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THE GEOLOGY OF THE CRUSADER COPPER MINE, DOBBYN, QUEENSLAND

by

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CANBERRA

26th May, 1952.

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Appendix 1 has not been supplied in the hardcopy of record 1952/41

ILLUSTRATIONS*

* At back of report.

SUMMARY

This report presents the results of a geological investigation of the Crusader copper deposit, Dobbyn, Queensland. The investigation was carried out to determine the geological setting and economic possibilities of the deposit.

Two geological maps have been compiled from air-photo mapping (Plates 1 and 2) and a third map (Plate 3) has been prepared from a plane-table survey. The maps are accompanied by one plan (Plate 4) and two sections (Plate 5) illustrating structural interpretations of the geological facts recorded.

The altered sedimentary rocks of the area consist of folded, metamorphosed Pre-Cambrian sediments. These are mainly quartzites and they have been intruded and, in part, altered by igneous rocks. The quartzites generally dip east and probably occupy part of the eastern limb of a regional anticlinorium. The regional plunge of the metamorphosed sediments is not definitely known but it may be to the south.

Major faulting trending W.N.W. to N.W. has occurred in the area and the two main faults have been named the Crusader Fault and the Crusader South West Fault.

Copper mineralisation, at the surface, extends at intervals over a length of 700 feet and over a width of up to 40 feet; the mineralisation is not uniformly distributed over the full 700 feet of length but appears to be most concentrated over 300 feet of this length. Copper ore occurs to a known depth of 200 feet in the Moran Shaft, but further extension is unknown at present.

Malachite red oxides and native copper occur in the oxidised zone where the ore probably averages 6 per cent. copper; the gold and silver content is very low. Some secondary enrichment probably occurred because some covellite and sooty and massive chalcocite has been reported from below the oxidised zone which extends to an average depth of only 30 feet from the surface.

The copper and iron minerals of the primary ore are mainly chalcopyrite and pyrite with some pyrrhotite, bornite and magnetite; the grade of the primary ore in the Moran Shaft probably averages 2.4 per cent copper. In one shaft a small amount of calcite containing chalcopyrite and pyrite has been reported.

The main orebody consists of talc, impregnated with copper-bearing minerals. The talc is localized within the Crusader Fault, where the fault has a hanging wall of amphibolite; it is considered that the talc is derived from this rock. It is also noted that where talc has its maximum occurrence the footwall rock is granite; the granite may have caused the metamorphism, leading to the development of the talc. It seems likely therefore, that the extension of the deposit in depth depends on the continuance of amphibolite hangingwall in conjunction with the granite footwall.

Diamond-drilling is the best method of testing at depth for a possible increase in size of the lode but as the localization of the ore appears to be controlled by intrusive

contacts, it is difficult to predict the behaviour of the deposit at depth.

INTRODUCTION.

Purpose of Survey

The purpose of the survey was to investigate the geological setting of the Crusader Mine and thereby to determine:-

(i) the factors controlling the deposition of ore,
(ii) the possibility of producing ore from the deposit.

An area of about six square miles was mapped on a scale of 1 inch to 1300 feet (Plate 1). and in the vicinity of the mine an area of half a square miles was mapped in more detail at a scale of 1 inch to 650 feet (Plate 2); this mapping was carried out using enlarged aerial photographs. A plane table survey of the mine area, using a telescopic alidade, was made at a scale of 1 inch to 40 feet (Plate 3).

The field work was carried out between 26th September and 13th October, 1951, by K.W.B. Iten and R.A. Searl of the Bureau of Mineral Resources and J.H. Brooks of the Geological Survey of Queensland.

Situation and Access

The Crusader Mine is situated 4 miles south-east of Dobbyn, which is the terminus of the Cloncurry-Dobbyn Railway line. Two tracks, providing alternative routes, give access to the mine from Dobbyn.

Climate and Vegetation

The average annual rainfall is 16 inches and most of the rain falls in the wet summer season. Adequate water for mining purposes could probably be obtained by sinking bores near the Leichhardt River; the river is approximately three miles east of the Crusader Mine.

Vegetation consists chiefly of spinifex grasses and small eucalypts; the latter are of little use in mining operations.

Mining History

The Crusader lode was discovered between 1890 and 1900. The Mount Elliott Company purchased the lease in 1915 but very little mining was carried out until 1922. During 1922 and 1923 tributors won 250 tons of oxidised ore (grade about 20 per cent copper). The lode was tested in 1928 by six churn drill holes distributed along lode length of 700 feet; the approximate position of these holes is shown on Plate 3.

Between 1928 and 1941 only spasmodic activity was reported. Interest in the mine was revived in 1941 when ten new shafts were sunk by tribute parties to depths between 40 and 100 feet. In 1947 the Moran Shaft was sunk to 200 feet by the Mount Elliott Company; 70 feet of driving 70 feet and 32 feet of crosscutting were carried out at the bottom of this shaft.

No detailed record of the ore produced from the mine is available but from study of records available

Dutton (1950) estimated that from 2,000 to 3,000 tons of oxidised ore with an average grade of about 15 per cent copper have been selectively mined.

Previous Investigations

A detailed geological survey of the Crusader area has not previously been made. Notes and unpublished reports dealing with some aspects of the geology have been made from time to time and the Queensland Government Mining Journals issued between 1916 and 1949 contain some references to the mine.

A regional geological sketch map of the Cloncurry District which includes the Crusader area was produced by Honman in 1937 and is included in the report of the Aerial, Geological and Geophysical Survey of Northern Australia for the period ended 31st December, 1936.

A general report on the Crusader Mine by Dutton (1950) includes abstracts of reports by Jack * (1898), Rutherford (1904) Y, Ball (1907-8) *, Yeatman Y and Berry Y (1920) and Mackay Y (1928); an account of the 1928 drilling programme with estimates of the productive potential of the lode by Heberlein is also included. Heberlein (in Dutton, 1950 p. 7 and 8) estimated the oxidised ore reserves to be 29,000 tons with an average grade of 6 per cent. copper. The assays of the six churn drill holes were summarised by Heberlein and are set out in the following table:-

Churn Drill Hole No.	Feet in Lode *	Average Assay	Total Depth of Hole
1	0 to 20'	11.2% Cu (oxidised)	128'
2	30 to 115'	3.2% Cu (Sulphide)	116'
3			30'
3a			23'
4	85' to 170'	1.9% Cu (sulphide)	176'
5	0 to 20'	7.2% Cu (oxidised)	88'
6	40' to 110'	1.8% Cu (Sulphide)	110'

* Feet in lode does not indicate width of lode as C.D. Holes intersected lode obliquely.

Average (sulphide) 2.34% Average (oxidised) 9.2%

* Jack R.L. 1898 Q'ld Geol. Surv. Bull. No. 10 p. 18

* Ball L.C. 1907-8 The Cloncurry Copper Mining District Q'ld. Geol. Surv. Pub. No. 215

Y Rutherford 1904 private report unpub. Vide Dutton 1950 Private Report S.B. Hill Unpub.

Y Yeatman and Berry. 1920 Private rep. for Hayden Stone and Co. New York. Unpub. Vide Dutton 1950 unpub.

Y Mackay 1928 Private rep. for Mt. Elliot Co. Unpub. Vide Dutton 1950 Unpub.

Y Hebehein 1927-28 Private rep. for Mt. Elliot Co. Unpub. Vide Dutton 1950 unpub.

