected were analysed by the W.A. Government Chemical Laboratories. It should be explained that, although some samples show a high iron content, the extent of the deposit was usually very small, and the text description should be read in conjunction with each analysis.

#### *Physiography.*

##### A.—General Relief.

The area may be considered as consisting of the following physiographic units:—

(1) The eroded Pre-Cambrian block of the uplifted Darling peneplain. This comprises a major portion of the area investigated. Rivers, which vary from young to mature, have well dissected this plateau or peneplain. Hills are generally rounded, the crests of which lie between the 600 and 1,000-foot contour. A few higher peaks, rising to 1,500-foot contour, are considered to be remnants of the more resistant hills which rose above the general level of the original peneplain, Mt. Keats, Mt. William, Driver's Hill and Hill 60 are such examples.

Remnants of the sedimentary formations of lacustrine and estuarine origin, such as the Collie and Wilga coal measures, and scattered sand and boulder deposits are found on the plateau. Compared with the granitic surfaces, the topography of these deposits is of a milder form and at a lower contour.

Dense sclerophyllous forests with eucalypts forming the dominant tree species grow on the lateritised soil of this plateau, whilst the undergrowth practically covers the ground surface, so that erosion in this country is almost entirely confined to the action of rain and rivers.

(2) The Darling Scarp running north-south and bifurcating just south of the Collie River producing an additional scarp running south-west towards Cape Naturaliste (Whicher fault scarp). The main Darling Scarp is considerably indented and modified by the many drainage systems which flow to the coast.

(3) The country enclosed by the Dunsborough-Augusta, Whicher and Darling (southern extension) faults. This area is a slightly dissected plateau occurring at an intermediate level between the coastal plain and Pre-Cambrian plateau.

(4) The coastal plain, which is a flat featureless plain, largely made up of unconsolidated gravels, sands and clays with limestone and dune sand fringing the coastline.

##### B.—Drainage.

Rivers are numerous and vary from young or early mature to mature. The principal drainages are the Murray, Harvey, Harris, Bingham, Brunswick, Collie, Preston, Capel, Vasse, Margaret and Blackwood rivers. Where the rivers enter the coastal plain the meandering courses through their flood-plains have features of old rivers.

Although some of the larger drainage systems are perennial, most of the rivers in this area are intermittent and flow only during the wet months (May to October).

The rivers are characterised by rectangular courses the abrupt changes being due mostly to river capture (following the Darling uplift) but in part to deflection by the more resistant basic rocks and to the existence of major right-angled joints. Near the mouths, the action of the sea has been responsible for the deflection to the north or to the south.

A few lakes present in the eastern portion of the area are considered to be remnants of dismembered drainage systems, whilst those occurring near

the coast have a barred basin origin, that is, portions of the ocean isolated by the building of sand bars.

#### *Geology.*

##### Rock Types.

##### PRE-CAMBRIAN.

##### *Greenstones.*

These are two ages of greenstones which, for convenience, will be called the "Younger" and the "Older Greenstones". This classification does not necessarily imply correlation with the various Greenstone Series of the Goldfields, although there is a certain similarity between the two. The "Older Greenstones" consist chiefly of amphibolites, some of which are metamorphosed basic lavas, various basic schists and meta-sediments. These "Older Greenstones" are scattered over the area and are usually of small extent, although some belts are up to ten miles in length.

The "Younger Greenstones", considered to be Proterozoic (Nullagine) age, are dolerites, which intrude both the "Older Greenstones" and the Granite/Gneiss Complex.

##### *Granite/Gneiss Complex.*

This Complex forms the bulk of the area. There are at least two stages of this Complex, one the "granite" which is truly a plutonic igneous intrusion and the other, the "gneiss", is generally considered to have been formed by granitisation.

The granite is considered to have been responsible for the mineralisation, e.g., tin, tantalite (and columbite), beryl, tourmaline and gold<sup>23 24</sup>, though the host rock of the gold has not been found.

##### PALAEOZOIC.

The only rocks of the Palaeozoic era are those of Permian and are confined to the Collie and Wilga coal measures.

##### MESOZOIC.

The Donnybrook sandstone is considered to be of Triassic age. This formation contains some insignificant coal seams and gold.

The extent of the belt has not been delineated, but, near Donnybrook, it appears to be wedged in between the Darling and Whicher Faults and overlaps in part the Granite/Gneiss Complex. It is possible that this formation may extend over the area bounded by these two faults as far west as the Dunsborough Fault.<sup>25</sup>

##### KAINOZOIC.

##### Boulder and Lake Beds.

These beds are lacustrine and estuarine deposits. Lord<sup>26</sup> considers that these beds may be of Pliocene age. Good exposures are found near Greenbushes, Collie and west of Kirup, but small deposits are found scattered throughout the area, not necessarily confined to the low ground. Tin is mined from these beds ("old Alluvium") at Greenbushes.

##### *Laterite.*

Lateritisation has been widespread throughout Western Australia, and this south-west portion of the State is no exception. Usually the best outcrops have been found on the ridges, but it is also found outcropping along the slopes and in the creeks. Its formation appears to be a function of the old topographies and of the underlying rocks.

