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IRON ORE DEPOSITS NEAR CAPE LAMBERT, NEW BRITAIN.

by

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SUMMARY

Iron ore deposits near Cape Lambert, Gazelle Peninsula, New Britain, were investigated by costeaning and diamond drilling. Although the investigation was hampered by a shortage of drilling equipment the position and dimensions of the deposits were approximately determined and an estimate made of probable and possible reserves.

The total reserves are:

Probable: 81,000 tons magnetite-hematite available as approximately 1,100 tons per vertical foot.

Possible: 53,000 tons magnetite-hematite available as approximately 800 tons per vertical foot.

These tonnages were estimated on an arbitrary assumption that the iron ore occupies 9 cu. ft. per ton. Pure compact magnetite occupies 7 cu. ft. per ton and hematite 7 to 8½ cu. ft. per ton.

It is possible that additional small reserves occur at two localities, where detrital iron ore occurs on the surface. The possible reserves would not exceed 37,000 cu. yd. and are probably much smaller.

The deposits are narrow as shown in the following table:

Name of Deposit and Locality	Width	(Reserves (Tons)		Tons per vertical foot	
	Ft.	Probable	Possible*	Probable	Possible*
Langinoa deposit in Rangarere Plantation	3	10,000	12,000	130	250
Cairngorm deposit in Cairngorm Plantation	6	16,000	42,000	120	570
Doilene deposit in Doilene Plantation	12	55,000		870	

* Does not include probable reserves.

The little sampling that was done indicates that the deposits contain pyrite ranging from about 1% up to, locally, more than 20% and averaging perhaps 5%, and a little quartz, probably less than 1%.

The iron ore, consisting of magnetite altered in part to hematite, occurs as vertical or steeply dipping bodies probably fissure-fillings in a garnet rock which has originated by metasomatism of limestone. The garnet rock rests probably unconformably on altered basalt, and in turn is unconformably overlain by a later basalt. The area is intersected by numerous faults, several of which appear as gossanous shear zones. Both the magnetite-hematite and the garnet rock are intersected locally by numerous small irregular fractures, filled or partly filled with pyrite and quartz. Diorite mapped at several localities south and west-south-west of the deposits may be the source of the mineralization in the area.

INTRODUCTION

A preliminary investigation of iron ore deposits near Cape Lambert was made during 1955 by A. Rahdon who mapped the area by plane table and alidade and dug several exploratory costeans. The present investigation was initiated by the Mines Division, Department of Lands, Surveys and Mines, Territory of Papua and New Guinea, who were responsible for the drilling. Geological supervision in the early part of the work was provided by J. E. Thompson, Senior Resident Geologist, Port Moresby, and for the remainder by the writer. In the initial stages of the investigation two drilling plants were used. One, a Hands-England plant, was too light for the job and work with it had to be discontinued. The other plant, a Mindril, operated satisfactorily. Because of a shortage of equipment, mainly diamond bits, casing shoe bits, and small-diameter casing, it was not possible to test the deposits thoroughly, but sufficient information was gained to make a reasonably reliable estimate of reserves.

The drilling party consisted of a driller, a native assistant driller, and four native labourers recruited locally. The geological party consisted of a geologist, a native geological assistant, and ten native labourers employed in cutting scrub, digging costeans and assisting in plane tabling. The natives quickly learned their tasks and their work was effective.

The iron deposits occur within the boundaries of four plantations - Rangarere, Langinoa, Cairngorm and Doilene (Plate 1). Langinoa Plantation is owned by Mr. F. Conroy, the others by Mr. J. Maclean. The individual deposits and the localities at which they occur are distinguished in this report by the appropriate plantation names. The Rangarere deposit and the Doilene deposit occur entirely within Rangarere and Doilene Plantations, respectively. The northern portion of the "Langinoa Deposit" lies within the Langinoa Plantation; the southern part, which includes all the indicated reserves estimated for this deposit, lies within Rangarere Plantation. Practically all of the "Cairngorm Deposit" occur within the boundaries of Cairngorm Plantation; a minor eroded western extension, which has not been included in the estimate of reserves, lies within the Rangarere Plantation.

SITUATION AND ACCESS

The area investigated is situated in Gazelle Peninsula, North Bainings district, New Britain, approximately 3 miles east of Cape Lambert and 60 miles west of Rabaul. It is shown in the locality map included in Plate 1. Access is by sea from Rabaul, using the small motor vessels that service the plantations along the coast. Because of coral reefs fringing the shore, and sand banks near the mouths of the Rangarere and Bulmaka Rivers, the vessels anchor several hundred feet off-shore. This results in some inconvenience in loading and off-loading heavy equipment. Deep anchorage is available during both seasons against Cape Wanawanur on the western side of Gareer Bay.

PHYSIOGRAPHY

The area investigated comprises a small coastal flat and foothills that rise southwards towards mountainous country (Plate 1). The iron deposits are situated on spurs that extend down from the foothills and access to them is relatively easy.

The climate is monsoonal, and the area has an annual rainfall of 150 inches, of which 100 inches fall during the wet season from November to April. Abundant streams flow down from the mountains. The country is heavily timbered except on the coastal flats and lower spurs of the foothills, where it has been cleared for planting.

GEOLOGY

Outcrops are few and geology is obscured by deep tropical weathering. Most of the information given here has been obtained by costeaning and drilling.

STRATIGRAPHY

The following succession is observed in the area:

Basalt (Upper Basalt)

Unconformity

Crystalline limestone, largely altered to a garnet rock

Probable unconformity

Basalt (Lower Basalt)

In places core fragments recovered from drill holes immediately above the garnet rock or crystalline limestone resemble calcareous shale. They are probably in part weathered Upper Basalt and in part a fossil soil horizon between the Upper Basalt and the garnet rock or crystalline limestone.

Lower Basalt

The Lower Basalt is dense, and blue-black to grey in colour. It includes holocrystalline, microcrystalline and porphyritic flows. Tuffaceous fragments are present in stream gravels. In some localities the Lower Basalt does not appear to be greatly altered. Elsewhere it is silicified and hornfelsed and intersected by fine quartz stringers. Its joint planes are generally thinly coated with pyrite. Mineragraphic and spectrographic reports on sludge samples from a drill hole in Lower Basalt are given in Appendix 2. Where intersected in some boreholes the Lower Basalt is silicified, hornfelsed and extremely hard, resulting in slow drilling and excessive wear of bits. In other holes a soft kaolinized zone is encountered and this passes gradually, through a depth ranging from a few inches to several feet, into massive basalt not obviously silicified or otherwise noticeably altered. The kaolinized basalt contributes very little to the sludge or cuttings recovered from the borehole. The kaolin is carried away in suspension in the returning water and practically all that is recovered of the basalt is a small proportion of iron oxide coated with white kaolinic material. Commonly in a bore hole that is not cased the sludge consists of grains of weathered garnet rock washed from the sides of the hole. This has to be inspected carefully to detect the presence of kaolinized particles from Lower Basalt. In some boreholes the actual depth to the boundary between garnet rock and Lower Basalt could be several feet less than the depth recorded in the bore log.

The distribution of the Lower Basalt, as far as has been observed, is shown in Plate 1. It forms at least the upper portions of the high ridges 1 mile and 2 miles south of the Rangarere area and occurs along the Bulmaka River at least as far as ½ mile south of the road to Nimke village. Its thickness must be at least several hundred feet and may exceed 2,000 feet. Thin section descriptions of Lower Basalt are given in Appendix 1.

Crystalline Limestone and Garnet Rock

Dense, white, medium-grained crystalline limestone outcrops on Langinoa and Cairngorm Plantations. Borehole R8 (Plate 3) shows that it rests directly on the Lower Basalt. Masses of limestone intersected in boreholes in the Cairngorm area are irregularly distributed in garnet rock, and it is clear that the garnet rock has been derived metasomatically from the limestone. Garnet rock forms outcrops on Rangarere, Langinoa, and Doilene and has been intersected in boreholes in each of the four areas investigated. In a small outcrop of limestone near costean 8 in the Langinoa area garnet rock replaces limestone along joints or tension fractures. The garnet rock consists essentially of andradite garnet (Appendix 1), mainly fine to medium grained. At several localities in the Langinoa area the garnets are coarse-grained, commonly up to ¼ inch diameter and occasionally up to ¾ inch. In some places the garnet rock is compact and dense; elsewhere it contains scattered small cavities around which the enclosing garnets have well developed crystal fraces. Where fresh the garnet rock is hard and brittle, and yellowish to dull orange in colour. Near the surface it is weathered to a reddish and yellowish-brown clay in which the original granular texture is generally recognisable. This relict texture provides a means of distinguishing weathered garnet rock from weathered Upper Basalt. Cuttings of fresh garnet rock from boreholes examined under a hand lens are composed of angular, highly refractive grains, honey-yellow to yellow-green in colour. In many localities the garnet rock contains micaceous hematite which appears to be a primary constituent, viz. it appears to have crystallized contemporaneously with the garnets. In the vicinity of faults the garnet rock contains small irregular open fractures filled with massive pyrite.

Fresh garnet rock drills fairly slowly under a fair hydraulic pressure but does not cause excessive wear of bits. Partly weathered garnet rock drills rapidly like poorly consolidated sandstone, and after it is passed through, in an un-cased hole, continues to contribute large quantities of granular material to the returning water.

Tabular bodies of iron ore, vertical or dipping at very steep angles, occur within the garnet rock. These are described later.

The limestone and garnet rock are unconformably overlain by basalt (Upper Basalt). Prior to the extrusion of this basalt the surface of the garnet rock was deeply eroded. The maximum estimated thickness remaining is approximately 160 feet (Plate 5, section H-H5).

Upper Basalt

Near the surface the Upper Basalt is weathered to a deep red structureless and textureless clay. Where exposed in costeans it is strongly weathered but otherwise is not appreciably altered. In costeans B, 9 and 5, on

Langinoa and in costean 1M on Cairngorm it consists of an apparently homogeneous weathered flow. In costeans A and B on Doilene (Plate 7) it consists of weathered flow-breccia and flow. The texture ranges from holocrystalline in the body of the flow to aphanitic near the contact with underlying garnet rock. In the localities tested the basalt occurs as thin remnants surrounding topographic highs of the pre-basalt surface, where crystalline limestone, garnet rock and iron ore form outcrops.

At some distance from these outcrops the Upper Basalt has a greater thickness, e.g. at the site of borehole 10 in the Doilene area (Plate 6), it has a thickness of at least 55 feet. At the bottom of this hole the basalt was fresh and hard and was mistaken by the driller for Lower Basalt. In all other holes it was very weathered and was drilled rapidly. For several feet below its upper surface no basalt fragments were recovered in the drill cuttings and its presence could be recognised only by occasional particles of accessory iron ore minerals coated by white kaolinic material.

