JERVOIS RANGE COPPER-LEAD DEPOSITS

NORTHERN TERRITORY

by

W.A. Robertson

RECORDS 1959/103

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SUMMARY

Mapping of the Jervois Range copper-lead deposits, which occur on leases held by Mr. K. Johannsen, situated 230 miles east-north-east of Alice Springs, is described. Plane-tabling of the deposits indicates that the better copper lodes are associated with weak shears in granulite, whereas the high-grade lead lodes are confined to limy bands in the metamorphic succession. Silver, zinc, and tungsten are sporadically associated with both copper and lead.

Pits dug since Blanchard mapped and sampled the deposits in 1939 prove that the copper values in the lodes are maintained with increase of depth better than anticipated. Sulphide mineralization was seen in the underground workings which were found to be totally inadequate to estimate the grade of the primary mineralization. Detailed mapping of 12 square miles surrounding the deposits revealed a belt of sporadic mineralization with an average width of 2,000 feet and a strike length of 6½ miles. The mineralization is predominantly contained in garnetiferous granulite and "skarn"-like lenses. Quartz-tourmaline veins, pegmatites, and small basic intrusive rocks are common in the area.

Mapping and sampling results show that there is sufficient carbonate ore to maintain Johannsen's leaching plant in operation for many years. A drilling programme is set out designed to test the primary copper and lead mineralization beneath the best surface showings.

INTRODUCTION

LOCATION AND ACCESS

The Jervois Range copper and lead lodes are situated on the plain about a mile east of the Jervois Range scarp (Map reference: south-east quadrant of the Huckitta 4-mile Sheet, F53/11), at Lat. 22°40'S, Long. 136°15'E. The locality is approximately 170 air miles east-north-east from Alice Springs and 250 air miles from Mt. Isa. The easiest access to it is by vehicle from Alice Springs. The road, which is the main one into Queensland from this area, leaves the Stuart Highway 36 miles north of Alice Springs and passes Mt. Riddick Station, the Harts Range Police Depot, and crosses the Plenty River at Red Tank, 60 miles west of Jervois Range. The total road distance from Alice Springs is 230 miles. The track is graded, much of it passing over granitic soil which may become impassable for a few days in some places, after heavy rain. Alternative access is from Mt. Isa via Urandangi and Tobermory along a graded road for a distance of about 300 miles. The section from Urandangi to Tobermory, across the Georgina River, is rough and impassable during most of the wet season. These two access routes have been much improved by K. Johannsen, and all other routes are markedly inferior. Mt. Isa is 605 miles by rail from the port of Townsville. Alice Springs is 771 miles by rail from Port Augusta.

An air service by Connellan Airways from Alice Springs makes fortnightly landings at the airstrip near the deposits.

The Royal Flying Doctor Service, operating from Alice Springs, provides medical attention, and emergency cases can be flown to the Alice Springs hospital within three hours. This service also provides telegraphic communications through its radio network.

HISTORY

The early history of the leases is described in a report by Blanchard (1939). The copper-stained outcrops of the Jervois Range had long been known to the aborigines, but it was not until July 1929 that they were investigated by Messrs. Hanlon and Mudge, while on a droving expedition. Mudge found the southern showing now known as the Killeen or Mudge-Killeen groups (which include the Bellbird): Hanlon found the northern showings, known as the Hanlon or Reward group. Subsequently, surface specimens of high grade copper carbonate and lead ores displayed at Alice Springs and elsewhere caused an immediate rush, and 40 leases were pegged. Only minor gouging was done, but examinations were made by several mining groups. C.G. Gibson, who reported for Broken Hill interests and S.R.L. Shepherd, who reported for Brisbane clients, were among those who visited the field before the end of 1929. These reports are not now available but are said to have been adverse. Nevertheless a company, Hanlon's Reward (Jervois Range) Limited, was formed in Sydney to work the deposits; and in 1930 it put down the Reward, Marshall and Green Parrot shafts to depths of almost 100 feet, with short crosscuts from the bottom of each. The drop in metal prices the following year caused the company to abandon the leases.

Hossfeld (1931), then Government Geologist for South Australia, visited the area before the leases were abandoned and reported for the Federal Government. He sent 39 samples from various parts of the field for analysis, but did not record sample widths in his report.

During 1932 Killeen tried unsuccessfully to interest Mount Isa Mines Limited in his own and Hanlon's group of leases. There is no record of further activity until the end of 1937 or early 1938 when Randolph Bedford acquired the leases under option and formed the Midland Metals Prospecting Company Limited. He was not successful in raising capital but his representations to Mount Isa Mines Limited led to an inspection by R. Blanchard (1939) on behalf of Anglo-Queensland Mining Pty. Ltd., an associated company. Blanchard carried out surface and underground sampling in addition to geological mapping.

From the time of Blanchard's visit the deposits lay idle until 1948, when several of them were worked on tribute, and small parcels of copper ore were taken to Mount Isa and sold. K. Johannsen, the present owner, carted the ore to Mt. Isa, and bought up the leases as they became available. He continued to win small quantities of copper ore, mainly from the Bellbird, for sale to Mt. Isa until 1956.

When Mt. Isa Mines Ltd. restricted their purchases of outside ore Johannsen began the erection of a copper leaching plant near his mine designed to produce one ton per day of copper sulphate from the carbonate ore for sale to fertilizer manufacturers. This plant is almost complete and should go into full scale copper sulphate production shortly. The plant has a capacity of 7 tons of ore per day. It is understood that Johannsen is starting to build a larger one. As the process can utilize carbonate ore containing as little as 2 percent copper, it is not expected that any difficulty will be met in supplying carbonate ore from nearby deposits for many years.

During the present investigations, the author under the supervision of E. K. Carter, spent five months in this area. He completed plane-table surveys of the 6 main lodes at a scale of 1" : 40' from which Plates 2 to 7 were drawn, and mapped the

mine workings, where accessible. He also mapped in outcrop detail an area of about 12 square miles surrounding the mineralization, using enlarged air photos at a scale of about 1":1,150'. Plate 1 is the resultant map.

TENURE

Six leases are at present current. They are the Bellbird, Green Hoard, Green Parrot, Attutra, Hanlon's Extended, and Hanlon's Reward; all are held by K. G. Johannsen.

The history of the leases is shown in Table 1.

WATER SUPPLY

Drainage is by creeks which flow east from the Jervois Ranges for short periods after heavy rain and debouch onto the plains or into Unkah Creek, a larger stream which loses its identity in sandy soil 7 miles east of the Reward. In Unkah Creek between the Reward and Attutra Lodes, and for about 1½ miles upstream, waterholes have water for five to ten weeks after the creek flows. A deeper hole, about 5 miles downstream from the Reward, has water for about eight months after rain.

Johannsen has sunk two bores, both of which yield water that is mineralized but fit to drink. The more plentiful supply comes from the bore on the west bank of Unkah Creek, in the gap between the Attutra and Reward Lodes: it is 187 feet deep and has produced as required 600 gallons per hour through an extended drought. The bores supply ample water for present requirements and could support a drilling programme. Dam sites suitable for water supply for development are available on creeks draining the Jervois Ranges; probably dams of the Mexican type using sand as the reservoir would be best suited to the district owing to the very high evaporation rate.

The climate is the arid sub-tropical continental type, with an unreliable rainfall which falls mainly during the summer and ranges from 4 to 12 inches annually. The lack of moisture limits growth mainly to stunted gidgea and mulga, with spinifex and some short grasses, except along the creeks, where eucalypts grow. The surrounding country supports cattle and goats with the aid of bore water.

REGIONAL GEOLOGY

The mineralization is exposed along a ridge, composed of rocks of the Archaean Arunta Complex, which rises from 25 to 200 feet above the surrounding plain. The ridge strikes north at its northern end, where it passes under the scarp formed by the unconformably overlying Upper Proterozoic Mopunga Group. At its southern end the ridge is hooked to the west in the form of a letter J. The important leases and strongest mineralization occupy the middle of the upright, and the south-western tip of the J (see Plate 1).

The country rocks containing the deposits consist in this area predominantly of quartz-mica schist. South of the area, granite crops out in small knolls through the alluvium about 2½ miles south of the Bellbird. To the west the Arunta Complex is overlain by rocks of the Mopunga Group (see Plate 1). North and east the dominant rock types in the Arunta Complex are granite gneiss and basic intrusives; and in the east some small hematite bodies are associated with the intrusives.

TABLE 1.

Name	Lease No.	Acreage	Held by	From	To	Expiry Date	Remarks
BELLBIRD	ML 60H	40	Crosbie, T.B., & Gregory, E.	17.9.46	3.8.49		Taken out in 1946 by Crosbie and Gregory as Prospecting Mineral Lease Area No. 22A.
			Crosbie, T.B., & Campbell, C.J.	3.8.49	28.11.49		
			Campbell, C.J., & Crosbie, T.B., and Erwin, W.D.	28.11.49	14.12.49		
			Crosbie, T.B., Erwin, W.D., and Northern Drillers Pty. Ltd.	28.3.51	2.7.52		
			Erwin, W.D., Northern Drillers Pty. Ltd., & Castagna, B.	2.7.52	21.6.55		
			Johannsen, K.G. & Northern Drillers Pty. Ltd.	21.6.55	20.12.56		
			Johannsen, K.G.	20.12.56		23.10.67	
GREEN BOARD	ML 173H	20	Wright, C.A., & Sharp, J.W.	1.6.49	22.12.49		
			Wright, C.A.	22.12.49	3.2.50		
			Johannsen, K.G.	3.2.50		10.7.70	
GREEN PARROT	ML 185H	40	Shanasy, D.A., & Crosbie, T.B.	30.8.45	30.8.49		Formerly ML55H (30.8.45-23.8.50), and before that it was Prospecting Mineral Lease 586.
			Johannsen, K.G.	25.9.49		29.10.71	
ATTUTRA	ML 186H	40	Crosbie, T.B.	13.8.45	23.8.50		Covers part of former Prospecting Mining Lease 585. Pegged by Crosbie as ML54H but forfeited for non-compliance of labour conditions. It includes Marshall & Attutra Lodes of Plate 3.
			Johannsen, K.G.	25.9.50		29.10.71	
HANLON'S EXTENDED	ML 263H	8	Johannsen, K.G.	23.5.55		29.5.76	Covers a portion of lease 152A.
HANLON'S REWARD	ML 265H	20	Johannsen, K.G.	3.5.55		15.6.76	Covers portion of leases 152A and 585.

Copper shows in the Bonya Creek area, 10 to 20 miles south-west, appear to be associated with basic intrusive rocks. The Plenty River and Harts Range Mica Fields lie 50 to 100 miles south-west of the Jervois Range deposits.

Lenses of porphyroblastic cordierite and andalusite schist are numerous in the quartz-mica schist, but nowhere crop out over a length of more than a mile. The porphyroblastic schist weathers more readily than the quartz-mica schist. The lenses are commonly 50 feet, or less, wide. The porphyroblasts are ellipsoids in which the long axes range from $\frac{1}{2}$ to $1\frac{1}{2}$ inches, but square cross-sections have been noted. They appear to be mainly poikiloblastic cordierite and andalusite crystals. Smaller equidimensional garnet porphyroblasts are also common in some places.

Many small lenses from 1 to 30 feet wide and up to 300 feet long appear in the field to consist of metasomatized impure arenaceous limestones (in places these display typical limestone weathering and react with dilute hydrochloric acid). Eight thin sections cut from these rocks (numbers JHA 4, 7, 65, 67, 93, 106, 117C and 142; see Appendix 2) show the predominant minerals to be garnet, epidote, vesuvianite, diopside and magnetite. Among other minerals believed to indicate metasomatism were patches of zoned andalusite, fluorspar, magnetite, scheelite and galena; calcite occurred in minor but widely varying amounts. These rocks will be referred to as "skarns", but they are not considered to be typical of rocks bearing that name, because much of the silica in the end product seems to be derived from arenaceous impurities in the original limy sediment rather than from introduction during metasomatism. Closely associated with these skarns in places, notably at the Green Parrot, are smaller lenses of pure marble and lead-bearing ferruginous manganiferous marble. Outcrop was inadequate to trace the relationship between the skarn and the relatively pure carbonate rocks.

Lenses of quartz-garnet granulite appear to be intimately associated with the copper mineralization. The lenses vary in width up to 70 feet at the widest part. The longest continuous outcrop of this rock type, at Cox's, is less than three-quarters of a mile long. The rock is notably inhomogeneous, and the outcrop provides marked contrast to the surrounding quartz-mica schist. It is a hard, strongly fractured rock, granoblastic in texture, which forms dark ridges. Its composition varies considerably: in places it is a quartzite; in others it contains over 60 percent of garnet in a siliceous matrix. The magnetite content may range from 3 to 75 percent. Numerous small quartz veins cut the rock in every exposure.

Nine small outcrops of basic intrusive rock in the north-east of the area (see Plate 1) appear to be consanguineous with two larger masses to the north and south of the area. All except one are hornblende diorite or hornblende gabbro; the exception is a hornblende granodiorite. Their igneous texture and lack of any sign of stress indicate that they were intruded after the regional metamorphism of the area. Some of the smaller outcrops are copper-stained and quartz veined.

Walls of black tourmaline-quartz rock, and white, or red-brown walls of quartz, rise 5 to 20 feet above the surrounding schist, and form conspicuous features. They are widespread, but are best developed on a hill about half a mile north-east of the Reward (see Plate 1). In broad outline they follow the strike of the schistosity and bedding, but in detail they are cross-cutting; many small veins of quartz follow fractures rather than bedding.

They are not persistent; they rarely attain a width of more than 6 feet and the longest crops out over about 2,000 feet. Tourmaline has been found in the schist adjacent to quartz-tourmaline walls several feet from the contact. At Cox's, and east of the Green Parrot and Marshall lodes, copper-staining is visible in the quartz-tourmaline rock.

In many places small pegmatite bodies are exposed. Commonly they consist predominantly of quartz, with many large (up to 2 inches) muscovite crystals, and less commonly feldspars.

