CHAPTER SEVEN

MINERALIZATION

OXIDISED ZONE:

The zone of oxidization extends down to a depth of approximately 120 feet below the surface over all the area mined. The payable rubble and oxidized ore have long since been mined out. Thus very limited material is available for examination. The oxidized ore was a very weathered and leached banded jaspilite, containing a high proportion of iron minerals, and was comparatively rich in gold in some places. According to records, the average grade of the ore mined before 1900 was above 12 dwts/ton. Where gossan was prominent favourable gold values were found. Where the weathered banded ironstone passed into a more massive cherty jaspilite along its strike, the values decreased.

No detailed examination of the oxide minerals has been made. They appear to be quartz and hydrated iron oxides. Thus weathered outcrops show only minor magnetic effect. One uncommon mineral occurs, however, which has been identified as vivianite-vauxite. Its occurrence and features are as follows.

In many places along the jaspilite outcrops, but best developed in the vicinity of the Magano section, a greenish yellow mineral is present. It occurs as small discontinuous flat lenses up to 10 millimetres thick with a horizontal attitude independent of the local rock. These lenses occur for the first five

or six . . / -

ARSENOPYRITE-LOLLINGITE:

Since the name "Arsenopyrite" is used in all the literature on Vubachikwe Mine - as well as on the property itself - it has been retained throughout the text, except partially in this particular section.

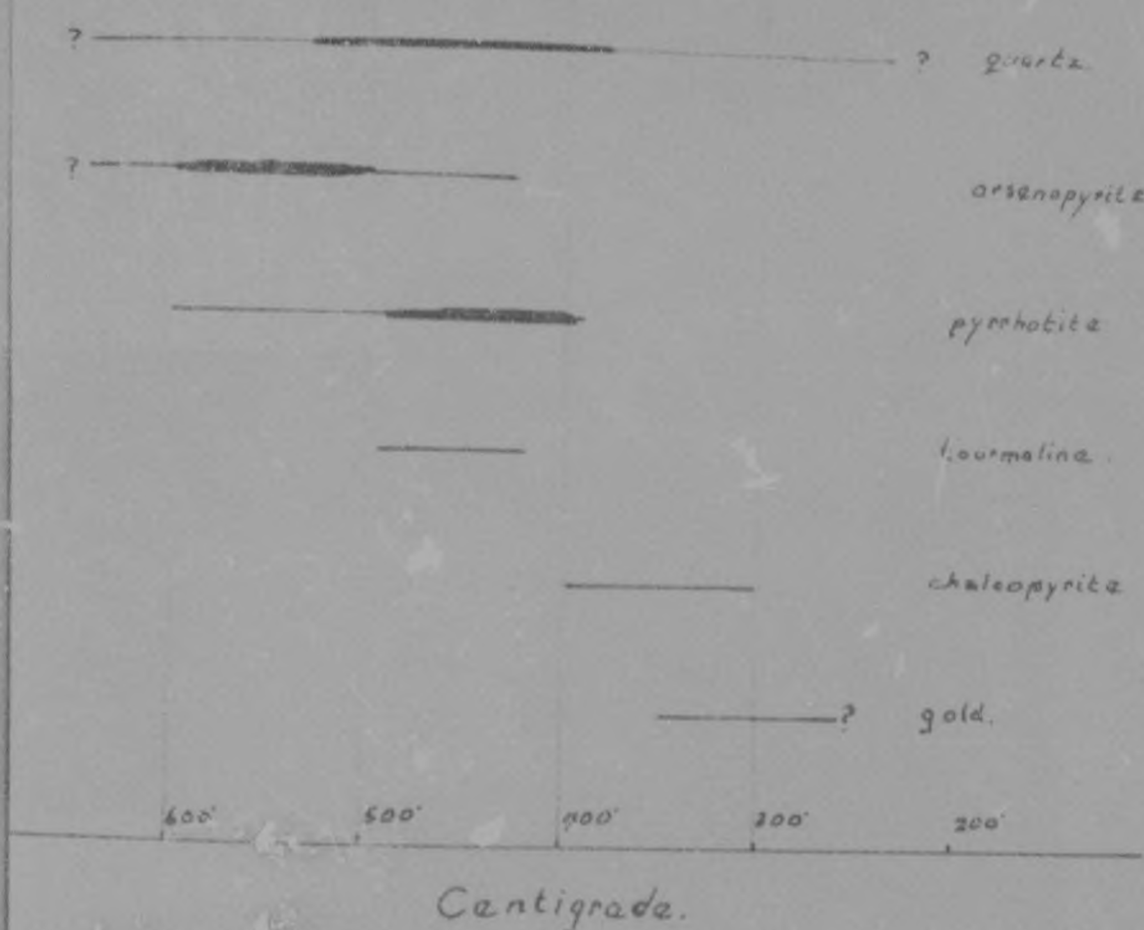
Arsenopyrite is the commonest sulphide of the ore, amounting to about 7% of the ore by volume. This estimate was reached by careful visual examination of the ore and of concentrate samples. The mineral occurs disseminated in the jaspilite. It ranges from small anhedral aggregates to euhedral crystals up to 15 millimetres long, and about 1·5 millimetres thick. Freshly broken crystals have a highly metallic lustre which tarnishes rapidly to a dull grey-white.

Under the microscope, the arsenopyrite is opaque in transmitted light, and bright white in reflected light. It is a very weakly pleochroic, the only change noticed being a slight variation in the intensity of colour on rotating the stage. Under crossed nicols it is weakly anisotropic, changing from a steel blue-grey to a brownish-grey.

Examination of the arsenopyrite in polished sections shows that it occurs with a fairly wide range of textures. The impression gained is that it was the earliest of the sulphides to crystallise, and that this crystallisation lasted through a considerable time, and probably over quite a wide temperature range. On the edges of ore-bodies - i.e., at the limits of impregnation of the

solutions . . / -

Paragenetic Chart.



or six feet below the surface and do not continue below this depth. Due to the greenish colour contrasting with the reddish brown of the limonitic soil and banded ironstone, the mineral was initially examined for the presence of radio active material. The occurrence has been noted by the Geological Survey of Southern Rhodesia and was described by Phaup*. The mineral was identified by the Geological Survey of Southern Rhodesia as vivianite, an obscure hydrated iron phosphate with the formula $Fe_3 P_2 O_8 8H_2O$. In the present investigation, however, it has been found that the mineral is almost amorphous. It has a massive clayey texture, unlike the fibrous flexible texture of vivianite. Analysis by Xray diffraction shows the mineral to belong to the Vauxite group, another series of hydrous iron phosphates. The variety examined corresponds most closely to the semi-amorphous mineral delavauxite with the formula $2 Fe_2 O_3 P_2 O_5 . 9H_2 O$. It is a secondary mineral resulting from soil water action, the formation being similar to that of calcrete. The origin of the phosphate content is obscure, since no phosphate minerals are known to be present in the local rocks. It is possible, however, that phosphate ions may be associated with carbonates which are so prevalent in the rocks of this area.

SULPHIDE ZONE:

In the sulphide zone, extending below the oxidized zone, the ore is found to contain the following minerals, each of which is described over page:-

. . . / -

*"Notes on the Magano Mine" (22-11-52)

solutions - the magnetite was only partially replaced. Within the orebodies, unreplaced magnetite does occur - but uncommonly. Thus it may be concluded that the first sulphide crystals formed in an iron-rich environment and actually absorbed the iron by replacing magnetite with arsenopyrite.

Arsenopyrite occurs in its commonest form in well formed crystals. The most common form observed is of the pseudo orthorhombic prism 110. Also common are vertically flattened crystals as well as columnar, straight, divergent, granular and compact. Twinned groups and combined crystal forms are not uncommon.

In the early stages of crystallisation of the arsenopyrite, discreet perfect euhedra was formed. Within the comparatively wide range of temperature of formation of arsenopyrite, tourmaline also crystallised in close association with the arsenopyrite. The larger arsenopyrite crystals seem to have suffered displacement and fracturing and this indicates that at least some of the sulphide is older than the tourmaline, which probably crystallised simultaneously with the last of the arsenopyrite. See Plates Nos. 24, 25, 26, 27 and 29.

Numerous aggregates of small arsenopyrite crystals occur. They all exhibit a mutual growth interference and suggest an increase in the rate of deposition as the temperature fell. Pyrrhotite is seen in mutual relationship with these aggregates and at approximately this stage began to crystallise together with the arsenopyrite. See Plates Nos. 28, 30 and 33.

PLATE NO. 22 : Garnet and Carbon in Slate. Opaque black is mostly quartz, coated with opaque graphite.

Plane polarised x 50.

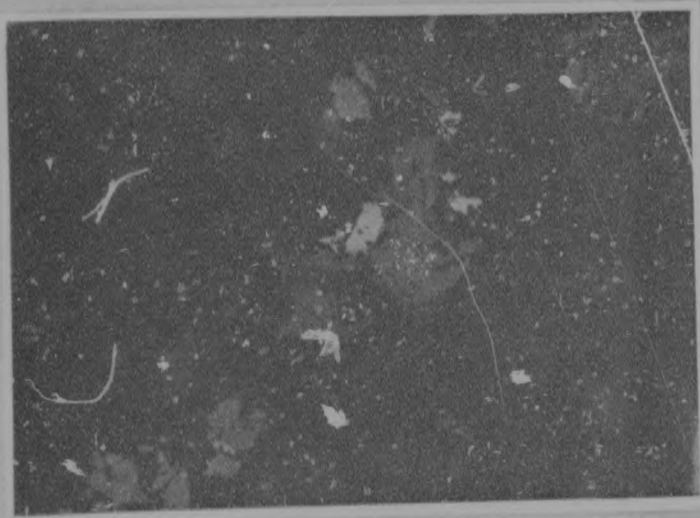


PLATE NO. 23 : Magnetite being replaced by Arsenopyrite and quartz. Note tendency to banding in magnetite diagonally across field.

Polished section. Plane polarised x 250.

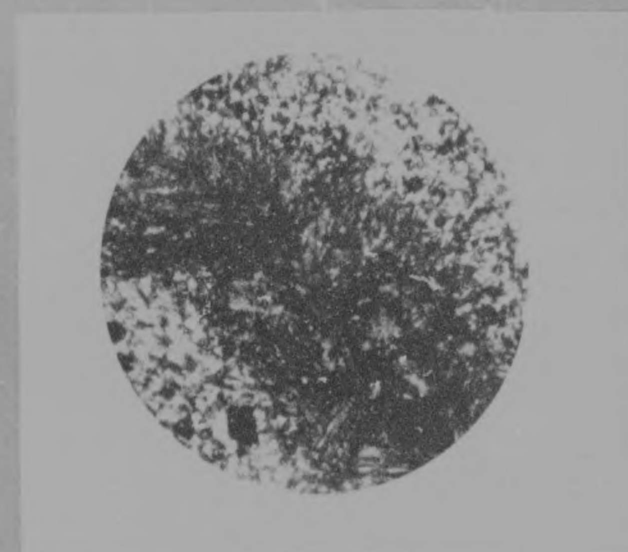


PLATE NO. 16 : Band of Felted Amphibolite (Grunerite) needles in Jaspilite: Note opaque mineral centre to band is magnetite; as found in altered siltstones, shales and Jaspilites. X nicols x 52

PLATE NO. 17 : Stellate growths of Grunerite around Magnetite grains in Jaspilite.

Plate polarised x 62

The arsenic bearing mineral, locally called arsenopyrite, occurs throughout the ores of Vubachikwe Mine, associated with economic gold values. It has been found by mining experience that gold values are related to the grain size of the arsenical mineral with which they are associated. Generally, higher gold values are found with fine grained arsenopyrite, although not in all cases. This is not really an uncommon feature in mines of this type: for example fine grained arsenopyrite is associated with relatively high gold values in the following Rhodesian Mines:-

MARVEL MINE, Filabusi;

MONARCH MINE, Penalonga;

BLANKET MINE, Gwanda.

