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The petrology of a sequence of sedimentary and volcanic rocks from the Strathmore district, Scotland

Geology and Landscape North Programme

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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.

Contents

Summary

This report describes the mineralogy and petrology of a suite of basaltic to andesitic volcanic rocks and sedimentary rocks as part of the regional mapping of the Strathmore district (Sheet 57).

1 Introduction

This report describes the mineralogy and petrology of a suite of basaltic to andesitic volcanic rocks and sandstones, microconglomerates and associated sedimentary rocks of the Strathmore district (Sheet 57). A total of 110 thin sections have been examined with the work forming part of a multidisciplinary project being undertaken by the British Geological Survey to examine the evolution of the Midland Valley of Scotland. This work forms part of the British Geological Survey's Integrated Geology and Landscape North programme.

2 Petrology

Collectors Number: MFH200. **Registered Number:** N9088. **Location:** [N0 77142 69499] Strathmore. **Geological map sheet:** 57. **Rock Type:** siltstone. **Symbol:** not applicable.

Description: This thin section is of a massive, fine-grained siltstone. No obvious sedimentary structures are preserved within this fine-grained sedimentary rock. Hematisation of the siltstone resulted in the reddening of the clay-grade matrix component of the rock. Detrital grains are angular with a low sphericity and mainly composed of monocrystalline quartz. Minor to accessory detrital white mica, opaque minerals and chlorite are also present. A weak preferred shape alignment of elongate detrital grains and micas can be recognised within the siltstone.

Collectors Number: MFH244. **Registered Number:** N9089. **Location:** [N0 76677 66825] Strathmore. **Geological map sheet:** 57. **Rock Type:** amygdaloidal, pilotaxitic, plagioclase macroporphyritic basalt. **Formation:** Montrose Volcanic Formation. **Symbol:** flplmaB^{B}.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals

alteration – chlorite, bowlingite, opaque minerals, white mica (sericite)

Description: This thin section is of a fine- to medium-grained, inequigranular, hypocrystalline, amygdaloidal, altered (chloritised), plagioclase macroporphyritic basalt which possess a well-developed pilotaxitic fabric. Large shape-aligned macrophenocrysts (up to 5.0 mm in length) are mainly composed of plagioclase. These phenocrysts are aligned parallel to a moderately well-developed pilotaxitic fabric present within the groundmass. Plagioclase is fresh, forming subhedral, twinned (simple and multiple) crystals which locally possess a weakly to moderately developed compositional zonation (gradational and oscillatory). Larger plagioclase crystals may possess sieve textured cores containing irregular to worm-like inclusions of chloritised glass. Chloritic pseudomorphs after olivine and/or clinopyroxene microphenocrysts are also present within this basalt. The larger of these anhedral phenocrysts are embayed to amoeboid in shape, indicative of partial resorption of this ferromagnesian mineral. Rare fresh clinopyroxene microphenocrysts have also been noted.

The groundmass is mainly composed of variably aligned, fine-grained plagioclase laths and very fine intergranular clinopyroxene and opaque minerals. Interstitial to intersertal areas are filled by a turbid mesostasis replacing original glass. The remainder of the groundmass has been replaced by a very finely microcrystalline to cryptocrystalline, yellow-green chloritic assemblage. Rounded to irregular amygdales are composed of a similar chloritic material.

Collectors Number: MFH245. **Registered Number:** N9090. **Location:** [N0 77170 68005] Strathmore. **Geological map sheet:** 57. **Rock Type:** fragmented, fine- to coarse siltstone. **Formation:** sandstone with conglomerate, Arbuthnot-Garvock Group. **Symbol:** not applicable.

Description: This thin section is of a fragmented or disrupted, fine to coarse siltstone or siltstone clast microconglomerate. This fragmented sedimentary rocks is composed of angular to rounded,

1.0 to 4.0 mm in size, low sphericity clasts of siltstone within a silty matrix. The clasts are locally irregular in form with lobate clast margins. Traces of a clay cutan are present within the matrix.

Detrital grains within the siltstone are mainly composed of monocrystalline quartz, with minor to accessory opaque minerals, white mica, biotite, zircon, chlorite, plagioclase, amphibole and epidote. Internally the siltstone clasts range from massive to laminated and, in some cases, show evidence of earlier soft sediment deformation. Fine, irregular voids or vugs within the matrix of the siltstone are filled with very finely cryptocrystalline chlorite and traces of quartz.

It is possible that the disruption of this siltstone occurred in response to water-escape.

Collectors Number: MFH246. **Registered Number:** N9091. **Location:** [N0 75536 65290] Strathmore. **Geological map sheet:** 57. **Rock Type:** calcareous quartz-rich arenite. **Formation:** sandstone with conglomerate, Arbuthnot-Garvock Group undivided. **Symbol:** not applicable.

Description: This thin section is of a fine- to medium-grained, poorly sorted, texturally immature, clast- to cement-supported, open to moderately packed, massive, relatively quartz-rich arenite. Angular to subangular detrital grains possess a low to rarely moderate sphericity. Rare subrounded quartzose grains have also been recognised. A weak preferred shape alignment of elongate detrital grains is developed within this sandstone.

The clast assemblage within this sandstone is dominated by monocrystalline quartz. Other minor to accessory detrital components include lithic clasts, polycrystalline quartz, chert/felsite, plagioclase, microcline, K-feldspar, opaque minerals, tourmaline, epidote, titanite, fragments of a very fine-grained metasedimentary rock and possible tuffaceous volcanic rock fragments.

The original matrix and/or cement of this quartzose sandstone, along with the more unstable detrital (lithic) components, have been replaced by carbonate. This replacive, crystalline carbonate cement is locally stained by a red-brown Fe-oxide and may have originally included ferroan dolomite. Traces of an earlier red-brown hematitic clay cement have also been recognised. Carbonate replacement locally resulted in the etching of quartz grain boundaries, modifying original grain shape. Localised pressure solution between adjacent quartz grains has also bee recorded.

Collectors Number: MFH247. **Registered Number:** N9092. **Location:** [N0 63047 64079] Strathmore. **Geological map sheet:** 57. **Formation:** Cromlix Mudstone Formation. **Rock Type:** lithic-rich granule sandstone to microconglomerate. **Symbol:** not applicable.

Description: This thin section is of a coarse-grained to pebbly, poorly sorted, open packed, clast supported, compositionally and texturally immature, massive, lithic-rich granule sandstone to microconglomerate. A well-developed hematitic clay rim cement is present within this coarse-grained sedimentary rock.

Larger, granule to small pebble sized clasts included within this sandstone are mainly composed of rock fragments. These clasts are subangular to subrounded in shape, with a low sphericity and include broken fragments of much larger pebbles. The shape of these detrital grains has been modified due to the etching of clast boundaries. The lithic clasts are mainly composed of very fine-grained volcanic rocks. Recognisable lithologies include fine-grained metasandstone (psammite), quartz mylonite, felsite, feldspathic volcanic rock, very fine-grained sandstone, pilotaxitic feldspar-phyric andesite, quartz-feldspar-phyric dacite, microdiorite, metasandstone, altered fine-grained sandstone and a granitic rock.

Finer grained, coarse-sand component of this sandstone possesses a more mixed clast assemblage dominated by monocrystalline quartz and lithic fragments; the latter comprise the same range of lithologies as larger clasts. Other minor to accessory detrital components include polycrystalline quartz, muscovite, micrographic intergrowth, altered plagioclase, opaque minerals, tourmaline, staurolite, siltstone and biotite.

A relatively high intergranular porosity has been preserved within this sandstone. Pore spaces are lined by an opaque mineral and/or hematitic clay rim cement.

Collectors Number: MFH248. **Registered Number:** N9093. **Location:** [N0 64767 64904] Strathmore. **Geological map sheet:** 57. **Rock Type:** sandy limestone or carbonate replaced sandstone. **Formation:** Deep Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a very fine-grained, massive to mottled, sandy limestone or carbonate replaced sandstone. The bulk of the rock is composed of very finely microcrystalline to cryptocrystalline sparry carbonate. Coarser grained sparry carbonate was noted filling irregular fractures/veinlets, the latter possibly associated with dewatering and shrinkage. A weakly developed or preserved layering is defined by a 2.0 to 3.0 mm thick band of dusty carbonate. Scattered, angular, low sphericity sand grade detrital grains are mainly composed of monocrystalline quartz. Minor to accessory detrital components include polycrystalline quartz, microcline, opaque minerals and garnet.

Collectors Number: MFH249. **Registered Number:** N9094. **Location:** [N0 64767 64904] Strathmore. **Geological map sheet:** 57. **Rock Type:** calcareous sandstone. **Formation:** Deep Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a medium- to coarse-grained, poorly sorted, open to very open packed, cement supported, massive, immature, quartzose sandstone which possesses a well-developed replacive carbonate cement. Detrital grains are angular, subangular to occasionally subrounded in shape with a low to moderate sphericity. Grain shape has, however, been modified due to grain boundary etching during the development of the replacive carbonate cement. A preferred shape alignment of detrital micas and, to a lesser extent, other elongate grains have been recognised within this sandstone.

The clast assemblage within this sandstone is dominated by monocrystalline quartz and fragments of a very fine-grained andesitic to dacitic igneous/volcanic rock. Other minor to accessory detrital components include plagioclase, polycrystalline quartz, biotite, felsite, chert, muscovite, garnet, microcline, tourmaline, epidote, opaque minerals, chlorite and serpentinite. Detrital biotite is a relatively common minor to accessory component. Garnet is also relatively common accessory phase within this sandstone.

The carbonate cement has preferentially replaced the original matrix/cement and more unstable lithic clasts within this sandstone. A variation in the intensity of carbonate replacement locally results in the overprinting of the original clastic texture of the rock. The overall texture of this rock is similar to sample N9093.

Collectors Number: MFH250. **Registered Number:** N9095. **Location:** [N0 61742 65436] Strathmore. **Geological map sheet:** 57. **Rock Type:** Fe-stained siltstone or silty mudstone. **Formation:** Cromlix Mudstone Formation. **Symbol:** not applicable.

Description: This thin section is of a fine-grained, Fe-stained, massive siltstone or silty mudstone with a distinctive mottled appearance. The latter results from patches of relatively more silt- or mud-rich sediment. Silt-grade clasts are angular to subangular in shape and mainly composed of monocrystalline quartz. Other minor to accessory detrital components include plagioclase, biotite, muscovite, opaque minerals, tourmaline and chlorite. Elongate fragments of finely laminated mudstone are also present. No obvious preferred alignment of detrital micas has been recognised in this sample.

The mottled appearance of this siltstone is reminiscent of the texture achieved as a result of soft-sediment deformation associated with liquefaction and water escape.

Collectors Number: MFH251. **Registered Number:** N9096. **Location:** [N0 62513 63802] Strathmore. **Geological map sheet:** 57. **Rock Type:** calcareous sandstone. **Formation:** Cromlix Mudstone Formation. **Symbol:** not applicable.

Description: This thin section is of a coarse- to very coarse-grained, very open packed, cement supported, poorly sorted, compositionally immature, lithic-rich, calcareous quartzose litharenite which possesses a well-developed replacive carbonate cement. Detrital grains are angular to subangular in shape with a low sphericity.

The mixed clast assemblage of this sandstone is dominated by fragments of a very fine-grained, andesitic to dacitic volcanic/igneous rock and monocrystalline quartz. Recognisable lithologies forming the lithic clasts include felsite, feldspar-biotite-phyric dacite and quartz-feldspar-phyric dacite or rhyodacite. Other minor to accessory detrital components include plagioclase, muscovite, chlorite, polycrystalline quartz and fragments of a very fine-grained schistose metasedimentary rock.

The carbonate cement preferentially replaced the original matrix and/or cement of the sandstone, as well as the more unstable lithic components. Two stages of cementation have been noted: (1) the development of an earlier sparry carbonate forming rims upon relict detrital grains; and (2) a later phase of finely microcrystalline carbonate filling the intergranular areas. The development of this replacive carbonate cement resulted in the variable overprinting of the original clastic texture of this quartzose sandstone.

Collectors Number: MFH252. **Registered Number:** N9097. **Location:** [N0 62513 63802] Strathmore. **Geological map sheet:** 57. **Rock Type:** quartzose litharenite. **Formation:** Cromlix Mudstone Formation. **Symbol:** not applicable.

Description: This thin section is of a coarse-grained, closely to very closely packed, clast supported, poorly sorted, immature, massive, lithic-rich, quartzose litharenite. This sandstone may represent the protolith to sample N9096.

Detrital grains are angular to subangular in shape with a low to moderate sphericity. Occasional rounded quartzose grains are also present. The sandstone is compact with no obvious primary porosity preserved. A weak preferred shape alignment of elongate clasts has been recognised within this sandstone.

The mixed clast assemblage present within this sandstone is dominated by lithic clasts and monocrystalline quartz. The lithic clasts are mainly volcanic derived and are typically composed of a very fine-grained, originally glassy andesitic to dacitic rock. Recognisable lithic clasts include hematised very fine-grained tuffaceous rock, fine-grained metasandstone (psammite), felsite, phyllitic to schistose metasedimentary rock, biotite-schist, siltstone and very fine-grained

sandstone. Other minor to accessory detrital components present include K-feldspar, polycrystalline quartz, biotite, opaque minerals, amphibole, microcline and tourmaline.

Compaction resulted in pressure solution, kinking of detrital micas and the localised plastic deformation of more unstable detrital grains; the latter are embayed against neighbouring more rigid quartzose grains. Pressure solution appears to have resulted in the main mode of cementation within this sandstone. Traces of a later (post-compaction) carbonate cement have been noted replacing the original matrix component.

Collectors Number: MFH255. **Registered Number:** N9098. **Location:** [N0 75897 64915] St. Cyrus, Strathmore. **Geological map sheet:** 57. **Rock Type:** altered, pilotaxitic, microporphyritic basalt. **Formation:** Montrose Volcanic Formation. **Symbol:** flmiB.

Mineralogy: major – plagioclase

minor – opaque minerals

alteration – carbonate, opaque minerals, sericite, chlorite, bowlingite, iddingsite

Description: This thin section is of a altered (chloritised and hematised), coarse-grained, hypocrystalline, inequigranular, pilotaxitic microporphyritic basaltic rock which possess a well-developed pilotaxitic fabric. This basaltic rock contains small (≤ 2.0 mm in size) microphenocrysts of olivine and/or pyroxene. These microphenocrysts are completely replaced by a very fine-grained assemblage of chlorite, bowlingite, opaque minerals and carbonate. Phenocrysts occur as single isolated crystals and glomerophyric clusters of several (3 to 4) smaller microphenocrysts.

The groundmass is composed of variably shape-aligned plagioclase laths which define a well-developed pilotaxitic fabric. Plagioclase forms anhedral, twinned (simple and multiple) crystals. The interstitial to intersertal phases, which probably included glass, have been replaced by chlorite, opaque minerals and minor carbonate. The pilotaxitic fabric within the groundmass wraps around the larger phenocrysts. Irregular to rounded amygdales are composed of cryptocrystalline chlorite. The basalt is cut by a number of thin carbonate veinlets.

Collectors Number: MFH256. **Registered Number:** N9099. **Location:** [N0 75897 64915] St. Cyrus, Strathmore. **Geological map sheet:** 57. **Rock Type:** laminated, fine-grained siltstone layer within a basaltic andesite. **Formation:** Montrose Volcanic Formation. **Symbol:** not applicable.

Description: This thin section is of a laminated, fine-grained siltstone layer within a fine-grained, aphyric to very weakly microporphyritic basaltic andesite. A pilotaxitic fabric developed within the hematised basalt is truncated at the boundary between the basaltic andesite and siltstone. This foliated is defined by shape-aligned plagioclase laths. Locally this primary igneous foliation is deflected/distorted immediately adjacent to this lithological boundary. No obvious chilling or reduction in grain size of the basaltic rock has been recorded immediately adjacent to this contact. Although sharp, the boundary between the basaltic andesite and siltstone is highly irregular with complex, delicate to wispy ‘flames’ of basaltic rock extending into the siltstone.

The lamination within the siltstone is defined by thin silty mudstone laminae. Individual laminae are graded from siltstone to mudstone. This lamination occurs parallel to the contact with the

basaltic andesite. Detrital micas present within the siltstone are aligned parallel to the lamination and siltstone-basaltic andesite contact. A very thin band (≤ 0.1 mm thick) of very fine-grained, altered mud/silt occurs immediately adjacent to the contact with the basaltic andesite.