Although the beds dip very steeply (frequently vertically), evidence for minor folding, except in the mineralized areas, is rare. The southern end of the area forms a steep-sided north-plunging syncline; the west limb passes under the scarp. No major structure is visible in the north part of the area near where the east limb of the syncline passes under younger formations.

A vertical foliation, striking between 330 and 005 degrees is a common feature of the schist. It is subordinate in intensity to the predominant schistosity which follows the bedding. This foliation may have been produced by the same forces which caused the gentle folding of the once-overlying Mopunga Group rocks. These have now been eroded back to the escarpment, but formerly they covered the Arunta Complex in a gently dipping anticline.

Faulting is not common in the area, but a number of small faults, oblique to the bedding, have been recorded.

The widespread copper-staining in the Jervois Range area has two main associations. The most common is with pegmatitic rock where it occurs with quartz and (in places) tourmaline. The other association is with the skarn bands where epidote, vesuvianite, pyroxene or garnet is the dominant mineral, and scheelite and galena are present in places.

GEOLOGY OF THE DEPOSITS

REWARD (SEE PLATE 2)

The hill on which the Reward Mine is situated forms a prominent dark landmark; it rises 120 feet above the plain, immediately on the north side of Unkah Creek. It lies in the middle of the long arm of the J-shaped ridges formed by the mineralized line of lode (see Plate 1). Although copper mineralization extends sporadically for two miles north, no noteworthy workings have been made north of the Reward lease.

The near-vertical beds and lodes strike north. The oldest rocks in the vicinity of the Reward Mine crop out on the eastern slopes of the hill. They are porphyroblastic cordierite-mica-quartz schists. Upwards in the succession these are followed by about 40 feet of flaggy biotite-muscovite-quartz schist, free from porphyroblasts: then by a complex lens of magnetite-garnet-quartz granulite. The lens is very heterogeneous and in places contains calcite, staurolite, and tourmaline, together with copper and lead minerals. Elsewhere it appears as an impure ferruginous quartzite. A gossan is associated with this lens. The granulite grades stratigraphically upwards, along an indefinite boundary into mica schist.

The gossan, which forms the summit of the hill and extends north along the ridge for about 450 feet, is greatly enriched in iron, but is otherwise similar in composition to the

garnet-quartz granulite. Smaller gossans occur on the south ridge of the hill. A study of three polished sections from the gossan, by W.M.B. Roberts, indicates that the finely crystalline hematite that forms much of the sections is derived from magnetite, which is believed to be of hydrothermal origin. Other magnetite-quartz lenses in the district are not gossanous, owing either to different degree of weathering, or lack of original sulphide.

Most of the outcropping magnetite-quartz granulite contains copper mineralization, mainly as carbonate. The richest copper lode follows a shear at the eastern margin of the gossan. A vertical shaft sunk to a depth of 96 feet on the shear has collapsed and filled up to a depth of 24 feet below the collar. Hodges-Smith (1932) found galena in the walls of the top part of the shaft, but below about 40 feet depth noted only muscovite-sericite schist impregnated with chalcopyrite. No galena was visible at the surface on this lode during the present investigation, but open cuts immediately north and south of the shaft have xxxxx collapsed, obscuring much detail. Blanchard (1939) examined the shaft and sampled the crosscut to the west (see Appendix 1, samples R.B.19-21). However, the crosscut did not extend to the edge of the mineralization. Blanchard noted the primary sulphides chalcopyrite and pyrite between 80 and 90 ft. depth. Drives from a second shaft, 21 ft. deep, 65 feet north of the deeper shaft, have been opened up to extract the high-grade ore. A wider copper lode along the ridge south of the summit has only been tested by surface sampling. Small patches rich in secondary copper occur in the garnet-quartz granulite on the south ridge of the hill. Analyses (see Appendix I), indicate that the copper ore averages 3.5 oz. of silver per ton.

The main lead lode, which is very erratic in grade, follows a limy band along the western margin of the gossan. At the surface it consists of pyromorphite and cerussite, with chalcedony, garnet and quartz as gangue minerals. Samples taken from the lead lode indicate 3 oz. of silver per ton of ore.

The southern end of the garnet-quartz-granulite at the Reward swings to the east: it seems likely that the lode is truncated by a fault which runs between the Reward and the Marshall and Attutra Lodes. A vertical foliation with a strike ranging from 300 to 320 degrees is a no able feature of the schist.

MARSHALL AND ATTUTRA

The Marshall and Attutra Lodes are two parallel copper lodes that form low hills about a quarter of a mile south-west of the Reward shaft.

The strike of the near-vertical beds and lodes is north. Regional considerations indicate that the lodes intrude the east limb of a north-plunging syncline, and that the older rocks lie to the east.

The oldest rocks are quartz-mica schists, overlain to the west by a band, about 50 feet thick, of porphyroblastic cordierite-quartz-muscovite schist. A further thickness of about 40 feet of quartz-mica schist separates the porphyroblastic schist from the lens of magnetite-garnet-quartz granulite which contains the Marshall Lode. This lens pinches out about 300 feet south of the Marshall Shaft but reappears again a further 160 feet south. The southern lens is also cupriferous and continues irregularly for several hundred feet beyond the south edge of the sheet (Plate 3). The Attutra assemblage is separated from the Marshall Lode by about 200 feet of quartz-mica schist, which

contain no copper minerals (except near the Marshall lode and in a small biotite-enriched lens south-east of the Attutra lode). The schist contains a band with cordierite porphyroblasts near the Attutra assemblage, with which the contact is irregular and shattered. The schist appears to be pushed apart by the Attutra rocks, best seen at about 440N, 220E (Plate 2).

The eastern portion of the Attutra lens, which is up to 70 feet wide, is essentially a heterogeneous schistose garnet-biotite-quartz granulite. It is followed to the west by a band not more than 10 feet wide of grossularite-vesuvianite skarn rock, and another band of similar width, of quartz-mica schist. Further west is a lens of quartz garnetite with a maximum width of 50 feet which grades westwards into an irregular lens of garnetiferous epidosite, nowhere more than 40 feet wide. Rubbly outcrops to the west of the epidosite indicate the rock type to be porphyroblastic cordierite-quartz-mica schist.

Copper staining occurs throughout the epidosite, garnetite, skarn and granulite on the Attutra deposit, with concentrations in the centre of the garnetite and less regularly in the granulite. The richest copper lode is along a zone of shearing in the granulite.

The Marshall Lode is confined to the partly sheared magnetite-garnet-quartz-granulite near its boundary with the schist to be east, but secondary copper minerals may be seen for several feet into the schist from the boundary.

The Marshall Shaft was sunk vertically on the strongest part of the lode at the surface. A drive from a short cross-cut to the east of the shaft at the 92 ft. level shows only weak copper mineralization; it follows the granulite-schist boundary. A drive to the west at the same level in magnetite-garnet-quartz granulite shows weak copper mineralization throughout, with strong secondary copper at the western end and in a band 2 feet 6 inches wide 12 feet from the end. The strongest mineralization at this level occurs in the shaft and in the crosscut immediately to the east (see Appendix 1). A concentration of bismuth has been reported by the leaseholder in the cut north of the Marshall Shaft.

Allotromorphic chalcopyrite and pyrite crystals are disseminated through some of the harder bands of granulite. Blanchard (1939) considers that post-mine enrichment is largely responsible for the high values of samples RG29 and RG30, and in his calculations he reduces them to the values of sample RB32. However, the band from which sample RB32 was taken contains less visible sulphides than the hard bands in the shaft which contain them, and the assay value obtained from samples RB29 and RB30 are considered not to be affected by superficial post-mine enrichment. If samples RB29 and RB30 are taken at their given value, a width of 8 feet containing 4.5% copper, or 18 feet with 2.3% copper, is indicated.

The apparent ore control, both for the Marshall and Attutra Lodes, is the shearing which parallels the schistosity and along which the copper is concentrated. Minor folds in the schist, and trace of cleavage on bedding indicate a southerly pitch of the rocks of more than 30 degrees; however, the folds do not appear to have exercised any control over the mineralization.

The northern ends of the ridges which contain both the Marshall and Attutra Lodes are abruptly truncated; probably they have been cut off by the oblique fault, which may also terminate the southern end of the Reward Lode. The line of the probable fault lies along the creek bed, in which there is no outcrop. Small quartz blows (up to 50 feet long) are a common feature of the

area. Many parallel the schistosity, but there are many crosscutting veins. Quartz and quartz-mica pegmatite veins are most abundant close to the lodes, and some lodes become barren toward the extremities. Probably the copper is associated with the introduction of the pegmatites.

A vertical foliation similar to that noted at the Reward, with the strike ranging from 315 to 335 degrees, is a marked feature of the mica schist.

GREEN PARROT

The Green Parrot lodes are about half a mile from the Marshall Shaft (see Plate 1) on the western slopes of the low ridge which continues south-south-west from the Marshall Shaft.

Although the attitude of the rocks at the Green Parrot is very steep to vertical, they are seen from the regional geology to lie on the eastern limb of the north-plunging syncline; hence the oldest beds lie to the east. These are garnetiferous quartz-mica schists, which contain lenses of garnetiferous magnetite-quartz granulite. Two of the lenses, part of which are shown on the plan (Plate 4), are not more than half a mile long, nor thirty feet wide. These two lenses do not carry copper at the surface, although similar lenses about 500 feet further east are cupriferous.

West of the schist there is a succession of thinly-banded metamorphics of diverse mineralogical content. The steep ridge on which the shaft "B" is sunk, and the lower ridge to the north and south, are composed essentially of gossanous garnet-quartz granulite, variously containing garnet, chlorite, epidote and actinolote. The granulite forms a lens 600 feet long and up to 70 feet wide, in mica schist, and also contains minor bands of schist. Further north, where outcrop is poor, the granulite is thinner and more calcareous. Small pods of limestone occur within it. The west slope of the ridge is not well exposed, but rubble and small outcrops indicate that lenses of limestone, quartzite and granulite are irregularly disposed in the schist. Westward again a few small outcrops of porphyroblastic cordierite-quartz-mica schist represent the youngest strata on the lease.

Six small exposures of pegmatitic muscovite-albite granite crop out 10-100 feet to the west of the main lodes; they are possibly related to the mineralization. Pegmatitic material, predominently quartz but also in places containing coarse mica, is commonly intruded into the schist.

The schist on the Green Parrot lease, as elsewhere, displays a vertical foliation which strikes between 320 and 340 degrees.

Copper mineralization is confined to the westernmost garnetiferous quartz granulite and the immediately adjacent schist. The highest grade copper is found in sheared rock, generally on the eastern margin of the granulite. Only the secondary copper minerals malachite, cuprite, azurite, chysocolla, atacamite and turquoise have been found in the cuts. Hodges-Smith (1932) noted a band of chalcocite in Shaft "B". Shaft "A" passes out of the richer lode material at about 15 feet below the surface, and at the 55 feet level only moderate copper staining is found.

High-grade lead lodes occur erratically in the impure near-vertical limy beds at the Green Parrot. Shaft "B" has been sunk on the highest grade continuous lode. At the surface this

follows an impure calcareous band in the granulite for about 90 feet north from the shaft, and 10 feet south. At the 90 ft. level in the shaft the band appears to be synclinally folded; as a result it does not go below this level. The syncline appears to pitch north and a greater vertical thickness of lead-lode may therefore be expected north of Shaft "B". The walls of a pit centred on 1010N, 240E, is composed of a carbonate-cemented breccia which contains both cerussite and galena. There are pockets rich in lead, much of it galena, in the ferruginous, manganiferous marble in the irregular-shaped pit at 300N, 160E. Here, as elsewhere, galena is to be seen within an inch of the ground surface. The widest known lead lode crops out along the ridge between 290N and 510N, along a band about 320E (see Plate 4). It is of lower grade than those mentioned above, but also contains appreciable quantities of zinc; so does the copper gossan between 700N and 790N.

Silver values in the copper lodes are variable but average 3 oz. per ton in the samples taken. The copper lodes in the Green Parrot deposit contain lead, commonly in percentages comparable with those for copper, resulting in a mixed ore. The lead lode in the area of Shaft B is exceptional in the high silver content of over 20 ounces per ton. No discernible relationship between the copper, lead, silver, and zinc exists at the surface but they are intimately though sporadically associated.

The lenticular shape of the ferruginous garnetiferous granulite inclusions which carry the ore, the manner in which the schist is seen to wrap round them or be pushed apart, and the mineral assemblage within them, all suggest that the mineralization has been introduced by solutions, probably related to the pegmatites, that have selectively permeated and partially replaced the coarser portions of the metamorphic series, because of their greater porosity.

The high lead, copper, and silver values at the surface and in the workings, and the extensive gossan, indicate that economic deposits of these minerals may be present and that a drilling programme to test the lodes would be justified.

COX'S (PLATES 5 AND 6)

Cox's Lode crops out about 1½ miles south-south-west from the Green Parrot Shaft, and about 1½ miles east-north-east from the Bellbird Shafts (see Plate 1). It lies on the inside edge of the series of ridges which form the southern nose of the north-plunging syncline, north-east from the nose.

The beds strike between 020° and 040°T and dip steeply west-north-west; the oldest rocks crop out in the east. The oldest rocks figured on Plates 5 and 6 are porphyroblastic biotite-staurolite-garnet-muscovite-quartz schist. There is a transition into less porphyritic schist to the east (not shown on plan) and an abrupt transition into overlying pegmatitic schist to the west.

The pegmatitic schist contains many strings of quartz nodules about 2 inches in diameter, set in a matrix of schistose material, which contains many crystals of muscovite. The muscovite plates are much coarser than those in the schist elsewhere. The top of the pegmatite schist forms a sharp boundary with the overlying quartz-garnet granulite, which is from 4 to 40 feet thick. Again, as noted further north, the granulite is markedly non-uniform, ranging from impure quartzite

to garnetite. The eastern portion of the granulite is rich in quartz, and in places contains many quartz veinlets, whereas the western portion, which also contains the copper, is poorer in quartz but rich in iron. The upper boundary of the granulite commonly forms a cliff, and the overlying quartz-mica schist is poorly exposed; it appears to be 20 to 40 feet thick and to be overlain by a porphyroblastic garnetiferous staurolite-biotite-muscovite-quartz schist containing larger and more elongated porphyroblasts than those in the lower stratum of the same rock type.

