

REPORT ON THE TENNANT CREEK
GOLDFIELD.

BY

H. B. OWEN.

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FORWORD.

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In commending this report to the earnest attention of prospectors, miners and investors at a time when Australia urgently needs every ounce of gold which can be produced, I wish to emphasize the immense amount of personal labour and sacrifice entailed upon the author in the accumulation of the data here published. For several years Mr. Owen has traversed the whole of the scattered field from end to end and has familiarised himself with the extraordinary problems presented by this most unusual goldfield.

It is this last factor, namely, the unorthodoxy of the field which, I think, is so little understood even by many of the miners themselves, and is certainly not appreciated by investors and critics who have not visited the area personally.

It is not intended to suggest that the "Laws of Nature" have been abrogated and that absolutely freak conditions have prevailed. It is a fact, however, that the combinations of geological conditions producing the gold deposits have been unusual, and the results are such that the "practical" miner, coming from a more "normal" area finds himself hopelessly lost.

In such a case it becomes necessary to abandon "experience" as a guide and to revert to consideration of fundamental principles. The unconscious confusion of superficial similarities with "normal" conditions and failure to appreciate fundamental differences have been responsible for untold waste of labour and money on this field.

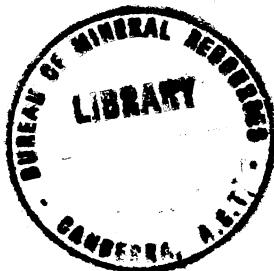
It should be realised that the geologist to whom the duty of preparing this report was allotted was faced with a task of more than ordinary difficulty. Routine methods and "normal" interpretations had to be abandoned and every observation had to be scrutinised and considered from all angles. It is fortunate that the work was in the hands of one who possesses an eminently judicial mind.

If the reader of the report will approach his task with a mind as open and receptive as that of the author he will certainly be rewarded. If prospectors and miners, applying old ideas with due caution, will avail themselves of the advice here given, it may be anticipated confidently that gold production at Tennant Creek will increase and will continue, naturally with fluctuations, for many years to come.

Commonwealth Geological
Adviser.

Canberra.

May, 1940.



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REPORT ON TENNANT GOLDFIELD.

INTRODUCTION.

Tennant Creek goldfield, an area of 2121 square miles, lies between the 19th and 20th parallels of south latitude and astride the 134th meridian east of Greenwich. The field derives its name from a Telegraph Station on the Overland Telegraph Line, and a township has grown up seven miles south of this Station, where it is more conveniently situated to a number of the important mines. The township lies midway between the railheads of Alice Springs in the south and Birdum in the north. The distance from Alice Springs is 320 miles by road, the total distance from Adelaide being rather less than 1300 miles, and from Darwin, the administrative centre of the Northern Territory, about 700 miles. (v. Locality Sketch, Fig. 1.).

The geological map herewith covers about 450 square miles within the proclaimed goldfield and includes all the auriferous ground except a small patch of very doubtful value in the north-east and the so-called "alluvial" find forty miles to the north west. This latter area has not yet been examined in any detail.

Literature bearing on the geology of this part of the Northern Territory is both scanty and sketchy. The Government Geologist of the time in the course of a journey from Darwin to Adelaide in 1895 (1) spent eight days in the Tennant Creek district.

FOOTNOTE. (1). BROWN, H.Y.L. Govt. Geol. Rept. on Explorations in N.T. Adelaide, 1895.

He found traces of gold in Bishop Creek, where, in the light of later experience, it appears that he was extremely fortunate to do so, and was particularly impressed by what is now the Mt. Samuel-Eldorado "line". Brown recommended the area to the attention of prospectors.

Allan A. Davidson (2) traversed the goldfield several

FOOTNOTE. (2) DAVIDSON, ALLAN, A. Journal of Explorations in Cent. Aust. 1898-1900 Adelaide 1905.

times but was not favourably inclined towards the locality and writes (p.7) "...the country west and north-west of Tennant's Creek (Telegraph Station) was given a cursory trial, but more on principle than anything else, as it had been run over at different times during the past 20 years, and offered but little prospect of making a big discovery."

Reason for the failure of earlier prospectors in this area is shown in the most recent publication dealing with Tennant Creek area (3) to which further reference will be made.

FOOT NOTE. (3) WOOLNOUGH, W.G. Rept. on Tennant Creek Goldfield N.T. Bulletin No. 22. Canberra 1936.

TRANSPORT.

Transport to and on the field is mainly by motor vehicle and in the absence of metalled roads (with minor exceptions) is subject to serious delays in wet weather. Summer rains may hold up heavier traffic such as ore carting for ten to fourteen days at a time. High temperatures, rough stony tracks, dust laden air and the very high cost of fuel, furnish further obstacles to motor transport.

A number of passengers and much perishable food now reaches the goldfield by air. Since the inauguration of the flying boat service with Great Britain, Tennant Creek has been served twice

weekly by fast aeroplanes connecting Adelaide and Darwin. Formerly there had been a weekly service in operation.

CLIMATIC INFLUENCE ON GEOLOGY AND TOPOGRAPHY.

The goldfield lies in the great semi-arid region of Central and northern Australia which stretches from the "gibber" deserts of northern South Australia to the area of heavy summer rains north of Newcastle Waters (approx. 17°30'S.)

Tennant Creek meteorological records, kept since the erection of the Overland Telegraph Line, show an average rainfall of about 14 inches, of which some 80% falls in December-February. In some years there is no winter rain.

The area displays the characteristics of all semi-arid regions; vegetations, chiefly spinifex, mulga, and snappy gum, is adapted to dry conditions and reacts rapidly to seasonal rains, but there is never sufficient plant life to provide protective cover to rocks and soil, thereby allowing high winds to play a most important part in erosion.

The prevailing wind is south-easterly and blows practically the year round, northerly and westerly winds blow for short periods during disturbed and stormy weather conditions.

After heavy rains (several inches may fall in one shower) the principal creeks flow for two or three days but never longer in the experience of the writer. Few streams persist for any great distance and, as far as the goldfield is concerned, no sediments are carried out by running water. Sediments in suspension are spread out over clay pans and flood plains or deposited in the stream channel as sand and gravel. The strong south-east wind constantly removes unconsolidated dust and sand.

Summer temperatures range up to, and sometimes exceed 115°F and before rain, the high humidity renders conditions very unpleasant. By comparison the short winter seems bitterly cold although maximum temperatures rarely fall below 55°F. Winter rain falls in a fine drizzle accompanied by cold south-east winds. There is no frost. Generally the climate is healthy and not altogether unpleasant although flies and dust are sources of constant annoyance.

INSOLATION AS AN IMPORTANT CAUSE OF DISINTEGRATION (BREAKING) OF ROCKS.

Insolation is the name given to the effects upon rocks of changes of temperature. It refers only to purely surface phenomena and has no reference to magmatic or deep-seated heat.

It is well known to most of the residents of Tennant Creek that rocks in the locality that are exposed to the direct rays of the summer sun become too hot to handle. At night, or particularly during a rainstorm, the heated rock loses some of its heat more or less rapidly according to its capacity to conduct heat well or badly. These changes of temperature have two effects which result in the same goal. The exposed surfaces of granular rocks are slowly reduced to crumbly layers of separate, or loosely cohering grains, whilst the surfaces of rocks of fine texture are liable to split off in scales and chips. Both processes are due to uneven expansion and contraction in the rock as the temperatures fluctuate, and can be compared to the result of rapidly cooling a glass object when it will crack or even fly apart with mildly explosive violence. With rocks the process does not stop until the particles produced are small enough to be carried away by the wind or other agency.

On this goldfield, with very high sun temperatures and clear night skies permitting maximum radiation, diurnal fluctuations of temperature in rock surfaces are of a high order. Insolation appears to be the most satisfactory explanation of the presence of the numerous angular fragments which litter the ground about outcrops of chert, jasper, jasperoid quartz, and, to a lesser extent, the porphyries. The porphyries are in some measure protected from this form of disintegration by chemical attack (decomposition) which coats the rocks with a veneer of decomposed matter which has a blanketing effect. The magnetite-hematite bodies are very little affected by the process of insolation as the better heat conductivity of their constituent minerals maintains a more even temperature throughout the whole mass.

TOPOGRAPHY.

The relief of Tennant Creek district is low, the highest point being the summit of Mt. Samuel which rises on the southern margin of the field as a bare three hundred feet above the general plain level. The general elevation of the sub-parallel lines of hills which form the McDouall Ranges, the chief topographic feature of the area, is about two hundred feet. (Plate 2, fig.1). H.Y.L. Brown commented on the "peculiar flat-topped structure" of the McDouall Ranges but was unable, not unnaturally at that time, to offer any explanation other than a vague suggestion that ice action might have been responsible. These hills have been shown by Woodnough to form part of the great Middle-Tertiary peneplain. Their duricrust capping and generally uniform level bear this out. This remnant of the peneplain is now in an advanced stage of dissection, and only those small areas which have been indurated by the mineralizing action of igneous intrusions have retained their former level. The valleys, in the writer's opinion, largely the result of wind erosion, are very wide compared to the insignificant elevation of the hills and from the outskirts of the hilly area the new peneplain stretches away to the west and south-west as far as the eye can see. Boring operations have revealed considerable depths of rock debris choking the valleys, a condition which can be expected in a locality where torrential but short lived rains can bring down large rock fragments into the depressions but cannot provide streams to carry the debris away.

The larger hill masses, notably Red Bluff, Mt. Bishop, several isolated hill groups to the north-west of the town, and the Great Western block, when viewed from a distance appear to be gentle domes, and may be anticlinal structures raised by granite cupolas.

Drainage is mature and sluggish and, as suggested above, unable to remove sediments for any appreciable distance. Excellent examples of meanderings and billabongs (oxbows) are to be found in the creek from which the district takes its name, particularly north of Mt. Cleland. The channels of the two major creeks, which have their source in the rocky granite outcrop west of the Telegraph Station, are in part controlled by the granite contact, and later, following the strike of the country, spread out over claypans and wide flat watercourses from which the water vanishes by evaporation. This also is the fate of all smaller streams.

VEGETATION.

Reference to plant life has been made above in the discussion dealing with climate but the following brief notes are appended in further explanation.

The northern limit of Mulga (*Acacia Aneura*) lies diagonally across the field from south-east to north-west. The boundary is, of course, very irregular and does not approximate to a straight line. This tree provides useful mining timber when sticks large enough can be obtained, but is rapidly becoming scarce. The tree rarely exceeds a total height of about fifteen to twenty feet and sound pieces of timber six feet or longer are now difficult to find. Mulga is immune to attack by termites which abound in the locality.

Stunted "snappy gum" (*Eucalyptus aspera*) grows on the slopes and hilltops, but generally gives place to a straighter and taller tree with white bark (*Euc. Rostrata*) in better watered localities. Several other varieties of gum grow along creek banks and are given various local names. Timber from these latter trees, including *rostrata*, has been used underground but is not to be trusted to the same extent as mulga. Snappy gum is useless for mine timbering but affords almost unlimited supplies of firewood and is used at one plant to provide gas for power purposes.

B. *Spinifex* (*Triodia*), well described by many writers, grows in profusion in all parts of the field. In positions where super drainage obtains, such as rocky slopes and hill-tops, a coarse variety with needle-sharp spines displaces the somewhat softer type which grows on the better watered flats.

In addition to the above there is also a very wide variety of flowering plants and shrubs, wattles, mallee, grevillea and feed grasses, the discussion of which is beyond the scope of this report.

Generally it is noticed that areas occupied by igneous rocks are but lightly vegetated in contrast to the sediments where the bush is comparatively dense but the marked change in vegetation north of the limit of mulga, whilst coinciding in places with igneous boundaries, has no geological significance.

REGIONAL GEOLOGY.

In discussing the geology of Tennant Creek Goldfield, brief remarks on the general geology of the Pre-Cambrian formations in Central Australia will not be out of place.

Dr. C.T. Madigan (1) describes the sequence of the

FOOTNOTE. MADIGAN, C.T. Geol. of the Macdonnell Ranges and neighbourhood. Rept. A. & N. Z. Adv. Sci. Vol. XXI, pp. 76-86.

Pre-Cambrians east and west of Alice Springs. He finds the newer Proterozoic (Pertatataka Series) apparently conformable upon the older Proterozoic (named by him the Pertaknurra Series), and this in turn resting unconformably upon the Archaean gneisses and quartz and mica schists of the Arunta Complex. The Pertaknurra Series contains a great thickness of quartzite, much ripple-marked in the Heavitree Range, and south of (above) the quartzite dense algal limestone. The Pertatataka Series, according to the same author, contain only thin limestone beds, quartzites and slates being predominant.

The accompanying section (Pl. 4) taken along the Overland Telegraph Line from Heavitree Range in the south to beyond Phillips Creek in the north, shows, in a generalized fashion, the relationships existing between Pre-Cambrian rocks between the Goldfield and Alice Springs.

The section shows a small area of subsidence immediately north of the Macdonnell Ranges where comparatively recent faulting has taken place. This basin is filled with fresh-water sediments containing lignitic clays to a depth of not less than 800 feet. The possibility of an undisclosed granite intrusion near Connor's Well is supported by the out-cropping of numerous narrow quartz reefs.

