THE UNIVERSITY OF ADELAIDE
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# A petrological study of Kalgooorlie greenstones

A PETROLOGICAL STUDY OF KALGOORLIE
GREENSTONES

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## ABSTRACT

The petrological study was undertaken to utilise the drill core obtained from a deep diamond drilling programme to the south of Kalgoorlie. These rocks are structurally most closely related to the greenstones of the "Golden Mile" yet have not been subject to such an intensity of the ore-forming processes.

However, these rocks are also highly "altered", and are best described as greenstones. Igneous characters are hard to find and should not be taken as conclusive.

Certain results have been obtained, which, I think, should be sufficient to modify present ideas on the history of these rocks, and I hope to convey the meaning of these results in this report. The chief such result is that the study has led me to discount albitisation as a major process in the evolution of rock types.

While not professing to be an expert operator of the microscope, I also seriously doubt the efficiency of the microscope as a tool in ultimately solving the problem.

I recognise that considerations of chemical changes are essential to the understanding of the problem; my own knowledge of chemistry is of an elementary character entirely unappropriate to the problem, and I have left this approach out of my report.

## ABBREVIATIONS

Certain abbreviations convey more meaning than the name in full to those associated with Kalgoorlie. These are

| | |
|---|---|
| Q.D. | quartz dolerite |
| Q.D.G. | quartz dolerite greenstone |
| C.S. | calc. schist |
| B.F. | black flag (sediments) |
| B.I.F. | banded iron formation. |

## INTRODUCTION

Setting - Kalgoorlie, Western Australia, is 360 miles east-north-east of Perth, and 220 miles north of Esperance on the south coast. It lies on a greenstone "island" in the granitic Precambrian shield of Western Australia. At Kalgoorlie a major structure forms a low ridge running north-north-west south-south-east, which has been the site of most of the gold-winning activity. This structure is a zone of intense deformation - folding and shearing - and is thought to form, in the aggregate, a drag-fold on the west limb of a major regional anticline.

The rocks concerned in these structures are stratigraphic in bulk consideration, and are -

Black Flag Sediments - thickness thousands of feet
Upper Quartz Dolerite - thickness hundreds of feet
Upper Fine-grained Greenstone " " " "
Lower Quartz Dolerite - " " " "
Lower Fine-grained Greenstone " " " "

Actual stratigraphic thicknesses cannot be determined; the rocks have been subject to thickening or attenuation of unknown extent.

The history of the field began when Hannan's prospecting crew found rich alluvial gold below Mt. Charlotte (not far from the present town-centre) in June 1893. Soon after, lodes on the ridge near Boulder, some three miles south, were discovered. Production since then has undergone many ebbs and surges. Now four major companies work the "Golden Mile"; the order of the production is about 10,000 oz per month each, in ore of 4-5 dwt/ton grade. The chief ore minerals are free gold, and gold-bearing tellurides. Up to 35% of the gold won from ore is free (this represents a minimum value). Tellurides are chiefly -

coloradoite $HgTe$
calaverite $AuTe_2$
and krennerite $(Au,Ag)Te_2$

Tellurides become rare at the north end (i.e. near Kalgoorlie township) and are absent at Hannan's North Mine. Their chief occurrence is in the Boulder Belt (Golden Mile).

The lodes are mineralised shears belonging to a fracture pattern. These are characterised by a central zone of minute telluride veinlets, quartz and finally pyrite extending out into the wallrock.

Gold values are irregular. Some lodes contain gold while others do not and within the lode the gold is randomly distributed. However, a broad feature has been known since the first recognition of the various types of greenstone. The upper Q.D. (quartz dolerite) is most productive. But gold is also won from the fine-grained greenstone, or "calc schist" as it is known in the "Golden Mile".

The reason for the greater production from the Q.D. is not known. Two suggestions have received attention.

(1) The Q.D. was a chemically more favourable host.

(2) The Q.D. was physically more favourable, in that it produced the type of shears most amenable to mineralisation.

The weight of opinion is that the explanation is contained in either or both of these ideas. Another explanation, which no doubt has been hypothesised from time to time, but is not well supported at present is -

(3) that the gold was introduced with the Q.D. rock, i.e. that the gold was syngenetic.

The structure which contains the lodes at Kalgoorlie has been the centre of geological interest, because of the possibility that other ore zones similar to the Golden Mile may exist.

Detailed mapping done over the past decade by Western Mining Corporation has proved useful in the understanding of the structure. This is especially true of the "South End", the Mt. Hunt structure. Mt. Hunt is a high hill 4½ miles south of the town of Boulder. Its existence is probably due to local extreme deformation. The understanding of this structure was facilitated by banded iron formations. These are thin (a few feet) sedimentary bands of fine-grained material, now rich in iron, and form excellent markers. Features in this area pertaining to structure are -

(1) a west facing for the beds is indicated by pillow lavas and graded bedding seen to the west of Mt. Hunt. A little further west Black Flag sediments outcrop. This means we have a regional anticlinal structure extending to the east. It is thought that the Kalgoorlie structural line is a complex zone approximating to a drag-fold on the west limb of this anticline.

(2) drag-folds, which are plentiful in the B.I.F. markers, are most frequently observed to pitch steeply, and sometimes not so steeply, to the south. To conform with the general anticlinal structure of Mt. Hunt, these observed south pitches must be regarded as overturned north pitches. This overturning is taken as an indication of the type of deformation which occurred, viz, pockets of greenstone acting almost plastically under the stress, being squeezed upwards in various spots. In fact, the term "intrusion" might convey the idea of what happened better than simply "folding". Nevertheless, the various horizons, chiefly the calc schist and quartz dolerite greenstone contact are mapped through a complexity of contortions at the Golden Mile.

PREVIOUS GEOLOGICAL WORK

The first geology was done by Goczel in 1894. In a passing reference to Kalgoorlie, he described it as a NNE - SSW line of diorite, in which countless lodes were due to intrusions of diabase dykes.

Nogelsang published the first detailed petrological descriptions of Western Australia in 1897. The schistose amphibolites commonly found on the goldfields he described as due to the metamorphism of a diabase. Kalgoorlie did not receive special attention; its predominant importance only arose with the discovery of telluride in May 1896.

Card, of the N.S.W. Department of Mines examined specimens collected for him, and concluded that the rocks were igneous, but acid in composition. He did not find chlorite as an alteration of other minerals, and concluded that it was introduced as a pigment.

Further work tended to bring out the basic nature of the rocks. Pancroft said the productive host-rock was an altered basic eruptive, containing serpentine and chlorite. He said that there was a similar greenish rock, which contained olivine, and was unproductive.

Maitland reviewed the knowledge of the field in 1900. He said the rocks were talc, mica, hornblende - and chlorite rocks, and some sediments, intruded by other igneous types. Simpson collaboratedon this with descriptions of thin sections and chemical analyses; from these he classified the greenstone complex as

(1) amphibolites and their derivatives -
 - (a) massive greenstones
 - (b) chlorite schists
 - (c) massive and foliated siderite rocks

(2) newer eruptives -
 - (a) felspar porphyry
 - (b) porphyrite
 - (c) peridotite

Mention of an andesitic rather than dioritic country rock was made by Richards, who quoted J. W. Judd's determination of a "highly altered quartz andesite".

The geological work of Maclaren, done in 1909-1910, covers the general geology of the region, and of the auriferous locality; the shearing and fault system and the nature of the lodes. Maps accompanied this comprehensive work. Of special importance is the large section devoted to petrology, done by a petrologist, J. A. Thompson. Thompson described many types, but a concise genetic classification by him is found on page 79 of their unpublished volume. It is -

(1) Serpentines resulting from alteration of peridotite.
(2) Horneblende rocks resulting from alteration of pyroxenites
(3) Lustre-mottled amphibolites resulting from the alteration of pyroxenites.
(4) Epidiorite rocks resulting from the alteration of quartz dolerites.
(5) Epidiorites with micropegmatite resulting from the alteration of quartz dolerites.
(6) A series of fine-grained amphibolites derived from a fine-grained parent, either volcanic or hypabysal. These are chiefly regarded as of volcanic origin, older than the intrusives.

(The term epidiorite tends to be confusing to those familiar with the terms now used for Kalgoorlie rocks.

An epidiorite is a dolerite or basaltic rock in which the augite has suffered alteration to horneblende so that the rock approaches the composition+ of a diorite (Rice).

+composition refers rather to the mineral assemblage than to the bulk chemical composition, I think)

Thus, to simplify his presentation, Thompson has -

(1) Serpentines derived from peridotites, and various amphibolites resulting from the alteration of basic intrusives ranging from pyroxenites to quartz dolerites
(2) Amphibolites derived from volcanics.

With the amphibolites in group (1) he correlates one greenstone, the Q.D.G.

With the amphibolites of group (2) he correlates the other greenstone, the C.S.

Thompson supports his classification with observations of the original texture of the rocks

He has exhibited great competence in his determination of the minerals in these difficult rocks, and for this reason his work should be highly regarded.

He has also, in my opinion, exhibited a highly developed imagination in his observations of texture.

The general theory proposed by these workers on the basis of the evidence which they present is -

In ancient time this was a sedimentary region containing a thick series of basaltic - andesitic lava flows. A period of intense crustal disturbance folded and otherwise distorted these rocks. Then a newer series of basic rocks was intruded, in the form of dykes on foliation planes. The existence of various types within this group is ascribed to a number of intrusions arising from one parent magma which was undergoing magmatic differentiation. The process of magmatic differentiation is not proved, but is given as the best explanation (Maclaren P.40).

Dr. C.O.G. Larcombe, working separately at this time, introduced some rather conflicting names, but made an important contribution in recognising the individuality of the calc schist. This he believed to be a metamorphosed tuff. The bleached greenstones he called "granophyric dacite" and "aphanite".

During the period 1912-1927 contributions were made by various workers including Feldtmann and Farquarson
Gibson
Larcombe
Maitland

The work was concerned chiefly with more detailed mapping, confirming the two greenstones (Q.D.G. & C.S., then known also as "younger" and "older" respectively). Various sub-types were established, and disagreements on suitable nomenclature for the various types and subtypes were ironed out.

But no notable advance was made over this period.

The survey begun in 1912 by Gibson had never been completed; agitation for a thorough survey led to the undertaking of the task by Dr. Stillwell in 1927. The work was published in 1929 (Bulletin 94, W.A. Geol. Survey). The chief interest was economic, concerning the relation of the lodes to country rock. Dr. Stillwell compiled lease-plans and sections of the lodes with the help of Feldtmann and Finucane.

The rock types he shows are -

| | | |
|---|---|---|
| (1) | Fine-grained greenstone and calc schist | older greenstone |
| (2) | Uralitic quartz dolerite<br>Quartz dolerite greenstone<br>Hornblendite | younger greenstone |
| (3) | Chloritised hornblende porphyry<br>Albite porphyry | |

Stillwell concurred with Maclaren and Thompson on the genesis of the greenstones, and made two important additional contributions -

(1) From the increased number of chemical analyses at his disposal he reasoned that the igneous rocks are magmatically related.

(2) He found frequent association of lodes with porphyrite dykes of all types, and found tourmaline usually associated with both lodes and dykes. He reasoned from this that the lodes are genetically related to the porphyry, precipitating from the associated solutions as an aftermath.

In the years 1934-1936, Gustafson and Miller applied the structural concept to the Kalgoorlie greenstones, and found that the twp were stratigraphically related in tight folds. They did not attempt to disprove the intrusive character of the younger greenstone, and therefore they called it a sill.

Minor contributions by various workers, including Prider, Gustafson, Stillwell and Finucane have been made since; the geology has followed the lead set by Gustafson and Miller, with the careful detailed mapping of the folded contacts of CS and Q.D.G. Western Mining Corporation has extended this careful work to mapping of the surface, both to the south and to the north.

Their classification of the greenstones used in this mapping is

(1) (a) fine-grained lavas, mainly ultra-basic
    (b) spherulitic pillow lava
(2) carbonate - talc - chlorite rock
(3) chlorite - talc - actinolite rock
(4) felspathic amphibolite (Q.D.A.)
and, at Mt. Hunt -
(5) basic recrystallised rock.

At the south end particularly, the stratigraphic nature of the greenstones has become apparent, with the exception of one type, No. (5) above, which is thought by Western Mining Corporation geologists to be intrusive and crosscutting.

The present views held by operating geologists at Western Mining Corporation are broadly these.

The greenstones of Kalgoorlie are a series of basic lava flows with minor variations in acidity etc. These formed in a geosynclinal environment. Severe deformation occurred, forming the s teep, tight, complex structures now observed. The greenstone rocks now outcropping and encountered in mining are thought of as being the roots of a very ancient mountain chain with an unknown, though very large, thickness of sediments above. At some stage during or after folding these rocks were invaded by a magmatically - related acid porphyry, rich in soda. This porphyry was responsible for the introduction of the ore, in its hydro-thermal phase. It is also believed to be possible that the mobile

components of the porphyry intrusion, at a fairly late stage, were responsible for the partial reconstitution of large masses of rock, - the B.F. sediments
the Q.D.
and the C.S.
- in that order of preference. One feature of this proposal is especially note-worthy; the Q.D.G. and Q.D.A. rocks are explained as the reconstitution, chiefly in the form of albite enrichment, of more basic, possibly ultra-basic, lava flows.

AIM. The hypothesis outlined above is a resume of a paper by J. D. Campbell ("The Kalgoorlie Petrological Problem" Western Mining Corporation, 23/4/56, unpublished). It fits rather well with the structural relations and macroscopic appearance of the rocks. However, it is only an hypothesis, and the next step is obviously to try and establish some proof. It was thought that petrology would be the best method. It is rather more speedy than chemical analysis; and, should any feature applicable to ore-finding be discovered by it, petrology could presumably be easily and quickly adapted to run-of-mine and prospecting samples.

The availability of a great quantity of new material from a deep diamond-drilling exploration programme at the south end, now at an advanced stage, was another reason for the petrological attack at this time.

The incentive is that, if (a) the rock types are dependent on the effects of the albite porphyry
and (b) the ore also owes its introduction to the albite porphyry -
then proof of this hypothesis, and further knowledge of the intrinsic nature of the rock types might lead to the detection of ore controls.

This work has also a flavour of economic obligation to Western Mining Corporation; the tasks set out by Mr. J. D. Campbell, as a guide to my work, were:-

(1) (a) Where does the serpentenous greenstone fit in? Is it original rock still unchanged in any way towards Q.D.

or is it unrelated to Q.D.

(b) Find the relation of actinolite and talc-actinolite rocks to normal Q.D.G. and Q.D.A.

(2) Investigate the albitization process in Q.D.A. and Q.D.G., in albite porphyry, and in Black Flag sediments; also in the albite porphyry and basic porphyrite dykes of the field (mining area).

(3) Compare the calc schist of diamond drill holes SD1, SE2, SE6, and SE7.

(4) Why is there so much ilmenite and leucoxene?

My aim was to try and help in

(a) the academic side, of establishing the origin of the greenstones.

(b) the economic side, in e stablishing some further guide to ore-finding.

Any contribution to (b) could only be accidental or as a corollary of (a).

METHOD

(a) At Kalgoorlie

I was introduced to the problem during an eleven week stay in Kalgoorlie. This took up the vacation at the beginning of the year, and was spent with Western Mining Corporation. The time was spent as follows:-

2 weeks at the mine of Gold Mines of Kalgoorlie.

5 weeks examining outcrops with the help of maps produced by Lewis and Woodall.

3 weeks laying out, examining and sampling fifteen thousand feet of selected drill core from the south end.

1 week at Western Mining Corporation office, copying relevant maps.

The diamond drill core recovered from the south end drill holes provided all but a few of the specimens I selected for the work. This is because it presumably covers the same section of rocks as occur in the Golden Mile, but which have not been subject to such alteration. This drilling warrants further description here.

The drilling programme was undertaken in the hope of finding another mineral zone equivalent to the Golden Mile. The Golden Mile is a structurally controlled ore-zone. It was thought to bé one of a series of structures favourable for ore-deposition, and that these structures occurred at regular intervals along the Kalgoorlie structural line, descending from north to south. The Hannan's North - Mt. Charlotte mineral zone was the lower extreme of the most northerly body visible, the rest having been removed by erosion. The Golden Mile itself represented the next such body, where vast quantities of ore still remained below the surface.

Deep diamond drilling was undertaken in order to discover the next ore-body, which should be further south at an unknown depth. The drill is BX size. The scheme was to drill a hole down from the west side, inclined at such an angle to the east that, by the time a depth of three to three and a half thousand feet had been reached, the hole had been deflected to nearly horizontally east. Thus is cut across the structure, giving a comprehensive section of the rocks present.

The first hole was drilled from a lower level of the Great Boulder mine; its collar was 2,650 feet below the surface. Seven other holes have been drilled from the surface at intervals to the south, but only a few gold values have been obtained.

We spread out the selected core viz:

SD1 - all hole, 3,200' deep
SE2 - 1,000' - 3,000'
SE3 - 770' - 3,200'
SE6 - all hole, 4,700' deep
SE7 - top - 3,600'

and examined this, wetted, several times. Finally I went through and selected 389 specimens. My considerations when selecting them were -

(1) to get specimens of all types
(2) to get comprehensive runs of specimens where a gradation

of rock types, one into another, occurred, especially the gradual increase in observable albite.

A subsidiary consideration was the amenability to thin-sectioning. I selected a few simply because of their coarser grain - size, in case the others proved too fine-grained and altered to lend themselves satisfactorily to microscopic examination.

I also selected 41 other specimens, chiefly from south end outcrops.

A complete list of the specimens taken is found in the appendix.

(b) In the laboratory.

Back in Adelaide I set about the task simply with a view of seeing what I could see. The rocks were unlike anything encountered in undergraduate microscope work, owing to their fine grain-size and alteration, and did not look very promising for thin sectioning and microscope examination.

I set about cutting sections, first of all the recognised types -

Q.D.G.
Q.D.A.
C.S.
Ultra Basics
Porphyry (albite - & basic - )
B.F. Sediments
Albitised Rock.

Immediate difficulties were encountered because -

(1) sulphides were often present in minute grains which were not detected in the hand specimen. This mineral tended to come away and tear up the section in the last stage of cutting.

(2) rarely was quartz present in large enough grains to guide the thickness of cutting. Therefore most of the fine-grained rocks are sectioned to an unknown thickness, usually less than the usual .03 mm, but presumably not thinner than half of this value.

(3) Initially a detailed examination of even the very finest rocks was attempted, which necessitated very thin cutting. This was finally dispensed with for reasons given later.

Initially more failures than success were encountered. However, about 30 slides were completed tolerably well, and microscopic examinations made; later another 14 slides were made on the basis of what appeared illuminating from the first 30. Thus 44 slides in all were made, which is many less than the number I expected to be able to turn out. I would have liked to have cut a few more if time had allowed, but there was really no point in cutting hundreds of sections, as I was not attempting a systematic petrological survey.

The microscopic examination proved equally difficult. The chief drawback was the fine grain-size. Interference figures cannot be obtained from grains smaller than .5 mm across, and the extraction of grains for accurate R.I. tests etc. was impracticable. Thus it was sometimes difficult to identify, and often impossible to confirm, mineral determinations. This was especially tantalising in the case of the chlorite material, and some of the smaller felspar crystals.

"Optical Mineralogy" by Rogers & Kerr has been used as the chief guide to mineral determination with occasional references to Dana's textbook of Mineralogy, and "Microscopic Determination of the Non-opaque Minerals" by Larsen and Berman.

The microscopic descriptions are attached in the appendix. A couple of X-ray photos were taken of felspar porphyroblasts, and the determination of plagioclase of some sort was confirmed. Not sufficient time remained to go into this approach thoroughly enough to make it of any value.

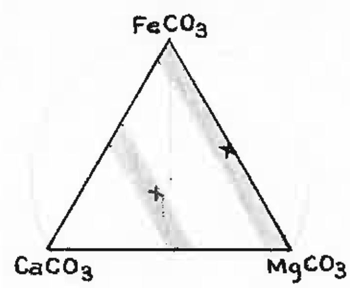
Microphotographs were taken of selected features in the thin sections, and are added in the appendix. Their value is limited, but they tend to show the type of fabric encountered. They are magnified 140 times, which is much more than the working visual magnification, without the hindrance of the relief of the high power lenses.

Consultation of chemical analyses also modified my ideas on the matter.

RESULTS I have compiled 44 microscope descriptions of rocks. In these there remain many gaps and tentative determinations.

The minerals encountered were :-

carbonate: the nature of the carbonate was not determined, and it no doubt varied from rock to rock. One specimen, found outcropping at the south end, contained two carbonates, a white one, and a brown one, coarsely crystalline. An X-ray analysis done by Mr. N. Markham showed that these carbonates, by their d-spacing, fit into the composition triangle thus, one in each of two recognised fields.




quartz
albite
muscovite-sericite
tremolite-actinolite and possibly a jade mineral
hornblende
biotite
bastite
possible hypersthene
various species in the range chlorite-serpentine
zoisite or clinozoisite
epidote
talc
sausserite
leucoxene
ilmenite
sulphide

Textures seen were spoilt by the frayed and badly defined grain boundaries, the fineness of grain-size, and the general alteration and invasion of the various grains. These rock descriptions have not enabled any proofs to be made. They have led to certain <u>conclusions</u>, which are not <u>conclusive</u>, and have caused me to form my own opinion of the sort of geological history ,which Kalgoorlie has experienced.

