THE GEOLOGY OF SOME PEGMATITES NEAR GUMERACHA SOUTH AUSTRALIA

by R.A.Eggleton, B.Sc.

ABSTRACT

Detailed mineralogical and petrological descriptions of the pegmatites are given, and a more generalized petrological description of the Adelaide System rocks enclosing the pegmatites. The tabular pegmatites are classified into three groups based on textural and mineralogical differences. Group 1 has a finely crystalline margin containing quartz, albite and tourmaline, and a coarsely crystalline core consisting of quartz, microcline and muscovite. Pegmatites of group 2 have a coarsely crystalline margin containing quartz, microcline, albite, muscovite, tourmaline and beryl, and a coarse core of quartz, microcline and muscovite. Group 3 pegmatites have no zoning and consist of quartz, feldspars and muscovite of variable crystal size. The irregular pegmatites show properties of all 3 groups. It is concluded that the pegmatites formed by intrusion of fluids rather than by differentiation or replacement. A Geological map of the area is included.

R A Eggleton, Honours 1959

Introduction.

Numerous pegmatite bodies occur in the rocks of the Adelaide system over an area of some five square miles about two miles east of the township of Gumeracha. The area was mapped for the South Australian Department of Mines one mile sheet Adelaide (1) in which the pegmatites were shown as roughly lenticular parallel bodies. Somewhat closer mapping was done, and the general stratigraphy of the area determined by A.W.G. Whittle; the results being published in 1951 by the South Australian Department of Mines. (2) No detailed work has been published which deals with the pegmatites, although some work was done on the large pegmatite which is quarried for feldspar ( ). The pegmatites have little economic significance. The largest body is quarried intermittently for feldspar.

The topography of the area is dominated by the River Torrens, which flows approximately east-west across the area. The hills on either side of the Torrens are moderately steep, with a maximum relief of 350 feet. The elevation of the Torrens is about 1100 feet about sea-level. The land is largely used for sheep grazing, hence the vegetation has been cleared leaving grassy paddocks with numerous large red gums.

The present study was undertaken as a project for an Honours Science degree, and done during 1959. The project as originally conceived, involved detailed study of the pegmatite minerals and the relation of the pegmatites to the country rock, in order to produce a complete description of the pegmatites, and, if possible, a theory of their origin. Further problems appeared as the work progressed demanding closer study, and where time permitted this was done.

General Geology.

The rocks in the area studied have been tentatively assigned to the Adelaide System by Whittle (2). They consist mainly of schists and calc-silicate rocks, metamorphosed to the almandine zone of regional metamorphism (almandine - amphibolite facies of Turner).

General Geology (cont.)

The general strike of the beds is north-south, the dip being to the east. Folding in the central and southern areas has been intense, with minor drag folds associated. The folding is isoclinal and overturned to the east, only in the crests and keels of folds do the beds dip to the west. Schistosity has only been observed parallel to the bedding.

Pegmatite intrusives from a few feet to 75 yards wide occur throughout the area, generally concordant where they intrude schist and discordant in the calc-silicate rock. The pegmatites, being more resistant than the schist, usually outcrop one or two feet above the surface. Where they are abundant, they form ridges. The pegmatites are normal coarse-grained quartz-feldspar types, with or without mica. Some portions show an aplitic facies.

The mapping has been based on Department of Lands air photographs, survey 215, numbers 9131, 9132, 9133. A three times linear enlargement of photograph 9132 has been used to draw the map. Strikes and dips shown on the map are given to the nearest 5 degrees.

Laboratory Methods.

Petrological descriptions have been done microscopically, using thin sections, the results of which are appended. Mineral percentages have been measured for the pegmatites on a Rosiwall integrating stage. The percentage of minerals in the slides so analysed is recorded with the slide descriptions. Preliminary examination of all minerals was done microscopically on crushed fragments. Where identification was uncertain, X-ray powder diffraction photographs were taken. More detailed methods are described with the minerals to which they were applied.

Petrology and mineralogy of the Country Rocks.

Stratigraphy.

The country rocks of the area in order of succession are

1. Grey phyllitic slate
2. Lower Quartzite
3. Interbedded schists and calc-silicates, with thin quartzite bands.
4. Upper Quartzites and schists.

1. Grey phyllitic slate.

This rock type occurs in the north-western part of the area in the vicinity of Forreston. It is a hard, grey, massive rock, with quartz, feldspar, actinolite and pyrite discernable in the hand specimen. The rock has a moderately good cleavage, bedding is not apparent. The thickness of this slate is unknown. One thin section has been cut of this rock, A176/63.

2. Lower Quartzite.

A quartzite bed, forming a prominent ridge just east of Gumeracha has been taken as the western limit of mapping in the central and southern areas. For the purposes of this study it has been named the Lower Quartzite. Outcrop of the bed is almost non-existent north of the River Torrens, and its position has been tentatively located from air photographs and occasional quartzite float. South of the Torrens the quartzite is seen to be a coarse-grained, slightly feldspathic variety with a haematitic upper facies. The rock is well banded and has occasional thin bands of fine sand grade. The thickness is approximately 150 feet.

3. Interbedded schists and calc-silicates, with thin quartzite bands.

These rocks occur throughout the whole central and southern region, and are the principal rock types studied. They form the host rocks for almost all the pegmatites. Their outcrop thickness varies, but is of the order of 4000 feet.

a. Quartz-biotite schist

The schist occurs as a soft foliated rock with some harder layers, and because of its softness and fissility has poor outcrop. It is best seen where it has been protected from erosion by the pegmatites and in the numerous small prospects in the area.

General macroscopic description.

Biotite and quartz are evident in the hand specimen, some of which show iron staining . The texture varies from fine, compact and somewhat phyllitic to a coarser, foliated and crenulated schistose rock. Some bands show numerous knots, ranging from five to ten millimetres in diameter. The knots are elongate and have their long axes parallel. The larger knots are grey and fine grained, and around them the biotite flakes have been pushed aside. The colour of the schist is predominantly grey-brown, but yellower and greener varieties are found, containing limonite and actinolite in the rock respectively.

General microscopic description.

In thin section, the schist proves to consist predominantly of quartz, muscovite and biotite, sometimes with actinolite and minor feldspar. (see slides A176/5,8,25,27,38,40,46.51,52,55.) The quartz is generally of silt grade in anhedral grains. The biotite is pleochroic brown to colourless, the crystals being elongate and sub-parallel. The muscovite is similarly elongated and oriented. Tourmaline is a frequent accessory mineral, pleochroic dark brown to colourless. Other accessory minerals are garnet (A176/51), sillimanite (A176/40,51), andalusite (A176/40), leucoxene (A176/25), magnetite (A176/40), and rutile (A176/46).

The knots observed in the hand specimen were examined in thin section. The smaller and poorly developed knots appear to be very fine grained quartz and muscovite, but are almost unresolvable. The coarser knots are muscovite and sillimanite with quartz in some cases, and andalusite in others. Both alumino-silicate polymorphs occur in a single slide (A176/40).

Mineralogy of the garnet in the schist.

The specimen of schist from which slide A176/51 was cut contains crystals of garnet. These are 2-3mm. across and ruby red.

Cell dimension.

X-ray powder diffraction photographs were taken of one garnet porphyroblast. A 114 mm. camera was used~~, the radiation~~ being filtered copper radiation. The exposure was for 12 hours. The d-spacings obtained for this garnet and the intensities of the lines as estimated by eye are listed in table 1. Using graphical methods to eliminate errors due to eccentricity and absorption a value for the cell dimension of 11.539 A ± 0.001 A was obtained.

Refractive index.

The refractive index was measured optically by matching with oils in sodium light. The index of the oil was measured on a goniometer by the method of minimum deviation applied to a hollow prism filled with the oil. The garnet was found to have a range of refrative indices, but most grains matched oil of index 1.807 ± .0005. The range in index of the garnet is from 1.804 to 1.807. These properties are listed with those for other garnets in table 2.

b. Calc-silicate rock.

This rock type occurs interbedded with the schist throughout the area in bands of varying thickness. It occurs as a very hard compact rock, usually with poor fissility. Banding is noticeable in some layers, others are massive. All visible banding appears to be parallel to the bedding. Where the calc-silicate outcrops, it does so in tabular sheets protruding above the surface, often showing as a more resistant band. Individual bands vary in thickness from inches to 40 or 50 feet. Only in the bed of the Torrens is it possible to be certain that one band of calc-silicate rock has no interbedded schists, as elsewhere the softer schists do not show well above the surface. The mineralogical composition of the rock is generally uniform, but of varying crystal size and macroscopic aspect.

General macroscopic description.

Most hand specimens of the calc-silicate rock show actinolite crystals 1-2 mm. long and occasionally identifiable feldspar. Some specimens have pyrite crystals on fracture surfaces.

General microscopic description.

In thin section, the actinolite is pleochroic pale green to colourless, usually slightly elongate and arranged sub-parallel. Frequently the crystals are poikilitic. Both plagioclase and microcline are usually present, with microcline predominant, and often acting as a host crystal to actinolite and biotite. Plagioclase varies from An 5-30%, twinning is rare. Biotite is usually present, although in considerably less quantity than actinolite. Sphene is ubiquitous and moderately abundant. Most crystals of sphene are irregular. Of the other minerals present tourmaline is the most common, it is usually pleochroic brown to pale straw colour. Quartz is present in some slides, its nature is variable, from discrete particles of silt grade to large interlocking crystals which form much of the slide. Diopside has been seen in two slides, (A176/9&15). In slide A176/9 the diopside occurs as a single band of large irregular crystals.

Other minerals occasionally met are zoizite (A176/15,16) pyrite (A176/21,22,28) chlorite (A176/26, 28) leucoxene (A176/25), and rutile (A176/45). Scapolite, showing seive structure and containing quartz crystals has also been seen. (A176/15).

Additional note on the sphene from rock A176/15.

Because of the small size and irregularity of the sphene crystals, optical determination was somewhat uncertain. The rock was crushed and seived and thr fraction between 90 and 120 mesh separated on the magnetic separator at 1.2 amps, with both slopes at 20°. The non-magnetic fraction was further separated with heavy liquids, and the fraction with S.G. more than 2.9 retained. This was found to be essentially monomineralic. X-ray powder diffraction photographs identified the fraction as sphene. Similar fractionation was applied to the fraction between 120 and 180 mesh. The total weight of sphene so obtained was 2% of the rock. Rosiwall analysis of slide A176/15 gave a sphene content of 4.3% by weight. The latter value is probably more correct, as the separation of the sphene from the crushed sample was not complete, as it was wanted for identification only.

c. Thin quartzite bands.

