A THESIS ON THE BASIC INTRUSIONS OF BLINMAN.

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ABSTRACT.

The Blinman dome is comprised of middle and upper Adelaide System rocks which were faulted and crushed and subsequently intruded in Post-Cambrian times. This diastrophism is discussed and petrological descriptions of the basic and related rocks submitted.

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INTRODUCTION

In the vicinity of Blinman occur a great number of small scale igneous intrustions into the middle Adelaide system, which consist of (1) an older group of basic intrusions giving rise to intraformational flows, and (2) a later period of igneous intrusions giving rise to dolerite bodies.

These occurrences and the rocks considered herein occur within a radius of four miles of the centre of the Blinman dome and no known intrusions occur outside nearer than Enorama, twelve miles to the south, at the head of the Oraparinna dome.

The horizon of the inner part of the Blinman dome has been determined in relation to a known marker horizon in the system at Mt. Emily, and falls into the slates overlying the main tillite horizon. Masses of intraformational melaphyre occur within this slate horizon, and later dykes and irregular shaped stocks intrude the system to a point just above this horizon.

Though the region has been an important copper field from 1862 until 1918, references to previous work are limited to Dickinson's Blinman Mine Report of 1942 and Howchin 1905, with subsequent petrological notes by Benson.

NOTES TO ACCOMPANYING MAPS.

Advantage of aerial photographs was taken, and a photogeological map of the Parachilna-Blinman-Wirrialpa district was drawn up from a Trimetrogon set consisting of two vertical runs coupled by an oblique set covering the central potion including Parachilna gorge, Blinman and Wirrialpa. A radial line plot was used and the scale of the southern run adjusted to the more northerly one, the scale being one and a half miles to the inch. The geological detail was transferred from the photographs and has been checked to the south of an east-west line through Blinman. It shows well the trend of the Adelaide System in the region, and the disturbances which can be traced right across the ranges from Parachilna to

Wirrialpa. A 3" to the mile inset map of the centre of the larger map has been submitted and was compiled from oblique photographs in conjunction with close ground checking, and relates an accurate picture of the topography and geological structure of the area dealt with in this paper.

No attempt has yet been made to do detailed mapping of the sediments inside the intruded area, as on the whole it is highly shattered by faulting and crushing which was part of the major movement causing the Parachilna faulting. This extends in a crushed zone up to a mile wide across the range, and into the central part of the dome. To the eastward faulting and crushing extend across the plain south of Angorichina, and to the north of Paddy's Gorge, across the south end of the Nildottie Range, and into the area about the Old Wirrialpa head station.

STRATIGRAPHY

The sections run were limited to the east and southerly portions of the dome, the direction of the submitted section is represented on the regional map. The line was staggered to avoid crushing effects and soil cover. The upper extent is at Mt. Emily and the strata recorded below follow in downward succession.

Cryptazoonic Arenaceous Limestone.

(1)	8 ft.	Arenaceous limestone with small limestone bands a few inches thick, which show extremely rich cryptazoonic horizons. Dip 5°.
(2)	12 ft.	Impure and arenaceous flaggy limestone.
(3)	10 ft.	Massive arenaceous limestone with coarse intraformational breccia.
	30 ft.	total thickness.

Shale.

(4)	700 ft.	Grey to green shales. Dip 10°.

Arenaceous Limestone and Sandstones.

(5)	91 ft.	Massive limestone with cryptazoonic horizons.
(6)	53 ft.	Sandstones with flaggy horizons.
(7)	18 ft.	Limestone commencing with a cryptazoonic horizon passing up into an intraformational breccia.
(8)	20 ft.	Massive quartzite and grit.

(9) 48 ft. Flaggy limestone passing up into massive cryptazoonic limestone, flaggy arenaceous limestone.

(10) 32 ft. calcareous grit

(11) 9 ft. Flaggy Sandstone.

(12) 8 ft. arenaceous limestone.

(13) 31 ft. limestone with cryptazoonic and gritty bands including intraformational breccia.

(14) 29 ft. Quartzite becoming gritty and calcareous.

339 ft. total thickness.

Slate.

(15) 400 ft. finely laminated graded chocolate slates. Becoming calcareous. Dip 16 degrees.

Arenaceous Limestones and Grits.

(16) 50 ft. Calcareous grits passing up into massive limestone with cryptazoonic horizons.

(17) 47 ft. Limestone, commencing with an arkosic grit becoming pelleted.

(18) 43 ft. Limestone with excellent cryptazoons in the purer bands. Ends with an intraformational breccia.

(19) 232 ft. Blue limestone with a wavy structure passing up into quartzite.

(20) 6 ft. Buff limestone.

(21) 9 ft. Arkosic grit.

(22) 111 ft. Massive limestone with good cryptazoonic horizons.

(23) 51 ft. Arkosic grit passing up into calcareous slate.

(24) 14 ft. Arkosic grit with interbedded Sandstones, passing up into a pelleted and cryptazoonic horizon. Piece of angular shale occur in the intraformational breccia.

563 ft. total thickness.

Shale.

(25) 270 ft. Shale, finely laminated with occasional quartzite bands. Dip 18 degrees.

Limestone.

(26) 127 ft. Massive blue arenaceous limestone with cryptazoons.

(27) 10 ft. Flaggy sandstone.

(28) 63 ft. Arenaceous limestone, both flaggy and massive passing up into a cryptazoonic horizon.

200 ft. total thickness.

Flaggy Quartzites.

(29)	158 ft.	yellow to green finely laminated flags with quartzite bands in the upper limits.
(30)	3 ft.	Grey arenaceous limestone with wavy markings.
(31)	55 ft.	Massive and flaggy quartzites. Dip 20 degrees
(32)	30 ft.	flaggy quartzites. Upper limit is terminated with a one foot band of blue oolitic limestone
(33)	10 ft.	calcareous shales.
(34)	12 ft.	flaggy quartzites with a four foot oolitic limestone horizon.
(35)	38 ft.	Quartzite becoming buff coloured, flaggy with ripple marks.
(36)	52 ft.	Quartzite ripple marked at the top.
	358 ft.	total thickness.

Slate.

(37)	185 ft.	flaggy slate readily splitting into large flags.
(38)	218 ft.	Slate - a little arenaceous.
(39)	231 ft.	Slate. Dip 34 degrees.
(40)	240 ft.	Slate, slightly calcareous at base then becoming arenaceous, occasionally showing cross-bedding.
	874 ft.	total thickness.

Flaggy Slates and Limestones.

(41)	10 ft.	intraformational breccia limestone.
(42)	2 ft.	Flaggy quartzite.
(43)	2 ft.	Flaggy limestone.
(44)	2 ft.	Flaggy quartzite.
(45)	50 ft.	Flaggy limestone.
(46)	28 ft.	Sandy slate.
(47)	2 ft.	blue limestone.
(48)	25 ft.	calcareous slate.
(49)	7 ft.	Limestone.
(50)	15 ft.	Flaggy quartzite.
(51)	10 ft.	Grey-blue limestone, as intraformational breccia.
	153 ft.	total thickness.

Flaggy Quartzites .

(52)	70 ft.	Quartzite becoming flaggy.
(53)	550 ft.	Flaggy quartzite.
(54)	420 ft.	Massive quartzite.

(55) 41 ft. Flaggy sandstone.

(56) 149 ft. Sandstones with dark bands. Dip 56 degrees.

1250 ft. total thickness.

From here the underlying beds are difficult to determine with any certainty, but the general sequence is slate, melaphyre, slate, dolomite, quartzite showing ripple marks and pseudomorphs after halite. From here in, the rocks for the most part consist of ripple marked and halite pseudomorphed slates.

It seems likely that (1) would correspond to (35) of Mawson's Brachina Creek Section, and that the quartzite ridge about the dome (including Mt. Elkington as seen on the inset map) would correspond to the greywacke horizon, indicated on Mawson's Stuctural Map of the Flinders Ranges. The rock in question, though dark in places and of a gritty nature, does not correspond to a true greywacke, but taking this as its equivalent, the centre of the dome corresponds to the slates overlying the tillite and accompanying grits which, however, are not exposed in the Blinman area.

The variation in thickness of the rocks in this area as compared to those at Brachina area is considerable, as is seen in the thickness of the submitted section, 2500 ft., as compared to the corresponding 1650 ft. at Brachina Creek.

DIASTROPHISM AND ACCOMPANYING INTRUSIONS.

