Geology 4 Student Portfolio

Bruce Lamond

G4 Student Portfolio

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Section: G4 Port 3.

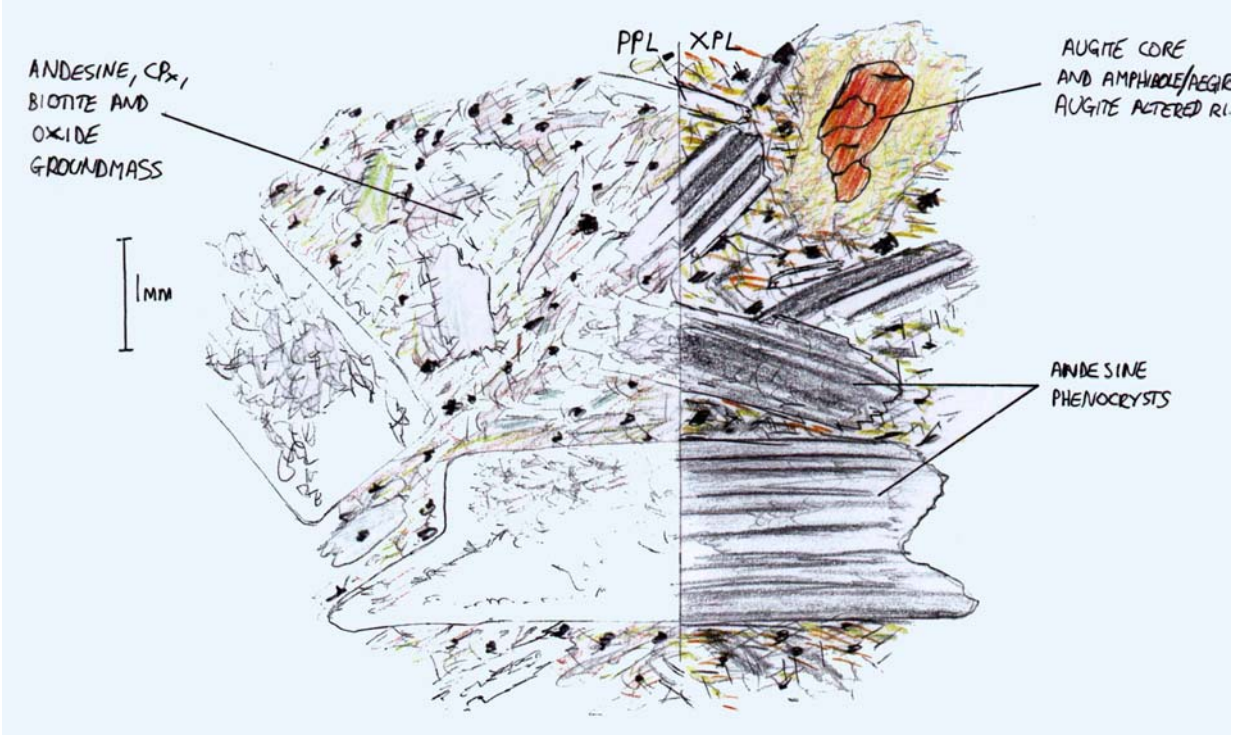
General Description.

The rock is a holocrystalline medium grained plagioclase and clinopyroxene-phyric extrusive, composed of two main phenocryst types.

Mineralogy and texture.

The predominant phenocryst is plagioclase, accounting for about 15% of the total volume. Petrologic analysis showed the plagioclase to have a composition in the andesine range. The andesine phenocrysts are medium grained and euhedral to subhedral often showing a poikilitic texture, enclosing small fragments of clinopyroxene. Most are slightly to heavily altered showing a speckled brown appearance in PPL, and a few are continuously zoned. Alkali feldspar accounts for a few percent of the total amount of feldspar.

The other phenocryst present is a highly altered mixture of pale green high relief augite cores with outer surfaces of an olive-green pleochroic amphibole or possibly aegirine-augite. These phenocrysts account for around 15% of the rock with the augite only present as sparse remnants, some showing simple twinning. Grain size is generally fine, and many crystals are very ragged although a few olive-green masses retain a pseudomorphic pyroxene lozenge outline.



The two phenocrysts are oriented randomly in a very fine-microcrystalline groundmass composed of plagioclase (30%), clinopyroxene (30%), an oxide (5%) and brown biotite (5%). No glass is present. The CPx in the groundmass is composed of the olive-green mineral and the plagioclase has the same composition as the phenocrysts. Also of note is the high percentage of oxide mineral which make this rock a very good potential ore body.

Interpretation.

The lack of basic assemblage minerals and the low amount of alkali minerals and abundance of relatively calcic plagioclase all suggest that this is an intermediate rock produced from a tholeiitic magma. Two stages of cooling are preserved in the general dichotomy in grain sizes: the first occurred in a magma chamber allowing the attainment of fairly large phenocrysts of feldspar and CPx, before these crystals together with a liquid of similar composition were erupted as lava. This type of eruption is attested to by the size of the crystals in the groundmass.

Aegirine-augite is difficult to account for in the section as it usually occurs in alkaline rocks, and not as a result of fluid action on primary crystals. This suggests that the olive-green mineral is actually an amphibole. The presence of andesine in the groundmass and as phenocrysts together with augite and biotite, and the porphyritic texture of the rock suggest it is an andesitic lava. This type of rock would be erupted above subduction zones.