Generally, fine sulphides rather than coarse sulphides are associated with high gold values on the following Rhodesian Mines:-

CONNEMARA MINE, Hunter's Road;

GAIKA MINE, Que Que;

VALLEY MINE, West Nicholson;

EMPRESS MINE, Mashaba.

All these instances have been noted by the writer in the course of work on those mines. It was suspected that the reason for this association on Vubachikwe Mine may lie in the possibility that the coarse and fine grained varieties may represent minerals of varying composition. Thus a series of Xray analyses was carried out on grains of varying size.

The following figures have been used.

TEMPERATURE OF FORMATION:	CENTIGRADE:	EXPONENT:	
Quartz	600° - 100°	Nicolaysen	(1961)
Tourmaline	400° - 450°	Smith	(1949)
Pyrrhotite	400° - 600°	Friedman	(1959)
Chalcopyrite	350° - 400°	Vokes	(1955)

- -

FEATURES OF THE ORE SOLUTION:

There are several notable features of the mineralising solution. It may be stated, from the absence of pyrite and the type of minerals contained in the ore, that, relative to the metallic ion content, the solution was poor in sulphur. With the sole exception of chalcopyrite (which occurs in very small amounts) the minerals found in the ore are of the sulphur poor varieties. Thus the ore contains:-

Arsenopyrite-lollingite, instead of arsenopyrite;

and

Pyrrhotite, instead of Pyrite.

The cause of this lack of sulphur is not known.

A further feature is the uniformity of the ore, and hence of the solution from which the ore minerals and gangue minerals was crystallised. It is true that

the Vubachikwe . . / -

GANGUE MINERALS:	Quartz	75%	Estimated	proportion
	Amphibole	10%	"	"
	Carbonate	3%	"	"
	Tourmaline	rare	"	"
	Carbon	rare	"	"
	Garnet	rare	"	"
ORE MINERALS:	Magnetite	1%	"	"
	Arsenopyrite-Lollingite	7%	"	"
	Pyrrhotite	4%	"	"
	Chalcopyrite	rare	"	"
	Gold	rare	"	"

* ** * ** * ** *

The estimated percentages of minerals comprising the ore are based on visual examinations of washed samples of the mill feed.

Hand specimens of the ore were found to contain a very variable proportion of sulphide minerals, and in highly mineralised specimens, the amount exceeded 50% by volume on visual examination. In the milling of the ore, an average amount of 12% of sulphides is assumed.

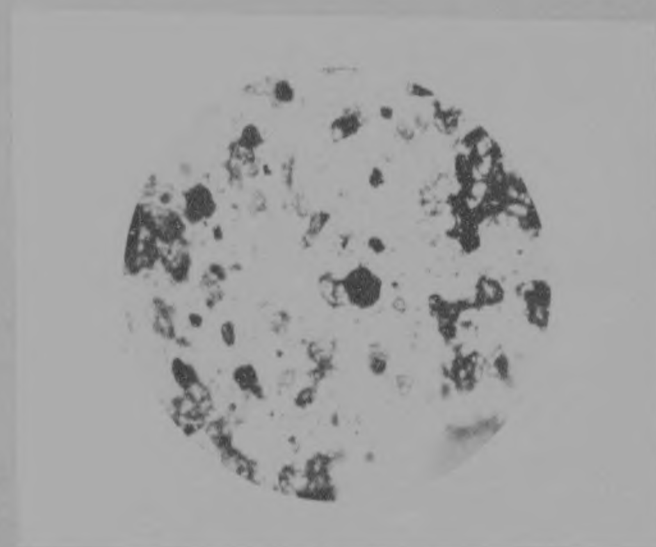


PLATE NO. 18 : Fine Subhedra of magnetite disseminated in quartz in jaspilite. Little or no amphibole is apparent.
Plane polarised x 200.

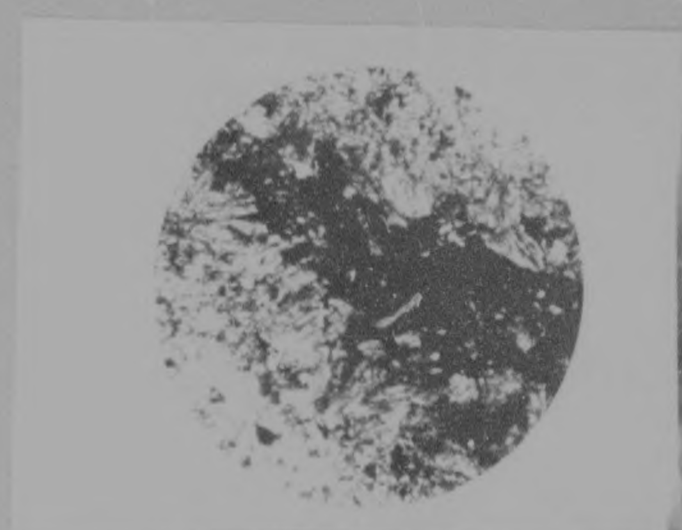


PLATE NO. 19 : Amphiboles growing towards quartz in jaspilite.
Plane polarised x 50

the Vubachikwe property has been mined to no great depth (1,500 ft.). However, from the top of the sulphide zone to the bottom of the mine there is no sign of any mineral zoning. Zoning may become apparent when the mine reaches greater depth.

According to Londgren's classification of hydrothermal deposits, the mineral association of Vubachikwe Mine places it in the lower range of the hypothermal class. As such, the deposit will probably continue comparatively unchanged for a very considerable distance underground, subject to the existence of suitable structural conditions such as the continued presence of certain host rock and fracture pattern.

* *** * *** *

ORIGIN OF THE MINERALISING SOLUTION.

A hydrothermal solution of high mesothermal type impregnated the limbs of the north-west Gwanda synform, and from it orebodies were deposited in favourable localities. These were examined in one particular area (Vubachikwe Mine) and in that limited field were found to contain sulphides of arsenic, iron and copper as well as quartz, tourmaline and native gold. At some later stage the rocks in the district were quite considerably carbonated. There are at least two possible theories for the origin of

this mineralising . . / -

The result proved that all the samples were of the same composition. However, the identification of the mineral presented a problem. The latest edition (1961) of the "Xray Powder Data File" published by the American Society for the Testing of Materials (Pa.) contains no reference to arsenopyrite, previous work on this mineral having been occluded due to unreliability. Standard minerals of known composition were not available, nor were funds or facilities for a detailed chemical analysis. The arsenic-iron-sulphides form a completely isomorphous series between arsenopyrite Fe S_2 Fe A_{s2} and lollingite Fe A_{s2}. Xray results, obtained for the Vubachikwe mineral, were very close to those quoted for reference by Harcourt (1942) as lollingite, and only vaguely resembling those for arsenopyrite. However, since the figures do not correspond exactly and qualitative tests proved the presence of sulphur, the mineral has been accepted as belonging to the isomorphous series arsenopyrite-lollingite, and of composition close to lollingite. (For the Xray data, see the Section on Mineral Identification by Xray Diffraction.)

PYRRHOTITE:

Pyrrhotite constitutes about 4% of the ore by volume. It is established as being the mineral pyrrhotite (approximating to the composition - Fe_n S_{n+1}) by analyses using Xray diffraction. (See section on Mineral Identification by Xray Diffraction). Results obtained correspond exactly with those obtained for similarly analysed standards. Mine metallurgical

tests . . / -

An examination of a sample of the mill concentrates was carried out under the binocular microscope, and the following proportions of minerals were found:-

MINERAL PROPORTIONS IN MILL CONCENTRATES.

GANGUE	approximately	10%
MAGNETITE	"	3%
ARSENOPYRITE	"	59%
PYRRHOTITE	"	27%
CHALCOPYRITE	"	less than 1%
GOLD	"	present but rare.

* ** * ** * ** *

GANGUE MINERALS:

QUARTZ.

In the ore two different types of quartz occur.

Original Quartz:

Considerably more than half the total volume of the ore consists of original quartz, hence the local term 'quartzite' for the ore. This quartz is very fine-grained, and consists of dark grey-blue cherty quartz grains. On fractured surfaces it has a slightly sugary texture. The blue varieties are translucent

in thin flakes . . / -

this mineralising solution:-

a) <u>CUPOLA ORIGIN</u>:

In the north-west Gwanda area, there are two cupolas - or stocks of quartz-monzonite. These are the Insindi and Sizeze stocks. It is suggested that these cupolas are evidence of igneous activity in the area, and the mineralising solutions may have emanated from the centres of such activity and have formed orebodies in suitable places. It has been shown in the section on Structure that the fracture pattern followed by the solution was probably formed by the "Second Deformation". Therefore, the igneous activity must have followed the "second Deformation". However, it has not been possible to determine the relative age of the quartz-monzonite cupolas. Their field relationships with the country greenstones are not at all clear: No clear contacts have been seen, and although no "second deformation" axial plane cleavage has been found in the stocks, it cannot definitely be stated that the cupolas are post second deformation.

Because no orebodies have been found directly associated with the two cupolas, it does not necessarily mean that no mineralising solution was with them. The cupolas are, however, evidence of quartz-monzonite igneous activity, and such activity is associated in many parts of the world with gold mineralisation.*

b) <u>LATERAL SECRETION</u>:

The possibility . . / -

* Emmons, 1937.

tests have revealed no nickel in the ore, and no pentlandite has been observed intergrown with the pyrrhotite. Pyrrhotite occurs in irregular grains and veinlets throughout the ore from submicroscopic up to four inches across, and is also noted in the slaty bands where it occurs in grains and as smears on partings of the slate. It is of the usual typical metallic brown colour when fresh, and tarnishes rapidly on oxidation. Tarnished surfaces sometimes show a brilliant peacock irridescence not unlike bornite, but more brassy-coloured. Euhedral crystals of pyrrhotite were not observed. In limited localities, associated with introduced quartz, concentrations of pyrrhotite as large as four inches across have been seen. Compared with the magnetite in the ore, the pyrrhotite is only weakly magnetic.

Under the reflecting microscope, the pyrrhotite appears a pinkish cream colour and contrasts sharply with the bright white of the arsenopyrite. It is also comparatively soft, being easily scratched with a steel needle. In polarised light, the pyrrhotite is quite discernible as anisotropic changing from a dark grey-brown to a paler shade of the same colour.

The pyrrhotite began to crystallise with the last fraction of the arsenopyrite, and is frequently associated with it in completely mutual relationship (see Plate No. 30): pyrrhotite replaced gangue to a fairly large extent and, to a limited extent, corroded and replaced arsenopyrite. Evidence for the continued crystallisation of pyrrhotite later than the arsenopyrite is seen in the form of veinlets of

pyrrhotite . . / -

in thin flakes. There is a tendency for the original quartz to occur as bands in the rock - apparently conforming to the original bands of the banded jaspilite. However, so much of the original texture has been obliterated by mineralization, that this banding is no longer a well marked feature. In thin sections, the quartz is seen to consist of a pavement-like mosaic of moderately interlocking quartz grains all of well sorted similar size. Occasionally very small grains of magnetite are present. There is a tendency for the pavement mosaic, as a whole, to follow a banded structure. This is sometimes accentuated by the regular orientation of amphibole and chlorite crystals which are occasionally present. This cherty quartz is very hard and, with its "reinforcing" of amphibole needles, has become a particularly tough rock. The dark-greyish colour may be due to a small amount of carbon contained in the rock. (See Plates Nos. 10, 11, 17 and 18.)

