The Geology of part of the Adelaide Series rock in portions of the Hundreds of Barossa and Moorooroo

I.A. Mumme.

Honours thesis 1949
Supervisor: Professor Sir Douglas Mawson

INDEX

INTRODUCTION.

In the area surveyed, the rock formations are mainly Adelaide series rock which belong predominantly to the lower Adelaide System in age.

Several major faults have been found in the area as well as a number of minor faults and belts of intense drag folding.

A major fault extending from Williamstown to Rosedale is approximately parallel in strike with the regional cleavage. The vertical displacement is several thousand feet. Injection of pegmatites took place in the zones of intense faulting and folding and under the high temperatures prevailing talc was formed through metasomatic processes and accumulated in dragfolds; clay and damourite were formed under hydrothermal conditions and an introduction of iron-ore in fault zones of the Mt. Kitchener area (this must not be confused with the Mount Bessemer iron ores).

According to Sprigg, middle Tertiary Time was a period of faulting (Kosciusko Epoch) in which the present "Horst" Range took place. The writer considers that the downfaulting of the Tanunda Angaston Senkungsfeld corresponds to this period.

The older rocks, although much covered by Tertiary sands, clays and gravel beds, and in places lateritized (see Diagram) to a white clay, which is evidence of much secular decay, shows evidences of much folding and severe faulting and considerable thermal metamorphic changes. From Barritt's Estate (north Para) a fault zone runs down to the foothills at Williamstown. This fault is probably of middle Cambrian age when pegmatites were injected into fracture zones during orogenic movements. This injection of pegmatites was accompanied by wide spread hydrothermal alteration with a development of talc, chrysotile, serpentine, sericitic mica.

The marble horizon above the basal grits can be traced across the area occupied by Tertiary sands and gravels in the Lyndock area, mainly from bore results.

Between Rosedale and Mr. Hermann Thunn's Winery, the limestones are deposed in the form of an anticlinal fold.

The presence of quartzite beds have prevented intense faulting and folding of the less competent strata except in fault zones and these quartzite bands have been found a useful index to the regional dip.

Mineralization does not generally occur on a commercial scale in the area surveyed. Copper ores occur at the Enterprise Copper mine and the Lord Lyndock mine. However, these have been practically worked out.

Rutile occurs as disseminatious in damourite schists and clay occurs in important deposits at Williamstown.

Gold has been found in many places in the Tertiary gravels.

Age of the Metasediments to the east of Williamstown.

The writer considers that the metasediments mapped to the east of Williamstown are equivalent to the lower Adelaide Series rocks. To the west of Williamstown the rocks have suffered only slight regional metamorphism but to the east of Williamstown the sediments have undergone varying degrees of contant metamorphism and regional metamorphism.

Howchin (1926) and Hossfeld (1935) hold that the ilmenitic basal conglomerates exposed in the foothills at Williamstown are the basal members of the Adelaide Series. The beds have undergone much pegmatization and have suffered severe dynamic metamorphism, especially marginal to the Mt. Kitchener Fault.

Howchin holds that the sequence is stratigraphically correct and that the beds to the east are of younger age, while Hossfeld considers them to be of Barossian age. Although the ilmenitic grits do show overturning, this is only local. The writer holds that the ilmenitic grits and conglomerates are of lower Adelaide Series age and that they are younger than the beds further east because of the factors,

(1) The series can be traced northward into obviously Adelaide Series rocks.

(2) Complete absence of a conglomerate OR unconformity skirting around the Mt. Kitchener area.

(3) Identical relation to the succession of Adelaide Series rocks overlying the Barossian complex rocks of the Humbug scrub area.

NATURE OF THE MT. KITCHENER MAJOR FAULT.

The fault mapped between the North Para and Williamstown is of the nature of an overthrust fault; the folding having been too severe and the beds were sheared through with an injection of pegmatites along the shear planes.

Minor overthrusts are evident in the marble horizon exposed in the creek behind Mr. Heusler's house and also in the basal beds where there is a deposition of quartz in the associated tension fractures. A noticeable feature resulting from the overthrusting concerns the marked difference in degree and folding to the east and to the west of the Fault zone.

The Fault in this region is obscured to some degree by alluvial debris, although bores sunk down to the west of this fault indicate that the fault is of considerable magnitude.

This fault is somewhat evident from the topography of the area surveyed. With the depression of the land surface to the west of a line running N-S through Williamstown deposition took place in the troughs formed which was a zone of lateritization.

Summary of the Succession of Beds above the Barossian Complex on the Eastern areas of the Mount Lofty Ranges.

(1) Basal Beds.

The total thickness is 1150' - 1200'.

This comprises (a) Basal white conglomerates.

(b) ferruginous haematite conglomerate

(c) Haematite schists and haematite sandstones.

(d) Feldspathic sandstone.

(See discussion on the haematite schists).

These outcrop on the eastern side of the divide between the South Para and Victoria Creek etc. and the contact as can be seen from the geological map, trends in a steady general south-south-easterly direction from Mt. Bessemer Ridge, Section 171, to south-eastern corner of section 6391, etc. The general dip varies from 45°-60°. These basal beds are overlain by a phyllite Shale Series. The thickness of this Series is 5000'-5500'.

At the base of this formation are sandy to silty phyllites with calcareous phases. The limestones developed are dark blue and are distributed through about 50'-100'. The thickness of each band is several feet.

This calcareous phase of the Phyllite Shale Series is overlain by a considerable thickness of Phyllites and a number of sandstones and quartzites. The quartzites are interbedded with phyllites and the quartzites have a total thickness of 100'.

The Mt. Kitchener fault then cuts off the succession of beds.

In the footnils in the Williamstown area are a strong development of ilmenitic sandstones, arkoses, conglomerate schists and haematite sandstones (derived from the weathering of the ilmenite).

These beds are strongly pegmatised by microcline perthite quartz pegmatites and albite-quartz pegmatites. As they are the locus of intense faulting and minor overturning

This succession of basal beds are conformably overlain by sericite biotite schists and then 50'-60' of marble followed by a succession of fine grained pyritic quartzites and actinolite schists and more fine grained quartzites. Finally come the quartzites which are known locally as the "Blue Rocks".

A. The Basal Beds. (Discussed fully later).

B. Sericite Biotite Schists.

These overly the basal beds and are of exceptional purity. Locally (sections 957, 996) they have been converted to kyanite schists in the zone of intense stress marginal to the Mt. Kitchener fault under moderately elevated temperatures due to the intrusion of pegmatites and at higher temperatures (sections 950, 942) have been converted to sillimanite schists. They have suffered severe hydrothermal alteration during late magmatic phases of pegmatitic intrusion.

Total thickness of these beds is 500'-1000'.

C. The Marble Horizon (Discussed in detail later). Thickness 50'-60'.

D. Sericitic Biotite Schists, Biotite quartz Schists, and Pyritic quartzites and a further succession of Sericitic Biotite Schists and fine grained quartzites.

In many instances and especially along the North Para, these beds have a pronounced banding and lamination in which there are alternations of coarseness or fineness in grainsize which suggests varve formations.

See Slides (31, 32.). These show a gradual variation in a vertical direction in the size of the grains of which the laminae are composed. The graduation in an orientated slide is from coarse material at the bottom to finer material at the top of a lamina.

This suggests (a) varve formations

(b) Density current effects (unlikely)

(c) settling of sediments through still bottom waters.

Some of these pyritic fine-grained quartzites contain interesting oolitic structures.

Successional detail of these Beds in the neighbourhood of the North Para - Mr. Barritt's Estate.

			feet
(1).	Chloritic phyllites		500
(2).	Flaggy quartzites and Phyllites		50
(3).	Fine-grained pyritic cherty quartzites showing current bedding, fractional sedimentation and varves? contains oolitic structures and marcasite or pyrites.		
(4).	Limestone lower white marble	26ft.	
	Upper grey blue marble	24ft.	50
(5).	Phyllites		50
(6).	Fine grained cherty quartzite grey quartzite		10
(7).	Phyllites		100
(8).	Fine-grained cherty quartzite		10
(9).	Soft sandy micaceous (biotite) gneiss		10
(10).	Dense fine grained quartzite		10
(11).	Pyritic mica schist		10
(12).	Quartz Biotite Schist		10
(13).	Quartz mica schist		40
(14).	Chlorite mica schist		40
(15).	Micaceous quartzite		4
(16).	Cherty quartzite		8
(17).	Low grade schists		100
(18).	Actinolite schists		50
(19).	Fine grained quartzite		40
(20).	Chlorite Schists.		100

These grade up into the quartzites of the Blue Rocks.

THE BLUE ROCKS

This is a very strong and siliceous quartzite. It overlies a succession of sericitic schists, fine grained quartzites etc, and in consequence of an eroded gap in the schists, causes the quartzites to take the form of a scarped face. Its striking prominence is due to its resistence to weathering coupled with stream action.

The quartzite is a light coloured, siliceous stone with some small flakes of kaolinized feldspar. The original quartz grains by metamorphic action have been blended and fortified by introduced silica in optical continuity which gives it the structure of a quartzite.

The estimated thickness (asmeasured beyond Kara Wirra) is 80 feet. The regional strike of the quartzites on the eastern side of the range is E. 12°N with a dip of 40° to the East.

See Slide No. 25.
Specimen No. 70.

These quartzites form the highest part of the Barossa Ranges.

According to P.S. Hossfeld "They first appear south of Section 1036 Barossa, as siliceous bands in the mica schist gradually widening until reaching their full development in section 3128, Barossa and the adjacent sections. It is obvious that they represent a temporary arenaceous phase, definitely limited in area, in the Barossian seas. The writer does not consider that these beds lens out in mica schists, but considers that they were an extensive formation. Field work points towards the fact that the quartzites of Mt. Kitchener area are the so called "Blue Rocks".

THE BASAL BEDS OF THE ADELAIDE SERIES TO THE EAST OF BAROSSIAN COMPLEX OF THE HUMBUG SCRUB AREA. (cont.)

The Basal beds comprise basal white conglomerate, ferruginous hematites, conglomerates and sandstones, feldspathic sandstones and ilmenitic grits.

These grits conglomerates and schists lie unconformably above the Barossian Complex.rocks.

Nature of the Hematite Schists

Jack considered that the hematite schists were of the nature of an ore body formed by the more or less complete replacement of a series of sedimentaries.

Although Dr. Jack recognised the intimate relationship of the hematite (specularite) with conglomerates, he considered that these were the undigested residues of sediments that had been partially replaced by iron-bearing solutions.

The current bedding effects observed in the hematite schists were also explained by molecular replacement of sedimentary rocks.

The writer considers that these hematite schists are the metamorphosed equivalents of ferruginous basal beds. The wide spread occurrence of ilmenite grains in the beds suggests that the ilmenite was the source of the hematite.

P.S. Hossfeld in "The geology of Part of the North Mount Lofty Ranges".
"A remarkable feature of the basal grits on the western side is the occurrence near the base of enormous quantities of micaceous hematite. In many of the specimens examined the original structure is well preserved, the current bedding of the grains and pebbles of quartz being indicated by lines of micaceous haematite.

