DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

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PETROGRAPHIC DESCRIPTIONS OF WILLYAMA COMPLEX ROCKS AND UMBERATANA GROUP METASEDIMENTS, southern OUTALPA INLIER, OLARY PROVINCE.

GEOLOGICAL SURVEY BRANCH

By

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MINERAL RESOURCES SECTION

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D.M. No. 725/75

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SUMMARY

Petrological examination of 129 rocks from the Willyama Complex and surrounding Umberatana Group metasediments in the southern portion of the Outalpa Inlier, Olary Province indicate that four deformation phases are present within this dominantly gneissic terrain: D_1, D_2, D_3, and D_5. Petrographic data for D_4 are available only from the northern portion of the Outalpa Inlier. In appropriate lithologies, sillimanite is aligned in the first phase gneissosity (S_1). Later phases produced lower metamorphic grade schistosities and/or crenulations where aligned minerals in the axial planes are dominantly muscovite and biotite, with some chlorite. Sericitisation is ubiquitous, and is occasionally accompanied by subhedral growth of staurolite, chloritoid and garnet.

INTRODUCTION

This report is a compilation of petrographic data for 129 samples from the southern portion of the Outalpa Inlier, Olary Province. Data for the northern portion of the Outalpa Inlier are presented separately (Flint, in prep.). Most samples are of Willyama Complex lithologies, while a few are from Umberatana Group metasediments surrounding the inlier.

The Outalpa Inlier consists of Early to Middle Proterozoic rocks surrounded by Late Proterozoic (Adelaidean) Burra and Umberatana Group metasediments (Fig. 1). The inlier is sandwiched between the Weekeroo Inlier to the west-southwest and the very large inlier to the east, which extends from Kalabity to south of Radium Hill (Fig. 1).

Samples were collected during the winter seasons of 1976 and 1977; sample localities are shown in Figure 2. All sample numbers are prefixed by 6933, the number of the Olary 1:100 000 map sheet. A suite of samples from the Faugh-a-Ballagh Mine, RS 572 to 576 inclusive, were collected by the author and W.B. Robinson (Senior Geologist, SADME). These were described by Dr. P. Moeskops (Amdel) in Amdel Report MP 1112/77; slightly modified descriptions and additional comments are included in this report. The samples were formerly labelled as P 440/76 to P 444/76. Two samples, RS 452 and 454, were collected by the author and R.S. Robertson (Geologist, S.A.D.M.E.) during a geochemical soil survey in the area (Robertson, 1979). Original descriptions were by Sylvia Whitehead (Amdel) in Amdel Report MP 459/77; slightly modified descriptions and additional comments are included in this report. All other descriptions are by the author.

This report describes many samples which contain a gneissosity, schistosity, crenulation or cleavage. These axial planar features are variously labelled S_1 to S_5; associated deformation phases are D_1 to D_5 respectively. A detailed structural analysis will be presented in a following report. The deformation phases and their classification are discussed in Berry et al. (1978) for the area to the northwest of Outalpa Hill and Outalpa Springs. Other structures described and labelled are:

S_o, the primary or original compositional banding

S_m, a mylonitic schistosity.

DESCRIPTION PROCEDURES

Samples are ordered with respect to their RS number. Descriptions include field notes, followed by a thin section description, then additional comments on unusual aspects,

syn-tectonic crystallisation phases, or probable correlatives.

Rock classification is based on texture and dominant phases; some lithologies include an index mineral in the rock name e.g. sillimanite gneiss. Gneiss is distinguished from schist only by grain size, and not by the presence or absence of banding. The arbitary transition is an average grain width of approximately 0.5 mm. Textural and migmatite terms are as used in Joplin (1968) and Mehnert (1968) respectively.

Identification of plagioclase composition is approximate. The principal method was by twin lamellae extinction angles. For extinction angles less than 20^{o}, which was the case for most specimens, optic sign and/or refractive index against n_{w} of quartz was used.

Fine-grained muscovite is often referred to as sericite. In nearly all cases, muscovite is not distinguished from paragonite, lepidolite etc., and biotite is not distinguished from phlogopite. Hornblende was distinguished from ferroactinolite by the size of the extinction angle γ:z.

PETROGRAPHIC SUMMARY

Samples are grouped according to their age and lithology (Table 1); a summary of the petrographic data is presented below for each suite.

WILLYAMA COMPLEX

Albitite

Albitite forms an unusual suite which is often in close proximity to calc-silicate or ironstone. With the presence of epidote, hornblende, diopside and garnet, albitite grades into calc-silicate. Albitites are characteristically thinly bedded and fine grained; bedding is planar and continuous within exposure limits. This delicate continuous bedding is only matched in the closely associated calc-silicate and banded albite + quartz granofels. Dominant phases and their range of abundances are:

Albite	80 - 95%
Quartz	0 - 10%
Opaques	2 - 10%

Micas, sphene, tourmaline and apatite occur in trace amounts; opaque phases include hematite, magnetite and pyrite.

Banding is defined by grain-size variations of the phases present and marked variations in opaque abundance; some bands contain up to 15% opaques. Albite is difficult to distinquish from quartz as it is often untwinned and unaltered. Average grain size is 0.5 mm or less, while the maximum grain size is 2.0 mm. Texture is granoblastic grading to granuloblastic. A weakly-developed schistosity is present in some samples where opaques + phyllosilicates are aligned; inequant and aligned albite is distinctly subordinate. Alignment is parallel with S_1 of the adjacent gneiss.

Some coarse-grained albite contains a sieve texture with very small inclusions or new subgrains of albite or quartz; their size is less tha 0.03 mm.

Calc-silicate

These lithologies have a wide variety of mineral assemblages, but nearly all contain thin layering which is typical of calc-silicate and albitite. Variations of the phases are:

Plagioclase	10 - 70%
Diopside	0 - 15%
Hornblende	3 - 45%
Quartz	7 - 78%
Epidote	0 - 30%
Orthoclase	0 - 37%
Opaques	1 - 7%
Garnet	0 - 20%

Some samples include minor biotite, scapolite, calcite, tremolite and chlorite.

Banding is always present and is defined by variations of grain size and mineral abundances. The average grain size is often near 0.5 mm while some samples have an average of only 0.1 mm. Maximum sizes grade up to 3 mm for hornblende in RS 453. Samples RS 452 to 454 illustrate the variation in grain size and mineralogy from the same outcrop. Quartz often has a dinstinctly finer grain size and rarely exceeds 0.3 mm, in some samples it is only 0.02 mm.

The texture is usually granoblastic; grains are often equant and interlocked. In some specimens, some of the phases, including feldspar, are elongate and aligned parallel to the banding. These phases are aligned in S_1. Often the alignment is dimensional only and not crystallographic.

Plagioclase compositions vary from albite to epidotised andesine; plagioclase grains, when epidotised, contain up to 40% fine-grained epidote and indicate that original plagioclase was more calcic than andesine.

Hornblende + andesine gneiss

Hornblende + andesine gneiss has often been referred to as gneissic amphibolite. They form thin (<10 m) conformable gneiss horizons which crop out poorly. Dominant phases and their abundance variations are:

Hornblende and ferroactinolite	15 - 50%
Plagioclase	10 - 60%
Quartz	2 - 25%
Epidote	1 - 15%
Opaques	6 - 15%

The texture is always gneissic with a dimensional alignment of hornblende, opaques, feldspar and quartz. Occasionally, a poorly-developed crystallographic alignment of hornblende is present. Average grain size is 0.6 mm though hornblende grains

range up to 2 mm long. Recrystallisation is extensive; many new grains have an average size of 0.1 mm.

Orthoclase is present in only one sample, RS 537. Plagioclase varies in composition from oligoclase to andesine, and is usually epidotised and sericitised. Sample RS 405 is transitional in composition and texture between a calc-silicate and a hornblende + andesine gneiss.

Biotite/chlorite schist

Several different lithologies are present within this group. Sample RS 407 is a biotite + muscovite + quartz schist, which contains sphene to 3% in the absence of opaques. Biotite is significantly coarser grained than muscovite (1.3 mm versus 0.05 mm) and shows alignment in both the S_1 and S_3 schistosities. Muscovite is aligned in S_3 only.

A black melanocratic gneiss (RS 423), containing 99% biotite, occurs as scree in the dump at the Centralia Copper Mine. Biotite with an average length of 0.3 mm exhibits a poor alignment, probably in S_1.

RS 417 to 420 represent a mafic to ultramafic dyke. Specimens are chlorite-rich while the texture varies from granoblastic to schistose. Clots or aggregates are present and are aligned in the schistosity (S_3). Mineral assemblages of the matrix to the clots are:

Chlorite	32 - 99%
Muscovite	0 - 60%
Opaques	1 - 6%
Biotite	0 - 6%
Quartz	0 - 6%

Muscovite is present in one sample only. Mineral abundances of the two clast types are:

(1)	Epidote	45%	(2)	Quartz	45%
	Opaques	25%		Chlorite	45%
	Chlorite	30%		Muscovite	10%

Chlorite is often dimensionally aligned. The average size varies from 0.01 mm in one sample to 1.2 mm in another; some grains range up to 3 mm. Distinctive are deformation structures in chlorite: - undulose extinction, curved (001) cleavages and kink-folded (001) cleavages.

Clots or aggregates have very sharp boundaries and are characterised by:

- a marked increase in opaque abundance (to 25%)
- the presence of epidote
- a significantly finer grain size than the surrounding schistose chlorite matrix.

Ironstone

Ironstone lithologies vary from opaque-rich (RS 408) to quartz-rich (RS 573, 576). Phases and their abundances are:

	RS 408	RS 573, 576.
Opaques	70%	15%
Quartz	26%	75 - 80%
Phyllosilicates	4%	5 - 10%

Opaque phases are predominantly maghemite; minor chalcopyrite and goethite occur in RS 576. Textures vary from massive, to banded, and to weakly gneissic. When gneissic, quartz and opaques show a dimensional alignment in the S_1 gneissosity which is parallel with banding. Bands in RS 573 vary from opaque-rich to quartz-rich, and average 1 to 2 mm thick. Opaque grains vary in average size from 3.5 mm in RS 408, to 0.5 mm within opaque-rich bands in RS 573.

The ironstone horizon at the Olary Silver Mine contains pyrite, up to 25%, below the water table (see Flint, 1977); samples described here are from the same or equivalent horizons.

Ironstone lateral equivalents

These form a diverse group of lithologies which crop out near, and along strike from, ironstones; the exception is RS 533 which is possibly equivalent to RS 526 and 527.

RS 409 is one of a very rare group of Willyama Complex lithologies which contain original clasts and was conglomeratic. Clasts are up to 4 mm long and 2 mm across, and are comprised of quartz and albite + opaques. Clast elongation is parallel with a dimensional alignment of matrix phases i.e. quartz, albite, opaques; these are aligned in the gneissosity S_1. Mineral assemblage is albite 50%, quartz 37% and opaques 12%. Average grain size is 0.3 mm.

RS 526 and 527 are lateral equivalents of the ironstone at the Olary Silver Mine. Dominant phases are:

Quartz	85 - 88%
Chlorite	5 - 10%
Muscovite	2 - 8%
Opaques	1%

Their texture is massive and granular with a wide variety of grain sizes within each sample. Although average grain size is 0.3 mm, quartz grains range up to 7 mm across. Chlorite occurs in radial clusters and aggregates to 6 mm across. Muscovite porphyroblasts are equant and up to 5 mm across. Small grains are apparently from recrystallisation. RS 526 and 527 possibly form as a vein deposit rather than as conformable granofelsic gneiss.

RS 533, a possible equivalent to RS 526 and 527, also has similarities to a chlorite schist (RS 417 to 420). The lithology is a masssive granofels which crops out amongst various gneiss types. Muscovite (55%) and chlorite (42%) are the dominant phases. Muscovite averages 0.1 mm but range up to 2 mm equant

porphyroblasts. Chlorite grains average 0.7 mm, and form networks and radial clusters.

Opaque-rich gneiss/schist

Many gneisses and schists contain appreciate maghemite and martite. Examples of these are RS 297 and 298; another example is RS 409 which is near an ironstone. RS 297 is a banded but granoblastic gneiss; opaques exhibit the banding and the average grain size is 2 mm. Mineral abundances are:

Albite	60%
Maghemite	20%
Quartz	15%
Muscovite	5%

Some bands contain up to 30% opaques. With lower opaque abundances, this lithology grades into a quartzofeldspathic gneiss.

RS 298 is schistose with biotite + microcline + quartz + opaques defining the S_1 schistosity. Average grain size is 0.3 mm. Biotite exhibits a good dimensional and crystallographic alignment, while quartz, feldspar and opaques vary from equant to elongate in the schistosity. Mineral abundances are:

Microcline	40%
Quartz and albite	33%
Biotite	12%
Opaques	8%
Muscovite	7%

Sillimanite-bearing gneiss

Many gneiss horizons contain pelitic segregations which often contain very coarse-grained sillimanite. RS 301 and 427 are representative and contain both coarse-grained and fibrolitic sillimanite; basal sections of sillimanite are up to 7 mm across. Fibrolite occurs in broad mats and radial

clusters. Minor corroded andalusite is present. Muscovite, in the form of sericitic masses and porphyroblasts to 7 mm long, is more abundant in RS 300. Both RS 301 and 427 contain greater than 94% sillimanite + fibrolite.

Samples containing sillimanite and/or fibrolite aligned in the first phase gneissosity (S_1) are RS 425, 426, 479, 525 and 929; their sillimanite content varies from 1 to 60%. Mineral abundances are:

	RS 425	RS 426	RS 479	RS 525	RS 92
Sillimanite	60	2	1	4	5
Muscovite	30	83	43	96	75
Chlorite	9	7			15
Quartz			55		

In these samples, the maximum length of sillimanite needles is 0.4 mm. The S_1 gneissosity contains sillimanite and muscovite. Post-S_1 events include:

- growth of muscovite porphyroblasts to 10 mm across
- extensive sericitisation which produces randomly oriented small grains which average less than 0.01 mm across.
- growth of randomly-oriented chlorite grains to 0.3 mm.

Tight D_2 crenulations of the S_1 schistosity are evident in RS 425 and 426. Muscovite, chlorite and biotite crystallised during the development of S_2, and are aligned along the axial plane of D_2 crenulations.

Gneiss samples containing fibrolite produced during retrogression (D_2 and/or D_3) are RS 410 and 895. Passive fragmentation of the coarse grained gneiss (average grain size 3 mm) occurs by pervasion of fine-grained muscovite and fibrolitic sillimanite. RS 410 contains muscovite and sillimanite which is aligned to produce a schistosity; this is interpreted as the S_3 schistosity.

Sericite gneiss

These gneisses are similar to the above group in that they contain abundant sericite (fine-grained muscovite), but differ in that sillimanite or fibrolite is absent. Typically they contain gneiss relicts which are invaded and surrounded by a matrix of fine-grained (0.01 mm) muscovite; matrix muscovite abundance varies from 40 to 70% of the sample volume. Gneiss relicts indicate on original grain size of approximately 1.8 mm; later recrystallisation and fragmentation by the matrix muscovite have reduced the grain size. Gneiss phases are quartz, feldspar, biotite and muscovite. Retrogressive fine-grained muscovite varies from randomly oriented to aligned, producing an S_2 and an S_3 schistosity (e.g. RS 398). Occasionally (e.g. RS 531), a new mineralogical banding occurs parallel with S_3.

Muscovite schist

These specimens are transitional to sericite gneiss and sillimanite-bearing gneiss; both RS 305 and 377 contain trace amounts of fibrolitic sillimanite, and have muscovite contents of 62 to 79%. Mineral abundances are:

Muscovite	79%	62%
Quartz and feldspar	14%	30%
Biotite	4%	6%

Both samples contain a relict S_1 schistosity defined by quartz, feldspar, biotite muscovite and trace fibrolitic sillimanite. Fine-grained muscovite is dominant and passively fragments the schist. RS 305 contains tight D_2 folds; syn-S_2 phases are muscovite, biotite and chlorite. Muscovite occurs as porphyroblasts to 8 mm, as well as the ubiquitous fine-grained muscovite. Tourmaline has apparently crystallised with its long axis parallel to the D_2 fold axis. RS 377 contains fine-grained muscovite aligned in S_3; deformed muscovite porphyroblasts have a

dimensional alignment in S_3.

Muscovite + quartz schist

Crenulated quartz + muscovite schists are abundant in the northern portion of the Outalpa Inlier, but are generally absent in the south. This specimen, RS 530, does not crop out and was collected from the mine dump at the Mount Perseverance Copper Mine. Mineral abundances are:

Quartz	50%
Muscovite	35%
Biotite	14%

The sample is distinctly fine grained; average grain size is only 0.04 mm. Quartz grains are equant, while micas vary from equant to elongate and aligned to produce a schistosity. The schistosity is possibly S_3.

Pelitic schist

These schists contain up to 10% of staurolite + chloritoid + garnet. The remaining phases are dominated by quartz and muscovite, with greater than 40% muscovite. RS 306 contains a relict S_1 schistosity of biotite + fibrolitic sillimanite + chloritoid + quartz, while RS 429 contains relicts of garnetiferous gneiss. Deeply-embayed chloritoid grains are up to 2.5 mm across while muscovite, apparently of the same age, averages 0.1 mm in length. In RS 306, open D_2 crenulations are accompanied by crystallisation of fine-grained muscovite and chlorite, and large subhedral garnet and staurolite. RS 429 contains two weakly-developed fine-grained retrogressive schistosities with equant subhedral staurolite to 1.4 mm.

With the absence of chloritoid, staurolite and garnet, these grade into quartz + muscovite schist, muscovite schist and sericite gneiss. Sillimanite-bearing equivalents are included in the group, sillimanite-bearing gneiss.

Garnet-bearing quartzofeldspathic gneiss

Sample RS 389 is essentially quartzofeldspathic gneiss which contains 4% garnet. Mineral abundances are:

Quartz + andesine + orthoclase	86%
Biotite	7%
Garnet	4%

Biotite has a dimensional and crystallographic alignment to define a gneissosity; average length is 0.9 mm. Quartz, feldspar and garnet form a granoblastic mosaic; average grain size is 0.5 mm while isolated grains range up to 1.3 mm. The lithology is gradational into quartzofeldspathic gneiss and feldspar + biotite gneiss.

Quartzofeldspathic gneiss

Lithologies within this group crop out over a wide area; they are characterised by a granoblastic mosaic of quartz and feldspar while a biotite gneissosity is subordinate to absent. Biotite content is consistently less than 7%. Plagioclase (albite to andesine) greatly exceeds potash feldspar (orthoclase and microcline) in most samples. Quartz and plagioclase often occur in subequal amounts. Table 2 lists the abundances for the dominant phases.

The average grain size varies from 0.2 mm in a quartz + albite granofels (RS 899) to an average of approximately 2 mm in RS 528. Samples RS 435 and 528 contain some grains to 7 mm across. All samples contain abundant small recrystallised grains which tend to reduce the average grain size.

This suite of samples is transitional to some of the granitoids, particularly RS 907 and 908 which are migmatite gneiss and contain an allotriomorphic granular texture.

Feldspar + biotite gneiss

This group of lithologies has several distinctive chacteristics:

- a high biotite abundance which is mostly in the range of 11 to 18% but reaches 47%.
- abundant combined feldspar with a minimum and maximum abundance of 30 and 85% respectively.
- quartz content does not exceed 30%.

Table 3 shows the range of abundances for the dominant phases.

Lithologies vary from granofels to gneiss. Biotite principally defines the gneissosity, but RS 534 contains 47% biotite which is randomly oriented. Most samples contain a granoblastic mosaic of feldspar and quartz; occasionally some grains are elongate and aligned in the biotite gneissosity.

The average grain sizes for granoblastic grains are mostly in the range 0.4 to 1.2 mm; relicts of larger grains to 2 mm are often present. Recrystallisation has produced abundant new small grains. Biotite, aligned in the gneissosity (S_1), has average lengths between 0.4 mm and 1.5 mm.

Occasional samples contain minor amounts of muscovite porphyroblasts, retrograded andalusite porphyroblasts or garnet. When muscovite is abundant (RS 381), it is fine grained and aligned in a cross-cutting retrogressive schistosity.

With lower biotite abundances, many samples of this suite are similar to the quartzofeldspathic gneiss suite. Albite-rich gneiss and granofels (RS 299 and 406) are transitional into the albitite suite.

Mylonite

Most mylonite samples are located within east-west shear zones across the Willyama Complex; most movement along these zones was prior to deposition of the Adelaidean sediments. Original rocks are varied and include pegmatite, gneiss, adamellite, granodiorite and quartz granofels.

Most samples contain augen of the original host rock which are up to 8 mm long and 3.5 mm across. Many host-rock clasts are extensively recrystallised and merge with the matrix. The mylonitic schistosity wraps around host-rock relicts. Only in RS 535 and 559 is there a weakly-developed deformational banding parallel to the schistosity. Although there is variation between the samples, the mylonitic schistosity is defined by a dimensional and crystallographic alignment of muscovite, biotite and/or chlorite; alignment is often poor and muscovite usually dominates. Occasionally (e.g. RS 559) quartz and feldspar show a dimensional alignment in the schistosity. Phyllosilicates have an average length of 0.1 mm. Large subhedral to euhedral garnet porphyroblasts to 0.8 mm across occur within the muscovite schistosity of RS 302.

INTRUSIVES

Diorite

All of these samples, with the probable exception of RS 480, form a suite of late- to post-D_3 intrusive dykes. Their most common orientation is striking 120°M; dyke width is usually 5 to 10 metres. RS 403 and 404 are from a dyke which is folded during D_3; all others are from dykes striking about 120°. The mineralogy of RS 403 and 404 is distinctly different from the remaining samples of this suite, but the texture is very similar. Table 4 shows the mineral assemblages and abundances for the samples. Not shown are the alteration products epidote, muscovite, tourmaline, opaques and sphene. RS 480 is unlike any other sample from the Outalpa Inlier; it is a biotite hornfels or biotite diorite containing embayed quartz and plagioclase laths set in fine-grained matrix of randomly-oriented biotite, hornblende, chlorite and opaques.

The texture is massive and subophitic; plagioclase laths

to 2 mm long are enclosed in a matrix dominated by hornblende. Laths are mostly randomly oriented while hornblende forms equant interlocking anhedra. Plagioclase within the matrix is either as very small laths, interstitial to hornblende and/or poikiloblastically enclosed by hornblende. Quartz is always minor to absent, when present it is often as small inclusions within hornblende. Plagioclase is variously epidotised with some grains intensely epidotised and now consisting of up to 80% epidote; remaining plagioclase is andesine. Plagioclase often contains a cryptocrystalline brown turbid alteration phase.

Recrystallisation has reduced the grain size in most samples. RS 416 contains plagioclase laths to 2 mm long which contain new recrystallised grains only 0.02 mm across. Maximum relict grain size of hornblende is 1.3 mm while the lowest average grain size is 0.2 mm; a typical average size is 0.6 mm. Common fine-grained alteration products are epidote, biotite (except in RS 480), sphene and dusty muscovite.

Granite

The suite comprises samples of various ages, from syn-D_1 to syn- to post-D_3. Samples RS 428, 523 and 905 contain a biotite $\pm$ muscovite gneissosity while the remainder contain an allotriomorphic granular texture. In all specimens, the total mica content is less than 6% and hence, even in gneissic granite, the granular texture is dominant.

Microcline grains are usually clear with less inclusions than plagioclase; plagioclase often contains abundant fine-grained muscovite inclusions. Sericitisation is not uniformly developed within plagioclase. Perthitic plagioclase is often sericitised but not the host microcline.

Grain size averages 1 mm but ranges up to 3 mm; rare microcline grains to 6 mm are evident in RS 536. Recrystallisation

has reduced the grain size in most samples. Original large grains tend to have very irregular boundaries, while small grains have sharper and straighter grain boundaries. Primary quartz grains are often completely recrystallised into a fine-grained granoblastic to granuloblastic mosaic.

Many of the samples are gradational to the adamellite suite.

Adamellite

All samples have an allotrimorphic granular texture; general characteristics are very similar to non-gneissic granite. Grain boundaries are typically irregular and diffuse while small recrystallised grains are abundant. Average grain size is often in the range 1 to 2 mm, RS 309 contains a microcline phenocryst 7 mm long. RS 380 contains orthoclase; all other adamellite and granite samples contain microcline. Plagioclase/microcline boundaries, like those in granite, are often myrmekitic. Dusty muscovite inclusions in plagioclase have an average size of 0.01 mm and are often aligned along feldspar cleavages. Like granite, biotite and muscovite abundance is low but several muscovite porphyroblasts occur in RS 521 and 524.

Granodiorite

This suite has many textural similarities to the granite and adamellite suites. The formation age of RS 894, 896 and 901 from this suite is probably the same age as RS 902 and 903 which are both adamellite.

Granodiorite samples have an allotriomorphic granular texture with an average grain size of 1 to 2 mm; relict andesine grains to 7 mm occur in RS 896 and may represent a phenocrystic phase. Other features such as the extent of plagioclase sericitisation, grain boundary characteristics and the presence of small recrystallised grains are the same as for the granite and adamellite suites.

UMBERATANA GROUP METASEDIMENTS

Rocks in the Umberatana Group range from quartz metasandstone to schistose dolomitic diamicite interbedded with ubiquituous grey-green metasiltstone. Bedding in the metasiltstone is defined by bands 0.5 to 10 mm thick, distinguished by slight grain-size variations and abundances of quartz & feldspar versus biotite & muscovite.

The modes of the main minerals are:

Quartz and feldspar	35 - 65%
Biotite	25 - 40%
Muscovite	4 - 35%
Dolomite	0 - 34%
Opaques	1 - 4%

The biotite content is higher than nearly all Willyama Complex rocks, while dolomite occurs only in trace amounts within mafic intrusive and calc-silicate. Average grain size is 0.12 mm or less; some micas are elongate to 0.6 mm long. Clasts within the diamicite are of Willyama Complex and Adelaidean lithologies; Willyama Complex clasts exhibit textural features typical of samples from the nearby Outalpa Inlier. Small clasts merge with the matrix. Wrapping around and deforming the clasts is a biotite + muscovite $\pm$ opques $\pm$ dolomite schistosity; this is axial planar to folded bedding. In many outcrops, particularly those containing diamicitie, the schistosity is more strongly developed than bedding.

Boldly outcropping, massive grey metasandstone are quartz-rich with an equant granular texture and an average grain size of 0.12 mm. The mineral assemblage is dominated by quartz (83%) and opaques (7%).

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APPENDIX A

PETROGRAPHIC DESCRIPTIONS -

Willyama Complex rocks and Umberatana Group metasediments

RS 296 FELDSPAR + BIOTITE GNEISS

FIELD NOTES: Outcrop area is of biotitic gneiss which grades into a biotite gneiss with a granoblastic texture also; this sample is of the gneiss containing both granoblastic quartz and feldspar, and a biotite gneissosity. Field evidence suggests the gneissosity is S_1.

THIN SECTION: A gneissosity is pronounced; it is defined by:

- a very good dimensional and crystallographic alignment of biotite and muscovite
- a fair dimensional alignment of plagioclase and microcline.
- possibly a crystallographic alignment of microcline.

Micas are disseminated. Quartz and feldspar form a granular mosaic; many grains are elongate in the gneissosity, with the maximum length:breadth ratio being 3:1. Average quartz + feldspar grain size is 0.8 mm. A very poorly-defined banding is present; this is defined only by a vague banding of microcline and plagioclase. The schistosity/gneissosity is oriented at 30^{o} to the banding. Mineral abundances are:

Microcline	45%
Plagioclase	25%
Biotite	18%
Quartz	10%
Muscovite	2%

Microcline, in contrast to plagioclase is relatively inclusion free. Extinction is somewhat undulose while grain boundaries are straight but diffuse.
Plagioclase is marked with extensive minute inclusions of muscovite, epidote, opaques and miniature indeterminable inclusions. Many grains have clear untwinned to poorly-twinned rims. Central zones with inclusions often lack twins. Irregular cracks or fractures sometimes present in central zones. Extinction is often undulose.
Biotite alignment is very good. Dark coloured pleochroism is unusual; from moderate yellow brown to very dark chocolate brown. Although biotite is disseminated, often have 2-3 grains forming a small aggregate. Average length is 0.35 mm, length: breadth ratio is 3:1. Boundaries are often sharp and straight.
Muscovite boundaries are like those of quartz. Grains average 0.4 mm in length and are slightly more elongate; length: breadth ratio is 4:1.

The high microcline abundance is somewhat unusual. The gneissosity is probably S_1.

RS 297 · ALBITE + MAGNETITE GNEISS

FIELD NOTES: Quartzofeldspathic gneiss, some horizons are particularly massive. Some horizons (this sample) are banded with abundant magnetite.

THIN SECTION: Texture is granular; no alignment is present. The sample is banded; opaques are concentrated in broad bands. Albite is abundant in all parts of the sample. Mineral abundances are:

Albite	60%	
Magnetite	20%	(up to 30% in selected bands)
Quartz	15%	
Muscovite	5%	

Albite ($\sim An_4$) grains vary from equant to slightly elongate. Elongation is apparently random with respect to crystal axes, and elongate crystals are randomly oriented. Albite twin lamellae are occasionally gently curved or are offset by minor faults. Common crystal size is 2 mm.
Opaques are equant ragged and anhedral; many grains are skeletal. Average size is 1 mm though grains range up to 3mm. Where opaque grain abundance is highest, albite and opaque grains are rimmed by small muscovite grains 0.05 mm long. In places larger muscovite grains appear like an overgrowth, with one optically continuous grain completely enclosing several large albite and opaque grains.
Quartz forms rare grains to 1.5 mm which are strongly polygonised. Most grains are smaller than 0.4 mm, but form aggregates to 2 mm across; these represent recrystallised gneiss grains. Grain boundaries are straight or gently curved but diffuse. Quartz is also abundant as small grains (0.03 mm) along albite/albite boundaries. This quartz has particularly lobate boundaries.

RS 298 BIOTITE + OPAQUE SCHIST

FIELD NOTES: Outcrop is of a dark grey-green quartzofeldspathic sandstone which contains abundant magnetite and biotite. Micas appear aligned but don't control the weathering style.

THIN SECTION: The sample has a strongly-developed biotite schistosity. Quartz, feldspar and opaques all vary from equant to elongate in the schistosity; their length: breadth ratios range up to a maximum of 3:1. The average grain size is 0.1 to 0.2 mm. Mineral abundances are:

Microcline	40%
Quartz + untwinned albite	33%
Biotite	12%
Opaques	8%
Muscovite	7%

Microcline has diffuse broad cross-hatched twinning and hence extinction is variable, occasionally somewhat concentric. Grain boundaries are irregular. A common grain size is 0.3 mm. Grains vary grom equant to elongate in the schistosity; maximum legnth: breadth ratio is 3:1.
Quartz grains have weak undulose extinction. Shape is the same as for microcline, but the average size is only 0.2 mm. Grain boundaries are gently curved to irregular.
Opaques vary from equant anhedra to elongate in the schistosity; maximum length: breadth ratio is 2:1. Grains are subhedral; many straight-edged grain boundaries meet at or near a 120° angle.
Biotite shows a good to very good alignment to form the schistosity. The alignment is both dimensional and crystallographic. Biotite is disseminated; there is not banding. Some stubby crystals occur across the schistosity. Average length is 0.15 mm, length: breadth ratio is 3:1. Pleochroism is straw yellow, pale yellow brown to very dark brown.
Muscovite grains are distinctly more randomly oriented;they are also smaller and not as elongate. Average size is 0.08 mm, while the length:breadth ratio is 2:1. A few grains are elongate in the schistosity.

The schistosity is S_1 and is defined by microcline + quartz + biotite + opaques (magnetite). Muscovite recrystallisation occurred after S_1; some muscovite is probably syn-S_1.

RS 299 · ALBITE + BIOTITE GNEISS

FIELD NOTES: Feldspar + biotite gneiss containing about 10% retrogressed porphyroblasts, which are only poorly elongate in the schistosity (i.e. elongate in S_1). Surrounding rocks are migmatite gneiss.

THIN SECTION: The texture contains a good biotite schistosity and a granoblastic mosaic of albite. The porphyroblasts, evident in hand specimen, are comprised almost entirely of two generations of muscovite. Some porphyroblasts seem to contain small cores of gneiss. Average grain size of albite is 0.5 mm while porphyroblasts are to 7 mm across.

Gneiss groundmass

Biotite, with minor muscovite and ?rutile, define the gneissosity. Alignment (dimensional and crystallographic) is good;muscovite and ?rutile alignment is poorer. Granoblastic albite is dominant.
Mineral abundances are:

Albite	85%
Biotite	12%
Muscovite	2%
Quartz	1%
Rutile	<1%

Albite grains are equant and form a granoblastic mosaic. Grain boundaries are smooth and gently curved but somewhat diffuse. Limonite staining pervades all boundaries. Distinctive is the very poorly-developed twinning (by any law).
Quartz grains are minor and contain gently undulose extinction. Boundaries are as above.
Biotite forms a strong schistosity/gneissosity. (001) boundaries with albite are straight; all boundaries are somewhat diffuse. Average length is 0.4 mm, length:breadth ratio is 4:1. Pleochroism is pale yellow brown to moderate orange brown; it is much darker when stained with limonite.
Muscovite has similar shape, size and orientation to biotite.
Rutile? forms subhedral crystals to 0.3 mm long which are elongate in the schistosity.

Porphyroblasts

These comprise about 10% of the slide area. The schistosity only slightly wraps around some of the porphyroblasts. Maximum size is 7 mm across. Their shape is variable, some are rounded while others are very irregular.
Mineral abundances are:

Fine-grained muscovite	90%
Coarse-grained muscovite	10%
Tourmaline	trace

Muscovite porphyroblasts are to 2 mm across and are extensively corroded and deeply embayed by fine-grained muscovite. The latter muscovite has an average size of approximately 0.01 mm, and dominates the porphyroblasts.
Tourmaline is subhedral to euhedral. Perfect hexagonal cross-sections are to 0.2 mm across, while longitudinal sections are to 0.5 mm long. Pleochroism is colourless, very pale brown to

RS 299 (cont.)

blue green. Numerous muscovite aggregates contain coarse-grained albite + biotite cores which have identical properties with those of the surrounding gneiss.

S_1 schistosity is defined by biotite + muscovite + ?rutile. Prophyroblasts are probably late- S_1 and now are extensively retrogressed to fine-grained muscovite. Unusual are the apparent cores of gneiss. Another phase probably predates muscovite within the porphyroblasts.

RS 300 SILLIMANITE GNEISS

FIELD NOTES: Muscovite gneiss containing large aggregates of sillimanite + muscovite. This sample is of one of the aggregates, and hence should contain sillimanite.