Significant copper mineralization is confined to the western edge of the granulite, which in places is weakly sheared. Surface mineralization is almost continuous, although locally displaced by cross faults for 1500 feet, but the width varies from 2 to 20 feet. The main copper mineral is malachite, with some azurite, atacamite and cuprite.

Exploration work, consisting of 2 large pits, 7 small pits and a shaft 21 ft. deep, indicates that the grade of the copper ore is lower than on other lodes that have been tested. Lead, silver and zinc are not associated with the copper in Cox's Lode.

Numerous blobs, lenses, and veins of quartz and tourmaline-quartz occur in the eastern part of the granulite and the western part of the pegmatitic schist. Large, radiating tourmaline crystals - typical late-phase granite material - are common. Many of the veins strike between 050° and 080°T, or between 170° and 180°T.

The vertical foliation in the schist at Cox's Lode strikes between 335° and 005°T.

Cox's Lode, although long, is thin and mainly low grade, and would only be worth further testing if some of the other deposits that appear richer at the surface were proved to be worth mining.

BELLBIRD (PLATE 7)

The Bellbird Lode occurs immed. tely east of the Alice Springs-Mt. Isa road, 3½ miles by road south-west of the Reward, and half a mile east of the Jervois Range escarpment. It forms a long low knoll on the west side of the steep ridges which outline the southern nose of the syncline.

The beds strike meridionally and dip about 80 degrees east. The oldest beds, west of the workings, are exposed as small rubbly outcrops of mica schist, containing a small lens of marble. They are overlain by a bed of chlorite schist about 5 feet thick. A bed, 10 to 20 feet thick, of ferruginous quartz granulite rests on the chlorite schist and is overlain by about 50 feet of part schistose, part granulitic, ferruginous quartzose rock. The sequence is continued upwards by about 20 feet of porphyroblastic andalusite gneiss, followed by ferruginous quartz-mica schist which contains a granulitic lens.

Copper mineralization is concentrated in the ferruginous quartz granulite, but copper minerals permeate the chlorite schist for several feet on its western side, and extensive copper mineralization may be seen in the schist on the eastern

slopes of the knoll formed by the lode. Joints, especially those with low dips, are commonly coated with copper minerals, but most of the copper replaces favourable bands in the granulite. Strong minor folding was well displayed in pits at 240N, 040E, but the mineralization in them appeared to be comparable with that in the unfolded portions of the host rock. The numerous pits that have been dug since Blanchard sampled the lode reveal a wide and irregular variation in grade of copper over the top 30 feet, rather than the rapid diminution in copper content with depth postulated by Blanchard.

Superficial leaching of the lode is a marked feature at the Bellbird. This results, in places, in a very porous, ironstained quartzose rock, in which the voids seem to have been formed largely by the leaching out of pyrite cubes.

Shaft C (see Plate 7) was sunk on the sheared western portion of the granulite to a depth of 79 feet. Sulphides first appear at about 60 feet but secondary minerals still predominate at the bottom. In a specimen taken from the 79 ft. level subhedral pyrite is moulded by chalcopyrite and both minerals are strongly fractured, indicating that shearing continued along this line after the mineralization. Sulphide mineralization, predominantly pyrite, may also be seen at 99 ft. in Shaft B. X-ray spectrographic analysis of the pyrite showed that it contained about 2 percent of copper in solid solution. Unfortunately easterly crosscuts, at the bottom for about 10 feet, and at 75 feet for about 15 feet, were inaccessible owing to rock falls. These are understood, however, to be in primary ore throughout.

Copper mineralization extends along the line of the lode for several hundred feet beyond the limits of Plate 7, both to the north and south. In both directions the copper minerals are associated with quartz flows; barren quartz blows are also common in the area. Quartz veins parallel the strike of beds and schistosity. No tourmaline was found at the Bellbird, but pegmatites containing tourmaline crop out within half a mile of the lode.

No lead or zinc minerals are associated with the Bellbird lode and analyses for bismuth yielded only traces. Silver values in this lode were quite low; they averaged less than 2 oz. per ton.

The length, width, grade, and accessibility of this lode make it the most favourable one in the area to develop for copper at shallow depths in the primary zone. Further testing to define the tonnage and grade of ore is warranted.

MINERALIZATION

Sporadic copper mineralization at the Jervois Range deposits may be seen over an area of more than two square miles. It occurs discontinuously at the surface over a strike length of 6½ miles over an average width of 2,000 feet. Although at many places the copper is merely displayed as copper staining associated with quartz veins, at least 3 sub-parallel beds carrying carbonate ore may be traced in the better portions of the field.

The copper lodes are associated either with magnetite-garnet-quartz granulite, or with skarn rock. The richest parts of the lode are commonly associated with shearing.

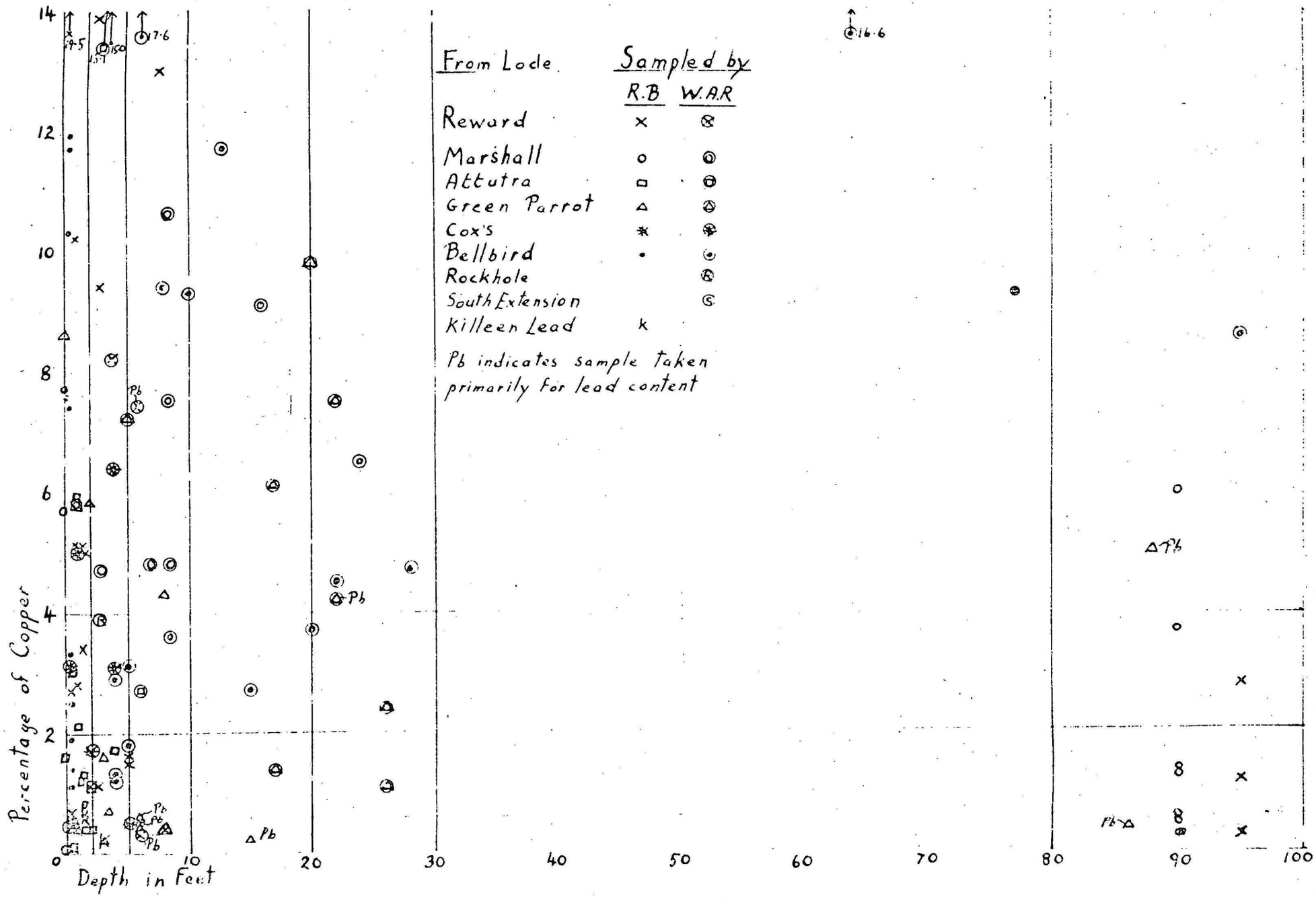
From Lode
Sampled by
R.B
W.A.R
Reward
Marshall
Attutra
Green Parrot
Cox's
Bellbird
Rockhole
South Extension
Killeen Lead
Pb indicates sample taken primarily for lead content
Percentage of Copper
Depth in Feet
0
2
4
6
8
10
12
14
10
20
30
40
50
60
70
80
90
100
Pb

Figure 1.

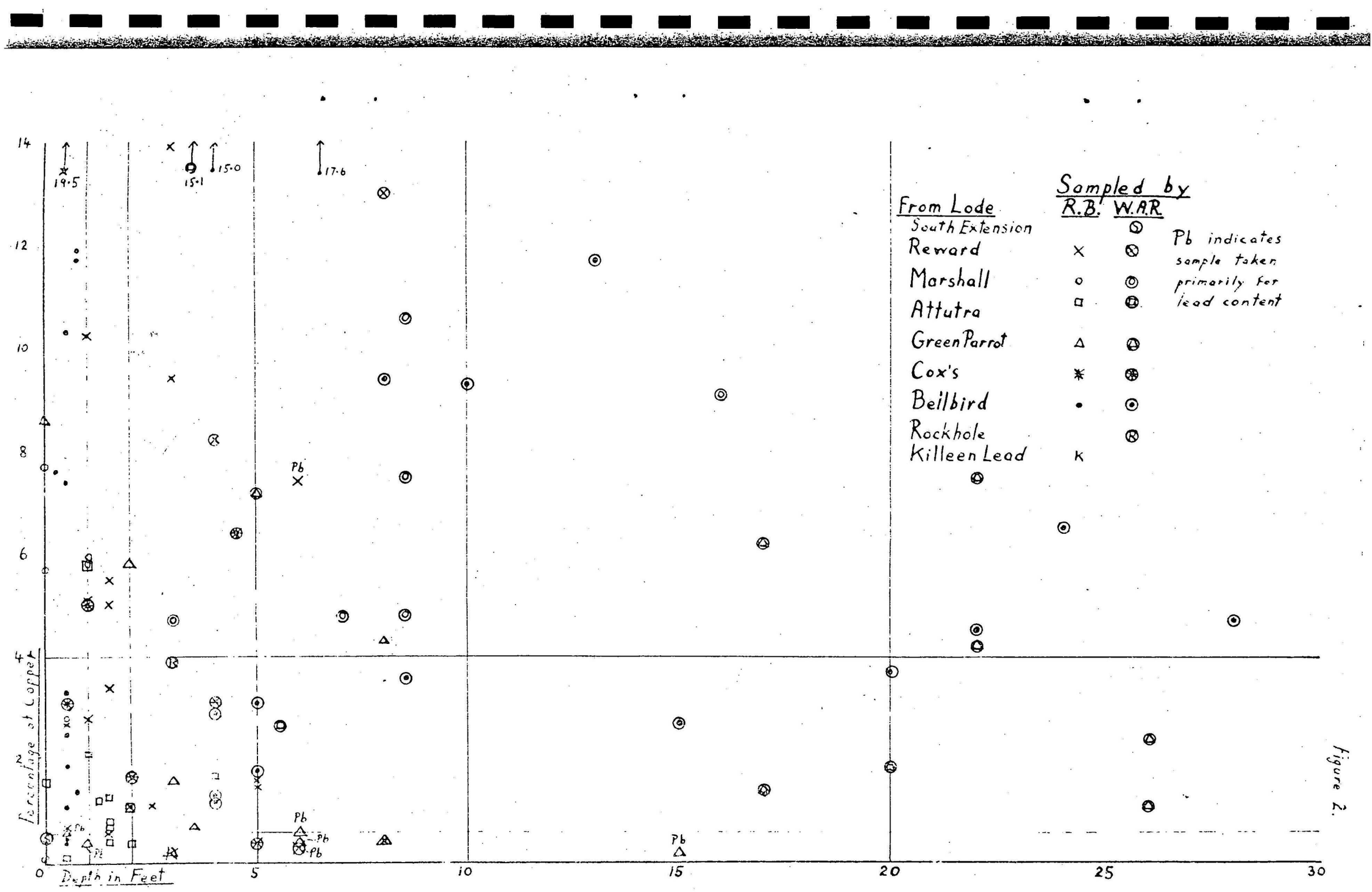
From Lode
Sampled by
R.B.
W.A.R.
South Extension
Reward
Marshall
Attutra
Green Parrot
Cox's
Bellbird
Rockhole
Killeen Lead
Pb indicates sample taken primarily for lead content
19·5
15·1
15·0
17·6
Pb
Percentage of Copper
Depth in Feet
0
5
10
15
20
25
30
2
4
6
8
10
12
14

Figure 2.

In some portions of the field, notably at the Bellbird and Cox's, the only metal associated with copper is silver in small quantities. In the central part of the field, however, copper lodes commonly contain appreciable lead and silver, and, in places, zinc. Bismuth has been reported in the Marshall Lode but none of the samples tested for bismuth, of those collected by the author and by Blanchard, contained more than 0.1% Bi, although 0.32% Bi was recorded in the lead lode at the Reward.

The main surface copper minerals are carbonates, but oxides, silicates and chlorides also occur in places. Scanty underground exploration indicates that there is unlikely to be a valuable zone of secondary enrichment in this field, as there appears to be a fairly abrupt transition with depth from carbonates to primary sulphides. A band of chalcocite, however, has been observed in the Green Parrot Shaft B (Hodges-Smith, 1932).