GENERAL GEOLOGY

Introduction

The mapping carried out by the present investigators is shown on Plates 1, 2, and 3. The Crusader area contains folded metamorphosed sediments and altered igneous rocks of Pre-Cambrian age. The geological sketch map (Scale 1 inch to 6 miles) of the Cloncurry District by Honman shows the rocks of the Crusader area as part as the Kalkadoon-Argylla Series. Further regional mapping is now in progress.

Metamorphosed Sediments

The metamorphosed sediments in this area are mainly quartzites with subordinate micaceous sandstones. These rocks which occupy most of the area shown on Plate 1, occur as large outcrops on north-trending hills; in the valleys soil and alluvium are present and the outcrops are much smaller.

Bedding is not well preserved in the quartzites but ripple marks, indicating the general attitude of the rocks, are found in some places. Some narrow bands of silicified quartz-pebble conglomerate occur within the quartzites but these could be traced over short distances only and consequently could not be used as marker horizons.

The quartzites close to the mine show alteration, and thin section examination of several speciment (Appendix I R3456, R3462) revealed the presence of felspar, black iron ore, tourmaline, biotite, zircon, apatite, chlorite and leucoxene in subordinate quantities. Other altered quartzites which have been called hornblende quartzites (Plate 1) contain hornblende and epidote. Some of the hornblende quartzites contain veins of hornblende crystals up to ¼ inch wide. The alteration of the quartzites has been caused by the intrusion of acid and basic igneous rocks and the alteration increases towards the contacts with the intrusives.

Basic Intrusives

Occuring irregularly throughout the area are outcrops of basic intrusives (Plate 1). Intrusives in the northern half of the area shown on Plate 1 appear to occur in zones which follow the regional strike; near the mine (Plates 2 and 3), intrusives crop out close to the Crusader Fault.

An irregular outcrop of amphibolite occurs on the north side of the M ran Shaft (Plate 3). Thin section examination (Appendix I R3454) showed that this amphibolite consists of hornblende, plagioclase, sphene, epidote, black iron ore and apatite. It is highly probable that the amphibolite was originally an intrusive dolerite.

Thin section examination of a basic intrusive rock which occurs 150 feet west of the Moran Shaft (Plate 3) showed that it is probably a lamprophyre (Appendix I, R3458); it contains biotite, quartz, plagioclase, horn blende, black iron ore, sphene, apatite and leucoxene. The lamprophyre is in contact with a sheared granite (Plate 3) but the contact was not well defined. From field observations it is considered that the granite has intruded and altered this basic intrusive. The lamprophyre may have originated from the same magmatic source as the amphibolite on the north-east of the Moran Shaft.

A regional survey party from the Bureau of

Mineral Resources has mapped, in the Dobbyn district, similar basic and acid intrusives to those that occur near the Crusader Mine (Bennet, and Gates, 1951). This survey has not been completed to date but Bennett and Gates consider that the granite in this area may be younger than the amphibolites.

Acid Igneous Rocks

Granite is found in the western section of the area shown on Plate 1 and the outcrops are irregular in shape and differ in size; well defined contacts of the granite with other rocks in the area were not found.

Granite is in contact with the footwall of the Crusader Fault near the mine (Plates 2 and 4). This granite, referred to in the description of the lamprophyre, is sheared, well jointed and silicified. Two sets of joints occur; one set strikes N60E and dips 70° north and the other strikes N35W and dips at 60° east. Copper staining is present within the joints and is more prominent in the N35W trending joints which parallel the Crusader Fault. The shearing, jointing and copper staining decrease as the distance from the fault increases. Veinlets of quartz, representing a later penetration, occur in the granite. Thin section examination (Appendix I, R3452) of the granite which occurs immediately west of the Crusader fault shows that it is an acid plutonic rock.

Structure

(a) Folding:- The metamorphosed sediments shown on Plate 1 are considered to occupy part of the eastern limb of a regional anticlinorium. The regional strike is approximately N30E and the quartzites near the mine dip east at 50 to 60 degrees. The regional plunge of the quartzites may be to the south but this is not proved as there is little indication of pitch throughout the area investigated.

(b) Faulting:- Two major faults which have been named the Crusader Fault and the Crusader South-west Fault (Plate 1) cut transversely across the quartzites in a W.N.W. TO N.W. direction. These faults are represented by long outcrops of barren quartz and can be seen extending for some miles to the south-east of the Crusader Mine (Plate 9). The displacement of beds by these faults in the area mapped could not be determined.

The Crusader South-west Fault, south of the Mine (Plate 1) breaks up into a series of smaller faults. Weak copper-staining occurs in one place along this fault. The Crusader Fault, north-west of the mine, is also not continuous; it is represented by several lines of individual quartz outcrops (Plate 1). The Crusader fault, at the surface, dips 65° north-east at the mine but this may not be the correct dip of the fault at depth. Near the mine, copper and iron mineralisation occur at intervals in this fault over a distance of 1,200 feet.

The area between the two major faults shown on Plate 1 has been disturbed by small complementary faults (Plate 8, Fig. 2), and some copper mineralisation occurs where these faults come in contact with amphibolites. One small fault has been interpreted by Iten to intersect and displace the Crusader South-west Fault, suggesting that, at least, minor movements occurred after the period of major faulting.

ECONOMIC GEOLOGY

Introduction

The workings of the Crusader Mine could not be entered during the present investigation as they are filled with water. Figures pertaining to the grade of ore and underground data mentioned in this section have been taken from the report by Dutton (1950).

Size of the Lode

Mineralisation at the surface extends at intervals over a distance of 1,200 feet; with the exception of approximately 100 feet at the southern end the mineralised zone is shown on Plate 3. Leached outcrop mapping of the lode reveals that important copper mineralisation is probably confined to a length of 700 feet; at either end of this some weak pyrite mineralisation predominates.

Due to the presence of dumps and to caving in workings it was not possible to define definitely the position of any individual ore lenses within the 700 ft. of copper-bearing lode, but inspection suggests that the best ore occurs over a length of 300 ft. in the shoot tested by the Moran Shaft.

Character and Grade of the Ore.

The copper minerals of the oxidised zone are malachite, red oxides of copper and native copper. The oxidised copper ore south of Station B(Plate 3) occurs in weathered talc rocks; north of Station B where mineralisation occurs in central portion of the Crusader fault the copper minerals are associated mainly with crushed iron-stained quartzitic rocks of the fault zone.

Some sooty and massive chalcocite and covellite were found on the dumps and these minerals are reported to occur immediately below the oxidised zone, which extends to an average depth of 30 feet from the surface. The minerals of the primary ore are reported to occur in talc and specimens collected from the dump of the Moran Shaft contain mainly chalcopyrite and pyrite with some pyrrhotite, bornite and magnetite. A small amount of chalcopyrite and pyrite in a calcite gangue have been mined from a shaft 65 feet north of Station B (Plate 3).

Primary ore averaging 2.4 per cent. copper has been reported from the 200 ft. level in the Moran Shaft. Heberlein (1928) estimated the average grade of the oxidised ore to be 6 per cent. copper with no appreciable amount of gold. Three of the holes drilled in 1928 intersected secondary sulphide and primary ore and the average grade was estimated by Heberlein to be 2.4 per cent. copper.

It is doubtful whether the effects of secondary sulphide enrichment have been adequately considered in making this estimate. Churn drill holes No. 2, No.4 and No.6 intersected sulphide ore (Plate 5).