The accuracy of the northern portion of the section has been enhanced somewhat by recent boring operations along the stock route. Bores six miles south of Mt. Samuel, and near Gilbert Well both penetrated granitic rocks; in the former case the rock contained abundant red orthoclase and is apparently of similar composition to the granite near Tennant Creek Telegraph Station. At Gilbert Well the rock is light coloured with appreciable amounts of biotite and comparable to that of the Devil's Marbles outcrop.

Between Watt Range and Taylor River, and on the Taylor-Wycliffe "Desert", bores penetrated 200 feet and 190 feet of unconsolidated sands and clays, then entering quartzite and limestone respectively.

A bore at Wycliffe Well passed through travertinous limestone containing fragments of crystalline limestone to a depth of 75 feet, then encountered water lying on gritty clay underlain by unconsolidated sand and gravel to 123 feet where the hole entered white sepiolite (meerschaum) which continued to the bottom of the hole a further 24 feet. The actual thickness is unknown.

All the plains are more or less covered with red sandy soil to a varying depth, but in many places the cover is very thin.

In all probability the section will require much modification as fresh information comes to hand especially regarding the country south of Barrow Creek.

The junction between the Tennant Creek sediments and the conglomerates which form the basal bed of the Proterozoic (Nullagine?) quartzites (1) on the southern margin of the field

FOOTNOTE. It has been suggested to the writer by Mr. Paul S. Hossfeld, of the North Australia Survey, that the quartzites shown in Plate 4 belong to two different series. It may well be that the mineralized quartzites of Wauchope, east of Bonney Well, and south of Tennant Creek are older than the ripple-marked quartzite of Heavitree Range and Barrow Creek.

unfortunately is masked by an intrusion of porphyry and also by recent deposits. The slight evidence which is available suggests an unconformity. It is tentatively suggested that the altered sediments of the goldfield are younger than the Archaean gneisses of Barrow Creek and Alice Springs but older than the Pertarnurra, but it must be borne in mind that these sediments occupy an area of marked crustal instability which is evidenced by the change of strike from east and west to roughly north and south which takes place on a grand scale north of Phillip's Creek. Similar folding takes place about thirty miles south of the goldfield, and the quartzites are much disturbed from this point to beyond the Devil's Marbles. Movement in such an unstable area could be expected to cause fine-grained sediments to assume a deceptive appearance of age. The absence of limestone exposures renders direct correlation of the series with the Proterozoic of Alice Springs or South Australia difficult, but the general horizontality of bedding and lack of dissection may leave limestones yet to be found, although such a possibility can be regarded only as remote. Impure travertinous limestone occurs in places in the locality but the sediments themselves are slightly calcareous.

Slaty cleavage is sufficiently highly developed to largely obscure the bedding planes in many places, but steep dips have been fairly well preserved. These, unfortunately, represent only very local folding of little structural importance.

In accordance with the usual custom of utilizing native names for local geology, the writer proposes to apply the name of the local aboriginal tribe - Warramunga - to the series of sediments and interbedded tuffs of Tennant Creek district. As investigation proceeds it is hoped that it will be found possible to identify the Warramunga series with one or other of the subdivisions proposed by Madigan.

The interbedded eruptive rocks are shown on the geological map as "Older porphyry" but it should be pointed out that many occurrences are too small to be shown and the term

"Older porphyry" includes some aureolar rocks and some highly decomposed intrusive rock, the true character of which is extremely difficult to determine. It is also possible that some highly metamorphosed sediments have been included. Further references to these anomalous rocks will be made in the notes dealing with type areas.

WATER SUPPLY.

Any discussion on water supply on this goldfield resolves itself into two parts, viz. the supply of potable water for domestic use, and of water for technical purposes. Both aspects of the subject have peculiar problems of their own, and many bores have proved disappointing.

In the selection of a townsite a primary consideration is water supply, but unfortunately Tennant Creek received scant regard in this respect and a town was encouraged to grow up seven miles south of the Telegraph Well, the only known source of drinking water. The only advantage this position enjoys is the relative proximity of such mines as Eldorado, Hammerjack, Mt. Samuel, The Pinnacles, Wheal Doria, Great Northern etc. Unhappily the townsite has disadvantages other than its distance from water; it is situated on low-lying ground, which, though very dusty in dry weather, was revealed by the first heavy rain after settlement to be a wide, shallow water-course.

A metalled road has been constructed connecting the well, since supplemented by two bores, and the town to facilitate cartage of water.

Proposals for the installation of a pipe-line and necessary pumping equipment should be discouraged as such a system must inevitably lead to waste of water obtained from a source of which the limits are not known. Further exploratory boring might prove an almost limitless supply, but until such reassuring results are obtained all effort should be made to conserve the only major underground body of freshwater known in the locality, as besides the people of the goldfield, travelling stock have also to be supplied from the Telegraph Well.

The water is of excellent quality as the following analysis shows:-

Assumed composition of salts.	Grains per Imperial Gallon.
Calcium carbonate	1.5
Magnesium carbonate	2.1
Sodium carbonate	5.5
Sodium sulphate	1.0
Sodium chloride	3.0
Total salts	13.1
equivalent to 0.03 oz. per gallon.	
(Analyst - H.B.Owen)	

Experience soon showed that fresh water could be obtained only from igneous rocks and in an attempt to obtain a source of supply nearer to the town than the outcrop at the Telegraph Station, bores were sunk in the Hill V area (to which further reference will be made) about a mile and a half west of the town. One bore encountered good water but in insufficient amount to warrant equipping the bore (see Plate 8).

No.24 Bore was sunk in porphyry near Peko Mesa (Pl.9) and yielded only a small supply of good quality water having a total salinity of 43 grains per gallon. This water was struck where the drill entered unweathered rock at 80 feet and a well may be sunk to provide fresh water for mines and batteries in the neighbourhood.

One of the last bores to be sunk in the locality was put down in rhyolite on the bank of Bishop Creek in the north-western part of the field and has afforded a large supply of water containing about 70 grains of total solids per gallon.

Another bore, No.1, near Deen's Battery, also yields water of a composition within the limits of toleration by man according to a scale prepared by Dr. R. Lockhart Jack (1) from observations made by him on Eyre Peninsula, South Australia.

FOOTNOTE. JACK, R.L. Geol. Structure and other Factors in Relation to Underground Water Supply in Portions of South Aust. Bull. 14, Geol. Survey of S.A. Adelaide 1930.

This water contains 130 grains of salts per gallon, which compared with Jack's upper limit of $\frac{1}{2}$ oz. (220 grains) would appear to be safe, but the writer considers that $\frac{1}{2}$ oz. water could not safely be consumed in this country owing to the prevailing high proportions of magnesium and sulphates, and that the water from No.1 Bore should be regarded as of maximum salinity for safety. An analysis by the writer is appended:-

Assumed composition of salts.	Grains per Imperial Gallon.
Calcium carbonate	12.5
Magnesium carbonate	4.9
Magnesium sulphate	18.8
Sodium sulphate	13.9
Sodium chloride	80.1
Total salts 130.2	
equivalent to 0.30 ozs.	

If required in the future additional supplies of fresh water could be obtained from the granite outcrop situated about five miles south-east of Rising Sun Mine.

WATER FOR TECHNICAL PURPOSES.

Mine owners have been encouraged by the departmental policy of sinking bores at selected sites adjacent to leases which showed any promise. In many cases the boring programme was carried out irrespective of the state of development of the mine most likely to benefit, and in a number of instances later results have amply justified this procedure. In all instances these bores have been sunk in slate, and have yielded salt water in widely varying quantities from almost nil to over one thousand gallons per hour. Four bores south of Mammoth together failed to maintain sufficient supply for a 10-head battery, and it might be suggested by the high salinity of the water that the bores had penetrated an area of close grained rocks holding virtually stagnant water, but for the fact that bores at the Central Gold Milling Co's. property have continued to yield an ample supply of intensely saline water for some years. Three typical analyses follow:-

Assumed composition of salts.	Bore No.20 Govt. Battery.	Bore near Mammoth.	Central Gold Milling Co.
Calcium carbonate	27.5	40.0	24.0
Calcium sulphate	19.4	49.5	113.5
Magnesium sulphate	107.4	269.1	304.9
Magnesium chloride	6.2	21.9	108.4
Sodium chloride	215.3	868.7	1070.8
Total Salts	375.8	1249.2	1621.6
		grains per gallon.	
Equivalent to ounces per gallon.	0.86	2.85	3.70
	T.W. Ward.	H.B. Owen.	H.B. Owen.

Small yields of saline water from a number of bores have led to a feeling amongst local residents that deeper drilling in an attempt to strike artesian flows is justified, and some criticism of the policy of abandoning bores at a depth of about 400 feet has been voiced. This is a result of an imperfect perception or knowledge of the geological structure of the goldfield. Inspection of the maps and sections accompanying this report will show that all necessary criteria for an artesian basin are absent. Firstly, there is no basin, secondly, there are no aquifers, that is water-carrying beds, and thickly, there are no intake beds which could serve this area. The enormous area of Australia underlain by artesian structures has given rise to a general belief that deep drilling will yield flowing water anywhere in this continent, and this conception is, unfortunately, entirely wrong.

Experience with regions in South Australia where the age of the rocks is similar to that at Tennant Creek inspired Jack in the abovementioned Bulletin to write:-

"Some conditions (of occurrence of underground water) are definitely absent in certain places; for example, deep sinking in the old geological formations (from Ordovician downwards) beneath a saline ground water in search of better water is sheer waste of money and thousands of pounds have been spent in boring foredoomed to failure..... In some districts the conditions are known to be so unfavourable that, unless special and strictly local structural and topographical features exist, it is unwise to waste money on a search for subterranean supplies."

ROCK TYPES OF TENNANT CREEK GOLDFIELD.

The following notes describe the rocks occurring in the area. It will be seen that they are of great age and can be regarded as representatives of some of the oldest of the world's sediments. They are here described in reverse order.

1. SEDIMENTARY ROCKS.

(1). RECENT.

(A). Cemented gravels.

Gravels consisting of fairly uniformly graded fragments of slate, quartz, and hematite occupy the wider valleys and are well exposed in the stream channel of Waggaridgi Creek two miles east of the town. The pebbles are loosely attached by limonitic cement and may be broken apart by hand.

(B). "Bulldust."

The writer understands that this term was originally applied to the finely comminuted dust that lies in cattle 'pads' but it is now used locally to designate a light grey or buff coloured dust which is found chiefly on swampy ground and claypans. With the consistency of flour or cement it is particularly unpleasant to walk or motor through, and a car raises clouds of dust, which with a following wind may obscure the driver's view completely. Examination of a typical sample from "slate" country near Pinnacles revealed that the greater part consists of red quartz sand of fairly uniform particle size ranging between 0.1 m.m. to 0.06 m.m. in diameter. The remainder, about 25% is composed of quartz and mica particles of a diameter of 0.01 m.m. and smaller. The sample also contained

approximately $\frac{1}{2}\%$ of charcoal fragments, 1% of unidentified spicule-like bodies, and a few splinters of a ferromagnesian mineral.

Dust with similar physical properties, but always grey in colour, occurs over the igneous rocks of the Bishop Creek area in the north-west, near the White Hill granite, and at other localities where intrusive rocks are to be found.

- (C). Calcareous clays containing angular to rounded fragments of quartz, quartzite and hard slate have been found to a considerable depth in some of the water bores, especially in the southern portion of the field. Graphic logs of some of the bores are appended (Plate 5). These clays may be an early stage in "bulldust" formation.
- (D). Travertine, Very impure and magnesian.
- (E). Sand and unconsolidated gravels. Ironstone and quartz talus.

2. PROTEROZOIC(?)

Proterozoic(?) rocks are represented by quartzites with basal conglomerate beds on the southern margin of the field, and quartzites and sandstones to the north.

The southern occurrence is best observed at a point about one and a half miles south-east of the Rising Sun Mine where the beds dip uniformly south at 23° (Fig.2). Here the conglomerate forms two distinct beds of which the lower, up to eight feet thick, has been invaded by porphyry and much silicified, the matrix in part being replaced by quartz and hematite. The rock itself consists of quartzite boulders from twelve inches in diameter to small pebbles. Generally the pebbles break out of the matrix, but in the zone of the most intense silicification they break across when the rock is fractured.

Overlying this lower conglomerate is a bed of dense, current bedded quartzite up to twenty feet thick.

The next pebble bed varies considerably in thickness, and passing into a coarse grit merges with the overlying quartzite. There are several other narrow lenticular conglomerate beds generally only a few feet in length. As a result of the porphyry intrusion the quartzite is seamed with narrow quartz veins and is intensely hard.

The quartzite beds on the northern boundary of the goldfield form a range of low rocky hills with an east-west axis. The range crosses the Telegraph Line three miles north of Phillip's Creek and some few miles west of this point swings south. This change to a meridional strike persists for two or three miles when the beds bend sharply back to the normal east-west trend. These rocks have been examined, only cursorily, at two points, namely, on the Telegraph Line and at the "Alluvial" field. At the former locality they appear to possess a gentle northerly dip, the rock is dense and similar to that described above. At the "Alluvial" field, some thirty miles west of the Telegraph Line and forty miles north-west of the town, quartzite is underlain by fine-grained, compact sandstone containing a few flakes of mica; dip is a little west of north and averages 45° to 50° . No conglomerates were observed at either point.

