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THE COPPER DEPOSITS OF THE REDBANK COPPER FIELD NORTHERN TERRITORY.

by

J.B. Firman

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SUMMARY

The Redbank Copper deposits occur in the Gold Creek Volcanics, a formation approximately 250 feet thick, which contains interbedded volcanic flow-rocks, pyroclastics, and sedimentary rocks deposited in a shallow-water environment. The volcanic rocks show hydrothermal alteration which is best developed adjacent to the ore-bodies. Fine-grained volcanic rocks and coarse-grained sedimentary rocks contain the most extensive mineralization.

The sedimentary rocks are essentially flat with a slight overall dip to the north-west. Steeply dipping, ill-defined faults which are present in the workings may have served as channelways for the original ore-bearing solutions. Secondary copper minerals are localized within suitable host-rocks or at the intersection of the steeply dipping faults with fine-grained volcanic flow-rocks or coarse-grained sedimentary rocks.

The deposits are characterized by the copper minerals malachite, dihydrite, azurite, chrysocolla and chalcocite, by the paucity of gangue minerals and by the absence of sulphide minerals other than chalcocite. It is suggested that they are the oxidized zones of epigenetic, epithermal sulphide deposits.

Known deposits are of sufficiently high-grade, but are too small for economic development at a company level. Successful exploitation may depend upon the discovery of other ore-bodies by geophysical survey and by exploratory drilling and shaft sinking.

INTRODUCTION

The Redbank Copper Field is in the Northern Territory 16 miles west of the Queensland Border and 63 miles south of the Gulf of Carpentaria, that is, in the north-east corner of the Calvert Hills 4-mile Sheet. The field is 194 road miles west of the nearest town, Burketown in Queensland, 17 road miles west of Wollogorang Homestead, and 33 road miles east of the nearest air-field at Calvert Hills Homestead .(Plate 1).

Access from the Barkly Highway is by graded earth road from Camooweal, via Doomadgee, Corinda and Westmoreland, or via Rockhampton Downs, Creswell Downs, Robinson River and Calvert Hills. Access from the Stuart Highway is by graded earth road from Newcastle Waters, via O.T. Downs, Borroloola, Robinson River and Calvert Hills, or from Elliot via Creswell Downs, Robinson River and Calvert Hills. Roads are impassable in places for several months during the summer rains.

Deposits of copper minerals were first discovered near Wollogorang in 1900. Other deposits were found in the area in 1912. W. Masterton, who is mining the Redbank deposit, discovered the Redbank deposit in 1916, and intermittent production of copper ore has continued from the Redbank area since that year.

The geology of the Redbank Field has been described by Jensen (1940), Blanchard (1940) and Benedict and King (1948). The results of a geochemical survey are incorporated in the report by Benedict and King, and a report on a geophysical survey is contained in a report by A.G.G.S.N.A. for the period ending 31st December, 1940.

The present report arises from an investigation of the deposits in 1957 during [illegible] geological mapping of the Calvert Hills 4-mile Sheet [illegible] of regional survey by [illegible].

Host-rocks have been described by W.R. Morgan and W.B. Dallwitz in Appendix I. Production figures are set out in Appendix 2.

REGIONAL GEOLOGY

STRATIGRAPHY

The copper deposits occur in the Gold Creek Volcanics, a sequence of flow-rocks and pyroclastics with interbedded clastic sedimentary rocks, including conglomerate. (Plate 2). The sequence and lithology of the sedimentary rocks indicates a shallow-water environment of deposition. The unit is approximately 250 feet thick and is probably Upper Proterozoic. Near the Redbank Field the Gold Creek Volcanics are overlain conformably by the Masterton Sandstone and underlain conformably by the Wollogorang Formation, a sequence of impure quartz sandstone, dolomite and siltstone.

A talus conglomerate, which contains plant fossils of Upper Jurassic to Lower Cretaceous age, abuts unconformably against the Masterton Sandstone in some places, notably in Echo Gorge and at Masterton's Cave. Residual lateritic soils of Tertiary (Miocene?) age occur near the deposits.

The present erosional surface, the Miocene(?) erosional surface (indicated by laterite) and the Mesozoic erosional surface (indicated by talus conglomerate) all lie close together. The Redbank copper deposits, therefore, have been subjected to weathering since the formation of the erosional surface below the talus conglomerate. The long period of weathering with consequent strong leaching of primary sulphides may account, in part, for the absence of sulphides other than chalcocite in the deposits.

Lithology and the relationship of the Gold Creek Volcanics to other formations in the area is set out below and on Plate 2.

Except for small outcrops of Mesozoic rocks, only the units below the Karns Dolomite and above the Westmoreland Conglomerate occur within the area shown on Plate 2.

TABLE I

STRATIGRAPHY CALVERT HILLS 4 MILE SHEET

Age(1)	Formation(2)	Lithology(3)
Mesozoic	Un-named Formation	Sandstone, ferruginous sandstone, claystone, friable conglomeratic sandstone, talus breccia, talus conglomerate.
	X X X X	
Upper Proterozoic	Bukalara Sandstone	Sandstone, friable and cross-bedded in most places, pebble conglomerate, calcarenite.
	X X X X	
	Karns Dolomite	Siltstone, bedded dolomite with thin chert beds near top.
	X X X X	
	Masterton Sandstone	Sandstones: flaggy and ripple-marked, massive, and cross-bedded with pebble conglomerate lenses.
	Gold Creek Volcanics	Trachyte, porphyritic rhyolite, tuff, dolerite, quartz sandstone, conglomerate, greywacke (water-sorted tuff?).
	Constance Sandstone Lenses out near Wollogorang	Quartz sandstone
	- - - - - - - - - -	- - - - - - - - - -
	Wollogorang Formation	Dolomite, quartz siltstone, chert and impure ferruginous sandstone.
	0 0 0 0	
	Peter's Creek Volcanics	Porphyritic rhyolite, uralitized quartz dolerite, basalt.
	Westmoreland Conglomerate	Quartz sandstone with interbeds of conglomerate. Arkose at base.
	X X X X	
Precambrian	Nicholson Granite	Coarse-grained granite, biotitic granite, pegmatite, biotite-actinolite tonalite with associated actinolite-biotite-quartz gabbro.
	0 0 0 0	
	Cliffdale Volcanics	Porphyritic rhyolite, dolerite, basalt and andesite.

1. Younger rocks than those of Mesozoic age excluded.
2. Unconformity X X X. Igneous contact 0 0 0 .
   Disconformity - - - - - - - -
3. Rocks occurring in the Redbank Field are underlined.

STRUCTURE

All rock units older than the Karns Dolomite are gently folded. Sharp anticlinal folds, trending west and north-west are a prominent structural feature 25 miles west of the mines. Minor dome and basin structures are found 5 miles south-east of the mines and a faulted synclinal fold trending north-east is present in the valley of Settlement Creek 6 miles south-east of the mines. None of these structures can be correlated with ore-deposition, and there are no prominent faults within a radius of 5 miles of the mines.