In holes Nos. 2 and 4, chalcocite and covellite were reported from the depths at which the highest grade ore was found. Although these minerals were not recorded from Hole No.6, the highest assays coincide with what would be the zone of secondary sulphide enrichment. If the high assays from this zone are eliminated the average grade of the primary becomes 1.8 per cent. Cu. The ore intersected in No. 2 hole, situated near the centre of the supposed ore shoot, averages 3 per cent. in what appears to be primary ore.

The origin of the talc is important as it is highly probable that ore will be found at depth only where talc occurs. It is evident that talc has been formed by alteration of amphibolite; it is also noted that granite is in contact with the footwall of the Crusader Fault where the maximum amount of talc occurs (Plate 4). As talc is commonly formed by hydrothermal metamorphism of magnesium-bearing rocks (Lindgren, 1933, p.391) it is considered that the injection of granite, in conjunction with the shearing of the amphibolite in the Crusader Fault, has been responsible for the formation of the talc. The structural implidations arising from this postulation will be discussed later in the report.

Structure of the Ore Deposit

Crusader Fault:- North of Station B (Plates 3 and 6) the Crusader Fault, in the mineralised zone, contains crushed iron-stained quartzitic material and oxidised copper ore. South of Station B the central portion and footwall side of the fault are filled with quartz containing limonite boxworks after pyrite; the hanging wall side contains the most important section of the ore deposit. The quartz filling may form the footwall of this section of the lode.

The measured dip of the fault at the surface near the Moran Shaft is 65° to the north-east. However, the Moran Shaft was sunk vertically for 84 feet before it intersected the quartz of the fault and construction of a cross-section (Plate 5) using this information indicates that the fault dips at 75°. Ball (1907-8) reported "ferruginous schists" dipping at 75° north-east in this area and Yeatman and Berry (1920) reported the dip of the lode to be 75° north-east.

Intrusive Amphibolite:- The amphibolite which occurs on the north-eastern side of the deposit has intruded the quartzites in an irregular manner and its sub-surface extent is unknown. Along the south-western margin the amphibolite probably grades into mineralised talc; if this occurs the hangingwall of the ore deposit will not be well defined.

The talc and the calcite reported in one shaft have been postulated to have been derived by pyrometasomatism of the amphibolite and the ore deposit is considered to have been formed during this period of alteration.

Diabase (equivalent to amphibolite of this report) was reported from the churn drill holes drilled in 1928. Churn drill hole No.1 passed through "diabase with quartz" from 60 feet to 126 feet (Appendix 2) and basic igneous rocks crop out on the south-western side of the Crusader Fault. Therefore it is possible that, at depth, basic rocks may occur close to the footwall side of the fault.

Granite:- Granite crops out irregularly on the south-western side of the Crusader Fault near the mine (Plate 3). The sub-surface extent of the granite is not known and no rocks resembling granite have been reported in any of the mine workings.

Malachite staining occurs in the granite immediately south-west of the Crusader Fault (Plate 3). The writer suggests that the staining is due to a secondary migration of copper into the joints of the granite. Iten postulates that the staining could indicate the presence of primary mineralisation in the granite at depth. Small veinlets of quartz occur in the granite and may be of similar age to the quartz filling the Crusader Fault.

As already discussed it seems likely that the copper-bearing talc, which contains the main ore deposit, owes its origin partly to the granite intrusion. The sub-surface shape of the intrusion is difficult to predict.

Metamorphosed Sediments:- The structure of the metamorphosed sediments is not considered to have influenced ore deposition at the Crusader Mine as the ore zone is within the transverse Crusader Fault and is bounded on the hanging-wall side by an intrusive and amphibolite. The footwall of the fault, opposite the ore-body is bounded mainly by granite,

Pitch:- As the ore deposit probably formed between two igneous intrusives, indications of pitch may not be shown very well; during the present investigation no evidence was found to suggest a pitch control of the lode.

Conclusion

Hydrothermal metamorphism which has probably formed the copper-bearing talc would be most effective where the basic intrusive is in contact with the granite and the Crusader Fault (Plates 3 and 4). Mapping has shown that this is the case because the main talc deposit occurs in the hangingwall of the Crusader Fault where granite is in contact with the footwall. The results of drilling indicate also that the average grade of ore is higher in the central portion of the mineralized zone, the grade of the primary ore averaging 3 per cent. copper in C.D. Hole 2 (Plate 3) and only 1.3 per cent. and 1.0 per cent. respectively in C.D. Holes No. 4 and No.6. As already discussed the portion of the mineralised zone containing the highest grade ore probably extends over a length of 300 feet.

An orebody 300 feet in length and 35 feet in average width would supply approximately 800 tons of ore per vertical foot. The average grade may be 2.4 per cent. copper to the 200 ft. level. It is possible that the deposit increases in size with depth but, owing to the nature of the ore controls, there is no evidence that this will or will not occur. No large tonnage of oxidised or secondary enriched sulphide ore is available.

ACKNOWLEDGMENTS

The writer is indebted to Dr. K.W. B. Iten for the preparation of plans accompanying this report. The recommendations and hypothesis expressed in the report result from discussions between the members of the party while in the field. The petrological work in Appendix No.1 was carried out by Mr. W. Dallwitz of the Bureau.

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APPENDIX 2. *

1928 Drilling Results - Logs of Churn Drill Holes Nos. 1-6

Churn Drill Hole No. 1

Position:- In open Cut

Log:-

Sample No.	Feet	Cu%	Remarks
1-2		11.9	Mostly copper carbonate
3		11.2	Carbonates, some oxides
4		9.7	Mostly carbonates, very clayey
5	27½	3.0	Clayey, carbonates, some red oxides
6		1.6	Free quartz-caly-carbonates
7		1.7	Some sulphides, red oxide, carbonate
8	40	2.9	Few carbonates, some sulphides, more oxides 1.0% S.
9		3.5	Some diabase, little carbonate, more oxide 0.3% S.
10	50	2.7	Less sulphide, more red oxide
11		2.1	at 58' heavy flow water - mostly oxide - little carbonate
12	60	1.5	Diabase with quartz, red oxide, some carbonate and sulphide 0.6%S.
13		1.7	Diabase with quartz, red oxide
14		2.1	Red oxide, native copper, diabase
15		1.7	" " " " " with quartz
16	80	1.8	Red oxide, native copper, diabase with quartz
17	85	1.1	Red oxide, native copper, diabase with quartz
18	90	0.7	Red oxide, native copper, diabase with quartz
19	97	0.5	Change in rock - more whitish - red oxide and native copper.
20	102½	0.4	Quartz diabase, sulphides, native copper, oxides
21	107½	0.3	Quartzy diabase, less sulphides and oxides, native copper
22	111½	0.2	Quartz in excess of diabase, no oxides, some sulphides and native copper, no red oxides.
23	116½	0.3	More sulphide, some native copper
24	120	0.2	
25	126	0.2	Cave-in at 78', sulphides
26		0.2	Casing placed, less sulphides; bottom of hole in bad shape, casing pulled, hole abandoned.

Notes (C.A. Heberlein).

Water level 58 ft.
Diorite from 45 to 128 feet.

* Extracted from the report on the Crusader Mine by A.H. Dutton (1950).

Church Drill Hole No.2

Position:- 37 ft. NE from No. 1 hole; in diabase 10' from h.w. of vein.

