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1959/61

PISOLITIC IRONSTONE DEPOSITS, PORT HEDLAND AREA, WESTERN AUSTRALIA

by

J.J. Veevers & A.T. Wells

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INTRODUCTION

In August, 1954, at the completion of field work in the south-western part of the Canning Basin, J.N. Casey visited a pisolitic ironstone deposit (called Deposit A in this report) beside the Great Northern Highway, 26 miles from Port Hedland aerodrome (Figs. 1-3). He made notes, and collected specimens. A brief description of the deposit appeared in Traves et al. (1956, p.31):

> "A hill 20 miles east of Port Hedland (actually 25 miles east-south-east of Port Hedland) is capped with 20 feet of pisolitic ironstone which resembles a ferruginous zone of a laterite; but it contains fossil wood and probably has a lacustrine origin. Chemical analysis of this deposit shows:

	%
Loss on ignition at 100°C*	13.80
SiO_2	1.89
Fe_2O_3	77.50
Al_2O_3	8.75 "

* This should probably be 1000°C. Analysis by I. Reynolds, November, 1954.

Analyses by S. Baker (14.5.59) of the two specimens of ironstone are -

	P.H. 1a	P.H. 1b
Fe_2O_3	74.90%	78.20%
SiO_2	7.23	4.35
Al_2O_3	2.80	1.70
Loss on ignition	12.94	15.50

The above results refer to the samples dried to constant weight at 105°C.

The estimates of ore reserves were based on the analysis by Reynolds and the new analyses do not materially alter these estimates.

In June, 1955, J.N. Casey and A.T. Wells visited part of another ironstone deposit (here called Deposit B). Like Deposit A, this deposit consists of a thin cap of pisolitic ironstone overlying granite; the cap is probably, on the average, 10 feet thick.

In November, 1958, as a contribution to the Tectonic Map of Australia, J.N. Casey prepared a geological sketch map of the northern half of the Port Hedland 4-mile sheet area, and included on the map two outliers of Mesozoic rocks within the Precambrian terrain; one is situated 18 miles south-east of Port Hedland (Deposit B), the other, much smaller area, 25 miles east-south-east of Port Hedland (Deposit A). Deposit A is too small to be included at the scale of the Tectonic Map.

In May, 1959, we interpreted the Phanerozoic sedimentary rocks of the Port Hedland 4-mile sheet area from air photographs, and examined the specimens from Deposit A. The following account includes an assessment of the economic possibilities of the ironstone deposits.

REGIONAL GEOLOGY

Within the Port Hedland 4-mile sheet area south of the Canning Basin, Precambrian rocks are overlain by small areas of probable Mesozoic sandstone and pisolitic ironstone. The Precambrian rocks may be grouped into three parts:

(a) deformed metamorphic rocks (greenstone, jasper, marble, slate) intruded by

(b) granite, which forms a plain covered by sparse spinifex and alluvial sand. On the air photographs, the granite plain is uniformly light-coloured, with a few platforms and hillocks of exposed granite. Linear structures in the exposed rock continue under the sand, and are indicated by lines of vegetation. In places, the granite is crossed by dykes of dolerite up to 250 yards across.

(a) and (b) are overlain unconformably by

(c) gently folded sandstone, dolomite and volcanic rocks.

The only other rocks in this area are flat-lying deposits of probable Mesozoic sandstone and pisolitic ironstone, which overlie the Precambrian granite. Two deposits ('J' and 'K') of probable ironstone unconformably overlie Precambrian metamorphic rocks.

PISOLITIC IRONSTONE

Deposit A

J.N. Casey's field notes (Sunday, 15th August, 1954) on this deposit are as follows:

"20' pisolitic ferruginous sandstone with much small wood - Jurassic

10' sst with pipes

40' white decomposed granite with quartz veins, mica, etc."

Deposit A (Figs. 2 and 3) is a 20 ft. thick ironstone cap on a west-elongated granite butte 70 ft. high, 1 mile long, and, on the average, 250 ft. wide at the top, and 1500 ft. at the base. The contact between granite and sandstone is obscured by ironstone talus, except at the eastern and western ends of the butte, where the granite is probably indicated on the air photograph by patches of white. The ironstone talus has straight or evenly curved contacts with the Quaternary sand. This is one of the main criteria for recognising ironstone deposits on air photographs of this area, because the talus from Precambrian rocks in the area is crossed by 'fingers' of sand, and the contact between this talus and the sand is nowhere straight or evenly curved. The contact between the sandstone and the ironstone lies at the base of the prominent 20 ft. scarp. Sparse vegetation grows on the talus, none on the ironstone. The ironstone cap lacks drainage, and is dark brown, almost black, and horizontal.

The following description of the two specimens from Deposit A was supplied by W.B. Dallwitz.