The occurrence is very irregular and is practically confined to the lower parts of the beds.

Micaceous hematite apparently owes its presence priparily to the deposition of iron oxides derived from the adjacent rocks when the basal grits were being formed. It occurs near the base only, in pockets which may, or may not, be connected, and probably marked formed depressions. It shows current bedding very clearly, and follows the bedding around pebbles and other obstructions. It is possible that subsequent thermal activity has caused a certain amount of consolidation of the iron oxides, but it evidently has left them substantially unchanged.

The basal beds show a regioned dip to the eastwards of from 45° - 60° Feldspathic sandstones overlie the hematite schists. These sediments gradually grade into coarse grits and shaly sandstones. Thickness of the basal series.

The Basal Series are overlain by phyllitic shale series. 4000' - 6000' in thickness. The phyllitic shale series comprise (1) phyllitic beds (2) several bands of limestone 1' - 2' in thickness in the calcareous phyllites (3) phyllitic beds (4) Sandstones. Individual beds of sandstone varying from a few feet to 30-40 ft in thickness.

VI.

Oolitic structures

in the rocks near Herman Thunn's Winery - North Para.

Oolitic structures in rocks near Herman Thunn's Winery North Para (Location Ford upstream from Rosedale).

Some of the slides show small oolitic structures which have a concentric zonation and are encased in an "augen" of calcite. This suggests shearing streeses but the fact that rocks show little deformation by contortion of the bedding planes are agin this.

Part played by organisms - This is difficult to say. No spines are observed which would suggest radiolaria. The oolites may have been formed by bacteria which have a tendency to precipitate calcum carbonate. It is more probable that these oolitic structures represent areas which once contained pyrites, and which dissolved out leaving a limonitic material. The cavities were subsequently filled with calcite.

See Slides (30,)

Rock no. 83
locality Section 547
(North Para River adjacent Mr. Thunn's Winery)/

III.

TERTIARY AND RECENT SANDS.

Ivan A. Mumme.

TERTIARY AND RECENT DEPOSITES

Large areas of the Hundreds of Barossa and Para Wirra are covered by Tertiary and recent fluviatile gravelbeds, clay and sand-beds. Much has undergone partial consolidation to ferruginous conglomerates and argillaceous grits.

The boulders and pebbles and coarse gravel consist mainly of milky quartz derived from breaking down of quartz reefs.

The areas covered by these fluviatile beds may possibly have constituted an old River system. The underlying Adelaide Series rocks outcrop only in a few isolated places and where exposed show much secular decay.

Along the North Para, fresh water shells were found in abundance. These are weak walled and were washed out of swamp basins of the Rowland's flat, Tanunda, Angaston Area.

Scattered over the surface of the Tertiary gravel and sand beds of the North Para, Rowland's flat and Altona areas are some residual limonitic nodules.

These fluviatile deposites overly very much leached Adelaide Series sediments. In the zone of weathering, the iron shows a tendency to move out and segregate in irregular and mamillary masses separated by clayey material. The tendency can be seen in the weathering of pebbles. Outside, the pebbles are hard, and at the centre consist of soft yellowish kaolin.

During concentration, the ferric hydroxides were transported as colloids and hardened as shown by the concentric structure of the concretions.
It is worthy to note that in the Bore put down at Seppelt's winery Lyndock, clay, gravel with pyrites was struck at a depth of 85' - 95'. This suggests the decomposition of pyrites which was later segregated as limonitic nodules which are hard and easily weather out of the loose Tertiary sands and gravels.

Thickness of Tertiary and Recent Sands gravels conglomerates etc.

Lyndock

Log of a Bore put down at Seppelt's Winery
(near railway-station)

0 - 2'	soil
2' - 20'	Brown clay
20' - 24'	red sandstone and clay
24' - 25'	variegated clay
50' - 85'	clay and gravel
85' - 95'	clay, gravel and pyrites.
95' - 110'	broken slates
117' - 125'	slates
126' - 208'	marble.

The "Lagoon" area

Mr. R. Kies put down two bores.

(1) One struck mica phyllites at a depth of 80'.

(2) The other penetrated 120' of gravel and clay without striking bed rock.

LOG OF BORE RESULTS AT ALTONA

Mr. J. Mahlo's Property.

0' - 30'	coarse red yellow sand
30' - 40'	five dark yellow sand
40' - 65'	micaceous clay.
65' - 76'	quartz vein in mica schist
76' - 86'	Decomposed mica schist and clay
86' - 87'	gravel wash
87' - 96'	cherty quartzite and micaceous schist
96' - 98'	micaceous quartzite
98' - 104'	whitish weathered micaceous schist
104' - 180'	green to grey chloritic mica schist
180' - 200'	quartz mica schist until abundant pyrites.
200' - 215'	kaolinised pyritic mica schist
215' - 240'	dense hard fine grained quartz biolite gneiss.
240' - 258'	soft sandy micaceous gneiss
288' - 262'	vein quartz in dense sandy biotile gneiss with pyrite.
262' - 300'	hard dense fine grained pyritised biotile quartzite

RECENT FOSSILS

In the redistributed sands which occur in the North Para are numerous thin walled Mollusca. These are pelecypods and they are the members of the species CORBICULINA ANGASI common at the present day in the Murray River and at other places in Southern Australia.

Such fossils are known back as far as the Pleistocene but these appear to be of recent age.

No gasteropods were found in the area. Later Tertiary fresh water gasteropods, have a characteristic of having low calcium carbonate in their shells developing a prevalence of chitinous matter. Hence there is a tendency for them to readily dissolve, leaving no trace.

Laterites and Travertine Limestones.

Laterites. These occur over large areas in the area mapped, particularly in the neighbourhood of Altona and Rowland's Flat, which is suggestive of impeded drainage in low lying areas under tropical conditions (possibly pleistocene in age).

Travertine occurs in the neighbourhood of the marble beds and dolomites in considerable thickness.

(see diagram for distribution of laterites and travertine limestones).

Ivan A. Mumme

VII

BASAL ILMENITE SANDSTONES

CONGLOMERATES, ARKOSES AND GRITS

as exposed on the foothills

EAST OF WILLIAMSTOWN.

+ + + + + +

THE BASAL ILMENITIC SANDSTONES,

ARKOSES, GRITS AND CONGLOMERATES.

This horizon has been located in the area mapped along the foothills in the neighbourhood of Williamstown.

It is difficult to estimate the thickness of the basal beds owing to the fact that they have been severely disturbed during the orogenic movements accompanied by intrusions of pegmatites, and severe faulting in which the sediments to the east of Williamstown have been elevated several thousand feet.

The basal beds have been folded into a number of anticlines and synclines with overturned axes (as measured by current bedding effects). An estimate of the thickness is 1300ft.

The ilmenite sandstones show little variation in the mean grain size of the sand fraction throughout its entire thickness except for the few conglomerate horizons and a coarse ferruginous grit 5-10ft. located at the top of the succession of basal beds.

The best development of conglomerate within the basal beds is in the valley north of Mt. Caddie and situated behind Mr. A. Creek's house. Here is a good development of basal conglomerates which contain large milky quartz pebbles, pebbles of quartzite and pegmatite (showing eutectic features).

Several pebbles were removed for examination, but they showed no evidence of glacial scratching and the evidence points to a purely water deposited conglomerate.

Further down the valley, and on the right hand side (facing downstream) the basal conglomerates have been severely stressed.

The pebbles have been lensed out in a plane 20° W of N. Nearby, intercalations of angillaceous matter have been converted to biotite and biotite actinolite sericite schists in the aureole of contact metamorphism neighbouring to a pegmatitic intrusion.

In these schists, the ilmenite has been converted to magnetite and rutile.

Epidotization is evident here as an alteration product of actinolite, biotite and feldspar and occurs as an infilling in veins and fissures.

The basal beds comprise altered ilmenitic feldspathic conglomerates and grits with intercalations of angillaceous material.

Within the contact aureole surrounding the pegmatitic intrusions they have been thermally metamorphosed to biotite schists, biotite feldspar actinolite quartz schists etc.

Beyond the immediate zone of thermal metamorphism the basal beds have been subjected to dynamothermal metamorphism which has produced plastic deformation of pebbles accompanied by the development of secondary sericitic mica and recrystallization of ilmenite grains to idiomorphic magnetite.

The faulting has produced minor slickensides which show a stepped structure in which the striae terminate abruptly at the edge of the steps and then continue at a lower level. An excellent example can be seen adjacent to a pegmatitic intrusion 800 yards direct south of Mr. Hammat's house.

In places the basal beds have been epidotized. Some specimens show a development uniformly through the rock whereas others show a development along joint planes, cracks etc. It is probable that this is due to two major factors -

(a) Saussuritization whereby the plagioclase feldspar altered to epidote and albite; (See Slide 4, Specimen 11)

(b) Hydrothermal activity accompanying pegmatization whereby epidote was dissolved and redeposited as infilling in cracks.

At the base of the basal beds is a dense grey quartzite containing recrystallized feldspar. Above this are ilmenitic sandstones and arkoses with occasional conglomerate horizons.

At the top is a relatively porous iron stained grit in which much of the ilmenite has been oxidized to haematite and limonite.

Intruding the basal beds are pegmatitic bodies and much milky quartz in reef form. Generally the swarms of quartz veins are associated with the pegmatites.

The pegmatites are of two varieties - (a) rich in albite feldspar, (b) rich in microcline feldspar.

Marginal to the pegmatitic intrusions in the foothills behind Williamstown and north of the Victoria Creek (in the vicinity of Mt. Caddie), there are silexite bodies (consisting of quartz and muscovite) which gradually change into milky quartz reefs on passing further away from the associated pegmatites.

In places the grits have been permeated by late magmatic fluids developing muscovite in small quantities.

Following along the line of strike of the basal beds one loses them 1½ miles north of Williamstown. Adjacent to where they disappear under the alluvium a bore was put down 166ft. on Mr. Minge's property -

0 - 2'	black soil
2' - 15'	yellow clay
15' - 98'	yellow slate
98' - 166'	hard grey blue slate

Travelling across the strike the last exposure is in a well sunk near Mr. Worden's house at a depth of 32'.

THE STRESSED PEBBLES IN THE BASAL BEDS.

The Boulders are regularly extended at both ends, have an oval cross-section and are rarely brought into relief by weathering of the micaceous schistose base.

This results in a flaserige structure. One of these flattened pebbles measured 7". It is probable that the pebbles have been extended not because of rolling but by solution on the stressed sides of the grains and transference of the material to the unstressed portions.

The surface of dislodged pebbles glisten with sericitic mica.

The most advanced stage shows the granulation of the fragments of feldspar and elongation of the pebbles. The original pebbles have now been reduced to the state of smears.

SUMMARY OF THE BASAL BEDS.

At the base is an intense zone of pegmatization and re-crystallization with a development of dense quartzites with prominent porphyroblasts of feldspar. Further up we pass into a small pebble feldspathic conglomerate which shows crushing in shear zones and lensing out of pebbles.