Log:-

Sample No.	Feet	Cu%	
1	5	1.2	Altered diabase, broken
2	10	1.4	Some carb, less oxide, no sulphide
3	15	1.0	" " " " " "
4	20	0.6	" " " " little sulphide
5	25	0.5	Little carb, " " more sulphide
6		1.6	some carb, chalcopyrite, pyrite, oxidized
7		5.6	No carbs, chalcicite and less pyrite
8		5.9	Chalcopyrite, very clayish
9	45	2.8	" " "
10		1.8	Strong chalcopyrite, clayish
11	55	3.9	Heavy pyrite and chalcopyrite
12		4.3	" " some chalcopyrite
13		3.5	" " " "
14		4.7	" " " "
15		3.0	" " chalcopyrite
16		4.0	" " " with some black sulphide
17		4.1	Heavier sulphide, some chalcopyrite, and black sulphide.
18		2.4	Heavier sulphide, some chalcopyrite no black sulphide
19		2.1	Heavier sulphide, some chalcopyrite
20		2.7	Heavy pyrite and more chalcopyrite
21		1.7	" " and less chalcopyrite
22	1.8	1.8	" " " " " some diabase
23		1.2	Heavy pyrite and less chalcopyrite some diabase.
			Entered diabase

Notes (C.A. Heberlein)

0-30' Hangingwall decomposed diabase with 1% copper.
30'-116' Sulphide ore, talcose gangue, vein apparently well defined. Ore composed of pyrite and chalcopyrite but no oxides. At times indications chalcocite. Average assay 3.17%.
At 116' Reached diabase footwall; orebody 40' wide, 64°dip.

Composite sample 30' - 115'.

SiO_2	56.4%	
Al_2O_3	4.0	
CaO	0.9	
MgO	17.6	- 53.0% talc
Cu	3.2	9.1% chalcopyrite
Fe	2.8	
S2	3.1	
Fe	1.8	3.8% pyrite
S_2	2.0	
Fe_3O_4	9.4	

Churn Drill Hole No.3 and No.3a

Position

50 ft. east from No.2 hole: intended to develop orebody at depth 210 feet. Calculated to pass through 120 ft. of diabase in the hangingwall before striking the vein.

Set up was in a creek and the diabase proved so difficult for drilling that hole was abandoned at 30 feet.

Drill then shifted nearer to No. 2 hole and Hole 3a started. No samples taken as pan did not show any copper; all diabase.

Ground is impossible to drill without great expense. Hole 3A abandoned at 23 feet.

Log. No. 3.

Sample	Footage	Copper
1		0.05
2		0.03
3	18.9	0.05
4		0.06
5		0.05
6	27.3	0.04

Church Drill Hole No. 4

Position.

200 ft. S.E. from No.2 started 40' from h.w. in diabase. Expected to cut vein 80-170 ft.

Log.

Sample	Feet	Cu%	Remarks
1-4	0-20-	0.04	
5	25	0.04	Diabase very much altered in parts
6-15	25-76	0.03	
16	81	0.04	Some quartz material
17	85	1.05	Lode entered between 80 and 85'.
18	90	2.7	
19	95	1.6	Covellite and bornite
20	102.6	5.8	
21		1.9	Pyrites
22	111	2.6	"
23		3.7	Covellite, chalcopyrite, and pyrite
24	120	3.3	Covellite, chalcopyrite, more pyrite
25	124	2.0	Less pyrite, dark honeycombed material
26	132	1.6	Dull looking quartz, little chalcopyrite
27	135	2.0	Dull looking quartz, little chalcopyrite
28	140	1.0	Dull looking quartz, no pyrite
29	147	1.0	" " "
30	154'6"	1.1	Mostly quartz
31		1.2	" "
32	162	1.1	" "
33		0.4	" "
34	170	1.0	About 170' struck footwall and diabase
35		0.6	
36	176	0.5	

Notes (C.A. Heberlein).

Feet	
0-80	Diabase assayed 0.02 to 0.08% copper
80-165	Crusader lode; 70-115' similar to No.2 hole
90-140	Covellite bornite and chalcopyrite with pyrite. Averages 2.58% copper. The quartzy material was "dead" looking and appears not conducive to making ore. Vein 40' wide.
90-165	Average assay 2.07% copper - discouraging.
165-175	Bored through the footwall, but no enrichment along the footwall as expected.

Churn Drill Hole No. 5

Position

300 ft. S.E. from open cut and Hole No.1. Commenced on hanging wall of lode.

Log.

Sample	Feet	Cu%	Remarks
1	5	8.1	Coarse quartz, some oxide and glance ore
2		4.4	" " " " " " "
3	17½	11.1	" " " " " " "
4		5.3	Brown silicious material, highly oxidised
5		2.0	" " " " "
6	30	0.8	" " " " "
7		0.5	" " " " "
8		0.5	Light coloured quartz-brown.
9		0.4	" " " "
10	50	0.6	Quartz, darker brown
11	56½	0.7	" " "
12	62½	0.3	Light quartz with dark oxide of iron
13		0.3	" " " " " " "
14	70½	0.2	Quartz, more rusty looking
15	77	0.2	
16	84	0.3	Quartz, and oxidized iron oxides
17		0.22	
18	88	0.22	

Notes (C.A. Heberlein)

0-20' Good copper values as expected; rich seams of chalcocite visible, but copper oxides exceed sulphide. Average 7.23%.

20'-70' Lode poor, consists mainly of reddish lode quartz, average 0.61%.

Churn Drill Hole No. 6

Position

Stated to be located 200 ft. N.W. from Hole No.1. The plan shows it to be 300 ft. N.W. of the first bore. Commenced 10 feet outside hanging wall of lode.

Log.

Sample	Feet.	Cu%	
1	6.6	0.04	
2		0.02	
3	15	0.02	First 15' diabase, altered.
4		0.02	Diabase with quartz
5	27½	0.05	Diabase altered, less quartz
6		0.07	Diabase with iron oxide
7		0.03	" " " "
8		0.10	Diabase, quartz and iron oxide
9	36½	0.75	Lode material, quartz and pyrite
10	50	1.81	Lode material, quartz, pyrite, and black sulphide
11		2.81	Quartz and pyrite
12		6.76	Lode material, chalcopyrite and pyrite
13		3.61	Heavy pyrite
14		1.42	Less pyrite
15		2.26	More pyrite
16		1.83	Little pyrite
17		1.30	" "
18		0.65	" "
19	95	0.31	More pyrite, some chalcopyrite
20		0.30	White pyrite
21	107½	0.22	" "
22	111	0.50	Little pyrite, some diabase

Notes (C.A. Heberlein)

0-40' Diabase, in places highly altered with iron and quartz.

40'-110' Lode, mostly siliceous with gangue and white pyrite. In places showed much pyrite; some bronze coloured indicating pyrrhotite. Average grade 1.75% copper.

At 111 ft. DARK DIABASE.

Surface of ground near this site indicates a more ferruginous lode than at S.E. end.

EXPLANATION OF PHOTOGRAPHIC PLATES

Plate 6

Panoramic veiw looking south-west towards to Crusader Mine, Dobbyn, showing surface workings of the mine and the Crusader Fault. On the skyline in the left of the photograph the Crusader South-West Fault can be seen. The rocks in the lower left are quartzites and amphibolite occurs in the valley between the quartzites and the mine.
Plane Table Station B (Plate 3) is on the edge of the creek crossing the Crusader Fault in the centre of the photograph.