STRUCTURE

Boundary Between Garnet Rock and Lower Basalt

The strike and dip of the boundary between the garnet rock and the Lower Basalt has been estimated in part from results of drilling and in part from geological surface mapping. In the areas investigated the boundary has the following strikes and dips:

Area	Strike (Magnetic)	Dip
Cairngorm	N34°W	11°SW
Rangarere	N7° E	15°W
Doilene	N21°E	32°ESE

The strike and dip appear to be uniform within each area and the observed variations could suggest a synclinal structure (Plate 2), the axis of which trends approximately north and is situated mid-way between the Rangarere and Doilene areas. The Cairngorm area could be situated on an easterly flexure of the eastern limb of the supposed syncline. However, no evidence has been found of folding of the thick Lower Basalt, such as slaty cleavage, and it is unlikely that the variations in the strike and dip of the boundary have a tectonic origin. Probably the limestone that was the parent rock of the garnet rock was deposited on a surface of some relief.

Faulting

The area in general is intersected by two series of normal faults, of which one trends approximately north and is downthrown to the west, and the other trends approximately north-west and is downthrown to the north-east. Some of these faults (Plates 3, 4, 5, 6) are definite, others are inferred.

The Langinoa and Cairngorm areas are cut by gossanous faults or shear zones that trend N15°E (magnetic) and dip steeply to the west (Plates 4 and 5), and apparently by a normal fault that trends N42°W (magnetic) and dips approximately 70°NE. The fault along section line C-C1 is partly exposed in costeans A and B (Langinoa) where it appears as a gossanous shear zone. The fault 180 feet east of it is inferred partly from the occurrence of limonitic gossan and sheared garnet rock in borehole R5, and partly from the high reduced level of the boundary between garnet rock and Lower Basalt in R5 relative to the boundary in Plantation Creek and in borehole R19. Its strike is not known but the assumption that it is parallel to the known fault 180 ft. west of it accords with the structural interpretation of the area. A gossanous shear zone is exposed in costean 8 (Cairngorm) where a minor non-mineralized fault is also exposed. The fault that trends NW in the Langinoa area is inferred and its position is approximate. The R.L. of the boundary between the limestone and the Lower Basalt in borehole 8 suggests that the borehole is within a down-faulted block. The strike and dip of the supposed fault are assumed to be parallel to a platy jointing in the large outcrop of limestone east of borehole 8.

In the Rangarere area a gossanous shear-zone exposed in costean N and outcropping at localities 20 feet and 40 feet east of the costean strikes N82°W (magnetic) and dips steeply to the north. In hole R20 the boundary between the garnet rock and the Lower Basalt is at a lower reduced level than the projection of the boundary intersected in boreholes R2 and R4 and hence the shear zone has been interpreted as a normal fault, or a fault with apparent vertical displacement equivalent to a normal fault with downthrow to the north. No direct evidence has been obtained of other faulting in the Rangarere area. The boundary between garnet rock and Lower Basalt, projected eastward, is at a lower level than in the Langinoa area. This suggests that one or more additional northerly-trending faults with downthrow to the west, may occur between Rangarere and Langinoa.

In the Doilene area (Plate 6) the distribution of the iron ore bodies and the position of the boundary between garnet rock and Lower Basalt indicate a series of faults that strike N20°E (magnetic) and are downthrown to the west. They have not been exposed and must be regarded as inferred faults. The main component of the displacement is horizontal, the eastern side apparently moving northwards. These supposed faults resemble, in their displacement, the northerly trending faults of Langinoa and Cairngorm but differ from them apparently in lack of any appreciable mineralization. A gosanous shear zone is exposed in costean E. It strikes approximately N36°W (magnetic). The adjacent outcrop of iron ore is cut by shear fractures that trend N73°W (magnetic) and apparently has been dragged westwards, indicating relative south-eastward movement of the north-eastern side of the shear zone. Nothing is known of the possible vertical displacement.

MINERALIZATION

General

Four stages of mineralization are suggested in the areas investigated. They are represented by the following:

1. Metasomatism of limestone to garnet rock. Possibly quartz stringers in Lower Basalt.

2. Magnetite in garnet rock.
3. Pyrite (and cellular limonite) and quartz in shear zones in garnet rock. Quartz and pyrite in fractured garnet rock and magnetite. Alteration of magnetite to hematite. Probably quartz stringers in Lower Basalt, and pyrite coating joints of Lower Basalt.
4. Quartz veins in Upper Basalt.

Stage 1. Silica and iron were introduced, and possibly some manganese. The Lower Basalt was locally silicified and hornfelsed and the limestone metasomatized to garnet rock. Excess iron appears in the garnet rock as small masses of micaceous hematite.

Stage 2. Iron was introduced as magnetite into garnet rock. The contact with garnet rock is commonly sharp and numerous veins with sharply defined walls branch off from the main body of the magnetite into the garnet rock. This suggests that the magnetite is essentially a fissure filling, although some local replacement of garnet rock appears to have taken place.

Stage 3. Shear zones that trend N36°W (magnetic) at Doilene, N82°W (magnetic) at Rangarere and N15°E (magnetic) at Cairngorm are occupied by pyrite and by cellular and massive limonite that represent weathered pyrite and possibly other sulphides. Quartz as well as sulphide has been introduced into the sheared garnet rock, particularly at Langinoa. In the vicinity of the shear zones minor fractures in magnetite and garnet rock are filled with varying proportions of massive quartz and pyrite or are coated with euhedral quartz and pyrite. The joint planes of the Lower Basalt are coated with thin layers of pyrite and pyrite appears locally to be disseminated in the basalt. Mineragraphic and spectrographic reports on sulphides in sludge from a drill hole in Lower Basalt are given in Appendix 2. In places the Lower Basalt contains narrow veins or stringers of white quartz. In the vicinity of the shear zones the magnetite is partly or wholly altered to hematite. This is not readily recognised in hand specimens, except in the case of the Langinoa "magnetite" which occurs within or adjacent to a shear zone throughout its length and appears to be completely altered to hematite.

Stage 4. Narrow irregular veins of grey or nearly colourless quartz occur in Upper Basalt in the Doilene area. They contain no sulphide minerals.

Sulphide Mineralization

The sulphide introduced into the area appears to be predominantly pyrite, which occurs within the gossanous shear zones and in minor fractures in garnet rock and magnetite. In the Langinoa area a small outcrop of fractured garnet rock containing oxidized copper minerals, mainly malachite occurs at the site of costean 8. A sample from a depth of 5 feet contains malachite and a little chalcopyrite, covellite and chalcocite (Appendix 2). A 30 cwt. parcel shipped to Port Kembla assayed 9.4 per cent copper. The garnet rock is little weathered at a depth of five or six feet from the surface and shows no sign, in hand specimen, of hydrothermal alteration. It is intersected by two sets of vertical platy joints that strike, respectively, N75°E (magnetic) and N30°W, and by less well-marked joints that trend N65°W, and dip 70 degrees northwards. The copper sulphides, including presumably the primary copper minerals, were apparently deposited in joint planes. The body of cupriferous garnet rock is small. At a depth of 4 feet it occupies an area of about 4 feet by 4 feet. The boundaries seem to be approximately parallel to the vertical platy jointing. At a depth of 6 feet its dimensions in plan are smaller. Below the near-surface zone of enrichment in oxidized minerals the copper content of the garnet rock must be small. Specimen RBO from the copper-bearing garnet rock is described in Appendix 2.

Near the surface, where the copper has been removed by leaching the small limonitic patches in the weathered garnet rock are coloured deep red. Limonitic gossan in the shear zone exposed in costean A is similarly coloured and it was thought that this might be an indication of the presence of copper sulphides prior to weathering and leaching. Borehole R19 put down to test this possibility passed through leached gossan down to 60 feet, the maximum depth that the disabled Hands-England plant was able to drill. A 2-inch length of core recovered from between 53 feet and 60 feet contained bright red limonite and a little pyrite. Spectrographic analysis (Appendix 2) shows that copper is present. Borehole R20 was put down to test the shear zone at depth but had to be abandoned before the shear zone was entered. Spectrographic analysis shows that copper sulphide occurs together with pyrite in the Lower Basalt (Appendix 2). The age relationship between the pyrite and the copper sulphide is not known.

The source of the mineralizing solutions in the area may be an intrusive mass of diorite. Fisher (1942) mapped diorite a mile south and 1¼ to 2 miles west-south-west of the Rangarere area. Diorite forms a small outcrop in the east bank of the Bulmaka River, 1,000 feet south of the road to Nimke village. A specimen, No. 634, from this locality is described in Appendix 1.

OCCURRENCE AND DISTRIBUTION OF IRON ORE DEPOSITS

GENERAL

Small outcrops of magnetite in part altered to hematite occur on Cairngorm Plantation and larger ones on Doilene Plantation. Detrital magnetite-hematite is widely distributed within the areas investigated and at some places has dimensions of several feet. After a little costeaning had been done it became clear that the detrital iron ore has reached its present position partly through distribution on the present-day surface, partly through distribution on the surface that had developed prior to the extrusion of the Upper Basalt and partly through rafting in the Upper Basalt flow. The present-day distribution of the detrital iron ore is not closely related to the positions of the parent bodies. Its broad distribution suggested that it was derived from flat-lying tabular bodies, and the initial drilling in the Rangarere and Langinoa areas was intended to test this possibility.

In the areas investigated four apparently distinct bodies of iron ore occur as vertical or very steeply dipping tabular bodies in garnet rock. In the Cairngorm and Doilene areas, where the deposits are exposed in costeans, veins are seen branching off from the main bodies. Small thickness of iron ore encountered at other localities in vertical drill holes near the main deposits suggest the presence of similar narrow veins. In nearly all exposures the contact of garnet rock with dense, high-grade iron ore is sharp. This, and the occurrence of the branchveins suggests that the deposits originated as fissure fillings. On the other hand in costean D in the Doilene area high-grade iron ore grades on its western side into magnetite-hematite containing a small proportion of disseminated, granular garnet rock, suggesting incomplete replacement of garnet rock by magnetite. Probably the deposits are essentially fissure fillings, and minor local replacement of the walls has taken place.

In the vicinity of faults the iron ore is fractured and mildly brecciated. Near the northerly-trending gossanous faults or shears on Langinoa and Cairngorm Plantation cavities are filled with massive pyrite and probably some of the former magnetite has been replaced by pyrite. In these gossanous shear zones particularly in the Langinoa area, the iron ore appears to consist of massive hematite formed by alteration of magnetite. Near a series of supposed northerly-trending faults in the Doilene area some cavities are filled with massive quartz and pyrite and others are lined with euhedral quartz or pyrite.

The apparent strikes of the magnetite hematite bodies are:

Locality	Strike (magnetic)
Cairngorm	N89°W
Langinoa	N15°E
Rangarere	Not exposed; probably approximately parallel to Cairngorm magnetite.

These apparently diverse strikes may conform to a systematic structural pattern. If it be supposed as discussed above under Structural Geology that the attitudes of the boundary between garnet rock and Lower Basalt indicate a synclinal structure between Rangarere and Doilene (Plate 2) with an easterly flexure of the boundary southwards from Langinoa to Cairngorm, the Doilene and Langinoa magnetite hematite bodies are symmetrically disposed on either side of the axis of the syncline, and the Cairngorm and Langinoa bodies are symmetrical with respect to the easterly flexure.

The outcrops of iron ore and the detritus derived from them have been found only in areas underlain by garnet rock, and it is concluded that the deposits terminate in depth at the boundary between garnet rock and Lower Basalt.