Lead mineralization is more erratic and less extensive at the surface than is copper. The rich lead lodes and pockets are confined to impure carbonate and skarn rocks. Cerussite and pyromorphite predominate at the surface, but galena occurs very close to it. Characteristically the copper lodes carry some lead.

All the lodes carry silver but the quantity varies from about 2 ounces per ton at the Bellbird to about 40 ounces per ton for the rich lead lode at the Green Parrot Shaft B.

Zinc appears to be sporadically distributed at the surface and is commonly absent, but in both a lead lode, at the Green Parrot, and a copper lode, at the Attutra, over 5 percent have been recorded.

Scheelite has been found in small quantities in three of the slides (JHA67, JHA117C and JHA142 (See Plate 1)) cut from the skarn rocks, and has been disclosed by application of the ultra-violet lamp on the hand specimens.

All Blanchard's samples were analysed for gold and none yielded over 1 dwt. per ton. Higher gold and silver values in early shipments by Hanlon (see Production, p.14) are due to handpicking of the ore.

GRAPHICAL AND STATISTICAL ANALYSIS OF COPPER SAMPLING

All the samples collected by Blanchard and by the author have been plotted on a graph (Fig. 1) using depth in feet as abscissae and percentage copper as ordinates. Each sample is represented by a symbol depicting the lode from which it was taken. Samples taken by the author have been enclosed in circles. Samples taken primarily for their lead content have been marked Pb. Figure 2 is an enlargement of Figure 1, showing only samples taken from 0 to 30 feet depth.

Results taken from these graphs have been tabulated in Figure 3. Samples containing less than 0.6 percent copper have been omitted in the calculation of percentages.

Four features that may be significant are evident from the graphs and the table. First, no falling off of average grade with depth is apparent within the portion of the lode so far prospected. Secondly, there is a noticeably greater

Fig. 3.

VARIATION OF COPPER VALUES WITH DEPTH

Depth Range within which samples were taken	Number by R.B.	Number by W.A.R.	Total Number	Total No. excluding 0.6%	0.6% Cu		0.6-2.0% Cu		2.0-4.0% Cu		4.0-6.0% Cu		6.0-8.0% Cu		8.0-10.0% Cu		10-12.0% Cu		12.0-14.0% Cu		14.0-16.0% Cu		More than 16% Cu	
					No.	*	No.	*	No.	*	No.	*	No.	*	No.	*	No.	*	No.	*	No.	*	No.	*
0 - 1 feet	22	2	24	20	4/		6	30	5	25	1	5	3	15	1	5	3	15	0	0	0	0	1	5
1 - 2 feet	18	1	19	17	2		5	30	4	24	7	42	0	0	0	0	1	6	0	0	0	0	0	0
2-- 5 feet	13	10	23	20	3/		9	45	3	15	2	10	1	5	2	10	0	0	1	5	2	10	0	0
5 - 10 feet	8	14	22	17	5/		4	24	3	18	3	18	3	18	1	6	1	6	1	6	0	0	1	6
10 - 20 feet	1	6	7	6	1/		1	17	1	17	0	0	1	17	2	34	1	17	0	0		0	0	0
20 - 30 feet	0	9	9	9	0		2	22	2	22	3	33	2	22	0	0	0	0	0	0	0	0	0	0
30 - 80 feet	0	2	2	2	0		0	0	0	0	0	0	1	50	0	0	0	0	0	0	0	0	1	50
More than 80 feet	13	1	14	9	5		4	44	2	22	1	11	1	11	1	11	0	0	0	0	0	0	0	0
TOTALS	75	45	120	100	20		31		20		17		12		7		6		2		2		3	

* Percentage of total

/ Includes samples taken primarily for their Pb content

TABLE 2 - GRADE AND TONNAGE

Name of Lode	Plate No.	Copper				Lead			
		Surface area of lode in sq. ft. >5% Cu	Tons/vert.ft. of lode taking 15 cu. ft. = 1 ton	Surface area mineralized in sq. ft. >1% Cu	Tons/vert.ft. mineralized taking 15 cu. ft. = 1 ton	Surface area in sq. ft. >10% Pb	Tons/vert.ft. of 10% Pb taking 14 cu. ft. = 1 ton	Surface area in sq. ft. >5% <10% Pb	Tons/vert.ft. of 5% 10% Pb taking 14 cu. ft. = 1 ton
Bellbird	7	4,005	267	20,000	1,333	Nil	Nil	Nil	Nil
Cox's	5 & 6	250	16	8,500	566	Nil	Nil	Nil	Nil
Green Parrot	4	1,400	93	11,000	733	435	31	1,285	92
Attutra	3	680	44	23,000	1,533	Nil	Nil	Nil	Nil
Marshall	3	1,050	70	3,000	200	Nil	Nil	200	14
Reward	2	1,600	107	28,000	1,867	800	57	Not known	
Killeen Lead	-	Nil	Nil	Nil	Nil	Nil	Nil	850	61
TOTALS			597		6,232		88		167+

range of copper values near the surface than below 10 feet. It appears that at the surface copper has concentrated in some portions of the lode at the expense of others. Thirdly, most of Blanchard's samples, two-thirds of which were taken within five feet of the surface, give a distorted picture due to near surface redistribution, a marked feature of the lodes. Lastly, all the lodes, with the possible exception of Cox's and the Attutra, contain sufficient ore of greater than 4 percent copper to warrant further testing.

Production figures since 1946, and field evidence from pits worked since Blanchard visited the deposits support the features observed in the analysis of the sampling results.

GRADE AND TONNAGE

Estimates of grade and tonnage are based inevitably at the present state of development on surface evidence. Sampling to date suggests that the grade at the surface is erratic and almost certainly unrepresentative of the lodes as a whole (see Fig. 3, ~~Fig. 2~~). Hence values in this section should only be regarded as probable and there is at this stage no justification for extrapolation below 100 feet depth.

Evidence from underground workings, though inadequate, shows that primary copper ore occurs below about 100 feet, and that a worthwhile zone of secondary enrichment is not to be expected, as the transition to primary ore seems to be abrupt, but this has not yet been adequately tested.

COPPER ORE

Nearly half of the high-grade ore occurs at the Bellbird. The six lodes that have been plane-tabled should yield about 500 tons per vertical foot of greater than 5 percent copper carbonate ore. A further 6,000 tons per vertical foot of low-grade material, probably slightly better than one percent copper, could be expected, mainly from the Reward, Attutra and Bellbird Lodes.

Most of the high-grade ore at the surface, which is predominantly in the form of copper carbonates, with subordinate oxides and silicates, occurs in lodes that are 4 to 5 feet wide and 50 to 300 feet long. These are commonly in sheared granulite. Scanty evidence from drives at the bottom of shafts indicates that at depth the lodes are of lower grade, but greater width. For tonnage details see ~~Figure 4~~. Table 2.

LEAD ORE

Only at the Green Parrot, Reward, and Killeen Lead leases have lead lodes been mapped. The lode-bearing rock is not continuously lead-bearing at the surface with the exception of two of the Green Parrot Lodes, but the lead occurs as pockets of high-grade ore. No development has been done more than 10 feet below the surface, except at the Green Parrot Shaft B. The evidence available indicates about 90 tons per vertical foot of greater than 10 percent ore, much of it probably greater than 20 percent, with an additional 160 tons per vertical foot of ore carrying 5 to 10 percent lead. A considerable but unknown tonnage of lead could be extracted from some of the copper lodes.

RECOVERY OF SILVER

All samples of lode material except those from Cox's and Killeen Lead contained appreciable silver. The silver content is very variable but averages more than 2 ounces per ton. In large scale operations silver recovery would be worthwhile, but it is doubtful if it would materially affect the value of the ore.

ZINC

At the surface zinc occurs sporadically. Only on the Green Parrot lease is there likely to be mineable quantities of zinc ore above the 100 ft. level. However, the location of the field renders the mining and concentration of zinc ore uneconomic under present conditions.

GOLD

Blanchard's gold samples are consistently less than 1 dwt. per ton. Higher values in ore shipped by Hanlon are undoubtedly due to hand sorting.

PRODUCTION

Full production records are not available owing to the wartime bombing of Darwin and the consequent destruction of records. Blanchard (1939) recorded a verbal statement by Crosby that about 200 tons of ore had been shipped from the properties prior to 1939.

Records of shipments made by T.T. Hanlon are set out in Table 3.

Little or no ore was shipped from the properties between 1939 and 1948. Almost complete records of production from 1948 to 1956 are given in Table 4, taken from "Statements of Value" held at the Mines Branch Office, Alice Springs. During 1957-58 no copper ore was shipped from the properties but a small quantity of carbonate ore was put through Johannsen's leaching plant and about 10 tons of copper sulphate shipped to Adelaide.

RECOMMENDATIONS

An initial diamond drilling programme, designed to test the width and grade in the primary zone of the lodes most promising at the surface, is recommended as detailed in Table 5.

It is recommended that the holes should be drilled in the order as numbered, and continuous coring should begin from 10 feet drill depth. All lode material in the core should be sampled and undergo spectrochemical analysis. Where results justify it chemical analyses for copper, lead, silver and zinc should be undertaken.

As an alternative or adjunct to the preliminary drilling programme outlined above it is recommended that the two shafts at the Bellbird, and the shafts on the Marshall and Reward Lode, be cleaned out and deepened to reach the primary zone, probably an

SHIPMENTS BY T.T. HANLON

TABLE 3

TYPE OF ORE	TONS	Au DWT. per ton	Ag OZ. per ton	Cu %	Pb %
COPPER ORE	2.38	1.00	17.4	33.3	2.2
	4.56	1.00	10.7	33.5	0.2
	3.51	1.00	27.2	26.2	7.1
	6.63	tr.	35.2	29.8	6.9
	17.08	0.61	24.5	30.5	4.9
LEAD ORE	2.48	2.00	104.2	3.8	54.8
	1.63	1.60	100.0	0.9	64.7
	4.08	N.D.	95.8	N.D.	40.8
	16.50	0.80	26.4	1.6	56.0
	6.13	0.80	28.4	0.5	56.8
	5.71	0.40	23.4	0.8	56.2
	19.03	0.20	24.2	2.75	47.1
	55.66	0.62	36.3	1.9	52.2
MIXED ORE	5.66	tr.	30.4	18.3	12.2
	8.74	tr.	27.6	N.D.	12.4
	10.77	0.80	52.8	18.9	23.2
	12.78	0.80	45.2	10.9	31.7
	3.39	0.84	49.1	13.3	30.1
	41.34	0.52	41.8	15.1	22.6

PRODUCTION 1948-1956

TABLE 4

YEAR	PRODUCER	LEASE	ORE IN TONS	CU CONTENT IN TONS	ASSAY %	GROSS VALUE TO NEAREST £
1948	Coppock	Bellbird	22.225		16.0	655
1949	Coppock	Bellbird	352.777		14.6	8,459
1949	Campbell	Bellbird	50.7		23.5	1,964
1950	Coppick & Erwin	Bellbird	183.5		19.8	6,372
1950	Johannsen	Not known	4.75		25.6	219
1951	Johannsen	Not known	55.9		18.3	2,647
1951	Johannsen	Green Parrot	34.6		23.8	2,041
1951	Erwin	Bellbird	56.55		24.0	4,062
1952	Johannsen	Not known	61.17		18.8	3,400
1952	Erwin	Bellbird	70.294		22.0	4,467
1952	Not known	Not known	20.732	3.96		1,304
1952	Johannsen	Attutra	27.922	6.422		1,944
1952	Johannsen	Green Parrot	47.087	10.538		3,633
1952	Coggin & Erwin	Bellbird	34.279	8.193		2,800
1953	Coggin & Erwin	Bellbird	65.204	14.922		4,924
1954	Not known	Bellbird	17.99			1,265
1954	Johannsen	Not known	28.343	4.437		1,532
1955	Johannsen	Not known	6.891	1.832		680
1955	Johannsen	Green Parrot	33.84	3.15		816
1955	Johannsen	Hanlon's Extended	10.28	2.57		994
1955	Johannsen	Bellbird	303.390	37.956		Not known
1955	Johannsen	Bellbird	Not known			1,642
1955	Johannsen	Bellbird	890.722	104.878		43,466
1956	Johannsen	Bellbird	388.954	49.784		19,081
1956	Johannsen	Not known	12.95	2.089		698
1956	Johannsen	Hanlon's Reward	Not known			1,000
1956	Johannsen	Hanlon's Reward	60.0	8.0		2,800
TOTALS			2,841.050 *	430.0 **		124,265 *

* Not Complete

** Approximate

TABLE 5

RECOMMENDED DRILLING PROGRAMME

Lode	Plate No.	D.D.H. No.	Co-ords. of collar	D.D.H. true bearing	D.D.H. depression	D.D.H. probable necessary depth in feet	Probable overburden at intersection in feet	Object
Bellbird	7	1	283E. 621N.	280	045	220	150	Determine width and grade of primary copper ore.
Bellbird	7	2	238E. 287N.	282	045	200	150	As 1 and with 1 get information on pitch of lode.
Reward	2	3	026E. 492N.	080	040	240	145-185	Determine width and grade of primary copper and lead ore.
Marshall	3	4	368E. 588N.	100	050	230	175	Determine width and grade of primary copper ore.
Attutra	3	5	309E. 384N.	272	045	90-180	80-130	Determine width and grade of copper ore in wider, lower grade deposit below surface weathering, and if values justify it to continue holes downwards to edge of mineralization which should include primary mineralization.
Attutra	3	6	068E. 324N.	091	045	100-150	80-130	
Green Parrot	4	7	205E. 646N.	095	045	190	100-165	Determine width and grade of primary copper and lead ore and silver and zinc values in this zone.
Green Parrot	4	8	240E. 383N.	080	045	130	90	Determine grade of lead, zinc, silver and copper in lode below surface weathering.
Green Parrot	4	9	200E. 1171N.	090	045	150	100	Determine relative percentages of copper and lead in lode.

extra 20 feet would be sufficient in each case. Drives should then be made to the extremity of mineralization both east and west. Along these channel samples should be taken to indicate the width and grade of the lodes.