3. ARCHAEOAN OR PROTEROZOIC. Warramunga Series.

The slates, schists, gritty beds and interbedded volcanics of the Goldfield.

Reds, browns, and buffs are the predominant surface colours of the altered sediments, generally referred to as 'slates', of which are formed the country rock of the ironstone ore-bodies. Below static water level, averaging between 250 to 300 feet, the redness gives way to greys and greenish greys, and much of the finer grained rock is "soapy" to the touch owing to the presence of talc, serpentine, chlorite etc.

Discounting the gritty beds, which, although widely scattered, occupy only a small proportion of the greater part of the total area under discussion, the 'slates' are very fine-grained and remarkably uniform in texture over the whole field; much of the rock is smooth and silky to the touch and possesses a satiny sheen on the cleavages.

Slaty cleavage, which as pointed out above is so strongly developed as to obscure bedding except where dips are steep, strikes east and west and generally dips to the north very steeply, in places passing through the vertical to a steep southerly dip. Gentle inclinations of the bedding, constant over distances of several hundred yards or more are strongly suggested when some hills are viewed from a distance and aerial photographs frequently afford confirmatory evidence of only gently inclined structures.

In proximity to ironstone bodies, which always lie concordantly in the schistosity, the 'country' beyond the immediate envelope of 'crush-rock' is for a greater or lesser distance deep red or chocolate in colour and much seamed with narrow veins of hematite and of quartz, it may also contain dendritic leaves of gold in the cleavages. Splendid examples of this 'paint' gold, which unfortunately is more spectacular than valuable, have been found at several mines on the goldfield particularly at the "Caroline" Mine. In other instances the rock, though not deeply stained with iron, may show itself under magnification to be a mylonite containing numerous small 'augen' of slaty material as shown in Plate 1, Fig. 1. Microscopic crystals of magnetite have been observed in light-coloured slate which was collected from within a few yards of an ironstone body west of Mt. Samuel.

The gritty beds are rarely deeply stained and unlike the argillaceous members of the series never contain dendritic gold.

Reference to the attached geological map will disclose a system of great jasperoid quartz reefs crossing the goldfield diagonally for over twenty miles, from south-east at Rocky Range to Quartz Hill a few miles north-west of the old Telegraph Station. On the south west side of this system of reefs the above mentioned gritty beds form only a minor part of the country and occur in bands usually only a few inches thick though persistent in strike for many yards. Two miles south of the Telegraph Station there is a noteworthy occurrence; several gritty bands each about 12 inches thick alternate with differing thicknesses of argillaceous sediments. The underside of the sandy components is sharply defined but the upper edge shows no such sharp differentiation and merges gradually with the finer rock until this in turn gives place abruptly to another gritty band.

On the opposite side of the line of quartz reefs different conditions obtain; gritty beds with little or no slaty structure are predominant, and in many of the hilly regions bedding may be recognised and followed with comparative ease. At "Golden Mile" a range about 150 feet high has been formed by the crumpling of the beds into an asymmetric fold with an east-west axis and with the steeper limb dipping almost vertically to the north. Boring about 200 yards north of the range revealed a thickness of 326 feet of quartzitic rock with some finer bands before smooth grey phyllitic slate was encountered. It is tentatively suggested that the gritty folded beds of the "Golden Mile" and that vicinity

represent an upper series which is absent on the south-west side of the fault now occupied by the great quartz reefs. This gritty series may well lie unconformably upon the smooth phyllites which agree in appearance with the normal 'slate' of the goldfield. At Black Cat (v. Fig. 3.), three miles east of Mammoth, beds of a compact medium-grained rock as well described as a sandstone with very poorly developed cleavage as anything else, dip south-west at 20° . They are gently folded and two less competent beds enclosed in them have been much shattered. The upper of these two 'rubble beds' carries payable gold values and will be further described elsewhere in this report.

II. IGNEOUS ROCKS.

1. The "Older Porphyrites".

The rocks under this designation vary somewhat in character and present some difficulty in interpretation. Generally they have this much in common - a more or less gneissic habit and an abundance of quartz phenocrysts. They occur inter-bedded as probable rhyolite flows and as dykes concordant with the grain of the country. They have suffered severely from regional metamorphism and would appear to have been injected at a time when the tectonic movements giving rise to this metamorphism had been active but were not complete, hence the concordance of the dyke walls with the schistosity. The bedded bodies are apt to be mistaken for coarse sediments, and the reverse holds true that some sediments may have been included in the "Older Porphyrites".

The quartz phenocrysts often appear to be rounded pebbles but microscope examination reveals them to be corroded crystals surrounded by a silified aureole. The original groundmass has been reduced to an indeterminate 'slaty' material which weathers out fairly readily giving the rock a very rough and irregular surface of protruding quartz grains. Any primary flow structure there may have been is now completely lost.

Notes on various occurrences are given below:-

(a) Hill V Area (Pl. 8). The "Older Porphyry" one mile west of the town represents a much altered tuff or rhyolite which has been invaded by a later intrusion of granite-porphyry. On the Peter Pan lease the rock is conformable to the bedding but the eastern exposure in the quarry is dyke-like in form and probably represents the neck of a small laccolith as suggested in Fig. 8 (2). The rock of this neck is now gneissic (i.e. banded) or coarsely schistose in texture and contains strained and shattered quartz phenocrysts which measure up to an eighth of an inch in length. The surrounding slate walls show signs of contact metamorphism.

(b) At the Black Angel the rock is undoubtedly igneous in origin and shows much less alteration than other occurrences and perhaps would be better included amongst the "newer" quartz porphyries. However, in the field it does not look igneous, in marked contrast-distinction to the newer porphyries, but rather resembles a quartzite in which are embedded round pebbles. These 'pebbles' are found to be corroded quartz crystals (Pl. 1, Fig. 2), similar to those observed in other members of the "Older Porphyries".

This outcrop forms a low rounded hill east of the mine workings.

(c) Adjoining the Queen of Sheba and Evening Star leases the rock assigned to this group forms a range about one and a quarter miles long and fifty feet high and is described on the sketch map accompanying this report (Pl. 11) as a contact breccia. There has been much igneous activity to the east of the area and this anomalous rock is very probably a phase of the contact aureole rather than an older igneous body.

At all the other localities which are denoted on the general geological map by the letters "O.P.", the rock is similar to that found in the quarry near the town and the description given above need not be repeated. Near the Golden Forty and Peko Hills it is deeply stained with iron but the usual corrosion and narrow siliceous zone surrounding the quartz grains can be observed.

2. RED GRANITE.

Two large outcrops of this granite occur near the centre of the field, and another mass of unknown extent was discovered under a thin cover of alluvium when boring operations were carried out six miles south of Mt. Samuel.

The outcrop which has been referred to as the 'main mass' lies to the west and north-west of the old Telegraph Station and the other exposure forms a number of rocky hills and tors north of and adjoining White Hill to the east of the Station.

Both cupolas, each several square miles in area, demonstrate the characteristic spheroidal weathering and tor building of granites and the piled boulders reach a height of some 120 feet above the plain level.

The southern contact of the western mass is roughly concordant with the general strike of the country and partially assimilated bands of highly silicified slate are enclosed in the granite along this margin. Contact metamorphism is marked in this locality and cherts and silicified slates occur over a wide area without however containing garnets or other metamorphic minerals. The appended sketch section (Fig. "4") which is not strictly to scale, shows the nature of the contact. Jasperoid quartz reefs which are shown in this section and in the general map are a prominent feature of both granite areas. There can be little doubt that these two outcrops are connected at shallow depth; slate showing on the road half a mile north of the Telegraph Station is obviously a small roof pendant.

The rock is a handsome red stone characterised by dominant pink or red orthoclase with bluish opalescent quartz and as far as its appearance is concerned would be eminently suited for ornamental building purposes if situated in a less remote locality. Meridional joint planes are most marked and are crossed at right angles by a system of joints only slightly less prominent. The western outcrop is traversed from east to west by several gneissic bands a few feet wide which are rendered particularly noticeable by very large orthoclase crystals and greyish groundmass which give the rock a porphyritic texture.

In addition to quartz, orthoclase and biotite both granites contain microcline, magnetite, a little hornblende and traces of the ever-present apatite.

3. WHITE GRANITE.

(a) On Gosse River near eastern edge of goldfield.

Little is known about this rock as it was the subject on only one hurried visit and no specimens of 'fresh' material could be collected. The rock is a sub-acid biotite granite with pre-dominant feldspars, biotite and clear glassy quartz. Its outcrop, probably not as extensive as shown on the map, is crossed by several aplite dykes.

The surrounding country is flat and some quartz reefs were observed at a little distance across the river on the eastern bank.

(b). South-east of Rising Sun.

This is a cupola of which the outcrop measures about $2\frac{1}{2}$ miles from north-east to south-west by $1\frac{1}{2}$ miles. The occurrence is of the familiar type of rounded boulders and tors, but near its eastern and western ends are more or less flat-topped hills of reddish decomposed granite (or porphyry) taken by the writer to represent remnants of the 'chilled' skin of the original molten rock. Much of the area between these hills and the piled boulders is occupied by grassy flats with odd boulders showing above the grass here and there.

The rock, particularly near its northern margin, is characterised by numerous clots or segregations rich in biotite and generally fine-grained. These clots are almost without exception spindle-shaped with their longer axes striking east and west. Not only are the clots strung out in parallel lines but the larger felspar crystals are often to be seen with their longer axes oriented to this general direction. The feature is undoubtedly a primary flow structure and worthy of more detailed examination at some future date.

On freshly broken faces in the hand specimen the rock is speckled black and light grey and sparkles with very black biotite crystals. A banded structure is faintly perceptible.

In section, it is seen to consist of very granular quartz, cloudy feldspars, plagioclase and orthoclase being present in about equal amount, biotite somewhat chloritized, and apatite. The quartz contains numerous pear- and cigar-shaped inclusions of greenish glassy matter, and large numbers of unidentified microscopic needles. No iron ore minerals were seen in the one section which was prepared.

The extension of metalliferous country south of this locality is a possibility not to be overlooked, and it is reasonable to expect that fresh water could be obtained by drilling on selected sites in the area.

4. PORPHYRIES.

Quartz-porphyry and granite-porphyry apophyses occur in numerous localities on the goldfield, arranged more or less radially about the granite cupolas. In area none exceed a square mile and each is traversed or bounded by the familiar quartz reefs, though on a smaller scale than near the Telegraph Station or at White Hill. The outcrops are generally somewhat elliptical in plan with the longer axis trending east and west.

There is a definite arrangement of quartz, jasper and hematite-magnetite bodies concentrically around the porphyries, and that order - quartz, jasper, hematite - is the general rule although occasional exceptions and anomalous mixtures of these three minerals in all possible combinations and permutations cloud the issue. The radial distances to the different components of the system vary from place to place, but the nearest hematite is usually well within one mile of the igneous boss. One exception to this rule is afforded by a large body of sheared quartz porphyry situated about four miles east of Red Terror; in this instance the nearest ironstone mass is an exceptionally large outcrop one and a half miles away. The area is very imperfectly prospected and other outcrops may yet be discovered at a lesser distance. The Mt. Samuel 'line' and Eldorado conform to the rule. A bore on the southern flank of the Mount entered porphyry and the same rock has been revealed in a gully three or four hundred yards east of the Eldorado mess hut.

(a). Hill V. Area.

A mile west of the town porphyry forms a conspicuous hill of piled boulders separated by the opening out of the joint-planes in the massive rock. The elliptical outcrop has a north-

south costate structure which is revealed by the contouring on the attached plan (Pl.8). The southern margin is bounded by a line of jasper bodies containing some hematite in disseminated grains, and two large quartz reefs cross the area occupied by porphyry from south-west to north-east.

Examination of the rock in the hand specimen reveals it to be a dense semipatic porphyry, greyish in colour, with quartz and plagioclase phenocrysts up to 5 mm. in length. The groundmass is dull and stony. In section it is seen that the rock contains leucoxene resulting from the alteration of ilmenite, and that the quartz and felspar crystals both have numerous inclusions of greenish slag. A little hornblende is also present.

(b). Peko Mesa Area. (v.Pl.9 and Pl1, Fig.6.).

A considerable area is occupied by igneous rock in this locality a mile east of the Peko mine but only a few square yards of porphyry show above the sand. The rock is reddish in colour with a lithoidal to granular groundmass and contains irregular dark coloured patches which probably represent digested xenoliths. These dark patches contain small phenocrysts of quartz and orthoclase principally. Occasionally crystals of quartz with a diameter up to 12 m.m. can be observed but few phenocrysts exceed 2 m.m. in length. The groundmass appears to be almost wholly silica, and a few minute grains of the iron ores are present. The porphyry to the north-west of the Golden Forty is essentially of the same nature.

Incidentally in passing it is worth noting that these bodies are in a very early stage of exposure and afford particularly fine examples of roof pendants and contact breccia.

(c). Near West's Hill, Bishop Creek.

The dacite porphyry occurring east of West's Hill forms an extensive outcrop at least two miles long from east to west and about half that distance in width. It takes the form of a jumbled mass of low rocky hills built up of piles of smooth round nearly black boulders. The rock is extremely hard and massive so that when a boulder is struck with a hammer it emits a clear bell-like note.