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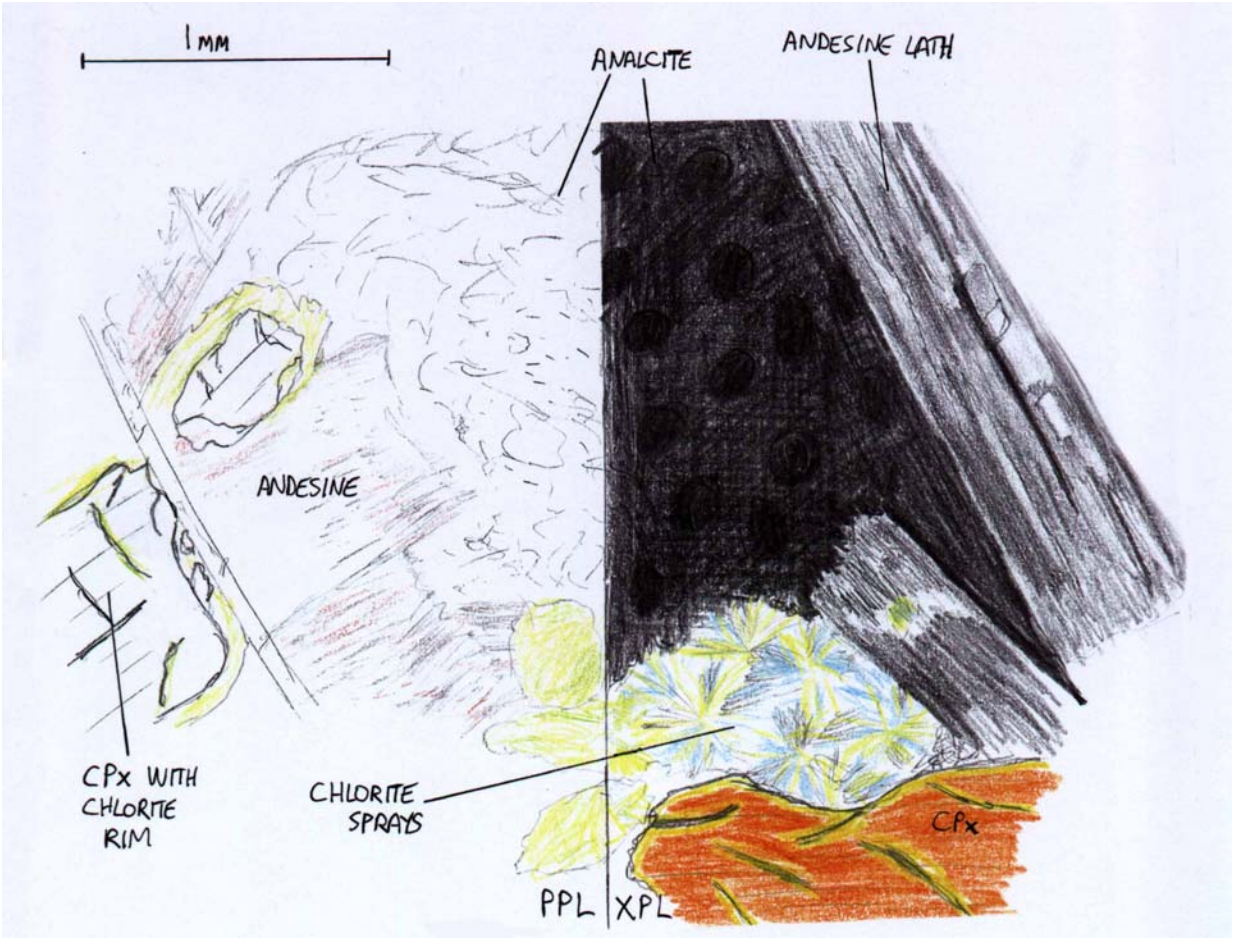
Section: G4 Port 7.

General Description.

This section is a holocrystalline phaneritic plutonic comprising inequigranular feldspars, CPx and chlorite largely, with some minor components.

Mineralogy and texture.

The major component of this rock is plagioclase which forms coarse elongate euhedral-subhedral laths, ubiquitously altered imparting a brown speckled appearance to them in PPL. Although the internal structure of these crystals is quite perturbed, it can still be seen that these crystals are represented by the albite-twinned and untwinned laths. The albite-twin method of plagioclase composition determination showed the crystals to be andesine plagioclase. This accounts for around 55% of the rock, and a further 10% is simple-twinned sanidine, exhibiting the same form and dimensions as the other feldspar.



The next main component by volume is chlorite, which makes up about 20%. It has two associations in the rock: the first is as radiating sprays, largely interstitial to the feldspars, but also at the expense of some analcite crystals; the second is as alteration rims to pyroxene crystals. Minor pleochroic biotite is frequently intergrown with the chlorite

The third constituent of the rock is medium-grained subhedral pale-green CPx, some examples of which show the pyroxene cleavages very well. This accounts for 10% of the rock.