MINERALIZATION - Regional Setting

Copper, tin, uranium, lead and manganese minerals are found within a radius of 40 miles of the mines. Most of these deposits are contained within a mineralized belt which trends north, is 40 miles long and 20 miles wide and has the Redbank Field in its north-west corner.

Jensen (1942) reports two deposits of secondary copper minerals east of the Redbank deposits near the Northern Territory-Queensland Border. These deposits occur at the contact between the Gold Creek Volcanics and the underlying Wollogorang Formation. The occurrence of copper minerals in lithologically favourable dolomite beds suggests that the same formation about 250 feet vertically below the surface in the Redbank Field may also be mineralized.

A tin deposit occurs within a quartz-biotite "pegmatite" genetically related to the Nicholson Granite. The Nicholson Granite forms part of the basement for the overlying rocks (including the Gold Creek Volcanics), and the tin deposit was emplaced therefore, in a period of mineralization older than that in the Redbank Field.

The relationship of the mineral occurrence to the stratigraphical succession is shown on Table 2.

TABLE 2

RELATIONSHIP OF MINERAL OCCURRENCES TO THE STRATIGRAPHICAL SUCCESSION, CALVERT HILLS 4-MILE SHEET

Rock Unit	Mineralization
Bukalara Sandstone	No known mineralization
Karns Dolomite	Manganese and copper; mainly manganese
Masterton Sandstone	Minor amounts of manganese
Gold Creek Volcanics	Copper and Minor amounts of manganese
Wollogorang Formation	Copper and minor amounts of lead and manganese
Peter's Creek Volcanics	Uranium and copper. Uranium most abundant, but copper minerals common
Westmoreland Conglomerate	Uranium and copper
Nicholson Granite	Tin, copper and uranium
Cliffdale Volcanics	Copper and uranium

GEOLOGY OF THE COPPER DEPOSITS OF THE REDBANK FIELD

Eleven copper deposits have been located on the field. Of the six inspected only four show sufficient mineralization to warrant further investigation. The deposits not inspected have all been reported upon unfavourably by other workers. The copper deposits are:

Redbank *	Bluff *	Seven Mile *
Azurite *	Glance (or Quartzite)	Cross-Lode
Prince *	Conglomerate	Yellow Girl
Black Charlie *	Masterton	

* Copper deposits inspected.

Production figures for the Redbank Mine are given in Appendix 2.

LITHOLOGY AND HOST-ROCKS

The rocks near the mines are trachyte, tuff, siltstone, quartz sandstone, conglomerate and greywacke (water-sorted tuff?). A fine-grained trachyte is the most common host rock, but secondary copper minerals are also abundant in conglomerate, sandstone and greywacke. Both volcanic flow-rocks and sedimentary rocks are lenticular, and individual beds are not traceable between deposits.

A petrographic study of the host rocks (see Appendix I) shows that all the trachytes have their feldspars partly kaolinized, while some are slightly sericitized. Two specimens have hydrated iron oxide which may be an alteration product of their ferro-magnesian content. Other specimens have their ferromagnesian minerals altered to chlorite or nontronite, or both. (Alteration is most pronounced near the ore-bodies). The field and petrographic evidence suggests some alteration of the host-rocks by hydrothermal activity at the time of introduction of the copper. Weathering has obscured some of the effects of hydrothermal alteration.

STRUCTURES NEAR THE DEPOSITS

The rocks are essentially shallow-dipping, but there are local changes in amount and direction of dip near the mines; most dips measured were to the north and west and ranged from five degrees to twenty degrees, so that there is an over-all dip to the north-west.

Weak fractures which strike between north-east and north-west are present in the workings. Some of these fractures are probably ill-defined faults of the same type as the fault in the Black Charlie workings, which strikes 40 degrees and dips 40 degrees south-east. Benedict and King (1948) refer to an east-trending fault at the Cross-Lode deposit where the north block has been down-thrown 50 feet. These fractures may have served as channel ways for the original ore-bearing solutions.

MINERALIZATION

The most common copper minerals in the Redbank deposits are malachite, dihydrite, azurite, chrysocolla and chalcocite. Blanchard (1940) mentions tenorite, cuprite, copper pitch and brochantite as being of minor inportance. Non-sooty chalcocite commonly occurs in veinlets, slugs or grains surrounded by secondary copper minerals. It is possible that uplift has caused a lowering of the water-table and has brought the chalcocite into the zone of oxidation. This would produce the mineral aggregates of chalcocite surrounded by carbonate minerals.

A characteristic feature of the deposits is the absence of gangue minerals; one specimen collected contained a carbonate mineral, probably calcite, and others contained only small amounts of vein quartz and hematite.

The deepest workings on the Redbank Field have been put down only 70 feet. At this depth the workings are still within the oxidized zone. A zone of secondary enrichment may not be well developed near the water-table because of the absence of acidic solutions derived from iron-bearing sulphides. Trestrail, quoted in Benedict and King (1948), reported small amounts of chalcopyrite, pyrite, arsenopyrite (?) and enargite (?) filling amygdules lined with amethyst at the Yellow Girl deposit, but similar mineral assemblages are not found in any other deposit in the field.

GEOPHYSICAL INVESTIGATIONS

The results of self potential, electrical (potential ratio), electro-magnetic and magnetic methods of geophysical exploration are reported in A.G.G.S.N.A. ... a (1940). The report states that: "The object of the survey, namely, locating the sulphide portions of the lodes which were presumed to exist beneath the oxidized outcrops, has not met with any marked success."

"Preliminary testing of geophysical methods eliminated, for use in the area, all but the electrical potential ratio and the magnetic methods. These two methods were used in surveys over the Redbank, Azurite, Prince and Bluff lodes and the country surrounding these lodes."

"With the exception of the Azurite and, possibly, the Redbank lodes, the results did not serve to indicate the possible limits of the ore-bodies. At the Redbank mine, the results suggest that the lode is of limited length and does not extend far beyond the limits of the present workings. The Azurite lode seems to be associated with a well-defined conductive zone which has a length of 400 feet in a north-west direction. It is suggested that the zone may represent one of intense kaolinization (some of the lodes are associated with kaolinized zones."

It is possible that more recent techniques and methods of geophysical exploration would provide more definite results.

NOTES ON INDIVIDUAL DEPOSITS

REDBANK

The portion of the Redbank deposit exposed at the surface is a flat-lying ore-body with minor rolls superimposed. The ore-body extends over a surface area of 40,000 square feet and has an average vertical extent of about 5 feet.

The copper minerals, chalcocite, malachite and azurite, with subordinate chrysocolla, occur in a weathered trachyte, which has been brecciated in some places. Thin beds of siltstone are intercalated in the trachyte. The paragenesis of the ore minerals appears to be chalcocite first and carbonate minerals later.