THIN SECTION: Retrogression and alteration is extensive; the sample is comprised of several generations and forms of muscovite and sillimanite. Detailed relationships are discernible but cannot be related to structural phases. A poorly-developed sillimanite + musocivte gneissosity is probably S_1. Mineral abundances are:

Muscovite (all forms)	50%
Sillimanite (all forms)	47%
Plagioclase	1%
Opaques	1%
Biotite	<1%

Muscovite occurs as sericitic masses to very coarse-grained crystals to 7 mm long. Some of the larger grains show a very poor dimensional alignment with the sillimanite. All coarse-grained muscovite contains abundant fibrolitic sillimanite, much of it forms radial clusters. Sericitic masses are up to 10 mm across and are marked by:

- their fine grain size of ~0.01 mm
- and the presence of opaques.

Opaques are markedly more abundant in these sericite masses than in any other part of the slide. They are very-ragged equant anhedra which average 0.12 mm across.
Sillimanite has several forms also. The most abundant sillimanite is as fibrous radial clusters. Large crystals are to 8 mm long and are particuarly needle-like; these are often origented parallel with the muscovite, and possibly define the S_1 gneissosity.
Biotite forms randomly oriented laths to only 0.3 mm long and which are rimmed by minute opaque grains. Pleochroism is pale to dark brown.
Plagioclase is very-poorly twinned and is extensively stained along fractures by limonite. Grains are equant and 1 mm across. They tend to form aggregates.

The very coarse-grained sillimanite is probably syn-D_1.

RS 301 SILLIMANITE

FIELD NOTES: Outcrop is of micaceous and muscovite gneiss with pelitic aggregates in the scree. Some very coarse-grained sillimanite mineral specimens are in the scree (this sample). The gneiss is equivalent to RS 300.

THIN SECTION: The thin section is cut across the large specimen and should give basal centred figures.
The specimen is similar to RS 300 except that muscovite is almost absent. Some large basal sections of sillimanite are present; these are up to 7 mm across.
Mineral abundances are:

Sillimanite	99%
Andalusite	<1%
Muscovite	<1%

As well as the large basal sections of sillimanite, there are extensive mats and clusters of fibrous sillimanite; these are also present within the basal section.
Andalusite forms one deeply-embayed grain to 1.5 mm across.

Collected as a mineral specimen, and to test the extent of retrogression and alteration of the syn-D_1 sillimanite.

RS 302 RETROGRADE GARNET GNEISS

FIELD NOTES: Garnetiferous schist/gneiss which crops out amongst well-banded calc-silicate horizons.

THIN SECTION: The sample contains large coarse-grained quartz grains to 8 mm long, small recrystallised quartz grains are abundant. Clasts are enclosed by a fine-grained muscovite schistosity which contains large subhedral to euhedral garnet. Mineral abundances are:

Muscovite	50%
Quartz	44%
Garnet	3%
Chlorite	2%
Opaques	1%

Clasts

The clasts are to 8 mm and are comprised predominantly of quartz; maximum size of a single quartz grain is 6.5 mm. Large grains have pronounced undulose extinction. Small recrystallised grains are abundant; some originally large grains now consist of a granuloblastic mosaic of quartz averaging 0.2 to 0.3 mm across. Their grain boundaries tend to be straight or gently curved, and are often quite sharp. Large grains have very irregular boundaries with the matrix.
Clasts are often equant to only poorly elongate in the schistosity. Numerous clasts are partly fragmented and invaded by the matrix.
Chlorite grains are distinctly elongate but are randomly oriented. Average size is 0.3 mm while the length:breadth ratio is 4:1. Pleochroism is in very pale brown shades; birefringence is anomalous purple.
Biotite occurs in aggregates within large quartz-rich clasts. Aggregates are to several mm; maximum grain size is 1 mm. Biotite/quartz boundaries are deeply embayed while biotite/biotite boundaries are sharp and straight. Minute opaque inclusions are abundant.

Matrix

The matrix consist of fine-grained muscovite with large garnet porphyroblasts; small opaque flakes and biotite are also present.
Muscovite is only 0.1 mm long with a length:breadth ratio of 3:1 Individual grain boundaries are difficult to distinguish. Alignment is fair producing a schistosity which wraps around quartz clasts.
Garnet forms large subhedral to euhedral porphyroblasts which average 0.8 mm across. Grains have limonite staining on the margins and along internal fractures. Opaque inclusions are present and are often zoned with concentration of opaques towards the rim. Colour is neutral.
Opaques have an unusual flakey form, maximum length is 0.05 mm, length: breadth ratio is 5:1. Grain boundaries are sharp and straight.
Biotite grains are to 0.15 mm with a length:breadth ratio of 3:1. Grains are not oriented in the muscovite schistosity. Pleochroism is pale to dark brown.

The schistosity is probably S_m and related to late- to post-D_3 east-west shear zones.

RS 303 HORNBLENDE + ANDESINE GNEISS

FIELD NOTES: Gneissic amphibolite containing the S_1 gneissosity. It crops out in close proximity to banded calc-silicates.

THIN SECTION: The sample is of a hornblende + andesine gneiss. A weakly-developed gneissosity is defined by a dimensional alignment of hornblende, andesine and opaques. Most grains are equant. No crystallographic alignment is evident. Plagioclase is sericitised and epidotised. Recrystallisation of hornblende has produced abundant small grains which are only 0.1 mm across. Average hornblende and andesine grain size is 0.8 mm and 0.5 mm respectively.
Mineral abundances are:

Hornblende	45%
Andesine	40%
Quartz	10%
Opaques	2%
Sphene	1%
Epiodote	<1%
Muscovite (sericitie)	<1%
Biotite	trace

Hornblende grains vary from equant to poorly elongate; maximum length: breadth ratio is 3:1. Elongate grains are aligned to define a gneissosity. Grains are to 1.2 mm but average 0.8 mm. Margins are embayed; small recrystallised grains are subhedral and average 0.1 mm across. Pleochroism is α = pale green brown, β = moderate green brown to γ = dark green, dark blue green. Some of the larger grains are weakly poikiloblastic with quartz inclusions; most grains are free of inclusions.
Andesine. Plagioclase composition is very approximate only. Grains vary from equant to elongate and aligned in the gneissosity. Average size is 0.5 mm; maximum length:breadth ratio is 2:1. Sericitisation and epidotisation of plagioclase is present but not often pervasive; occasional grains of plagioclase are completely sericitised.
Quartz grains have a similar size and shape to andesine, except that small rounded grains 0.1 mm across are common. Quartz and feldspar boundaries are irregular.
Opaques form equant to elongate anhedra to 1.5 mm long. Most grains are rimmed with sphene. Maximum length:breadth ratio is 2:1.
Sphene, as well as occurring along opaque margins, also forms discrete grains to 0.25 mm. Boundaries are sharp and gently curved to straight.

This lithology is equivalent to many other samples of conformable gneissic amphibolite or hornblende + andesine gneiss horizons. Most occur in close proximity to well-banded calc-silicate lithologies.

RS 304 OLIGOCLASE + FERROACTINOLITE GNEISS

FIELD NOTES: Outcrop is of an actinolite/hornblende-bearing schist or fine-grained gneiss which contains noticeable opaques. Hand specimen is magnetic. Outcrop area is in the hinge zone of a regional D_3 fold.

THIN SECTION: A granoblastic texture is dominant but a dual grain size distribution is distinctive. Original gneiss grains which are preserved average 0.6 mm but range up to 1.8 mm. Recrystallisation, particularly of quartz and ferroactinolite has produced numerous small grains at 0.1 to 0.2 mm. Chlorite and inequant opaque grains tend to be aligned to form a very weakly-developed schistosity.
In comparison with RS 303 the sample is more extensively recrystallised, plagioclase is more sodic and less altered, and hornblende/ferroactionolite is finer grained.
Mineral abundances are:

Oligoclase	60%
Ferroactinolite	15%
Quartz	14%
Opaques	6%
Chlorite	4%
Ciotite	<1%

Oligoclase grains are to 1.5 mm across but the average is 0.6 mm. Grains are equant with only very minor alteration. Albite twin lamellae are occasionally slightly curved, extinction is often undulose. Grain boundaries are mostly gently curved and limonite stained.
Ferroactinolite/hornblende form relect embayed and poikiloblastic anhedra to 1.8 mm. Most grains range down to a minimum of 0.1 to 0.2 mm. Smaller grains often have subhedral to rounded forms. Pleochroism is α = pale brown, β = pale to moderate brown green, γ = moderate green.
Quartz mostly occurs as small grains and grain aggregates along oligoclase/oligoclase boundaries. Average size is 0.1 to 0.2 mm. Grain boundaries are gently curved and lined with limonite. Quartz/quartz boundaries are occasionally sharp and straight.
Opaques form ragged anhedra which tend to be slightly elongate and aligned parallel with the chlorite 'schistosity'. They range in size up to maximum of 0.9 mm.
Chlorite crystals occur in clusters where individual grains and the elongate clusters exhibit a fair alignment, which is parallel with that of the opaques. Grains are only to 0.2 mm long but are elongate with a 6:1 average. Birefringence is anomalous, grains are length fast. Pleochroism is pale brown to moderate green.
Biotite grains are equant to elongate but are not aligned in the 'schistosity'. Grains appear to be from recrystallisation. Elongate grains are to 0.25 mm and have a length:breadth ratio of 3:1. Pleochroism is pale to moderate orange brown, darker and more orange if limonte stained.

The sample exhibits extensive recrystallisation, the timing of which is not definitely known. The chlorite + opaque 'schistosity' probably formed during D_2 or D_3.

RS 305 CRENULATED MUSCOVITE + SILLIMANITE SCHIST

FIELD NOTES: Muscovite schist which has been strongly crenulated during D_2. Kink folds and transposed bedding are evident. This sample contains tight D_2 crenulations which fold the S_1 schistosity.

THIN SECTION: The sample is dominated by fine-grained muscovite. Some of it is aligned to produce the S_1 schistosity, which is close to tightly folded during D_2. Large muscovite porphyroblasts are overgrowths on the folded S_1 schistosity.
Mineral abundances are:

Muscovite (fine grained)	60%
Muscovite (prophyroblasts)	19%
Quartz + feldspar	14%
Biotite	4%
Opaques	2%
Tourmaline	<1%
Sillimanite	<1%

S_1 schistosity

The schistosity is defined by:
- aligned fine-grained muscovite
- bands of opaques and tourmaline
- aligned sillimanite needles.

Muscovite grains grade down from 0.1 mm. They usually have only a dimensional alignment in S_1. Many grains are aligned across S_1. Maximum length:breadth ratio is 3:1. Grain boundaries are very irregular and diffuse; it is difficult to distinguish individual grains.
Sillimanite forms very slender needles to 1 mm long. These show a very good alignment in S_1; trains of sillimanite are folded during D_2.
Opaques occur in bands parallel with S_1. Most grains are equant anhedra which average 0.12 mm across; smaller grains tend to be elongate in S_1. Grain boundaries are often straight.
Tourmaline occurs in bands parallel with S_1 and help to define S_1.
Biotite occasionally occurs as grains to 1 mm long which are aligned in S_1. Boundaries are very irregular. See biotite in the following section for further details.
Quartz forms grains which vary from equant to particularly elongate and aligned in S_1. Maximum length is 1 mm, and the maximum length:breadth ratio is 10:1. The grains appear to be interstitial to muscovite; quartz/muscovite boundaries are very ragged.

S_2 crenulation

During D_2, close to tight folds in the S_1 schistosity were produced. Recrystallisation was extensive, much of the S_1 schistosity was obliterated. Muscovite and biotite recrystallised with an alignment parallel to S_2. Tourmaline appears to have recrystallised parallel with F_2.
Tourmaline grains only exhibit euhedral hexagonal basal sections. As the thin section is perpendicular to F_2, tourmaline is probably elongate parallel with F_2.
Biotite flakes are occasionally aligned parallel with S_2 and distinctly across S_1. These grains are up to 1.5 mm with a length:breadth ratio of 6:1. Some grains have curved (001) cleavage traces. Chloritisation is very minor. Pleochroism is moderate

RS 305 (cont.)

brown to deep red brown. Grain boundaries are irregular. Muscovite forms small grains aligned in S_2 but more strikingly, it occurs as large porphyroblastic overgrowths. These are up to 8 mm across and crystallise across folded S_1 schistosity; single grains occupy both limbs and a hinge of a D_2 fold. Such muscovite grains have even extinction yet contain a folded S_1 sillimanite schistosity. Their shape indicates pre-S_2 to syn-S_2 porphyroblastic growth, with deformation and recrystallisation during D_2.

S_1 schistosity contains sillimanite + muscovite + biotite + quartz. During D_2 folding, muscovite, biotite and tourmaline rectystallised to have orientations related to S_2 and F_2.

RS 306 PELITIC SCHIST

FIELD NOTES: Pelitic schist which is on the same stratigraphic horizon as RS 305. The outcrop area contains a schist with:

- a strongly-developed S_1 schistosity.
- D_2 crenulations on S_1
- abundant garnet and chloritoid. These often form in alternate bands.

THIN SECTION: The thin section contains a biotite schistosity (S_1) which is crenulated into open D_2 folds. Recrystallisation during D_2 is extensive.
Mineral abundances are:

Muscovite	40%
Quartz	35%
Biotite	16%
Staurolite	3%
Garnet	2%
Chloritoid	2%
Chlorite	1%
Opaques	<1%
Sillimanite	trace

S_1 schistosity

This is defined principally by biotite which has a good dimensional and crystallographic alignment; at times the alignment is dimensional only. Other phases which show a dimensional alignment in S_1 are muscovite, fibrolitic sillimanite, chloritoid and quartz.
Biotite pleochroism is noticeably dark and varies from moderate orange brown to deep red brown. Average length is 0.8 mm while the length:breadth ratio is 3:1. Grains are embayed, and contain pleochroic haloes and opaque inclusions.
Muscovite grains rarely are aligned parallel with biotite, most is aligned across S_1 and parallel with S_2. Muscovite grains are 0.1 mm long and elongate; length:breadth ratio is 4:1. Alignment is dimensional and crystallographic.
Quartz grains are often equant but where bounded by biotite, are elongate in S_1 to a maximum of 3:1. Size varies markedly; the maximum is 1.6 mm while the average is 0.5 mm. Extinction, particularly in larger grains, is undulose.
Chloritoid is possibly a syn-S_1 phase. It forms deeply - embayed ragged grains to 2.5 mm long which vary from equant to elongate in the schistosity. Their growth may be post-S_1 but controlled by existing S_1 phases.
Sillimanite (fibrolite) occurs only as a folded phase within a large muscovite porphyroblast (for further details see RS 305).

S_2 crenulations

During D_2, open crenulation folds were produced in S_1. Recrystallisation, particularly of muscovite and chlorite, has produced these phases aligned parallel with the axial plane of D_2 folds. Staurolite and garnet are either synchronous with or post- D_2 folding.
Muscovite is fine grained and has a fair alignment parallel with the axial plane of D_2 folds. Average grain size is 0.08 mm while the length:breadth ratio is 2:1. Muscovite also occurs as one large porphyroblast, 3 mm across, which is superimposed on a folded S_1 sillimanite schistosoty. Porphyroblast margin appears to be folded yet the grain is in optical continuity; syn-D_2 recrystallisation must have occured.

RS 306 (cont.)

Chlorite has the same size, shape and alignment as fine-grained muscovite. Pleochroism is pale to moderate green, while birefringence is anomalous purple.
Staurolite forms ragged embayed anhedra to subhedral grains. They are apparently superimposed on the S_1 biotite schistosity. No definite syn-D_2 features are evident. Grains are up to 2 mm long.
Garnet forms equant rounded to subhedral grains. Colour is neutral to pale brown, and up to 1.2 mm across. No definite syn-D_2 relationships were observed, crystallisation is distinctly post-S_1 only.

S_1 schistosity contains biotite + fibrolitic sillimanite + quartz + muscovite + chloritoid. Definite syn-D_2 phases are muscovite and chlorite. Probable syn-D_2 phases are staurolite and garnet. RS 305 is similar but contains less garnet, staurolite and chloritoid.

RS 307 RETROGRADED QUARTZ + MUSCOVITE GNEISS

FIELD NOTES: Sample is of a quartz + muscovite gneiss containing an S_1 schistosity which is very tightly folded during D_2. A new layering/schistosity is developed, in places, during D_2.

THIN SECTION: The sample exhibits relicts of an S_1 gneissosity which are now parallel with extensive bands of recrystallised fine-grained muscovite. These bands indicate the orientation of S_2, which is parallel with S_1.
Mineral abundances are:

Muscovite	70%
Quartz	20%
Biotite	9%
Opaques	1%

Relict S_1 gneissosity

The gneissosity is defined by:
- a good to very good dimensional and crystallographic alignment of biotite
- a dimensional alignment of quartz and opaques
- a dimensional alignment of coarse-grained muscovite. with and without a crystallographic alignment.

Biotite has a maximum length of 1.5 mm while the average is 1.0 mm. The length: breadth ratio is 4:1 while the maximum is 10:1. Pleochroism is straw yellow to dark green brown. Boundaries are slightly embayed; minor pleochroic haloes are present. Quartz grains are to 1.7 mm long and are distinctly elongate parallel with the biotite gneissosity. Grains are rarely equant, they are elongate up to 5:1. Grains are fragmented, invaded by fine-grained muscovite, but remain in optical continuity. Boundaries are ragged; extinction is weakly undulose. Muscovite forms large porphyroblasts to 3 mm long which are elongate parallel with the biotite gneissosoity. Some porphyroblasts are fragmented, invaded by fine-grained muscovite, but remain in optical continuity. Boundaries are ragged. Opaques form elongate ragged grains to 1.2 mm long which are aligned in S_1. Some have a few straight edges and tend to be subhedral.

D_2 retrogression

This forms extensive bands of fine-grained muscovite; this produces a pseudo-clast appearance of the gneiss mineral. Only muscovite occurs in these bands; it is fine grained with an average size of less than 0.02 mm. Grain boundaries and individual grains are difficult to distinguish, no preferred orientation is apparent.

S_1 gneissosity is defined by muscovite + quartz + biotite. Extensive fine-grained muscovite recrystallised during tight D_2 folding and is not aligned parallel with the known S_2 orientation.

RS 308 and 309 ADAMELLITE

FIELD NOTES: Outcrop is of a granite, which in places, contains small areas of gneiss outcrop. There are often rapid and local lithology changes, gneissosity is often vary variable in orientation.

THIN SECTION: The texture is allotriomorphic granular and very similar to other granitoids in the southern Outalpa Inlier. The average grain size is 1.5 mm; microcline in RS 309 occurs as a phenocryst 7 mm across. Other phases are more even grained; RS 308 is slightly finer grained than RS 309. All grain boundaries are very irregular and often diffuse.
Mineral abundances are:

Microcline	35%
Albite	30%
Quartz	30%
Biotite	2%
Mucovite	2%
Opaques	1%

Microcline contains pronounced grid-iron twinning and slightly concentric undulose extinction. Average grain size is 1.4 mm; one grain occurs as a phenocryst and is 7 mm across. Fine-grained muscovite inclusions are minor, some rounded quartz inclusions or exsolution grains are up to 0.2 mm across.
Albite (~An_8) has undergone marked sericitisation. Fine-grained muscovite inclusions (~0.01 mm) are abundant and are often aligned along cleavage directions. Average size is 1.5 mm.
Quartz occurs as grains to 2 mm across and as recrystallised aggregates to a similar size. Smaller grains have more even extinction and straighter sharper boundaries; these grains have an average size of only 0.3 mm.
Biotite mostly forms equant anhedra; some grains are slightly elongate but not with respect to any crystallographic direction. Maximum length is 0.7 mm; most average 0.2 mm in width. Pleochroic haloes are present and some grains are chloritised.
Muscovite forms irregular embayed anhedra up to 1.3 mm across. Some (001) cleavages are slightly curved.
Opaques also form ragged equant anhedra up to 0.9 mm across, but the average size is 0.3 mm. Larger grins tend to be embayed.

RS 377 . RETROGRESSIVE MUSCOVITE SCHIST

FIELD NOTES: Spotted muscovite schist. Main schistosity is probably S_3.

THIN SECTION: Sample contains a poorly-preserved early schistosity which is folded and retrogressed during a later schsitosity-forming event. Replacement by muscovite is very intense during retrogression. Much of the former quartz and feldspar is extensively invaded by the schistosity forming a pseudo breccia.
Mineral abundances are:

Muscovite	Quartz	Orthoclase	Biotite	Plagioclase	Opaque
62%	12%	12%	6%	6%	2%

Muscovite porphyroblasts occur in sericitic muscovite bands which are parallel to the S_3 schistosity; the prophyroblasts have a strong dimensional, but not crystallographic, preferred orientation in S_3. They appear to at least partly predate D_3 as they contain undulose extinction, deformation bands and polygonised aggregates. Individual crystals are up to 3 mm but often occur in slightly larger aggregates. Porphyroblasts also contain fibrolitic sillimanite which is oriented parallel to S_3.
Quartz forms polygonised grains with strong undulose extinction up to a maximum of 1.8 mm. Grains are often equant but where elongate, the length:breadth ratio is to 2.5:1; there is no preferred orientation. Elongation appears to have been controlled by the pre-existing S_1 schistosity. Grain boundaries are sharp but irregular and marked by an abrupt changed in muscovite abundance. Quartz also forms isolated grains in sericite or extensively-sericitised feldspars.
Plagioclase - twinning is rare and grains often form a pseudobreccia. Extensive replacement by biotite and sericite along cracks, joints and deformation zones leave many smaller plagioclase grains in optical continuity. Some grains show an inward-converging undulose extinction with clear even-extinction rims.
Orthoclase(?) forms grains which are clear, unaltered and contain no grid-iron twinning. Largest grains are up to 1.2 mm and, like plagioclase, are now 'fragmented' into smaller grains of optical continuity.
Biotite is generally disseminated though a few biotite-rich aggregates occur. Form varies from equant to poorly elongate with the length:breadth ratio rarely exceeding 2:1. Grains are randomly oriented except in muscovite-rich bands parallel to S_3 where the biotite also shows a preferred orientation. Average size of 0.06 mm.
Opaques occur as grains with highly irregular outlines which form long trails up to 2 mm elongate in, and parallel to, the muscovite-rich bands defining S_3. These minerals appear to predate D_3.

Note: The schistosity has many characteristics transitional to those of the strong east-west shear zones in the Faugh-a-Ballagh Mine area, and hence the schistosity may be S_m.

RS 378 HORNBLENDE DIORITE

FIELD NOTES: Intrusive amphibolite; late stage with relict igneous textures.

THIN SECTION: Typical massive diorite with a subophitic texture; short plagioclase laths are set in a randomly oriented groundmass of hornblende and interstitial andesine. Plagioclase is extensively epidotised and the sample contains one quartz-rich xenolith. Quartz is present only in the xenolith.
Mineral abundances are:

Hornblende	Andesine	Epidote	Biotite	Opaques/Sphene
81%	9%	4%	3%	2%

Sericite	Quartz
<1%	<1%

Hornblende has an average size of 0.6 mm but often occurs as smaller apparently-recrystallised grains which have the same pleochroism as larger poikiloblastic crystals i.e. α = moderate brownish green, β = moderate greenish brown to γ = deep green and deep blue green. Grains are equant, show no preferred orientation, and are mutually impinging with very irregular grain boundaries.
Andesine commonly shows a brown turbid alteration which is often restricted to the centre outlining zoning within the plagioclase. Most often as isolated grains which average 0.4 mm and now consist of less than 10% epidote. Can form large aggregates to 7 mm long which are heavily epidotised (now approx. 65% fine-grained epidote) and appear to have been former more-calcic plagioclase crystals.
Epidote occurs only as a replacement product in plagioclase, either as small elongate crystals to 0.1 mm with a length:breadth ratio of 5:1, or as small irregular-shaped equant grains.
Sericite occurs only within heavily-altered plagioclase in association with epidote.
Opaques and sphene occur as very irregular-shaped aggregates which consist of numerous small opaque grains set in a matrix of sphene. Average size of the aggregates is 0.4 mm and they consist of equal amounts of opaques and sphene.
Biotite has two forms; as distinct overgrowths on hornblende and as equant to poorly elongate grains with no preferred orientation. All grains show dark brown pleochroism.

Xenolith

One xenolith was sectioned and this contained numerous small needles of hornblende set in a granular mosaic of quartz which shows diffuse grain boundaries. Average grain size is 0.08 mm and the xenolith is 3 mm long.

RS 379 · MICROCLINE GNEISS

FIELD NOTES: Fine-grained feldspar + mica gneiss

THIN SECTION: Mineral abundances are:

Microcline	Quartz	Biotite	Muscovite	Opaque
70%	12%	16%	2%	trace

A pronounced and well-developed gneissosity is illustrated by a very strong crystallographic and dimensional preferred orientation of biotite. Pleochroism of biotite is an unusual extremely dark brown. The biotite gneissosity is superimposed on a coarse-grained granoblastic mosaic of microcline. Abundant fine-grained recrystallisation occurs along microcline grain boundaries; much of this recrystallisation is myrmekitic.

S_1 gneissosity

The gneissosity is outlined by a very strong preferred orientation of biotite with markedly dark pleochroism:

α = dark brown, yellow brown

$\beta\gamma$ = very deep chocolate brown which is near black or opaque

Biotite varies considerably in size and there is a relation between the size and degree of preferred orientation. Large crystals are up to 1.5 mm long, have a length:breadth ratio averaging 5:1 and show the strongest preferred orientation in S_1. For the smaller biotite crystals, their size is only to 0.1 mm long, length:breadth ratio is 3:1 and their preferred orientation in S_1 is poor. Grain boundaries are sharp for all biotite.
A thin compositional band, only 1 mm wide, occurs parallel to the biotite gneissosity and consists entirely of muscovite. The muscovite has an average size of 0.08 m, length:breadth ratio of 5:1 and is aligned at an angle to the gneissosity. The alignment is probably equivalent to the trace of S_3. Muscovite has sharp grain boundaries.

Granoblastic mosaic

Microcline is the dominant mineral and exists as equant grains which average 1.2 mm. Grid-iron twinning is pronounded and undulose extinction occurs in a concentric style.
Quartz: Fine-grained recrystallisation of quartz and microcline is very extensive along the margins of large microcline crystals; myrmekitic intergrowths of quartz into microcline is common and these usually have a very lobate form. Rounded quartz blebs within microcline appear to have been exsolved; these have an average size of 0.05 mm. Much of the fine-grained recrystallisation along microcline boundaries appears to have been derived from myrmekitic activity.
Muscovite does not occur in the granoblastic mosaic, only within the thin band (vein?)

Microcline + biotite gneiss with recrystallisation of muscovite, possibly during S_3.

RS 380 ADAMELLITE

FIELD NOTES Noticeably a massive gneiss with no evidence of a gneissosity or schistosity; interlayed with banded schists and gneisses. The lithology may be an intrusive adamellite.

THIN SECTION: Sample has a massive granitoid texture with no preferred orientation. The composition is adamellitic; quartz and feldspar grain boundaries vary considerably:

- sharp and gently curved
- sharp but high irregular
- very diffuse.

Some of the feldspars have undulose extinction while cores of some crystals are preferentially sericitised.
Mineral abundances are:

Oligoclase	Quartz	Orthoclase	Biotite	Muscovite	Opaques	Epidote
35%	30%	27%	4%	2%	2%	trace

Oligoclase (An_{28}) has an average grain size of 1 mm but commonly occurs as larger crystals to 1.6 mm across. Pericline twinning is well developed.
Orthoclase forms mostly clear and unaltered grains with rare Carlsbad twins. Developed in both feldspar types is patchy and irregular fine-grained muscovite; this is more strongly developed in some oligoclase cores.
Quartz has a relict grain size of 1.5 mm but most grains now average 0.6 mm; undulose extinction present.
Biotite is unusually equant and anhedral; isolated laths are randomly oriented. Boundaries are predominantly sharp and clear. Pleochroic haloes are abundant while chloritisation is minor. Pleochroism is α= yellow brown to $\beta\gamma$ = dark chocolate brown while the average size is 0.6 mm.
Muscovite occurs as fine-grained inclusions in feldspars and as large individual crystals to 0.7 mm. For both types, grain boundaries are notably diffuse.
Opaques form disseminated isolated grains which are subhedral to anhedral; hexagonal outlines being evident. Grains are equant; average size is 0.3 mm.
Epidote has a pale yellow colour and anomalous blue-yellow birefringence. Grains are to 0.7 mm across, irregular and deeply embayed.

Lithology is probably an adamellite rather than a massive quartzo-feldspathic gneiss as:

- there is no biotite gneissosity
- texture is not as granuloblastic as are many massive quartzofeldspathic gneisses.
- potash feldspar is orthoclase rather than microcline.

RS 381 ANDESINE + BIOTITE GNEISS

FIELD NOTES: Coarse-grained feldspar+mica schist containing retrogressed pelitic porphyroblasts which have been flattened in a superimposed retrogressive schistosity. Prophyroblasts may contain sillimanite and/or kyanite. Retrogessive schistosity may be S_2.

THIN SECTION: original lithology is of a slightly-granoblastic gneiss with a pronounced biotite gneissosity. Superimposed on this is a strong retrograde sericitic schistosity with long bands of almost pure sericite parallel to the retrograde schistosity. The gneissosity and retrograde schistosity are often subparallel. Evidence for original porphyroblast mineral(s) is not preserved.
Mineral abundances are:

Andesine	Quartz	Muscovite	Biotite	Opaques
35%	30%	20%	14%	<1%

S_1 gneissosity

The gneissosity is defined by a good to very good dimensional and crystallographic preferred orientation of biotite and, to a lesser extent, muscovite.

Biotite occurs both as disseminated elongate crystals and as biotite-rich trains parallel to the gneissosity; these may represent a D_1 differentiation feature. Grain boundaries are usually sharp, grains average 1.3 mm in length and have a length:breadth ratio of 4:1. Biotite is often intergrown with muscovite. Pleochroism of α = bright yellow brown to $\beta\gamma$ = very dark chocolate brown.
Muscovite often forms large, almost porphyroblastic crystals to 2.5 mm long; in some of these, the preferred orientation is dimensional only and not crystallographic. When intergrown with biotite, grain boundaries are sharp; isolated crystals are irregular and deeply embayed. Some of the muscovite may be post-S_1.

The gneissosity is also defined by a poor dimensional preferred orientation of quartz and plagioclase; their length:breadth ratio varies up to a maximum of 2.5:1.
Andesine (An_{32}) often is twinned by the pericline and albite laws with abundant pericline twins. Grains have a maximum size of 1.3 mm and grain boundaries are regular but lined with very fine-grained muscovite.
Quartz forms grains up to 1.8 mm long but are strongly polygonised; smaller grains have strong undulose extinction. Quartz also commonly forms myrmekitic intergrowths in plagioclase. Quartz/quartz boundaries very variable; rarely as lobate forms in plagioclase.
Opaques occur as dustsize inclusions in biotite and along biotite boundaries; the latter is more common.

Retrograde sericitic schistosity

The schistosity is mainly formed by thin discontinuous compositional bands, which extend for up to 15 mm and contain fine-grained randomly oriented muscovite. Grains are equant, interlocking and have an average size of less than 0.02 mm.
Within the gneiss are extensively recrystallised zones which now consist of up to 40% new muscovite grains; these grains are randomly oriented, mostly equant, of average size 0.06 mm and occur with extensive fine-grained recrystallisation of quartz and andesine.

RS 381 (cont.)

Retrogressed Andesine + biotite gneiss; once containing aluminous porphyroblasts which have been completely retrogressed and flattened during $?D_2$.

RS 382 LAYERED ALBITITE

FIELD NOTES: Thinly bedded fine-grained quartzofeldspathic unit from within the calc-silicate lithologies. Bedding is well-preserved and the grain size is much finer than in the adjacent gneisses.

THIN SECTION: A very distinct granuloblastic texture is developed with a strong tendency for polygonal outlines. Mineralogy is predominantly albite and opaques, average grain size is 0.1 mm with opaques being finer grained. Compositional banding (S_o) is defined by slight variations in albite grain size and by marked changes in opaque abundance.
Mineral abundances are:

Ablite	Quartz	Opaques	Chlorite	Sphene
>82%	<10%	7%	1%	trace

Albite has a pronounced tendency for forming gently-curved and straight grain boundaries with polygonal outlines. Most boundaries are sharp but some grains have diffuse boundaries and undulose extinction. All grains are clear and unaltered. Coarser-grained layers contain crystals up to a maximum of only 0.2 mm. Albite is difficult to distinguish from quartz because of fine grain size, similar R.I., albite is often untwinned and many grains show few to no cleavage traces.
Opaques; their abundance varies dramatically from layer to layer and is often from 2% to 15%. They mostly occur as grains less than 0.03 mm with abundant grains at approx. .01 mm; rare grains to 0.5 mm. The largest aggregate is integrown with a little sphene. Grains are anhedral and vary from equant to elongate but are randomly oriented.
Chlorite occurs in several forms: as large chloritised biotite crystals to 0.5 mm long, as smaller disseminated grains averaging 0.2-0.4 mm which are poorly inequant and randomly oriented, and as an aggregate containing a radial cluster of chlorite.

Layered albitite or albitic hornfels

RS 383 . PLAGIOCLASE GNEISS with porphyroblastic andalusite

FIELD NOTES: Thinly-bedded quartzite or quartzofeldspathic metasandstone with porphyroblasts which appear to be retrogressed andalusite. Adjacent to quartzofeldspathic gneiss horizons and thinly-bedded calc-silicates and albitites (e.g. RS 382)

THIN SECTION: Several textural features are prominant; a granuloblastic mosaic of plagioclase, a biotite schistosity, and retrogressed alumina-rich porphyroblasts which were probably andalusite.
Mineral abundances are:

Albite/Oligoclase	Biotite	Muscovite	?Andalusite	?Rutile
70%	18%	7%	3%	2%

S_1 schistosity

Disseminated biotite has a good dimensional and crystallographic preferred orientation and defines the schistosity, which is probably S_1. Grain boundaries are often diffuse, average length is 0.4 mm and the length:breadth ratio is 4:1. Pleochroism is α = pale brown to $\beta\gamma$ = moderate olive brown.
Rare muscovites are aligned in the schistosity but these are as overgrowths on biotite.
The schistosity does not wrap-around the porphyroblasts; the prophyroblastic ?andalusite may be syn-tectonic to D_1.

Porphyroblasts

The porphyroblasts appear to be from a largely-retrogressed alumino-silicate. They are now comprised of a fine-grained discontinuous network of small (average 0.03 mm) high relief, colourless grains of δ = .006 - probably andalusite. These grains are however in optical continuity and have been substantially replaced by muscovite. Relict andalusite grains are often rounded and embayed, and may form up to 50% of the porphyroblast area/volume.
Replacement muscovite is up to 2.5 mm across, randomly oriented, has undulose extinction and contains a few kink bands in the cleavage.

Granuloblastic mosaic

Equidimensional plagioclase forms a granuloblastic mosaic with many areas of polygonal outlines; throughout the slide there is strong tendency for straight grain boundaries. Most grains are untwinned, limited albite twinning grain boundaries. Most grains are untwinned, limited albite twinning and optic sign determination suggests an albite/oligoclase composition. Average grain size is 0.7 mm.
Muscovite occurs disseminated throughout as:

- randomly oriented grains of av. size 0.65 mm with diffuse edges
- and as fine-grained muscovite along and near grain boundaries.