The laterite occurring over the Granite/Gneiss Complex has a high alumina and a low iron content. This is as expected, but occasional boulders of high grade ferruginous laterite have been found, but the extent of the deposit was always small and was probably due to a concentration of ferro-magnesium minerals in that particular part of the Complex.

In the majority of cases it was not possible to determine the underlying rocks, but it is reasonable to assume that the larger deposits do not

<sup>23</sup> HOBSON, R. A. and MATHESON, R. S.: Greenbushes Mineral Field. G.S.W.A. Bull. No. 102, pp. 44, 71.

<sup>24</sup> CARROLL, D.: Mineralogy of the Donnybrook Sandstones, Western Australia. Journ. Roy. Soc. W.A., Vol. XXVII, pp. 211, 213.

<sup>25</sup> CARROLL, D.: Op. cit., p. 211, and Fig. 1.

<sup>26</sup> LORD, J. H.: Collie Mineral Field. G.S.W.A. Bull. No. 105

overlie the Granite/Gneiss Complex. Near East Kirup a deposit showed bands of quartz separated by limonite suggesting that the deposit was overlying a jaspilite, which is probably the origin of larger deposits in the Pre-Cambrian section of the area. At Wilgee Springs a laterite with a low iron content overlies Lake Beds.

The laterite found in the creeks, particularly to the west of the Darling Scarp suggests a different or supplementary mode of origin. This type of laterite has a high iron and silica content in places in the creek beds, but the laterite found away from the creeks, as well as some in the creeks, is always very poor and sandy. It appears as if portions of the laterite in the creeks have undergone secondary enrichment.

The laterite is generally considered to be Miocene or thereabouts. At Collie there is definite evidence of lateritisation having taken place before and after the deposition of the Lake Beds.<sup>27</sup> In the Greenbushes area,<sup>28</sup> lateritisation is considered to be post "Old Alluvium," i.e., late Tertiary.

#### Late Tertiary and Recent Deposits.

These deposits form the coastal plain consisting of limestones (usually sandy), sands, clays, unconsolidated gravels and basaltic flows near Bunbury.

#### Stratigraphy.

The summarised stratigraphical column may be given as follows:—

Era.	Period.	Rock Types, Groups or Formations.
Kainozoic ....	Quaternary	Coastal limestones, sands, clays and unconsolidated gravels. Basaltic flows at Bunbury.
	Tertiary ....	Laterite. Boulder Beds, Lake Beds, Old Alluvium. Laterite.
Mesozoic ....	Triassic ....	Donnybrook Sandstones.
Palaeozoic....	Permian ....	Collie and Wilga coal measures.
Pre-Cambrian	Proterozoic	Dolerite dykes ("Younger Greenstones").
	Archaeozoic	Granite/Gneiss complex and mineralisation. "Older Greenstones."

#### Structures.

The most significant structural features within this area are the faults. The Darling Fault, striking north and south, is the most prominent and extends from the south coast to some 200 miles north of this area. Within the area it passes approximately through Nannup, Donnybrook and a few miles east of Pinjarra. Near Donnybrook this fault bifurcates, one part continuing southwards and the other (the Whicher Fault) trends south-westwards (see Plate V.) dividing the Triassic from the coastal plain by the Whicher Range. The Whicher Fault is cut off by the Dunsborough-Augusta fault, which strikes north and south. To the west of this Dunsborough-Augusta Fault is granitic country in part overlain by coastal limestones which is thought to be cut off at or near the coast by the Naturaliste Fault.

The regional strike of the Pre-Cambrian is north-north-west, though strikes varying to N.60°E. were observed. Dips, where observed, were close to vertical.

<sup>27</sup> LORD, J. H.: Op. cit.

<sup>28</sup> HOBSON, R. A. and MATHESON, R. S.: Op. cit., p. 37.

Structural basins occur within the Pre-Cambrian and are occupied by Permian coal measures.

#### Economic Geology.

In the Pre-Cambrian, the only minerals of economic significance are tin and tantalite-columbite. These have been and are still being mined on a very small scale at Greenbushes.

Some dolerite dykes have been quarried for road metal.

The coal measures at Collie are the only one of importance. It is proposed to use coal from this field for the proposed steel industry.

At the beginning of the century, gold was mined from Donnybrook sandstone formation. This sandstone is an excellent building stone.

The iron possibilities of this area are discussed below.

#### Iron Deposits Located and/or Investigated.

Iron deposits found in this area are only superficial deposits which have formed by chemical action at or near the surface during lateritisation. The laterite containing the highest percentage of iron usually occurs three to six feet below the surface as a thin horizontal layer and does NOT extend to depths as a reef or lode. The nature of the underlying rocks influences the quality of the laterite as a possible iron ore.

In the course of the programme of work outlined above, many deposits were investigated from reports received, but the majority proved worthless. Some small areas of the type of laterite required were found, which however proved to be only a few boulders; therefore they are not recorded in this report. No doubt many deposits of this nature will be found from time to time, as it is impossible to cover every square yard of this large area.