A few examples of a low relief colourless mineral are present as coarse and ragged edged crystals. The XPL view shows that the mineral is very nearly isotropic and some sections showed multiple twinning, suggesting this is analcite. Calcite, rutile and an oxide are also present as minor accessories.

Interpretation.

The mineralogical composition of pyroxene and calcic plagioclase with a significant amount of alkali feldspar suggest a basic composition for the rock. The large amount of chlorite may represent the demise of a previous ferromagnesian phase. The tholeiitic parent may have intruded this body as an insubstantial volume of melt, perhaps as a sill or dyke and the grain size suggests a dolerite.

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Section: G4 Port 9.

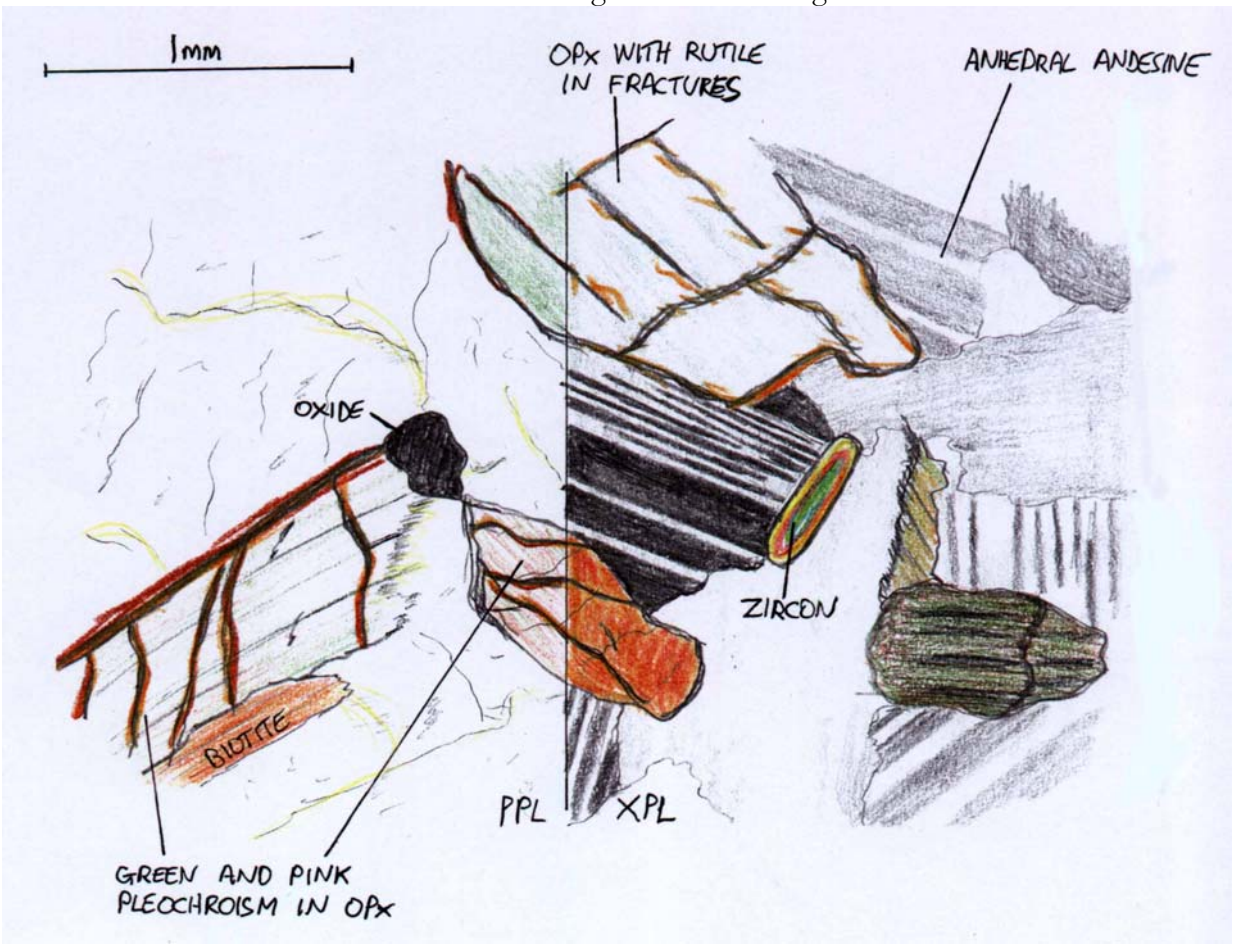
General Description.

This section depicts a holocrystalline phaneritic medium grained plutonic composed mostly of plagioclase (with lesser alkali feldspar) and Opx , with biotite and minor quartz and accessories.

Mineralogy and texture.

The major component is large anhedral unaltered plagioclase, which makes up 65% of the rock. Analysis shows the composition to be andesine. A further 10% of the rock is alkali feldspar and quartz in equal amounts which also form anhedral crystals of a similar size. All other minerals are interstitial to the feldspars

Orthopyroxene is responsible for a further 10% of the section, as revealed by the characteristic green to pink pleochroism, low birefringence and straight extinction in sections showing a single good cleavage. The crystals retain some competent faces but are generally ragged and usually contain a fair amount of rutile as alteration along fractures and edges.