Rutile? also occurs as equant to poorly elongate, anhedral, dark yellow-brown grains with extreme birefringence.

Andalusite is probably syn-S_1 and syn-D_1.

RS 384 · GRANITE

FIELD NOTES: Massive granite, noticeably magnetic in hand specimen. Field relationships suggest that it may be approximately equivalent in age to D_3.

THIN SECTION: Section is notably feldspathic with abundant microcline; typical granitoid texture with some myrmekitic intergrowths. Composition varies across the slide from granitic to adamellitic; average mineral abundances are:

Microcline	Albite/oligoclase	Quartz	Biotite	Muscovite
50%	30%	13%	4%	2%

Opaques + sphene
1%

Microcline often has strong grid-iron twinning while poorly-twinned grains are perthitic. Grain boundaries are often irregular and sutured, myrmekitic, and sometimes they contain a thin diffuse border/reaction zone of clear albite. Fine-grained recrystallisation occurs along grain boundaries. Within perthitic microcline are albite subgrains with diffuse boundaries.
Albite/Oligoclase has irregular and diffuse grain boundaries. Crystals show a variable extent of sericitisation; some grains unaltered while others have sericitised cores and clear rims. Average size is 0.8 mm though there are abundant finer-grained recrystallised and exsolved crystals. Composition approx. An_{10}.
Quartz forms large primary grains to 1.5 mm with undulose extinction and polygonisation. Fine-grained exsolved and recrystallised quartz is rare.
Biotite is equant to poorly elongate with a maximum length: breadth ratio of 2:1 and has a very poor alignment. Grain boundaries are sharp but irregular. Pleochroism varies from α = moderate brown to $\beta\gamma$ = dark brown and dark olive brown. Av. size of 0.8 mm.
Opaques and sphene are commonly intergrown in biotite aggregates. Average size of individual grains are 0.5 mm. Opaques are magnetic.

RS 385 · MYLONITISED ADAMELLITE

FIELD NOTES: Same massive granite as RS 384 but has undergone shearing/mylonitisation. Shear plane is oriented at 86° towards 356°M and is equivalent to the east-west shears through the Faugh-aBallagh Mine area.

THIN SECTION: The sample is noticeably mylonitic with a biotite + muscovite schistosity which wraps around relict granite fragments. Clasts range down in size from 2.1 mm long until they are difficult to distinguish from the recrystallised matrix. Within the clasts plagioclase is highly sericitised, while the schistosity has a very good dimensional and crystallographic preferred orientation of biotite and muscovite. The micas and clasts occur in a matrix of recrystallised quartz and feldspars; these areas are clearly from recrystallisation but which have not obtained equilibrium.
Mineral abundances are:

Quartz	Albite/oligoclase	Orthoclase	Muscovite	Biotite	Opaques
30%	35%	20%	7%	7%	1%

Mylonite schistosity

Disseminated biotite has a good crystallographic and dimensional preferred orientation in the schistosity. Grains are not as long and have a lower length:breadth ratio than muscovite in the schistosity. Average length is 0.11 mm and the length:breadth ratio is 3:1.
Muscovite grains in the schistosity have an average length of 0.15 mm and with a length:breadth ratio of 8:1. Grain boundaries are diffuse, muscovite has a good alignment in the schistosity, and the schistosity wraps around the porphyroblasts.
Opaques are often elongate in the schistosity with a length: breadth ratio of2:1 and an average size of 0.2 mm.
Deformed orthoclase and quartz also have a dimensional preferred orientation in the schistosity; to a maximum length of 0.8 mm.

Relict adamellite clasts

Clasts range down in size fom 2.1 mm unti they are difficult to distinguish from extensively recrystallised clasts which form the matrix.
Plagioclase ($\sim An_{10}$) is extensively sericitised with the sericite being fine grained and randomly oriented. Plagioclase grains are of average size 1 mm.
Quartz forms large recrystallised aggregates to 2.5 mm which are elongate in the schistosity with a length:breadth ratio of 3.5:1 Most common average size of individual crystals is 0.4 mm (after recrystallisation).
Orthoclase is marked by a lack of sericitisation and is almost inclusion free.
Opaques are subhedral with incomplete hexagonal outlines and have an average size of 0.2 mm; sometimes intergrown with minor tourmaline.
Some of the smaller relict clasts are composed of a single feldspar and these tend to have even extinction, while large quartz clasts are extensively recrystallised with subgrain development.

Mylonite matrix

Much of the matrix has an average size of only 0.05 mm and is obviously derived from recrystallisation of clast minerals. Quartz/feldspar boundaries are diffuse and grains tend to be equant. In these zones alignment of biotite is poor.

Mylonite or mylonitised adamellite

RS 386 ALBITITE

FIELD NOTES: Fine-grained quartzite or albitite horizon amongst schist and gneiss. Horizon has been prospected with shallow pits because of malachite staining along joints.

THIN SECTION: A granoblastic texture is dominant and is mainly comprised of albite and opaques. Compositional banding is defined by a slight variation in grain size of albite and opaques as well as a change in abundance of opaques. Cross-cutting veins and joints are usually filled with opaques and biotite. Abundances including minerals within joints are:

Albite	Biotite	Opaques	Tourmaline
91%	1%	8%	trace

Albite is clear, unaltered and not always shows twinning. Untwinned grains appear to be albite; quartz abundance appears very low, if present at all. Grain boundaries are diffuse but tend to be near-straight or only gently curved. Grain size varies from 0.05 mm to 0.2 mm.
Opaques commonly show euhedral to subhedral outlines; rhomboidal, hexagonal and triangular shapes are most common while square outlines occur infrequently. Average size is 0.16 mm in coarse-grained layers but only 0.04 in fine-grained layers.
Biotite is more abundant and slightly coarser grained in the coarse-grained albite layers but the greatest abundance is within joints/veins. Biotite is equant to poorly inequant, and when elongate is randomly oriented. Chloritisation of biotite is extensive while grain boundaries are diffuse and irregular.
Tourmaline occurs as disseminated isolated grains with a hexagonal outline, green colour, diffuse boundaries and an average size of 0.06 mm.

Albitite or albitic granofels

RS 388 HORNBLENDE DIORITE

FIELD NOTES: Massive amphibolite or diorite; in places contains a weak schisotisty oriented at 70° towards 156°. Age of schistosity i probably S_3.

THIN SECTION: Dioritic texture with distinct plagioclase laths which are poorly aligned. Plagioclase exhibits an extensive very-fine brown turbid alteration. Hornblende is more equant with no preferred orientation.
Mineral abundances are:

Hornblende	Andesine	Quartz	Epidote	Opaques + Sphene
75%	18%	3%	trace	4%

Hornblende: most grains have been extensively recrystallised so that the present grain size is quite small; relict grains occur to 1.3 mm and have a very poor dimensional preferred orientation parallel to the aligned plagioclase laths. Many grains have deformed cleaveages and grain boundaries are very iregular. Pleochroism is α = pale brownish green, β = blue green and γ = deep green; pleochroism of large and small hornblende grains is identical.
Andesine forms laths to 1 mm long but these have irregular contacts with adjacent hornblende. Albite twinning abundant, as is an extensive fine brown turbid alteration. In general epidotisation is minor but isolated grains are extensively epidotised; up to 80% of these grains are epidote. Sericite and biotite within andesine is absent. Quartz occurs as small inclusions in poikiloblastic hornblende. Sphene and opaques form intergrowths, disseminated throughout the sample, which are equant and contain more opaques than sphene.

RS 389 FELDSPATHIC AND GARNETIFEROUS GNEISS

FIELD NOTES: A sandy schist containing abundant quartz and feldspar but with a pronounced biotite schistosity; garnets present. Lithology is in close proximity to calc-silicates, albitites and epidotic quartzites. Contained schistosity is S_1.

THIN SECTION: Sample consists of a coarse-grained biotite gneissosity and a granoblastic mosaic of quartz, plagioclase, orthoclase and garnet.
Mineral abundances are:

Andesine	Orthoclase	Quartz	Garnet	Biotite	Muscovite
30%	30%	26%	4%	7%	2%

Opaque + Sphene	Epidote	Tourmaline
1%	trace	trace

S_1 gneissosity

The gneissosity is defined by a good dimensional and crystallographic preferred orientation of biotite; some grains show only a dimensional preferred orientation in S_1. Average length is 0.9 mm; many grains to twice that length, and the average length:breadth ratio is 2.5:1. Pleochroic haloes are common while pleochroism varies from α = yellow brown to $\beta\gamma$ = deep reddish brown. (001) boundaries are sharp but others are more diffuse, some grains are slightly embayed.

Granoblastic mosaic

Large garnet crystals are distinctly embayed while smaller grains are quite rounded; average grain size is 0.5 mm. Biotite crystallises along cracks within garnet. Garnet and biotite may form a stable co-existing pair. Colour is pale pink to pale brown.
Quartz forms isolated larger grains to 1.3 mm with strong undulose extinction and polygonisation, but the more common grain size is 0.5 mm with undulose extinction. Also occurs as small exsolved grains in feldspar with rounded forms. Grain boundaries variable from sharp and straight to diffuse.
Andesine (An_{38}) has pronounced undulose extinction, poorly-developed sericitisation, irregular boundaries and an average size of 0.5 mm.
Orthoclase is untwinned and often has a broad and diffuse reaction rim surrounding the grain; diffuse zones are most often along orthoclase/orthoclase and orthoclase/biotite boundaries. A strongly-concentric undulose extinction is present and noticeable, microcline twinning absent.
Fine-grained muscovite is mostly concentrated along grain boundaries; sericitisation of feldspars is minor.
Numerous small opaque grains have a wide rim of sphene, producing an aggregate of average size 0.1 mm. Near these aggregates are small epidote grains with some chlorite, and isolated small tourmaline with pale brown to deep green blue pleochroism.

Feldspar + garnet gneiss

RS 390 . SCHISTOSE DIAMICTITE

FIELD NOTES; Typical tillite/diamicite in this area; contains a pronounced cleavage and flattened clasts. The cleavage is definitely identified as S_5.

THIN SECTION: Sample is gritty with fine-grained clasts and detritus; largest clasts are only 2 mm across. A biotite/muscovite schistosity is present which wraps around the largest clasts only. Rarer outsized biotite/opaque clasts are flattened in S_5 and one in particular, appears to be extensively annealed. Clasts constitute approximately 80% of the total volume.
Mineral abundances are:

Quartz	Plagioclase	Biotite	Muscovite	Opaques
50%	18%	25%	4%	3%.

Willyama Clasts

Average clast size is 0.2 mm. They are mostly comprised of quartz; some are of single quartz grains up to maximum size of 1.6 mm while others are quartz-quartz and quartz-plagioclase aggregates. These aggregates have features typical of Willyama Complex lithologies of the immediately-adjacent Outalpa Inlier: irregular grain boundaries, decrease of grain size with recrystallisation and annealing, extensive sericitisation of plagioclase, and exsolution of quartz. Many of the small quartz grains have pronounced undulose extinction. Coarse-grained muscovite occurs in the clasts also. Clasts vary in roundness and sphericity; many are equant and those that are elongate, are not always aligned in S_5.

Adelaidean clasts

Two biotite-rich areas are probably clasts; these consist of equal proportions of biotite, dolomite and reddish opaques. The clasts are up to 18 mm long and distinctly elongate in S_5. Biotite has a good crystallographic and dimensional alignment in S_5, while the alignment of dolomite is apparently only dimensinal. Biotite has an average size of 0.05 mm, length:breadth ratio of 1.5:1 and pleochroism of α = pale greenish brown, $\beta\gamma$ = dark olive brown. Dolomite has an av. length of 0.03 mm and a length:breadth ratio of 2:1.
Another biotite-rich clast contains approximately 80% biotite and 20% red isotropic iron staining. The clast is 4 mm long and flattened in S_5. Biotite grains are equant and randomly oriented, have an average size of 0.15 mm and pleochroism of α = pale green to $\beta\gamma$ = dark olive green. The clast apparently consists of an annealed biotite aggregate.

Matrix and matrix schistosity (S_5)

The fine-grained detritus and clasts merge into the matrix; the matrix is mainly typified by a fair alignment of biotite to produce a poor S_5 schistosity. Biotite has an average length of 0.12 mm, length:breadth ratio of 2:1, pleochroism of α = pale green to $\beta\gamma$ = dark olive, and notably diffuse grain boundaries Muscovite is minor.

Schistose diamictite; schistosity is S_5.

RS 391 GRANODIORITE CLAST IN DIAMICTITE

FIELD NOTES: Very similar sample to RS 392 - granitoid clast within tillitic siltstone. Diamictite unit is only 2-3 m thick.

THIN SECTION: The section contains a coarse-grained granodiorite clast within a schistose matrix containing the S_5 schistosity. The matrix is similar to RS 393 and RS 394 except for higher dolomite content and perhaps a slightly poorer development of the S_5 schistosity.

Mineral abundances of the matrix are:

Quartz/feldspar	Biotite	Dolomite	Muscovite
35%	25%	25%	15%

Clast mineral abundances are:

Albite(?)	Quartz	Orthoclase	Chlorite	Muscovite	Biotite	Epidote
65%	28%	2%	2%	2%	1%	trace

Albite(?) forms large equant grains with pronounced ductile deformation of twin lamellae. Undulose extinction is present, grain boundaries are very irregular, and the average grain size is 3 mm. Minor exsolved quartz and muscovite is present; muscovite is mainly along grain boundaries.

Quartz forms large primary grains to 4 mm across with undulose extinction and polygonisation. Large grains have sharp but irregular grains boundaries. Smaller grains are from exsolution and have well-rounded forms and many grain boundary types, including sharp, highly diffuse and very irregular. The exsolved grains range down in size from 0.5 mm.

Orthoclase forms one large untwinned crystal to 20 mm long with minor exsolved quartz.

Aggregates

Aggregates within the sample consist almost entirely of biotite, chlorite, muscovite and fine-grained apatite.

Biotite is recrystallised into aggregates which indicate relict equant ctystals to 1.4 mm across. New grains have diffuse boundaries, are intergrown with apatite and have embayed margins. Pleochroisim is α = pale brown to $\beta\gamma$ = very dark brown.

Chlorite appears to have formed from altered biotite, and occurs as randomly-oriented, length fast crystals. Pleochroism varies from green (slow direction) to brown (crystal long axis, fast direction); average size is less than 0.3 mm.

Muscovite within these aggregates is distinctly deformed with curved (001) cleavage traces; recovery processes have formed short segments with straight (001) traces. Also forms as crystals to 1.2 mm long with pronounced diffuse edges.

Epidote occurs with chlorite and minor opaques and forms aggregates to 1.2 mm across which consist of an extensive network of very fine-grained epidote. May form as a retrogression product of ?amphibole.

RS 392 GRANODIORITE

FIELD NOTES: Specimen occurs as a clast within a diamictite (Adelaidean); hand specimen illustrates an unusual and distinctive surface sheen.

THIN SECTION: Sample contains a coarse granular texture with pronounced muscovitisation of all feldspars. Biotite and K-feldspar are absent. Mineral abundances are:

Albite	Quartz	Muscovite	Opaques	Sphene	Epidote
45%	40%	14%	1%	trace	trace

Albite has very irregular grain boundaries; quartz and muscovite form embayments into albite. As inclusions with albite are numerous fine-grained muscovite grains, and coarser slender muscovite to 0.7 mm long which are oriented along albite cleavages. Average grain size is 1.7 mm.
Quartz occurs mostly as primary grains of 1.4 mm average size with moderate undulose extinction but no polygonisation. Large grains tend to have diffuse and irregular grain boundaries; some boundaries are sutured. Quartz also occurs as small apparently - exsolved blebs within plagioclase and along albite/albite boundaries
Muscovite has numerous forms: as two types of inclusions within albite (see above), as small randomly oriented flakes along albite/albite grain boundaries in diffuse zones, and as larger porphyroblasts to 1.4 mm square. In some muscovite-rich zones along grains boundaries, opaques occupy all inter-muscovite spaces. The average grain size of fine-grained muscovite is 0.08 mm, while the length/breadth ratio is 2:1.
Sphene: small subhedral grains occur with minor epidote in two quartz-rich lobes.

Samples show muscovite retrogression of feldspar and distinct textural disequilibrium.

RS 393 SCHISTOSE METASILTSTONE

FIELD NOTES: Typical Umberatana Group grey bedded metasiltstone exhibiting an S_5 cleavage.

THIN SECTION: Bedding, evident in the hand specimen, is poorly defined; slight variations of the proportion of biotite and muscovite to quartz and feldspar represent the relict original bedding. A poor to fair schistosity is across the bedding at a high angle and represents the S_5 schistosity. The average mineral abundances are:

Quartz + feldspar	Biotite	Muscovite	Opaques	Chlorite
45%	35%	20%	<1%	trace

Tourmaline
trace

Quartz and feldspar are undifferentiated as no twinning was observed and the grain size is too small; the average grain size is 0.03 mm and the largest grains are only 0.06 mm. Grains are equant.

S_5 schistosity

Elongate biotite, muscovite and opaques have a fair to good alignment and define the S_5 schistosity.
Biotite has an average length of 0.6 mm and a length:breadth ratio of 3:1; grain boundaries are sharp except on the smallest grains. Pleochroism is α straw yellow $\beta\gamma$ = dark olive brown.
Muscovite is fine grained and the average length is only 0.18 mm and the length: breadth ratio is 3:1. Grain boundaries are often diffuse. Two large muscovite porphyroblasts are present. One is 0.5 mm long and with a length:breadth ratio of 10:1, is across S_5 and apparently postdates S_5. Another has the S_5 schistosity deflected around it and hence schistosity development or flattening of the schistosity probably occurred after development of the muscovite lath.
Chlorite replaces a small proportion of the biotite and has pale green pleochroism and low birefringence (δ = 0.003).
Opaques vary from equant to elongate and are aligned in the S_5 schistosity. Grains are often ragged with an irregular outline, have a maximum length:breadth ratio of 2:1 and a maximum grain size of 0.04 mm.

Schistose metasiltstone, containing the S_5 schistosity.

RS 394 SCHISTOSE DIAMICTITE

FIELD NOTES: Diamictite unit with grit-sized clasts; neighbouring lithologies are cleaved and schistose metasiltstone containing D_5 axial plane fabrics.

THIN SECTION: The sample contains a variety of small clasts set in a schistose biotite+muscovite matrix. The matrix:clast ratio is approx. 65:35.
Clast mineral abundances are:

Quartz	Plagioclase	Muscovite
60%	36%	4%

Matrix mineral abundances are:

Quartz/Feldspar	Biotite	Muscovite
35%	40%	25%

Clasts

The clasts have an average size of 1 mm, are predominantly quartz-rich and are often monominerallic. Some clasts are single mineral grains. Clasts vary in angularity but the quartz grains are often fairly well rounded.
Quartz clasts have strong undulose extinction and polygonisation. Clasts are usually equant and of single grains. Quartz also occurs as small exsolution blebs in plagioclase clasts.
Plagioclase clasts are much more angular than quartz but are not flattened or aligned inthe matrix schistosity. The feldspar is untwinned, feldspar cleavages are strong and dusty inclusions are abundant. Maximum grain size is 1.4 mm long.
Muscovite forms one large clast 1.6 mm long which is oriented at 90° to the matrix schistosity, and has the schistosity wrapping around it.

Schistose matrix

The S_5 schistosity only weakly deflects around the clasts, and is defined by a good dimensional and crystallographic alignment of biotite and muscovite. The matrix contains abundant fine-grained quartz and feldspar (undifferentiated) which is generally equant and of average size about 0.02 mm.
Biotite alignment is good; grains have an irregular outline, an average length of 0.6 mm, length:breadth ratio of 2.5:1, and pleochroism of α = pale straw brown to $\beta\gamma$ = dark olive brown.
Muscovite is smaller but more elongate than biotite and has a better alignment in S_5. Outlines are variable from sharp to diffuse, average length is 0.02 mm and the length:breadth ratio is5:1.

Schistose diamictite, with an S_5 schistosity

RS 395 SCHISTOSE DOLOMITIC DIAMICTITE

FIELD NOTES: Area of two diamictite types which have sharp but irregular boundaries. The most common type is the grey-green silty diamictite (described in samples RS 393 and 394), while the second type is more arkosic, contains abundant dolomite clasts, and has a dolomitic matrix.

THIN SECTION: Thin section contains approximately 65% clastic grains and about 35% matrix. The average mineral abundances are:

Dolomite	Quartz	Plagioclase	Muscovite
34%	26%	36%	4%

However the matrix is comprised of 99% dolomite and 1% muscovite.

Clasts

Clasts are of variable grainsize with a maximum of 3 mm. Grains are typically composed of quartz, plagioclase (probably albite) and fine-grained muscovite inclusions.
Quartz clasts either contain undulose extinction and polygonisation, or are fine grained containing annealed quartz with sharp straight grain boundaries.
Plagioclase contains abundant and irregular pericline twinning which dominates over albite twinning. Some of the feldspar clasts are also characterised by very fine-grained recrystallisation, and in some clasts albite twins are deformed into short, straight -line segments.

Schistose matrix

The dolomite + muscovite matrix contains inequant grains which show a good alignment and define the S_5 schistosity. The schistosity tends to wrap around the clasts.
Dolomite is often inequant to 3:1, the average size is 0.03 mm, while grain boundaries are sharp and straight or only gently curved.
Muscovite is to 0.07 mm long and with a length:breadth ratio of 5:1.

Schistose dolomitic diamictite, contains the S_5 schistosity.

RS 396 · BANDED QUARTZOFELDSPATHIC GNEISS

FIELD NOTES: Distinctive banded gneiss with zebra-like striping defined by bands several centimetres thick, which oscillate from very feldspathic pale-coloured layers without any micas to darker bands containing biotite. Lithological banding appears to be original compositional layering (S_0) and the biotite gneissosity appears to be parallel to the compositional banding.

THIN SECTION: The variation in abundance of the biotite and feldspars is the main difference between the different bands; both layers have a granoblastic texture. In the biotite-bearing bands, quartz greatly exceeds feldspar while in the biotite-free bands albite + microcline exceed quartz.
Mineral abundances of biotite-bearing bands are:

Quartz	Albite/Oligoclase	Biotite	Opaques	Microcline	Muscovite
81%	10%	6%	1%	trace	2%

Mineral abundances of biotite-free bands are:

Quartz	Albite	Microcline	Muscovite
40%	40%	20%	trace

S_1 gneissosity

The gneissosity is defined by a strong alignment of biotite and muscovite, and to a lesser extent by trails of opaques
Biotite is often intergrown with muscovite within single crystals. Smaller biotite grains have more pleochroic haloes and have more diffuse boundaries. The length:breadth ratio is small at 2:1 and the average length is 0.25 mm
Muscovite is as large as biotite and shows the same degree of alignment. For muscovite the tendency exists for smaller grains to show a stronger alignment in S_1.
Opaques form thin trails, to 1.1 mm long, parallel to the gneissosity. Where the biotite alignment is at a slight angle to the compositional banding, so is the trail of opaques.
Isolated grains have incomplete square and hexagonal outlines.

Granofelsic mosaic

Quartz and feldspars form a granoblastic mosaic of average grain size 0.4 mm. Grain boundaries are variable from:

- straight and sharp with triple points
- sharp but gently curved
- to diffuse and irregular.

Feldspars all tend to have fine-grained inclusions from minute new grains as well as fine-grained muscovite. Plagioclase has an anorthite content of ~An_{10} and is poorly-twinned while microcline also has only very poorly-developed perthitic exsolution and grid iron twinning.
Quartz has an average grain size of 0.2 mm; these are apparently from completely recrystallised larger gneiss grains but relict large grains are not preserved.

RS 397 SERICITIC GNEISS

FIELD NOTES: Spotted-muscovite mica schist containing two muscovite schistosities. Later schistosity appears to be sericitic and retrogressive while the early schistosity streaks-out muscovite. The schistosity ages are not known with any certainty.

THIN SECTION: The texture is produced from relict gneiss clasts, superimposed first schistosity and a superimposed second schistosity.
Mineral abundances for the whole rock are:

Quartz	Albite/Oligoclase	orthoclase	Muscovite	Biotite
18%	18%	4%	46%	12%

Opaques 2%

Gneiss fragments

Quartz forms relict grains to 1.7 mm but is mostly much smaller with strong undulose extinction and weak polygonisation.
Plagioclase has little twinning and when it does occur, is often discontinuous across the grain. Probably albite or oligoclase. Relict large grains to 1.2 mm.
Orthoclase is untwinned with one prominent cleavage trace.
All of these minerals have biotite and muscovite 'overgrowths' so that quartz/feldspar and feldspar/feldspar boundaries are difficult to observe.
Also within the gneiss are disseminated biotite and muscovite flakes.

First schistosity

Gneiss fragments and biotite/opaque aggregates are elongate in the schistosity which encloses them. Parallel to the schistosity is a new muscovite-rich compositional banding. Biotite + opaques may be retrograded garnets. This deformation phase appears to produce more randomly oriented biotite in the gniess fragments. Biotite is pleochroic in browns with distinct orange tints.

Second schistosity

This deformation phase strongly reorients the fine-grain muscovite of the first schistosity and reorients some of the biotite in the gneiss clasts.
Alignment within the schist (muscovite-rich) bands is very good but in the gneiss it is only poor. Alignment of biotite ranges from nil to poor. Muscovite in the schist bands has an av. length of 0.03 mm but in the gneiss it has an av. length of 0.1mm .

The schistosities observed are tentatively classified as S_2 and S_3 respectively. Sample was probably from a quartzofeldspathic gneiss which has been extensively retrogressed.

RS 398 HORNBLENDE+ ANDESINE GNEISS

FIELD NOTES: A hornblende and plagioclase-rich gneiss which has similarities to a gneissic diorite. The unit forms a conformable sill or stratigraphic horizon; sedimentation or igneous activity occurred prior to D_1. This rock type occurs in other localities and is not apparently related to well-banded calc-silicates.

THIN SECTION: The sample has been altered and extensively recrystallised so that the amphibole gneissosity is not well preserved. A relict gneissosity does exist and is defined by a poor to moderate dimensional alignment of hornblende; this represents S_1. The present assemblage and grain boundary relationships indicate pronounced disequilibrium. Present mineral abundances are:

Andesine	Hornblende	Quartz	Opaques	Epidote	Musc.	Biotite	Chlorite
45%	35%	9%	7%	3%	1%	<1%	<1%

Hornblende - the largest crystals are 2 mm long and elongate; their alignment defines S_1. Crystals have irregular and ragged outlines and simple twinning on (100) is common. Grain size varies down from a maximum of 2 mm. Pleochroism is α = pale brown, β = brown, γ = dark green, lesser amounts of dark blue green.
Andesine (An_{40}) is marked by highly diffuse and extremely irregular grain boundaries. Some old plagioclase grains now consist almost entirely of new small recrystallised grains. Other old grains are highly altered to epidote and fine-grained muscovite. Original plagioclase was probably more calcic than An_{40}; determinations could only be made on fairly clear probably recrystallised grains. Average grain size is 0.5 mm and there is no apparent preferred orientation.
Quartz mainly forms inclusions within hornblende and in areas of recrystallised feldspars, where it mostly occurs along plagioclase/plagioclase boundaries. Quartz has undulose extinction, diffuse boundaries and an average size of 0.3 mm.
Opaques also define the original gneissosity(S_1); they occur as elongate grains to 1.8 mm long with a length: breadth ratio of 10:1. Smaller grains are equant and have an average size of 0.3 mm. All grains have an irregular and ragged outline and there is no association with sphene.
Epidote occurs as isolated grains and grain aggregates to a maximum size of 0.4 mm; grain aggregates consist of crystals in optical continuity. It is equally abundant as inclusions in hornblende and plagioclase. Colour is a very pale yellow green.
Biotite occurs only as small inclusions in heavily altered plagioclase; these crystals have very diffuse outlines; an average length of only 0.03 mm and a length:breadth ratio of 3:1
Chlorite exists as pennine from altered hornblende.

Retrogressed andesine + hornblende gneiss
or retrogressed gneissic amphibolite

S_1 gneissosity defined by a dimensional alignment of hornblende and opaques. Retrogression and recrystallisation is extensive.

RS 399 BANDED CALC-SILICATE

FIELD NOTES: Sample is of a banded calc-silicate which appears to have been recrystallised. Within each band, texture is granofelsic. Adjacent units to the banded calc-silicate are a garnetiferous sericitic schist and massive amphibole-rich calc-silicate.

THIN SECTION: Sample shows a mineralogical banding; parallel to the banding is a poorly-defined gneissosity which is defined by a weak dimensional preferred orientation of slightly-inequant diopside, quartz and plagioclase. Gneissosity is S_1. As well as the banding and poorly-defined gneissosity, the texture contains a granoblastic mosaic modified by extensive fine-grained recrystallisation.
Mineral abundances are:

Albite	Diopside	Quartz	Opaques	Hornblende	Sphene
70%	15%	7%	4%	3%	1%

Albite (An_5) forms clear equant grains up to 1.6 mm but the average size is 0.6 mm. Albite twinning is abundant. Grain boundaries vary from sharp but irregular to very diffuse. Some grains elongate in the gneissosity with a maximum grain length:breadth ratio of2:1. Albite contains no fine-grained muscovite or epidote.
Diopside has a poor dimensional alignment parallel to the banding (S_0) and partly defines the gneissosity(S_1). Grains are up to 2 mm, are non-pleochroic but with a distinct light green colour. Hornblende/actinolite grains are often aligned along the diopside cleavages.
Quartz predominantly occurs as small rounded-outline grains which have crystallised along grain boundaries; fewer crystals occur within plagioclase and as isolated larger grains to 0.6 mm. Average grain size is 0.1 mm and grain boundaries are sharp but rounded and lobate. Some grains show a weak alignment parallel to the banding and gneissosity.
Opaques are disseminated throughout; approximately 40% of all opaques have a partial rim of sphene but individual sphene crystals occur away from the opaques. Grains are subhedral with squarish outlines; average size is 0.2mm.
Hornblende occurs almost entirely as an alteration product within diopside; it occurs along diopside cleavages and as diffuse aggregates within diopside. Pleochroism is α = pale brown, $\beta\gamma$ = dark green and pale blue green. Large extinction angles (γ :z) indicate hornblende rather than ferroactinolite. Maximum size is 0.4 mm.
Sphene has rounded outlines and is often equant; maximum length is 0.3 mm.

Banded calc-silicate containing diopside and albite. Low hornblende abundance and absence of epidote distinguish it from other calc-silicates. Minerals which appear to be syn-D_1 are diopside, quartz and plagioclase (probably albite).

RS 400 SERICITIC GNEISS

FIELD NOTES: Sericitic gneiss; containing a retrogressive fine-grained muscovite schistosity which is parallel to the gneissosity in adjacent rocks.
Retrogressive schistosity is probably S_3 or S_m.

THIN SECTION: Sample is of an extensively retrogressed gneiss and now consists of gneiss fragments which have been sericitised and are set in a fine-grained muscovite schistosity.
Mineral abundances are:

Muscovite	Quartz	Oligoclase	Biotite	Opaques
65%	18%	11%	6%	trace

Gneiss fragments

Gneiss fragments contain a dominant granoblastic texture but with a poorly-defined biotite alignment which may be a relict S_1 gneissosity. Sericitic replacement is pervasive but not complete; alignment of sericite within the gneiss fragments is poor.
Quartz often forms adjacent grains in optical continuity which are separated by fine-grained muscovite. Grain boundaries are sharp but irregular; grains contain weak undulose extinction and have an average size of 1.5 mm.
Plagioclase (approximately An_{25}) is often smaller than quartz but occurs as relict large crystals to 1.8 mm; average size is 1.1 mm. Twinning is poorly developed and graphic intergrowths are present.
Biotite has a poor alignment in the largest gneiss clasts and is likely to be an S_1 gneissosity relict. Maximum grain size is 1.6 mm and maximum length:breadth ratio is 4.5:1. Pleochroism is α = dark yellow brown, $\beta\gamma$ = deep brown to opaque.
Muscovite within gneiss fragments is coarser grained than that within the schistosity and has an average size of 0.025 mm.

Sericitic schistosity

Muscovite forms concentrated bands which enclose the gneiss fragments and are continuous across the sample. These bands define the orientation of the retrogressive schistosity; the alignment of muscovite within these bands is poor. Grainsize is gradational; muscovite grain size steadily decreases from 0.025 in the gneiss to 0.01 mm in the centre of an adjacent band.

Retrogression and muscovite recrystallisation is extensive, new schistosity is S_3 or S_m.

RS 401 GRANOBLASTIC QUARTZO-FELDSPATHIC GNEISS

FIELD NOTES: Semipelitic schists grade into a micaceous granofels i.e. a quartzofeldspathic granular rock with a poor micaceous schistosity. The granofels has the form of a large boundin block and an intrusive plug. The schistosity is probably S_1.

THIN SECTION: Consists of a granoblastic mosaic of quartz, plagioclase and muscovite, and a gneissosity which is defined by a poor alignment of biotite. In places there is a weak alignment in the gneissosity of the larger plagioclase crystals. Smaller quartz and plagioclase grains are more equant and randomly oriented.

Mineral abundances are:

Plagioclase	Quartz	Biotite	Mucovite	Opaques + epidoite
54%	30%	11%	4%	1%

S_1 Gneissosity

The gneissosity is defined by a poor alignment of biotite. Laths to 1.2 mm long are the most common form of biotite while the length:breadth ratio averages 2:1 but varies up to 4:1, some grains are equant. Pleochroism is in dark brown shades, α = brown, $\beta\gamma$ = dark chocolate brown. Grain boundaries are sharp.

Granoblastic mosaic

This mosaic is formed of plagioclase, quartz and muscovite.
Plagioclase is distinctly zoned with extensively sericitised cores. Twinning is rare; limited data suggests a composition of sodic oligoclase. Relict large grains to 2 mm exist but the average size is 0.6 mm. Grain boundaries are irregular.
Quartz shows a similar size distribution to plagioclase and has variable grain boundaries from sharp and distinct to irregular and diffuse. Undulose extinction is common and polygonisation is present.
Muscovite forms large crystals to 1.8 mm with pronounced undulose extinction and curved twin lamellae. Muscovte is not aligned in the gneissosity and tends to form equant grains; grain boundaries are diffuse. Also occurs from sericitisation of plagioclase.
Opaques occur with minor epidote and form randomly oriented grains to 0.2 mm.

RS 402 CALC-SILICATE

FIELD NOTES: Very well-banded calc-silicate occurring amongst micaceous and quartzofeldspathic gneisses. Same stratigraphic horizon is RS 431. Calc-silicates in the vicinity of this sample contain abundant epidote.