Introduced Quartz:

All the quartz observed of this nature is of "vein quartz" type. The veins are seen filling all manner of fractures in the rocks, from comparatively large fault-fillings, such as the two foot wide vein on 11 Level footwall drive, to tiny microscopic veins healing cracks in the massive ore. Throughout the Vuba-Long-John sections of the mine it is a pale grey glassy looking quartz, showing pronounced shattering. It often contains wispy growths of tremolite. The interior of the large veins (i.e. those greater than four inches thick) consist of comparatively pure quartz,

while the margins . . / -

The possibility that the orebodies were formed by lateral secretion must be considered. The term is used reservedly and the agency for secretion was not meteoric waters as propounded in the early theories of Daubree (1887) but rather envisaged along the following lines : - *

All the elements found in the Vubachikwe orebodies (Except Bi and Au) are present to a greater or lesser extent, some as minor constituents in Rhodesian greenstones and granites.** Sulphur has been found in amounts up to 0·10%, and arsenic 0·05%. Unfortunately, no rock analyses are available for the area under discussion, but no logical reason can be seen for the area to be an exception to Rhodesian gold-belt rocks. Thus it is suggested that all the required elements to form orebodies were spread through the regional rocks. Under metamorphic conditions, probably at considerable depth, the marginal portions of the greenstones were subjected to granitizing conditions. Processes of granitisation were already advanced in the rocks in which the greenstone complexes lay, thus the ore minerals together with carbonates and silica were mobilised into solutions within the rock. During the metamorphism, the solutions migrated into fractures and cracks, and were forced away from areas of greatest compression.*** Hence, they came to be hydrothermal solutions. The minerals

from these . . / -

*Ref. Bateman, Chapter 1.
**Golding, 1936.
***Macgregor, 1951.

pyrrhotite formed in arsenopyrite and original quartz, and also as partial rims to arsenopyrite crystals, as well as filling interstitial cracks and occurring as graphic growths in quartz. The pyrrhotite was partially replaced by later quartz in places. See Plates Nos. 32, 33, 34, 35 and 36.

CHALCOPYRITE:

A very small amount of chalcopyrite was found in the ore. At the end of the stage of crystallization of pyrrhotite, chalcopyrite crystallised, partly contemporaneously with the pyrrhotite, and partly replacing pyrrhotite. (See Plate No. 37.) The chalcopyrite is a yellow soft sulphide, positively identified by Xray diffraction analyses. (Ref. section on the Identification of Certain Minerals by Xray Diffraction.) The largest grains seen are associated with pyrrhotite and are up to 12 millimetres across; however, usually the chalcopyrite forms a very insignificant portion of the ore.

Under the reflecting microscope, the chalcopyrite is seen to be a yellow colour which, in very finely divided grains, can be mistaken for gold. The larger grains are easily distinguished by their brittleness, compared with the malleability shown by the gold. Also when the two are seen together, the gold has a deeper yellow colour and a much higher reflectivity. The chalcopyrite does not exhibit pleochroism. Under reflected polarised light it is slightly anisotropic, varying in shade of yellow-brown on rotation of the

microscopic stage. / -

while the margins may contain considerable amounts of sulphides. There is a very close association between this "clean" quartz and all the "visible" native gold seen on the mine.

In the Magano section the quartz has a dense white milky colour. This may be due to a faster rate of cooling, forming smaller crystals than the quartz of the northern parts of the property. However, it is thought this effect may be due to a carbonate content in the quartz. A gentle gradation from the highly vitreous and glassy quartz in the north to the milky white variety in the south, is believed to exist. There is insufficient data available on the 2,500 foot space between the Magano and Long John sections to prove this contention, although surface indications are that generally there is an increase in the carbonate proportion of the rock southwards. (See Plates Nos. 12 and 45).

CARBONATES:

Whilst a portion of the undifferentiated sediments was probably calcareous, the major portion of the carbonates are believed to have arisen through carbonitisation of the country rocks. As such, most of the carbonates have been introduced into the surrounding greenstones and relatively little occurs in the actual ore. The ore is, however, transversed by many carbonate veinlets. They fill cracks and small fractures which cut across all the other minerals and structures. It is considered that a large proportion of these veinlets (up to two from these solutions would be emplaced in chemically and physically suitable environs. The general impression of the Canada Area is very similar to the Yellowknife Goldfield of the North-West territories of Gwanda: it has been shown that the economic deposits there were formed by this type of lateral secretion,* and it is believed that this could have been the mode of origin of the mineralising solution in the north-west Gwanda area.

* * * * *

*Boyle, 1959.

microscope stage. The chalcopyrite is rarely seen associated with arsenopyrite, being usually separated from it by gangue or pyrrhotite. Occasionally it is enclosed in pyrrhotite (see Plates Nos. 37 and 38), but more often fills up little spaces at the ends of pyrrhotite veinlets (see Plates Nos. 32, 33 and 38), or occurs between grains of pyrrhotite. Thus since it is found at extremities of the pyrrhotite, it probably was introduced at a later stage of pyrrhotite crystallisation and, as the chalcopyrite crystallised, it replaced small amounts of pyrrhotite.

<u>GOLD</u>:

Gold is the mineral of economic importance in this orebody. Rich specimens containing visible gold are rarely found on Vubachikwe Mine. In order to examine the gold more closely, samples of concentrate obtained from the spillage James table in the mill were panned, and the product, enriched in gold, was mounted and prepared in polished sections. Coarse gold is known to occur on the mine since nuggets of several millimetres in size are recovered from the ball-mill periodically. The only available coarse gold actually seen in situ was taken from the Magano Section. (Plate No. 45.)

Polished sections of the gold under the reflecting microscope show it to be a very rich yellow, and under polarised reflected light it shows a distinct but weak anisotropism. Although persistent buffing of the section fails to remove this anomaly, it is a polishing effect. No crystals of gold have been seen, all the grains being irregular in shape: doubtless, some of the

grains . . / -

inches thick) was deposited by percolating ground waters, which dissolved carbonates from the greenstone, and redeposited them in cracks in the orebodies. However, since some of these veinlets contain carbonates of highly crystalline nature, it is thought that these may have been precipitated from hydrothermal solution at the end of the mineralizing phase. No analytical work has been done on the carbonates, but hard specimen examination suggests that the bulk of the mineral is calcite, while some very brown and well crystallised portions are thought to be siderite. The ore of the Magano Section contains a very much greater proportion of carbonates than the ore of the main sections. This is not surprising since the local rocks around the Magano Mine are much more calcareous than those further north.

It is interesting to note that although the ore contains carbonates, these are present in insufficient quantity - or insoluble form - to preserve the protective alkalinity necessary for the cyanidation process used by the mine; and considerable lime has to be added to the mill. (See Plate No. 13).

AMPHIBOLES:

The clay minerals, iron minerals and the fine grained quartz originally present in the banded ironstones probably reacted under metamorphic conditions to form iron-rich amphiboles. Some of these amphiboles have subsequently been altered to chlorites. Exceptionally, the amphiboles form as much as 40% of the rock

by volume; . . / -

PLATE NO. 24 : Arsenopyrite band in Ore. Note euhedral-subhedral crystals in quartz and magnetite, and penetration crystals.
Polished section.
Plane polarised x 82·5.

PLATE NO. 25 : Arsenopyrite. Subhedral crystal shattered and being replaced by quartz and tourmaline in quartz vein. Tourmaline is dark grey mostly at bottom of white arsenopyrite crystal. Polished section.
Plane polarised x 82·5.

PLATE NO. 20 : Tourmaline needles in quartz, associated with arsenopyrite in quartz veins.

Plane polarised x 50.

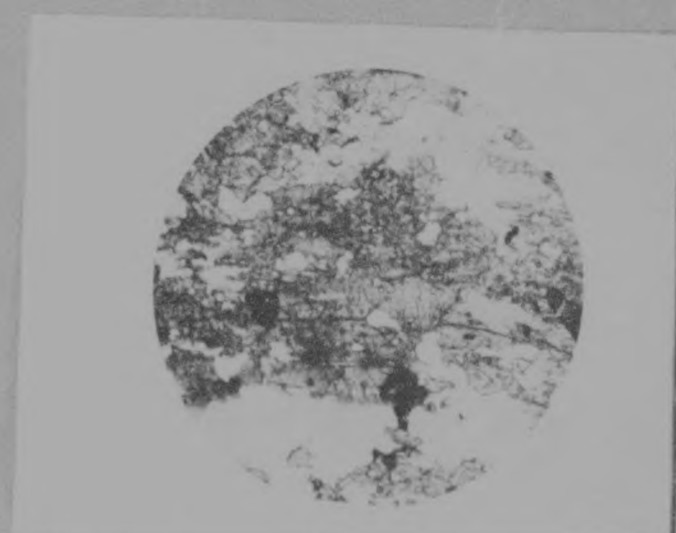


PLATE NO. 21 : Tourmaline Schist. Tourmaline impregnated in country greenschist in close proximity to tourmaline quartz vein.

Plane polarised x 50.

by volume; but usually only about 10%. The amphiboles were identified by Phaup and are discussed in his unpublished report dated 2.3.1935. Grunerite is the commonest amphibole, and occurs as finely divided, thin, felted crystals. These crystals often radiate from magnetite bands into quartz bands in the jaspilite. Where the original iron content was low, hornblende has formed rather than grunerite; and in the immediate vicinity of quartz veins, tremolite occurs, occasionally in crystals over an inch long. (See also the description of amphiboles in section on Jaspilite, under Local Geology.) See Plates Nos. 6, 7, 8, 14, 15, 16, 17 and 19.

TOURMALINE:

The only tourmaline seen on the mine occurs associated with very coarse arsenopyrite in and near quartz veins. It is sometimes seen to penetrate the rock through which the quartz vein passes, generally with crystals orientated at about right angles to the plane of the vein. In some cases a band consisting almost entirely of tourmaline is formed on the edge of quartz veins. The size of such occurrences averages about one inch of tourmaline on each side enclosing about three inches of quartz. Typically, the tourmaline forms masses of combined crystals, usually about 0·3 millimetres thick, and up to 15 millimetres long. They are all intense black in colour. Microscopically, the crystals show very typical cross fracturing along their length. They are coloured a very deep brown and are very pleochroic. The pleochroic formula is O - transparent pale buff; E - dark greenish brown. From the association with arsenopyrite, the tourmaline is considered to have crystallised at an early stage in the mineralization.

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C H A P T E R   E I G H T

* * * * * * * * * * * * * * *

C O N C L U S I O N S

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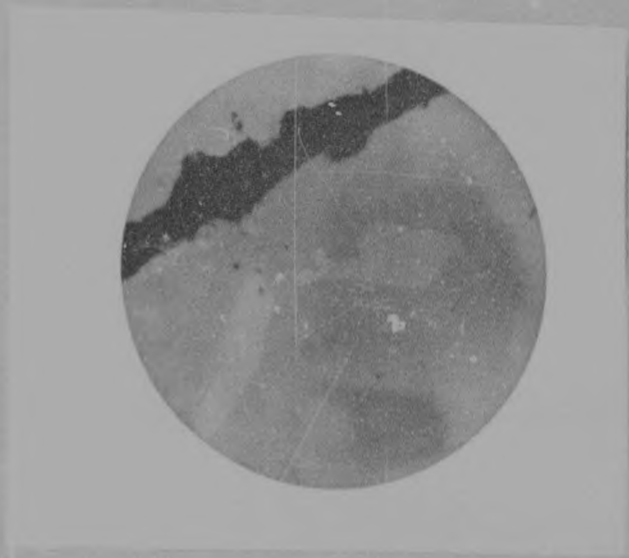

PLATE NO. 57 : Chalcopyrite completely enclosed in Pyrrhotite and also as a rim to small quartz vein filling crack in Pyrrhotite. Probably all particles are connected by veinlets of Chalcopyrite.
Polished Section. Plane Polarized x 1200.