Higher up, we pass into ilmenitic fine grained grits showing clearly current bedding features characteristic of shallow water conditions. There are intercalations of angillaceous material in these ilmenitic sandstones.

At the top of the basal series is a ferruginous coarse grained grit.

Some of the quartz reefs which transgress the basal beds contain ilmenite and feldspar which suggests that it was derived in part from solution of the basal beds and redeposition.

The writer holds that the ilmenitic sandstones, arkoses, conglomerates and grits exposed in the foothills of the Williamstown area are the equivalent of the basal beds exposed on the western side of the Barossian complex (and also on the eastern) as exposed in the Humbug Scrub area and that the age is lower Adelaide series.

Superior to the basal beds are sericitic biotite schists which are overlain by a marble bed and then a considerable thickness of chloritic biotite sericite schists with intercalations of cherty quartzites which are ~~pegmatitic~~ Pyritic and show well. Fractional sedimentation and microscope study revealed that they are highly feldspathic.

Above the chloritic biotite sericite schists are a number of quartzites 10' in thickness, about 4 in number and constitute the so-called "Blue Rocks".

ALMANDINE GARNET ZONE.

Pegmatized garnetiferous muscovite quartz apatite beryl rock. (See Specimen 12)

The basal beds have been permeated under high temperature conditions by pegmatitic emanations with a development of pink garnets, blue apatites, green beryl and white mica.

The garnets often tend to occur in bands suggesting remnants of bedding. Such structures suggest limited molecular diffusion of ions.

The accessory minerals Beryl apatite, tourmaline, etc. in the pegmatites suggest the presence of fluoring boron etc. volatiles as well as water which catalysed many chemical processes.

It is possible that the titanum dioxide in the ilmenite was removed and deposited in the overlying altered sediments.

The best development of garnet in the basal ilmenitic sandstones occur marginal to the kyanite sillimanite biotite sericite schists which represent intense alteration of sericite chlorite schists.

Epidote intimately associated with the plagioclase feldspar and has high Birefringence and is strongly pleochroic from yellow to colourless.

Biotite. This shows alteration to a Protochlorite.

Basal Beds.

Slide (3) Specimen (3)

Macroscopic description

This is a quartzite which contains some ilmenite. The handspecimen is light coloured, and shows secondary silicification of a sandstone.

Microscopic Description

The rock is a leucocratic quartz feldspar rock which contains only a little dark mineral which is mainly ilmenite.

In thin section the rock is seen to have a coarser grain than usual consists of crystals of plagioclase (oligoclase) and quartz. There is accessory ilmenite Alteration has produced a mass of tiny flakes of white mica and epidote. Protochlorite occurs as an accessory mineral.

Slide No. (39)

Rock No. (98)

Locality 2500

Sericitized Amphibole Biotite Schist

Macroscopic Description -

The hand-specimen is a coarse grained rock containing large elongated prisms of amphibole (actinolite) and flakes of Biotite. The rock is fairly homogenious and has no trace of relic structure or cleavage.

Microscopic Description -

This is a melanocratic coarse-grained metamorphic rock which consists predominantly of actinolite. In thin section , the rich is seen to consist essentially of plagioclase green hornblende, sericilized biotite and rutile.

Actinolite - When received in ordinary light it is a green - blue colour. In polarised light it shows a strong pleochroism - the colour varying from pale brown to dark green. The absorption Z>Y>X; Z us a deep green, Y a blue green and X straw yellow.

Biotite - This is distributed regularly throughout the slide. The pleochroism of the mineral is weak generally. It shows sericitization to secondary muciovite.

Basal Beds as exposed in section 517, 516, and 2500 at the base of the ilmenitic quartzites and conglomerates.

Slide (1) specimenI.
Recrystallized ArKosic Quartzite.

Macroscopic Description

Medium to fine grained rock which is light coloured and contains abundant feldspar. The rock is dense and has no obvious fissibility or banding structures.

Microscopic Description

In the microscope slide, the texture is almost homogeneous granoblastic. The quartz present shows undulose extinction and minor granulation while the feldspar shows fracture and peripheral sericitization. There are also small amounts of white mica in cracks and enclaves within the quartz and feldspar.

The feldspar has been largely saussuritised with a development of epidote

Epidote. The Birefringence is high and the mineral is strongly pleochroic from yellow to colourless crystals in thin section. The epidote occurs in large crystals or in tiny colourless grains.

Plagioclase

This is clouded with minute alteration products. The composition is that of oligoclase.

BASAL BEDS

Slide (1) specimen (1)
continued.

Accessories are Biotile and ilmenite. The Biotile is practically all altered to a Protochlorite.

Slide (2) specimen (2)

Macroscopic Description

The hand specimen is grey coloured and is rather fine grained. Feldspar is prominent in the hand specimen.

Microscopic Description

Microscopically it is holocrystalline, hypidiomorphic with porphyroblastic texture consisting of feldspar, quartz, and epidote with accessory ilmenite, and altered Biotile.

The quartz present shows undulose extinction and under X nicols polarizes in yellow (of the first order).

The feldspars are most abundant and consist of oligoclase and show intense saussuritization. A little peripheral granulation of feldspar is apparent.

MICA MINES SOUTH OF THE

WARREN RESEVOIR. SECTION 343.

The mica in many of the pegmatite bodies is not evenly distributed throughout the mass but is most abundant in certain zones.

These zones appear to be distributed throughout the pegmatite in a totally haphazard manner bearing no relation to the general form of the pegmatite mass not to the position of the wall rocks. The central portions of theemuscovite belts for a width of a few inches consists of an aggregate of heterogeneously arranged muscovite plates. The distribution of some of the muscovite is peculiar and seems to represent a muscovite crystallization proceeding not from a single centre but from a plane or from a large number of centres lying in nearly the same plane.

Beryl apatite and tourmaline are often concentrated in pockets in the pegmatites and occur in sections 941, 3101, 125 etc.

In sections 343 and in the neighbourhood there are highly garnetiferous zones in which the garnet is associated with a granular aggregate of quartz and nuciocline feldspar and represents pegmatized country rock.

Rutile and Ilmenite

Rutile occurs in sections 941, 3101, 938, 2725 etc. and is derived from ilmenite under hydrothermal conditions which prevailed in this area during late stages of pegmatitic intrusion. The rutile often occurs associated with damourite kyanite schists and sericite schists. Field work supports the fact that these beds were originally ilmenitic bearing sediments which represent an argillaceous phase of the basal conglomerates and grits and that the rutile was derived from the ilmenite "in situ" under hydrothermal conditions.

Nowhere in the overlying limestones is there a development of sphene which could result if there was a migration of Titanium dioxide.

$$3FeO.TiO_2 + 3Ca(HCO_3)_2 + 3SiO_2 = 3CaO.TiO_2.SiO_2 + 3Fe(HCO_3)_2$$

See specimens of Rutile (from Rutile Mine)

Ivan A. Mumme.

VIII

"NATURE AND EMPLACEMENT OF

THE PEGMATITES".

\+ + + + +

\+ + + +

\+ + +

SLIDE NO. ..3......

ROCK NO. .3........

LOCATION MR ROSS'. PROPERTY (Section 1181)

DESCRIPTION OF A PEGMATITE SLIDE

Macroscopic Description:

The pegmatite is lightly coloured with a mottling of pink and white feldspars, and greasy translucent quartz grains. Muscovite occurs in small flakes. A few beryl crystals as well as apatile crystals can be seen in the hand specimen.

Microscopic Description:

Under the microscope the essential minerals are quartz and feldspar. The minor minerals are muscovite and biotite, while the secondary minerals include kaolin and sericitic mica, which appears as dusty inclusions in the feldspar.

The slide shows a fluted aggregate in which the anhedral crystals of quartz and plagioclase have a tendency to intergrow.

In the slide, anhedral crystals of plagioclase are seen on a ground mass of plagioclase and sometimes quartz. This property is due to the gradual crystallization involving long continued and repeated deposition, solution and transportation.

The quartz is colourless and contains numerous inclusions of muscovite etc. Undulatory extinction is pronounced, suggesting stressing of the pegmatitic body. A few plagioclase crystals show shearing.

Feldspar - Predominantly plagioclase.
The maximum extinction angle in the symmetrical zone of extinction is 20^{o} (perpendicular to the 010).

The refractive index is greater than the Canada Balsam.

Composition Albite. $Ab_{10}.An_0$.

Microcline - A small amount of microcline feldspar occurs. This shows the typical cross-hatching under crossed nicols.

Quartz - The quartz occurs in clear and colourless anhedral grains with very few inclusions but is often intergrown with the albite.

The mineral possesses a somewhat shadowy extinction due to strain, which is often noticed in the quartz.

Muscovite and Biotite Micas - occur occasionally as flakes irregularly distributed throughout the slide.

PEGMATITES.

The occurrence of large areas of coarse microcline perthite pegmatites as well as subordinate albite pegmatites is suggestive of orogenic movements.

In places blocks of optically continuous feldspar often show penetration by regularly arranged quartz growths. The coarsely crystalline pegmatitic material extends generally to the contact, there being no evidence of a chilled zone.

As noted in the geological map, the outcrops are not in the form of a solid homogeneous mass but are largely constituted of dike-like apophyses separated by biotite actinolite schists and ilmenitic feldspathic quartzites which constitute the basal beds of the Adelaide series in this area. The pegmatites eventually join at depth.

Some bands of albitic character occur, forming albitic rich pegmatites.

Tourmaline usually occurs in the pegmatites and patches of quartz and tourmaline intergrown in a graphic manner are occasionally seen.

In these large anhedral crystals sometimes appear embedded in a eutectic base.

In places some of the boric acid has, however, escaped into the surrounding schists which in places have been converted into the state of schorl. All gradations can be traced from schorl bearing schists into the unaltered schists. Inclusions of quartz often occur in the tourmaline.

Some phases of the basal beds are highly micaceous, containing muscovite. The pegmatites show a general tendency to follow the bedding of the original rocks and also tension gashes.

At the extreme phase of the pegmatites representing crystallization from the coolest and most attenuated juvenile waters is in the formation of quartz reefs. In parts, the basal beds have been observed to have suffered severe silification until reduced practically to the state of a quartz rock resembling normal quartz reefs.

Generally speaking north of the Victoria Creek the pegmatites are poor in muscovite and consist essentially of microcline and quartz or albite and quartz.

Much of the microcline feldspar of the pegmatite contains numerous cracks into which later quartz was injected during the later phases of crystallization. An excellent example can be seen in a pegmatite outcrop halfway between Mr. Ross' house of the Victoria Creek road and Mr. Hammat's house neighbouring to the Enterprise Copper Mine.

RELATIONS OF THE PEGMATITES TO THE META SEDIMENTS.

The basal beds have been folded into a number of tight folds with overturned axeal planes along which the pegmatites were injected during a period of intense faulting in which the rock formations to the east of a line running NS through Williamstown were elevated several thousand feet. Later silexite bodies (muscovite and quartz) and quartz reefs were injected, being the latter phases of crystallization of the pegmatites. The large number of quartz reefs associated with the pegmatites suggest that the pegmatitic fluids contained a high concentration of aqueous liquids.