Detrital grains within the siltstone are angular in shape with a low sphericity, and mainly composed of monocrystalline quartz and variably hematised biotite. Other minor to accessory detrital components include muscovite, opaque minerals, chlorite, epidote, ?pyroxene/epidote, titanite and rutile. The muddy laminae are locally broken/disrupted into several raft-like fragments. No obvious fragments of the adjacent basaltic andesite are included within the siltstone.

Collectors Number: MFH1. **Registered Number:** N5130. **Location:** [N0 81724 69385] Gourdon Village/Benholm, Strathmore. **Geological map sheet:** 57. **Rock Type:** quartzose litharenite. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a medium-grained, very closely packed, immature, lithic-rich, clast supported, quartzose litharenite. Detrital grains are angular, subangular to occasionally subrounded in shape with a low sphericity. A weakly developed preferred shape alignment of elongate clasts is developed within this sandstone.

The mixed clast assemblage present within this sandstone is dominated by monocrystalline quartz and volcanic derived lithic clasts. The volcanic lithics are mainly composed of very fine-grained, variably hematised basaltic, andesitic and dacitic rocks. Other lithologies present include hematised rock, felsite, very fine metasedimentary rock (psammite), pilotaxitic basalt or andesite, biotite-bearing metasedimentary rock and a phyllitic metasedimentary rock. Minor to accessory detrital components include polycrystalline quartz, muscovite, chlorite, opaque minerals, garnet, plagioclase, chloritised biotite, very fine-grained sandstone or siltstone, biotite, epidote and zircon.

Compaction resulted in pressure solution, the kinking of detrital micas and the plastic deformation of unstable detrital components; the latter are embayed against neighbouring more rigid quartzose grains. Traces or a well-developed pale yellow-green chloritic cement is present within this sandstone. Minor to trace amounts of a secondary porosity was recorded, which developed as a result of the dissolution of unstable detrital grains.

Collectors Number: MFH2. **Registered Number:** N5131. **Location:** [N0 81724 69385] Gourdon Village/Benholm, Strathmore. **Geological map sheet:** 57. **Rock Type:** quartz-feldspar-microporphyritic dacite or rhyodacite. **Formation:** clast within Catterline Conglomerate Formation. **Symbol:** not applicable.

Mineralogy: major – plagioclase, quartz, K-feldspar

minor – opaque minerals, apatite

alteration – chlorite, opaque minerals, sericite, carbonate

Description: This thin section is of a very fine-grained, hypocrystalline, originally glassy, devitrified, microporphyritic to weakly macroporphyritic dacite or rhyodacite which possess a variably developed pilotaxitic to hyalopilitic fabric. Microphenocrysts are mainly composed of anhedral to subhedral plagioclase (± K-feldspar). Small microphenocrysts of a ferromagnesian mineral are pseudomorphed by chlorite, opaque minerals and carbonate. Feldspar phenocrysts

exhibit minor to trace alteration to sericite and carbonate. Feldspar phenocrysts are locally broken and show varying degrees of rounding due to resorption. The phenocrysts occur as single, isolated crystals and glomerophyric clusters of 2 to 4 microphenocrysts. Elongate feldspar phenocrysts are variably shape-aligned parallel to a pilotaxitic to hyalopilitic fabric developed within the groundmass.

The originally glassy groundmass is very fine-grained and composed of a cryptocrystalline to finely microcrystalline mosaic of feldspar and quartz. This mosaic exhibits minor alteration to sericite. The foliation present within the groundmass wraps around the feldspar phenocrysts and is defined by thin chains or stringers of very fine-grained, granular quartz and/or feldspar.

Collectors Number: MFH3. **Registered Number:** N5132. **Location:** [N0 82093 69929] Benholm Head, Strathmore. **Geological map sheet:** 57. **Rock Type:** plagioclase macroporphyritic basalt or basaltic andesite. **Formation:** Crawton Volcanic Formation. **Symbol:** plmaB^{B}/A^{B}.

Mineralogy: major – plagioclase

minor – opaque minerals, apatite

alteration – opaque minerals, chlorite, carbonate, sericite

Description: This thin section is of a fine-grained, relatively feldspathic, inequigranular, hypocrystalline, Fe-stained, macroporphyritic basalt or basaltic andesite which possess a weakly developed pilotaxitic fabric. Phenocrysts are mainly composed of plagioclase with occasional to rare pseudomorphs after small clinopyroxene microphenocrysts. Plagioclase forms anhedral to subhedral, twinned (simple and multiple), lath-shaped crystals which exhibit minor alteration to carbonate and sericite. Plagioclase occurs as single isolated crystals and glomerophyric clusters of 3 to 4 microphenocrysts and macrophenocrysts. The feldspar phenocrysts are shape aligned, defining a moderately well-developed pilotaxitic fabric. This fabric is absent within the groundmass.

The groundmass is mainly composed of fine- to very fine-grained plagioclase laths with occasional chloritic pseudomorphs after pyroxene. Interstitial to intersertal phases have been replaced by cryptocrystalline chlorite and a dusty looking mesostasis containing finely disseminated opaque oxide.

Collectors Number: MFH4a. **Registered Number:** N5133. **Location:** [N0 80761 67764] Gourdon Village/Benholm, Strathmore. **Geological map sheet:** 57. **Rock Type:** xenolithic dacite or rhyodacite. **Formation:** intrusive or extrusive rock in Catterline Conglomerate Formation. **Symbol:** $xR/R^{D}/R^{R/D}$.

Mineralogy: major – plagioclase, K-feldspar, quartz

minor – opaque minerals

alteration – opaque minerals, sericite

Description: This thin section is of a fine- to very fine-grained, xenolithic, massive, originally glassy (now devitrified) dacite or rhyodacite composed of a microcrystalline mosaic or quartz and feldspar. Included grains or xenoliths are randomly orientated and range from angular to

rounded in shape. These medium sand to granule, to occasionally small pebble sized clasts are composed of volcanic, sedimentary and occasional metamorphic rock fragments. This xenolith rich rock is poorly sorted to unsorted. No obvious fabric is developed/preserved within the matrix. The origin of this rock is uncertain. It could be a xenolithic lava or intrusion, or alternatively a lapilli-tuff.

Collectors Number: MFH4b. **Registered Number:** N5134. **Location:** [N0 80761 67764] Gourdon Village/Benholm, Strathmore. **Geological map sheet:** 57. **Rock Type:** xenolithic dacite or rhyodacite. **Formation:** intrusive or extrusive igneous rock in Catterline Conglomerate Formation. **Symbol:** $xR/R^{D}/R^{R/D}$.

Mineralogy: major – feldspar, quartz

minor – opaque minerals

alteration – opaque minerals, sericite

Description: This thin section is of a xenolithic dacite or rhyodacite and is lithologically similar to sample N5133. In thin section it is dominated by a few large lithic fragments (up to 10 mm in size) which are cut by quartz veinlets. These angular to rounded, low sphericity xenoliths or lithic clasts are composed of altered sandstone and quartz-feldspar-phyric dacite/rhyodacite. The clasts occur within a patchy matrix or vein network of finely crystalline quartzose material.

Collectors Number: MFH5. **Registered Number:** N5135. **Location:** [N0 80952 68128] Gourdon Village/Benholm, Strathmore. **Geological map sheet:** 57. **Rock Type:** quartzose litharenite. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a medium- to coarse-grained, moderately sorted, massive, very closely packed, clast supported, immature, quartzose litharenite with very little porosity and containing traces of a replacive carbonate cement. Very little or no primary matrix has been recognised within this sandstone. Detrital grains are angular, subangular, to occasionally rounded in shape with a low to moderate sphericity. However, grain shape has locally been modified during compaction and the development of the replacive carbonate cement.

The clast assemblage present within this sandstone is dominated by monocrystalline quartz and lithic clasts. The latter are dominated by fragments of very fine-grained to glassy basaltic, andesitic to dacitic volcanic rocks. Recognisable lithologies include pilotaxitic basalt, basaltic andesite, altered very fine-grained sandstone or siltstone, rhyolite/rhyodacite, felsite, basalt and very fine-grained biotite-bearing metasedimentary rock. Minor to accessory detrital components include plagioclase, microcline, muscovite, biotite, opaque minerals, polycrystalline quartz, micrographic intergrowth, perthite and chlorite.

Compaction resulted in pressure solution, kinking or detrital micas and plastic deformation of unstable lithic clasts; the latter are embayed against neighbouring more rigid quartzose grains. Pressure solution apparently resulted in the main mode of cementation within this sandstone. Traces of a secondary porosity have been identified in this sample formed by the dissolution and removal of carbonate.

Collectors Number: MFH6a. **Registered Number:** N5136. **Location:** [N0 80451 67354] Johnshaven, Strathmore. **Geological map sheet:** 57. **Rock Type:** quartzose litharenite

containing a very large clast of pyroxene-plagioclase-phyric basalt. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a fine- to medium-grained, moderately to poorly sorted, open packed, clast to cement supported, immature, lithic-rich quartzose litharenite containing a very large clast (pebble) of pyroxene-plagioclase-phyric basalt. The sandstone possesses a well-developed yellow-brown coloured, pore lining and filling cement. Traces of a later, replacive carbonate cement are also present.

Detrital grains are angular, subangular to occasionally subrounded in shape with a low sphericity. A weakly developed preferred shape alignment of elongate detrital grains has been recognised within this sandstone. The mixed clast assemblage is dominated by volcanic derived lithic clasts, monocrystalline quartz and subordinate plagioclase. Minor to accessory detrital components include plagioclase, K-feldspar, muscovite, opaque minerals, chlorite, variably hematised biotite, polycrystalline quartz, mudstone, siltstone and garnet.

Three stages of cementation have been recognised within this sample: (1) an early, dark honey brown coloured pore linking clay cement; (2) a later yellow-brown coloured, pore filling clay cement; and (3) a late replacive carbonate cement. The carbonate cement post-dated the compaction of the sandstone and preferentially replaced feldspar and unstable lithic clasts.

The large (> 1 cm in diameter) clast of pyroxene-plagioclase microporphyritic basalt dominates this thin section. This amygdaloidal, hypocrystalline, relatively crystal-rich basaltic rock is altered (chloritised) resulting in the replacement of primary ferromagnesian minerals by a very fine-grained chloritic assemblage. Amygdales are composed of cryptocrystalline chlorite and opaque minerals. Plagioclase is variably altered to sericitic white mica and carbonate. No obvious pilotaxitic foliation has been recognised within this relatively crystal-rich basalt.

Collectors Number: MFH6b. **Registered Number:** N5137. **Location:** [N0 80451 67354] Johnshaven, Strathmore. **Geological map sheet:** 57. **Rock Type:** weakly macroporphyritic granite with patchily developed micrographic intergrowth **Formation:** clast in Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a fine- to medium-grained, holocrystalline, inequigranular, massive, weakly macroporphyritic granite containing anhedral to subhedral phenocrysts of plagioclase and K-feldspar. Plagioclase forms twinned and untwined, zoned, lath-shaped crystals. K-feldspar phenocrysts locally possess an irregular core of perthite or mesoperthite. K-feldspar is the dominant feldspar in the groundmass and is locally intergrown with plagioclase and quartz, the former resulting in an irregular ‘replacive’ perthitic intergrowth. Quartz forms anhedral, strained crystals with a variably developed undulose extinction. Minor to trace biotite present within this granite has been partially replaced by opaque minerals.

Collectors Number: MFH7. **Registered Number:** N5138. **Location:** [N0 80462 67298] Johnshaven, Strathmore. **Geological map sheet:** 57. **Rock Type:** pilotaxitic, plagioclase microporphyritic basalt. **Formation:** Intrusive, extrusive or clast of igneous rock in Catterline Conglomerate Formation. **Symbol:** flplmiB^B/B.

Mineralogy: major – plagioclase

minor – opaque minerals

alteration – carbonate, opaque minerals, sericite, chlorite

Description: This thin section is of a very fine-grained, inequigranular, hypocrystalline, microporphyritic, weakly amygdaloidal basalt. Microphenocrysts are mainly composed of anhedral to subhedral, twinned (simple and multiple), occasionally zoned plagioclase laths with occasional carbonate pseudomorphs after pyroxene and/or olivine microphenocrysts. Plagioclase phenocrysts are shape-aligned, defining a moderately well-developed pilotaxitic fabric. This foliation has not been recognised within the groundmass of this basalt. Amygdales are mainly composed of carbonate with an outer rim of very fine-grained opaque oxide.

The groundmass is very fine-grained and mainly composed of randomly orientated plagioclase laths and needles, and finely disseminated opaque minerals. The remaining interstitial to intersertal phases are replaced by fine-grained carbonate.

Collectors Number: MFH8. **Registered Number:** N5139. **Location:** [N0 80149 67106] Johnshaven, Strathmore. **Geological map sheet:** 57. **Rock Type:** plagioclase macroporphyritic basaltic andesite. **Formation:** intrusive, extrusive or clast of igneous rock in Catterline Conglomerate Formation. **Symbol:** plmaA^{B}.

Mineralogy: major – plagioclase

minor – opaque minerals, apatite

alteration – opaque minerals, chlorite, biotite

Description: This thin section is of a medium-grained, inequigranular, hypocrystalline, relatively feldspathic, macroporphyritic basalt or basaltic andesite which possess a weakly developed pilotaxitic fabric. Randomly orientated plagioclase phenocrysts occur as single isolated crystals and glomerophyric clusters of several macrophenocrysts. Plagioclase forms twinned lath-shaped, weakly zoned crystals which exhibit a dusty appearance in plane polarised light due to sericitic alteration. The larger plagioclase macrophenocrysts are locally rounded indicative of partial resorption of these early formed crystals. The cores of the larger plagioclase phenocrysts may contain irregular to elongate inclusions of chloritised glass. Occasional carbonate pseudomorphs after either olivine or clinopyroxene microphenocrysts have also been noted.

The groundmass is mainly composed of variably aligned plagioclase laths which define a weakly developed pilotaxitic fabric. Plagioclase also occurs as an intergranular phase overgrowing earlier formed laths. The remaining interstitial to intersertal areas are filled by a pale yellow coloured chloritic assemblage, very fine-grained, granular opaque minerals and secondary biotite. Biotite is a relatively common accessory phase within this andesite.

Collectors Number: MFH9. **Registered Number:** N5140. **Location:** [N0 80149 67106] Johnshaven, Strathmore. **Geological map sheet:** 57. **Rock Type:** litharenite. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a medium-grained, immature, lithic-rich, closely packed, clast supported, compact, matrix-poor litharenite which contains minor amounts of secondary porosity. This secondary porosity was formed by the dissolution of unstable detrital grains and removal of an earlier formed chloritic cement. Detrital grains are angular to subangular in shape with a low sphericity. A preferred shape alignment of elongate grains is developed within this sandstone.

The mixed clast assemblage present within this sandstone is dominated by lithic clasts and monocrystalline quartz. The lithic clasts are mainly composed of fragments of a very fine-grained to glassy basaltic to dacitic volcanic rocks. Recognisable lithologies forming the lithic clasts include hematised basalt, very fine-grained phyllitic metasedimentary rock, felsite, siltstone and very fine-grained sandstone. Minor to accessory detrital components include polycrystalline quartz, staurolite, biotite, plagioclase, chlorite, muscovite, zircon, garnet, microcline and K-feldspar.

A well-developed yellow-green coloured chloritic cement is locally present. Compaction resulted in pressure solution, kinking of detrital micas and plastic deformation of unstable detrital grains.

Collectors Number: MFH10. **Registered Number:** N5141. **Location:** [N0 79967 67056] Johnshaven, Strathmore. **Geological map sheet:** 57. **Rock Type:** laminated siltstone and fine-grained quartzose litharenite. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a interlaminated siltstone and fine-grained quartzose litharenite. The massive siltstone is fine-grained and possesses a well-developed preferred shape alignment of detrital micas. Detrital grains are angular in shape and are mainly composed of monocrystalline quartz and muscovite. Other minor to accessory detrital components include needle-like to granular opaque oxides, chlorite, plagioclase and biotite.

The interbedded sandstone is a fine-grained, pebbly, open to very open packed, immature, matrix poor, clast supported, quartzose litharenite. This litharenite contains a number of larger siltstone rip-up clasts and andesitic volcanic lithic clasts. The siltstone clasts are plastically deformed and are embayed against neighbouring, more rigid, quartzose grains. The remaining detrital clasts are angular to subangular in shape with a low sphericity.