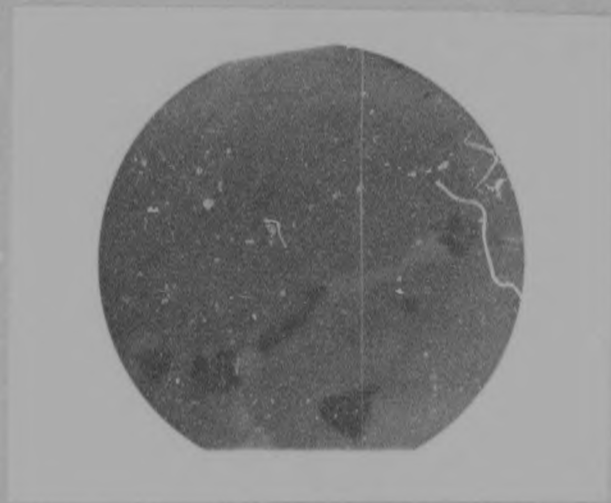

PLATE NO. 58 : Chalcopyrite as residual filling of crack in Pyrrhotite partially filled with quartz and filled with Chalcopyrite. Polished Section.
Plane polarized x 1200

Year:	Tons:	Oz. Au:	dwt/ton:	Sands:	Slimes:	Oz. Au:	dwt/ton:
	M I L L			C Y A N I D E			
191[illegible]	?	46	?	-	-	-	-
1923	10,000	2,656	5·31	-	-	-	-
1924	20,150	5,777	5·73	-	-	-	-
1925	10,900	2,164	3·97	6,000	-	with mill	
1926	8,500	1,894	4·46	2,500	-	with mill	
1927	-	1	-	-	-	-	-
1932	-	5	-	1,500	-	75	1·0
1933	4,484	710	3·17	2,907	-	with mill	
1934	11,45[illegible]	2,215	3·87	4,890	480	-	-
1935	10,193	592	1·16	22,694	-	1,072	0·95
1936	12,100	753	1·24	24,000	100	1,591	1·32
1937	9,500	868	1·83	36,000	1,900	1,643	0·91
1938	9,735	2,085	4·28	34,350	2,550	with mill	
1939	4,550	2,540	11·16	17,700	1,900	with mill	
1940	16,250	3,078	3·79	2,700	2,600	with mill	
1941	18,800	4,496	4·79	17,700	-	591	0·67
1942	26,000	5,574	4·29	9,497	-	3[illegible]2	0·64
1943	33,300	6,273	3·77	-	-	-	-
1944	32,600	6174[illegible]	4·14	-	-	-	-

CHAPTER EIGHT

CONCLUSION ON STRUCTURE AND MINERALIZATION.

The present structure of Vubachikwe Mine arose through a complex succession of geological processes; these processes have been sub-divided into a series of three tectonic disturbances accompanied by considerable metamorphism. The introduction of economic minerals is associated with the second tectonic disturbance which resulted in the formation of a regional synform. Vubachikwe Mine lies in the north limb of this synform; the localisation there of orebodies is dependent on a combination of the nature of the rocks being replaced, and on structural features dependent on - or parasitic to - the regional synform. These features are mainly a system of plunging folds along the limbs of the synform, some folds being quite intense, others very gentle.

The localisation of minerals in a sequence of plunging folds is a common occurrence in Precambrian mining areas of the world.

The mineral association seen in the ores of Vubachikwe Mine is considered ample evidence of its high temperature mesothermal conditions of deposition. Although it is possible that zoning may become apparent when a greater vertical section is visible, the deposit has so far been very uniform in the sulphide zone. The mineral solutions are particularly characterised by their having been of low sulphur content, the mineral ensemble showing a distinct paucity of that element.

Thus . . / -

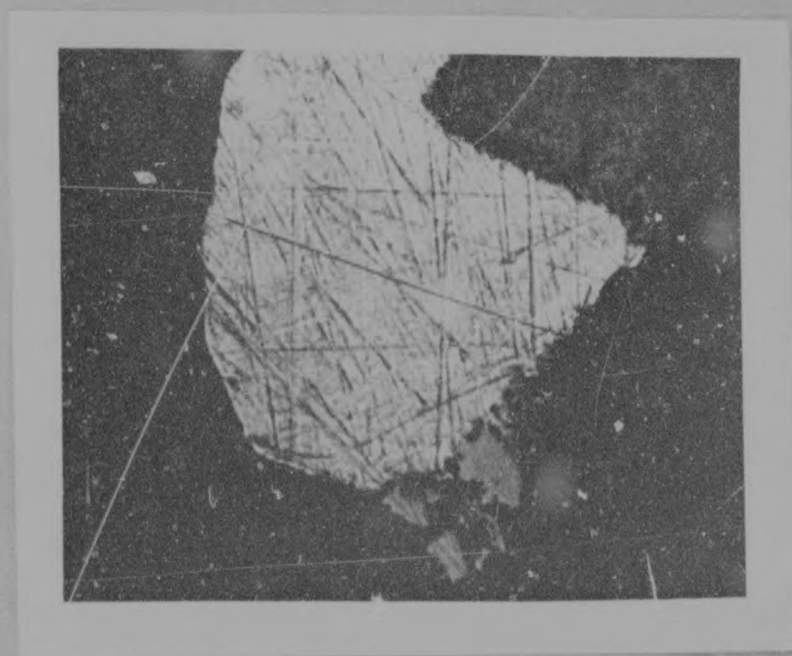

PLATE NO. 39 : Gold in groundmass of bakelite - mounted polished concentrate. Peculiar striation effect was originally believed to be silver exsolving. Subsequently found to be polishing effect only. Plane polarised polished section x 200.

PLATE NO. 40 : Gold showing inclusions of pyrrhotite. Plane polarised x 1000

	MILL			CYANIDE			
Year:	Tons:	Oz.Au:	dwt/ton:	Sands:	Slimes:	Oz.Au:	dwt/ton:
1945	36,000	7,087	3·93	-	-	-	-
1946	39,800	7,121	3·98	-	-	-	-
1947	33,900	7,397	4·36	-	-	-	-
1948	31,300	6,745	4·31	-	-	-	-
1949	34,700	6,607	3·81	-	-	-	-
1950	35,260	7,128	4·04	-	20,380	266	0·26
1951	35,000	5,921	3·39	-	-	-	-
1952	9,454	1,311	2·77	2,900	30,645	880	0·51
1953	10,338	906	1·77	-	8,361	394	0·94
1954	55,122	8,681	3·13	-	-	-	-
1955	68,374	8,822	2·58	-	-	-	-
1956	73,974	11,489	3·10	-	-	-	-
1957	75,790	11,835	3·12	-	-	-	-
1958	81,850	15,988	3·90	-	-	-	-
1959	77,068	19,906	5·16	-	-	-	-
1960	5,424	17,805	4·66	-	-	-	-
TOTALS :	1,008,850	193,223	3·85				

Thus this deposit may be considered as a high temperature mesothermal replacement, or impregnation along a system of pre-existing fractures with a very minor amount of open-space filling, most of the sulphides being of wall rock replacement type.

* * * * *

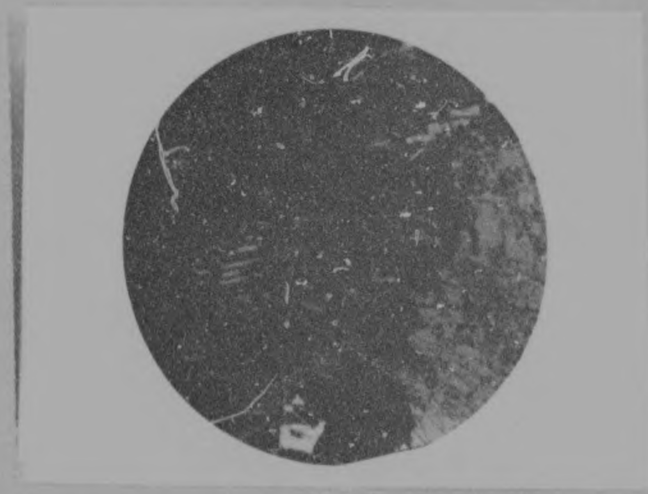

PLATE NO. 41 Gold in groundmass of Amphibole and Quartz. Note linear structure of gold to conform with gangue crystal structure. See Plate 42. Plane polarised x 62

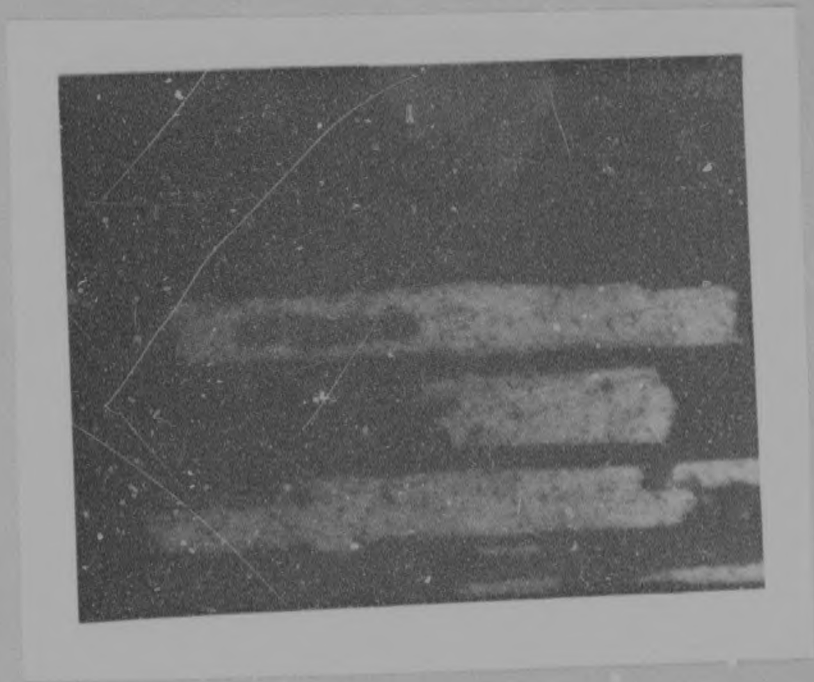

PLATE NO. 42 : Gold - enlarged from Plate No. 41. Note Pyrrhotite inclusions in gold. Plane polarised polished section x 3300

	M I L L			C Y A N I D E			
Year:	Tons:	Oz.Au:	dwt/ton:	Sands:	Slimes:	Oz.Au:	dwt/ton:
1945	36,000	7,087	3·93	-	-	-	-
1946	35,800	7,121	3·98	-	-	-	-
1947	33,900	7,397	4·36	-	-	-	-
1948	31,300	6,745	4·31	-	-	-	-
1949	34,700	6,607	3·81	-	20,380	266	0·26
1950	35,260	7,128	4·04	-	-	-	-
1951	35,000	5,921	3·39	2,900	30,645	860	0·51
1952	9,454	1,311	2·77	-	8,361	394	0·94
1953	10,338	906	1·77	-	-	-	-
1954	55,122	8,681	3·15	-	-	-	-
1955	68,374	8,822	2·56	-	-	-	-
1956	73,976	11,439	3·10	-	-	-	-
1957	75,790	11,635	3·12	-	-	-	-
1958	81,830	15,988	3·90	-	-	-	-
1959	77,068	19,906	5·16	-	-	-	-
1960	76,424	17,805	4·66	-	-	-	-
TOTALS :	1,008,650	193,223	3·83				

PLATE NO. 26 : Arsenopyrite in Jaspilite ore. Note opaque Arsenopyrite in quartz mosaic. Thin Section.

Plane polarized x 50

PLATE NO. 27 : Arsenopyrite. Note aggregate and discreet crystals in ore. polarized x 300. Polished section.