CONCLUSIONS

Detailed surface mapping of the copper lodes has indicated the probability of a moderate tonnage of copper ore in the primary zone. Examination of the shallow workings has shown them to be totally inadequate to estimate the probable grade and size of the ore bodies, but indicate that the primary mineralization is predominantly as the sulphides pyrite, chalcopyrite, and galena.

The mapping proves that there is sufficient copper carbonate available to keep Johannsen's leaching plant, designed to produce copper sulphate directly from carbonate ore, in full production for many years.

The surface mapping shows that the copper is associated with granulites, and is generally concentrated in weak shears, whereas the lead favours the less disturbed lime-bearing lenses. The abundance of pegmatitic rocks, commonly rich in boron, suggests the possibility of a late-phase magmatic source for the introduced material.

Chemical analyses show silver in appreciable but very variable quantities to be present in both copper and lead lodes. In places zinc also occurs. Scheelite has been noted from several of the skarn rocks.

Surface indications are sufficiently encouraging to warrant a drilling programme designed to test the grade of ore in the primary zone.

ACKNOWLEDGEMENTS

I wish to thank Mr. K. Johannsen and Mr. and Mrs. H. Hillom for their helpful co-operation, without which my task would have been so much more difficult. I would also like to thank Mt. Isa Mines Ltd. for supplying Blanchard's Report and maps.

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APPENDIX I

JERVOIS RANGE COPPER LEAD DEPOSITS

CHEMICAL ANALYSES OF CHANNEL AND CHIP SAMPLES

RB-Samples by Blanchard in 1939 JHA-Samples by Robertson in 1958

Sample No.	Channel	Chip	Depth below surface in feet	Width in feet	Cu %	Pb %	Zn %	Bi %	Ag oz/long ton
REWARD LODE									
RB1	x		1.0	2.17	10.2	0.2			3.5
RB2	x		1.5	6.33	0.6	1.5	-	-	1.0
RB3	x		1.5	9.25	5.5	0.7	-	-	1.9
RB4	x		1.5	10.25	5.0	0.2	-	-	2.9
RB5		x	0.5	8.5	0.7	0.1	-	-	0.4
RB6		x	2.0	3.5	1.1	0.3	-	-	0.2
RB7	x		3.0	4.5	13.9	0.2	-	-	2.3
RB8	x		3.0	4.5	9.4	0.2	-	-	1.1
RB9		x	0.5	2.0	2.7	1.8	-	-	1.9
RB10	x		8.0	3.0	13.0	0.9	-	-	7.1
RB11	x		8.0	1.5	0.4	0	-	-	0.3
RB12	x		0.5	3.25	19.5	1.7	-	-	7.0
RB13		x	1.0	1.75	5.1	0.4	-	-	3.3
RB14	x		1.0	3.0	2.8	0.2	-	-	4.3
RB15	x		1.5	6.5	3.4	7.2	-	-	0.2
RB16	x		2.5	10.0	1.1	3.4	-	-	0.2
RB17	x		5.0	2.75	1.6	0	-	-	0.2
RB18		x	5.0	4.0	1.5	0	-	-	Tr.
RB19	x		96.0	2.75	1.2	0.2	-	-	1.8
RB20	x		96.0	3.08	2.8	0	-	-	3.9
RB21	x		96.0	1.92	0.3	0	-	-	0.2
JHA131	x		6.0	1.8	7.4	5.0	0.02	0.32	6.4
JHA132	x		6.0	6.0	0.3	0.3	0.02	0.02	0.6
JHA146		x	4.0	4.5	8.2	0.5	0.02	0.23	-

Appendix 1 (Cont'd.) - 2 -

Sample No.	Channel	Chip	Depth below surface in feet	Width in feet	Cu %	Pb %	Zn %	Bi %	Ag oz/long tons
MARSHALL LODE									
RB22	x		S	3.25	0.1	0.1	-	-	0.2
RB23	x		0.5	4.42	3.0	0	-	-	0.9
RB24	x		S	1.83	5.7	0.1	-	-	2.6
RB25	x		1.0	1.5	5.8	0	-	-	3.5
RB26	x		S	4.5	7.7	0	-	-	4.1
RB27		x	90.0	3.83	0.3	0.1	-	-	0.1
RB28		x	90.0	2.75	0.5	0	-	-	0.1
RB29	x		90.0	3.17	6.0	0	-	-	2.7
RB30	x		90.0	4.92	3.7	0.2	-	-	4.2
RB31		x	90.0	7.59	0.6	0	-	-	0.3
RB32	x		90.0	2.17	1.4	0.1	-	-	1.1
RB33		x	90.0	11.92	0.3	0	-	-	0.2
RB34		x	90.0	1.42	1.3	0	-	-	0.8
JHA21	x		16.0	4.0	9.1	6.2	-	0.06	3.0
JHA22	x		7.0	4.1	4.8	4.9	-	0.01	3.0
JHA23	x		8.5	1.5	4.8	0.5	-	0.05	0.5
JHA 24	x		8.5	2.25	10.6	0.4	-	0.03	1.9
JHA25	x		8.5	1.25	7.5	0.3	-	0.01	1.9
JHA26	x		3.0	4.0	4.7	-	-	-	1.7
ATTUTRA LODE									
RB63	x		1.0	5.5	5.9	0.8	-	-	6.5
RB64		x	4.0	8.5	1.7	0	-	-	2.3
RB65	x		1.0	2.25	2.1	0	-	-	2.3
RB66		x	1.5	6.5	0.8	0	-	-	0.4
RB67	x		1.0	3.5	5.8	0	-	-	10.5
RB68		x	2.0	9.5	0.4	0	-	-	1.6
RB69	x		2.0	1.0	1.1	0	-	-	2.9
RB70		x	1.5	15.5	0.7	0	-	-	0.3
RB71		x	0.5	8.0	0.1	0	-	-	2.5
RB72		x	1.5	11.0	0.4	0	-	-	3.7
RB73	x		1.25	8.5	1.2	0	-	-	1.4
RB74	x		1.5	8.5	1.3	0	-	-	0.7
RB75		x	S	17.0	1.6	0	-	-	3.0
JHA20	x		3.5	6.5	15.1	0.6	5.2	0.01	-
JHA27		x	6.0	9.5	2.7	0.4	0.3	0.01	1.0

Sample No.	Channel	Chip	Depth below surface in feet	Width in feet	Cu %	Pb %	Zn %	Bi %	Ag oz./ long tons
GREEN PARROT LODES									
RB48	x		6.0	3.5	0.6	20.6	0	-	1.3
RB49	x		6.0	1.0	0.4	41.1	0.4	-	3.6
RB50	x		?	3.25	0.6	9.5	0.5	-	0.9
RB51		x	15.0	10.0	0.2	0.8	1.2	-	1.7
RB52	x		S	2.67	8.6	6.7	5.1	-	10.0
RB53	x		0.5	3.0	0.6	15.8	7.8	-	2.8
RB54	x		1.0	4.0	0.4	40.4	0.2	0.10	23.4
RB55	x		86.0	1.75	0.4	25.4	1.1	0.06	20.0
RB56	x		88.0	2.17	5.0	30.8	1.9	0.10	38.6
RB57	x		8.0	4.67	4.3	2.7	-	-	3.5
RB58		x	2.0	8.5	5.8	4.2	-	-	8.3
RB59	x		3.0	6.0	0.2	0	-	-	0.7
RB60		x	3.0	8.0	1.6	0	-	-	1.8
RB61		x	3.5	7.0	0.7	0	-	-	1.5
RB62		x	8.0	10.0	0.4	0	-	-	0.4
JHA28	x		17.0	4.0	1.4	-	-	-	0.6
JHA29	x		17.0	3.5	6.1	-	-	-	1.1
JHA30	x		5.0	3.75	7.2	-	-	-	2.3
JHA31	x		26.0	3.8	2.4	6.7	0.1	0.05	2.3
JHA32	x		26.0	3.7	1.1	6.8	0.02	0.005	1.0
JHA33	x		22.0	3.1	7.5	5.3	-	-	2.7
JHA34	x		22.0	3.9	4.2	9.9	-	-	2.2
JHA35	x		20.0	4.6	9.8	1.9	0.02	0.01	-
COX'S LODE									
JHA36	x		0.5	1.3	3.1	-	-	-	0.1
JHA37	x		4.0	3.25	3.1	0.05	0.02	0.02	0.1
JHA38	x		5.0	2.25	0.5	-	-	-	0.1
JHA39	x		1.0	2.0	5.0	-	-	-	0.3
JHA40	x		2.0	5.0	1.7	-	-	-	0.1
JHA41	x		4.0	1.9	6.4	-	-	-	-
ROCK POOL LODE									
JHA 158		x	3.0	9.0	3.9	0.05	0.02	0.01	0.3
SOUTH EXTENSION MINERALIZATION									
JHA159		x	S	22.0	0.5	0.05	0.02	0.005	-
KILLEEN LEAD LODE									
RB47	x		3.0	7.0	0.2	8.7	0.8	0.026	0.2

Sample No.	Channel	Chip	Depth below surface in feet	Width in feet	Cu %	Pb %	Zn %	Bi %	Ag oz/ long ton
BELLBIRD LODE									
RB35	x		4.0	7.0	15.0	0	-	-	3.6
RB36	x		0.75	3.5	1.4	0	-	-	0.3
RB37	x		0.75	9.0	11.7	0.1	-	-	2.1
RB38	x		0.75	7.0	11.9	0.1	-	-	2.1
RB39	x		0.5	4.5	1.1	0	-	-	0.2
RB40	x		0.25	9.0	7.6	0	-	-	0.8
RB41	x		0.5	3.5	2.5	0	-	-	0.5
RB42	x		0.5	5.5	10.3	0	-	-	1.0
RB43	x		0.5	4.0	3.3	0	-	-	0.4
RB44	x		0.5	4.0	1.9	0	-	-	0.3
RB45	x		0.5	5.0	7.4	0	-	-	0.7
RB46		x	0.5	2.0	0.5	0	-	-	0.1
JHA70	x		10.0	2.9	9.3	-	-	-	-
JHA71	x		5.0	8.0	3.1	0.05	0.02	0.005	-
JHA72	x		8.0	7.0	9.4	-	-	-	1.2
JHA73	x		5.0	4.0	1.8	-	-	-	-
JHA74	x		13.0	3.4	11.7	-	-	-	1.9
JHA75	x		4.0	4.4	2.9	-	-	-	-
JHA76	x		4.0	2.4	1.3	-	-	-	-
JHA77	x		4.0	2.25	1.2	-	-	-	-
JHA78	x		28.0	4.5	4.7	0.05	0.02	0.01	0.9
JHA79	x		15.0	4.6	2.7	-	-	-	-
JHA80	x		20.0	3.0	3.7	-	-	-	-
JHA81	x		24.0	5.1	6.5	-	-	-	-
JHA82	x		22.0	4.9	4.5	-	-	-	-
JHA83	x		8.5	13.5	3.6	0.05	-	-	-
JHA84		x	95.0	4.0	8.5	0.05	0.02	0.01	0.7
JHA85	x		6.5	3.6	17.6	-	-	-	0.7
JHA126	x		77.0	3.8	9.3	0.05	0.02	0.005	3.3
JHA130	x		64.0	2.9	16.6	-	-	-	3.3

APPENDIX 2

Synopsis of descriptions by W. R. Morgan of slides cut from specimens collected in the Jervois Range Metals Mapping Programme, 1958.

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* Specimens typical of rocks carrying the copper lodes

** Specimens typical of rocks carrying the lead lodes

Specimen No. and Locality	Mineral Percentages	Name of Rock	Remarks
JHA1* Attutra	Epidote 45, quartz 35, garnet 16, remainder 4.	Garnetiferous-epidosite	Medium-grained, granoblastic, inequigranular.
JHA2* Attutra	Grossularite 80, quartz 10, iron oxide 5, tremolite 3, malachite 2.	Tremolite-quartz garnetite.	Coarse grained.
JHA3 Attutra	Quartz 30, muscovite 25, cordierite 20, albite 15, chlorite 5, remainder 5.	Chlorite-albite-muscovite-quartz schist.	Cut by vein containing apatite, chlorite, fluospar, and black iron ore.
JHA4* Attutra	Magnetite 50, garnet 45, chlorite and iron oxide 5.	Manganiferous garnet-magnetite (?) skarn.	Intergrowth of garnet and black ore.
JHA5 Attutra	Muscovite 50, quartz 20, biotite 17, garnet 10, remainder 3.	Garnet-biotite-quartz-muscovite schist.	Medium-grained lepidoblastic.
JHA6* Attutra	Quartz 47, biotite 20, garnet 25, spinel 3, black iron ore 4, remainder 1.	Garnet-biotite quartz schist.	Medium-grained granoblastic and sub-idioblastic.
JHA7* Attutra	Vesuvianite 45, grossularite 35, epidote 15, remainder 5.	Grossularite-vesuvianite (?) skarn.	Coarse-grained xenoblastic.
JHA8* Attutra	Grossularite 70, quartz 25, remainder 5.	Quartz-garnetite.	Medium-grained granoblastic.
JHA9 Green Parrot North	Quartz 40, biotite 30, garnet 20, black iron ore 8, remainder 2.	Garnet-biotite-quartz schist.	Medium-grained granoblastic-lepidoblastic.
JHA10* Green Parrot North	Garnet 90, remainder epidote, malachite and nontronite.	Garnetite	Medium-grained.