The groundmass is dense and liver-coloured and phenocrysts consist of large orthoclase crystals and smaller ones of hematite; quartz is almost entirely absent. In section the groundmass which is dominant giving the rock a dyptatic fabric, has a suggestion of flow structure.

White jasperoid quartz reefs are well displayed and the crest of one which traverses the entire length of the outcrop rises to about 180 feet and glistening in the sun serves as a very prominent landmark. Smaller quartz reefs occur circumferentially about the mass.

(d). "East of Sheba".

About one mile north of the abovementioned dacite there occur a few scattered outcrops of a rock with the appearance of a quartz trachyte; a dull stony rock, grey in colour, with a very few phenocrysts of quartz just visible to the naked eye. On sectioning this rock it was found to be a devitrified pitchstone and its perlitic structure is well shown in Plate 1, Fig.4. The exposure forms inconspicuous piles of boulders displaying the usual spheroidal weathering. This rock is also associated with jasperoid quartz reefs.

(e). South of the Rising Sun Mine.

A wide dyke of porphyry, much decomposed and partly obscured by alluvium, occurs in contact with conglomerates and quartzites in the southern portion of the field. The intrusive rock has stopped up through a considerable thickness of quartzite

in two places and has much silicified the basal conglomerate included in it, has been faulted off and the fault filled with the usual white quartz. A nearly longitudinal fault near this point has also faulted off the quartzites and the fault breccia apparently contains traces of gold. The porphyry lies in a creek bed and its northern contact with slates is completely obscured by gravel etc.

(f). East of Red Terror Mine.

Approximately a square mile of sheared and weathered porphyry is exposed about four miles east of the Red Terror Mine. No jasper and very little quartz is associated with it.

(g). South of Honeymoon Range.

The presence of this body was unsuspected until disclosed by boring; subsequent search revealed small outcrops south of Aurora lease and in a gully near Kathleen mine. The rock is similar to that of Hill V and no doubt is connected with it at shallow depth.

(h). Mt. Samuel.

A pink coloured rock with quartz crystals and much lithoidal groundmass was encountered in percussion boring at a depth of 60 feet under a mantle of slate and quartz pebbles, and clay. The bore was situated near the foot of the Mount on the south-west side.

(i) Eldorado.

Silicified slates, chert and contact breccia in a stock-work of quartz veins are to be found in a valley half a mile east of the mine. A small exposure of what is taken to be much weathered porphyry was found nearby in a narrow gully.

(j). Miscellaneous.

Small occurrences of porphyry are found in low-lying ground in many parts of the field. The following are some of the larger of these exposures. Just south of, and north of, the Jasper Area; south of and at the Euro Mine; north-east of Caroline and Casey's Knob; north of Black Spot; south-east of and at the Black Angel Mine; ten miles north of the Telegraph Station.

5. RHYOLITE. (v Plate 1, Fig.5).

A much jointed pink rhyolite is exposed for a short distance in the channel of the Bishop Creek in the north-western quarter of the field and forms two or three low scattered hills in the same locality.

The rock is felsitic with a few idiomorphic phenocrysts of quartz a little corroded and showing evidence of strain. Each corroded crystal is surrounded by a narrow aureole of silicified rock.

Boring operations seeking fresh water were carried out in this locality with success.

Flow structure in the rock is east and west and much less pronounced at depth suggesting that the present surface more or less nearly coincides with the original upper surface. Some of this structure is probably secondary in origin and suggests that this rock represents an earlier phase of igneous activity than the nearby porphyries and has been subjected to the regional metamorphism which they have, for the most part, escaped.

6. BASIC IGNEOUS ROCKS.

Small dykes and sills of basic rocks occur in a few places on the goldfield. Broadly, there are two types; Pre-gold and Post-gold. The former have suffered considerable alteration and are now represented by hornblende schists, chlorite schists and small masses of serpentine. The latter have been found in shallow

excavations and being pyroxenites have undergone much alteration by weathering.

(a). The Pre-gold hornblendites etc.

The hornblende-serpentine schists are associated with gold at two mines viz. the Pinnacles, which has produced 1005 ounces of bullion from 998 tons of ore, and the Mary Lane with a production of 9 ounces from 47 tons. Neither of these figures takes into account gold recovered by cyaniding after crushing.

At the first mentioned mine the greater part of the gold has been won from magnetiteiferous 'greenstone' schist closely associated with hematite bodies in the familiar relationship of the crush rock envelope. The stone was much copper stained in places and values were often spectacularly high. Fifty yards or so to the west of the main workings a small rocky hill composed of tremolite schist and covered with a siliceous capping two or three feet thick carries a narrow lens of highly copper stained rock from which small specimens of chrysocolla (copper silicate) may be obtained. Between this small hill and the mine trenching disclosed a body of rock almost wholly composed of minute octahedra of magnetite in a matrix of dark green material, probably hornblende. The principal mine workings are adjacent to a hematite mass and gold occurs in the surrounding 'crush rock', as mentioned above.

At the "Mary Lane" mine about two miles north-west of the Great Northern, small hematite-magnetite lenses, generally only a few feet in length, occur 'en echelon' in a basic dyke. The dyke rock is now metamorphosed to a dark green chloritic schist. Adjacent to the ironstone lenses the rock is harder, lighter in colour and contains much iron in disseminated grains of the oxides. Gold occurs in narrow lenticular shoots some of which are very rich in places but stone from them is much diluted with low grade material unavoidably included owing to their small dimensions.

A small body of serpentine rock containing some fibrous chrysotile occurs north of the Euro Mine, but, as far as the writer know, no gold is associated with it.

(b). Post-gold Pyroxenites.

A flat sill of much weathered soft basic rock, tentatively regarded as an enstatite extends over a considerable area north-west of the town. It underlies a small horizontal hematite-magnetite body on the Euro lease (Fig.5) and is also found beneath, and intersecting, vertical ironstone masses on the adjoining Caroline lease. At the Nipples, south of the Caroline, the sill, dipping gently south with the bedding, is only ten inches thick and completely intersects an auriferous body of ferruginous slate and quartz. At Casey's Knob the rock stands nearly vertically in the schistosity of the country, and the pipe is at least twenty feet wide but is probably very irregular in shape and fills a cavity resulting from a system of faulting which has displaced upper portions of the enormous quartz-hematite 'blow' forming the Knob. Two diagrams are appended (Fig.6).

Owing to the much weathered and crumbly condition of the rock it is to be found nowhere on the surface and has been revealed only by costeans, adits etc.

THE MINERAL BODIES.

The three common types of mineral bodies outcrop boldly forming striking features of the area; they are (a) very large reefs of white jasperoid quartz which cross the goldfield from south-east to north-west and are also disposed more or less circumferentially about the acid intrusives, (b) jasper-hematite bodies of roughly lenticular habit and (c) lenticular, irregular and pod-like masses of hematite associated with magnetite which occur in strings and bunches.

The jasper bodies are found in close proximity to the porphyries but are generally separated from them by a greater distance than are the quartz reefs whilst the hematite-magnetite deposits are situated at a greater distance again. The mutual relationship of these bodies is however not readily apparent as much contradictory evidence can be collected.

(a). The white jasperoid quartz reefs vary in width from veins of less than one inch to reefs twenty and more feet in thickness. The larger reefs, which individually may be a mile to a mile and a half in length, form impressive hills rising abruptly from the plains. Not of great height, rarely exceeding 100 feet, they are however very striking in appearance with their steel talus slopes crowned with a vertical crest of glistening white rock. Three such hills rise sufficiently above the general hill level to have been utilised for minor trigonometrical stations. Many of these jasperoid reefs have invaded faults and consist of breccias containing highly silicified fragments of 'country' in a matrix of pure white quartz. Near Mammoth the reef contains a great number of angular fragments of hematite which evidently represent the remains of an ironstone body shattered by earth movements. Traces of gold have been discovered in the reef at this point and this fact has some bearing on the origin of gold deposits. A diagonal fault between Casey's Knob and Caroline is silled with quartz and similar highly siliceous fault breccias may be noted at Quartz Hill, Peko Hills and the Jasper Area.

Where denudation is deep the quartz reefs are responsible for covering large areas with white gravel, and in many cases only a vein three or four inches wide can be found in a patch of quartz gravel covering two or three acres.

It will be observed from the geological map that a roughly linear system of very large reefs extends from Rocky Range in the south-east to Quartz Hill a distance of about 25 miles, with a fair degree of continuity, and it should be noted that at the north-west end near Quartz Hill the reef is intimately associated with granite for six or seven miles whilst porphyry is to be found at no great distance from Rocky Range. Similar large reefs at White Hill (1) are also in close relation to granite and almost

FOOTNOTE. (1). The quartz bodies at White Hill are indicated only diagrammatically on the map.

without exception the smaller reefs are situated within or about porphyry bosses. For this reason it is assumed that these jasperoid reefs represent the final phase of the granite intrusions and are post-gold in time. Where no field relations between quartz and granite or quartz and porphyry can be observed it seems reasonable to contend that the intrusive is hidden below thin cover. The vast size of the quartz reef near Mammoth suggests that the granite cupola of White Hill extends at no great distance below the surface as far south as the Great Bear. This contention is partly borne out by the result of water boring at Cleland Water-hole where granite was penetrated at 181 feet.

All these quartz bodies have so far been found to be barren with the exception mentioned above, but this appears easily explained by attributing the gold discovered therein to included fragments of the shattered hematite mass.

The word quartz when used in this discussion applies to the white jasperoid quartz of the reef systems and is not to be confused with the quartz which will be mentioned later when the hematite-magnetite bodies and gold occurrence are discussed.

(b). The Jasper-hematite bodies.

Less prominent and less widely distributed than the quartz reefs, the jaspers are also closely associated with porphyry

occurrences as marginal deposits except at Golden Mile and Metallic Hill where hematite is the dominant constituent of the mineral masses and the jasper occurs as bright red contorted strings and veins. Where the body is essentially of jasper it usually lies in the contact zone of a porphyry, is reddish or a dark indeterminate colour and much injected with white quartz veinlets. Segregations of crystalline specular hematite also occur in places, but generally the rock is uniform in composition with a dense crypto-crystalline texture. Although all the jasper contains some disseminated hematite many of the masses are virtually pure silica but the hematite content increases in some until they almost pass into the normal hematite type of body.

The rock is very resistant to weathering and to all intents and purposes is attacked only by insolation.

It is a general rule that the jasper bodies and those hematite bodies containing much jasper are barren or nearly so.

THE HEMATITE-MAGNETITE BODIES AND GOLD OCCURRENCE.

(v. Fig. 7 and Plate II, Figs. 2, 3, 4, 5, & 6).

The ironstone masses which constitute the orebodies of the goldfield vary within wide limits in size, shape and position; from mere blebs of iron ore a foot or so in diameter they range up to the enormous masses 300 feet long met with on Mt. Samuel, the Peko and other localities. Lenticular forms are common but the masses may be irregularly oval or even roughly circular in plan. Those bodies which lie in the plane of schistosity usually have considerable vertical extent but shallow tabular shapes are frequently encountered giving a false impression of bulk owing to the large flat outcrop resulting from the uncovering of the upper surface. When denudation is well advanced and the flanks of the ironstone are concealed by fallen blocks and boulders of hematite it is extremely difficult and sometimes quite impossible without much labour, to determine the actual boundaries of the body and prospectors have been frequently misled.

Chemically the ironstone represents all shades of difference from high-grade iron ores to those containing more silica than iron. Silica is present chiefly in the form of quartz veins or quartz intergrown with stellate clusters of hematite (specularite) in plates and blades. The high-grade iron ores contain a greater or lesser amount of admixed magnetite and, in places, some superficial brown limonite with resinous lustre. Sulphides are also present at depth and have been encountered in several diamond drill holes; pyrite (iron pyrites) is the most abundant, with chalcopryrite (copper pyrites) and galena (lead sulphide) in lesser amounts but by far the bulk of the deeper bodies is composed of magnetite and hematite, and there is some evidence to suggest an increase in magnetite content with depth.

The ironstone is dense and tough and breaks with difficulty to present a bluish face with a fracture not unlike that of cast iron in the case of the fine-grained varieties; the coarser kinds usually show a little specular iron in fresh fractures and break with slightly less force required than the former types. Mining is virtually impossible in such ground and advantage has to be taken of all joints and cracks. The more siliceous hematites, although very hard, are more regularly jointed and shoot well, rendering mining rather less difficult than is the case with the purer iron oxides.

Each body at its contact with the 'country' slates is surrounded with iron to a deep red or brown colour, frequently crossed and criss-crossed with narrow veinlets of hematite and quartz, and containing angular blocks and fragments of ironstone. This casing constitutes the frequently valuable 'crush-rock' from which much gold has been won. The width of the 'crush-rock' casing may be less than one inch or more than twenty feet but is not in any way proportional to the bulk of the parent body.