RANGARERE AREA

General

The Rangarere area is shown in plan and section in Plate 3. Masses of iron ore occur at the surface near the residence of Mr. J. Maclean at the crest of a spur that trends northwards. Smaller detrital fragments are scattered on the slopes of the spur up to about 200 feet to the north and 300 feet to the south-east. When diamond-drilling was started difficulties with equipment precluded the drilling of inclined holes and two vertical holes, R2 and R4, were put down to test the possibility that the iron ore occurred as a flat-lying, tabular body. After the drilling plant (Mindrill) had put down two additional vertical holes in the Langinoa area it was moved back to Rangarere for the purpose of experimental inclined drilling. at the foot of the spur (holes R17 and R20). Here the difficulties of drilling leached country well above ground-water level would be minimized. Hole R17 was intended to define the position of the boundary between garnet rock and Lower Basalt and to test the possibility of sulphide mineralization in the area. Hole R20 was intended to intersect a gossanous shear-zone outcropping 120 feet north of Mr. J. Maclean's residence.

Geology

All the boreholes passed through Upper Basalt. The garnet rock is deeply weathered, and contains an appreciable proportion of pyrite and of limonite, presumably derived partly by weathering of pyrite and partly by weathering of garnet rock. Specimen RB1 from borehole R2 is described in Appendix 2. Near its contact with the garnet rock the Lower Basalt is soft and clayey. When first encountered in boreholes this was thought to be fault gauge. However it has been found in nearly all the boreholes that entered Lower Basalt and is now considered to be a result of weathering of the basalt. Specimen RB2 of Lower Basalt from borehole R2 is described in Appendix 1.

The strike and dip of the boundary between garnet rock and Lower Basalt, determined from intersections in holes R2, R4 and R17 is plotted in Plate 3. The two areas of Lower Basalt shown in Plate 3 near the eastern ends of V-VI and Y-YI were not observed in the field. They are plotted approximately from sections V-VI and Y-YI. The Lower Basalt at these localities is probably covered by surface detritus and clay, and possibly by Upper Basalt. Shaft 6 which went down 15 feet appeared to be entirely in weathered Upper Basalt.

Costean M shown in section on Plate 3 failed to expose the gossanous shear zone that outcrops approximately 100 feet to the east. At the costean site the shear zone is covered by Upper Basalt. The garnet rock exposed in the costean contains numerous small irregular fractures filled with pyrite. They may be tension fractures developed in the southern wall of the shear zone.

Iron Ore

The iron ore body at Rangarere was not exposed, either by costeaning or drilling and its position and width are not known. The two vertical boreholes R2 and R4 failed to intersect it, and probably it is, like the deposits elsewhere in the area, a narrow, vertical or steeply-dipping body. The distribution of detrital iron ore at the surface suggests that the parent body trends approximately easterly, like the Cairngorm deposit. If so, it might be expected to occur approximately in the position of section V-VI. The possible reserves in such an ore body, assuming a width of 4 feet, and dimensions shown in section V-VI amount to 18,000 tons. Although the estimate is based on insufficient data it indicates the maximum reserves which could be expected to occur in the Rangarere area.

LANGINOA AREA

General

Initially two vertical holes R5 and R8 (Plate 4) were drilled in the Langinoa area (Plate 4) by the Mindril plant and one hole, R1, by the Hands-England plant. Borehole R5 was intended to test the possible occurrence of a flat-lying, tabular body of iron ore, R8 to obtain geological information below the outcrop of crystalline limestone and R1 to find the position of the boundary between garnet rock and Lower Basalt. Later, after the Hands-England plant had developed a mechanical defect which precluded deep drilling, except under very favourable conditions, several shallow holes were put down, viz. Nos. R13, R14, R15, R16 and R18, in an attempt to find the source of gossanous detritus which appeared to be slightly cupriferous. Costean A exposed a gossanous shear-zone containing a band of iron ore and hole R19 was put down by the Hands-England plant with the intention of testing the gossan for copper at depth. Later, after costean B had exposed the iron ore and the western edge of the gossan, thus defining the position of the shear zone, an inclined hole R21 was put down with the Mindril plant to sample the iron ore and gossan at depth. Because of lack of casing shoe bits and of suitable casing this hole failed to reach its target.

Geology

Drill holes R1 and R5 passed through garnet rock into Lower Basalt and R8 through crystalline limestone into Lower Basalt. Borehole R5 passed through a gossanous shear zone down to approximately 70 feet. This is interpreted as a fault parallel to the exposed gossanous shear 180 feet to the west. The section between R5 and R1 gives an apparent dip in this direction for the boundary between garnet rock and Lower Basalt approximately the same as the dip estimated in the Rangarere area.

The dip determined from the intersections in R5 and R8 is less than would be expected to account for the apparent dip between hole R5 and the Lower Basalt exposed in Plantation Creek. It is probable that borehole R8 is within a down-faulted block. The strike and dip of the probable fault are suggested by a platy jointing in the large outcrop of crystalline limestone, which strikes N40°W (magnetic) and dips 75°NE. A vertical platy jointing in garnet rock in costean 8 strikes approximately N30°W. The limestone core from borehole R8 is cut by fractures or joints that dip (visual estimate) approximately 70 degrees. These probably correlate with the platy jointing in the limestone outcrop. It has been assumed that a normal fault occurs between boreholes R8 and R5, striking and dipping approximately parallel to the platy jointing in the outcrop of limestone. The strike and dip of the boundary between garnet rock and Lower Basalt has been assumed to be approximately the same as in the Rangarere area, and this gives a satisfactory interpretation of the positions of the boundary in the boreholes and in Plantation Creek.

The areas of Lower Basalt shown on Plate 4 at the northern ends of section lines E-E1-E2 and D-D1 were not mapped in the field, but are plotted from the approximate outcrop-positions indicated in the sections.

"Granodiorite boulders" shown by Rahdon (1956) approximately 250 feet north-north-west of boreholes R5 may represent Lower Basalt.

A specimen RB4 from an outcrop of Lower Basalt near Plantation Creek approximately 540 feet west of costean A is described in Appendix 1.

In the small outcrop of crystalline limestone on the eastern side of costean 8 joint-planes or fractures $\frac{1}{4}$ inch to $\frac{1}{2}$ inch wide, striking N5°E (magnetic) and dipping 35°E are filled with garnets. This indicates that the garnet rock originated by metasomatism of the limestone, and in this particular locality the solutions travelled along joint planes or fractures.

Iron Ore

Deposit. Iron ore is exposed in costeans A and B and at the bottom of costean 9 where it is probably not in situ. Its width is approximately 3 feet. In costean A it consists mainly of massive haematite derived by alteration of magnetite and contains much limonite, which probably has resulted from weathering of pyrite. In costean B the iron ore appears to consist of dense magnetite not appreciably altered. It is broken by numerous irregular fractures that contain both pyrite and cellular limonite. The probable extent of the Langinoa iron ore deposit is shown in plan and section in Plate 4 (Section E-E1).

Reserves. The dimensions of the deposit and an estimate of reserves are given in Table 1. The tonnage estimated between costeans A and 9 can be regarded as probable reserves. The remainder is possible reserves.

Table 1. Dimensions of Langinoa Iron Ore Deposit and Estimated Reserves

Portion of Deposit	Width	Length	Av.Vert. Dimens.	Volume	Reserves (Tons*)	
	Ft.	Ft.	Ft.	Cu.yd.	Total	Per vert ft.
Probable Reserves						
Between costeans A and 9	3	400	78	3,466 (say 3,500)	10,400 (say 10,000)	130
Possible Reserves (not including probable reserves)						
South of Costean A	3	160	29	512 (say 500)	1,554 (say 1,500)	50
North of Costean 9	3	600	50	3,333 (say 3,000)	10,044 (say 10,000)	200
Total Possible Reserves (not including Probable Reserves)	3			3,845 (say 4,000)	11,588 (say 12,000)	250

* Based on arbitrary estimate of 9 cu. ft. per ton.

Grade. The Langinoa iron ore occurs within a gossanous shear-zone. At costean A it contains much pyrite and limonite. At costean B it contains large masses of pyrite and large limonitic cavities. A high content of pyrite, at least 5%, may be expected throughout.

CAIRNGORM AREA

General

The Cairngorm area is shown in plan and section in Plate 5. Access was difficult for the Mindril plant and it was decided to use only the light Hands-England equipment to test the area. However this plant could drill only vertical holes and those to a maximum depth of about 80 feet. In addition repeated mechanical trouble was encountered, and because of this the depths of holes were kept to a minimum. The contact between garnet rock and Lower Basalt was not reached in any of the boreholes and its approximate position had to be assumed by mapping detrital Lower Basalt in the eastern part of the area. The iron ore deposit was exposed in costeans 12 and 8 and sampled in costean 8. Boreholes R3 and R6 were put down to test the possible occurrence of a flatly-dipping tabular body of iron ore. Hole R7 was intended to sample the deposit. It cored 4 inches of iron ore between 34' and 41' and 6 inches between 41'8" and 46'3" but this is believed to represent veins rising from the main body. Boreholes 9, 10 and 11 were intended to ascertain very approximately the width of the deposit.

Geology

All the boreholes (Plate 5) passed through weathered Upper Basalt and entered crystalline limestone, garnet rock, or garnet rock containing patches of incompletely metasomatized limestone. The apparent dip of the boundary between garnet rock (or crystalline limestone) and Lower Basalt along section H-H5 is given approximately by the detrital Lower Basalt mapped 180 feet east of costean 8 and the outcrop of Lower Basalt in Plantation Creek. It is assumed that the dip at right angles to H-H5 is the same as in the Langinoa area.

In the mid portion of costean 8 the iron ore has been displaced approximately 10 feet by a minor non-mineralized fault. In the small pit near the southern end of the costean a gossanous shear zone is exposed. This trends approximately north and is interpreted as a fault parallel to the gossanous shear zones of the Langinoa area. It is assumed that the inferred faults of the Langinoa area extend south and south-east, respectively, to intersect section H-H5.

Iron Ore

Deposit. The iron ore deposit is shown in plan and section (section H-H5) in Plate 5. Evidence for its extension west-north-west from costean 12 is the occurrence of magnetite in borehole R3, the detrital iron ore mapped 400 to 500 feet west-north-west of R3 and the outcrop of iron ore in Plantation Creek 100 feet east-south-east of H.

In costean 8 iron ore is exposed in the western face. North of it is a zone 7 feet wide which appears to consist of a stockwork of pockets and veins of magnetite in garnet rock. On the eastern face of the costean the iron ore band occurs 10 feet to the north, having been displaced by a minor fault. A joint in the iron ore which strikes parallel to this fault dips 70°E and is slickensided horizontally.

The iron ore in costean 8 is mainly massive but contains numerous small cavities which could have originated through weathering of sulphides. It was sampled across the face (sample No. 612). The small pit at the southern end of costean 8 exposed a gossanous shear-zone comprising cellular and massive limonite, brecciated magnetite-hematite containing much massive pyrite and limonitic cavities resulting from weathering of pyrite, and sheared and brecciated garnet rock.

In costean 12 the iron ore exposed is massive like that in costean 8 but is intersected by a band 2 feet wide of brecciated garnet rock and magnetite-hematite containing a large proportion of pyrite and numerous cavities resulting apparently from the leaching of pyrite. A small mass of magnetite-hematite exposed in the bottom of the costean at the south-western end may be detrital or it may be a vein branching off from the main body.