The pegmatites occupy a central position in the basal grits and sandstones which have been overturned partly due to uparching which was brought about by the injection of pegmatites and secondly reverse faulting.

In places marginal to the pegmatites there is a development of muscovite (not sericitic mica) in the basal beds. This suggests the migration of potassium rich solutions from the intrusive bodies into the sedimentary series. Such a process is conceivable as the basal grits are porous; a factor which would readily facilitate diffusion processes.

North of the Victoria Creek the temperature of the intrusive pegmatites was not generally high; the schists in the immediate neighbourhood being biotite actinolite schists, and the overlying marble containing tremolite.

The outcrops of pegmatites emplaced in the basal ilmenite grits occur in a tectonic belt roughly 18°W of N. This is apparently the average direction of schistosity of the meta sediments, and also the direction of shearing and lensing out of the pebbles in the conglomerate horizons in the ilmenitic basal sandstones and grits.

Thus the pegmatites are emplaced in the axis of the folded basal grits and sandstones.

As stated by Mr. Hossfeld, "it is probable that the pegmatites in the eastern half of the Hundred of Para Wirra are of the same petrographic period as those pegmatites in the south eastern part of the Barossa and in the central portions of the Hundred of Jutland and in some parts of Talunga, Onkaparinga and Tungkillo. Such a group of pegmatites have many lithological and chemical constitutional similarities, and are probably connected with orogenic movements whereby they were squeezed out into fracture zones."

However, Mr. Hossfeld did not realize the full extent of the magnitude of the orogenic movements which resulted in an uplift of considerable magnitude of the meta sediments to the east of Williamstown producing a repetition of the Adelaide series east of Williamstown.

QUARTZ REEFS.

These are associated with the pegmatitic intrusions. Some of the quartz reefs contain primary and secondary copper minerals and minor quantities of gold. It is possible that the gold found in the Victoria Creek and South Para came from the pegmatites and associated quartz reefs.

As far as the writer knows, no gold has ever been found in the Victoria Creek further up stream than the outcrops of pegmatites and quartz reefs.

The metalliferous bearing quartz reefs occur in a zone extending from 1/4 mile in front of Mr. Hammat's house and extending through the Enterprise Copper Mine to the Lord Lyndock Mine.

The reef is almost vertical and is approximately 5ft. wide. Behind Mr. Hammat's house is the Lord Lyndock Copper Mine. This is located in this milky quartz reef. Here, there are cupriferous pyrites, chalcopyrites and the associated secondary minerals malachite and azurite.

The quartz reef is located in a zone of intense shearing in the marble bed. Much inferior talc was brought to the surface during the mining operations

S U M M A R Y.

The pegmatites are associated with orogenic movements. Two varieties of pegmatite occur -

(1) microcline quartz muscovite pegmatites poor in albite.

(2) albite quartz muscovite pegmatites poor in microcline.

It is possible that albite replaced the earlier formed microcline as most of the albite pegmatites contain tourmaline on a somewhat greater scale, which suggests residual magmatic liquids rich in boron and soda.

Pegmatite

Locality golf course Victoria Ck Rd.

Section 3169

Specimen 77

Slide No. 28.

Macroscopic Description

The specimen is rather coarse grained which is granitic in composition. The rock is somewhat crushed with an introduction of silica into fracture zones. The quartz present has somewhat a vitreous lustre and the hand specimen has a mottled colour.

Microscopic Description

Under the microscope the quartz and feldspar (albite and microcline) are anhedral and meet along sutured contacts. The pattern is best described as a mosaic texture. The texture is xenomorphic granular. Minerals present are the following.

Feldspar. This group is represented by two distinct forms including plagioclase and potash feldspar.

The plagioclase feldspar is in excess of the potash variety and is clouded by dusty decomposition products. The maximum extinction Angles observed on a plane normal to the 010 give the composition ~~$A69A_n$~~ Ab_9An_1, (The R I >Balsam). The twinning in the section is almost entirely on the albite law. The plagioclas has undergone decomposition to some extent with a development of epidote and kaolin.

Microcline shows the usual cross-hatching due to twinning on the albite and pericline laws. The ~~swim~~ twin- lamellae are irregular and spindle shaped.

I. A. MUMME.

IX

SERICITE DAMOURITE AND KYANITE

of the

WILLIAMSTOWN AREA.

SIGNIFICANCE OF THE KYANITE OF THE WILLIAMSTOWN AREA.

The writer holds that the Kyanite was a product severe stressing of ilmenite sericite chlorite schists under thermal conditions.

Evidence accumulated suggests that the beds were severely faulted with an uplift of the meta sediments to the West of Williamstown to an extent of several thousand feet.

Under higher temperatures, and in the neighbourhood of the most intense zone of injection of pegmatites, the stressed schists were converted to sillimanite kyanite biotite schists.

During the initial process of intense shearing and stressing of the sediments and at moderately elevated temperatures kyanite was the main metamorphic stress mineral developed, whereas at a higher stage of metamorphism, the kyanite as well as the biotite were replaced by sillimanite.

A study of section (959) reveals that the Kyanite pegmatites are a purer phase of the Kyanite (now Damourite) sericite biotite Schists, in which there was a greater development of Kyanite.

During the latter phases of pegmatitization much volatiles hydrolysed the high temperature minerals to give clay, damourite and sericite. The sillimanite was converted to clay, and the stress mineral Kyanite to clay or damourite dependent upon the introduction of potash:-

(1) from the biotite sericite schists by leaching;

(2) potash displaced from the schists during conversion to Kyanite sillimanite schists.

The process of Hydrolysis is easy to conceive because the sediments were intensely dragfaulted and folded in the neighbourhood of the fault plane allowing a ready entrance of volatiles and pegmatitic fluids. It is possible that the sillimanite schists and the adjacent biotite sericite kyanite schists were intensely faulted and folded to give the appearance of Kyanite (now Damourite) veins traversing the clay as observed in the vicinity of the clay mine.

In section (959) the Kyanite Pegmatites are the products of stressing of the sediments and do not suggest intrusion.

PROCESS OF ALTERATION OF KYANITE TO DAMOURITE.

The sediments from which the Kyanite was derived under severe stress conditions with thermal conditions superimposed were ilmenitic bearing sericitic chlorite schists which are superior to the ilmenitic conglomerates, sandstones and arkoses.

The schists suggest that they were originally rich in potash.

During the phase of injection of volatiles in the Kyanite sericite biotite schists, it is possible that the biotite was strongly leached and the potash rich aqueous solutions altering the Kyanite to Damourite.

CONCLUSION.

The Kyanite sericite biotite schists are located in a crush zone neighbouring to a fault of large vertical displacement. Locally, the schists have been converted to sillimanite in the locus of more intense thermal metamorphism.

Late magmatic processes hydrolysed the high temperature minerals to clay.

The writer does not hold the view taken by Dr. Alderman that there was an introduction of Alumina rich solutions from which sillimanite was developed and later hydrolysed to clay, nor that Kyanite was introduced, in part, as Kyanite pegmatites, but holds the view that the Kyanite was solely a product of severe stressing under moderately elevated temperatures.

Evidence points to the fact that the schists were originally rich in alumina.

INITIAL STAGE.

(1) (Sericite and Biotite) → Kyanite (stress conditions)
→ Sillimanite (higher temperatures and decreasing stress).

(2) Sericite + ilmenite → Biotite

HYDROTHERMAL STAGE.

(1) H_2O + Kyanite + Biotite → Rutile + Sericite + Damourite

(2) H_2O + Kyanite → Clay

(3) H_2O + Sillimanite → Clay

Much sericitic mica has been mistakenly called damourite because of the close association of Kyanite and Biotite in the stressed schists which latter were converted to sericite damourite schists.

Sericitization of Biotite Schists adjacent to the Intrusive Pegmatites during a late Magmatic Stage.

The stages in the hydrothermal sericitization of biotite schists can be seen in its progressive stages in the schists outcropping in the Victoria Creek several hundred yards due east of Mr. Ross's house. During the initial stages of intrusion of Pegmatites, the argillaceous sediments were converted to Biotite schists which are of exceptional purity, (see specimens 22,25) in the contact aureole surrounding the intrusions. During late magmatic stages where much high pressure steam was evolved from the crystallizing pegmatitic fluids, the biotite schists were partially hydrolysed to a sericitic mica in many cases similar in appearance to Damourite.

Slide No. (6) Locality. Section 3168

The structure displayed by the slide is lepidoblastic. The essential mineral present is biotite and its alteration products. The biotite has a platy nature. The unaltered biotite is generally strongly pleochroic in yellow and brown. The maximum absorption occurs when the trace of the cleavage is parallel to the polarisation plane of the lower polarising prism. The cleavage is perfectly basal. Most of the biotite shows alteration to a green variety or to a white sericitic mica. The original biotite is biaxial negative with a 2V approximately 10°. The chloritic alteration product which is green in thin section. lacks pleochroism, had a 2V = 20° and is optical negative. The white mica is also biaxial negative and has a 2V = 30°. The sericitic mica is generally fine-grained.

Quartz occurs in a simple mosaic structure.

Iron ore occurs as segregations in the altered biotite and in the sericite and its presence suggests that it originated during the alteration of biotite to sericite.

(see slides Nos. (6,7,8) Locality. Section 3168

Brucite? or Kaolinite or ?

Metasomatism of the Williamstown Area during late magmatic stages

Although the writer does not agree with Dr. Alderman as regards the intrusion of sillimanite quartz pegmatites and Kyanite quartz pegmatites, the writer believes that metasomatic processes played an important part in the formation of clay and demourite during late magnatic stages. The theory suggesting the metasomatic replacement of pre-existing rocks by alumina rich solutions is partly based on Sillimanite or Kyanite quartz Pegmatites. The sillimanite and Kyanite quartz pegmatites are schistosic rocks which have resulted under thermal metamorphic changes as well as stress effects induced by intrusions of albite or microcline quartz pegmatites. The schists themselves were originally rich in alumina as can be observed in places where the metamorphic effects are not to severe (see specimens 22, 23, 24, 25)

However the writer holds local metasomatism took place during the hydrothermal phases in which clay was formed at the expense of sillimanite and damourite formed from the alteration of Kyanite.

Schists of the North Para Area

The Damourite Sericite Kyanite Schists of the Williamstown are pass into sericite biotite schists which are often of the nature of spotted schists.

See specimens 96 - (Section 3053 slide No. 34)
95 - (Section 589 slide No. 37)

and along the North Para they are represented by low grade spotted slates and schists.

The development of "flecken", "Knoten" and "andalusite crystals" seems to be dependent somewhat upon the composition of the bands in which they are segregated.

I. A. MUMME.

X

SERPENTINE, TALC AND OPAL

of the

WILLIAMSTOWN AREA,

NORTH PARA

and

KARA WIRRA.

FORMATION OF TALC.

The formation of the Talc which is generally located in a zone of dragfolding in the area investigated is due to the migration of magnesia rich solutions from the neighbouring host rocks namely the biotite actinolite schists during the period of severe deformation and squeezing by tectonic agencies in which pegmatites were injected along a major fault zone. The development of Talc was facilitated by the attendant heat and pressure.

