DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

REPT.BK.NO. 83/41

PETROGRAPHY OF TWO METAMORPHIC ROCKS FROM THE WILLIAMSTOWN QUARRY

GEOLOGICAL SURVEY

by

M. FARRAND

JUNE, 1983

DME.454/82

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Rept. Bk. No. 83/41
D.M.E. No. 454/82
Disk No. 4

SADME PET. REP. 8/83
1:100 000 Sheet 6628
Williamstown Quarry

PETROGRAPHY OF TWO METAMORPHIC ROCKS FROM THE WILLIAMSTOWN QUARRY

ABSTRACT

The two rocks have been metamorphosed to the amphibolite facies with relatively severe deformation. One specimen is of an amphibolite which probably originated as a basic volcanic or minor intrusive but which has undergone several stages of retrogressive metamorphism and the metasomatic introduction of quartz. The other specimen is of a quartz sandstone with a clay matrix in which the metamorphism was probably isochemical.

The rocks are more likely to be members of the Barossa Complex than of the Adelaidean succession and their exposure suggests that the Williamstown quarry has either penetrated the contact between the two series or has exposed an upthrust block of Barossa Complex.

INTRODUCTION

Two specimens of rocks from the Williamstown Quarry were received from Mrs Susan Daly for petrographic examination with emphasis on metamorphic grade. The rocks had been collected by Mrs Daly and Dr Tony Belperio, at the request of Mr Jack Townsend, because they appeared to be of higher metamorphic grade than that prevalent in the Adelaidean succession so far quarried.

PETROGRAPHY

Specimen 6628 RS 2115, TS C 39922S

Rock name Amphibolite

Hand specimen

On the weathered surface the rock has an orange-brown coating of limonite marked on some faces with shortbands and lenticular patches of a darker iron oxide. The latter markings have a preferred orientation. On the broken surface the metamorphic cleavage is emphasized by fracture along a series of sharp-edged ridges, parallel along their length but with a serrated cross-section. The sawn surface reveals a tightly crenulated foliation parallel to the serrated faces of the cross section of the broken surface.

Apart from the metamorphic foliation the texture consists of a fine grained, black and white speckled fabric with strong preferred orientation of elongated grains and patches along the foliation.

Thin section

The rock consists largely of quartz and a green amphibole. Minor pyroxene and plagioclase are distributed patchily through the section and the green amphibole is altered, particularly in a weathered part of the section, to a fibrous, pleochroic chlorite and a green, non-pleochroic chlorite. Grains of opaque oxides are abundant and yellow-brown limonite is common in the weathered part of the specimen. Fine grains of apatite, patches of epidote and few grains of a carbonate are accessory constituents.

The quartz is strongly recrystallised and forms a mosaic of grains which are in close contact along simple grain boundaries, often meeting in 120° triple junctions. The grains are roughly equidimensional and have no observable preferred orientation. A discontinuous band of quartz crosses part of the section but it is probably a discordant vein which has undergone minor recrystallisation and deformation, since it is not conformable to the contorted foliation.

The amphibole occurs as rather poorly-shaped grains with a long dimension which is usually oriented along the foliation. Owing to the highly contorted nature of the foliation, the orientation is not consistent over more than a few milimetres and the foliation is more strongly marked in the hand specimen than in the thin section. The amphibole is pleochroic from the blue green through pale green to colourless or pale straw yellow. Its birefringence is moderate to low and its crystal structure is probably less than perfect due to incipient alteration. The mineral appears to be a hornblende rather than actinolite.

The pyroxene occurs as irregular and fragmented grains closely intergrown with the hornblende. In most instances the textural evidence supports the not unreasonable assumption that the amphibole surrounding pyroxene grains is an alteration product. It should be noted, however, that much of the hornblende displays no evidence of having been derived in place from original pyroxene. The pyroxene is rarely present without contiguous hornblende. It is colourless and probably diopsidic.