Reserves. The dimensions of the deposit and an estimate of reserves are given in Table 2.

Table 2. Dimensions of Cairngorm Iron Ore Deposit and Estimated Reserves

Portion of Deposit	Width	Length	Av. Vert. Dimens.	Volume	Reserves* (Tons) Tons	
	Ft.	Ft.	Ft.	Cu. yd.	Total	Per vert foot.
Probable Reserves						
Between Costeans 12 and 8	6	180	134	5,360 say 5,000	16,107 say 16,000	120
Possible Reserves (not including probable reserves)						
West of Costean 12	6	700	84	13,066 say 13,000	39,375 say 39,000	470
East of Costean 8	6	160	28	996 say 1,000	3,000	100
Total Possible Reserves (Not including Probable Reserves)	6			14,062 say 14,000	42,375 say 42,000	570

* Based on arbitrary estimate of 9 cu. ft. per ton.

The Cairngorm deposit has not been investigated west of costean 12 and east of costean 8. Tonnages estimated for these portions must be regarded as "possible".

Grade. In the small pit at the southern end of Costean 8 the iron ore is brecciated, the cavities are filled with pyrite, and pyrite appears to have replaced some of the iron ore. The exposed iron ore probably contains up to 50% pyrite. In costean 8 small cavities probably represent leached pyrite but in the aggregate they form only a very small proportion of the bulk of the iron ore. In costean 12 a 2-foot band of pyritic brecciated garnet rock occurs within the deposit, and minor irregular fractures in the iron ore contain massive pyrite. It is likely that the iron ore between the two costeans, estimated in Table 3 as probable ore, contains an average of about 5 per cent pyrite. No gossanous faults are known to occur within the supposed westward extension of the orebody, and the possible reserves may contain less pyrite.

DOILENE AREA

General

The Doilene area is shown in Plates 6 and 7. Costeans A and B, started near large masses of iron ore not in situ, exposed former outcrops of iron ore beneath Upper Basalt. Large masses of iron ore at costeans H and I are enclosed in Upper Basalt and apparently have been transported in it. Costeans C, D and DD established the position of a band of iron ore in situ. Because of a more satisfactory supply of diamond bits drilling at Doilene was more effective than it had been in the other areas. Even so lack of a casing shoe bit necessitated abandonment of borehole No. 9 before the target depth was reached.

The deposit appears to have been separated by parallel faults into eight separate bodies (Plate 6). For convenience they will be identified by alphabetical letters corresponding to those of the sections drawn along them, viz. the B body, C body and so on.

Drill hole No. 6 was put down to ascertain the approximate position of the fault between the B body of iron ore and the iron ore exposed in costeans A and B. Drill holes 8 and 9 were intended to sample the iron ore. Hole No. 8 failed because it entered a pre-basalt gully between costeans D and DD (Plate 7, section B-B1).

Geology

With the exception of some relatively small outcrops of iron ore and garnet rock the area is covered by Upper Basalt, which continues down to a depth of 77 feet at borehole No. 8 and at least to 55 feet at borehole No. 10 In costeans A and B (Plate 7) the Upper Basalt consists of holocrystalline blocks of flow breccia up to 5 feet in dimensions enclosed in aphanitic basalt. In costean B the basalt is cut by parallel shear-joints that strike N30°E (Magnetic) and dip 70° SE. A slight slickensiding on one of these joints pitches 20°NE. In costean A a similar shear-joint strikes approximately north and dips 65°E. Other parallel joint planes dip very steeply. In both costeans the basalt contains a few small, irregular quartz veins up to 2 inches thick.

The Lower Basalt is in part silicified and hornfelsed and intersected by fine stringers of quartz. Its joint planes are thinly coated with pyrite. In some localities, e.g. boreholes 1 and 2 the Lower Basalt does not appear in hand specimen to be greatly altered. It is dark blue-grey and porphyritic in felspar, which has dimensions up to 3 mm.

The Lower Basalt shown in plan in Plate 6 was not mapped in the field, but has been interpreted from its positions in sections X-X1 and A-A1. A detrital fragment, Specimen RB3 of Lower Basalt picked up about 80 feet south of L1 is described in Appendix 1.

The garnet rock at Doilene appears to have been subjected to closer fracturing or crackling than in the other areas investigated. The small fractures, apparently irregular and of the order of ½ inch or less in width and a few inches in length are filled with massive quartz or coated with euhedral quartz, which appears plentifully in cuttings from the drill holes. Limonite fragments also appear in the cuttings and they suggest that the fractures may formerly have contained pyrite as well as quartz.

It has been assumed that the strike and dip of the boundary between garnet rock and Lower Basalt are constant throughout the area and, apart from some difficulty concerning the position of the boundary in some boreholes, no inconsistencies have arisen in the interpretation of the drilling results. The strike and dip are plotted on Plate 6 using the reduced levels at which the boundary is intersected in boreholes 6 and 7 and 3 and 4. The difficulty in deciding the position of the boundary between garnet rock and Lower Basalt in drill holes is explained earlier in the section dealing with Stratigraphy.

It is quite likely that, as a result, small errors have entered into the estimates of dip and of vertical displacement on faults. If so, they do not materially affect the interpretation of the area, and are too small to bring about any appreciable error in the estimate of reserves.

Faulting

In the Doilene area the distribution of the orebodies and the positions of the boundary between skarn and Lower Basalt indicate a series of vertical or steeply-dipping faults (Plate 6) that trend approximately N20°E (magnetic). The main component of the displacement is horizontal and ranges from 34 feet to 560 feet, the eastern side apparently moving northwards. The western side of each fault is downthrown 15 to 30 feet. In strike and direction of downthrow these inferred faults resemble the northerly-trending faults in the Langinoa and Cairngorm areas, but are not accompanied by noticeable shearing and sulphide mineralization.

A strong gossanous shear trending N36°W (magnetic) is exposed in costean E adjacent to ore body H. The deposit has been disrupted by shear-fractures that trend N73°W (magnetic) and has been dragged westward adjacent to the shear, thus indicating apparent south-eastward displacement of the north-eastern side. A large mass of gossan between costeans H and I is not in situ. Like the adjacent masses of iron ore it has been transported in the upper basalt. Probably it represents the gossanous shear exposed in costean E and on this assumption the gossanous shear is older than the faults that trend N20°E (magnetic). The gossan shown 50 feet west of magnetite body I may represent an extension of the shear zone of costean E.

Iron Ore

The Deposit. The iron ore deposit maintains a fairly uniform width. At costean C and near its north-eastern wall in costean D it is dense, uniform and high grade. Its walls are sharply defined, and veins 15 to 18 inches wide branch out from it (Plate 7). These characteristics suggest that the lode originated as a fissure filling. In costean D dense, uniform magnetite, 8 feet wide, gives place on its south-western side to a zone 7 feet wide of magnetite containing a small proportion of disseminated granular garnet rock. This suggests incomplete replacement of garnet rock by magnetite. Probably the deposit is essentially a fissure filling, and minor replacement of the walls has taken place.

In the vicinity of the faults that trend N20°E (magnetic) the iron ore is fractured or slightly brecciated. It contains irregular narrow cavities up to about 5 inches long and ½ inch wide filled with white quartz or encrusted with clear, euhedral quartz, and empty cavities which could formerly have contained pyrite. The magnetite-hematite cored in borehole 9 is brecciated in part, and contains a large proportion of pyrite. At some distance from the faults, e.g. in costeans D and DD comparatively few fractures and cavities were seen, but throughout the remainder of the Doilene area nearly all the exposed iron ore, detrital or in situ, contains cavities, many of them quartz-filled.

The orebodies are shown in plan and section in Plate 6. The position of the boundary between the garnet rock and the lower basalt beneath bodies B, C, E and F was obtained from boreholes 7, 5, 2, and 3 respectively. For bodies D and G it was estimated by assuming that the fault at the northern end of each body has a vertical component of displacement of the same order of magnitude as on the parallel faults whose displacement is known from the results of drilling. The position of the boundary below body H is not known. Assuming a proportional vertical displacement on the fault at the northern end the probable position of the boundary south-west of the gossanous shear zone is as shown in section AA.

The horizontal displacement on the shear would tend to raise the level of the boundary on its north-eastern side but presumably this was compensated by some downward displacement to the north-east. It is thought that the boundary is at a shallow depth, as shown in section H-HI but the actual depth is not known. An iron ore body I is assumed to exist a short distance up-slope from a small detrital mass of magnetite hematite mapped near the intersection of section lines I-I1 and X-X1. Section XI shows that an orebody can be expected in the vicinity of I-I1 only if the boundary between garnet rock and Lower Basalt has been displaced downwards by a westerly extension of the system of faults that trend N20°E (magnetic). The supposed ore body shown in sections XX1 and II1 is the largest that could be expected to occur. Probably the actual body is smaller.

Reserves. The dimensions of the deposits and an estimate of reserves are given in Table 3. The estimate for orebodies B to G inclusive are regarded as probable reserves. The supposed occurrence of orebody I is based on the presence of detrital magnetite hematite and its possible dimensions are shown in section I-I1. Assuming it to have the same width as the other iron ore bodies in the Doilene area, the estimated reserves are 14,000 tons. This may be regarded as possible reserves. The depth to Lower Basalt beneath orebody H is not known, and no useful estimate of reserves can be made. Using the assumed depth shown in section H-H1 the reserves amount to 6,000 tons. This cannot be regarded as an estimate of "possible reserves" but it probably indicates the order of magnetude of the reserves at the locality.

Table 4. Dimensions of Doilene Iron Ore Deposits and Estimated Reserves

Magnetite body	Width (ft.)	Length (ft.)	Av.vert. dimens. (ft.)	Volume cu.yd.	Reserves (tons)*	
					Total	Tons per vert.ft.
Probable						
B	12	320	85	12,088	36,426	430
C	12	44	68	1,329	4,007	60
D	12	73	? 63	2,044	6,159	100
E	12	32	44	626	1,886	40
F	12	126	22	1,232	3,712	170
G	12	54	? 45	1,080	3,254	70
TOTAL				18,400 say 18,000	55,444 55,000	870

* Based on arbitrary estimate of 9 cu. ft. per ton.

Grade. Throughout the closely-faulted area including orebodies C to G and to a lesser extent body B the detrital and outcropping iron ore contains abundant cavities representing leached pyrite and cavities filled or partly filled with quartz. The magnetite cored in boreholes No. 9 contains a large proportion of pyrite. It is likely that the Doilene magnetite contains about 5 per cent pyrite and an appreciable proportion, perhaps of the order of 1 percent of quartz.

An analysis of iron ore cored in borehole No. 9 between 8' and 30' is:

Fe	SiO_2	Mn	TiO_2	S	As	P_2O_5
62.7	2.6	0.04	Less than 0.1	7.2	Not detected	Trace

SUMMARY OF RESERVES

Reserves of iron ore and dimensions of deposits throughout the area are summarized in Table 4.

