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Petrographic descriptions of a number of thin sections of sandstone and igneous rocks from the Ayr district (sheet 14W), Scotland

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Petrographic descriptions of a number of thin sections of sandstone and igneous rocks from the Ayr district (sheet 14W), Scotland

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Foreword

This report is the published product of a study by the British Geological Survey (BGS) on the regional geology of the Midland Valley of Scotland. It is part of the Science Budget funded programme which forms part of the core programme of BGS. This core programme is designed to undertake a multidisciplinary geological survey to meet user and strategic needs for geological information.

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Summary

This report describes the mineralogy and petrology of a suite of sandstones, microconglomerates and other sedimentary rocks as part of the regional mapping of the Ayr district (sheet 14W).

1 Introduction

This report describes the mineralogy and petrology of a suite of sandstones, microconglomerates and other sedimentary rocks from the Swanshaw Formation (Lanark Group) of the Ayr district (sheet 14W). The rock samples were collected by Dr Alison Monaghan as part of the regional mapping of the Midland Valley of Scotland. This work forms part of the British Geological Survey's Integrated Geological Survey (North) programme.

2 Thin section descriptions

2.1 SEDIMENTARY ROCKS

Collectors Number: ASW 106A. **Registered Number:** N2829. **Location:** [NS 1989 0340] on shore to the west of Dowhill Farm. **Formation:** Swanshaw Sandstone Formation (Lanark Group). **Rock Type:** pebbly, medium-grained quartzose, lithic-rich sandstone (litharenite).

Description: This thin section is of a medium-grained, immature, poorly sorted, lithic-rich, relatively quartzose, pebbly, clast-supported, closely to very closely packed, matrix-poor, sandstone which contains granule to small pebble-sized lithic clasts. The large lithic clasts are typically composed of a pale brown coloured (in plane polarised light), massive to laminated mudstone and fine siltstone. The laminated lithic fragments may contain a fine-scale sedimentary grading. The clasts range from 1.5 mm up to *c.* 10.0 mm in length and are subrounded to rounded in shape with a low sphericity. The shape of some of the more unstable lithic clasts has been modified during compaction. This led to the embayment/indentation of these unstable lithic fragments against neighbouring more rigid quartzose grains. Other lithologies recognised forming these granule to pebble-sized clasts include: cryptocrystalline, aphyric to very weakly quartz microporphyritic rhyolite; altered, very fine-grained sandstone; biotite-bearing granitic rock; recrystallised, fine-grained granitic rock; and sericitised fine-grained sandstone.

The bulk of the thin section is composed of a medium-grained sandstone. Detrital grains within this sandstone are angular, subangular to occasionally subrounded in shape with a low to moderate sphericity. The clast assemblage is dominated by monocrystalline quartz and lithic fragments. The lithic clasts are, in general, altered to a cryptocrystalline chloritic assemblage. This alteration makes positive identification of the protolith of these rock fragments difficult. However, recognisable lithologies include felsite, chert, schistose rock, sericitised rock, metasedimentary rock, biotite-schist, serpentine and mudstone. Minor to accessory detrital components present within this sandstone include muscovite/white mica, polycrystalline quartz, plagioclase, microcline, chlorite and myrmekite or micrographic intergrowth. Compaction resulted in the localised kinking of detrital micas and deformation of unstable lithic clasts.

Minor to trace amounts of a replacive carbonate cement are present within this sandstone. Carbonate appears to be replacing the original matrix component of the sandstone as well as unstable detrital components and any earlier developed cement. Two generations/phases of cementation have been recognised: (1) an early, weakly developed hematitic cement forming rims or coatings upon some detrital grains; and (2) later apparently contemporaneous carbonate and hematite cements resulting in the development of carbonate containing included hematitic oxide. The presence of hematite ‘intergrown’ with carbonate locally preserves rhomb-shaped crystals (probably dolomite). The type of carbonate mineral(s) present is uncertain as this thin section is unstained.

Collectors Number: ASW 106B. **Registered Number:** N2830. **Location:** [NS 1989 0340] on shore to the west of Dowhill Farm. **Formation:** Swanshaw Sandstone Formation (Lanark Group). **Rock Type:** pebbly, medium-grained quartzose, lithic-rich sandstone (litharenite).

Description: This thin section is of a medium-grained, poorly sorted, immature, closely to very closely packed, clast-supported, relatively quartzose, lithic-rich sandstone (litharenite) which contains granule to pebble sized lithic clasts. These large lithic clasts are mainly composed of laminated to massive mudstone, siltstone and sandy siltstone. The clasts exhibit a preferred shape alignment and are subrounded to rounded in shape with a low sphericity. The shape of the mudstone lithic clasts has locally been modified during compaction with the weaker mudstone rock fragments embayed or indented against neighbouring more rigid quartzose grains. Compaction also resulted in the localised fracturing of the rock fragments, with the mudstone lithic clasts also showing very little evidence of syn-sedimentary plastic deformation/distortion. The latter suggests that the mudstone clasts were at least partially lithified prior to their incorporation within this sandstone. Other, more angular, granule to small pebble sized lithic clasts are composed of: amygdaloidal, glassy volcanic rock; quartz-phyric felsite or rhyolite; altered, fine-grained, feldspathic sandstone; foliated tuffaceous rock or mudstone in which the fabric is defined by the optical alignment of sericitic white mica; and a deformed quartzofeldspathic rock.