THIN SECTION: Banding is present and is defined by a variation in abundance of hornblende, epidote, quartz and feldspars. There is no preferred orientation; quartzofeldspathic bands have a pronounced granoblastic orientation; quartzofeldspathic bands have a pronounced granoblastic texture. Texture is distinctly of disequilibrium with extensive replacement and alteration, and areas of considerable fine-grained recrystallisation.
Average mineral abundances for the whole sample are:

Quartz	Plagioclase	Epidote	Orthoclase	Diopside	Hornblende	Opaqu
30%	25%	20%	10%	8%	6%	1%

sphene + zircon - trace

Quartz is clear with only weak undulose extinction. Quartz/quartz boundaries are sharp while boundaries with other minerals are diffuse Average grain size is 0.45 mm.
Plagioclase is extensively retrogressed with abundant fine-grained sericite, epidote and sphene. Sericite is oriented along feldspar cleavages. Plagioclase/plagioclase boundaries are often lobate and stained with a brown dust. Limited twinning data suggests sodic andesine. Pericline twinning pronounced.
Epidote has distinctly yellow pleochroism with birefringence of δ = 0.042. It occurs as grains replacing diopside and hornblende, and as fine-grained inclusions in altered plagioclase. Largest grains are 0.6 mm.
Orthoclase is clear and unaltered with an average size of 0.5 mm.
Diopside is pale green and weakly pleochroic, and occurs as grains to 2 mm with an irregular outline.
Hornblende is pleochroic in deep greens; some grains have a pale - coloured core (after diopside?) with a dark-coloured hornblende rim. Also occurs as highly-embayed grains to 1.3 mm across. Inequant hornblende is randomly oriented.
Opaques are subhedral with square outlines.

RS 403 HORNBLENDE + PLAGIOCLASE DIORITE

FIELD NOTES: Sample is from a massive hornfelsic diorite which appears as if it has the form of an igneous sill. In a few places it contains a weak schistosity oriented at 88° towards 154°M, and field patterns indicate folding of the diorite ?sill. Folding and schistosity development is D_3; diorite intrusion is probably syn-D_3.

THIN SECTION: The most striking feature is the extensive fine-grained recrystallisation with complex grain-boundary patterns. Otherwise the texture is similar to massive intrusive diorites which appear to be slightly post-D_3 e.g. RS 430. The sample shows no preferred orientation of contained minerals.
Mineral assemblage is:

Plagioclase	Hornblende	Opaques	Quartz	Epidote	Biotite
42%	40%	8%	7%	2%	<1%

Plagioclase is poorly twinned and heavily altered; composition was not established. Fine-grained recrystllisation is very extensive and forms intricate patterns; recrystallised grains have extremely irregular and diffuse grain boundaries. Epidotisation and brown turbid alteration is minor. Average size is 0.7 mm with a length:breadth ratio of 3:1, grains are randomly oriented.
Hornblende is anhedral with very irregular but sharp grain boundaries; twinning is present. The average size is 0.6 mm and pleochroism is α = moderate brownish green, β = brown, γ = dark green, dark blue green. Many small needle-like hornblende crystals occur and these show the same dark pleochroism; these may be produced during retrogression of the plagioclase.
Opaques are disseminated, subhedral with some square outlines, equant of average size 0.12 mm, but some grains are up to 0.43 mm, occur with a small amount of sphene.
Quartz mostly occurs as new grains and has an average size of only 0.1 mm; larger grains are up to 0.4 mm. Quartz occurs mostly with recrystallised feldspars and may form from exsolution.
Epidote forms small inclusions from alteration in plagioclase and as rare aggregates to 0.35 mm; these aggregates contain epidote with sharp but irregular outlines, pale yellow colour and anomalous blue-yellow birefringence.
Biotite is minor but forms isolated laths to 0.25 mm and fine-grained inclusions in plagioclase; pleochroism is in dark brown shades.

RS 404 HORNBLENDE + ANDESINE DIORITE

FIELD NOTES: Sample is from the same dioritic ?sill as RS 403. Sample is massive, hornblende-rich and contains plagioclase phenocrysts. As for RS 403, the diorite intrusion is interpreted as syn-D_3.

THIN SECTION: Typical diorite texture of randomly oriented plagioclase laths enclosed by coarser-grained hornblende which tends to be equant and randomly oriented. Large plagioclase phenocrysts are extensively epidotised.
Mineral abundances are:

Hornblende	Andesine (epidotised)	Biotite	Opaques/sphene
70%	26%	2%	2%

Ferroactinolite
trace

Phenocrysts

Phenocrysts are up to 8 mm long and apparently consisted of quite calcic plagioclase; phenocrysts are now plagioclase aggregates and contain up to 30-40% fine-grained epidote. Brown turbid alteration is particularly common. Epidote forms small slender crystals 0.11 mm long and with a length:breadth ratio of 4:1; also occurs as aggregates to 0.4 mm. Epidote is either randomly oriented or oriented along feldspar cleavages. Ferroactinolite which is very dark blue and weakly pleochroic occurs as an alteration product.

Matrix

Hornblende is the dominant mineral and occurs as isolated large crystals to 2 mm but is usually distinctly equant and of average size 0.5 mm. Grains are complexly interlocked and grain boundaries are hard to distinguish. Many examples exist with curved cleavage traces and twinning is common. Pleochroism is typical of hornblende in syn- and post-D_3 diorites; α = moderate brownish green, β = brown, γ = dark green, dark blue green. Some of the large hornblende crystals are poikiloblastic with small inclusions of quartz and feldspar.
Plagioclase within the matrix may represent a fine-grained phenocryst phase. Crystals are elongate to 0.7 mm long, have a length:breadth ratio of 5:1, are randomly oriented and contain an intense brown turbid alteration. Twinning indicates andesine ($\sim An_{40}$).
Biotite occurs as grains to 0.3 mm and tends to be equant; pleochroism is in dark brown shades. Biotite usually crystallises in plagioclase, and to a lesser extent, in hornblende.
Opaques always form aggregates with sphene; the aggregates have a rounded form but individual opaque grains have a very irregular outline. Sphene and opaques are in equal abundance.

RS 405 GRANOBLASTIC ALBITE + HORNBLENDE GNEISS

FIELD NOTES: Sample is of a fine-grained metasandstone from amongst schists and gneisses; sample has lithological characteristics similar to many calc-silicates and appears to contain actinolite. Coarse-grained magnetite is common in the vicinity of the sample collection point. Structural evidence suggests that this is probably the stratigraphic horizon which contains well-banded calc-silicates further north and south.

THIN SECTION: A granoblastic texture dominates with randomly oriented plagioclase, hornblende, biotite and muscovite. All crystal types tend to be equant. Fine-grained recrystallised grains are abundant.
Mineral abundances are:

Albite	Biotite	Hornblende (actinolitic)	Diopside	Opaques	Quartz	Chlorite
74%	15%	6%	2%	2%	1%	trace

Albite ($\sim An_8$) grains are equant but with diffuse boundaries. Although the primary larger grains average 0.6 mm across, small recrystallised grains are abundant. These have an average size of only 0.02 mm. Albite/albite boundaries vary from smooth and regular but diffuse, to noticeably irregular and diffuse.
Biotite forms large equant and elongate flakes to 1 mm across. Smaller grains may be more elongate but contain curved (001) cleavage traces. Pleochroism is in pale shades; α = colourless to pale brown green to $\beta\gamma$ = moderate green brown. Grain boundaries noticeably diffuse but grains are not as embayed nor as poikiloblasti as hornblende and diopside. Fine-grained rutile needles are abundant in some basal sections; pleochroic haloes around zircon? inclusions are also present.
Actinolitic hornblende has pleochroism of α = light green, β = light brown to γ = moderate green, blue green. Grains are poikiloblastic and embayed. Average size is 0.8 mm but larger grains are to 1.8 mm long; grains can be distinctly elongate but are randomly oriented. Rutile needles are also present in hornblende basal sections.
Diopside has similar features to hornblende except for paler colours and tends to be equant.
Opaques mostly occur as limonitic staining within diopside and actinolitic hornblende, and as small opaque grains rimming biotite. Latter grains average 0.01 mm in size.

The lithology is most probably a lateral equivalent of well-banded calc-silicates which are on the same stratigraphic horizon further north and south.

RS 406 ALBITE + BIOTITE GRANOFELS

FIELD NOTES: Sample is from the same locality as RS 405 and is designed to test possible correlation with lithologies occurring on or near calc-silicate horizons. Typical calc-silciate minerals i.e. hornblende, epidote etc. are absent. Sample appears to be a quartzofeldspathic metasandstone with biotite.

THIN SECTION: Granoblastic texture is dominant with abundant cloudy and altered plagioclase. Biotite tends to occur in aggregates; aggregates and individual biotite crystals tend to be randomly oriented.
Mineral abundances are:

Albite	Quartz	Biotite(brown)	Biotite (green)	Opaques
60%	20%	15%	3%	2%

Albite forms relict large grains to 1.8 mm but most grains are 0.5 mm. Grains are very clouded with abundant fine-grained muscovite and biotite inclusions. Grain boundaries are very irregular and diffuse. Composition approx. An_8.
Quartz occurs in two forms; either as small exsolved-type blebs in albite with an average size of 0.05 mm or, more commonly, as grains averaging 0.5 mm with very irregular and diffuse grain boundaries.
Brown biotite has noticeable dark brown pleochroism of α = brown, $\beta\gamma$ = very dark brown. Biotite occurs within clusters. Most grains are equant; rare elongate grains to a maximum length: breadth ratio of 3:1 are not elongate parallel to (001). Grain boundaries are diffuse; average grain size is 0.16 mm.
Green biotite has pronounced colourless to deep green pleochroism. The green biotite occurs only as an alteration product within plagioclase and has an average size of only 0.02mm. Edges are diffuse.
Opaques, with one exception, occur only within biotite aggregates. Grains are anhedral, equant and of average size 0.3 mm; largest grains are up to 0.5 mm. When inequant, grains show no alignment.

The sample's common feature to granofels near calc-cilicates is the high albite content (60%). Note that a relict S_1 gneissosity, usually defined by biotite, is not evident. The average grain size is finer than gneisses and there is little evidence of any originally coarser grain size.

RS 407 BIOTITE SCHIST

FIELD NOTES: Sample is of a biotite schist occurring amongst gneisses. It contains a superimposed schistosity which is probably S_3. Both S_3 schistosity and the gneissic layering have a similar strike but distinctly different dips. There is a faint possibility that the superimposed schistosity is S_2; schistosity orientation is dipping 76° towards 332° M.

THIN SECTION: Two schistosities are present; a relict biotite schistosity is overprinted by a stronger muscovite schistosity. Muscovite is distinctly finer grained than the coarse biotite. The biotite schistosity is interpreted as relict S_1 while the muscovite schistosity is S_3.
Mineral abundances are:

Biotite	Quartz	Muscovite	Sphene	Albite
50%	25%	20%	3%	2%

Biotite orientation and shape have been modified during D_3. Some grains retain a dimensional and crystallographic alignment in S_1 and define S_1. Others have been changed so that they define a dimensional alignment in S_3; but note that some of these biotites stil a crystallographic alignment in S_1. These biotites have diffuse boundaries, an average length of 1.3 mm and can have a length:breadth ratio of up to 7:1 but is more commonly at 4:1. Pleochroism is α = pale yellow brown to $\beta\gamma$ = dark brown. Biotites having a dimensional alignment in S_3 but a crystallographic alignment in S_1 are quite common, and provide good evidence for S_1 and S_3.
Muscovite crystals have an average length of only 0.05 mm which is considerably less than biotite. Crystals show a good alignment parallel to the dimensional alignment of biotite and this defines S_3. The average length:breadth ratio is 5:1 while the maximum length is still only 0.4 mm. Biotite and muscovite can be intergrown; these grain boundaries are very sharp.
Quartz varies from equant to inequant and elongate in S_3; the maximum length:breadth ratio is only 2:1. The average size is 0.18 mm and grains contain a weak undulose extincton. Quartz/quartz boundaries vary considerably from sharp and straight to very diffuse. Quartz/biotite boundaries are diffuse.
Sphene occurs as elongate crystals to 0.4 mm long and is aligned in S_3. Grains have a sharp but irregular outline and a dark yellow orange colour.
Albite (identification tentative) forms a few equant grains to 0.4 mm across.

Sample contains an S_1 and S_3 schistosity, and may have been originally a biotite gneiss. Fine-grained muscovite crystallised during D_3. The sphene abundance (3%) is unusually high, especially as opaques are absent.

RS 408 IRONSTONE

FIELD NOTES: Massive to poorly-bedded ironstone containing quartz and hematite, with minor relict magnetite. Similar to ironstones at the Olary Silver Mine and near Ameroo Hill.

THIN SECTION: Sample shows a good alignment of inequant quartz and opaques; these minerals dominate the assemblage. The preferred orientation is most probably S_o - S_1.
Mineral abundances are:

Opaques (hematite, maghemite)	Quartz	Muscovite
70%	26%	4%

Quartz is elongate in ?S_1 to a maximum length:breadth ratio of 2:1. Maximum grain size is 4 mm and the average is 2 mm. Grains exhibit undulose extinction and poorly-developed polygonisation.
Opaques define the alignment/gneissosity. Although it is difficult to distinguish individual grains, the typical length appears to be 3.5 mm and grains are often elongate to 2:1, rarely 3:1.
Muscovite typically forms along opaque/opaque grain boundaries, and more rarely along opaque/quartz or quartz/quartz boundaries. Muscovite has an average length of 0.15 mm and with a length: breadth ratio of 3:1 but is randomly oriented.

The alignment is probably the S_1 gneissosity.

RS 409 GRAVELLY METASANDSTONE

FIELD NOTES: Sample is from an area of quartzites, hematitic quartzites, and hematitic metasandstone; some of these contain quartz clasts which are elongate and oriented parallel to the bedding and layering (S_0). This sample contains some of these clasts, and represents one of the very few samples within the Willyama Complex which approaches a conglomerate.

THIN SECTION: Clasts are elongate to a maximum length of 3.4 mm and a width of 1.8 mm; they show a good alignment parallel to a poor, but distinct, alignment of minerals in the matrix. Average mineral abundances are:

Albite	Quartz	Opaques	Muscovite
50%	37%	12%	1%

Clasts

Clasts are of two types; monomineralic quartz clasts, and clasts containing albite + opaques. Albite-rich clasts can be as large as quartz clasts but are usually finer grained. The average size of quartz clasts is 2 mm long and with a length:breadth ratio of 2.5:1; clasts contain undulose extinction, weak polygonisation and irregular quartz/quartz boundaries. Isolated long clasts are to 3 mm with a width of only 0.4 mm and appear to have formed, at least in part, by flattening. Albite clasts have similar properties to those of quartz, except that fine-grained opaques occur along grain boundaries.

Matrix

The matrix is comprised of a mosaic of quartz, albite and opaques which have a poor, but pronounced, dimensional alignment. Muscovite forms a minor phase which is randomly oriented except in one band, which contains elongate muscovite oriented parallel to the band margins. The alignment of quartz, albite and opaques is only poor because all species are only poorly elongate i.e. from 1.5:1 to 2.5:1 and averageing no more than 2:1
Albite grain boundaries are often sharp, gently curved and lined with fine-grained opaques. Typical grainsize is 0.3 mm and undulose extinction is developed in some grains.
Quartz has very similr properties to albite, except that there is minor polygonisation. In both species undulose extinction is minor.
Opaques are disseminated and mostly occur along quartz and feldspar grain boundaries; cryptocrystalline red iron-staining also occurs along these boundaries. Grains can be inequant to a maximum of 3:1; these are aligned parallel to the clast orientation. The maximum grain size is 0.9 mm but the average is 0.1 mm.
Muscovite forms small equant disseminated crystals which are only rarely elongate to a maximum length:breadth ratio of 5:1. Grains are randomly oriented except in one thin band; and the average grain size is 0.5 mm.

The clasts are concluded to represent a relict depositional feature, and are now aligned parallel to S_0 and S_1. Flattening of the clasts probably occurred, with recrystallisation, during D_1. Origin is most probably related to that of RS 408.

RS 410 RETROGRESSIVE MUSCOVITE + SILLIMANITE GNEISS

FIELD NOTES: Micaceous gneiss; mica portions have a grey silky appearance and are apparently fine-grained sericite. Contains coarser muscovite porphyroblasts and possibly chloritoid.

THIN SECTION: The sample contains relicts of a coarse-grained biotite + muscovite + plagioclase + sillimanite gneiss which has a strong superimposed muscovite schistosity. The retrogressive schistosity dominates the sample and is comprised predominantly of fine-grained muscovite, which has an average length of only 0.03 mm. The schistosity wraps around and encloses the relict gneiss fragments.

Average mineral abundances are:

Muscovite	Biotite	Sillimanite	Oligoclase	Opaques
65%	17%	10%	5%	3%

Oligoclase: In several instances, large original oligoclase crystals are 'passively-fragmented' as biotite and muscovite crystallise along the cracks and form a network of isolated grains. Most plagioclase grains are now 1-2 mm but relict larger grains indicate an orignal grain size of at least 3 mm.

Muscovite has several forms: as large relict gneiss grains which are enclosed by the schistosity, as overgrowths on the schistosity, and as a syn-schistosity phase. Trains of fine-grained fibrolite, which are aligned parallel to the retrogressive schistosity, often exhibit curved trails through muscovite porphyroblasts. Basal sections of porphyroblasts show some graphic-type intergrowths with quartz.

Biotite is often closely intergrown with muscovite and forms isolated larger crystals to 3 mm, but the more common grain size is 1.2 mm. In large crystals (relicts from the gneiss) grain boundaries are sharp but in smaller crystal aggregates boundaries are notably diffuse. Rare crystals are aligned in the schistosity. Pleochroism is in shades of green and brown but with green dominant.

Opaques also form as large relicts from the gneiss and these are enclosed by the schistosity, and have extremely irregular and embayed crystal margins. Grains vary from equant to elongate in the schistosity with a length:breadth ratio of 3:1.

Sillimanite occurs as fibrolite in the schistosity; no coarse-grained sillimanite was identified in the relict gneiss portions.

Coarse-grained mineralogy observed was probably formed during D_1, or perhaps D_2; sillimanite probably formed during this phase. Extensive retrogression, with development of abundant muscovite and fibrolite occurred during D_3. The schistosity present in the sample is S_3.

RS 411 HORNBLENDE + ANDESINE GNEISS

FIELD NOTES: Conformable amphibolite amongst quartz + feldspar + mica gneisses; amphibolite is poorly gneissic and apparently predates D_1. In places the amphibolite contains the D_3 schistosity, oriented at 84° towards 133°M.

THIN SECTION: Sample is very similar to RS 412. The gneissosity is defined by a very poor dimensional alignment of only slightly inequant opaques, hornblende and andesine. Many grains are equant, or if inequant, then not aligned in the gneissosity. Mineral abundances are:

Hornblende	Andesine	Quartz	Epidote	Opaques	Biotite
40%	32%	10%	8%	7%	3%

Hornblende is occasionally elongate with the length:breadth ratios up to 2:1, but the dimensional alignment is poor. Outlines are ragged but sharp. Not uncommon to have crystals up to 0.9 mm but the average is 0.5 mm. Pleochroism is α= pale greenish brown, β = moderate brown, γ = dark green, dark blue green.
Andesine, like hornblende, forms large primary grains to 0.8 mm but the average grain size is 0.4 mm. Albite twinning is well developed, undulose extinction is sometimes present. Some crystals are heavily epidotised; epidotisation in a few cases is strongly concentrated along grain boundaries.
Opaques have irregular ragged outlines and are up to 0.9 mm long. Often elongate (length:breadth) to 3:1 and they probably define the gneissosity slightly better than hornblende and andesine.
Epidote mostly occurs as an alteration product of plagioclase, where it forms as inclusions having either rounded forms or small crystal shapes. Birefringence is typical blue-yellow while the colour is pale yellow. It also occurs as large crystals in epidote aggregates; these crystals are up to 0.5 mm across and the birefringence (δ) is 0.031.
Quartz exists in two forms; either as grains to 0.6 mm with irregular and diffuse grain boundaries, and undulose extinction, or as small rounded blobs enclosed by hornblende and andesine.
Biotite is a minor phase often intergrown with hornblende and/or andesine; pennine is also present. Although elongate to 3:1 (length:breadth) and up to 0.06 mm, it is not aligned in the gneissosity. Pleochroism is α = pale brown to $\beta\gamma$ = brown.

Hornblende + andesine gneiss or gneissic amphibolite

Gneissosity is poorly-developed and/or poorly-preserved.

RS 412 HORNBLENDE + ANDESINE GNEISS

FIELD NOTES: Sample is of a gneissic amphibolite which shows no banding but an alignment of hornblende is present. Lithology is the same as RS 411. Sample does not appear to have been cut to best display the relatively poor gneissosity which is present.

THIN SECTION: A very weak preferred orientaion of hornblende and opaques define the gneissosity. The texture and mineralogy is typical of many of the metabasics. Mineral abundances are:

Hornblende	Andesine	Quartz	Opaques	Epidote	Biotite	Chamosite(?)
50%	30%	8%	6%	4%	2%	<1%

Hornblende grains are often inequant and define the weakest of alignments. Grain boundaries are often sharp and straight though some are irregular and embayed. The average size is 0.5 mm. Pleochroism varies from α = pale green brown, β = moderate brown to γ = deep green, deep blue green.
Andesine (An_{45}) is marked by a variable extent of epidotisation. Epidote, from alteration, is often concentrated along grain boundaries. Albite twinning is well preserved; twinning indicates calcic andesine though sign data suggests a more sodic plagioclase may also be present.
Quartz forms clear grains with strong undulose extinction. Quartz/plagioclase boundaries are sharp but gently curved and lined with fine-grained epidote. Average size is 0.3 mm.
Opaques show an alignment parallel to the very poor hornblende gneissosity. Grains are inequant with a maximum length:breadth ratio of 4:1.
Epidote occurs as small, approximately 0.02 mm, grains closely associated with weakly altered plagioclase.
Biotite occurs only within altered plagioclase and hornblende. Pleochroism is in olive brown shades; crystals are up to 0.04 mm long. The biotite is typical of many metabasics throughout the Outalpa Inlier.
Chamosite (?) appears to form from precipitation in a void, and occurs as adjoining radiating aggregates around a central nucleus. Extinction is parallel and hence radiating too, while the colour is pinky red. Birefringence δ = 0.010.

Hornblende + andesine gneiss or gneissic amphibolite. Lithology is interpreted as predating D_1.

RS 413' QUARTZ + OLIGOCLASE GRANOFELS

FIELD NOTES: Hand specimen has the appearance of a granitic gneiss or gneissic granite with a distinct granoblastic texture and a poor-to-absent gneissosity. Biotite is disseminated and appears to have a preferred orientation. Sample is somewhat similar to, but coarser grained, than fine-grained granoblastic lithologies near calc-silicate and albitite lithologies.

THIN SECTION: The gneissosity, which is from an alignment of biotite and muscovite, is very poorly developed. The texture is generally massive and granoblastic, and more indicative of granitoids.
Mineral abundances are:

Oligoclase	Quartz	Muscovite	Biotite	Microcline	Tourmalin
48%	39%	6%	4%	3%	minute trace

Oligoclase often contains patches of fine-grained muscovite; the extent of muscovite development is highly variable both within a single grain and between adjacent grains. Oligoclase often contains rounded to very well rounded exsolved quartz of average size 0.19 mm, while the oligoclase has an average size of 1 mm. Feldspar/feldspar grain boundaries are diffuse and irregular. Much of the oligoclase is poorly twinned.
Quartz has a primary grain size of 1.4 mm, but in small areas where recrystallisation is extensive, the average grain size is 0.2 mm and boundaries are straight but often diffuse. Large grains often have irregular boundaries. Quartz contains a strong undulose extinction with polygonisation. Also occurs as exsolved grains in oligoclase.
Microcline is usually clearer than oligoclase i.e. muscovite-free. Grid-iron twinning is present but poorly developed, while undulose extinction is pronounced as are also some graphic intergrowths Average size is 1.4 mm.
Biotite shows only a very poor alignment in the gneissosity, and this alignment is often dimensional and not crystallographic. Most grains are only poorly inequant, the length:breadth ratio rarely exceed 5:1. Alteration of biotite to pennine varies from partial to near-complete. Pleochroism is α = pale yellow brown to $\beta\gamma$ = very dark brown.
Muscovite like biotite, has only a very poor alignment in the gneissosity and this is only a dimensional alignment. Grain size is variable from dusty muscovite to large equant crystals 3 mm across. Finegrained muscovite within oligoclase is often oriented along feldspar cleavages. Most grain boundaries are diffuse. One large crystal consists of an interlayered stack of biotite and muscovite, with interlayering parallel to (001).
Rock classifications:

- poorly-gneissic granodiorite
- granoblastic quartz + oligoclase gneiss
- Quartz + oligoclase granofels

RS 414 VEIN QUARTZ

FIELD NOTES: Lode rock from the Centralia Mine; quartz vein.

THIN SECTION: Composed predominantly of quartz with minor muscovite. Quartz shows a large variety of gran sizes; largest grains are to 7 mm but the average grain size is 0.35 mm. Many grains tend to be slightly inequant and define a very weak alignment;length:breadth ratio rarely exceeds 1.5:1.
Large grains, to 7 mm, are highly polygonised with strong undulose extinction. Smaller grains, many of which have a size near 0.35 mm and near 1.1 mm, have more even extinction while grain boundaries are regular and only slightly diffuse.
Muscovite tends to be equant; inequant grains are randomly oriented. Grain boundaries are diffuse, and the average size is 0.9 mm.
Mineral abundances are:

Quartz	Muscovite
100%	trace

RS 415 QUARTZ + ALBITE GNEISS

FIELD NOTES: Leucocratic gneiss from the mine dump at the Centralia Mine main workings. Contains pyrite and minor chalcopyrite; sample is one of the lode rock types.

THIN SECTION: Host rock is a quartzofeldspathic gneiss which has been fragmented and a biotite+muscovite schistosity superimposed. Brittle fracturing of plagioclase is prominent. Opaque formation (mineralisation) is synchronous with the brittle fracturing and schistosity development. Recrystallisation of gneiss minerals occurred during the schistosity development. Mineral abundances are:

Quartz	Albite	Muscovite	Biotite	Opaques/Sulphides
45%	37%	8%	7%	3%

Gneiss fragments

Gneiss fragments consist essentailly of quartz and albite; biotite and muscovite of the gneiss merge with those of the overprinting schistosity.

Albite ($\sim An_4$) occurs as relict large grains to 3 mm but deformation and recrystallisation has reduced the average grain size to 1.3 mm. Brittle fracturing of twin lamellae is common, undulose extinction is common and plagioclase/plagioclase boundaries are diffuse. Dusty muscovite occurs along grain boundaries.

Quartz forms relict large grains to 2.2 mm across but, like albite, the average grain size is reduced to 1.1 mm. Undulose extinction is strongly developed and polygonisation is abundant. In areas of extensive fine-grained recrystallisation, aggregates of quartz grains occur with an average size of 0.18 mm; opaques line these quartz/quartz boundaries. Within these aggregates, grains are equant and quartz/quartz boundaries are still irregular and diffuse. Quartz/plagioclase boundaries of large grains are very irregular and quartz is often lobate into plagioclase.

Superimposed schistosity

The schistosity is defined by a moderate alignment of biotite and muscovite. These micas are concentrated in the finest-grained recrystallised quartz + feldspar zones. Biotite has an average length of 0.25 mm and a length:breadth ratio of 3:1 while muscovite has an average length of 0.2 mm and a length:breadth ratio of 5:1. At times biotite has only a dimensional alignment in the schistosity. Biotite pleochroism is α = pale brown, $\beta\delta$ = dark olive brown.

Opaques (sulphides) occur along grain boundaries of fine-grained muscovite, but occur mostly along the margins of the schist zones and within the fine-grained recrystallised quartz.

Brecciated and recrystallised quartz + albite gneiss

Age and orientation of the schistosity is unknown.

RS 416

PLAGIOCLASE + HORNBLENDE DIORITE

FIELD NOTES: Massive diorite from thin dyke trending 125°M. Dyke orientation and massive texture is typical of the post -D_3 diorite intrusions. Sample is proably very similar to RS 403 and 404.

THIN SECTION: Sample contains relict simple-twinned plagioclase laths to 2 mm, which are randomly oriented and disseminated in a slightly finer-grained massive matrix of blue-green hornblende and altered plagioclase.
Mineral abundances are:

Plagioclase	Hornblende	Opaques	Biotite	Epidote
55%	27%	12%	5%	1%

Plagioclase forms abundant relict laths to 2 mm but these are reduced in size by extensive recrystallisation; new grain size averages 0.02 mm. New grains are equant, contain undulose extinction, and have irregular and diffuse grain boundaries. Albite twinning is not evident.
Hornblende has irregular outlines, tends to be equant and randomly oriented, has an average grain size of 0.2 mm and the pleochroism is α = pale green brown, β = moderate brown, γ = deep blue green.
Opaques are subhedral with incomplete square outlines, are equant and have an average size of 0.18 mm.
Biotite forms small elongate crystals which are intergrown with plagioclase and hornblende. Although elongate with a length: breadth ratio of 6:1 grains are randomly oriented. Basal sections are equant. All biotite has noticeably diffuse grain boundaries; average grain size is 0.16 mm. Pleochroism is α = pale brown, $\beta\gamma$ = brown.
Epidote is intergrown with altered plagioclase and, occasionally, in hornblende. Maximum grain size is 0.1 mm and grains are pale yellow.

RS 417 CHLORITE SCHIST

FIELD NOTES: A chlorite-rich chlorite + biotite schist crops out within feldspathic gneisses and magnetite-bearing quartzo-feldspathic gneisses. The unit probably occurs in a dyke. A poorly-developed schistosity within the chlorite schist is subparallel to the gneissosity in adjacent lithologies; the schistosity is also subparallel to the local S_3. Within the schist are chlorite-rich clots which are elongate in the schistosity.

THIN SECTION: Contains a weak chloritic schistosity; bands parallel to the schistosity contain randomly oriented chlorite. Biotite/biotite boundaries are very diffuse whereas biotite/chlorite boundaries are sharp.
Mineral abundances are:

Chlorite	Biotite	Opaques
88%	6%	6%

Chlorite often has a dimensional alignment which, in some cases, is parallel to a dimensional alignment of opaques. Zones exist of well-aligned chlorite separated by bands of randomly oriented chlorite; within these non-schistose bands chlorite has undulose extinction, curved (001) planes and kink-folded cleavages. Biotite, when intergrown with chlorite, also shows alignment parallel to the schistosity. Chlorite forms crystals to 1 mm long with a highly variable length:breadth ratio; birefringence δ is 0.006-0.007.
Biotite shows a random orientation except when intergrown with schistose chlorite. Biotite tends to be equant with an average size of 0.9 mm; pleochroism is in green shades from α = colourless to $\beta\gamma$ = moderate green while the birefringence δ = 0.035.
Opaques form grains which are elongate in the schistosity and enclosed by the schistosity; also occur as large transgressive grains. Grains are up to 4 mm long and are often inequant with a maximum length:breadth ratio of 6:1.

The schistosity present is probably S_3 while the original lithology may have been an ultramafic intrusive.

RS 418 MUSCOVITE + CHLORITE SCHIST

FIELD NOTES: The same general details for sample RS 417 apply here. The elongate clots and the schistosity are more strongly developed.

THIN SECTION: The specimen contains a schistosity which is defined by a good alignment of fine-grained muscovite and chlorite; the average grain size is only 0.01 mm. Within the schistosity are flattened aggregates containing coarser-grained quartz, opaques and chlorite; retrogressed gneiss fragments are also present.
Mineral abundances are:

Muscovite	Chlorite	Quartz	Sphene	epidote
60%	32%	6%	2%	trace

Retrogressed aggregates

Quartz has poor undulose extinction, irregular grain boundaries, equant shapes and an average size of 0.1 mm.
Chlorite has pale brown and green pleochroism, a length to 0.6 mm, and are elongate in the schistosity. The alignment is generally poor but some chlorite grains are parallel with the matrix schistosity.
Muscovite shows a poor alignment in the matrix schistosity, and although elongate to only 0.1 mm, have a length:breadth ratio of 5:1. Also present are chlorite + sphene + epidote aggregates Sphene is usually concentrated along trains across the aggregate, and probably indicates cleavage orientations in the pre-retrogression mineral.

Its origin is probably a completely-retrogressed potassic mafic. The schistosity present is probably S_3.

RS 419 · CHLORITE GRANOFELS

FIELD NOTES: The same general comments apply as for RS 417 and 418. All samples are from the same locality. This particular sample contains a large clot or aggregate.

THIN SECTION: The thin section contains aggregates, to 25 x 17 mm, comprising of epidote, opaques and chlorite; these are set in a coarse-grained chlorite matrix which is non-schistose.
Mineral abundances of the aggregates are:

Epidote	Chlorite	Opaques
45%	30%	25%

Mineral abundances of the matrix are:

Chlorite	Opaques
99%	1%

Aggregates

Fine-grained epidote dominates the aggregates; grains vary from rounded and 0.8 mm across to much smaller and with ragged boundaries. Opaques are intergrown with epidote, always have a very irregular outline, are up to 2.5 mm across and large grains are very elongate. These large grains, 2.5 mm long, have a length:breadth ratio of 10:1 and are randomly oriented. Smaller opaques are more equant, have an average size of 0.15 mm and have very ragged irregular boundaries.
Opaques and epidote are set in a background of chlorite with undulose extinction, ?deformation twins and kinked lamellae.

Matrix

The edges to the aggregates are very sharp and marked by:
- sharp change in opaque abundance
- complete absence of epidote in the matrix
- coarse grain size of chlorite in the matrix

Chlorite is randomly oriented and does not define a schistosity. Where a thin joint exists through an aggregate, then elongate chlorite crystals infill the joint perpendicular to the joint wall.
Kinked and curved (001) lamellae are abundant. Crystals are often to 1.5 mm long.

The parent lithology may have been an ultramafic and the aggregate may represent a xenolith.

RS 420 CHLORITE SCHIST

FIELD NOTES: Same general comments and locality as for RS 417, 418 and 419. This sample contains several chlorite aggregates partly-enclosed by a poorly-developed chlorite schistosity.

THIN SECTION: The thin section contains two chlorite clots which are distinguished by their markedly finer grain size; these are set in a coarse-grained chlorite matrix which contains a poor schistosity.
Mineral abundances are:

Chlorite	Opaques
99%	1%

Clots

Clots are comprised only of fine-grained chlorite which forms an interlocking network with a poor dimensional alignment. Grains are elongate with a length:breadth ratio to 3:1, average 0.15 mm in length but range up to 0.9 mm long, and have pale green and brown pleochroism.

Schistose matrix

The boundary between the clots and matrix is sharp, and is defined mainly by the abrupt change in grain size. A poor schistosity is present and is defined by:

- a dimensional and crystallographic alignment of elongate chlorite laths; these are to 3 mm long and with a maximum length:breadth ratio of 6:1.
- a dimensional alignment of some chlorite; these grains are only to 2 mm long, length:breadth ratio maximum of 3:1 and are often oriented as basal or near-basal sections.