Specimen No. and Locality	Mineral Percentages	Name of Rock	Remarks
JHA11 Green Parrot North	Calcite 95, remainder quartz and hydrated iron oxide.	Marble	Xenoblastic
JHA12** Green Parrot South	Garnet 70, tremolite-actinolite 20, remainder epidote cerrusite and quartz.	Actinolite-garnet (?) skarn.	Coarse-grained xenoblastic.
JHA13** Green Parrot South	Quartz 60, epidote 25, chlorite 15.	Chlorite-epidote-quartz granulite.	Medium-grained xenoblastic granular.
JHA14** Green Parrot South	Quartz, predominant, remainder hydrated iron oxide.	Limonite-quartz granulite.	Contains cavities, possible due to leaching of Pb mineral.
JHA15 Green Parrot South	Calcite 65, pyrolusite 30, galena 5.	Galena-bearing ferruginous manganiferous marble.	Medium-grained xenoblastic.
JHA16 Green Parrot South	Calcite predominant, remainder black ore and hydrated iron oxide.	Ferruginous and manganiferous marble.	Medium-grained xenoblastic.
JHA17 Green Parrot South	Contains andradite garnet, black iron ore, tremolite, prehnite & carbonate	Tremolite-garnet skarn.	Inequigranular sub-idioblastic.
JHA18 Green Parrot South	Quartz 50, garnet 40, black iron ore 7, chlorite 3.	Garnet-quartz granulite.	Medium-grained granoblastic.
JHA19 Green Parrot North	Ablite 50, quartz 30, muscovite 15, orthoclase 3, remainder 2.	Muscovite-albite (aplitic?) granite.	Coarse-grained hypidiomorphic.
JHA43 Cox's North	Quartz 50, muscovite 15, biotite and chlorite 10, magnetite 10, almandine 10, tourmaline 1, remainder 4.	"Magnetite-" garnet-biotite-muscovite-quartz gneiss.	Medium-grained granoblastic-lepidoblastic.
JHA44* Cox's North	Quartz 60, almundine garnet 15, tourmaline 10, black iron ore 10, muscovite 5.	Magnetite tourmaline garnet-quartz-granulite.	Foliated granoblastic.

Specimen No. and Locality	Mineral Percentages	Name of Rock	Remarks
JHA47 Cox's North	Quartz 50 muscovite 20, biotite 15, staurolite 10, almandine 5, black iron ore 3, remainder 2.	Porphyroblastic garnetiferous staurolite-biotite-muscovite quartz schist.	Medium-grained, lepidoblastic-granoblastic.
JHA49 Cox's North	Quartz 65, magnetite 25, chlorite 7, muscovite, biotite and chrysocolla 3.	"Magnetite"-quartz granulite.	Medium-grained granoblastic, sheared ?
JHA51* Cox's South	Quartz 50, magnetite 18, biotite 10, hydromuscovite 10, muscovite 2and quartz biotite 15, garnet 10, black iron ore 5.	"Magnetite"-quartz granulite + garnetiferous chlorite-quartz-schist.	Medium-grained granoblastic. Contact between 2 rock types
JHA52 Cox's South	Quartz 35, muscovite 35, garnet 15, staurolite 10, biotite 5.	Porphyroblastic staurolite-garnet-muscovite-quartz schist.	Medium-grained lepidoblastic-granoblastic.
JHA53 Cox's South	Tourmaline 70, Quartz 30	Quartz-tourmaline gneiss	Coarse-grained inequigranular.
JHA55 Cox's South	Predominantly hematite, remainder quartz and hydromuscovite.	Hydromuscovite-quartz-hematite rock.	Iron derived from magnetite.
JHA57* Cox's South	Hematite 75, malachite 15, remainder chlorite and muscovite and calcite.	Cupriferous hematite rock.	Malachite in veins.
JHA58 Green Parrot North	Quartz 40, black iron ore 35, garnet 20, biotite 5.	Garnet-"magnetite"-quartz granulite.	Medium-grained granoblastic.
JHA59 1,000 ft. 11/5210 S6/44	Quartz 25, muscovite 24, lepidolite 24, magnetite 15, tourmaline 10, apatite 2.	Porphyroblastic tourmaline-magnetite-muscovite-lepidolite-quartz-gneiss.	Medium-grained granoblastic-nematoblastic.
JHA60 1,000 ft. 11/5210 S7/13	Plagioclase (An45)50, hornblende 40, remainder black iron ore, traces of apatite.	Recrystallized porphyritic diorite.	Possibly contact metamorphosed.

Specimen No. and Locality	Mineral Percentages	Name of Rock	Remarks
JHA62 1,000 ft. 11/5210 S7/80	Tremolite 45, quartz 40, sericite 8, epidote 5, remainder 2.	Quartz-tremolite-gneiss.	Coarse-grained.
JHA65 1,000 ft. 11/5210 S3/114	Diopside 60, tremolite 25, sericite and ? prehnite 13, remainder 2, including fluospar.	Tremolite-diopside (?) skarn.	Coarse-grained xenoblastic.
JHA67 1,000 ft. 11/5210 S3/115.	Vesuvianite 55, wollastonite 25, calcite 10, diopside 5, scheelite 3, opaque ore and quartz 2.	Scheelite-bearing wollastonite-vesuvianite (?) skarn.	Coarse-grained xenoblastic.
JHA68 1,000 ft. 11/5210 S3/119	Mainly tremolite and diopside. Also talc, epidote, apatite and quartz.	Diopside-talc-tremolite schist.	Coarse-grained xenoblastic except talc as fine-grained veins.
JHA69B 1,000 ft. 11/5210 S3/121	Quartz 65, epidote 20, hornblende and biotite 15, traces of garnet.	Garnetiferous hornblende epidosite.	Medium-grained xenoblastic.
JHA69C 1,000 ft. 11/5210 S3/121	Garnet 70, actinolite 20, magnetite 7, quartz 3.	Magnetite-actinolite garnetite.	Subidioblastic.
JHA86* Bellbird	Predominantly hematite, also quartz.	Gossan	Boxwork
JHA87* Bellbird	Predominantly goethite and quartz, also malachite.	Cupriferous goethite-quartz granulite.	Xenoblastic, sheared and veined.
JHA88 Bellbird	Predominantly chlorite, accessory quartz.	Chlorite schist.	
JHA89* Bellbird	Quartz 80, hematite 20.	"Magnetite"-quartz granulite.	Some boxwork.
JHA90* Bellbird	Mainly quartz and chlorite with black iron ore, biotite and chrysocolla.	Biotite-"magnetite"-chlorite-quartz schist.	Veined by coarser cupriferous material.

Specimen No. and Locality	Mineral Percentages	Name of Rock	Remarks
JHA91 Bellbird	Biotite 35, andalusite 35, quartz 20, garnet 5, black iron ore 5.	Porphyroblastic garnetiferous quartz-andalusite-biotite schist.	Porphyroblastic, nematoblastic-granular.
JHA93 1,000 ft. 10/5008 S9/132	Predominently epidote, also tremolite, quartz and calcite.	Tremolite-epidote (?)skarn.	Probably metasomatic replacement.
JHA94A 1,000 ft. 10/5008 S9/134	Muscovite 35, quartz 33, cordierite 15, andalusite 10, biotite 5, black iron ore 2.	Porphyroblastic andalusite-cordierite-quartz-muscovite schist.	Probably contact metamorphosed schists.
JHA94B, 1,000 ft. 10/5008 S9/134.	Plagioclase (An50) 47, hornblende 43, accessory black iron ore, carbonate, biotite and apatite.	Hornblende gabbro.	Hypidiomorphic granular.
JHA95 1,000 ft.	Actinolite 77, chlorite 20, remainder black iron ore and malachite.	Chlorite-actinolite schist.	Porphyroblastic fine-grained.
JHA96 1,000 ft. 10/5008 S6/194	Plagioclase (An59) 50, hornblende 45, accessory black iron ore and apatite.	Hornblende gabbro.	Hypidiomorphic granular.
JHA97A 1,000 ft. 10/5008 S2/159	Microcline 40, quartz 30, plagioclase 28, biotite and muscovite 2.	Adamellite.	Coarse-grained gneissic.
JHA97B 1,000 ft. 10/5008 S2/159	Microcline 40, albite 30, quartz 27, black iron ore 2, muscovite 1.	Aplitic granite.	Medium grained aplitic.
JHA98 1,000 ft. 10/5008 S6/194	Epidote 45, quartz 40, actinolite 10, black iron ore 4, apatite 1.	Actinolite-epidosite.	Medium-grained equigranular granoblastic.
JHA101** Green Parrot Shaft "B"	Quartz 57, garnet 25, chlorite 15, black iron ore 3.	Cupriferous "magnetite" chlorite-garnet-quartz-granulite.	Medium-grained granoblastic, probably lead-bearing.
JHA103** Green Parrot Shaft "B"	Quartz 70, remainder mainly black iron ore, galena and calcite.	Lead-bearing "magnetite"-quartz granulite.	Coarse-grained inequigranular.

Specimen No. and Locality	Mineral Percentages	Name of Rock	Remarks
JHA105* Green Parrot Shaft "A"	Magnetite 40, oligoclase 35, quartz 13, garnet 10, biotite 2.	Garnet-quartz-oligoclase-magnetite-ganulite.	Good slide to show schist-granulite relationship.
JHA106* Green Parrot Shaft "A"	Garnet (grossularite) 60, actinolite 20, calcite 10, also hematite, diopside, quartz, tremolite, ?phlogopite and vesuvianite.	Calcite-actinolite-grossularite skarn.	Xenoblastic metasomatic?
JHA109* Bellbird Shaft "B"	Predominantly quartz and pyrite, also chalcopyrite and black iron ore.	Siliceous sulphide ore.	Sheared lode.
JHA110 Bellbird Shaft "B"	Predominantly chlorite, with muscovite and quartz, also garnet, tourmaline and malachite.	Cupriferous garnetiferous muscovite-chlorite-quartz-schist.	Crumbly, examined in oils.
JHA111A 1,000 ft. 10/5008 S6/203	Plagioclase (An45) 49, hornblende 44, black iron ore 4, epidote and apatite 3.	Recrystallized diorite.	Medium-grained xenomorphic porphyritic.
JHA113 1,000 ft. 10/5008 S6/205	Plagioclase (An47) 37, hornblende 35, quartz 21, black iron ore 4, epidote and apatite 3.	Hornblende granodiorite.	Coarse-grained hypidiomorphic.
JHA117C** 1,000 ft. 10/5008 S6/224.	Epidote 35, quartz 30, garnet 25, chlorite and actinolite 8, scheelite, cerussite and black iron ore 2.	Scheelite-bearing garnet-quartz-epidote skarn.	A possible fringe of a new lead lode. Coarse-grained.
JHA118** 1,000 ft. 10/5008 S6/225.	Calcite 80, tremolite 10, black ore 5, chlorite 5.	Galena-bearing chlorite-tremolite-marble.	Medium-grained. A possible new lead lode.
JHA119 1,000 ft. 10/5008 S6/233	Muscovite 35, quartz 33, cordierite 10, biotite 10, andalusite 10.	Porphyroblastic andalusite-cordierite-quartz-mica schist.	Porphyroblasts probably due to contact metamorphism?

Specimen No. and Locality	Mineral Percentages	Name of Rock	Remarks
JHA120 1,000 ft. 10/5008 S5/239	Sericite 35, quartz 30, biotite 30, black iron ore 3, remainder 2. Accessories epidote, tourmaline and apatite.	Quartz-biotite-sericite schist.	Fine-grained granoblastic lepidoblastic.
JHA123 1,000 ft. 10/5008 S6/261	Biotite 30, quartz 25, muscovite 25, andalusite 15, black iron ore 3, garnet 2.	Porphyroblastic andalusite-quartz-muscovite-biotite schist.	Medium-grained lepidoblastic granoblastic.
JHA124 1,000 ft. 11/5210 S3/123	Hornblende (actinolite) 90, epidote 10.	Epidote-hornblende schist.	Coarse-grained.
JHA125 Bellbird	Quartz 20, andalusite 45, biotite 25, garnet 5, iron ore 3, muscovite 1.	Porphyroblastic garnetiferous quartz-biotite-andalusite gneiss.	Coarse-grained, cut by vein of fluorspar.
JHA127* Bellbird Shaft C bottom	Quartz predominant, also iron ore, pyrite, chalcopyrite, chalcocite, carbonate, chlorite, and malachite and muscovite.	Cupriferous ferruginous chlorite-muscovite-magnetite-quartz-granulite.	Sheared. Chalcopyrite moulds, pyrite.
JHA133* Reward	Predominantly quartz and hematite also garnet and chlorite.	Ferruginous quartz-garnet granulite.	Gossan
JHA134** Reward	Pyromorphite 70, chalcedony 17½ cerussite 6, garnet 5, quartz 1.	Garnet-cerrusite-chalcedony-pyromorphite rock.	Weathered lead lode.
JHA135* Reward	Quartz 55, hydrated iron oxide 20, calcite, 15, muscovite 5, biotite 1, black iron ore 1, remainder 3.	Cupriferous and ferruginous carbonated muscovite-garnet-quartz-granulite.	Coarse-grained granoblastic.
JHA136* Reward	Quartz 55, muscovite 23, black iron ore 8, tourmaline 7, garnet 2, remainder 5.	Tourmaline-"magnetite-" muscovite-quartz schist.	Metasomatic, coarse-grained granoblastic nematoblastic.