Twelve pits and five shafts are visible, but only one shaft and two pits give good exposures of the host-rock, structure and ore. All workings over 15 to 20 feet deep contained water and were inaccessible during the inspection.

The shaft that provides good exposures is covered and inaccessible below 15 feet. A lode visible between 5 and 10 feet is controlled by the bedding and strikes 260 degrees and dips 5 degrees north. According to Mr.Masterton, the shaft is 60 feet deep and contains glauconite at a depth of 50 feet. Post-ore fractures strike 025 degrees and are curved and irregular, with dips ranging from flat-lying to 85 degrees west.

In one of the pits the lode again follows the bedding which strikes 250 degrees and dips 20 degrees north. The lode is 5 feet thick. Malachite is visible on all walls. The grade is not known, but Mr.Masterton claims it can be up-graded to 27 percent copper by hand-picking. In another pit on the east side of the shaft the lode also appears to be controlled by the bedding which strikes 355 degrees and dips 10 degrees west. The pit is 12 feet deep and is mineralized from top to bottom. Fractures strike parallel to the strata in the country rock, but dip 30 degrees west.

A study of previous reports shows that the majority of assay values, obtained from pits and shafts intersecting the surface lode, range from 2 percent to 10 percent copper. It is possible that there are barren patches within the ore-body. Assay values reported from the deeper inaccessible workings probably represent intersections of the workings with near-vertical mineralized fractures, and possibly, with other flat-lying ore-bodies of unknown extent. The highest assay values from the deeper levels - up to 50 percent copper - probably indicate small high-grade ore shoots.

AZURITE

This deposit was soil covered and did not crop out on the surface. Mr.Masterton claimed that it was found by knapping an isolated boulder.

The copper-bearing minerals are chalcocite, malachite, and azurite. Azurite was abundant in this deposit, hence the name. The ore minerals occur in a trachyte which appears to be overlain by a quartz sandstone, possibly the basal member of the Masterton Sandstone.

The workings consist of an open-cut 150 feet long and 30 feet wide at the surface. The open-cut is 10 feet deep. Masterton states that there were originally five shafts, one of which was put down 65 feet. He also reports that good ore was intersected near the base of this shaft.

The open-cut is partially filled by rubble and no structure is visible. However, the dimensions and orientation of the open-cut suggest a north-trending steeply dipping lode.

Mr.Masterton claims that the grade of ore was greater than 40per cent copper and that some ore was up to 60 percent copper after hand-picking. Soil conceals rocks and structure near the open-cut, and geophysical methods would be needed to test for repetitions.

PRINCE

The ore minerals are malachite with some chocolate and minor amounts of cuprite.

The workings, seven pits and two shallow shafts, extend over a surface area of 30,000 square feet. The ore-body does not crop out on the surface and laterite obscures lithology and structure near the mine.

The main shaft has been put down 20 feet through a lenticular ore-body, which is localized at the intersection of a fracture (striking 040 degrees and dipping 45 degrees north-west) and a flat-lying weathered fine grained volcanic rock. The ore-body has a maximum width of 3 feet and pinches out to the north-east.

The deposit appears to be of lower grade than the Redbank or Azurite. The mine was not being worked during the inspection. Ore was reported to assay 17 percent copper after hand-picking. Jensen (1940) reported an average grab-sample assay from the dumps of 14 percent copper, and sample assays, of 14 percent and 20 percent copper of two sections of a channel sample, "representing about 14 feet of the lode 4 to 5 feet below the surface."

BLACK CHARLIE

Malachite and dihydrite occur as nodules and as coatings on fracture surfaces. At the east end of the deposit a finely disseminated manganese mineral (pyrolusite?) was deposited after the malachite.

The Black Charlie workings consist of a line of shallow pits and costeans trending 020 degrees for 250 feet. The costeans and pits have been put down on a soil-covered flat. The deposit is so poorly exposed that its lateral extent under soil cover is unknown.

Jensen (1940), reports that a grab sample of the manganiferous copper-bearing ore assayed 6.8 percent copper and 1.3 percent manganese.

BLUFF

Weak showings of malachite are found coating the walls of thin fractures and surrounding thin (half inch wide) veinlets of chalcocite in trachyte which strikes 290 degrees and dips 5 degrees south. Other showings are found in amygdules in an amygdular trachyte. Pyrolusite also occurs in small amounts.

Small amounts of kaolin and hematite are the only gangue minerals present.

The showings occur where thin open fractures which strike 345 degrees and dip vertically intersect a suitable host rock. Although the showings occur over a length of 800 feet the mineralization is so weak that the deposit does not warrant further investigation.

SEVEN MILE

Two pits three feet apart have been put down through a pebble conglomerate into the underlying trachyte.

The copper-bearing minerals are azurite, malachite and dihydrite. Mineralization is weak and the deposit does not warrant further investigation.

CONCLUSIONS AND RECOMMENDATIONS

The Redbank deposits are probably epigenetic epithermal deposits localised within the Gold Creek Volcanics by ill-defined, steeply dipping fractures and by flat-dipping favourable host-rocks. Both controls are important, but the deposits wherein favourable host rocks are the dominant control offer the best chance for an economic tonnage.

The most common secondary copper minerals are malachite, dihydrite, azurite and chrysocolla. The occurrence of chalcocite in the oxidized zone could be due to incomplete alteration to carbonate minerals after uplift and a fall in ground-water level.

The most important deposits on the field are the Redbank, Azurite and, to a lesser extent, the Prince. Any testing programme should also include the Black Charlie, because of its proximity to the Redbank and Prince, and because it has never been adequately exposed by surface workings.

The dolomitic rocks of the Wollogorang Formation, which probably occur below the deposits at a depth of about 200 feet offer a suitable target and should be included in any testing programme.

Although the grade of the deposits is encouraging, and the ore could be up-graded by beneficiation, the tonnage in the known ore-bodies is probably too low for economic exploitation. The main purpose of any testing programme should be to test for other orebodies beneath soil cover in the area containing the Redbank, Azurite, Prince and Black Charlie, and in the zones of oxidation and secondary enrichment.

The following test programme is suggested:

1. Geophysical survey of the area containing the Redbank, Azurite, Prince and Black Charlie.
2. Pitting, costeaning and waggon drilling as a follow-up to the geophysical survey.
3. Diamond drilling below the Redbank and Azurite deposits to intersect the zone of secondary enrichment and the favourable dolomite beds of the Wollogorang Formation.
4. Dewatering of the deepest shafts of the Redbank Mine and thorough exploration of this deposit by shaft sinking and drilling.

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APPENDIX I

PETROGRAPHIC NOTES ON HOST-ROCKS FROM THE REDBANK FIELD.

by

W.R. Morgan and W.B. Dallwitz.

9051 Redbank Mine

Hand Specimen

The rock is fine-grained and pink-coloured, and is rather friable and dusty. It has several thin, parallel ferruginous bands running through it.