Kink planes, undulose extinction and curved lamellae are very abundant; kink plane orientation is similar to that of the schistosity. Chlorite is pleochroic in pale green and brown shades.

Opaques are generally equant although some are elongate in the schistosity; maximum size is 1 mm.

The schistosity present is probably S_3.

RS 421 and 422 MYLONITE

FIELD NOTES: Mylonite on major fault contact between the Willyama Complex and Umberatana Group metasediments. Parent material was a pegmatite or quartzofeldspathic gneiss within the Willyama Complex. Mylonitic schistosity is dipping 69° towards 340° M.

THIN SECTION: The sample consists of relict gneiss clasts, which are up to 7 mm long and 3.4 mm across, enclosed by a mylonitic schistosity. Alignment of clasts within the schistosity is not well developed. A feature of the clasts is the extremely irregular quartz/quartz boundaries.
Mineral abundances are:

Quartz	Muscovite	Albite	Biotite	Opaques
50%	38%	9%	2%	1%

Gneiss clasts

Clasts comprise quartz, albite, biotite and muscovite. Quartz is the dominant phase and has very irregular and diffuse grain boundaries. Undulose extinction and polygonisation is pronounced; new subgrain boundaries are parallel to the mylonitic schistosity. Albite is fragmented and invaded by muscovite. Aggregates of albite grains are from an originally larger single crystal; fragmentation has only slightly re-oriented (010) twin planes. Subsequent muscovite development has occurred only the fragment's margins. New grain size for quartz and albite is 0.4 mm.
Muscovite porphyroblasts occur within quartz-rich clasts and are up to 3 mm long. They contain pronounced undulose extinction and warped (001) cleavage traces.
Biotite tends to occur in aggregates within the clasts. Both individual crystals and the aggregate shape define an alignment which is not that of the mylonitic schistosity; this alignment may be a relict S_1 gneissosity. Crystals have an average length of 0.3 mm and a length:breadth ratio of 3:1. Pleochroism varies from α = brown to $\beta\gamma$ = dark brown.

Mylonitic schistosity

The schistosity development is variable as it merges with extensively altered clasts. The best development of the schistosity is in muscovite-rich areas where muscovite is fine-grained and strongly aligned; average length is 0.02 mm and the length:breadth ratio is 2.1 only. Zones which appear to be clasts contain:

- coarser muscovite (to 0.6 mm)
- muscovite with a more random orientation
- more abundant quartz and albite.

Late-stage opaques

Opaques are concentrated in bands which are slightly transgressive to the mylonitic schistosity. These appear to have been produced at a late stage of the mylonitisation process.

RS 423 BIOTITE SCHIST

FIELD NOTES: Sample is from the mine dump at the main workings of the Centralia Mine, and is of a melanocratic biotitic segregation from a gneiss or a biotite gneiss. Sample has a very black colour which contrasts it with the steel-grey biotitic segregations from surrounding gneisses in the mine area.

THIN SECTION: Sample is a biotite schist containing two alignments of biotite. Pleochroism is in greens rather than the almost-ubiquitous reddish browns.
Mineral abundances are:

Biotite	Quartz
>99%	trace

Two alignments of biotite are present. One is a fair to moderate dimensional and crystallographic alignment which outlines a schistosity. Average length of these crystals is 0.3 mm and the length:breadth ratio is 3:1. Pleochroism varies from α = pale green, pale brownish green to $\beta\gamma$ = deep green. The second alignment is defined by numerous basal plates of biotite. These plates are equant to very-slightly-elongate in the schistosity. Basal sections have an average size of 0.22 mm.

Age of the schistosity is unknown.

RS 424 MYLONITE

FIELD NOTES: From an east-west shear zone which is parallel with, but to the north of, the main shear zone through the Faugh-a-Ballagh Mine. Probable pre-mylonite lithology is a poorly-gneissic quartzofeldspathic gneiss or pegmatite.

THIN SECTION: Dominant fabric is of a pronounced muscovite schistosity which wraps around quartz-rich aggregates, large quartz grains and muscovite porphyroblasts.
Average mineral abundances are:

Quartz	Muscovite	Chlorite
50%	40%	10%

Mylonitic Schistosity

The schistosity is defined by a good dimensional and crystallographic alignment of muscovite, chlorite and quartz.
Muscovite is usually fine grained, average length of 0.1 mm and has a length:breadth ratio of 7:1. In places the schistosity is very muscovite rich with all grains bunched together and in good alignment, hence individual grains are difficult to distinguish.
Chlorite is more disseminated and often occurs in quartz-rich areas. Average length is 0.15 mm, length:breadth is 3:1 though some are elongate to 6:1. Pleochroism is α = pale brown, $\beta\gamma$ = pale green.
Quartz is inequant with length:breadth ratio rarely exceeding 2:1, has an average size of 0.1 mm, contains weak undulose extinction and exhibits diffuse grain boundaries.

Clasts and pressure-shadow zones

Muscovite clasts contain myrmekitic quartz intergrowths, are up to 1.8 mm long, and the muscovite mylonitic schistosity strongly wraps around the clast.
Most of the clasts are quartz-rich and their form varies from:

- large equant grains to 2 mm with the mylonite schistosity only mildly wrapping around the clast.
- large grains elongate in the schistosity and up to 3 mm long
- large quartz aggregates with the schistosity strongly wrapping them.

Clasts which are more tightly enclosed by the schistosity show a greater degree of undulose extinction and polygonisation. Quartz/quartz boundaries are irregular and diffuse. Some quartz-rich clasts contain randomly-oriented disseminated chlorite.
Pressure shadow effects are pronounced. The zones consist of abundant aligned quartz, similar to the quartz in the schistosity, and minor, very elongate, disseminated muscovite.
Textural elements are in the approximate abundances of:

Mylonitic schistosity	Clasts	Pressure shadow zones
55%	20%	25%

No evidence of feldspars; parent lithology probably was a quartzmuscovite pegmatite.

RS 425 SILLIMANITE GNEISS

FIELD NOTES: Micaceous gneiss, containing sillimanite, which is tightly folded by a superimposed crenulating phase. Gneissosity/schistosity is S_1 while the crenulating phase is D_2.

THIN SECTION

Average mineral abundances are approximately:

Sillimanite	Muscovite	Chlorite	Opaques	Tourmaline
60%	30%	9%	1%	trace

S_1 schistosity

The schistosity is defined by a perfect alignment of sillimanite and by a moderate alignment of muscovite
Sillimanite occurs as needles to 0.4 mm long, is abundant and disseminated.
Muscovite is mostly elongate in the schistosity with a length: breadth ratio of 5:1; average length is 0.4 mm.

D_2 deformation

The S_1 schistosity is tightly folded; in hinges of D_2 folds muscovite and chlorite grains are not folded and appear to be from syn-D_2 recrystallisation. Large chlorite grains conspicuously occur only along S_2 hinge traces. Other chlorites, which range up to 2 mm and contain opaques and tourmaline, are more randomly distributed. Some chlorite grains in the limbs of D_2 folds are pseudomorphs after ?staurolite or ?garnet.

Note: S_1 schistosity is sillimanitic, and muscovite + chlorite crystallisation (retrogression) occurred during D_2.

Retrogressed sillimanite gneiss

RS 426 RETROGRESSED SILLIMANITE GNEISS

FIELD NOTES: Same locality as RS 425. Sample is a pelitic aggregate containing relict folded layering; appears very similar to RS 425 except for more extensive retrogression.

THIN SECTION: A relict S_1 schistosity is present which contains sillimanite despite extensive retrogression; the schistosity is tightly folded and in many places has been completely obliterated through retrogression and recrystallisation.
Mineral abundances are:

Muscovite	Sillimanite	Chlorite	Biotite	Tourmaline	Opaques
83%	2%	7%	4%	2%	2%

S_1 schistosity

Defined, as in RS 425, by the strong preferred orientation of sillimanite, intergrown with later retrogressive muscovite; this occurs mainly in one well-preserved hinge area.

D_2 folding and retrogression

The S_1 schistosity is tightly folded and partially obliterated from very extensive recrystallisation of muscovite, biotite and chlorite.
Muscovite is most commonly equant to poorly inequant with a length:breadth ratio rarely exceeding 2:1; these muscovite grains average 0.04 mm and occur in extensively recrystallised zones. Some large porphyroblasts to 4 mm appear to be oriented parallel to S_2. Zones showing a strong muscovite alignment are relict S_1; these muscovites have an average length of 0.1 mm and a length:breadth ratio of 5:1.
Chlorite occurs up to 1.5 mm long, is pleochroic in very pale greens and browns and with an anomalous purple-black birefringence. Often, the chlorite occurs in fold hinges either randomly oriented or as porphyroblasts aligned parallel to S_2.
Biotite exists in two forms. Firstly, as relict grains in the S_1 schistosity and are up to 0.35 mm long, have a length to breadth ratio of up to 8:1 and are pleochroic α = pale orange, pale brown to $\beta\gamma$ = deep red, reddish brown. Secondly, biotite occurs in chlorite-rich recrystallised areas.
Tourmaline occurs as a probable retrogression product and is concentrated in selected areas
Opaques occur either as fine-grained dusty opaques or in opaque-rich aggregates to 2 mm around which the S_1 schistosity appears to deflect. Chlorite also occurs within these aggregates which may represent pre- or early-D_1 garnets.

RS 427 RETROGRESSED SILLIMANITE

FIELD NOTES: Pelitic gneiss containing very coarse-grained sillimanite. The sample collected and sectioned is of the sillimanite only.

THIN SECTION: The sample is dominated by sillimanite and its retrogressed form, fibrolite. Mineral abundances are:

Sillimanite	Fibrolite	Andalusite	Muscovite	Biotite
50%	44%	2%	2%	2%

Sillimanite is intergrown with fibrolite, and contains numerous very fine-grained inclusions oriented along the cleavage trace. Basal sections are to 4 mm across, give centred figures with a 2V of approx. 20^{o}.
Fibrolite occurs in fibrous wispy mats, as clots containing radial clusters, and as aggregates exhibiting a parallel alignment of fibrolite.
Muscovite occurs as intergrowths in the fibrous mats and as porphyroblasts to 2.5 mm across.
Andalusite occurs as relict clear grains intergrown with sillimanite.
Biotite forms large flakes to 3 mm long with a length:breadth ratio varying up to 8:1 maximum. Grain boundaries are irregular, and pleochroism is α = very pale yellow to $\beta\gamma$ = dark orange brown.

The sample is of a retrogressed sillimanite segregation from a pelitic gneiss. Development of sillimanite was possibly during D_1.

RS 428 GNEISS GRANITE

FIELD NOTES: Area of granitic gneiss or gneissic granite.

THIN SECTION: Specimen contains a massive granular texture of quartz and feldspar; grain boundaries are sharp but irregular. In addition a biotite + muscovite dimensional and crystallographic alignment defines a gneissosity. Micas are present to only 5% (volume) and hence the gneissosity is subordinate to the granular texture.
Mineral abundances are:

Microcline	Quartz	Andesine	Muscovite	Biotite	Opaques
40%	35%	20%	4%	1%	trace

Microcline has an average size of 2.5 mm and contains a variety of inclusions; these include small exsolved quartz which has an average size of 0.07 mm, small muscovite crystals, and plagioclase grains. Quartz and plagioclase inclusions have curved lobate boundaries.
Andesine (sodic, approx. An_{30}) contains scattered dusty muscovite inclusions.
Quartz, as well as occurring as small exsolved blebs, forms large primary grains which average 2.5 mm across. These large grains are polygonised and contain undulose extinction.
Muscovite - most grains have either a dimensional and crystallographic, or just dimensional, alignment. Grains are to 3 mm long and have length:breadth ratios of up to 7:1, grain boundaries are diffuse. Some small muscovite grains occur along grain boundaries.
Biotite shows a dimensional and crystallographic alignment which is parallel with that of muscovite. The size and elongation of grains is small; average size is 1.2 mm while the length:breadth ratio is rarely greater than 3:1.

The sample is probably of a gneissic granite, rather than of a granitic gneiss. The gneissosity is most likely to be S_1.

RS 429 RETROGRADE SCHIST

FIELD NOTES: Outcrop area is of a garnetiferous schist, and lies between gneissic granite to the west and banded calc-silicate to the east.

THIN SECTION: The section contains an extensive retrogressive assemblage; this appears to be superimposed on a gneissic assemblage. Two weak schistosities and a compositional banding are present, the ages of which are not known with any certainty.
Gneissic minerals which are slightly coarser grained and apparently predate retrogression are biotite, garnet and quartz.
Retrogressive minerals are chlorite, staurolite and muscovite. A weak chlorite schistosity occurs at a high angle to a very poor muscovite schistosity. The compositional banding is subparallel with the chlorite schistosity.
Mineral abundances are:

Muscovite	Quartz	Chlorite	Garnet	Staurolite	Biotite
45%	30%	13%	8%	2%	2%

Relict gneissic minerals

Biotite is not aligned in the schistosity but is randomly oriented. It has an average length of 1.1 mm and a length:breadth ratio of 3:1. Pleochroism is α = pale brown yellow to $\beta\gamma$ = dark brown.
Garnet forms ragged grains with a very irregular outline. These grains form aggregates which tend to occur in bands, while individual aggregates are elongate in the chlorite schistosity. Single grains have an average size of 0.8 mm while aggregates are up to 2.5 mm long.
Quartz grains are widely variable in size with a maximum of 5 mm; usually occur in smaller aggregates. Grains are polygonised, contain undulose extinction and definitely predate the schostosity.

Retrogressive minerals

Chlorite shows a good alignment to define a schistosity which encloses the relict gneissic grains. Chlorite has pale green and pale brown pleochroism, contains abundant very fine-grained inclusions, has anomalous purple birefringence, has an average length of 0.2 mm and an average length:breadth ratio of 3:1.
Muscovite occurs in broad bands across the slide; within these bands most of the muscovite is fine-grained (0.02 mm) and randomly oriented. Grain boundaries are very irregular and sutured. In places there is a very weak schistosity which is at a high angle to the chlorite schistosity, and at an angle to the compositional banding.
Staurolite occurs within the muscovite-rich bands and generally forms equant crystals to 1.4 mm; one elongate crystal is to 2 mm long and has a length:breadth ratio of 4:1. The chlorite schistosity does not enclose, nor is wrapped around, the staurolite whereas the muscovite schistosity does slightly. The staurolite may be synchronous with the development of the chlorite schistostiy and predates the muscovite schistosity.

Alternate names: Retrograde schist
Garnetiferous schist
Retrogressed garnetiferous gneiss

The timing of retrogression is not definitely known but is probably broadly synchronous with D_3.

RS 430 HORNBLENDE DIORITE

FIELD NOTES: Massive diorite occurring in a narrow dyke which trends 125°M. Typical trend and texture of slightly post-D_3 diorite dykes which occur throughout the Outalpa Inlier.

THIN SECTION: Massive texture dominated by abundant and randomly-oriented hornblende; relict plagioclase laths are evident. Mineral assemblage is dominated by hornblende:

Hornblende	Plagioclase	Opaques	Epidote	Quartz
77%	10%	7%	3%	3%

Hornblende forms interlocking grains with irregular grain boundaries; pleochroism is α = pale to moderate brown and greenish brown, β = moderate brown, γ = deep green, deep blue-green.
Plagioclase composition is approx An_{35}. Crystals occur in lath-like forms with very irregular outlines but more commonly as irregular interstitial grains to hornblende. Interstitial grains have an av. size of 0.2 mm while laths are approximately 1 mm long and with a length:breadth ratio of 4:1.
Epidote forms isolated larger grains to 0.1 mm but more commonly forms as small retrogression products within andesine. Epidotisation of plagioclase is not extensive.
Opaques are disseminated, have an irregular outline and an average size of 0.15 mm.

Some of the hornblende is highly poikiloblastic, these crystals contain abundant quartz and dusty opaque inclusions.

RS 431 CALC-SILICATE

FIELD NOTES: Typical well-layered calc-silicate with good preservation of thin and continuous horizontal banding; occurs amongst micaceous and feldspathic gneisses.

THIN SECTION: Banding in thin section is defined by a variation in hornblende and epidote abundance; this variation is inversely proportional to feldspar abundance. Apart from the banding, texture is massive and there is no alignment. The average mineral abundances are:

Hornblende	Epidote	Quartz	Plagioclase	Orthoclase	Opaques
45%	20%	15%	10%	7%	2%

Biotite	Actinolite
1%	<1%

Hornblende is equant to poorly elongate, though some grains are elongate to 3:1; these grains have an average size of 1.7 mm. Hornblende also occurs as fine-grained recrystallised grains of average size 0.1 mm. Grains are mutually impinging and with irregular grain boundaries.
Pleochroism is α = pale greenish brown, β = moderate, brown, γ = deep green, deep blue green; some grains have rims (overgrowths?) which are pleochroic in deeper shades.
Epidote has several forms:

- as coarse-grained crystals in hornblende-rich layers where they are yellow to pale green, are mutually impinging with some sharp straight boundaries, and have an average size of 0.5 mm
- as inclusions in hornblende
- as fine-grained crystals from the epidotisation of plagioclase.

Quartz has a fairly uniform distribution throughout the sample and an average grain size of 0.3 mm. Grain boundaries are variable with some sharp, planar boundaries and triple points present. Many grains contain undulose extinction and some actinolite needles. Quartz also forms minor graphic intergrowths with orthoclase.
Plagioclase was distinctly calcic but most of the grains have been extensively retrogressed and now contain abundant fine-grained epidote, biotite, hornblende or actinolite; twinning is poorly preserved. Some crystals consist of extensive patchy and fine-grained recrystallised crystals; an original grain size of 2.5 mm is indicated.
Clear orthoclase is restricted to the finer-grained layers which do not contain the coarse-grained and abundant hornblende and epidote; average size of orthoclase is 0.5 mm.
Opaques are mostly grouped in one aggregate about 5 mm across which contains about 30% opaques; individual grains average 0.4 mm.
Biotite only occurs as fine-grained inclusions in plagioclase and always has diffuse boundaries. The largest observed crystals are 0.07 mm long.
Actinolite On the margins of some hornblende crystals are rims of actinolite needles with the needles oriented at high angles to the grain boundary. Actinolite also occurs as needles in quartz and as isolated larger grains with colourless to pale green pleochroism intergrown with hornblende.

RS 432. MYLONITE

FIELD NOTES: Mylonite; original rock was a pegmatite. Located within the main east-west shear through the Faugh-a-Ballagh Mine.

THIN SECTION: The texture is dominated by three factors:
- relict large coarse-grained crystals (10% of total volume)
- fine-grained zones of extensive recrystallisation (80%)
- a superimposed schistosity (10%).

Approximate mineral abundances are:

Biotite	Muscovite	Quartz	Albite
3%	7%	50%	40%

Relict large crystals

These consist of poorly-twinned plagioclase to 4.5 mm which contain extensive fine-grained dusty muscovite and rounded exsolved quartz blebs to 0.4 mm. Plagioclase shows brittle fracturing, curved and gently-folded twin lamellae and pronounced undulose extinction.

Superimposed schistosity

The superimposed schistosity (mylonite schistosity) is defined by an imperfect alignment of biotite and muscovite. Most of the micas are dispersed across the section but some are concentrated in trails. Biotite has a length:breadth ratio of 5:1, av. length of 0.15 mm and pleochroism = pale yellow; $\beta\gamma$ = dark brown, dark oran brown. Muscovite has a length:breadth ratio of 5:1, av. length of 0.16 mm and briefringence (δ) of 0.030. Isolated large crystals to 1 mm occur; some of which are aligned in the schistosity.

Recrystallised zones

These areas are dominated by a mosaic of quartz and plagioclase; grains are equant, all less than 0.2 mm and average size is 0.1 mm. Recrystallised zones also contain weakly-aligned fine-grained biotite and muscovite both of which, have very diffuse boundaries. Quartz/feldspar boundaries are often very irregular and diffuse. These zones represent extensive subgrain development and recrystallisation.

Mylonite or mylonitised pegmatite

RS 433 MYLONITE

FIELD NOTES: Sample from within the main east-west shear through the Faugh-a-Ballagh Mine. Sample appears to be a sericitic schist with the schistosity wrapping around relict gneiss fragments.

THIN SECTION: Texture is similar to RS 432 and consists of:
- relict gneissic clasts (20% of total volume)
- mylonitic schistosity (33%)
- recrystallised and annealed zones (57%)

Mineral abundances are:

Quartz	Oligoclase (An_{12})	Muscovite	Biotite	Opaques
35%	27%	35%	2%	1%

Proportions of the dominant textural factors are:

Clasts	:	Mylonitic schistosity	Recrystallised zones
20		33	57

Clasts

The clasts are noticeable by:
- their large size, to 3 mm long
- coarse grain size with crystals to 2.5 mm
- the schistosity wrapping around them to give an augen structure.

Clasts consist of poorly-sericitised plagioclase and quartz. Clast boundaries are highly irregular with pronounced new grain development. Boundaries within clasts are usually irregular but where subgrains have developed, boundaries are straighter and sharper. Average size of subgrains is 0.2 mm.

Mylonitic schistosity

Defined by a preferred orientation of biotite, muscovite and opaques
Muscovite occurs in bands containing fine-grained crystals averaging 0.2 mm long and with a length:breadth ratio of 5:1; grain boundaries are very diffuse.
Biotite is intergrown with muscovite but is not as abundant. Its crystallographic alignment is poorer with an average length of 0.1 mm, length:breadth = 3.1 and pleochroism of α = pale yellow β = dark chocolate brown.
Opaques form a minor schistosity phase and form narrow bands or trails elongate in the schistosity containing grains averaging 0.08 mm long and with a length:breadth ratio of 3:1.

Recrystallised zones

They have similar characteristics to RS 432 with extensive fine-grained recrystallisation and subgrain development with highly irregular grain boundaries.

Mylonite or Mylonitised gneiss

RS 434 ADAMELLITE

FIELD NOTES: Massive granoblastic granitic lithology; in places micas are aligned and define a gneissosity/schistosity. This sample is of the massive granitoid.

THIN SECTION: Specimen exhibits a massive granoblastic texture with no alignment of biotite or muscovite. Grain size is coarse with an average of 2 mm, while grain boundaries are typically irregular, highly curved and often diffuse. Myrmekitic intergrowths and quartz lobes are present along grain boundaries.
Mineral abundances are:

Microcline	Oligoclase	Quartz	Muscovite	Biotite	Opaques
35%	35%	24%	3%	2%	1%

Oligoclase has abundant fine-grained muscovite inclusions whereas microcline is much clearer.
Microcline contains only poorly-developed grid-iron twinning.
Quartz contains strongly-developed undulose extinction and polygonisation. It also occurs as small graphic intergrowths within feldspars and these grains have an average size of 0.1 mm.
Biotite forms crystals to 1.4 mm long with a length:breadth ratio up to 4:1. Opaques are often intergrown with biotite. Pleochroism is α = moderate yellow brown, $\beta\gamma$ = deep chocolate brown.
Muscovite crystals are up to 1 mm long and have broad diffuse boundaries, but also commonly occur as dusty inclusions in oligoclase.

RS 435 QUARTZ + OLIGOCLASE GNEISS

FIELD NOTES: Quartzofeldspathic gneiss containing a significant mica abundance. Across the gneissosity (S_1) is an overprinting schistosity (S_3).

THIN SECTION: The gneissosity is defined mainly by a compositional banding where muscovite and biotite abundances vary. Parallel to the banding is a very poor dimensional and crystallographic alignment of biotite. Within thin muscovite-rich bands, fine-grained muscovite is poorly aligned at an angle across the banding and indicates partial recrystallisation during formation of S_3.
Mineral abundances are:

Quartz	Oligoclase	Orthoclase	Muscovite	Biotite	Opaques
40%	32%	12%	8%	7%	1%

Oligoclase has a variable grain size which ranges up to a 6 mm maximum; albite twinning is poorly developed.
Orthoclase is extensively altered to muscovite
Quartz has a variable grain size to 7 mm; even large grains have fairly even extinction. Many boundaries with other minerals are lobate; quartz/quartz boundaries are sharp and curved, and lobate.
Biotite shows a fair alignment and helps define the gneissosity; many grains are equant however. The average grain size is 0.5 mm and the length:breadth ratio is up to 3:1. Pleochroic haloes and dusty opaque inclusions are abundant. Pleochroism is α = pale yellow brown to $\beta\gamma$ = olive brown.
Muscovite is strongly concentrated within altered orthoclase and oligoclase, particularly along grain boundaries. Muscovite also occurs in thin muscovite-rich bands which contain a poor cross-cutting alignment of muscovite; some of these crystals are up to 1 mm long.

Quartz + oligoclase gneiss or quartzofeldspathic gneiss. The gneissosity present is relict S_1, while the cross-cutting schistosity is S_3.

RS 436 HORNBLENDE ± ANDESINE GNEISS

FIELD NOTES: Gneissic amphibolite which is conformable with surrounding quartz + feldspar + mica gneiss.

THIN SECTION: The specimen contains a distinct gneissosity which is defined by a dimensional alignment of inequant hornblende and opaques and, to a lesser extent, feldspar and quartz. Banding is absent.

Mineral abundances are:

Hornblende	Andesine	Quartz	Opaques	Epidote	Biotite
30%	30%	20%	15%	3%	2%

Hornblende shows a good dimensional alignment and possibly a crystallographic one also. Grains which are elongate in the gneissosity are up to 1.2 mm long and have a length:breadth ratio of 6:1; the average size is 0.4 mm. Grain boundaries are irregular and embayed. Pleochroism is α = light to moderate green, β = pale green brown to γ = dark green, dark blue green.

Andesine (approx. An_{45}) contains irregular and diffuse grain boundarie and has undergone only minor epidotisation. The average grain size is 0.5 mm.

Quartz has two forms; exsolved grains within feldspar and hornblende, with an average size of 0.08 mm, is minor. Most quartz occurs in quartz-rich aggregates where straight grain boundaries and triple points occur; these represent zones of recrystallised quartz.

Opaques always have a very irregular outline and are distinctly elongate in the gneissosity. Although up to 1.5 mm long, their width rarely reaches 0.3 mm; the average length:breadth ratio is 8:1.

Epidote is pale yellow, anhedral, ragged, equant, and occurs mainly in altered plagioclase and as inclusions in hornblende.

Biotite occurs as small fine-grained inclusions in andesine and hornblende. Boundaries are very diffuse, pleochroism is from colourless to moderate brown, and grains are randomly oriented.

The sample contains a higher quartz abundance than other amphibolitic gneiss samples examined. The gneissosity present is S_1.

RS 452 BANDED CALC-SILICATE

FIELD NOTES: Well-layered or banded calc-silicate unit; banding is S_0 which is parallel to S_1. Hand specimen contains visible garnets.

THIN SECTION: S_0 is defined by a broad compositional banding; hornblende abundance changes are pronounced and one band contains diopside. A gneissosity is present parallel to the compositional banding and is defined by a poor dimensional and crystallographic alignment of hornblende.
Mineral abundances are:

Plagioclase	Orthoclase	Hornblende	Epidote	Quartz	Andradite
35%	34%	10%	10%	5%	4%

Diopside	Opaques	Sphene
1%	1%	trace

In hornblende-rich layers, the abundance of epidotised plagioclase is greater than orthoclase. However in diopside-bearing bands which are also hornblende-poorer, orthoclase exceeds plagioclase.
Hornblende is sometimes inequant to a maximum length:breadth ratio of 3:1 and shows a dimensional and crystallographic alignment in S_1. Grains have an irregular outline and are embayed, have an average size of 0.6 mm, and pleochroism of α = pale to moderate brown, β = brown, γ = deep green, blue green.
Diopside forms equant, anhedral grains with an irregular outline and an average size of 0.2 mm. Iron-staining is abundant within cracks across the crystals. Pleochroism is in very pale green shades.
Plagioclase is extensively altered to epidote; alteration is near complete. Average grain size is 0.8 mm.
Orthoclase forms large clear (almost inclusion-free) grains to 2 mm across.
Quartz forms small exsolved-type grains with rounded and lobate forms; average size is 0.2 mm. All quartz and feldspar boundaries are in distinct disequilibrium; boundaries are irregular and diffuse.
Epidote occurs as abundant fine-grained inclusions in altered plagioclase, and as fine-grained aggregates rimming opaques.
Andradite forms equant subhedral grains which have a pale brown colour and average 0.2 mm across.
Opaques are often intergrown with sphene and epidote, and form isolated grains to 2mm across.

Specimen contains a mineralogical banding (S_0) which is parallel to a relict hornblende gneissosity(S_1).

RS 452 BANDED CALC-SILICATE

Sample: P1435/76; TSC16806
Applicant's Mark: T46 G299/76

Hand Specimen:
A metasedimentary rock in which original straight and parallel layering is clearly preserved and is defined by variations in the proportions of light and dark coloured minerals and also by variations in grain size. The rock tends to split along some of the original bedding planes and there is evidence of a very weak foliation parallel to this direction.

Mineral abundances are:

Quartz	Plagioclase	Hornblende	Epidote	Magnetite	Garnet	Apatite	Sphene
5-10%	50-60%	25-30%	3-5%	3-5%	1-2%	trace	trace

Grain size: Mainly 0.5-1 mm

Special Features:
Plagioclase and hornblende are intergrown with generally smooth to slightly curved grain boundaries and in general, the quartz is finer grained and occurs in interstices and also as a few small inclusions within plagioclase. Magnetite is relatively coarse-grained and occurs as slightly elongated crystals up to 1.5 mm long and these are parallel to the weak foliation. Garnet occurs mainly as small, slightly pink crystals averaging 0.3 mm in size and these are included within both plagioclase and hornblende.
A notable feature of this rock is that most of the plagioclase crystals now contain concentrations of very fine-grained epidote suggesting that there may once have been a more calcic plagioclase which has recrystallized during a later period of lower grade metamorphism. Some coarser grained epidote occurs in a few interstices in aggregates composed of intergrown hornblende and magnetite. Trace amounts of sphene are also intergrown with some hornblende and magnetite.

Conculsion: This was originally a layered, calcareous sediment which now shows evidence of at least two episodes of metamorphism. The presence of epidote developing in plagioclase suggests that a more calcic plagioclase which crystallized during an earlier period of metamorphism has recrystallized during a later period of lower grade metamorphism to a less calcic plagioclase and epidote.

See preceding description for comments; that sample is from the same outcrop.

RS 453 BANDED CALC-SILICATE

FIELD NOTES: This sample is from the same locality and is a very similar lithology to that of RS 452, except that garnet is apparently more abundant. This unit is probably an along-strike extension of calc-silicates and albitites near Ameroo Hill.

THIN SECTION: The specimen contains a compositional banding (S_0) which is defined by variations in mineralogical abundance and grain size. Some bands contain a dimensional alignment of hornblende, andradite, opaques and feldspars; coarser-grained bands have an average grain size of 2 mm and have no alignment.
Mineral abundances of bands containing the S_1 gneissosity are:

Plagioclase	Orthoclase	Quartz	Hornblende	Andradite	Opaques	Biotit
30%	35%	22%	7%	4%	2%	trace

Mineral abundances of the coarse-grained bands without the gneissosity are:

Plagioclase	Orthoclase	Quartz	Hornblende	Andradite	Opaques
62%	6%	7%	4%	20%	1%

Hornblende has only a dimensional alignment in the gneissosity; these grains are elongate to a maximum length:breadth ratio of 4:1. Many grains are equant; larger grains (about 3 mm across) are distinctly poikiloblastic. Pleochroism is in darker colours of α = moderate green brown, β = brown to γ = very dark green and blue green.
Plagioclase has only poorly-preserved albite twinning as alteration to fine-grained epidote and clear garnet is extensive; minor biotite is also present. Plagioclase and orthoclase boundaries are irregular. Within non-gneissic bands, feldspar is more intensely altered, fine-grained inclusions are more common, and sphene and epidote inclusions are slightly coarser grained.
Orthoclase is clear and unaltered; although most grains are equant some are elongate to 2:1 and aligned in the gneissosity.
Quartz typically forms smaller exsolved rounded grains with very smooth lobate grain boundaries; the average size is only 0.02 mm. In places, small opaque inclusions noticeably pin movement of the quartz grain boundary.
Andradite is pale brown and subhedral with partial square and octagonal outlines; grain boundaries are highly ragged. Many grains are equant but some are aligned in the gneissosity with a length:breadth ratio of 3:1. Within non-gneissic bands, garnets are more euhedral with near-complete octagonal outlines.
Opaques are equant and subhedral with cubic cleavages indicated; sphene is often intergrown with opaques.
Tourmaline; trace amounts occur in the coarse-grained non-gneissic layers. It is highly embayed, has parallel extinction and pleochroism is α = pink to brown to $\underline{w}$ (cleavage trace) = dark smoky blue.

The average grain sizes varies between gneissic and non-gneissic bands and are:

	gneissic bands	non-gneissic bands
hornblende	1.0 mm	1.5 mm
andradite	1.5 mm	2 mm
plagioclase	0.8 mm	2 mm
orthoclase	0.8 mm	1.6 mm
quartz	0.02 mm	0.8 mm

The specimen exhibits a mineralogical banding which is classified as S_0, and andradite + hornblende + plagioclase + orthoclase + opaques define the S_1 gneissosity.

RS 454 BANDED CALC-SILICATE

Sample: P1436/76; TSC16807
Applicant's mark: T46-approx. 950 metres. G2993/76.

Hand Specimen: A moderately fine-grained, yellowish-grey rock with some evidence of layering defined by variations in colour but locally this appears to have been disturbed or deformed. The rock tends to split along some bedding planes producing a flat surface.

Mineral abundances are:

Quartz	Plagioclase	Epidote	Tremolite	Pyroxene	Sphene	Calcite
10-15%	4--50%	30-35%	5-10%	3-5%	1-2%	2-3%

Scapolite	Goethite	Tourmaline
trace	trace	minute trace

Grain size: Mainly 0.1-0.2 mm with coarser grained layers containing epidote and tremolite up to 2 mm in grain size.

Special Features: The finer grained layers contain an even-grained mosaic of intergrown plagioclase and quartz crystals and generally scattered small crystals of pyroxene of similar size. These layers also contain a scattering of very minute crystals of sphene.
Coarser grained layers are composed largely of intergrown epidote and tremolite with minor amounts of calcite filling some interstices. There are also a few small crystals of sphene and adjacent to one coarser grained layer there is a trace of scapolite. Much of the epidote is almost colourless and shows anomalous blue interference colours suggesting that it contains little or no iron.
In one of the coarser grained, tremolite+epidote layers there are numerous small patches of goethite and it is possible that at least some of this goethite has replaced a sulphide mineral possibly pyrite. Very few small crystals of tourmaline were found in the section mainly in the finer grained layers.

Conclusion: This was a layered calcareous sediment which has been metamorphosed probably to the equivalent of lower amphibolite facies.

This sample is from the same calc-silicate outcrop as RS 452 (two descriptions) and RS 453.