The remainder of the slide is composed of about 10% biotite, large amalgamations of an oxide, accessory sphene, calcite, rounded prisms of zircon (showing very high relief and birefringence), and small isolated pleochroic amphibole (or perhaps aegirine-augite) interstices.

Interpretation.

The high proportion of calcic versus alkali feldspars and general lack of minerals of a basic composition makes the sample intermediate from a tholeiitic magma. The composition is similar to an andesite but coarse grained which suggests the name diorite for the rock. Rocks such as this usually occur in association with island-arc volcanism.

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Section: G4 Port 22.

General Description.

This section represents a sample of a fine-grained limestone slightly cryptically composed of various sizes of shelly fragments and calcareous red and green algal debris in a matrix of limestone mud. The section shows a lamination to the naked eye.

Mineralogy and texture.

The most widespread bioclasts are thin straight needle-like composite structures which have an average length of about 0.2 mm and a width a tenth of that. They show an internal structure of coarse calcite spar, suggesting an original aragonitic composition, and a highly irregular external surface of very fine grained micritic mud. These structures show a preferred orientation throughout the section, in line with the lamination. The description suggests that these are phylloid algae.

Much less abundant but still significant are small (0.05mm diameter) oval to spherical structures. These are seen to be composed of single or several sparry calcite crystals and close examination reveals a denticled surfaced. The replaced mineralogy (opal to calcite) and morphology are characteristics of radiolarian casts.

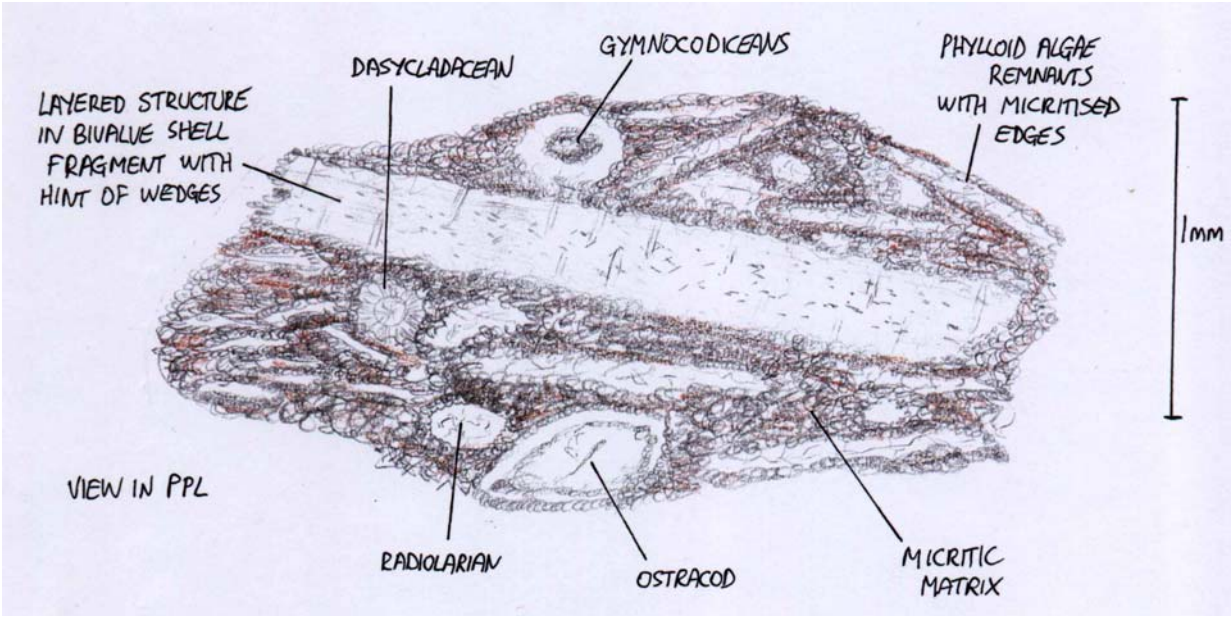
A few small (0.02mm) circular clasts are seen with a radial calcite core and an outer circular ring also with a radial appearance and a frilled outer surface. This is a variety of calcareous green algae called dasycladacean and the structure represents a cross-section through the central stem. These erect rooted plants have many branches and the frilled surface is probably broken branch stumps.

Of similar size and abundance are some oval structures which have a sparry outer ring with a centre of micrite. These are probably gymnocodiceans, a type of red algae, which are also erect plants. In this case the outer wall of aragonite has been replaced by calcite and the soft parts in the core have decomposed to be replaced with micritic sediment.

A single large (2mm) needle-shaped bioclast is preserved in the rock. Close examination reveals a two layer structure parallel to the length and the hint of many small wedge shaped structures at right angles. The outer layer is a thin micritised layer of sparry calcite over a core of finer calcite with the small wedges penetrating both layers from both edges. The replacement of aragonite in the outer layer and low preservation of internal structure are characteristic of bivalve shells.

A couple of examples of eye shaped structures are seen. These comprise two nutcracker shaped outer layers over an eye shaped core, all composed of sparry calcite. This suggests that these are ostracods.

The matrix of the limestone is micritic mud and the whole rock is about 50% allochems and 50% matrix with no appreciable porosity.



Interpretation.