The Talc is as stated above, generally located in a belt intermediate to the marble and biotite actinolite schists which being incompetent beds have been the locus of dragfolding.

During the initial phases of regional metamorphism tremolite was developed in moderate quantities in the marble. Evidence points to the fact that originally, the marbles were limestones with a small amount of dolomite.

It is possible that some of the tremolite was altered to Talc (see slides 11, 12 , and specimens 27).

Associated with the Talc are a number of opaline quartz veinlets which indicate an introduction of silicate solutions and which may have carried magnesia, which was leached from the magnesia rich biotite actinolite schists.

Specimens (29, 30) show the development of Talc crystals in the zone of drag folding between the marbles and the biotite actinolite schists.

DEVELOPMENT OF TALC.

(A) Metasomatism from the Biotite Actinolite Schists:

(1) Biotite + H_2O → Sericite + potash + magnesia

(2) Magnesia + silica + water → Talc

(B) Alteration of Tremolite: (see page 2)

(B) Alteration of Tremolite:

$$3MgO\ CO_2\ CaCO_3 + 4SiO_2 = CaO\ 3MgO\ 4SiO_2 + 2CaO\ CO_2 + 4CO_2$$

$$CaO\ 3MgO\ 4SiO_2 + H_2O + CO_2 = 3MgO\ 4SiO_2\ H_2O + CaCO_3$$

or

$$3(MgCO_3\ CaCO_3) + 4SiO_2 + H_2O$$
$$= 3MgO\ (4SiO_2)\ H_2O + 3CaO\ CO_2$$

In the neighbourhood of Springfield, the small outcrops of Talc are of good quality and occur as silky lustrous platy aggregates often associated with opalized calate.

As stated previously, its origin is possibly due to alteration of tremolite, but more probably to magnesia metasomatism from the neighbouring biotite actinolite schists along a belt of drag folding between the marbles and the schists.

South of the Victoria Creek much of the marble has been replaced by opaline silica to give a poch opal containing flakes of Talc and tremolite. It is possible that during the latter active phases of pegmatization when much superheated steam was evolved some silica was dissolved along with magnesia under the moderately elevated temperatures and metasomatically replaced much of the marble to give an opaline product as well as Talc.

Under the thermal conditions prevailing tremolite was also formed. This may then have undergone alteration to Talc.

Tracing northwards from Springfield, the Talc is adjacent to damourite and damourite biotite kyanite schists in the golf course near Mr. Mewett's garden plot adjacent to pits and adets sunk for rutile.

In the mine sunk on the other side of the Victoria Creek and in Mr. Ross's property: Much of the talc here is of an inferior grade and contains much recrystalized calcite and is stained with malachite and azurite.

The talc occurs in a continuous belt to the Enterprise Copper Mine in Mr. Hammat's property (only a short distance from his house).

The talc is very inferior and partakes a grey green colour. Here, unlike at Mr. Ross's property where it is white and massive, the talc is fibrous.

At the Lord Lyndock Gold and Copper Mine north of the Enterprise Copper Mine and in the same line of strike of the drag-fold is a small pit sunk in talc. The variety here is again a white talcose mineral containing abundant tremolite.

Microscope work suggests that the tremolite altered to talc.

This belt of talc is now lost under the Alluvium between Williamstown and the North Para. Bore results obtained at Seppelts' Winery at Williamstown prove that the zone of drag-folding pass under Lyndock. Here the marble has been upfaulted and is met with at a depth of 126' and are penetrated to a depth of 208'.

Tracing northward towards the North Para, the zone of intense shearing and dragfaulting is again observed. The talc is developed neighbouring to biotite actinolite schists, and also chrysotile serpentine is found in association with a crushed and recrystallized marble which has been partly replaced by opaline silica to form a potch opal.

The chrysotile serpentine has a length of fibre varying from a fraction of an inch to 6 inches in length and generally occurs as cross-fibre in the shear zones.

Apart from the development of talc and chrysotile under severe crushing, the strong silicification of the schistose tremolite marble is a strong feature in the mineralization.

Hence the talc and serpentinized opalized marbles occupy a zone of dragfolding and metasomatism mapped from Springfield to the North Para. The fault zone was probably developed during the phase of pegmatization of the Adelaide series which accompanied the faulting.

The fault zone provided a passage for hydrothermal solutions carrying siliceous and magnesia bearing solutions and some pyrites and chalcopyrites.

NATURE OF THE TALC DEPOSIT.

At Mr. Heusler's property the talc is located behind his house. Here the talc body once formed has been subjected to no further dislocation or disturbance. The final product consisted of fissile layers of small talc flakes orientated parallel to the general schistosity developed in the area.

However, at Mr. Ross's property (on the Victoria Creek Road) the talc body has suffered later deformation and has been squeezed into irregularly shaped masses.

Talc being soft and possessing high slip presents little resistance to the subsequent dynamic stresses and being the least competent of the rock assemblage in which they occur, have readily yielded. Evidence of such movement is to be seen in the intense slickensiding developed in the talc body. Similar conditions are found at the North Para at Mr. Barritt's estate.

Chrysotile and talc of the North Para Area.

Two varieties of talc occur -

(a) A soft green foliated talc;

(b) a white fibrous talc.

The talc crystals give a biaxial negative interference figure with a low 2V and

Refractive Indices	1.54	α
	1.53	β
	1.52	γ

The chrysotile asbestos possesses the

Refractive Indices	1.54	α
	1.55	β
	1.56	γ

Some of the chrysotile has been washed out by the river and the finer fibres have meshed together to form "Mountain leather" (see specimen 35).

OPAL AND CHALCEDONY OF BARRITT'S ESTATE.

Poch opal occurs mainly in shear zones in the tremolite marble and it is probable that its formation accompanied the hydrothermal alteration of the marble bed which under these conditions had recrystallized to an extremely coarse marble.

Apart from the hydrothermal opal there is a second variety a chalcedonic (banded) opaline product of silicification of the marble.

This occurs close to the surface and probably represents a more recent metasomatic replacement.

Throughout the talc body are developed numerous slickensides which have a strong development in planes which are vertical with a strike N - S.

Opaline silica replacing the marble occurs almost everywhere in the area mapped. However, it is only slightly replacing the marble north of the Victoria Creek on Mr. Ross's property and Mr. Hammat's property, etc. However, below the Victoria Creek in the golf course and near Springfield most of the calcium carbonate has been replaced to give an opaline silica.

In the Victoria Creek, serpentine as well as calcite have yielded pseudomorphs after replacement by silica.

$$H_4 Mg_3 Si_2O_9 + 3CO_2 = 2SiO_2 + 3MgCO_3 + 2H_2O$$

As the calcium carbonate has been metasomatically replaced by silica from dilute aqueous solutions, the migrating calcium carbonate may explain the close association of schists containing almost pure actinolite with subordinate amounts of Biolite.

TALC DEPOSITS OF KARA WIRRA.

At Kara Wirra talc occurs in considerable quantities in drag folds in Biotite schists.

The talc is not in any way associated with marble.

It is probable that the magnesia was derived from the metasomatism of Biolite schists and the talc concentrated in pockets in the drag-folded schists.

This process of metasomatism is connected with the period of faulting and accompanying pegmatization in the area investigated by the writer, and the concentration of talc in the pockets developed in the drag-folded schists may be due to the action of H_2O, CO_2, etc. passing up through fractures and fissures in the schists bringing about a metasomatic replacement.

Thus, in the Kara Wirra area, talc occurs in Biotite sericite schists. It is due to metasomatism of schists under dynamo-thermal conditions.

In contrast to the development of talc in pockets in the drag-folded Biotite sericite schists we have the talc of the Williamstown area and of the North Para area where under hydrothermal conditions talc developed in the drag-folds between marble and magnesia rich biotite actinolite schists and metasomatically replaced the marble.

ORIGIN OF CHRYSOTILE.

The chrysotile of Barritt's property (North Para) is an essential stress mineral developed in the presence of an aqueous environment.

The chrysotile may have been developed from the talc under conditions of fairly high temperature. It appears as cross-fibre mainly in the crushed marble and the fibres appear to have grown by lateral secretion - the fibres supplied with a supersaturated solution at their base and the growing veins pushing aside the enclosing walls.

CONCLUSION.

Along a tectonic aris N18°W (generally) and adjacent to the basalilmenitic sandstones of the Williamstown area, the superior beds - the marbles and biotite schists have been crumpled and folded into tight anticlines and synclines. This was accompanied by pegmatization and hydrothermal activity.

A major shear plane occurs from the North Para on Mr. Barritt's property running south through Lyndock through the Lord Lyndock Mine, the Enterprise Copper Mine and the Talc Mine at Mr. Ross's property, Victoria Creek. Under hydrothermal conditions prevailing during the period of faulting talc was developed under metasomatic conditions from the Biolite actinolite schists.

A second zone of drag-folding runs from Rowland's Flat through Kara Wirra to the Victoria Creek. At Kara Wirra talc was developed in pockets in the drag-folded schists.

LANDSLIDES.

These have occurred extensively in the vicinity of the talc deposits of Kara Wirra.

The mica schists have slipped on the weak talc schists which provided an excellent lubricant for movements.

BIOTITE CHLORITE TALC SCHISTS

The Biotite occurs as a strongly pleochroic yellowish brown mineral associated with chlorite which occurs as cleavage masses with low index of refraction and with greyish green interference colours and basal cleavage. The chlorite shows alteration to Talc. The talc appears to have been derived from original Biotite through the chlorite stage to Talc.

The talc is seen in the slide as small flaky and rarely felty colourless to faint green aggregates of rounded or irregular form with low index.

Origin of the Talc.

It is probable that the original rocks of this group were biotite schists, These rocks were acted upon by hot waters with the following changes taking place.

(1) chlorite replaced the Biotite of the schists.

(2) Talc replaced the chlorite. Along with this development of Talc is chalcopyrites formed during these hydrothermal phases of alteration of the Schists. Definite evidence of the Talc replacing the country schists can be seen in its progressive stages outlined above in most of the areas studied (see sections 70, 48 & 24)

Hot magmatic solutions are thought to be responsible for these changes for the following reasons:-

(i) The minerals present and their occurrence are highly indicative of hydrothermal conditions.

(ii) The order in which these minerals were deposited suggest strongly that cooling solutions were responsible i.e. alteration of Biotite through the chlorite stage to Talc.

(3) In the schists which have suffered accompanying dynamic metamorphism there is a definite orientation of the mineral components showing that Dynamic metamorphism accompanied the hydrothermal alteration of the rocks.

(4) The presence of Talc replacing amphibole and Biotite suggests hot waters as its origin.

(5) The presence of the replacement talc and (chrysotite) shows dependence on fissure filling suggests also fluidal solution as being an active agent. These hot waters must have carried CO_2 and Silica through out the greater part of their active period.

The condition of differential stress appears necessary for the formation of Talc and accounts for its accumulation of this mineral in drag folds in the areas investigated.