The mixed clast assemblage present within this sandstone is dominated by monocrystalline quartz and lithic clasts. The lithic clasts are mainly composed of fragments of a very fine-grained to originally glassy (now devitrified) andesitic to dacitic volcanic rock. Other minor to accessory detrital components present within the sandstone include polycrystalline quartz, plagioclase, opaque minerals, muscovite, biotite, metasedimentary rock fragments, chlorite and microcline.

An intergranular porosity and secondary porosity due to the dissolution of unstable detrital components are present within the sandstone laminae.

Collectors Number: MFH11. **Registered Number:** N5142. **Location:** [N0 79844 67041] Johnshaven, Strathmore. **Geological map sheet:** 57. **Rock Type:** pilotaxitic, altered, microporphyritic basaltic rock. **Formation:** igneous rock in Catterline Conglomerate Formation. **Symbol:** flmiB/B^{B}.

Mineralogy: major – plagioclase

minor – opaque minerals

alteration – opaque minerals, carbonate, chlorite, sericite

Description: This thin section is of a altered, medium- to coarse-grained, inequigranular, hypocrystalline, microporphyritic basalt which possesses a weakly to moderately developed pilotaxitic fabric. Anhedral to weakly subhedral microphenocrysts of a ferromagnesian mineral (olivine and/or clinopyroxene) are completely pseudomorphed by carbonate and opaque oxides.

The opaque minerals for an outer rim to the pseudomorph and also thin films or veinlets along fractures within the original mineral. The microphenocrysts occur in glomerophyric clusters of several crystals.

The groundmass is mainly composed of variably aligned plagioclase laths and a very fine-grained intergranular ferromagnesian mineral; the latter is completely replaced by carbonate and opaque minerals. The remaining interstitial to intersertal areas are filled by a cryptocrystalline, pale yellow coloured chloritic assemblage. Radiating to crudely spherulitic aggregates of small plagioclase laths are locally developed within the groundmass. The rock is cut by a number of irregular veinlets of cryptocrystalline chlorite and carbonate.

Collectors Number: MFH12. **Registered Number:** N5143. **Location:** [N0 81548 68921] Benholm, Strathmore. **Geological map sheet:** 57. **Rock Type:** volcaniclastic litharenite or breccia. **Formation:** igneous rock in Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a coarse- to very coarse-grained, open to moderately packed, clast supported, lithic-rich, very poorly sorted, monolithic to weakly heterolithic, volcaniclastic litharenite or volcaniclastic breccia. The clast assemblage within this sandstone is solely composed of angular to subangular, low sphericity, volcanic derived lithic fragments. These lithic clasts are composed of a very fine-grained, aphyric, variably hematised basaltic to andesitic rock. Occasional fragments of hematised, vesicular volcanic glass are also present. The complex, irregular margins of these clasts is indicative of only a very limited period (if any) of transport in the sedimentary environment. These vesicular lithic clasts are typically finer grained and more intensely altered (hematised) that the remainder of the lithic clasts. Traces of an intergranular porosity and pale yellow-green coloured chloritic cement are present within this volcaniclastic rock.

Collectors Number: MFH13. **Registered Number:** N5144. **Location:** [N0 81548 68921] Benholm, Strathmore. **Geological map sheet:** 57. **Rock Type:** litharenite or microconglomerate. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a very coarse-grained, poorly sorted, immature, matrix-rich, clast supported, moderately to open packed, heterolithic, massive litharenite or microconglomerate. Detrital grains are angular, subangular to weakly subrounded with a low sphericity.

The clast assemblage present within this sandstone is dominated by lithic clasts, including volcanic, metamorphic and sedimentary rock fragments. Recognisable lithologies include aphyric andesitic rock, feldspar-phyric andesite, biotite-feldspar-bearing schist or hornfels, serpentinite, quartz-feldspar-phyric dacite/rhyodacite, hematised mudstone or metamudstone, pilotaxitic basaltic to andesitic rock, phyllitic to finely schistose metasedimentary rock, fine-grained metasandstone (psammite) and amphibole-plagioclase-phyric andesite. Other minor to accessory detrital components include monocrystalline quartz, polycrystalline quartz, plagioclase, muscovite, opaque minerals, biotite, chlorite and zircon.

The silty matrix to this coarse-grained sandstone contains very fine sand to silt-grade, angular, low sphericity clasts of monocrystalline quartz.

Collectors Number: MFH14. **Registered Number:** N5145. **Location:** [N0 81504 68757] Benholm, Strathmore. **Geological map sheet:** 57. **Rock Type:** coarse-grained litharenite or microconglomerate. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a coarse- to very coarse-grained, poorly to very poorly sorted, immature, lithic-rich, clast supported, closely packed, matrix-poor, heterolithic litharenite or microconglomerate. Medium sand to granule, and occasional small pebble, sized clasts are angular, subangular to occasionally rounded in shape with a low sphericity.

The clast assemblage within this sandstone is dominated by volcanic derived lithic clasts. These lithic clasts are mainly composed of fragments of a very fine-grained to originally glassy (now devitrified) basaltic to andesitic rocks. Recognisable lithologies include aphyric felsitic rock, amphibole microporphyritic andesite, feldspar-phyric andesite or dacite, pilotaxitic andesite and devitrified glassy volcanic rock. Minor to accessory detrital components include monocrystalline quartz, polycrystalline quartz, very fine-grained phyllitic to schistose metasedimentary rock fragments, plagioclase, fine-grained metasandstone (psammite), chlorite, garnet and muscovite. Garnet is a common accessory phase forming fine to medium sand grade clasts.

Compaction resulted in pressure solution and the plastic deformation of unstable detrital grains which are embayed against more rigid quartzose clasts. Traces of a moderately to well-developed, yellow-green coloured chloritic cement are present within this sandstone.

Collectors Number: MFH15. **Registered Number:** N5146. **Location:** [N0 79835 67038] Johnshaven, Strathmore. **Geological map sheet:** 57. **Rock Type:** litharenite. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a coarse-grained, poorly to very poorly sorted, closely packed, clast supported, immature, matrix-poor, lithic-rich, heterolithic litharenite which contains traces of secondary porosity formed due to the dissolution and removal of unstable detrital grains. Traces of an intergranular (?primary) porosity are also present.

Medium to coarse sand grade clasts are angular, subangular to occasionally subrounded in shape with a low sphericity. A preferred shape-alignment of elongate clasts can been recognised. The clast assemblage within this sandstone is mainly composed of fragments of a very fine-grained, aphyric basaltic to andesitic rock. Recognisable lithologies include amphibole microporphyritic andesite, hematised basalt, chloritised siltstone or metasiltstone, pyroxene-phyric basalt and very fine-grained, biotite-bearing phyllitic metasedimentary rock. Minor to accessory detrital components include monocrystalline quartz, opaque minerals, epidote and biotite.

Traces of a pale yellow coloured chloritic cement have been noted within this sandstone.

Collectors Number: MFH16. **Registered Number:** N5147. **Location:** [N0 79261 66707] Johnshaven, Strathmore. **Geological map sheet:** 57. **Rock Type:** litharenite. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a fine- to medium-grained, moderately to poorly sorted, immature, closely packed, clast supported, lithic-rich, massive, matrix-poor litharenite which possesses traces of an intergranular porosity.

Angular, subangular to occasionally subrounded, low sphericity detrital grains are mainly composed of volcanic derived lithic fragments and monocrystalline quartz. The volcanic lithic clasts are typically composed of very fine-grained to glassy (now devitrified), aphyric basalt to

andesite fragments. Minor to accessory detrital components include polycrystalline quartz, muscovite, biotite, opaque minerals, chlorite, plagioclase, very fine-grained low-grade metasandstone and/or sandstone, biotite-bearing metasedimentary rock, chert, microcline, perthite, K-feldspar, siltstone and rhyolitic rock fragments.

Compaction resulted in the kinking of detrital micas and the plastic deformation of unstable detrital grains which are embayed against neighbouring more rigid quartzose clasts. Accompanying pressure solution appears to have resulted in the main mode of cementation. However, traces of a chloritic cement are also present within this sandstone.

Collectors Number: MFH17. **Registered Number:** N5148. **Location:** [N0 79261 66707] Johnshaven, Strathmore. **Geological map sheet:** 57. **Rock Type:** laminated siltstone. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a fine-grained, dusty looking, laminated siltstone containing angular to subangular, low sphericity grains of monocrystalline quartz. Other minor to accessory detrital components include muscovite, opaque minerals, plagioclase, biotite, tourmaline, chlorite, apatite, epidote and titanite. The detrital micas and elongate opaque grains exhibit a moderately well-developed preferred shape alignment. The lamination is defined by slight variation in grain size of the siltstone. Internally, a number of the laminae are weakly graded. Traces of a replacive carbonate cement are present within this siltstone.

Collectors Number: MFH18. **Registered Number:** N5149. **Location:** [N0 79040 66000] Johnshaven, Strathmore. **Geological map sheet:** 57. **Rock Type:** laminated, coarse to fine siltstone. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a laminated, fine- to coarse-grained, dusty looking siltstone. The lamination is defined by a variation in grain size with individual laminae possessing finer grained tops rich in detrital micas. These micas are shape-aligned parallel to the sedimentary lamination. Angular to subangular, low sphericity detrital grains are mainly composed of monocrystalline quartz. Other minor to accessory detrital components include opaque minerals, biotite, chlorite, plagioclase, chlorite, tourmaline and garnet. Traces of an intergranular porosity are present within the coarser grained bases of the graded laminae.

Collectors Number: MFH19. **Registered Number:** N5150. **Location:** [N0 78697 66403] Johnshaven Narrows, Strathmore. **Geological map sheet:** 57. **Rock Type:** weakly laminated, medium-grained quartzose litharenite. **Formation:** Catterline Conglomerate Formation. **Symbol:** note applicable.

Description: This thin section is of a medium-grained, weakly laminated, very closely packed, clast supported, moderately sorted, massive, matrix-poor litharenite containing traces of a secondary porosity formed due to the dissolution and removal of unstable lithic clasts.

Detrital grains and angular to subangular in shape with a low sphericity. However, the shape of unstable lithic clasts has been modified during compaction. The clast assemblage within this sandstone is dominated by lithic fragments and monocrystalline quartz. The lithic clasts are mainly composed of altered, very fine-grained andesitic volcanic rock fragments. Minor to accessory detrital components include plagioclase, polycrystalline quartz, biotite, very fine-grained phyllitic metasedimentary rock, fine-grained biotite-bearing schistose metasedimentary

rock, opaque minerals, siltstone or mudstone, garnet, felsite, rhyodacite, epidote, zircon, metamafite, K-feldspar and microcline.

A preferred shape alignment of elongate detrital grains has been recognised within this sandstone. Compaction resulted in pressure solution and the kinking of detrital micas. Traces of a chloritic cement are present. Traces of a matrix component present within this sandstone appears to have been derived from degraded lithic clasts.

Collectors Number: MFH20. **Registered Number:** N5151. **Location:** [N0 79655 67451] Johnshaven, woodland near junction, Strathmore. **Geological map sheet:** 57. **Rock Type:** quartzose litharenite. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a medium- to coarse-grained, very closely packed, clast supported, matrix-poor, massive, lithic-rich quartzose litharenite which is lithologically similar to sample N5150. No obvious porosity has been recognised within this sandstone.

Detrital grains are angular to subangular in shape with a low sphericity. However, clast shape has locally been modified during compaction with unstable lithic clasts embayed against neighbouring more rigid quartzose grains. The clast assemblage within this sandstone is dominated by volcanic lithic fragments and monocrystalline quartz. The lithics are mainly composed of fragments of a very fine-grained, originally glassy (now devitrified) andesitic to possibly dacitic rock. Minor to accessory detrital components include plagioclase, biotite, muscovite, opaque minerals, garnet, polycrystalline quartz, phyllitic metasedimentary rock, hematised basalt, tourmaline, zircon, perthite, amphibole-phyric andesite, biotite-phyric dacite and a rhyolitic rock.

Elongate detrital grains display a weakly developed preferred shape alignment. Compaction resulted in the kinking of detrital micas. Traces of matrix present within this sandstone appear to be derived from degraded lithic clasts.

Collectors Number: MFH21. **Registered Number:** N5152. **Location:** [N0 78034 65810] East Mathers, Strathmore. **Geological map sheet:** 57. **Rock Type:** calcareous quartz arenite. **Formation:** Kinnesswood Formation. **Symbol:** not applicable.

Description: This thin section is of a medium-grained, moderately to poorly sorted, open to very open packed, clast to cement supported, calcareous quartz arenite which contains granule to small pebble sized, angular to rounded carbonate concretions or pebbles. Detrital grains are subangular, subrounded to well-rounded in shape with a low to moderate sphericity. Occasional well rounded, high sphericity clasts have been noted within this sandstone. However, clast shape has been variably modified due to grain boundary etching during the development of anhedral, sparry carbonate cement. Traces of a hematitic stain are present within the cement, and surrounding the carbonate concretions, suggesting it may have included ferroan dolomite.

The clast assemblage within this sandstone is dominated by monocrystalline quartz. Other minor to accessory detrital components include polycrystalline quartz, plagioclase, microcline, staurolite, muscovite, tourmaline, opaque minerals, K-feldspar and rare siltstone lithic fragments.

Collectors Number: MFH22. **Registered Number:** N5153. **Location:** [N0 78238 66249] East Mathers, Strathmore. **Geological map sheet:** 57. **Rock Type:** quartz arenite. **Formation:** Kinnesswood Formation. **Symbol:** not applicable.

Description: This thin section is of a weakly laminated, fine- to medium-grained, clast supported, open to very open packed, poorly cemented, massive, poorly sorted compositionally mature quartz arenite which possesses a relatively high intergranular porosity. The lamination is defined by a slight variation in the grain size of the sandstone and thin (c. 0.6 mm thick) fine siltstone partings. Detrital grains are angular, subangular to subrounded in shape with a low to moderate sphericity. However, clast shape has been modified due to pressure solution during compaction and localised growth of a quartz rim cement.

The clast assemblage within this sandstone is dominated by monocrystalline quartz. Other minor to accessory detrital components include plagioclase, polycrystalline quartz, microcline, opaque minerals, zircon, tourmaline and muscovite.

Traces of a chloritic or clay rim cement have been noted. Also present are trace amounts of possible ?gypsum forming irregular to bladed, twinned, poikilitic intergranular crystals which enclose finer grained clasts.

Collectors Number: MFH23. **Registered Number:** N5154. **Location:** [N0 76269 64878] Milton Ness/West Mathers, Strathmore. **Geological map sheet:** 57. **Rock Type:** pilotaxitic, altered, microporphyritic basaltic rock. **Formation:** Montrose Volcanic Formation. **Symbol:** flmiB.

Mineralogy: major – plagioclase

minor – opaque minerals

alteration – opaque minerals, carbonate, chlorite, sericite

Description: This thin section is of a altered (hematised), fine-grained, inequigranular, microporphyritic basaltic rock which possesses a well-developed pilotaxitic fabric. Anhedral to rounded microphenocrysts of olivine and/or clinopyroxene are completely pseudomorphed by carbonate enclosed within a rim of a opaque mineral. The larger of these phenocrysts are rounded to embayed, indicative of resorption. Phenocrysts occur as single isolated crystals as well as small, glomerophyric clusters of several (2 to 4) microphenocrysts.

The groundmass is mainly composed of fine-grained, anhedral to subhedral, weakly altered plagioclase. Plagioclase crystals are twinned (simple and multiple) are shape-aligned defining a well-developed pilotaxitic fabric. Interstitial phases within the groundmass, which may have originally included glass, have been replaced by a dusty looking mesostasis, as well as carbonate and opaque oxide.

The rock is cut by a number of irregular carbonate veinlets and a 0.4 mm wide vein of Fe-oxide and chlorite.

Collectors Number: MFH24. **Registered Number:** N5155. **Location:** [N0 76457 64987] West Mathers ‘Castle’, Strathmore. **Geological map sheet:** 57. **Rock Type:** altered, volcaniclastic litharenite. **Formation:** Montrose Volcanic Formation. **Symbol:** not applicable.

Description: This thin section is of a fine-grained, lithic-rich, very closely packed, immature, clast supported, altered, matrix-poor, volcaniclastic litharenite with locally intense hematisation and/or chloritisation of unstable detrital components. Detrital grains are angular, subangular to subrounded in shape with a low sphericity. However, the clast shape has been modified during

compaction and alteration. The original shape of the most intensely altered lithic clasts is locally difficult to determine.