The bulk of the thin section is composed of a medium-grained sandstone. Detrital grains within the sandstone are angular, subangular to occasionally subrounded in shape. The shape of the more unstable detrital components has been modified during compaction and the development of the later carbonate cement. The clast assemblage is dominated by variably altered lithic fragments and monocrystalline quartz. The protolith of the majority of the lithic clasts is uncertain due to their alteration to a very fine-grained or cryptocrystalline chloritic/clay assemblage. Recognisable lithologies include felsite/chert, very fine-grained white mica-rich schistose rock, serpentine, very fine-grained volcanic rock, and mylonitic quartzite or sheared vein quartz. Other minor to accessory detrital components include polycrystalline quartz, muscovite, plagioclase, chloritised biotite, tourmaline and microcline. Compaction resulted in the kinking of detrital micas.

Trace to minor amounts of a replacive carbonate and hematitic cements are developed within this sandstone. Carbonate appears to have preferentially replaced the original matrix and cement (if present), as well as unstable lithic clasts. The carbonate and hematite are intergrown, with the red-brown coloured (in plane polarised light) Fe-oxide locally preserving the original rhombic shape of the carbonate crystals (probably dolomite). The composition of the carbonate minerals present is uncertain as this thin section is unstained.

Collectors Number: ASW 107. **Registered Number:** N2831. **Location:** [NS 1988 0328] on shore to the west of Dowhill Farm. **Formation:** Swanshaw Sandstone Formation (Lanark Group). **Rock Type:** hematitic, medium-grained, relatively quartzose, lithic-rich sandstone (quartzose litharenite).

Description: This thin section is of a fine- to medium-grained, clast-supported, moderately to poorly sorted, closely packed, hematitic, massive, relatively quartzose, lithic-rich sandstone (quartzose litharenite). Detrital grains are angular to subangular in shape with a low sphericity. The elongate grains exhibit a weakly developed preferred shape alignment, probably parallel to bedding. Rare subrounded to rounded clasts were also recorded within this overall immature sandstone.

The clast assemblage is dominated by monocrystalline quartz and variably altered rock fragments. Fragments of opaque oxide and/or hematised rock are a common minor component

within this sandstone. The lithic clasts are mainly composed of cryptocrystalline felsitic rock or chert. Other recognisable rock fragments include very fine-grained schistose rock, altered very fine-grained sandstone, coarse siltstone and possible serpentinite. Minor to accessory detrital components p[resent within this sandstone include plagioclase, polycrystalline quartz, muscovite and microcline. Elongate muscovite flakes are a relatively common accessory component with compaction resulting in the localised kinking of these detrital micas.

A hematitic rim cement present within this sandstone forms variably developed coatings upon detrital grains. This hematitic cement predates the formation of a replacive carbonate cement. Carbonate appears to have replaced the original matrix component within this sandstone, as well as the unstable detrital components. The outline of the replaced detrital clasts is locally preserved by the earlier developed hematitic rim cement.

Collectors Number: ASW 108. **Registered Number:** N2832. **Location:** [NS 2114 0213] on in stream south of Westfield. **Formation:** unknown. **Rock Type:** hematitic, medium-grained relatively quartzose sandstone.

Description: This thin section is of a medium-grained, poorly sorted closely packed, clast supported, altered, relatively quartzose sandstone which possesses a patchily developed hematite stained matrix or cement. This matrix fills intergranular pore spaces. Detrital grains are angular to subangular in shape with a low sphericity. However, occasional subrounded to rounded, moderate to low sphericity grains are also present. A weak preferred shape alignment of elongate grains has also been recognised.

The clast assemblage is dominated by monocrystalline quartz and altered, unstable lithic clasts. The protolith of the majority of these lithic clasts is uncertain due to their alteration to a very fine-grained or cryptocrystalline chloritic assemblage. Recognisable lithologies forming these clasts include: a very fine-grained schistose rock; very fine-grained metasandstone or metasiltstone; cherty rock; and a very fine-grained volcanic rock. Other minor to accessory detrital components present within this sandstone include muscovite, biotite, polycrystalline quartz, chlorite, epidote and hornblende. Detrital micas are typically undeformed, however, minor kinking in response to compaction has been noted.

Traces of quartz overgrowths have been recorded developed upon detrital monocrystalline quartz. Localised pressure solution between quartz grains has also been noted. Traces of a cryptocrystalline, colourless, possibly chloritic cement is present and appears to predate the formation of the later hematitic cement.

Collectors Number: ASW 112. **Registered Number:** N2834. **Location:** [NS 2116 0477] Chapleton Burn. **Formation:** Swanshaw Sandstone Formation (Lanark Group). **Rock Type:** calcareous, relatively quartzose sandstone with mudstone to siltstone partings.

Description: This thin section is of a fine- to medium-grained, laminated, open packed, apparently cement-supported, quartzose, immature sandstone which possesses a well developed carbonate cement. The composition of the carbonate minerals present within this cement is uncertain as this thin section is unstained. The presence of fine-grained, rhombic crystals suggests that the cement may have included dolomite. Carbonate appears to be replacing the

original matrix component of the sandstone as well as an earlier developed chloritic/clay cement. Carbonate was also noted replacing lithic clasts and feldspar. The variation in the intensity of the development of this carbonate cement is reflected in the a change in the overall texture of the sandstone. In the areas in which the carbonate cement is well developed, the sandstone possesses a more open packed cement-supported texture. This carbonate cement appears to be of a single generation.