Plate 7

Fig. 1 - View looking north-west along the north-eastern side of the Crusader Fault showing the main lode formation. The poppet legs of the Moran Shaft can be seen in centre of the photograph.

Fig. 2 - View looking south-east along the Crusader Fault showing the surface workings of the mine.

Plate 8

Fig. 1 - The Crusader Fault near the Moran Shaft. Copper-stained granite is shown in the upper right of the photograph and part of the main lode formation is shown in the lower left.

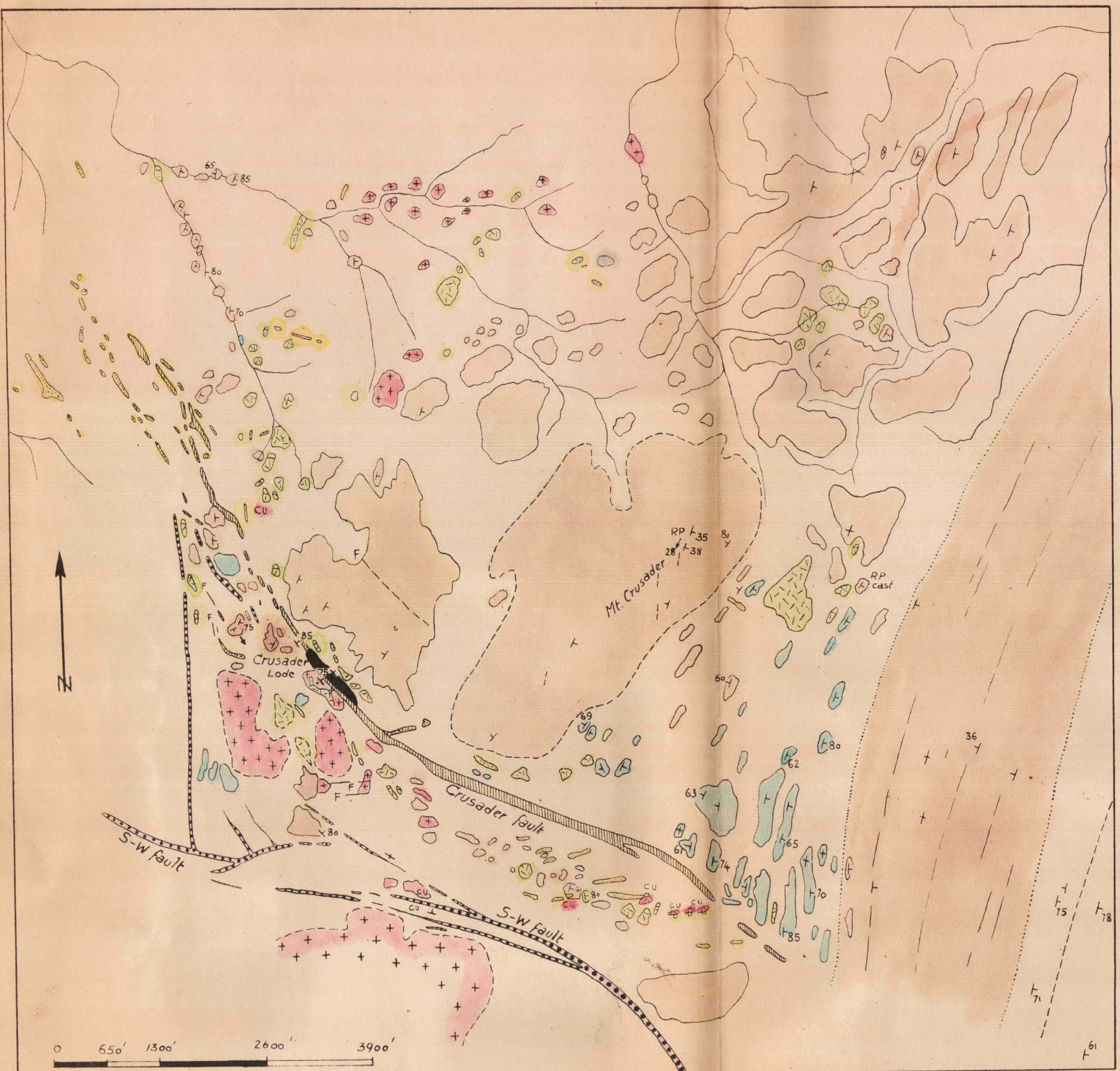
Fig. 2 - East-trending fault containing quartz which occurs between the Crusader fault and the Crusader South-west fault.

Plate 9.

View looking south-east from Mt. Crusader showing the Crusader and Crusader South-west Faults.