The Blinman dome has a peculiar feature in that, ringing about its inner 20 square miles is a ridge of flaggy quartzite within which a zone of great shattering and faulting occurs. From a brief study of the accompanying map this zone is readily distinguished, as into it has been intruded the dolerites of the district. This belt is approximately one mile wide and runs parallel to the above-mentioned ridge leaving a central core or area which is free of intrusions and consists chiefly of practically undisturbed grey slates rich in halite pseudomorphs.

Coupled with this it is found that the greater part of the dome, except the south-west block, shows a pronounced increase of dip in the last 800-900 yards approaching the perimeter ridge. Thus there is an increase of 50 degrees, from 20 degrees at the Youangera Springs horizon to 60-70 degrees at the ridge itself. Inside this is the belt of shattering and intrusions.

This has a parallelisim on the island of Arran where sediments were not in any way part of a domal structure, but consisted of an arenaceous series including the Lower Old Red Sandstone, a lower group of sandstone and basic lavas, tuffs, red shales and marls which were assumed to be flat-lying Mesozoic rocks, ~~and~~ lying on Dalradian schists and post schist sediments without any angular unconformity. During the Cainozoic came a great boss of granite which formed the neucleus of the north portion of the island for a radium of 4 miles. The granite intruded ~~into~~ the ring of Dalradian schists, and where their strike was S.W. - N.E. with dip predominantly to the S.E. it was steepened, and on the other side of the intrusion where the sediments were originally dipping towards the granite, the uplift overturned the sediments, so that they dipped away from the intrusion. This is well seen in the section across North Arran.

However, the point which is to be emphasised is that the structure of the surrounding sediments is clearly dependent on the intrusion. In general, the strike of the adjacent rocks curve in uniformity with the granite margin. Their dips are outward; steep for a distance up to 1¾ miles out from the margin, before they gradually fall back to their low angle dip. See section.

Comparing the Blinman area with Arran, there seems to be a direct analogy. Though the centre of Blinman dome is not occupied by a huge mass of igneous rock, nevertheless it is clearly seen that to form the structure that now exists there must have been a great force from beneath to lift the sediments into their upturned position, so causing a circumferential belt of shattering, perforated by dolerite intrusions, and leaving a central core comparatively little disturbed.

It would therefore seem that this phenomenon represents the emplacement of a large basic igneous body from beneath, which has been arrested while plugging a central core of sediments upwards. The intrusion would have followed at a late declining phase of the Post Cambrian faulting which affected the district from Parachilna to Wirrialpa as already pointed out. This faulting would have been accompanied by much minor faulting and shattering near the apex of the dome. Where a dome is both small and weak enough, the area could become favourable for the emplacement of a large intrusive body, the arrested stage or upper limits being represented as at Blinman by a belt of shattered rocks perforated by irregular shaped basic intrusions. This would amount to a bysmalith effect due to two factors; faulting and intrusion, of which the faulting was predominant, but accentuated by later intrusions.

The shattered zone of shale, quartzite and dolomite is for the most part steeply dipping, however, extremes of shallow dipping to overturned beds exist and huge blocks are seen in the south east portion which have been faulted into positions at 90 degrees to the regional strike. Since intrusions took place into such conditions, their shapes were consequently indefinite, and the occurrence of anything but short, ill-defined dykes is uncommon. The shape and form of the intrusions is generally non-descript , and are found as slightly elongated bodies often lens-shaped with the sediments parallel to their elongation. They occur even more commonly sub-circular with brecciated sediments drawn round by the uplift of the intrusion, so that their strike swings into approximate parallelisim with the margin of the intrusion.

The diastrophism causing this phenomenon and the time of the intrusions would appear to have been well Post-Cambrian.

Support for this lies in the fact that the shattering of the dome has been at shallow depth, as indicated by the lack of type folding and a scarcity of any minor drag foldings. Even the shales tend to shatter into large blocks in a comparatively fine matrix. Thus there must, of necessity, have been a long period of erosion after the upthrowing of the Adelaide System in middle Cambrian times, prior to the subsequent faulting and intrusion.

To suppose that the central core was of an older age, folded, faulted and intruded, before the deposition of the remainder of the Adelaide System, would infer an unconformity which should be clearly evident. Moreover, why should the central portion be free of intrusion? On studying the map it will be seen that the shattered zone is far from being confined to a strictly limited horizon within the flagging quartzite and slates. The southern block is quite free from intrusions, whereas the same horizons south of Sth. Blinman are intruded.

EFFECTS OF RESIDUAL STRESS ON INTRUSIONS.

The general shattering brecciation with little folding even in the slates and shales, and the formation of the present conditions at shallow depth, did not result in a regional uniform pressure. On the contrary differential pinching on the sediments (according to varying stresses) accounts for the wide number of coarsely foliated bi-mica schists and gneisses in close association with the intrusions. (See Page). A following period of low grade stress must have persisted for a great length of time, with intermittent revivals causing brecciation of isolated dolerite bodies, as in the case of locality 96. However, in general the dolerites do not show many effects of severe stress such as the bending of felspar lathes, granulation or actual brecciation, but their highly altered composition and the slow destruction of their original textures serve to indicate that a low grade stress insufficient to impart a new type texture was operative.

An interesting occurrence of acid rocks in the area is seen at localities 157 and 172, where there are coarse pegmatitic rocks. 157 is hypidiomorphic granular containing a large number of accessories, and must represent a late phase of extreme differentiation of the basic magma, which is not unlikely as the occurrences are few and their extend comparatively small.

Similarly, in locality 172 there is a small reddish granitic gneiss not unlike the Murray Bridge granite, in appearance, and was named a granite by Howchin in 1905. Microscopically it is very similar to the pegmatite of 172 except for its gneissic structure and greater amount of biotite, and would appear to be its stressed equivalent. These two would have been intruded well after the dolerite, one accompanied by a pinching and the other not, showing that the stressed were still operating. Post crystallization granulation of these two rocks points to repetition of stress at a later period.

FIELD RELATIONS OF BASIC ROCKS.

The melaphyres are interformational and thus belong to a much earlier period of igneous activity than the dolerite bodies, which are found intruded into the overlying younger sediments. The earth movements causing the shattering and brecciation before and during these intrusions were responsible for the frequent faulting and cutting out of melaphyre beds, and in some cases the overturning as at 119, which is overturned 5 degrees to the E.S.E. still remaining parallel to the regional strike.

Nevertheless, the melaphyres can be distinguished at intermittent intervals about the dome, and though no lensing or variation of thickness can be distinguished in any one outcrop, the flows occur in several closely separated horizons. This indicates that the flows were not confined to one limited eruption. Moreover, very few melaphyres are found in the north and north-west portions of the dome in the same horizon, showing that the flows were hardly of a regional scale, but confined in extent about their source.

Overlying ash beds are very limited and measure only a few inches in thickness, grading into arkoses containing actinolitic and chloritic material, grading through chocolate sandstones to chocolate slates, to normal grey and purple shales.

Similar impure sandstones are found underlying the melaphyres as at 112, 82 and 79, and are often current bedded. However, these are not universal, indicating the varying conditions over a small area under which the flows were laid down. Shallow water and arid conditions were universal in the area as a whole, as can be judged by the underlying sediments which consist of grey slates showing ripple marks and halite pseudomorphs, grading up into ripple marked quartzite and sandstone, also bearing halite pseudomorphs and lines of current bedding indicated by fine ilmenite grains.

As no structure indicative of deposition under water is evident, it seems likely that these deposits were caused by fissure eruption on to flat-lying lake beds, dry or nearly dry. That the mechanism of eruption was by fissure flows is supported by the small amount of ash and tuff in the area. In several areas, such as 78 or 85 and 77 however, amygdaloidal melaphyre is actually interbedded with very thin bands of shale, sandstone and other sediments, so that they must have either been submarine or shallow water conditions. In the case of 77, the large spheroidal shapes of weathering melaphyre in situ strongly suggests former pillow structure. The total thickness of basalt, its amygdaloidal counter part, and interbedded sediments, is upward of 300 ft. and is quite similar to 77. This occupies a very large hill capped with brecciated fine grained basalt, which appears to have been intruded by later dolerite found about it in numerous small off-shoots.

Proceeding N.W. from the summit the basaltic rock, amygdaloidal melaphyre is interbedded with bands of sediments which eventually pass up into purple shales. To distinguish these rocks as spilites under the microscope is quite difficult, because the stresses which have operated on the area have effected destruction of the felspar with the production of very little epidote and a residual felspar which is often albite. Thus the original composition of the felspars need not have been very basic in composition.