*Wilga.*—To the east and south-east of Wilga siding, a belt of small deposits is located. The largest of the three deposits consists of boulders outcropping over an area of five acres at the south-east corner peg of Location 9251 (Lands Lithograph 415A/40). An average sample (No. 8—see Plate V.) from this area analysed Fe 49.54 per cent. and TiO<sub>2</sub> 0.28 per cent. Whether there is sufficient ore here to make up the minimum tonnage of a workable deposit would require testing by pits, but it is doubtful.

The second deposit, a small deposit approximately 0.6 miles south-east of the south-east peg of Location 3944 (L.L.415A/40), covers less than half an acre, analysing Fe 47.67 per cent., TiO<sub>2</sub> 0.11 per cent. (No. 9—Plate V.). The deposit consists of large boulders, but not in a continuous sheet. It is doubtful if prospecting could increase the size of this deposit to the minimum requirements.

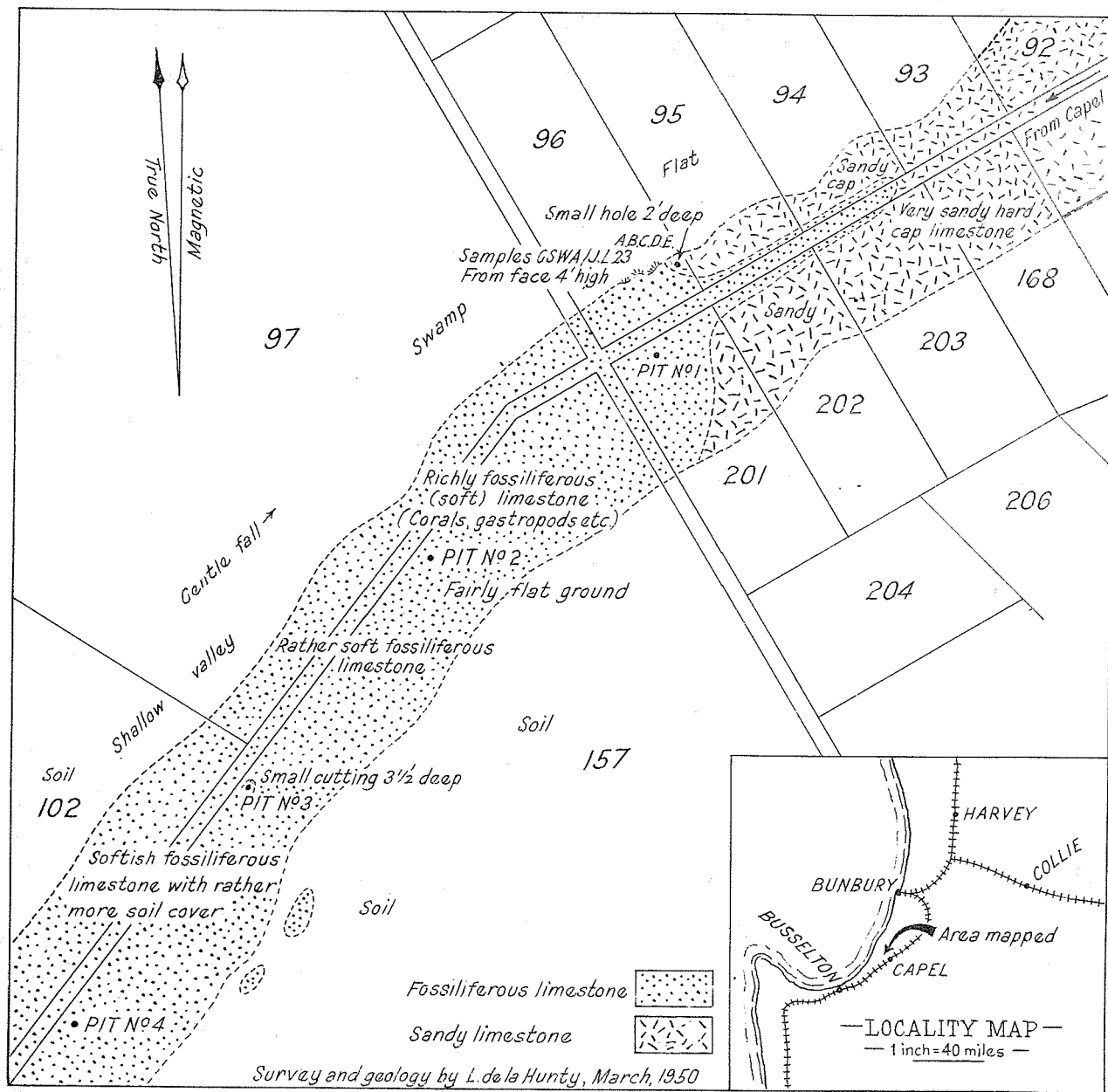
The third deposit occurs near the south-east corner of Location 2945 (L.L.414B/40) and covers nearly two acres, but it is surrounded by poor quality laterite with a high silica content. This deposit consists of large and small boulders in a laterite soil, with boulders analysing Fe 51.14 per cent. and TiO<sub>2</sub> 0.15 per cent. (No. 7—Plate V.). This deposit would not be of sufficient size to develop.

These three deposits are within a mile of good gravel roads and within two miles of the railway.

Detailed mapping along the belt formed by these three deposits may locate other such small deposits, but reconnaissance traverses did not disclose any large deposits although traces were found south of Wilga siding along the railway. It is considered that either the first or the three deposits together may produce the minimum tonnage for one single deposit.