The disrupted external surfaces of the phylloid algae skeletal fragments suggests they have been micritised (the deposits left behind as a result of non-skeletal algae consuming the phylloid skeleton). The fact that many of the allochems show a horizontal orientation suggests they were allowed to settle out in a low energy environment. There is no evidence for compaction after deposition as the clasts retain their original shapes. Diagenesis has been limited to dissolution and replacement of aragonite by sparry calcite. According to the classification of Folk, this rock is a packed biomicrite, and Dunham's classification suggests a name of wackestone. These classifications, the lagoonal setting for dasycladaceans, and the generally fine grained undisturbed nature of the components suggests that the sediments were deposited in a shallow protected lagoon, which was sporadically breached allowing an influx of fine-grained sediment from different environments.

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Section: G4 Port 23.

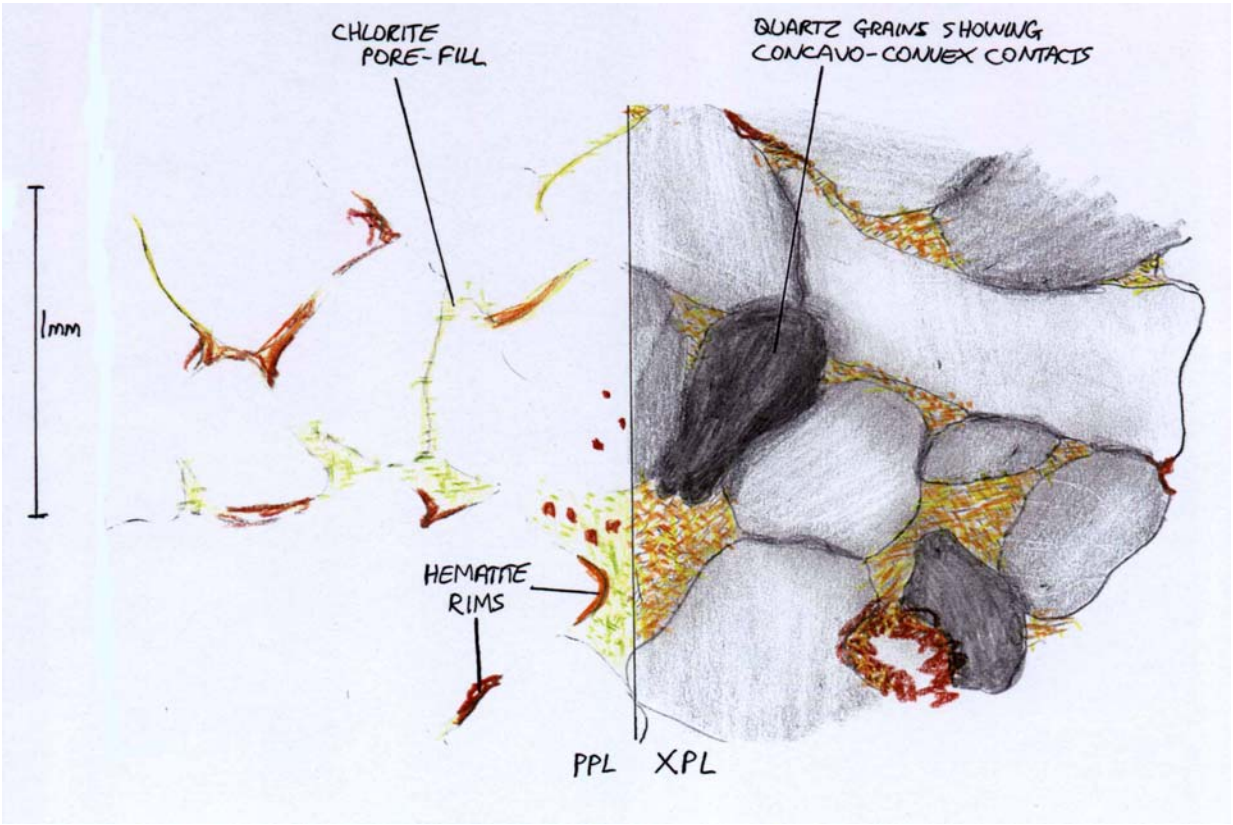
General Description.

This is a sedimentary rock composed of a large percentage of quartz grains which show a moderately high textural maturity. Some diagenetic information can be inferred from the grain contacts and pore fill relationships.

Mineralogy and texture.

As much as 95% of the rock is quartz grains. The grains are well rounded, with a variable shape and a spread of sizes from about 0.05mm to 0.5mm with an average of 0.25mm. The nature of the contacts is that about 25% show sutured contacts but concavo-convex contacts predominate. Primary porosity would have been high but the pores are now completely filled by fine grained sediment and no cement is present. The grains exclusively show slight undulose extinction

The remainder of the rock is composed of slightly pleochroic fine-grained chlorite which fills all the original pore space and occurs between some grain boundaries. Also present as a minor constituent is hematite which forms some clumps in pores but usually occurs as a coating on the quartz grains associated with the pores. Hematite does not occur between grain boundaries. A single small round detrital grain of epidote is also seen.



Interpretation.