At locality 71 occurs a fine graded intraformational basalt clearly conformable with the underlying sandstone, and this in thin section is wholly albite, chlorite and magnetite, and possibly represents a spilite, though no pillow structure can be detected.

This is a class of flow which is quite distinct from those seen at localities 65, 112, 72 and others, where occurrences which are obviously sections of one and the same flow, having the identical amygdaloidal rock resting on a chloritic sandstone. The base of the melaphyre is a highly scoriaceous zone where eruption has been on to a cold or wet surface. This is followed by a more compact rock with lines of drawn out vesicles parallel to the base, indicating flowage. Nearer the top the scoriation becomes greater to the extreme at the surface, and is followed by a few inches of ash, a foot or so of arkosis chloritic rock, and so on as mentioned previously. The thickness of the three outcrops is constant at approximately 140 ft. In the case of 65 and 112 and possibly 82, there are two flows, the upper one separated from a lower body of melaphyre by over 400 ft, in the case of 65, and over 300 ft. at 112, of slaty sediments which are mostly soil-covered.

Dykes in the district are not common and the only good example is seen at locality 165, where it is seen crossing several creeks. The body is 40 ft. wide and has a length of approximately 200 yds. The contacts are clearly defined by white bands of decomposing fritted edges. Dip vertical, strike 265°. Less well defined bodies occur at localities 149, 69 and 68, and in all cases they are comparatively short in length as at locality 68, where the dyke is 8 yds. wide and 30 yds. long. This outcrop stands out as a ridge 3 ft. high and has weathered into spheroidal boulders.

Localities 149 and 69 are cases where the contacts are not good but widths of outcrops maintain their thicknesses for their observed lengths, 50 ft. and 120 ft. respectively. However the majority of dolerite bodies fall between this type of intrusion and the subcircular stocks or plugs. Creeks transecting such lens or subcircular bodies give the effect of a dyke which is quite erroneous. The majority of the outcrops referred to as dykes by Howchin in 1905 are usually slightly elongated plugs. In some instances Lines of weaknesses are intruded by a number of such bodies which on the surface are separated by a distance of disturbed sediments as in the case of 64, 65 and 66. In each case the bodies have the same direction of elongation. This type of intrusion is seen more clearly to the south at Enorama where lens shaped bodies occur up to a mile long. Such individual bodies are joined to others by sudsidiary dykes or stringers.

At Blinman such minor dykes in the form of stringers off larger bodies are seen in localities 67, 130, 186, 135 and elsewhere. Usually they measure up to a few feet wide and up to 50 yds. long.

MINERALOGY.

The dolerites considered are composed chiefly of basic plagioclose, sub-calcic augite, pigeonite, plus or minus olivene. Magnetite, ilmenite and apetite are primary accessories. Late dueteric minerals comprise quartz, albite while anorthoclose may be present in some instances, but its presence is difficult to distinguish under the ordinary microscope due to its small size. Because of the universal alterations of the minerals by saussuritization and uralitization, details of minerals become more descriptive in nature than specific optical data.

PLAGIOCLASE. This mineral is marked by brown dusty inclusions which are found in nearly all the older basic rocks of South Australia, including the Musgrave Ranges, the Barrossian Complex, and in the intrusions of the Flinders Ranges. This fact may have importance in delineating a petrographical province.

The inclusions become particularly dark in some instances, and resemble near basal sections of biotite such as in slide B 143 of Blinman and slides 3136-7 and 3142 from between Ernabella and Mt. Carruthers, and 11 miles N.N.E. of Ernabella in the Musgraves. In all cases these inclusions are expelled immediately recrystallization commences, and thus it is a useful guide in determining whether or not a plagioclase has suffered recrystallization, or to what degree, as judged by the clear peripheral zone about the dusty brown core. In cases such as the labradorite of the meta basic igneous rocks of Woodside which is quite clear, it would be inferred that though it may still have a composition close to its original one, it nevertheless, has been regenerated.

Saussuritization with concommittant regeneration of plagioclase to a more acid variety is so common that there is little chance of determining how basic the composition originally was. Slide B104 shows the least affected pagioclase found in the area, and this has a maximum basic composition of $Ab_{36}An_{64}$, which is only mid-labradonite. Zoning is obliterated at an early stage and again B104 is one of the only examples. Shows from $Ab_{36}An_{64}$ to $An_{60}An_{40}$ on the one lath.

The predominant composition is that of andesine ~~bordering on~~ oligoclase ~~lathes~~, itself being untwinned and of low relief ≏ balsam.

The average size of the lathes being 1.3 x 0.4 m.m., and up to 7 m.m. x 1 m.m. in the gabbroic types.

The saussuritization has given rise to great quantities of epidote, clinozoisite and zoisite with a little scapolite in a limited number of sections. Calcite is at times quite prominent. However, as common as the epidotes is white micaceous matter in the plagioclase which appears to have formed as a result of the saussuritization. Though usually colourless, it is sometimes seen in shades of light green and cannot be imagined as resulting from a later deuteric introduction as suggested by E. B. Baily and G. W. Grabham. "Albitization of Basic Plagioclase Felspars."

It would be more logical to assume that it is a soda mica such as paragonite, and has come from the plagioclase enclosing it. In so many cases, it is the chief alteration product and forms in such a manner as to cast little doubt as to its origin. In altered lathes, it is found either parallel to the basal cleavage or to the "c" axis, that is, the length of elongation. These phenomena are best seen in slides B107, B300 and 2823.

The <u>epidote</u> usually forms in much larger grains than does the zoisite in addition to which, it is at times strongly pleochroic in yellow-greens. Cleavage may or may not be evident as in B88 where the epidote occurs as remarkably large anhedral to subhedral crystals free of cleavage and fractures. Biaxial (-ve) with a large optic axial angle of 80 degrees.

<u>Zoisite</u> always forms in rather small grains which are not large enough to yield an optical figure. Odd grains are biaxial (+ve) figure with a low 2V in vicinity of 40 degrees. It is most readily distinguished from the epidote by its lack of pleochroism and its lower birefringence, often showing anomalous effects.

<u>Clinozoisite</u> is common, and it is possible that, as it also shows a low birefringence like zoisite and anomalous blues, it may occur more frequently than supposed. In sufficiently large grains it is readily distinguished by its Biaxial +ve figure 2V 80. In the case of B143, a phenocryst of felspar has been completely replaced by it.

PYROXENES.

Augite: this is not common but when occurring has a 2V(+ve) 45-60; an accurate range of Z∧C cannot be determined without the universal stage, but is in the vicinity of 39/40 degreees. Given size is as with the other pyroxenes from 1.9 x .50 to average .90 x .40 mm.

Sub-calcic augite is the predominant pyroxene and is taken as ranging from 2V 35/45 degrees, Z∧C 37/41 degrees. Twinning is not common and at times a faint pleochoism is evidenced. X=faint fawn, Y=faint pink, Z=yellowish fawn. The crystals are subhedral to anhedral occurring intersertally between the interlocking plagioclase lathes, or crystallizing after the plagioclase giving ophitic textures. Generally the ophitic textures are poorly developed.

Grain sizes as above average 0.9 x 0.4 mm. The ophitic host crystal in B165 being 8 mm. in diameter.

Pigeonites. Here there is little ~~outward showing~~ obvious distinction between these and the more calcic varieties, but optically the axial angles fall into a group between 12 and 35 degrees Though not proven the possibility of the occurrence of bronzite exists, and only accurate optical work would detect it. The importance of microscopic work on these rocks lies more in the study of the metamorphic effects and alterations.

Uralitization in its earliest stages is seen in slide B104 commencing at the edges of the pyroxene as a green coating giving a marked change in birefringence from middle record order down to first order greys and yellows. Prismatic form showing 120 degrees cleavage makes an early appearance, but in general the alteration is from the predominantly elongated pyroxene lathes parallel to "c" axis, and the resulting amphibole is consequently also in lathes, needles and fibrous felted masses of elongated habit. Concomitant with this is the release of brown-green biotite in odd fragments. In other cases as B107 and B300, you have a very abundant release of magnetite into small grains which align themselves in very definite parallel lines, representing cleavage or pratings. The most common amphibole resulting from the uralitization is of a moderate optic axial angle which ranges down to 40 degrees and below, and up to approximately 60 degrees thus corresponding to hornblende. Actinolite also occurs, having a higher optic axial angle of 70/90 degrees. The maximum extinctions, though varying from 12/23 degrees are almost constant at 15/16 degrees.