Thin Section

The section consists of three parts:

i a lava
ii some sediment
iii another lava

The sediment lies between the two lavas. It contains the following minerals: quartz, plagioclase, microcline, sericite, with minor amounts of epidote, zircon and tourmaline. A lot of hydrated iron oxide grains and dust occur, with kaolin clay material. The sediment layer is 20 mm. thick.

The texture of the sediment is fine-grained, with sparse medium grains (0.032 mm. to 0.13 mm. in size), and is inequigranular. The grains are subangular. Some grading of the sediment may be seen, in fact three graded series possibly occur, although this is not clear because of the amount of hydrated iron oxide, etc., obscuring the view. In the lowest of the three, which is relatively clear, although the sediment remains inequigranular all through, the larger grains decrease in size from base to top, i.e. from 0.112 mm. to 0.048 mm.

Felspar (acid plagioclase and microcline) occurs as lath-shaped grains of irregular orientation. Some grains are broken, or have rounded edges. Quartz is granular. Sericite occurs as small flakes in the groundmass, orientated parallel to the bedding. Some rather more coarse fragments occur containing very small laths of felspar showing a trachytic texture. Tourmaline occurs as subrounded grains, and zircon is prismatic. Epidote and red iron ore are granular. Above the lower graded series, alternating layers of dense ferruginous and kaolinitic material occur, each layer being 2 - 3 mm. thick, the layering being parallel to the bedding.

The lava lying at the base of the coarser part of the sediment, and therefore, probably, underneath it, consists of very small crystals of tabular felspar, whose refractive index is lower than Canada Balsam. A little carlsbad twinning can be seen. The felspar is biaxial negative, possibly with a small optic angle; these points show that it is orthoclase, possibly sanidine. Much fine hydrated iron oxide dust and kaolin exists in the groundmass in patches, increasing towards the junction with the sediment. The lava is a leucocratic sanidine trachyte. The actual junction with the sediment is obscured by the hydrated iron oxide dust and kaolin, but appears to be rather uneven.

The lava above the sediment again consists of small crystals of tabular felspar, which is porphyritic and spherulitic. There is no definite flow texture present. The phenocrysts consist of felspar which has a negative refringence, and a negative biaxial figure with a low optic angle, suggesting sanidine. The groundmass felspar is similar. Both groundmass and phenocryst sanidine are tabular, with rather crenulate margins. A cognate xenolith of a rock showing a very prominant trachytic texture occurs; it is probable that it is a fragment of early-crystallized material which has been broken off. Near the junction with the sediment, angular fragments of quartz, and microcline occur, probably xenocrysts derived from the sediment. Interstitially, and in minor veins, flakes of chlorite occur, which are pleochroic in very pale green, and have a very low birefringence, with parallel extinction and are length slow. A little zircon occurs. Irregularly shaped grains of leucoxene, which tend to be stained with hydrated iron oxide are present. Some leached pseudomorphs consisting of hydrated iron oxide of octahedral shape and with hollow centres are present. Some spherulites composed of felspar? occur. The refractive index is less than that of Canada balsam.

Dense patches of kaolinized material occur, often stained with hydrated iron oxide. The rock is trachyte.

The junction with the sediment is quite even, with few irregularities.

The thin section therefore shows two leucocratic sanidine trachyte lavas sandwiching a layer of sediment (ferruginous (silty) claystone and kaolinitic siltstone).

9052 Kaolinized and altered sanidine trachyte.
Azurite Mine, 70 foot shaft.

Hand Specimen

A fine to medium-grained pink coloured rock, very slightly friable, and breaking with a sub-conchoidal fracture. It contains felspar and some irregular grains of quartz in a fine pink matrix.

Thin Section

Mineralogy: Felspar: Sanidine. R.I. less than that of Canada balsam; Twinning is indistinct. It has a biaxially negative figure, with a small optic angle. It is heavily kaolinized.

Quartz. A small amount is present.

Sericite. Finely crystalline masses occur which have a sub-prismatic shape, possibly pseudomorphing an original plagioclase. Sanidine and sericite make up 90% of the rock.

Epidote.

Leucoxene is stained with hydrated iron oxide. It occurs either as rather large (0.22 mm) euhedral to anhedral crystal shapes, or as small (0.064 mm.) subhedral to euhedral pseudomorphs.

The larger areas of leucoxene appear to be intergrown with epidote. Running through the grains are lines along which iron oxide has been more concentrated. These lines, in "rectangular" shaped grains run parallel to the larger sides. In other grains, the shape resembles amphibole (basal section). One such grain showed two directions of lines of iron oxide concentration crossing at approximately 124-6, suggesting, again, an amphibole origin. Others show similarities to pyroxene basal sections.

The smaller grains are six-sided or four-sided in the thin section and it seems likely that they represent altered magnetite.

Texture

Holocrystalline, fine-grained, porphyritic, with a hypidiomorphic fabric. The felspar tabulae in the groundmass show crenulate margins. Also in the groundmass irregular grains of hydrated iron oxide occur. The "phenocrysts" consist of hydrated iron oxide showing the characteristics described above.

The rock is probably an altered trachyte. However, it does not show the typical trachytic texture.

9053A Leucocratic trachyte. Azurite Mine.

Hand Specimen

The rock is fine to medium grained, porphyritic and vesicular. The phenocrysts appear to be tabular felspars. The groundmass consists of pink-coloured felspar. A small amount of green copper mineral is present, occupying some of the vesicles. This was shown by chemical test to be malachite with a trace of dihydrite.

Thin Section

Mineralogy: Felspar. The refractive index is lower than that of Canada balsam in the groundmass and phenocrysts. A little lamellar twinning is seen in the groundmass felspar, but none in the phenocrysts. A biaxial (?) negative interference figure with a 2V about 80° was seen in several phenocrysts, showing a composition of orthoclase. Groundmass felspar is often completely altered to Kaolin in irregular areas with only slight sericitization. Phenocryst felspars are patchily kaolinized, forming dense areas, and may also be strongly sericitized. Orthoclase comprises 95% of the rock.

Hydrated iron oxide occurs as grains, or intergranular dust.

Zircon is uniaxial positive, with high relief and birefringence.

Texture.

Holocrystalline, fine-grained, hypidiomorphic and porphyritic. A pilotaxitic fabric is present, as are some spherulites. The groundmass felspar is tabular to granular in shape, with slightly crenulate margins. The spherulites also consist of felspar. Small anhedral grains of hydrated iron oxide occur which do not appear to pseudomorph aby pre-existing mineral.

The phenocrysts consist of partly kaolinized and sericitized orthoclase, having a tabular shape with rather rounded edges, as though very slightly resorbed.

The rock thus appears to be a leucocratic trachyte which has been rather strongly kaolinized and, in places sericitized. The hydrated iron oxide grains may replace pre-existing ferromagnesian minerals, but no "tell-tale shapes" or pseudo-cleavage lines are present to give any information on this.