The clast assemblage within this sandstone is dominated by basaltic to andesitic volcanic rock fragments. Other minor to accessory detrital components include plagioclase, opaque minerals, chlorite, biotite, monocrystalline quartz, muscovite, epidote and zircon.

Minor to trace amounts of matrix present within this volcaniclastic sandstone appears to have been derived from degraded lithic clasts. Trace amounts of a secondary carbonate cement have been noted replacing plagioclase.

Collectors Number: MFH25. **Registered Number:** N5156. **Location:** [N0 76457 64987] West Mathers 'Castle', Strathmore. **Geological map sheet:** 57. **Rock Type:** amygdaloidal, pilotaxitic, microporphyritic basaltic rock. **Formation:** Montrose Volcanic Formation. **Symbol:** flmiB.

Mineralogy: major – plagioclase

minor – opaque minerals

alteration – carbonate, opaque minerals, sericite, chlorite

Description: This thin section is of a altered (chloritised and hematised), medium-grained, inequigranular, amygdaloidal, microporphyritic feldspathic basaltic rock which possesses a weakly to moderately developed pilotaxitic fabric. Microphenocrysts of olivine and/or clinopyroxene are pseudomorphed by carbonate and opaque minerals. These phenocrysts occur as single, isolated crystals (≤ 0.5 mm in size) or as glomerophyric clusters of 2 to 4 microphenocrysts.

The groundmass is mainly composed of variably aligned, anhedral to subhedral plagioclase laths with intergranular plagioclase and opaque minerals. Plagioclase is variably altered to sericite and carbonate. The opaque minerals occur as small granules and fine needle-like crystals. The remaining interstitial to intersertal areas are filled by a cryptocrystalline felsitic mosaic containing finely disseminated, dusty opaque oxides.

Rounded amygdales (up to 5.0 mm in diameter) present within this basaltic rock are composed of a cryptocrystalline assemblage of chlorite, quartz and carbonate.

Collectors Number: MFH26. **Registered Number:** N5157. **Location:** [N0 76638 64863] West Mathers, Milton Ness, Strathmore. **Geological map sheet:** 57. **Rock Type:** sandy calcareous rock. **Formation:** Knox Pulpit Formation. **Symbol:** not applicable.

Description: This thin section is of a massive to locally fragmentary looking, sandy calcareous rock which is cut by a number of sparry carbonate veinlets. This carbonate replaced sandstone contains isolated grains of monocrystalline quartz which represent relict detrital grains. It is possible that a small number of these grains are diagenetic in origin. Other accessory detrital components include zircon, opaque minerals, plagioclase and polycrystalline quartz. The bulk of this rock, however, is composed of fine to very finely crystalline carbonate.

Collectors Number: MFH27. **Registered Number:** N5158. **Location:** [N0 77145 64762] Tanglelia, Strathmore. **Geological map sheet:** 57. **Rock Type:** calcareous quartz arenite. **Formation:** Kinnesswood Formation. **Symbol:** not applicable.

Description: This thin section is of a medium-grained, moderately sorted, mature, very open packed, cement supported, massive, calcareous quartz arenite which possesses a well-developed coarse, sparry carbonate cement. The cement is composed of large (up to 6.0 mm in length), poikilitic, intergranular carbonate crystals which overgrow and include the finer grained clasts. Carbonate crystals are unstrained, and anhedral to irregular in shape.

Clastic grains present within this sandstone are angular, subangular, to occasionally well rounded in shape with a low sphericity. However, clast shape has locally been modified due to grain boundary etching during the development of the replacive carbonate cement. Detrital grains are mainly composed of monocrystalline quartz and minor polycrystalline quartz. Other minor to accessory detrital components include plagioclase, biotite, microcline and staurolite.

Collectors Number: MFH28. **Registered Number:** N5159. **Location:** [N0 74150 63476] Nether Warburton, SNH car park, Strathmore. **Geological map sheet:** 57. **Rock Type:** indurated quartz arenite. **Formation:** Whitecraig Sandstone. **Symbol:** not applicable.

Description: This thin section is of a fine- to medium-grained, moderate to well sorted, very closely packed, clast supported, matrix poor, mature, indurated to weakly recrystallised quartz arenite. Detrital grains are subrounded to well rounded in shape with a moderate to low sphericity. The shape of these clast has, however, locally been strongly modified due to the growth of a quartz rim cement, pressure solution and/or recrystallisation. The quartz overgrowths and pressure solution form the main modes of cementation within this sandstone. Traces of an earlier clay rim cement are locally preserved.

The clast assemblage within this compositionally mature sandstone is dominated by monocrystalline quartz. Other minor to accessory detrital components include plagioclase, polycrystalline quartz, muscovite and microcline.

Collectors Number: MFH29. **Registered Number:** N5160. **Location:** [N0 77440 65285] Tanglelia, Strathmore. **Geological map sheet:** 57. **Rock Type:** calcareous quartz arenite. **Formation:** Kinnesswood Formation. **Symbol:** not applicable.

Description: This thin section is of a fine-grained, mature, very open packed, cement supported, massive calcareous quartz arenite which is lithologically similar to sample N5158. This sandstone possesses a very well developed replacive, sparry carbonate cement. Carbonate forms large (≤ 1.5 mm in size), anhedral, poikilitic intergranular crystals which include the finer grained clasts. Traces of ?gypsum cement are also present. Irregular bands or patches of finer grained, dusty looking carbonate also occur associated with very minor Fe-staining. The sandstone contains a single nodule of massive carbonate.

Clastic grains within this sandstone are angular, subangular to rounded in shape with a low to moderate sphericity. However, grains shape has been modified due to grain boundary etching during the growth of the replacive carbonate cement. The clast assemblage is dominated by monocrystalline quartz. Other minor to accessory detrital components present within this sandstone include polycrystalline quartz, plagioclase, tourmaline, opaque minerals, altered felsite (rare) and microcline.

Collectors Number: MFH30. **Registered Number:** N5161. **Location:** [N0 77634 65473] Tanglelia-Milton of Mathers, Strathmore. **Geological map sheet:** 57. **Rock Type:** calcareous quartz arenite. **Formation:** Kinnesswood Formation. **Symbol:** not applicable.

Description: This thin section is of a fine- to very fine-grained, mature, very open packed, cement supported, massive, poorly sorted calcareous quartz arenite which possesses a very well-developed replacive carbonate cement. Carbonate forms large (up to 6.0 to 7.0 mm in size) anhedral to bladed, poikilitic crystals which include finer grained clastic grains. The carbonate crystals possess a uniform to slightly undulose extinction. Patches of finer grained (c. 0.2 mm in size), granular looking carbonate are also present.

Clastic grains within this sandstone are angular to rounded in shape with a low to moderate sphericity. Clast shape, however, has been modified due to grain boundary etching during the development of the carbonate cement. The clast assemblage of this compositionally mature sandstone is dominated by monocrystalline quartz. Other minor to accessory detrital components includes polycrystalline quartz, plagioclase, hematised lithic fragments (rare), opaque minerals, zircon, microcline and tourmaline.

The rock is cut by a number of coarse-grained, sparry carbonate veinlets.

Collectors Number: MFH31a. **Registered Number:** N5162a. **Location:** [N0 75973 64815] St. Cyrus beach, Strathmore. **Geological map sheet:** 57. **Rock Type:** micaceous siltstone. **Formation:** Montrose Volcanic Formation. **Symbol:** not applicable.

Description: This thin section is of a fine-grained, laminated, micaceous siltstone which possess a pronounced shape alignment of detrital micas parallel to the sedimentary lamination. The lamination is defined by a slight variation in grain size. The detrital micas are dominated by red-brown, variably hematised biotite with subordinate to minor muscovite. Other detrital grains within the siltstone are angular in shape with a low sphericity. The clast assemblage in this siltstone is dominated by monocrystalline quartz and mica. Other minor to accessory detrital components include opaque minerals, tourmaline, garnet, chlorite, zoisite, plagioclase and apatite. Traces of a secondary carbonate are present within this siltstone replacing both the matrix and some detrital grains. The rock is cut by a carbonate veinlet.

Collectors Number: MFH31b. **Registered Number:** N5162b. **Location:** [N0 75973 64815] St. Cyrus beach, Strathmore. **Geological map sheet:** 57. **Rock Type:** altered, amygdaloidal, pilotaxitic, olivine microporphyritic basaltic rock. **Formation:** Montrose Volcanic Formation. **Symbol:** flomiB/B^{B}.

Mineralogy: major – plagioclase

minor – opaque minerals

alteration – carbonate, opaque minerals, sericite, chlorite, iddingsite/bowlingite

Description: This thin section is of a altered (hematised), fine-grained, inequigranular, hypocrystalline, microporphyritic basalt which possesses a weakly to moderately developed pilotaxitic fabric. Anhedral, subhedral to occasionally euhedral microphenocrysts of olivine are pseudomorphed by mesh textured bowlingite. Thin foils and seams of opaque minerals preserve fractures within the original olivine.

The groundmass of this basalt is mainly composed of variably shape aligned plagioclase laths. Plagioclase is variably replaced by chlorite and sericite. The interstitial to intersertal phases are replaced by opaque minerals. Small iddingsite/bowlingite pseudomorphs after granular clinopyroxene and/or olivine are also present within the groundmass.

Rounded to irregular amygdales (up to 5.6 mm in length) are zoned and composed of very fine bands of cryptocrystalline to microcrystalline chlorite. The amygdales may be shape aligned and wrapped by the pilotaxitic fabric developed within the groundmass.

Collectors Number: MFH32. **Registered Number:** N5163. **Location:** [N0 75973 64815] St. Cyrus beach, Strathmore. **Geological map sheet:** 57. **Rock Type:** amygdaloidal, pilotaxitic, microporphyritic basalt. **Formation:** Montrose Volcanic Formation. **Symbol:** flmiB/B^{B}.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals, analcime

alteration – opaque minerals, chlorite, iddingsite/bowlingite, carbonate, sericite

Description: This thin section is of a altered, fine-grained, amygdaloidal, inequigranular, hypocrystalline, weakly microporphyritic basalt which possesses a weakly to moderately developed pilotaxitic fabric. Anhedral to subhedral olivine and/or clinopyroxene microphenocrysts are pseudomorphed by chlorite, bowlingite and opaque minerals. Original fractures within the ferromagnesian microphenocrysts are preserved by thin foils or veinlets of opaque minerals.

The groundmass is composed of fine-grained, anhedral to subhedral, plagioclase laths which are variably altered to chlorite and sericite. Interstitial to intersertal phases are replaced by dusty granular opaque minerals. Traces of relict clinopyroxene have been noted within the groundmass. Plagioclase is variably aligned, defining a weakly to moderately well-developed pilotaxitic fabric which wraps around the amygdales, indicating that inflation of the vesicles post-dated the formation of this foliation. Large (up to 3.0 to 4.0 mm in size), amygdales are zoned and comprise an outer rim of carbonate enclosing low relief, colourless analcime.

Collectors Number: MFH33. **Registered Number:** N5164. **Location:** [N0 76231 64917] St. Cyrus beach, Strathmore. **Geological map sheet:** 57. **Rock Type:** amygdaloidal, pilotaxitic, basalt. **Formation:** Montrose Volcanic Formation. **Symbol:** flB/B^{B}.

Mineralogy: major – plagioclase

minor – opaque minerals, analcime

alteration – chlorite, opaque minerals, sericite, bowlingite/iddingsite, carbonate

Description: This thin section is of a altered (chloritised), coarse-grained, inequigranular, amygdaloidal, weakly microporphyritic basalt which possesses a weakly developed pilotaxitic fabric. Rounded to irregular amygdales are mainly composed of cryptocrystalline, yellow-green coloured chlorite with traces of carbonate. Chlorite or bowlingite pseudomorphs after occasional to rare olivine and/or pyroxene microphenocrysts have been noted within this highly altered basalt.

The bulk of the rock is composed of variably aligned, anhedral to subhedral plagioclase laths. Interstitial to intersertal phases, which may have included pyroxene and glass, are altered to a cryptocrystalline chloritic assemblage. Small chlorite/bowlingite pseudomorphs after intergranular pyroxene are rimmed by a red-brown opaque oxide.

Analcime was only recognised within the largest amygdale developed within this basalt.

Collectors Number: MFH34. **Registered Number:** N5165. **Location:** [N0 76231 64917] St. Cyrus beach, Strathmore. **Geological map sheet:** 57. **Rock Type:** weakly laminated siltstone with minor soft-sediment deformation. **Formation:** Montrose Volcanic Formation. **Symbol:** not applicable.

Description: This thin section is of a weakly laminated, fine-grained siltstone containing thin, impersistant clay-rich partings. The lamination and clay partings are deformed by small-scale convolute and disharmonic folds. These folds are locally associated with small scale water escape conduits. The lamination is defined by a variation in grain size of the siltstone. Angular, low sphericity detrital grains are mainly composed of monocrystalline quartz and detrital micas. Minor to accessory detrital components present include muscovite, opaque minerals, biotite, chlorite and titanite. The detrital micas and elongate opaque mineral grains exhibit a preferred shape alignment parallel to the sedimentary lamination.

Traces of a replacive carbonate cement and Fe-staining of the clay grade matrix have been noted within this siltstone. Minor recrystallisation of quartz and quartz filled veinlets and vugs are also present.

Collectors Number: MFH35. **Registered Number:** N5166. **Location:** [N0 76231 64917] St. Cyrus beach, Strathmore. **Geological map sheet:** 57. **Rock Type:** interlayered, hematised siltstone and altered microporphyritic basalt. **Formation:** Montrose Volcanic Formation. **Symbol:** not applicable.

Description: This thin section is of a interlayered hematised siltstone or very fine-grained sandstone, and altered (hematised) microporphyritic basalt. The basalt is a fine- to very fine-grained, hypocrystalline, originally glassy, amygdaloidal rock which possesses a moderately to well-developed pilotaxitic fabric. Small (≤ 0.4 mm in diameter), rounded amygdales are composed of single crystals or aggregates of carbonate or a colourless to very pale green coloured, cryptocrystalline chloritic assemblage. Chloritic pseudomorphs after small (≤ 0.5 mm in size), anhedral to subhedral olivine and/or clinopyroxene microphenocrysts occur as single isolated crystals and glomerophyric clusters of 3 to 4 phenocrysts. The groundmass is mainly composed of variably aligned, very fine-grained, anhedral to weakly subhedral plagioclase laths. Interstitial to intersertal phases, which probably included glass, are replaced by a dusty grey mesostasis containing finely disseminated opaque minerals.

The laminated siltstone to very fine-grained sandstone is weakly graded and contains thin Fe-stained muddy partings. The lamination in the siltstone is parallel to the contacts with the adjacent basalt. Patchy carbonate replacement of the clay-grade matrix to this siltstone has been noted. Angular to subangular, low sphericity detrital grains are mainly composed of monocrystalline quartz, opaque minerals and detrital micas. Other Minor to accessory detrital components include rare basalt rock fragments (derived from the adjacent basalt), muscovite, chlorite, plagioclase and biotite. No obvious alignment of the detrital micas has been recognised within this siltstone.

The contact between the siltstone and basalt is irregular with complex 'flame-like' extensions of basalt into the adjacent sedimentary rock. The contact between the two rock types cuts across the pilotaxitic fabric developed within the basalt. No obvious chilling, grain size reduction or fracturing have been noted within the basalt. The siltstone appears to be undisturbed and there is no evidence of soft-sediment deformation and/or water escape within this fine-grained sedimentary rock. Small patches of cryptocrystalline chloritic material and carbonate present within the siltstone may represent small amygdales. Minor increase in Fe-staining of the basalt along the contact within the siltstone has been noted. Both the siltstone and basalt are cut by late carbonate veinlets.

Collectors Number: MFH36. **Registered Number:** N5167. **Location:** [N0 81807 69264] Benholm beach, Strathmore. **Geological map sheet:** 57. **Rock Type:** xenolithic, hyalopilitic feldspar-quartz-microporphyritic rhyodacite/rhyolite or parataxitic rhyodacitic to rhyolitic lapilli-tuff. **Formation:** uncertain. **Symbol:** flfqmiR^{D}/R or flLZ^{R}.