<u>CONCLUSIONS</u> The work done on Kalgoorlie in the past may be summed up as -

(A) Mapping with its various corollaries -
structural relations
age relations

(B) Laboratory work -
(1) mineralogical (microscope work
(2) chemical (rock analyses)
I am concerned only with the latter - (B)

In the past the attack has been first to compile various microscopic and chemical data. After that the method has tended to follow these lines:-

(1) a certain mineral texture is commonly noted during the microscopic examinations; by reference to either literature or experienced observers, it is found that this texture resembles* a texture commonly found in a rock whose genesis has been established. Therefore, it is deduced that the two rocks have a similar genetic history, and the origin is solved.

(2) the average chemical composition is found for a group of rocks which have been put into the same field classification. This analysis is found to agree closely with a standard type such as given by Daly or Washington. Therefore it is deduced that the rocks have the same genetic history and the origin is solved (or, if already solved by method (1), then it is confirmed).

Such methods have the advantage of simplicity and are satisfactory where ideas and not facts are sought. To observe that rocks have the same appearance and composition, and then to conclude that they have had the same history can lead to a good working hypothesis. It has a certain usefulness; while method (2) alone can never be more than a guide, method (1) (of texture) supported by method (2) (of composition) can carry a certain definiteness. That is, if we can establish that the textures are the same as the recognised standards; in Kalgoorlie rocks, however, I believe that we cannot get past the fact that they only resemble the standard textures*.

Some people believe that by making such work more thorough, and the coverage more complete, the hypothesis can be made factual. With this I must disagree. If these methods are persisted with long enough, some factor applicable to ore-finding may be discovered, but that is an unscientific way of gaining knowledge.

Such methods of comparing rocks with standards are to be deplored at Kalgoorlie, where we are concerned with a rather difficult corner of the petrological table of classification. The difference between basalt and andesite is not clear-cut, and often even fresh specimens are hard to classify. Then the textural difference between dolerite and basalt is sometimes non-existent.

Chemical analyses have been regarded as of varying importance. The high silica of the younger greenstone was put aside when the rock was named, and it was called a dolerite.

Again the microscopic fabric of the rocks has not been fitted to the regional picture. I have only observed schistosity in the rocks which in macroscopic appearance are sheared. Certain rocks show no preferred orientation. If these rocks are the roots of great eugeosynclinal mountain-chains, a general strong preferred orientation would be expected. If recrystallisation under the action of hot mobile components has obliterated this, how can we expect textures resembling ophitic, pochilitic, and micropegmatitic textures to be valid?

In the examination of these rocks it soon became obvious that a simply mineralogical determination of the rocks, viz,

x% of albite

y% of calcite

z% of chlorite

etc. was not going to avail much; firstly because of the difficulties in determination, I could never do more than estimate to say 10%, and secondly because the usefulness of such data is dubious. The knowledge of the existence of certain mineral in a rock does not have much value. More recent research has shown that this does not fix the rock as high temperature or low temperature. The existence of mineral assemblages, when properly understood and correlated with experimental work, can enable us to say that mineral assemblage was formed within a certain range conditions of temperature, pressure, and mobile components, but this does not necessarily fix the environment.

Therefore I placed my hopes on finding textures which meant something. I was not happy about the validity of this approach either, but it was the only one I knew.

Thompson has observed ophitic textures (pages 96, 98) poikilitic textures (pages 88, 90, 93), and micropegmatite in the younger greenstone. He has observed serpentine pseudomorphing olivine. On this evidence and the similarity to the quartz-gabbros of Carrock Fell, Scotland (page 79) he says (of the younger greenstone) "they are for the most part typically coarse-grained rocks, and certainly of intrusive, if not plutonic, habit" (page 79).

Olivine and pseudomorphs are rather definitely established (page 90). I have not recognised this mineral, but its existence is not disputed. I have not observed any micropegmatite (graphic intergrowth and felspar). This arises from the simultaneous (eutectic) crystallisation of quartz and felspar. This is most common in intrusive rocks, but it can form whenever the conditions of temperature, pressure, chemical composition, and the rate of change of these are suitable. Thus it can arise during metamorphism, and does, but more rarely.

I have observed possible poikilitic textures, notably in

rocks number 61
143
146
171
338

When small crystals are included randomly in larger ones we have a poikilitic texture.

However, I cannot use this as evidence of an intrusive origin, as, in such altered and disturbed rocks, I cannot be sure that the observed texture is not glomeroporphyritic (see "Petrography" by Williams, Turner & Gilbert, illustration B, page 42) or something similar.

Ophitic textures were observed by Thompson, and later by Prider. An ophitic texture is developed when laths of plagioclase penetrate pyroxenes. I saw possible ophitic texture in rock number 338. But it certainly cannot carry much weight. Ophitic textures occur in tholeiitic basalts according to Williams ("Petrography" page 44).

Relics of pre-existing minerals were observed from time to time. A reliable one was sausserite. The edges of relics are sometimes preserved by a certain mineral, e.g. in numbers 146 and 519 we have an outline shown by strings of ilmenite grains. In number 272 highly altered crystals are differentiated by rims of felspar. In some rocks (e.g. number 283), the ilmenite has formed euhedral crystals. These are observed to alter to leucoxene, and the relic structure of the ilmenite preserved by the leucoxene looks very like the well known skeletal form of the leucoxene.

However I find that epidote - zoosite occurs in the alteration of both felspar and ferromagnesians. Therefore I would not extrapolate back to what the original grains were without further evidence, as Thompson has done, e.g. talking of the excessively bleached greenstones, he says "if certain very dense carbonate aggregates be interpreted as pseudomorphs of pyroxenes, then these coarse pink rocks are alterations of Q.D.G" (page 80).

Commonly there are no relics, and the appearance of the rock is (1) simply of felted masses of minute crystals, sometimes aggregated roughly, and sometimes having certain areas richer in certain constituents.

or (2) more or less larger distinguishable grains with indeterminate borders, invaded and speckled by other minerals.

I am rather inclined to think there may be a gradation of (2) (coarse indeterminate) to (1) (fine), and that the very fine grain-size of some rocks could result from the alteration of original large grains to minute grains of chlorite, felspar, tremolite, talc and quartz, with a slight shearing disturbance to complete the process. Rocks which support this idea are numbers 143-147.

The possibilities are that the fine grain-size of the majority of the greenstones are such because of

(1) an original glassy or very fine-grained original texture.

(2) retrogression of t exture during alteration by processes such as carbonatisation, chloritisation, and shearing.

I believe the fine-grainedness has arisen in each of these ways. Some rocks, e.g. the calc schist are extremely uniform and fine-grained. I accepted these as being originally very fine-grained, and gave up the hopeless task of detailed examination of the grains. Others, such as numbers 53 and 143 (see photos) have a suggestion of larger grains now almost completely obscured. Detailed examination under high power objective was of little avail; the best picture was the more comprehensive view under an intermediate power objective. Therefore the risky job of cutting sections very thin for examination under high power objectives was dispensed with.

My own observations are that relic textures, hazy and indefinite as they were, are not necessarily, poikilitic, ophitic etc. such as is representative of dolerites; they could as easily have been -

pilotaxitic (flow alligned microlites in a groundmass of cryptocrystalline or microcrystalline material)

Hyalo-ophitic (phenocrysts of felspar enclosed in glass

hyalopilitic (phenocrysts of felspar in a groundmass of microlites and glass).

These are characteristic of flow rocks and are illustrated on pages 23-24 of Petrography by Williams, Turner and Gilbert.

This is in comparison to the holocrystalline ophitic to poikilitic textures of dolerites. (Petrography, pages 45,46.

I have had to consider the bulk chemical composition of the rocks, but have not made any contribution in this field. The position has been capably reviewed in a recent report by S.A. Tomich of Western Mining Corporation. He has compared rocks under this classification -

ultra - basic rocks
hornblendites
quartz dolerite amphibolite
quartz dolerite greenstone
bleached quartz dolerite greenstone
calc schist
quartz dolerite greenstone, sheared lode-stuff.

His comparison shows the chief variation in composition to be in the MgO content, which would tend to support the idea of magmatic differentiation in some phase of the genetic history of the rocks. I think he has established that the rocks belong to the one suite. This could mean that they were all derived from the one mobile magma.

While disagreeing with the method of comparing analyses to establish the origin of the rocks, I did check through analyses in Washington and Daly, and it is apparent that the chief factor which prevents Q.D.G. from being linked with common types is the low alumina and high iron (chiefly FeO). The other Kalgoorlie rocks are similar in this respect, yet they all fit satisfactorily into established categories Williams ("Petrography", page 45) says "tholeiitic diabases (dolerites) are generally sub-aluminous, and saturated or slightly oversaturated with silica".

On page 29 he says "the deficiency of alumina should affect the composition of dark minerals. These should be olivine, othorhombic pyroxene (enstatite - hypersthene) and diopside. In the late stage og magmatic crystallisation we get ferric oxide, zirconia and titania taking the place of alumina.

The occurrence of chloritoid is outlined by Prider ("Chloritoid at Kalgoorlie" by R. T. Prider). It is found in both calc schist and quartz dolerite. This mineral allegedly is characteristic of shearing (Dana, page 667) and of rocks rich in alumina (Harker "Metamorphism" page 213) but this should not be taken as a criterion of rock composition.

The composition of the Q.D.G. fits andesite except for the alumina and iron; the silica and soda fit well.

The hornblendite and ultra - basic rocks have similarities in composition with the oceanites (picrite - basalts), viz.

| | ultra-basic rocks Kalgoorlie quote Tomich | Oceanite Average quote Daly | Hornblendite Kalgoorlie quote Tomich |
|---|---|---|---|
| $SiO_2$ | 45.4 | 45.9 | 50.6 |
| $Al_2O_3$ | 6.5 | 8.3 | 7.6 |
| FeO | 1.3 | 2.3 | .7 |
| $Fe_2O_3$ | 9.8 | 10.3 | 10.2 |
| MgO | 29.5 | 21.9 | 19.8 |
| CaO | 4.2 | 7.5 | 8.5 |
| $Na_2O$ | 1.2 | 1.3 | .4 |
| $K_2O$ | .6 | .4 | .1 |
| $TiO_2$ | | 1.7 | |
| $MnO_2$ | .6 | .1 | .6 |

The basic - ultra-basic bulk composition of certain Kalgoorlie rocks should not therefore cause a flow origin to be discounted.

I agree with Tomich in that we need more chemical analyses. When too few have been done to obtain a reliable average it is possible to select certain ones for the purpose of any argument. An example of this is seen on page 60 of the report by Stillwell (W.A. Geol. Survey, Bulletin 94); here he gives analyses of Kalgoorlie rocks, which, contrary to the averages given by Tomich, all have normally high alumina and low iron.

In these analyses the soda content is neither abnormally high nor variable, and certainly no basis for postulating a general albitisation process.

The wholesale introduction of soda by a process of porphyritisation is questioned. Albite does occur in the rocks. Two distinct types of felspar are observed, often in the same rock, e.g. number 338. One is in the form of small, often sausseritised laths, and is too altered to be determined but it is quite possibly the soda-lime felspar of the original rock. The other felspar tends to be larger, more equidimensional, and often twinned. It is usually decayed, invaded, and flecked by alteration material, but not sausseritised, and hence a microscopic determination of albite (or sometimes oligoclase) is possible on the evidence of

relief, relative to balsam
extinction angle
optic character and sign
axial angle.

It seems likely that this material forms an appreciable part of the groundmass in cases of more extreme decay. It is beyond the scope of the microscope to determine the albite quantitatively, and we must turn to chemical analyses to see whether the rocks are distinctly sodic. The analyses recorded by Thompson, Simpson and Feldtmann show a percentage of soda slightly higher than Daly's standards. The Kalgoorlie averages are far from being comprehensive, but about ½% on 3% is the order of the excess soda. Variations within the rock types are of a much greater order than this. Therefore a theory of wholesale albitization, while not being discounted by existing analyses, has not sufficient foundation in them.

The process of albitization seems most reasonable when dealing with macroscopic specimens, and I worked with this theory in mind. But I did not observe any preponderance of albite. Some specimens of Q.D.A. core appeared to be rich in a hard white material. Under the microscope this appeared to be the sausseritised type of felspar; see number 181.

If soda were introduced by metasomatising hydrothermal solutions, it is assumed that albite would be a stable phase, and under the conditions of high volatile ($H_2O$, $CO_2$ etc) concentration, the development of large clear euhedral crystals of albite would be expected.

This is not what is found. Rather, we get large and small albites, usually not euhedral, usually flecked, decayed and generally tending to "melt into" the general rock mass. It looks very much as though it has been subject to as much retrograde metamorphism as some of the other constituents.

The additional proposal of later metamorphism to make the albite melt back into the general mass of the rock and become an older mineral makes the albitization process lose its value even as a working hypothesis. However, if it is still wished that the possibility of such a process should be maintained, the way is to start from what we see in the rocks now, and work back step by step as far as possible (present techniques and knowledge won't allow many steps to be evaluated). The various sets of conditions (temperature, pressure, and volatile) to which the rocks have been subject should be evaluated by a combination of experimental and observational work.

While I disagree with the idea of wholesale albitisation, local enrichment in albite must be allowed on the evidence of rocks such as number 219, which was given a field name of "porphyritised Q.D.", and under the microscope appears to consist chiefly of albite and chlorite.

Quartz dolerite amphibolites which I have examined include numbers 529-339. Number 529 in particular shows simply a crystalline aggregate of amphibole and felspar. Other related types show less felspar. If albite has been introduced into these rocks, the whole must have been recrystallised later. It therefore does not seem to me that Q.D.A. has resulted from the grafting of porphyry characters to the fine-grained Q.D.G. Rather it would appear that the Q.D.A. is either a parent or a coarser relation of the Q.D.G. The presence of ilmenite in Q.D.A., and leucoxene in Q.D.G., is a general feature on the field, but this is not an invariable difference between the two rock types. In thin section the both are often seen together. The ilmenite is seen altering to leucoxene in number 283, in places maintaining relics of the structure of the ilmenite. This presumably is the origin of the skeletal leucoxene so common in mine Q.D.G. Both numbers 283 and 284 looked like Q.D.G., and contain no noticeable amphibole, but ilmenite (altering to leucoxene) is liberally dispersed through them in tiny, sometimes euhedral (see photo) grains, and is partially responsible for the dark colour.

The Q.D.G. and porphyry have much more in common; both are very fine-grained, and rich in carbonates. The Q.D.G. tends to be richer in chlorite, while the porphyry has occasional large albites.

Microscopic examination of the calc-schist does not reveal any features beyond the macroscopic appearance. In general appearance it is very similar to some specimens of Q.D.G., but tends to contain less chlorite. In specimen number 312, no chlorite was detected. The grey is probably due to minute specks of iron ore. Failing the discovery of any more definite features of this rock, I would agree with Tomich and take it as an altered basalt.

The ultra-basic rocks have a tendency to a coarser but diffuse grain. Granular relations are spoilt by talc and tremolite fibres (see photo of number 143); however, large grains are not seen, the biggest being 1-2 mm in the largest dimension. This does not accord with plutonic origin. I did not observe any olivine relics, but Whittle described rocks from near Mt. Hunt which he calls altered dunites (numbers 1 and 9, Pet. Report, 19/10/55, S.A. Mines Dept. unpublished).

I see no conclusive reason why all the basic and ultra-basic rocks of Kalgoorlie could not have been flows. However, my opinion is that the origin is slightly more complex.

My own picture of the geological history is this. At Kalgoorlie in Archaean time, and in an unknown environment (geosynclinal, basinal, terrestrial, paralic etc) there existed a volcanic district. Such a volcanic district could not have consisted only of continuous sheets of lava flows, but there must have also been vents, volcanics, calderas, minor intrusions. The possible complexity of such a district is indicated by the Tertiary volcanic district of Western Scotland (see reference, J. E. Richey). I do not suggest that any such special features as ring-dykes, cone-sheets, etc., are warranted at Kalgoorlie, but certain features of the Tertiary volcanic district of Scotland may also have counterparts at Kalgoorlie, viz,

(1) On the Isle of Mull the most complete sequence is seen; olivine-rich plateau types change to porphyry types near the caldera, and show pillows.

(2) At Compass Hill, on the east coast of the Isle of Canna, a cliff 450' high shows sheets of columnar dolerite traversing the cliff, and have been variously interpreted as lava flows and sills. They contain porphyritic felspars.

(3) The various rock-types ranging from basic to acid, alkaline to calcic, have been related into a magma-series.

(4) On the Isle of Mull, pneumatolytic alteration is widespread, causing olivine to disappear and epidote to form.

(5) A typical flow consists of a thin basal slag, a solid lower section, and a thick upper layer of slag. The flows are jointed. The gas vesicules of the slag are filled with late stage minerals - zeolites, calcite, chlorite, chalcedony and quartz.

In the area which is now the Golden Mile it is likely that we are concerned only with flows, how thick I don't know. Flows may be very thick. McKinstry refers to a flow 1000' thick in the Keweenaw Peninsula. Williams in "Petrography" says "Settling and accumulation of olivine crystals on the bottoms of thick flows and sills leads to the formation of purite-basalts or oceanites".

Other types which are hard to place in the picture could have arisen in more complex areas nearer the extrusive source, e.g. as minor intrusives.

The rocks became buried in the sedimentary column. The area was then metamorphosed. The agents of metamorphism were heat, pressure, and volatile components. As I picture it, the pressure agent was minor, as regional schistosity and gneissosity are not reflected in the rocks (as distinct from shear-foliation). The heat agency was possibly rather uniform, while the volatile components, chiefly $CO_2$ and water, which were associated with minor acid dykes, varied from place to place. Where the volatiles were at a minimum, slight recrystallisation occurred, sufficient to form amphibolites. Where the volatiles were at a maximum, carbonated and chloritic greenstones were formed. Hence the mineral assemblage in the zone of greatest action, in the Golden Mile itself, conforms to a low grade of metamorphism or facies, while further away we get a higher grade with amphibolites forming.

This phase of activity caused the introduction of an epigenetic ore into structurally deformed zones; or, just as likely caused the concentration of syngenetic, epithermal minerals usually geochemically associated with basaltic flows.

The final phase was erosion and oxidation.

This picture may have no more justification than any other, but I have postulated it here as I believe it has no less justification than any other.

SUMMARY The geological history of Kalgoorlie may be rather more complex than is thought at present. The differences between rock types are most likely original genetic differences. Albitisation as a major process is altering large rock masses is not favoured.

Textures which are possibly relics of the original igneous rock are seen but are not satisfactory basis for conclusions; the value of extensive microscope study is questioned.

ACKNOWLEDGMENTS.

My thanks are due to Professor Rudd for making this task possible, and for keeping me at the job when it looked rather futile; to Western Mining Corporation for introducing me to the problem and for acquainting me with the field evidence; especially to Mr. J. D, Campbell, chief geologist of W.M.C., for establishing me with a working hypothesis, and for obtaining various useful data and advice for me throughout the year. Finally I am indebted to Mr. Neville Markham for his friendly discussion of the problem and willing assistance when asked for.

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(3) "Igneous Rocks and the Depths of the Earth". by R. A. Daly 1933

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# ROCK DESCRIPTIONS

These are given in a set form viz.

Number (all belong to the Adelaide University Geology Department accession group A85).

Location.

Field Description.

Macroscopic Description.

Microscopic Description (A) Fabric

(B) Minerals

Conclusion.

The carbonate minerals have not been differentiated and are generally referred to as calcite, although the composition probably included iron and magnesia.

The distinction between sericite, talc or tremolite in the very fine material is not reliable.

Black sparkling iron ore has been called ilmenite on account of its commonly observed alteration to leucoxene, but its determination is not confirmed.

Microphotographs have been added to some descriptions. All these photos have a m-a magnification of 140 times,,which is considerably greater than the maximum working magnification. Some are taken with the slide between crossed nicols, others simply in plane polarised light, whichever gave the best contrast. No descriptions have been added to these photos as their purpose is simply to show the texture of the rock and deposition of some of the larger grains.

No. 1    SD1, 212'

"Q.D.G., medium grained, with carbonate developed".

MACRO. The rock is rather dark, contrasting to the dark mass are small evenly distributed white spots of carbonate. The rock is softer than most, but not talcose. It has a definite schistosity. Pyrite is observed.

MICRO. (A) Fabric. Large (up to 1 mm across) and partially euhedral calcites set in a groundmass of felspar, quartz and chlorite,

(B) Minerals. Green Mineral. This occupies about 50% of the slide. It is a browned-olive-green in colour pleichroic from light parallel to the NS crosswire to dark parallel to the EW crosswire. It appears biaxial (figure not satisfactory), has low birefringence, higher relief. It is possibly an iron-rich prochlorite.