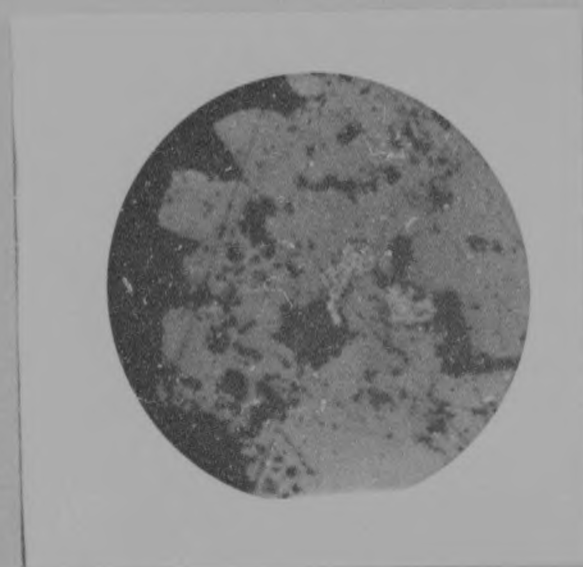

PLATE NO. 43 : Gold in fine grained aggregate arsenopyrite. Black sections are gangue. Plane polarised polished section x 250.

PLATE NO. 44 : Gold in roasted arsenopyrite - (probably converted to magnetite) in roasted concentrate mounted in bakelite. Plane polarised polished section x 1200.

In addition, the following tonnages have been declared separately, having been worked on tribute:-

[illegible] MINE:

1940 - 1957 47,592 tons 8,039 ozs. 3·39 dwt/ton

[illegible] MINE:

1934 - 1941 89,915 tons 10,664 ozs. 2·37 dwt/ton

Thus, to date, a minimum of 1,231,000 tons have been mined from the property; and 241,000 ounces of gold produced of an approximate grade of 3·9 dwts/ton.

* ** * ** * ** * ** *

H I S T O R Y

It is said that ancient workings led to the rediscovery of gold in the north-west Gwanda gold belt about 1890. In the early 1890's a host of "pioneer workings" were started. Prior to 1894, practically nothing is known of the Vubachikwe Mine area: in 1894 the area was acquired by the Rice Hamilton Exploration Syndicate. That this mining venture failed miserably seems due to inefficiency and bad management. By 1911 the syndicate was bankrupt and the property was taken over by the firm Rhodesia Limited. The Vubachikwe string of claims lay dormant from 1912, except for a short period in 1916, and passed to the London and Rhodesia Mining and Lands Company Limited, (LonRho), in 1922. They tributed out portions of the area and

the main mines . . / -

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C H A P T E R N I N E

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T H E I D E N T I F I C A T I O N O F C E R T A I N M I N E R A L S B Y X - R A Y D I F F R A C T I O N

* ** * ** * ** * ** * ** **

* VIVIANITE-VAUXITE *

* CHALCOPYRITE *

* PYRRHOTITE *

* ARSENOPYRITE-LOLLINGITE *

* *

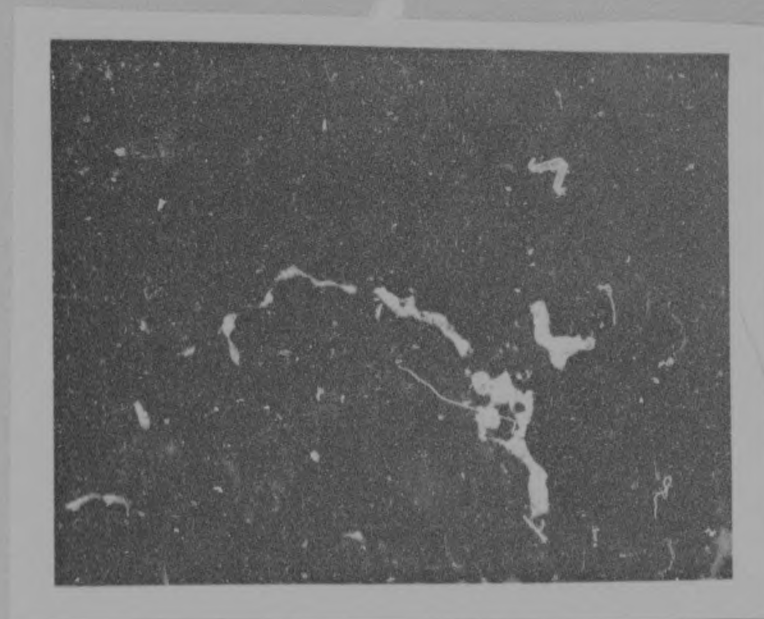

PLATE NO. 45 : Gold as veinlet or interstitial filling in secondary quartz. Plane polarised polished section x 250.

PLATE NO. 46 : Talc schist composed of talc, chlorite and carbonate. X nicols x 50.

the main mines produced intermittently. From 1933 to 1952 Lonrho worked the main sections of Vubachikwe on a lease. In 1952 the Lonestake General Mining Company, a Lonrho subsidiary, acquired the mine area and tributed it to Forbes & Thompson (Gwanda) Limited, who purchased it in April, 1955.

Since then, through careful management and practical mining and milling, the mine has proved a profitable proposition. The present tonnage is about 6,000 tons per month (1961).

* * *

GENERAL:

Although a comparatively small mine, Vubachikwe is run on modern methods employing a considerable degree of mechanisation, including the use of electric locomotive haulage on the 10th Level. Normal mining practice is employed, and broken ore is brought to the surface with as little handling as possible. The broken ore all passes through a 1½ inch grizzley before being hauled to the surface. The main shaft is the Arthur Thompson vertical shaft (See Plate No. 4) and is well equipped to the bottom of the Mine.

SORTING:

Although sorting experiments carried out on the property have been successful, serious sorting of ore has not been carried out, since the mill capacity is greater than the tonnage mined.

* * *

PLATE NO. 47 : Dolerite - Chill zone.
Plane polarised x 60.

PLATE NO. 48 : Dolerite - Chill zone.
Plane polarised X nicols x 60.

T H E   M I L L

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A study of the diagram of Vubachikwe Mill (Page No.127) shows nothing out of the ordinary for a gold reduction plant. Ore is crushed, classified, tabled and floated, and the concentrate is subjected to a simple cyanidation.

Within the limits of economics, and compared with similar mills of other Rhodesian gold mines, and the refractory nature of the ore, this mill is considered efficient. Over 80% of the total gold content of the ore is recovered. Gold is the only product from the mine. The only other possible by-product, arsenic, is not produced commercially. The small amount of silver in the bullion is insignificant.

Two features of the plant are noteworthy:-

1) <u>FINE GRINDING</u>:

Because the gold is so finely divided, an extreme degree of grinding is necessary to free it for cyanidation. Thus, concentrates are reground to a fineness of 94% - 325 mesh.

2) <u>GALLAGHER TABLES</u>:

This is not a metallurgical treatise, but a brief description of these ingenious contrivances is of interest. These tables were developed (and patented) by the Mine's Chief Engineer, Gallagher. The table consists (in

essence) . . / -

essence) of a short broad belt of corduroy tilted at an adjustable angle and rotating very slowly. The top surface of the belt is evenly supported to form a table top, functioning exactly as a normal corduroy or blanket strake. The pulp is fed evenly over the high edge of the table top and runs down over the surface leaving a deposit of concentrate in the riffles. The rotation at right angles to the flow of the pulp ensures an automatic clearing of the concentrates. The top of the table is constantly being replaced, and the concentrate carried over the edge to be removed by water sprays underneath. A gentle jigging vibration can be applied if necessary. Approximate dimensions of the table are 6 ft. x 4 ft., the diameter of the rollers at each end being about 12 inches, and the speed of the rotation about 12 inches/minute.

The obvious advantage of such a machine is its large capacity for concentrate extraction. It is particularly useful when applied to an ore containing a high perecntage of heavy material.

* * *

FLOWSHEET OF VUBACHIKWE MINE REDUCTION PLANT (MILL)
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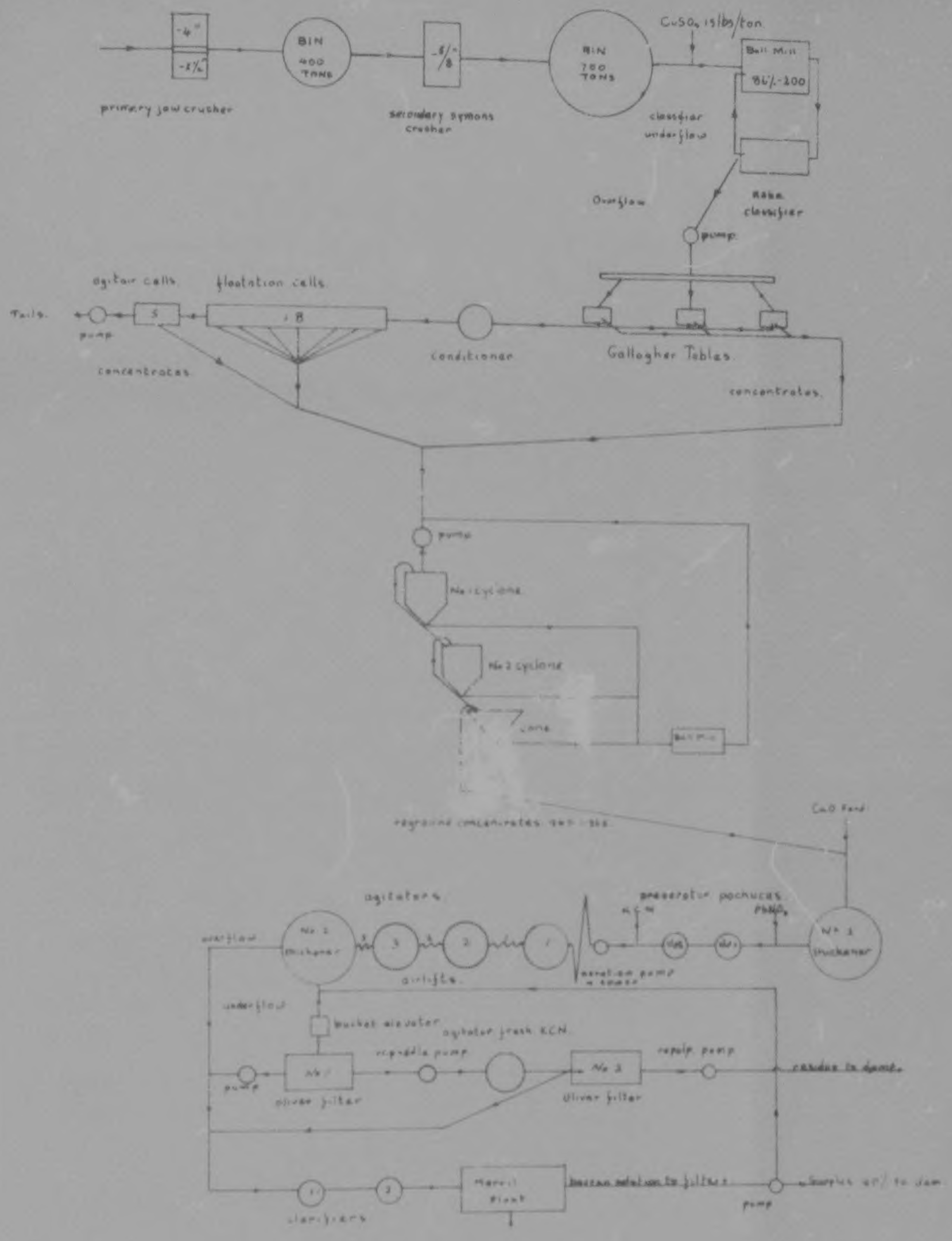
PLATE NO. 49 : Dolerite. Coarse grained from centre of sill.

X nicols x 50.



VUBACHIKWE MINE REDUCTION PLANT

May 1961.