Description: This thin section is of a xenolithic, fine-grained, originally glass (now devitrified), matrix- or groundmass-rich rhyodacitic to rhyolitic rock with a well-developed hyalopilitic or parataxitic fabric developed within the matrix. This fabric is defined by elongate, dusty stringers of opaque minerals and cryptocrystalline quartz. It is uncertain if this rock is a xenolithic or lithic-rich felsitic rock represents a lava/high-level intrusive or primary pyroclastic deposit.

Scattered, anhedral to rounded quartz and feldspar crystals are either partially resorped microphenocrysts or crystal fragments included within a lapilli-tuff. Occasional to rare chloritic pseudomorphs after ?pyroxene crystals have also been noted. Rounded xenoliths or lithic fragments are composed of a very fine-grained granitic rock and basalt. Dusty looking, opaque-rich coronas or reaction rims are developed enclosing these lithic fragments. Both the crystals and rock fragments are wrapped by the fabric developed within the matrix. The dusty pink (in plane polarised light), originally glassy matrix is composed of small (< 0.1 mm in diameter), spherulitic aggregates of very fine-grained to cryptocrystalline, fibrous quartz and/or feldspar. Small. Irregular patches of secondary quartz are also present within the matrix.

Collectors Number: MFH37. **Registered Number:** N5168. **Location:** [N0 82140 69931] Benholm beach, Strathmore. **Geological map sheet:** 57. **Rock Type:** calcareous litharenite. **Formation:** Crawton Volcanic Formation. **Symbol:** note applicable.

Description: This thin section is of a medium- to coarse-grained, poorly sorted, immature, clast supported to locally cement supported, open to very open packed, massive, lithic-rich, matrix-poor, calcareous litharenite which possesses a well-developed replacive sparry carbonate cement. The carbonate replaced the original matrix and most unstable detrital components within this sandstone. Detrital grains within this sandstone are angular, subangular to occasionally subrounded in shape with a low sphericity. A weak preferred shape-alignment of elongate grains has been noted.

The clast assemblage is dominated by monocrystalline quartz, volcanic lithic fragments and subordinate plagioclase. The volcanic lithic clasts are mainly composed of variably hematised, very fine-grained to originally glassy basaltic to andesitic rock fragments. Other minor to accessory detrital components include polycrystalline quartz, perthite, biotite, siltstone, very fine-grained phyllitic metasedimentary rock fragments, biotite-bearing metasedimentary rock, garnet, opaque minerals, microcline, tourmaline and rhyodacite/rhyolite. Sedimentary lithic clasts are a relatively common minor detrital component within this sandstone.

Compaction resulted in the kinking of detrital micas.

Collectors Number: MFH38. **Registered Number:** N5169. **Location:** [N0 82201 69841] Benholm beach, Strathmore. **Geological map sheet:** 57. **Rock Type:** altered, pilotaxitic, plagioclase macroporphyritic basaltic andesite. **Formation:** uncertain. **Symbol:** flplmaA^B.

Mineralogy: major – plagioclase

minor – opaque minerals, apatite

alteration – chlorite, sericite, bowlingite, biotite, opaque minerals

Description: This thin section is of a altered, fine- to very fine-grained, hypocrystalline, inequigranular, macroporphyritic basaltic andesite which possesses a weakly to moderately well-developed pilotaxitic fabric. Prismatic to bladed, elongate plagioclase macrophenocrysts range up to over 10.0 mm in length and are aligned parallel to the pilotaxitic fabric developed within the groundmass. Plagioclase is twinned and forms anhedral to weakly subhedral crystals which are variably altered to sericitic white mica. Rare pseudomorphs after small ferromagnesian mineral microphenocrysts have also been noted.

The fine- to very fine-grained groundmass is mainly composed of variably shape aligned, anhedral plagioclase laths with intergranular feldspar and opaque minerals. The remaining interstitial to intersertal phases have been replaced by a yellow-green coloured, cryptocrystalline chloritic assemblage.

Collectors Number: MFH39. **Registered Number:** N5170. **Location:** [N0 74150 63476] St. Cyrus, SNH car park, Strathmore. **Geological map sheet:** 57. **Rock Type:** quartz arenite. **Formation:** uncertain. **Symbol:** not applicable.

Description: This thin section is of a medium-grained, massive, very closely packed, clast supported, moderate to well sorted, compositionally mature quartz arenite with approximately 5 to 7 % intergranular porosity. The porosity is locally formed by the dissolution and removal of feldspar.

Clastic grains within this sandstone are angular, subangular to rounded in shape with a moderate to low sphericity. The shape of the detrital grains has, however, been modified due to pressure solution and grain boundary etching during compaction. Grain shape has also been modified due to the localised growth of a quartz rim cement. The quartz cement and pressure solution appear to form the main modes of cementation within this sandstone. Traces (very minor) of a chloritic cement have also been noted.

The clast assemblage within this compositionally mature sandstone is dominated by monocrystalline quartz. Other minor to accessory detrital components include plagioclase, polycrystalline quartz, muscovite, zircon, opaque minerals and perthite.

Collectors Number: MFH41. **Registered Number:** N5172. **Location:** [N0 82116 70004] South of Gourdon Village, Strathmore. **Geological map sheet:** 57. **Rock Type:** laminated calcareous litharenite. **Formation:** Whitehouse Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a laminated, medium- to coarse-grained, poorly sorted, lithic-rich, open to very open packed, clast to cement supported, immature calcareous litharenite. A weak preferred alignment of elongate clasts and detrital micas have been noted parallel to the sedimentary lamination preserved within this sandstone. The lamination is defined by the variation in grain size with one of the laminae possessing a very coarse grained base, containing granule sized lithic clasts, grading upwards into finer grained sand.

Clastic grains are angular, subangular to occasionally subrounded in shape with a low sphericity. The clast assemblage is dominated by volcanic lithic clasts with subordinate monocrystalline quartz and plagioclase. The volcanic lithic clasts are composed of a very fine grained basaltic to andesitic rock. Minor to accessory detrital components include opaque minerals, muscovite, biotite, cleaved mudstone, chlorite, phyllitic metasedimentary rock, very fine biotite-bearing metasedimentary rock, perthite, siltstone, garnet, chloritic rock or serpentinite and microcline. Detrital biotite is variably replaced by hematite.

The sparry carbonate cement within this sandstone is locally formed by 0.3 to 0.5 mm long poikilitic crystals which partially or completely enclose finer sand grains. The shape of these clastic grains has been variably modified due to grain boundary etching during the growth of the carbonate. Ghost outlines of replaced detrital grains have also been recognised within the larger carbonate crystals. Compaction resulted in the kinking of detrital micas.

Collectors Number: MFH42. **Registered Number:** N5173. **Location:** [N0 82116 70004] south of Gourdon Village, Strathmore. **Geological map sheet:** 57. **Rock Type:** calcareous litharenite. **Formation:** Whitehouse Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a medium- to coarse-grained, immature, lithic-rich, closely to very closely packed, clast supported, poorly sorted, compacted, calcareous litharenite which is lithologically similar to sample N5172. This sandstone possesses a patchily developed carbonate cement which replaces the original matrix and/or most unstable detrital components.

Detrital grains within this sandstone are angular, subangular to occasionally subrounded in shape, with a low sphericity. The shape of these clasts has, however, been modified due to pressure solution during compaction, as well as localised grain boundary etching during the development of the carbonate cement. Compaction also resulted in the plastic deformation of the most unstable lithic clasts which become embayed against neighbouring more rigid quartzose clasts.

The mixed clast assemblage is dominated by volcanic lithic fragments, monocrystalline quartz and subordinate plagioclase. The volcanic fragments are composed of a very fine-grained andesitic rock. Other minor to accessory detrital components include chlorite, muscovite, very fine grained metasedimentary rock, felsite, opaque minerals, garnet, cleaved mudstone, siltstone, biotite, basalt, chloritic rock or serpentinite, polycrystalline quartz, hematised volcanic rock, mylonitic rock and microgranitic rock.

Compaction resulted in the kinking of detrital micas and plastic deformation of unstable lithic clasts which become embayed against neighbouring more rigid quartzose grains. A preferred shape alignment of elongate grains and detrital micas has been noted within this sample.

Collectors Number: MFH43. **Registered Number:** N5174. **Location:** [N0 82159 69910] Benholm beach, Strathmore. **Geological map sheet:** 57. **Rock Type:** pebbly to granule calcareous litharenite. **Formation:** Whitehouse Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a medium- to coarse-grained, poorly sorted, immature, lithic-rich, open to very open packed, clast to locally cement supported, pebbly calcareous litharenite which possesses a well-developed replacive carbonate cement. Carbonate has replaced the original matrix and/or most unstable detrital components within this sandstone. Sparry carbonate locally forms poikilitic crystals which overgrown and include the finer grained clasts.

Detrital grains within this sandstone are angular, subangular to occasionally subrounded in shape with a low sphericity. Clast shape has, however, been variably modified by grain boundary etching during the development of the carbonate cement. The mixed clast assemblage is dominated by volcanic rock fragments, monocrystalline quartz and subordinate plagioclase. The volcanic lithic clasts are composed of very fine grained, basaltic to andesitic rocks. Other minor to accessory detrital components present within the sandstone include polycrystalline quartz, biotite, muscovite, biotite-bearing schistose metasedimentary rock, very fine-grained biotite-bearing metasedimentary rock, opaque minerals, perthite, garnet, hematised sandstone, phyllitic metasedimentary rock, epidote, siltstone, tourmaline, microcline and epidote metamafite rock fragments. Detrital biotite is variably replaced by a hematitic oxide.

A weakly developed lamination is defined by a slight variation in grain size. Compaction resulted in the localised kinking of detrital micas.

Collectors Number: MFH44. **Registered Number:** N5175. **Location:** [N0 82134 69859] Benholm beach, south of lava, Strathmore. **Geological map sheet:** 57. **Rock Type:** laminated, fine-grained sandstone with a high intergranular porosity. **Formation:** Whitehouse Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a laminated, fine-grained, poorly sorted, clast-supported, open to very open packed, immature quartzose sandstone with a high intergranular porosity. The porosity appears to have partially developed in response to the dissolution and removal of the original matrix or most unstable detrital components in the sandstone. The sedimentary lamination is defined by a variation in grain size. A preferred shape alignment of elongate clasts and detrital micas occurs parallel to bedding within this sandstone.

Detrital grains are angular to subangular in shape with a low sphericity. The clast assemblage is mainly composed of monocrystalline quartz and plagioclase, as well as variably degraded lithic clasts. Other minor to accessory detrital components include biotite, opaque minerals, muscovite, chloritised basaltic rock, siltstone, andesite, garnet, tourmaline, chlorite and K-feldspar.

Compaction resulted in pressure solution and the kinking of detrital micas. Pressure solution appears to have resulted in the main mode of cementation within this sandstone.

Collectors Number: MFH46. **Registered Number:** N5177. **Location:** [N0 82009 69672] Benholm beach, Strathmore. **Geological map sheet:** 57. **Rock Type:** quartzose litharenite. **Formation:** Whitehouse Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a medium- to coarse-grained, very closely packed, clast supported, immature, lithic-rich, matrix-poor, massive quartzose litharenite which is lacking in any obvious porosity. Clastic grains are angular, subangular to occasionally subrounded in shape. However, clast shape has locally been modified due to pressure solution during compaction. This also resulted in the main mode of cementation within this sandstone.

The clast assemblage is dominated by variably degraded lithic clasts, monocrystalline quartz and subordinate plagioclase. Other minor to accessory detrital components include K-feldspar,

polycrystalline quartz, siltstone, opaque minerals, andesite, rhyolite, felsite, muscovite, garnet, very fine-grained metasedimentary rock, epidote, zircon, very fine-grained phyllitic metasedimentary rock and tourmaline.

Traces of a pale yellow-green chloritic cement have been noted within this sandstone. The matrix component is apparently largely secondary in origin and derived from degraded lithic clasts.

Collectors Number: MFH48. **Registered Number:** N5182. **Location:** [N0 97159 94433] Meadow Hill open cast coal pit, Strathmore. **Geological map sheet:** 57. **Rock Type:** laminated sandy mudstone or muddy sandstone. **Formation:** uncertain. **Symbol:** not applicable.

Description: This thin section is of a laminated, fine-grained, graded, mud-rich, very open packed, matrix supported sandy mudstone or muddy sandstone containing angular, subangular to occasionally subrounded detrital quartz grains. The individual laminae are graded from a fine- to medium-grained sand at the base, to a clay or fine-silt at the top. Replacement of the clay-grade material by very fine-grained carbonate has been noted within this sample.

Detrital grains are mainly composed of monocrystalline quartz. Other minor to accessory detrital components present include opaque minerals, muscovite, hematised rock fragments, ?tuffaceous rock, chlorite and polycrystalline quartz. A small number of detrital grains have been replaced by carbonate.

The rock is cut by a thin carbonate veinlet.

Collectors Number: MFH51. **Registered Number:** N5346. **Location:** [N0 38083 76894] St. Benholm Bridge, in stream section, Strathmore. **Geological map sheet:** 57. **Rock Type:** laminated siltstone. **Formation:** uncertain. **Symbol:** not applicable.

Description: This thin section is of a weakly laminated siltstone in which the fine-silt to clay-grade component is predominantly chloritic in appearance. Angular to subangular detrital grains possess a low sphericity and are mainly composed of monocrystalline quartz and subordinate detrital micas. Other minor to accessory detrital components include biotite, muscovite, plagioclase, opaque minerals, zircon and possible spinel. A preferred shape alignment of detrital micas, parallel to the sedimentary lamination, is developed in this siltstone.

Collectors Number: MFH52. **Registered Number:** N5347. **Location:** [N0 38083 76894] Benholm Bridge, in stream section, Strathmore. **Geological map sheet:** 57. **Rock Type:** altered, amygdaloidal, pilotaxitic basaltic rock. **Formation:** uncertain. **Symbol:** flB.

Mineralogy: major – plagioclase

minor – opaque minerals

alteration – opaque minerals, chlorite, carbonate, quartz, sericite

Description: This thin section is of a altered (hematised), very fine-grained, hypocrystalline, originally glassy, aphyric to weakly microporphyritic, amygdaloidal basalt with a well-developed pilotaxitic fabric. Large (up to over 10 mm in length), rounded to irregular amygdales are zoned and composed of cryptocrystalline, fibrous chlorite, carbonate and quartz. The largest of the amygdales is composed of a single carbonate crystal.

The bulk of this basaltic rock is composed of closely packed, very fine-grained plagioclase laths. Plagioclase forms anhedral, twinned crystals which are variably altered to carbonate and sericite. Plagioclase laths are aligned and define a well-developed pilotaxitic fabric which is deformed by a set of shear bands. These fabrics wrap around the amygdales. Interstitial to intersertal phases within the groundmass are replaced by finely disseminated opaque minerals, chlorite and carbonate.

Collectors Number: MFH53. **Registered Number:** N5348. **Location:** [N0 37832 76756] near Boghead, Strathmore. **Geological map sheet:** 57. **Rock Type:** amygdaloidal, plagioclase microporphyritic basalt. **Formation:** uncertain. **Symbol:** plmiB/B^{B}.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals

alteration – opaque minerals, bowlingite/iddingsite, chlorite, chalcedony, carbonate, sericite

Description: This thin section is of a coarse-grained, hypocrystalline, inequigranular, amygdaloidal, hematised, microporphyritic basalt. Anhedral to subhedral microphenocrysts are composed of twinned (simple and multiple) and weakly zoned plagioclase which is variably altered to carbonate and sericite. A weak preferred shape alignment of plagioclase phenocrysts defines a weakly developed pilotaxitic fabric. No obvious foliation has been recognised within the groundmass. Rare anhedral clinopyroxene microphenocrysts are rounded in shape, indicative of partial resorption.

The groundmass is mainly composed of anhedral, randomly orientated plagioclase laths with chlorite (± opaque minerals) pseudomorphs after granular looking pyroxene and/or olivine. Minor fresh pyroxene was also noted forming an intergranular phase within the groundmass. The remaining interstitial to intersertal phases have been replaced by a cryptocrystalline chlorite and a dusty looking mesostasis containing finely disseminated opaque minerals.

A large (up to over 10 mm in diameter), amygdale is mainly composed of cryptocrystalline, radial fibrous to massive chalcedony and carbonate. A chilled glassy rind is developed within the basalt immediately adjacent to this amygdale.