Most of the Talc shows that the mineral has a parallel arrangement. The mineral association and paragenesis seems to indicate that the talc was formed under deep or under moderate conditions of depth e.g. several thousand feet.

These conditions of Talc formation might possibly be expressed under chemico-physical relations (X) . (Y.) (Z) = K

in which X = temperature

Y = pressure

Z = composition and character of solution.

& K = condition of formation of Talc.

Action of Carbon Dioxide in the formation of Talc.

Often the talc is associated with marble adjacent to the Biotite Schists, This however, is not always the case. This effect of CO_2 is believed to take care of any extra base, especially bases not needed in the formation of the mineral being actively precipitated. In this role, it hadm in part the same function as silica would have for they both tend to increase the silica percentage of the minerals formed the carbon dioxide having the additional function of removing bases not needed.

Opal of the North Para River Area

Mr. Barritts property.

Occurrence and associations

This is a secondary mineral which was introduced in a fault zone where it metasomatically replaced crushed marble.

In the handspecimen it occurs as yellow green and brownish varieties which have a slight waxy to ritreous lustre. The fracture is concloidal.

Under the microscope it is seen to contain fibrous chrysotite showing the strong silicification of the marble was subsequent to the development of chrysotile serpentine. The opal occurs in sections 1800 etc.

Slide Description

Chlorite Talc Schist

See specimen 29.
Slide No. 13.

Macroscopic Description:

The rock is a soft Talcose rock, which readily fragments,

Microscope Description

Talc.

Optical Properties. The optical Angle is low-$\simeq 3^\circ$ and the mineral is negative.

$$\left.\begin{array}{l} N_g = 1.58 \\ N_m = 1.58 \\ N_p = 1.64 \end{array}\right\}$$

The mineral is a pale green to colourless in thin section and occurs as platy aggregates. The Birefringence is strong $N_g - NP = 0.04$ and the maximum interference colours are upper third order.

Chlorite

This occurs as a brownish green mineral in thin section and is slightly pleochroic The Birefringence is weak. The mineral is biaxial positive with an optic axial angle of 40°.

The talc occurs as an alteration product of the chlorite mineral which was derived from biotite of the original Biotite Schist.

Intergrowth structures between tourmaline and quartz, and tourmaline, quartz and feldspar.

One of its most significant relations is its graphic intergrowth with quartz and for feldspar. In places previously mentioned quartz, and mica have been attacked by the dark tourmaline and it is possible that the graphic intergrowth (see specimen) is a replacement.

Ivan A. Mumme.

XI

SLIDES DEALING WITH :-

CHRYSOTILE

OPAL

TALC

MARBLE

TREMOLITE.

... ...

ROCK NO. 52

LOCALITY Section 24

SLIDE NUMBER 18

TREMOLITE TALC SCHIST

Macroscopic Description:

The rock is a finegrained marble which contains laths of silky tremolite in radiating and subradiating bunches, and also small green flakes of talc.

Microscopic Description:

The marble shows a fairly simple character with noticeable evengrained character.

Calcite:

Variable relief with a rhombohedral cleavage and high Berefringence. Extreme interference colours are observed. Some lamellar twinning is seen.

Tremolite:

Maximum extinction (Z to C) = 23°. The tremolite is often in subradiating bunches. Calcite sometimes occurs intergrown with the tremolite.

Talc:

The talc occurs in small greenish clots though sometimes it is mingled with calcite.

The relief is low and the flakes possess third order colours in the standard section. The 2V is low $\simeq$ 10°.

Originally the marble was a cherty dolomitic limestone which under dynamothermal conditions had altered to a tremolite marble. Aqueous agencies metasomatically replaced some of the marble to form talc and in the intense shear zones developed chrysotile serpentine generally in the crushed marble. The magnesia from which the talc was formed was derived from the adjacent biotite schists. This may account for the greenish colour of the talc, due to iron impurities.

ROCK NO. ....37..

SLIDE NO. .....15..

LOCALITY ..Section 24..

CHRYSOTILE ASBESTOS

Measurements of the Refractive Indices gave (mixing oils)

= 1.546 α

= 1.550 β

= 1.557 γ

The hand specimens show the fibrous and asbestiform properties ("Mountain Leather") of the mineral.

On treatment with concentrated hydrochloric acid the mineral readily decomposed.

Slide: (15)

The maximum interference colours are yellow of the first order. Low colours are generally observed in the slide because of the small diameters of the fibres. The fibres show parallel orientation.

The mineral has low to moderate relief with Indices of refraction less than that of Canada Balsam.

Dispersed throughout the Serpentine are small amounts of opaline silica.

ROCK NO. 27.........

SLIDE NO. 18........

TALC TREMOLITE ROCK

from Mr. Heusler's property (Lord Lyndock Copper Mine).

Macroscopic Description:

The talc occurs in the hand specimen as a white massive soft rock with a greasy feel. Small laths of tremolite occur distributed through the talc.

On treating with acids the talc was found to be insoluble.

Microscopic Description:

Talc. This occurs as flakes and is colourless. Maximum interference colours in the standard section are third order colours. The talc has low relief.

Some of the talc appears to be pseudomorphic after tremolite.

Tremolite: This occurs as small bladed crystals dispersed throughout the talc. Its maximum extinction $Z \wedge C = 17^{\circ}$.

In transmitted light the presence of tremolite is hardly suspected.

SLIDE NO. 22......
ROCK NO. 59.......
LOCALITY Section 1181

AMPHIBOLE BIOTITE CALCITE SCHIST

Macroscopic Description:

The rock is medium to coarse grained and contains large elongated prisms of amphibole (Actinolite). The rock is massive and fairly homogenious and has no trace of relic structure or cleavage.

The actinolite Biotite calcite schists occur superior to the tremolite marble and its relation to the marble can be seen in the Victoria Creek about 1/2 mile upstream from Mr. Ross' house. The schist contains segregations of talc, suggesting a metasomatic replacement during the hydrothermal conditions prevailing at the time of injection of the pegmatites.

Associated with the Actinolite are some flakes of biotite and grains of calcite and quartz.

Microscopic Description:

The rock consists of a granoblastic aggregate of calcite and quartz with a development of porphyroblasts of green actinolite.

Actinolite - Maximum extinction $Z \wedge C = 17^{o}$. Calcite occurs rarely intergrown with the actinolite. The pleochroism is weak in yellows and greens. The mineral has a conspicuous prismatic cleavage and a moderate relief. Under X nicols the maximum colour in standard section is second order.

Biotite - Pleochroic in yellow and brown with a minimum absorption parallel to the polarizing plane of the lower nicol. The mineral has moderate relief.

Near extinction a "Birds-eye" structure (continued over page

AMPHIBOLE BIOTITE CALCITE SCHIST

Biotite is apparent.

Calcite:

Colourless with a perfect rhombohedral cleavage. The relief is low to moderate changing as the stage is rotated. Lamellar twinning is common.

Quartz:

R.T. is a little higher than Canada Balsam with first order polarizing colours.

Feldspar:

Slightly turbid feldspar occurs with first order polarising colours. RI $>$ Canada Balsam. The maximum extinction angle in the symmetrical zone of extinction is 20^{o} (perpendicular to the 010) composition.

The rock possibly represents a metasomatized marble.

Ivan A. Mumme.

XII

"THE MARBLE HORIZON"

THE MARBLE HORIZON

This represents the metamorphic equivalent of a limestone. The thickness of the marble in the Williamstown Area is 50 - 60ft. The main tectonic feature is that a single bed has been folded several times, and sheared through along a tectonic axis 18°W of N producing repetitions of outcrop, and minor overfolding.

Tremolite occurs as small flakes dispersed throughout the marble which has undergone strong silicification in places especially marginal to the Kyanite Damourite Biotite Sericite Schists.

This suggests -

(a) metasomatism whereby silica from the "stressed schists" during the Hydrothermal phase of activity (when the sillimanite was converted to clay) metasomatically replaced the marble, producing a poch opal.

(b) Metasomatism from pegmatitic fluids escaping from the pegmatites during their emplacement.

Between Rosedale and the Area north of Lyndock, the limestone is dispersed in a south pitching anticlinal fold.

It extends towards Lyndock and at Lyndock the limestone (recrystallised as a marble) is met in a bore hole put down at Seppelts Winery (opposite the railway station).

The marble is met in a couple of other bores south of Lyndock, and finally an exposure occurs at Mr. Heusler's property about 1½ miles north of Williamstown.

The marbles in the Williamstown area are underlain by a considerable thickness of sericite chlorite schists which contain ilmenite. In regions of intense stress accompanied by elevated temperatures due to the injection of pegmatites along the major fault zone, kyanite sillimanite rutile schists were formed.

Marginal to these schists the tremolite marble shows replacement by silica with a development of poch opal.

Superior to the marble horizon are more sericitic biotite chlorite schists with bands of pyritic cherty quartzite.

SPECIMEN NO. 57

SLIDE NO. 21

Section 1180

TREMOLITE MARBLE.

Macroscopic Description:

This is an even grained marble containing silky fibrous crystals of tremolite.

Microscopic Description.

The slide shows a gravoblastic aggregate of calcite crystals which have extreme interference colours under crossed nicols.

Calcite:

The cyrstals are anhedral and show perfect rhombohedral cleavage. The relief changes on rotating the stage from low to moderate, producing a twinkling effect.

Lamellar twinning is often observed in the slide, which is a result of stress.

Tremolite:

This occurs as a white fibrous mineral with a silky lustre and has a tendency to occur in subradiating aggregates.

The crystals are clear and colourless and have many cleavage traces. They are readily distinguished from the calcite under crossed nicols by virtue of the fact of their polarising colours. The maximum extinction angle Z/\C is 18°.

The tremolite occasionally occurs as intergrowths with the calcite.

The rock is the metamorphic equivalent of a dolomitic limestone recrystallised under dynamothermal conditions.

HISTORY AND CONCLUSIONS

The writer considers that to the east of Humbug scrub Adelaide Series rocks were deposited in a geosynclinal basin. At the base is a great development of arkoses, ilmenitic grits and conglomerates. These beds were possibly derived from the erosion of the Barossian complex rock. There is little evidence that the grits and conglomerates were of glacial action. The pebbles distributed irregularly through the basal succession are not large and do not show glacial scratchings. Then followed a succession of mudstones and cherty beds and a succession of calcareous phyllites and limestones. Above these beds were a considerable thickness of more mudstone and bands of sandstones.
These beds appear to be the equivalents of the lower Adelaide Series rock.

Orogenic movements during early palaeozoic time brought about intense faulting of these beds and an uplift of the sediments to the east of a line through Williamstown - Rosedale.

Mid Tertiary Time was a period of block faulting with a further elevation of the fault block often along the older faults and a collapse of the beds in the Senkungsfeld area of the Tanunda Angaston area. The pegmatites appear to be connected with early Palaeozoic faults and the Talc formed in structural traps (drag folds) under Hydrothermal conditions.

The ilmenitic grits and conglomerates generally do not determine the base of the Adelaide Series rocks but are generally underlain by a thickness of several thousand feet of arkoses which may correspond to an Eparchaean period of erosion.