Specimen No. and Locality	Mineral Percentages	Name of Rock	Remarks
JHA137 Reward	Predominently quartz and muscovite, also cordierite, black iron ore, tourmaline and biotite.	Porphyroblastic cordierite-quartz-muscovite schist.	Medium-grained, lepidoblastic, showing slip-strain cleavage.
JHA138* Reward	Quartz 60, muscovite 15, black iron ore 15, biotite and garnet 10.	Garnetiferous-"magnetite"-mica-quartz granulite.	Coarse-grained weakly sheared.
JHA139 Reward	Quartz 50, staurolite 25, garnet 15, black iron ore 7, biotite and muscovite 3.	Mica-"Magnetite"-garnet-staurolite-quartz gneiss.	Medium-grained granoblastic.
JHA142* 1,000 ft. 10/5008 S10/268.	Fluorspar 30, garnet 25, vesuvianite 30, altered felspar 10, scheelite 3, epidote 2.	Scheelite-bearing garnet-vesuvianite-fluorspar skarn.	Fluorspar appears to have veined and shattered remaining minerals.
JHA144* Reward	Predominantly quartz, with black iron ore and hydrated iron oxide.	Quartz-magnetite-granulite.	Coarse-grained inequigranular.
JHA145* Reward	Predominantly hematite with quartz.	Quartz-hematite rock.	The hematite is derived from magnetite.
JHA147 Cox's North	Quartz 40, staurolite 30, black iron ore 13, tourmaline 12, biotite 3, garnet and muscovite 2.	Tourmaline-staurolite-magnetite-quartz granulite.	Porphyroblastic with equigranular groundmass.
JHA148 Cox's South	Quartz 40, sericite 20, black iron ore 20, chlorite 15, garnet 5, traces of apatite and (?)allanite.	Garnet-chlorite-sericite-"magnetite"-quartz granulite.	Fine-grained ?metasomatic.
JHA152 Bellbird	Predominantly quartz, also limonite, pyrite and other sulphides and many cavities.	Gossanous limonite "magnetite"-quartz granulite.	Sheared boxwork, typical of lode at surface.
JHA154* Marshall	Quartz 70, black iron ore 18, sericite 18, garnet 1.	Garnet-sericite-"magnetite"-quartz granulite.	Medium-grained granoblastic.
JHA155* Attutra-Marshall	Quartz 50, garnet 25, biotite 20, black iron ore 5.	Biotite-garnet-quartz schist.	Medium-grained inequigranular, granoblastic-lepidoblastic, but [illegible]

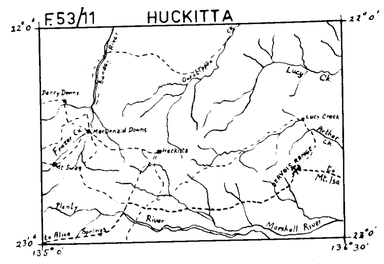
PLATE 1

REGIONAL GEOLOGY
JERVOIS RANGE
MINERAL DEPOSITS
NORTHERN TERRITORY

Geology by:- W.A.Robertson AUGUST - SEPTEMBER 1958

Scale of Feet

1000 500 0 1000 2000 3000 4000 5000

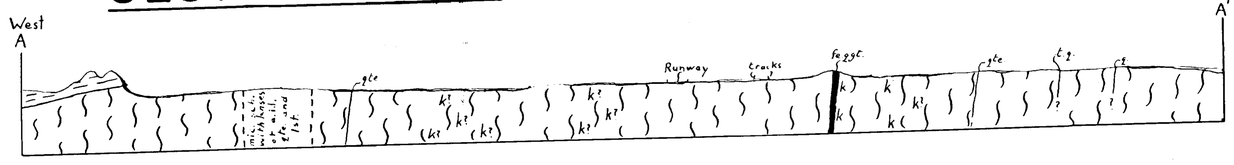


REFERENCE

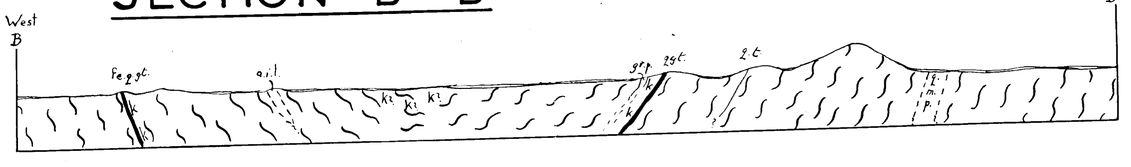
- Unconformity between Arunta Complex and Mopunga Group
- Established boundary, position accurate
- Approximate or inferred boundary
- Outcrop boundary
- Pitch of minor anticline
- Synclinal axis
- Fault, probable, position accurate
- Trend lines
- Strike and dip of beds
- Vertical beds
- Strike and dip of lineation
- Vertical lineation
- Gneissose granite
- Basic intrusive
- Quartz-mica schist

k	Knotted pophyroblasts	p.	Pegmatite
Cu	Copper	a.	Aplite
Pb	Lead	t.	Tourmaline
lst.	Crystalline limestone	m.	Mica
ggt.	Quartz-garnet rock	q.	Quartz
a.l.	Altered calcareous rock	gt.	Garnet
gr.	Granite	Fe.	Iron staining
qte	Quartzite	Mn.	Manganese staining
		B.I.	Basic intrusive
------	Vehicle tracks	e	Epidote
JHA 96	Rock specimen		
⚒	Mine shafts		
JHA 158	Chip sample		

SECTION A-A'



SECTION B-B'



W.A.Robertson FEBRUARY 1959

F 53/A11/57 ~~NT 2/11~~

PLATE 2

REWARD COPPER-LEAD DEPOSITS

JERVOIS RANGE

NORTHERN TERRITORY

Geology by:- J.W.Smith and W.A.Robertson. 1957-1958.

Scale of Feet

40 20 0 40 80 120 160

REFERENCE

- Quartz-mica schist
- Quartz garnet rock
- Ferruginous gossan
- Lode, copper unless otherwise stated
- Visible copper mineralization

k = Knotted porphyroblasts
=q= quartz
b = Biotite dominant mica
Pb = Lead

Bedding — Strike and dip; Vertical
Joint — Strike and dip
Lineation — Vertical
Shear — Dip
Boundary — Established; Inferred; Outcrop

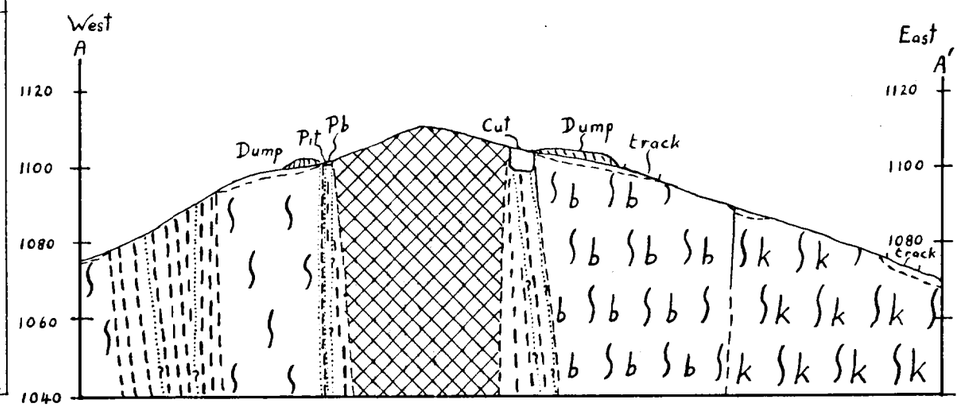
Contour, in feet, assumed datum — 1055

General Symbols — Pit, depth in feet; Dump; Shaft, depth in feet; Track

L.R. = Loading Ramp

Rock Specimens JHA 134
Channel Sample, 1958 JHA 146
Channel Sample, 1939, by R. Blanchard
Channel Samples 17, 20, and 21 were taken by R. Blanchard along the west drive from the 96 ft. level of the south shaft, now inaccessible

SECTION A-A´



W.A.R. DEC. 1958

F53/A11/58 ~~NT2/12~~

PLATE 3

MARSHALL and ATTUTRA COPPER DEPOSITS
JERVOIS RANGE
NORTHERN TERRITORY

GEOLOGY by:- E.K.Carter and W.A.Robertson MAY 1958

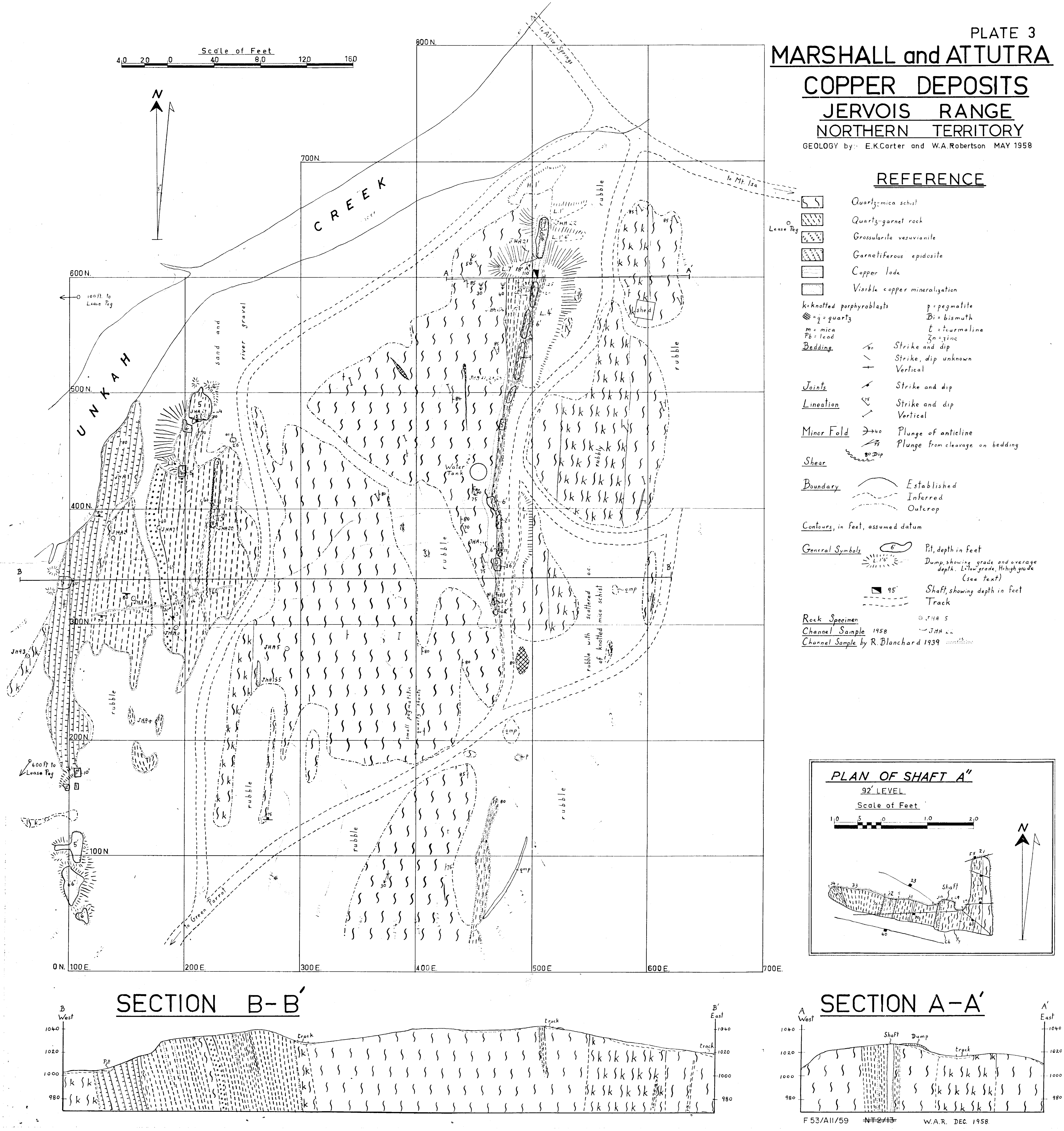


PLATE 4

GREEN PARROT

COPPER-LEAD DEPOSITS

JERVOIS RANGE

NORTHERN TERRITORY

Geology by : W.A.Robertson. JUNE 1958.

SCALE OF FEET

40 20 0 40 80 120 160

REFERENCE

- Quartz-mica schist.
- Quartz-garnet rock.
- Quartz magnetite rock.
- Quartzite.
- Limestone.
- Lode.
- Visible mineralization.

k = Knotted porphyroblasts

p = Pegmatite
gr = Granite
q = Quartz
Pb = Lead
m = Mica
Mn = Manganese
t = Tourmaline
Zn = Zinc

Bedding:- 80 strike and dip. — strike, dip unknown. ✕ Vertical.

Joint:- 20 strike and dip. — vertical.

Lineation:- 75 strike and dip. — vertical.

Minor Fold:- ↠40 plunge of anticline. ↞50 plunge of syncline. ↗75 plunge from cleavage on bedding.

Fault, probable, position accurate, showing inferred horizontal movement:-

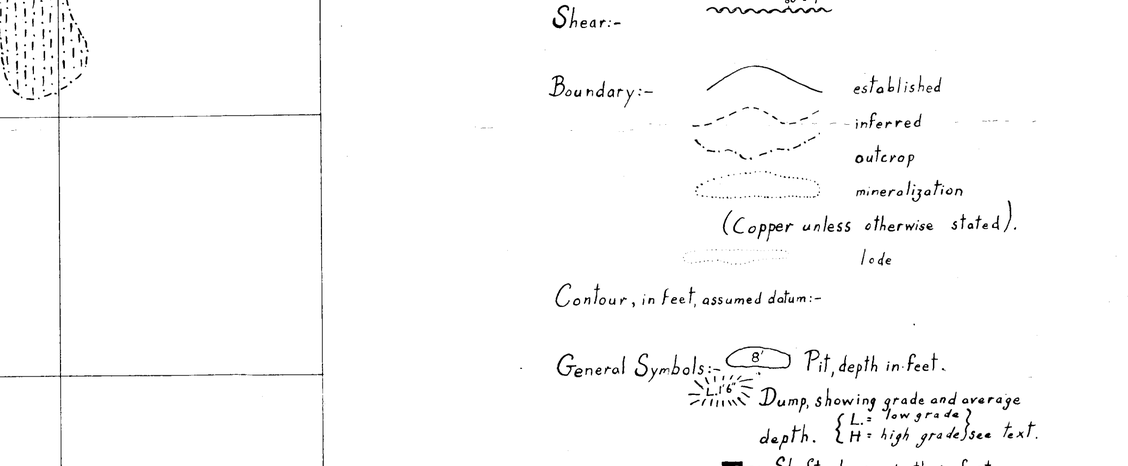
Shear:- 80 Dip

Boundary:- established; inferred; outcrop; mineralization (Copper unless otherwise stated). lode