Quarts. This has a low D.R., low relief. It occurs in small grains, about .02 mm across, with prismatic inclusions, presumably of apatite. The mineral is irregularly distributed throughout the section, sometimes in clusters.

Felspar. Faint ragged and decayed crystals, up to .2 mm across are seen. Both - ve and +ve biaxial figures were obtained. The relief is very low, no twinning is seen. It is probably oligoclase.

Carbonate. This occurs in large, regular crystals and also in smaller irregular fragments. Some of the crystals are rather decayed. I estimate it to constitute about 20% of the rock. I cannot say whether it is calcite, siderite, or ankerite. It was determined as a carbonate by (i) its uniaxial -ve interference figure

(ii) high RI varying on rotation

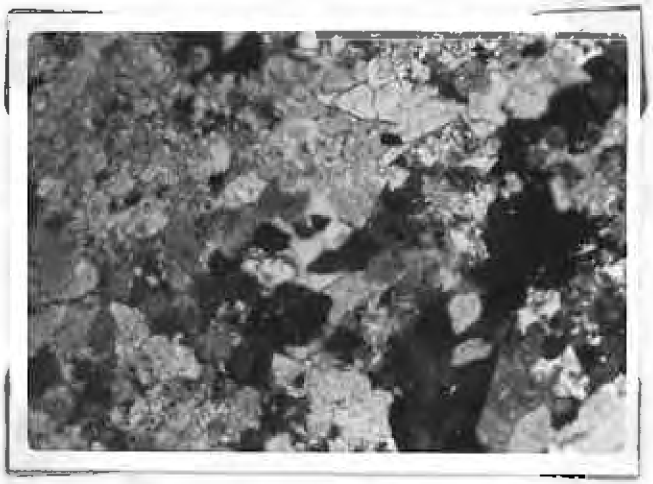
(iii) high D.R.

(iv) cleavage, and twin stripes

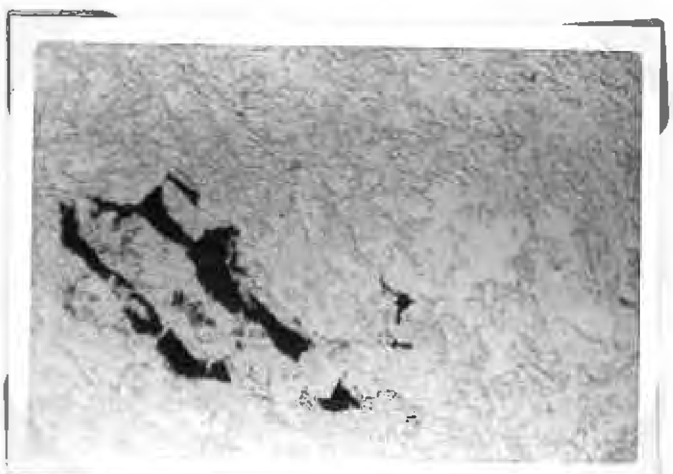
Pyrite. This is detected by its opaquity and brassy sparkling reflection. It occurs as large, irregular blobs and also as tiny speds here and there, chiefly in association with carbonate and felspar.

No. 1 cont.

CONCLUSION. This is a fine-grained greenstone, whose chief features are (i) richness in chlorite
(ii) decayed look of carbonates.



X140 Nicols crossed.



X140 Plane Polarised Light.

No. 3 SD1, 221'

"Sheared contact material, more like Q.D."

MACRO This rock is very fine-grained, dark coloured, with a more shistose appearance. One to two larger grains are noticed. Leucoxene is present.

MICRO (A) Fabric. The grains are small and hard to concentrate on individually. Even under high-power objective, the view of most grains is spoilt by flecks of sericite etc, The rock shows a definite shear direction.

(B) Minerals.

Carbonate. This mineral is prominent occurring in large grains, mostly irregular and with fuzzy boundaries. Twinning is common, but cleavage is not. This mineral also features in the fine shredded mass of the rock.

Felspar. This substance has very low relief. While it cannot be distinguished from quartz in the groundmass. Laths of it do occur, rather altered. One, showing carlsbad twinning, gave an extinction of greater than $11^{\circ}$, and the interference figure was definitely biaxial positive.

Chlorite. This mineral is prevalent, say 20-30% and follows the general shear direction. It is reasonably pleochroic in green - browny-green, with greatest absorption in the EW direction. It appears almost isotropic, but its relief is quite high, n $>$ balsam. It thus is best fitted to the properties of prochlorite.

Sericite. This occurs in small flecks of rather uneven distribution over the section. It does seem to form "shear bands", as the chlorite does. It does not prefer association with the altered felspar or the calcite. It has the form of micaceous chips; it has bright D.R. colours,
low relief, but n $>$ balsam,
parallel extinction

Leucoxene. This substance is quite opaque but gives a dead reflection in fawn grey, and has a smooth surface.

CONCLUSION. This rock contains a typical greenstone mineral assemblage. I cannot say whether shearing is responsible for the

No. 3 cont.

fine-grained character, or whether it is an original feature; igneous fabric is not seen.

No. 7 SD1 230'

"Bleached rock with dark remnants".

MACRO. This is a veined greenish rock mottled with whiter substance, and is schistose.

MICRO. (A) Fabric. This a uniform even-grained rock (estimated .02 mm average grain size), with occasional iron ore spots to break the monotony. Irregular runs of chlorite show the schistosity.

(B) Minerals.

Carbonate. This is the chief mineral. It occurs in very small grains, and a few larger ones.

Quartz. This occurs in extremely small grains; its determination is not confirmed.

Chlorite. This is slightly pleochroic; and has very low birefringence, but quite high relief. It is presumably the same as in number 1, which I called prochlorite.

Iron ore. This occurs in irregular groups of grains here and there.

CONCLUSION. This section shows little. We note the prevalence of carbonate, and absence or inconspicuousness of felspar.

No. 14      SD1.      264'

"Bleached mineralised contact rock, more like CS".

MACRO. The specimen is schistose, and looks a homogeneous soft resinous- to greasy - lustred mass with a few darker spots here and there. A vein of carbonate has been missed by the section. Pyrite occurs in blobs and veins.

MICRO. (A) Fabric. The section shows an extremely fine-grained shear-mass of minerals.

(B) Minerals.

Carbonate. This is again prominent. It forms small grains but much larger than the other minerals. Neither twinning nor cleavage is apparent.

Chlorite. This is present uniformly through the rock as small rather more sparse flakes. Pleochroism is not noticeable. The mineral is almost isotropic.

Sericite. This mineral follows the shear direction in very small usually orientated flakes. Sheared together with what I presume is chiefly chlorite and felspar (with possibly quartz), these form the major part of the rock.

Felspar. The mineral with extremely low relief and low birefringence is probably felspar, although its granular and untwinned habils are suggestive of quartz.

Sulphide. The metallic mineral is quite conspicuous forming possibly 5% of the rock. Some grains have a core of black material with golden rims. This could mean that the iron ore minerals of the greenstones form sulphides under high chemical potential of sulphur.

CONCLUSION. A typical greenstone assemblage, this rock gives no clue to its origin.

No. 53 SD1 2842'

"Even-grained Q.D.G. with leucoxene".

MACRO. This is a darker rock, and it looks shear-disturbed. Some dislocated whitish areas are seen. Leucoxene of a browner colour is prominent.

MICRO (A) Fabric. The texture of this rock is of a very fine, felted groundmass with occasional relics of felspar and large areas of carbonate.

(B) Minerals.

Felspar. This is observed in altered relics, which still show twinning, and have an extinction angle of about 12°. Fresher untwinned grains gave biaxial +ve interference. figures.

Leucoxene. This is seen and tends to occur in conjunction with the epidote.

Chlorite. This forms large areas where it is notably pleochroic from pale green to pale yellow-brown. Its extinction is parallel, birefringence low, and relief moderate. It agrees best with prochlorite.

Quartz ) These with chlorite and felspar, make up
Carbonate ) the groundmass.

CONCLUSION. The rock is best considered as an altered flow type, or at least containing fine to glassy groundmass in the original stage. Some relics should be from the original igneous texture.

X140 Nicols Crossed.

No. 61 SD1 3@59'

"Dark actinolitic Q.D."

MACRO. The rock is a dark blue-grey colour, hard, and heavy. The body of the rock is not notably schistose. A coarser grain is evident, though it is also noticed that the grains are not very distinct.

MICRO. (A) Fabric. The section is rather thick, as it began to lose grains in the final cutting. Most of the crystals are fritted, partially altered, and the grain boundaries are not distinguishable. There are rather wavy wisps and bands of mica etc., indicating some degree of shearing, and a very fine-grained zone looks as though it has resulted from a local crushing.

(B) Minerals.

Tremolite-actinolite. This mineral has high relief, high R.I. It is noticeably pleochroic in a browned green, being darker when parallel to the E-W crosswire. A good interference figure gave biaxial −ve, with moderately high zv. Cleavage in some sections is perfect as in mica, but end-on amphibole cleavages are also seen. The browny colour suggests incomplete alteration from hornblende.

Quartz. This mineral is recognised by its clearness low birefringence, and lack of cleavage or twinning.

Biotite. This is recognised by its marked pleochroic brown colour, and high birefringence. It occurs in small isolated micaceous wads.

Bastite+. A mineral of purplish brown (Dana "Pinchbeck brown") colour gives a biaxial − ve figure. It has moderate birefringence and is seen to be surrounded by tremolite with biotite associated. One altered grain contains euhedral laths which have inclined extinction. If these are felspar (they are very small) this is possibly a relic pockilitic texture.

Chlorite. A very pale chlorite with delectable pleochroism but very low birefringence is observed.

Iron Ore. This is sparse.

Epidote. Minute grains of this (or zoisite) are beginning to form.

CONCLUSION. Undoubted relics are observed, but I cannot get

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+ Bastite is a serpentine resulting from the alteration of hornblende.

No. 61

back beyond hornblende, or get any ideas on felspars, as none are observed. The relics are all wrapped in shear material; a late destructive effect is apparent.

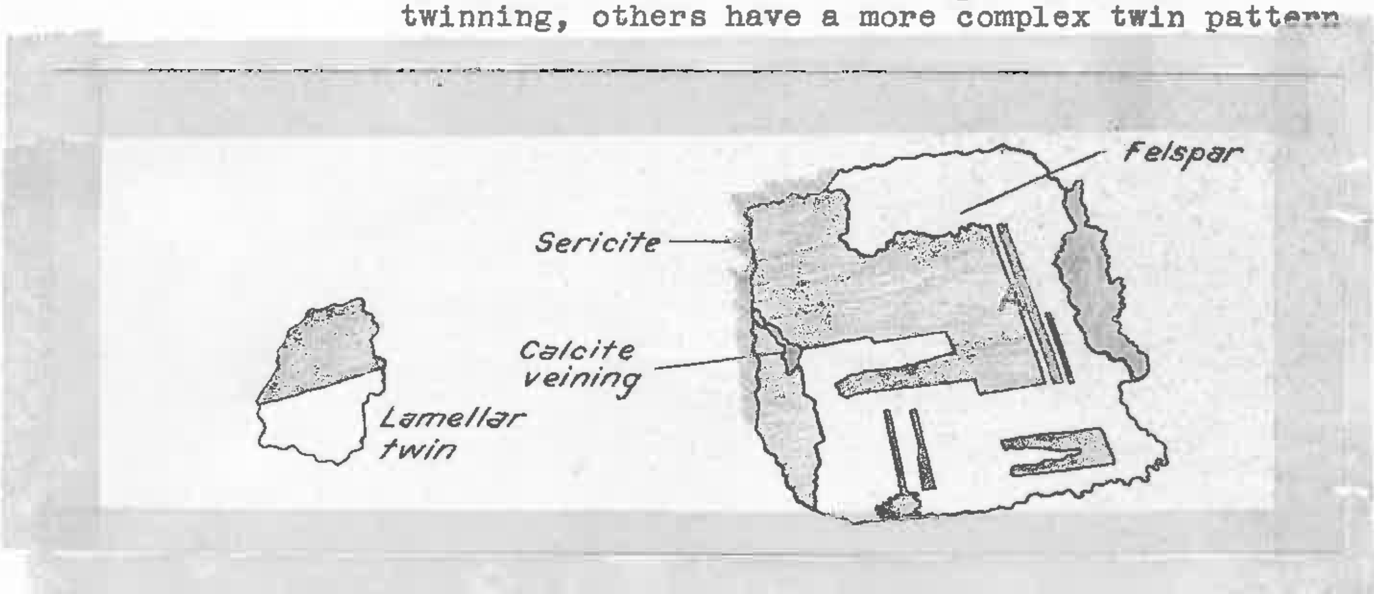
No. 111 SE3 771'

"Pink sheared porphyry (having graded up from greyer variety)".

MACRO. This rock is fairly solid, but a shear direction is indicated, though more by veining than schistosity. The colour is glassy salmon pink (orthoclase colour). There are bands of fine reddish sheared material alternating with greyer bands, and white veins, with large, equidimensional crystals of clearer, although still turbid, mineral studded here and there, also smaller darker grains.

MICRO. (A) Fabric. The rock is very fine-grained, with the exception of a few large phenocrysts. Noticeable is the lack of ferromagnesian minerals.

(B) Minerals.
Felspar. This occurs as irregular grains, possibly a remnant mineral which has lasted through dynamic and metasomatic changes. There are two types.
(a) Large porphyroblasts, apparent under low-power objective. They are clouded with flecks of mica-sericite? Some show simple lamellar twinning, others have a more complex twin pattern




The extinction angle of lamellae at A is 27° to the left. and 13° " " right.

The schistose mica flecks in the rock mass appear to "pile up" and veer around the felspar crystals

(b) Small felspar crystals are seen throughout the mass of the rock. Some are elongate, twinned, and exhibiting crystal shape, and some are just irregular.

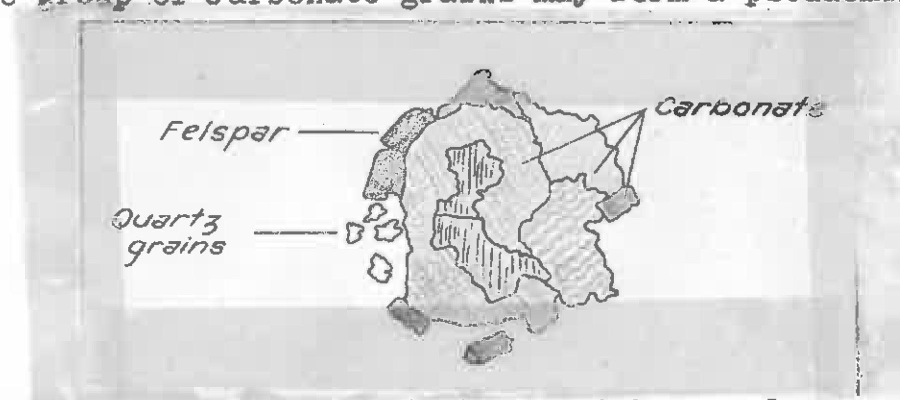
No. 111 (cont).

All are hard to distinguish from the groundmass due to the clouding of the felspar. The maximum lamellar-twin extinction angle observed was 18°.

There are some intermediate size felspar grains, much clouded by alteration, but forwhich the crystal shape can be roughly envisaged. Thus there may be a gradation between felspars in groups (a) and (b).

Carbonate. The carbonate appears to be a later mineral. It is seen veining the felspar; it veins the rock as a whole, but also occurs as small grains distributed through the rock-mass. It is also seen replacing the felspar directly. It does not show distinct boundaries with the general rock-mass. This is because in places it is bordered by fine grains of quartz, in places by sericite. The carbonate seems to trend along, but not be internally affected by the shearing.

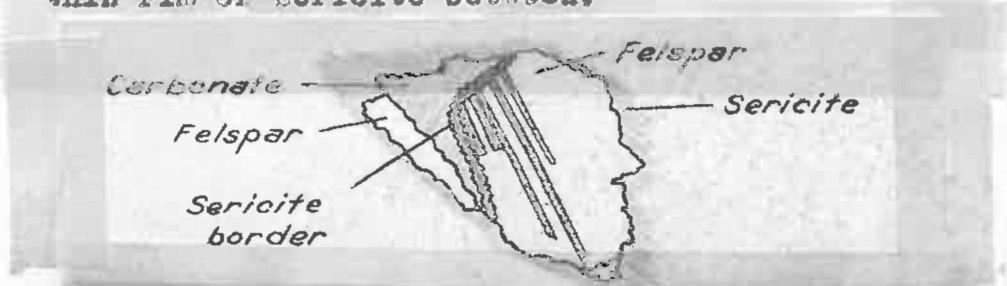
One group of carbonate grains may form a pseudomorph.




The two central grains in the sketch are clearer. These grains are differently oriented but have twinning in the same direction, which is parallel to the long edge of the presumed pseudomorph.

The carbonate veins are liberally dispersed and bordered with small quartz grains. The quartz could almost be imagined to vein the carbonate.

Carbonate is seen bordering a large felspar with a thin rim of sericite between.



No. 111 (cont).

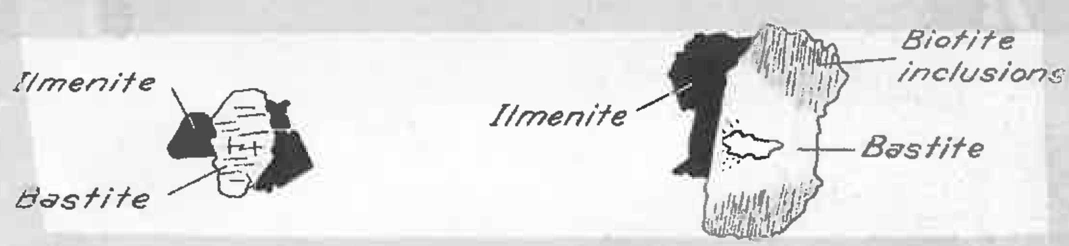
Thus the felspar may be sericitised, and the sericite replaced by carbonate, with quartz accompanying carbonate emplacement.

Quartz. This occurs chiefly in conjunction with the carbonate veins and in rather diffuse aggregates of small grains here and there in the rock. It also forms rather indefinite veins of its own. It occurs in the groundmass, though to what extent I cannot estimate, as felspar is also present and my impression is that the groundmass is chiefly felspar, much clouded by the effects of metasomatism.

Sericite. This appears ubiquitous, but in too small grains to completely determine. It shows high birefringence, moderate relief, parallel extinction, and occurs in the form of micaceous chips. It lies in winding runs forming the schistosity. It is very probably at least in part an alteration of the felspar. A feature is the browny pink colour of certain bands which I cannot attribute to any mineral in particular, but it may be the hydromuscovite alteration, which is very similar to sericite.

Iron Ore. One crystal, which has a more or less square outline, consists of ilmenite in the role of residuals, surrounded by a green rather structureless mineral, possibly serophite. The whole is probably derived from a ferromagnesian.

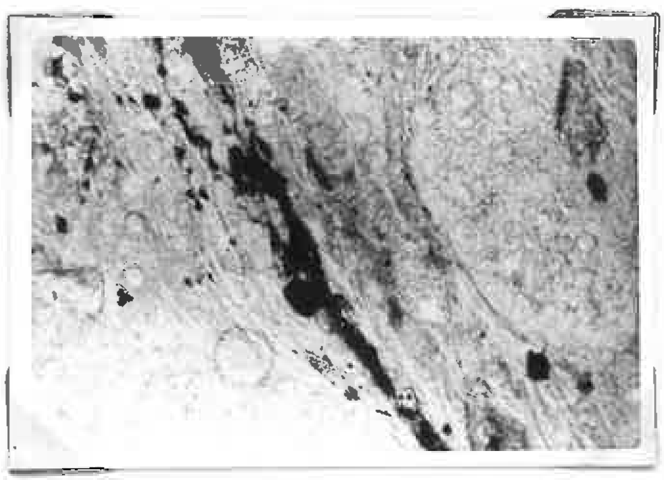
Biotite-Bastite. A couple of grains, occurring in conjunction with ilmenite, posed a problem for a long time. The body of the mineral has moderate relief, low birefringence and a rough cleavage. It is biaxial, with small axial angle, but no sign could be fixed. It had a very light brown colour, but the marked pleochroism in certain areas is seen to be related to the inclusion of prisms or flakes of brown mineral, together with a little iron ore, on an extremely minute scale. Thus I call the mineral a composite one of biotite and bastite.



No. 111 (cont).

Pyrite. Well formed pyrite is seen in small scattered grains, chiefly associated with the carbonate.