9053B. Trachyte. Azurite Mine.

Hand Specimen.

The rock is medium-grained, slightly porphyritic, with a very slightly vesicular groundmass. The rock consists of pink-cream felspars with some dark mineral. Some green copper mineral occurs along a thin joint vein, and is disseminated in the groundmass. It is shown by chemical test to be malachite with a trace of dihydrite.

Thin Section

Mineralogy: Sanidine. The refractive index is less than that of Canada balsam. A biaxial negative figure with a small optic angle was obtained. Some carlsbad twinning may be seen.

Albite. Again, the refractive index is less than of Canada balsam. A biaxial positive figure was obtained. Albite and carlsbad twinning may be seen.

Albite and sanidine make up 55% of the rock.

Leucoxene is commonly iron-stained.

Chlorite. Very pale green, almost isotropic, although an anomalous blue polarization colour is present, suggesting that the mineral is penninite. Chlorite makes up 40% of the rock.

Kaolin and sericite are present as alteration products of felspar. Granular epidote is also present.

Texture.

Holocrystalline, fine-grained, hypidiomorphic and porphyritic, with some slight radial arrangement of the felspars. Albite is subhedral and tabular, and is partly kaolinized and sericitized. Sanidine also tends to be tabular. The margins of both felspars tend to crenulate. Chlorite is interstitial to felspar, and shows no trace of pseudomorphing any pre-existing mineral, though its relationship to the felspar does suggest an ophitic intergrowth texture.

Leucoxene forms euhedral to subhedral, often skeletal grains, as though it pseudomorphs ilmenite. Sphene forms small rounded grains.

A few phenocrysts formed of long, tabular crystals of felspar showing negative refringence and a negative interference figure, are present.

The rock, on its present mineralogy, is possibly an albitized, chloritized, sericitized, and kaolinized dolerite.

9054. Cupiferous Quartzite. Azurite Mine.

Hand Specimen

A medium-grained, cream-coloured friable sandstone containing mostly quartz grains, with an interstitial green copper mineral irregularly desseminated through the rock. This mineral was shown by chemical test to be malachite.

Thin Section

Mineralogy:

Quartz: The dominant mineral

Tourmaline: A few very well rounded grains.

Malachite: is present as a fine, fibrous material. It is pleochroic from very light green to green. The extinction of the fibres is 20°.

Sericite: A few flakes, occupying an interstitial position, and seemingly "corroding" the quartz grains.

Biotite: One flake was observed enclosed within a quartz grain.

Hydrated iron oxide: Occurs as interstitial dust, or cement. Opaque dust often occurs within quartz grains as a layer a short distance from the edges of these grains, suggesting silicification of the sandstone, with silica being added to the grains in the interstices "drowning" the iron oxide dust.

Texture

Medium-grained (0.1 to 0.4 mm), inequigranular, with sub-rounded to sub-angular grains. Silicification has taken place, enlarging quartz grains, and making them appear more angular than they actually are. Some iron oxide is present as a cement. Malachite is present, occupying quite large interstitial positions within certain areas, and giving a patchy appearance, as though silicification was not complete and silica had not filled all the available space.

9058. Trachyte. Bluff Prospect.

Hand Specimen

A fine to medium-grained pink vesicular rock containing tabular felspar. A green copper mineral is disseminated in small patches in the groundmass, and is present in some vesicles in the rock, together with a little quartz.

Thin Section

Mineralogy: Sanidine has a refractive index less than that of Canada balsam, while it gives a negative figure with a very small optic angle.

Albite again has negative refringence, but it gives a biaxially positive figure with a large optic angle. Both felspars have carlsbad twinning, while there is a suggestion of albite twinning in some crystals. It is not possible to estimate the relative proportions of sanidine and albite.

Alteration minerals: Hydrated iron oxide, leucoxene, kaolin, sericite.

Secondary minerals : Quartz and dihydrite. The latter mineral is fibrous in acicular prisms formed radially. It is biaxial negative with a 2V=C.45°.

A yellow mineral occurs in small clots and veinlets. It has radially arranged fibres, and is faintly pleochroic in yellow. Refractive index is greater than that of Canada balsam, but less than that of dihydrite. It has parallel extinction, with a birefringence of 0.030, and is length slow. It is possibly nontronite. The mineral is sometimes intergrown with hydrated iron oxide.

Texture

Holocrystalline, hypidiomorphic, and fine-grained, showing a variolitic structure. The rock is inequigranular.

Felspar occurs as tabular laths with slightly crenulate margins; between the laths is a microcrystalline mass of granular grains apparently formed of felspar - they have negative refringence, and appear to have been kaolinized. Hydrated iron oxide occurs as rather interstitial grains. Patches of hydrated iron oxide dust are also present. Leucoxene is probably altered from ilmenite.

Some quartz occurs in the groundmass occupying exceedingly irregular openings and veins; it is thus thought to be secondary. Dihydrite occurs in a similar way.

The rock appears to be a trachyte, whose ferromagnesian minerals have been entirely decomposed.

9059. Sanidine trachyte. Bluf Prospect

Hand Specimen

The rock is fine-grained, and pink containing tabular felspar and green chlorite. It is porphyritic.

Thin Section

Felspar: Refractive index is lower than that of Canada balsam. Simple carlsbad twinning is present, no multiple twinning seen. Biaxial negative, with a small optic angle. All these points, and especially the last one, suggest sanidine. Sanidine is partly kaolinized, and slightly sericitized. It comprises 75% of the rock.

Chlorite: Faint green colour, slightly pleochroic, with parallel extinction. Birefringence = 0.009.

Apatite occurs as long acicular crystals enclosed within sanidine.

Iron-stained leucoxene occurs as subhedral grains, probably derived from magnetite or ilmenite, and as irregular grains associated with, and enclosed by, chlorite. Hydrated iron oxide dust occurs in the groundmass.

Some subhedral zircon is present.

Texture

Holocrystalline, fine-grained, hypidiomorphic and sparsely porphyritic. In the groundmass sanidine forms subhedral laths with crenulate margins. Chlorite is in patches interstitial to sanidine, and forms foliated masses, often associated with irregular masses of leucoxene or dusty hydrated iron oxide. Zircon occurs in very small amounts as subrounded, tabular crystals. Apatite is acicular and enclosed by felspar.

The phenocrysts consist of sanidine. They form subhedral, tabular crystals which are apparently partly resorbed. The phenocrysts show some kaolinization, and often are strongly sericitized in patches.

On the composition of the felspar, the rock is termed a sanidine trachyte.

9060. Cupriferous Trachyte. Black Charlie.

Hand Specimen

Fine-grained, pink rock containing possible felspar, a black mineral, and some chlorite. A green mineral is present in the veins, and in irregular masses in the groundmass. Chemical test showed that the mineral contained copper, and was a phosphate; hence it is probable that the mineral is dihydrite.