Thin quartzites are more numerous to the east of the area where their increase provides a basis for a fourth subdivision of the country rocks. Within the schist they are only a few feet across and of sporadic occurrence. They consist predominantly of quartz grains from coarse sand to fine sand grade.

4. Upper quartzites and schists.

The bottom of this sequence has been taken as the strong quartzite in synclinal disposition on the eastern side of the area. This is a coarse grained crystalline quartzite. The other quartzites are similar. One slide has been cut (A176/20) and shows actinolite and clay among the quartz grains. The schists of this sequence are similar to those below it. Occasional bands of calc-silicate rock are met interbedded with the schists.

Pegmatites.

The pegmatites occur throughout the area as sills, dykes and irregular elongate bodies. They range in thickness from a few feet to 150 yards across; the central pegmatite has a more or less continuous outcrop for more than over ½ a mile. As can be seen from the map, the pegmatites occur most commonly as sills in the schist. Those bodies which are discordant are at least part enclosed by calc-silicate rock or quartzite. It seems probable that the pegmatites have developed along planes of weakness, these being parallel to the foliation in the incompetent schists, and to fracture surfaces in the more competent calc-silicates and quartzites. The main minerals of the pegmatites are quartz, albite, microcline, muscovite and tourmaline.

Texture.

The texture of the pegmatites is extremely variable, ~~and the variation is rarely systematic~~. The marginal phases of some of the tabular bodies is finer grained than the centre; others have extremely coarse edges and aplitic material within.

Considering texture and mineralogy, the sills and dykes fall into three broad groups.

1. Zoned pegmatites with fine-grained borders carrying

tourmaline and coarse cores with large quartz masses.

2. Zoned pegmatites with coarse borders carrying tourmaline and coarse cores carrying quartz.

3. Unzoned pegmatites, generally without tourmaline.

Pegmatites of group 1.

The marginal zone of these pegmatites is very fine grained, almost granodioritic in aspect. The crystals are rarely more than 4 mm. across, the quartz and feldspar anhedral and closely interlocking. Albite is present in this zone, containing from 5 to 10% anorthite molecule. Microcline is uncommon, but is sometimes found subordinate to albite. Muscovite is rare in the first 6 to 12 inches of this zone; beyond this books up to an inch across are found. Tourmaline is characteristic of the marginal zone. In many cases this mineral is only found in the first 18 inches of the pegmatite. The crystals of tourmaline are frequently arranged roughly parallel, their c-axes being perpendicular to the contact face of the pegmatite. Small blue apatite crystals occur in this zone. Their distribution within the zone is random. Occasional crystals of beryl are found here also, but are not confined to the margin.

Between the marginal zone and the core of these pegmatites may be a transitional zone in which muscovite increases in quantity and tourmaline decreases, as does apatite. The crystal size increases through this transition region to about 2 inches or more.

The cores of the pegmatites of group 1 consist of quartz and feldspar or quartz, feldspar and muscovite. Beryl may be present. Large masses of milky quartz, up to a foot long occur in the core. The feldspar is predominantly microcline, the crystals of which are two to three inches long. They carry usually some exsolved albite in them. The cores of these pegmatites are by no means regular, areas of medium grain size carrying both albite and microcline occur. Tourmaline occasionally is found in these masses.

Pegmatites of group 2.

The pegmatites of this group are similar to those of group one, except that the margins are coarsely crystalline, and carry microcline. Tourmaline is concentrated in the first two feet, the crystals may be up to 9 inches long. They are oriented as in group 1, with their c-axes sub-parallel and perpendicular to the contact face. One pegmatite of this class has large beryl crystals in the marginal zone which are up to a foot long and four inches across. (2 ℓ)* They have their c-axes parallel to those of the tourmaline crystals. Microcline crystals six inches across and nine inches long also occur in this sill. Other pegmatites of the group do not always have beryl in such large crystals, but it is often found. Apatite and muscovite are also present in the margin.

The cores of these pegmatites are little different from the edges, except that tourmaline, beryl and apatite are much rarer. Irregular veins and masses of finer grained aplitic rock are found both in the margin and core. The aplite is generally richer in albite than either zone of the pegmatites.

Pegmatites of group 3.

The pegmatites of the third group are usually narrower than those of the first two. They show no zoning, either texturally or mineralogically, from the edge to the centre. Quartz, albite, microcline and muscovite are their constituent minerals. Their texture is variable from aplitic to typically pegmatitic. They resemble the cores of the pegmatites of group 2.

Properties common to all three groups.

Many of the pegmatites of all the three groups show a foliation perpendicular to their length. This plane contains the c-axis of the tourmalines of the marginal zones, and occasionally the quartz and feldspar crystals are roughly tabular parallel to this foliation. This foliation is probably parallel to a joint system set up by contraction of the pegmatites parallel to their length after formation. The books of muscovite do not appear to favour this direction more than any other.

A second planar feature often appears in the pegmatites of

* – see ref. map.

group 3, and sometimes in those of groups 1 and 2. Bands with differing crystal size and mineralogy occur along the length of the pegmatites, extending for some yards. A sequence observed in a pegmatite of group 3 is; 3" of fine grained quartz, feldspar muscovite, 6" of medium grained quartz and feldspar, 9" of coarse quartz and feldspar, 6" of medium grained quartz and feldspar, 3" of fine grained quartz feldspar muscovite, etc. This sequence was repeated. The sequence as listed is rarely so symmetrical and the width of the bands is not characteristic of all such banded pegmatites. The margins and cores of pegmatites of groups 1 and 2 do not show this banding; the transitional zones and aplitic bands sometimes do.

Those pegmatites which are concordant dip at angles between 50 and 80 degress to the west, and in almost every instance, the eastern edge of the sill shows a sharp contact, and the marginal zone can be readily examined. The western margin is very rarely exposed, but the little evidence available suggests that the pegmatites have in fact similar margins on both sides. In particular, tourmaline can sometimes be seen increasing again away from the core just before the outcrop is obliterated.

Irregular pegmatites.

Those pegmatitic masses which are of irregular shape show properties of all three classes of tabular pegmatites. They commonly have alternate bands of coarse and fine material, the bading being roughly parallel to the longes axis (in plan) of the pegmatite. As in the pegmatites of group 1, the fine material consists of quartz, albite and tourmaline, with microcline and apatite and occasionally garnet and beryl. The finely crystalline bands may be separated from the coarser bands by a joint plane. Quartz and feldspar constitute the bulk of the coarsely crystalline layers, with local muscovite, tourmaline and beryl. The feldspar may be either microcline or albite, with microcline slightly more common. The foliation plane perpendicular to the length of the tabular pegmatites show as a prominent joint plane in the massive bodies, there is no tendency for the long axis of the tourmaline crystals to lie in this plane as there is in the sills and dykes. Quartz veins occasionally cut these large pegmatites; their direction appears to have no control. A few veins cut the pegmattite almost horizontally. These veins frequently carry pyrite, or limonite pseudomorphous after pyrite.

Stages in the formation of the pegmatites.

Consideration of the above textural and mineralogical variations in the pegmatites suggests that they were foremed in two staages.

1. A period during which quartz, albite and tourmaline, with some potash feldspar crystallized along planes of weakness in the country rock. This phase formed the marginal zones of the pegmattites of groups 1 and 2, and the fine phase of the massive pegmatites. The difference in crystal size between the margins of group 1 and group 2 pegmatites may relate to local differences in physical conditions.

2. A period during which quartz, potash feldspar and muscovite, with some albite crystallized, either in the centre of the already consolidated pegmatites, producing the sills and dykes of groups 1 and 2, or along new foliation or joint planes, to produce the pegmatites of group 3. This stage was responsible for the coarse material of the massive irregular pegmatites, where quartz and feldspar crystallized aroynd the already formed fine grained pegmatite. The second stage was probably not a continuous and regular one, but proceded in a series of small epochs of pegmatization, producing the parallel banding seen in the coarse phases of all groups of pegmatites. The problem of the origin of the pegmatites, whether intruded, differentiated or replacement, will be discussed later.

Pegmatites; detailed description of minerals.

Feldspar

The composition of some of the feldspars was determined from refractive index measurement on crushed crystals using oil immersion. White light was used; the refractive index oils were checked periodically on an Abbe refractometer. Two values for the composition are given, one from the curves of Chudoba (4), and one from those of Smith (5). The full results are listed in Table 3.

The proportion of albite to potash feldspar varies in thin sections from albite with a little exsolved potash feldspar, to microcline with a little exsolved soda feldspar. Between these extremes are slides with discrete crystals of both feldspars, neither showing exsolution features.

Alteration of the feldspar is nowhere greatly advanced. In many slides, the feldspar is quite free from clay minerals or sericite. The most extensively altered pegmatite is the quarried one, and even this has only about 5% clay in the feldspar. (See Kaolinite below). Some of the larger crystals show evidence of sericitization, small flakes of mica being scattered throughout the crystals. (see slides A176/4, 8, 27)

Tourmaline.

In the Gumeracha pegmatites, tourmaline is the commonest of the ~~so-called rare~~ accessory minerals. It occurs as black prismatic crystals in over half of the pegmatites, varying in length from ½ mm. to about a foot. Quartz, feldspar and apatite inclusions are common in the larger crystals. As has been described, the tourmaline of the sills and dykes occurs mainly in the marginal zone, and the crystals show a tendency to be arranged at right angles to the contact.

In thin section, many of the tourmaline crystals are zoned, particularly the larger ones. The zoning shows as an abrupt colour change, with the rim usually paler than the centre. Centres are blue-grey pleochroic paler, or deep olive green. Rims of crystals may be brown or pale olive green. A common pleochroic scheme for unzoned crystals is olive green to pale pink. A few crystals, almost colourless and non-pleochroic have been found in the quarry pegmatite.

Pyrite.

Small crystals of pyrite occur occasionally in the pegmatites as cubes or pyritohedra. All pegmatites in the area have either pyrite or pseudomorphous limonite, which minerals occur only in quartz.

Beryl.

Beryl has been found in most of the pegmatites bearing tourmaline, but not neccessarily in close association with this mineral. Beryl is most abundant in the quarry pegmatite where it occurs in two ways. Most of the crystals are either single or in radiating clusters enclosed by quartz. These crystals reach a length of about 4". They are pale green or yellow-green, sometimes with occasional darker green areas. Some of the crystals are zoned faintly, with the cores of the crystals greener and the rims yellower. These beryls are only slightly altered, containing a little clay.

Beryl is also found enclosed by feldspar in the quarry pegmatite. These crystals are smaller than those enclosed by quartz and are much more altered. Their zoning is very pronounced, the typical zonal scheme being; core, 3 - 6 mm. across, opaque yellow-green; middle zone, $\frac{1}{2}$ mm. wide, deep brown to black; rim, 1 mm. wide, semi-transparent yellow-green. The zones are concentric about the c-crystallographic axis.