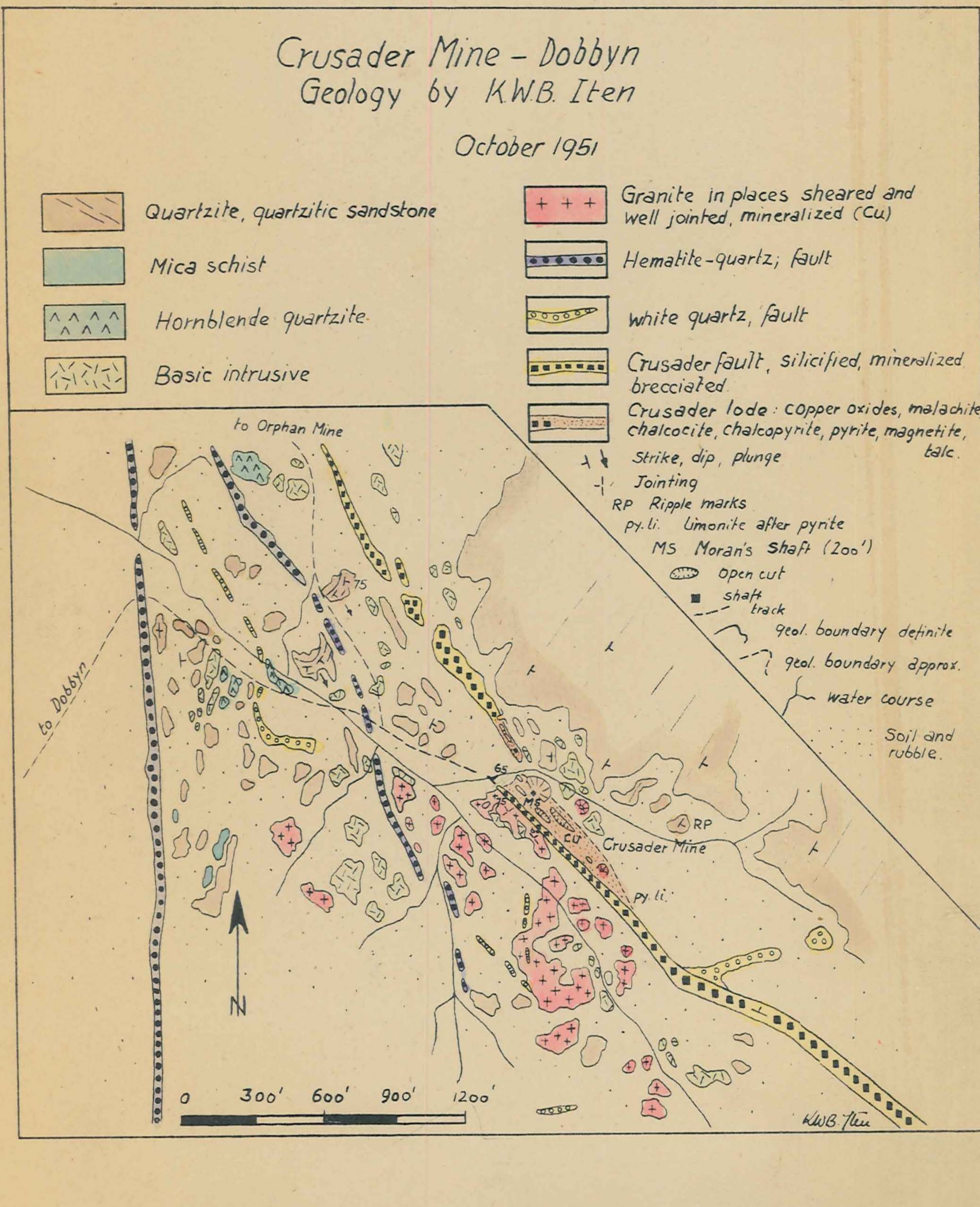
REGIONAL GEOLOGY - CRUSADER AREA

Geology by K.W.B. Iten, R.A. Searl & J.H. Brooks September 1951



- Soil, rubble, alluvium
- Quartzite, quartzitic sandstone
- Hornblende quartzite
- Basic intrusives
- Granite in places sheared and well jointed, mineralized (Cu)
- Crusader South-West Fault, hematite-quartz brecciated, fault.
- Crusader fault, silicified, mineralized brecciated.
- white quartz, fault
- Crusader lode: copper oxides, malachite, chalcocite, chalcopyrite, pyrite, magnetite, talc.
- F Fault definite
- F Fault approximate
- Geological boundary definite
- Geological boundary approximate
- Geological boundary inferred
- Strike, dip, plunge
- Jointing
- RP Ripple marks
- CU Copper staining, copper mineralization
- Structural trend lines

PLATE II



Crusader Mine - Dobbyn
Geology by K.W.B. Iten
October 1951
Quartzite, quartzitic sandstone
Mica schist
Hornblende quartzite
Basic intrusive
Granite in places sheared and well jointed, mineralized (Cu)
Hematite-quartz; fault
white quartz, fault
Crusader fault, silicified, mineralized brecciated
Crusader lode: copper oxides, malachite, chalcocite, chalcopyrite, pyrite, magnetite, talc.
Strike, dip, plunge
Jointing
RP Ripple marks
py. li. Limonite after pyrite
MS Moran's Shaft (200')
open cut
shaft
track
geol. boundary definite
geol. boundary approx.
water course
Soil and rubble.
to Orphan Mine
to Dobbyn
75
65
MS
Cu
RP
Crusader Mine
py. li.
N
0
300'
600'
900'
1200'
KWB Iten

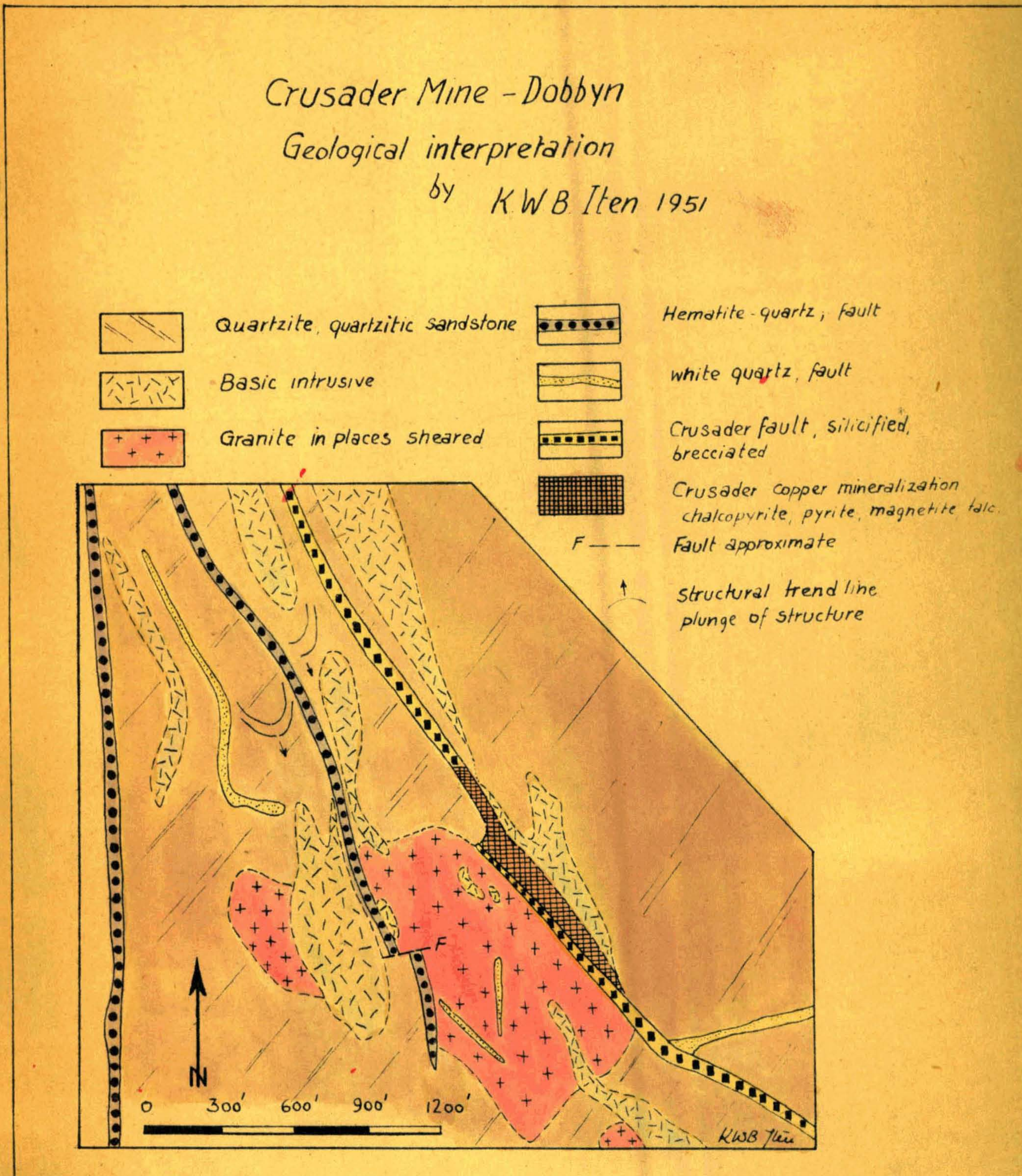
PLATE III

THE CRUSADER MINE - DOBBYN - CLONCURRY DISTRICT QLD.