RS 478 HORNBLENDE DIORITE

FIELD NOTES: Massive intrusive diorite which is similar to late and post-D_3 amphibole-rich diorites.

THIN SECTION: The sample is very similar to other post-D_3 intrusives; it is hornblende rich, has a massive texture, and contains interstitial and poikiloblastic plagioclase. Mineral abundances are:

Hornblende	Plagioclase	Sphene + opaques	Epidote	Muscovite
80%	15%	4%	1%	trace

Hornblende is mutually impinging producing interlocking equant grains of average size 0.6 mm. Pleochroism is α = pale greenish brown, β = pale brown to γ = deep green, deep blue green.
Plagioclase is poorly twinned with albite twins almost non-existant; optic sign is +ve. Inclusions are farily common and include fine-grained lath-shaped actinolite, small rounded epidote grains and fine-grained muscovite. The extent of epidotisation is small.
Opaques form very irregular-shaped aggregates, with sphene, to 0.9 mm; opaques appear to be strongly interstitial to hornblende.

Sample is from a post-D_3 intrusive.

RS 479 MIGMATITIC GNEISS

FIELD NOTES: Area consists of a migmatite gneiss containing a gneissosity which changes in orientation rapidly i.e. within a few metres. Gneissosity shows little consistency in orientation and has a 'chicken-guts' appearance. Micaceous restites have a distinctive blue grey appearance on weathering.

THIN SECTION: The sample contains gneiss fragments within an extensive matrix of fine-grained, randomly-oriented muscovite. The gneiss fragments contain a relict quartz + biotite + sillimanite gneissosity; contained sillimanite is partially altered to muscovite.

Mineral abundances are:

Quartz	Muscovite	Biotite	sillimanite
55%	43%	2%	trace -1%

Quartz forms large grains to 4 mm which are passively fragmented by the retrogressive matrix muscovite; fragmented grains remain in optical continuity.

Biotite occurs as grains to 2 mm which show an alignment parallel with sillimanite and quartz aggregates. Inclusions of opaques are common and pleochroism is α = pale green brown, $\beta\gamma$ = deep green brown.

Sillimanite is poorly aligned in the gneissosity and is now partially altered to muscovite.

Muscovite forms the matrix; it is fine-grained with sharp clear boundaries which are curved and irregular; grains are inequant to a maximum length:breadth ratio of 2:1, grains are randomly oriented and have an average size of less than 0.01 mm.

Extensively-retrogressed gneiss; originally containing sillimanite and probably abundant feldspar.

RS 480 BIOTITE DIORITE

FIELD NOTES: The sample is from a thin (20-30 cm) dyke which has a hornfelsic texture and is rich in mafic minerals:- hornblende, biotite, chlorite. The dyke dips 59° towards 251°M and cross-cuts a gneissic granite.

THIN SECTION: The specimen contains small quartz and poorly-twinned feldspar laths which are set in a fine-grained matrix of randomly oriented biotite, hornblende, chlorite and opaques. Feldspar laths are highly corroded and embayed, and contain abundant inclusions. The general texture is hornfelsic.
Mineral abundances are:

Biotite	Plagioclase	Opaques	Hornblende	Chlorite	Quartz
50%	23%	11%	10%	4%	2%

Phenocrysts

Quartz and plagioclase form laths to 1.3 mm long. Plagioclase contains very poor and diffuse albite twinning; extinction angles have approximately a 24° maximum. Lath outlines are corroded, embayed and irregular. Inclusions of opaques, chlorite and hornblende are common, as is brown turbid alteration, but biotite inclusions are absent.

Matrix

Biotite is mostly anhedral but a few randomly oriented laths occur, the average size is 0.05 mm and pleochroism is α = pale brown to $\beta\gamma$ = olive brown.
Opaques. Although most commonly as irregular-shaped equant grains, they are also elongate to 0.1 mm long and with a length:breadth ratio of 15:1. These elongate grains are probably controlled by a previous mineral cleavage which is certainly not evident in the presently existing minerals. The most common grain size is 0.02 mm.
Hornblende is pleochroic in dark green and green blue shades, is anhedral and equant, and has an average size of 0.1 mm.
Chlorite, like hornblende, is often intergrown with opaques. With an average size of 0.2 mm, it is slightly coarser grained than the remaining matrix minerals. Birefringence is an anomalous brownish purple, while pleochroism is α = pale brown to $\beta\gamma$ = pale green.

Alternative name is biotite hornfels.
The age of intrusion and retrogression is not known.

RS 481 GRANOBLASTIC ALBITE GNEISS

FIELD NOTES: Fairly-massive feldspathic gneiss, in places weakly magnetic. Staining indicates no potash-feldspar.

THIN SECTION: The specimen is of a coarse-grained gneiss containing a very poor gneissosity; this is defined:

- by a banding due to variation in quartz and feldspar grain size
- by a poor alignment of biotite
- and by concentration of biotite in discontinuous trains.

Muscovite is absent.
Mineral abundances are:

Albite	Quartz	Biotite
75%	22%	3%

Albite (approx. An_4) has a maximum grain size of 2.5 mm. Deformed and curved albite twin lamellae are common; partial recrystallisation has reduced the grain size to an average of 0.9 mm.
Quartz is much finer grained, average grain size is 0.25 mm, and the most common form is exsolved inclusions within ablite. Grain boundaries tend to be distinct and sharp, and only gently curved; straight boundaries are rare.
Biotite has an average length of 0.15 mm, a length:breadth ratio of 3:1, and pleochroism of α = pale brown to $\beta\gamma$ = moderate olive green.

The gneissosity present is relict S_o and S_1.

RS 482 · HORNBLENDE GNEISS

FIELD NOTES: The sample is from a conformable amphibolitic gneiss horizon which apparently contains an S_1 hornblende gneissosity. Staining indicates no K-feldspar.

THIN SECTION: The specimen contains a pronounced gneissic texture defined by a dimensional alignment of hornblende, quartz, plagioclase and opaques.
Mineral abundances are:

Hornblende	Quartz	Epidote	Andesine	Opaques	Biotite
45%	25%	15%	10%	3%	2%

Hornblende/hornblende boundaries are sharp and planar, while other boundaries with hornblende are often deeply embayed. Typical grains have a length of 0.8 mm and a length:breadth ratio of 2:1. Pleochroism is α = pale yellow brown, β = deep blue green to γ = deep green.
Andesine (calcic, An_{45}) is highly epidotised; the original plagioclase was probably significantly more calcic than An_{50}. Twinning within the plagioclase is poorly developed.
Epidote usually occurs within altered plagioclase and forms ragged grains of average size 0.003 mm. Birefringence is both normal and anomalous blue-yellow while the colour is pale yellow. Isolated large grains are to 0.5 mm.
Quartz forms a primary mineral and has an average grain size of 0.4 mm. Grains contain undulose extinction, are only rarely inequant and are not apparently related to epidotisation.
Opaques are commonly large and up to 0.6 mm. Although often equant, many grains are elongate and parallel to the gneissosity. Average size is 0.3 mm, some subhedral grains indicate cubic symmetry, and the length:breadth ratio rarely exceeds 3:1.
Biotite and epidote are the only minerals which do not show some alignment in the gneissosity. Biotite is only poorly inequant, has an average length of 0.09 mm and pleochroism of α = colourless to pale yellow, $\beta\gamma$ = moderate olive green.

Gneissosity present is a relict S_1 gneissosity.

RS 483 QUARTZ METASANDSTONE

FIELD NOTES: The sample is of a grey massive silty metasandstone of the Umberatana Group. In outcrop it is generally more resistant than the grey-green metasiltstones and diamictites, and forms moderate-size rounded boulders.

THIN SECTION: A massive texture is dominant; grains are either equant or if elongate, show no preferred orientation. The general grain size is 0.12 mm but there are abundant very fine-grained, possibly syn-tectonic grains along grain boundaries and in small aggregates. Mineral abundances are:

Quartz	Opaques	Feldspar	Biotite	Muscovite	Zircon	Tourmaline
83%	7%	5%	3%	2%	trace	trace

Quartz forms equant grains with diffuse grain boundaries; grains contain undulose extinction and have an average size of 0.12 mm.
Feldspar, probably plagioclase, is also fine-grained with an average size of 0.12 mm. Twinning is very poorly developed to absent. Fine-grained inclusions are very abundant producing clouded grains.
Opaques are equant with cubic and octahedral cleavages evident, are reddish on thin edges, and have an average size of 0.04 mm.
Biotite is partly chloritised; chloritisation produces a lowering of the birefringence and a deeper green colour. Pleochroism is α = colourless to pale brown to $\beta\gamma$ = moderate olive green. The average grain size is 0.12 mm; most grains are equant with very rare grains being elongate to 2:1.
Muscovite has very diffuse edges and a very irregular outline. The average size is 0.1 mm and although grains are elongate to 3:1, they remain randomly oriented.
Tourmaline occurs in trace amounts. Basal sections show green pleochroism, length sections show colourless to blue pleochroism.

RS 520 HORNBLENDE DIORITE

FIELD NOTES: Massive amphibolite or hornblende diorite dyke containing scattered feldspar phenocrysts. Lithology is fairly typical of post-D_3 hornblende-rich intrusives.

THIN SECTION: The sample is very similar to other post-D_3 diorites:

- it contains abundant green and green blue hornblende
- hornblende is ragged, equant and interlocking
- feldspars are clear but epidotised.

Within the thin section, feldspar is interstitial to hornblende rather than in laths or phenocrysts.
Mineral abundances are:

Hornblende	Andesine	Epidote	Sphene	Biotite	Tourmaline
75%	15%	3%	3%	4%	<1%

Hornblende forms equant interlocking grains with very irregular grain boundaries. Grain size is variable but averages 0.4 mm. Hornblende contains very abundant extremely dusty inclusions of indeterminable mineralogy; these are arranged to suggest zoning. Pleochroism is α = pale brownish green, β = moderate brown to γ = dark green and dark blue green.
Andesine forms an interstitial phase, compositon is approx. An_{38}. Some grains have been epidotised to about 25%, brown turbid alteration is present but minor. Average grain size is 0.3 mm.
Epidote forms small ragged inclusions in andesine. Largest grain observed was rounded and 0.1 mm across. Colourless.
Biotite is usually equant, rarely elongate. Biotite is closely associated with hornblende and forms mostly on the margins of hornblende; this association is not apparently from direct replacement of hornblende. Grain boundaries are often diffuse and pleochroism varies from α = medium brown to $\beta\gamma$ = dark brown.
Sphene forms aggregates to 0.15 mm across which are characterised by extremely furry boundaries, and indicate ultrafine-grained crystals on the margins of these aggregates.
Tourmaline occurs as two grains only with dark and strong pleochroism from w (crystal long axis) = very dark blue green to ϵ = pale purplish brown; extinction is parallel.

The intrusion age is most probably post-D_3.

RS 521 · ADAMELLITE

FIELD NOTES: Granitoid or massive gneiss with no observable gneissosity. Sample is from a ?sill which has radioactivity of 5X background(broad band).

THIN SECTION: The sample is particuarly coarse grained and is one of the coarsest-grained specimens studied. No alignment is present; the texture is granular with quartz and feldspar boundaries being irregular and diffuse. Texture is not similar to granoblastic quartzofeldspathic gneiss.
Mineral abundances are:

Microcline	Quartz	Albite	Muscovite	Biotite	Opaques
40%	30%	25%	3%	2%	trace

Microcline commonly forms crystals to 7 mm, an unusually coarse grain size. Microcline is perthitic and has minor quartz inclusions, is generally clear with some fine-grained muscovite inclusions, and has highly irregular, ragged and diffuse grain boundaries.
Quartz has a maximum grain size of 4.5 mm with very ragged and diffuse boundaries. Largest grains have strongly developed undulose extinction and polygonisation.
Albite (An_4) often has fine-grained muscovite inclusions of approx. 0.1 mm; these vary from randomly oriented to oriented along feldspar cleavages. Albite grains often have a clear untwinned, thin, sericite-free rim; other albite grains have ragged and diffuse baoundaries.
Muscovite has two forms. The small grains, which occur as inclusions in feldspar, have diffuse boundaries and an average size of 0.1 mm. Large crystals to 5 mm appear to have crystallised at the same time as quartz and feldspar.
Biotite forms small equant grains of 0.6 mm or less. Pleochroic haloes are abundant, while pleochroism varies from α = medium brown to $\beta\sigma$ = very dark brown. Grain boundaries are ragged and irregular but vary from sharp to moderately diffuse.
Opaques occur as subhedral grains with incomplete square outlines. The maximum grain size is 0.4 mm, and several aggregates exist with a much finer grain size.

RS 522 GRANITE

FIELD NOTES: Outcrop area is of granite and pegmatite. Sample is of the granite; this sample may be comagmatic or related to RS 521.

THIN SECTION: The sample is similar to RS 521 except that it is poorer in plagioclase, plagioclase is more clacic, muscovite is slightly more abundant, is finer grained, and quartz exsolutions are more pronounced.

Mineral abundances are:

Quartz	Microcline	Oligoclase	Muscovite	Biotite
45%	35%	14%	5%	1%

Microcline has a relict grain size of only 1.2 mm in comparison with 7 mm for RS 521. Grid-iron twinning is strongly developed while sericitisation is minor . Myrmekitic lobes from oligoclase into microcline are common; these have an average size of 0.2 mm. Grain boundaries are diffuse and very irregular.

Oligoclase (An_{12}) has the same style of grain boundaries as microcline. Sericitisation is variable and patchy; also present are numerous very-fine-grained unidentifiable inclusions which give oligoclase a cloudly appearance.

Quartz appears to be strongly recrystallised. In zones of finer-grained quartz, there are some sharp straight grain boundaries with a few triple points. Larger grains have diffuse grain boundaries, undulose extinction, minor polygonisation and a maximum size of 1.5 mm. Quartz is also present in the myrmekitic lobes.

Muscovite, although elongate to 3:1 and to 1 mm long, is randomly oriented. Some crystals appear to have once formed a larger grain and to have formed from recovery processes of a deformed porphyroblast. Grain boundaries typically diffuse.

Biotite is disseminated, has an irregular shape, has an average size of 0.3 mm, and is pleochroic in dark brown and dark red brown shades.

RS 523 GNEISSIC GRANITE

FIELD NOTES: Granitic gneiss or gneissic granite, a faint but regular gneissosity is present. The sample is 5X background radioactivity (broad band).

THIN SECTION: The sample has many similarities in composition and texture to that of RS 521 and 522, except that there is a poor gneissosity which is defined by a good alignment of biotite (only 3% of the total rock volume). Other mineral species have a granular texture with highly irregular, ragged grain boundaries.
Mineral abundances are:

Microcline	Quartz	Plagioclase	Biotite	Muscovite
45%	30%	20%	3%	2%

Microcline is clear with only minor sericitisation; exsolved plagioclase within microcline contains abundant fine-grained muscovite. Some relict grains are to 2 mm but the more typical grain size is 0.7 mm. Grain boundaries are irregular and diffuse.
Plagioclase is noticeably more heavily sericitised than microcline. Compositon is approx. An_{12} - oligoclase. At times, sericitisation is controlled by position in plagioclase; greatest sericitisation occurs along certain albite twin planes and in those parts of a crystal with extensive pericline twinning. Indeterminable dusty inclusions are also present. Some grains are up to 1 mm across but the average is approx. 0.5 mm.
Quartz has a variety of shapes, sizes and forms. Relict large polygonised grains are to 1.8 mm across and have diffuse irregular grain boundaries. Smaller grains are apparently recrystallised and have sharper, straighter grain boundaries. Quartz lobes in feldspar have diffuse boundaries.
Biotite defines a good dimensional and crystallographic alignment. Grain boundaries are sharp, the average length is 0.8 mm, and the average length:breadth ratio is 3:1. Pleochroism is in brown shades; α = medium yellow brown to $\beta\gamma$ = very dark brown.
Muscovite is often closely intergrown with biotite. Coarser crystals are to a maximum of 2.7 mm long and average 1.5 mm long. The degree of alignment in the biotite gneissosity is noticeably poorer than that of biotite; most grains have a dimensional preferred orientaiton only. Diffuse boundaries are common.

Age of gneissosity is not definitely known but is probably D_1 The other, less-likely, possibly is that the granite is a syn-D_3 intrusive and the biotite gneissosity/schistosity is S_3.

RS 524 ADAMELLITE

FIELD NOTES: Granitoid with muscovite porphyroblasts and some feldspar blastesis; no gneissosity is present.

THIN SECTION: Massive granular texture dissimilar to that of granoblastic gneiss; grain boundaries are typically ragged and diffuse. Texture is similar to samples RS 521 and 522. Biotite and muscovite form small randomly oriented grains; several muscovite porphyroblasts are present.
Mineral abundances are:

Quartz	Oligoclase	Microcline	Muscovite	Biotite
35%	31%	30%	2%	2%

Oligoclase is extensively sericitised and often clouded with very fine-grained inclusions. The average size is 0.7 mm but several grains are up to 1.7 mm across; these large grains have a clear unaltered rim. Grain boundaries are diffuse and irregular, especially oligoclase/microcline boundaries; these boundaries are often myrmekitic.
Microcline is often clearer than oligoclase but muscovite inclusions are present. Grain boundaries are diffuse and irregular; average grain size is 0.7 mm.
Quartz has relict large grains to 1.8 mm containing polygonised subgrains but the average size is 0.8 mm. Rarely occurs as exsolved inclusions in feldspar. Grain boundaries into feldspar are extremely ragged; although ragged some of these are sharp and distinct.
Muscovite occurs as porphyroblasts to 4 mm across but mostly forms smaller equant grains less than 0.6 mm across. Large crystals have deeply embayed margins, while smaller crystals have diffuse boundaries. Some grains have gently curved (001) cleavages and hence slight undulose extinction. When occurring as small inclusions in feldspar, the average grain size is 0.015 mm.
Biotite occurs as small aggregates containing 5-10 grains; aggregates and individual grains are only poorly inequant and randomly oriented. Individual grains have an average size of 0.25 mm and pleochroism of α = brown to $\beta\gamma$ = dark brown.
Samples RS 521 and 522, and possibly 523, probably form a suite of related intrusives.

RS 525 · RETROGRESSED SILLIMANITE GNEISS

FIELD NOTES: Sample is of a pelitic segregation from feldspathic gneiss. Similar specimens in the area contain sillimanite and muscovite.

THIN SECTION: Only minerals present are sillimanite and muscovite. Sillimanite defines a relict schistosity/gneissosity, while muscovite occurs as large post-schistosity porphyroblasts and as extensive fine-grained retrogressive sericite.
Mineral abundances are:

Fine-grained Muscovite	Porphyroblastic Muscovite	Sillimanite
87%	9%	4%

Sillimanite schistosity

The schistosity is defined by a good alignment of individual sillimaite needles and elongate crystal aggregates. The sillimanite has a needle-like form with very slender crystals to 0.3 mm long.

Muscovite porphyroblasts

Porphyroblasts also occur only as relicts; the original grain size was at least 12 mm across but extensive retrogression has produced disjointed crystals in optical continuity.

Retrogression

The alteration is very extensive; most of the sample has been replaced by very fine-grained muscovite/sericite with an average grain size of less than 0.02 mm. Grain boundaries are apparently interlocking and produce an irregular mosaic, the fine grain size obscures detail.

The sillimanite schistosity is probably S_1. The timing of porphyroblast development and fine-grained retrogression is indeterminable from this sample.

RS 526 QUARTZ + MUSCOVITE + CHLORITE GRANOFELS

FIELD NOTES: Sample is from the same stratigraphic horizon as the ironstone at the nearby Olary Silver Mine, and is regarded as a lateral equivalent to the ironstone. The ironstone is known to be lenticular.

THIN SECTION: The texture is massive and granular but with a wide variety of grain sizes. In particular, quartz has a complete range in grain size below 2 mm. Grain boundaries are often irregular and diffuse. Other notable points are randomly-oriented muscovite porphyroblasts, and both disseminated and aggregated chlorite.

Mineral abundances are:

Quartz	Muscovite	Chlorite	Biotite	Opaques
85%	8%	5%	1%	1%

Quartz has a highly variable grain size with a gradual variation up to 2 mm. Large grains have undulose extinction and polygonisation; smaller grains contain undulose extinction only. Grain boundaries are highly variable but tend to be irregular and diffuse. The grain size variation appears to be from extensive recrystallisation; small quartz grains tend to have sharper and straighter grain boundaries.
Muscovite occurs as disseminated porphyroblasts to 0.9 mm long; the length:breadth ratio is 2.5:1. Crystals are randomly oriented, contain abundant very fine-grained opaque inclusions, and often have sharp distinct grain boundaries.
Chlorite forms small disseminated single crystals and chlorite-rich aggregates containing radial clusters. The chlorite is randomly oriented, and often intergrown with muscovite and apparently forms a stable pair. The average length is 0.2 mm with a maximum of 0.4 mm, while the average length:breadth ratio is 3.5:1 while the maximum is 5:1. Crystals have parallel length-slow extinction and pleochroism of α = moderate brown to $\beta\gamma$ = dark green; birefringence is low and anomalous.
Biotite is not chloritised and may stably co-exist with chlorite. Grains have diffuse boundaries, average length of 0.25 mm, and length:breadth ratio of 2.5:1. Pleochroism is α = moderate brown to $\beta\gamma$ = dark brown.
Opaques often border biotite crystals, are equant and subhedral with apparently cubic symmetry, and have a maximum size of 0.6 mm.

Texture and composition is probably more indicative of a vein deposit rather than originating as a granoblastic gneiss.

Note: This sample is referred to as DJF 255 in
Flint, D.J., 1977. Evaluation of the Olary Silver Mine and the Mount Perseverance Mine. Mineral Resour. Rev., S. Aust., 147: 68-78 and S. Aust. Dept. Mines and Energy report 77/145 (unpublished).

RS 527 QUARTZ + CHLORITE GRANOFELS

FIELD NOTES: Sample is collected from the same locality as RS 526, and the same general comments are applicable.

THIN SECTION: This sample is much coarser grained than RS 526; recrystallisation is far less evident and is apparently very minor. The primary grain size is probably represented. The mineralogy is similar to RS 526:

Quartz	Chlorite	Muscovite	Opaques
88%	10%	2%	<1%

Quartz forms poorly-elongate grains averaging 7 mm long but which are randomly oriented. Polygonisation is pronounced while grain boundaries are very irregular and sharp. Small amounts of quartz occur in aggregates of recrystallised grains where the average size is 0.3 mm.
Chlorite occurs in large elongate randomly-oriented aggregates. Within the aggregates are clusters of radiating chlorite with a radius of less than 0.1 mm. Aggregates are up to 6 mm long and contain greater than 99% chlorite (remainder is quartz).
Muscovite forms large irregular-outline porphyroblasts to 5 mm long with a length:breadth ratio of 3:1. Most of the muscovite forms as fine dust either disseminated or in trails along cracks through quartz. Occasionally it forms small crystals to 0.25 mm long with a length:breadth ratio of 2:1.
Opaques are disseminated, grain size to 0.4 mm, and are subhedral wth some partial hexagonal outlines.

Like RS 526, its origin is probably as a vein deposit rather than as a granoblastic gneiss.

Note: This sample is referred to as DJF 256 in
Flint, D.J., 1977. Evaluation of the Olary Silver Mine and the Mount Perseverance Mine. Mineral Resour. Rev., S. Aust., 147: 68-78 and S. Aust. Dept. Mines and Energy report 77/145 (unpublished).

RS 528 QUARTZOFELDSPATHIC GRANOFELS

FIELD NOTES: Outcrop area is just northwest of the Olary Silver Mine, and consists of very massive gneisses with a biotite gneissosity developed in only some outcrops. Samples without a gneissosity, including RS 528, are transitional in texture between gneisses and granitoids.

THIN SECTION: The texture is massive and granular with highly irregular grain boundaries. Muscovite and quartz indicate an original very coarse grain size; muscovite probably formed a porphyroblastic phase.
Mineral abundances are:

Quartz	Plagioclase	Muscovite
45%	40%	15%

Quartz often forms grains to 6.5 mm but averages 2 mm and is highly polygonised . Quartz/quartz boundaries are strongly sutured and diffuse. Quartz also forms as a few graphic intergrowths in plagioclase.
Plagioclase is heavily clouded with very fine-grained muscovite and indeterminable dusty inclusions. Cloudiness and alteration is particularly intense. Some contacts with quartz are highly diffuse. Compositon is probably albitic, possibly oligoclase. The average grain size is 1.5 mm.
Muscovite occurs in aggregates containing grains in only slight optical discontinuity. These probably represent a single larger grain originally. Some grains have undulose extinction, and kink bands in (001). Grain boundaries are diffuse but thin. Individual crystals have a maximum size of 1.7 mm.

Quartz + plagioclase + muscovite granofels

The origin is not definitely known, but a granoblastic gneiss origin is favoured over an igneous/hydrothermal granodioritic origin. Granofels terminology is adopted as it has less genetic implications.
Note: This sample is referred to as DJF 257 in
Flint, D.J., 1977. Evaluation of the Olary Silver and the Mount Perseverance Mine. Mineral Resour. Rev., S.Aust., 147: 68-78 and S. Aust. Dept. Mines and Energy report 77/145 (unpublished).

RS 529 BANDED CALC-SILICATE

FIELD NOTES: Sample is from dump material at the most eastern-northeastern workings of the Mount Perseverance Mine. The sample is banded and contains appreciable garnet. No obvious mineralisation is present.

THIN SECTION: A banded and granoblastic texture predominates. Bands are defined by distinct grain size variations and various mineral assemblages. A poorly-developed biotite schistostity is subparallel with the banding. Finer-grained bands have an average grain size of 0.03 mm and tend to be quartz + biotite rich. Coarser grained bands have a mineral assemblage of quartz + actinolite + calcite + garnet + opaques.
Overall mineral abundances are:

Quartz	Garnet	Biotite	Calcite	Actinolite
78%	7%	5%	4%	2%

Chlorite	Opaques
2%	2%

Quartz has a highly variable grain size; from a maximum of 0.9 mm down to smaller grains averaging 0.03 mm. Quartz is dominant in forming the granoblastic mosaic. In coarse-grained bands, boundaries are gently curved or straight but mostly diffuse, while in finer-grained bands boundaries are sharper. Extinction is even to slightly undulose.
Garnet is extensively embayed and forms anhedral grains with a very irregular outline. Several subhedral, but deeply embayed grains remain. Average grain size is 0.5 mm. Colourless to very pale brown.
Biotite defines a very poor dimensional and crystallographic alignment which is subparallel with the banding. Biotite is disseminated and hence the schistosity is suborindate to the granoblastic mosaic. Grains are equant to elongate, maximum length:breadth ratios are 3:1. Some grains contain pleochroic haloes; pleochroism is light to dark brown.
Actinolite often forms elongate crystals or crystal aggregates to 2mm long. Equant grains tend to be deeply embayed and produce disjointed, but optically continuous, grains.
Chlorite forms equant grains which contain partly radial aggregates. Pleochroism is in pale brown and green shades. Average size is 0.04 mm.
Opaques and limonite staining occur dominantly in garnet + actinolite bearing bands. Grains have very irregular forms and have an average size of 0.02 mm.

Banded metasandstone

The lithology has mineralogical affinities with banded calc-silicate. Noticeable is the presence of garnet + actinolite in the absence of plagioclase.

RS 530 · QUARTZ + MUSCOVITE SCHIST

FIELD NOTES: This sample is from the same mine dump as RS 529, it is a yellow fine-grained muscovite-rich schist. No obvious mineralisation is present, and like RS 529, the lithology does not crop out.

THIN SECTION: The sample is noticeably fine grained; the average grain size is only 0.04 mm. Quartz, muscovite and biotite are the dominant phases. Quartz tends to form a granoblastic mosaic while micas define a very poor schistosity. A muscovite-rich band may represent the original composition banding; the schistosity is distinctly across the banding. Several post-schistosity veins are comprised of extremely fine-grained quartz and albite. These grains have very diffuse boundaries and their average size is less than 0.01 mm.
Mineral abundances are:

Quartz	Muscovite	Biotite	Albite	Tourmaline	Garnet
50%	35%	14%	1%	trace	trace

Quartz grains tend to be equant and form a granoblastic mosaic; grain boundaries vary from straight and sharp to gently curved and diffuse.
Muscovite best defines the schistosity which is only very poorly developed. Grains vary from equant to elongate with a maximum length:breadth ratio of 3:1. Grain boundaries are often sharp.
Biotite grains show less alignment than muscovite and grain boundaries are noticeably diffuse. Shape and elongation is as for muscovite.
Dusty inclusions are abundant throughout.

The schistosity age is not known.

RS 531 RETROGRESSED QUARTZ + MUSCOVITE PEGMATITE

FIELD NOTES: Micaceous gneiss with a strongly-superimposed schistosity. The strong schistosity in this sample is S_3.

THIN SECTION: The sample contains a muscovite schistosity which wraps around relict fragments of a gneiss or pegmatite. These relicts are particularly coarse grained with grains to 7 mm long. Sections of the schistosity indicate an approach towards equilibrium textures.
Mineral abundances are:

Quartz	Muscovite	Chlorite	Opaques	Limonite
52%	40%	7%	<1%	trace

Gneiss relicts

These are up to 10 mm long and are elongate in the schistosity. The grain size is unusually coarse, some grains are to 7 mm long. Some of the gneiss relicts consist of large single grains. Clasts are composed essentially of quartz and muscovite, minor chlorite is present where gneiss grades into the enclosing schistosity. Clast boundaries are often sharp, some are gradational into zones which are probably extensively recrystallised gneiss and are now part of the schist. Large quartz grains are polygonised while muscovite has only minor curved (001) cleavage near the end of some grains.

S_3 schistosity

The schistosity wraps around gneiss relicts. Parallel with the schistosity is a mineralogical banding. Bands vary from muscovite-rich and fine grained to coarser grained and with abundant quartz and chlorite.
Muscovite-rich bands are almost entirely muscovite, which is fine grained with an average length of 0.08 mm and an average length: breadth ratio of 4:1. The schistosity is strongly developed with a very good dimensional and crystallographic alignment; the dimensional alignment is more strongly developed.
Quartz-rich zones are gradational into clasts and probably represent recrystallised gneiss. Within these zones is a good chlorite schistosity and a fair muscovite schistosity. Quartz varies from equant to elongate in the schistosity with a length: breadth ratio up to 4:1. Many grain boundaries are straight and sharp; some 120° triple point grain boundaries occur. Limonite staining occurs along many grain boundaries.
Chlorite often shows a near-perfect alignment but this is not uniform across the slide. The schistosity in these quartz-rich zones is more variable than in the muscovite-rich zones. Chlorite grains are particularly slender; grains are to 1 mm long with length: breadth ratios exceeding 5:1. Grain boundaries along (001) are sharp and straight. Pleochroism is in pale green and brown shades, birefringence is anomalous. Muscovite alignment is poor, grain size is finer and boundaries are more diffuse.

Retrogressed quartz + muscovite gneiss or pegmatite

The schistosity is S_3; extensive recrystallisation occurred during D_3 in this area.

RS 532 SCHISTOSE METASILTSTONE

FIELD NOTES: Grey diamictite containing gneiss clasts up to 20 cm across; this grades to a gritty metasiltstone containing the S_5 schistosity (Sample RS 532). The outcrop contains small isoclinal folds in bedding with the schistosity as axial plane; the specimen sectioned contains the schistosity parallel to bedding.

THIN SECTION: Specimen is of a gritty metasiltstone containing abundant quartz, feldspar and mica schist clasts. A superimposed schistosity wraps around and encloses the clasts. Mica schist clasts are difficult to distinguish from the schistose matrix; and very small quartz and feldspar clasts grade to quartz and feldspar in the matrix.
Mineral abundances are:

Quartz + feldspar	Biotite	Muscovite	Opaques
64%	25%	10%	1%

Clasts

Clasts range down in size from 1.5 mm and contain predominantly polygonised quartz and plagioclase; clasts are equant but with distinctly angular outlines. Although the clast boundaries are sharp, within clasts recrystallisation has been extensive and grain boundaries are often diffuse.
Schist clasts are up to 8 mm long and are highly elongate in the schistosity; their length:breadth ratio is often greater than 10:1. Smaller schist clasts grade into mica-rich portions of the schistose matrix. Micas within the clasts are fine-grained and oriented parallel to the enclosing schistosity. The schist clasts are dissimilar to Willyama Complex schists, and probably represent metamorphosed clay-rich clasts of Adelaidean age.

S_5 Schistosity

The schistosity is defined by a good alignment of both biotite and muscovite. Both minerals have similar sizes; an average length of 0.08 mm and a length:breadth ratio of 3:1. Boundaries are diffuse. Biotite has very distinctive red pleochroism of α = pale brown to $\beta\delta$ = deep reddish brown.

Schistose diamictite

The superimposed biotite + muscovite schistosity is S_5, and indicates recrystallisation during D_5.

RS 533 MICACEOUS GRANOFELS

FIELD NOTES: Sample is from a chlorite + muscovite schist which is about 30 m thick and occurs amongst feldspathic, granitic and amphibolitic gneiss. The unit has some lithological similarities to a quartz + chlorite + muscovite granofels, which occurs on the same stratigraphic horizon as the ironstone at the Olary Silver Mine. The schistosity present is dipping 60^{0} towards 132^{0}M.

THIN SECTION: The schistosity present in parts of the outcrop is very poorly represented by this sample; only some muscovite grains define a very weak alignment. Randomly oriented muscovite and chlorite dominate the texture.
Mineral abundances are:

Muscovite	Chlorite	Quartz	Biotite
55%	42%	2%	1%

Muscovite mostly occurs as disseminated porphyroblasts to 2 mm which are equant, have very diffuse margins and an irregular outline, occasionally contain undulose extinction, and contain abundant dusty inclusions. A common crystal size is 0.1 mm and these, in a few places, define a very weak alignment.
Chlorite crystals are elongate, randomly oriented, have a maximum size of 0.7 mm and have an average length:breadth ratio of 4:1. Crystals form dense interlocking networks and radiating clusters. Birefringence is purple and anomalous, while preochroism is pale brown (crystal length) to dark green.
Quartz is partly replaced by chlorite so that there is a strong tendency for passive brecciation; relict grains indicate an original grain size of at least 2 mm.
Biotite forms isolated crystals to 2 mm but the average size is 0.5 mm long. The average length:breadth ratio is 3:1 and crystals are randomly oriented. Pleochroism is α= pale green and moderate orange brown to $\beta\delta$ = deep orange brown and deep green.

Muscovite + chlorite granofels

Its origin is unknown, but there are mineralogical and textural similarities to a quartz + muscovite + chlorite granofels near the Olary Silver Mine.

RS 534 BIOTITE + MICROCLINE GRANOFELS

FIELD NOTES: A biotite schist crops out amongst feldspathic gneiss, often has a very poor schistosity and tends to be granoblastic; the lithology is not abundant.