Table 4. Iron Ore near Cape Lambert, New Britain.
Summary of Reserves

Name of Deposit and Locality	Dimensions (ft.) Width	Length	Aver. Vert. Dimen.	Volume cu.yd.	Reserves (Tons)* Total	Per Vert. foot.
Probable Reserves						
Langinoa Deposit on Rangarere Plantation	3	400	78	3,500	10,000	130
Cairngorm Deposit on Cairngorm Plantation	6	180	134	5,000	16,000	120
Doilene Deposit on Doilene Plantation	12	See Table 3		18,000	55,000	870
TOTAL				26,500	81,000	1,120
Possible Reserves (not including probable reserves)						
Rangarere Deposit on Rangarere Plantation.	In the text "Rangarere Area, Ore Deposit" some information is given on a possible small deposit for which insufficient information is available to make an estimate.					
Langinoa Deposit (see above)	3	See Table 1		4,000	12,000	250
Cairngorm Deposit (see above)	6	See Table 2		14,000	42,000	570
Doilene Deposit (see above)	In the text, "Doilene Area, Ore Deposit" some information is given on possible small deposits for which insufficient information is available to make an estimate.					
TOTAL					53,000	820

* Based on arbitrary estimate of 9 cu. ft. per ton.

GRADE

On the basis of visual examination of samples obtained from costeans and drill holes it is estimated that the deposits contain up to about 5 per cent pyrite. Near the surface the pyrite has been partly oxidized to limonite and partly removed by leaching, and little if any sulphur remains. At shallow depth the deposits contain fresh pyrite e.g. at a depth of 9 feet in borehole 9 in the Doilene area and at a depth of 3 to 4 feet in costeans 8 and 12 in the Cairngorm area.

The results of analysis of a surface sample from costean 8 and of the core from borehole 9 are given in Table 5.

Table 5. Analyses of Iron Ore from Cairngorm and Doilene Areas.

Locality	Fe	SiO_2	Mn	TiO_2	S	As	P_2O_5
Cairngorm area, Costean 8, channel sample	68.8	1.1	0.12	Less than 0.1	Not deter.	Not deter.	Trace
Doilene area bore-hole 9, 8 ft. to 30 ft. (9' of core recovered)	62.7	2.6	0.04	Less than 0.1	7.1	Not detected	Trace

REFERENCES

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APPENDIX I. THIN SECTION DESCRIPTIONS

by

W.B. Dallwitz.

LOWER BASALT

Specimen No. RB 2

Locality: Rangarere Area, borehole R 2, depth 153 ft.

This rock is fine-grained, and the only mineral that can be identified in hand-specimen is pyrite, which occurs as isolated grains.

In thin section the rock is found to consist of numerous porphyritic crystals of plagioclase (labradorite) and rather rare irregular grains of pale green actinolite in a groundmass of very fine-grained plagioclase, actinolite, and black iron ore. The size of the porphyritic plagioclase crystals ranges between 0.1 and 0.3mm.

Veinlets of quartz and actinolite, and of actinolite alone, traverse the rock, and small isolated pockets of granular quartz are scattered through the rock. The pyrite seems to be confined to the veins and pockets of quartz, and is not plentiful.

The rock is a uralitized plagioclase-rich basalt. The conversion of pyroxene to actinolite, the introduction of pyrite and quartz (or its formation as a by-product of mineral changes), and the formation of the veinlets most probably took place during the period of mineralization at Rangarere.

Specimen No. RB 3

Locality: Doilene Area, 480 ft. west of costean 8. A detrital fragment.

This is a grey rock containing porphyritic crystals of feldspar measuring up to 6 mm., though most are only between 1 and 3 mm long. Pyrite occurs as scattered grains and as fillings of narrow fractures.

In thin section it is seen that the groundmass of the rock has a basaltic texture. Original ferromagnesian material in the groundmass has completely changed to actinolite.

Two determinations on the porphyritic plagioclase crystals showed that they had the composition of anorthite (An 92 and AN 95). These crystals are partly altered to sericite and a clay mineral. Original porphyritic pyroxene has been completely changed to actinolite. Pockets of epidote and actinolite are irregularly distributed through the rock, and a veinlet made up of the same minerals traverses the slide. All of the pyrite is associated with these bodies of epidote and actinolite - fairly conclusive evidence that they were formed at the time of mineralization at Rangarere. It is probable also that the formation of actinolite in the groundmass is attributable to the same mineralizing activity.

Accessory minerals in the groundmass are leucoxene and magnetite.

The rock is a uralitized, epidotized and pyritized anorthite basalt.

Specimen No. RB 4

Locality: Langinoa Area, approximately 540 feet west of Costean A.

This is generally similar, both in handspecimen and in thin section, to specimen RB3. However, it contains much less epidote and no leucoxene, though some of the grains of black iron ore are bordered by fine-grained sphene. Pyrite is more abundant than in RB3. The porphyritic plagioclase is labradorite (An 55 - An 58).

The rock is a uralitized and pyritised labradorite basalt.

Specimen No. 635

Locality: Bed of Bulmaka River, 800 feet south of road to Nimke Village.

A hard, dense, fine-grained, greenish grey rock containing two bands which are conspicuous because of the presence of abundant white grains measuring about 0.5 mm. across. These bands are 0.75 to 1 cmm. thick.

In thin section the bulk of the specimen is seen to consist of fine-grained plagioclase and chlorite, with rather rare pyrrhotite. Some of the plagioclase grains are lath-shaped, but most are angular; the average size of the larger angular grains is about 0.03 mm. The rock is most probably a basaltic ashstone.

One of the bands containing abundant white grains appears in the section. This band consists of fragments of partly epidotized labradorite (the white grains) and of chloritized basalt embedded in a matrix of finely divided, altered, basaltic material. Pyrrhotite is much more abundant in this band than in the ashstone.

The plagioclase-rich band is most probably a chloritized basaltic tuff.

Specimen No. 635A

Locality: Same as for Specimen No. 635.

A medium-grey, fine-grained, compact rock having the appearance of basalt. It contains scattered pockets of chlorite ranging up to 3 mm. across.

In thin section the rock is found to be an altered basalt. It consists mainly of acid plagioclase (probably oligoclase), chlorite, and augite. The plagioclase is crowded with minute grains of chlorite, and its composition is, therefore, difficult to determine. Most of the chlorite in the rock occurs interstitially between the plagioclase laths, and may be an alteration-product of glass.

Black iron-ore is the most abundant accessory. Quartz is a very minor constituent. The chloritic pockets noted in handspecimen may consist of chlorite alone, but they generally contain quartz as well; some also contain prehnite and calcite, with or without epidote. Scattered small pockets consisting of prehnite alone and epidote alone are sparsely distributed through the slide. A veinlet of prehnite and quartz was noted.

This rock appears to be a fairly old basalt, which has undergone extensive chloritization; prehnite and epidote, although present in small quantity only, are indicative of changes which might be expected in the greenschist facies of regional metamorphism.

The rock may be briefly referred to as a chloritized basalt.

Specimen No. 636

Locality: Cape Wanawunur, 2400 feet north of mouth of Bulmaka River.

The handspecimen has the appearance of a basaltic agglomerate or breccia. Black, fine-grained rock fragments measuring up to 3 cm. across are embedded in a dark greenish grey matrix containing numerous irregular pockets of white mineral or minerals; these pockets measure up to several millimetres in length.

Under the microscope the black fragments consist of apparently finely amygdaloidal pyroxene basalt; the (?) amygdales are mostly filled with chlorite, but some contain minute spherules of (?)chalcedony, and/or prehnite, and/or epidote as well.

The matrix in which these fragments are embedded is basaltic also, but is more strongly altered. It consists of chlorite, plagioclase, minute spherules of probable chalcedony, augite, accessory leucoxene, and rare epidote. The white pockets noted in handspecimen are made up of one or more of the following minerals: quartz, prehnite, calcite, chlorite and (?)analcite.

The rock is an altered and chloritized basaltic agglomerate.

Specimen No. 637

Locality: Crest of divide approximately 3 miles south-east of Rangarore Plantation.

Macroscopically this is a dense, fine-grained medium-grey rock having the appearance of an altered basalt.

Under the microscope the rock is found to consist of plagioclase, fine-grained actinolite, subordinate chlorite and black iron ore, accessory leucoxene, scattered prehnite-bearing pockets, and rare epidote and calcite. Porphyritic crystals of plagioclase (labradorite) are common. The actinolite has replaced pyroxene, none of which remains.

The rock is a chloritized and uralitized plagioclase basalt.

Specimen No. 640

Locality: Doilene Area, borehole No.I, 80'-83'.

Macroscopically this is dark grey basaltic rock containing numerous phenocrysts of plagioclase measuring up to about 3 mm.in length.

The thin section shows that the rock is an altered basalt. The porphyritic crystals of plagioclase are acid labradorite (An 50-55). The few large porphyritic crystals of pyroxene which were present have been pseudomorphed by actinolite; this mineral has also replaced pyroxene in the groundmass. Black iron ore in minute grains is abundant in the groundmass, and leucoxene is a rare constituent. A few grains of ilmenite bordered by leucoxene are scattered through the rock.

Several amygdales filled entirely, or almost entirely, by actinolite are present; one contains brown hornblende and plagioclase in addition to actinolite, and one or two contain a little plagioclase and micaceous hematite as minor constituents. A few veinlets of actinolite traverse the slide.

The rock is a uralitized plagioclase basalt.

ALTERED LIMESTONE

Specimen No. 641

Locality: Cairngorm Area, borehole R 10, 86'4 - 93'4.

A dense, hard, fine-grained, irregularly mottled rock consisting of pale pinkish buff, very pale greenish buff, and pale grey patches.

Apart from a little limonite staining, all the minerals in this rock are colourless or almost colourless when observed in polarized light. Their average grainsize is about 0.1 mm.

Probable vesuvianite is the most plentiful mineral. Grains of this mineral generally show anomalous brown interference colours. Some grains, however, have a zone with normal double refraction (first order white to grey) surrounding an anomalous zone; a few grains have normal double refraction throughout.

Scapolite is the next mineral in order of abundance. It occurs as rather well-cleaved prismatic grains with straight extinction.

Both vesuvianite and scapolite are fairly evenly distributed, but the third mineral of importance, lime-garnet, is very irregularly dispersed.

A veinlet consisting of quartz and basic plagioclase traverses the slide. A little colourless (?)chlorite is also present.

The rock is a garnet-scapolite-vesuvianite hornfels or skarn.

DIORITE.

Specimen No. 634

Locality: East bank of Bulmaka River, 1,000 ft. south of road to Nimke village.

A medium-grained, holocrystalline igneous rock consisting macroscopically of feldspar and subordinate hornblende and biotite.

In thin section the rock is seen to consist of subhedral plagioclase (65%), hornblende (20%), biotite and associated chlorite (5%), accessory quartz, orthoclase, magnetite, and rare hematite, sphene, and apatite.

The plagioclase is commonly rather strongly zoned, and its composition is very difficult to determine. Cores of some of the crystals gave An67, An58, and An48. Probably its average composition is that of a basic andesine. Orthoclase and quartz are interstitial between the plagioclase grains.

The rock is a hornblendic quartz diorite.

APPENDIX 2

MINERAGRAPHIC AND SPECTROGRAPHIC REPORTS

by

W.M.B. Roberts.

CUPRIFEROUS GARNET ROCK

Specimen No.RBO

Locality: Langinoa Area, Costean 8.