PLATE VI  
 GEOLOGICAL SURVEY OF WESTERN AUSTRALIA  
 GEOLOGICAL MAP  
 OF  
 PORTION OF STIRLING ESTATE  
 3 MILES N.W. OF CAPEL  
 SOUTH WEST DIVISION  
 SHOWING LIMESTONE OUTCROP AREA

Scale: 1 inch = 10 chains





**Donnybrook-Claymore.**—On the northern side of P.U.3801 (L.L. 414A/40) occurs a waterfall (winter only) on a southern tributary of the Capel River. The face of these falls is ferruginous laterite which analyses as follows:—

6a	Top to 3ft. below	Fe 39.04%,	SiO <sub>2</sub> 27.37%	TiO <sub>2</sub> 0.62%
6b	3ft. to 6ft.	Fe 35.78%,	SiO <sub>2</sub> 32.03%	TiO <sub>2</sub> 0.54%
6c	6ft. to 9ft.	Fe 36.25%,	SiO <sub>2</sub> 29.31%	TiO <sub>2</sub> 0.70%
6d	9ft. to 10½ft.	Fe 36.69%,	SiO <sub>2</sub> 20.99%	TiO <sub>2</sub> 0.30%
6e	10½ft. to 12ft.	Fe 46.19%,	SiO <sub>2</sub> 16.86%	TiO <sub>2</sub> 0.35%

This laterite outcrops for a quarter of a mile southwards upstream. Further southwards it occurs spasmodically in this creek and its tributaries to Claymore. The quality is also variable.

At a point 120 chains east-north-east of the north-east corner of Location 1359 (L.L. 414D/40) is a rich patch in the creek, 20 feet wide over a length of 300 feet, which disappears under the sandy soil. This analysed Fe 57.70 per cent., TiO<sub>2</sub> Nil and Si 1.80 per cent. (No. 11—Plate V). It is surrounded by poor quality laterite.

Near the old Claymore mill site (two miles south-east of Claymore siding) a similar occurrence in a creek bed analysed Fe 36.78 per cent., Si 8.92 per cent. (No. 12—Plate V).

It is obvious that, although there may be a large tonnage available in this vicinity, the silica content is too high and the iron content too low to be exploited as an iron ore. It may be possible to use it to dilute very high-grade ore.

**Nannup.**—To the east and south-east of Nannup are numerous laterite-covered ridges. In this laterite occur small areas where there is a higher concentration of iron. However, the areas are too small and scattered to be worked economically, and unfortunately the specimen samples from a few of these selected areas showed a high titanium content, which makes it unusable as an ore for blast-furnace purposes.

No geologist of this survey issued any statement regarding the quality or quantity of these deposits, which are of no value.

The following samples were taken as specimen, not average, samples:—

No. 14. One mile east of North-east corner of Location 8301 (L.L. 439A/40).

Fe .... 34.9%      TiO<sub>2</sub> .... 1.62%

No. 15. 3¼ miles east of north-east of C.G. 28 (L.L. 439A/40).

Fe .... 50.0%      TiO<sub>2</sub> .... 0.21%

No. 16. North-west corner Location 3725 (L.L. 439B/40).

Fe .... 43.27%      TiO<sub>2</sub> .... 1.45%

No. 17. 2½ miles east of east boundary of C.G. 7326 (L.L. 439B/40).

Fe .... 52.8%      TiO<sub>2</sub> .... 2.16%

No. 18. 30 chains north-west of the north-east corner of Location 11077 (L.L. 439A/40).

Fe .... 53.9%      TiO<sub>2</sub> .... 2.01%

No. 19. North-east corner peg Location 11187 (L.L. 439D/40).

Fe .... 48.15%      TiO<sub>2</sub> .... 1.69%

Numerous small deposits were examined but were unsuitable either through their poor quality or through insufficient quantity. Some of such deposits were:—

**Willowdale**—approximately 20 chains south-west of the north-west corner peg of C.G. 857 (L.L. 383B/40) exists a small patch of laterite analysing Fe 48.00 per cent. (No. 1—Plate V), but examination showed that it had no extent.

**Treesville**—to the north-east of Treesville and four miles south-west of Location 3642 (L.L. 384D/40) is a small patch of laterite analysing Fe 56.27 per cent. (No. 2—Plate V), but close examination of this isolated area showed only low grade laterite elsewhere.

**Collie**—10 miles north-east of Collie and approximately 20 chains south-east of the 2-mile peg on the northern boundary of Location 80/11 (L.L.

411B/40), is a small area of laterite bearing large pieces of iron ore, but analyses show that the titanium content is far too high.

	%		%
No. 3a Fe	56.25	TiO <sub>2</sub>	9.45
No. 3b Fe	54.06	TiO <sub>2</sub>	8.05
No. 3c Fe	51.30	TiO <sub>2</sub>	11.75

**Collie Cardiff**—a large area of ferruginous laterite occurs in Location 1784 (L.L. 410D/40) on the north bank of the river, seven miles south of Collie Cardiff. The iron content 33.18 per cent. (No. 4—Plate V) is too low.