Each ironstone mass acting as a massif, or miniature stable foreland has resisted the pressure and movement during the metamorphism of the region to a better degree than the surrounding sediments with the result that they have been crushed and ground against the iron walls. The iron mass itself has not entirely escaped and has contributed slickensided blocks and fragments to the breccia. These shattered and powdered fragments of ironstone, containing no doubt much ferrous iron are thought to have played an important part in the precipitation of secondary gold about the main mass. At this juncture quotations from a report by Dr. F.L. Stillwell (1)

FOOTNOTE.(1). STILLWELL, EL. Rept. No.117, Mineragraphic Investigations. C.S.I.R. University of Melb. Jan.1938.

will not be out of place. With reference to casing material from the open-cut at Eldorado the report states:-

"The ...casing is a red-brown decomposed shaly rock, containing small disseminated crystals of hematite and intersected by ramifying veinlets of hematite and quartz. The main parts of the veinlets consist of martite or hematite with numerous remnants of magnetite. The edge of the veinlets are, however, often fringed with small bladed crystals of hematite which by reason of their shape and absence of magnetite inclusions, did not pre-exist as magnetite. Gold particles visible in the hand specimen appear mostly in or on the walls of the hematite veinlets. Occasionally small particles of gold have been observed in section in the decomposed rock. In some cases oxidised bismuth occurs on the walls of the hematite veinlets and suggests that both gold and the bismuth are later than the development of magnetite, but may have accompanied the development of the bladed hematite."

The presence of two types of hematite in the deposits is clearly demonstrated and Stillwell in the same report states:-

"A large amount of it (the hematite) consists of martite or hematite which has been derived by the oxidation of magnetite. This type of hematite contains residual inclusions of the magnetite from which it was derived, and sometimes retains the form of the original magnetite crystals. It is not certain whether the martitization was a supergene or hypogene process.---- It is, therefore, premature to conclude that the auriferous hematites will pass into magnetite in depth, although they may do so".

The second type of hematite which can be observed exhibits its own form clearly, especially in the siliceous zones of a body and Stillwell thinks that it is probably developed by the recrystallization of the martite during the introduction of hydro-thermal solutions which carried quartz, bismuth and gold.

It is interesting to point out that an ironstone mass encountered at 270 feet in a diamond drill hole east of the Peko consisted almost wholly of magnetite and quartz with some chalcopyrite, but, on the other hand cores consisting essentially of hematite with traces of sulphides have been recovered from greater depths elsewhere, notably near Eldorado and Cat's Whiskers. The following quotation from the same report throws additional light upon the mineral composition of the ore-bodies and refers to the 'bladed hematite':-

"It is frequently accompanied by much quartz, and it may occur as fine needles disseminated throughout the quartz or gangue, but it has been observed accompanying the little altered martite ---. Some of the quartz is clearly younger than martite, because it occupies fractures in the martite crystals where the twin lamellae are displaced by the fractures. Occasionally ----- coarse bladed hematite crystals enclose idiomorphic crystals of magnetite, indicating that the hematite can crystallize around

earlier crystals of magnetite independently of the oxidation of magnetite. The development of the bladed hematite is not likely, therefore, to be due to weathering, and probably resulted from the circulation of the hydrothermal solutions.

Another feature which suggests the hydrothermal origin of the bladed hematite is that gold and native bismuth are commonly associated with it."

Faults and joints within this type of dense hematite-magnetite-quartz mass have played a conspicuous part in the disposition of ore-shoots but most faulting within the formations appears to be post-mineral and leads to difficulties in interpretation at the shallow depths to which mining on the field has so far attained. Joints, commonly called 'heads' by the miners are very persistent in some of the larger bodies, but small faults and joints cross each other at every conceivable azimuth and dip. The general result is that the ironstone is divided up into roughly tetrahedral blocks.

It is frequently found that values cease abruptly when the more persistent of these joints are crossed and breaking through the 'head' yields disappointing results. Usually the north-south system of joints is better developed than others in the Eldorado-Mt. Samuel locality and the phenomenon of disappearing values is often encountered in this area, where the gold is usually associated with quartz and bismuth and is considered to be primary. It appears, therefore, that some of the joints had a damming effect on hydrothermal solutions and acting as feeders permitted the mineralizing solutions to impregnate the ironstone on one side of the joint only.

Minor fault zones occasionally carry secondary gold and particularly is this so when the fault extends appreciably into the breccia casing. For this reason any transverse structures, whether filled with quartz, limonite or shearded material or merely represented by open fissures, are valuable guides for the surface prospector who should begin pit-sinking or trenching in positions adjacent to any such features and carry his excavations down on the edge of the body for several feet. In this connection it is pointed out that there exists at Tennant Creek a superficial impoverishment attributed to leaching, and shallow prospecting, known as 'loaming', cannot be wholly relied upon. This aspect is further discussed at a later stage in this report.

THE ORIGIN OF THE IRON ORES.

It has been contended that the ironstones of the goldfield are gossans derived by the oxidation of sulphide deposits and exponents of this theory point out examples of cavernous ('honeycombed') ironstone of a typically gossanous appearance and also lay much stress upon the presence of sulphides in diamond drill holes. On the other hand it is held by others that the bodies are directly magmatic in origin and were injected into openings in the 'country' as magnetite and hematite much as they are today.

This latter view is more strongly supported by the evidence but requires further elaboration to explain certain anomalies.

The invariable proximity of the ironstones to igneous rocks and their presence concordantly in the plane of schistosity, frequently cutting across bedding planes at high angles, together with the irregularity of their disposition are sufficient facts on which to dismiss consideration of sedimentary origin as an explanation.

The presence of considerable gossanous material

at the Northern Star and Peko can be explained if these deposits are regarded as belonging to the normal magnetite-pyrite type, but in which sulphides have been unusually strongly developed and not present in the minor proportion revealed by diamond drilling elsewhere. At the latter of these two mines a bold outcrop of dense hematite measuring 300 feet long by 80 feet wide covers a mass of soft, highly leached gossan, generally brown in colour but with some sooty black patches. This information of soft 'picking' ground consists largely of limonite and contains odd blocks of hematite from an inch to several feet across, and is traversed by a number of horizontal quartz veins several inches wide. The slate contacts are sharply defined on the 60 and 120 ft. levels, below which insufficient development has yet been carried out to determine the nature of the walls. A slate horse 10 feet thick on the lower level does not show evidence of crushing or mylonization and it would appear that the reduction of the ore-body to a mass of earthy pulp has been brought about by chemical attack and not by the earth movements which have in other localities surrounded the ironstone bodies with an envelope of breccia. Some diamond drill cores recovered from below water-level consisted of fairly dense hematite containing a little native copper and sulphides. An analysis of a sample of ore from the oxidised zone is given. This analysis conveys a clear hint as to what may be expected at greater depths.

Gold per long ton.....	38 dwts.
Silver " " "	5 dwts.
Insoluble matter	24.8%
Ferric oxide	56.7%
Copper	0.9%
Zinc	NIL
Lead	0.4%
Arsenic	1.4%
Bismuth	1.6%

(Analysis quoted from C.S.I.R. Rept. No.43 by Messrs. H.W. Gartrell and L.M. Abell. Adelaide).

At the Northern Star similar conditions obtain; the mass of gossan contains flakes of micaceous hematite and patches rich in bismuth oxide or carbonate and residual magnetite. The water-table has not been reached in this mine yet, but at 237 feet the ore is siliceous and contains native bismuth, bismuth oxide and carbonate and magnetite. In association with bismuth gold values are frequently high as the following assays of a specimen from 237 feet at this mine show:-

Gold	29 dwts. per ton.
Bismuth	14.4%

At the risk of much repetition the following descriptions of the more "normal" type of deposit is included.

The dense non-gossanous deposits can be divided into two types; (a) the lenticular or rectangular bodies, and (b) the multiple bodies. Examples of the former are to be found at the Burnt Shirt and Kathleen, the Dot, the Pattie and the Enterprise and many other places, whilst the multiple type of ore-body is to be observed at Eldorado, Hammerjack, Mt. Samuel, Queen of Sheba, probably also at the Gigantic, and at other mines.

The lenticular bodies invariably consist of dense black or blue-black ironstone with little or no quartz except where joints or minor fissures have been invaded by this mineral. Very rarely does one of the siliceous deposits of intergrown quartz-hematite possess a lenticular outline generally being more nearly circular. The narrow lenses may occur quite isolated from others, but are often found associated in roughly linear fashion when several may be connected to each other by a narrow 'stringer'. More usually, however, a line such as that at the Skipper, west of the Westward Ho (v.Pl.6) has many of the bodies lying slightly

off-set from each other and not connected. It is sometimes observed that end pressure has occasioned an impaction (or telescoping) of two bodies situated thus and then it is impossible to say whether they were originally 'en echelon' or joined in line.

The attitude of these masses in the field is controlled by the openings in the 'country' (slates into which they have been injected, and they agree in general character and shape with most mineral deposits in slate or schist country. Their strike is east and west (except at the Queen of Sheba) and they are inclined steeply to the north, although the dip may be vertical or even in a few localities steeply south. While the upper extremities are narrow and converging to a wedge some bodies appear to be truncated or blunted at the base, giving their lower portion a cross-section like the hull of a ship. This flattened base rests upon much hardened and hematized country which, when denudation has proceeded sufficiently far, may be found outcropping round the hematite as a red jasper-like band. Many of these deposits are, however, truly lenticular in form, and this applies particularly to the smaller occurrences up to about 50 to 60 feet in length. Where any impaction has taken place, or where pressures have been to any degree tangential to the body where greater development of crush-breccia at the ends of the outcrop than may be present along the walls but this factor appears to have little bearing on the distribution of secondary values within the casing material.

Whilst bodies of this kind are smaller than those of the multiple type and usually possess a thinner envelope of 'crush' much gold has been recovered from them and notable examples are afforded by the Burnt Shirt on Honeymoon Range and the Rising Sun.

THE HILL V AREA. TYPE AREAS. (v. Pl.8 & Fig.8).

The area mapped occupies rather less than one square mile and is situated just to the west and north-west of the town and includes part of the aerodrome.

The principal topographic features are provided by the short range of slate hills, which includes as its highest point Town Hill, the gentle dome of the aerodrome outcrop of porphyry with its remnant of a roof pendant at Major Clark's old camp, and the rocky outcrop of Hill V itself. The Town Hill Range terminates abruptly just east of the site of No.4 Diamond Drill hole and only a gentle fold in the ground traversing the length of the Peter Pan lease connects it with its western counterpart in the isolated Big Ben hill.

Between this low rise and Hill V a wide shallow watercourse overgrown with comparatively dense sub-tropical vegetation, carries drainage west, but run-off from Town Hill finds its way through, no defined channels eastward into the town where it is controlled by artificial drainage, although some of the heavy summer showers cause much water from the northern slopes of these hills and from the aerodrome to sweep through the town.

Two jasperoid quartz reefs of the familiar pure whiteness striking north-east to south-west in the porphyry and several of the larger jasper bodies in the contact zone stand out boldly.

The presence of a large mass of igneous rock gave rise to hopes that fresh water might be discovered in sufficient quantity to supply the needs of the town and thereby save the long haulage from the Old Telegraph Well seven miles north. Accordingly a bore (No.26) was put down on a small grass- and scrub-covered flat on the south side of Hill V, but after passing through 70 feet of decomposed porphyry the drill entered unaltered rock without any water being encountered. The plant was then moved to No.27 site in the watercourse to which reference has already been made. Owing to the absence of outcrops, other than the inconspicuous westerly extension of one of the quartz reefs, in the vicinity of this second bore site

and the presence of porphyry south of the watercourse it was surprising to find that the drill immediately entered slate and continued in this formation to a depth of 250 feet before encountering the intrusive. At the junction a meagre supply of potable water amounting to rather less than 100 gallons per hour, was struck. As this quantity was quite inadequate the hole was abandoned and no further boring was carried out in this locality. Further boring west in the same watercourse at approximately half a mile downstream was considered but the project was dismissed on the grounds of the very probable salinity of any water discovered.

The porphyry of Hill V, which has been described elsewhere in this report, is crossed by two major systems of joints intersecting approximately at right angles. The east-west system are closely spaced and dip to the north at a steep angle with the result that the outcrop has a peculiar appearance of a stack of columnar boulders leaning at a somewhat precarious angle to the south. On the western edge of the aerodrome the outcrop is composed of scattered rounded boulders protruding but little above the soil.

On the northern boundary of the igneous rock the contact, where not hidden by recent sands etc. is found to be marked by slates only but slightly indurated, while the contact with the large pendant through which No.27 Bore was sunk is characterised by the development of large masses of jasper-hematite of magmatic, or at least sub-magmatic origin.

These jasper bodies form a continuous line of greatly varying width for more than one mile, with the exception of the place shown in approximately the centre of the plan where the jasper has been transgressed by the later quartz. The bodies are composed of dark grey to purplish rock consisting of cryptocrystalline silica containing a few scattered crystals of hematite in insignificant amount. The two larger bodies shown on the plan are quite impressive in size and bear a superficial resemblance to the hematite-magnetite masses; probably for this reason much prospecting has been carried out by pit sinking and costeaning along this margin of the porphyry but, as far as the writer is aware, no gold has been discovered, and it may be taken as a general rule that such jasper bodies are very unfavourable and not worth the spending of much time or trouble by the prospector.