The colours vary according to the composition. The most common one giving a light coloured mineral which is only faintly pleochoic with X=near colourless, Y=light brown-green, Z=light green Through gradations of deepening colours, some varieties are found to be distinctly blue as in rocks B135, B143 and 2823. Due to its limited occurrence and size such properties as X=light green to colourless, Y=blue green, Z=blue, 2V 40 degrees are subject to query, and would bear checking in a universal stage. The Z∧C seems to be much the same as the more common hornblende i.e. approximately 15 degrees. Alterations of this type have been met with in Canada, New Zealand and elsewhere, and will be mentioned later under the heading of petrology.

It is common in some places to find destructive weathering of the dolerites such as B38, and in such instances the most common minerals formed are chlorite and calcite. Light green hornblende may be found in needle-like form intergrown with chlorite and calcite. The distinction between the amphibole and chlorite is determined by the signs of elongation, the two being opposite. This is very useful as at times they appear to be the one and same mineral.

OLIVINE. a~~s pseudomorphs are~~ found in a fair proportion of the rocks but in no case is olivine itself found. The pseudomorphs are mostly magnetite together with antigorite or talc. The magnetite, in many cases, preserves the original idiomorphic outlines and indicates the irregular cracks and fissures so common to olivine. ~~Commonly~~ Associated is red brown limonite material ~~which~~ has probably resulted from the alteration and hydration of iddingsite.

MINOR CONSTITUENTS. Under this heading may be referred the granophyric intergrowths and accessory minerals. The introduction of quartz-albite as interstitial intergrowth is of late magnetic origin, and will be referred to under the petrology.

Magnetite and ilmenite are the two main minerals to be mentioned here. The exact proportion of primary magnetite cannot be determined at all because of the release of large amounts during uralitization. The ilmenite though not distinguishable from the magnetite when fresh, readily shows once alteration to leucoxeme occurs. This takes place in several ways. Firstly as a peripheral ring, and secondly as complete alteration giving rise to disseminated grains and stringers of leucoxeme , which on recrystallisation give rise to larger grains and might be better called sphene. The third mode of alteration is seen in the large ilmenite grains, and takes ~~plac~~ place along definite parallel planes, possibly corresponding to crystallographic symmetry.

Pyrite is seen in many of the hand specimens, and sometimes figures quite prominently.

Apatite is seen in some rocks quite abundantly, but on the whole is not common. In small rods and prisms often found in those rocks which have suffered most deuteric introductions.

A host of secondary minerals such as zoisite, clinozoisite, epidote, sericite, talc, chlorite, antigorite, limonite, iddingsite, scapolite, and albite occur, but have been mentioned in connection with the minerals fromwhich they arose.

The mineralogy of the minerals contained in the melaphyres bears a separate mention as they are of a different age and therefore need not be the same.

PLAGIOCLASE. Here ~~xxx~~ no cases of dusty brown inclusions have been found and whether they ever occurred cannot be determined. The plagioclase has been in all cases regenerated to acid andesine and lower, and only one instance of labradorite can be found. The determinations of the R.I. in relation balsam is particularly difficult as decomposition products crowd the edges sufficiently to confuse the true nature of Becke's bright line. On the other hand the method of using the intersections of the basal cleavage against the twin planes is not possible because regenration has obliterated all such evidence. As the extinction angles of the twin planes in the symmetrical zones rarely exceed 16 degrees it is possible that the plagioclase could be albite. However, twinning is strongly developed, and is too regular and coarse for an albite composition. Strongly developed in places is Braveno twinning.

Unlike the dolerites, comparatively little epidote occurs and instead the predominant secondary mineral is clear white flecks of mica orientated parallel to the twin planes. Where the epidote occurs it is usually recrystallised into larger pleochroic crystals.

Pyroxenes are quite unknown and the amphibole is not abundant, being replaced by chlorite quite often. Generally speaking the melaphyres are a felspar-rich and ferromagnesian-poor rock.

Olivine is again only as pseudomorph of magnetite, chlorite, antigorite and limonite but are more clearly distinguished as residual olivine, than in the case of the dolerites.

MINOR CONSTITUENTS that were not contained in the dolerites include rutile, haematite and anorthoclase. The latter is found in slide 2829 of South Blinman, and is a late deuteric introduction. Associations are muscovite, chlorite, and quartz. More usually the introductions are of albite and not anorthoclase. Rutile only forms in small grains, too small to show cleavage, but their red brown colour and adamantine lustre in reflective light readily distinguish it. Haematite is common, forming micaceous linings in amygdales. Where basal sections occur its red nature is discernible, otherwise it appears quite similar to the magnetite. It is also very common filling joint fissures with regular patterns.

PETROLOGY.

The course of enrichment of the pyroxenes and olivines is not known but the plagioclases follow a normal soda enrichment as indicated by zoning and subsequent late deuteric introductions of albitic solutions.

The order will vary in specific instances, but in general the first mineral to crystallize is olivine, followed by the pyroxene with slight overlapping of the plagioclase as evidenced by the tendency towards sub-ophitic texture of felspar lathes imbedded in pyroxene. In B165 there is the only instance of true ophitic texture where the plagioclase has crystallised and later has had the pyroxene crystallised about it.

The crystallisation of sub-calcid augite appears to precede the pigeonite which in all cases occurs as small residual crystals in a finer mass of the rock.

The course of crystallisation of the minor constituents is obscured by alteration and late deuteric introductions.

The late deuteric alterations and introductions include (1) leaching effect of albitic solutions on original plagioclases, (2) introduction of quartz, ~~or~~ quartz-albite and anorthoclase on rarer occasions, (3) introduction or reintroduction of chlorite, biotite, and actinolite in vesicles of the melaphyres.

One important change which takes place ~~commences~~ in the late magmatic stage is the alteration of the pyroxene to amphibole. Though the majority of the cases give rise to hornblende or actinolite some show variation in giving the blue variety with 2V(-ve) 35/40 degrees. This low 2V, if it is so, can only be explained by the introduction of a sodic glaucophane or riebeckite molecule or by the absorption of the sodic element of secondary albite as in the case of rock 2823 where the amount of plagioclase remaining after the break-down in calcite, epidote, and sericite is negligible. Such low 2V amphiboles are not uncommon and have been mentioned by Winchell from New Zealand, and again by Hutton also in New Zealand. J. P. Bateman in his article on "Gold deposits of Urchi goldfields", mentions occurrences of sodic amphibole as possibly due to hydrothermal introduction of sodic molecules.

A chemical analysis was carried out on specimen B30 from locality 188.

CHEMICAL ANALYSIS.

SiO_2	48.11
Al_2O_3	15.08
Fe_2O_3	4.73
FeO	8.37
MgO	5.87
CaO	9.75
Na_2O	3.33
K_2O	1.45
H_2O+	0.72
H_2O-	0.17
CO_2	0.44
TiO_2	2.10
S	0.19
MnO	0.12
	100.43

NORM.

Orthoclase	8.34
Albite	27.77
Anorthite	21.46
Nepheline	0.28
Diopside	20.55
Olivine	9.21
Calcite	1.00
Magnetite	6.73
Ilmenite	3.95
Pyrite	0.36
Water	0.89
	100.54

PETROGRAPHY

The Blinman melaphyres and dolerite intrusions have, as pointed out, suffered a long period of intermittent low grade stress. This stress varied sharply from point to point due to the nature of the shattering, and consequently some dolerite bodies suffered little stress at all (b104), while others a considerable amount such as B300 which is greatly altered by saussuritization and uralitization. Between these two extremes there is every gradation. Though not strictly accurate a normal classification is followed, based on the presence of pseudomorphs after olivine and the residual textures. Thus -

Doleritic Gabbros

Few in number and show little variation. B107, B300, 2823.

Dolerites

A Olivine free

(1) ophitic texture (B165, B88, SB6.)

(2) sub-ophitic to intersertal (B104, B143, B147, H18.)

(3) relic textures (b301, B59, H21, B38)

B Olivine bearing

(1) ophitic texture (2830, B135, B37.)

(2) sub-ophitic to intersertal textures (2832, B54.)

Melaphyres

C Amygdaloidal

(1) olivine free (B111, B55, ~~B158~~ B185, H48.)

(2) olivine bearing (186, B172, B166,)

D Fine grained non amygdaloidal (B171, B176, H38, H105, H75.)

Doleritic Gabbros

These coarse grained rocks are not common in the area and are confined to localities 202 and 38. Of these, locality 38, 6 miles down the Parachilna road is the only large mass, and may in part represent the upper extent of a cupola of a larger underlying mass.