CONCLUSION. I have no reason to doubt that this rock was initially igneous, but whether it was originally an acid type, or whether it represents the extreme metasomatism of a basic type I don't know. Quartz appears chiefly secondary. Extinction angles put the composition of the plagioclase at albite or andesine. The form of the felspar would indicate either a hypabyssal or effusive origin. If the larger porphyroblasts are original, the rock was a felspar porphyry. However it is possible that the larger felspar crystals are later developments, in which case this would be an extremely altered greenstone; the relics of ferro-magnesians, although few, support this.



x140 Plane Polarised Light.

No. 117 SE3, 1152'

"Q.D., more altered and sheared".

MACRO. The rock is heavy. In colour it is a light milky blue-green, laced with other darker material. A schistosity is evident but not pronounced. Porphyroblasts are visible. The grain-size of the rest of the rock would seem to be extremely fine.

MICRO. (a) Fabric. The rock consists of a fine-grained shear-mass, with a few larger crystals. It is very similar to the pink porphyry (number 111), the chief difference being the greater amount of dark-coloured mineral.

(b) Minerals.

Felspar. This forms a couple of large phenocrysts; these are much clearer than those seen in number 111, but still liberally flecked with sericite; it also contains patches of chlorite and carbonate. There is a concentration of sericite outside the border of the grains. It lacks crystal form and twinning, and could possibly be a later development. It is biaxial +ve, with moderate 2v. The R.I. is slightly greater than balsam. It is therefore probably albite.

Sericite. This forms a fine even pattern of streaks across the remainder of the rock, and also occurs in minute flecks in the background.

Chlorite. This, sometimes together with the felspar, also forms lacey wisps running across the section.

Carbonate. This is observed, and with the chlorite felspar and sericite forms the very fine mass of the rock.

CONCLUSION. This rock gives no information on original texture. Its similarity to the pink porphyry is interesting. The chlorite is the main difference. Some felspar may be a later introduced material, or simply developed when conditions favoured it.

No. 119                SE3,   1248'

"Centre of small zone of porphyritisation".

MACRO. This is a fine, even-grained rock with occasional dark dots, and pasty-looking shear surfaces running throught it.

MICRO. (A) Fabric. The rock has large carbonate grains (up to .2 mm across) in a mass of fine material of average grain-size about .03 mm. A general schistosity is seen.

(B) Minerals.

Carbonate. This forms about 50% of the rock and occurs in large irregular grains.
small grains
veiny wisps

Quartz. This occurs in clear, more or less equidimensional grains up to .1 mm across, and is also prominent in the groundmass.

Sericite. This is also prominent in the groundmass, particularly along shears and veins.

Felspar. This occurs in relics, and a few decayed laths. There is possibly more hidden in the groundmass.

CONCLUSION. This porphyry is rich in carbonate but contains little felspar.

No. 132 SE3, 2420'

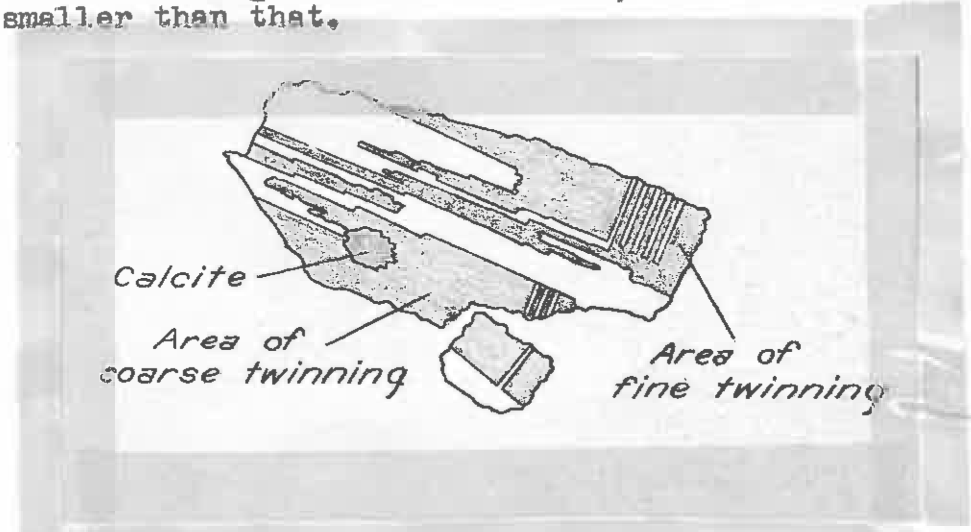
"Specimen in zone tending to Q.D. (from more "hybrid rock").

MACRO. This rock is a lighter grey colour. Schistosity shows and controls the fracturing, but is not marked. Porphyroblasts are present, but the general mass looks extremely fine-grained, and homogeneous.

MICRO. (A) Fabric. Between corssed nicols, more appears than might have been expected. The grain-size is small, grading down to indiscernable. However, schistosity and flecking of grains with sericite is not as pronounced.

(B) Minerals.
Felspar. This occurs in two forms again; whether these are an expression of the same mineral or not I don't know.

(a) Large crystals of felspar, well formed in some cases, are seen occasionally. These are up to 2 mm across. Twinning of various types is seen. A maximum extinction angle of 16° was read, but most were much smaller than that.




An interference figure of biaxial -ve with high 2v was confirmed. This should make the composition near the oligoclase - andesine border.

One or two crystals showed a stronger aggregation of sericite at their borders. The sericite veered around the felspar in its attempt to maintain the schistosity, but this is not general. A little clouding with sericite is seen.

(b) I am not completely sure that this second mineral

No. 132 (cont).

is a felspar. It occurs in the form of small chubby laths with a single twin plane. The largest symmetrical extinction angle is 13°. A consistent biaxial + ve interference figure was obtained. The single twin plane is not invariable; occasionally we get multiple twins. All laths are clouded with alteration mica, and the edges are not distinct. The laths may have been disturbed by later stresses, but they are not alligned. They are not extremely plentiful, being more prevalent in some parts of the rock than others, and constitute say 5% of the rock. The composition should be albite on the evidence. The form suggests that it is an original mineral, and of a hypabyssal or effusive rock.

Carbonate. This is quite plentiful, about 10-15%. It has no crystal form, occurring in irregular, rather clouded, and sometimes twinned grains. It is seen in, bordering, and possibly replacing the larger felspar crystals.

Sericite. This is again present throughout, but not so prominent.

Quartz. One large clear crystal of quartz is seen, of dimensions about 1 mm. It shows internal strain, and has relic bands of minute dark inclusions, a few fractures, and veins of small grains of later quartz. The boundary is clear cut, and has somewhat displaced a wisp of sericite. Quartz may also constitute a large part of the groundmass. The small grains of the groundmass are too minute to test, but constitute the major part of the rock, say 60%.

Other material (a) One or two grains of very low-birefringence mineral were seen. They are rather clear, possibly biaxial. It could be bastite as in number 111.

(b) One aggregate, consisting of a replacement by small quartz grains, with a core of calcite and a rim of iron staining, could represent the form of a pre-existing euhedral grain.

(c) Small traces of ferromagnesian are seen One is in the form of high birefringence and high R.I. rods, which is probably tremolite - actinolite. The other is in the form of structureless trains or blobs, greeny-brown in

No. 132 (cont).

colour, possibly a serpentine or chlorite mineral.

CONCLUSION. While certain characters of igneous effusive or hypabyssal characters are seen, there must have been considerable mineralogical reconstitution of this rock, with metasomatic introduction of at least carbonate, probably quartz, and possibly felspar. A feature is the inconspicuousness of ferromagnesians. The dark-colouration is apparently due to the carbonate and minute specks of iron ore.

No. 139 SE3, 3160'

"Fine, rather massive porphyry"

MACRO. This rock is a pink-grey colour, with no tendency to break parallel to a very poor schistosity. The graining in the rock can be seen; it is veined with darker material. It has a few crystals of sulphide, presumably pyrite.

MICRO. (A) Fabric. The rock is fine and even-grained. Schistosity is detected. Clear quartz forms diffuse veins; the grains in this are the only ones large enough for proper analyses.

(B) Minerals.

Carbonate. This predominates, forming say 45% of the rock. It is again irregular, not seen twinned, and is clouded and rather more intimately associated with sericite, which often borders it. The carbonate is seen veining the quartz, filling spaces between grains, etc.

Quartz. This occurs as meandering veins. It is recognised by its clear smooth appearance. It probably forms a considerable part of the general mass of the rock.

Felspar. This is suspected in the general mass, but cannot be resolved from the quartz.

Sericite. This once again liberally flecks the body of the rock.

Chlorite. This is minor, and, with iron ore stains, is the only ferromagnesian representative.

CONCLUSION. Igneous texture is not noticed. This is one of the albite porphyries, but albite is not prominent. Carbonate is the mineral which is responsible for the white appearance. Thus the rock could be an extreme case of a metasomatised greenstone.

No. 142 SE6 209'

"Heavy dark ultra-basic rock"

MACRO. This rock is heavy and composed of softish material, but is extremely tenuous. It is a dark green-grey colour. Schistosity is not apparent, but this piece of core shows a chlorite shear plane. Diffuse glints suggest the presence of some reasonably large crystals.

MICRO. (A) Fabric. The section is not well cut, it has spread while being covered. However, small areas are left to work on. The granularity indicated in the handspecimen is disappointing; everything is rather diffuse. It is a general felted mass of low grade ferromagnesian minerals.

(B) Minerals.

Tremolite. This mineral occurs plentifully in small rod-like fibres. The relief is high. Birefringence appears low on account of the small size of the fibres. The extinction angle is up to $20^\circ$. The grains are too small to give interference figures.

Talc. This mineral has a high birefringence; it also has high relief, which distinguishes it from sericite. It occurs in small lamellar flakes, which have parallel extinction. It rather tends to provide a groundmass for the rest of the minerals. The softness of the rock is attributed to this mineral.

Serophite. This dubious mineral had no noticeable structure. It has low relief ($n > $ balsam), and is near enough to isotropic. One larger grain was rimmed with iron ore.

Iron ore. This occurs in minute specs, probably ilmenite and very occasionally forms relic rims.

CONCLUSION. Relics are possible here; areas are seen to have simultaneous extinction, but they are too small and diffuse to mean anything. The rock is composed chiefly of basic material, all low grade and hydrated.

No. 143 SE6, 216'

"Heavy dark ultra-basic rock with actinolite".

MACRO. The rock is heavy, and in colour a dark grey with a green tinge. It is soft to scratch and soapy to feel, but extremely tenuous. Shining faces of mineral grains, were taken as actinolite in Kalgoorlie, show up well on the cut surface. The rest of the rock looks very fine-grained. Sulphide is noticed.

MICRO. (A) Fabric. The rock is fine-grained diffuse mixture of about three minerals, with other minor constituents. The only grains of notable size are carbonate, tremolite, and serophite (?).

(B) Minerals.

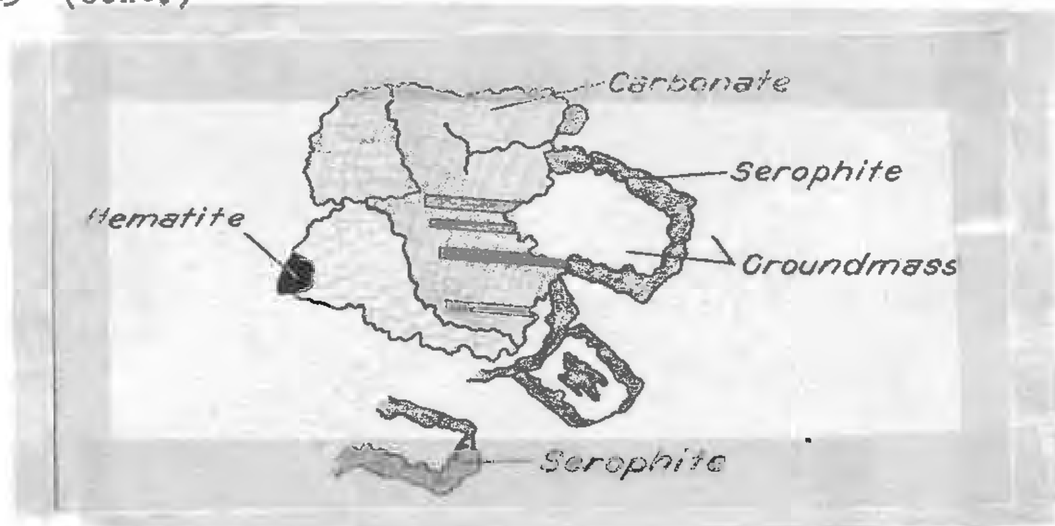
Talc. This mineral occurs plentifully in highly birefringent flakes, say comprising 20% of the rock. These flakes have parallel extinction, high relief (which changes on rotation, and high birefringence.

Tremolite. This has moderate birefringence, high relief (the RIs are greater than those of the talc. Its extinction is inclined at at least 12° to the length of the fibres. It occurs as a major part of the groundmass. in elongate grains, lath-like to fibrous. It also occurs as a pseudomorphing mineral. These pseudomorphs are irregular, and often enclosing, or encroached upon, by the groundmass. The pseudomorph consists of parallel fibres of this mineral, slightly ruptured, and with slightly varying extinction positions.

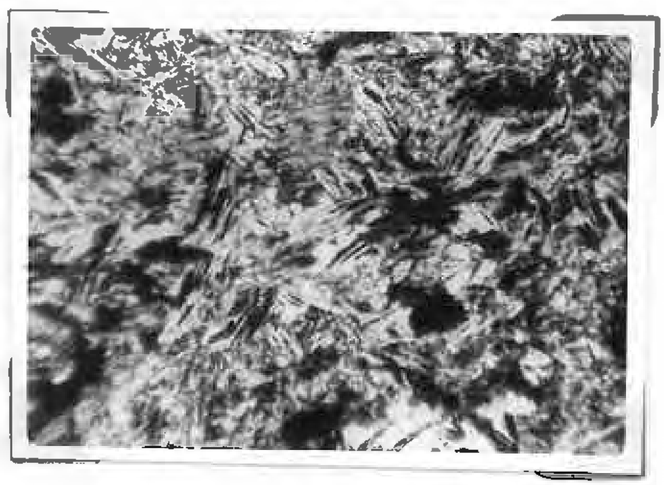
Bastite. This mineral has pleochroic inclusions alligned inside it so that they all are almost black parallel to the EW crosswire, and brown parallel to the NS crosswire. A more completely altered grain showed a pleochroism of its own from greenish (EW) to pinkish brown (NS). It has a very low DR. It is probably a serpentine such as bastite, slightly coloured by iron. Hence an original orthorhombic pyroxene is suspected.

Serophite (?). This mineral is not confirmed. It occurs in structureless smudges. Its most notably occurrence is in the form of bordering rims of relic crystals projecting from an area of calcite, and cored by material indistinguishable from the groundmass. This may be a relic ophitic or glomeroporphyritic aggregate, but I can't say what the original minerals were. The alleged serophite is light green, isotropic, structureless.

No. 143 (Cont.)




CONCLUSION. This is definitely a more basic rock. It tells little, rather disappointing considering the coarser granularity of the hand-specimen. The rock is definitely much more basic; we possibly once had a coarser grain here, with large orthorhombic pyroxenes in a possible ophitic texture.



X140 Nicols Crossed.

No. 144 SE6, 288'

"Dark ultra-basic rock with lighter band parallel to shear".

MACRO. This is a tough yet soapy-looking rock. Its colour is dark blue-grey. Glints of light on broken surfaces indicate crystal grains. Flecking by slightly lighter material is noted.

MICRO. (A) Fabric. This rock is extremely fine-grained. Some groups of grains form aggregates which are possibly altered and decayed remnants of former grains.

(B) Minerals.

Talc. This is quite prevalent in tufts. It has high birefringence, moderate to high relief, and parallel extinction.

Carbonate.

Chlorite. This has certain areas which are rather strongly pleochroic from brown to green.

Tremolite

Magnetite

CONCLUSION. A feature of this rock is the lack of schistosity in the sense of metamorphic lineation and foliation. This is at least one rock which does not fit the tectonic picture proposed. It is one of the most basic rocks examined, but shows little in the way of texture.

No. 146 SE6, 276'

"Talc actinolite ultra-basic rock".

MACRO. This is a hard dark rock with a rough fracture. Spots of lighter and darker material indicate a coarseness in texture, but the powdery look of the broken surface does not promise any very good crystallinity.

MICRO. (A) Fabric. The rock, after several failures, was cut rather thick. Hence it now appears as large grains (up to 3 mm) of various minerals all extremely clouded; it is possible that the whole rock consists of largish grains (say an average of 1mm) with a minimum of fine, interstitial material.

(B) Minerals.

Bastite. This mineral (unconfirmed) contains poikilitic inclusions, the shape of which is reminiscent of olivine, but they are altered to a tremolite mass.

Chlorite. The slightly pleochroic, chlorite of low birefringence also forms pseudomorphs enclosing olivine. This chlorite most nearly approximates prochlorite.

Carbonate. Occasional large grains of this are seen.
Ilmenite. This forms small trains of grains, and also larger (.1mm) grains tending to be euhedral.

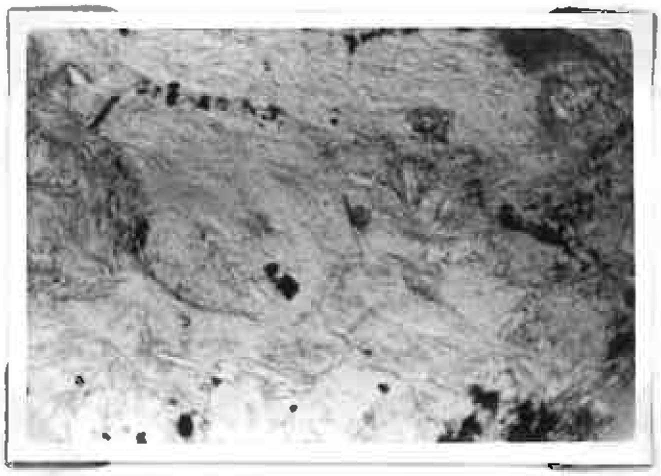
Biotite. Small highly cleaved, highly birefringent wads with high relief are presumeably biotite on their marked pleochroism in brown. It looks secondary.

Tremolite. This forms the body of the rock, but does not occur in large crystals. It is randomly orientated in fibrous form, even within pseudomorphs.

Talc and/or Felspar could constitute the indeterminate mass within some grains.

CONCLUSION. This rock is more basic, coarser grained, but highly altered. Poikilitic textures are possible, and an effusive origin is doubtful here.

No. 146 (cont.)



X140 Plane Polarised Light.

No. 147 SE6, 286'

"Dark ultra-basic rock with a band of albite spots".

MACRO. This is a dark soapy looking rock, but glints of crystal grains are seen on the broken surfaces.

MICRO. (A) Fabric. The rock is differentiated into areas rich in different minerals, but has the all-over general appearance of dull ferromagnesian material criss-crossed with fibres of higher relief tremolite.

(B) Minerals.

Tremolite ) These are the only minerals determined, but a
Carbonate ) possible similarity with number 526 in the mineral content is postulated.

CONCLUSION. Even if a better section were available it is doubted whether much could be seen. It is an extreme example of the indeterminateness of these rocks. The appearance of the coarser grain fading away into a finer grain makes me think that possibly fine-grained Q.D. rocks, such as Q.D.G., may have originated from such a parent.

No. 156 SE6, 430'

"Dark actinolitic rock tending to Q.D.A."

MACRO. This is a dark rock with possible amphibole crystals glistening in a dark grey-blue groundmass. Veining (by serpentine?) is noticed.

MICRO. (A) Fabric. This is afine flecked aggregate of small grains, with a couple of possible pseudomorphs.

(B) Minerals.
Tremolite. This occurs with occasional cross wads of biotite, and possibly pseudomorphs pre-existing amphibole, possibly hornblende.

Chlorite. Thisbis a very weak green colour, and is almost isotropic. It is structureless; it may be serophite.

Felspar. These are suspected but not seen in sufficiently large grains to confirm.

Sericite. Very fine flecks, presumably of this material, are seen.

CONCLUSION. Possible relic areas are seen. The rock lacks schistosity; it is very basic. However, it yields little information.

No. 159 SE6, 479'

"Rather messy Q.D. actinolite rock".

MACRO. A glassy, diffuse granular rock, this is crossed by veinlets and shears.

MICRO. (A) Fabric. The rock consists of highly flecked and altered grains up to ½ mm in diameter. To distinguish these from the groundmass becomes difficult.

(B) Minerals.

Tremolite. This occurs in diffuse grains and scattered fibres.

Felspars. These are ragged and cannot be determined. They look to be relics.

Chlorite. This is once again the weakly coloured, lowly birefringent material. It could be serophite (really a serpentine).

Sericite. Flecks of this are minor. It is not really definite whether this is really talc.

Zoisite. Very minute grains of this high relief material are seen scattered through the rock.

CONCLUSION. This rock supports the idea that coarse-grained rocks form fine-grained ones by a retrogressive process.

No. 169 SE6, 657'

"Tough talc actinolite rock".

MACRO. This is a lighter glassy to milky green-grey rock with a diffuse coarseness.