Thin Section

Mineralogy. Felspar: The refractive index of felspar throughout the rock is less than that of Canada balsam. Some crystals give a negative interference figure with a small optic angle, and others show biaxially positive figures with a large 2V. This suggests that both sanidine and albite are present. Felspar makes up 65% of the rock.

Chlorite	)
Ilmenite	) 5%
Hydrated iron oxide	)
Leucoxene	).

Nontronite(?) occurs with chlorite. Fine-grained, fibrous flakes, like chlorite, only pleochroic in light brown. R.I. approximately 1.65. Length slow. Chlorite and nontronite comprise 30% of the rock.

Texture

Fine-grained, hollocrystalline, equigranular hypidiomorphic. Felspar forms subhedral, rather tabular crystals with crenulate margins. Some alteration to kaolin has taken place, along the old twin places. Chlorite, sometimes intergrown with nontronite(?) forms minutely lamellar intergrowths in patchy areas interstitial to the felspar. Hydrated iron oxide forms subhedral and irregular grains, and has euhedral faces towards felspar.

The rock is cupriferous trachyte.

9065A. Cupriferous sodic trachyte. Seven Mile.

Hand Specimen

The rock is a fine-grained, pink-coloured, vesicular and amygdaloid rock. The vesicles are either empty or filled with a green copper mineral. The amygdales are filled with a very light greenish-white mineral, probably chlorite.

Thin Section

The felspar has a refractive index less than that of Canada balsam, and is biaxial positive, with a large optic angle. Some indistinct albite twinning is present. The mineral is albite. Albite makes up 80 - 90% of the rock.

Apatite: Prismatic, with parallel extinction, weak birefringence and negative elongation. The relief is fairly high.

The amygdales are filled with an unknown minutely lamellar, colourless mineral whose refractive index is higher than that of Canada balsam. Relief is low, and the mineral is very weakly birefringent. It has parallel extinction.

Hydrated iron oxide.
Leucoxene
Dihydrite and malachite
Dense clouds of kaolin are present in patches.

Texture

Holocrystalline, fine-grained, equigranular and idiomorphic. Amygdules and vesicles are present. The fabric is pilotaxitic and sub-variolitic. Albite forms small euhedral laths and is slightly kaolinized away from the kaolin clouds. Apatite forms numerous tiny euhedral prismatic grains, usually enclosed by albite. Hydrated iron oxide forms misty patches around the vesicules and amygdales. Malachite and dihydrite fill the vesicules, and are sometimes intergrown, or stained, with hydrated iron oxide.

The rock appears to be a sodic trachyte.

9065B. Conglomerate. Seven Mile.

Hand Specimen

A pink inequigranular rock composed of sub-rounded pebbles. The greater number of the pebbles consists of a pink igneous rock which is very fine-grained, and apparently quartzo-felspathic. Phenocrysts of tabular felspar are present. Other smaller grains are present consisting of a deep pink, microcrystalline material. A few pale green grains occur. Numerous cavities appear between the pebbles, some of which are drusy with crystals of quartz.

Thin Section

In general texture the rock is coarsely clastic with grains up to 5 mm in size as seen in the section. The grains are inequigranular and subrounded. The intergranular material consists of angular grains of quartz and chloritized ferromagnesian mineral. Some hydrated iron oxide is present.

The fragments seen in section were:-

(i) Fine grained aplite, consisting of quartz with sutured margins partially poikilitic about subhedral, slightly tabular felspar.

(ii) A quartz siltstone consisting subangular grains of quartz with a few flakes of sericite. Intergranular hydrated iron oxide is present, often forming thick rims about the quartz grains. This rock is present as one grain only.

(iii) One pebble consisting of a very fine-grained, holocrystalline, porphyritic rhyolite. The groundmass consists of an intergrowth of quartz and felspar, with patches of haematite dust. The phenocrysts are mostly of partially resorbed crystals of quartz, with one or two of orthoclase. Apatite is included in the quartz.

(iv) The greatest number of grains and pebbles in the rock consist of a fine-grained and sparsely porphyritic granophyre. The phenocrysts consist of partially resorbed crystals of quartz and orthoclase. The groundmass is micrographic, and consists of an intergrowth of quartz and felspar, possibly orthoclase. Quartz, in the intergrowth, forms a series of "plates" enclosing numerous laths of the felspar. The felspar laths are often radially arranged, and sometimes have a spherulite at the centre of a radiating set. Sometimes the density of felspar laths is so great that the intervening quartz may hardly be seen.

Pebbles showing differing grain sizes of this texture and mineralogy are present, from very fine-grained to nearly medium-grained, indicating that the pebbles were from different parts of the intrusion or flow to which they belong, i.e., chilled margin or centre.

(v) One small grain consists almost entirely of thin laths of felspar showing a pronounced trachyte texture. Hydrated iron oxide dust is seen between the grains. The felspar has indistinct twinning, andits refractive index is lower than that of Canada balsam. It is biaxial negative and is, therefore, orthoclase. The fragment is trachyte.

(vi) One small pebble composed of angular quartz grains, with sutured margins, intermixed with tabular, untwinned felspar, all without any kind of igneous texture. The fragment is thus possibly a crystal tuff.

Groundmass:

The intergranular groundmass of the rock appears to vary from one part of the specimen to another. Two sections of this specimen were made. In one section the groundmass consisted of a microcrystalline mixture of minute quartz grains and hydrated iron oxide with some sericite flakes and a few isolated, rather more coarse grains of quartz. In the second section this groundmass grades into a siltstone of angular quartz grains showing sutured margins.

The drusy cavities mentioned in the hand specimen description are shown by microscopic identification to contain quartz.

Comment:

Some interesting points arise from this specimen.

(i) The tuff was consolidated at the time of formation of this rock.

(ii) The pebbles in hand specimen and thin section are seen to be subrounded, although they are of low sphericity.

The significance of this conglomerate is that it shows a possible stratigraphical break in the local succession, during which time the pyroclastic rocks were able to harden. That the pebbles are subrounded suggests that they are water-worn.

9070. Greywacke. Black Charlie.

Hand Specimen

Fine to medium-grained, felspathic sandstone. It is rather ferruginous, with some grains composed of hydrated iron oxide. A green copper mineral, which is shown by chemical test to be dihydrite, occurs interstitially.

Thin section

Mineralogy: Microcline perthite. Identified by its familiar form of repeated twinning on the albite and pericline laws. Biaxial negative.

Albite: Refractive index lower than Canada balsam and a biaxial positive figure.

Quartz. Is present in minor quantities.

Hydrated iron oxide.

Muscovite

Nontronite (?) A small grain is present containing numerous pale green-brown lamellae showing parallel extinction and fairly strong birefringence.