B107 at locality 202 is a remarkable coarse grained whitish-grey gabbroic rock with S.G. 2.894. In thin section the rock is holocrystalline, hypidiomorphic tabula with a conspicuous granophyric intergrowth between the interlocking crystals. The grain size is average at 3.8 x 1.0 m.m. but individual lathes reach lengths of 8.0 m.m.

Plagioclase with a modal figure of 56% is in tabula form and is highly altered such that the multiple twinning is now only indicated by sericitic decomposition products along the former twin planes. The alteration products are sericite, zoisite, epidote and scapolite. The latter occurs as disseminated flakes showing cleavage and straight extinction, and therefore difficult to distinguish from sericite. However, sections without cleavage are more easily determinable giving uniaxial (-ve) figures. The epidote is pleochroic in yello-greens and has a distinctly higher birifringence and occuring in larger masses than the zoisite in which the lower order colours are marked by anomalous blues. Where residual twinning is seen, it has extinctions up to 15 degrees with R.I.< b. Best seen in perpheral zones with twin planes far apart. Biaxial (+ve) 2V 70.Albite

The uralite has a modal occurrence of 36.7% and has resulted from the breakdown of the original pyroxene, but residual properties remain in part. Thus, the twinning and parallel magnetite lines ~~which~~ represent either an original extra parting as seen in diallage or an exaggeration of the schiller structure as seen in bronzite by release of magnetite during the process of uralitization. The alteration does not appear complete but 120 degrees cleavage with extinctions of 16 degrees on lathes appear. The interference figure is biaxial (-ve) with a moderate 2V and pleochroism is weak in shades of green when the replacement is complete, otherwise near to colourless poikilitically including magnetite and epidote. The uniformity in colouring would seem to be at least partly due to the explusion of the abundant iron during the uralitization.

Magnetite (apart from that contained in the ferromagnesian) has a modal figure of 3.1% of which a fair proportion would be primary. Grains show octahedral and rhomb form and include crystals of clear non-pleochroic epidote and high brown rutile. Chlorite and limonite material are accessory.

Granophyric intergrowth with quartz is late deuteric, filling the junction of large crystals and has a modal occurrence of 4.1% of which quartz is 2.2% and felspar 1.9%. The growth is of albite in a quartz base, the albite showing multiple twinning with extinctions of 12 degrees.

B300. A coarse white speckled rock with a highly weathered coarser phase which was not collected. Locality 38.

In thin section it is similar to the previous rock except that it is even more altered so that in the case of the Plagioclase the signs of original twinning have gone due to complete saussuritization, sericitization and the regenneration of the felspar to untwinned albite - oligoclase. Biaxial (+ve) 2V 70.

Uralite. Tabula form made up of aggregates of small lathes and fibrous forms. Colour X=light brown, Y=green, Z=blue green, but some is almost colourless. Ilmenite forms skeletal forms in process of breakdown to leucoxeme. Individual crystals of epidote are larger than the zoisite. Biotite and rutile occur.

Granophyric intergrowth is not as marked as in B107. Occurs as an intergranular mixture of quartz and oligoclase or with the plagioclase grown into a quartz base. The felspar is partially altered.

Rock 2823 is a similar medium to coarse grained basic rock collected by Howchin and labelled "Dyke west of gneiss, 1 mile west of Blinman." This corresponds to locality 140 on the accompanying map.

Microscopically, this is similar to the foregoing specimens except the original twinning is indicated only by the parallel orientation of the sericite with respect to the old twinning planes. ~~Regmarked~~ Pleochroism such that X=light brown, Y=deep green, Z=blue. The optic axial angle is (-ve) 2V 40 approximately, but would bear checking on the universal stage. The breakdown of the pyroxene to amphibole has given rise to magnetite which on hydration has resulted in limonite. Alteration of the hornblende has yielded chlorite and epidote. The granophyric intergrowth is prominent.

Olivine free dolerites.

A1. B165 is a grey porphyritic rock in which the pyroxene may be distinguished being set in a medium grained base. The rock is from locality 86.

In thin section this rock has an ophitic texture where felspar lathes are set in phenocryst of pyroxene. The larger pyroxenes are glomerophenocrysts of commonly orientated crystals which have altered along cleavage planes and lines at 90 degrees to them. Composition varies from pigeonite (+ve) 2V 25/35 degrees and sub-calcic augite (+ve) 2V 35/45 degrees. However, no clear cut distinction between these. The plagioclase is represented by a ~~consists of~~ typical saussuritic mass containing ~~with~~ untwinned acid plagioclase. The uralite occurs in a fibrous and acicular aggregate, X=light brown, Y= green, Z= blue, Z∧C 12 degrees, usually intergrown with light green non-pleochroic chlorite.

Accessories include odd grains of calcite, deuteric quartz, appetite, pleochroic biotite (X= light brown, Y=Z= strong brown), secondary magnetite and primary ilmenite in skeletal grains give rise to leucoxeme.

B88 from locality 174. Microscopically the rock is holocrystalline with an ophitic texture. The plagioclase is strongly coloured by brown inclusions which are expelled in the peripheral zones where regeneration of the mineral has been effected. Zoning shows from $Ab_{44}An_{56}$. Labradorite to $Ab_{54}An_{46}$ Andesine.

The uralite light coloured and similar to the previous rock. Deeper colours occur in patches within the lighter variety which has a somewhat higher Z∧C of 18 degrees. Again the optic axial angle appears to be somewhat lower than normal hornblende.

Sub-calcic augite is mostly broken down into uralite. Optic axial angle varies from (+ve) 2V 32° to (+ve)2V 45°, Z∧C = 38degrees

Epidote (-ve) 2V 80° and lower is non-pleochroic and shows cleavage where elongated. Ilmenite breaking down into sub-translucent mass due to hydration. Magnetite is present.

SB6 is a medium grained dark grey specimen in which a fair amount of green epidote may be detected. At South Blinman it is common to find green flakes and needles filling joints and veins and apparently has originated by the removal of secondary epidote from the breakdown of the calcic felspar.

In thin section it is holocrystalline with an ophitic texture and is traversed by an epidote vein. The plagioclase is Ab64An36 Andesine, and shows little sign of the brown inclusions due to regeneration. The extreme phase yields glassy clear acid plagioclase R.I∠b Albite - oligoclase. The uralite shows usual pleochrism and is twinned. Z∧C 25 degrees. Optic axial angle (-ve) 75 degrees. A different variety occurs in the vein as slender lathes resembling biotite and chlorite and have a máximum extinction of 16 degrees. Chlorite occurs. Epidote is both colourless and pleochroic. Accessories also include skeletal grains of ilmenite, and sphene has resulted from the recrystallization of the leucoxeme.

A2. B104 is a dark grey compact medium grained rock containing clear lathes of fine felspar with multiple twinning and black ferro-magnesium. Found at locality 180.

The plagioclase is elongated lathes which are clear but for the brown-pink inclusions. Zoning is such that the more calcic core has a máximum extinction of 36 degrees, Ab36An64 Labradorite. Biaxial (+ve) 2V 80 while the outer portions of the same crystals indicate Andesine Ab60An40. The probable average composition would be Ab44An60. The twinning is on two laws, albite, pericline and combined albite pericline.

The pyroxeme is faintly pleochroic sub-calcic augite, X=faint fawn, Y=pink fawn, Z=yellow fawn. The lowest optic axial angle recorded was (+ve) 37° at the rim and a maximum on the same crystal of positive 43°. Simple twinning on the 010 is present and a slight tendency towards plumose structure is noticed. This is the only pyroxene present. Associated with it as a product of uralitization is hornblende both in the fibrous and prism sections showing 120 cleavage. The birefringence is mostly masked by absorption but indicates second order colours. Strongly pleochroic X=pale brown, Y=green, Z= blue green. Optic axial figure (-ve) 80° Z∧C 16 Biotite is associated and also strongly pleochroic from bright golden brown to lighter shades. Magnetite occurs in massive pieces indicating octohedral cleavage while secondary megnetite is somewhat smaller.

The late deuteric introduction seems to include apatite as well as quartz. Clear felspar ringing more calcic variety is albite which has resulted from regeneration of original plagioclase.

B143 is a porphyritic dolerite from locality 147. In thin section the former phenocryst of plagioclase have been completely altered to clinozoisite with a little muscovite. Sub-calcic augite also occurs in the phenocrystic state.

The plagioclase has deep red brown dusty inclusions, which do not appear unlike basal sections of biotite. Composition is Ab52An48 Andesine-Labradorite. Where the lathes have been included in the pyroxene, subsequent uralitization has been strongest at the edges, and thus included plagioclase has its edges ringed by strongly pleochroic amphibole. Clinozoisite is elongated parallel to the "b" axis and shows one strong cleavage parallel to the 001. Extinctions from 0/5°. Faintly pleochroic in yellow-green to colourless. Optic axial angle (+ve) 2V 65°.