PLATES 1 to 4 - photos by C. Zawartko, captions by W.B.Dallwitz

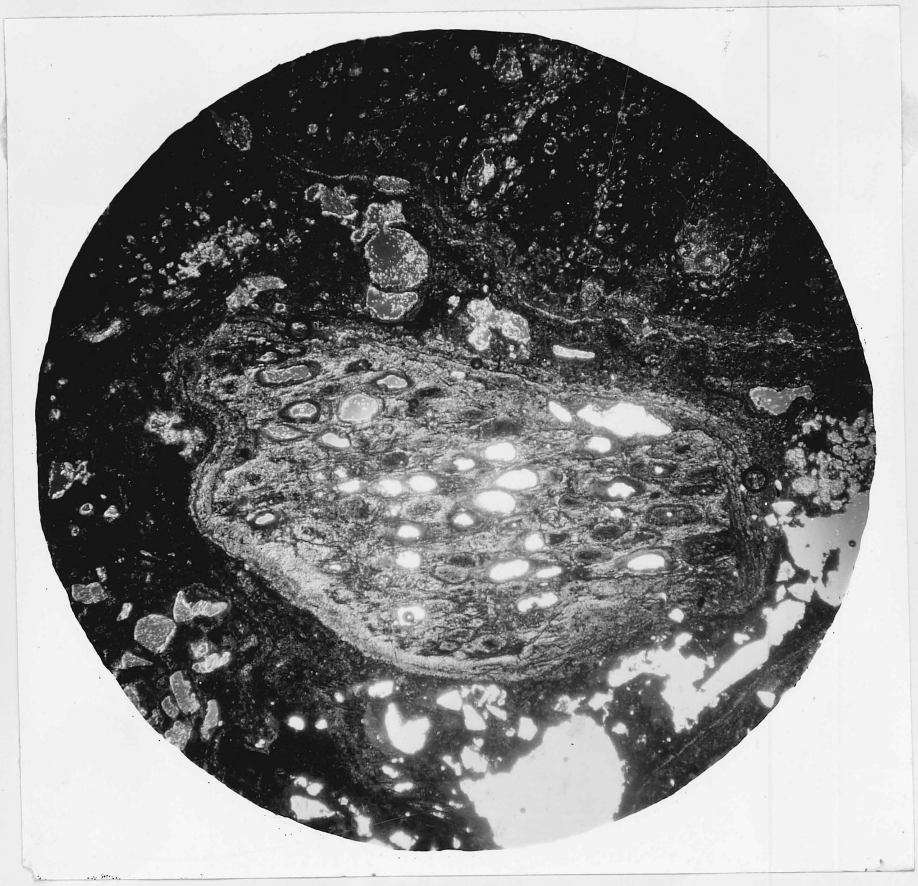


PLATE 1. Specimen PH la, slide 4539.
Ferruginized wood in porous ironstone containing angular quartz grains x34.5