The rock is compositionally very mature and texturally mature which limits the number of possible environments. Subsequent compaction has reduced the primary porosity, and then chlorite has been deposited by movement of fluids through the pores. This is also the mechanism by which many of the grains are rimmed with hematite. The fact that none of the contacts between grains are stained attests to the diagenetic origin of the mineral. The undulose character of the quartz grains strongly suggests an original provenance of the grains to be igneous or metamorphic. The fact that the sediments are not extremely well-sorted and the small grain size suggests an environment like a marine shelf sand.

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Section: G4 Port 45.

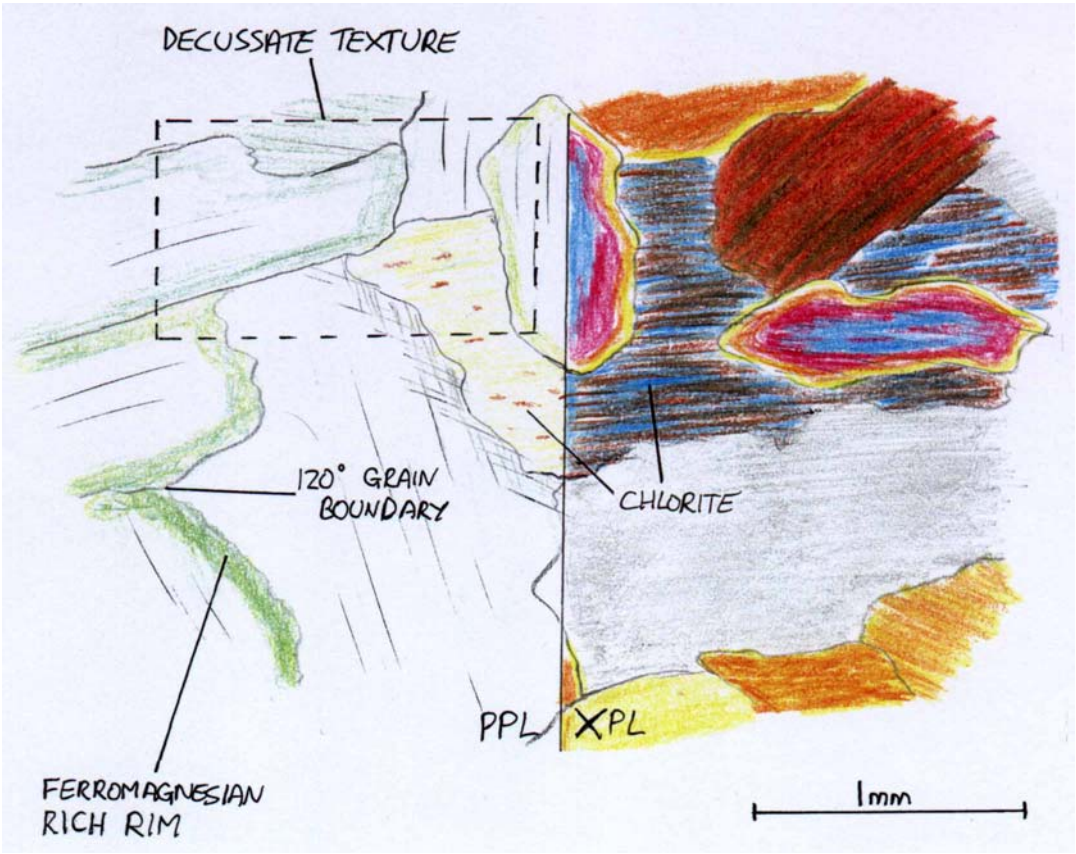
General Description.

A holocrystalline metamorphic rock composed of 90% colourless to pale green amphibole and 10% chlorite.

Mineralogy and texture.

By far the main constituent of this section is a medium grained sub-idioblastic pale blue-green amphibole. Many of the grains are weakly to moderately pleochroic clear to pale blue-green, and most show thick rims of different amphibole composition such that the rims are more coloured. This suggests an increase in mafic content towards the rim. The lack of colouration suggests the composition to be actinolitic perhaps becoming more ferric at the rims. The arrangement of grains is decussate and the grain boundaries show a tendency towards 120^{o} angles at the junctions. This reflects the minimal accomodation of strain in competing grains.

The other main constituent of the section is interstitial stacks of chlorite grains. These show a slight clear to yellow pleochroism and characteristic anomalous polarisation colours. Minor green-orange pleochroic biotite (as intergrowths with the chlorite), rutile, sphene and an oxide also occur.



Interpretation.

The decussate arrangement of strain minimised grains may well reflect an original granoblastic texture in the igneous protolith. The singular mineralogical nature of the rock and the texture suggest a protolith approaching pyroxenite in composition, subsequently metamorphosed to greenschist facies and changing to a nearly pure hydrated pyroxenite or amphibolite.