THIN SECTION: Specimen is of a biotite + microcline granofels; elongate biotite grains are randomly oriented and there is no suggestion of an alignment or banding.
Mineral abundances are:

Biotite	Microcline	Quartz	Opaque + sphene	Garnet	Muscovite
47%	30%	20%	3%	<1%	trace

Plagioclase
trace

Biotite is elongate to 0.4 mm with a length:breadth ratio of 2:1 but the elongation is often not along (001). Grains are randomly oriented, have sharp grain boundaries and have very irregular shapes.
Microcline has undergone extensive recrystallisation; some crystals now consist of a fine-grained mosaic with adjacent grains in only slight optical discontinuity. Randomly oriented biotite, to 0.04 mm long, occur within these mosaics. Microcline grains within the mosaic have diffuse boundaries and an average size of 0.1 mm; the former grain size was at least 1 mm. Microcline is usually clear, with poor and variable development of grid-iron twinning, and often has small biotite inclusions.
Quartz has a coarser grain size than microcline and its grain size is apparently not as diminished by recrystallisation as microcline. The average grain size is 0.4 mm and undulose extinction is only weakly developed.
Opaques and sphene can occur in aggregates to 0.8 mm long. Individual sphene grains are equant and rounded with an average size of 0.1 mm.
Garnet is colourless, has irregular internal fractures and well-rounded shape; boundaries with biotite are sharp and distinct. Average size is 0.2 mm.

RS 535 MYLONITISED GRANODIORITE

FIELD NOTES: Outcrop area is of a massive granitoid which is cut by east-west shear zones; within the shear zones the abundance of chlorite and biotite increases. The shear layering is dipping 81° towards 350°M.

THIN SECTION: The specimen is of a sheared granite and contains a poorly-developed biotite schistosity; a weak deformational compositional banding is developed. Quartz is extensively recrystallised into fine-grained mosaics while albite shows deformed twin lamellae; one grain contains albite twin lamellae curved through 30°.
Mineral abundances are:

Albite	Quartz	Biotite	Muscovite	Chlorite
45%	33%	18%	3%	1%

Albite (An_8) occurs as large grains to 1.8 mm but the average (after recrystallisation) is now 0.8 mm. Large grains contain abundant fine-grained graphic intergrowths in irregular patterns. Sericitisatio is almost absent. Albite twinning is well developed while pericline twinning is minor.
Quartz occurs in aggregates with a well-developed granular mosaic texture; these are from deformation and recrystallisation of larger original grains. Within the mosaics undulose extinction is poorly developed, while grain boundaries are straight or gently curved and diffuse. The mosaics and rare large individual grains indicate an original grain size of at least 1.6 mm; the average grain size is 0.4 mm.
Biotite has a poor to fair alignment and principally defines the schistosity. Grains average 0.3 mm in length and have a length: breadth ratio of 2.5:1; grain boundaries are diffuse. Pleochroism is distinctly pale, from α = colourless to pale green to $\beta\gamma$ = pale to moderate green.
Chlorite has similar properties to biotite; except that grain boundarie are sharp; pleochroism is also in pale colours from colourless to very pale brown and green.
Muscovite is mostly a pre-schistosity phase, but when fine grained and intergrown with biotite, they show a poor alignment in the biotite + chlorite schistosity. Isolated muscovite porphyroblasts are to 3 mm long and have irregular embayed margins; smaller crystals occur as inclusions in quartz and albite.

Mylonitised granodiorite, probably contaminated or metasomatised. Alternative name if the host rock is not igneous, is a mylonitised albite + biotite granofels. The original grain size before mylonitisation, is probably between 1.6 mm and 3 mm. The schistosity present is S_m which is probably equivalent in age to D_3 or slightly post-D_3; aligned biotite, chlorite and minor muscovite define the schistosity.

RS 536 GRANITE

FIELD NOTES: Outcrop area is of massive granitic and quartzo-feldspathic gneisses, and massive granitoids. The gneissosity is poorly developed; most samples are massive (including RS 536).

THIN SECTION: Specimen has a massive coarse-grained granular texture with irregular and diffuse boundaries. Smaller grains are produced from recrystallisation; the original grains are often to 3 mm and rarely to 6 mm. No indications of a schistosity or gneissosity are present.
Mineral abundances are:

Microcline	Quartz	Oligoclase	Biotite	Muscovite	Opaques	Garnet
40%	35%	21%	2%	2%	<1%	<1%

Microcline has the coarsest maximum grain size of 6 mm, with many grains to 3 mm. Microcline is often perthitic with plagioclase inclusions averaging 0.2 mm across; plagioclase inclusions are more heavily sericitised than the microcline host. Plagioclase/microcline boundaries are mostly irregular and diffuse; some contain narrow myrmekitic borders.
Oligoclase (An_{20}) is extensively sericitised and contains only poorly-developed diffuse albite twinning. Average size is 2 mm.
Quartz forms large relict grains to a maximum size of 3.5 mm which are highly polygonised. Recrystallised large grains are now finer-grained mosaics containing straight or gently curved sharp grain boundaries, some 120° triple points and an average size of 0.5 mm.
Muscovite also has a maximum grain size of 3 mm and has irregular embayed margins. Most muscovite occurs as fine-grained inclusions in albite or along grain boundaries; these have a maximum length of 0.06 mm. Larger muscovite is elongate but often is not parallel with (001).
Biotite has a variable grain size; average length is 0.5 mm. Grain boundaries are sharp and only rarely diffuse; pleochroic haloes are abundant. Pleochroism is α = moderate yellow brown to $\beta\gamma$ = dark brown
Garnet is rounded, elliptical and to 0.6 mm in length: boundaries with biotite are sharp.
Opaques form disseminated small subhedral grains with an average size of 0.2 mm and incomplete hexagonal outlines; sphene is absent.

RS 537 . HORNBLENDE + ANDESINE GNEISS

FIELD NOTES: Gneissic amphibolite unit which is 6-7 m thick and conformable with quartz + feldspar + mica gniess. Some samples are massive and appear to be from recrystallisation and mobilisation.

THIN SECTION: Specimen has a poorly-developed gneissosity and is defined by a poor dimensional and crystallographic alignment of hornblende and opaques. Quartz and feldspars form equant grains. The mineral assemblage is dominated by hornblende and andesine, and is similar to all other amphibolitic gniesses.

Andesine	Hornblende	Opaques	Orthoclase	Quartz	Biotite	Epidote
56%	30%	8%	4%	2%	trace	trace

Hornblende has a poor dimensional and a weak crystallographic alignment. Some simple twins with sharp twin planes are present. Grain boundaries are sharp but irregular; average grain size is 0.9 mm but some grains are to 2.2 mm long.
Andesine is ragged with sharp grain boundaries; epidotisation and sericitisation is minor.
Opaques are elongate with ragged and irregular boundaries; the alignment parallel with the hornblende is good. Although the average grain size is 0.4 mm they range up to 1.4 mm.
Orthoclase tends to have a poorly-sericitised rim and inward concentric extinction; grain centres are clear and unaltered. Grain boundaries are irregular and vary from sharp to diffuse. Average grain size is 0.9 mm.
Quartz forms isolated grains to 0.4 mm but mostly exsolved grains in andesine; these grains are less than 0.1 mm across and have very diffuse boundaries. Larger grains have ragged diffuse boundaries.

Hornblende + andesine gneiss or gneissic amphibolite

The gneissosity is S_1.

RS 538 BIOTITE + ORTHOCLASE SCHIST

FIELD NOTES: Outcrop area is at the Old Pennynellie Bore where biotite schist crops out amongst quartzofeldspathic gneiss. This specimen is of one of the biotitic schists; as they contain abundant quartz and feldspar the sample is both granoblastic and schistose.

THIN SECTION: Most noticeable in the thin section is the very extensive recrystallisation of feldspars producing a mosaic of small grains with an average grain size of only 0.03 mm. A poor alignment and a weak banding of fine-grained bioite defines a weak schistosity. Numerous large biotite porphyroblasts show no alignment. Mineral abundances are:

Biotite	Orthoclase	Opaques/sphene	Quartz	Garnet	Epidote
41%	36%	12%	11%	<1%	trace

Biotite forms numerous large porphryoblasts to 2 mm long with a length:breadth ratio of 3:1; grain boundaries are irregular and vary from sharp to diffuse. Pleochroism is α = pale brown to $\beta\gamma$ = dark brown. Abundant smaller biotites tend to be aligned to define the schistosity and are characterised by highly diffuse boundaries. There is a complete gradation in grain size down from 2 mm; the average size is approx. 0.4 mm. Within orthoclase are fine-grained biotite inclusions.

Orthoclase shows amazingly extensive fine-grained recrystallisation; no coarse-grained relicts are preserved. The new grains have an average size of only 0.03 mm. Grains are clear and unaltered, grain boundaries are notably diffuse. Identification is tentative.

Opaques and sphene occur as bi-mineralic aggregates with equal mineral abundances; aggregates have a maximum size of 1.5 mm but average 0.15 mm. Aggregate margin is often defined by a rim of fine-grained ragged sphene.

Quartz contains weak undulose extinction, very irregular outlines; the average grain size is 0.2 mm and the maximum is 0.7 mm.

Epidote has pale yellow pleochroism and occurs as crystal aggregates with individual crystals of 0.09 mm across. Grain boundaries are sharp but irregular.

The ages and timing of the schistosity and extensive recrystallisation are not known.

RS 559 QUARTZ MYLONITE

FIELD NOTES: Sample is from the most eastern pit at the Faugh-a-Ballagh Mine and from within the east-west shear zone. Sample has weathering characteristics similar to many albitites.

THIN SECTION

Mineral abundances are:

Quartz	Opaques	Albite
70%	12%	18%

Staining tests indicate no K-feldspar

All minerals show a distinct alignment with length:breadth ratios of up to 3:1; ratios of 2:1 are common. Banding is notable and is produced from a variation in grain size and not composition. Coarse-grained bands exhibit an average grain size of 0.18 mm and sharper straight grain boundaries. Finer grained bands contain more inequant grains and have an average grain size of 0.04 mm. Many grain boundaries are irregular from the presence of numerous small new grains. Large grains are possibly annealed; the strong bimodal grain size distribution is probably from annealing.

RS 572 ALBITITE

Sample No. P440/76; TS 36699; PS 25097
Location: Faugh-a-Ballagh Mine; main shaft.
HAND SPECIMEN: Light coloured, fine-grained rock containing abundant haphazardly-oriented veins of hematite which range in width from about 1 mm to 1 cm.

THIN SECTION: An optical estimate of the constituents gives the following:

Albite	Opaques, semi-opaques	Muscovite, chlorite, secondary phyllosilicates	Carbonate
95%	5%	~1%	minute trace

This is a hematite-veined albite rock containing trace amounts of muscovite, chlorite and secondary phyllosilicates. The section is composed almost entirely of an interlocking mosaic of euhedral to subhedral albite crystals which range in size from about 0.1 to 1.5 mm, averaging about 0.3 mm. Most grains of albite are sieved by numerous minute inclusions of sericite and most show some iron staining along irregular internal fracture surfaces.
Opaques make up about 5% of the section and occur both as dissemination and as discontinuous irregular veinlets of variable orientation. In detail individual opaque grains average about 0.1 to 0.2 mm in diameter and are generally equant to slightly elongated. The discontinuous veinlets and disseminations of opaque material are associated with traces of secondary opaques (?secondary iron oxides) and secondary phyllosilicates. The last are generally iron stained and are probably after original K-feldspar or an unknown ferromagnesian mineral. Traces of chlorite are associated with some of the secondary phyllosilicates.
In addition to occurring as sericite which sieves most albite grains, muscovite forms isolated flakes which range up to about 0.3 mm in lengt and which tend to be preferentially associated with the opaques.
The section also contains minute traces of carbonate.

The origin of this rock is uncertain. On the one hand it may be a fine to medium-grained albitic sediment which has suffered hematite veining and on the other it may be a metasomatic or igneous albitic rock which has suffered hematite veining. The absence of heavy mineral and related grains suggests that the rock is not a sediment, however the texture is not particularly suggestive of an igneous origin. Albitic igneous intrusives may be expected to contain associated minor amounts of, for example, quartz and micropegmatite. It is tentatively suggested that this rock is of metasomatic origin and probably occurs within or close to a major granitic intrusion.
In polished section the opaques consist of a mixture of martitized magnetite, which mainly occurs as equant crystals, in association with lesser amounts of specular hematite. The latter occurs as elongate and splintery crystals which in detail contain minute scallop-shaped inclusions of ilmenite and occasional inclusions of silicate.

Albite or albite granofels

This lithology grades southwards into calc-silicate.

RS 573 IRONSTONE

Sample No: P441/76; RS 36700; PS25098
Location: Faugh-a-Ballagh Mine area; from the ironstone on the hill top above the main shaft.
HAND SPECIMEN: Finely-banded hematite and secondary iron oxide-rich, dark brown, cherty rock.

THIN SECTION: An optical estimate of the constituents gives the following:

Quartz	Opaques, semi-opaques	Iron-stained secondary phyllosilicates
75%	15%	10%
	Muscovite, sphene trace	

In thin section this rock is readily divisible into opaque-rich and opaque-poor bands which average about 1 to 2 mm in thickness. The thicker, opaque-rich bands consist of an interlocking mosaic of euhedral to subhedral opaques associated with lesser amounts of quartz and secondary phyllosilicates. The opaques average about 0.5 mm in diamter and are intimately associated with discontinuous patches of iron-stained secondary phyllosilicates, which appear yellow-orange under plane polarized light, which range up to about 4 mm in extent. The thicker opaque-rich bands contain numerous rounded to scallop-shaped inclusions of quartz which average about 0.2 mm in size. The thinner opaque-rich bands range down to about 0.5 mm in thickness and consist of about equal proportions of euhedral, fine-grained (less than and up to 0.1 mm) opaques and fine-grained quartz (less than and up to 0.3 mm) associated with blob-like areas of secondary phyllosilicates which range up to about 2 mm in extent. The opaque-poor bands average about 1 to 1.5 mm in thickness and consist largely of an interlocking mosaic of quartz grains which average about 0.3 mm in diameter. The quartz grains are typically anhedral and sutured and show weak undulose extinction and there is a slight tendency for the quartz grains to be elongated in the direction of banding as defined by the discontinuous stringers of opaques. The section contains minor trace amounts of very fine-grained muscovite grains, generally associated with quartz.
Prior to alteration this rock was probably a cherty ironstone which contained poikiloblasts and porphyroblasts of an unknown metamorphic mineral which has now been entirely replaced by iron-stained secondary phyllosilicates.
In polished section the opaques consist almost exclusively of martitized magnetite euhedra which are associated with minor areas showing microbotryoidal textures about ?voids. In detail, these areas consist of a mixture of geothite and lesser secondary hematite. Locally these secondary iron oxide areas appear to be forming boxworks after ?carbonate grains. No other opaque phases were observed in the section.

Prior to alteration this rock probably consisted largely of quartz and magnetite in association with lesser amounts of an unknown metamorphic silicate mineral. The rock was probably originally a chemical or volcano-chemical sediment.

Equivalent to other ironstones near Ameroo Hill and the Olary Silver Mine, and the one represented by sample RS 408.

RS 574 ALBITITE

Sample No: P442/76;
Location: Faugh-a-Ballagh Mine area; eastern workings

HAND SPECIMEN: Light grey, very weakly veined and fractured, fine to medium-grained, featureless feldspathic rock.

THIN SECTION: An optical estimate of the constituents gives the following:

Albite	Opaques	Quartz, chlorite, secondary phyllosilicates, biotite, sphene, apatite
95%	3-5%	1-2%

This is an albitic rock of uncertain origin which is composed almost entirely of an interlocking mosaic of fine to medium-grained albite euhedra and subhedra which contains a sprinkling of fine-grained opaques.
Albite grains are characteristically anhedral to subhedral and average about 0.5 mm in diameter, although the variation in size is from about 0.01 to 2.0 mm. Deformation features, such as undulose extinction effects and bent and kinked twin lamellae are not uncommon throughout the section. Boundaries between adjacent albite grains are typically sutured rather than straight.
Opaques are more-or-less evenly disseminated through the albite mosaic and occur as euhedral to anhedral grains and patches, which range in size from about 0.01 to 2.0 mm, averaging about 0.1 mm.
The most common accessory mineral in the rock is apatite which occurs as evenly-disseminated grains which range up to about 0.3 mm in size. In detail the apatite grains are highly irregular in outline and contain numerous irregular fractures, and, under crossed polarizers, appear weakly anisotropic. The apatite crystals appear slightly leached along grain boundaries and fractures.
The section is transected by several narrow (less than 0.5 mm thick) quartz-rich veins which contain lesser amounts of chlorite, secondary phyllosilicates and biotite. Some of the veins are preferentially enriched in narrow discontinuous stringers of opaques.
The section also contains trace amounts of extremely fine-grained sphene and incipient iron staining and alteration to secondary phyllosilicates is evident in the albite grains throughout the section.

In polished section the opaque minerals consist almost entirely of magnetite euhedra and subhedra which show very slight alteration to secondary hematite (martite), about margins and along internal octahedral cleavage lines. In detail, some of the magnetite grains contain minute, bleb-like inclusions of ilmenite. No sulphides were observed in any of the narrow cross-cutting veinlets, however considerable plucking has occurred during section preparation and there is a possibility that some may have originally been present.

The origin of this rock is conjectural. It may have originally been an albitic sediment or formed as a metasomatic rock; in either case the rock suffered some late-stage deformation and veining. The rock does not appear to have suffered high-grade regional metamorphism as grain boundaries are generally sutured rather than sharp and equilibrated.

Albitite or albitic granofelsels

The specimen is located within an east-west shear zone; movement on the shear is apparently late - to slightly post-D_3. Deformation features, such as kinked albite twin lamallae, are produced during this event.

RS 575 ALBITITE

Sample No: P443/76; TS36702; PS25100
Location: Faugh-a-Ballagh Mine area; eastern workings

HAND SPECIMEN: A somewhat brecciated, weakly-banded, iron oxide-bearing, pinkish-grey felsic rock.

THIN SECTION: An optical estimate of the constituents gives the following:

Albite	Opaques	Quartz	Jarosite	Secondary phyllosilicates, apatite
~80%	10%	10%	trace	trace

This is an intensely brecciated and somewhat silicified albitic rock containing a moderate proportion of primary iron oxides. Under plane polarized light it is weakly divisible into opaque-rich and opaque-poor bands which range up to about 2 mm in thickness although overall the rock is composed simply of a mosaic of interlocking albite and opaque crystals in association with minor amounts of secondary silica.
Under crossed polarizers the texture of the rock is clearly indicative of intense deformation. Highly sutured and deformed albite grains and clusters of grains ranging up to about 2 mm in extent reside in a sea of finer-grained albite and lesser fine-grained quartz. There is a weak tendency for both the finer and coarser-grains to be oriented in a common direction parallel to the banding. Deformation effects, such as marked undulose extinction in albite and quartz grains and deformed and kinked twin lamellae in albite are evident throughout the section. Wheras the largest grains range up to about 2 mm in length, the average grain size is generally less than 0.1 mm. Opaques are disseminated throughout the section however, as mentioned above they are preferentially segregated into bands which range up to about 2 mm in width. In detail opaques are generally euhedral to subhedral and average about 0.1 mm in diameter. Most grains are equant in shape, although a few elongated grains are also present. Opaques show some alteration to secondary iron oxides and these have preferentially precipitated along cleavages and grain boundaries.
In some zones there are a few polygonal leached voids, 0.1 to 0.3 mm in size, and in one area some of these voids contain jarosite suggesting that pyrite may have been present. Iron-stained secondary phyllosilicate patches are evident throughout the section, forming somewhat irregular patches which range up to about 0.2 mm in extent, and the section also contains one or two tiny apatite crystals.

In polished section the opaques consist simply of a mixture of strongly martitized magneite euhedra and subhedra in association with fewer primary hematite laths. A few minute grains of ilmenite were noted within some of the magnetite relics. No other opaque phases were noted.

This rock appears to have been an albite-primary iron oxide-bearing rock, similar to those described above, however it has suffered intense brecciation with attendant loss of primary textural features.

Banded albitite or mylonitised albite + opaques granofels

The sample is located on a major east-west shear; movement along the shear was late - to post-D_3. Deformation within the slide was produced during this event. Features are very similar to RS 574.

RS 576 SULPHIDE-BEARING IRONSTONE

Sample No: P444/76; TS 36703; PS 25101
Location: Faugh-a-Ballagh Mine area; from the small working near the hill top and to the east of the ironstone.

HAND SPECIMEN: Dark, medium-grained, quartz-rich rock containing a moderate proportion of primary and secondary iron oxides in association with primary copper sulphides and secondary copper carbonate.

THIN SECTION: An optical estimate of the constituents gives the following:

Quartz	Opaques	Green biotite	Secondary phyllosilicates, chlorite
80%	15%	3%	2%

Garnet, apatitie, sphene
minute trace

This is a weakly mineralized, iron oxide-bearing quartzite which contains accessory amounts of green biotite, chlorite and secondary phyllosilicates.
Quartz is the dominant mineral in the rock and occurs as a mosaic of anhedral to subhedral grains which range in size from 0.1 to 1 mm, averaging about 0.5 mm. Grain boundaries are variably almost straight to somewhat sutured and most grains exhibit weak undulose extinction although the effects of intense deformation and/or recrystallization are not evident.
Opaques make up about 15% of the rock and occur both as patches, ranging up to about 3 mm in extent, (which are sieved by silicates) and as solitary grains. The majority of grains are less than about 0.2 mm in dimater and most are subhedral and equant, although a few lath-like grains are also present.

The rock is transected by several highly discontinuous veins which range up to about 0.5 mm in thickness, which contain abundant green biotite in association with minor chlorite and some secondary phyllosilicates. The chlorite is largely an alteration product of the green biotite which occurs as laths and flakes averaging about 0.2 mm in length. The green biotite is markedly pleochroic from yellow-green to colourless and is closely associated with secondary phyllosilicates. Some of the larger opaque areas seem to be semi-enveloped by patches of green biotite, chlorite and secondary phyllosilicate although it would be difficult to be certain whether the opaques were introduced at the same time as the biotite. The section contains traces of apatite and some malachite in altered grains. The rock is somewhat weathered. This is indicated by the observation that most quartz grains are outlined by thin films of semi-opaque secondary phyllosilicates and secondary iron oxide.

In hand specimen, in addition to containing iron oxide, the sample clear ly contains an accessory amount of chalcopyrite and its secondary alteration product malachite. In polished section the dominant opaque phase is magnetite which is variably altered to martite about the margins of grains and along internal fractures. The second most abundant opaque phase is goethite which contains associated with it several relics of chalcopyrite in part showing alteration to minerals such as covellite, chalcocite and bornite. Under crossed nicols several patches of malachite were also identified. Some of the goethite patches show microbotryoidal textures and rather weakly-developed chalcopyrite box works. In addition to the above-mentioned phases there is also a small proportion of what appears to be primary hematite laths dispersed through the section and associated with the geothite are very minor amounts of secondary hematite.

RS 576 (cont).

This rock appears to have been an iron-bearing quartzite containing accessory amounts of chalcopyrite which later suffered weathering and oxidation. The textural evidence is not sufficiently strong to indicate whether the copper was an integral part of the rock or whether it was introduced along veins and fractures.

The sample was obtained from shallow workings which are located to the east of the ironstone and the hill top. Sulphides are probably an introduced phase.

RS 894 GRANODIORITE

FIELD NOTES: Granite in contact with gneiss. Sample is more siliceous and finer grained than granite away from the contact. Intrusion age may be the same as samples RS 902 and 903.

THIN SECTION: The texture is allotriomorphic granular with a coarse average grain size of 1 mm, many plagioclase grains are to 2 mm. New small recrystallised grains are not as abundant as in other samples. Mica abundance is very low.
Mineral abundances are:

Oligoclase	Quartz	Orthoclase	Biotite	Muscovite	Opaques
50%	43%	5%	1%	1%	trace

Oligoclase ($\sim An_{27}$) often has slightly deformed or kinked twin lamellae. One thin irregular zone across the slide is marked by more intense deformation of plagioclase and extensive new small grains. This is apparently a superimposed feature. Fine-grained muscovite is common within oligoclase; these are often elongate along the feldspar cleavage and are much less than 0.01 mm long. Grain boundaries tend to be gently curved and somewhat lobate.
Orthoclase has similar properties to plagioclase, including sericitisation.
Quartz boundaries tend to be more lobate and rounded. Also occurs as small rounded subgrains in feldspar; these have an average size of only 0.02 mm.
Muscovite forms embayed grains to 1 mm across; these vary from equant to slightly elongate. No preferred orientation is defined by the elongate grains. Grain boundaries are diffuse.
Biotite forms small equant to poorly-elongate grains with an average size of only 0.2 mm. Pleochroism is in dark olive green colours.

RS 895 SILLIMANITE GNEISS

FIELD NOTES: Sample is typical of gneiss for this area; outcrop area is of granite (RS 894) and this gneiss type.

THIN SECTION: Retrogressive sericitisation is superimposed on a coarse grained gneissic texture. These retrograde bands transgress the slide in several orientations and consist of extremely fine-grained sericite. Plagioclase and quartz are often pervaded by sericite producing passive fragmentation; fragmented gneiss grains remain in optical continuity. Sillimanite occurs only within these sericite bands.

Mineral abundances are:

Within gneiss relicts		Within sericitic bands	
Andesine	36%	Sericite	25%
Quartz	25%	Sillimanite	2%
Biotite	7%	Cordierite?	1%
Muscovite	3%	Chloritoid	trace
Opaques	1%		

Gneissosity

Biotite shows a poor to fair alignment (dimensional and crystallographic) to define the S_1 gneissosity. Muscovite shows a poor dimensional, and a very poor crystallographic, alignment in S_1. Many muscovite grains are randomly oriented. Quartz and feldspar form a granular mosaic.

Andesine ($\sim An_{31}$) occurs as relict large grains to 2 mm; recrystallisation has reduced the average grain size to 1.2 mm. Grain boundaries are often gently curved and quite sharp; boundaries with quartz are particularly lobate and embayed. Some boundaries are very irregular and/or diffuse. Disseminated sericitisation is absent; sericitisation occurs in bands which leave new 'subgrains' in optical continuity.

Quartz forms primary grains to 3 mm long; grains are usually equant with embayed boundaries with andesine. Many small rounded grains occur within andesine; these have an average size of 0.02 mm.

Biotite has noticeably smoother straighter grain boundaries. Their alignment principally defines the gneissosity. Pleochroic haloes are abundant while pleochroism is from pale to dark brown. Grains are to 3.5 mm long with a length:breadth ratio averaging 4:1.

Muscovite forms large grains to 3 mm which are often equant; if elongate they vary from randomly oriented to occasionally aligned in the gneissosity. Boundaries are often embayed and irregular. The alignment in S_1 is occasionally dimensional only.

Opaques occur as equant anhedra to 0.5 mm with some straight edges.

Sericite bands

These have several orientations; all consist of very fine-grained sericite which is randomly oriented. Grain size is very much less than 0.01 mm.

Sillimanite forms very wispy mats to 2 mm long.

Cordierite? forms highly corroded grains (replaced by sericite) which are twinned and of low birefringence.

Chloritoid forms small subhedral to euhedral grains within a sericite matrix; their average size is 0.02 mm.

RS 896 GRANODIORITE

FIELD NOTES: Forms part of the same granite body as RS 894. Staining indicates about 7-10% K-feldspar. Sample is massive, medium to coarse grained, leucocratic and with 1-2% randomly - oriented biotite grains.

THIN SECTION: The sample is coarse grained and has an allotriomorphic granular texture. Some plagioclase grains are to 7 mm long although the average grain size is about 2 mm. Plagioclase may form a porphyritic phase; microcline is distinctly interstitial to plagioclase and quartz. Grain boundaries are irregular and often quite sharp.
Mineral abundances are:

Andesine	Quartz	Microcline	Biotite	Muscovite	Opaques	Chlorite
50%	37%	8%	2%	2%	<1%	trace

Andesine ($\sim An_{32}$) is noticeably more sericitised than microcline. The fine-grained muscovite varies from randomly oriented and equant, to elongate along the feldspar cleavage. Minor slightly curved twin lamellae exist. Within large andesine grains are equant to rounded subgrains of quartz and plagioclase which are up to 0.5 mm across.
Microcline is weakly perthitic with equant plagioclase subgrains which tend to have polygonal boundaries. Grains are only poorly sericitised, and it tends to occur as an interstitial phase to quartz and andesine.
Muscovite forms deeply embayed equant anhedra to 2 mm across; some immediately adjacent and disjointed grains are in optical continuity. Grain boundaries are diffuse.
Biotite is smaller than muscovite; grains vary from equant embayed anhedra to elongate randomly-oriented laths. Typical elongate grains are 1 mm long with a length:breadth ratio of 3:1. Opaques often crystallise with biotite. Pleochroic haloes are abundant; pleochroism is pale brown, pale green brown to dark green brown. Some biotite grains are chloritised, producing aggregates of fine-grained randomly-oriented chlorite, with opaques.

The sample is very similar to RS 894; the two are equivalent samples.

RS 897 RETROGRADED MICA GNEISS

FIELD NOTES: Micaceous gneiss which crops out amongst feldspathic gneiss, pegmatite and granitoid. Looks to have once contained sillimanite; magnetic porphyroblasts are present.
Staining indicates no K-feldspar.

THIN SECTION: A broad mineralogical banding is present which has a poor parallel schistosity. Quartz + chlorite bands alternate with broad sericitie + muscovite bands. Muscovite-rich bands are very fine grained and contain a slight schistosity almost at right angles to the banding.
Mineral abundances are:

Fine-grained muscovite	Quartz	Muscovite	Biotite	Chlorite	Opaques
45%	32%	13%	6%	4%	trace

Tourmaline	Sillimanite	Staurolite
trace	trace	trace

Quartz-rich bands

These have a granular texture from quartz, and a poorly-developed schistosity from aligned chlorite.
Quartz boundaries are often sharp, lined with limonite, and vary from straight to irregular. Average grain size is 0.7 mm. Grains are equant and have undulose extinction.
Chlorite shows a poor alignment parallel to the banding. Grain boundaries are often sharp and straight. Average length is 0.6 mm, length:breadth ratio is 3:1. Pleochroism is pale brown to moderate green; birefringence is anomalous.
Opaques have two forms. They occur as subhedral crystals with trigonal to hexagonal outlines to 0.3 mm across, and as an equant aggregate of anhedral grains which is 2 mm across.

Muscovite-rich bands

These bands are broad and consist predominantly of very fine-grained muscovite or sericite; average grain size is 0.01 mm. This fine-grained sericite shows a fair to poor alignment which is almost at right angles to the mineralogical banding.
Large muscovite flakes are to 3.5 mm long; these define a very poor dimensional, with or without a crystallographic, alignment parallel to the mineralogical banding. Many grains are randomly oriented or equant. Grain boundaries are embayed and irregular.
Tourmaline forms small euhedral crystals with colourless to deep blue green pleochroism; maximum length is 0.3 mm.
Biotite is concentrated mostly within these muscovite-rich bands. Grains are equant, to 1 mm across, have an irregular outline and contain abundant pleochroic haloes. Pleochroism is pale brown to dark brown green and dark red brown.
Sillimanite is a very minor phase and occurs as slender needles within large muscovite flakes.
Staurolite - one large anhedral grain which is 1.2 mm across; is slightly elongate across the mineralogical banding.

The schistosity age(s) is not known. Unusual, is the complete absence of feldspar. The sample has mineralogical affinities to a gneissic version of a quartz + muscovite schist.

RS 898 SCHISTOSE QUARTZOFELDSPATHIC GRANOFELS

FIELD NOTES: The sample is fine grained and banded. Although biotite is present and aligned, it is disseminated and hence the granoblastic quartz and feldspar dominate the weathering style. The lithology has many similarities to feldspathic granofels which are often found in close proximity to calc-silicate horizons.

THIN SECTION: Two distinct textural features are present. A very strongly-developed biotite schistosity is superimposed on a granoblastic mosaic of quartz and feldspar. Banding, which is readily evident in hand specimens, is defined by only slight biotite abundance variations and quartz + feldspar grain size variations. Banding defines S_o while the biotite schistosity is S_1; they are parallel. Quartz and feldspar have an average grain size of 0.2 mm; maximum size is 0.7 mm.
Mineral abundances are:

Microcline	Quartz	Biotite	Plagioclase	Opaques	Muscovite	Apatite
35%	30%	14%	10%	7%	4%	trace

Microcline is only very rarely elongate in the biotite schistosity; maximum elongation is to 2:1. Grain boundaries very irregular. Stringlet perthite is present.
Plagioclase is noticeably poorly twinned.
Quartz occurs as small rounded grains completely enclosed by feldspar; these grains have a maximum size of 0.05 mm.
Biotite exhibits an extremely good alignment producing a very good schistosity. Biotite grains are disseminated; weathering style is is of a granofels, not of a schist. Maximum length is 1 mm while the average is 0.4 mm; average length:breadth ratio is 3:1. Pleochroic haloes are present; pleochroism varies from pale yellow brown to dark brown. Outlines are sharp but irregular and embayed.
Muscovite is smaller and not as elongate as biotite; their alignment is considerably poorer. Many muscovite crystals occur along quartz/feldspar grain boundaries, and have the orientation of the boundary and not S_1.
Opaques are subhedral with numerous straight-edged forms; average size is 0.03 mm.
Apatite forms rounded grains to 0.3 mm across.

Mineralogical banding is S_o, while the parallel biotite schistosity is S_1. Although the biotite schistosity is very strongly developed, the granoblastic texture is dominant.

RS 899 QUARTZ + ALBITE GRANOFELS

FIELD NOTES: Outcrop consists of a quartz + albite granofels containing large streaks of biotite. This sample lacks the biotite streaks but is otherwise typical; this type of lithology grades into that represented by RS 898. Staining indicates no K-feldspar. The sample is pinky-white with a fine-grained saccharoidal texture; small clots of randomly oriented biotite are present.

THIN SECTION: A granoblastic texture is pronounced; a very very weak dimensional alignment of some quartz and feldspar is present. This dimensional alignment would represent S_1. Average quartz and plagioclase grain size is 0.2 mm.
Mineral abundances are:

Quartz	Albite	Muscovite	Chlorite + biotite	Opaques
55%	42%	1%	1%	1%

Quartz and albite are difficult to distinguish, much of the plagioclase is untwinned to poorly twinned. Dusty inclusions are present in quartz and feldspar. Limited data suggests that the plagioclase is albite with an anorthite content of less than An_5. Many grain boundaries are gently curved to lobate, most are diffuse though a few are sharp. Maximum elongation is 1.5:1.
Muscovite commonly forms small ragged grains 0.2 mm across. Isolated larger grains are to 1 mm; these are ragged and deeply embayed. Grain edges are diffuse. Web-like rutile needles are present in basal sections.
Chlorite is randomly oriented and has an average size of 0.2 mm. Isolated larger grains are to 1 mm and are probably pseudomorphing biotite. Chloritised biotite is present. Many small opaque inclusions are oriented along the chlorite (001) cleavage. Pleochroism is pale brown to moderate green; birefringence is anomalous.
Opaques are subhedral with numerous straight-edged forms; average size is 0.3 mm.