The "Older Porphyry" in this area has the appearance of a highly altered tuff or rhyolite. As mentioned previously the region-metamorphism, which has conferred the slaty habit on the country rock of the district, has given this 'older porphyry' a coarsely schistose or foliated character, and the western exposure on the Peter Pan lease has been invaded by the latter intrusion of the Hill V granite-porphyry further altering it from its original appearance and constitution. Diamond drill hole No.4 was put down vertically from a position 40 feet north of this outcrop and 100 feet north of the Peter Pan jasper vein and, although intersecting the vein material at 120 feet, did not encounter the tuff which apparently lies conformably to the virtually horizontal bedding in contradistinction to the vein lying concordantly in the schistosity or slaty cleavage of the country. In the quarry at the eastern end of Town Hill the rock appears again but at this place stands nearly vertically with the slates and is not influenced by bedding planes. It is much weathered, particularly where quarrying operations have exposed it at shallow depth, and may be easily crumbled in the hand. The matrix or groundmass surrounding the quartz phenocrysts still shows foliation but is almost completely decomposed to a grey clayey substance of indefinite composition.

The "Mineralised Siliceous Bodies" of the Wheal Doria-Peter Pan-Big Ben 'line' form a lenticular vein of yellow to greenish-brown jasper containing much hematite in streaks parallel to the strike and cavities lined with chalcedony or drusy quartz crystals. Lying in openings in the slate the width of the vein is extremely variable characteristically of deposits in slate or schist country and from a width of 15 feet the vein may rapidly pinch to one or two inches. Little gold has been discovered in association with this formation on the Peter Pan but the eastern

end has yielded some rich crushings(X).

FOOTNOTE(X). Production by amalgamation to 30/6/39.

<u>Lease.</u>	<u>Tons (2240 lbs.)</u>	<u>Ounces bullion</u>
Big Ben	Nil	Nil
Peter Pan	146	62
Wheal Doria	649	1159

Most of the Wheal Doria stone, however, has been recovered from small shoots in basic rock on the footwall of the yellow vein and some has been derived from a hematite 'blow' on the same lease.

The basic rock mentioned is now represented by talc schist with some serpentine and carbonates and containing small irregular masses of hematite-magnetite. The ore-shoots appear to be irregular masses of hematite-magnetite. The ore-shoots appear to be placed haphazardly to such ironstone bodies. Cores recovered from beneath the vein material contained calcite, siderite and probably magnesite in addition to galena, copper-pyrites and pyrite.

A specimen of Wheal Doria talcose ore together with others was submitted to the Council for Scientific and Industrial Research and Dr. Stillwell reported on it as follows:- (X)

FOOTNOTE(X) STILLWELL, F.L. C.S.I.R.Rept.No.117. Auriferous ores from Tennant Creek. Univ.of Melbourne 1938.

"The specimen, except where ironstained, is pale greenish in colour, and simulates a chloritic schist. A thin section shows that the main transparent constituent is probably talc, which is altered in places to a whitish translucent indefinite mineral. ----- The opaque minerals distributed through the talc consist of martite with abundant remnants of magnetite. The specimen is remarkable in showing a more or less continuous thin sheet of gold, forming a vein along the schistosity with hematite and quartz. A little limonite and the whitish oxidation product of talc also appear in the vein, and these secondary minerals, as well as the form of the gold, suggest a secondary enrichment.----- On the other hand, some gold is embedded in quartz and, unless the quartz is secondary, some of the gold must be primary. In either case the character of the gold vein suggests that its occurrence would be very localised."

The hematite body near Town Hill has yielded good values from 'crush-rock' casing on the northern side and some gold has been recovered by following joints into the mass itself. The body is characterised by a very marked cross structure towards the eastern end and further attention to this feature is strongly advised. Denudation is at a fairly advanced stage and it is unlikely that values will continue beyond shallow depths unless there is a repetition of the body below. With regard to the talc schists and jasper vein the area is much more favourable and systematic underground exploration is well warranted, not only at the Wheal Doria lease but on the eastern end of the Peter Pan as well.

No trace of the vein material could be found east of the trig station on Town Hill where the vein apparently dies out as there is no evidence of faulting.

Incidentally the marginal arrangement of the vein to the 'older porphyry' appears to be accidental and in one of the Peter Pan shafts the formation transgresses the old tuff.

GOLDEN MILE.

The optimism which led the prospectors to choose this name for a range near the eastern extremity of the goldfield has not yet been adequately rewarded although up to the end of

1938 the area, including the Blue Bird mine, had returned 148 ounces of bullion from crushings of 211 tons of ore.

The chief physical feature of the area is a broken line of hills with a steep northerly scarp and a more gentle slope to the south. These hills, which possess the usual dominant east-west axis, are crowned with large bodies of hematite containing much red jasper in strings and angular inclusions. The bodies are very irregular in plan. The principal part of the range is divided by a narrow gap in which, after rain, lies a useful sheet of water. North of the hills the terrain is flat with clayey soil and much straggly scrub but to the south the ground is covered with quartz gravel and clumps of spinifex. About one and a half miles south of the mine workings (see sketch map Fig.9) a gently domed 'slate' hill is traversed to the north-west by a large quartz reef roughly parallel to and nearly two miles north of the enormous reef at Rocky Range. A similar, but larger group of 'slate' hills with a suggestion of dome structure occurs just to the east of the plan and south of the Blue Bird from these hills and the presence of quartz on such a large scale it may be inferred that a granite cupola lies not far below the surface.

The Golden Mile Range is a structural hill lying along the axis of an asymmetric fold with the steeper limb forming the northern scarp and less steeply inclined limb forming the uniform dip-slope to the south. The range lies beyond the great quartz reef system and is in that region where the deposition of ironstone has been controlled by a large extent by bedding. The rocks forming this line of hills are buff-coloured sandstones with quartzitic bands, and have slaty cleavage only poorly developed. For this reason the word slate has been enclosed in inverted commas in this description. These gritty beds, which are at least 350 feet thick, lie upon phyllitic slates and are probably resting unconformably on them. It is put forward as a suggestion and has been mentioned earlier in this report, that the phyllites penetrated in No.30 Bore beneath the sandstone beds represent the usual slate of the goldfield and that upper and younger beds are present as much thinner beds or not at all on the south-west side of the jasperoid-quartz reef system.

The ironstone bodies are more siliceous than is usual and contain brecciated blocks and angular fragments of red jasper. In some instances the jasper is present as thin strings and is often accompanied by veinlets of quartz and of hematite giving the rock a very handsome ribbon effect in red, white and black. This type of jasper must represent much altered inclusions of 'country' and is of quite different origin to the dark reddish and liver-coloured bodies of magmatic origin which occur marginally about the porphyry apophyses. 'Crush-rock casing' is not strongly developed enveloping the siliceous ironstones except near the eastern end of the range where the principal workings are situated. Here complicated minor faulting has taken place and the 'country' between the bodies is much brecciated and jasperised. For the most part the bodies lie in the bedding and may form small saddles when lying in the axis of the fold. Fig.10 is a simple generalised section across the range and depicts the attitudes that have been assumed by some of the ironstone masses. The low scarp near the southern end of the section may be due to faulting but it is more likely to be a feature due to erosion as shown. The anticlinal fold with its axis just north of the small scarp is strongly suggested by air photos but all evidence on the ground is obscured by detrital matter. The unusual composition of the ironstones and their peculiar attitude suggest that they may be of different origin to the hematite-magnetite lenses and irregular bodies of the more westerly portion of the goldfield or that they were formed under conditions that in some way permitted a comparatively free intermingling of iron and silica solutions from the magma. Structurally the area is not favourable for the discovery of large ore-bodies and though it is not likely that the Golden Mile will become an important producer, some further prospecting in the area is justified if it is carried on in a systematic manner.

THE HONEYMOON RANGE.

This range runs east-south-east from the Telegraph Line at a point about one and a half miles north of the township. The range is a remnant of the old peneplain surface; rises to the general level of about 150 feet above the alluvium flats; is a little over one mile in width from north to south at its widest and two miles long. Locally the name is used only for the southern margin of this hilly area and included two discontinuous and 'staggered' lines of hematite-magnetite bodies, several of which are being, or recently have been, worked for gold. Only this southern portion of the range will be described in the ensuing discussion. (Pl.10).

The southern scarp rises steeply to an average height of 50 feet and thence more gently to a ridge crowned by the roughly linear northern system of ironstone masses. The range is deeply embayed by wide valleys and also much dissected by narrow steep-walled gullies, and toward the eastern end dissection has advanced until only the silicified "backbone" of the range is left. This remnant, which carries two hematite bodies and at its extreme eastern tip, a very siliceous quartz-hematite 'blow', is about 1000 yards long by 100 yards wide.

The slate of which the range is composed is fine-grained and much hardened and silicified by contact metamorphism brought about by an intrusion of porphyry which underlies the hilly area, and is exposed in a gully near the Kathleen lease and on the flats to the south. Injections of the familiar white quartz are present near the porphyry but on a much smaller scale than elsewhere. The intrusive is similar in character to the porphyry of Hill V to which it is no doubt connected but all attempts to trace the connection on the surface failed, owing to the mantle of alluvium being too thick over the swampy ground north of the town. Magnetic geophysical observations did not yield interpretable results even when traverses crossed known igneous boundaries. (v.Fig.10a).

The so-called 'lines' of ironstone are too irregular to be continuous shears or weak zones into which the deposits have been injected, nor can they be of sedimentary origin for the reasons formerly stated. The southern 'line' is particularly irregular and consists of small bodies, 100 feet or so long by up to 50 feet wide, containing much quartz in vein filled cracks and joints and partly intergrown with hematite and in most instances an appreciable amount of bismuth as carbonate or oxide. Referring to a specimen from the Kathleen Mine Stillwell reported:-

"The specimen consists of hematite and quartz with rather less hematite than quartz. Some of the gold visible in the hand specimen is embedded in the quartz.

Some of the crystals of hematite contain numerous ragged inclusions of magnetite ---- and it is clear that such hematite is the result of the oxidation of magnetite and may be distinguished as martite. Frequently at the edges of the masses of martite there are coarse bladed crystals of hematite which protrude into areas of quartz----.

----- Some of the quartz is clearly younger than the hematite as it occupies fractures in the hematite crystals where the twin lamellae are displaced on either side of the fracture. On the other hand, much of the quartz and bladed hematite would appear to be more or less contemporaneous.

A small gold particle has been observed in quartz in the prepared section, while several larger gold particles have been observed embedded in hematite. Rarely minute inclusions are observed in the hematite which are suggestive of pyrite, as well as partially oxidised particles of native bismuth."

Three mines in this area are the Kathleen, the Leichhardt (two leases) and the Burnt Shirt (also two leases). The workings have been so far confined to the southern zone and the northern 'line' has been almost entirely neglected. 'Crush-rock

casing' seems to be of minor importance in the siliceous bodies and much gold, probably of primary origin for the most part has been recovered from the solid ironstone-quartz mass itself by following joints and minor displacements. When the writer first visited the Burnt Shirt a perfectly lenticular ore-body had been completely removed to a depth of 50 feet and had been crushed for a recovery of about 1½ oz. per ton. After this ore-body was exhausted, operations lapsed for some months when the owners continued sinking in the hope of encountering a second body as suggested in Fig. 14C. After following a narrow seam of yellowish clay for a distance of 40 feet below the lower limit of the first lens a second hematite body was met, and to this extent the policy of the owners was justified. Unfortunately the low values of the lower body did not warrant further work.

At the western Leichhardt lease, gold is being recovered from quartz-hematite with a similar, almost graphic appearance to that met with at the Kathleen but much more siliceous than the Burnt Shirt body as it has been described to the writer. The Leichhardt ore-body appears to be a pipe-like mass, roughly circular in plan and pitching north-north-west, while its counterpart on the Kathleen is of an irregular shape best described as a thick, blunt-ended lens. The evidence strongly suggests that the gold (except that of the casings) is of primary origin and was introduced contemporaneously with the hydrothermal quartz-bismuth solutions which caused a recrystallization of part of the pre-existing hematite.

The production of bullion by amalgamation for the mines mentioned up to 30/6/39 is as follows:-

<u>Name.</u>	<u>Tons (2240 lbs.)</u>	<u>Ounces bullion.</u>
Burnt Shirt	882	1216
Leichhardt	533	523
Kathleen	541	332

The northern bodies are for the most part less siliceous but much larger. In common with most of the purer ironstone masses their length greatly exceeds the breadth, and may be even as much as twenty times the latter, whilst the siliceous ironstone bodies in which there is an apparent inter-growth of quartz and hematite always have a roughly circular or rectangular outcrop.

A cursory examination reveals that usually each mass consists of a group composed of a large narrow body, up to 200 feet long by 40 feet wide, with several smaller connected bodies at each end. There are nine such groups on the range of handsome proportions and that at Battery Hill together with its 'satellites' extends over a distance of about 600 feet. There are also a number of small isolated 'blows'. These bodies represent various stages of denudation, some being only just exposed, others little else than a heap of boulders; intermediate stages are of course also present.

Despite the fact that these outcrops are situated in a favourable locality prospecting has been very half-hearted and the area is worthy of a renewed attack.

ELDORADO-MT. SAMUEL ' LINE'. (Pl.7).

The following figures showing the production of bullion by amalgamation from mines in this area are not without interest. They include production from the inception of mining operations on the field to 30th June, 1939.