The pyroxene occurs in two varieties both of which are faint pinkish fawn to colourless. The sub-calcic variety shows common orientation parallel to the 010, devoid of cleavage Z∧C 42. 2V varies from (+ve) 32° to 45°. Values up to 55 indicate augite. The common light green uralite occurs in fibrous and small lathe aggregates. Strong blue patches occur. X=light green, Y= olive green, Z= blue. Some extinctions are considerably less than 16 . Deuteric quartz is present.

B147 from locality 141 contains pink to flesh red felspar and ferromagnesian together with abundant iron ore. In thin section the rock has an intersertal texture with occasional structureless patches. The plagioclase is regenerated Andesine. Ab58An42 and still shows bent lathes due to stress.

The uralite is hornblende. Biaxial (-ve) 2V 60 . Maximum extinction 30 . X= light brown, Y=greenish Z= bluish. Chlorite and magnetite are associated. Hydration of the magnetite gives rise to brown limonite. Accessories include ilmenite, leucoxeme, strongly pleochroic biotite and sericite. Apatite is very abundant as needles and stubby prisms.

The late deuteric alterations and introductions are much more pronounced in this section. Quartz formed as interstitial grains but has also affected an intergrowth with untwinned felspar on the edges of the plagioclase lathes. The growth resembles myrmekite.

H18 from locality 62. Miscroscopically it is holocrystalline with an altered intersertal texture. The plagioclase has suffered regeneration to Ab66An34 Andesine. Further regeneration has resulted in glass clear acid types together with sericite, epidote and chlorite.

The uralite is typical and bears no special mention except that it is intergrown with chlorite. Associated biotite is strongly pleochroic from deep olive green to light brown. X= light brown, Y=Z= olive green. Very fine skeletal grains of ilmenite remain, together with much secondary magnetite.

The saussurite is very abundant. Epidote is in the larger crystals being biaxial (-ve) 2V 80°, strongly pleochroic, elongated parallel to cleavage. Its birefringence is second order with some anomalous colours produced making it very similar to clinozoisite which is biaxial (+ve) 2V 80°.

A3. B301 is a dark grey rock from locality 96 where the outcrop is brecciated in a crush zone where phyllitic contact rock is veined with green fibrous chrysotile.

In thin section the original texture has been entirely obliterated giving rise to a structureless mass of secondary minerals. The plagioclase is oligoclase. The uralite is light coloured pleochroic X= pale brown, Y= pale green, and Z = pale teal blue. It is very abundant as fibrous, flaky and lathe-like aggregates having oblique extinctions up to 15 , and intergrown with pale green, antigorite and chlorite. The antigorite has very low birefringence, straight extinction and opposite sign of elongation to the chlorite. Anomalous blue chlorite is found in several veins crossing the section, Pleochroic epidote is abundant and biotite pleochroic from pale brown to greenish is also present. Ilmenite as skeletal crystals has given rise to translucent leucoxeme.

B59 from locality 139 has a relic ophitic texture. The plagioclase except for a small few flakes still showing dusty brown intrusions has been completely regenerated to low R.I. glassy albite-oligoclase though some andesine is still present in the sericite, zoisite, epidote, pseudomorphs after original labradorite.

The uralite is typical hornblende and associated with it is fibrous, radiating, length slow antigorite. A little pyroxene still survives as colourless anhedral fragments bordered by zones of uralitization. It is biaxial (+ve) 2V moderate, Z∧C 40 . Augite.

The accessories are secondary except for ilmenite which occurs in skeletal grains. Zoisite in fine aggregates shows anomalous blues as distinct from the epidote with higher colours and biaxial (-ve) 2V 80°. Secondary magnetite has resulted from the uralitization.

H21 from locality 63 is a dark porphyritic rock and in thin section is holocrystalline with an average grain size of 0.6 x 0.2 m.m. but felspar lathes up to 1.8 m.m. long occur. The texture is interlocking in nature. The original plagioclase twinning is now only indicated by alteration characteristics such as parallel arrangements of the sericite flakes in constant relation to the twin planes. The alterations products assume large sizes and specific properties may be determined.

The uralite is similar to foregoing examples Z C 16 . optic axial angle (-ve) 80°. However, the bluer sections appear to be very much lower than the lower angle set for normal hornblende (52). Magnetite and biotite are associated. Frayed fragments of sub-calcic augite are abundant with optical axial angle (+ve) 2V 40° with maximum extinction of 40°. 2V 25/35° pigeonite occurs.

Epidote and zoisite occur together as before. No leucoxeme is evident and therefore, the skeletal sub-translucent grains are taken to be hydrated magnetite. Limonite occurs in dense red brown amorphous material.

B38 occurs at locality 137 where the dolerite is finely jointed into flags about 3 inches wide. From these joints destructive weathering of the doleritehas taken place giving yellow green bands either side of a normal dark grey medium grained rock.

In thin section this hollow chrystalline rock is almost structureless. The felspar is Ab62An38 Andesine. Regeneration has mostly obliterated the multiple twinning giving a mass of low relief acid plagioclase. The decomposition products are sericite and epidote.

The uralite is complex due to destructive weathering following the uralitization. The hornblende is light coloured, shows simple twinning, and occurs mostly in needle-like aggregates. X= light green brown, Y=Z= light green. Z∧C 16 . The optic axial angle is (-ve) 50°. This amphibole is intergrown with calcite and chlorite, the latter exhibiting low birefringence and often anomalous blues.

Epidote is strongly pleochroic and has been re-chrystallized and segrated from the original saussurite. The iron ore is titaniferous and has been broken up into microchrystalline masses showing adamantine lustre in reflected light and these grade into granules of sphene.

Olivine bearing dolerites.

B1. 2?30 is a "fine grained compact rock containing small crystals of felspar and dark green silicate" collected by Howchin and described by Benson. Labelled "west side of Blinman mine" which probably corresponds to locality 142.

In thin section the rock is holocrystalline with an ophitic texture and has a porphyritic tendency. The pyroxene is abundant as colourless anhedral phenocrysts with peripheral uralite associated together with a little secondary magnetite. The pyroxene is sub-calcic with an optic axial angle of (+ve) 36/44° showing maximum ext~~ension~~inction of 40°.

The plagioclase has been completely altered and shows no sign of original multiple twinning. The alteration product is almost entirely sericite and no regenerated plagioclase can be identified. A little epidote is evident.

The olivine occurs only as antigorite and talc (?) pseudomorphs with the production of much secondary magnetite indicating its former idiomorphic form.

B135 from locality 201 is a dark grey medium grained rock containing blotchy patches of ferromagnesian.

The rock has residual ophitic texture with altering plagioclase lathes interlocking within larger pyroxene crystals. The pyroxene is colourless pigeonite which an optic axial angle as low as (+ve) 20 and higher carrying it into the sub-calcic augite zone. $Z \wedge C$ 35.

The uralite is hornblende which shows pale green colours weak pleochroism, but in many places the colour and pleochroism become marked. X= light brown, Y= green blue, Z= blue. The angle $Z \wedge C$ remains high in the vicinity of 20°, but the optic axial angle lowers as seen in other slides. Here the source seems to be late deuteric introductions along a fissure, as in the immediate vicinity the pronounced blue colour appears. Possible pseudomorphs after olivine are comprised of felted masses of light green chlorite and antigorite associated with magnetite which form irregular lines corresponding to original fractures. Limonitic material may result from the hydration of iddingzite.

The plagioclase is altered to a dense microgranular aggregate of zoisite, epidote and sericite - epidote often removed and recrystallized into large pleochroic grains. The residual plagioclase is of low $R.I. < b$, and shows occasional twin lamellae. Composition albite-oligoclase. Ilmenite forms skeletal crystals with pronounced lines along which leucoxeme has formed and it could be that these represent octahedral cleavage, along which the alteration to leucoxeme has been initiated. Sphene and magnetite are accessory.

B37 is a dark grey medium grained rock containing lathes of fine felspar and black ferromagnesians. Found at locality 137.

Microscopically this is holocrystalline originally of ophitic texture but now showing patches of structureless alteration products. The felspar where still fresh shows dusty brown inclusions as in B104 and is $Ab_{50}An_{50}$ Labradorite where not regenerated. Alteration parallel to the 001 basal cleavage has resulted in a serocotoc mesh-work varying with the orientation. Clinozoisite occurs in lathes yielding biaxial (+ve) figures 2V 70°. The regeneration of the plagioclase has thrown off the inclusions in the peripheral portion of the lathes giving rise to glassy plagioclase R.I. $<$ b.