Detrital grains are subangular, subrounded to rounded in shape with a low to moderate sphericity. The shape of the clasts has, however, been modified during the development of the carbonate cement with resulted in the etching of clast grain boundaries. The finer-grained sand to silt grade clasts are typically more angular in shape. The clast assemblage is dominated by monocrystalline quartz with subordinate rock fragments. The protolith(s) to the majority of these lithic clasts is uncertain due to alteration, including replacement by carbonate. Recognisable lithologies include felsite/rhyolite, quartzite, sheared quartzite or vein quartz, schistose metasedimentary rock, possible serpentinite, possible tuffaceous rock and psammite. Other minor to accessory detrital components include polycrystalline quartz, tourmaline, muscovite, plagioclase, K-feldspar, apatite, opaque minerals, zircon, possible rutile and epidote.

Compaction of the sandstone resulted in localised pressure solution between detrital grains and embayment of relict lithic clasts against neighbouring, more rigid, quartzose grains. The sedimentary lamination present within this thin section is denoted by a variation in grains size of the rock, with the sandstone containing thin mudstone and/or siltstone partings. Bedding surfaces were apparently sharp, however, carbonate replacement has partially obscured these relationships.

Collectors Number: ASW 113. **Registered Number:** N2835. **Location:** [NS 2153 0829] northeast of Maidens near high tide mark. **Formation:** Swanshaw Sandstone Formation (Lanark Group). **Rock Type:** heterolithic microconglomerate with a well developed calcareous cement.

Description: This thin section is of a coarse-grained, clast- to cement-supported, moderate- to open-packed, poorly sorted, heterolithic, lithic-rich microconglomerate which possesses a well developed, replacive carbonate cement. Carbonate has largely replaced or over printed the original matrix to the conglomerate. Small relict patches of the matrix are preserved and are composed of cryptocrystalline quartzose or chloritic material.

Detrital grains range in size from fine sand to small pebbles in size with a distinct break in grain size between the sand-grade and coarser grained clasts. Clast are subrounded, rounded to well rounded in shape with a low to moderate sphericity. The quartzose clasts tend to be more angular in shape and are more common within the sand-grade component of the microconglomerate. The clast assemblage is, however, dominated by rock fragments. The lithic clasts are mainly composed of a very fine-grained cryptocrystalline cherty rock and cherty mudstone or tuffaceous rock. Other recognisable lithologies present include: felsite; very fine-grained rhyolite; siltstone partially replaced by carbonate; fine-grained, altered quartzose sandstone; quartzite; vein quartz; altered, fine-grained litharenite; and quartz-phyric rhyolite. Quartzose clasts are mainly composed of variably strained monocrystalline quartz with minor amounts of polycrystalline quartz. The shape of some of the quartzose clasts suggests that may represent rounded/partially resorbed phenocrysts from a rhyolitic rock.

Compaction resulted in localised fracturing of some clasts and pressure solution along inter-clast grain boundaries. The main form of cementation within this microconglomerate is a fine- to medium-grained, crystalline carbonate cement. Carbonate appears to be of a single generation and possesses a dusty appearance in plane polarised light. The areas of finer grained carbonate appears to reflect a variation in the grain size of the original matrix (finer grained sandstone) to the microconglomerate. Traces of an earlier chloritic cement have also been recognised within relict patches of the fine-grained sandstone matrix. Carbonate has preferentially replaced the matrix of the microconglomerate, with very little replacement of the lithic clasts. The composition of the carbonate minerals present within the cement is uncertain as this thin section is unstained.

Collectors Number: ASW 116. **Registered Number:** N2836. **Location:** [NS 2491 0434] south of Chapleton Farm. **Formation:** Swanshaw Sandstone Formation (Lanark Group). **Rock Type:** mudstone.

Description: This thin section is of a very fine-grained mudstone which possesses a moderate to well developed foliation. This foliation is defined by the alignment of the clay plasma and probably developed during compaction and dewatering. Rare very fine silt-grade quartz grains and spots of hematitic oxide have been recorded within this mudstone.

Collectors Number: ASW 117A. **Registered Number:** N2837. **Location:** [NS 1992 0305] on shore northwest of Dipple factory. **Formation:** Swanshaw Sandstone Formation. **Rock Type:** conglomerate.

Description: This thin section is of a coarse-grained, heterolithic, clast- to matrix-supported, moderately packed, immature, poorly sorted conglomerate which possesses a poorly sorted, coarse sandstone matrix. The thin section is dominated by a number of large lithic clasts which range from coarse sand/granule up to pebbles in size (up to ≥ 25.0 mm in size). These large clasts are rounded to well rounded in shape with a low sphericity. They locally appear to represent broken fragments of larger clasts and are, therefore, probably polycyclic in nature. These large clasts are mainly composed of rock fragments, in particular a fine-grained, variably altered, immature, quartzose sandstone. This sandstone is petrographically similar to thin sections of other sandstones from the Swanshaw Formation. The sandstone lithic clasts possess a patchy to locally well developed hematitic cement. Other lithologies present forming granule to pebble-sized clasts include: cryptocrystalline cherty rock; quartz-microporphyritic graphic microgranite; mudstone or tuffaceous rock; silicified mudstone which preserves a water escape conduit/flame structure; coarse siltstone; felsite; altered sandstone; coarse-grained quartzose sandstone; polycrystalline quartz; and quartz-phyric rhyolite.