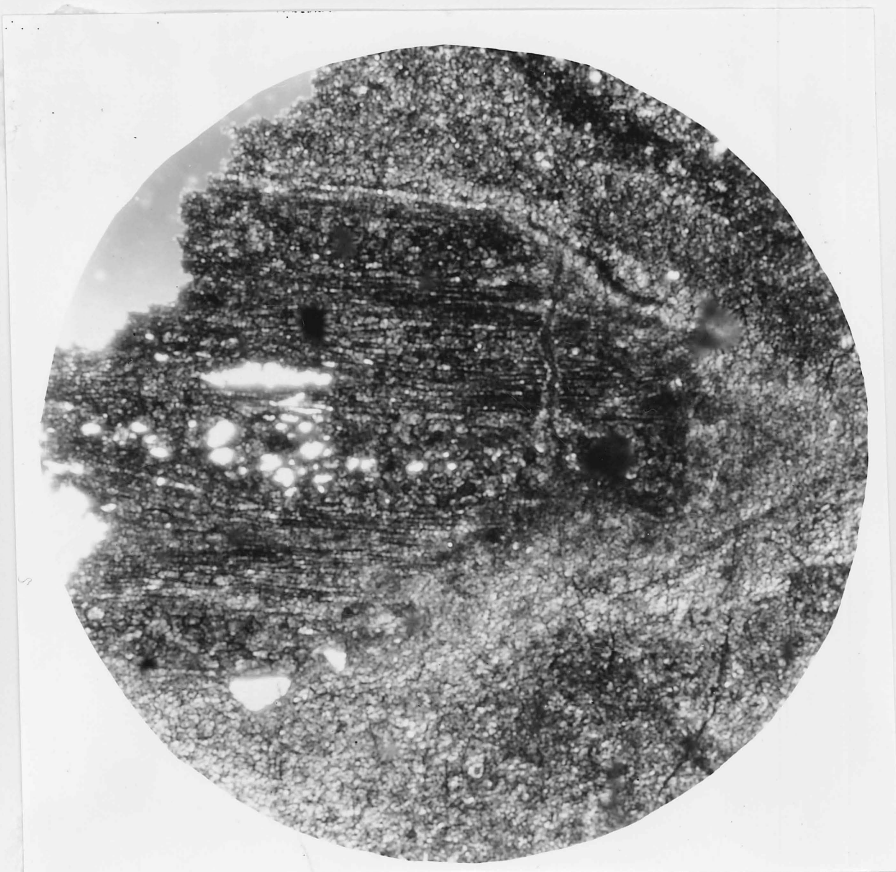


PLATE 2. Specimen PH la, slide 4539.
Ferruginized wood in ironstone. x74.5

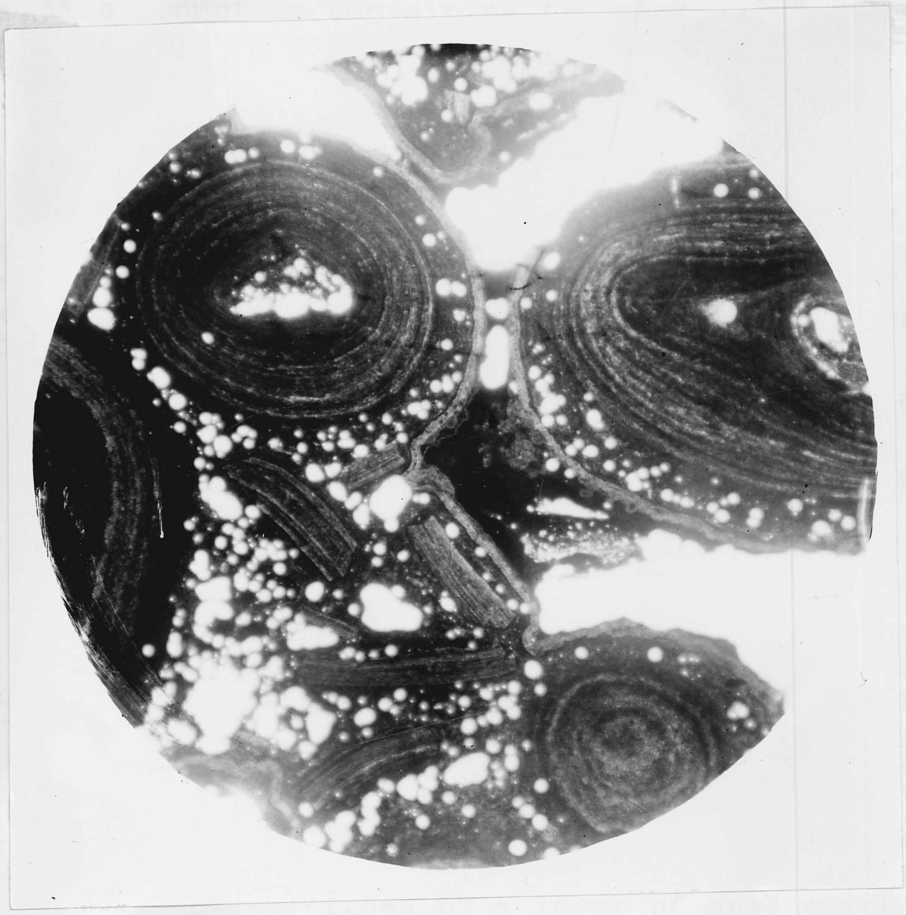


PLATE 3. Specimen Ph 1b, slide 4541.

Pisolites and fragments of pisolites in porous ironstone containing a few quartz grains. A broad porous zone is continuous in three of the pisolites.
x19.5

PLATE 4. Specimen PH 1b, slide 4541.

Fragment of pisolite as nucleus of subsequently-formed pisolite. Matrix as described for Plate 3.
x19.5

<u>Specimen PH 1a</u> (slides 4539 and 4540) is a rather coarsely pisolitic ironstone containing fragments of fossil wood measuring up to 2.5 cm. x 1 cm. Pore-spaces commonly remain near contiguous pisolites, and are also found in other positions throughout the rock. The largest pisolite measures about 1 cm. across. Some soft whitish patches of probable argillaceous material are scattered through the rock.

In thin section the rock is seen to consist of ironstone pisolites and fragments of wood replaced by ironstone, set in a matrix of ironstone containing angular grains of quartz. Concentric banding of various degrees of perfection is developed in the pisolites.

The cores of the pisolites may be composed of any of the following materials:

1. Fragments of wood replaced by ironstone (Plates 1 and 2)
2. Unbanded or faintly banded ironstone.
3. Fragments of sandy ferruginous argillite.
4. Pieces of broken, banded pisolites.

The pisolites are held together by structureless ironstone which may be rather porous, and may contain very unevenly distributed angular quartz grains, pieces of broken, banded pisolites, and large to small fragments of sandy ferruginous argillite which are not surrounded by banded ironstone.

Kaolin or other clay mineral occurs in small pockets (these are the whitish patches noted in handspecimen). Some cavities are partly lined by a layer of opal which may be up to 0.08 mm. thick. In one place thin, alternating layers of clay mineral and opal line a cavity.