To examine the zoned beryls further, some were crushed and seived. The fraction between 60 and 120 mesh was put through the isodynamic magnetic separator at 0.9 amps. and again at 1.35 amps. Three fractions, one pale yellow, one yellow brown and one deep brown were obtained. The refractive index of each fraction was determined by matching with suitable oils, and the specific gravity of the extreme fractions by suspension in heavy liquid, the density of which was then determined. The results are in Table 4.

Examination of a slide cut of one such zoned beryl shows that the transition from one zone to the next is rapid but transitional. There is no suggestion from optical examination that either the colour or the magnetic properties of the dark zone are due to inclusions in the crystal. In section, the dark zone shows as a homogeneous deep brown.

X-ray powder diffraction photographs were taken of the two extreme fractions with a 114 mm. camera, using filtered copper radiation. The complete beryl pattern was given with each (compared with the A.S.T.M. index values). The dark fraction showed a few very faint extra lines, corresponding to spacings of 2.576 Å, 2.357 Å, 2.115 Å, 1.873 Å , and 1.669 Å. The mineral causing these extra lines cannot be identified, but they could well derive from small amounts of feldspar and clay. Possibly they are due to sub-microscopic inclusions which give the beryl its dark colour and magnetic susceptibility.

It was thought desirable to determine the dimensions of the unit cell of both the dark and light coloured zones, to see if the colouring material showed its effect on an atomic scale, and if so, what the effect was. Accordingly, an attempt was made to index the powder photographs. Because of overlap of lines in the high angle region of the photographs, the lines are diffuse, making accurate measurement impossible, and the indexing is ambiguous.

Single crystal oscillation photographs were taken of a fragment from the dark zone of a beryl crystal. These photographs show no evidence of crystalline impurity in the crystal X-rayed, and it is concluded that the colouring material occurs within the crystal lattice. The oscillation axis for the photographs was the c-axis of the crystal. Indexing was done using orthorhombic axes, with 'b' = $\sqrt{3}$a. The reflection 10,2,0 was selected as a high angle reflection for which to measure θ, and the a cell dimension determined from this by the 'θ-method' (6). Because of the time needed for this method, it was not possible to determine the 'c' cell dimension accurately. 2θ for 10 2 0 was found to be 155°55', using cobalt radiation with a wave-length of 1.78892 Å. The 'a' cell-dimension was calculated as 9.206 $\pm$ 0.001 Å.
A partial analysis of the dark and light zones of the beryl was done by T.R.Sweatman of the C.S.I.R.O. Soils Division. The dark zone was found to contain 1.92 $\pm$ .02% Fe_2O_3. Sosedko (6) lists

values of cell dimension with analyses of three pegmatitic beryls. The beryls, which have varying amounts of alumina, silica, BeO, and alkalies, have the following a cell-dimension and iron content:

'a'	Fe_2O_3
9.202	0.13
9.202	0.12
9.200	0.08

The results from the dark zone of the beryl from Gumeracha, when compared with these values of Sosedko, suggest that the larger Fe^{3+} ion replaces Al^{3+} in the structure, thus increasing the cell dimension. More work should be done before a definite conclusion is reached.

Beryl also occurs in pegmatite 2ℓ (see map). The crystals in this sill are few in number but comparitively large, some being a foot long. They are mostly orange brown to green brown. These beryl crystals, like the associated tourmaline, are oriented with their c-axes sub-parallel and roughly perpendicular to the contact face of the sill. They do not extend more than two or three feet into the pegmatite. A few small unzoned beryls have been found in other pegmatites. ~~none of which are zoned~~.

Apatite.

Apatite is an accessory in all the pegmatites, except possibly those of group 3. Crystals large enough to be seen in the hand specimen are usually pale blue, sometimes grey. They rarely exceed 3 mm. in length. Refractive indices determined with index oils in white light are: ordinary ray = 1.636 ± 0.002.

extraordinary 1.630 ± 0.002.

One large mass of apatite was found and sectioned. It appeared to be an intergrowth of apatite in apatite, similar in appearance to an exsolution texture, but with different optical orientation of the two phases.

Garnet.

Garnet has been found in three pegmatites, one of groups one and two, and in one irregular pegmatite. Two pegmatites are very close, and may be the same pegmatite. (1c + Ia)

The garnets from pegmatite 1c occur on the western edge of this body. They are euhedral, rarely more than two millimetres in diameter, and most are about ½ mm. across. They are found in the fine grained phase of the pegmatite, and are associated with quartz, feldspar and tourmaline. ref. A176/2.

The garnets of pegmatite Ia, are in its fine phase, and have the same appearance and occurrence as those of pegmatite 1c.

The garnets of pegmatite 2F are somewhat larger than those of the preceding pegmatites. They range in size from ½ to 5 mm. Whole crystals are difficult to obtain, as most are somewhat cracked. The pegmatite is coarsely crystalline, the quartz and feldspar being up to 3 cms. long. Tourmaline is infrequent, muscovite is common. ref. A176/13.

The garnets from pegmatites 1c and 2 F were separated from the crushed rock on the Franz magnetic separator, and purified by heavy liquid methods. The few remaining impurities were removed by hand picking. About 200 mgm. of each garnet was thus obtained.

Refractive index.

The refractive index of the garnets for sodium light was determined first on a single crystal using a goniometer, by the method of minimum deviation. A second determination was made by oil immersion, the index of the matching oil being determined on a goniometer, the oil being held in a hollow glass prism.

Cell dimension.

The dimensions of the unit cell was found from X-ray diffraction photographs of powdered garnet. Filtered copper radiation was used, the powder rod being mounted in a 114 mm. camera. Exposure was for 12 hours, using Ilford industrial B X-ray film. Values of d-spacing , intensity of the lines, and the index of each line are listed in table 1. The values of cell-dimension and refractive index are listed in table 2.

Specific gravity

This was determined for the garnet from pegmatite 1c , by the displacement of water from a 5 cc. density bottle.

Muscovite.

Muscovite is found in all the pegmatites. The books of mica are never very large, about 2" across being the maximum. Muscovite is rare in the tourmaline rich fine grained phases of the pegmatites, and common in the coarsely crystalline parts. It shows no tendency to a parallelism of crystals.

Quartz is an essential constituent of all the pegmatites. Its occurrence is for the most part typically pegmatitic. In some parts of the quarry pegmatite it is intergrown with feldspar in a semi-graphic fashion.

Hydrous minerals of the quarry pegmatite.

The large central pegmatite in which there is a quarry worked for feldspar is the only one which shows evidence of alteration of the primary pegmatite minerals. The rock is very friable, only the quartz and larger feldspars holding together. The principal alteration minerals are kaolinite, montmorillonite and vermiculite.

Kaolinite.

A specimen of the pegmatite was selected which appeared to have a large proportion of clay mineral in it. This was hand broken and seived, and the fraction passing through 300 mesh crushed and X-rayed. The pattern resulting was that of a feldspar, with a weak 7 Å line suggestive of a clay mineral. (Table 6, 2554) A further portion of the rock was crushed and seived, and the fraction passing through 300 mesh dispersed in water with 1 % calgon. After allowing the coarser material to separate for 1 hour, the deposit from a further 16 hours standing was X-rayed. (Table 6, 2562). This photograph showed the 7 Å line intensified, and the strong 3.2 Å line of feldspar reduced in comparison.

This sample of powder was then heated to 580 ^{o}C ± 20 for 1½ hours, and again X-rayed. (Table 6, 2593). The absence of lines at 7.2 Å , 4.35 Å, 3.57Å, in this photograph is caused by the breakdown of the kaolin structure by heating, thus confirming the prescence of this mineral in the original sample. Other photographs were taken using slightly different methods of separation and the composite set of results for these exposures is given in the first column of table 6. Standard values for the d-spacings of kaolimite, albite and microcline are also listed for comparison.

The results of these experiments show that the main mineral in the sample selected is albite, with slightly less microcline. Kaolinite is present, probably only about 5%, this value estimated from relative intensities of the reflections. See also PLATE 3.

Montmorillonite.

In the walls of the pegmatite, seams of a mineral with a pink colour and distinctly soapy feel are found, apparently filling cracks in the pegmatite.

A sample from the west side of the quarry was examined optically, and appeared to be a clay mineral, altered from feldspar. A further sample was agitated in water and allowed to deposit on a microscope slide over a period of 16 hours. Optical orientation of the grains after this treatment was slight, but the crystals appeared under highest power to be stubby irregular laths. One optically homogeneous area gave tentative values for 2V and refractive index:

2V moderate, -ve.

R.I. between 1.504 and 1.535.

A sample of the clay was crushed, dissolved in sulphuric and hydrofluoric acids, and tested for manganese with potassium periodate. A positive result was obtained.

A further sample was x-rayed by powder diffraction dry, and again after glycerol solvation. The 14 Å line shown by the dry sample, increased to 19 Å on glycerol solvation. This swelling of the basal spacing, together with the optical properties, identified the clay as montmorillonite. (See Table 7, and plate 4)

The pink montmorillonite, and a white montmorillonite, also from the quarry were analysed for manganese content by Dr. Norrish of the C.S.I.R.O. Soils Division with an X-ray spectrograph. this gave:

White montmorillonite	85 ± 10 p.p.m. manganese.
Pink montmorillonite	270 ± 30 p.p.m. manganese.

Vermiculite.

Occasional clots of a bronze micaceous mineral are found in the more altered parts of the quarry. Crystals are up to 1 cm. across, frequently with clayey material between cleavage flakes.

Optical examination gave:

2V(-ve) = 0-10

= 1.575 ± 0.005.

An X-ray powder diffraction photograph was taken. This showed a 1.53 Å line, the 060 spacing of a tri-octahedral mica, and a 12 Å line, suggesting a hydro-biotite.

Heating the mica causes it to swell rapidly.

x-ray after heating to prove vermiculite

The pale colour of the mica, its lack of pleochroism, and the absence of fogging on the X-ray film using copper radiation, all suggest that the vermiculite is iron poor.

Grateful acknowledgement is given to Dr. K.Norrish and all the members of the C.S.I.R.O. Soils Division for the assistance given in the examination of these hydrous minerals.

Beryl.

The zoned beryl already described is probably produced by the same late stage of pegmatite formation that is responsible for the clay minerals. The zoned beryls are much more broken and kaolinized than the unzoned beryls from the same pegmatite. It is suggested that the kaolinizing fluids affected the beryl at the same time as it altered the surrounding feldspar, the zoning probably being produced by concentration of elements released from the beryl as it changed to clay.