**Brookhampton**—at the junction of a creek and the road three-quarters of a mile north-west of the south-east peg of C.G. 288 (L.L. 414A/40) laterite occurs in the creek bed and extends upstream probably for half a mile, with an average width exposed of eight feet. The laterite is of no economic importance, because of its poor quality, namely, Fe 34.02 per cent., TiO<sub>2</sub> 0.41 per cent. (No. 5—Plate V).

**East Kirup**—1½ miles south-west of south-west corner of Location 1922 (L.L. 414C/40). The quality is good, analysis showing Fe 52.16 per cent. (No. 10—Plate V), but the deposit, which occurs only as scattered boulders in a lateritic soil covering nearly an acre, is surrounded by poor laterite. Some boulders also show bands of quartz, suggesting that it is overlying a jaspilite.

**Wilgee Springs**—north-east corner C.G. 5294 (L.L. 414C/40), two miles south-west of Wilga. Large quantity exists covering over half of this location and some of the adjoining location, but the quality is too poor. An analysis showed Fe 27.12 per cent. (No. 12—Plate V).

**Busselton-Jarrahwood**—seven miles south-east of Busselton in a drain excavation at the south-west corner of Location 441 (L.L. 413C/40) there is a deposit with a maximum thickness of 2 feet showing covering approximately 1½ acres. Any possible extension is soil covered. An analysis showed Fe 49.50 per cent., TiO<sub>2</sub> Nil, and SiO<sub>2</sub> 14.08 per cent. (No. 20—Plate V).

**Greenbushes**—a few small deposits occur in the vicinity of this town, the best and largest being at an old quarry 30 chains from the railway station. This quarry produced iron ore many years ago, and the best quality material has been removed. Although some ore which remains is of high enough grade, there is not sufficient available for the minimum requirements.

**Hester's Siding**—although slightly outside the 50-mile radius, there is a small deposit at the south-east corner of Location 7595 (L.L. 439B/40). The quality appears to be good, but the area is small.

#### Conclusion.

There is not two million tons of ferruginous laterite adhering to the specifications for iron ore set down by H. A. Brasserts & Co. within this area.

It is doubtful if further examination and testing by shafts of the deposits described would produce more than two deposits with the minimum tonnage of 50,000.

Under these specifications, no further work is justified.

#### SUMMARY REPORT ON SOUTH-WEST LIMESTONE RECONNAISSANCE.

By J. H. Lord, B.Sc., F.G.S.

The specifications of the limestone required by H. A. Brasserts & Co., for smelting iron ore were as follows:—

(a) It must contain less than 6 per cent. silica and less than 20 per cent. magnesia; (b) must have sufficient crushing strength to support a charge in a blast furnace, and (c) each locality must contain more than 10,000 tons of limestone, at least three feet thick, while the total requirement is 600,000 tons.

The investigation has been reported on in detail by Messrs. W. Johnson and L. de la Hunty, and the following conclusions are drawn from their reports.

The limestone within 50-miles radius of Bunbury occurs along the coastline extending inland for an average of two to three miles. There is an abundance of limestone within this area but the silica content is too high.

Four types of deposits were recognised by Johnson:—

- (i) Aeolian limestones—on the coast between Cape Naturaliste and Cape Leeuwin, up to 400ft. in thickness—containing 14 to 30 per cent. silica with a capping rarely exceeding two feet in thickness of purer limestone.
- (ii) Sandy fossiliferous marine limestone, containing 20 to 60 per cent. silica and an occasional capping as in (i).
- (iii) Mechanical and chemical limestones, similar in composition to (ii).
- (iv) Fossil reef limestones, considered originally to provide the best possibilities, but test pits showed it to be equivalent to type (ii) with a slight surface concentration of detrital coral.

The cappings found over some deposits of sandy limestone is the only limestone of sufficient hardness within the area, but these are too variable in quality and thickness to be exploited economically as a flux for smelting iron ore.

#### REPORT ON TESTING A LIMESTONE DEPOSIT THREE MILES NORTH-WEST OF CAPEL, SOUTH-WEST DIVISION.

By J. H. Lord, B.Sc., F.G.S.

This is the area recommended by W. Johnson in his report on a "Survey of the Limestone Deposits of the South-West Division within 50 miles radius of Bunbury," as the only area worthy of detailed examination. The area covers a portion of the Stirling Estate Locations 96, 97, 102, 157 and 201 as shown on Plate VI.

Four test pits were sunk along the centre line of the outcrop area of this deposit at positions shown on Plate VI, to an approximate depth of eight feet each. These pits were channel sampled and the material collected was analysed by the Western Australian Government Chemical Laboratories.

#### Geology.

The outcrop area of this deposit is shown on Plate VI. At the northern end approximately 25 per cent. of the surface is covered with limestone deposits, but this percentage decreases rapidly to the south. The soil cover appears to vary from one half to two feet in thickness.

The rubble found on the surface is mainly reef corals, which led Johnson to suggest that it was a fossil reef. However, on closer examination of the outcrops and the sinking of test pits, it was found that coral does not occur abundantly in the deposit. Apparently the odd pieces of detrital coral in the deposit have resisted weathering far better than the other marine shells and, in consequence, the surface rubble tends to give a false impression of the type of limestone below.