MICRO. (A) Fabric. Grains with indefinite borders are of up to .4mm in diameter, averaging say .1mm, with the finer particles down to about .02mm. Tremolite fibres etc are bent and a general shear foliation is followed.

(B) Minerals.

Felspar. This is inthe form of altering laths. The laths have a chubby shape. Poor polysynthetic twinning was observed. The extinction angle is not reliable but was 12° to the left and 4° to the right. A biaxial positive figure was obtained.

Tremolite occurs in the form of bunches of fibres, sometimes bent. It looks like an alteration product.

Calcite. This is definitely a later mineral. It occurs in irregular blebs, especially in conjunction with tremolite.

CONCLUSION. This rock shows a stage in the alteration of a coarse rock to a finer, bleached type. The original rock may have been igneous or it may have been a metamorphic amphibolite.

X140 Nicols crossed.

No. 171 SE6, 733'

"Albitic(?) actinolite rock".

MACRO. A heavy rock with mottled texture, due to the spreading apart of the greenish material by whitish material.

MICRO. (A) Fabric. This rock consists of fat crystals of tremolite and more elongate laths of saussurite. The tremolite crystals are somtimes over 1mm long. The saussarite tends to be more euhedral, but smaller, and often appears to be poikilitically enclosed by, or ophitically intruding on the tremolite.

(B) Minerals.

Tremolite. This is the chief mineral. It occurs in large grains, sometimes with residual spots of hornblende.

Saussurite. This dull material consists chiefly of clinozoisite. This is what appears white in the hand specimen.

Clinozoisite. One or two larger grains, separate from the saussarite, are noticed.

Quartz. A clear interstitial grain of quartz was recognised.

Ilmenite. One or two grains nearly completely altered to leucoxene were noted.

CONCLUSION. The rock has well-preserved pseudomorphic relations of one-time hornblende and plagioclase. It appears to a coarser effusive of a doleritic type.

X140 Plane Polarised Light.

No. 181 SE6, 880'

"Typical of the albitisation which is evident here over 20-30'".

MACRO. This rock is very solid, and is lighter in colour, due to the dispersion of the dark green mass by white material.

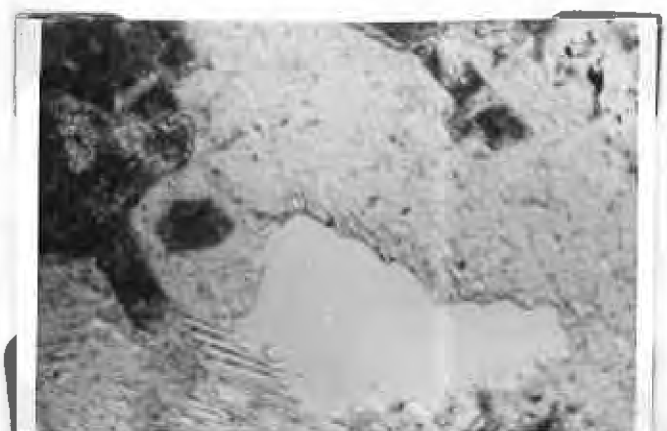
MICRO. (A) Fabric. This rock is relatively coarse with grains up to .5mm long. The texture is interesting. It consists of small laths (say 5) (say 50%), and bigger, more equidimensional grains of amphibole. The relations between the felspar and amphibole are not suggestive of very great rearrangement. It could be a slight disruption of the texture of an igneous rock.

(B) Minerals.
Tremolite. This mineral occurs in large grains, sometimes looking like the direct alteration of higher grade ferromagnesians. It is almost colourless, has well-inclined extinction (about 10°). Its birefringence is moderate; it has a high axial angle, and -ve sign.

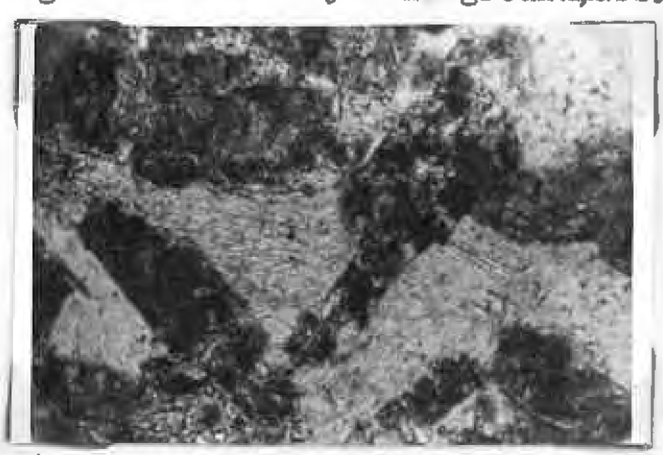
Felspar. The other chief mineral, this forms well shaped laths, and is so saussuritised as to be indeterminable, in fact opaque. The laths are distributed in a way suggesting a fine dolerite or basalt. A notable feature is that what looks like albite in macroscopic examination is definitely not a new mineral, but an altered original felspar of unknown composition.

Groundmass. Areas of very fine indeterminate felted amphibole and felspar are very reminiscent of Q.D.G.

CONCLUSION. This rock lacks quartz, calcite, and introduced felspar. Its chief difference from Q.D.G. is that in certain areas of coarser texture is evident. The rock is regarded as of extrusive igneous origin, with some porphyritic grains in a very fine groundmass.



X140 Plane Polarised Light



X140 Plane Polarised Light.

No. 187 SE6, 991'

"Isolated fairly typical Q.D.G. in Q.D.A."

MACRO. This is an even-grained rock with a fine diffuse-looking texture. It is a khaki-green-grey in colour, and has white shear-bands of carbonate.

MICRO. (A) Fabric. The rock is fine-grained. The grain-size ranges from .05 to .2mm, with an occasional large grain or relic. The general indeterminateness is enhanced by the carbonate.

(B) Minerals. These are hard to resolve, as the section is a bit thick, and overlapping and invasion of grains is rife.

Carbonate. This is the chief constituent, occurring in both large and small grains.

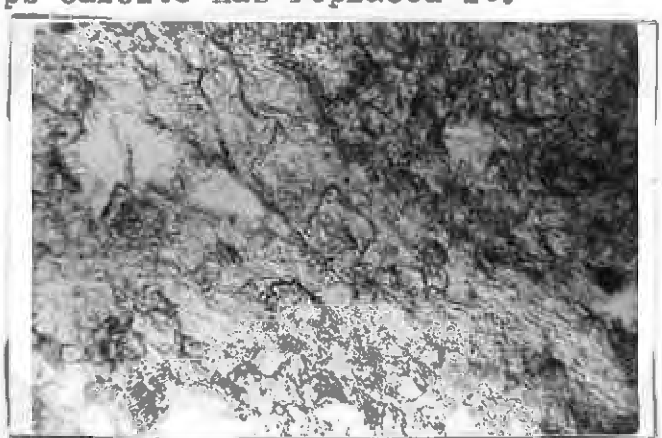
Quartz. This is rather common in randomly distributed clear grains.

Tremolite. Tremolite occurs in larger crystals with frayed outlines.

Epidote. This is strongly coloured (orange) and commonly occurs in conjunction with carbonate in alteration aggregates.

Felspar. Relics of this are postulated. One quite large area could not be determined. Small felspar relics no doubt constitute an appreciable part of the fine ground-mass.

CONCLUSION. This section gives no clue to the origin of the rock. Subsequent alteration and carbonatisation have occurred. A feature is the lack of coloured chlorite. Perhaps calcite has replaced it.



X140 Plane Polarised Light.

No. 191 SE6, 1177'

"Even-grained Q.D.A".

MACRO. A hard dark-grey rock with a tendency to coarser texture but not granularity. This is on account of whitish flecks in a green-grey mass. Sulphide is seen.

MICRO. (A) Fabric. The rock consists chiefly of carbonate in clusters of minute (.05mm) grains, which, together with sericite, obliterate the lowly birefringent mineral which tend to form a background granularity.

(B) Minerals.

Felspar. This occurs in small to larger decayed grains. No really satisfactory interference figures were obtained, but a negative sign was found several times. Therefore, I suspect oligoclase or andesine.

Chlorite. This is abundant in minute flecks. It has a very weak green colour.

Carbonate. This mineral is the only one to show up well. It is a major constituent.

Sericite. This is present in characteristic flecks

Biotite. One minute wad of strongly pleochroic biotite was seen.

Ilmenite. This occurs not noticeably altered to, leucoxene.

CONCLUSION. There are no relic textures and the rock is not really much help at all.

No. 202 SE6, 1597'

"Q.D.A. with kaolinised felspar".

MACRO. This is a coarse rock consisting of dull grey areas interspersed with a speckly mass of whitish, black, and epidotic - coloured grains.

MICRO. (A) Fabric. The rock consists of large areas of tremolite-chlorite with various other materials set randomly, and usually as poorly-defined grains, in it.

(B) Minerals

Tremolite. This mineral, apart from being associated with the chlorite, has a slight green-brown colour of its own, and may tend to actinolite.

Saussurite. This possibly shows part of the original form here and there; it occasionally gives way to recognisable Epidote and Zoisite.

Chlorite. This is slightly pleochroic in green. It seems to be forming directly as the alteration of tremolite.

Leucoxene. This occurs in grains up to .2mm in diameter, and sometimes contains relics of ilmenite.

Carbonate )
Quartz ) These occur in minor amounts.

CONCLUSION. Original ophitic to poikilitic inclusions of felspar in the ferromagnesians could be imagined; the rock may have been recrystallised before the retrogressive alteration phase.

No. 208 SE6, 1751'

"Dark diffuse Q.D. with spots of white material".

MACRO. A dark blue-grey turbid rock, this has greener epidotic-coloured areas, and flecks of very white leucoxene.

MICRO. (A) Fabric. A highly disturbed mass of minerals is seen. A shear direction is noticeable. The tremolite forms decayed grains up to .8mm long, and felspar remnants may exist in the clouded remainder of the section.

(B) Minerals.
Tremolite. This occurs in large grains with some hornblende residuals. It also occurs in small needles in the groundmass.
Felspar. This is hard to distinguish from some of the lower birefringence sections of tremolite, except where the R.I. can be compared to balsam. Faded suggestions of twinning are seen.

Epidote. This occurs sparsely in irregular clusters.
Carbonate. This is a minor constituent, occurring in small irregular grains in runs along the shear direction.
Chlorite, This has a very weak green colour here. It occurs throughout the mass, chiefly as an alteration of tremolite, I think.

Quartz. This is minor. A few small single grains and clusters of grains are seen.

Ilmenite. This is seen altering to smooth white leucoxene. It tends to be associated with epidote.

CONCLUSION. It looks to me that this rock is in a stage of retrogressive alteration from a rock consisting chiefly of hornblende and felspar. The observations of this section can be used to support the hypothesis that the retrogressive alteration (chloritisation, carbonatisation, etc) causes the coarser-grained original rock to become fine-grained in the greenstone stage.

No. 217 SE6, 2148'

"Q.D. with leucoxene".

MACRO. A coarse almost gneissose structure with tendency to granularity is seen. Whiter bands are noted, and leucoxene is prevalent.

MICRO. (A) Fabric. Clusters of carbonate (individual grains up to .8mm across) are seen to peter out into an extremely fine rock mass.

(B) Minerals.

Carbonate. This is predominant in large twinned grains. I cannot detect any pseudomorphism; rather the feature is the irregular and decayed form of the grains.

Chlorite. This occurs in large shapeless masses and clusters along the shear directions. It is a darker green, weakly pleochroic, and almost isotropic, and agrees best with prochlorite.

Felspar. Larger, but extremely faded and dissipated felspar grains give varying optic signs. The R.I. is greater than balsam. It could be oligoclase.

Quartz. Very small quartz grains are detected in the groundmass by their smooth clear appearance.

Leucoxene. This is quite prominent, and shows good structural relics after ilmenite.

CONCLUSION. This would be Q.D.G. It once again shows a chlorite nature, and shows a likeness to the porphyry.

No. 219 SE6, 2156'

"Porphyritised Q.D.".

MACRO. This is a lighter coloured rock consisting of green splinters and wisps in a pinked grey-white groundmass. Sulphide is present.

MICRO. (A) Fabric. This rock consists of large grains of felspar in a typical fine greenstone groundmass.

(B) Minerals.
Felspar. This forms the chief part of the rock, being present in large grains up to 2mm across.

Some grains of felspar are equidimensional, irregular in outline, and untwinned.

Some are twinned and tend to be euhedral.
Some tend to lath-shapes.

The extinction angle goes up to 18; the character is biaxial + ve, with a large axial angle. The R.Is are very close to the balsam, possibly one above and one below.

The mineral tends to be altered, spotted, invaded, and generally made irregular by carbonate. Its composition should be albite.

Calcite. This occurs in small euhedral crystals in the background, and invading the felspar.

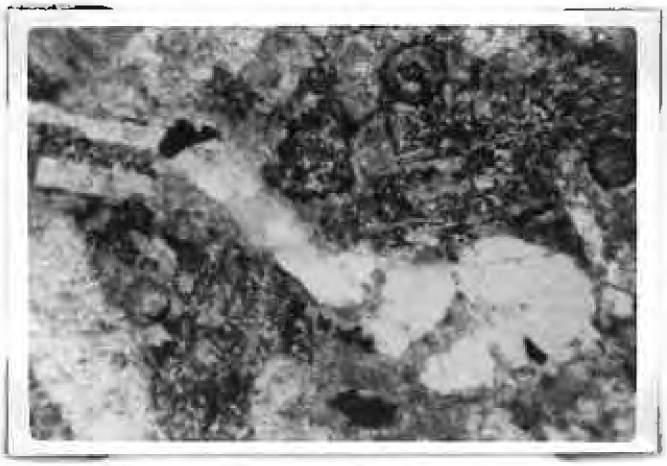
Chlorite. This is present in considerable amounts, usually aggregated in certain areas, sometimes surrounding a particular albite crystal. It looks more micaceous here, and its properties -

pleochroism - brownish to green.
birefringence - anomalous Berlin Blue.

- agree best with pennine. This mineral has been reported at Kalgoorlie, but is supposed to be formed from the alteration of garnet.
Ilmenite. This is also present.

CONCLUSION. There is little doubt that albite has been introduced here, at some atage before the carbonate. Residuals of ferromagnesians, in the form of ilmenite and chlorite, show that the process is probably the alteration of a basic rock.

No. 219 (cont).        SE6,        2156'



X140        Nicols Crossed.

No. 227 SE6, 2411'

"Partially porphyritised Q.D.".

MACRO. This is a hard, blue-grey rock with a coarsish but not granular appearance. Whitish slithers in a green mass are observed; pyrite, and possible leucoxene, are seen.

MICRO. (A) Fabric. The texture is fine and indeterminate, with largish (up to .4mm) carbonate grains set in a groundmass of fine quartz felspar and chlorite.

(B) Minerals.
Carbonate. This occurs in largish grains, and also as minute spots in the groundmass.

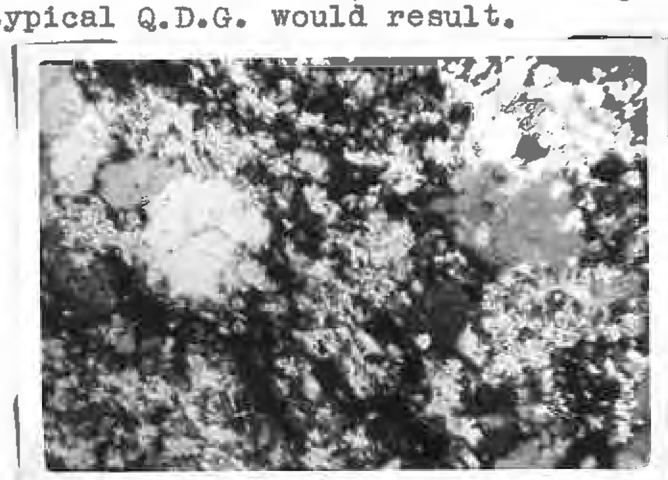
Chlorite. This is the browner variety agreeing more closely with pennine.

Quartz. This is distinguished in the groundmass by its smooth transparency.

Felspar. Relic spots which look most like the decayed felspar in othe rocks are seen in the groundmass.

Ilmenite. This is again observed altering to leucoxene.

CONCLUSION. The alteration, which was called porphyritisation, is observed to be only carbonate enrichment. It could well be imagined that if this rock were a little more altered, and then slightly crushed, typical Q.D.G. would result.



X140 Nicols Crossed.

No. 229 SE6, 2485'

"Albitised Q.D."

MACRO. This is a hard grey rock with epidote green areas mottled amongst white and grey. Sulphide is observed, and leucoxene is plentiful.

MICRO. (A) Fabric. Predominent saussurite pseudomorphs are set in a base of chlorite and fibrous amphibole.

(B) Minerals.
Saussurite. This consists chiefly of epidote with some zoisite.
Some epidotes are larger and pleochroic.

Quartz. This occurs in large composite grains and in large composite grains and clusters.

Amphibole. This occurs in fibrous radiating crystals.

It is very similar to tremolite but has parallel extinction.

Chlorite. This is the more strongly pleochroic variety, going from brown to green, and agrees best with pennine.

Ilmenite, is seen altering to and associated with leucoxene.

CONCLUSION. The relic fabric of the felspar is interesting, but it is impossible to say anything about the nature and habit of the other material.

No. 272 SE6, 3463'

"Uniform grey-grain Q.D. with laths of felspar".

MACRO. This has a dark green mass, in which white blury laths are contrasted.

MICRO. (A) Fabric. The rock contains large grains and laths up to 3mm long, possibly in an intersertal texture with a minimum of interstitial material. However it is all very speckled and retrograded now.

(B) Minerals.

Epidote. This is the most striking mineral, It occurs in veins and in the body of certain alteration laths. These laths are rimmed by felspar and the interiors occupied by epidote, clinozoisite, chlorite, and quartz.

Clinozoisite. This is distinguished by its anomalous low birefringence, and forms the fine, indeterminate masses of dull-looking saussurite which paradoxially look white in reflected light.

Tremolite. This is prominent, forming pseudomorphs with residual spots of hornblende in them.

Quartz. This occurs in irregular but fractured grains. It is seen to contain inclusions.

Chlorite. This is more strongly pleochroic here, in green to browny green. It is possibly an iron rich prochlorite.

Felspar. Felspar is postulated, but it is not distinguished.

Ilmenite. This occurs, but it is always partially to completely altered to leucoxene, leaving structural relics in the leucoxene.

CONCLUSION. Many minerals are present, and the rock has been a coarser type. Albite has not been introduced; in fact albite is lacking, and a more calcic plagioclase is seen in a highly saussuritised state. The coarseness could indicate a recrystallisation into a felspar hornblende amphibole at some s tage in the history of this rock.

No. 283 SE6, 3824'

"Q.D.G., (Typical?)".

MACRO. A hard even-grained dark rock with slightly epidotic colouration. Black spots, and sulphide are seen.

MICRO. (A) Fabric. The rock has, on a superficial scale a coarser texture, but all larger areas of mineral are dissected and decayed by other mineral.

(B) Minerals.

Chlorite. This fits the properties of prochlorite best, though not very well, and it could be a serpentine mineral such as serophite. The chlorite with zoisite forms some direct pseudomorphs of an elongate mineral.

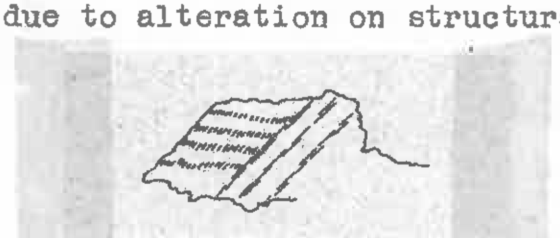
Epidote. This is observed chiefly with chlorite as an alteration, but also scattered and in clusters.

Felspar. Areas of what looks like one-time felspar are seen as granular carbonate plus minute felspar.

Quartz. This is present in clear interstitial grains.

Amphibole. This is recognised by one cross-section showing cleavage, but is rare.

Ilmenite & Leucoxene. The ilmenite is not in scattered alteration grains but rather in large (up to 1.5 mm) euhedral grains showing square and triangular outlines. It is often altered to a white coating of leucoxene. A structure in this leucoxene is seen in one place, possibly due to alteration on structural planes of the ilmenite.



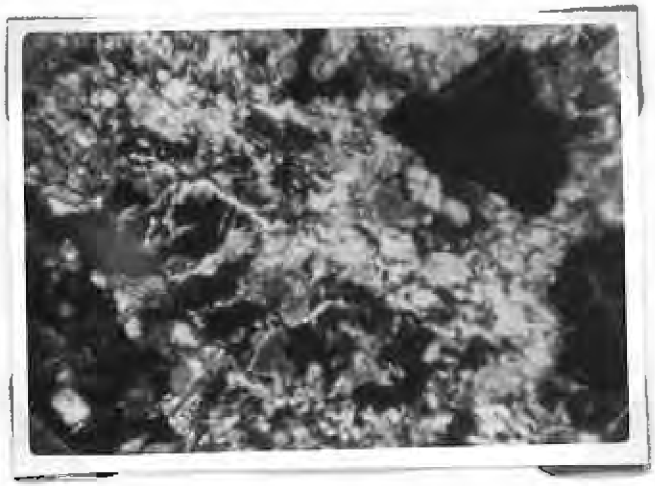
This may be the origin of the skeletal leucoxene in the Q.D.G.