A small quantity of pink montmorillonite was found within one zoned beryl. Whether this clay has formed from the beryl, or from feldspar nearby and subsequently entered the beryl via the cracks in it, is not certain. This problem may be resolvable when a partial analysis of the dark zone of the beryl becomes available.

Contact effect of pegmatite with schist.

Where the pegmatite contacts schist, the harder pegmatite protects the softer rock from weathering, and in many cases a sharp contact can be seen. No evidence has been found to show that the schist has been forced aside by the pegmatites, but outcrop is so limited more than a few feet away from the pegmatite that any distortion would be concealed. The schist on either side of one transgressive pegmatite retains its strike.

The mineralogical effect of the pegmatites on the schist is local only, contact effects being visible over a few inches, and sometimes within the field of a single thin section. Most noticeable in thin section is the sharp transition from schistose to pegmatitic texture, and the concentration of tourmaline at the contact. (See slide A176/8).

The schist tourmaline, which is brown, increases in amount toward the pegmatite, until at the junction this mineral constitutes up to 50% of the rock. The tourmaline then changes to the blue-green pegmatitic variety.

The biotite of the schist is pleochroic dark brown to pale straw. Approaching the pegmatite this mineral grows paler, until near the contact it is yellow and non-pleochroic. The value of 2V is still low. (A126/27). At another contact where the schist is more granular, the biotite appears to be altering to muscovite. The muscovite crystals have ragged edges with biotite in and around them. Small crystals of rutile, and areas stained with limonite, which are found with the micas, indicate alteration of biotite with loss of iron and titanium.

The alteration of biotite is best seen in a schist inclusion in the quarry pegmatite. The mica in the schist has the same optical properties as the vermiculite already described from this pegmatite. Dr. Walker of the C.S.I.R.O. suggests that the vermiculite of the pegmatite was picked up from the schist as biotite during the intrusion of the pegmatite, and then altered to vermiculite.

It is concluded that the pegmatites generally only affect a few inches of schist, unless the schist has been completely enclosed. No contact metamorphic effects have been seen.

Contact effect of pegmatite with Calc-silicate.

As with the schist, there is no evidence of distortion of the calc-silicate by the pegmatites. The calc-silicate bands on either side of one narrow dyke have been displaced laterally about a foot, suggesting that this dyke formed along a fault plane. Good contacts are very rare, and specimens have only been obtainable from one locality. Three slides are described, one from the calc-silicate about 5' from the pegmatite, one of calc-silicate about 1' from the pegmatite, and one of the contact. (A176/60, 61, 62). The most obvious feature is the recrystallization of amphibole. At the contact the crystals of this mineral exceed 3" in length, and they form a narrow band which is almost entirely amphibole immediately before the pegmatite. Approaching the pegmatite from the unaltered calc-silicate, the crystals of amphibole, which are pale green slightly pleochroic, become larger, more poikilitic, and less abundant. At the contact they form a narrow band of pure amphibole, the crystals being complete. They rapidly grow smaller and less abundant after the pegmatite is entered.

The feldspar crystals are plagioclase throughout, gradually increasing in size toward the pegmatite. Twinnigg of the crystals is poorly shown.

Metamorphic grade of the country rock.

The two most typical assemblages of minerals for the Gumeracha area are: quartz-muscovite-biotite-albite &/or microcline; actinolite albite-microcline- with any of: epidote, diopside, scapolite, quartz. Both almandine (A176/51) and sillimanite have been found with the first association.

These assemblages are found in the Staurolite-quartz subfacies of the Almandine-amphibolite facies of Turner, Fyfe and Verhoogen (7). The anorthite content of the plagioclase (5 - 30%) is slightly lower than usually found in this facies, whereas the presence of sillimanite suggests a grade of metamorphism higher than the Staurolite-quartz subfacies. Too little work has been done on the country rocks to explain these apparent anomalies; possibly the rocks have suffered a degree of retrograde metamorphism, with the plagioclase being more affected than the sillimanite. More work should be done on the problem.

Mode of formation of the pegmatites.

Consideration of the structure, texture and mineralogy of the pegmatites near Gumeracha, leads to the conclusion that they were formed by the intrusion of pegmatitic fluids into the country rock. Many of the pegmatites are sills and dykes, lying along planes of structural weakness; the foliation plane of the schist, and fracture planes in the more competent calc-silicate rock. Such an attitude is to be expected for intruded bodies. If the pegmatites formed by differentiation during metamorphism of the country rock, one would expect them to show a foliation parallel to the schistosity of the surrounding rock, with the constituent pegmatite minerals showing some degree of preferred orientation within this plane, Actually, the foliation parallel to the schistosity of the country rock only shows by changes in crystal size and mineral composition, whereas the direction of preferred orientation of the pegmatite minerals is perpendicular to the foliation of the schist. The weak foliation of the pegmatites parallel to the regional foliation can be regarded as the result of successive waves of pegmatitic fluid depositing after each other. The stronger foliation perpendicular to the length of the pegmatites is probably caused both by orientation of some minerals, notably tourmaline, because they grew from the wall into the pegmatite; and by cross-jointing caused by contraction and other stresses.

The occurrence of certain minerals in definite zones of the pegmatites also suggests that these rocks are intrusive. Assuming that the sequence of minerals from the edge of the pegmatites to the centre is roughly their sequence of deposition, we arrive at the following order:

1. quartz, albite, tourmaline, apatite, garnet.
2. quartz, albite,microcline, muscovite, tourmaline,apatite, beryl.
3. quartz, microcline, albite, muscovite, beryl.
4. kaolin, montmorillonite.

This sequence of crystallization is almost the same as that suggested by Fersman and quoted by Turner and Verhoogen(8).

The evidence bearing on the formation of the pegmatites that can be derived from the contact phases is ambiguous, and could favour either intrusion or differentiation. The tourmaline in the schist increases in quantity toward the pegmatite, when the latter has a tourmaline rich border. This effect could be caused either by concentration of the tourmaline by differentiation, or by reaction of the pegmatitic fluids with the wall rock. The sharp change in optical properties and crystal size at the contact perhaps favours intrusion more than differentiation, The sharp change in crystal size and mineral composition at the schist-pegmatite junction, and the alteration of the biotite to vermiculite may also indicate the action of intrusive active fluids.

The only observed contact between pegmatite and calc-silicate rock shows interaction between the two rock types over a much greater distance than in the case of the schist. The amphibole appears to be being removed and replaced by albite, with the removed amphibole recrystallizing nearby. This suggests that the pegmatites have formed by replacement rather than intrusion, but the possibility of an assimilative reaction between intruded pegmatite and calc-silicate must not be overlooked. More such contacts must be examined before the physical and chemical effects of the pegmatites on the calc-silicate rocks can be stated with certainty.

Structure.

The structure of the area has not been examined in detail. The folding is isoclinal, overturned to the east, with the fold axes plunging south at about 30 degrees. A π-diagram was prepared from the bedding planes of the beds south of the fault and this showed a girdle of points which was somewhat indefinite, but which had its pole at about 145°, plunging 35° south. This agrees fairly well with the direction of the fold axes as found from the map and from the few minor folds whose axes were measured. Foliation of the rocks is, as far as can be determined, parallel to the bedding. Occasionally a weak foliation at about 5° to the major foliation is suspected. More detailed structural analysis is necessary determine the nature of the deformation of the rocks.

The writer wishes to thank all the staff of the Geology Department of the University of Adelaide for their interest and willing assistance in this work.

References.

1. Sprigg, R.C. et al. (1951) Geological Survey of South Australia, 1 mile sheet, Adelaide.
2. Dickinson, S.B. and Whittle, A.W.G. Gumeracha talc deposits. (1952) Geol. Survey S.A.
3.
4. Chudoba, K. (1933) The determination of feldspars in thin section.
5. Smith, J.V. (1958) Optical properties of heated feldspar. Amer. Min. vol. 43, p.1179.
6. Weisz, O., Cochrane, W. and Cole, W.F. (1948) The accurate determination of cell dimensions from single crystal X-ray photographs. Acta. Cryst. 1948, vol 1, p.83.
7. Turner, F.S., Fyfe, F.J., Verhoogen, J. (1958) Metamorphic reactions and metamorphic facies. Geol. Soc. Amer. Mem. 73.
8. Turner, F.S. and Verhoogen, J. (1951) Igneous and metamorphic petrology.

PLATE 1.
Typical pegmatite outcrop, showing the sharp contact to the east and the western contact obliterated.

PLATE 2.
Pegmatite - schist contact.

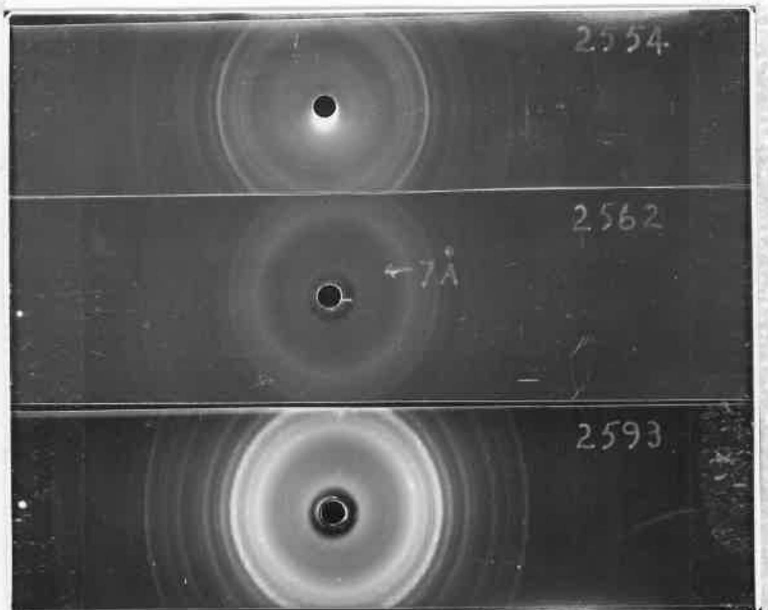
PLATE 3.
X-ray powder photographs of feldspar and kaolin. Films numbered 2554, 2562, 2593.

PLATE 4.
X-ray powder photographs of montmorillonite. Untreated - 2550a, Glycerol solvated - 2550b.

1

2

3



4

TABLES

TABLE 1.