The sandstone matrix is a poorly sorted, immature, lithic-rich rock. There is no obvious bimodal grain size distribution within this conglomerate, with the finer grained matrix component apparently grading into the granule to pebble-sized clasts. Detrital grains within the sandstone matrix are subangular to rounded in shape with a low to occasionally moderate sphericity. The close packing and localised partial degradation of the unstable lithic clasts makes identification of original grain boundaries difficult. The clast assemblage within the matrix is dominated by rock fragments and monocrystalline quartz. The range of lithologies forming these lithic clasts is similar to that forming the granules and pebbles. Monocrystalline quartz grains tend to be more angular in shape than the lithic clasts. Other minor to accessory detrital components include

polycrystalline quartz, opaque minerals, muscovite/white mica, sericitised rock, chloritic siltstone or very fine-grained sandstone and possible serpentinite.

Three generations of cement have been recognised within this conglomerate: (1) An early hematitic rim cement forming variably developed coatings upon detrital grains, pore spaces and larger cavities left by the patchy nature of the sandstone matrix; (2) a carbonate and hematite cement characterised by dusty, reddened carbonate containing inclusions of hematitic Fe-oxide. The hematitic oxide locally preserves rhomb-shaped crystals (probably after dolomite) and growth zones within carbonate filling a large cavity present between several large pebble sized clasts; and (3) clear, crystalline carbonate infilling the centres of cavities/voids. Trace amounts of quartz have been noted associated with this cavity filling carbonate. The large, intergranular cavity present within this conglomerate is partially filled by a geopetal sediment composed of weakly laminated, fine siltstone and mudstone.

Collectors Number: ASW 117B. **Registered Number:** N2838. **Location:** [NS 1992 0305] on shore northwest of Dipple factory. **Formation:** Swanshaw Sandstone Formation. **Rock Type:** conglomerate with carbonate cement, comparable to N2837.

Description: This thin section is of a coarse-grained, poorly sorted, heterolithic, immature, clast-supported, moderate to closely packed conglomerate which possesses a patchily developed sandstone matrix and carbonate cement. The larger clasts range from coarse sand up to pebble sized (up to ≥ 29.0 mm in size) and are composed of rock fragments of mainly fine-grained sandstone and siltstone. These rock fragments are petrographically similar to sandstones from the remainder of the Swanshaw Sandstone Formation. Other lithologies present include: altered sandstone; mudstone or tuffaceous rock; silty mudstone; hematised siltstone; quartzite; very fine-grained metasandstone; felsite; autobrecciated, weakly quartz-phyric rhyolite; and chert. These large clasts are subrounded, rounded to well rounded in shape with a low sphericity. A number of these lithic clasts appear to be broken fragments of much larger pebbles, indicating that they are polycyclic in origin.

The sandstone matrix to the conglomerate is poorly sorted, immature and lithic-rich. Detrital grains are angular to rounded in shape with a low to occasionally moderate sphericity. The clast assemblage is dominated by lithic clasts and monocrystalline quartz. The quartzose clasts are, in general, more rounded in shape than the accompanying lithic fragments. The range of lithologies forming the lithic clasts are similar to those listed above. Other minor to accessory detrital components present within the sandstone matrix includes plagioclase, polycrystalline quartz, metasandstone, microcline, opaque minerals and muscovite/white mica.

Four generations of cement have been recognised within this conglomerate: (1) An early hematitic rim cement forming variably developed coatings upon detrital grains, pore spaces and larger cavities left by the patchy nature of the sandstone matrix; (2) a fine-grained to cryptocrystalline chloritic or clay poor filling cement which is variably replaced by the later carbonate cements; (3) a carbonate and hematite cement characterised by dusty, reddened carbonate containing inclusions of hematitic Fe-oxide. The hematitic oxide locally preserves rhomb-shaped crystals and growth zones within carbonate filling a large cavity present between several large pebble sized clasts; and (4) clear, crystalline carbonate infilling the centres of cavities/voids. Trace amounts of quartz have been noted associated with this cavity filling carbonate.

Collectors Number: ASW 118. **Registered Number:** N2839. **Location:** [NS 1990 0301] on shore northwest of Dipple factory. **Formation:** Swanshaw Sandstone Formation. **Rock Type:** interbedded, coarse- and fine-grained sandstones with patchily developed carbonate cement.

Description: This thin section is of interbedded, coarse- and very coarse-grained, immature, lithic-rich, moderately to locally open-packed, clast- to cement-supported sandstones with the coarser grained lithologies containing occasional granule to pebble sized lithic fragments.