PLANE TABLE SURVEY BY K.W.B. ITEN, R.A. SEARL AND J.H. BROOKS

OCTOBER 1951

PLATE IV


Crusader Mine - Dobbyn
Geological interpretation
by K.W.B. Iten 1951
Quartzite, quartzitic sandstone
Basic intrusive
Granite in places sheared
Hematite-quartz; fault
white quartz, fault
Crusader fault, silicified, brecciated
Crusader copper mineralization chalcopyrite, pyrite, magnetite, talc.
F — — Fault approximate
structural trend line plunge of structure
F
N
0 300' 600' 900' 1200'
KWB Iten

THE CRUSADER MINE

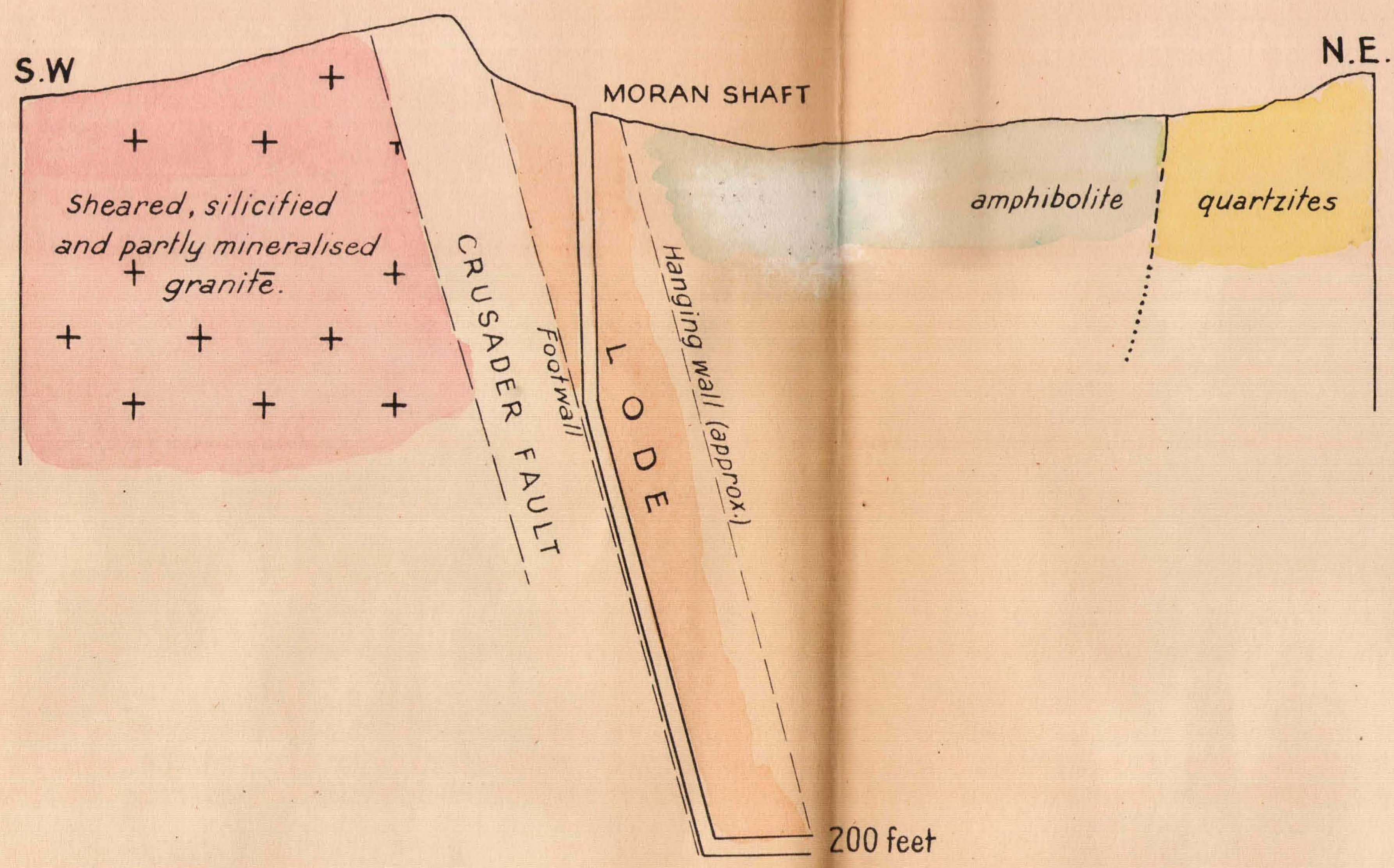
DOBBYN-CLONCURRY DISTRICT, Q'L'D.