Texture

Clay to fine-grained sand grain sizes, exceedingly inequigranular in fabric. The larger grains are sub-angular to sub-rounded. Microcline-perthite forms "square-shaped" grains, and albite tends to form tabular grains with rounded corners. Both felspars are often stained with iron oxide. Hydrated iron oxide forms rounded grains up to 0.15 mm. in diameter, comparable with the felspar grains in size; it also forms irregular grains which enclose smaller felspar grains, pointing to a secondary origin for these. Muscovite forms numerous small flakes with no definite orientation. The nontronite (?) grain is sub-rounded.

Small fragments of trachyte-looking rocks are present, composed of long, tabular felspar crystals with a flow orientation, all enclosed in hydrated iron oxide.

Quartz occurs as sub-angular grains.

The fine-grained groundmass is almost cryptocrystalline. It appears to consist of greenish chloritic material, possibly mixed with felspar and sericite. In patches hydrated iron oxide dust is present.

The rock appears to be a greywacke. It is possible also that it is a water sorted tuff, whose conposition could well be that of greywacke.

9073. Trachyte. Redbank Field, Bluff.

Hand Specimen

A fine-grained, amygdaloidal lava, with a green ferro-magnesian mineral occupying the amygdales. The hand specimen is highly amygdaloidal in one half; amygdales are absent in the other. A green copper mineral, shown by chemical test to be malachite, is present in thin veins and one or two vesicles.

Thin Section

Mineralogy: Felspar: Refractive index less than that of Canada balsma. Biaxially negative, with a large optic angle. It is therefore orthoclase. It is uniformly altered to kaolin, with minor amounts of sericitization, though a few crystals are wholly altered to that mineral. Orthoclase comprises 75% of the rock.

Nontronite(?). Occurs as pseudomorphs after the original ferromagnesian minerals in the groundmass. Also as fibrous masses in the amygdales. RI: = 1.587, = 1.612. Birefringence = 0.025. Biaxially negative. Nontronite makes up 20% of the rock.

Epidote.

Chlorite.

Hydrated iron oxide.

Apatite

Zeolite: negative refringence, parallel extinction, small 2V, positive.

Texture:

Holocrystalline and fine-grained hypidiomorphic, sparsely porphyritic. The rock has a trachyte texture.

In the groundmass orthoclase occurs in two ways: Firstly as small euhedral laths, and secondly as anhedral, poikilitic grains enclosing the first. Nontronite occurs in the groundmass as prismatic crystals, probably replacing hornblende; it also occurs interstitially. Epidote is present as minute granules enclosed by the interstitial nontronite. Hydrated iron oxide occurs as small anhedral granules. Apatite forms acicular prisms.

The phenocrysts, where present, consist of euhedral, tabular orthoclase.

A few irregular masses in the groundmass are exposed of fibrous zeolite which may possibly replace the porphyritic orthoclase.

The amygdales are filled with fibrous nontronite; the fibres radiate from a number of points on the edge of the openings.

Another section was cut in the part of the specimen without amygdales. This rock shows rather similar mineralogical and textural characteristics, except that it is badly kaolinized. Some veining of chlorite is present. Malachite occurs in the groundmass close to the veining and also as thin bands within the vein, along with the chlorite.

REMARKS

1. All the trachytes have their felspars partly kaolinized, while some are slightly sericitized. Specimens 9053A and 9065A have hydrated iron oxide which may be an alteration product of their ferro-magnesian content. The remainder have their ferro-magnesian minerals altered to chlorite or nontronite, or both.

2. The conglomerate (9065B) is composed mostly of pebbles of a granophyre, with some other constituents, i.e. aplite, siltstone, rhyolite, trachyte and crystal tuff. The fragments may, or may not, belong to this volcanic sequence.

3. (i) Kaolinization and sericitization form from low temperature activity of neutral and alkaline solutions respectively. Both may result from weathering or low temperature late liquids, or the action of mineralizing fluids. Turner and Verhoogen (Igneous and Metamorphic Petrology, pp.494-5), in summarizing relevant literature, suggest that sericite is more likely to result from hydrothermal action than weathering.

(ii) The formation of chlorite and nontronite, by replacement of the ferromagnesian minerals, shows deuteric action of the late liquids. The formation of hydrated iron oxide may show a continuation of this action at lower temperatures, or even the action of weathering solutions. Weathering is probably the cause of the spreading out of the hydrated iron oxide dust in the groundmass of these rocks.

4. Conclusion. All the volcanics retain their original igneous textures. Hence the alteration does not result from contact or regional metamorphism.

According to field evidence there is no intrusive rock near the locality of the specimens whose late liquids would metasomatize them. Hence, itis suggested on present evidence that the alteration results from hydrothermal activity.

This hydrothermal activity may be either a late-magmatic effect or may be associated with copper mineralization in the area. According to the field evidence, as we understand it, alteration is, in general, most intense in the area of mineralization, so it is likely that fluids active at the time of introduction of copper are responsible for at least some of the changes noted. Nevertheless, a far more detailed study would be necessary to determine the possible extent and degree of auto-metamorphic effects. The effects of hydrothermal alteration have, of course, been obscured by the effects of weathering.

Copper Minerals:

Malachite and dihydrite occur in these rocks; they were determined by optical properties and chemical test. No copper sulphide was observed. The copper minerals present occur in veins, in vesicles and in small intergranular patches. No evidence is present to show whether or not the copper results from sulphides formed during the alteration of the rocks.

APPENDIX 2.

PRODUCTION FIGURES FOR THE REDBANK FIELD

(1) Date of Shipment		Tons Ore Shipped	Per cent Copper Content
June	1916	3	39.90
October	1916	4	37.50
May	1917	3.5	31.92
March	1918	8	31.02
June	1918	1	31.63
June	"	17.5	30.23
August	"	21.75	30.00
May	1920	2.5	44.96
May	"	2.5	39.60
July	1921	12	31.2
July	"	4.5	40.0
July	"	2.5	33.5
November	1921	5.5	31.9
February	1931	5.25	37.6
February	"	3.25	39.2
February	"	1.8	36.3
February	"	3.9	39.6
July	1935	5.05	28.4
July	"	2.05	28.2
July	1935	28	35.4
July	"	11	26.7
July	"	5	32.0
July	"	5	35.8
July	"	1.6	40.0
July	"	2.2	48.3
July	1936	3	36.2
July	"	3	30.7
July	"	24	35.7
September	1937	25	44.7
September	"	5.15	39.3
September	"	9.05	28.2
September	"	3.06	27.6
September	"	1.9	28.1
September	"	2.45	25.4
September	"	34.65	42.0
September	"	4.05	45.2
September	"	4.4	52.3
September	"	18.95	47.6
September	"	6.35	39.8
September	"	4.2	38.0
September	"	0.6	46.8
September	"	3.025	34.0
December	"	35.9241	40.57
December	"	8.7701	35.65
December	"	3.7192	31.72
December	"	13.7924	35.90
December	"	5.4196	36.47
December	"	6.0299	28.08
December	"	4.2134	29.53
February	1939	15.2625	39.92
February	"	24.9937	38.00
February	"	53.0312	39.19
February	"	6.6625	45.82