<u>Mine or Lease.</u>	<u>Tons crushed.</u>	<u>Ounces bullion.</u>
The Mount	231	62
Eldorado	13240	6764
Pattie	14	1
Enterprise	524	653
Hammerjack	1619	1519
Red Ned	386	360

<u>Mine or Lease.</u>	<u>Tons crushed.</u>	<u>Ounces bullion.</u>
Intermediate	--	--
Mt. Samuel	1544	3280
Southern Cross	317	180
Totals	17,875	13,419

Estimated value £114,300 (Australian)

The range forming the Eldorado-Mt. Samuel 'line' is characterised by fairly continuous lines of ironstone bodies and is similar in many respects to the Honeymoon Range although on a larger scale. Reference to Pl.6, and Fig.16 will convey an idea of the dominant features.

From Hammerjack to Mt. Samuel a system of dense black hematite lenses forms the crest of a low range, whilst to the north a number of scattered bodies, of which the Red Ned is the largest form a sub-parallel system.

Beyond Mt. Samuel rather intensive folding has occurred with the result that the range has been eroded into a jumble of irregular hills containing a few large but well exposed hematite bodies. Mt. Samuel itself is crowned with ironstone masses of impressive proportions and, but little over 300 feet in height, forms a conspicuous landmark visible for many miles. Despite the high yields from this lease the owners have worked it only intermittently and half-heartedly and little is yet known from a structural point of view. Most shoots worked so far appear to be controlled by north-south joints and cracks which may have acted as feeders and in some instances have behaved as dams preventing impregnation by mineralizing solutions on one side or the other. A difficulty to be faced in underground development of Mt. Samuel and the adjoining Southern Cross lease on the west is the extreme hardness of the hematite-magnetite to be penetrated, which, mentioned before, renders mining operations slow and difficult without adequate machinery.

Absence of gold in 'loams' about the intermediate outcrop east of the Mount has discouraged prospectors at the outset and beyond a costean across the centre of the blow and one or two shallow pits sunk near the margin, no work has been done on this body. The mass consisting of the familiar dense blue-black hematite-magnetite is very large in plan measuring some 250 feet long by 100 feet wide. It bears a distinct resemblance to the southern magnetic body by Mt. Samuel trigonometrical station and should not have been abandoned without further effort being expended upon it. Near its western end a transverse structure visible in air photos but not discernible on the ground makes contact with small satellite bodies of rather siliceous ironstone. It is noteworthy that this structure whatever its true nature may be, is parallel to the strike of a group of ironstone lenses on the I.M.O. lease south of the Hammerjack.

The Red Ned workings are of shallow depth and are situated in a very siliceous body (v.Pl.III, Fig.5) divided by jointing into rectangular blocks. This ore body lies to the north of the black ironstones, which at this point have been prospected without success and contains much bismuth carbonate.

The Hammerjack lease has been worked intermittently with varying success and is now principally being exploited by parties of tributors. The ironstone bodies are irregular in shape and of great size, being comparable with those of Mt. Samuel, and crossed at right angles by two systems of fissures filled with concretionary limonite. This limonitic material does not appear to extend to greater depths than 30 or 40 feet and in some instances carries values up to an ounce or more of gold per ton. Probably more than half the 1500 ounces shown in the above table

was recovered from limonite in an east-west fissure near the northern margin of the largest ironstone mass, but extremely rich stone is now being mined by tributors on the north-eastern corner of the same outcrop and is massive hematite containing coarse gold. On the eastern side of the open-cut in which these tributors are working, a well defined plane, apparently a joint, divides this valuable ore from barren or low grade, but in other respects precisely similar stone.

East of the Hammerjack the range slopes gently down to a swampy flat which extends about half a mile to the foot of the Western Enterprise, where an equally gentle slope is crowned by a double body of siliceous hematite to which little attention has yet been paid, but appearances suggest that these two bodies are of very limited depth, or in other words have been injected into the nearly horizontal bedding-planes, and do not offer much opportunity of recovering reasonably large tonnages. Further east again the 'line' resumes its normal character, the bodies being narrow and standing at high angles in the schistosity.

At the Enterprise a shaft has been sunk to approximately 100 feet on the south side of a northerly dipping, narrow ironstone lens and ore is being stoped from a short cross-cut at the bottom. The stope is bounded towards the north by a fault striking about N.W. to S.E. and dipping steeply north-east and a continuation of values along this feature may be confidently expected.

The Pattie lease adjoins the Enterprise on the east. Except for an isolated find of high values (presumably secondary) nothing of note has been discovered on this lease despite fairly thorough exploration.

Eldorado is worthy of description in greater detail than the foregoing, as apart from its greater production and the extent of the workings the formation possesses features common to other properties on the goldfield. (V.figs.12 & 13).

The mine is situated on the crest of the range at a point where the bedding is gently inclined to the north giving the range a steep southern scarp. To the west of the main shaft ironstone outcrops are narrow and the country slate has been much altered and silicified to a red jasper, and to the east there is a great display of both siliceous and massive hematites, the latter being on the southern margin whilst the large hematite-quartz outcrops occupy the crest and upper northern slope of the hill.

Near the western boundary of the lease a gully has exposed a small anticlinal fold in the slates and it was observed that the axis of the fold coincides with the strike of a line of narrow hematite lenses a few yards to the east. Following the ironstones further east a change of **strike** from 80° to 115° is encountered, and it is a noteworthy fact that at this point there is, just to the north, a development of jasper and ironstone deposits. These observations suggest that deposition of the iron³ stones has been largely influenced by antecedent folding.

The surface near the mine workings is now obscured by dumps and plant buildings which have been located with little regard to future operations.

The outcrops east of the shaft and plant consist of two very large masses with smaller satellite bodies. The southernmost outcrop is wedge-shaped in plan and about 100 feet in length with its longer axis cutting across the grain of the country at a high angle. It is extremely probable that a considerable extension of the values revealed in the open-cut will be found ~~trending~~ trending north easterly beneath this outcrop. The northern body is elliptical in plan and contains much quartz intergrown with specular hematite which sometimes occurs in stellate clusters.

The main shaft has been sunk vertically to a depth of 200 feet but activities have been chiefly confined to the open-cut and the 50 and 100 ft. levels below which little exploratory work has yet been carried out. In sinking the shaft dense siliceous ironstone was first encountered and carried sporadic values from about 50 feet to below 100 feet, at this depth it gave place to highly ferruginous mylonised and brecciated slaty rock with much included specular hematite. Below this at about 170 feet the shaft passed into unaltered slate.

From the bottom of the shaft a cross-cut was carried south to a point beneath the open-cut in the hope of intersecting a continuation of the values originally found on the surface but, with the exception of a narrow body of hematite-talc schist filling a fault with a gentle easterly dip, only slate was encountered.

Extensive workings on the 100 ft. level disclose a total width of over 200 feet of 'formation' consisting of bunches of massive hematite and hematite-quartz surrounded by a wide aureole of the familiar ferruginous crushed material. The contacts between the crush envelope and the country are usually unexpectedly sharp and well defined not only in this mine but in many others, although examples of a gradual passage to normal buff-coloured or greenish slate are not altogether uncommon. A great proportion of the values produced from about this level (chiefly from No. 2 Stope) has occurred in siliceous ironstone in which it seems highly probable that the gold is of primary origin and associated with busmutz and quartz and, in fact, gold has been observed completely imbedded in quartz. Where gold has been won from the slaty rock it may be found either associated with quartz-hematite veinlets in a similar relationship to that mentioned above, or as scales and films of secondary origin in the cleavages. Such secondary gold is almost invariably accompanied by notable quantities of sericite or talc.

From No. 1 Stope and the open-cut reddish hematized slate as described by Stillwell in the quotation given on p. has yielded probably the bulk of the gold produced at the mine. Much ore still remains in the open-cut in the north wall and also underfoot and recent operations have disclosed an additional thickness of casing material of some four feet to the east of the old No. 1 shaft and a depth of 25 feet near the extreme eastern end of these workings.

Magnetic observations by a geophysical section of the Aerial, Geological and Geophysical Survey of Northern Australia indicated the presence of a large body of high magnetic susceptibility 200 yards north of the Eldorado main shaft and subsequently a diamond drill hole entered hematite at 223 feet after passing through fine-grained slates with gritty bands to 174 feet. From this point downward veinlets and impregnations of hematite were observed in increasing amount with depth until the hematite mass itself was encountered. This hematized slate from below 188 feet was found on assay to contain a small amount of gold. Difficulties in drilling the hematite together with considerations that the primary object of drilling the hole as a check on the geophysical observations had been achieved, caused abandonment at 235 feet so that the shape and size of the body are not known but the magnetic indications strongly suggest that the mass is roughly spherical and 400 feet in diameter (1).

FOOTNOTE. A.G. & G.S.N.A. Northern Territory Rept. No. 4 Magnetic Prospecting at Tennant Creek. Canberra 1936.

By analogy with the nearby Eldorado formation it seems more probable that the magnetic anomaly is caused by a globular cluster of ironstone bodies separated from each other and surrounded by highly ferruginous slaty rock rather than one spherical mass.

With regard to future operations at the Eldorado the writer recommends that exploration north and east of the present working is justified on the grounds that all the available evidence indicates that values are pitching north at an inclination of from 45° to 60° , and an easterly extension of ore beneath the outcrops before mentioned and north of the eastern end of the open-cut may reasonably be expected. Cross-cutting north from both the 150 and 200 ft. levels for about 60 and 120 feet respectively should be put in hand and a winze from the northern end of the 100 level cross-cut should be sunk to at least the next level to test the brecciated zone in the northern wall. The southern member of the eastern group of outcropping bodies could be explored easily at 40 feet by driving from the open-cut, or at the 100 ft. level by approximately 60 to 70 feet of driving east from the bottom of the open-cut winze.

Three quarters of a mile east of Eldorado and at the eastern end of the area under discussion a second diamond drill hole was put down to test an anomaly located by the North Australia Survey. The site was in close proximity to a suspected porphyry apophysis and different results to those met in the first hole were expected. At 250 feet a band of quartzite was encountered underlying ferruginous slates, and for the next 158 feet the cores consisted of uniform grey, slate, soft slate containing disseminated magnetite for two feet gave place to hard siliceous rock with quartz veins and pyrite to 426 feet. The hole finished at 452 feet having penetrated a thickness of 26 feet of complex material consisting essentially of siliceous hematite, magnetite, calcite, talc (?), pyrite and chalcopyrite. Assays revealed traces of gold and up to nearly 1% copper.

THE WESTWARD HO AREA.

Mt. Beryl, Westward Ho and the Skipper leases form a western extension of the Mt. Samuel system and the foregoing descriptions apply with equal force to the ore-bodies in this locality. Near the Westward Ho shaft a large siliceous hematite mass was found to be surprisingly shallow and was not intersected by cross-cutting at an insignificant depth. Field observations between Mt. Samuel and Mt. Beryl suggest that a body of porphyry lies at no great depth and the presence of quartz reefs on the Westward Ho lease supports this view. To avoid needless repetition a plan of the area (Pl. 6) is given without further comment.

QUEEN OF SHEBA GROUP (v. Sketch Map, Fig. 11)

The Queen of Sheba group of hills and ore-bodies, while possessing most of the features generally characteristic of the mineralised areas of the goldfield, is unusual in that the strike of the area is meridional. The north-south grain can be traced over an area of several square miles before it disappears beneath alluvium.

The area is bounded on the south-east, east and north by igneous rocks; quartz and felspar porphyries, rhyolite and jasperoid quartz reefs being represented on an extensive scale. Low rounded hills of silicified breccia separate the auriferous ironstones from the margins of the igneous area.

Among the hematite bodies are a number of quartzose ironstones containing quartz, as the principal constituent, and specular hematite intergrown. As noticed in other parts of the field the siliceous bodies are bluntly elliptical or rectangular in plan and some masses deeply exposed by denudation on the slopes of the Evening Star Hill and further south, reveal a square cross section. Three sets of joint planes divide the rock masses into cubical blocks. Virtually no gold has been discovered in these very siliceous bodies, the quartz component being akin to the barren jasperoid reefs and probably representing the ultimate stage of magmatic differentiation. Some of these quartz-hematite bodies are of handsome proportions, one on the Queen of Sheba lease was pierced by a tunnel for a distance of over 100 feet, while dimensions of the order of 100 ft. by 50 ft. are common.

As elsewhere the black hematite-magnetites are much narrower in proportion and one continuous reef-like body forms a conspicuous ridge 600 feet long with a narrow crest of massive ironstone a few feet wide.

The area has not been very productive as yet and the Queen of Sheba with a yield of 159 ounces of bullion from 224 tons is the only lease in the group from which crushings have been taken. What ore that has been mined has been chiefly richly ferruginous 'crush-rock' surrounding a hematite lens in the relationship usual on other parts of the field.

The group is at present abandoned but the Queen of Sheba lease shows considerable promise and cannot be deemed to have been adequately prospected yet.

The Evening Star lease includes a linear arrangement of siliceous ironstones on the western side of a conspicuous slate hill about which some prospecting has been carried out with little success. At this point the introduction of quartz has taken place in two stages; after the assimilation of the original hematite-magnetite by silica solutions a second invasion has intersected the bodies with jasperoid quartz veins. (Pl. 111, Fig. 6).

The whole area is much disturbed locally and the slates are highly contorted in the neighbourhood of the mineral bodies giving rise to structures favourable to impregnation by mineralizing solutions, but it appears unfortunately true that, except for a small favoured area on the Queen of Sheba lease, the area has been invaded by magmatic solutions post-gold in origin.