<u>Specimen PH 1b</u> (slide 4541) is a pisolitic ironstone in which the average size of the pisolites is notably less than that seen in specimen PH1a. Fragments of fossilized wood are rare as compared with the quantity noted in specimen PH 1a. Plate 3 shows pieces of broken pisolites in this rock, and Plate 4 shows similar fragments with new material built up round them.

The cores of the pisolites consist of materials similar to those described for specimen PH 1a.

<u>Deposit B</u>

Four miles west of Deposit A is a west-trending discontinuous chain of buttes (Deposit B). The buttes are thinly capped with pisolitic ironstone, and rise abruptly above talus-covered granite. The chain is cut by the north-flowing Petermarer Creek. Seven of the eight buttes east of Petermarer Creek form an almost continuous west-trending chain 2 miles long, about 220 yards wide at base of talus, and about 50 yards wide at the ironstone cap. One small butte lies about 1½ miles north of the others. The five ironstone-capped buttes on the western side of the creek form a less continuous chain; three are surrounded by a continuous sheet of ironstone talus which is 3½ miles long, and from 100 to 900 yards wide. These three buttes are only about 30 feet high. Nearer the creek are two isolated buttes; one is elongated east-west, in the same direction as those east of the creek; the other is almost conical.

Deposits A and B are the only ones that were visited. Air-photograph interpretation indicates the probable occurrence of other ironstone deposits in the Port Hedland Sheet area. These are:

Deposit C (Air photograph: Port Hedland Sheet Run 6/5210)

Four isolated rounded hills, photo pattern black, sharp boundary of talus slope with sand plain, top of hill rounded, no visible structure.

Deposit D (Run 6/5207)

Four isolated steep-sided hills of exposed granite thinly capped with probable pisolitic ironstone. The air photograph shows granite tors overlain by dark-grey massive rock (probably ironstone).

Deposit E (Run 7/5192)

An isolated granite peak probably capped by ironstone on the west bank of Petermarer Creek, 4½ miles upstream from Deposit B. The edge of the thin cap is an escarpment.

Deposit F (Run 9/5010)

Two isolated hills with a cap of probable ironstone. Sandstone 10 to 20 feet thick is probably indicated by smooth light-coloured benches and shelves beneath the inferred ironstone. The probable sandstone is apparently not penetrated by dolerite dykes which continue through the underlying granite on either side of the sediments.

Deposit G (Run 9/5009)

A north-trending ridge half a mile long of granite capped by a sheet of (?) sandstone 10 to 20 feet thick. A thin remnant, probably 5 to 10 feet thick, of pisolitic ironstone forms a peak at the southern end of the ridge. Dark-coloured talus is found only on the slopes immediately below the probable ironstone cap.

Deposit H (Run 9/5003)

An isolated black hillock on west bank of Turner River. Boundary between talus and sand sharp. No visible structure.

Deposit J (Run 11/5099)

A sinuous north-north-west ridge 1 mile long, base of talus slope 0.3 mile wide, probable ironstone cap, on the average, 40 yards wide, thickness about 10 feet. This cap rests unconformably on vertically folded Precambrian metamorphic rocks.

Deposit K (Run 12/5072)

One and a half miles south-west of Indee Homestead. There are two elongated outcrops - the eastern one trends north-west, is two and a half miles long, 0.3 mile wide, is capped by an unknown thickness of probable ironstone, and unconformably overlies deformed Precambrian metamorphic rocks. The Precambrian ridges and the long axis of the/ironstone outcrop intersect at an /inferred angle of 70°. This outcrop differs from other ironstone-capped hills in the area in that the cap is not flat but forms a trough whose axis coincides with the long axis of the outcrop. Since the surface of the ironstone cap in other deposits is probably parallel to the bedding, this concavity possibly indicates a syncline with low-dipping limbs.

The western outcrop is 1 mile long and up to ½ mile wide; it contains several hummocks of probable ironstone up to 40 yards wide.

Several hills east of Deposit K on the bank of the east branch of Turner River possibly have a cap of ironstone but from the air photographs no detail is clearly visible.

ORIGIN AND AGE OF THE PISOLITIC IRONSTONE

The abundance of replaced wood in the pisolitic ironstone of Deposit A suggests that it is similar to the bog limonites being deposited at the present day in Sweden, Finland and Canada. Bog limonites commonly consist of concretionary limonite. 'Precipitation appears to take place most vigorously in extremely shallow water, and many lakes with extensive bog-iron deposits in the marginal marshes appear to deposit sediments containing much smaller proportions of iron materials in their deeper parts'. (Hatch, Rastall & Black, 1950, p.146-147).

Traves et al. (1956, p.31) considered the ironstone to be lacustrine, but pointed out that it could be easily confused with laterite, presumably because it protects the underlying rock from erosion, and is itself eroded by scarp retreat only. It differs from the ferruginous zone of a laterite profile by the high content of replaced wood, the low content of silica, and the high content of iron oxide.