Collectors Number: MFH54. **Registered Number:** N5349. **Location:** [N0 37745 76957] near Muirton, northern slope of hill, Strathmore. **Geological map sheet:** 57. **Rock Type:** vesicular, plagioclase-clinopyroxene-olivine microporphyritic basalt. **Formation:** uncertain. **Symbol:** plpomiB/B^{B}.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals

alteration – opaque minerals, chlorite, sericite, quartz, bowlingite/iddingsite

Description: This thin section is of a fine-grained, inequigranular, hypocrystalline, vesicular to weakly amygdaloidal microporphyritic basalt which possesses a weakly developed pilotaxitic fabric within its groundmass. Irregular to rounded vesicles and amygdales are variably filled by cryptocrystalline chlorite, chalcedony and/or carbonate. Microphenocrysts are composed of

plagioclase, clinopyroxene and olivine. Anhedral to subhedral, equant olivine crystals are pseudomorphed by cryptocrystalline chlorite and opaque minerals. Clinopyroxene occurs as anhedral to rounded, partially resorped single, isolated crystals and glomerophyric clusters of several smaller microphenocrysts. Anhedral to subhedral, lath-shaped plagioclase phenocrysts are twinned (simple and multiple) and display minor alteration to sericite. Plagioclase phenocrysts are variably aligned defining a weakly developed foliation.

The groundmass is mainly composed of very fine-grained plagioclase laths and needles with minor granular looking interstitial clinopyroxene. The remaining interstitial to intersertal phases have been replaced by a dusty mesostasis containing very fine-grained opaque minerals.

Collectors Number: MFH55. **Registered Number:** N5350. **Location:** [N0 37753 76965] near Muirton, northern slope of hill, Strathmore. **Geological map sheet:** 57. **Rock Type:** lava breccia or volcaniclastic breccia. **Formation:** uncertain. **Symbol:** not applicable.

Description: This thin section is of a very coarse-grained, poorly sorted, lithic-rich, heterolithic, clast supported, fragmentary lava breccia or volcaniclastic breccia. A primary pyroclastic origin for this rock is suggested by the highly complex, angular shape of the lithic clasts, indicative of very little (if any) transport in the sedimentary environment. However, very minor rounding of the clasts has been noted. A very fine-grained, tuffaceous matrix to this breccia is similar in composition to the lithic clasts and contains very fine-grained plagioclase laths and crystal fragments.

The thin section is dominated by one large clast of a hematised, vesicular to amygdaloidal basaltic rock fragment. A similar lithology also dominates the finer grained lithic clasts. Other clasts are composed of pilotaxitic basalt to basaltic andesite, plagioclase microporphyritic andesite and plagioclase-olivine microporphyritic basalt. A pilotaxitic fabric is developed in a number of these lithic clasts. All the volcanic lithic clasts are similar in composition and were, therefore, probably derived from the same source. No obvious ‘exotic’ detritus has been recognised within this volcanic breccia.

Collectors Number: MFH56. **Registered Number:** N5351. **Location:** [N0 37920 76911] northern extent of Burn of Benholm, Strathmore. **Geological map sheet:** 57. **Rock Type:** volcaniclastic litharenite. **Formation:** uncertain. **Symbol:** not applicable.

Description: This thin section is of a coarse-grained, clast supported, open to very open packed, lithic-rich, immature, massive volcaniclastic litharenite which possess a well-developed intergranular chloritic cement. The cement is zoned and comprises an outer cavity lining rim of radial fibrous, cryptocrystalline chlorite. The remained of the pore space is filled by massive chlorite. Two large, rounded reduction spots are present within this sample. Reduction resulted in the bleaching of lithic clasts.

Detrital grains are angular to subangular in shape with a low sphericity. A relatively high proportion of irregular shaped lithic clasts suggests that the original sediment has undergone only a limited period of transport. Clasts are mainly composed of a suite of variably hematised, very fine-grained volcanic rocks including plagioclase-pyroxene-phyric basalt, pilotaxitic basalt to basaltic andesite, plagioclase-phyric basalt and basaltic andesite. The lithic clasts are broadly similar in composition and were probably derived from the same source terrane. No obvious exotic material has been recognised within this sample.

Collectors Number: MFH57. **Registered Number:** N5352. **Location:** [N0 37920 76911] northern extent of the Burn of Benholm, Strathmore. **Geological map sheet:** 57. **Rock Type:** siltstone containing irregular fragments of amygdaloidal basalt. **Formation:** uncertain. **Symbol:** not applicable.

Description: This thin section is of a weakly laminated siltstone containing angular to irregular fragments of basalt. The basalt is a fine-grained, aphyric to weakly microporphyritic, amygdaloidal, variably hematised rock which possesses a pilotaxitic fabric. The microphenocrysts are replaced by chlorite. The margins of the basalt fragments are highly irregular, with complex embayed terminations. The formation of the amygdales and pilotaxitic fabric within the basalt predated fragmentation. No obvious chilled margin or decrease in grain size has been recognised within the basalt adjacent to the contacts with the siltstone.

The siltstone contains angular clasts of monocrystalline quartz, variably hematised biotite and opaque minerals. Although this fine- to very fine-grained sedimentary rock contains clay grade material, no obvious clay minerals where observed in thin section. A weak 'lamination' present within the siltstone is defined by thin laminae composed of fine- to very fine-grained, aligned detrital micas. This wispy lamination is laterally impersistant and locally wraps around the included basalt fragments. Comparable fine-grained material occurs as a thin 'coating' on the basalt fragments. The more massive, slightly coarser grained parts of the siltstone possess a preferred alignment of detrital micas. The resultant foliation is distorted and locally crenulated. These features are comparable to soft-sediment deformation structures developed during liquefaction and water escape.

Collectors Number: MFH58. **Registered Number:** N5353. **Location:** [N0 38033 76921] Corbies Pot in stream bank, Strathmore. **Geological map sheet:** 57. **Rock Type:** quartzose litharenite. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a medium- to coarse-grained, weakly graded, lithic-rich, clast supported, closely to very closely packed, matrix-poor quartzose litharenite. Clastic grains are angular, subangular to rarely subrounded in shape with a low sphericity. A preferred shape alignment of elongate clasts and detrital micas is developed within this sandstone. The shape of the clasts has, however, been modified during compaction which resulted in pressure solution and the kinking of detrital micas. Pressure solution apparently resulted in the main mode of cementation within this sandstone.

The mixed clast assemblage is mainly composed of monocrystalline quartz, plagioclase and volcanic lithic clasts. These lithic clasts are predominantly volcanic derived and composed of a very fine-grained to glassy, aphyric andesitic rock. Other minor to accessory detrital components include muscovite, variably hematised biotite, felsite, very fine-grained phyllitic metasedimentary rock, apatite, garnet and zircon.

The limited matrix component within this sandstone was apparently derived from degraded lithic clasts. Traces of a cryptocrystalline quartzose cement have been noted.

Collectors Number: MFH59. **Registered Number:** N5354. **Location:** [N0 37941 76994] Tullo' of Benholm, quarry below house, Strathmore. **Geological map sheet:** 57. **Rock Type:** amygdaloidal, pilotaxitic, hematised basalt to basaltic andesite. **Formation:** uncertain. **Symbol:** flB^{B}/A^{B}.

Mineralogy: major – plagioclase

minor – opaque minerals

alteration – opaque minerals, chlorite, quartz, bowlingite/iddingsite

Description: This thin section is of a altered (hematised), fine- to very fine-grained, amygdaloidal, hypocrystalline, aphyric to weakly microporphyritic basalt to basaltic andesite which possesses a well-developed pilotaxitic fabric. Rounded to irregular amygdales are composed of very fine-grained chlorite and/or quartz. The pilotaxitic fabric is cross-cut by and locally wraps around the amygdales. The main pilotaxitic is deformed by narrow shear bands resulting in an ECC or SC fabric geometry.

The bulk of the rock is composed of anhedral, variably aligned plagioclase laths which defined these pilotaxitic fabrics. Plagioclase is twinned (simple and multiple) and also forms rare, anhedral to subhedral microphenocrysts. Chloritic pseudomorphs after fine-grained, granular pyroxene occur within the groundmass, intergranular to plagioclase. The remaining interstitial to intersertal phases have been replaced by a dusty looking (under plane polarised light), pale yellow-green chloritic assemblage which contains finely disseminated opaque minerals.

Collectors Number: MFH60. **Registered Number:** N5355. **Location:** [N0 37980 76896] near Den of Brotherton, near waterfall, Strathmore. **Geological map sheet:** 57. **Rock Type:** pilotaxitic, plagioclase microporphyritic basalt. **Formation:** uncertain. **Symbol:** flplmiB^{B}.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals, quartz

alteration – opaque minerals, chlorite, bowlingite/iddingsite

Description: This thin section is of a relatively fresh, fine- to medium-grained, inequigranular, weakly amygdaloidal, hypocrystalline, microporphyritic basalt which possesses a moderately well-developed pilotaxitic fabric. This basaltic rock is distinguished by the presence of trace amounts of interstitial to intersertal quartz. Microphenocrysts are composed of anhedral, twinned (simple and multiple), zoned plagioclase laths. These plagioclase microphenocrysts are shape aligned parallel to the pilotaxitic fabric present within the groundmass. Rare anhedral, fractured clinopyroxene microphenocrysts are also present.

The groundmass is mainly composed of fine-grained, variably aligned plagioclase laths with intergranular, very fine grained clinopyroxene and opaque minerals. The remaining interstitial to intersertal areas are filled by feldspar, cryptocrystalline chlorite and trace amounts of quartz. Rounded amygdales are composed of cryptocrystalline chlorite and quartz.

Collectors Number: MFH61. **Registered Number:** N5356. **Location:** [N0 38006 76796] burn above Lathallen School, Strathmore. **Geological map sheet:** 57. **Rock Type:** very weakly laminated quartzose litharenite. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a medium- to coarse-grained, very weakly laminated, immature, clast supported, very closely packed, poorly sorted quartzose litharenite in which the lamination is defined by a slight variation in modal quartz. Detrital grains are angular to

subangular in shape with a low sphericity. The shape of the clasts has, however, been modified during compaction due to localised pressure solution. Pressure solution appears to have resulted in the main mode of cementation within this sandstone. However, traces of a yellow-green chloritic cement are also present.

The mixed clast assemblage is mainly composed of monocrystalline quartz, volcanic lithic clasts and subordinate plagioclase. Lithic clasts are mainly composed of a very fine-grained to glassy andesitic rock. Detrital micas are also a common minor to accessory component. Elongate grains and detrital micas are preferentially aligned parallel to the sedimentary lamination. Minor to accessory detrital components include polycrystalline quartz, biotite, hematised biotite, chloritised basalt, siltstone, muscovite, microcline, very fine-grained metasedimentary rock, felsite, mudstone, phyllitic metasedimentary rock, opaque minerals, chlorite, garnet and tourmaline.

Traces of matrix present within this litharenite appears to be secondary in nature and derived from degraded lithic clasts. Compaction resulted in the kinking of detrital micas and plastic deformation of unstable lithic clasts which are locally embayed against neighbouring more rigid quartzose grains. A heavy mineral band within this sandstone is mainly composed of opaque minerals and garnet.

Collectors Number: MFH62. **Registered Number:** N5357. **Location:** [N0 37985 76793] burn above Lathallen School, Strathmore. **Geological map sheet:** 57. **Rock Type:** amygdaloidal, plagioclase-pyroxene microporphyritic basaltic rock. **Formation:** uncertain. **Symbol:** plpmiB/B^{B}.

Mineralogy: major – plagioclase

minor – opaque minerals

alteration – opaque minerals, chlorite, quartz, sericite, bowlingite/iddingsite

Description: This thin section is of a coarse-grained, inequigranular, hypocrystalline, altered (hematised), amygdaloidal basaltic rock which possesses a crudely developed seriate texture and weakly developed pilotaxitic fabric.

The bulk of the rock is composed of variably aligned, anhedral plagioclase laths which range up to 2.0 mm in length. Chlorite (± opaque minerals) pseudomorphs after rare, partially resorped olive and/or pyroxene microphenocrysts have also been noted. Interstitial to intersertal phases have been largely replaced by hematitic oxide which locally contains microlites of feldspar and chloritic pseudomorphs after ?pyroxene. Rounded to irregular amygdales are composed of Fe-stained, cryptocrystalline chlorite and minor quartz. The amygdales are enclosed within a glassy, chilled margin.

Collectors Number: MFH63. **Registered Number:** N5358. **Location:** [N0 38015 76782] burn above Lathallen School, Strathmore. **Geological map sheet:** 57. **Rock Type:** olivine microporphyritic alkaline microgabbro. **Formation:** uncertain. **Symbol:** omiD/D^{A}.

Mineralogy: major – plagioclase, Ti augite

minor – opaque minerals, apatite, analcime, ?spinel

alteration – chlorite, opaque minerals, carbonate, bowlingite/iddingsite, amphibole

Description: This thin section is of a fine- to medium-grained, inequigranular, hypocrystalline, anhedral granular, microporphyritic alkali microgabbro which possesses a weakly developed pilotaxitic fabric. The rock is composed of an inequigranular assemblage of plagioclase, Ti augite, chloritised olivine and minor to accessory opaque minerals. Traces of interstitial to intersertal analcime and a dusty mesostasis after glass are also present.

Plagioclase forms a crystal framework of anhedral, randomly orientated to weakly aligned, twinned and zoned laths. The zoned crystals locally possess a distinct core. Weakly zoned Ti augite is pale pink in colour and forms anhedral, ophitic to subophitic crystals. Olivine formed anhedral to subhedral crystals which are pseudomorphed by chlorite and opaque minerals. No fresh olivine has been recorded in this sample. Traces of possible prehnite or pumpellyite have been noted forming radiating fans of acicular crystals in the interstitial areas.

Collectors Number: MFH64. **Registered Number:** N5359. **Location:** [N0 38049 76931] Bridge of Benholm, crop below major road bridge, Strathmore. **Geological map sheet:** 57. **Rock Type:** quartzose litharenite. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a coarse-grained, poorly sorted, immature, lithic-rich, matrix-poor, clast supported, very closely packed, massive quartzose litharenite. Detrital grains are angular, subangular to occasionally rounded in shape with a low sphericity. Clast shape ahs, however, been modified due to pressure solution during compaction. This resulted in the main mode of cementation within this sandstone. However, traces of a yellow-green coloured chloritic cement are also present.

The clast assemblage is dominated by volcanic rock fragments with subordinate monocrystalline quartz. The lithic clasts are mainly composed of a suite of very fine-grained, aphyric andesitic to dacitic rocks. Other minor to accessory detrital components include muscovite, biotite, opaque minerals, plagioclase, polycrystalline quartz, felsite, microcline, biotite-phyric dacite, amphibole-phyric andesite, very fine-grained metasedimentary rock, altered basalt, zircon, micrographic intergrowth and garnet.

Compaction resulted in the kinking of detrital micas and plastic deformation of unstable lithic clasts which become embayed against neighbouring more rigid quartzose grains. Traces of a matrix component within this sandstone appear to be secondary in nature and derived from the breakdown of unstable lithic clasts.

Collectors Number: MFH65. **Registered Number:** N5360. **Location:** [N0 38051 76983] small, low crop on eastern bank of stream, Strathmore. **Geological map sheet:** 57. **Rock Type:** silty sandstone. **Formation:** uncertain. **Symbol:** not applicable.

Description: This thin section is of a fine- to medium-grained, very open packed, matrix supported silty sandstone containing elongate red-brown coloured mudstone and fine siltstone lithic clasts. The mudstone lithics are laminated and variably flattened, the latter possibly due to collapse and plastic deformation during compaction.

Angular to subangular, low sphericity detrital grains are mainly composed of monocrystalline quartz. Other minor to accessory detrital present within this sandstone include polycrystalline quartz, plagioclase, muscovite, opaque minerals, chlorite, K-feldspar, garnet, very fine-grained metasedimentary rock, zircon and epidote.

The silty matrix to the sandstone is Fe-stained and contains a weakly to moderately developed foliation defined by variably aligned white mica flakes and thin seems or stringers of hematitic oxide.

Collectors Number: MFH67. **Registered Number:** N5371. **Location:** [N0 75970 66835] near Lauriston Quarry, Strathmore. **Geological map sheet:** 57. **Rock Type:** quartzose litharenite containing a large felsite/silicified volcanic rock pebble. **Formation:** Dundee Flagstone Formation. **Symbol:** not applicable.

Description: This thin section is of a medium-grained, very closely packed, clast supported, matrix-poor, lithic-rich, massive quartzose litharenite which contains a large, pebble sized clast of altered (silicified and hematised) felsite or silicified volcanic rock.