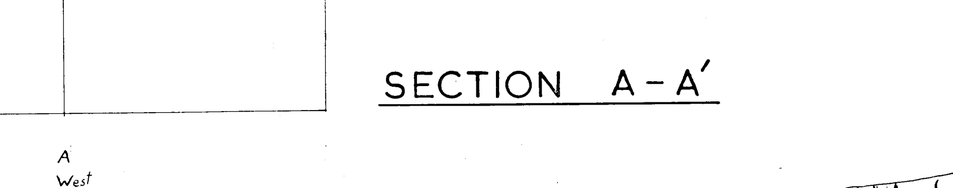
Contour, in feet, assumed datum:-

General Symbols:- 8' Pit, depth in feet. L.16' Dump, showing grade and average depth. {L.= low grade, H = high grade} see text. 90 Shaft, showing depth in feet. Adit, showing portal and length. Track. Rock sample. JHA 33 Channel sample, 1958. Channel sample by R. Blanchard, 1939. 48-51 in Adit

SECTION A-A'



SECTION B-B'



PLAN OF SHAFT A"

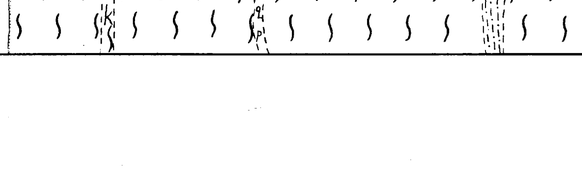
55' LEVEL

PLAN OF SHAFT B"

90' LEVEL

SCALE OF FEET

10 5 0 10 20



F53/A11/60 ~~NT2/14~~ W.A.R. DEC.1958

PLATE 5

COX'S COPPER DEPOSITS

JERVOIS RANGE

NORTHERN TERRITORY

Geology by W.A. Robertson. JULY 1958

SHEET I

Scale of Feet

40 20 0 40 80 120

REFERENCE

- Quartz mica schist
- Quartz garnet granulite
- Ferruginous quartzite
- Quartzite
- Staurolite quartz granulite
- Copper lode > 3%
- Visible copper mineralization

st. Staurolite and g. Garnet porphyroblasts; m. Mica; fr. Ferruginous; p. pegmatitic; q. Quartz; t. Tourmaline; chl. Chlorite

Bedding — Strike and dip; Strike, dip unknown; Vertical

Joint — Strike and dip; Vertical

Lineation — Strike and dip; Vertical

Minor Folds — Plunge of anticline

Fault, probable, position accurate, showing inferred horizontal movement

Shear

Boundary — Established; Inferred; Outcrop

Contour, in feet, assumed datum

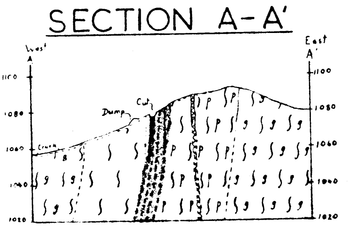
General Symbols

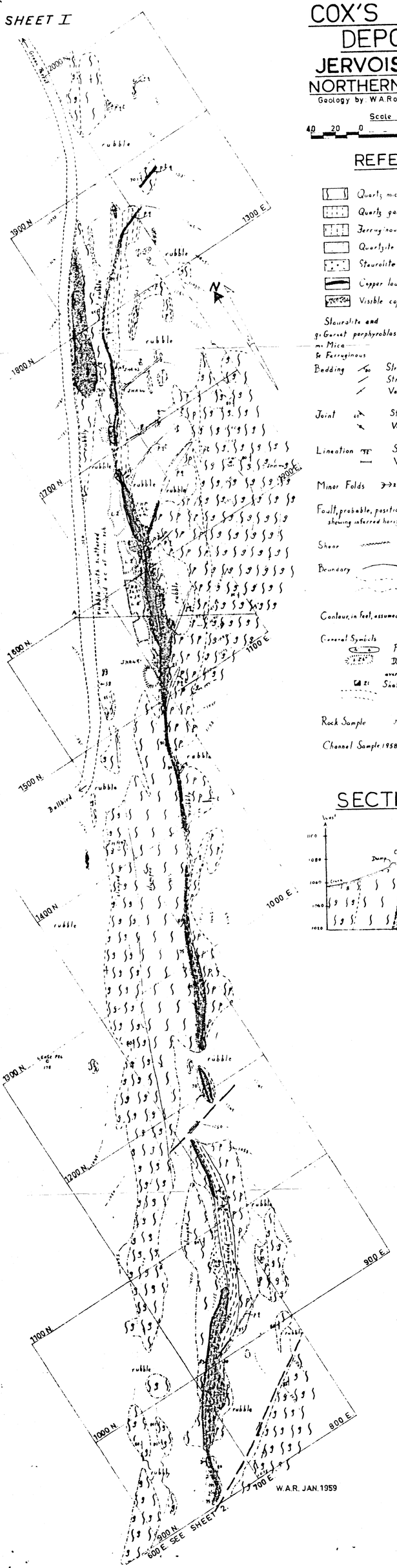
- Pit, depth in feet
- Dump showing grade and average depth. Below grade see text
- Shaft, showing depth in feet
- Track

Rock Sample

Channel Sample 1958

SECTION A-A'





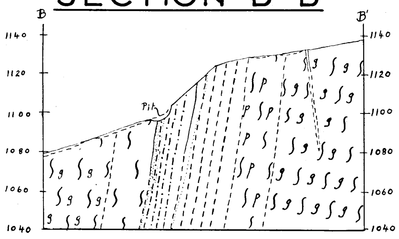
W.A.R. JAN. 1959

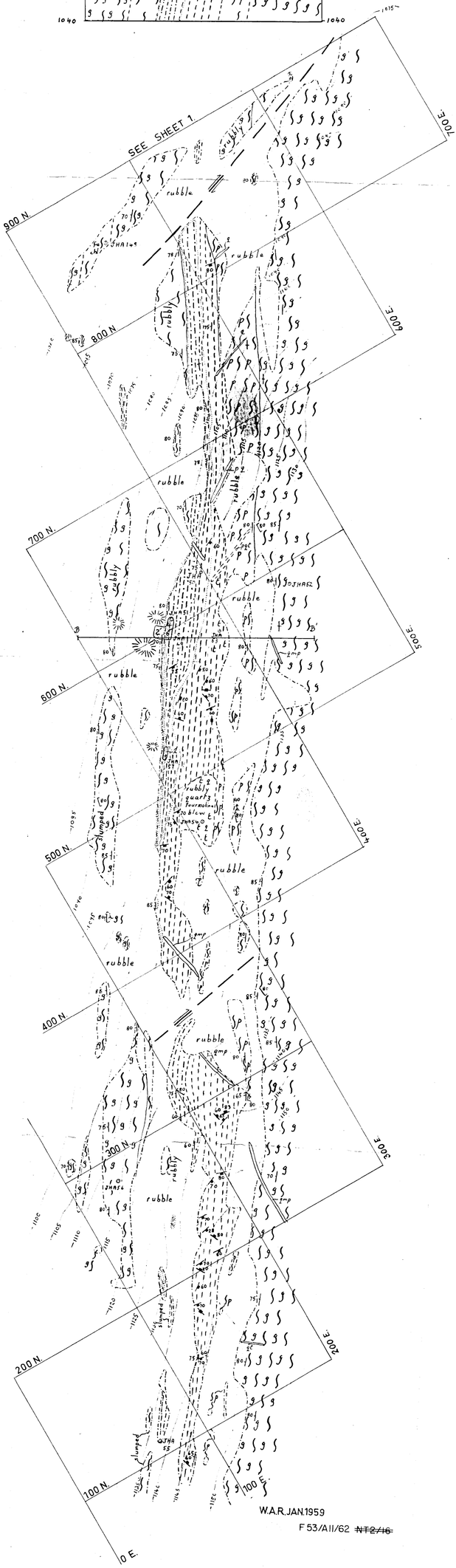
F 53/A11/61 ~~(NT 2/15)~~

SHEET II

PLATE 6

COX'S COPPER DEPOSITS
JERVOIS RANGE
NORTHERN TERRITORY
SECTION B-B'





W.A.R. JAN. 1959

F 53/A11/62 ~~NT2/16~~

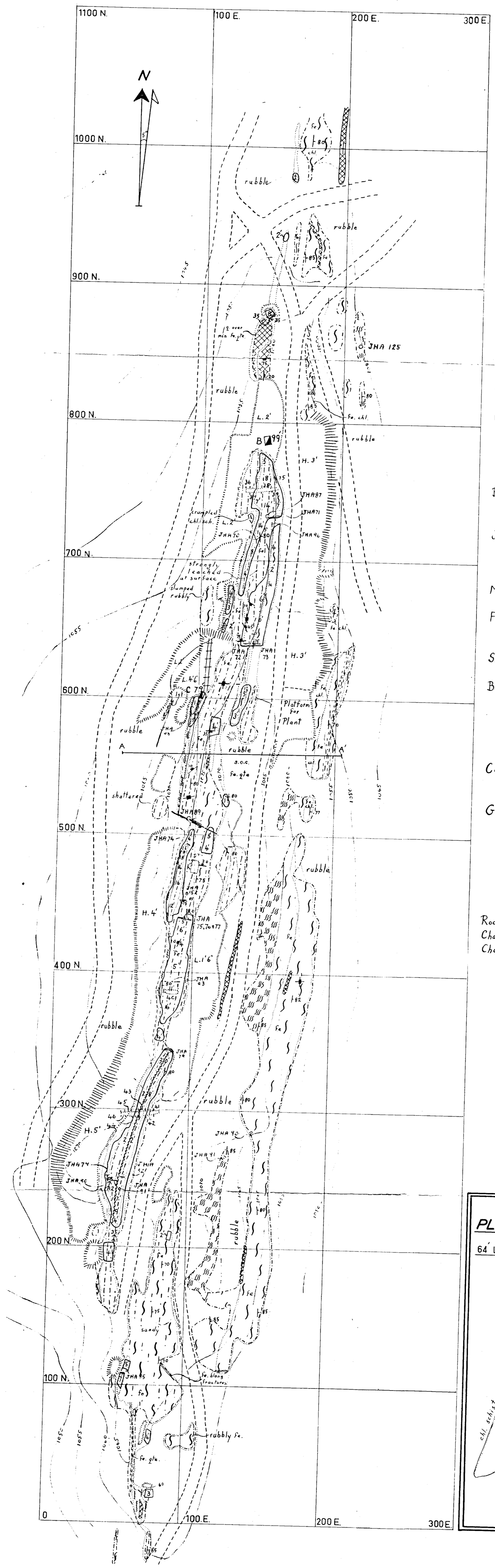
PLATE 7

BELLBIRD COPPER DEPOSITS

JERVOIS RANGE

NORTHERN TERITORY

Geology by:- W.A.Robertson AUGUST 1958



Scale of Feet

40 20 0 40 80 120 160

REFERENCE

- Quartz mica schist
- Chlorite schist
- Ferruginous quartz granulite
- Crystalline limestone
- Andalusite gneiss
- Copper lode
- Visible copper mineralization

q = Quartz
chl = Chlorite
fe = Ferruginous
py = pyrite
cp = chalcopyrite

Bedding — Strike and dip; Vertical

Joints — Strike and dip; Horizontal; Vertical

Minor Folds — Plunge of anticline

Fault, probable, position accurate, showing inferred horizontal movement

Shear

Boundary — Established; Inferred; Outcrop

Contours, in feet, assumed datum

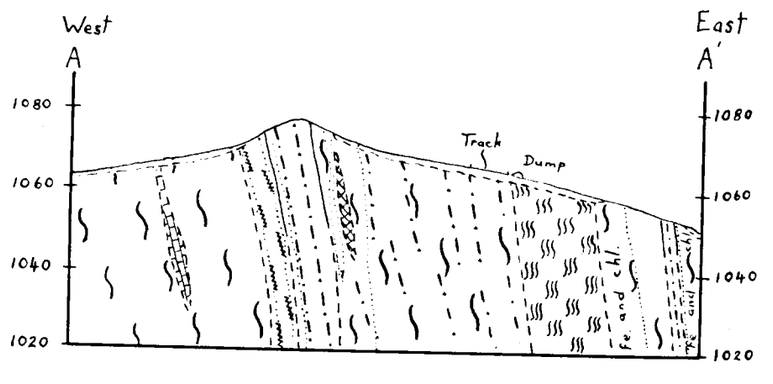
General Symbols — 20' Pit, depth in feet; H. 2'6" Dump, showing grade and average depth (L: low grade, H: high grade) see text; 78' Shaft, showing depth in feet; Track

Rock Specimen — JHA 79

Channel Sample, 1958 — JHA 78

Channel Sample, 1939, by R. Blanchard

SECTION A-A'

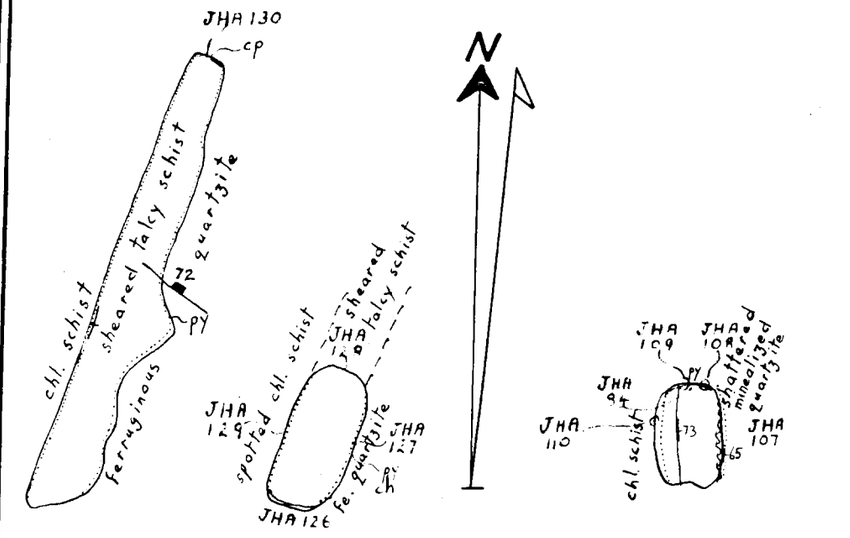


PLAN OF SHAFT C PLAN OF SHAFT B

64' LEVEL 78' 6" LEVEL 99' LEVEL

Scale of Feet

10 5 0 10 20 30



W.A.R. JAN.1959

F53/A11/63 ~~NT 2/17~~