The nearest wood-bearing sediments are the outcrops of Callawa Formation along the margin of the Canning Basin, 25 miles to the north-east. These rocks are Mesozoic, probably Jurassic. They are deltaic deposits of sandstone and conglomerate, and contain abundant plant remains, including wood. The best estimate of the age of the ironstone deposits (and the underlying conformable sandstone) is therefore Mesozoic, probably Jurassic. Traves et al. (1956, p.30) consider that the ironstone is possibly Tertiary, because the laterite present earlier in the Tertiary could provide a source of iron oxide. A palaeobotanical examination of the replaced wood may indicate the age.

ECONOMIC GEOLOGY

Deposits of ironstone

The composition of one of the specimens collected from Deposit A is:

	%	% recalculated to 100%
Fe_2O_3	77.50	76.04
Loss on ignition (1000°C)	13.80	13.53
Al_2O_3	8.75	8.58
SiO_2	1.89	1.85
	101.94	100.00

This rock contains 53.2% Fe.

After ignition, the residue has the following composition:

	%
Fe_2O_3	87.93
Al_2O_3	9.93
SiO_2	2.14
	100.00

The residue contains 61.5% Fe.

Since Deposits A and B are the only ones that were visited, and hence the only ones with known ironstone, estimates of the tonnage of ironstone are given for these deposits only. Furthermore, only Deposit A was collected from, and its thickness measured. Thus three types of estimates are given:

probable estimates of tonnage at Deposit A;
possible estimates at Deposit B;
and possible estimates of the relative amount of ironstone at the other deposits.

Deposit A

From the air photographs, the area of pisolitic ironstone is conservatively estimated to be 1,533,000 ft.^{2}. The deposit is approximately 20 feet thick, so the volume is 30,660,000 ft.^{3}. The average value of bulk density of the two samples of ironstone is 11.84 ft.^{3}/ton. The estimated weight of this deposit is therefore

2,601,000 tons

containing 52.3% Fe, that is, 1,384,000 tons of Fe. With these figures, it can be estimated that if the water were removed from the ironstone, the figure would be 2,250,000 tons of ore containing 61.5% Fe.

Deposit B

The possible figures for Deposit B are

area 1,672,000 ft.^{2}

thickness (?) 10 feet

tonnage 1,419,000 tons of ore.

Other Deposits

The amount of ironstone at the remaining deposits is conjectural.

The amount at C or J is possibly similar to A or B, much less at D, E, F, G or H, and much larger at K.

RADIOACTIVE ANOMALIES

The published B.M.R. map (G.214-31, 1956) of radioactive anomalies in the western part (Sheet 1) of the Pilbara Region of Western Australia shows the radioactive anomalies detected by airborne scintillograph in the Port Hedland area (see Fig. 2). The aircraft was flown at a height of 500 feet along lines 1 mile apart, so only 10% of the area was covered. Deposits C and D lie immediately outside the surveyed area.

Three radioactive anomalies occur over granite close to ironstone deposits. Anomaly 1 is at the edge of the talus slope of Deposit B, 200 yards from the ironstone cap; Anomaly 2 is 1 mile west of Deposit E; and Anomaly 3 is on the edge of the talus slope of Deposit F, 200 yards from the (?) ironstone cap.

Radioactive anomalies may occur near the other deposits of ironstone in the area but since only 10% of the area was covered other anomalies, if they exist, would not have been detected. The 2 specimens of ironstone from Deposit A show no radioactivity.

A similar association of radioactive anomalies near the contact of granite and sediments containing plant remains is reported from Russia by Nekrasova (1958, p.29):

"The Jurassic beds are up to 700 m. thick, and are composed of deltaic-fluviatile, lacustrine, and paludal sediments....

The ore zones are narrow belts in the Jurassic rocks, near the (faulted) contact of these rocks with Proterozoic granites and metamorphic rocks. Coal-bearing beds occurring away from the granites do not contain economic concentrations of uranium."

The main differences between the Russian and the Port Hedland sediments are 1) the greater thickness of the Russian sediments; 2) the faulted contact between the Russian sediments and the granite; and 3) no ironstone in the Russian sediments. But the high content of organic matter in the original sediments, the contact with granite, and the radioactive anomalies at or near the contact of granite with the sediments, are features common to both areas.

CONCLUSION

This study indicates the probable occurrence of 2½ million tons of ironstone containing over 50% of iron, and the possible occurrence of further deposits of similar rock within a quadrant 36 miles south and east of Port Hedland. These deposits are small compared with worked deposits elsewhere, but their accessibility to Port Hedland, which is equipped for handling manganese ore, increases their potential value.

Also within the quadrant are four radioactive anomalies detected by airborne scintillograph; three of these lie at or near the contact of pisolitic ironstone and granite.

REFERENCES

HATCH, F.H., RASTALL, R.H. & BLACK, M., 1950 - The Petrology of the Sedimentary Rocks. 3rd Ed., Murby, London.

NEKRASOVA, Z.A., 1958 - The origin of uranium mineralization in coal in THE GEOLOGY OF URANIUM. Consultants Bureau Inc. New York, pp.29-42, 15 figs., 2 tables.