No.	hkl	N	A176/2 I	A176/2 d	A176/13 I	A176/13 d	A176/51 I	A176/51 d
1	211	6	20	4.707	20	4.778		
2	220	8	10	4.105	10	4.154		
3	310	10	10	3.648				
4	222	12	20	3.362	10	3.382		
5	321	14	10	3.108	10	3.130		
6	400	16	60	2.901	50	2.924		
7	420	20	100	2.591	100	2.615		
8	332	22	15	2.473	10	2.489		
9	422	24	40	2.368	40	2.385		
10	510	26	30	2.267	40	2.288		
11	521	30	40	2.116	50	2.131		
12	440	32	10	2.053	10	2.063		
13	532	38	50	1.882	50	1.892		
14	444	48	30	1.675	40	1.680		
15	640	52	50	1.608	50	1.614		
16	642	56	70	1.548	60	1.567	60	1.541
17	800	64	20	1.448	20	1.4541	30	1.4417
18	660	72			20	1.3813		
19	840	80	20	1.296			30	1.2896
20	842	84	30	1.265	40	1.2749	40	1.2581
21	664	88	10	1.235	20	1.2376	20	1.2285
22	871	98	30	1.086	5	1.1725		
23	1020	104			5	1.1373		
24	1030	110					5	1.1011
25	1040	116			40	1,0783	40	1.0716
26	1042	120	20	1.057	20	1.0589	20	1.0537
27	880	128	20	1.0255	20	1.0255	20	1.0204
28	1200	144			5	0.96647		
29	1220	148			5	0.95281		
(30 α_1	1064	152	25	0.93928	20	0.94051	30	0.93553
(30 α_2	1064	152			5	0.94041		
31) α_1	1084	180	30	0.86312	20	0.86371	30	0.85990
31) α_2	1084	180			10	0.86395	10	0.85989
32 α_1	1262	184			5	0.85449		
33 α_1	888	192	10	0.83593	5	0.83646	5	0.83236
34 α_1	1280	208			10	0.80253		
(35 α_1	1282	212	30	0.79543	40	0.79497	20	0.79246
(35 α_2	1440	212	10	0.79538	20	0.79475	5	0.79262
36) α_1	1266	216	40	0.78793	50	0.78738	20	0.78519
36) α_2	10104	216	10	0.78795	20	0.78746	5	0.78506

Table of hkl, $h^2 + k^2 + l^2$, I (intensity) and d-spacing for garnets from rocks A176/2, A176/13, A176/51.

TABLE 2.

No. A176/	R.I. single crystal	R.I. oil	'a'	S.G	%Fe	%Mn
2 & 3	1.8065 ±.0005	1.8060 ±.0005	11.580 ±.002	4.05 ±.05	9.8	20.1
13,14	1.8105 ±.0005	1.8085 ±.0005	11.560 ±.002	-	15.7	13.95
51	-	1.8055 ±.0015	11.539 ±.001	-	24.7	3.55

Properties of garnets

Analyses for iron and manganese content were made by T.R.Sweatman by X-ray fluorescent spectrography. The error in the quoted values is unknown, as no standard was available with which to calibrate the apparatus. The accuracy is not as great as suggested by the number of decimal places.

Composition of the garnets, calculated from the above results using the equations developed by Dr. A.W.Kleeman.

No.	Alm.	Spess.	Pyr.	Gross.
2 & 3	40%	60%	-	-
13,14	60%	40%	-	-
51	71%	10%	13.5%	5.5%

TABLE 3

No. A176/	Twinning	α	Compn. (Smith)	β	Compn. (Smith)	γ	Compn. (Smith)	Composition (Chudoba)
2	grill	1.518	–	–	–	1.526	–	microcline
2	albite	1.526	An 0	1.533	An 2	–	–	An 5
4	albite	–		1.533	An 2	–	–	An 5
13	grill	–	–	1.527	–	–	–	microcline
13	albite	1.537	An17	1.531	An 5	1.539	An13	An 17%
45	albite	1.532	An 7	–	–	1.538	An 1	An 10%.
50	albite	1.525	–	1.533	An 3	1.539	An 2	An 3%
51	poor	1.542	An27½	1.546	An26½	–	–	–
52	grill	1.518	–	–	–	–	–	microcline.
53	grill	1.519	–	1.523	–	1.525	–	microcline.
54	albite	1.533	An 9	1.536	An 7	1.541	An7	An 8%.

Values of refractive index and the corresponding composition for pegmatitic feldspars. Compositions are given from low temperature feldspar tables of Smith (5) and from the graphs of refractive index v. composition of Chudoba (4)
Values of refractive index are given ± 0.001, the corresponding compositions are given ± 2% An.
(N.B. A176/51 is of schist feldspar)

TABLE 4

Colour	magnetic at amp	slope //	slope ⊥r	R.I. o-	R.I. e-	S.G.	%Fe_2O_3
dark brown	0.9	20°	20°	1.582 ±.002	1.570 ±.002	2.70 ±.01	1.92 ±.02
pale brown	1.35	20°	15°	1.582	1.575		
yellow	non-magnetic 1.35	20°	15°	1.582	1.575	2.71	0.94 ±.01

Properties of zoned beryls.

Table 5.

X-ray data from zoned beryls.

a. Powder pattern of core material.

Film 2672. Filtered copper radiation, 36 kv., 18 ma.

No.	I	d (Å.U)	No.	I	d (Å.U)
1	10	7.84	25	4	1.2780
2	6	4.55	26	5	1.2636
3	5	3.94	27	½	1.2149
4	10	3.235	28	4	1.2048
5	4	2.997	29	2	1.1499
6	10	2.852	30	1	1.1401
7	4	2.515	31	2	1.1189
8	2	2.288	32	½	1.0858
9	3	2.201	33	2	1.0495
10	3	2.1455	34	1	1.01695
11	1	2.0505	35	1	0.99912
12	5	1.9825	36	2	0.92180
13	2	1.8265	37	3	0.91603
14	3	1.7915	38	3	0.8942
15	5	1.7395	39	3	0.8551
16	3	1.7090	40	2	0.83640
17	4	1.6250	41	1	0.82412
18	2	1.5967	42	2	0.81478
19	3	1.5758	42	½	0.81490
20	1	1.5316	43	3	0.8076
21	4	1.5149	44	2	0.78640
22	3	1.4547	44	½	0.78715
23	4	1.4324	45	2	0.78408
24	3	1.3662	46	1	0.77394

must give intensities

TABLE 6

Combined values of d-spacings for all powder photographs of a white clay mineral from the quarry pegmatite, and d-spacings of films numbered 2554, 2562, 2593, compared with the d-spacings of kaolinite, albite and microcline, obtained from standard values.

No.	Combined.		Kaolin	Albite	Micro.	2554		2562	2593
1	2θ	d (Å.U)	d	d	d	I	d	d	d
1	12.3	7.2	7.15	[illegible]			7.21	7.20	
2		6.37		6.37	6.47		6.37		6.45
3	19.9	4.45	4.45						4.48
4	20.5	4.33	4.35				4.32	4.33	
5	20.9	4.25			4.25				4.26
6	22.5	3.95		4.05	3.94		4.04		4.04
7	24.1	3.66		3.66		2	3.68		3.67
8	24.6	3.61		3.61	3.61			3.61	
9	25.0	3.56	3.57			2	3.54		
10	25.4	3.51		3.53	3.50				
11	25.6	3.48			3.48			3.48	3.49
12	26.3	3.39			3.38				
13	26.5	3.36	3.36		3.35	3	3.35		
14	27.8	3.21		3.20	3.22	10	3.22	3.24	
15	30.2	2.96		2.96	2.94	4	2.96	2.95	2.94
16	32.3	2.76		2.77	2.75	2	2.76		2.77
17	35.0	2.56	2.55	2.56	2.56	5	2.56	2.55	
18	36.0	2.49	2.49	2.49					2.50
19	38.7	2.33	2.33	2.32	2.34	3	2.33	2.33	2.33
20	41.8	2.17	2.18	2.18	2.16				2.16
21	42.3	2.14	2.13	2.13	2.11	3	2.14	2.15	2.12
22	45.8	1.98	1.98	1.99	1.99	3	1.99	1.97	1.98
23	48.0	1.90	1.89	1.90					1.92
24		1.86				4	1.86		1.85
25		1.84		1.83		4	1.84		
26	50.8	1.80	1.80	1.80	1.80	5	1.80	1.80	1.80
27	50.8	1.66	1.66	1.67		3	1.66	1.67	
28	59.5	1.55	1.54			2	1.55		1.54
29	62.5	1.49	1.49	1.50		2	1.49	1.49	1.51
30	63.6	1.46	1.46	1.46					1.45
31	65.2	1.43	1.43	1.43					1.43.

Filtered copper radiation, 36 kv., 18 ma., 57 mm. camera.

Table 7.

No.	I	2θ	d (Å.U)
1	9	6.4	13.8
2	2	13.5	6.56
3	10	19.75	4.49
4	2	28.8	3.10
5	6	34.8	2.58
6	4	54.4	1.69
7	7	62.0	1.50
8	2	73.2	1.29
9	2	76.8	1.24

Montmorillonite-
untreated

Film 2550 a.

No.	I	2θ	d (Å.U)
1	10	4.7	18.8
2	9	19.8	4.48
3	5	35.0	2.56
4	2	54.5	1.68
5	4	62.0	1.50

Montmorillonite-
glycerol solvated.

Film 2550 b.

Filtered copper radiation, 36 kv., 18 ma. 57 mm. camera.

Table of intensities, 2θ and d-spacing for montmorillonite X-ray powder diffraction photographs.

DETAILED DESCRIPTIONS OF THIN SECTIONS.

A176/2.

Macro. Coarse pegmatite, predominantly quartz and feldspar, with large tourmaline crystals, some hexagonal and up to 5mm. across. Also carrying muscovite and with some iron staining.

Micro.

Quartz: very irregular in outline, tending poikilitic. The crystals have uneven extinction and small inclusions.

Plagioclase: composition An 0-2, (extinction 19° in the symmetrical zone). The crystals are very intergrown with quartz, but they retain their outline. Some alteration to clay has occurred. An 0-2 (Table 3)

Microcline: not as common as plagioclase, somewhat perthitic and somewhat altered to clay.

Tourmaline: all but the smallest crystals show a colour zoning. Centres are pleochroic blue-grey to pale blue or colourless, rims pleochroic yellow-brown to pale yellow. Pleochroic grey haloes occur. The crystals are euhedral.

Beryl: fairly common, some crystals completely altered to clay, others are unaltered.

Apatite: anhedral crystals in accessory quantity.

A176/3

Macro. As for A176/2.

Micro. As for A/176/2, also

Plagioclase: An 4. (Extinction angle in the symmetrical zone =17°)

Tourmaline: birefringence is higher over the orange areas than the blue-grey.

A176/4

Macro. Finer phase of pegmatite, maximum crystal size about 2mm. Quartz and feldspar predominant, with some tourmaline and muscovite. The rock is somewhat weathered.

Micro.

Quartz: anhedral crystals up to 3mm. across, some showing wavy extinction.