In this section the rock is seen to consist principally of a garnet which was identified from its X-ray diffraction pattern as andradite variety topazolite. It forms large subhedral to anhedral masses which have been strongly stressed the resulting fractures being filled with chalcedony, malachite, limonitic material, the opaque minerals, and a colourless mineral having a high birefringence, the exact nature of which could not be determined. It is possibly anhydrite, which could have formed from the chemical breakdown of the garnet in the presence of H_2So_4.

The opaque minerals present are: Chalcopyrite, covellite, grey chalcocite, the cuprous and cupric oxides, cuprite and tenorite respectively, and hematite.

The two earliest formed minerals are hematite and grey chalcocite both of which are strongly fractured, the hematite retaining its subhedral crystalline form, while the chalcocite has its characteristic irregular habit. These minerals are not in contact in the sections so it is not possible to determine their relative order of deposition. The hematite crystals range up to 0.6 mm. across, and have been replaced along fractures by chalcopyrite, which has in places completely psuedomorphed the iron oxide. The only evidence of the former identity of the pseudomorphs is the marked set of partings lying at approximately 30 degrees to each other, as in the unreplaced hematite areas. Chalcopyrite is also replacing, and filling fissures in, the chalcocite areas, where it in places retains the cubic parting which has been developed in this mineral as a result of the stress to which it has been subjected.

The chalcopyrite is a relatively minor constituent of the specimen, the largest piece being 0.5 mm. across. It is weakly anisotropic, and does not show any evidence of twinning.

The major opaque minerals present in the ore are cuprite and tenorite, which occur in roughly equal amounts, forming areas which range up to 5.0 mm. in length and of varying width. The cuprite is granular, and has a fairly even grainsize of 0.1 mm. It shows the typical strong anomalous anisotropism, from green to purple.

Tenorite forms as irregular areas and as masses of radially fibrous aggregates.

Covellite is being formed throughout the ore by alteration of chalcocite, forming thin veinlets along fractures. The examination of the ore shows that the two earliest deposited opaque minerals are hematite and chalcocite. They have been deposited prior to the stress which has severely fractured the rock, along interstices between the garnet crystals, and have been fractured with this mineral. Subsequent to the fracturing chalopyrite has been introduced, replacing hematite and chalcocite. The absence of strain-twinning in the chalcopyrite and its retention of the original fracture pattern of the replaced minerals conclusively establishes its later introduction.

An analysis by M.J. Cullen gives the percentage Cu as 8.8.

LANGINOA GOSSAN.

Specimen No.RB 11

Locality: Langinoa Area, drill hole R 19; core fragments between 52'10" and 59'10".

This sample consisted of small fragments of skarn material and hydrated iron oxide containing irregular masses of sulphide.

Polished sections of several fragments showed the sulphide to be pyrite altering extensively to goethite.

Spectrographic analysis showed that copper is present in the specimen, but no trace of gold.

FRACTURED GARNET ROCK CONTAINING PYRITE AND QUARTZ

Specimen No.RB 1

Locality: Rangarere Area, Borehole R 2, depth 32 feet.

The core examined was submitted by J.E. Thompson for identification and comment on the metallic minerals present.

The mineralised rock consists of strongly fractured garnet, pyrite, and some quartz which have been recemented by chalcedony and chlorite. The only other opaque mineral in the core is hematite. In the weathered edge of the specimen a large amount of hydrated iron oxide is intermingled with the chalcedonic matrix.

In the original rock, garnet was the earliest deposited mineral; euhedral crystals of this mineral are moulded and enclosed by pyrite which has immediately followed it. Quartz was the last deposited mineral, moulding both garnet and pyrite. The rock was then strongly fractured, and chalcedony and chlorite introduced. The position of hematite is obscure; some of it appears to have formed from the alteration of pyrite, although in general, with the exception of the weathered edge of the rock, the pyrite has suffered very little from the weathering processes.

SULPHIDES RECOVERED FROM LOWER BASALT

Specimen No.RB 12

Locality: Rangarere Area, sludge from drill hole R 20, 30'-35'.

The sample, sludge from the above drill hole, was separated on the Haultain superpanner; the heavy mineral fraction was found to form approximately 10% of the sample, and consisted of pyrite and magnetite. One grain of chalcopyrite was observed. Several grains of magnetite showed a grid-like arrangement of hematite lamellae, probably due to alteration along their octahedral planes.

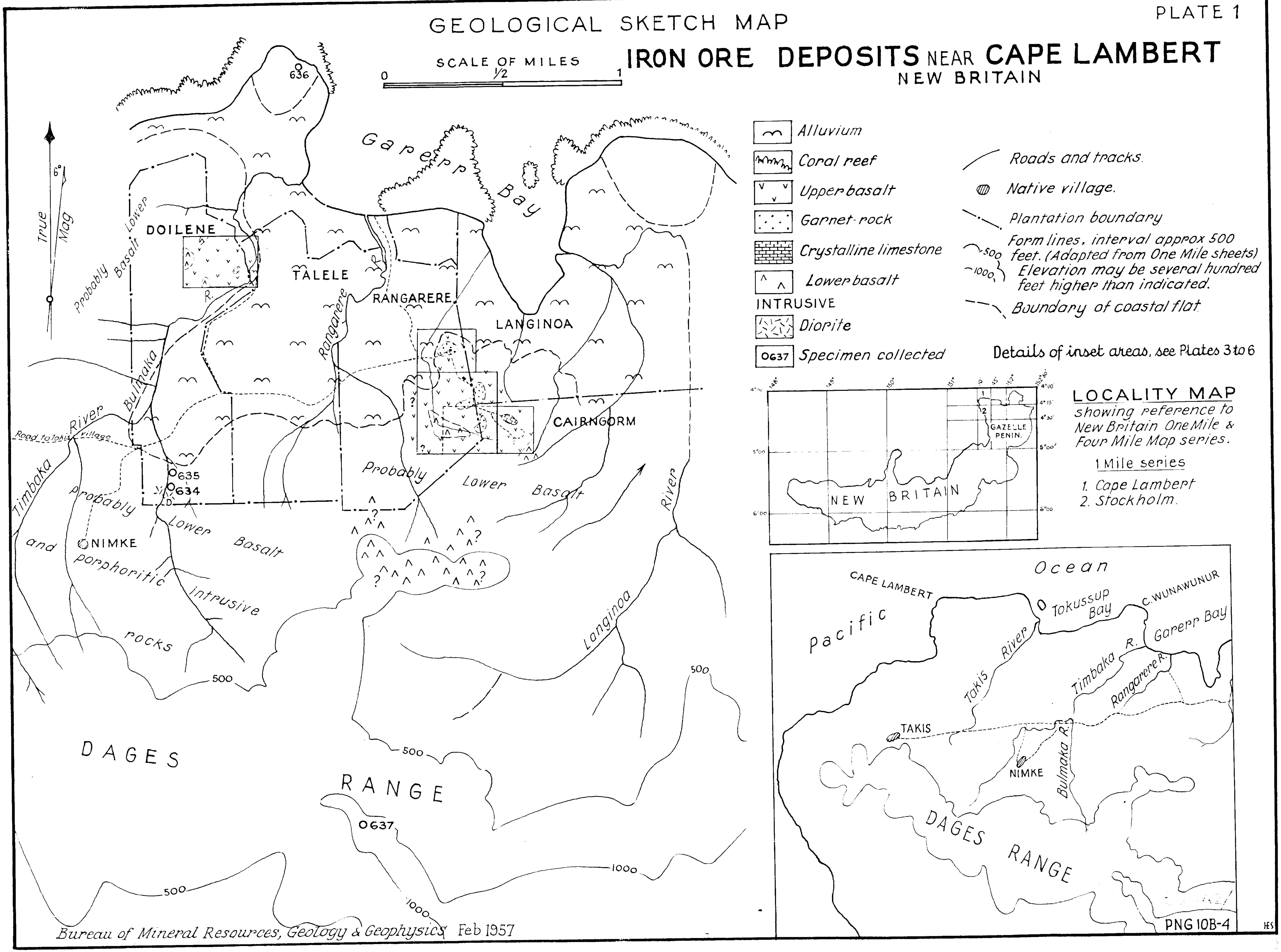

PLATE 1
GEOLOGICAL SKETCH MAP
IRON ORE DEPOSITS NEAR CAPE LAMBERT
NEW BRITAIN
SCALE OF MILES
0
1/2
1
True
Mag
6°
Alluvium
Coral reef
Upper basalt
Garnet-rock
Crystalline limestone
Lower basalt
INTRUSIVE
Diorite
O637 Specimen collected
Roads and tracks.
Native village.
Plantation boundary
Form lines, interval approx 500 feet. (Adapted from One Mile sheets) Elevation may be several hundred feet higher than indicated.
Boundary of coastal flat
Details of inset areas, see Plates 3 to 6
Gaperp Bay
DOILENE
TALELE
RANGARERE
LANGINOA
CAIRNGORM
Probably Lower Basalt
Rangarere R.
Bulmaka River
Timbaka River
Road to Takis Village
635
634
636
NIMKE
Probably and porphoritic Lower Basalt intrusive rocks
Probably Lower Basalt
Langinoa River
500
1000
DAGES RANGE
O637
LOCALITY MAP
showing reference to New Britain One Mile & Four Mile Map series.
1 Mile series
1. Cape Lambert
2. Stockholm.
GAZELLE PENIN.
NEW BRITAIN
Ocean
Pacific
CAPE LAMBERT
Tokussup Bay
C. WUNAWUNUR
Gaperp Bay
Takis River
Timbaka R.
Rangarere R.
Bulmaka R.
TAKIS
NIMKE
DAGES RANGE
PNG 10B-4
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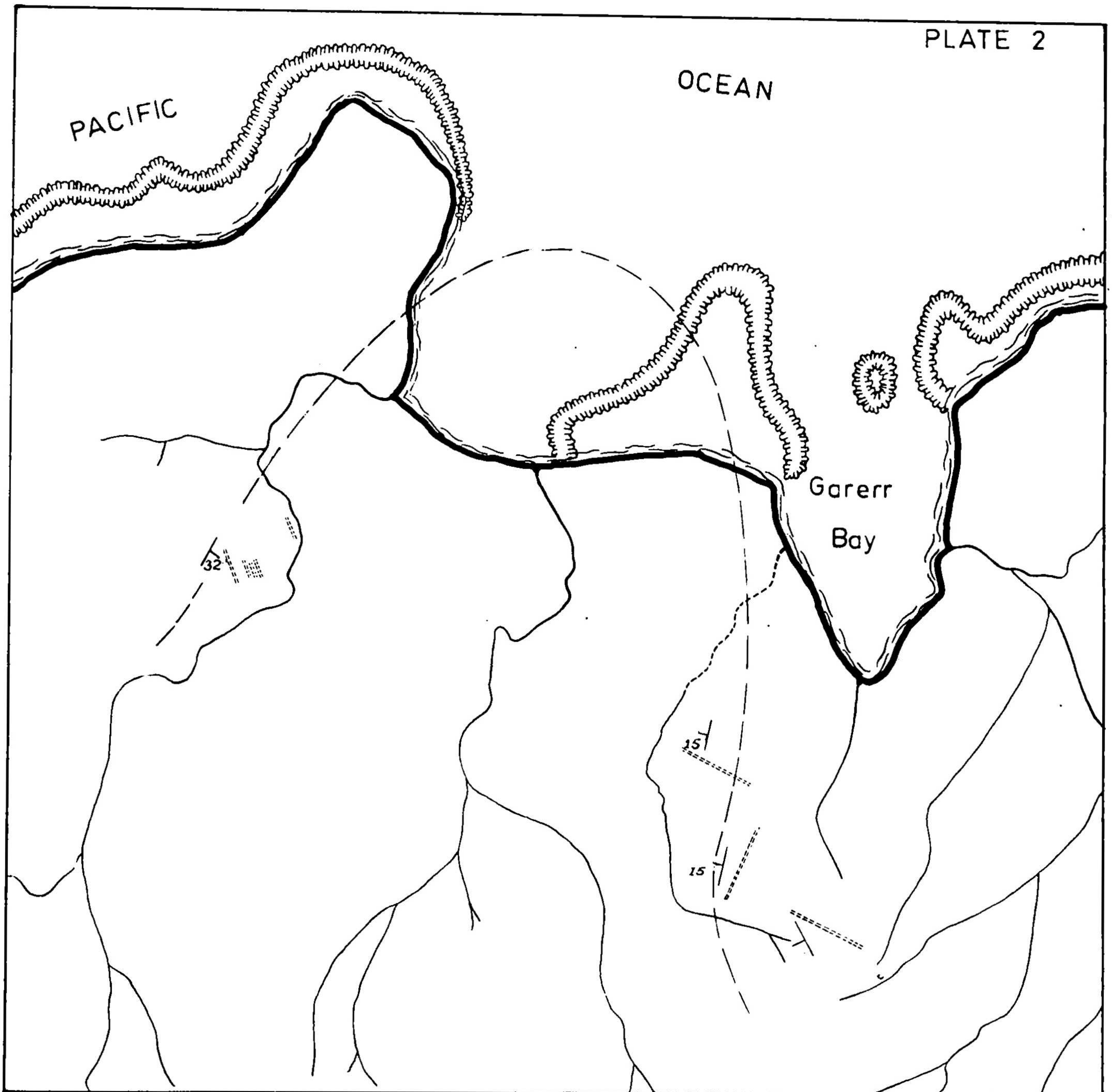
PLATE 2