TRAVES, D.M., CASEY, J.N., WELLS, A.T., 1956 - The geology of the south-western Canning Basin, Western Australia. Bur.Min.Resour.Aust.Rep.29.

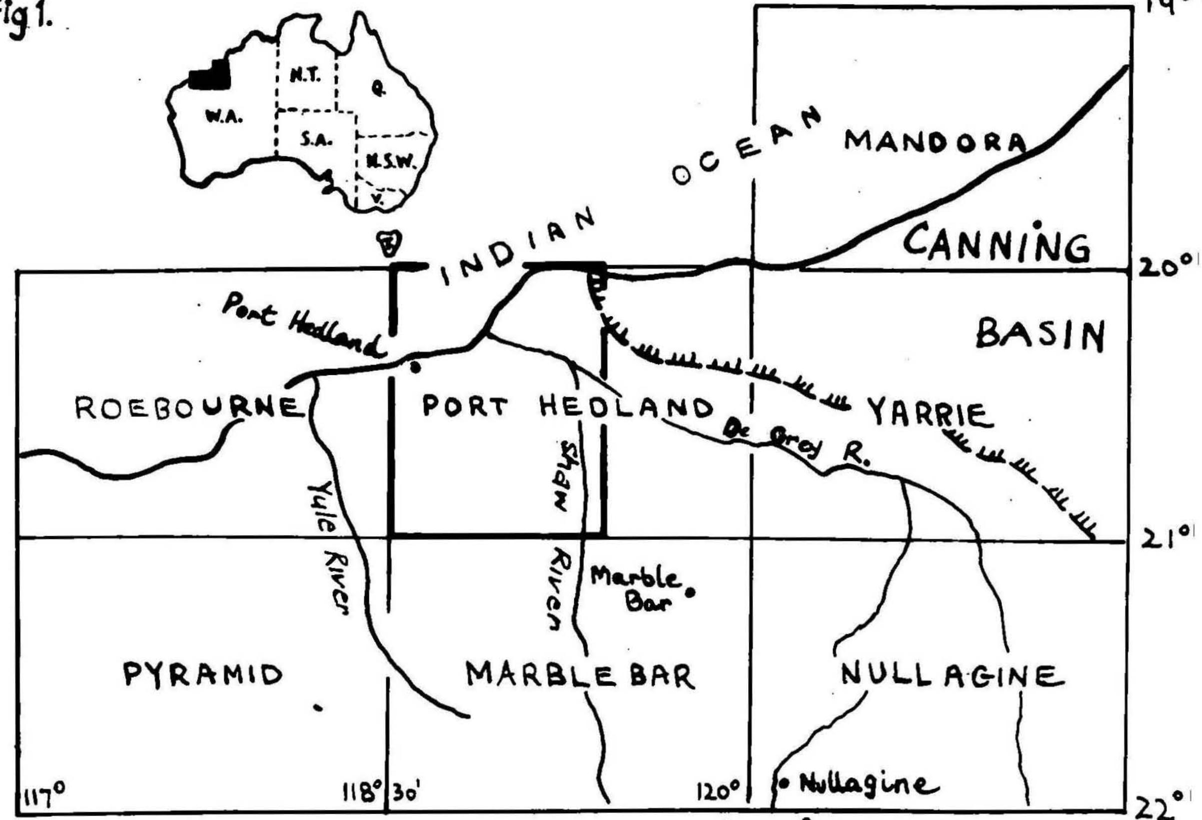
POSTSCRIPT

Just before this record was issued, we came across a published reference to the pisolitic ironstone deposits on the Port Hedland 4-mile sheet area. This appears in McWhae et al (J.Geol.Soc.Aust., 4(2), 1958, p.124), and is as follows:

> Poondano Formation (new name, Lindner and Drew, defined herein). Lindner and Drew have supplied the following information on the unit: "The Poondano Formation caps mesas in the area between Poondano Well (20°26'S., 118°48'E.) and Wallaringa Peak, 20 miles south-east of Port Hedland. It consists of pisolitic ironstone containing fossil wood, and unsorted silty kaolinitic quartz sandstone. The formation unconformably overlies Precambrian crystalline rocks and perhaps also the Lower Cretaceous Callawa Formation. It is believed to be of lacustrine origin, and the character of its occurrences suggests that it may be homochronous with the development of the Oakover Beds."

This confirms our air-photo interpretation of pisolitic ironstone near Wallaringa Peak (Deposit J), but otherwise adds nothing to our descriptions.

Fig 1.