Detrital grains within the sandstone are angular to subangular in shape with a low sphericity. Clast shape has, however, been variably modified due to pressure solution during compaction. Pressure solution appears to have resulted in the main mode of cementation within this sandstone. Compaction also resulted in the kinking of detrital micas. A weak preferred shape alignment of elongate clasts and detrital micas was noted.

The mixed clast assemblage is dominated by volcanic derived lithic clasts and monocrystalline quartz. The volcanic rock fragments are broadly andesitic in composition. Minor to accessory detrital components include plagioclase, muscovite, polycrystalline quartz, very fine-grained phyllitic metasedimentary rock, altered siltstone, hematised biotite, opaque minerals, felsite/chert, fine-grained metasedimentary rock, perthite, ?fibrolite-bearing schistose metasedimentary rock, garnet, epidote and chlorite.

Traces of a chloritic cement and clay to fine silt-grade matrix have been recognised within this sandstone.

Collectors Number: MFH68. **Registered Number:** N5372. **Location:** [N0 79957 67015] Johnshaven harbour, Strathmore. **Geological map sheet:** 57. **Rock Type:** interlaminated siltstone and litharenite. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a interlaminated siltstone and altered litharenite. The siltstone is massive with a variably developed preferred shape alignment of detrital micas and small, elongate opaque minerals. The contacts between the siltstone and adjacent sandstone laminae are sharp with small indentations developed adjacent to rigid quartzose grains within the sandstone.

The sandstone is a medium- to coarse-grained, closely to very closely packed, clast supported, immature, poorly sorted, lithic-rich rock which contains traces of a yellow-green chloritic cement filling intergranular pore spaces. Detrital grains are angular, subangular to occasionally subrounded in shape. However, clast shape has been modified as a result of pressure solution during compaction. Pressure solution and chloritic cement are the main modes of cementation.

The clast assemblage within the sandstone is dominated by variably hematised basaltic to andesitic rock fragments and subordinate to minor plagioclase. The andesitic rock fragments locally contain pseudomorphs after small amphibole microphenocrysts. Siltstone rip-up clasts only occur as larger granule to small pebble sized clasts. Other minor to accessory detrital components include monocrystalline quartz, very fine-grained sandstone, biotite and polycrystalline quartz.

Collectors Number: MFH69. **Registered Number:** N5373. **Location:** [N0 76497 65020] Kame of Mathers, Strathmore. **Geological map sheet:** 57. **Rock Type:** fine siltstone. **Formation:** uncertain. **Symbol:** not applicable.

Description: This thin section is of a weakly laminated, fine siltstone in which the detrital micas and elongate grains of opaque are aligned parallel to bedding. Recognisable detrital components include monocrystalline quartz, biotite, muscovite and chlorite. The fine silt to clay-grade components of this siltstone are patchily replaced by carbonate. Replacement by carbonate and reduction of the Fe-stained matrix are associated with an irregular fracture.

Collectors Number: MFH70. **Registered Number:** N5374. **Location:** [N0 71204 53518] Boddin Point, fault zone, Strathmore. **Geological map sheet:** 57. **Rock Type:** calcareous quartz arenite. **Formation:** Kinnesswood Formation. **Symbol:** not applicable.

Description: This thin section is of a medium- to coarse-grained, very poorly sorted, open packed, clast to locally cement supported, massive, compositionally mature, texturally immature calcareous quartz arenite which possesses a locally well-developed replacive carbonate cement. The carbonate cement is patchily developed with sparry carbonate forming anhedral, intergranular poikilitic crystals. A very fine-grained to cryptocrystalline quartzose cement is also developed within this sandstone. Rare pseudomorphs after possible dolomite rhombs have been noted within the carbonate cement.

Clastic grains are angular, subangular to occasionally subrounded in shape with a low sphericity. However, clast shape is locally modified due to grain boundary etching during the development of the siliceous and, apparently later, carbonate cements. The clast assemblage is dominated by monocrystalline quartz. Minor to accessory detrital components include polycrystalline quartz, K-feldspar, plagioclase, muscovite, microcline, opaque minerals, felsite, very fine-grained metasedimentary rock, biotite and tourmaline.

Collectors Number: MFH71. **Registered Number:** N5375. **Location:** [N0 80290 67156] Johnshaven, Strathmore. **Geological map sheet:** 57. **Rock Type:** calcareous litharenite. **Formation:** Catterline Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a coarse-grained, poorly sorted, closely packed, clast supported, immature, lithic-rich, matrix-poor, massive calcareous litharenite with a well-developed carbonate cement. This cement has replaced the original matrix component (if any) and unstable detrital grains within the sandstone.

Clastic grains are angular, subangular to occasionally subrounded in shape with a low sphericity. Grain shape has locally been modified due to pressure solution during compaction and grain boundary etching during the development of the carbonate cement. The mixed clast assemblage within this sandstone is mainly composed of andesitic to dacitic rock fragments, monocrystalline quartz and subordinate feldspar. Minor to accessory components include polycrystalline quartz, hematised rock, muscovite, opaque minerals, cleaved metasedimentary rock, very fine-grained phyllitic metasedimentary rock, chloritised basalt, felsite/chert, siltstone, microgranitic rock, chlorite, garnet and zircon.

Compaction resulted in the kinking of detrital micas and localised pressure solution. A weak preferred shape alignment of elongate clasts and detrital micas has been noted.

Collectors Number: CYY241. **Registered Number:** N9100. **Location:** [N0 67623 52601] field entrance west of Drumbertnot, Strathmore. **Geological map sheet:** 57. **Rock Type:** altered, pilotaxitic, olivine microporphyritic basaltic rock. **Formation:** Montrose Volcanic Formation. **Symbol:** flomiB.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals

alteration – bowlingite/iddingsite, opaque minerals, chlorite, carbonate, quartz

Description: This thin section is of a altered (hematised), very fine-grained, inequigranular, hypocrystalline, weakly amygdaloidal, microporphyritic basaltic rock which possesses well-developed pilotaxitic fabric within its groundmass. Small (≤ 0.4 mm in size), microphenocrysts of olivine are pseudomorphed by bowlingite/iddingsite and opaque minerals. Occasional microphenocrysts of plagioclase and clinopyroxene are also present within this basalt. The phenocrysts are locally aligned parallel to the pilotaxitic fabric.

The groundmass is very fine-grained and possesses a well-developed pilotaxitic foliation defined by shape-aligned, very closely packed plagioclase laths. This foliation is deformed by narrow shear bands. Very fine-grained, granular looking crystals of clinopyroxene and opaque minerals occur intergranular to plagioclase. The remaining interstitial to intersertal phases are replaced by a dusty mesostasis and cryptocrystalline chlorite. Amygdales are composed of chlorite. The rock is cut by a number of quartz-carbonate veinlets.

Collectors Number: CYY242. **Registered Number:** N9101. **Location:** [N0 67448 52586] road side quarry, Deils Knowe, Strathmore. **Geological map sheet:** 57. **Rock Type:** altered, pilotaxitic, plagioclase-olivine-clinopyroxene macroporphyritic basaltic rock. **Formation:** Montrose Volcanic Formation. **Symbol:** flplopmaB/B^{B}.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals

alteration – bowlingite/iddingsite, opaque minerals, quartz, chlorite, sericite

Description: This thin section is of a altered, fine-grained, inequigranular, hypocrystalline, weakly amygdaloidal, relatively crystal-rich, macroporphyritic basalt with a weakly developed pilotaxitic fabric. Phenocrysts are mainly composed of plagioclase and pseudomorphs after olivine with minor clinopyroxene. Plagioclase macrophenocrysts and microphenocrysts are fractured and variably altered to sericitic white mica. The larger plagioclase phenocrysts may possess a sieve textured core containing irregular to worm like inclusions of chloritised glass. Plagioclase forms single isolated crystals as well as glomerophyric clusters of several (2 to 3) crystals. The phenocrysts are variably shape aligned and define a weakly developed pilotaxitic fabric which is absent within the groundmass. Anhedral to subhedral olivine microphenocrysts are completely replaced by cryptocrystalline chlorite enclosed by a rim of opaque minerals. In contrast to olivine, clinopyroxene is fresh and forms fractured, rounded, partially resorped microphenocrysts. Clinopyroxene crystals are locally sieve textured.

The groundmass is very fine-grained and mainly composed of randomly orientated plagioclase laths and needles. Granular looking clinopyroxene and opaque minerals occur intergranular to

plagioclase. The remaining interstitial to intersertal areas are filled by feldspar and cryptocrystalline chlorite.

Amygdales are composed of cryptocrystalline, radial fibrous quartz and/or chlorite.

Collectors Number: CYY243. **Registered Number:** N9102. **Location:** [N0 67155 52773] Ighty Burn, Strathmore. **Geological map sheet:** 57. **Rock Type:** weakly amygdaloidal, plagioclase-clinopyroxene microporphyritic basaltic rock. **Formation:** Montrose Volcanic Formation. **Symbol:** flomiB.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals

alteration – chlorite, amphibole, carbonate, bowlingite/iddingsite, opaque minerals

Description: This thin section is of a fine-grained, hypocrystalline, inequigranular, massive, weakly amygdaloidal, microporphyritic basalt which contains a relatively high proportion (c. 40-50 % of the total rock) of devitrified glass within the groundmass. The interstitial to intersertal glass has been replaced by a turbid, grey to brown, Fe-stained mesostasis.

Phenocrysts are mainly composed of anhedral to subhedral plagioclase laths which form single isolated crystals as well as glomerophyric clusters of several microphenocrysts. Plagioclase forms equant to lath-shaped, twinned (simple and multiple) and zoned (oscillatory) crystals. Clinopyroxene forms small, anhedral crystals which are variably altered to chlorite and tremolitic amphibole. Clinopyroxene microphenocrysts typically occur as glomerophyric clusters or aggregates of several crystals.

Amygdales are composed of very fine-grained to cryptocrystalline, radial fibrous chlorite.

Collectors Number: CYY244. **Registered Number:** N9103. **Location:** [N0 66822 52588] pond in Ighty Burn, Strathmore. **Geological map sheet:** 57. **Rock Type:** pilotaxitic, clinopyroxene-plagioclase-olivine microporphyritic basaltic rock. **Formation:** Montrose Volcanic Formation. **Symbol:** pplomiB/B^{B}.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals

alteration – chlorite, carbonate, bowlingite/iddingsite, opaque minerals

Description: This thin section is of a altered, fine- to very fine-grained, glassy, hypocrystalline, inequigranular, microporphyritic basalt with a weakly to moderately well-developed pilotaxitic fabric. Microphenocrysts are mainly composed of anhedral to subhedral clinopyroxene, as well as minor amounts of anhedral plagioclase and pseudomorphs after olivine. Olivine has been completely replaced by opaque minerals, carbonate and/or chlorite. Plagioclase typically forms single isolated microphenocrysts. In contrast to plagioclase, pyroxene forms glomerophyric clusters of several small granular crystals, as well as single isolated microphenocrysts.

The originally glassy (now devitrified) groundmass is very fine-grained and contains small, irregular ‘vugs’ filled by cryptocrystalline chloritic material. These ‘vugs’ may represent

distorted vesicles or amygdales, or small patches of chloritised glass. Original glass within the groundmass has been replaced by a turbid, brown coloured (Fe-stained) mesostasis. Small laths and needles of plagioclase are variably aligned and define the weakly to moderately well-developed pilotaxitic fabric.

Collectors Number: CYY245. **Registered Number:** N9104. **Location:** [N0 67171 52840] Ghighty Burn, Strathmore. **Geological map sheet:** 57. **Rock Type:** intercalated siltstone and amygdaloidal, plagioclase-clinopyroxene microporphyritic basalt. **Formation:** Montrose Volcanic Formation. **Symbol:** not applicable.

Description: This thin section is of a 1.0 to 1.5 cm thick layer of siltstone intercalated with an amygdaloidal, plagioclase-clinopyroxene microporphyritic basalt. The basalt is very fine-grained, hypocrystalline rock in which the original glass has been replaced by a dusty grey to brown mesostasis containing feldspar microlites and granular opaque minerals. Plagioclase forms anhedral to subhedral, twinned (simple and multiple) and variably zoned laths which occur as single isolated crystals or glomerophyric clusters of several crystals. Clinopyroxene microphenocrysts are replaced by a very fine-grained chloritic assemblage and/or cryptocrystalline quartz. The amygdales are zoned and composed of fine layers of cryptocrystalline quartz and chlorite. A number of the amygdales also contain geopetal-like partial infills of massive to weakly laminated siltstone. Chlorite and carbonate filled amygdales also occur within the siltstone.

The contacts between the siltstone and basalt are sharp, but highly irregular in form. A thin (≤ 0.1 mm thick) layer of very fine-grained, clay-grade material occurs along the contact between the siltstone and basalt. The siltstone is fine-grained and massive. Angular, low sphericity detrital grains are mainly composed of monocrystalline quartz. Minor to accessory phases include muscovite, chlorite, opaque minerals, zircon, tourmaline, ?spinel, garnet and biotite. A variably developed preferred alignment of detrital micas can be recognised within the siltstone. This alignment occurs parallel to the margins of the siltstone layer.

The presence of amygdales within the siltstone is indicative of hot rock-wet sediment interaction. However, there is no obvious chilling or fracturing of the basalt has been noted immediately adjacent to the siltstone layer. Although, broken crystals occur within the basalt at the contact, very few small basaltic fragments occur within the sedimentary rock.

Collectors Number: CYY246. **Registered Number:** N9105. **Location:** [N0 67171 52840] Ghighty Burn, Strathmore. **Geological map sheet:** 57. **Rock Type:** intercalated siltstone and amygdaloidal, plagioclase-clinopyroxene microporphyritic basalt, comparable to sample N9104. **Formation:** Montrose Volcanic Formation. **Symbol:** not applicable.

Description: This thin section is of a intercalated siltstone and amygdaloidal, microporphyritic basalt. The section is mainly composed of a weakly laminated siltstone with laminae of very fine-grained sandstone. Cross-cutting, erosive bases can be recognised at the bases of some of the coarser grained laminae. Individual laminae are locally graded. Detrital grains within the siltstone are angular in shape with a low sphericity and mainly composed of monocrystalline quartz. Other detrital components include opaque minerals, chlorite, muscovite, biotite, apatite and zircon. The detrital micas and elongate opaque grains are variably aligned. The siltstone is cut by a thin quartz veinlet.

The basalt is a fine- to very fine-grained, hypocrystalline rock in which the originally glassy groundmass has been replaced by a turbid, brown coloured mesostasis. No obvious perlitic

cracking of the glassy groundmass has been recognised. Plagioclase phenocrysts and finer grained crystals are variably replaced by a cryptocrystalline chloritic assemblage. Amygdales are composed of very fine-grained to cryptocrystalline chlorite and quartz. Occasional geopetal-like infills of siltstone were observed in a small number of amygdales/vesicles.

The contact between the basalt and siltstone is sharp, but highly irregular in form. The presence of irregular chlorite filled amygdales do occur within the siltstone, indicative of hot rock-wet sediment interaction. Spiky to shard-like aggregates of chlorite within the siltstone may represent small, filled vesicles or alternatively altered shards of glass. However, very few small fragments of recognisable basalt occur within the siltstone. No obvious chilled margin occurs within the basalt along this lithological boundary. However, very fine, needle-like opaque minerals grow into the basalt away from this contact. Plagioclase crystals are broken at this contact. A thin (≤ 0.3 mm thick) very fine silt to clay-grade layer occurs along the boundary between the siltstone and the basalt. Lithologically similar very fine-grained, wispy looking layers occur within the main body of the siltstone. The preferred alignment of detrital micas within the siltstone becomes lost immediately adjacent to the contact with the basalt.

Collectors Number: CYY247. **Registered Number:** N9106. **Location:** [N0 67732 54288] Govan Hill Quarry, Strathmore. **Geological map sheet:** 57. **Rock Type:** altered, pilotaxitic, microporphyritic basaltic rock. **Formation:** Montrose Volcanic Formation. **Symbol:** flmiB.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals

alteration – carbonate, opaque minerals, chlorite, bowlingite/iddingsite, sericite, prehnite/pumpellyite

Description: This thin section is of a fine- to very fine-grained, inequigranular, holocrystalline, microporphyritic basalt with a well-developed pilotaxitic fabric. Anhedral to subhedral microphenocrysts of olivine and possibly pyroxene have been completely replaced by very fine-grained chlorite, carbonate and/or prehnite/pumpellyite enclosed within a rim of opaque minerals. Rare phenocrysts of anhedral plagioclase are aligned parallel to the pilotaxitic fabric developed within the groundmass. This fabric wraps around the larger microphenocrysts. The groundmass is composed of fine- to very fine-grained, closely packed plagioclase laths with fine, granular clinopyroxene and accessory opaque minerals.