SKETCH MAP

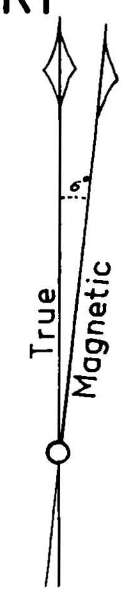
SHOWING POSITIONS OF

IRON ORE DEPOSITS NEAR CAPE LAMBERT

NEW BRITAIN

Scale of Miles

0 ¼ ½ ¾ 1



REFERENCE

Iron ore deposits

15 Strike and dip of boundary between Garnet-rock and lower Basalt

Possible synclinal structure

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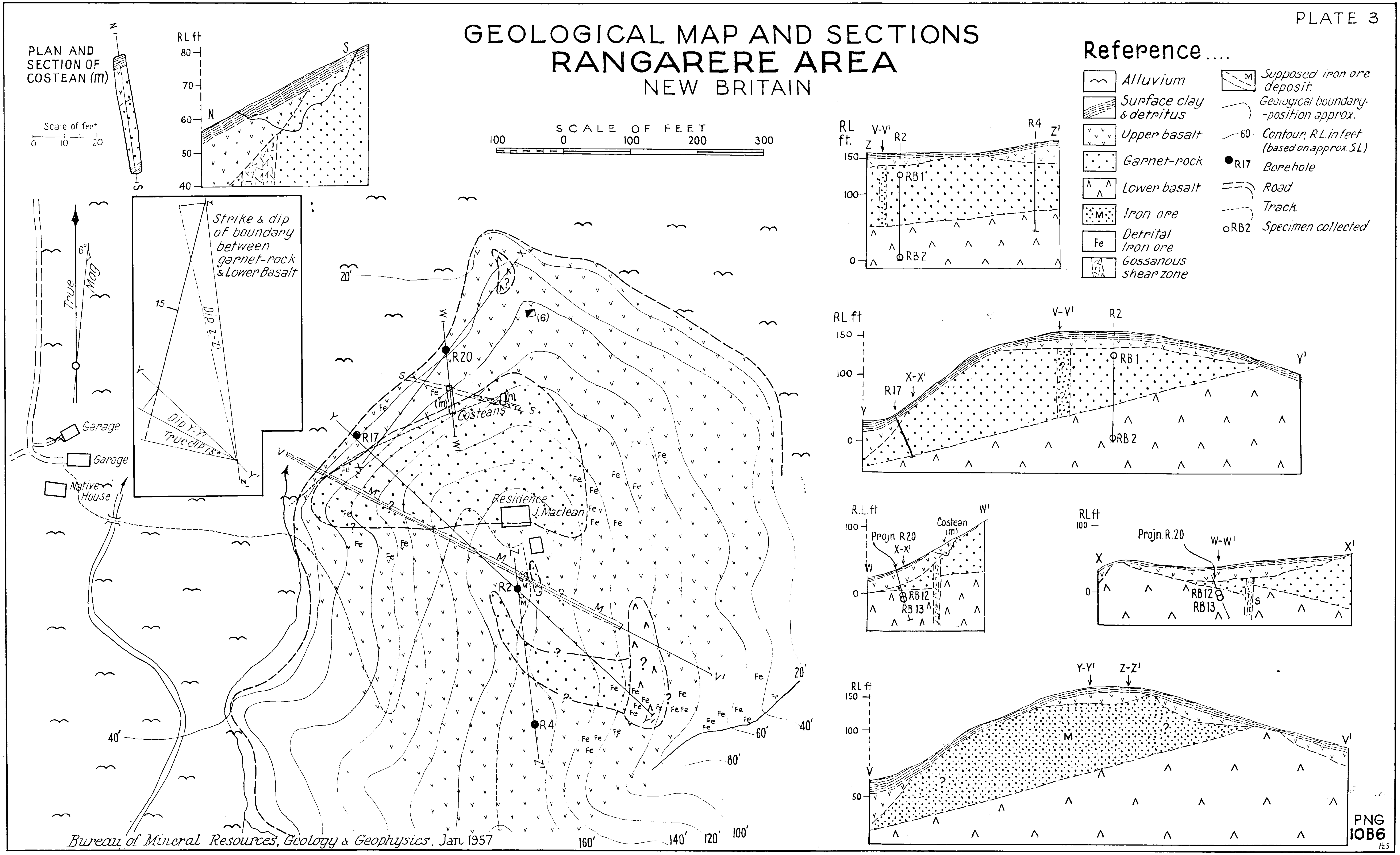
PLATE 3
GEOLOGICAL MAP AND SECTIONS
RANGARERE AREA
NEW BRITAIN
SCALE OF FEET
100 0 100 200 300
PLAN AND SECTION OF COSTEAN (m)
Scale of feet
0 10 20
Strike & dip of boundary between garnet-rock & Lower Basalt
Dip Z-Z'
Dip Y-Y'
True dip 15°
True
Mag
Garage
Garage
Native House
Residence J. Maclean
Costeans
R20
R17
R2
R4
20'
40'
60'
80'
100'
120'
140'
160'
Reference....
Alluvium
Surface clay & detritus
Upper basalt
Garnet-rock
Lower basalt
Iron ore
Detrital iron ore
Gossanous shear zone
Supposed iron ore deposit.
Geological boundary-position approx.
Contour, R.L in feet (based on approx. S.L)
Borehole
Road
Track
Specimen collected
RL ft
RB1
RB2
RB12
RB13
Projn R.20
Costean (m)
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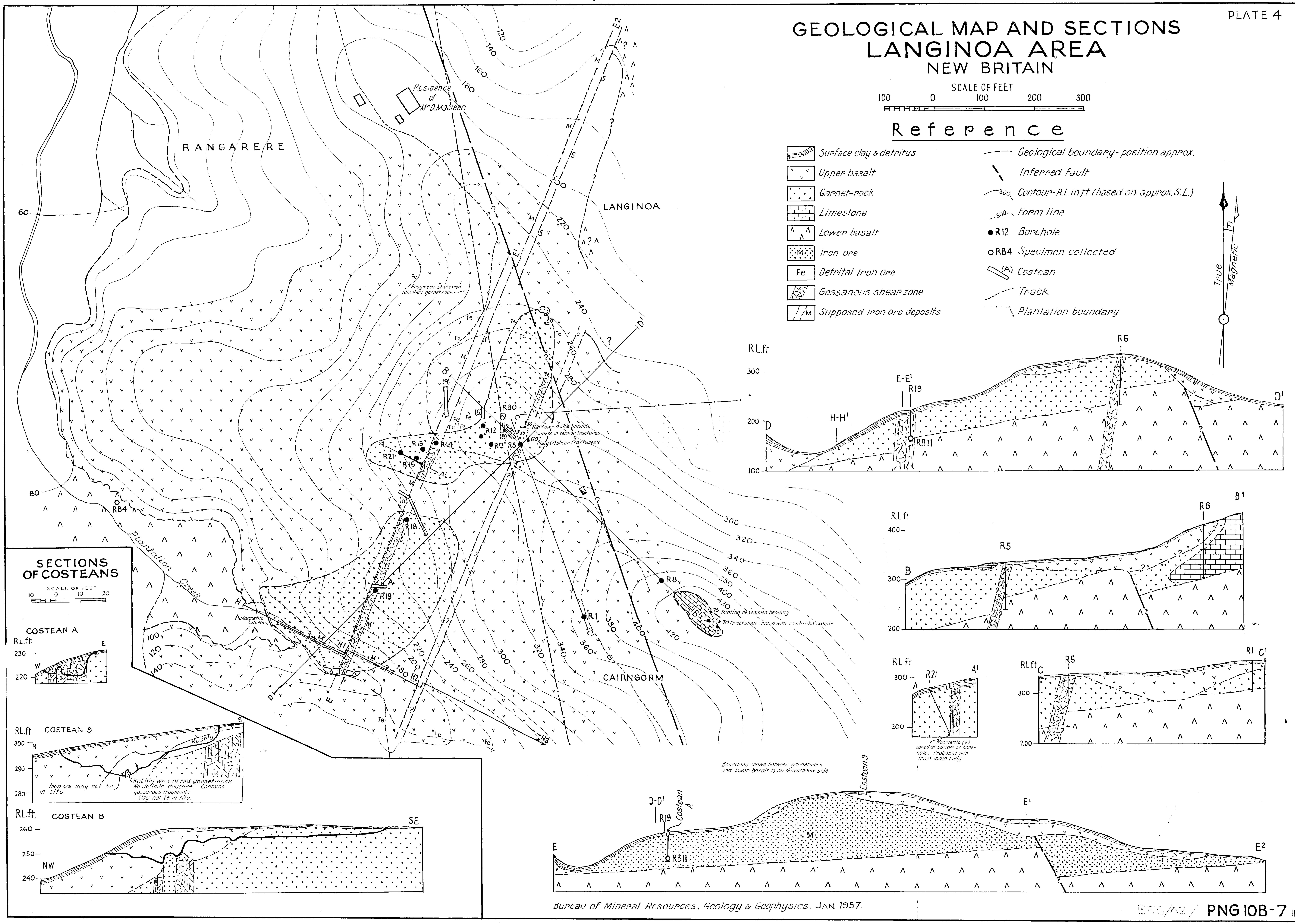
PLATE 4
GEOLOGICAL MAP AND SECTIONS
LANGINOA AREA
NEW BRITAIN
SCALE OF FEET
100 0 100 200 300
Reference
Surface clay & detritus
Upper basalt
Garnet-rock
Limestone
Lower basalt
Iron ore
Fe Detrital Iron ore
Gossanous shear zone
Supposed iron ore deposits
Geological boundary - position approx.
Inferred fault
Contour - R.L. in ft (based on approx. S.L.)
Form line
R12 Borehole
RB4 Specimen collected
(A) Costean
Track
Plantation boundary
True
Magnetic
RANGARERE
LANGINOA
CAIRNGORM
Residence of Mr D. Maclean
Plantation Creek
Magnetite outcrop
Jointing resembles bedding
70 Fractures coated with comb-like calcite
SECTIONS OF COSTEANS
SCALE OF FEET
COSTEAN A
COSTEAN 9
Iron ore may not be in situ
Rubbly weathered garnet-rock. No definite structure. Contains gossanous fragments. May not be in situ
COSTEAN B
Boundary shown between garnet-rock and lower basalt is on downthrow side
Magnetite (?) cored at bottom of bore-hole. Probably vein from main body
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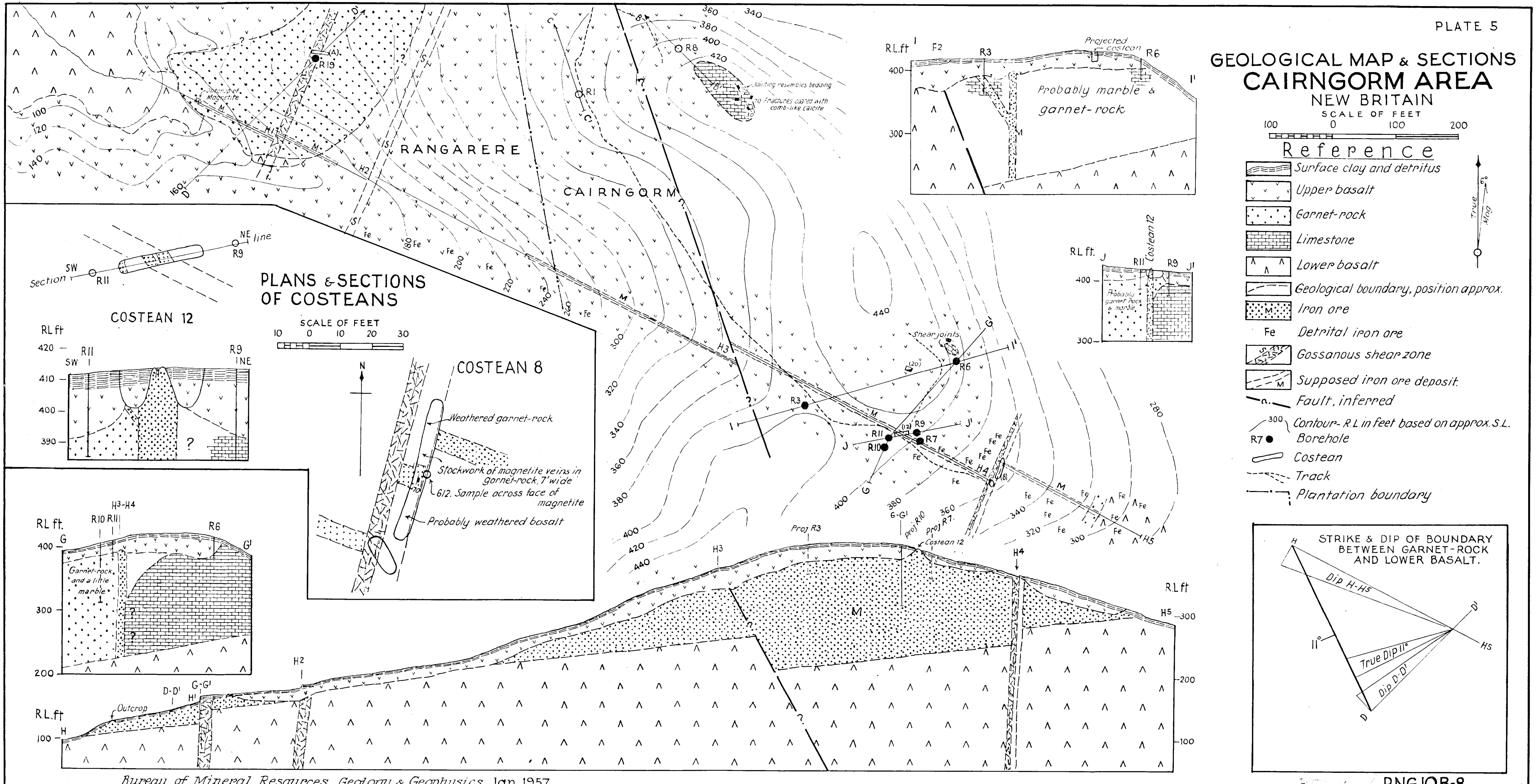
PNG 10B-7