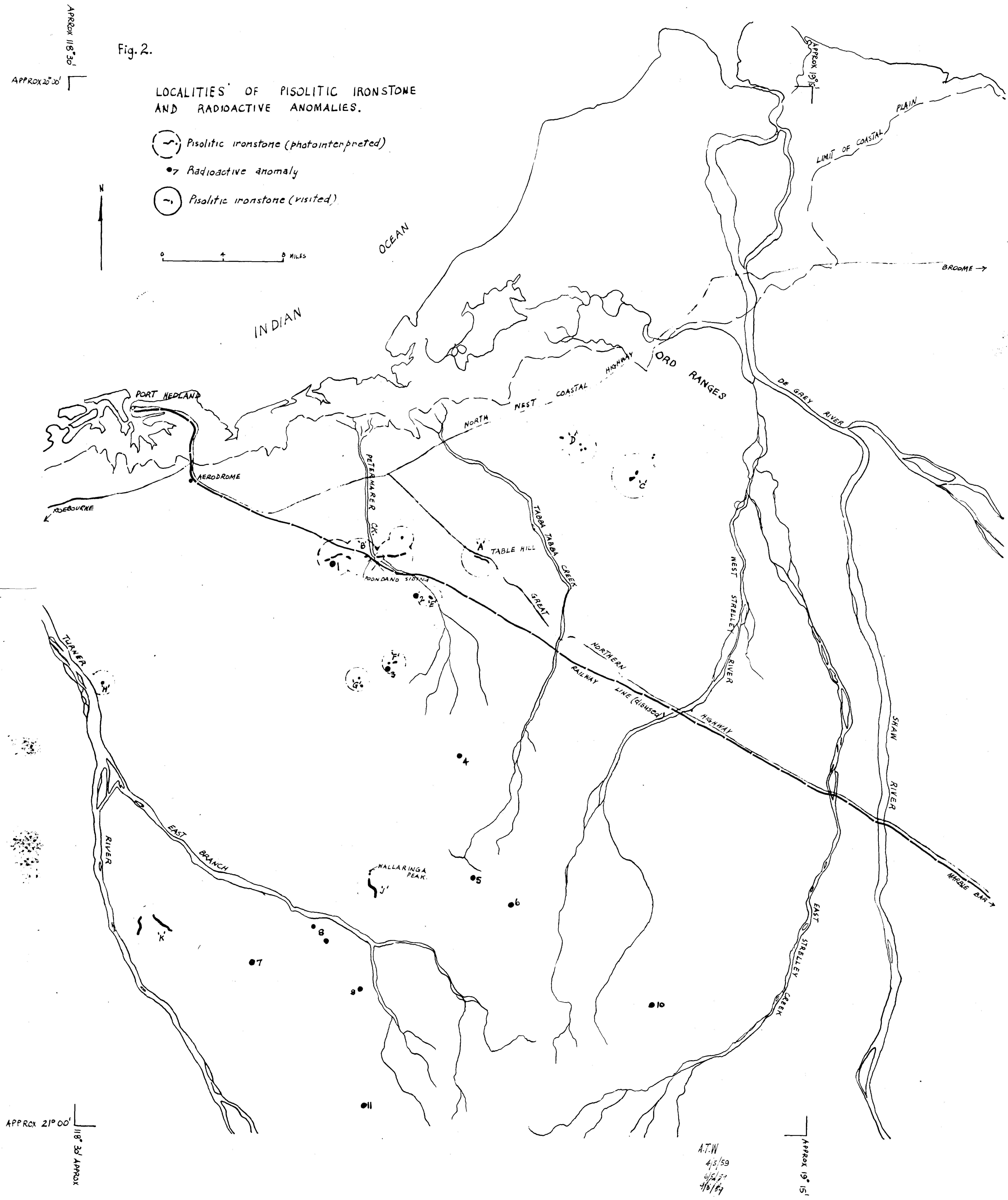


Locality map with reference to Australian FOUR-MILE MAP SERIES

4/5/59
6/5/59

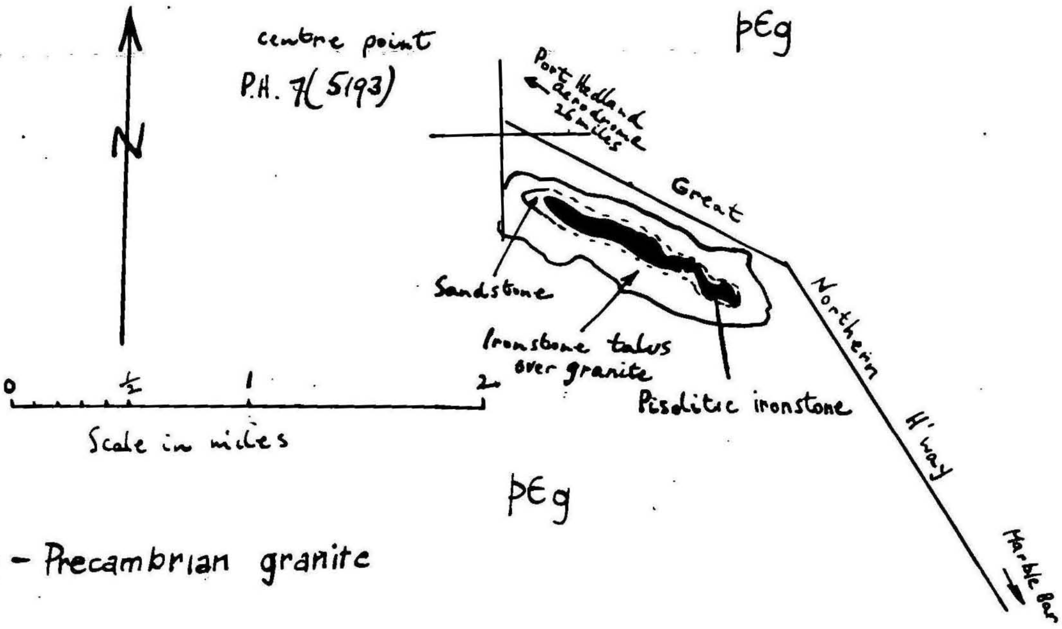
Fig. 2.