B I B L I O G R A P H Y

Canada) and also did not resemble the data file figures - but were very close to the Yubachikwe sample.

"d" VALUES:

YUBACHIKWE:	SUDBURY:	DATA FILE:
2·62 (60)	2·61 (60)	2·69 (100)
2·05 (100)	2·05 (100)	2·98 (90)
1·66 (50)	1·67 (60)	2·67 (90)

The data file does not quote the radiation or filter used and this is probably where the discrepancy arises.

ARSENOPYRITE-LOLLINGITE:

Since gold is associated with a fine grained variety of the arsenic sulphide rather than with the coarse, on Yubachikwe Mine it was suspected that there may be a chemical as well as physical variation in the mineral. A series of analyses on various samples was done using the Xray powder diffraction method. The results were compared with Harcourt's (1942) figures, since arsenopyrite is excluded from the "Xray Powder Data File", 1961. From the results obtained, it would appear that the various samples (described below) are all approximately the same and belong to the isomorphous series, arsenopyrite-lollingite, being somewhat sulphur poor and hence

nearer . . / -

P O W E R

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For many years, Vubachikwe Mine has been linked to the electricity grid of the Electricity Supply Commission of Southern Rhodesia. Power is supplied from the station at Gwanda.

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F I N

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nearer to the lollingite end member of the isomorphous series.

"d" VALUES:

INTENSITY	(Harcourt) LOLLINGITE	H2	H11	H12	H13	H15	K12
100	2·43	2·38	2·39	2·38	2·38	2·41	2·37
80	2·67	2·65	2·64	2·61	2·63	2·67	2·63
60	1·81	1·79	1·80	1·79	1·80	1·81	1·79

The "d" Values for arsenopyrite are considerably different as the line intensities are so different.

"d" VALUES (Harcourt 1942)

ARSENOPYRITE:

INTENSITY:	"d"
100	2·65
100	2·42
80	1·81

The samples listed above are briefly described:-

H2. Extremely fine arsenic sulphide assaying 10dwts Au/ton.

H11. Fine 0·5 millimetre aggregate arsenic sulphide - low Au content.

H12. Very coarse +5 millimetre crystal arsenopyrite. Au less than 0·5 dwt/ton.

H13. Very fine aggregate arsenopyrite, approx. 60dwts Au/ton.

H15. Extremely coarse arsenopyrite crystals 15 millimetres, Au less than 2 dwt/ton.

K12. Coarse arsenopyrite associated with tourmaline gold, less than 0·2 dwt/ton.

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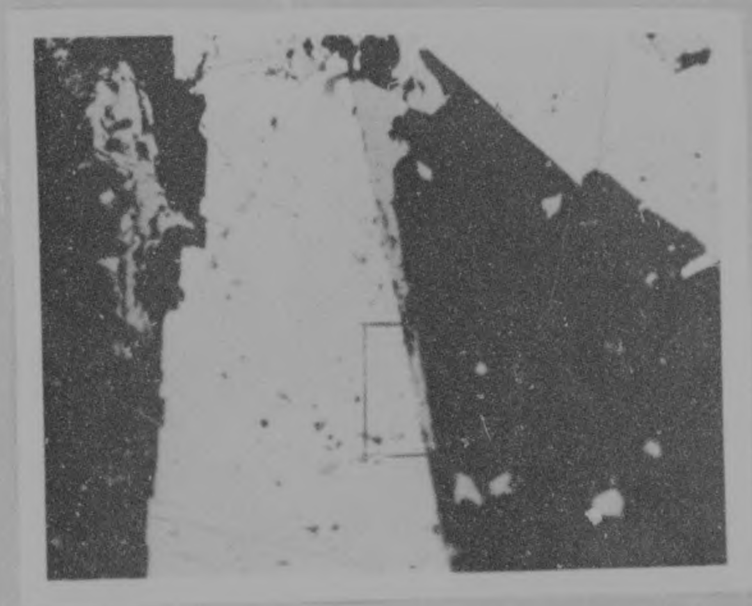

PLATE NO. 32 : Bis veinlet of Pyrrhotite and Chalcopyrite on crystal of Arsenopyrite in quartz matrix. See Plate No. 33. Polished Section.

Plane polarized x 250.

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" Log of Borehole 17. 10th Level Long John Section. 16. 6. 60.

" Log of Borehole No. 20. 29. 4. 60.

" Log of Borehole No. 16. 26. 4. 60.

" Log of Borehole No. 21. 26. 4. 60.

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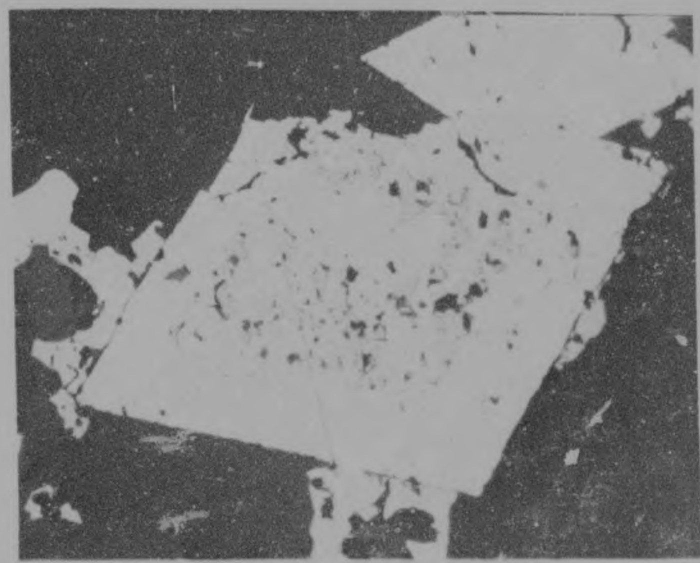

PLATE NO. 30 : Arsenopyrite crystal showing mutual intergrowth and partial replacement by Pyrrhotite. Polished Section.

Plane polarised x 300

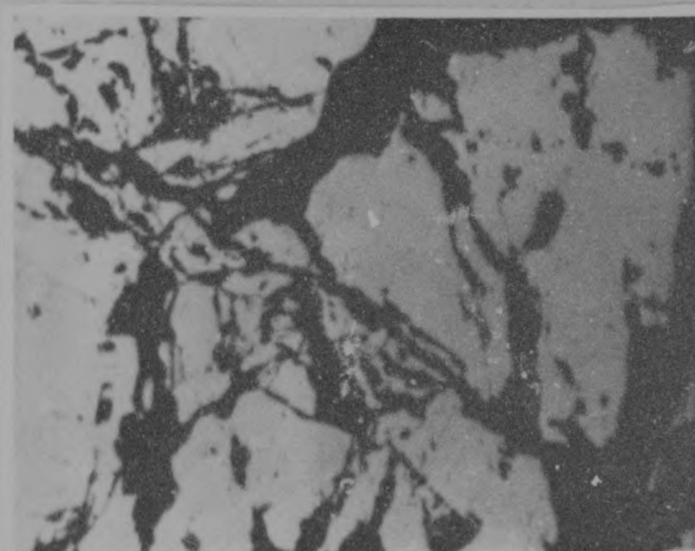

PLATE NO. 31 : Pyrrhotite - shattered and partially replaced by quartz. Note if pieces are "jigsaw"-fitted, there are gaps indicating partial replacement.

Polished Section. Plane polarised x 72.5.

B I B L I O G R A P H Y

*************************(Cont..)

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Note on the Vubacheque and Cheque Mines. 23. 1. 59.

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Notes on Magano (15593) Mine. 20. 1. 59

(Above unpublished reports all in the Library of the Geological Survey of Southern Rhodesia, Salisbury.)

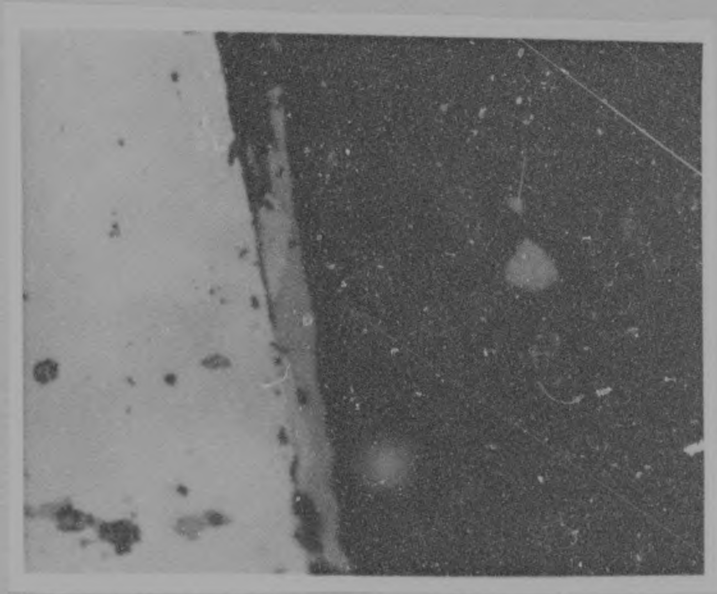

PLATE NO. 33 : Arsenopyrite with rim veinlet of Pyrrhotite and Chalcopyrite in Quartz. Polished Section.

Plane polarised x 1200

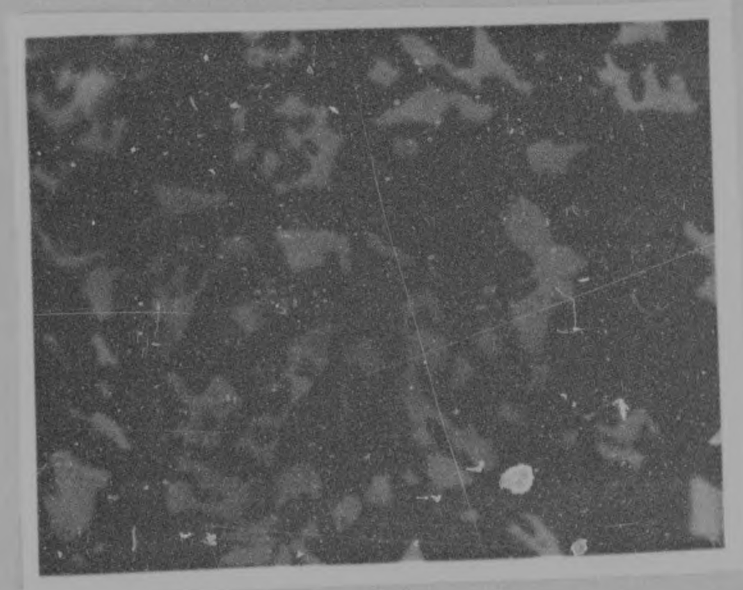

PLATE NO. 34 : Graphic growth of Pyrrhotite in Quartz. Polished Section.

Plane polarised x 1200.

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C H A P T E R   T E N

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O U T P U T S

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H I S T O R Y

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G E N E R A L

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S O R T I N G

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T H E   M I L L

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1. FINE GRINDING
2. GALLAGHER TABLES

*

FLOWSHEET OF

[illegible] MINE

REDUCTION PLANT (MILL)

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P O W E R

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PLATE NO. 35 : Pyrrhotite being replaced by quartz.
Polished Section.
Plane polarised x 250

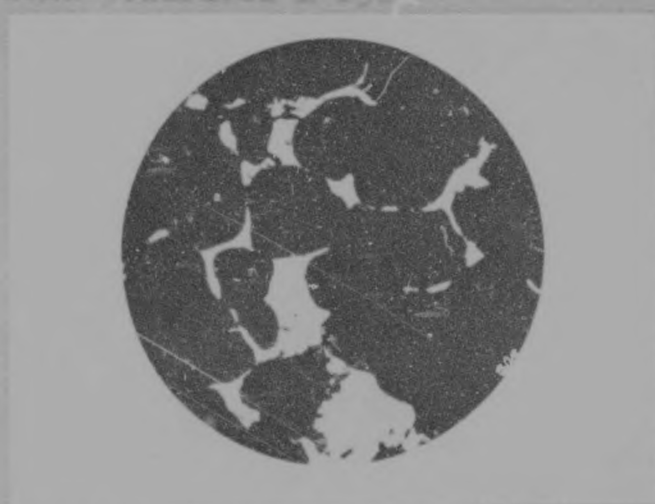


PLATE NO. 36 : Pyrrhotite as interstitial filling between quartz grains - probably original quartz in the Jaspilite.
Polished Section.
Plane polarised x 100.