The coarse-grained sandstone is an open-packed, cement supported rock due to the replacement of the original matrix and/or cement by secondary carbonate. Detrital grains are angular, subangular to occasionally subrounded in shape with a low sphericity. The clast assemblage is dominated by monocrystalline quartz and rock fragments. Quartzose clasts are typically more angular in shape. The lithic clasts are mainly replaced by a cryptocrystalline chloritic assemblage. Recognisable lithologies forming these clast include: a very fine-grained probably igneous rock; mudstone; siltstone; cryptocrystalline quartz; felsite or cherty rock; originally glassy, pilotaxitic/hyalopilitic, amygdaloidal volcanic rock; altered basaltic rock; and sandstone. Other minor to accessory detrital components present within these coarse sandstone layers include polycrystalline quartz, microcline, plagioclase, muscovite, opaque minerals and chloritised biotite. Traces of a dusty looking clay matrix is present. The carbonate cement appears to be of a single generation and is locally composed of coarse, up to 1.0 mm in size, poikilitic crystals which enclose the smaller detrital grains.

The very coarse-grained to pebbly sandstones are closely to very closely packed, heterolithic, poorly sorted, clast supported rocks (litharenites) which possess a variably developed replacive carbonate cement. The grain size is highly variable and ranges from fine-sand up to pebble (up to *c*. 18.0 mm in size). Detrital grains are angular to well-rounded in shape with a low sphericity. A weak preferred shape alignment of the elongate grains is developed parallel to bedding. The lithic clasts are, in general, more rounded in shape and may be polycyclic in nature. A number of the clasts appear to represent broken fragments of larger pebbles. Quartzose clasts are relatively more angular and are more common within the finer grained component of the sandstone. Patches of a dusty looking matrix are variably replaced by secondary carbonate. A distinctive feature of the lithic assemblage within these sandstones is common occurrence of fragments of a hematised, originally glassy, amygdaloidal, weakly microporphyritic volcanic rock. Other recognisable lithologies include: siltstone; fine-grained sandstone; biotite-feldspar-phyric dacite or rhyolite; hematised possibly tuffaceous rock; mudstone; basaltic andesite; quartz-chlorite vein material; felsite; pilotaxitic, feldspathic volcanic rock; volcaniclastic sandstone; and chloritised basaltic rock. Sedimentary and volcanic derived lithic clasts are common components within these very coarse-grained sandstones.

Collectors Number: ASW 119. **Registered Number:** N2936. **Location:** [NS 2288 0494] Chapleton Burn, top of gorge section. **Formation:** Swanshaw Sandstone Formation. **Rock Type:** fine- to medium-grained, quartzose, lithic-rich sandstone (quartzose litharenite).

Description: This thin section is of a fine- to medium-grained, poorly to moderately sorted, clast supported, closely packed, immature, massive, low porosity, relatively lithic-rich, quartzose sandstone (quartzose litharenite). This sandstone possesses minor amounts of a replacive carbonate cement. The composition of the carbonate minerals present are uncertain. However,

these carbonate crystals possess a hematitic/ochre rim or stain suggesting that they may have included ferroan dolomite and/or ferroan calcite. Carbonate occurs as single crystals or aggregates of several grains which appear to be replacing either the original matrix or earlier developed cement.

Detrital grains are subangular to subrounded in shape with a low to moderate sphericity. Occasional well-rounded grains have also been recorded within this sandstone. The shape of the detrital grains has locally been modified due to pressure solution and/or growth of the carbonate cement. The clast assemblage is dominated by monocrystalline quartz with subordinate lithic fragments. These lithic clasts are mainly composed of, or have been replaced by a very fine-grained to cryptocrystalline felsitic or cherty-looking quartzofeldspathic assemblage. Other minor to accessory detrital components include polycrystalline quartz, quartzose metamorphic rock, muscovite/white mica, siltstone, cleaved/foliated mudstone, very fine-grained sandstone or metasandstone, opaque minerals, plagioclase, deformed polycrystalline quartz or vein quartz and titanite.

Traces of an early formed cryptocrystalline, colourless chloritic or clay cement has been noted within this sandstone. Although fine- to medium-grained occasional to rare coarse sand to granule sized sedimentary lithic clasts are also present.

Collectors Number: ASW 120. **Registered Number:** N2937. **Location:** [NS 2288 0494] Chapleton Burn, top of gorge section. **Formation:** Swanshaw Sandstone Formation. **Rock Type:** laminated, very fine-grained, quartzose sandstone.

Description: This thin section is of a fine- to very fine-grained, moderately sorted, clast-supported, closely packed, immature, massive, low porosity, quartzose sandstone (quartz-arenite). The sedimentary lamination present within this sandstone is defined by the variation in the grain size and modal content of the clay matrix; the latter is higher within the finer grained to silty laminae. Bedding surfaces are sharp with individual laminae being up to 1.0 to 2.0 mm thick. No obvious grading has been recognised. A weakly to moderately developed replacive carbonate cement is present within the coarser grained sandstone laminae.

Detrital grains are angular, subangular to subrounded in shape with a low to moderate sphericity. Grain shape has, however, locally been modified due to pressure solution, grain boundary etching and growth of the carbonate cement. The clast assemblage is dominated by monocrystalline quartz and variably degraded lithic fragments. These lithic clasts are mainly composed of, or have been replaced by a very fine-grained to cryptocrystalline felsitic or cherty-looking quartzofeldspathic assemblage. Other minor to accessory detrital components include polycrystalline quartz, quartzose metamorphic rock fragments, muscovite/white mica, plagioclase, apatite, chloritised biotite, tourmaline and spinel.