LOCALITIES OF PISOLITIC IRONSTONE AND RADIOACTIVE ANOMALIES.



Deposit 'A'

Fig.3.

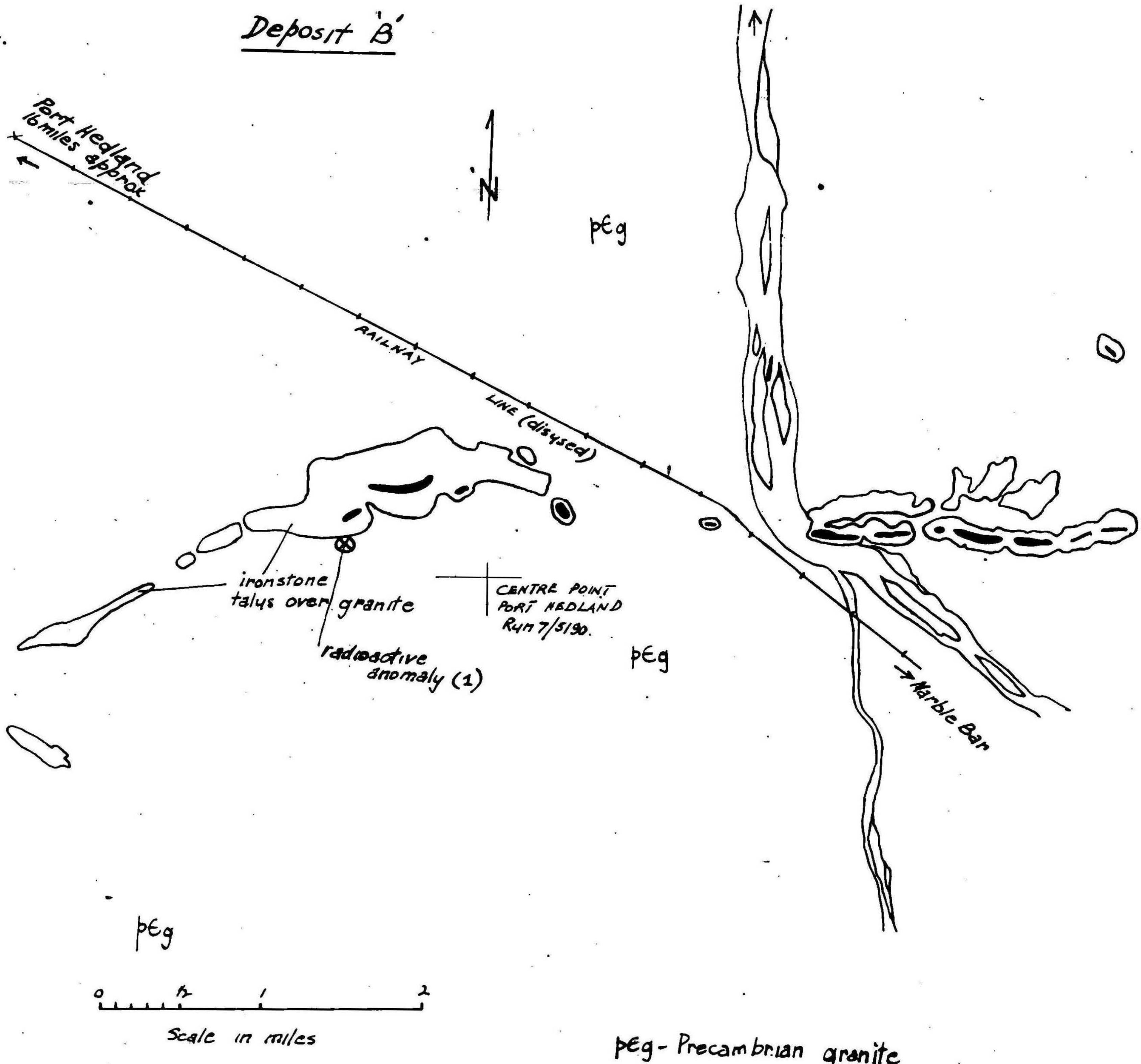


pEg - Precambrian granite

4/5/59.
6/5/59

Fig. 4.

Deposit 'B'



pЄg - Precambrian granite
- outcrops of pisolitic ironstone

4/5/59
6/5/59