C H A P T E R   T E N

O U T P U T S

****

Mbachikwe Mine has had an erratic history, as is shown in the following output tables.

No output figures are available before 1905.

1905 - 1908; 85,125 tons were milled, recovering 29,212 ounces of gold at an average grade of 6·86 dwts/ton.

OUTPUT TABLES . . / -

C H A P T E R   N I N E

THE IDENTIFICATION OF CERTAIN MINERALS BY XRAY DIFFRACTION.

Since the latest (1961) Phillips Xray equipment was available, it was decided to use Xray Diffraction for positive identification of certain minerals occurring in the ore.

VIVIANITE-VAUXITE:

This mineral, described in the section on Mineralogy, occurs commonly in the oxide zone in the Magano Section. Since comparatively large specimens were available, it was analysed using the diffraction goniometer with the automatic recording device. The graph obtained showed a substance of almost amorphous nature, with only three very broad, low amplitude peaks being registered. Due to the lack of definition of the peaks, accurate readings were not obtained. The "d" values and intensity are recorded here together with the values quoted in the "Xray Powder Data File" (1961) for delvauxite, the mineral to which the figures most closely correspond.

"d" VALUES:

EXAMINED MINERAL:	INTENSITY:	DATA FILE:	INTENSITY:
4·08	100	4·35	100
4·27	90	3·91	90
4·50	90	4·60	90

The comparison is not very satisfactory, but indicates that the mineral is almost amorphous and belongs to the Bauxite series.

CHALCOPYRITE:

Only very small amounts of this mineral were available and hence the powder diffraction method was employed, using Fe radiation with the Mn filter and the 57·3 millimetre camera with small ports. The mineral was exposed for 45 minutes to the X-ray beam.

The "d" values obtained are almost identical with the data file figures.

"d" VALUES:

ZAMBIAN MINERAL:	INTENSITY:	DATA FILE:	INTENSITY:
3·04	100	3·03	100
1·65	80	1·65	80
1·59	60	1·59	60

PYRRHOTITE:

Pyrrhotite was analysed using Co radiation and Fe filter. The powder diffraction method was employed, with the 57·3 millimetre camera, small ports and 40 minute exposure to radiation. The "d" values obtained for the sample bore no relationship to the figures quoted in the data file. A standard sample was similarly analysed (Pyrrhotite from Sudbury, Canada) . . / -

PLATE NO. 28 : Arsenopyrite partially replaced by quartz and showing replacement or exsolution inclusions of pyrrhotite. Polished Section.

Plane polarised x 1200.

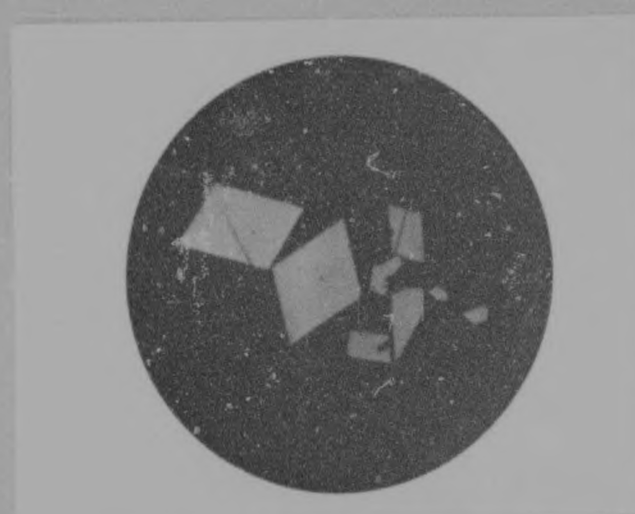
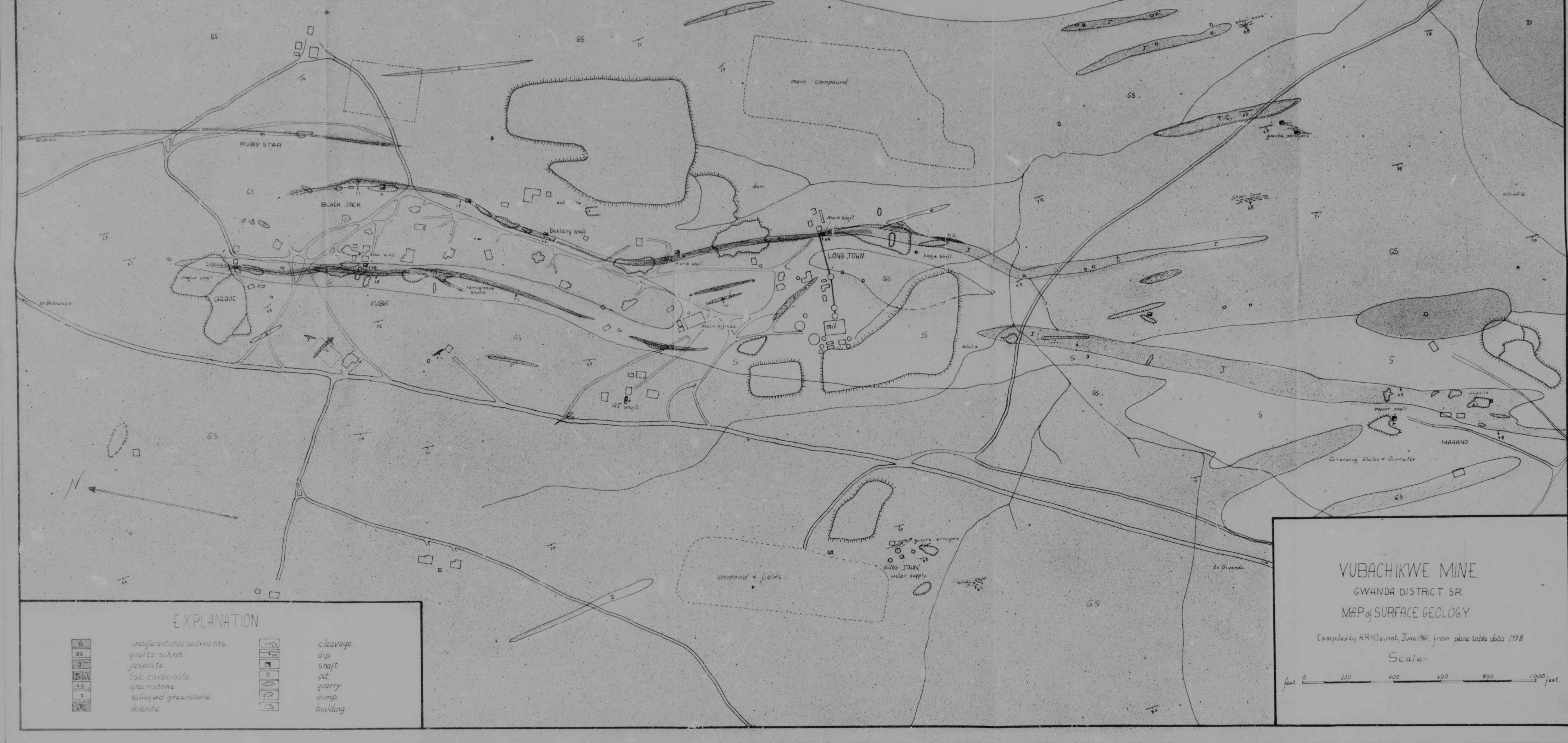
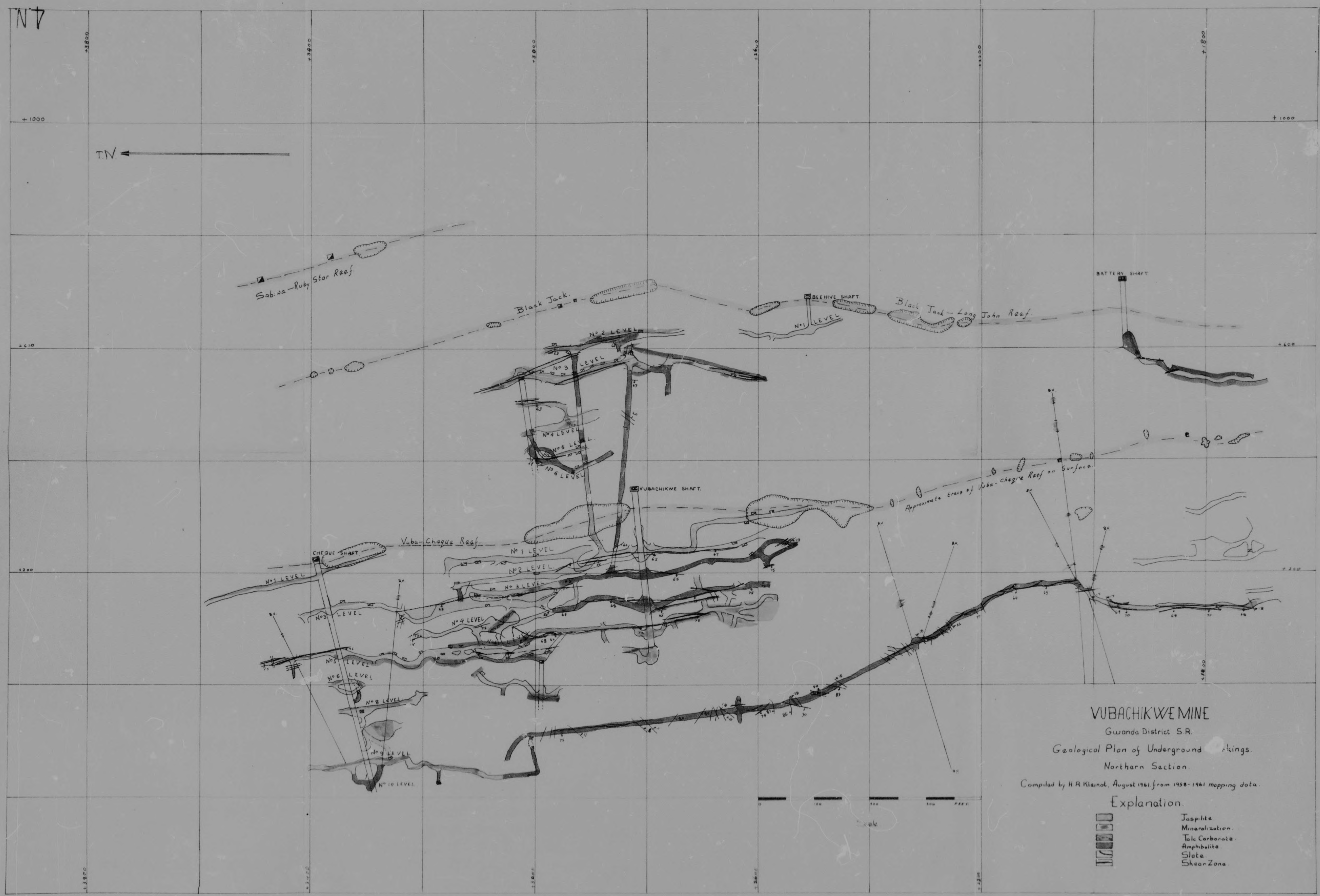
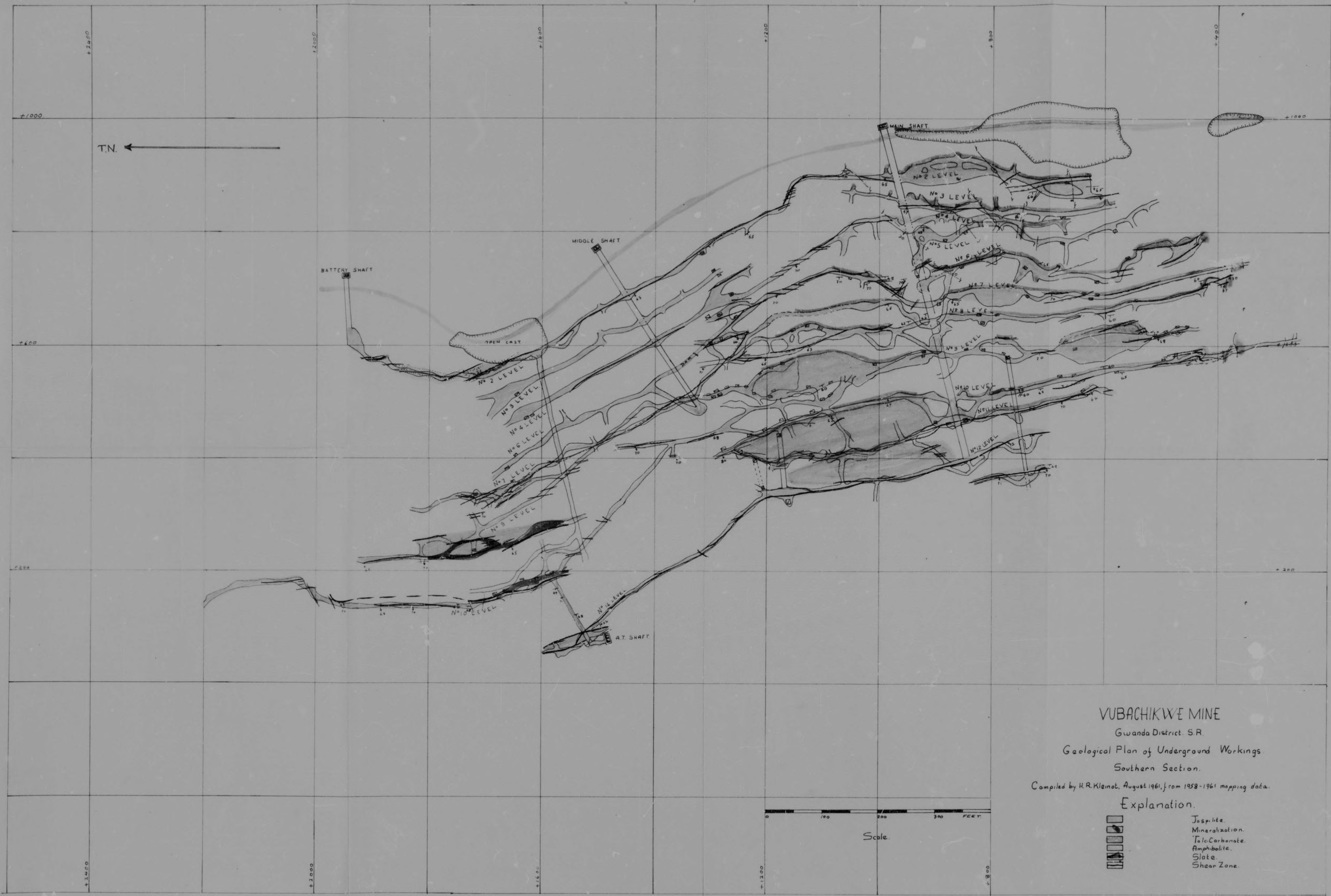