Minor to trace amounts of a dusty looking (under plain polarised light) pale grey matrix and clay and/or hematitic rim cement have been noted within this sandstone. Elongate, low sphericity clasts may show a weak shape alignment parallel to the sedimentary lamination

Collectors Number: ASW 121. **Registered Number:** N2938. **Location:** [NS 2298 0479] Chapleton Burn, above top water fall. **Formation:** Swanshaw Sandstone Formation. **Rock Type:** coarse-grained, quartzose, lithic-rich sandstone (quartzose litharenite).

Description: This thin section is of a coarse-grained, poorly to very poorly sorted, clast-supported, moderately to closely packed, immature, massive, low porosity, relatively lithic-rich, quartzose sandstone (quartzose litharenite). A sedimentary lamination is defined by the presence of a single lamina of slightly finer grained, weakly graded and matrix–rich sandstone.

Detrital grains are subangular to rounded in shape with a low to moderate sphericity. Occasional well-rounded grains have also been recorded within this sandstone. The clasts within this sandstone tend to be more rounded in shape than detrital grains observed within other sandstones from the Swanshaw Formation. These clasts range up to 0.7 mm in size. The clast assemblage is dominated by monocrystalline quartz with subordinate lithic fragments. These lithic clasts are mainly composed of a very fine-grained to cryptocrystalline felsitic or cherty-looking rock. Other minor to accessory detrital components include polycrystalline quartz, quartzose metamorphic rock, muscovite/white mica, siltstone or metasiltstone, cleaved/foliated mudstone, quartzite, opaque minerals and plagioclase.

This sandstone possesses a well developed yellow-brown chloritic or clay cement. Darker coloured clay rims or coatings have been noted on some detrital grains. Compaction resulted in localised pressure solution between adjacent detrital grains and embayment of unstable lithic clasts against neighbouring more rigid quartzose clasts.

2.2 IGNEOUS ROCKS

Collectors Number: ASW 109. **Registered Number:** N2833. **Location:** [NS 1975 0487] low water mark, Connacharrie Rock. **Rock Type:** altered, plagioclase-pyroxene-olivine microporphyritic basaltic rock. **Symbol:** plpomiB.

Description: This thin section is of a fine- to very fine-grained, inequigranular, hypocrystalline, weakly altered, microporphyritic basaltic rock which comprises the assemblage plagioclase, clinopyroxene and olivine with trace amounts of opaque minerals. Hydration and alteration of the primary igneous assemblage resulted in the development of a very fine-grained assemblage of chlorite, biotite, bowlingite and carbonate.

The phenocrysts are composed of plagioclase, highly altered olivine and clinopyroxene. Plagioclase forms anhedral, twinned and weakly zoned lath-shaped crystals which range up to 2.1 mm in length. The larger crystals may possess a distinctive sieve textured core containing numerous inclusions of opaque and chloritised glass. Plagioclase exhibits very minor replacement by carbonate. Clinopyroxene is colourless to very pale grey-brown (in plane polarised light) and forms anhedral, fractured, equant to prismatic crystals. These pyroxene microphenocrysts occurs as single isolated crystals as well as clusters of 2 to 3 crystals. Olivine has been preferentially altered to, and pseudomorphed by a very fine-grained to cryptocrystalline

assemblage of chlorite/bowlingite. This chloritic assemblage is variably replaced by later carbonate. Olivine original formed rounded, anhedral, equant to slightly elongate crystals which are in some cases partially overgrown by clinopyroxene. Olivine was observed replaced by chloritised biotite, with altered biotite flakes also being present within the groundmass of this basalt.

The fine-grained groundmass of this basalt is massive and mainly composed of randomly orientated plagioclase laths with interstitial granular clinopyroxene. Granular to needle-like crystals of an opaque mineral are also present within the groundmass. The remaining interstitial to intersertal phases have been replaced by a cryptocrystalline chloritic assemblage and chloritised biotite. Trace amounts of a dusty grey looking (in plane polarised light) mesostasis is also present, occasionally forming rims upon plagioclase laths.

Collectors Number: ASW 115. **Registered Number:** N3259. **Location:** [NS 2375 0626] east side of Knox Hill Quarry. **Rock Type:** pilotaxitic, quartz-bearing andesite or microdiorite. **Symbol:** flqA or P.

Description: This thin section is of a fine- to medium-grained, altered, pilotaxitic, inequigranular to weakly equigranular, anhedral to subhedral granular, holocrystalline, aphyric, quartz-bearing andesite or microdiorite. The rock is composed of plagioclase, chlorite and quartz with minor to accessory carbonate, sericite, opaque minerals and apatite. Quartz is a common minor to accessory phase and occurs interstitial to intersertal to earlier formed plagioclase. This microtextural relationship suggests that quartz forms part of the primary igneous mineral assemblage. The bulk of the rock is composed of anhedral to subhedral, zoned and twinned plagioclase laths which exhibit a slight dusty appearance in plane polarised light. The zoned crystals show preferential alteration of their cores to very fine-grained or cryptocrystalline chlorite, sericite and, in some cases, carbonate. The closely packed plagioclase laths are shape-aligned and define a very well developed pilotaxitic fabric. Chlorite (± opaque oxide) was also noted forming pseudomorphs after a ferromagnesian mineral; possibly mainly amphibole with some biotite. Rare carbonate and bowlingite pseudomorphs after pyroxene microphenocrysts were also recognised within this andesitic to microdioritic rock.