RS 900 QUARTZ + ALBITE GNEISS

FIELD NOTES: Gneiss where quartz + feldspar greatly exceeds the total mica content. Present are thin sericitic bands; these have the typical grey silky sheen. The sample from which the thin section was cut contains: - a fine-grained gneiss portion
- a thin sericite band
- a coarse-grained gneiss or pegmatite

Staining indicates a trace of K-feldspar in the coarse-grained pegmatite portion.

THIN SECTION: As for the hand specimen, the thin section contains several parts. About 5% of the sample consists of a thin band of muscovite + sillimanite, which transgresses the middle of the slide and separates two contrasting textures. A fine-grained gneiss with a biotite gneissosity is separated from a very coarse-grained pegmatite.

Gneiss

The gneissosity, which is S_1, is defined by a good dimensional and crystallographic alignment of biotite. A few elongate opaque grains are also aligned, as are muscovite grains.
Mineral abundances are:

Albite	Quartz	Biotite	Opaques	Muscovite
46%	45%	7%	1%	1%

Biotite has an average length of 0.5 mm and a length:breadth ratio of 5:1; some grains are up to 1.2 mm long. Pleochroic haloes around small radioactive inclusions are present; pleochroism is straw yellow to dark brown. Boundaries are sharp and often straight.
Albite ($\sim An_5$) has particularly lobate boundaries with quartz. These are distinctive and pronounced. Boundaries vary from sharp to diffuse. Average size is 1 mm while sericitisation within grains is minor.
Quartz grain size is similar to albite; small grains are obviously from subgrain development. Boundaries of subgrains are often straighter but still diffuse.
Muscovite flakes are to 0.3 mm and also show a good alignment in the gneissosity.
Opaques are usually equant to very poorly elongate; when elongate they are aligned in the gneissosity. Maximum length:breadth ratio is 2:1. Boundaries are sharp and straight to slightly irregular. Near the sericite band, all grains are rimmed with fine-grained muscovite; much of it is oriented perpendicular to the grain margin.

Muscovite band

This forms a discontinuous band across the slide; maximum width is 3 mm. The band is parallel to the gneissosity and may represent a retrograded pelitic band.
Mineral abundances are:

Muscovite	Sillimanite
97%	3%

Sillimanite is restricted to a narrow zone along the middle of the band. Sillimanite needles are very fine; there is a strong alignment along the length of the band.
Muscovite has two forms. Large flakes are up to 3.5 mm long with a length:breadth ratio greater than 5:1; these have a dimensional alignment along the length of the band. Large muscovite contrasts with the majority of the muscovite which is extremely fine grained. It defines an indefinite schistosity parallel to the sillimanite and

RS 900 (cont.)

large muscovite. Grain boundaries are intensely sutured.

Pegmatite

This is particularly coarse grained; grains are up to 10 mm across. Distinctive is the pervasion of muscovite which has fragmented grains and invaded along thin fractures. Much of the coarse grain size is diminished by fragmentation, invasion by fine-grained muscovite, and rotation of the new grains. Many of the grains have a rim of fine-grained muscovite which is oriented perpendicular to the grain margin. Mineral abundances are difficult to establish because of the coarse grain size. The same phases are present as in the gneissic portion; abundances are probably very similar too.

Albite ($\sim An_5$) has a maximum grain size of 10 mm. Twinning, particularly pericline, is pronounced. Large grains are fragmented by sericite/muscovite. Former larger grains either remain in optical continuity or are in only slight optical discontinuity. Stress cracks are evident within some grains. Near the sericite + sillimanite + muscovite band, plagioclase contains deformed twin planes. Average grain size is 2 mm; small grains are obviously from fragmentation and rotation.

Quartz has a maximum observable grain size of 8 mm. Undulose extinction is pronounced. Many features are similar to those of albite.

Biotite forms large grains to 3.5 mm but the average is 1.5 mm. Grains vary from equant to elongate. When elongate, it has a length: breadth ratio of up to 4:1; this elongation is dimensional and not crystallographic, and there is no alignment. Boundaries are sharp and a little embayed. Pleochroism is from straw yellow, pale yellow brown to dark brown.

Muscovite is often intergrown with biotite and has similar size and shape properties. Distinctive is concentration of tiny opaque grains near the rim of muscovite.

Opaques are subhedral with trigonal and hexagonal forms. Average size is 0.15 mm.

S_1 gneissosity contains biotite + muscovite + opaques. Possibly sillimanite in the muscovite-rich band is aligned along S_1. Timing of retrogression is not definitely known. Pegmatite formation is most probably during D_1.

RS 901 GRANODIORITE

FIELD NOTES: Outcrop of granite amongst migmatitic and feldspathic gneiss. Hand specimen is of a pink massive medium-grained granite. Staining indicates 20-25% K-feldspar.

THIN SECTION: The texture is allotriomorphic granular. Strong grain-size variations are evident. Some plagioclase crystals are to 2 mm while extensive recrystallisation has reduced most of the quartz to an average size of 0.3 mm. Deformation features are evident:

- muscovite basal plates have undulose extinction
- muscovite (001) cleavages are gently curved
- plagioclase has pronounced undulose extinction
- albite twin lamellae are gently curved and, in several cases, are folded.

Quartz is more extensively recrystallised than the other phases.
Mineral abundances are:

Plagioclase	Quartz	Orthoclase	Muscovite	Biotite + Chlorite	Opaque	Epidote
40%	35%	20%	3%	1%	<1%	trace

Plagioclase, like quartz and orthoclase, has some extremely irregular boundaries, most boundaries are irregular and diffuse. Disseminated sericitisation of plagioclase is extensive. Maximum grain size is 2 mm while the average is 1 mm.
Quartz grains are to 1.8 mm, grains at 0.3 mm are abundant. These smaller grains form aggregates up to a maximum size of 2 mm; they represent recrystallised grains. Their recrystallisation has apparently exceeded that of plagioclase and muscovite which still contain deformed lattices.
Orthoclase has few inclusions but is weakly perthitic; plagioclase inclusions are usually as small grains. Boundaries with plagioclase are particularly lobate but in detail are still irregular and diffuse. Orthoclase possibly tends to form an interstitial phase to quartz and plagioclase.
Muscovite often forms as small inclusions in plagioclase, these grains are commonly elongate along feldspar cleavages. Larger primary grains are to 1.6 mm across and are ragged embayed anhedra. Cleavage (001) is curved (deformed).
Opaques crystallise with biotite and chloritised biotite. Grains are ragged but subhedral with a few straight edges. Average size is 0.3 mm. Biotite, chloritised biotite and trace epidote all form small elongate aggregates along quartz/feldspar grain boundaries.

Equivalent samples are RS 894 and 896.

RS 902 . ADAMELLITE

FIELD NOTES: Outcrop area is 95% granite, this sample contains more abundant biotite than an 'average' or 'typical' sample of this granite.

THIN SECTION: The texture is allotriomorphic granular, coarse grained and with noticeable highly irregular and diffuse boundaries. Textural characteristics are very similar to RS 907 and 908. Quartz and feldspar grain boundaries are always irregular, but vary from an occasional sharp grain boundary, to the more typical diffuse boundary. Fine-grained muscovite within plagioclase is abundant. No gneissosity (banding or preferred orientation) is present. Small recrystallised grains are abundant; these still have diffuse irregular boundaries.
Mineral abundances are:

Oligoclase	Quartz	Microcline	Muscovite	Biotite	Opaques	Chlorite
31%	30%	30%	5%	3%	<1%	trace

Sphene
trace

Oligoclase (~An_{11}) has extensive fine-grained muscovite, some of which are elongate parallel with and at right angles to feldspar cleavage directions. Many muscovite inclusions are apparently randomly oriented. Oligoclase preferentially contains muscovite; it is rare within microcline. Average grain size is 1 mm but some grains are to 2 mm.
Microcline - noticeably more inclusion-free than oligoclase. Grid-iron twinning is fine. Average crystal size is 1.1 mm, some to 1.8 mm.
Quartz has a variety of forms but the large primary grains are dominant. Minor quartz occurs as very fine stringlike graphic intergrowths in oligoclase. Average grain size is approx. 1mm, rare grains are up to 2.5 mm. Undulose extinction and polygonisation is strongly developed; polygonised subgrains have boundaries which vary from highly irregular to straight and parallel with adjacent subgrains.
Muscovite is generally restricted to oligoclase. Isolated larger grains are to 1.5 mm; these are equant and embayed and have distinctive pleochroism of colourless to pale green.
Biotite forms equant to elongate grains to 1.5 mm long. Grains are often embayed, often intergrown with opaques and are only weakly chloritised. Pleochroic haloes are abundant, average size is 0.4 mm. Most grains occur with biotite.

Intrusion age not known; it may be a syn- to post-D_3 intrusive.
The same adamellite/granite is represented by RS 903.

RS 903 ADAMELLITE

FIELD NOTES: The outcrop apparently consists of the same granite as RS 902; it is massive, medium-to-coarse grained and contains 2-3% biotite.

THIN SECTION: The texture is allotriomorphic granular. All features are very similar to those of RS 902. The sample consists of variable grain size; large primary plagioclase grains are to 2.5 mm across while small recrystallised grains are 0.01 mm across. Grain boundaries are noticeably very irregular and diffuse.
Mineral abundances are:

Albite	Quartz	Microcline	Muscovite	Biotite	Opaques
37%	32%	25%	3%	2%	1%

Albite ($\sim An_6$) contains the ubiquitous fine-grained muscovite. Boundaries are diffuse and very irregular. Although the average grain size is 1.5 mm, some grains are to 2.5 mm. Minute dusty inclusions are abundant.
Microcline, like plagioclase, contains abundant dusty inclusions but is relatively free of muscovite. Boundaries are very diffuse. Some inclusions of quartz have very diffuse boundaries. Average grain size is 0.6 mm though some grains are to 1.9 mm.
Quartz - largest grains are to 1.4 mm. Most of the quartz is recrystallised and now forms aggregates of small grains; some grains have straight sharp boundaries but most are diffuse. Larger grains have diffuse irregular boundaries.
Muscovite, apart from the small inclusions in feldspar, forms isolated larger flakes to 1.4 mm across. These are equant and deeply embayed, have diffuse boundaries, and have very pale pleochroism of colourless to very pale brown. Fine-grained muscovite inclusions in plagioclase vary from randomly oriented to aligned along cleavage directions.
Biotite forms embayed equant grains to 0.4 mm across. Boundaries are diffuse and the average size is 0.25 mm across. As for RS 902, biotite is often intergrown with opaques. Chloritisation is present but very minor. Pleochroism is from a very pale brown to dark olive green, deep brown.
Opaques vary from anhedral and irregulr to subhedral with incomplete trigonal and hexagonal forms. Average size is 0.25 mm.

The sample is equivalent to RS 902, and has many similarities to the leucocratic neosome of the migmatite gneiss (RS 907 and 908).

RS 904 BANDED ALBITITE

FIELD NOTES: Grey banded albitite; outcrops in the area contain magnetite. Adjacent rocks are banded calc-silicates; this sample represents a typical banded albitite in close proximity to calc-silicate. Staining indicates only trace K-feldspar.

THIN SECTION: The sample contains bands which are essentially only defined by grain size variations; albite dominates the slide. Albite forms a granoblastic mosaic of equant grains. Biotite is disseminated and shows little tendency for abundance variations as albite grain size varies. Small recrystallised or exsolved quartz or feldspar form an unusual sieve texture in certain coarse-grained albite bands; within these bands this texture is dominant. Biotite shows a good alignment to define a fair schistosity which is parallel with the banding.
Mineral abundances are:

Albite	Biotite	Opaques	Chlorite	Sphene	Apatite
93%	3%	2%	2%	trace	trace

Albite grain size varies from 1.8 mm to 0.18 mm (average) in various bands. Grains are equant to poorly elongate, but when elongate are randomly oriented. Grain boundaries are gently curved and vary from sharp to diffuse; the texture approaches granuloblastic. Various twin forms are abundant. Certain coarse-grained bands have a distinct sieve texture with abundant small grains. These are disseminated throughout and show no apparent control by other features. They represent either exsolved grains or new recrystallised grains. They are untwinned, quite rounded, and have grain boundaries which range from sharp to diffuse. Their mineralogy is either albite or quartz; average size is only 0.02 mm.
Biotite is disseminated and shows no tendency for banding. Much of the biotite occurs within albite. Biotite shows a good alignment (dimensional and crystallographic); often this alignment is best within an albite grain. The biotite orientation, which defines S_1, is strikingly unrelated to the feldspar host. Pleochroism is pale brown to dark olive green, dark brown. Grains are often quite elongate but are small; average length:breadth ratio is 4:1 while the average length is only 0.02 mm. Boundaries are diffuse.
Opaques vary from equant rounded grains to elongate in the schistosity. Average size is 0.02 mm; grains are elongate to 3:1 (length:breadth). Opaques are also disseminated.
Chlorite is obviously a late retrogressive mineral. It forms equant to elongate aggregates which are randomly oriented. Maximum aggregate size is 0.3 mm; all aggregates contain fine-grained chlorite only. Pleochroism is in pale to moderate brown and green shades.

The banding reflects original bedding and is S_0. Aligned biotite (+ opaques) indicate S_1. Opaques include magnetite. The most striking textural features are the sieving of albite and aligned biotite within albite.

RS 905 SCHISTOSE GRANITE

FIELD NOTES: Granite predates the mylonitic schistosity and in places contains abundant pegmatite. Locally, there is a suggestion of a layering/banding within the granite as well as the biotite schistosity. Schistosity would be S_1 or S_2.

THIN SECTION: Approximate mineral abundances are:

Microcline	Quartz	Oligoclase	Biotite	Muscovite	Opaques	Hornblende
75%	15%	5%	3%	<1%	1%	trace

Microcline contains pronounced grid-iron twinning and is slightly cloudy due to numerous minute inclusions. Average grain size is 1 mm but varies from 3.5 mm down to 0.3 mm.
Oligoclase, to An_{30}, is usually clearer than microcline and finer grained with an average size of only 0.5 mm.
Quartz has an average size of 1.2 mm and contains undulose extinction. Quartz-oligoclase-microcline boundaries are very ragged and somewhat lobate, particularly those of quartz.
Biotite is poorly aligned to give a weak schistosity. Biotite pleochroism varies from α = straw yellow to $\beta\gamma$ = dark brown. Minor hornblende and chlorite is intergrown with biotite; hornblende is particularly ragged and is distinctly a relict phase. Hornblende probably is a relict igneous mineral.

RS 907 and 908 MIGMATITIC GNEISS

FIELD NOTES: Outcrop area is of quartzofeldspathic and migmatitic gneiss; mica abundance is generally low. Gneissic banding is poorly developed within outcrop; the lithology has many similarities to the leucocratic neosome of a migmatite and massive granitoid gneiss. Both samples are from the same locality. The outcrop contains abundant mesoscopic D_3 folds; D_2 folds are present but scarce.

THIN SECTION: The texture is allotriomorphic granular, partial recrystallisation is extensive and grain boundaries are highly irregular. The highly irregular sutured grain boundaries are distinctive. Primary grains of quartz, feldspar and mica average 1 mm to 2 mm in size. Small recrystallised grains and subgrains are abundant; their boundaries are very irregular and diffuse. No gneissosity (banding or mineral alignment) is present. RS 908 is slightly coarser grained than RS 907.
Mineral abundances are:

	RS 907	RS 908
Oligoclase	40	45
Microcline	35	20
Quartz	20	30
Muscovite	4	4
Biotite	1	1
Opaques	trace	

Oligoclase ($\sim An_{11}$) contains abundant fine-grained muscovite inclusions. In RS 908 these inclusions are only within oligocene, while RS 907 contains muscovite inclusions within microcline also. Muscovite inclusions are often oriented along feldspar cleavage directions and elongate in those planes. Average size is 1.4 mm. Grain boundaries are very irregular and often diffuse.
Microcline is often perthitic and in RS 907, contains abundant fine-grained muscovite. Average size is 1.3 mm and grain boundaries are extremely irregular and diffuse.
Quartz has strong undulose extinction and polygonisation, average grain size is 2 mm. Grain boundaries are highly irregular and diffuse. Also occurs as graphic intergrowths with oligoclase.
Muscovite only forms small inclusions in feldspar; average size is 0.05 mm. Grain boundaries are diffuse; grains vary from equant to elongate along feldspar cleavages.
Biotite forms large grains to 1.8 mm long and, although elongate are randomly oriented. Pleochroic haloes are abundant, pleochroism is α = pale yellow brown, β = dark red brown and green brown.

Gneissosity in outcrop is S_1, hence migmatite formation is most likely to have been during D_1.

RS 927 ALBITE GNEISS

FIELD NOTES: Outcrop area consists of a variety of gneiss types which all show close to tight folding by the D_2 phase. Axial plane features, such as schistosity or crenulation, are absent. Such outcrops are generally rare, and provide a good opportunity to look for syn-D_2 recrystallisation.

THIN SECTION: The specimen contains a gneissosity which is defined by trails of aligned biotite. Muscovite has a more random orientation and probably developed later than the schistosity, but some muscovite is aligned with the biotite.
Mineral abundances are:

Albite	Quartz	Biotite	Muscovite
55%	25%	12%	8%

Albite commonly contains quartz blebs up to 0.2 mm; these have rounded and lobate grain boundary shapes. Albite grains have an average size of 0.8 mm and are equant; grain boundaries are irregular.
Quartz: large grains are extensively polygonised and have an average size of 0.5 mm.
Biotite trails indicate fold limbs and exhibit straight-line segments around the fold hinge. Biotite often has a muscovite rim, has an average length of 1 mm and a length:breadth ratio of 5:1. Pleochroism is α = orange brown to light orange, to $\beta\gamma$ = deep red brown and dark olive green.
Muscovite, at times, forms large equant grains within the hinge zone defined by folded biotite trains; these grains have a very irregular outline but undeformed cleavage. Muscovite crystallisation appears to have been during D_2 folding.

Muscovite crystallisation probably occurred during D_2, as did recovery within biotite.

RS 928 CRENULATED BIOTITE + OLIGOCLASE GNEISS

FIELD NOTES: Sample is of a biotite schist which contains a D_3 crenulation; no new minerals are evident parallel to the axial plane. The schistosity being crenulated is S_1.

THIN SECTION: The gneissosity (S_1) is defined by a crystallographic and dimensional alignment of biotite and muscovite. Rare scattered biotite and muscovite may be aligned parallel to the axial plane, suggesting possible syn-D_3 recrystallisation.
Mineral abundances are:

Oligoclase	Quartz	Biotite	Muscovite
45%	22%	25%	8%

Oligoclase (sodic, approx. An_{12}) has irregular boundaries, an average size of 1 mm, and often contains small rounded exsolved quartz grains which average 0.15 mm across.
Quartz has similar properties to oligoclase, except for the undulose extinction.
Biotite has an average length of 0.8 mm and pleochroism of α = pale brown, pale yellow, $\beta\gamma$ = moderate brown. Pleochroic haloes are abundant.
Muscovite has an average length of 0.3 mm.

Recrystallisation during D_3 is very limited.

RS 929 RETROGRESSED MUSCOVITE + SILLIMANITE GNEISS

FIELD NOTES: Pelitic gneiss containing porphyroblastic muscovite; schistosity present is S_1 which is anticipated to have contained sillimanite.

THIN SECTION: Specimen is similar to other pelitic gneiss samples. It contains a strong muscovite + sillimanite schistosity (S_1) and post-schistosity muscovite porphyroblasts. Also present are aggregates of randomly-oriented muscovite, and poorly-oriented chlorite.
Mineral abundances are:

Muscovite	Chlorite	Sillimanite	Opaques	Biotite
75%	15%	5%	4%	1%

Muscovite porphyroblasts are up to 10 mm across.
Biotite is randomly oriented, has an average length of 0.6 mm, and is pleochroic in pale yellow and brown shades.
Chlorite shows a very poor alignment in the schistosity which is probably from mimetic crystallistion. Pleochroism is in pale green colours and the average length is 0.3 mm.
Sillimanite is present as fibrolite.

The lithology has been extensively retrogressed; few of the original gneissic minerals are preserved.

RS 930 FELDSPATHIC METASANDSTONE

FIELD NOTES: Sample is of a reddish magnetic metaquartzite or quartzo-feldspathic metasandstone. Cropping out immediately to the west is a calc-silicate horizon.

THIN SECTION: Sample is bedded with bands varying in composition and grain size. Staining with cobaltinitrite shows that the coarsest layer in the thin section contains approx. 50% K-feldspar while the remainder averages approx. 20% K-feldspar.
The mineral abundances, are approximately:

Quartz	Andesine	Microcline	Muscovite + opaques
>45%	25%	25%	<5%

The coarsest-grained layer contains microcline to 3.5 mm, andesine ($\sim An_{33}$) to 0.5 mm, and quartz to 1.5 mm. Some of the microcline and andesine appear to have been larger still but to have been fragmented by deformation and annealing. Some curved albite twin lamellae exist. Grain boundaries are often irregular and lined with reddish opaques (altered magnetite or oxidised pyrrhotite). Finer-grained layers are notably richer in quartz. The average grain size is 0.3 mm compared with approx. 1.5 mm in the coarser, more feldspathic bands. Quartz/quartz boundaries are clear (opaque-free) and gently curved but not straight. Muscovite is fine-grained, randomly oriented and occurs in very small aggregates.

RS 931 DIAMICTITE

FIELD NOTES: Hand specimen is of a diamictite, clasts are to several centimetres long and set in a fine-grained matrix. Clasts are strongly flattened and elongate in the S_5 cleavage/schistosity. The most southerly shaft of the Kings Bluff Gold Field is located about 40 m to the west. (Umberatana Group metasediment).

THIN SECTION It is very difficult to distinguish some of the clasts from the matrix; many of the clasts are schists and the matrix appears to be schistose. Lithic fragments represent approximately 75% by volume.
Matrix schistosity is apparently defined by a very good dimensional and crystallographic alignment of biotite and muscovite. Biotite is pleochroic α = pale yellow to $\beta\delta$ = orange brown, and an average length of 0.1 mm. Muscovite is colourless and has an average size of 0.01 mm. These comments on the schistosity may be derived from a clast which has not been correctly distinguished from the matrix.

Cleaved diamictite or tillite

Extent of recrystallisation during D_5 is not clear. Sample RS 932 suggests that biotite and fine-grained muscovite do form an S_5 schistosity.

RS 932 SCHISTOSE BANDED METASILTSTONE

FIELD NOTES: Outcrop area is of grey well-banded metasiltstone containing weathered pyrite and a crosscutting S_5 cleavage. Cleavage development is pronounced. (Umberatana Group metasediment)

THIN SECTION: The sample contains a compositional banding which is bedding S_o (Adel.) and a crosscutting schistosity (S_5). Mineral abundances are:

Biotite	Muscovite	Quartz
40%	35%	25%

Banding (S_o (Adel))

This is evident by slight variations in mineral assemblage and grain size. Bands are from 0.5 mm to 10 mm thick. Even in coarse-grained layers, biotite has an average length of only 0.04 mm; muscovite is consistently finer grained.

Schistosity (S_5)

Superimposed on the bedding is a strongly-developed crosscutting schistosity (S_5). This refracts noticeably across the banding; and gives the impression of later open crenulation folds. The schistosity is defined by a good dimensional and crystallographic alignment of biotite and fine-grained muscovite. Some grains are definitely not aligned in the schistosity. Biotite pleochroism is α = pale yellow brown to $\beta\gamma$ = dark brown.

Present are bedding (S_o(Adel)) and the S_5 cleavage/schistosity which is defined by aligned biotite and muscovite. See also sample RS 931.

T A B L E S

TABLE 1

Samples grouped according to age and lithology. All sample numbers are prefixed by 6933.

LATE PROTEROZOIC

Umberatana Group metasediments

RS 390 to 395, 483, 532, 931, 932.

EARLY TO MIDDLE PROTEROZOIC - WILLYAMA COMPLEX

Albitite RS 382, 386, 572, 574, 575, 904.
Calc-silicate RS 399, 402, 431, 452 to 454, 529.
Hornblende + andesine gneiss RS 303, 304, 398, 405, 411, 412, 436, 482, 537
Biotite/chlorite schist RS 407, 417 to 420, 423
Ironstone RS 408, 573, 576
Ironstone lateral equivalent RS 409, 526, 527, 533
Opaque-rich gneiss/schist RS 297, 298
Sillimanite-bearing gneiss RS 300, 301, 410, 425 to 427, 479, 525, 895, 929
Sericite gneiss RS 307, 397, 400, 531, 897
Muscovite schist RS 305, 377
Muscovite + quartz schist RS 530
Pelitic schist RS 306, 429
Garnet-bearing quartzofeldspathic gneiss RS 389
Quartzofeldspathic gneiss RS 396, 413, 415, 435, 481, 528, 899, 900, 907, 908, 930.
Feldspar + biotite gneiss RS 296, 299, 379, 381, 383, 401, 406, 534, 538, 898, 927, 928.
Mylonite RS 302, 385, 421, 422, 424, 432, 433, 535, 559

EARLY TO MIDDLE PROTEROZOIC - INTRUSIVES

Diorite RS 378, 388, 403, 404, 416, 430, 478, 480, 520.
Granite RS 384, 428, 522, 523, 536, 905.
Adamellite RS 308, 309, 380, 434, 521, 524, 902, 903.
Granodiorite RS 894, 896, 901.

TABLE 2

Mineral abundances for the dominant phases within the quartzo-feldspathic gneiss suite; figures in per cent.

	RS 396	396	413	415	435	481	528
QUARTZ	81	40	39	45	40	22	45
PLAGIOCLASE	10	40	48	37	32	75	14
K-FELDSPAR	tr	20	3	-	12	-	35
BIOTITE	6	-	4	7	7	3	1
MUSCOVITE	2	tr	6	8	8	-	5

	RS 899	900	907	908	930
QUARTZ	55	45	20	30	45
PLAGIOCLASE	42	46	40	45	25
K-FELDSPAR	-	-	35	20	25
BIOTITE	1	7	1	1	-
MUSCOVITE	1	1	4	4	2

TABLE 3

Mineral abundances for the dominant phases within the feldspar + biotite gneiss suite; figures in per cent.

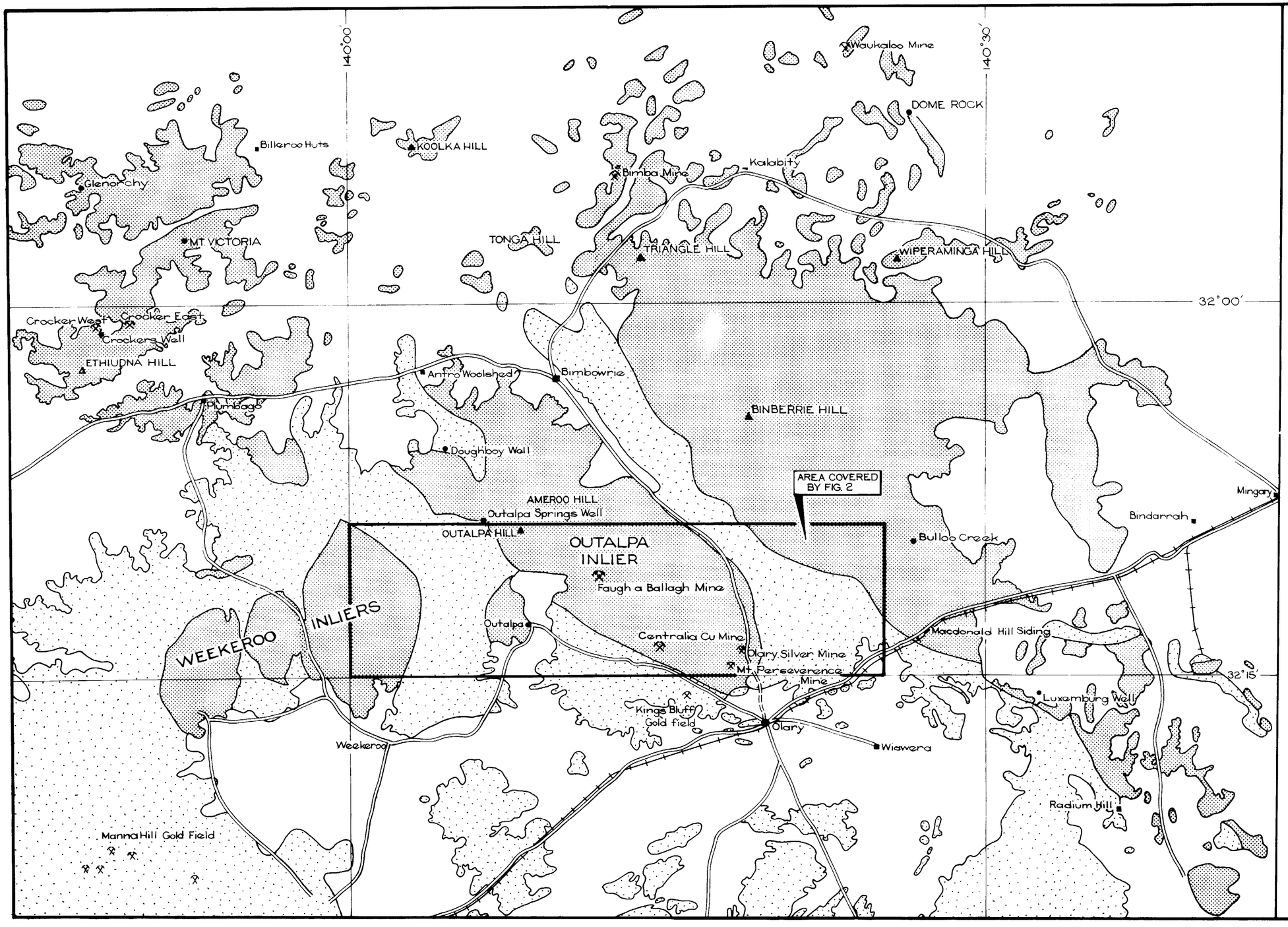
	RS 296	299	379	381	383	401	406
K-FELDSPAR	45	-	70	-	-	-	-
PLAGIOCLASE	25	85	-	35	70	54	60
QUARTZ	10	1	12	30	-	30	20
BIOTITE	18	12	16	14	18	11	18
MUSCOVITE	2	2	2	20	7	4	-

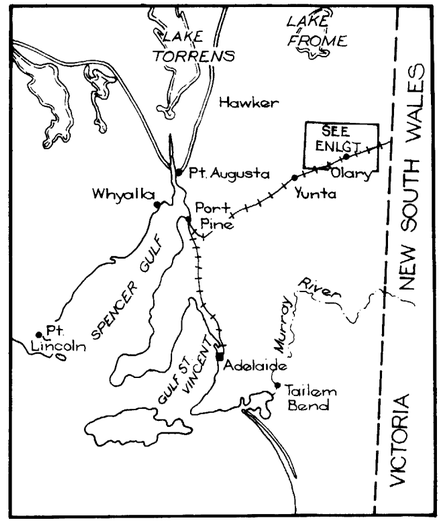
	RS 534	538	898	927	928
K-FELDSPAR	30	36	35	-	-
PLAGIOCLASE	tr	-	10	55	45
QUARTZ	20	11	30	25	22
BIOTITE	47	41	14	12	25
MUSCOVITE	tr	-	4	8	8

TABLE 4

Mineral abundances for significant phases within the diorite suite; figures in per cent.

	RS 378	388	403	404	416	430	478	480	520
HORNBLENDE	81	75	70	40	27	77	80	10	75
PLAGIOCLASE	9	18	42	26	55	10	15	23	15
QUARTZ	tr	3	7	-	-	3	-	2	-
BIOTITE	3	tr	tr	2	5	tr	-	50	4





LEGEND

- Undifferentiated post-Adelaidean Sediments.
- Adelaidean, Burra and Umberatana Group Metasediments.
- Early to Middle Proterozoic Willyama Complex.

KILOMETRES
0 5 10 15

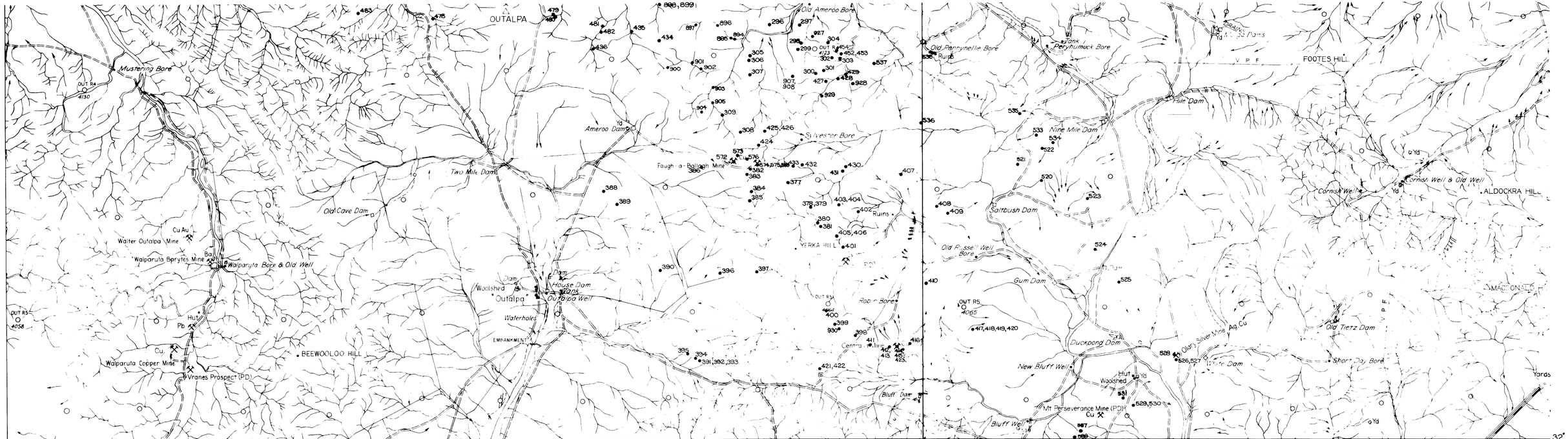
FIG. 1

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

COMPILED D. Flint
DRAWN J.W.
DATE April 1980
CHECKED
SCALE 1:250,000
PLAN NUMBER 80-264

PETROGRAPHY—OUTALPA INLIER
LOCALITY PLAN

Job no. 1911



Note: All numbers are R.S. numbers and prefixed by 6933.

FIG. 2

SCALE

KILOMETRES 0 1 2 3 4 5 6 KILOMETRES

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

OUTALPA INLIER, OLARY PROVINCE SOUTHERN SECTION PETROGRAPHY SAMPLE LOCALITY PLAN

COMPILED	D. Flint	C.D.O.	DATE
DRAWN	J.W.	SCALE	1:50,000
DATE	March '80	PLAN NUMBER	80-198
CHECKED			