Uralite is often porphyritically included in the felspar and though usually light green more highly patches occur. X= light yellow brown, Y= olive green, Z= blue. maximum extinction is 23°. Optic axial angle is (-ve) moderate. Light green lathes of chlorite and apatite are often associated with the introduced deuteric quartz.

Pseudomorphs after olivine occur consisting of magnetite and antigorite. Pyroxene is sub-ordinate, and is seen only as anhedral residual lathes that have escaped uralitization. Accurate optical properties are difficult to determine due to scarcity. However, appears to pigeonite biaxial (+ve) 2V 20° approximately. Z∧C 45°.

B2. 2832 is a specimen collected by Howchin and later described by Benson as a fine grained diabase with large grains of dark green ferromagnesian silicate and small pale green felspar phenocrysts. Labelled " the dyke near the gorge, on the old road five miles west of Blinman."

Microscopically the rock is porphyritic with a sub-ophitic texture. The phenocrysts are sub-calcic augite, biaxial (+ve) 38/44° with maximum observed extinction of 35°. Phenocrysts of olivene are completely altered to aggregates of magnetite, antigorite and higher birefringent talc.

The plagioclase is secondary andesine $Ab_{56}An_{44}$. The alteration product is mostly sericite, but a little epidote is present. Secondary magnetite results from the breakdown of the olivine and of the pyroxene to uralite. The latter is in an early stage of formation.

B54 in hand specimen ~~this~~ is similar to B38 in having one weathered edge along the joint plane grading from yellow green into normal dark grey compact rock. Locality

In thin section it is holocrystalline with residual ophitic texture in which the plagioclase phenocrysts have regenerated to low relief albite oligoclase.

Olivine pseudomorphs consisting of light green antigorite and associated red brown limonitic material.. The latter may have resulted from the hydration of iddingsite. The original pyroxene has been completely uralitised to light coloured aggregates of needle and fibrous structures with maximum extinction 16°, associated with it is light green chlorite. Accessories include calcite, sphene and magnetite both primary and secondary.

Melaphyres

C1. H48. This is a dark grey porphyritic vesicular rock containing phenocrysts of light brown felspar and light green chloritic masses set in a dark fine grained groundmass. Vesicles are filled with deep brown siderite associated with a certain amount of limonite. Other vesicles contain calcite and quartz. A common feature is the lining of vesicles with micaceous haematite, the occurrence of green copper stains and odd grains of pyrite. This is a specimen from locality 77.

In thin section the rock is holocrystalline porphyritic and highly vesicular. The phenocrysts are set in a devitrified groundmass. The plagioclase gives extinctions up to 29° in the symmetrical zone. Ab58An42 Labradorite, but majority has maximum distinction of 16°. The R.I. inrelation balsam is difficult to determine due to the interference of alteration products and the obliteration of the basal cleavage. But as good and well defined multiple twinning is present the composition is assumed to be Ab56An34 Andesine.

The ferromagnesian is wholly light green chlorite occurring in large isotropic basal section. Siderite is abundant as pleochroic brown to lighter shade fragments and show and both greater than balsam. Limonite is associated and is quite common as a coating over the siderite. Calcite is intersertal with groundmass but is difficult to distinguish from siderite as the former grades into siderite by a simple Fe replacement.

The groundmass is fine grained with an intersertal texture which does not show any flow structure. The above minerals are represented in addition to abundant magnetite., haematite and rutile. The late deuteric introductions are uniaxial (+ve) glass clear quartz, low relief biaxial (-ve) 2V 43° anorthoclase, together with minor muscovite and chlorite which are probably a recrystallization of the alteration products.

The amygdales are all filled with calcite or pleochroic siderite associated with red brown limonite, quartz, felspar and chlorite showing a regular zoning commencing with magnetite of the groundmass to a light green isotropic chlorite zone, followed by a haematite-chlorite zone in which the chlorite is intersertal between the flaky haematite which in basal sections is translucent red. This is followed by an intergranular mass of potash felspar and quartz before the final residual cavity is filled by siderite.

B111. From locality 161 is a light grey porphyritic amygdaloidal rock containing phenocrysts of white felspar set in a fine grain groundmass. The vesicles are filled with white to slightly ferruginous calcite.

In thin section the rock is holocrystalline porphyritic with felspar phenocryst set in a fine grained goundmass predominantly felspar with microcrystalline patches representing devitrified glass. The plagioclase is twinned on the albite and albite-pericline laws and though twins are sharp sericitic alteration products obscure the R.I. Maximum extinction in the symmetrical zone 16°. Biaxial (+ve) 2V 70° suggests albite.

The groundmass is holocrystalline and consists predominently of plagioclase, calcite, magnetite, red rutile and well defined lathes of light green faintly pleochroic chlorite, showing low R.I. < b, biaxial (+ve) 2V 25°, extinction 2°. The plagioclase has extinctions of 16 and the majority occur as ragged lathes with frayed edges perforated with sericite. Clear interstitial partially twinned felspar is more specifically albite. Biaxial (+ve), 2V 70°. Biotite occurs as brown fibrous masses with chlorite.

B158 from locality 92 is a pronounced variation. A fine grained amygdaloidal containing a series of long drawn vesicles lined with dark green silicate and calcite.

In thin section the texture has an intersertal form with glomerophenocrysts of felspar alteration products. The former felspar phenocrysts have been saussuritized resulting in a fine mass of clear untwinned albite intergrown with chlorite. The mass does not show epidote which has been removed and recrystallized to the general groundmass. The latter shows saussuritised plagioclase as frayed fragments with very little multiple twinning. Unlike the phenocrysts the plagioclase here includes epidote. Ilmenite is partially altered to leucoxeme. Visicles are elongated and vein-like, lined with thick green mattered chlorite as non-pleochroic isotropic sections, inside which is quartz, calcite, and haematite with disseminated lathes of green chlorite.

B55 is a light grey porphyritic containing stumpy pink plagioclase phenocryst set in a fine mass containing little dark mineral content.

In thin section the felspar has prominent Braveno and albite twinning. R.I. greater than balsam. Biaxial (+ve) 2V 85°. Andesine Ab An . Regeneration of a higher order has given glassy clear varieties of oligoclase. The groundmass is oligoclase with original ferromagnesian represented by green chlorite and biotite in skeletal lathes. Interstitial cavities and vesicles are filled with calcite and micaceous haematite which is readily detected by its red basal sections. The late deuteric introduction is quartz and possibly oligoclase associated with which is accessory apatite. Magnetite ilmenite and leucoxeme are accessory.

C2 B186 is a light green amygdaloidal specimen containing plagioclase phenocryst and dark green silicate in a finer mass. Locality 94.

In thin section felspar and olivine occur as phenocrysts, the former is by far the most abundant mineral. Saussuritization has given rise to sericite, calcite and epidote and a little regenerated plagioclase on the periphery of the larger lathes. General composition is Ab62An38 Andesine.

Olivine forms euhedral phenocrysts which have suffered breakdown into magnetite and a mass of light green low birefringent antigorite. Red amorphous haematite or limonite represent iddingsite. Uralite is not common but where it occurs it is distinguished from the chlorite by its extinction angle of 15°. Introductions along a vein structure have given calcite, quartz and albite oligoclase.

B172 from locality 85 is a light grey fine grained basaltic rock in which theamygdals and only partially filled with radiating needles of dark green epidote, actinolite and chlorite.

In thin section phenocrysts of felspar are set in a devitrified groundmass. Plagioclase is Ab58An42 Andesine with alteration products including sericite and zoisite with green chlorite filling odd fissures.

The uralite is light green actinolite Z∧C 17 . Chlorite is similar. Epidote occurs as pleochroic grains, sphene also pleochroic and appears to have originated from the ilmenite. Magnetite is abundant from the breakdown of pyroxene and olivine. Vesicles are filled with radiating masses of epidote, actinolite and chlorite. Associated is late deuteric albite, quartz and apatite.

B166 from locality 82 is a fairly typical melaphyre in appearance, having porphyritic plagioclase set in a purplish fine grained groundmass spotted with green silicate. Amygdals are filled with calcite.

In thin section plagioclase lathes show albite and Braveno twinning while some carsbad is evident. Composition Ab54An46 Andesine. Magnetite and antigorite form pseudomorphs after olivine

Red brown iddingsite has been hydrated to amorphous limonite.