CONCLUSION. The rock may be looked at in a broad way as having once consisted of interlocking grains of felspar and ferromagnesians, up to 2mm long, with the possibility of interstitial groundmass. Quartz and ilmenite may

No. 283 (cont).

have been resolved at some stage, or, more unlikely, introduced.

This rock could be a partially carbonatised and chloritised equivalent of Q.D.G., and hence could be considered as a parent of Q.D.G. It should not be Q.D.C. itself on account of the fact that both chlorite & amphibole
leucoxene & ilmenite.
and only a sprinkling of calcite are present.



X140 Nicols Crossed

X140 Plane Polarised Light

No. 284 SE6, 3872'

"Epidotic mineralised Q.D.".

MACRO. This is a brittle, heavy, fine dark rock with schistose appearance. Epidotic colouring and sulphide are observed.

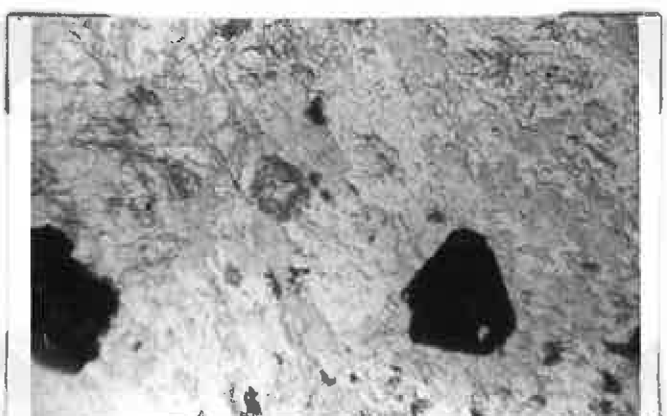
MICRO. (A) Fabric. This rock has few textural relics as seen in number 283; a few relic laths consisting now of chlorite and epidote are found. It is probably a further alteration of the type of number 283.

(B) Minerals.

Chlorite. This agrees best with prochlorite.
Epidote.
Quartz.
Ilmenite - leucoxene
Calcite
Pyrite.

CONCLUSION. The chief differences between this rock and number 283 are that this rock has
(1) more quartz
(2) no visible felspar.
(3) calcite in more obvious traces
(4) more frequent and more obvious alteration of ilmenite to leucoxene, again on structural planes.

All these features agree with the idea of further alteration.



X140 Plane Polarised Light

No. 312 SE7, 673'

"Calc Schist".

MACRO. The rock is typical light-grey calc schist with dark veiny shear-fractures.

MICRO. (A) Fabric. This is a very fine-grained rock with a definite lineate structure shown chiefly by carbonate. The largest grains (of carbonate) would be about 1mm across, and all others would average in the order of .01 mm.

(B) Minerals.
Carbonate. This occurs as large grains and in strings following the shear-direction. It also occurs amongst the finer material of the groundmass.

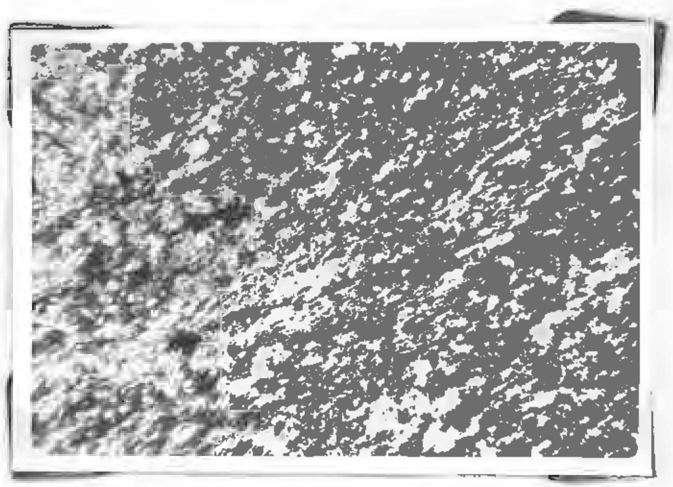
Quartz. This is recognised by its smooth clearness; although it only occurs in minute grains.

Felspar. This is suspected to be an important constituent of the fine indeterminate groundmass.

Iron ore. This is noticed in minute amounts. The colour of the rock must be due to this and the carbonate, as coloured chlorite is not noticed.

CONCLUSION. This is taken as an example of what subsequent alteration produces from an e xtremely fine-grained rock.

X140 Plane polarised Light



X140 Nicols Crossed.

No. 323 SE7, 1271'

"Black Flag sediment, showing bedding".

MACRO. This is a highly banded specimen, having white and dark bands ranging from a fraction of a millimetre to about 5 mm thick. Metallic looking grains are noticed.

MICRO. (A) Fabric. The rock is again extremely fine-grained. Sedimentary evidence is not noted. The planar element appears to be due to shearing, giving lenses of groundmass between layers of powdered magnetite. Apart from this, the texture looks extremely like that of the fine-grained greenstones.

(B) Minerals.
The largest grains are of magnetite or ilmenite, and calcite. These are set in a fine groundmass of felspar, calcite and epidote (or zoisite).

CONCLUSION. A feature of this rock is its similarity to calc schist. The lighter and darker bands are due to the presence or absence of fine powdered iron ore.

No. 328 SE7, 1415'

"Q.D. at the immediate lower contact of porphyry".

MACRO. This is a very fine even-grained grey rock with carbonate veins and a little sulphide.

MICRO. (A) Fabric. Very small irregular carbonate granules (about .1mm average diameter) are scattered thickly through a much finer mass.

(B) Minerals.

Carbonate.
Quartz.
Chlorite. This is quite strongly pleochroic in green.
Sericite. This is a minor constituent, flecking all else.

} These constitute the ground-mass.

Ilmenite. This is prevalent in grains averaging .02 mm diameter. It is frequently altering to leucoxene.

CONCLUSION. No evidence of origin is provided by this section, unless we take the present grain-size as indicative of a very fine-grained original rock.

No. 338 SE7, 1722'

"Actinolite Q.D; looks like serpentinous talcose stuff from the top of SE6".

MACRO. This is a coarse-textured rock with very dark areas set in lighter speckled material. Possible leucoxene, and some sulphide, is present.

MICRO. (A) Fabric. The fabric is of a more coarse rock, with grains showing continuity up to 1mm. However, all grains are partially altered, frayed at the edges, and lack distinct boundaries. There is a wealth of ferromagnesian minerals.

(B) Minerals.
Amphibole. The amphibole is of two types one strongly pleochroic in blues and greens, and is probably hornblende. The other is colourless and is tremolite.

Bastite. A grain showing schiller structure, and with a biaxial - ve optical character, is put down as this variety of serpentine. The grain is not very clear. It could be original hypersthene as it has a slight pleochroism from green to pink.

Chlorite. This green material has a biaxial + ve character, and is suspected to be clinochore.

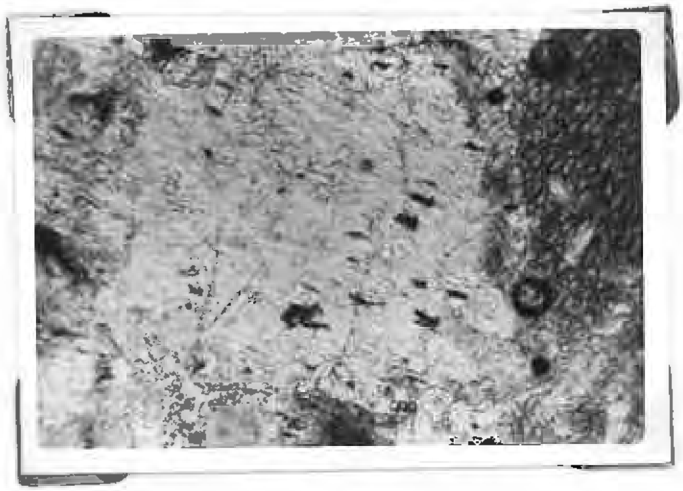
Felspar. Certain very murky lath-shaped areas are most probably altered felspar. They include euhedral but small grains of presumed pyroxene.

Laths of felspar with lamellar twins are seen, and have a biaxial - ve optical character. Extinction angles of about $10^{\circ}$ are read, but are not very reliable, as symmetrical extinction could not be obtained. However, I call this felspar andesine-labradorite as an approximation. Freshher untwinned grains gave biaxial + ve figures, and are most likely albite.

Epidote and Zoisite are both found.

CONCLUSION. Relic structures occur in this rock; there is a possible poikilitic inclusion in one felspar, but on a very small scale. This could be imagined as an original effusive with a few more porphyritic crystals than usual. No traces of olivine are observed, but pyroxene or an alteration of it occurs as the cores of grains of amphibole.

No. 338 (cont)



X140 Nicols Crossed

X140 Plane Polarised Light.

No. 339 SE7, 1730'

"Coarse actinolite Q.D.".

MACRO. This is a coarse-textured rock consisting of dark blue-grey areas, lighter areas with epidote-coloured grains, and very white leucoxene grains. Sulphide is observed.

MICRO. (A) Fabric. Large grains up to 2 mm long of ferromagnesian alteration products are seen to be rather ragged and decayed, and constitute a considerable portion of the rock. They sit randomly in a fine mass whose chief recognisable constituent is saussurite laths, up to .5mm long and averaging .3mm.

(B) Minerals.

Tremolite. This occurs in large grains, rather ragged. In spots it is a green colour and pleochroic. Here the composition must approach actinolite. Twinning is seen in one large grain in a direction at an angle to alteration lines.

Chlorite. This green mineral could as easily be a serpentine mineral. It occurs at the cores of grains of tremolite. Occasionally it occurs as rims or grains surrounded by chrysotile. It is pleochroic to a browner colour, and has a very low birefringence.

Epidote. This occurs in the saussurite, and also as larger individual grains (up to 1 mm diameter).

Carbonate ) These are observed in very insignificant
Quartz ) amounts on careful examination.
Felspar. Residuals of this are suspected in the groundmass.

CONCLUSION. The section seen, although poor, possibly gives a picture of the original rock. Ferromagnesians, including possible orthorhombic pyroxenes may have been set in a groundmass containing smaller felspar laths, and microlites, grading down to glass.

No. 344 SE7, 2044'

"Porphyry with Q.D. remnants".

MACRO. This is a more brittle rock, grey in colour, with blue-green streaks running through whiter material. Sulphides are noticed.

MICRO. (A) Fabric. The section is thick, but shows only a stretched out mass of chlorite-rich and carbonate-rich area with occasional grains of other material.

(B) Minerals.

Carbonate. This is the chief mineral; it occurs in largish, badly defined grains tending to join up and continue over large areas.

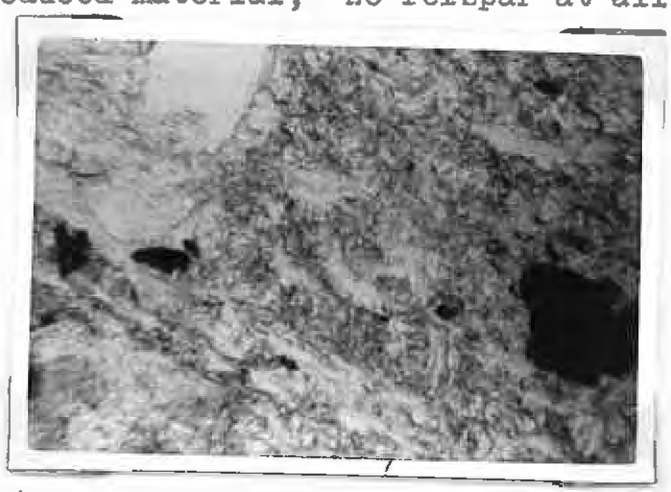
Chlorite. This is quite strongly pleochroic from dark green to olive-green. It has low birefringence. It occurs in small grains constituting sheared-out clusters.

Quartz. This occurs in largish (up to .5mm across) grains, clearer, but with minor inclusions, sometimes of apatite needles.

Sericite. This occurs in small clusters and throughout the more indeterminate mass as a minor constituent.

Ilmenite. This is seen; in one place it is altered to leucoxene and invaded by sulphide.

CONCLUSION. The carbonate and chlorite together form possible pseudomorphs of laths. A feature of this "porphyry" rock is that carbonate and not felspar is the chief introduced material; no felspar at all was observed.



X140 Plane Polarised Light.

No. 517 Location Preseverence Mine, 1900' Level, BH1892, 71'6"

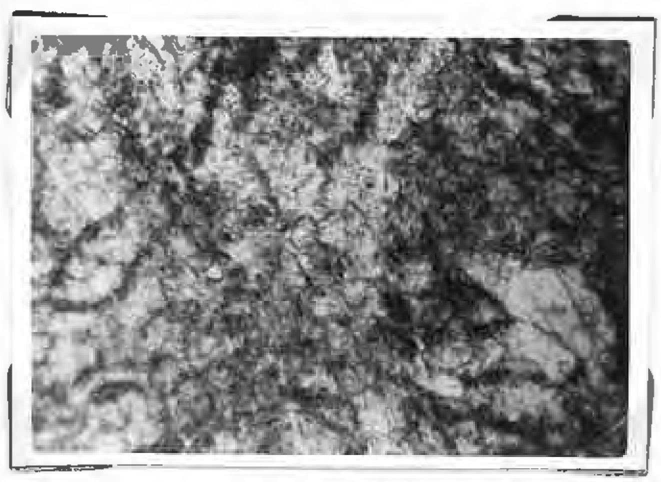
"Mine Q.D.G".

MACRO. This is a lighter-coloured rock with large whitish elongated areas in a fine green mass. Leucoxene is abundant.

MICRO. (A) Fabric. Shadowy relics of a pre-existing fabric are seen, but the rock is very fine-grained, with a shear direction noticeable.

(B) Minerals.
Carbonate - abundant
Chlorite. This more strongly pleochroic. It may be prochlorite.
Quartz.
Sericite. This is in its usual habit of small micaceous flecks.
Ilmenite. This is altering to leucoxene. Residuals of ilmenite are seen within the leucoxene.

CONCLUSION. This section reveals little beyond what is observed in the hand specimen.



X140 Plane Polarised Light.

No. 519 SE4, 2126'

"Typical basic dyke".

MACRO. This is a uniform-textured rock, a dull-glassy pink-grey colour, with spots of greenish material in a shear grain.

MICRO. (A) Fabric. The rock is fine-grained (averaging in the order of .01mm), with larger carbonate grains (up to .2mm). Occasionally a patch of chlorite or a cluster of quartz is seen lensed into the shear grain.

(B) Minerals.

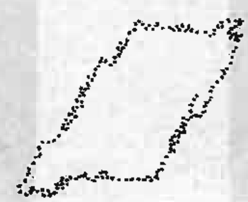
Carbonate. This is liberally dispersed through the rock in large and small grains.

Chlorite. This is dispersed through the rock and also occurs concentrated in spots where it is seen to be strongly pleochroic from green to light greeny-brown. Its extinction is nearly parallel, birefringence is weak, and R.I. just above balsam. It looks to be nearly isotropic and agrees best with pennine. In certain clumps it tends to be associated with quartz, carbonate, ilmenite, and an occasional grain of muscovite.

Quartz. This occurs in small clusters of clear grains.

Muscovite. This is occasionally noticed in chlorite clumps or along shear-lines.

Ilmenite. This occurs in small to larger, sometimes subhedral grains. Sometimes strings of this outline decayed and otherwise obliterated crystals.



Groundmass. This is probably a fine-grained equivalent of the discernible minerals, with carbonate and chlorite predominating, and possibly some very diffuse felspar.

CONCLUSION. This is a carbonate-rich rock, in all probability a metasomatised greenstone. The lack of obvious felspar is a feature.

No. 526 Location . A few Yards north of Mt. Hunt Trig Point

"Dark blue basaltic-looking greenstone".

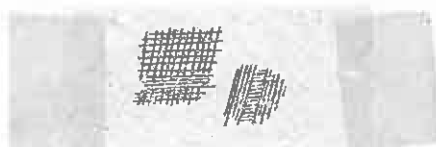
MACRO. This is a hard darkish blue-grey rock; small glistening spots indicate the presence of crystals, but the cut surface shows a milky appearance.

MICRO. (A) Fabric. The rock has a most peculiar fabric of long clear stripes of material triangularly criss - crossing irregular darkish areas, with lighter areas indispersed. The rock is traversed by thin veins of a clear composite material.

(B) Minerals. These are rather hard to resolve.

Zoisite is obvious on account of its high relief and deep blue interference colours.

Ferromagnesian. This is a darkish pleochroic material, witha cleavage, to which extinction is parallel in an undulose fashion. A biaxial -ve interference figure was obtained. It has a woven structure like a mat.



It seems to grade into tremolite in places. Therefore I imagine it to be a jade material.

Clear areas. These are seen to consist of zoisite together with another isotropic mineral of low relief, possibly a colourless serpentine.

Quartz. Two decayed - looking quartz grains surrounded by small zoisites seemed to pseudomorph a pre-existing mineral. I cannot say which mineral is doing the replacing; probably the two arose simultaneously from the destruction of felspar.

CONCLUSION. This interesting rock could possibly yield more if properly understood. I see alteration of felspar in a peculiar mass of material, chiefly ferromagnesian, much altered from its original state, no doubt. Possible ophitic relations are seen (see photo). Thus the rock could have been once doleritic or basaltic.

No. 527 Location 50 yds. North-east of Mt. Hunt Trig Point.

"Dark blue-grey rock with a wealth of actinolite needles".

MACRO. This is a dense fine glassy rock with various shades of green material discernible, and in the right light, needles of dark mineral are seen.

MICRO. (A) Fabric. Randomly oriented needular laths and other more rounded and decayed crystals are set randomly in a fine-grained mass. The texture looks basaltic to doleritic except that the laths are not felspar.

(B) Minerals. This occurs in long randomly oriented needles, and also in smaller clumps of fibres. Alteration of hornblende or pyroxene is suggested in parts.

Sericite. This occurs occasionally in small clusters.

Quartz. A few small clear grains were distinguished.

Epidote. Very small grains of this high relief material were observed.

Groundmass. Other material than the tremolite can rarely be resolved from the groundmass, which constitutes the major part of the rock.

CONCLUSION. This looks a typical slightly altered fine-grained basic igneous rock. A higher grade of alteration is suggested by the occurrence of tremolite rather than chlorite.

No. 529 Location 16310S, 25320W (Southend)

"Coarse-grained actinolite rock".

MACRO. The rock is hard and dark and looks to be composed almost entirely of dark shiny grains, with possibly some small specks of leucoxene.

MICRO. (A) Fabric. The section is very thin and nearly all lost. However the appearance under the microscope confirms the macroscopic description, except that felspar is observed.

(B) Minerals.

Tremolite. This occurs in ragged grains, the biggest being ,88mm long.

Zoisite. This is seen in minute grains (.01mm across) within the tremolite.

Felspar. Grains over 1mm long are seen. They are only recognised by the twinning, as the tremolite and other alteration has so clouded the grains. The twinning gives extinction angles of up to 12° symmetrically. A good interference figure was obtained which gave 2v about 80°, and a -ve sign. The R.I. was almost indistinguishable from that of balsam. Its composition should therefore be on the oligoclase - andesine, border. As this section is cut very thin a peculiar alteration forming a crisscross structure like that in number 526 (but not as pronounced) is seen.

CONCLUSION. The rock looks far from igneous. It may have undergone radical textural reconstitution during its history.

No. 540 Location. Knob 11,730W, 26,760S (South End)

"Highly carbonated greenstone".

MACRO. The rock is composed of a brown resistant carbonate and a softer white carbonate, both coarsely crystalline.

MICRO. (A) Fabric. A coarse aggregate of grains, which are individually continuous up to 1mm, is seen. Grains sometimes have straight boundaries and sometimes irregular ones. There are also areas of finer interlaced composite material.

(B) Minerals.

Carbonates. The two carbonates are not distinguished under the microscope. An xray was done of each, and by Mr. N. Markham, and the composition of the darker one was found to be $(FeMg)CO_3$ with Fe:Mg about 1:1. The lighter one was found to be $(C2FeMg)CO_3$ with Ca:Fe:Mg about 1:1:1.

The grains are well cleaved and continuous for up to 1mm. Some have slightly opened cleavages filled with brown iron stains.