Collectors Number: unknown. **Registered Number:** S25581. **Location:** at Hollow Sheau Camp 6 inch sheet 44SW. **Rock Type:** pilotaxitic, quartz-bearing andesite or microdiorite. **Symbol:** flqA or P.

Description: This thin section is of a fine- to medium-grained, altered, pilotaxitic, inequigranular, anhedral to subhedral granular, hypocrystalline, weakly microporphyritic, quartz-bearing andesite or microdiorite. This rock is petrographically similar to sample N3259. It is composed of plagioclase, chlorite and quartz with minor to accessory carbonate, opaque minerals, bowlingite, iddingsite, apatite and titanite. Quartz is a common minor to accessory component and occurs intergranular to plagioclase. Locally quartz is associated with a dusty looking (under plane polarised light) feldspathic mesostasis which fills the majority of the interstitial areas between the feldspar laths. The mesostasis is replacing primary glass within this andesitic or microdioritic rock and contains needle-like to fine granular inclusions of opaque minerals. The bulk of the rock is, however, composed of anhedral to subhedral, twinned and zoned plagioclase laths. The zoned plagioclase laths may show a preferred alteration of their cores to very fine-grained to cryptocrystalline chlorite and/or sericitic white mica. Chlorite is locally being replaced by later fine-grained carbonate. Plagioclase laths are shape-aligned and

define a well developed pilotaxitic fabric. Chlorite pseudomorphs (± opaque oxide) after amphibole and possible biotite are also present. Pseudomorphs (bowlingite, chlorite, carbonate) after rare pyroxene microphenocrysts were also noted within this microdioritic rock.

Collectors Number: unknown. **Registered Number:** S25579. **Location:** 200 yards east-southeast of Glenside Farm. **Rock Type:** pilotaxitic, pyroxene-plagioclase microporphyritic basalt. **Symbol:** flpxplmiB.

Description: This thin section is of a fine-grained, inequigranular, hypocrystalline, pilotaxitic, microporphyritic, weakly altered basalt. It comprises the assemblage plagioclase, carbonate and clinopyroxene with minor to accessory chlorite, opaque minerals and sericitic white mica. The phenocrysts range in size from 0.3 to *c*. 2.0 mm in length and are mainly composed of carbonate pseudomorphs after pyroxene. Minor plagioclase microphenocrysts and traces or fresh clinopyroxene are also present. Plagioclase is typically finer grained than the pyroxene phenocrysts. The pseudomorphs after pyroxene phenocrysts are composed of fine- to medium-grained carbonate. They are texturally zoned and possess a distinct dusty looking to inclusion-rich rim which may preserve an sieve textured rim on the original pyroxene phenocryst.

The groundmass is mainly composed of fine-grained plagioclase and granular pyroxene. Chlorite pseudomorphs after another ferromagnesian mineral (olivine or orthopyroxene) were also noted within the groundmass occurring intergranular to plagioclase. Chloritised biotite flakes are also present. A well developed pilotaxitic fabric present within the groundmass is defined by shape-aligned plagioclase laths. This fabric wraps around the larger phenocrysts. Plagioclase forms anhedral to weakly subhedral, twinned and occasionally zoned crystals. Feldspar is fresh with very little alteration to sericite and carbonate.

Collectors Number: unknown. **Registered Number:** S25580. **Location:** Knox Hill Quarry 0.5 miles south-southwest of Minniebrae. **Rock Type:** altered microdioritic rock. **Symbol:** P.

Description: This thin section is of a altered, fine- to medium-grained (average grain size 0.1 to 0.2 mm), inequigranular, massive, hypocrystalline microdioritic rock which may represent a slightly coarser grained variety of N3259 or S25581. It is composed of the assemblage plagioclase, quartz and chlorite with minor to accessory carbonate, K-feldspar, opaque minerals, apatite, titanite and biotite. The bulk of the rock is composed of randomly orientated to weakly aligned plagioclase laths with subordinate chlorite pseudomorphs (± carbonate, opaque oxide) after amphibole and possible biotite. Interstitial to intersertal quartz is a common minor to accessory component and forms anhedral unstrained to weakly strained crystals with a variably developed undulose extinction. Plagioclase forms anhedral to weakly subhedral, twinned and zoned lath-shaped crystals. The cores of these zoned crystals may show preferential alteration to very fine-grained or cryptocrystalline chlorite and carbonate; the latter appears to be replacing the earlier formed chlorite. Feldspar was also noted forming a late crystallising interstitial phase forming variably developed irregular rims upon the earlier formed plagioclase laths. Traces of possible intergranular K-feldspar were also recorded within this microdioritic rock.

Glossary

Grain size – (a) clay < 0.0039 mm in size; (b) silt, 0.0039 to 0.0625 mm in size; (c) fine sand, 0.0625 to 0.25 mm in size; (d) medium sand, 0.25 to 0.5 mm in size; (e) coarse sand, 0.5 to 1.0 mm in size; (f) very coarse sand, 1.0 to 2.0 mm in size; (g) granules 2.0 to 4.0 mm in size; (h) pebbles 4.0 to 64 mm in size.

Rounded – Describes the smoothness of the surface of a grain. The terms well-rounded, rounded, subrounded, subangular, angular, very angular are used to describe the increasingly angular/irregular/rough nature of the surface of detrital grains.

Sphericity – Describes the how closely a detrital grain approximates to a sphere. The terms low sphericity, moderate sphericity and high sphericity are used to describe how spherical (ball-like) the detrital grains are.