In the pits the deposit was found to be a sandy marine limestone. It is a soft, friable deposit, with occasional hard bars through it, which appear to be lines of secondary enrichment of calcium carbonate, but even these when broken are quite friable.

#### Sampling Results.

Each sample was obtained by quartering the material gathered, by cutting a channel down the wall of the pit. It is pointed out that to be of use as a flux the limestone must contain less than 6 per cent. silica.

The results of the analyses of dried samples are shown in Table I below.

TABLE I.

Field No.	Chem. Lab. No	Shaft No. Positions on Plate I.	Depth.	CaO.	CaCO <sub>3</sub> .	SiO <sub>2</sub> .
			Feet. From to	%	Equiv. %	Equiv. %
GS/L 8	4361	1	1-4	46.61	83.16	9.44
GS/L 9	4362	1	4-6	46.40	82.80	11.60
GS/L 10	4363	1	6-8	42.93	76.64	17.86
GS/L 11	4364	2	1-4	48.01	86.01	7.93
GS/L 12	4365	2	4-6	47.09	84.54	9.20
GS/L 13	4366	2	6-8	45.33	81.42	11.49
GS/L 14	4367	Cutting	0-3½	49.91	88.05	4.39
GS/L 15	4368	3	1-2	53.14	94.84	2.11
GS/L 16	4369	3	2-4	53.37	95.24	1.81
GS/L 17	4370	3	4-6	52.07	92.92	1.03
GS/L 18	4371	4	3-3½	41.53	74.41	15.50
GS/L 19	4372	4	3½-5½	49.86	88.98	7.29
GS/L 20	4373	4	5½-7½	47.46	84.69	1.03

From these results the only pit that fulfils the quality specification is No. 3. Although the pits were sited at random, it appears from field evidence that pit No. 3 encountered a small patch of secondary enriched limestone.

#### Conclusion.

This deposit is not a fossil limestone reef and has been proven to be unsuitable as a flux for the iron industry because of its friability and high silica content.

#### REPORT ON SURVEY OF THE LIMESTONE DEPOSITS OF THE SOUTH WEST DIVISION OF W.A. WITHIN A RADIUS OF 50 MILES FROM BUNBURY.

By W. Johnson, B.Sc. (Hons.).

#### Introduction.

The purpose of the survey was to locate limestone deposits for use as a flux in blast furnaces, smelting iron ore. It was required by H. Brasserts Ltd., who propose to establish iron smelting works at Bunbury. The specifications required that the limestone contain less than 6% silica, less than 20% magnesia, and must have sufficient crushing strength to support a charge in the blast furnace.

To work any deposit economically it was required to be at least three feet thick and to contain more than 10,000 tons. The total initial requirements of limestone was 600,000 tons.

#### Method of Work.

Before commencing the survey the insoluble residue of various specimens of Coastal Limestone was determined (insoluble in warm HCl). Inspection of these samples showed that it would be possible to distinguish, by visual inspection, those limestones containing too much silica to be worth sampling.

The search took the form of walking rapid traverses through country in which the limestone outcropped and taking samples of that rock which it was impossible to discard by visual inspection.

This search took the form of a rapid reconnaissance and it was intended to return and sample in detail, and to determine the reserves of, those deposits which showed promise.

#### Geology.

Preliminary work showed that limestone from the southern boundary of the area north to the Harvey River Diversion Channel is confined to a strip whose landward boundary is two miles to three miles from the coast. In this strip the actual outcrops of limestone are one quarter mile to one mile wide and are usually on the landward side of the narrow coastal lakes and swamps. The limestones were of four types—

- (i) Aeolian limestones—mostly 14% to 30% silica.