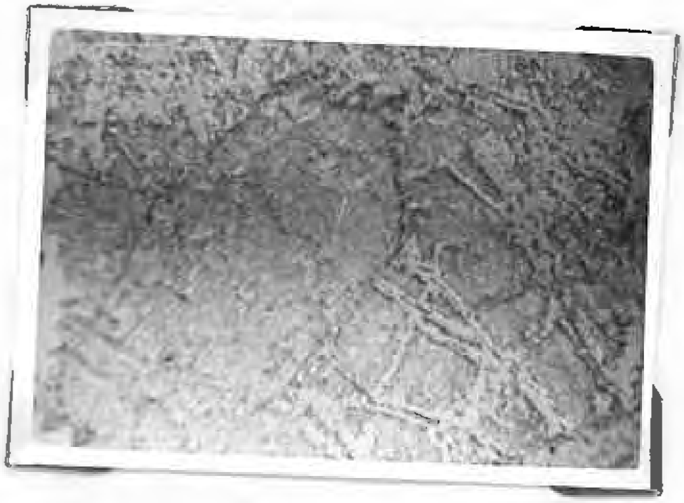
Felspar. This mineral, although subordinate, occurs in large clear grains (up to .8mm across). It is twinned on the albite law. Extinction angles up to $8^o$ were read. The R.Is are very near balsam. The optical character is biaxial +ve. It should be albite. It is noticed to have a ragged contact with the carbonate. These may have originated almost contemporaneously with a slight tendency of one to replace the other.

Quartz. One or two minor grains of this were observed pretty definitely, but not confirmed.

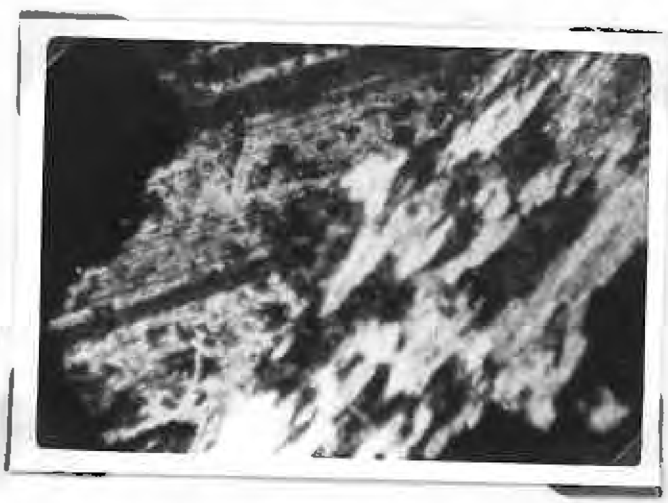
Sericite. Certain areas of exceedingly fine-grained mateial consists chiefly of this.

CONCLUSION. This has no trace of greenstone character. It is therefore either a more highly metasomatised greenstone than any other observed, or it is an intrusive. It has the composition of what I imagine has been added to a lot of rocks in Kalgoorlie to form the greenstones and "porphyries".

No. 540 (cont).



X140 Plane Polarised Light



X140 Nicols Crossed.

ROCK STUDY, BY MR. P. FORWOOD FOR HONOURS THESIS 1956

SPECIMENS FROM - GOLD MINES OF KALGOORLIE (AUST) LTD.

| No. | Hole | Depth | Description |
|---|---|---|---|
| 1 | SD1 | 212'4" | Q.D.G. medium grained, with felspars developed. |
| 2 | " | 214'10" | Sheared Q.D.G. just above contact. |
| 3 | " | 221' | Sheared contact material, more like Q.D. |
| 4 | " | 224' | Finer and lighter coloured sheared contact rock. |
| 5 | " | 226'4" | Schisty contact rock with some Q.D. character. |
| 6 | " | 229'2" | Bleached, sheared contact rock. |
| 7 | " | 230' | Bleached rock with dark remnants. |
| 8 | " | 231'9" | Bleached contact rock. |
| 9 | " | 240' | Bleached & mineralised rock on shear. |
| 10 | " | 243'1" | Bleached rock, tending to C.S. |
| 11 | " | 250'8" | Sheared & bleached C.S. |
| 12 | " | 257'4" | Contact rock with less bleaching. |
| 13 | " | 261'8" | Sheared rock with felspar vein. |
| 14 | " | 263'9" | Bleached mineralised contact rock, more like C.S. |
| 15 | " | 305'9" | Mineralised C.S. rather dark in colour. |
| 16 | " | 471'11" | Typical C.S. |
| 17 | " | 681'9" | Light coloured C.S. in zone of partially digested darker rocks. |
| 18 | " | 690'5" | Rather darker, even grained, C.S. |
| 19 | " | 698'4" | Rock showing contact of Q.D'ish material in C.S. |
| 20 | " | 726'11" | C.S. varying in colour (melacrity) |
| 21 | " | 739'7" | Sheared C.S. with white veins. |
| 22 | " | 766'10" | Porphyry with C.S. remnants. |
| 23 | " | 880' | Bleached, veined C.S. leading to darker mottled type. |
| 24 | " | 882'6" | Dark mottled C.S. |
| 25 | " | 917'10" | Typical C.S. |
| 26 | " | 1066'7" | Typical slightly fractured C.S. |
| 27 | " | 1219'10" | Typical C.S. |
| 28 | " | 1297'7" | Typical slightly fractured C.S. |
| 29 | " | 1427'6" | C.S. with amygdoles or spherulites. |
| 30 | " | 1534'10" | Dark green brecciated rock near shear zone. |
| 31 | " | 1591'11" | Dark green sheared rock with light coloured brecciated fragments. |
| 32 | " | 1667'10" | C.S. laced with greener material. Surface rusting may be characteristic. |

| No. | Hole | Depth | Description |
|---|---|---|---|
| 33 | SD1 | 1838'10" | Dark, grainy C.S. |
| 34 | " | 2064' | Amygdoles or crystal growths in C.S. |
| 35 | " | 2077'6" | " " " " " " |
| 36 | " | 2140'2" | Shearing & albitisation in C.S. |
| 37 | " | 2141'2" | Mottled, albitised C.S. (the result of shearing & injection?). |
| 38 | " | 2141'8" | Specimen showing albitisation fading out. |
| 39 | " | 2158'1" | Sheared rock with vein for identification. |
| 40 | " | 2192' | Light coloured C.S. rock with dark remnants. |
| 41 | " | 2354'1" | Rock from porphyritised C.S. horizon which looks not unlike Q.D. |
| 42 | " | 2482'5" | Dark unbleached C.S. |
| 43 | " | 2489'8" | Dark unbleached C.S. with noticeably more white specs, presumably albites. |
| 44 | " | 2509' | Dark rock, mineralised sheared & felspathised or carbonated. |
| 45 | " | 2550'7" | Well formed albites or carbonate crystals in C.S. |
| 46 | " | 2682'7" | Sheared C.S. porphyry contact. |
| 47 | " | 2693'7" | Looks like porphyritised Q.D. but is 40' inside C.S. horizon. |
| 48 | " | 2699' | Sheared hybrid greenstone porphyry with albite coming in. |
| 49 , | " | 2744'5" | Coarse-grained (sheared?) albitic greenstone. |
| 50 | " | 2757'10" | Porphyritised greenstone. |
| 51 | " | 2765'10" | Greenstone, more massive, speckled with albite. |
| 52 | " | 2780'3" | Coarse, mottled, greenstone with leucoxene. |
| 53 | " | 2842' | Even-grained Q.D.G. with leucoxene. |
| 54 | " | 2845'10" | Q.D. |
| 55 | " | 2862'8" | Lighter coloured Q.D. |
| 56 | " | 2917'2" | Mineralised and albitised (?) Q.D. with leucoxene. |
| 57 | " | 2918'8" | Mineralised Q.D. with leucoxene. |
| 58 | " | 3034'2" | Massive Q.D. |
| 59 | " | 3124'10" | Actinolitic Q.D. |
| 60 | " | 3162'4" | Dark, massive actinolitic Q.D. |
| 61 | " | 3259'1" | Dark actinolitic Q.D. |
| 62 | " | 3331' | Dark massive actinolitic Q.D. |
| | | | |
| 63 | SE2 | 1052' | Calc schist (C.S.) |
| 64 | " | 1103'2" | Granular variations of C.S. |
| 65 | " | 1228'8" | " " " " |
| 66 | " | 1399'5" | Massive C.S. from area of noticeable variations. |

| No. | Hole | Depth | Description |
|---|---|---|---|
| 67 | SE2 | 1405'11" | Sheared hybrid rock, with leucoxene. |
| 68 | " | 1656'10" | Bedding traces in C.S. |
| 69 | " | 1756'8" | Section showing spread of bleaching from vein in C.S. |
| 70 | " | 1935'8" | Typical calc schist. |
| 71 | " | 1950'9" | More massive sample of C.S. from sheared zone. |
| 72 | " | 1954'10" | C.S. with white material causing coarser granularity; leucoxene present also. |
| 73 | " | 1957'11" | Indefinite sheared contact rock. |
| 74 | " | 1974'6" | Darker, sheared speckly rock tending to Q.D. |
| 75 | " | 1977'10" | Even-grained Q.D. looking rock. |
| 76 | " | 1981'4" | Q.D.'ish hybrid rock with leucoxene. |
| 77 | " | 1991'2" | Sheared W.D. type, porphyritised. |
| 78 | " | 2000' | Coarse Q.D. dispersed with porphyry. |
| 79 | " | 2050'2" | Fine Q.D. with shear fragments of porphyritic material. |
| 80 | " | 2057'6" | Dark patchy rock with ilmenite. |
| 81 | " | 2121'3" | Shear-porphyritised Q.D. |
| 82 | " | 2124'5" | Dark green rock between albitic zone and leucoxene rich zone. |
| 83 | " | 2133'4" | Dark leucoxene rich Q.D. |
| 84 | " | 2150'6" | Rusty Q.D. lighter in colour (on fresh surface) with leucoxene plentiful. |
| 85 | " | 2164'5" | Q.D. showing signs of porphyritisation. |
| 86 | " | 2174'10" | Porphyritisated Q.D. with shear grain. |
| 87 | " | 2179'4" | " " " " " |
| 88 | " | 2194'7" | Salmon pink porphyry showing green fuchsite. |
| 89 | " | 2260' | Slightly porphyritised Q.D. |
| 90 | " | 2278' | Sheared, bleached Q.D. porphyritised & mineralised. |
| 91 | " | 2291'8" | Bleached sheared schistose rock in veined zone above black flag (B.F.) contact. |
| 92 | " | 2306'3" | Porphyritised Q.D. with rusty felspar spots. |
| 93 | " | 2317'6" | Bleached spotted porphyritised rock. |
| 94 | " | 2323'3" | Finely sheared and porphyritised rock. |
| 95 | " | 2326'8" | " " " " " |
| 96 | " | 2329'6" | Finely sheared rock above sed-contact. |
| 97 | " | 2332'9" | Sheared porphyritised rock & sediments. |
| 98 | " | 2337'10" | B.F. slates. |
| 99 | " | 2361'10" | Coarse shear-grain in hybrid rock. |
| 100 | " | 2454'4" | Fine grained hybrid rock. |
| 101 | " | 2464'9" | " " " " with leucoxene. |
| 102 | " | 2495'5" | Specimen showing relation of hybrid injection (?) to B.F. |

| No. | Hole | Depth | Description |
|---|---|---|---|
| 103 | SE2 | 2658'6" | Rock showing contact between B.F. seds. & hybrid Q.D. |
| 104 | " | 2678'4" | Rock showing various degrees of "digestion". |
| 105 | " | 2735'1" | Fine-grained hybrid material. |
| 106 | " | 2823'9" | B.F. sediments showing cleavages & bedding. |
| 107 | " | 2885'2" | Porphyritised rock below B.F. band. |
| 108 | " | 2886'6" | Porphyritised (hybrid) rock, with albites developing. |
| 109 | " | 2929'10" | Hybrid material with albites. |
| 110 | " | 2997'6" | Hybrid porphyry with rusty albites. |
| 111 | SE3 | 771'6" | Pink sheared porphyry (having graded up slowly from greyer variety). |
| 112 | " | 771'6" | Dyke rock with large grains of albite and quartz. |
| 113 | " | 856'2" | Light-pink porphyry. |
| 114 | " | 945'1" | Hybrid porphyry. |
| 115 | " | 1119'2" | Streaky contact of salmon coloured porphyry and Q.D.G. |
| 116 | " | 1125'7" | Q.D. less porphyritised. |
| 117 | " | 1151'6" | Q.D. more altered and sheared. |
| 118 | " | 1247'2" | Light coloured sheared porphyritised rock. |
| 119 | " | 1248'6" | Porphyritic centre of small zone of porphyritisation. |
| 120 | " | 1439'4" | Schistose porphyry. |
| 121 | " | 1501'2" | More like Q.D. but still sheared and porphyritised. |
| 122 | " | 1512' | Porphyritised Q.D. with albite developing. |
| 123 | " | 1619'11" | Getting nearer plain Q.D. |
| 124 | " | 1726' | Light coloured hybrid rock with white spots. |
| 125 | " | 1737' | Specimen shows more definite porphyry surrounding darker material. |
| 126 | " | 1746' | Breccia |
| 127 | " | 1817'4" | Lighter porphyritised rock from below brecciated zone. |
| 128 | " | 1855'5" | Hybrid rock showing variation along length of selected piece. |
| 129 | " | 2081'5" | Light coloured uniform hybrid rock. |
| 130 | " | 2180'4" | Uniform rock from brecciated and mashed zone. |
| 131 | " | 2382'10" | Specimen from area of brecciation and digestion. |

| No. | Hole | Depth | Description |
|---|---|---|---|
| 132 | SE3 | 2419'6" | Specimen in zone tending to Q.D. |
| 133 | " | 2719'10" | Mineralised shear rock in B.F. |
| 134 | " | 3055'6" | Dark schistose mineralised B.F. near shear. |
| 135 | " | 3062'6" | Probably porphyritised B.F. |
| 136 | " | 3091'10" | Slightly porphyritised B.F. |
| 137 | " | 3112'7" | Porphyry with traces of surrounding shear slices of B.F. |
| 138 | " | 3135' | Porphyry with slight shear. |
| 139 | " | 3160' | Fine, rather massive porphyry. |
| 140 | " | 3178' | Grey schisty porphyry with white spots. |
| 141 | " | 3200'6" | Light-coloured fine-grained porphyry tending to pinker type. |
| 142 | SE6 | 209'5" | Heavy dark U.B. rock. |
| 143 | " | 215'8" | Heavy dark U.B. rock with actinolite. |
| 144 | " | 228'1" | Dark U.B. rock with lighter band parallel to shear. |
| 145 | " | 239'2" | U.B. rock showing a tendency to be more crystalline past a soft talcose vein. |
| 146 | " | 275'9" | Talc actinolite U.B. rock. |
| 147 | " | 286'6" | Dark U.B. rock with band of albite spots. |
| 148 | " | 305'9" | Talc actinolite rock. |
| 149 | " | 343'5" | Dark U.B. rock. |
| 150 | " | 358'8" | U.B. rock. |
| 151 | " | 376'6" | Dark U.B. rock with white mineral spots. |
| 152 | " | 381'8" | Lighter actinolite U.B. rock. |
| 153 | " | 382'5" | Fairly crystalline dark U.B. rock. |
| 154 | " | 402'4" | Lighter, sheared, actinolite rock. |
| 155 | " | 411'6" | Light-coloured talcose actinolite rock. |
| 156 | " | 430'4" | Dark actinolite rock now tending to Q.D.A. |
| 157 | " | 436'2" | Actinolite ultra-basic A.D.A. rock. |
| 158 | " | 467'11" | Dark actinolite rock. |
| 159 | " | 478'7" | Rather messy Q.D. actinolite rock. |
| 160 | " | 509'5" | Light coloured talc actinolite rock. |
| 161 | " | 512'2" | Dark actinolite looking rock. |
| 162 | " | 518'1" | Talcose U.B. rock. |
| 163 | " | 530'11" | Actinolite U.B. rock. |
| 164 | " | 559'10" | Very talcose actinolite rock. |
| 165 | " | 596'9" | Talcose, more chloritic and less actinolitic dark rock. |
| 166 | " | 608'5" | Talcose medium grained U.B. rock. |
| 167 | " | 634'11" | Actinolite U.B. rock. |
| 168 | " | 650'3" | Less talcose, possibly more chloritic dark rock. |
| 169 | " | 656'10" | Tough talc actinolite rock. |
| 170 | " | 731'9" | Coarse albitised actinolite chlorite rock. |
| 171 | " | 733'3" | Albitic (?) actinolite rock. |
| 172 | " | 751'5" | Hard albitised actinolite rock. |

| No. | Hole | Depth | Description |
|---|---|---|---|
| 173 | SE6 | 759'11" | Looks like chloritic and actinolite rock, with well-dispersed albite. |
| 174 | " | 769'1" | Albitic actinolitic shear rock. |
| 175 | " | 784'11" | Albitised actinolite rock. |
| 176 | " | 801'10" | " " " |
| 177 | " | 812'5" | Hybrid or altered actinolite rock. |
| 178 | " | 823'9" | Veiny albitisation of actinolite rock. |
| 179 | " | 838'11" | " " " " " |
| 180 | " | 851'6" | Contact of dark vein bordering shear zone. |
| 181 | " | 880' | Rock typical of the albitisation which is evident here over 20 - 30 feet. |
| 182 | " | 900'2" | More khaki coloured albitic rock. |
| 183 | " | 905'8" | Coarse albitic Q.D.A. (?) rock. |
| 184 | " | 937'10" | Rather murky albitic-fade-out zone. |
| 185 | " | 962'6" | Albitic actinolitic rock bordering zone richer in albite. |
| 186 | " | 964'9" | Albite actinolite Q.D. rock. |
| 187 | " | 991'1" | Isolated fairly typical Q.D.G. in Q.D.A. |
| 188 | " | 1006'8" | Fine indiscriminate greenstone slightly mineralised and probably carbonated. |
| 189 | " | 1038'8" | Bleached actinolite rock below quartz vein and shear. |
| 190 | " | 1129'6" | Actinolite rock - Q.D.A. |
| 191 | " | 1177'5" | Even grained Q.D.A. |
| 192 | " | 1236'9" | Mineralised & bleached Q.D. above quartz zone. |
| 193 | " | 1322'1" | Messy Q.D.A. with albite developing. |
| 194 | " | 1376'1" | C.S. material from shear zone. |
| 195 | " | 1386'11" | Typical C.S. of this area. |
| 196 | " | 1427'7" | Sheared, rather dark C.S. material. |
| 197 | " | 1478'10" | C.S. strongly sheared. |
| 198 | " | 1532'5" | Coarser sheared rock. |
| 199 | " | 1536'7" | Sheared Q.D. type of rock. |
| 200 | " | 1541'9" | Q.D. |
| 201 | " | 1558'11" | Q.D. with shear lacing of chloritic material. |
| 202 | " | 1597'3" | Q.D.A. with kaolinised felspar. |
| 203 | " | 1600'6" | Dark Q.D. rock in zone of occasional quartz shears. |
| 204 | " | 1610'10" | Dark mineralised Q.D. rock. |
| 205 | " | 1654'8" | Dark actinolitic Q.D. with epidote. |
| 206 | " | 1686'9" | Diffuse actinolitic Q.D. |
| 207 | " | 1718'6" | Finer altered Q.D. (A) |
| 208 | " | 1751'3" | Dark diffuse Q.D. with spots of white material. |
| 209 | " | 1764'8" | Fine-grained with white spots. |
| 210 | " | 1779'7" | Rather diffuse Q.D. with white spots. |
| 211 | " | 1833'4" | Q.D. with white material. |