Sorting – Well sorted describes a deposit in which all the detrital grains are of approximately uniform size. In reality most fragmentary deposits contain a range of grain sizes and can be described as moderately sorted, poorly sorted or in extreme cases unsorted.

Packing – Describes, as the term suggests, how closely the individual detrital grains are packed together within a fragmentary deposit. The term closely packed is used where all the grains are in contact and there is very little obvious matrix or cement; moderately packed and open packed are used with an increase in the porosity, matrix and/or cement.

Clast supported – Describes a fragmentary deposit where all the detrital grains are in contact.

Matrix supported – Describes a fragmentary deposit where the detrital grains are, to varying degrees, isolated/supported within a finer grained matrix.

Cement supported – Describes a fragmentary deposit where the detrital grains are, to varying degrees, isolated/supported within the cement.

Cement – The material bonding the fragments of clastic sedimentary rocks together and which was precipitated between the grains after deposition.

Porosity – The volume of voids expressed as a percentage of the total volume of the sediment or sedimentary rock.

Matrix – Material, usually clay minerals or micas, forming a bonding substance to grains in a clastic sedimentary rock. The matrix material was deposited with the other grains or developed authogenically by diagenesis or slight metamorphism. Also used more generally for finer grained material in any rock in which large components are set.

Detritus – A general term for fragmentary material, such as gravel, sand, clay, worn from rock by disintegration. Detrital grains in clastic sedimentary rocks may be composed of single mineral grains (e.g. monocrystalline quartz, plagioclase), polycrystalline mineral grains (e.g. polycrystalline quartz) or lithic fragments including sedimentary, igneous and metamorphic rock fragments.

Crystallinity – (a) *holocrystalline*, an igneous rock composed of 100% crystals; (b) *holohyaline*, an igneous rock composed of 100% glass; and (c) *hypocrystalline*, intermediate between the two end-members and can be described more precisely by stating the relative proportions of crystals and glass.

Microcrystalline – crystals can be identified with a petrological microscope. Crystals only just large enough to show polarisation colours (less than 0.01 mm in size) are called microlites.

Cryptocrystalline – crystals are too small to be identified even with the petrological microscope.

Grain size – (a) coarse-grained, crystals > 5.0 mm in size; (b) medium-grained, crystals 1.0 to 5.0 mm in size; (c) fine-grained, crystals < 1.0 mm in size.

Equigranular – all crystals are approximately the same size.

Inequigranular – crystals of substantially different grain size. Common variety, *porphyritic* texture consists of large crystals of a particular mineral or minerals set in a finer grained groundmass. Porphyritic texture can be subdivided into: (a) *microporphyritic*, phenocrysts equal to or less than 2.0 mm in size; and (b) *macroporphyritic*, phenocrysts greater than 2.0 mm in size.

Seriate texture – continuous range in crystal size of principal minerals.

Trachytic texture – sub-parallel alignment of microcrystalline feldspar in the groundmass of a holocrystalline or hypocrystalline rocks. Sub-divided into *pilotaxitic texture* and *hyalopilitic texture* depending on whether the material between the feldspar is crystalline or glassy. Trachytoid texture, alignment of tabular, bladed or prismatic crystals which is visible to the naked eye. The terms flow and fluxion texture are sometimes used as synonyms for trachytic and trachytoid textures. However, they are best avoided due to their genetic implications.

Andesite – An intermediate volcanic rock, usually porphyritic, consisting of plagioclase (frequently zoned from labradorite to oligoclase), pyroxene, hornblende and/or biotite.

Basalt – A volcanic rock consisting essentially of calcic plagioclase and pyroxene. Olivine and minor feldspathoids may also be present.

Basaltic andesite – A volcanic rock with plagioclase compositions expected for andesites but containing ferromagnesian minerals more commonly found in basalts.

Dacite – A volcanic rock composed of quartz and sodic plagioclase with minor amounts of biotite and/or hornblende and/or pyroxene.

Gabbro – A coarse-grained plutonic rock composed essentially of calcic plagioclase, pyroxene and Fe-oxides. If olivine is an essential constituent it is referred to as an olivine-gabbro – if quartz, a quartz-gabbro.

Peridotite – A collective term for ultramafic rocks consisting essentially of olivine with pyroxene and/or amphibole.

Dolerite – A rock of intermediate grain size between a basalt and gabbro (i.e. synonym for microgabbro), and composed of essentially plagioclase, pyroxene and opaque minerals. Often contains an ophitic texture. If olivine is present may be called an olivine-dolerite; if quartz, a quartz-dolerite.

Felsite – A rock term initially used for the microcrystalline groundmass of porphyries. Now commonly used for microcrystalline rocks of granitic composition (i.e. dacite to rhyolite).

Rhyolite – A collective term for silicic volcanic rocks consisting of phenocrysts of quartz and K-feldspar, often with minor plagioclase and biotite, in a microcrystalline or glassy groundmass.

Olivine-basalt – A commonly used term for a basalt containing olivine as an essential constituent.

Granite – A medium- to coarse-grained plutonic rock consisting essentially of quartz, K-feldspar and plagioclase in variable amounts usually with hornblende and/or biotite.

Accessory – A minor constituent of rocks which is present only in small amounts, for example the minerals apatite, zircon, titanite.