(2)

Date of Smelter Return	Tons of Ore Shipped	Percentage of Copper
Shipped during 1939	56.00	30.00 ±
Shipped during 1940	95.00	28.00 ±
12. 6. 1945	6.56	40.60
12. 6. 1945	24.61	30.17
13. 6. 1945	19.43	29.96
13. 5. 1946	41.86	23.34
13. 5. 1946	18.23	26.50
23. 6. 1948	48.62	29.06
23. 6. 1948	9.17	31.02
23. 6. 1948	12.15	22.41
23. 5. 1948	6.37	21.23

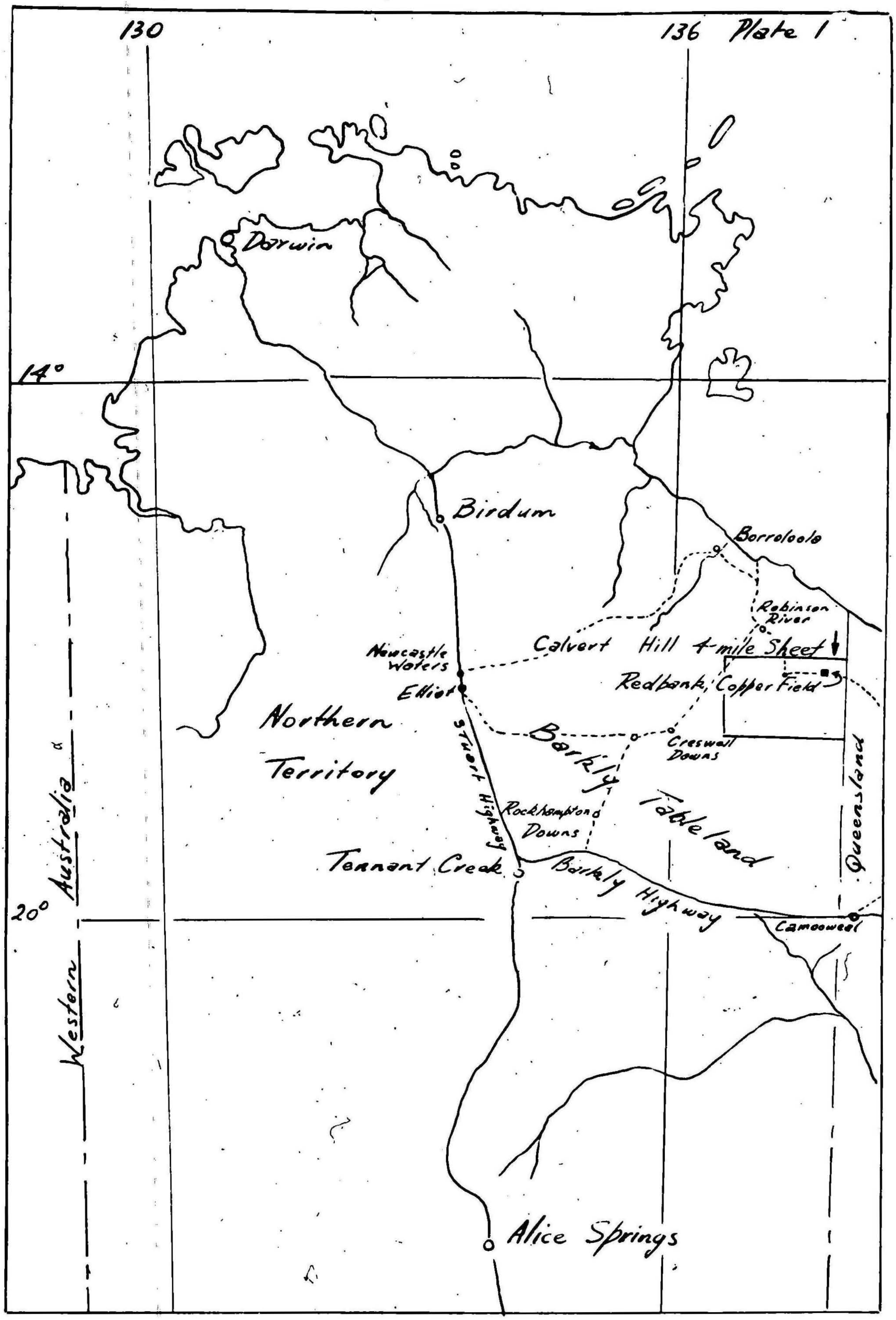
(3)

Date		Ore Purchase Note No.	Dry Weight	Copper Per cent	Silver ozs.
January	1950		14.9875		
January	1950		7.4607	24.3	
January	1950		14.7065	27.9	
March	1950		7.8054	21.5	
March	1950		12.4134	21.5	
March	""		17.2522	19.9	
July	"		3.423	21.5	
July	"		6.0563	19.5	
Q.E. June	1951		20.55	21.1	
Q.E. June	"		5.8	19.8	
Q.E. June	"		6.8	22.5	
September	1952		53.21		
December	"		2.88		
February	1955	6588	7.2464	27.87	0.17
February	"	6857	3.3006	32.01	0.29
March	"		1.14	26.57	
March	"		4.71	22.05	
March	"		3.31	28.35	
September	"	7346	4.9182	26.45	0.29
Q.E. March	1956		2.333	26.5	
September	"		6.4286	30.1	
Q.E. December	"		10.5202	30.99	
Q.E. December	"		5.0465	28.89	
March	1957		2.2422	27.81	
Q.E. September	"		1.8	29.97	
Q.E. September	"		3.5	27.57	

(1) Figures from Jensen, H.I. (1940).
(2) Figures from Benedict and King (1948)
(3) Figures from Mines Branch, Darwin (December, 1957).

No reliable computation of tonnage is possible for all figures given because those from Mines Branch, Darwin, refer to dry weight. Benedict and King (1948) state that "To June 1948, the ore shipped from the area amounted to 882.8 tons of 33.1% copper. Silver averages about one ounce to the ton. Gold is negligible". Their estimate of production from individual deposits to the end of 1940 is -

Deposit	Tons Shipped	Average% Cu.
Azurite	455	35.65
Redbank	155	34.2
Prince	85	29.0



Locality Map
Redbank Copper Field

Scale of Miles

100 0 100 200 300

True North

Plate 2.

Regional Geological Plan — Redbank Copper Field. N.T.

Scale
0 1 2 Miles

Reference

Cainozoic	C3	Soil
Mesozoic	M	Un-named Formation — Quartz sandstone & conglomerate
	~	Unconformity
Upper-Proterozoic	Rum	Masterton Sandstone
	Rug	Gold Creek Volcanics
	Ruh	Wollogorang Formation — Dolomite & impure sandstone. Constance Sandstone has lensed out in this area.
Igneous contact in places.	Rup	Peter's Creek Volcanics
	⚒	Copper-bearing Deposits
	◎	Algal fossils — Collenia-type

True North