PLATE NO. 29 : Arsenopyrite in discreet euhedral crystals in jaspilite ore.
Polished Section.

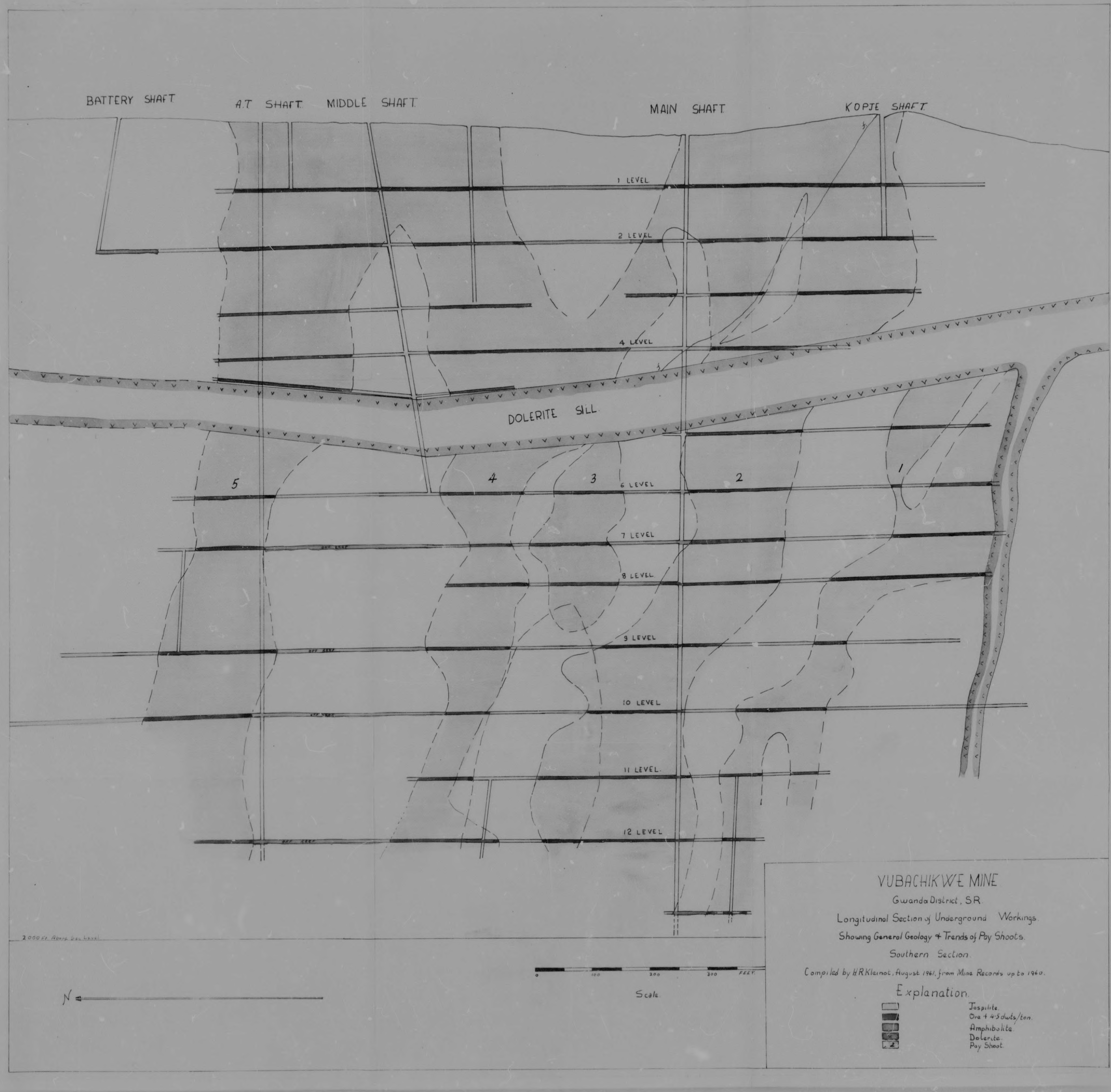
Plane polarised x 250.


RUBY STAR
BLACK JACK
LONG JOHN
CHEQUE
VUBA
mill
main compound
compound & fields
KING JOHN
water supply
MARANO
EXPLANATION
undifferentiated sediments.
quartz schist
jaspilite.
talc carbonate.
greenstone
silicified greenstone
dolerite
cleavage.
dip
shaft
pit.
quarry.
dump.
building.
VUBACHIKWE MINE.
GWANDA DISTRICT S.R.
MAP of SURFACE GEOLOGY.
Compiled by H.R.Kleinot, June 1961, from plane table data 1958.
Scale:-
feet 0 200 400 600 800 1000 feet.


T.N.
Sabiwa—Ruby Star Reef
Black Jack
BEEHIVE SHAFT
No 1 LEVEL
Black Jack—Long John Reef
BATTERY SHAFT
No 2 LEVEL
No 3 LEVEL
No 4 LEVEL
No 5 LEVEL
No 6 LEVEL
VUBACHIKWE SHAFT
Approximate trace of Vubo-Cheque Reef on Surface
CHEQUE SHAFT
Vubo—Cheque Reef
No 8 LEVEL
No 10 LEVEL
Scale
VUBACHIKWE MINE
Gwanda District S.R.
Geological Plan of Underground rkings.
Northern Section.
Compiled by H.R. Kleinot, August 1961 from 1958-1961 mapping data.
Explanation.
Jaspilite.
Mineralization.
Talc Carbonate.
Amphibolite.
Slate.
Shear Zone.


T.N.
MAIN SHAFT
MIDDLE SHAFT
BATTERY SHAFT
OPEN CAST
A.T. SHAFT
No 2 LEVEL
No 3 LEVEL
No 4 LEVEL
No 5 LEVEL
No 6 LEVEL
No 7 LEVEL
No 8 LEVEL
No 9 LEVEL
No 10 LEVEL
No 11 LEVEL
No 12 LEVEL
+2400
+2000
+1600
+1200
+800
+400
+1000
+600
+200
0
100
200
300
FEET
Scale.
VUBACHIKWE MINE
Gwanda District. S.R.
Geological Plan of Underground Workings.
Southern Section.
Compiled by H.R. Kleinot, August 1961, from 1958-1961 mapping data.
Explanation.
Jaspilite.
Mineralization.
Talc-Carbonate.
Amphibolite.
Slate.
Shear Zone.


CHEQUE SHAFT
VUBA SHAFT
BATTERY SHAFT
A.T. SHAFT
1 LEVEL
2 LEVEL
3 LEVEL
4 LEVEL
5 LEVEL
6 LEVEL
8 LEVEL
9 LEVEL
10 LEVEL
4 Level
5 Level
6 Level
8
7
6
5
Probable position of Dolerite Sill
DOLERITE SILL
3000 Ft. above sea level
N
0 100 200 300 FEET
Scale
VUBACHIKWE MINE.
Gwanda District, S.R.
Longitudinal Section of Underground Workings.
Showing General Geology + Trend of Pay Shoots.
Northern Section.
Compiled by H.R. Kleinot, August 1961, from Mine Records up to 1960.
Explanation.
Jaspilite.
Ore + 4·5 dwt/ton
Amphibolite
Dolerite
Pay Shoot.


BATTERY SHAFT
A.T. SHAFT
MIDDLE SHAFT
MAIN SHAFT
KOPJE SHAFT
1 LEVEL
2 LEVEL
4 LEVEL
DOLERITE SILL
5
4
3
6 LEVEL
2
1
7 LEVEL
8 LEVEL
9 LEVEL
10 LEVEL
11 LEVEL
12 LEVEL
N
Scale
FEET
VUBACHIKWE MINE
Gwanda District, S.R.
Longitudinal Section of Underground Workings.
Showing General Geology & Trends of Pay Shoots.
Southern Section.
Compiled by H.R.Kleinot, August 1961, from Mine Records up to 1960.
Explanation.
Jaspilite.
Ore + 4·5 dwts/ton.
Amphibolite.
Dolerite.
Pay Shoot.