Plagioclase: very common, turbid, and with muscovite inclusions. Composition: An 5% ($010 \wedge X' = 20°$, perp. Z)
$010 \wedge X' = -14°$ perp. X)
An 2 (Table 3)

Microcline: not as common as plagioclase. Turbid and with muscovite inclusions.

Tourmaline: pleochroic dark blue-grey to pinkish-grey. Some crystals altered to an isotropic granular mass.

Apatite: numerous thin rod shaped crystals, very few are greater than ½ mm.

Muscovite: accessory.

Some iron staining occurs.

A176/5.

Macro. A weathered, well foliated schist, consisting of biotite and felspar with limonite.

Micro. Plagioclase: extinction in the symmetrical zone c. 10
$010 \wedge X' = 13°$.
Composition = An 30%.

Actinolite: Common, non-pleochroic.

Biotite: Present but uncommon.

Tourmaline: small amount, pleochroic brown to colourless.

Sphene: small amount, anhedral small crystals.

A176/6

Macro. Quartz-feldspar pegmatite, foliated, fairly coarse crystals up to 2 cms. long, and 2-3 mm. wide.

Micro.

Single feldspar crystal with very imperfect lammellar twinning. Anhedral quartz crystals throughout.

A176/7

Macro. Almost entitely muscovite and quartz, in random orientation. Crystals 2 by 4 mm.

A176/8

Macro. Pegmatite vein 1 cm wide, parallel to the foliation of a fine grained schist.

Micro.

a. Vein.

Quartz: anhedral crystals up to 3 mm. across. Uneven extinction.

Plagioclase: subhedral crystals of varying size, which are somewhat turbid and with numerous muscovite inclusions. Crystals are anti-perthitic.
Extinction angle in symmetrical zone = 27°
2V = c.75 +ve.
Composition: An 55 ± 10%.

Muscovite: occurs in flakes up to 2 mm. long.

Tourmaline: one euhedral crystal, blue-grey, pleochroic.

b. Schist.

Biotite: numerous thin flakes, all parallel, pleochroic dark brown to straw, with frequent grey haloes.

Muscovite: slightly less in quantity than biotite. Habit the same.

Tourmaline: frequent euhedral crystals, pleochroic brown to colourless. Most common near the vein, further away the crystals are smaller and sparse.

Zircon: small anhedral crystals in accessory amount.

A176/9.

Macro. A grey, moderately fine-grained crystalline rock, with poor banding.

Micro.

Microcline: small euhedral crystals and larger anhedral poikilitic crystals.

Actinolite: common in pale green poikilitic crystals,
8 arranged sub-parallel.

Diopside: a single band of large (c 1 mm.) broken, irregular, colourless crystals is present.

Zircon: a few small rounded pale yellowish-brown crystals are present.

Sphene: one euhedral crystal and many irregular crystals are present. Actinolite is dark grey where it includes sphene.

A176/10

Macro. A coarse grained quartz-feldspar-muscovite pegmatite, with prominent tourmaline and accessory garnet and apatite.

Micro.

40.9% Quartz: Crystals large, uneven extinction.

50.9% } Plagioclase: extinction angle = + 7 , composition += An 35

Microcline: less in quantity than plagioclase.

8.1% Tourmaline: zoned crystals, having the centre pleochroic blue grey to slightly paler, and th e rim brownish orange. Alteration of the larger crystals has occured. Small crystals are less altered and are largely euhedral. The small crystals are brown only.

Apatite: faintly blue, non-pleochroic.

A176/11

Macro. Single beryl crystal with inclusions and a dark rim.

Micro.

Inclusions:

Microcline: one irregular crystal, about ¼mm across.

Muscovite: numerous thin laths, parallel to the 'c'-axis of the beryl crystal.

Zones: the centre of the crystal is colourless. At the edge it grades rapidly into a pale brown variety. The brown zone is about ½ mm. wide, beyond which is a colourless zone again.

A176/12

Macro. Pegmatite, with medium sized quartz and feldspar and books of muscovite. A few tourmalines and one garnet crystal 0.4 in, across occur.

A176/13

macro. As for A176/12.

Micro.

Feldspar: predominantly An 8% (extinction angle = 16°) antiperthitic. An 10% (Table 3)
A little microcline is present.

Quartz: frequent large, irregular crystals.

Tourmaline: a few crystals, pleochroic olive-green to colourless.

Garnet: one small crystal is present.

Muscovite: small amount.

A176/15.

Macro. A poorly banded crystalline calc-silicate, with crystals 1-2 mm. across. The weathered surface is dark green-grey.

Micro.

Microcline: large crystals are frequent.

Actinolite: very common, most crystals euhedral, some poikilitic.

Diopside: common, but not as much as actinolite. Crystals are colourless and irregular.

Scapolite: large anhedral poikilitic crystals occur, having anhedral quartz crystals within them.

Biotite: common, pleochroic brown to colourless, concentrated in bands.

Sphene: irregular crystals are common, concentrated in bands with the biotite, and strung out in lines.

Zoizite: a few small fibrous patches are present.

Quartz: anhedral rounded crystals occur in the scapolite.

A176/16.

Macro. A well banded crystalline calc-silicate, alternate bands of pale grey-green and brownish white. The grey bands are largely actinolite rich, the paler bands have much feldspar.

Micro.

Microcline: small anhedral crystals are present.

Actinolite: large euhedral crystals are frequent. They are pleochroic pale green to colourless.

Tourmaline: small euhedral crystals are numerous, pleochroic deep brown to straw coloured.

Sphene: very common in small crystals, rounded or irregular.

Zoizite: present in fibrous masses.

A176/17.

Macro. Fine grained pegmatite, having crystals less than 3 mm. across. Main minerals are quartz, feldspar and tourmaline with some muscovite and apatite.

Micro.

Quartz: very intergrown with the feldspar, and having curved edges on all crystals.

Feldspar: predominantly antiperthitic albite (An = c 5%) with some crystals kaolinised. Microcline is uncommon.

Tourmaline: frequent, the crystals are 1-2 mm. long, usually zoned, with blue centres and brown rims. They are somewhat poikilitic.

Apatite: in needles and very pale blue crystals up to 2 mm. long.

Muscovite: a little is present in small crystals.

A176/18

Macro. Coarse quartz-feldspar pegmatite, crystals intergrown.

Micro. The slide is of a single microcline crystal with patches of exsolved albite. Anhedral quartz crystals occur throughout with a very little muscovite.

A176/19.

Micro. A single large microcline crystal, with some plagioclase, (An = 25, extinction angle = 6°) and with elongate quartz in roughly parallel layers. A little muscovite is present.

A176/20.

Macro. A coarse quartzite, grains about 2 mm. across. Some feldspathic or clayey material is also present. The rock is cream in colour.

Micro. Mostly quartz grains, varying from 0.1 to 2 mm. in diameter. Muscovite, clay and microcline occur between some of the quartz grains. The microcline rarely exceeds ¼ mm. across. The quartz grains are angular and unrounded, and are mostly touching each other.

A176/21.

Macro: A coarse grey crystalline calc-silicate.

Micro.

Quartz: large interlocking anhedral grains form most of the slide.

Microcline: a few turbid crystals occur.

Actinolite: forms about 30% of the slide. The crystals are elongate and parallel.

Sphene: (?Zircon) small crystals occur in accessory quantity.

Iron staining on some crystals is seen.

A176/22.

Macro. A coarsly crystalline pinkish grey calc-silicate, with actinolite and feldspar.

Micro. Actinolite: crystals are poikilitic and pale green, anhedral.

Microcline: turbid poikilitic crystals occur.

Plagioclase: turbid crystals, having an extinction angle of + 20°. Composition An 40%.

Sphene: common, but not abundant.

Tourmaline: numerous small euhedral crystals.

Biotite: a little brown biotite is present.

Pyrite: large (c 1 mm.) crystals are common.

A176/25

Macro. A fine grained brownish-grey rock, with elongate blue-grey knots arranged subparallel. The knots appear micaceous.

Micro.

Quartz: sub-spherical grains of silt grade are present.

Tourmaline: fairly numerous small crystals, pleochroic brown blue to pale straw.

Biotite: flakes are elongate and subparallel, concentrated in roughly oval areas. Pleochroic brown to colourless.

Muscovite: colourless and very fine grained throughout the slide, with larger sub-parallel crystals.

Plagioclase: scarce.

Leucoxene: in accessory amount.

Iron staining on some crystals.

A176/26

Macro. A fine grained grey phyllitic calc-silicate.

Micro.

Quartz: anhedral, subspherical crystals of silt grade.

Biotite: parallel crystals, pleochroic brown to colourless.

Actinolite: common, the crystals are poikilitic.

Chlorite: a small amount of pale green chlorite occurs.

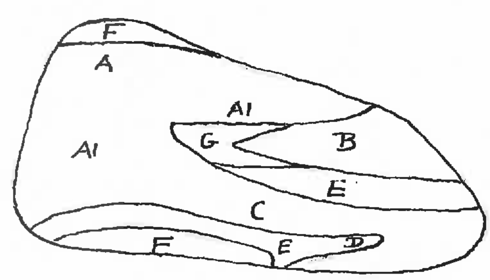
Tourmaline: accessory, pleochroic grey-brown to colourless.

Sphene: accessory.

A176/27

Macro. A fine grained pegmatitic vein in schist.

Micro. Showing major changes in mineralogy across the slide only. See diagram for reference letters.



A Albite: sericitized.
Quartz: irregular crystals.

A1. As for A, plus
Tourmaline: large blue-grey crystals

B. Schistose, with
Biotite: pleochroic brown to straw.
Tourmaline: poikilitic.
Quartz: anhedral., elongate.

C. Feldspar: sericitized.
Quartz: large crystals.
Apatite.
Tourmaline:

D. Quartz:
Tourmaline: poikilitic

E. Tormaline: poikilitic.
Quartz:
Biotite(?): non-pleochroic, colourless.

F. Biotite: weakly pleochroic, pale straw to colourless.
Quartz:
Tourmaline: a little, euhedral.

G. Tourmaline: poikilitic.
Feldspar:
Mica: a little
Quartz.

A176/28 A&B.

Macro. A coarsely crystalline calc-silicate with pink black and green crystals up to 4 mm. long. Pyrite occurs, notably on fracture surfaces.

Micro. The rock is an irregular intergrowth of feldspar and amphibole, with numerous flakes of brown biotite.

Microcline: anhedral turbid crystals, somewhat poikilitic, about ½ mm. across.

Plagioclase: similar in texture to the microcline, but more abundant. Extinction angle = +14°, composition An 30%.

Actinolite: very common in large poikilitic crystals, slightly pleochroic pale green.

Biotite: small complete flakes occur in random orientation, pleochroic brown to straw.

Sphene: small irregular crystals are common.

Pyrite: euhedral crystals occur in accessory quantity.