From a study of the relationship of the "Tanunda creek granite" to the country rock the writer is of the opinion that these represent recrystallized arkose corresponding to the basal beds.

List of References

Chatterjee S.K. 1931 Record Geol. Survey India 65. 285 - 305

Dana E.S. 1899 System of Mineralogy

Dunn J.A. 1929 Memoirs Geological Survey India.

Hossfeld P.S. 1935 Trans Roy. Soc. South Australia. 50, 1 - 16.

Jack R.L. 1926 Geological Survey South Australia Bull. 12.

Lindgren W. 1933 Mineral deposits New York.

Hossfeld Paul S. The Tanunda Creek granite and its field relations.

Howchin W. The geology of the Mt. Lofty Ranges.

Jack R.L. The iron Ore Resources of South Australia Bulletin No. 9.

Acknowledgement

The writer wishes to express his thanks to Sir Douglas Mawson for his assistance during the year in discussing aspects of the work undertaken.

SLIDES

Slide 1, 2 & 3 see specimens. 1,2, 3 recrystallized arkosic quartzite. Section 517 (Located at Base of basal series)

Slide 4. (specimen 11) Epidotized Basal beds section 35.

Slide 5. Microcline perthite. See specimen 14.

(Slide 6. sericitized Biotite Schists (Specimen 21 - section 3168)
(
(Slide 7. Same " "
(
(Slide 8 & 9.

Slide 10. Fine grained Pegmatite associated with haematite in fault zone Mt. Kitchener area.

Slide 11. Talc schist containing Tremolite Specimen 27 section 569.

Slide 12. Talc " " "

Specimen 28 Section 1521

Slide 13 Talc

Specimen 29.

Slide 14 Injection gneiss. Section 569.

Slide 15 See specimen 36 chrysotile serpentine section 24.

Slide 16, 17 Talc or serpentine replaced by opaline silica in a marble. Section 3168

Specimen 50.

Slide 18. Marble containing Tremolite and Talc Section 24. See Specimen 52.

Slide 20. Haematite and opaline silica. Fault zone Mt. Kitchener area. See specimen 26.

Slide 21 Tremolite marble locality section 1180 (near Victoria Ck).

Slide 22 Amphibole Biotite calcite schist. Section 1180.

Slide 23. Amphibole schist.Victoria Creek. Section 3168.

Slide 24. Opal specimen 68

Slide 25. "Blue rocks" quartzite

Slide 26. Gold from South Para directly beneath the Weir.

Slide 27. Epidote Actinolite pyritic schist.

Slide 28. Crushed pegmatite. See specimen 77.

Slide 29. microcline. Feldspar see specimen 78.

Slide 30. oolitic structures observed in specimen 83. Section 553.

Slide 31. slide showing fractional sedimentation. Section 553.

Slide 32. Fine grained quartzite overlying marble beds section 53. Although somewhat thermally metamorphosed the slide still exhibits fractional sedimentation.

Slide 33. Diopsite scapolite rock (alteration of a marble). Mt. Kitchener area.

Slide 34. Spotted Schist locality. Section 3053.

Slide 35. " "

Slide 36. Fine grained Pyritic quartzite. Section 458 (near Rosedale).

Slide 37. Andalusite schist. Section 589. See specimen 95.

Slide 38. Actinolite Biotite Schist Section 2500.

Slide 39. Slide of opal see specimen 53.

SPECIMENS.

Note. The Section numbers refer to Hundred of Barossa unless otherwise stated.

Specimens Submitted.

Specimens 1, 2 & 3. Base of the Basal conglomerates as exposed in Section 517.

Recrystallized arkosic quartzite see slides. 1, 2 & 3. resp.

Specimens 4, 5, 6,

Typical specimens of stressed pebbles. Section 35.

Specimen 7. Typical specimen of the Basal conglomerate horizon.

Specimen 8. Pebbles of quartzite, pegmatite etc, from the basal conglomerate. Section 35.

Specimen 9. Typical ilmenitic arkosic grit. Section 35.

Specimen 10. Hydrothermally altered basal grit which contains rutile along its bedding planes. Section 3166 (near Rutile Mine).

Specimen 11. Epidotized basal beds. Section 35 see slide 4.

Specimen 12. Pegmatised Basal Bed. Development if Mica, apatite, Beryl and garnet. Section 673. Note the absence of ilmenite, due to its removal under pegmatitic alteration.

Specimen 13. Specimen of mica from the mica mines. Section 673.

Specimen 14. Microcline Perthite.

Specimen 15. Tourmalinized basal grit showing the development of tourmaline at the expense of mica and feldspar in the grit section 35.

Specimen 16. Typical ilmenitic grit. Section 35.

Specimen 17. Pegmatised basal grits with a development of muscovite and quart reefs. Section 35.

Specimen 18. Quartz reef carrying chalcopyrites, from the Enterprise Copper Mine (Mr. Hammat's Property. Section 35).

Specimen 19. Oxidized Copper Ore - malachite and Azurite from the Enterprise Copper Mine.

Specimen 20. Damourite containing some unaltered Kyanite. Section 942.

Specimen 21. Biotite sericite Schists overlying the basal conglomerates and grits Section 3168.

Specimen 22. Highly sericitized Schist with a development of fracture cleavage in a zone of intense drag - folding Section 3132 Tweedies' Gully.

Specimen 23. Pure Biotite Schist Victoria Creek. Section 22.

Specimen 24. Sericitized Biotite quartz Schist Victoria Creek Section 22.

Specimen 25. Sericitic Schist contains rutile Victoria Creek Section 22.

Specimen 26. Hematite Schist from fault zone at Mt. Kitchener area.

Specimen 27. Talc Schist containing Tremolite Mr. Heusler's Property, Section 569.

Specimen 28. Talc schist golf course Victoria Creek.

Specimen 29. Segregations of talc in drag folds between Biotite Actinolite schists and the marble beds Section 3168 See slide No. 13.

Specimen 30. Green Fibrous Talc in marble contact with Biotite Schists. Section 3168.

Specimen 31. Injection gneiss. Basal beds injected by pegmatite, Slide 14. Section 569.

Specimen 32 and 33. Talc schist. Mr. Barritt's Estate North Para. Section 24.

Specimen 34. Talc specimens . Golf course Williamstown Section 1521.

Specimen 35. Mountain leather (Chrysotile Serpentine) Section 24. Mr. Barritt's Estate. North Para River.

Specimen 36. Chrysotile Serpentine in crushed marble North Para. Section 24. See slide 15.

Specimen 37. Fibrous chrysotile serpentine. Section 24.

Specimen 38. Fine fibrous asbestos. Section 24.

Specimen 39. Talc bearing marble.

Specimen 40. Chrysotile serperpentine in fracture in Talc bearing marble.

Specimen 41. Talc crystals. Golf Course Victoria Creek.

Specimens 42, 43, 44. These show slickensides in Talc. The slickensides are developed in a Talc body North Para River and are orientated with a N - S strike (fault zone) and the fault plane is vertical.

Specimen 45. Slickenside with a development of wood asbestos in a sheared talc. Locality Enterprise Copper Mine.

Specimen 46. Kara Wirra Talc. Section 48.

Specimen 47. Talc stained with malachite and azurite from a small Talc mine. Mr. Ross' Property Victoria Creek. Section 1181.

Specimen 48. Green Talc section 24. Green colour possibly due to iron impurities.

Specimen 49. Chrysotile Serpentine. Section 24.

Specimen 50. Opaline silica replacing Talc or serpentine in a marble. See slides 16 & 17. Section 3168.

Specimen 51. Talc associated with calcite Mr. Ross' Property. Section 3168.

Specimen 52. Marble containing flakes of talc and small fibrous crystals of

Mr. Barritt's estate North Para River. Section 24. See slide 18.

Specimen 53. Hydrothermal opal locality North Para River. Section 24. Brown variety.

Specimen 54. Yellow and green varieties of opal. Section 24.

Specimen 55. Chalcedonic silica, obtained near surface. Section 24.

Specimen 56. Actinolite quartz schist which has been brecciated in a fault zone and contains talc formed during the faulting. Locality Section 3182.

Specimen 57. Typical specimen of the marble of the Williamstown area. Contains small fibrous crystals of Tremolite. Section 1180. Victoria Creek See slide 21.

Specimen 58. Limestone recrystallized as a coarse grained marble neighbouring a pegmatitic intrusion section 1189.

Specimen 59. Actinolite Biotite Schist section 1180.

Specimen 60. Actinolite Schist Section 3168.

Specimen 61. Potch opal Enterprise Copper Mine

Specimen 62. Opaline silica Encrustation on surface. Section 24.

Specimen 63. Typical specimen of Travertine limestone developed in the area.

Specimen 64. Fracture cleavage well developed in sediments marginal to Talc deposits at Kara Wirra.

Specimen 65. Selexite pegmatites. quartz and muscovite but no feldspar Mt. Caddie Williamstown. Section 1181.

Specimen 66. Fault Breccia Mt. Kitchener Area associated with haematite. See specimen 26.

Specimen 67. Limonitic nodule in Tertiary sands at Rowland's flat.

Specimen 68. Opaline replacement of marble Mt. Kitchener area. Under crossed nicols . slide shows a fine banded structure.

Specimen 69. Sillimanite Schist claymine.

Specimen 70. Talc developed metasomatically in a sandstone behind Mr. Ross' House Victoria Creek. Section 1181.

Specimen 71. Fine grained quartzite direcly overlying marble bed at the Enterprise Copper Mine shows current bedding effects.

Specimen 72. Injection Schist Rutile min.

Specimen 73. Quartz pseudomorphic after calcite. Section 74.

Specimen 74. Damourite pseudomorphic after Kyanite. Section 3169

Specimen 75. Pegmatite containing abundant ilmenite Enterprise Copper Mine.

Specimen 76. Rutile Mine Section 3169. quartz rutile rock.

Specimen 77. Crushed Pegmatite with introduced quartz. See slide 28.

Specimen 78. Intergrowth structure with quartz and microcline. Section 3156.

Specimen 79. gneissic grit Section 24.
In association with crushed marble.

Specimen 80. Epidote Actinolite Schist see slide 27 Section 3156.

Specimen 81. Fine grained Pegmatite. See slide 10.

Specimen 82. Specimen showing good jointing and varves (?) and oolitic structures. Section 553.

Specimen 83. Specimens of phyllites and Pyritic quartzites above marble bed (North Para River) Section 553.

Specimen 84. Specimen showing fractional sedimentation or varves? Section 54

Specimen 85. Specimen showing fractional sedimentation Section 53.

Specimen 86. Diopsite scapolite rock, Mt. Kitchener area. See slide 33.

Specimen 87. Pyritic quartzite. Section 458 (near Rosedale) see slide 36.

Specimen 88. Ilmenitic arkose overlying Barossian augen gneisses. Section 177.

Specimen 89. Ilmenitic basal bed. Section 177.

Specimen 90. Barossian complex rock specimen contains augen of quartz. Section 178.

Specimen 91. Mt. Kitchener granite.