AREA BETWEEN PEKO AND GOLDEN FORTY MINES.
(Pl. 9)

Three quarters of a mile east of the Peko Mine a broken ridge of six hills rises a little over one hundred feet above the spinifex flats and contains some notable deposits of hematite. To the south and west the area is occupied by granite porphyry with attendant quartz and jasper reefs, stringers and lenses.

Referring to the hills in consecutive order from west to east No. 1 is the remnant of an almost completely dismembered ironstone body, now a few blocks perched upon a conical hill of slate. The slopes of the hill and ground about are littered with small boulders and gravel of black hematite. The ironstone is one of the few examples of a gossan and is cavernous and honeycombed in the manner typical of the ironstones forming the outcrops of sulphide bodies. North-west of this hill occur four parallel slate combs or ridges with an east-west strike the largest being about 100 yards in length. They are bounded on the east by a narrow fault, filled with quartz breccia which passes south through the base of Hill 1 into an area obscured by detritus. These narrow combs probably represent weak zones, such as minor fold axes which have been slightly hardened by exhalations from the nearby porphyry.

No. 5 diamond drill hole was sunk vertically on a magnetic anomaly a little to the north of the group of combs and from the surface to 202 feet penetrated reddish-brown slate with a few gritty bands. From this depth grey chloritic schist with bands of brown slate continued to 265 feet, then passing into two feet of unctuous grey slate with disseminated crystals of magnetite. Below this the drill entered dense black magnetite containing quartz veinlets with a little pyrite and chalcopyrite.

No. 2 Hill is a large flat-topped slate mesa in which indications of bedding are discernible here and there. Horizontal bedding at the western end of the hill has been flexed into a steep northerly dip at the north-east corner. A large hematite mass is deeply exposed on the south-east side near the top of the precipitous scarp.

In the centre of the flat summit a small body of ironstone containing numerous quartz veins outcrops, and the surrounding alteration suggests that the outcrop is only the initial exposure of a larger body. This deposit, being situated in the axis of the fold mentioned above and being probably intersected beneath the surface by a transverse quartz reef, visible near the northern margin of the hill-top is favourably placed for mineral invasion and worthy of a limited amount of prospecting by pit-sinking.

The third hill is an imposing monolith of black ironstone stripped entirely of country rock and standing some sixty feet high. On close inspection the rock is found to contain a large proportion of jasper, some being present as sub-angular inclusions of bright red highly siliceous material with a finely granular texture, and the remainder uniformly distributed throughout the whole mass giving it the composition of an iron-silica rock similar to taconite.

South of this monumental outcrop a rectangular body of liver-coloured jasper has been intersected diagonally by a white quartz reef affording some evidence of the order of succession.

Hill 4 bears a strong general resemblance to No. 2 but the ironstone masses are, however, very much larger and are offset to the north of hills 2 and 3. The northern body, measuring 200 feet long by 60 to 80 feet wide, is exposed right to its base and forms an overhanging cliff of smooth nearly black rock 100 feet high. The base appears to be flat and, except for its disproportionate width, in general resembles the shape of the hull of a steamship. The rock of which it is composed is jaspery in character like its neighbour No. 3, and also included blocks and fragments of red jasper. The southern body is similar though smaller except for a narrow easterly extension of black hematite with inclusions of white quartz and strongly developed hematized slate envelope.

The two easternmost hills in the area mapped are characterised by a development of white quartz veins and stringers and small jasper bodies.

A tongue of highly sheared and decomposed quartz-porphyry forms the sixth hill and the southern flank of hill No. 5. The foliation of the rock is concordant with the direction of cleavage of the surrounding slate and was apparently produced contemporaneously, thus distinguishing this porphyry in age from the 'fresh' granite porphyry to the south. It seems probable from the slight evidence of bedding which remains that this example of 'older porphyry' represents an ancient sill, and it is noteworthy that a narrow tongue on the northern margin has been injected into a weakened sheared zone.

Pl. 9 shows only a small part of the granite porphyry in the locality; several outcrops to the east and north-east of hill No. 6 form low rocky hills containing highly altered roof pendants, and provide excellent examples of the stopping action of igneous intrusions.

The Golden Forty mine consists of a group of hematite-magnetite masses situated in close proximity to the eastern margin of the newer porphyry.

SURFACE PROSPECTING.

Even at this stage in the history of Tennant Creek Goldfield it is readily apparent that prospecting has not been adequately carried out. It cannot be denied that, owing to some of the peculiarities of the area, thorough prospecting requires much time and trouble but rich rewards are still there for those who are prepared to face a not great initial expenditure.

It has been pointed out in the foregoing discussion relating to the hematite bodies (generally called 'blows') downward leaching by meteoric waters (rainfall etc.) has, in the course of time, nearly completely removed the surface gold which has been carried down in solution into cracks and fissures and various microscopic cavities existing in the rocks. By this means the familiar 'paint' gold has deposited in the cleavages of slates, and it might be said that, within reason, the more porous the rock the more chance it has of carrying gold below the surface. This surface leaching has been so active in places that gold values are low or completely non-existent from the surface down to a depth of several feet and only due to persistence on the part of the prospector has gold been discovered, often after abandonment by earlier searchers. It follows from this and the foregoing discussion that no "ironstone blow" can be regarded as barren until prospecting pits have been sunk to a depth of several feet, and the writer recommends sinking trial holes as deep as may be conveniently done without going to the trouble of rigging a windlass, i.e. six or seven feet. As the sinking proceeds samples should be tested by dollying and panning.

This method of prospecting naturally involves much arduous labour and expense but no amount of 'loaming' can give conclusive results under the conditions existing at Tennant Creek. Of course 'loaming' should not be abandoned as surface samples may afford valuable indications as to the best positions for trial pits, but at the same time negative results from 'loams' should not be relied upon as proof of the barrenness of a 'blow'.

It has been found by experience that values in association with hematite bodies are most likely to be found in the 'crush-rock' envelope immediately adjacent to fractures and joints developed transversely across the solid ironstone. These cracks form the familiar vertical 'heads' so frequently encountered (v. Pl. 111, Fig. 5).

In some 'blows' these cracks may be filled with white quartz or limonite or other material dissimilar to the main mass of the 'blow' itself. These fractured zones offer the best places for pit sinking at the outset and the diagrams in Fig. 14 show the most suitable positions for trial pits round the periphery of an ironstone mass. In "A" the pits are sunk at points where a fractured zone has been invaded by quartz and in another place where the 'blow' is crossed by a rusty band of limonitic ironstone. Honeycombed or gossany iron in a 'blow' is also a good sign, and any place where some change in the composition of the main mass can be detected should not be passed over. Sudden irregularities in outline of the body such as re-entrant angles or bulges often give rise to a greater distortion in the surrounding country with correspondingly greater chances of impregnation by auriferous solutions and instances of enrichments in such positions are not unknown.

The general east-west strike of the slaty cleavage of the country is crossed by many narrow oblique channels bordering which a thin band of slate has been slightly hardened by silica or hematite solutions and stands as an irregular ridge two or three inches above the surrounding unaltered slate. Good examples of these small transverse openings are to be found on the Hammerjack lease south of the main workings and at many other places. Occasionally the angle made with the schistosity is very acute and the channel may be several feet wide. It may not be siliceous or ferruginous in character but, as at the Pinnacles and Shamrock, may contain copper associated with altered basic rocks. These transverse structures are frequently difficult to discern but when they are detected close to, or abutting against a hematite body, extensive prospecting near the contact is advisable.

Costeaning is nearly always a waste of time and effort. The ore bodies have rarely any continuity of length. In other words what you can see on top is all that can be reached by shallow excavations. Fig. 15 explains diagrammatically the

failure of costeaning.(1).

FOOTNOTE.(1). It is admitted that actually the hematite lenses do not form such uniform figures as is represented in Fig.15 and that occasionally costeaning "to pick up the lode" may discover an extension of the mineral body, but the writer fails to understand why the prospector must go and look for such an extension before he has examined what is already apparent on the surface. Many hundreds (if not thousands) of feet of costeans have been cut at Tennant Creek and it is very doubtful if a single foot has ever paid for itself either in values discovered or information gained.

The sketch shows in side elevation three ironstone lenses in various stages of denudation equivalent to Stages 3, 1 and 5 respectively according to the scale proposed by Woolnough. Ore-body "B" in an early stage of erosion is the only type with any horizontal extension beyond the surface outcrop but the plunge at each end is too steep for costeans to reveal further ore. The writer has again and again seen useless costeaning of the sort represented in the diagram and would urge prospectors to concentrate their efforts on the visible ore-body before expending time and labour in the search for problematical extensions.

Reverting to Fig. 14, "B" shows two blows which are parallel to each other and overlapping (en echelon). In these cases there has often been considerable crushing between the bodies and a large body of gold-bearing crush-rock may fill the space between the hematite masses. Before trenching across such a place the prospector should examine the surface and satisfy himself that the intervening slate is much broken and jumbled in character, and is "hematized" i.e. contains at least sufficient iron to stain it deep red or brown and on dollying and washing leaves a large "tail" of fine iron in the dish. Unless the slates are so discoloured and contain hematite no extensive work would appear to be justified.

Failure to discover any cross fractures of note in the ironstone or transverse structures in the adjacent 'country' does not mean that the body is a barren one and pits as shown in Diagram "C" should be put down at intervals round the very edge of the iron so that it as the envelope material can be tested for gold by dollying.

The prospector must remember that gold is discovered not only in the surrounding breccia and mylonite but also in very dense ironstone as well, as, for example, at the Rising Sun, the Burnt Shirt and (in part) Mt. Samuel, but as a general rule examination of the casing, apart from being easier, is more likely to yield results quickly. Values in the 'crush-rock' often lead the miner to further strikes in the parent mass of hematite-magnetite.

For guidance in small scale or preliminary operations, the following quotation from N.T. Bulletin No. 22 (Rept. on Tennant Creek Goldfield by W.G. Woolnough, D.Sc) is not out of place.

"If promising values are discovered on no account stand off and sink a shaft with the intention of cross-cutting to intersect the reef at depth, as is the correct procedure in more orthodox mining. When on values stick to them, no matter how irregular the workings may become."

Prospecting can never be carried out too thoroughly and this remark applies with particular force at Tennant Creek. Small rich pockets are continually being discovered near workings previously abandoned and such finds, the reward of persistent effort, can be expected for many years yet.

UNDERGROUND PROSPECTING.

This report is based upon field observations which were concluded in the early days of 1939 and at that time underground development had not proceeded to a stage which rendered it possible to lay down general rules for the guidance of miners. References in various parts of this report indicate that ore shoots are very irregular, and controlled at least in most mines, by both pre-mineral and post-mineral faulting. Until the workings reach "settled country" very irregular structures with sporadic enrichments will be encountered. Clay-filled seams, the development of sericite, and, in the denser ironstone, much fractures zones are favourable indications underground. Each miner must, however, be guided by the special conditions with which he meets at the particular locality in which he is working.

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RISING SUN AND ADJOINING LEASES.

The Rising Sun mine has been worked continuously from the early days of the goldfield until recently and has been a most uniform producer; this latter feature is unusual for the area and no other property has produced ore of such constant grade.

This mine is situated on the easternmost of four amalgamated leases under the same ownership and lies about 11 miles E.S.E. of the township. All the leases have produced some gold, a parcel of less than $1\frac{1}{2}$ tons from Weaber's Find lease yielding over 50 ounces of bullion at Peterborough (S.A.) battery in 1933, but operations have been almost wholly confined to the Rising Sun.

The property was fairly well opened up when the writer first saw it, all the original outcrop had been removed and an open-cut approximately 100 feet by 30 feet by 50 feet deep was in active production. It is understood that the exposure of hematite when first discovered was small and only the absence of ironstone talus on the nearby slopes suggested that it might be the top of a large body. This was the case and a large tonnage of ore yielding an average of about one ounce of gold per ton by amalgamation was won from both the mylonised envelope, which was about 16 feet thick on the southern side and the vertical hematite itself. A considerable proportion of the values were recovered from a body of weathered red micaceous slate, the micaceous mineral, which was soft and iron stained, probably being sericite. This gold was very fine, never visible to the eye, and apparently evenly disseminated.

The auriferous slates continued to 100 feet where they become more ferruginous and contained blocks and fragments of hematite, but carried little or no flakes of micaceous material. There was a steady decline in values below this level, particularly in the ironstone, and the writer understands that activity has been transferred to Nobles' Knob lease on the western end of the 'line'.

At this stage the excavation, excluding the haulage shaft and cross-cuts would measure in the order of 150-200 feet in length from east to west, by from 40 - 15 feet wide and 100 feet deep; practically the whole of this excavated material has been crushed profitably.

Nobles' Knob consists of a large hematite outcrop in which gold had been discovered during early prospecting. A shaft had been sunk at the time of the writer's visit and a small parcel of ore has since been crushed.

The Rising Sun conveys a lesson to miners in that it demonstrates that a small outcrop may represent only the upper limits of a large body which has just become exposed, and it also shows that considerable thicknesses of auriferous "crush-rock" can be associated with ironstone bodies, as this particular hematite body was many times longer than its greatest width and does not appear to have exceeded the thickness of "crush" at any point.