Plagioclase which is readily recognisable by optical methods is distributed irregularly in patches and constitutes only a minor proportion of the rock. The proportion of plagioclase may have been underestimated if some of it is not visibly twinned. However, even if grains which may possibly be untwinned plagioclase are included, it is doubtful whether the content of plagioclase in the rock would exceed 5% overall. Locally, concentrations are higher. The habit of the plagioclase is similar to that of the quartz. It tends to occur as equidimensional grains rather than elongated laths. There is no observable preferred orientation in the plagioclase grains.

The amphibole is subject to two types of chloritic alteration. In one type the chlorite has a low but anomalous birefringence and forms radiating fans of acicular prisms which are pleochroic from blue green to colourless. The chlorite is probably a prehnite. The other type of chloritic alteration produces a non-pleochroic, isotropic green mineral with no expression of crystal form. Both chlorites occur together, in the vicinity of a fracture cutting across the section.

Opaque black oxide grains are the third most abundant constituent of the rock. It occurs as relatively coarse grains of subhedral to anhedral shape which are unevenly distributed throughout the rock. Most grains are separate but linear groups of oxide grains are responsible for the short, dark bars on the weathered surface of the hand specimen.

Limonitic iron oxide is present as a brown stain along the fracture cutting the specimen and along grain boundaries of grains in zones each side of the fracture. This gives a weathered appearance to one end of the thin section.

The fracture is also the locus of a concentration of large patches of highly birefringent epidote. Scattered patches occur less abundantly elsewhere in the specimen. The epidote is interstitial in habit and is probably derived from the alteration of amphibole, but not always directly and in place.

The fracture which has carried solutions which altered amphibole to chlorite and introduced limonite has also been the path for deposition of dolomite. It is not abundant but occurs as interstitial and replacement patches scattered along the fracture.

Fine grains of apatite, consisting of moderately well-shaped, stumpy prisms are distributed widely but not abundantly throughout the rock.

Comment

The rock is far from an equilibrium assemblage of minerals and reactions which have not gone to completion were initiated at several times and in several conditions of temperature and pressure. The rock is of at least amphibolite, possibly of granulite facies but whether the high grade is due to regional metamorphism or was inherited from an initial high temperature of intrusion depends on whether the rock is in fact igneous. The current composition is far from that of a basic intrusive. The quartz content is far too high and the plagioclase content far too low. On the other hand, although the highly contorted foliation suggests a high grade of regional metamorphism, pyroxene is normally associated with garnet in the granulite facies.

These somewhat contradictory factors can be reconciled if an original pyroxene-bearing basic lava or intrusive retrogressed to the amphibolite facies during regional metamorphism. The composition of the rock was subsequently altered at a relatively low temperature by the replacement of plagioclase by quartz. Further alteration occurred at a later stage, and lower temperature, with the introduction of epidote and dolomite and the alteration of hornblende to chlorite along fractures in the rock. The introduction of limonite along the same fractures may have occurred at this stage but probably originated even later as a product of atmospheric weathering.

With a metamorphic grade in the amphibolite facies the rock is more likely to be part of the Barossa Complex than of the Adelaidean sequence.

Specimen 6628 RS 2116, TS C 39923

Rock name Quartz, sillimanite gneiss

Hand specimen The rock has a strong foliation due to parallel bands of quartz. A few flakes of white mica are visible and on close examination a cloudy white mineral is seen to form clusters of fibres, often in radiating tufts.

The quartz bands are seen to vary in thickness and to be irregularly contorted on the sawn face of the specimen.

Thin section

In thin section it is apparent that the quartz bands are distinguished by an abundance of quartz rather than by the absence of any other mineral. The other major constituent is sillimanite which forms radiating tufts and random masses of acicular crystals. Minor constituents are white mica, staurolite, ?andalusite and fine grained rutile.

The quartz occurs as mainly coarse grained crystals, closely interlocked along complex inter-granular structures. In some places the quartz has been shattered and the fragments have commenced to recrystallise. Some of the coarse grains are highly strained. Much of the quartz contains acicular inclusions of sillimanite. The quartz bands are not as clearly distinguished as in the hand specimen.