Chlorite: a little green chlorite occurs around the pyrite.

A176/32, 35, 36, 37, are all of a schist inclusion in the quarry pegmatite.

Macro. Very altered schist, with much clay and narrow cross-cutting quartz veins.

Micro.

A176/32.

Quartz; elongate ragged crystals from silt to sand grade through the rock, and also in veins across the foliation in which the individual crystals retain their orientation parallel to the foliation.

Biotite: pleochroic pale yellow brown to grey brown, parallel and elongate.

Muscovite: less than biotite, parallel .

Iron staining.

A176/35.

Feldspar: largely untwinned, 2v less than 90 , +ve. One crystal twinned on the albite law has an extinction angle of 14° .

Mica: non-pleochroic yellow-brown irregular crystals, and some bioite also occurring as pleochroic laths.

Quartz: small anhedral crystals, no ordered orientation.

A176/36.

Feldspar: untwinned crystals, biaxial +ve, 2V 70-80 .

Quartz: equidimensional crystals of sand grade.

Mica: brown or yellow crystals, most are golden brown and non-pleochroic. Crystals are small, some slightly parallel others in masses.

A176/37.

Quartz: larger crystals than in A176/32, and not so well oriented as in that rock.

Biotite: pleochroic as in A176/32, also non-pleochroic as in A176/36.

Muscovite: parallel laths occur.

Clay: large areas of very fine grained material, statistically isotropic occur, presumably of clay.

A176/38A.

Macro. Contact of schist and pegmatite. Pegmatite is coarsely crystalline, with quartz, feldspar, tourmaline and apatite. Crystals are up to an inch long. The schist is fairly coarse with a tourmaline rich band at the contact.

Micro.

1. Schist end. 3mm wide on the slide. Grain size increases toward the pegmatite from 0.2 to 1 mm.

Tourmaline: tending euhedral, cracked, and with numerous holes. The crystals are pleochroic pale pink to deep blue or olive green and are patchy; some crystals are zoned irregularly with an olive centre and blue rim.

Feldspar: plagioclase dominant, anhedral, with iron stained cracks and edges. Extinction angle = 16°, composition = An 5 %.

Microcline: very little.

Quartz: larger than the feldspar, c. 1 mm. Patchy extinction.

Muscovite: some fine grained sericite occurs within the tourmaline.

Apatite: crystals ½ mm. across occur on the pegmatite side of this band.

2. Band 10 mm. wide, free from tourmaline.

Quartz: large crystals, about 5 mm. across, with fairly even extinction.

Plagioclase: large crystals with fine polysynthetic twinning, extensively altered to sericite. Some crystals have a little exsolved microcline.

3. Tourmaline rich band, in the pegmatite.

Tourmaline: crystals about 5 mm. across, colour scheme as in the first band. Muscovite fibres, plagioclase and microcline occur within the crystals. Feldspar frequently rims the tourmaline.

A176/39.

Macro. As for A176/38A.

Micro. Schist end.

1. Quartz: fairly cracked and with uneven extinction.

Plagioclase: quite turbid and iron stained.

Microcline: numerous small crystals occur.

Tourmaline: small crystals, not very abundant. Pleochroic pink-brown to nearly black. Poikilitic.

Muscovite: crystals up to 2 mm., containing 5% biotite. Iron stained.

2. Quartz: clear crystals with even extinction, up to 1.5 mm.

Tourmaline: Constitutes about 40% of the rock in a narrow band. Crystals are subparallel, otherwise as in the first band.

Feldspar: predominantly albite, somewhat iron stained.

Muscovite: iron stained crystals containing small patches of biotite, the edges are ragged and sericitic.

Rutile: 2 small anhedral crystals are present in the muscovite.

Apatite: accessory euhedral crystals.

3. Quartz: as in 2.

Tourmaline: pleochroic pale pinkish-fawn to deep olive green, roughly euhedral but cracked and slightly poikilitic. Crystals slightly smaller than in zone 2, 1 mm. by 0.3 mm.

Plagioclase: extinction angle = 11° , composition = c. An 10% Crystals are irregular, cracked and a little turbid,

Apatite: accessory euhedral crystals.

A176/40.

Macro. A schistose rock, consisting largely of quartz and biotite, with numerous knots of a hard grey mineral. The biotite has been pushed aside by the knot.

Micro.

Schist.

Quartz: xenoblastic, some crystals elongated parallel to the biotite, many not so oriented.

Biotite: flakes elongate and sub-parallel, pleochroic pale brown to dark straw.

Porphyroblasts:

Quartz: as in the schist proper.

Muscovite: the predominant mineral, crystals parallel.

Sillimanite: Occurs in thin needles parallel to the muscovite, slightly pleochroic. Slightly less abundant than the muscomite.

Andalusite: euhedral crystal, slightly pleochroic, about 4 mm. across.

Magnetite: accessory.

A176/41.

Macro. Fine grained pegmatite, with quartz, feldspar, tourmaline and apatite. Crystals less than 4 mm. long.

Micro. Quartz: anhedral crystals, showing patchy extinction.

Albite: extinction angle = 16°. Some is anti-perthitic.

Apatite: common, either as needles, euhedral or irregular crystals.

Tourmaline: poikilitic crystals, pleochroic black to pale green.

A176/42

Macro. Coarse pegmatite, with quartz and feldspar intergrown in roughly parallel layers.

Micro.

30.8% Quartz: little cracked crystals with regular extinction.

69%. Plagioclase: twinning diffuse and broken, extinction uneven. Extinction angle = 17°. Composition An 5%.

0.2% Apatite: euhedral crystals are common but not abundant.

Sericite: in accessory quantity.

A176/44.

Macro. Large irregular quartz feldspar and muscovite crystals with euhedral tourmaline.

Micro:

Quartz:

Plagioclase: turbid crystals, greater than 5 mm. across. Extinction angle = 12°, refractive indices less than those of quartz. Composition = An 10%.

Tourmaline: euhedral crystals with colour zoning, blue-green interior, pale green rim. The edges show alteration to sericite.

Muscovite: the slide shows only one crystal.

A176/45.

Macro. A fine grained metamorphic rock, banded pale green oand white. The bands are 2-5 mm. wide.

Micro.

Tremolite-actinolite: colourless to pale green slightly elongate crystals, sub-parallel. The crystals are irregular.

Microcline: a few large crystals are present.

Plagioclase: irregular crystals of varying size, rarely showing twinning. Extinction angle = -15°, composition = An 5%. An 5% (Table 3)

Quartz: a few crystals are present

Rutile: small irregular grains are common.

A176/46.

Macro. A fine grained grey brown rock, with oval patches darker.

Micro.

Quartz: very common as small anhedral crystals.

Biotite: crystals subparallel, pleochroic colourless to pale-brown.

Tourmaline: a few crystals occur.

Rutile: accessory in clumps and needles.

Muscovite: accessory.

The oval patches observable in the hand specimen are patches of unresolvable quartz and mica.

A176/47.

Macro. Coarse grained pegmatite with irregular quartz and feldspar.

Micro. Pedominantly quartz and plagioclase in irregular intergrowth.

Quartz: irregular crystals, greater than 3 mm.

25.4%

74.0% Plagioclase: large turbid crystals, refractive indices less than those of quartz, extinction angle = 18°, composition = An 2%.

0.4% Biotite: a little occurs, pleochroic pale brown to yellow.

0.2% Apatite: in accessory quantity as needles and rods.

A176/48.

Macro. A massive fine grained cream coloured rock.

Micro. The slide consists entirely of plagioclase. The crystals are irregular, and all but the smallest are elongate and sub-parallel.

Extinction to 010 cleavage = 18°.
Refractive index between 1.528 and 1.538.
2V approx. = 90 .
Composition - An 5%.

A176/49.

Macro. A fine grained pegmatite, mostly quartz and feldspar, with tourmaline and apatite. Crystals less than 4 mm. long.

Micro.

Quartz: Somewhat less in quantity than most other pegmatite slides.

Plagioclase: irregular turbid crystals, anti-perthitic. Extinction angle = 18°, composition = An 2%

Microcline: common, more turbid than the plagioclase.

Apatite: frequent but not abundant, occurring as needles, small euhedral crystals and irregular large crystals.

Tourmaline: Pleochroic colourless to grey, showing seive structure, and some alteration to muscovite.

A176/50

Macro. Pegmatite, coarse and irregular, with quartz, feldspar, tourmaline and limonite, pseudomorphous after pyrite.

Micro.

Feldspar: large turbid crystals with polysynthetic twinning and some unaltered plagioclase, of composition An 5%.
(An 3% table 3)

Quartz: clear crystals, some of which are euhedral. Small crystals occur in cracks in the feldspar.

Muscovite: small flakes occur at random.

A176/51.

Macro. Schistose rock, principally biotite, muscovite and quartz. with garnet porphyroblasts. Grey brown rock, well foliated but not crenulated.

Macro.

Biotite: common as elongate and parallel crystals, pleochroic brown to straw. Numerous grey, pleochroic haloes occur.

Quartz: small irregular crystals.

Feldspar: twinned on the albite law, biaxial -ve. Composition from refractive indices = An 27% ± 1%. (Table 3)

Sillimanite: numerous needles of sillimanite occur, mostly in the quartz.

Apatite: accessory

Garnet: none in the slide.

A176/60

Macro. Grey green slightly banded calc-silicate, with actnolite and feldspar.

Micro.

Feldspar: plagioclase predominant, crystals anhedral and little altered, about 1 mm. across. Extinction angle = 17°, 2V +ve. Composition about An 5%.

microcline: very little present, occurs as exsolution product in plagioclase.

feldspar constitutes about 60% of the slide.

Amphibole: pale green, slightly pleochroic. The crystals are slightly poikilitic, about 1 mm. across, and not oriented.

Sphene: in accessory amouht.

A176/61

Macro. Patchy calc-silicate rock, with numerous clots of green amphibole surrounded by white feldspar.

Micro.

Feldspar: plagioclase predominant, crystals anhedral, about ½ mm. across. Extinction angle c. 10°, composition c. An 10%. About 80% Of the slide is plagioclase.

microcline: very little, exsolved from the plagioclase

Amphibole: small colourless irregular crystals and larger (3 mm.) very broken and poikilitic crystals constitute about 20% of the slide.

Sphene: accessory only.

A176/62.

Macro. Contact of pegmatite with calc-silicate. One side of the rock is almost pure green actinolite, occurring as large crystals (about 3" long) in a random orientation. The other side of the specimen is almost pure feldspar, with occasional smaller amphibole crystals. The junction between the two is quite sharp.

Micro.

Plagioclase: turbid crystals about 5mm. long, optically discontinuous. Twinning very irregular, but on the albite law.

Microcline: a little only, exsolving from the plagioclase.