Specimen 92. Tertiary gravel containing Rutile, gold, Kyanite, mica etc,

Specimen 93. Actinolite Schist neighbouring pegmatite intrusion. Mt. Kitchener area 738 (Moorooroo).

Specimen 94. Spotted andalusite schist. Section 589. See slide 37.

Specimen 95. Actinolite Schist see slide 38.

Specimen 96. Actinolite Biotite Schist. See slide 38 Section 2500.

Specimen 97. Spotted Schist Section 3053. See slide 34.

Specimen 98, Albite tourmaline quartz. Pegmatite Section.

Specimen 99. Fault Breccia associated with Hematite. See hematite schists (from this fault zone) specimens 26. Locality 738 Moorooroo.

Specimen 100. Typical low grade schists of the North Para area which are equivalent to the sericite Biotite schists of the Williamstown Area. Section 547.

-----oOo-----

Slide No. 10

Rock No. 81

Locality Mt. Kitchener area

Slide Description

Fine - grained Pegmatite

Macroscopic Description

This is a medium grained holocrystalline rock, which has a mottle colouring. The grain size is very even except for a few scattered individuals.
The minerals distinguished in the hand specimen are feldspar, quartz, biotite, and iron ore. The quartz has a vitreous lustre, and the feldspars have a pinkish colour. Biotite is present in appreciable quantities, and is generally associated with graings of iron ore.
None of the minerals present show idiomorphic outlines in the hand specimen.

Microscopic Description:-

This is a holocrystalline medium grained rock. The rock texture is allotriomorphic granular. No trace of fluidal arrangement of the minerals is noticeable.

The minerals present are the following:-

Feldspar This groups is represented by two distinct forms including plagioclase and potash varieties. The plagioclase is in excess of the potash variety and is somewhat clouded by dusty decomposed products. The maximum extinction angles observed on a plane normal to the 010 give the composition $Ab_9 An_1$
The Refractive Index is slightly greater than that of Canada Balsam. The twinning in the sections is almost entirely on the albite law but some Carlsbad twins and Pericline twins occur.

Graphic intergrowths with quartz and microcline occur.
The plagioclase has undergone decomposition to some extent with a development of epidote and kaolin.
Microcline is for the most part clear and undecomposed. It shows the usual Cross-hatching due to twinning on the Albite and Pericline laws. The twin lamellae as is usual in microcline are irregular and spindle shaped.

Quartz

occurs in clear and colourless anhedral grains with very few inclusions, but is often intergrown with microcline. A somewhat shadowy extinction due to strain is often noticed in the quartz.

Biotite is plentifully distributed throughout the slide. It is associated with ilmenite and actinolite. In places the biolite has undergone alteration to chlorite. Only rarely are pleochroic halves observed in the biotite.

Titaniferous iron-ore: which is black and opaque, occurs through the section.

Sphene: is present in occasional irregular masses and sometimes shows the wedged shaped outlines typical of the mineral.

Its colour is greyish brown and its displays a feeble pleochroism.

Calcite occurs as an alteration of the plagioclase.

Hornblende green pleochroic hornblende occurs as granular aggregates in conjunction with irregularly arranged plates of brown pleochroic mica, and small grains of quartz. In some cases the hornblende is altered to epidote and the biotite to chlorite.

This outcrop occurs neighbouring to a coarse grained microcline albite tourmaline quartz pematite, and intersects a marble horizon. It is the opinion of the writer that the medium grained igneous rock is a hybrid-pegmatite. The hornblende was possibly formed by the reaction of calcite and biotite.

In the neighbourhood of the intrusion the marble bed has been strongly silicified and the overlying calc-phyllites have been converted to hornblende schists of exceptional purity. In the same zone of pegmatization is associated a quantity of micaceous haematite and blackopal.

See specimen of albite
tourmaline quartz pegmatite

Specimen 99.

Locality is 971 East)
305 North) grid system Reference

Using Gawler sheet.

DIOPSITE SCAPOLITE

Slide No. 33.

Macroscopic Description

Strongly banded gneissic rock in which the folier are alternately dark and light being richer in diopsite or scapolite respectively.

Details of minerals present.

Scapolite Uniaxial negative with a birefringence greater than that of quartz

Diopsite. This occurs as green grains with a prismatic cleavage at 90°.

The plane of the optic axis is parallel to the 010 and the acute Bisectrix Z makes an angle with the vertical axis C in the obtuse angle which is 40°.

XIV

Haematite Schists of the Mt. Kitchener Area.

In a fault zone mapped in the neighbourhood of Mt. Kitchener occurs appreciable amounts of haematite with opaline silica dispersed through the mass. This is associated with pegmatites which have been squeezed up fracture zones and which are often found to contain appreciable amounts of iron ore and suggests that the pegmatites are the mechanism by which the haematite was introduced into the fault zone.

Specimens 26 Slide 20

Locality 738 Mooroovoo

(Slide of fine grained pegmatite No. 10 Locality 738 Mooroovoo).

In places the neighbouring calcareous rocks have been converted to scapolite which suggests that the iron was introduced as a chloride.

"GRANITES" OF THE TANUNDA CREEK AREA
AND ITS ASSOCIATED SEDIMENTS.

by I.A, Mumme.

THE TANUNDA CREEK GRANITE

The occurrence of granite rock in the Barossa Ranges to the south-east of Tanunda has been described by P.S. Hossfeld in 1925. The rocks of this area were described under

Three main headings:-
(1) Sedimentary Rocks

(2) The Tanunda Creek Granite

(3) Other igneous rocks.

According to P.S. Hossfeld evidence in favour of this view is as follows:-

" (1) The whole of the rocks to which a Barossian age has been assigned are bordered by a peripheral zone of newer sediments which lie unconformably above them.
These newer sediments have been correlated definitely with the beds of the Adelaide Series. The lowest of these beds consist of grits, sandstones and conglomerates. These beds contain ilmenite in many places, exhibit current bedding to a marked degree, are unconformable to the highly contorted and metamorphosed rocks on which they lie and conformable to the sediments above them.

(2) In general the high degree of metamorphism exhibited by the Barossian rocks is not a characteristic of the newer sediments.

(3) The older rocks in most localities have been pegmatized considerably."

Field work proves definitely that there is no demarkation between the socalled "newer sediments" and "older sediments" of the Tanunda area. There is no unconformity with basal beds consisting of grits, sandstones and conglomerates nor is there a marked change in metamorphism.

The pegmatites are located mainly in fault zones and shear zones.

Pegmaties. These are developed mainly in sections 744, 740, 738, 644, 82, 80, 79 and are the only typical igneous rocks in this area of the Barossa Ranges.

Structurally the pegmatites are of two classes minor lenses injected parallel to the foliation of the schist, and minor dykes cutting the foliatiose at low angles. Both dykes and lenses have local irregularities in their contacts. Near the pegmatite lens, the foliation as seen in vertical section is almost everywhere parallel to the contacts.

The structures of these pegmatites lead to the following deductions.

(1) The pegmatites were injected after a period of regional metamorphism possibly during lower palaeozoic time.

(2) The pegmatites show evidences such as shearing and granulation suggesting later orogenic movements (Mid- Tertiary?)

(3) The magma must have had a viscosity rather high as the lens shaped bodies are not often attenuated but are always rounded.

The dominant feature of the magmatic phase was the precipitation of quartz, microcline, albite, muscovite. Less abundant mineral is tourmaline which is always iron-rich.

In several areas the feldspar, quartz mica of the pegmatites as well as the country rock have been attacked by late magmatic fluids rich in boron producing an iron rich tourmaline (all specimens) and hence generally speaking the tourmaline is confined to the border of the Pegmatitic intrusions.

The igneous rocks of section 653, 654, 644 .

These igneous rocks have been referred to as Diorites, Tonalites etc. Petrological work has proved that they are pegmatitic rocks which are fine grained. They are interesting in that they contain appreciable amounts of iron oxide. (In a neighbouring fault zone there is much iron oxide.)

The basic intrusion of section 653 is in reality the metamorphic equivalent of a calcareous phyllite (see specimen 94). Under contact metamorphic conditions adjacent to a pegmatitic intrusion the calcareous phyllite has been converted to a Actinolite quartz schist and the less arenaceous sediments were converted to pure Actinolite schists. See specimens 94 A & B.

The gneiss represents a granitized sedimentary rock. The writer considers tha this was originally a feldspathic quartzite possibly equivalent to the arkoses of tha basal members of the Adelaide Series.

It was originally believed that this was an injected granite. P.S. Hossfeld states.

"This granite outcrops in the drainage area of the Tanunda Creek and is exposed over an area of approximately two and a half square miles. It is intrusive into the schists and gneisses of the older series referred to above, but nowhere into the rocks belonging to the newer series.

The schists and gneisses have undergone much pegmatization in the vincinity of the intrusion. This is much more readily observable in the schists but can frequently be detected in the gneisses by the presence of the pink feldspar contributed by the granite. The granite outcrops in two main areas; a smaller one in section 775 and 747, and a larger one to the south, with several small outcrops between the two. The most northerly area is very much gneissified, the gneissic structure becoming less pronounced towards the south, being least so in the area around section 754, in the vincinity of which some of it has been quarried and, it is said, used for monumental work."

In places in the "granites" are occurrences of biotite schists and very coarse grained marble representing the metamorphic equivalent of phyllites and limestones respectively. It is evident here that sedimentary strata have suffered severe Dynamo thermal metamorphism through geosynclinal burying of the lowest parts of the Adelaide syste, which subsequently have been elevated and been exposed through at mospheric agencies.

The writer consideres that these granites are the metamorphic equivalents of arkoses. Strong orogenic thrust movements are testified by the almost persistent and identical gneissosity developed in this recrystallized rock.

It is improbable that these granites which were developed in situ ever possessed any mobility unlike the pegmatitic intrusions

Slide Description of the Tanunda Creek Granite

Macroscopic Description:-

Gneissic rock consisting essentially of quartz pink feldspar and subordinate amounts of Biotite. The rock is medium grained.

Microscopic Description:-

It is a holocrystalline medium grained granular rock. The minerals present are microcline, plagioclase feldspar, quartz and Biotite.

Quartz is present in numerous irregular grains mostly clear, but some exhibit relics of former cracks and contain fine dust-like inclusions.

Microcline This is the more abundant feldspar present. The crystals exhibit crosshatching due to twinning on the Pericline and albite laws.

Plagioclase:-

This is less abundant than the microcline and many crystals show alteration. Twinning on both the Carlsbad and Albite laws ane observed.

Refractive Index ? Canada Balsam. The composition was found to be Ab45 An 55.

Biotite

The Biotite is pleochroic: X = light brown, Y=Z = very dark brown almost opaque. Tha flakes are often clustered together into small aggregates.
Alteration to pleochroic green chlorite is to be seen.
Accessories include magnetite, zirion and apatite.

Dolerites and Amphibolites of Sections 80, 82 and 905.

These have been referred to by P.S. Hossfeld in his paper "The Tanunda Creek granite and its field relationships".

These rocks appear as intrusions into the granite gneisses referred to By P.S. Hossfeld as the Moorooroo gneisses.

OPTIC ORIENTATION OF TALC