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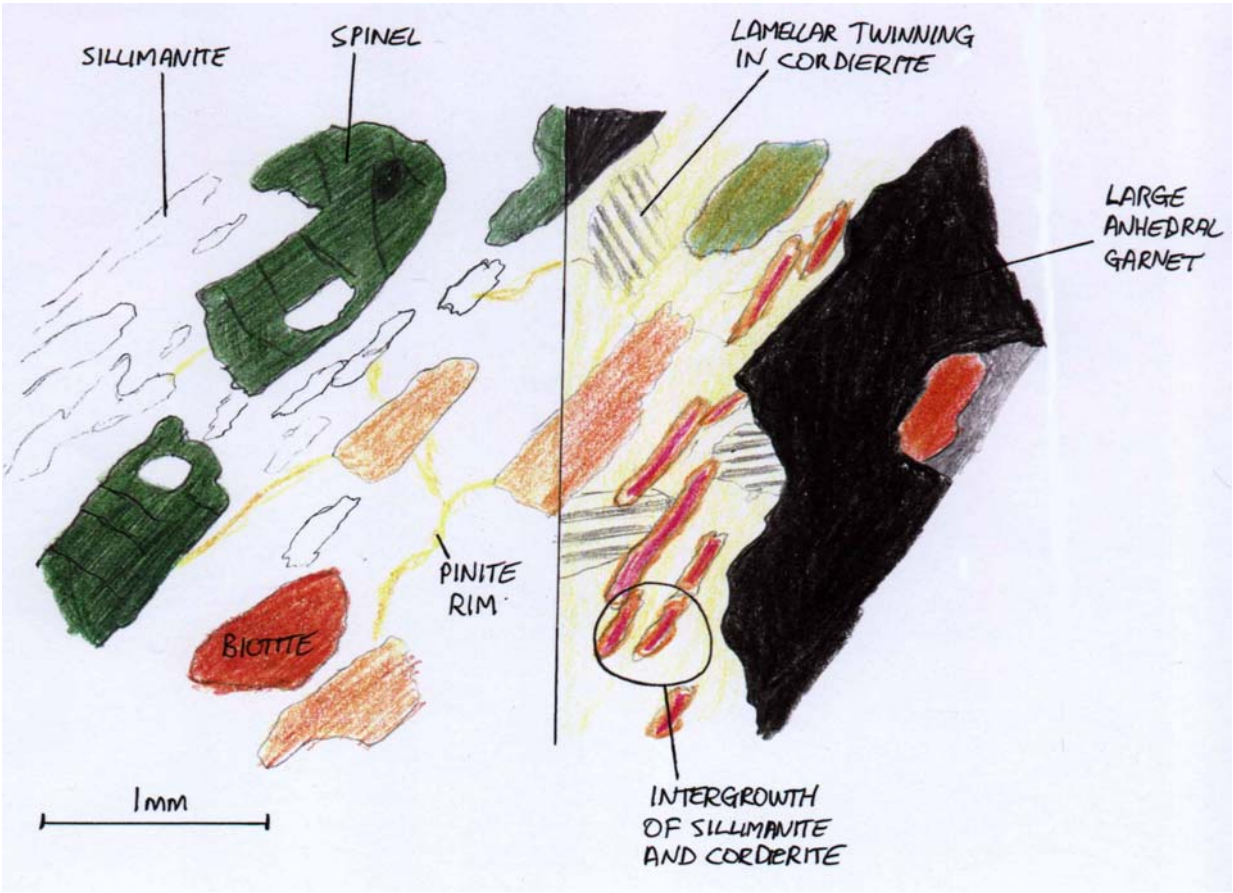
Section: G4 Port 48.

General Description.

Fairly coarse-grained crystalline rock comprising alternating layers of darker and lighter minerals. There is a fabric to the rock but it is too distended to be a schist so it is a gneiss.

Mineralogy and texture.

The layers including the dark minerals (melanosomes) are about 5mm thick and are seen to be composed of several minerals (see accompanying sketch representing a melanosome). Large colourless to slightly green garnets occur as anhedral porpyroblasts with small inclusions of quartz, biotite and sillimanite. The garnets show a preferred orientation where elongate. Medium grained anhedral blebs of dark green spinel are isotropic in XPL and also show a preferred orientation. Finer red-orange subhedral grains of biotite are scattered throughout the layer also showing alignment. These minerals occur within and around large intergrowths of sillimanite and cordierite. The sillimanite forms acicular glassy moderate relief blades throughout the low relief cordierite. Along grain boundaries, the cordierite is commonly altered to yellow pinite, and in XPL it shows lamellar twinning very similar to albite-twinning in plagioclase. The intergrowths are aligned with the other minerals.



The layers in between the melanosomes are similar thickness, are composed of colourless material and called leucosomes. These layers are composed of medium-grained xenoblastic equigranular intergrowths of alkali feldspar, plagioclase and quartz in roughly equal amounts. Noticeable amounts of biotite occur with the leucosomes.

Interpretation.

The occurrence of sillimanite and cordierite and the gneissose fabric of the rock suggest a high grade of metamorphism. The intergrowth of the two feldspars in the leucosomes suggests an igneous origin, so this is a composite rock – igneous and high-grade metamorphic. These factors suggest that the rock is a migmatite with the melanosomes depleted in granitic material (called the restite) and the leucosomes enriched in this igneous fraction. The garnet-cordierite-sillimanite assemblage is typical of high-grade pelitic migmatites and is taken to mark the beginning of the granulite facies. The protolith would have been granitic which then underwent granulite facies metamorphism and partial melting to segregate into a migmatitic gneiss.

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Section: G4 Port 54.