PLATE 5

GEOLOGICAL MAP & SECTIONS CAIRNGORM AREA NEW BRITAIN



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PNG10B-8


PLATE 6
GEOLOGICAL MAP & SECTIONS
DOILENE AREA
NEW BRITAIN
SCALE OF FEET
100 0 100 200 300 400
Reference
Alluvium
Clay and surface detritus
Upper basalt
Garnet-rock
Lower basalt
Geological boundary-position approx.
Iron Ore
Fe Detrital Iron ore
Gossanous shear zone
Supposed iron ore deposit
Fault, inferred.
Contour, RL in feet based on approx. sea level.
Form line
RB3 Specimen collected
Borehole
Costean
True
Mag
6°
NOTE - For details of costeans see PLATE 7.
For detail see Plate 7.
Bulmaka River
STRIKE & DIP OF BOUNDARY BETWEEN GARNET-ROCK & LOWER BASALT.
Dip A-A'
Dip of boundary between skarn & lower basalt
32°
Lower basalt in borehole
RL ft
Costean (8)
Costean (D)
Costean DD
Costean C
Costean B
Costean A
Costean F
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PNG 10B-9

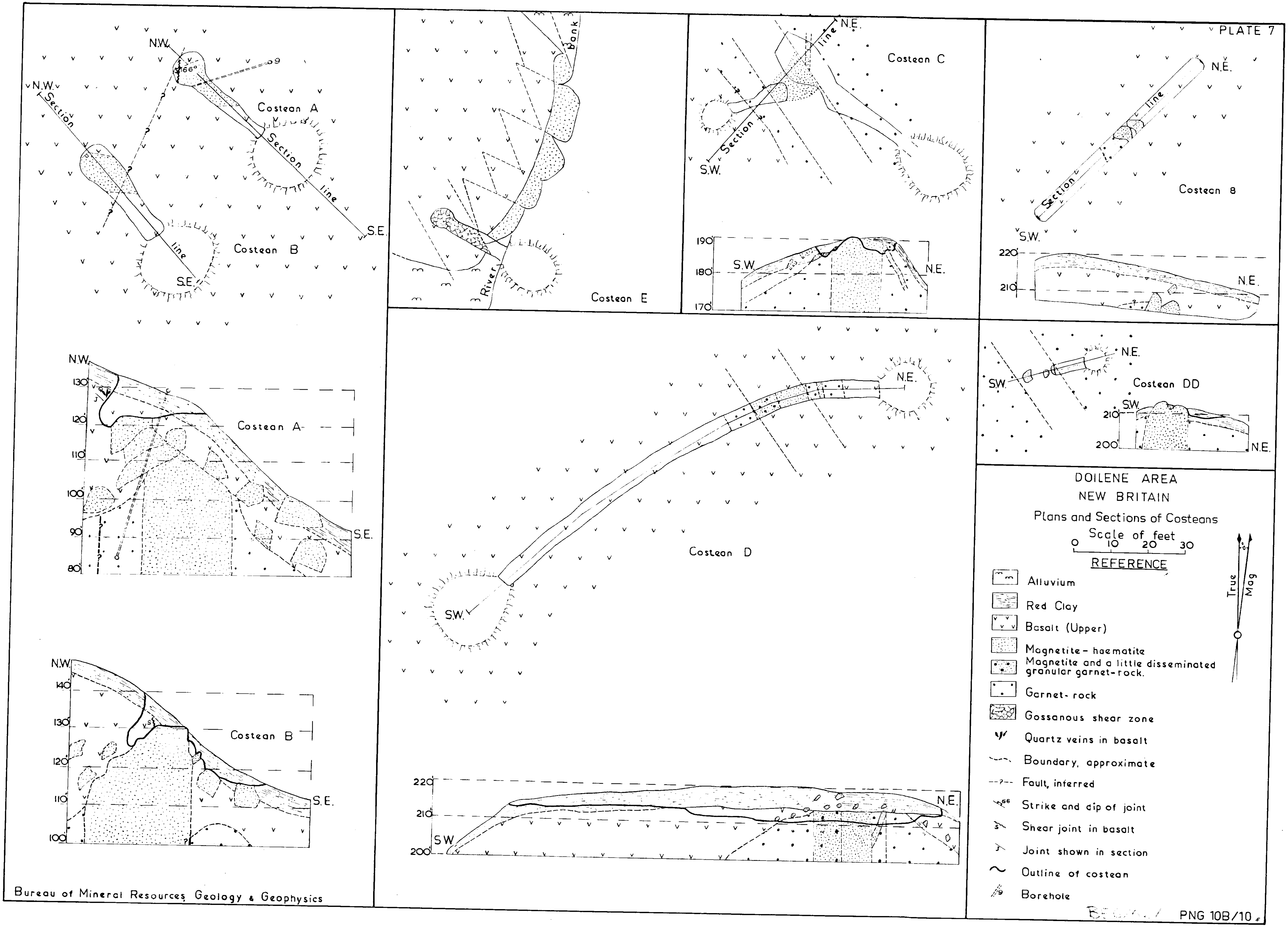
PLATE 7
Costean A
Section line
N.W.
S.E.
66°
Costean B
Costean E
River
Bank
Costean C
Section line
N.E.
S.W.
190
180
170
Costean 8
Section line
220
210
Costean A
130
120
110
100
90
80
Costean B
140
130
120
110
100
Costean D
Costean DD
200
DOILENE AREA
NEW BRITAIN
Plans and Sections of Costeans
Scale of feet
0 10 20 30
REFERENCE
Alluvium
Red Clay
Basalt (Upper)
Magnetite - haematite
Magnetite and a little disseminated granular garnet-rock.
Garnet-rock
Gossanous shear zone
Quartz veins in basalt
Boundary, approximate
Fault, inferred
Strike and dip of joint
Shear joint in basalt
Joint shown in section
Outline of costean
Borehole
True
Mag
Bureau of Mineral Resources, Geology & Geophysics
PNG 10B/10