The sillimanite is distributed throughout the rock but is concentrated into patchy and irregular bands. Parallel bundles of needles show a moderate birefringence but individual crystals are too fine to show high polarisation colours. Parallel bundles of fibres have no discernable preferred orientation and many are curved. Others end in radiating tufts. These tufts are also common independently of parallel bundles. Sparse, fine, acicular inclusions of sillimanite in quartz often occur in oriented arrays, parallel or radiating, although they are not in contact with each other in the plane of section.

Muscovite mica occurs as small, irregular flakes, singly and in small clusters, with no discernable preferred orientation. The flakes are enclosed in quartz grains both in quartz-rich bands and in sillimanite-rich patches. They are most abundant at the margins of sillimanite bundles and are often in contact with sillimanite and staurolite.

Staurolite occurs as small, irregular grains included in quartz. It is more common in the quartz-rich bands and often occurs without accompanying sillimanite. However it occurs most frequently with mica and sillimanite, also included in quartz. The staurolite is pleochroic from pale yellow to colourless. In some grains the yellow tint is not detectable and the pleochroism appears to be in pale shades of pink and green. The refractive index, judging by the relief of the grains, is still high but the mineral has been identified as ?andalusite.

Very fine, often euhedral, yellow-brown grains of high refractive index and high birefringence occur in the sillimanite patches. Because of the small grain size and the high refractive index there are no clear extinction positions and optical properties are not precisely measurable. The mineral appears to be optically uniaxial positive, and hence probably rutile, although the grains tend to be equidimensional rather than prismatic.

Comments

No feldspar was identified in the rock, which appears to be the product of the regional metamorphism of a quartz sandstone with a dominantly kaolinitic matrix. A relatively low potassium concentration is contained in muscovite and a very low iron concentration in pale staurolite.

Evidence of recrystallisation is found in the complex intergranular sutures and occasional unannealed granulation of quartz, in which residual strain is still evident in undulose extinction. This recrystallisation is probably part of the same episode in which substantial quartz was introduced into the amphibolite but there is no evidence that quartz was introduced into the gneiss or that any phase changes in other minerals accompanied it.

The relatively simple mineralogy of the rock prevents a precise determination of metamorphic grade. The diagnostic assemblages are sillimanite with andolusite-staurolite and muscovite with quartz. The coexistence of major sillimanite with minor, and presumably metastable, andalusite is the result of sluggish phase transitions in alumino-silicate systems but suggests that the assemblage probably developed near the sillimanite-andalusite phase boundary. This is at about 630°C with a pressure of 5kb but at over 800°C at atmospheric pressure.

The assemblage muscovite-quartz is converted to potash feldspar and an alumino-silicate in conditions ranging between 650°C at 3kb and 770°C at 10kb, assuming excess water. Unfortunately, the two phase boundaries, those of the andalusite-sillimanite transition and the muscovite-potash feldspar transition, are roughly parallel with an intersection only at the 10kb 770°C point. However, the low-temperature eutectic melt in the system quartz, two feldspars and water cuts the muscovite-potash feldspar boundary at 3kb and about 660°C. Although no plagioclase is present this limit gives approximate boundary conditions for the gneiss since no melting textures are evident. Since sillimanite is not stable below 630°C and 5kb, an approximate but reasonable estimate of the pressure and temperature prevailing at the time the gneiss was formed is given by the overlap of the minimum sillimanite field and the solid versus melt field at, say, 5kb and 650°C. This is fairly high in the amphibolite facies and is broadly in agreement with the proposed grade of the amphibolite RS2115 after retrogression from the temperature of intrusion.

CONCLUSION

The two rocks examined appear to be regionally metamorphosed to amphibolite facies with fairly intense deformation. Both are more likely to be members of the Barossa Complex than the Adelaidean succession. The Williamstown quarry has exposed the earlier rocks either in an upfaulted block or by penetration of the contact between the two rock series.

M. Farrand.

MF:AF DR. M. FARRAND