## SAMPLING RESULTS S.W. LIMESTONE SURVEY TO 3RD FEBRUARY, 1950.

Sample No.	Lithograph.	Locality of Sample.	Type of Limestone.	Type of Sample.	Residue after dissolving in warm HCl.
JL 1	413D/40	At N.W. corner of Loc. 540 ....	Cap of aeolian sandy granular limestone	Chip sample of small area of outcrop	Per cent. 4.5
JL 2	413D/40	At S.W. corner of Loc. 540 ....	Cap of aeolian sandy granular limestone JL 1	Specimen only ....	1.0
JL 3	413D/40	15 chns. east of S.W. corner Loc. 810 ....	Cap of aeolian sandy granular limestone JL 1 and 2	Chip sample of small area of outcrop	8.5
JL 4	413D/40	5 chns. N.E. of the N.E. corner Loc. 540 ....	Cap of aeolian sandy granular limestone JL 1, etc.	Specimen only ....	1.0
JL 5	413D/40	8 chns. S. 20 chns. E. of S.W. corner Loc. 928 ....	Cap of aeolian sandy granular limestone JL 1, etc.	Chip sample only ....	7.0
JL 6	413D/40	15 chns. W. 12 chns. S. of N.W. corner Loc. 928 ....	Cap of aeolian sandy granular limestone JL 1, etc.	Specimen ....	0.5
JL 7	413D/40	30 chns. N. of S.W. corner of Loc. 346 ....	Cap of aeolian sandy granular limestone JL 1, etc.	Specimen ....	3.0
JL 8	413D/40	70 chns. N. of S.W. corner of Loc. 346 ....	Cap of aeolian sandy granular limestone JL 1, etc.	Specimen ....	4.5
JL 9	413D/40	40 chns. S. 10 chns. E. of S.W. corner Loc. 810 ....	Cap of aeolian sandy granular limestone JL 1, etc.	Specimen ....	1.5
JL 10	413D/40	15 chns. S.W. of Moses Rock, Loc. 495 ....	Cap of aeolian sandy granular limestone JL 1, etc.	Chip sample ....	0.5
JL 11	413B/40	40 chns. W. 20 chns. N. of S.E. corner of Loc. 4, Wonnepur	Cap limestone over sandy soft fossiliferous limestone	Specimen ....	1.0
JL 13	413A/40	On Loc. 1581 Locke Estate corner of N.-S. and E.-W. drains	Cap limestone over sandy soft fossiliferous limestone JL 11 but under cover of 3 ft. sand	Specimen ....	16.5
JL 14 A & B	413B/40	8 chns. W. of corner of roads and Locns. 102 CG, 60 and 157 Stirling Estate (corner P).	Sandy fossiliferous coral reef limestone plus capping	Channel samples down face of two old lime quarries, length of channel 2 ft. to 3½ ft. A and B from adjacent quarries	A 6.5 B 2.0
JL 15	413B/40	10 chns. S.W. of corner P (see above) ....	Capping of fossiliferous sandy limestone	Specimen ....	9.5
JL 16	413B/40	At corner P ....	A capping of B fossiliferous granular sandy limestone	Specimen ....	A 4.5
JL 17	413B/40	16 chns. along road N.E. from corner P ....	A capping of B fossiliferous granular sandy limestone JL 15	Specimen ....	B 14.5 14.5
JL 18	413B/40	32 chns. along road N.E. from corner P ....	A capping of B fossiliferous granular sandy limestone JL 15, etc.	Specimen ....	1.0
JL 19	413B/40	48 chns. along road N.E. from corner P ....	A capping of B fossiliferous granular sandy limestone JL 15, etc.	Specimen ....	1.0
JL 20	413B/40	S.E. corner Loc. 97 Stirling Estate 72 chns. N.E. along road from corner P	Calcareous algae and coral reef	Specimen ....	0.5
JL 21	413B/40	On road at common corner of Locns. 106 (N.E. corner) and 106 (S.E. corner) Stirling Estate	Cap of fossiliferous sandy limestone	Chip sample of fairly large area	5.5
JL 22	413B/40	At meeting corners Locns. 102, 103, 60, Stirling Estate	Cap of fossiliferous sandy limestone	Specimen ....	5.0
JL 23 A B C D E	413B/40	Loc. 95 Stirling Estate 2 chns. W. 3 chns. N. of S.W. corner A, B, C, D, E, at 20 feet intervals along quarry face and natural bank going S.E. from A located at 3 chns. W. 4 chns. N. of S.W. corner of Loc. 95	Fossil calcareous algae and coral reef with mollusco and brachipod shells	Channel samples average length 3 ft.	A 6.0 B 4.5 C 3.5 D 2.5 E 2.5
JL 25	411A/40	10 chns. due S. of S.E. corner Loc. 17 C.G. ....	Cap of and normal fossiliferous limestone	Channel sample 4 ft. long	14.5
JL 26	383D/40	65 chns. S., 5 chns. E. of N.E. corner Loc. 20 C.G.	Cap limestone ....	Specimen ....	9.5
JL 27	383D/40	Bank of Harvey River diversion channel where it meets E. boundary of Loc. 42 C.G. B and C 600 ft. apart	Fossiliferous granular sandy limestone	Channel samples 5 ft. long	B 45.5 C 27.5
JL 28	383D/40	20 chns. N. 28 chns. W. of S.E. corner Loc. 21 C.G.	Normal fossiliferous sandy limestone underlying cap	Specimen ....	16.0

(ii) Sandy fossiliferous marine limestones 20% to 60% silica.

(iii) Mechanical and chemical limestones.

(iv) Reef limestones.

Type (i) is confined to the western side of the Cape Naturaliste—Cape Leeuwin granite ridge. These sandy limestones are quite thick (up to 400 feet and more) and have a capping of very pure limestones of travertinous nature (see table of residues). Unfortunately this capping rarely exceeds two feet in thickness and is very variable in thickness, lateral extent and silica content.

Types (ii) and (iii) are associated and are all too sandy (siliceous) to be of any use, though they too have a travertinous capping of great purity in parts.

Type (iv) occurs most rarely and is the only one which offers promise of moderately large supplies of limestone of sufficient purity to be used in the blast furnace.

#### Sampling.

Most of the samples are chip or grab samples taken horizontally from outcrops of travertinous capping. As such they indicate no more than that the capping in the vicinity of the specimen or sample is pure or impure. More useful samples were taken from natural or artificial vertical sections. These invariably illustrated that in deposits of types (i) (ii) and (iii) the capping was much purer than the body of the deposit. Samples JL 16 A and B are an excellent example; JL 16

A representing the top nine inches of travertinous capping has a residue of 4.5 per cent. JL 16 B representing the underlying normal rock has 14.5 per cent. residue.