CROSS AND LONGITUDINAL SECTIONS

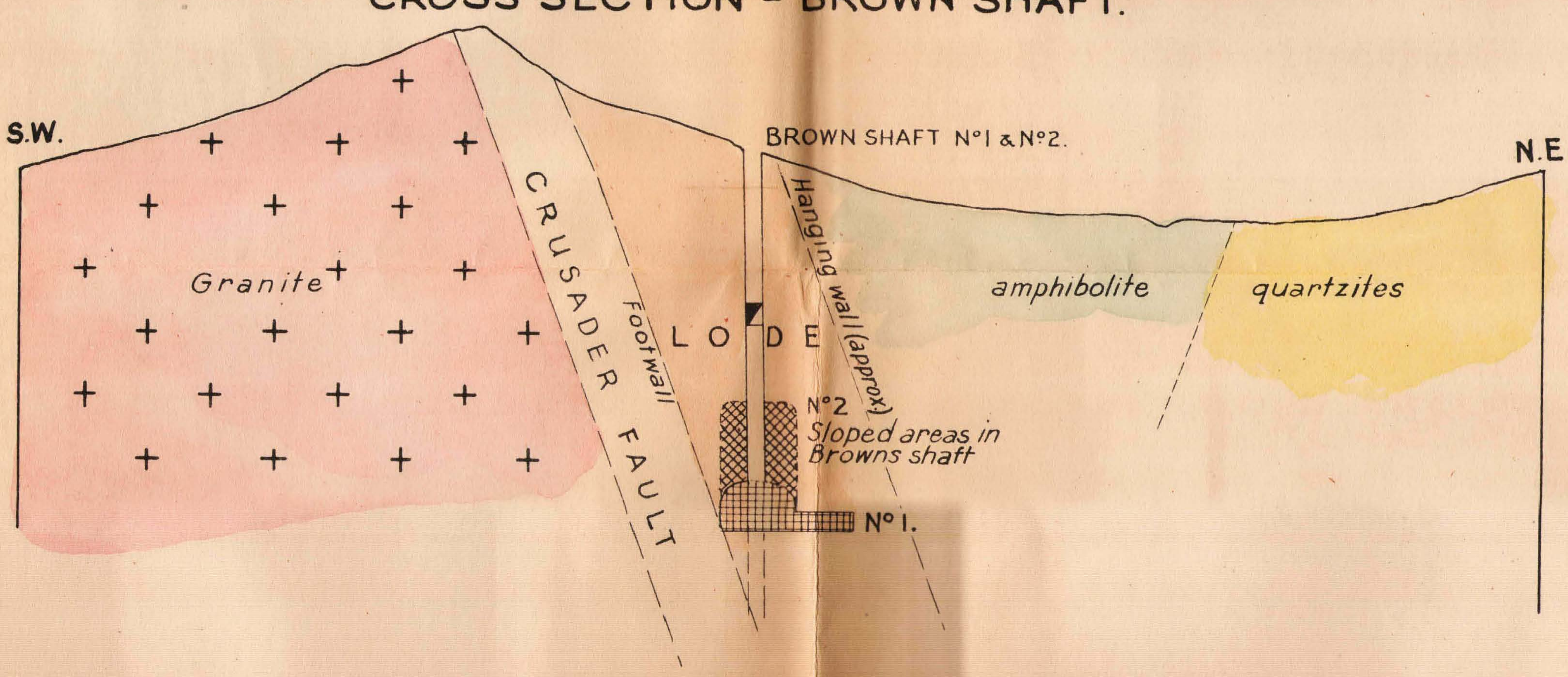
SCALE

40 0 40 80 120 FEET

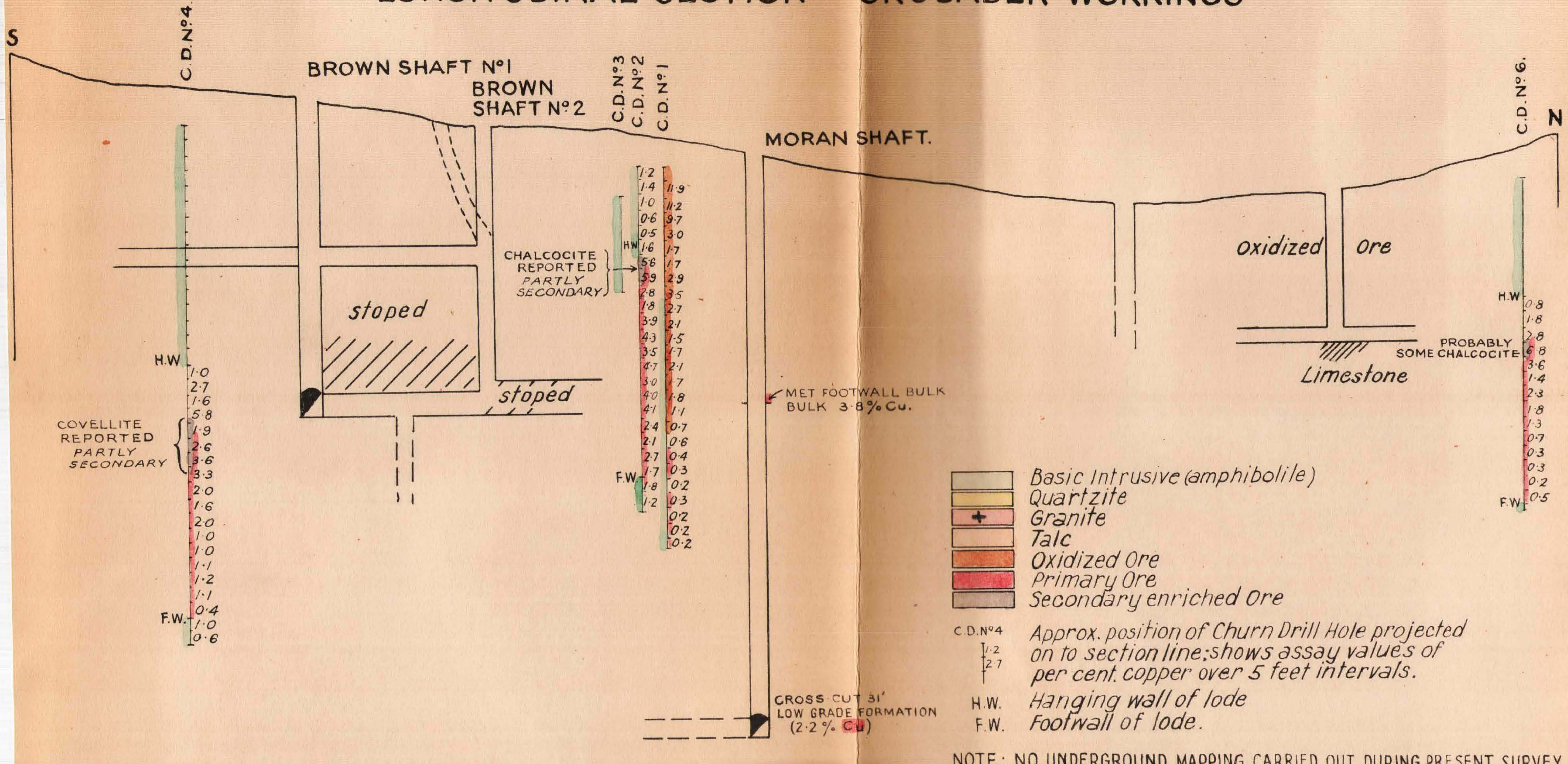
CROSS SECTION - MORAN SHAFT



CROSS SECTION - BROWN SHAFT.



LONGITUDINAL SECTION - CRUSADER WORKINGS



NOTE: NO UNDERGROUND MAPPING CARRIED OUT DURING PRESENT SURVEY. MINE WORKINGS PLOTTED FROM RECORDS OF WORKINGS AND INFORMATION SUPPLIED BY C. BROWN OF DOBBYN; SUB-SURFACE GEOLOGY INFERRED FROM SURFACE OBSERVATIONS.

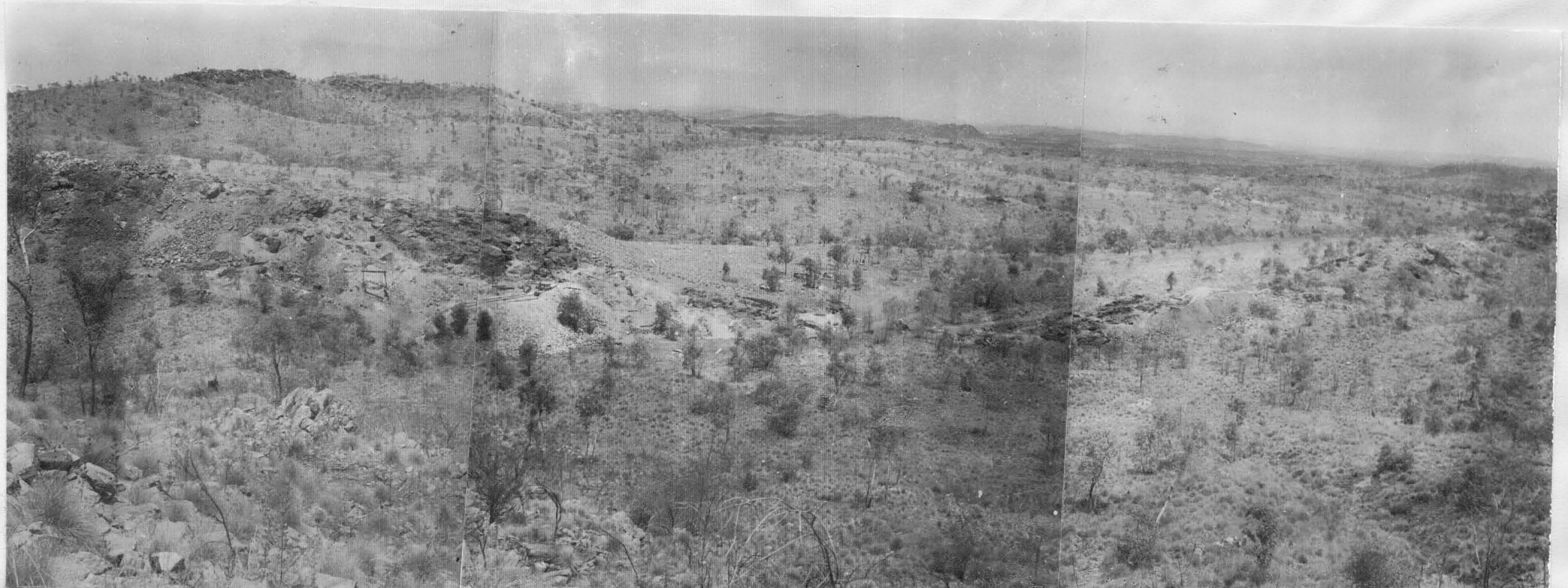


PLATE 6

Fig. 1

Fig. 2

Fig. 1

Fig. 2