Amphibole: pale green pleochroic whole crystals about 5 mm. long.

Sphene: present in more than accessory quantity, crystals are irregular and about ½ mm. across.

Apatite: accessory.

A176/63

Macro. Fine grained grey rock with a moderate cleavage. Specks of pyrite visible.

Micro.

Quartz: elongate crystals of silt grade arranged parallel.

Plagioclase: elongate parallel crystals of silt grade. Extinction angle = 10°, Composition = c. An 10%

Muscovite: constitutes about 10% of the slide, occuring as parallel laths less than 0.1 mm. across.

Iron ore: numerous irregular specks

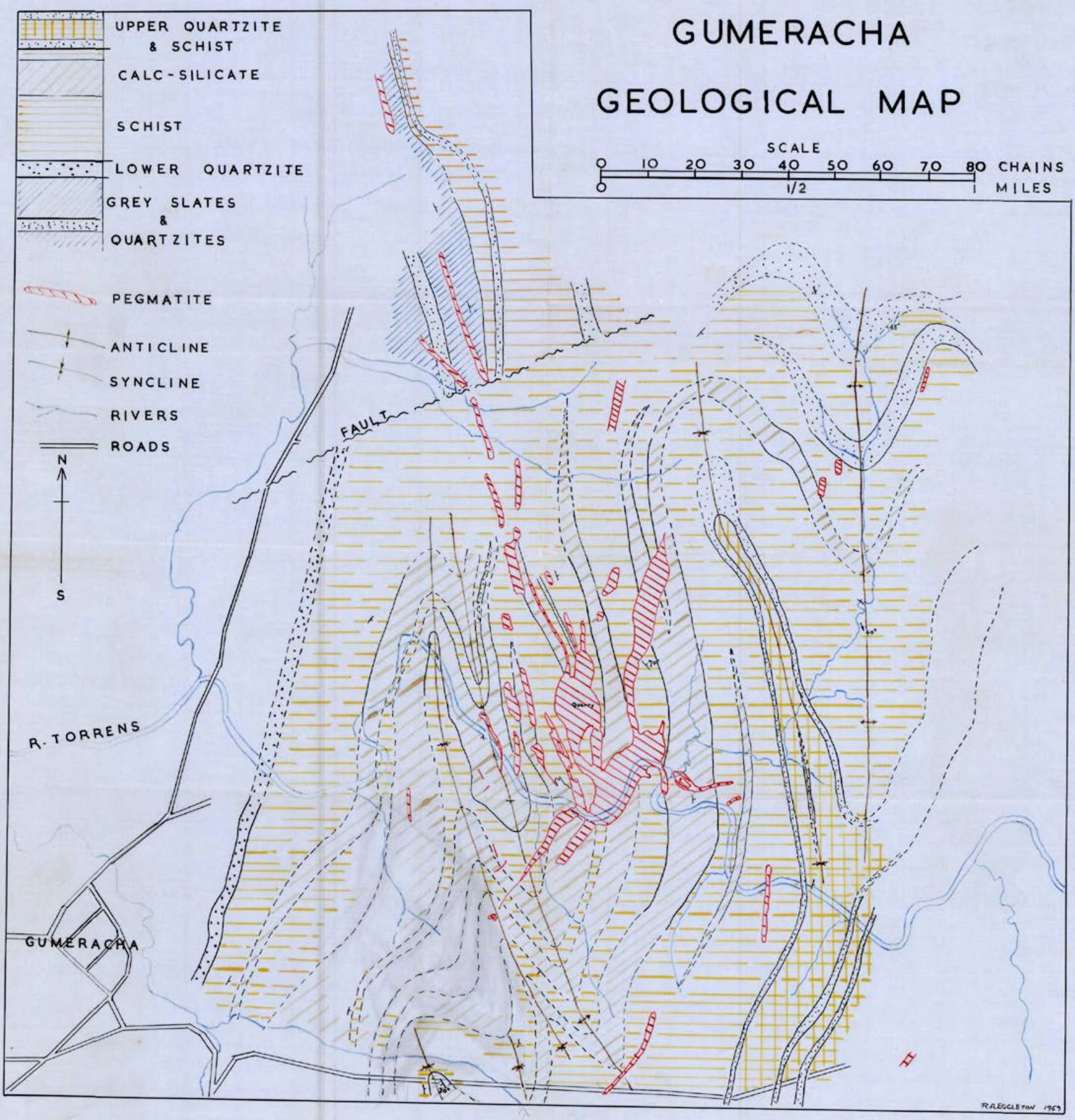
Accessory apatite and monazite.

R.A. EGGLETON, HONOURS THESIS 1959

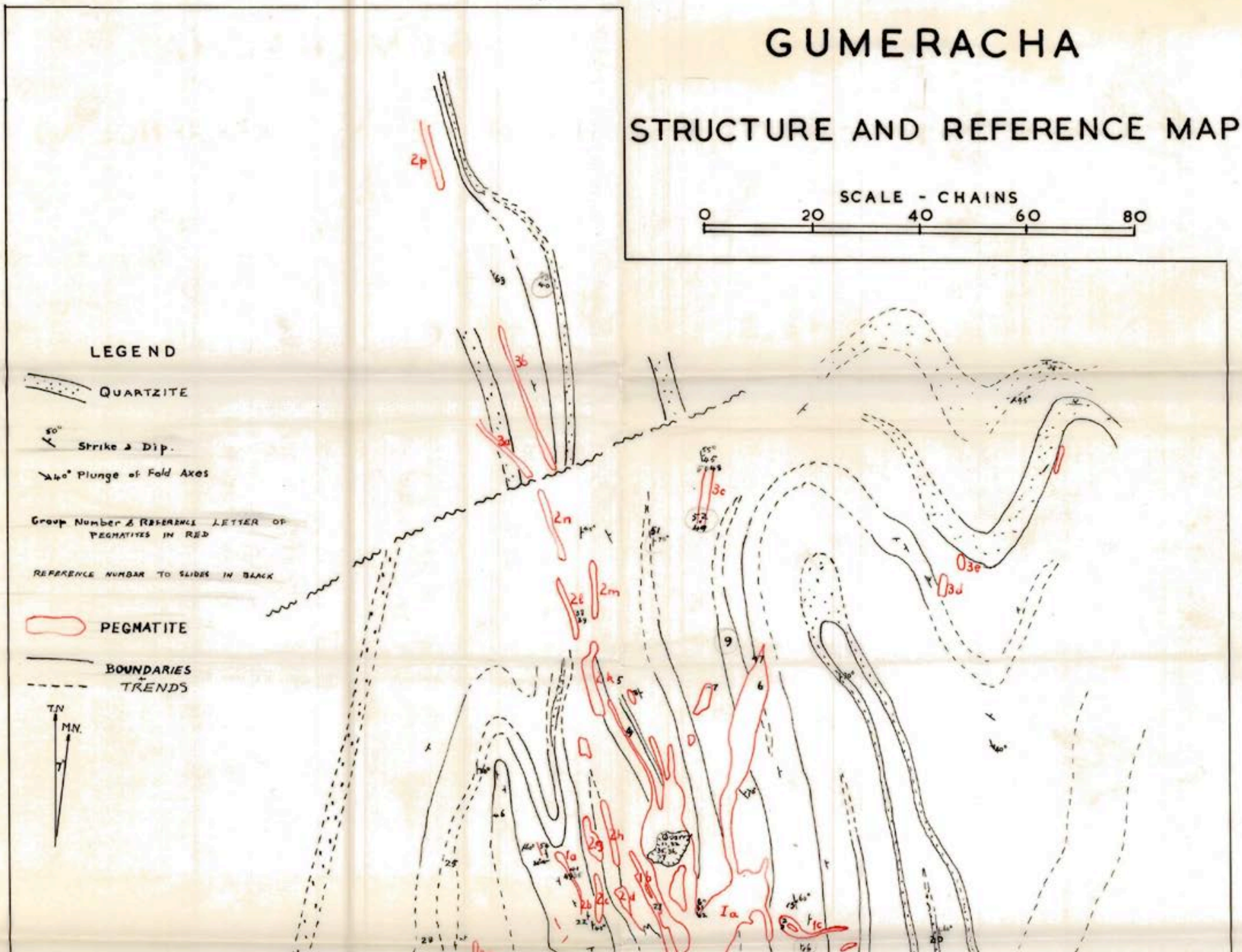
Gumeracha Pegmatites

Locations of specimens

A176/	Ref.	Bearing	Distance (chains)	
2) 3)	Quarry	120°	25	
4	"	35°	20	
5	"	"	20	
6	"	45°	30	
7	"	N	30	
9	"	30°	40	
11	"	in it		
12) 13)	Pipeline	N	15	from pt.1½ miles E of Gumeracha
15	Quarry	110°	25	
16	"	130°	30	in Torrens bed
17	"	130°	35	" "
18	"	140°	60	
19	"	130°	55	
20	"	E	50	Torrens, N, 15 ch.
22	"	240°	20	
23	"	E	75	in Torrens bed
25	"	W	42	
27	"	S	10	
28	"	250°	50	in Torrens bed
32) 35) 36) 37)		in Quarry		
38) 39)	"	340°	48	
40	Forreston Rd	E	20	2 miles N Gumeracha
41	Quarry	W	20	
42	Torrens	S	20	2 miles from Gumeracha
45	Quarry	N	70	
46	"	280°	30	
47	"	30°	40	
48	"	N	70	
49	"	W	20	
50	"	NW	50	sharp bend in Torrens
51	"	N	60	
53	"	240°	40	
60) 61) 62)	"	150°	10	
63	Forreston Rd	E	10	2 miles N of Gumeracha



GUMERACHA
GEOLOGICAL MAP
SCALE
0 10 20 30 40 50 60 70 80 CHAINS
0 1/2 1 MILES
UPPER QUARTZITE & SCHIST
CALC-SILICATE
SCHIST
LOWER QUARTZITE
GREY SLATES & QUARTZITES
PEGMATITE
ANTICLINE
SYNCLINE
RIVERS
ROADS
N
S
FAULT
R. TORRENS
GUMERACHA
R.A.EGGLETON


GUMERACHA
STRUCTURE AND REFERENCE MAP
SCALE - CHAINS
0 20 40 60 80
LEGEND
QUARTZITE
Strike & Dip.
40° Plunge of Fold Axes
Group Number & Reference Letter of Pegmatites in Red
Reference Number to Slides in Black
PEGMATITE
BOUNDARIES + TRENDS
T.N.
M.N.
GUMERACHA
1a
1c
2a
2b
2c
2d
2e
2f
2g
2h
2k
2l
2m
2n
2p
3a
3b
3c
3d
3e
3F
R.A. EGGLETON '59