#### Recommendation.

From the results of the reconnaissance examination of the area as far north as the Harvey Diversion Channel it is recommended that only one area is worthy of immediate detailed examination. This is the area extending approximately from the south-west corner Loc. 122 to the south-west corner Loc. 104 Stirling Estate. The area averages 20 chains in width and may extend under cover farther south-east. The area is depicted by cross hatching on a litho 413 B/40, in the Geological Survey Office. Within this area the most favourable portion to investigate is the portion enclosed in the red line comprising parts of Locs. 97, 157, 96, 95, 94, 201, 202 and 203, Stirling Estate.

If this area fails to prove of use on detailed examination by means of sample pits or bore holes, then it is doubtful whether usable limestone will be located in other parts of the coastal area within 50 miles of Bunbury. But as a last resort any of the areas of cap limestone shown on the lithographs might be investigated. However, the writer is of the opinion that none of the deposits of high grade cap limestone are of sufficient vertical or lateral extent to be economically mined. The remarks in this report apply only to that area investigated by the writer and the geologists under his charge.

REPORT ON SURVEY OF LIMESTONE  
DEPOSITS BETWEEN HARVEY RIVER  
DIVERSION CHANNEL AND MANDURAH,  
SOUTH-WEST DIVISION.

By L. E. de la Hunty, B.Sc.

*Introduction.*

This report is in furtherance to that of Mr. W. Johnson.<sup>29</sup> It is therefore patterned on his report and his classifications will be adhered to.

*Method of Work.*

Work was carried out under the instruction and supervision of Mr. W. Johnson.

It took the form of rapid reconnaissance in search of limestone likely to fulfil the qualifications already outlined by him. General gridding of the area was carried out, together with inspections of any likely areas suggested by local inhabitants.

Samples were taken wherever the rocks were not obviously too sandy.

*Geology.*

Only the coastal strip is dealt with since limestone only outcrops up to five miles east of the coast.

The country to the west of Lakes Preston and Clifton consists of sand dunes with outcrops of very sandy aeolian limestone. The limestone around the Harvey Estuary and Peel Inlet also falls into the same category. Only that limestone to the east of the coastal lakes is worthy of consideration.

The types of limestone outlined by Mr. Johnson<sup>30</sup> are—

- (i) Aeolian limestones.
- (ii) Fossiliferous marine limestones.
- (iii) Mechanical and chemical limestones.
- (iv) Reef limestones.

Most of the limestone in this area is of type (i) and occupies all the ridges. It has the usual travertine cap which is low in silica content.

In the low-lying parts type (ii) is apparent but seems to have a lower silica content than the outcrops to the south.

Type (iii) is sandy and of little use, while type (iv) is rare.

The floors of Lakes Preston and Clifton consist, in places, of loosely packed shell beds—mainly small pelecypods with occasional ostrea. As a source of lime, these beds should be ideal but they are quite unsuitable for the present purpose.

*Sampling.*

The method of sampling used was that of taking random chips (approximately one cubic inch) from the surface—over areas up to one acre. Where boulders outcropped two to three feet above ground level, chips were taken from ground level as well as from the tops of the boulders.

*Results.*

No deposits of limestone conforming to the specifications laid down were located.

Sample No.	Lithograph No.	Locality of Sample.	Type of Limestone.	Residue after dissolving in warm HCl.
LD 1	413A/40	30 chains W of NE corner Loc. 1044	Cap of aeolian sandy limestone	% 1.5
LD 2	413A/40	10 chains N of Sugar-loaf Spring, Loc. 332	Cap of aeolian sandy limestone	2.0
LD 3	413B/40	14 chains N30°W of SE corner Loc. 318	Fossiliferous marine	4.0
LD 4	413B/40	35 chains SW of NE corner Loc. 9	Fossiliferous marine	13.5
LD 5	413B/40	25 chains N of SE corner Loc. 6	Fossiliferous marine	8.6
LD 6	413B/40	37 chains NW of SE corner Loc. 6	Fossiliferous marine	3.5
LD 7	413B/40	Junction of Busselton-Augusta Railway with S boundary Loc. 6	Fossiliferous marine	6.0
LD 8	383D/40	SE corner Loc. 1794	Cap of aeolian sandy limestone	14.5
LD 9	383D/40	15 chains W of NE corner Loc. 1251	Cap of aeolian sandy limestone	1.0
LD 10	383D/40	37 chains S60°W of NE corner Loc. 48	Cap of aeolian sandy limestone	2.5
LD 11	383D/40	10 chains W of SE corner Loc. 2622	Fossiliferous marine	1.0
LD 12	383A/40	2 chains W of NW corner of Reserve 11708	Cap of aeolian sandy limestone	12.0
LD 13	383A/40	E shore of Lake Clifton	Soft chemical limestone	2.0
LD 14	383D/40	SE corner of Loc. 1794	Cap of aeolian sandy limestone	6.0

<sup>29</sup> "Report on Survey of the Limestone Deposits of the South-West Division of W.A. Within a Radius of 50 Miles from Bunbury."

G.S.W.A. Ann. Rept., 1950.

<sup>30</sup> Op. cit.