The groundmass is holocrystalline intersertal in texture with microcrystalline patches. Felspar is less basic than phenocrysts. $Ab_{66}An_{34}$ Andesine. Chlorite and calcite replace nearly all original ferromagnesian. Minor accessories include ilmenite, leucoxeme, magnetite and apatite.

The vesicles show zonal arrangement in which the inner zone is occupied by finely divided calcite flakes, followed by radiating vein structure across the remainder of the space by green pleochroic chlorite, and non-pleochroic matted chlorite. Sometimes within this zone there is a very thin calcite, felspar, quartz deuteric ring armoured by magnetite and haematite.

Fine grained melaphyres.

This group represents the non amygdaloidal melaphyres which are usually dense, dark and fine grained and often represent the fine grained equivalents of the preceeding groups such as B171 from locality 85, corresponding to B172. The same outcrop shows an even more pronounced amygdaloidal structure. Filled evidence has shown no structures indicating flow under wet conditions, however H75 has all the indications of being a spilite as seen under the microscope.

B171 has an intergranular texture with a slight parallel banding which is much more evident in the hand specimen. The felspar is in frayed lathes showing very poor multiple twinning and is albite - oligoclase. The uralite is in the form of light green actinolite with $Z \wedge C$ 20 . Chlorite is similar but not abundant. Accessories include calcite, ilmenite with accompanying leucoxeme and epidote.

H38 from locality 78 is similar to B171 but a little coarser grained. In thin section a texture is intersertal. Plagioclase is albite. Actinolite is abundant as fibrous and compact lathes. Z C 15 Biaxial (-ve) 2V 80°. Remaining minerals are subordinate and include epidote, chlorite in small lathes and fibrous to matted structures. Magnetite and calcite and clear quartz are of a secondary nature. Scapolite possibly occurs.

B176 from locality 71 is a light grey, fine-grained rock which is finely vesicular, in which most of the cavities are filled with quartz and green silicate.

In thin section the fine felspar lathes visible in the hand specimen are largely decomposed to sericite. Multiple twinning is largely obliterated but sufficient to indicate its low extinction. R.I. < b, Oligoclase. The remaining minerals are included in the holocrystalline intersertal groundmass. Chief minerals are plagioclase, chlorite and iron ore which is largely ilmenite with associated leucoxeme. Red brown rutile is very abundant.

Zircon and calcite are also evident. Secondary quartz is seen in small fragments which have filled minute spaces in the porous groundmass. However, it mainly is confined to the larger vesicles which also include fibrous light-green chlorite and lathes of strongly pleochroic biotite, brown to light-brown and showing alteration to chlorite.

H105 from locality 18 is a very fine-grained dark compact rock with no distinguishable minerals in the hand specimen. In thin section it is microcrystalline porphyritic with glomerophenocrysts of plagioclase lathes and various secondary minerals. Other phenocrysts appear to pseudomorphs after pyroxene. Outlines are enhedral as indicated by secondary magnetite running in parallel lines indicating from 90° cleavage planes. Chlorite forms the bulk of these pseudomorphs.

The felspar has R.I. < b, multiple twinning show very small extinction angles up to 14°, albite - oligoclase. As a result of the plagioclase alteration sericite and epidote have become abundant. Iron ore is exceedingly abundant giving a false impression of a merocrystalline base. Leucoxeme, brown and sub-transluscent occrs. Vesicles are not abundant and where they occur are filled with calcite, chlorite and sphene. Calcite also occurs in the groundmass.

H75 from locality 71 is dark grey, very fine-grained rock in which vesicles are filled with rhomb-shaped porphyroblasts of siderite.

In thin section the rock holocrystalline with an intersertal texture between the three main minerals, plagioclase, chlorite and magnetite. The felspar is difficult to determine, due to alteration and very little residual twinning may be seen. The lathes are broken and mottled near extinction. R.I. $<$ b Albite- oligoclase.

Chlorite is much more abundant than first appears, due to very light green to colourless appearance. Magnetite occurs in very great quantity, suggestive of original iron, rich ferromagnesians, - calcite biotite and rutile, - occur. Siderite and calcite rhombs grow in the general rock base and indicate a certain amount of thermal metamorphism to form these porphyroblasts. In addition to this biotite occurs within their limits indicating combination of sericite, muscovite, calcite and iron under the thermal conditions.

ASSOCIATED ROCKS.

Associated with the basic rocks of Blinman area are several outcrops of gneiss described by Howchin as gneissic granites, and later as conglomerate paragneisses by Benson. However, a clue to their origin is seen at locality 157, where a pegmatitic rock has been intruded into a brecciated quartzite and purple slate. About it is a small iron rich aureole. This rock, B 114, is principally microcline perthite, oligoclase, quartz and a great number of accessories including biotite, magnetite, sphene, rutile, zircon, apatite, haematite and pyrite.

In thin section the gneiss at locality 172 is very similar to this in mineral conent, with the exception that it contains more biotite and has suffered stress during emplacement.

B 114 from locality 157 is a coarse-grained pink rock consisting of large crystals of buff to flesh-red felspar, colourless quartz and odd patches of black micaceous material.

In thin section the rock is holocrystalline hypidiomorphic granular. The chief mineral is plagioclase in large anhedral crystals showing few inclusions. Twinned on the albite and combined albite-pericline with maximum extinction of 6° R.I. $<$ b Ab_{80} An_{10} Oligoclase. Biaxial (+ve) 2V approaching 90°. It is severely stressed and shows undulose extinction to a high degree; the twinning planes are stressed and buckled to such a degree as to sheer along definite planes in a manner similar to false cleavage.

Quartz is in anhedral crystals, showing peripheral granulation. Optical figure varies from uniaxial to biaxial with small 2V. Microcline perthite shows exsolution of albite plagioclase. The relief of the albite is less than microcline, and figure is biaxial (+ve) 2V 75°, while the microcline is biaxial (-ve) 2V 80°. The accessories are as mentioned above.

B64 is a coarse-grained gneissic rock containing buff to flesh-coloured felspar, clear quartz with schistose bands of biotite. Speciment from locality 172.

Microscopically the rock is granulose with a suggestion of gneissic structure. Post crystallization cataclastic effects have commenced mylonization along parallel zones of both the felspar and quartz, giving rise to fine sericite and chlorite about lensed felspar and quartz. Microcline perthite occurs as turbid xenoblastic crystals sheaved in the peripheral zones and in general having undulose extinction, low relief, biaxial (-ve) with a large optical axial angle. The felspar included is albite, R.I. host. Biaxial (+ve) with moderate 2V 75°. The plagioclase is not common and is slightly turbid, due to incipient decomposition. R.I. $<$ b. Biaxial (+ve) 2V approaching 90°. Ab_{90} An_{10}. Oligoclase.

Quartz is cloudy due to inclusions, and shows marked peripheral granulation causing undular extinction and an optic axial angle up to 20°. The primary mica is biotite, which is strongly pleochroic; x = light straw yellow, y = z = dark green brown. Biaxial (-ve) 2V $10/12^\circ$ as in B114.

The granulation has developed parallel to gneissosity, with the result that secondary sericite has developed with the biotite. Accessories include magnetite, limonite, sphene, chlorite and zircon included in the biotite.

Apart from such pegmatites, there occurs an abundant suite of paragneisses which have resulted from the combined action of pintching, due to severe cataclastic effects, coupled with the heat of the basic intrusions. This adequately explains the limited extent of each individual occurrence.

Generally the intrusions are small or quickly cooling, so that contact effects on the immediate surrounding rocks are small. However, when a hornfels would be expected in surrounding slates, it is repeatedly found that coarse gneisses have formed in its stead, as in the case of locality 7, where gradation occurs from slate to bi-mica schist to coarsely foliated biotite gneiss in which coarsely saccharoidal quartz bands nearly a quarter of an inch thick alternate with micaceous bands.

Associated with gneisses at two localities, 4 and 200, are occurrences of talc schists, such as B137. In the hand specimen the rock is light-green to grey and greasy, with the micaceous flakes in schistose arrangement. In thin section the talc is in granoblastic colourless flakes and lathes with extinctions of 3°; distinguished from muscovite by its lower axial angle. Other minerals are quite accessory and include amorphous limonitic material, golden-brown rutile and magnetite which is arranged in single and double sets of parallel stringers, showing the presence of former twinning so commonly seen in the uralitic hornblende of the area. The present form has possibly resulted from the pneumatolytic alteration of a dolerite rock, as in both cases the outcrops occur in the centre of gneissic bodies.

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