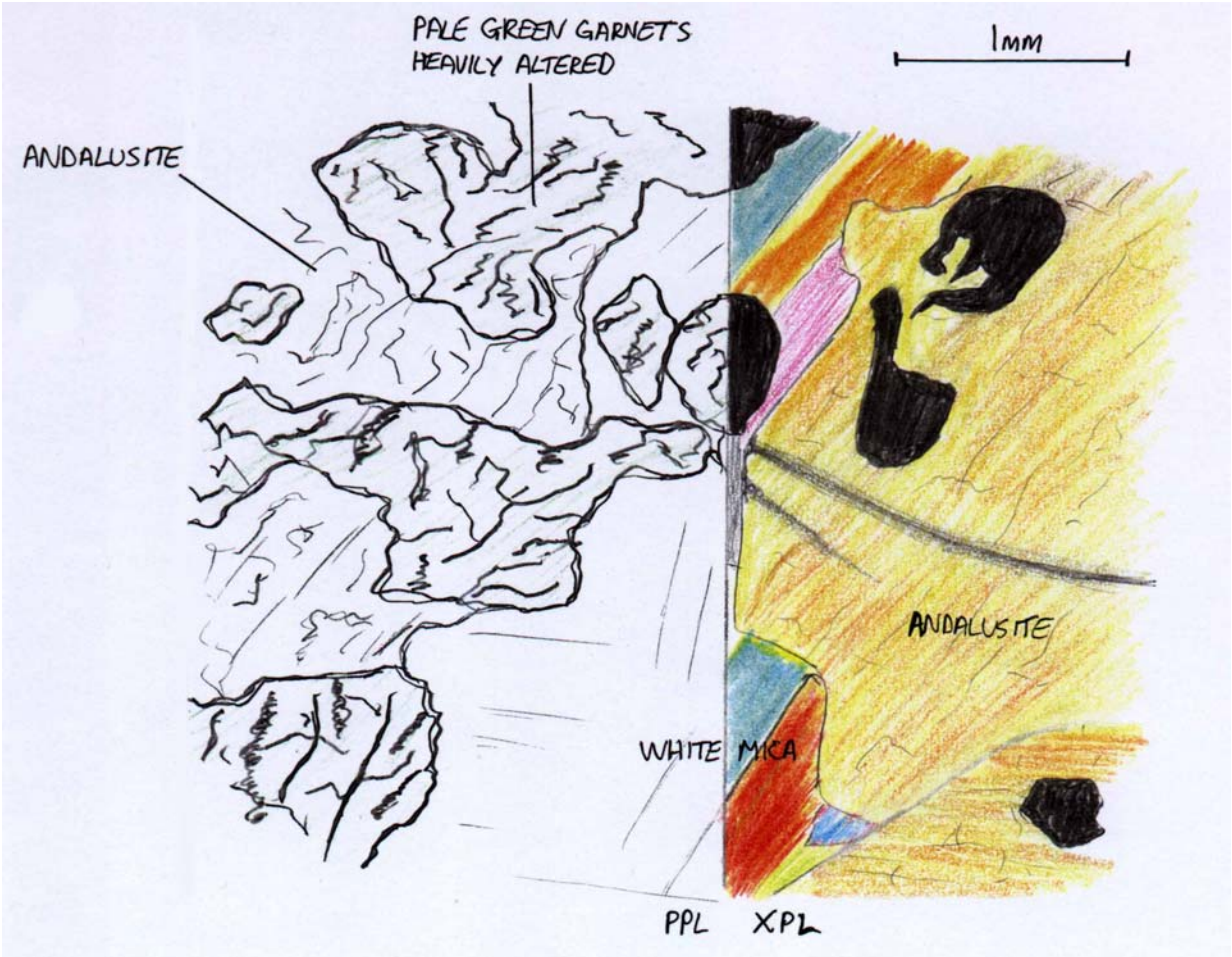
General Description.

This section is a medium to coarse-grained garnet and andalusite rich schist with a complex polymetamorphic history .

Mineralogy and texture.

The most obvious porphyroblastic material in the section is anhedral generally rounded garnet. These are fairly abundant and contain inclusions of quartz, white mica and andalusite. Some of the larger garnets are broken into smaller round garnets at the edges, suggesting fragmentation.

The most abundant mineral in the section is poikiloblastic showing a square cross-section, high relief, low birefringence and length-fast character. These factors indicate it is andalusite. One poikiloblast has a regular arrangement of fine-grained impurities in its centre . These are likely to be carbonaceous inclusions in a crystal of chiastolite.



There is a general fabric to the mineral, shown by elongate aligned crystals of white mica. These show no deviation in orientation even when right up against the garnets and andalusites. Some minor amphibole, quartz and sphene occur with the mica.

Interpretation.

Inclusion trails are absent in the two index minerals so limited information about relative timing of events can be established, except to say that the index minerals were probably fully formed by the time of latest fabric growth (and accompanying tectonics). Garnet is a moderately high pressure-temperature index mineral and andalusite is formed at low P-T conditions, and is common in contact metamorphism aureoles. Chiastolite is indicative of low grade metamorphism. A possible scenario for the formation history of this rock could involve regional metamorphism of an argillaceous sediment to amphibolite facies, forming garnet. This has then undergone a retrogressive metamorphism as an aureole under andalusite forming conditions, resulting in the formation of an andalusite-garnet-schist.