| No. | Hole | Depth | Description |
|---|---|---|---|
| 212 | SE6 | 1904'1" | Coarse Q.D.A. |
| 213 | " | 1918'6" | Coarse variegated Q.D.A. |
| 214 | " | 1931'10" | Coarse-grained Q.D.A. |
| 215 | " | 2118'11" | Dark messy Q.D. |
| 216 | " | 2140'2" | Messy Q.D. near shears. |
| 217 | " | 2147'9" | Q.D. with leucoxene. |
| 218 | " | 2150'10" | Sheared altered Q.D. |
| 219 | " | 2155'9" | Porphyritised Q.D. |
| 220 | " | 2157' | " " |
| 221 | " | 2159' | Porphyritised and sheared Q.D. |
| 222 | " | 2164' | Sheared but less porphyritised Q.D. |
| 223 | " | 2239'4" | Sheared, messy Q.D. |
| 224 | " | 2268'9" | Sheared Q.D. |
| 225 | " | 2306'10" | Fine-grained Q.D. near veins of quartz. |
| 226 | " | 2352'10" | Coarser, rusty Q.D. from mineralised zone. |
| 227 | " | 2411' | Partially porphyritised Q.D. |
| 228 | " | 2416'2" | Porphyritised Q.D. |
| 229 | " | 2485'3" | Albitised Q.D. |
| 230 | " | 2485'3" | " " |
| 231 | " | 2486'7" | Well albitised Q.D. |
| 232 | " | 2557'11" | Slightly porphyritised Q.D. |
| 233 | " | 2640'5" | Dark sheared-looking Q.D. |
| 234 | " | 2655'8" | " " " " |
| 235 | " | 2755'4" | Coarse dark Q.D.A. type of rock. |
| 236 | " | 2779'1" | Dark fine-grained Q.D. rock. |
| 237 | " | 2863'7" | Dark Q.D. |
| 238 | " | 2870'7" | Mineralised Q.D. specimen |
| 239 | " | 2873'3" | Patchy Q.D. with albites developing. |
| 240 | " | 2877'10" | Fine-grained mineralised Q.D. with coarse albites. |
| 241 | " | 2882'5" | Albites well developed, making rock look similar to Q.D.A. |
| 242 | " | 2889'3" | Highly albitic coarse grained Q.D. |
| 243 | " | 2894'11" | " " " " " |
| 244 | " | 2901'5" | Q.D. with big albites developed. |
| 245 | " | 2920'3" | Medium grained Q.D. slightly epidotic. |
| 246 | " | 2923' | Quartz-veined Q.D. |
| 247 | " | 2924'3" | Fine Q.D. with larger albite spots. |
| 248 | " | 3026'6" | Fine grained Q.D. with albite spots. |
| 249 | " | 3030'4" | Q.D. with numerous large albites. |
| 250 | " | 3034'3" | Epidotic & albitic Q.D. |
| 251 | " | 3038'4" | Coarse grained albitic Q.D. |
| 252 | " | 3049' | Medium grained Q.D. with large albites and leucoxene. |
| 253 | " | 3106'4" | Medium grained Q.D. with leucoxene. |
| 254 | " | 3128'4" | Fine-medium grained Q.D. with albite below shear. |
| 255 | " | 3131'2" | Sheared albitic Q.D. |
| 256 | " | 3146'2" | Q.D. with coarse albites. |

| No. | Hole | Depth | Description |
|---|---|---|---|
| 257 | SE6 | 3156'5" | Medium grained Q.D. with coarser albite. |
| 258 | " | 3188'6" | Slightly porphyritised Q.D. above shear. |
| 259 | " | 3220' | Pale fine grained Q.D. with coarse albite. |
| 260 | " | 3227'2" | Q.D. with albite fading out. |
| 261 | " | 3227'7" | Dark Q.D. |
| 262 | " | 3229'8" | Q.D. slightly sheared with coarse albite. |
| 263 | " | 3279'9" | Slightly porphyritised Q.D. |
| 264 | " | 3387'11" | Porphyry with traces of Q.D. |
| 264 | " | 3295'9" | Porphyry spotted with Q.D. remnants. |
| 266 | " | 3346'11" | Q.D. a few feet below porphyry zone. |
| 267 | " | 3353'9" | Very mottled Q.D. |
| 268 | " | 3364' | Light coloured mottled Q.D. |
| 269A | " | 3397'9" | Coarse mottled Q.D. |
| 269B | " | 3452'3" | Medium-grained Q.D. in zone of slight porphyritisation. |
| 270 | " | 3459'11" | More like normal Q.D. but still coarse. |
| 271 | " | 3463'8" | Light grey Q.D. with felspars developing. |
| 272 | " | 3465'6" | Uniform grey-green Q.D. with laths of felspar. |
| 273 | " | 3484'4" | Coarsely-mottled, mineralised Q.D. |
| 274 | " | 3490'11" | Medium-grained Q.D. with felspar laths. |
| 275 | " | 3506'8" | Shear-fine Q.D. |
| 276 | " | 3549'9" | Coarse Q.D. with actinolite. |
| 277 | " | 3622'10" | Epidotic Q.D. with ilmenite. |
| 278 | " | 3661'6" | Fine-grained ilmenitic Q.D. |
| 279 | " | 3666'1" | Fine-grained epidotic Q.D. |
| 280 | " | 3700'10" | Coarse-grained albitised Q.D. |
| 281 | " | 3702' | Specimen of very coarsely albitised Q.D. |
| 282 | " | 3783'9" | Mineralised and lightly albitised Q.D.(G). |
| 283 | " | 3823'6" | Q.D.G. (typical?) |
| 284 | " | 3872'3" | Epidotic mineralised Q.D. |
| 285 | " | 3876'6" | White spots in Q.D. confined to border of white vein. |
| 286 | " | 3893'10" | Dark uniform Q.D. (epidotic?) |
| 287 | " | 3924'7" | Well porphyritised Q.D. |
| 288 | " | 4028'1" | Q.D. slightly speared, porphyritised and mineralised. |
| 289 | " | 4077'8" | Dark, mottled, rusty Q.D. |
| 290 | " | 4173'2" | Porphyritised Q.D. |
| 291 | " | 4187' | Lacey porphyritisation of Q.D. |
| 292 | " | 4261' | Mottley porphyritisation of Q.D. |
| 293 | " | 4317'2" | Coarse-grained Q.D. with felspar & magnetite. |
| 294 | " | 4340'6" | Coarse-grained Q.D. |
| 295 | " | 4381'10" | Coarse-grained, mottled, Q.D. |
| 296 | " | 4435' | Coarse-grained, slightly sheared Q.D. |
| 297 | " | 4448'1" | Fine-grained bleached Q.D. |
| 298 | " | 4488'10" | Fine-grained, slightly-bleached Q.D. |

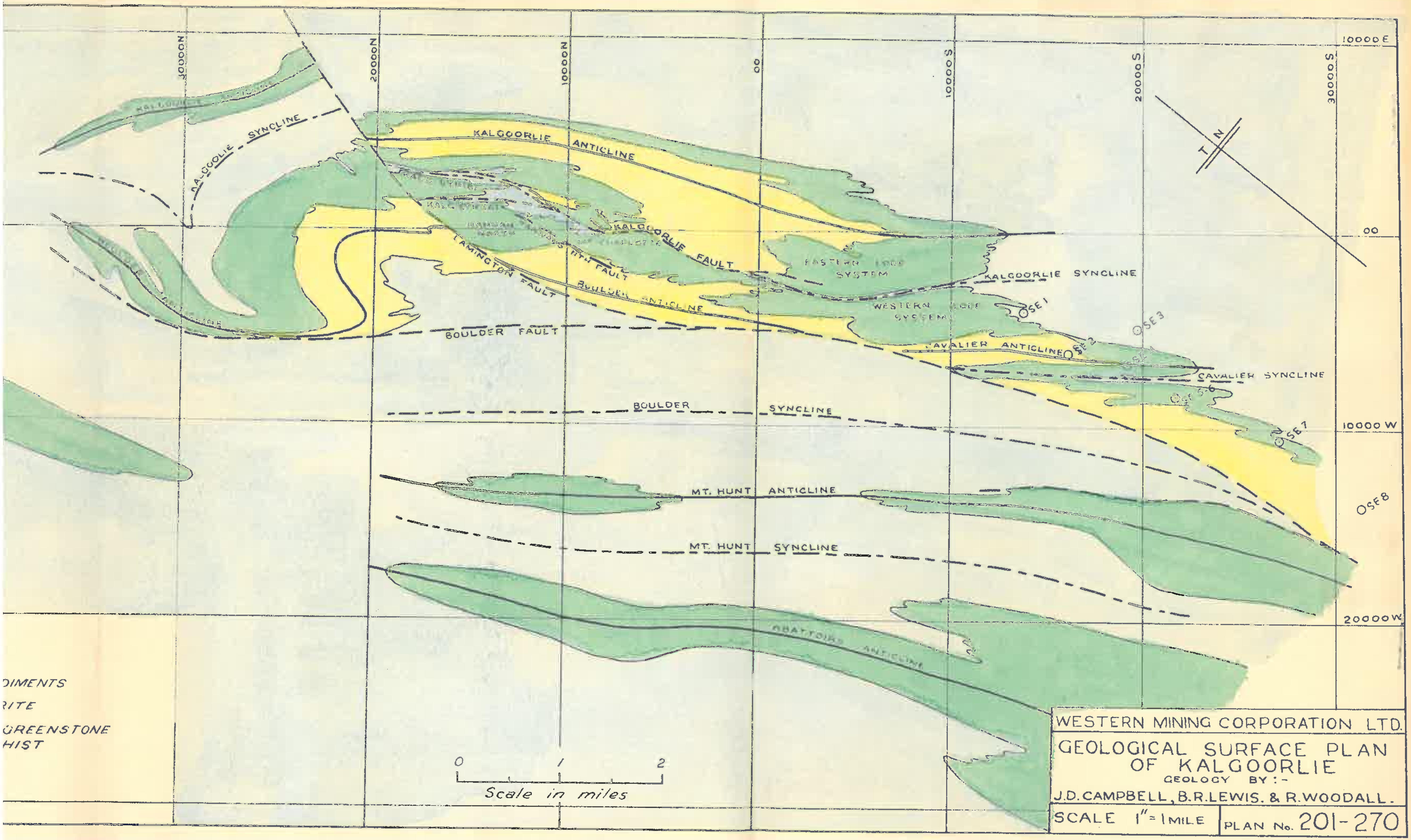
| No. | Hole | Depth. | Description |
|---|---|---|---|
| 299 | SE6 | 4493'8" | Fine-grained, bleached or porphyritised Q.D. |
| 300 | " | 4498'11" | Well porphyritised Q.D. from zone containing B.F. shear-slices. |
| 301 | " | 4562'8" | Porphyritised Q.D. |
| 302 | " | 4573'7" | Lacey porphyritised Q.D. |
| 303 | " | 4582'6" | Fine-grained altered Q.D. |
| 304 | " | 4635'11" | Highly altered Q.D. just above slates. |
| 305 | " | 4647'10" | Mineralised slate contact. |
| 306 | " | 4657'7" | Q.D. slate contact. |
| 307 | SE7 | 258'4" | Fairly massive but slightly shear-grained C.S. |
| 308 | " | 320'8" | Massive C.S. |
| 309 | " | 349'11" | Slightly sheared C.S. |
| 310 | " | 603'8" | Massive C.S. |
| 311 | " | 660'10" | Massive C.S. |
| 312 | " | 672'8" | C.S. |
| 313 | " | 677'3" | Porphyritised C.S. |
| 314 | " | 682' | Massive C.S. |
| 315 | " | 746'8" | Sheared C.S. |
| 316 | " | 706'10" | Slightly coarser grainedCS. |
| 317 | " | 885'6" | Grainy C.S. |
| 318 | " | 938'9" | " " |
| 319 | " | 980'8" | " " |
| 320 | " | 1098'10" | Fine-grained, slightly porphyritised and sheared C.S. |
| 321 | " | 1209'10" | Faded C.S., possibly porphyritised, near mineral zone. |
| 322 | " | 1224'7" | Slightly mineralised C.S. |
| 323 | " | 1271' | B.F. showing bedding. |
| 324 | " | 1283' | Mostly porphyry. |
| 325 | " | 1289'5" | Rock from the middle of a strong porphyry zone. |
| 326 | " | 1318' | Porphyritised B.F. seds. |
| 327 | " | 1376'8" | Porphyry with remnant B.F. bedding. |
| 328 | " | 1415'2" | Q.D. at immediate lower contact of porphyry. |
| 329 | " | 1421'9" | Spotted Q.D. |
| 330 | " | 1434' | Dark, more spotted Q.D. |
| 331 | " | 1475'2" | Coarser, lighter-coloured Q.D. |
| 332 | " | 1513'8" | Dark Q.D. with white spots. |
| 333 | " | 1531'4" | Lighter-coloured, mottled Q.D. |
| 334 | " | 1565'9" | Coarser-grained Q.D. |
| 335 | " | 1575'3" | Dark, slightly-sheared Q.D. |
| 336 | " | 1658'9" | Slightly sheared Q.D. |
| 337 | " | 1699'7" | Actinolitic, albitic Q.D. |
| 338 | " | 1721'8" | Actinolitic Q.D., looks a little like serpentinous talcose stuff from the top of SE6. |

| No. | Hole | Depth | Description |
|---|---|---|---|
| 339 | SE7 | 1730'2" | Coarse actinolitic Q.D. |
| 340 | " | 1739'4". | Coarse actinolitic Q.D. |
| 341 | " | 1900'3" | Slightly porphyritised Q.D. with veining. |
| 342 | " | 1955'4" | Massive Q.D. (G) |
| 343 | " | 1995' | Q.D. (very slightly porphyritised?) |
| 344 | " | 2043'11" | Porphyry with Q.D. remnants. |
| 345 | " | 2103'7" | Dark patchy Q.D. |
| 346 | " | 2164'3" | Sheared, slightly porphyritised Q.D. |
| 347 | " | 2179'9" | Sheared Q.D. (slightly porphyritised). |
| 348 | " | 2227'6" | Q.D. intermingled with porphyry by shearing. |
| 349 | " | 2229'4" | Porphyry with relict of Q.D. |
| 350 | " | 2318'6" | Albite-spotted Q.D. |
| 351 | " | 2334' | Streaky, leucoxene-rich Q.D. |
| 352 | " | 2419'2" | Slightly altered Q.D. just below porphyry zone. |
| 353 | " | 2429' | Albitised or slightly porphyritised Q.D. |
| 354 | " | 2454' | Mineralised, porphyritised Q.D. |
| 355 | " | 2627'4" | Q.D. with uniformly greater amount of light-coloured constituents. |
| 356 | " | 2541' | Slightly mineralised albitised Q.D. |
| 357 | " | 2542'4" | Somewhat altered Q.D. |
| 358 | " | 2585'6" | Altered (albitised)Q.D. |
| 359 | " | 2621'9" | " " " |
| 360 | " | 2731'3" | Dark ilmenitic epidotic Q.D. |
| 361 | " | 2738'3" | Epidote tinged Q.D. |
| 362 | " | 2861'8" | Rusty, slightly mineralised Q.D. from below shear zone and above porphyry. |
| 363 | " | 2943'5" | Slightly porphyritised Q.D. |
| 364 | " | 3001'1" | Porphyry made to look gneissic by Q.D. remnants. |
| 365 | " | 3081'1" | Q.D. sheared down to look like C.S. |
| 366 | " | 3112'3" | Fine-grained Q.D., sheared and porphyritised. |
| 367 | " | 3194'11" | Mottley, leucoxene rich Q.D. |
| 368 | " | 3209'10" | Light-coloured porphyritised Q.D. |
| 369 | " | 3221'2" | Porphyritised Q.D. |
| 370 | " | 3258'6" | Mottley Q.D. with gypsum filling recent fracture. |
| 371 | " | 3270'9" | Streaked out Q.D. with porphyry vein. |
| 372 | " | 3281'3" | Leucoxene rich streaked out Q.D. |
| 373 | " | 3435'2" | Dark Q.D. with rusty albite. |
| 374 | " | 3437'3" | Dark Q.D. with coarse blebby tecture, presumably due to sheared up veins. |
| 375 | " | 3474'7" | Porphyritised Q.D. |
| 376 | " | 3485'10" | Brecciate veining in bleached, mineralised Q.D. |
| 377 | " | 3496'6" | Strongly porphyritised Q.D. |
| 378 | " | 3520' | Porphyritised or bleached Q.D. |
| 379 | " | 3546' | Slightly altered B.F. showing 3 cleavages. |
| 380 | " | 3570'7" | Porphyritised B.F. |

| No. | Hole | Depth. | Description |
|---|---|---|---|
| 381 | SE7 | 3578'5" | Mainly porphyry rock. |
| 382 | " | 3593'7" | B.F. almost obliterated with porphyry. |
| 383 | SE8 | 352'6" | Dark U.B. rock with white specs. |
| 384 | " | 871'4" | Dark, even-grained U.B. rock. |
| 385 | " | 871'4" | Blotchy dark U.B. rock. |
| 386 | " | 1019'6" | Actinolitic (?) U.B. rock. |
| 387 | " | 1227'4" | Actinolitic and chloritic U.B. rock. |
| 388 | " | 1317'2" | Dark serpentinous U.B. rock. |
| 389 | " | 1331'2" | Dark serpentinous U.B. rock showing fracture pattern. |
| 501 | | | Glassy serpentinous rock from surface near Kapai shaft, approx. 3000E, 14700N. |
| 502 | | | Q.D.A. from 1300E. 24,000N (outcrop 220 R.W.). |
| 503 | | | Q.D.A. from 00E, 25,000N (outcrop 219RW) |
| 504 | | | Q.D.A. from 4000W, 25,000N (outcrop 156 RW) (approx. Location)2 chips from same outcrop). |
| 505 | | | C-Mg Q.D.A. from 5,800E, 31,200N (outcrop 227 RW) |
| 506 | | | Spherulitic? ultrabasic from 3000W, 19,700N (356RW). |
| 507 | | | Calc schist from 4,000W, 21,400N (15 RW). |
| 508 | | | ? from 4,100W, 3,150S. |
| 509 | | | Actinolite rock from dump approx. 3900W, 2000S 2 specimens from same area. |
| 510 | | | Actinolite needles in rock from (3000W, 2,250S) a deep shaft to the west of Golden Gate siding. |
| 511 | | | Dark calc schist looking rock from 3200W, 1860S. |
| 512 | | | From dump at back of Govt. Battery approx. 00S, 3800W. |
| 513 | | | Schistose U.B.? rock from 4300W, 6600S back of Ivanhoe shaft. |
| 514 | | | Actinolite rock from 5500W, 7500S large old dump. |
| 515 | | | Q.D. with actinolite needles from dump on nor north side of Boulder - Boulder block road (4200W, 4750S). |
| 516 | | | (core) Perse B.H. 1892 No. 1900 level 71'6" core drilled in Q.D.G. in drn somewhat towards the proximate C.S. contact, shear is a few feet beyond 518. This shows increase in white carb. or felspar. |

| Number | Description |
|---|---|
| 517 | (core) Perse BH 1892 No. 19 level 74' slightly sheared, rich in leucoxene and no ilmenite. |
| 518 | (core) Perse BH 1892 No. 1900 level 79'3" nearer mineral zone, has ilmenite and no leucoxene. |
| 519 | (core) SE 4 2125'8" Typical basic dyke. |
| 520 | (core) SE4 2136'3" Dyke, fine-even-grained looks less basic. |
| 521 | (core) SE4 2139'11" leucoxene - rich rock, maybe still dyke. |
| 522 | Rock from centre of pillow lava outcropping on quarry approx. 26750 south 18000E. |
| 523 | Massive type of rock from some locality as 522 but slightly E. |
| 524 | Coarse albitic, actinolitic grst. The area from which it is taken seems to be marked as "porphyry". |
| 525 | Comes from a chain or so east of 524 and is of the Mgs variety. |
| 526 | Dark blue basaltic-looking rock grst. from the summit of Mt. Hunt (a few yds. N of trig pt). There is no actual outcrop here but all the rock is like this and les about in chunks which look to Mr. Frank Campbell like the breaking up of lava. |
| 527 | Dark blue-grey rock with a wealth of actinolite needles. Taken from about 50 yds. northeast of Mt. Hunt Trig. |
| 528 | CgA rock from a few yards further east of 527. |
| 529 | CgA as marked on map. |
| 530 | CgA to north of Mt. Hunt in position marked SBD5. |
| 531 | Pegmatitic Q.G.A. |
| 532 | Looks like real blue basalt only about 15 yards from 531. |
| 533 | MgS a little further east of 532. |
| 534 | CgA. |
| 535 | FgS, rather oxidised from approx. 17950W, 25750S. |
| 536 | FgS from 17750W 25650S. |
| 537 | Rock from horizon showing pillows further south and also U.B. weathering in places. Looks amygdaloidal in outcrop. Location 18080W, 25750S. |

| Number | Description |
| --- | --- |
| 538 | Altered grst. from 14190W, 27500S |
| 539 | Fine grst. lava type from about 12900W, 28400S. |
| 540 | Highly carbonated grst. from knob 11730W, 26760S. |
| 541 | Two specimens of black altered rock (one showing banding like seds) from 12800W, 26250S. |



10000N
20000N
10000N
00
10000S
20000S
30000S
10000E
00
10000W
20000W
T.N.
KALGOORLIE SYNCLINE
KALGOORLIE ANTICLINE
KALGOORLIE FAULT
EASTERN LODE SYSTEM
KALGOORLIE SYNCLINE
LAMINGTON FAULT
BOULDER ANTICLINE
WESTERN LODE SYSTEM
BOULDER FAULT
CAVALIER ANTICLINE
CAVALIER SYNCLINE
OSE 1
OSE 2
OSE 3
OSE 5-6
OSE 7
OSE 8
BOULDER SYNCLINE
MT. HUNT ANTICLINE
MT. HUNT SYNCLINE
ABATTOIRS ANTICLINE
DIMENTS
RITE
GREENSTONE
HIST
0
1
2
Scale in miles
WESTERN MINING CORPORATION LTD.
GEOLOGICAL SURFACE PLAN OF KALGOORLIE
GEOLOGY BY :-
J.D. CAMPBELL, B.R. LEWIS. & R. WOODALL.
SCALE 1" = 1 MILE
PLAN No. 201-270