Collectors Number: CYY248. **Registered Number:** N9107. **Location:** [N0 67624 54318] 200 m southwest of entrance to Govan Hill Quarry, Strathmore. **Geological map sheet:** 57. **Rock Type:** siltstone. **Formation:** Montrose Volcanic Formation. **Symbol:** not applicable.

Description: This thin section is of a massive to weakly laminated siltstone or very fine-grained sandstone with rounded pale green reduction spots. Angular to subangular, low to moderate sphericity detrital grains are mainly composed of monocrystalline quartz. Other minor to accessory detrital components include opaque minerals, biotite, polycrystalline quartz, chlorite, plagioclase, garnet, apatite, epidote, zircon and tourmaline. Detrital micas and elongate opaque grains are preferentially shape-aligned parallel to the sedimentary lamination. The clay-grade matrix to the siltstone lacks obvious clay minerals.

Collectors Number: CYY249. **Registered Number:** N9108. **Location:** [N0 67624 54318] 200 m southwest of entrance to Govan Hill Quarry, Strathmore. **Geological map sheet:** 57. **Rock Type:** intercalated, laminated siltstone and pilotaxitic, amygdaloidal basaltic rock. **Formation:** Montrose Volcanic Formation. **Symbol:** not applicable.

Description: This thin section is of intercalated, laminated siltstone and a altered (hematised) amygdaloidal basalt. The basalt is a very fine-grained, weakly microporphyritic to aphyric, hypocrystalline rock in which the microphenocrysts of olivine and/or pyroxene have been completely replaced by a cryptocrystalline chloritic assemblage. Rounded to irregular amygdales are composed of a cryptocrystalline, radial fibrous zeolite and/or Mg-chlorite. The groundmass is composed of closely packed, shape aligned plagioclase laths which define a moderate to well-developed pilotaxitic fabric. This fabric is truncated against the amygdales and the contact with the adjacent siltstone. Interstitial to intersertal glass within the groundmass has been replaced by a dusty looking (under plane polarised light) mesostasis containing finely disseminate opaque minerals.

The fine-grained siltstone is red-brown in colour with pale green coloured reduction spots. No obvious disruption of the sedimentary lamination has been recognised within the siltstone, even immediately adjacent to the contacts with the basalt. Individual laminae are graded with muddy partings at the top. The laminae can be traced to within 0.3 mm of the contact with the basalt. Detrital grains within the siltstone are angular to subangular in shape and mainly composed of monocrystalline quartz. Other minor to accessory detrital components include opaque minerals, muscovite, chlorite, biotite and epidote. A variably developed shape alignment of the detrital micas occurs parallel to the lamination.

The contact between the basalt and siltstone is sharp, but irregular in form with elongate to flame-like projections of basalt extending into the siltstone. The overall appearance of the contact is consistent with hot rock-wet sediment interaction. However, there is no obvious evidence of wide spread liquefaction and homogenisation of the sediment which would be expect if boiling and vaporisation of the pore water had occurred. No water escape conduits have been recognised and the sedimentary lamination is not disrupted and is preserved immediately adjacent to the siltstone-basalt contact. Patchy hematisation of the siltstone occurs immediately adjacent to the contact with the basalt, and were present has preferentially followed individual laminae. Rare chlorite filled vesicles (amygdales) do occur within the siltstone immediately adjacent to the contact with the basalt.

Collectors Number: CYY250. **Registered Number:** N9109. **Location:** [N0 67155 54096] quarry 350 m east of Westerton, Strathmore. **Geological map sheet:** 57. **Rock Type:** plagioclase-clinopyroxene microporphyritic basaltic rock. **Formation:** Montrose Volcanic Formation. **Symbol:** plpmiB^{B}.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals

alteration – chlorite, bowlingite, opaque minerals, ?prehnite/pumpellyite

Description: This thin section is of a relatively fresh, fine-grained, hypocrystalline, originally glassy, massive, inequigranular, microporphyritic basalt containing anhedral to subhedral plagioclase and clinopyroxene microphenocrysts. Anhedral, pale brown to colourless clinopyroxene phenocrysts are typically finer grained than plagioclase, and exhibit minor alteration to chlorite. Plagioclase crystals are twinned (simple and multiple) and locally possess a

well-develop oscillatory compositional zonation. It occurs as single isolated crystals as well as glomerophyric clusters of several crystals. The larger plagioclase microphenocrysts may possess sieve textured cores containing irregular to worm-like inclusions of altered glass.

The groundmass is composed of small, randomly orientated plagioclase laths with finer grained, granular clinopyroxene and opaque minerals. Original, interstitial to intersertal glass has been replaced by a brown coloured, dusty looking (under plane polarised light) mesostasis. Small patches of chloritic alteration also occur within the groundmass.

Collectors Number: CYY251. **Registered Number:** N9110. **Location:** [N0 66602 54634] quarry 400 m north of Woodpark, Strathmore. **Geological map sheet:** 57. **Rock Type:** pilotaxitic basalt. **Formation:** Montrose Volcanic Formation. **Symbol:** flB^{B}.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals

alteration – chlorite, opaque minerals, bowlingite

Description: This thin section is of a weakly altered, fine- to medium-grained, inequigranular, holocrystalline, aphyric to weakly microporphyritic basalt with a very well-developed pilotaxitic fabric in the groundmass. This fabric is defined by shape aligned, closely packed plagioclase laths. It is deformed by low angle shear bands resulting in a well-developed ECC or SC-fabric geometry.

Small anhedral, equant to slightly elongate crystals and microphenocrysts of possible olivine are pseudomorphed by opaque minerals, chlorite and red-brown bowlingite. Clinopyroxene typically occurs within the groundmass forming small granular crystals intergranular to plagioclase. Slightly larger (up to 0.3 mm in size) irregular, skeletal, ophitic to subophitic clinopyroxene crystals also occur. Rare, small plagioclase microphenocrysts have been noted, aligned parallel to the pilotaxitic fabric.

Collectors Number: CYY252. **Registered Number:** N9111. **Location:** [N0 66730 54925] north-northeast of Woodpark, Strathmore. **Geological map sheet:** 57. **Rock Type:** rhythmically laminated siltstone and mudstone with pale green reduction spots. **Formation:** Montrose Volcanic Formation. **Symbol:** not applicable.

Description: This thin section is of a rhythmically laminated, red-brown coloured siltstone and mudstone with pale green reduction spots. Individual laminae are graded from fine silt to clay and possess sharp, planar bases and tops. Cross-cutting, possibly erosive bases have been recorded at the base of the thicker, slightly coarser grained laminae. Very minor, gentle wrap like folds are locally developed at one end of the thin section deforming the laminae. The reduction spots have sharp boundaries. However there is no obvious new mineral growth within these spots and they are simple represented by a change in colour of the siltstone. Very minor soft sediment deformation features have been noted at the top of the sequence of laminae. This may be generated by minor slumping or traction induced. This sedimentary rock is reminiscent of finely laminated lake sediments.

Collectors Number: CYY253. **Registered Number:** N9112. **Location:** [N0 66125 54724] quarry, Pitarris Hill, Strathmore. **Geological map sheet:** 57. **Rock Type:** pilotaxitic, olivine microporphyritic basaltic rock. **Formation:** Montrose Volcanic Formation. **Symbol:** flomiB.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals

alteration –chlorite, opaque minerals, biotite, bowlingite

Description: This thin section is of a very fine-grained, inequigranular, hematised, microporphyritic, hypocrystalline basalt which possess a very well-developed pilotaxitic fabric within its groundmass. This fabric is defined by shape aligned plagioclase laths. The fabric is deformed by locally closely spaced shear bands resulting a well-developed ECC or SC-fabric geometry. Small anhedral ?olivine microphenocrysts are pseudomorphed by opaque minerals and chlorite/bowlingite. Larger (c. 0.3 to 0.4 mm in size), microphenocrysts are wrapped by the pilotaxitic fabric. Rare, small clinopyroxene microphenocrysts are also present.

The groundmass is mainly composed of closely packed, shape aligned plagioclase laths. Plagioclase forms anhedral, twinned crystals. Minor to accessory granular clinopyroxene and opaque minerals occur intergranular to plagioclase. A distinctive feature of this thin section is the presence of small (≤ 0.3 mm in size), anhedral, poikilitic biotite crystals which cross-cut and, therefore, postdate the pilotaxitic fabric. Biotite appears to be secondary in nature. However, biotite growth is not associated with any obvious recrystallisation or alteration of earlier formed mineral phases. Biotite appears to be associated with the slightly more feldspar-rich foliae marking the shear bands which define the ECC or SC fabric.

This rock is lithologically similar to sample N9110.

Collectors Number: CYY254. **Registered Number:** N9113. **Location:** [N0 65399 55023] out crop northeast side of Cair Carry Hill Wood, Strathmore. **Geological map sheet:** 57. **Rock Type:** pilotaxitic, olivine microporphyritic basalt. **Formation:** Montrose Volcanic Formation. **Symbol:** flomiB^{B}.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals

alteration – biotite, chlorite, opaque minerals, bowlingite, carbonate

Description: This thin section is of a altered (hematised), very fine-grained, inequigranular, hypocrystalline, microporphyritic basalt which is lithologically similar to sample N9112. This sample is distinguished by the presence of 0.3 to 0.5 mm in size, anhedral to irregular crystals of biotite. Biotite is typically associated with irregular patches of chlorite and appears to be replacing this earlier formed mineral. Consequently, biotite appears to be secondary in nature and not part of the primary igneous mineral assemblage within this rock.

Anhedral to weakly subhedral olivine microphenocrysts are pseudomorphed by opaque minerals and a cryptocrystalline chloritic assemblage. Rare, rounded to embayed, partially resorped clinopyroxene microphenocrysts are also present within this basalt.

The groundmass is mainly composed of closely spaced, variably aligned plagioclase laths with very fine-grained, intergranular clinopyroxene and opaque minerals. Plagioclase defines a locally

well-developed pilotaxitic fabric. The remainder of the groundmass is composed of a very finely cryptocrystalline feldspathic mesostasis.

Collectors Number: CYY255. **Registered Number:** N9114. **Location:** [N0 66210 53400] quarry, southwest side of Ginshot Hill, Strathmore. **Geological map sheet:** 57. **Rock Type:** pilotaxitic basalt. **Formation:** Montrose Volcanic Formation. **Symbol:** flB^{B}.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals, apatite

alteration – opaque minerals, chlorite, biotite

Description: This thin section is of a weakly altered (hematised), fine- to medium-grained, inequigranular, hypocrystalline, aphyric to weakly microporphyritic basalt containing minor amounts of secondary biotite. The rock is mainly composed of closely spaced, anhedral, twinned plagioclase laths which defined a well-developed pilotaxitic fabric. Rare, slightly larger zoned plagioclase microphenocrysts are present, aligned parallel the pilotaxitic fabric. The remainder of the rock is composed of fine-grained, granular clinopyroxene and opaque minerals. Slightly larger (c. 0.2 to 0.3 mm in size), pale green clinopyroxene crystals form subophitic intergranular crystals partially enclosing plagioclase.

Collectors Number: NCG013. **Registered Number:** N5330. **Location:** [N0 71649 65203] Den of Morphie, Strathmore. **Geological map sheet:** 57. **Rock Type:** calcareous micaceous sandstone. **Formation:** Dundee Flagstone Formation. **Symbol:** not applicable.

Description: This thin section is of a weakly laminated, fine-grained, moderately to poorly sorted, very open packed, cement supported, micaceous sandstone which possesses a well-developed fine-grained carbonate cement. Carbonate replaces unstable detrital components and the original matrix within the sandstone. Clastic grains are angular to subangular in shape with a low sphericity. However, clast shape has locally been modified by grain boundary etching associated with the growth of the carbonate cement.

The clast assemblage is dominated by monocrystalline quartz with subordinate detrital micas. Detrital micas and elongate clastic grains exhibit a preferred shape alignment parallel to the sedimentary lamination. Minor to accessory detrital components include biotite, chlorite, bowlingite, iddingsite, opaque minerals, very fine-grained phyllitic metasedimentary rock, garnet, epidote, plagioclase, zircon and possible ?chloritoid.

The sedimentary lamination is defined by a slight variation in grain size and modal proportion of detrital micas. The high proportion of detrital micas are a distinctive feature of this sandstone.

Collectors Number: NCG014. **Registered Number:** N5331. **Location:** [N0 71649 65203] Den of Morphie, Strathmore. **Geological map sheet:** 57. **Rock Type:** calcareous micaceous sandstone. **Formation:** Dundee Flagstone Formation. **Symbol:** not applicable.

Description: This thin section is of a medium-grained, moderate to open packed, clast to locally cement supported, immature, massive calcareous micaceous sandstone with a replacive carbonate cement. Carbonate replaces original matrix component in the sandstone and the more

unstable detrital grains. Clastic grains are angular to subangular in shape with a low sphericity. However, clast shape has locally been modified by grain boundary etching associated with the growth of the carbonate cement.

The clast assemblage in this sandstone is dominated by monocrystalline quartz with subordinate detrital micas. Detrital micas and elongate clastic grains exhibit a preferred shape alignment. Other minor to accessory detrital components include biotite, plagioclase, polycrystalline quartz, muscovite, opaque minerals, chlorite, felsite, very fine-grained metasedimentary rock, mudstone, garnet, very fine-grained phyllitic rock and tourmaline.

Compaction resulted in the kinking of detrital micas. Occasional mudstone rip-up clasts are also present within this sandstone. The high proportion of detrital micas are a distinctive feature of this sandstone.

Collectors Number: NCG015. **Registered Number:** N5332. **Location:** [N0 74381 66500] Woodstone Hill, Strathmore. **Geological map sheet:** 57. **Rock Type:** plagioclase-olivine/pyroxene microporphyritic basalt. **Formation:** Montrose Volcanic Formation. **Symbol:** plopmiB^{B}.

Mineralogy: major – plagioclase

minor – opaque minerals

alteration – bowlingite, chlorite, opaque minerals, amphibole, biotite

Description: This thin section is of a altered (hematised), fine-grained, weakly amygdaloidal, originally glassy, hypocrystalline, inequigranular, massive, microporphyritic basalt. Microphenocrysts are mainly composed of plagioclase and bowlingite pseudomorphs after a ferromagnesian minerals, possibly olivine and/or clinopyroxene. Plagioclase forms anhedral, locally broken, twinned (simple and multiple), lath-shaped crystals. The larger phenocrysts may possess a well-developed oscillatory zonation. Ferromagnesian microphenocrysts also include yellow-brown coloured ?amphibole pseudomorphs after clinopyroxene.

The groundmass is mainly composed of very fine-grained plagioclase laths and needles set within a turbid, red-brown coloured (hematised) mesostasis. Small chloritic pseudomorphs after pyroxene and possibly olivine are also present, intergranular to plagioclase. Amygdales are zoned and composed of very fine-grained to cryptocrystalline quartz and opaque minerals.

Collectors Number: NCG016. **Registered Number:** N5333. **Location:** [N0 74296 63841] St. Cyrus, Strathmore. **Geological map sheet:** 57. **Rock Type:** highly altered basaltic rock. **Formation:** Montrose Volcanic Formation. **Symbol:** B.

Mineralogy: major – plagioclase

minor – opaque minerals

alteration – chlorite, opaque minerals, bowlingite, quartz, sericite

Description: This thin section is of a highly altered (chloritised), medium- to coarse-grained, inequigranular, aphyric, amygdaloidal, hypocrystalline basaltic rock which possesses a very weakly developed pilotaxitic fabric. The rock is mainly composed of variably shape-aligned to locally radiating (spherulitic) plagioclase laths. Plagioclase forms anhedral, twinned, dusty

looking (under plane polarised light) crystals and also occurs as an interstitial phase. Rounded, anhedral, intergranular pyroxene has been completely replaced by cryptocrystalline chlorite and opaque minerals.

Amygdales are composed of very fine-grained to cryptocrystalline quartz and chlorite. Patchy chloritised results in the overprinting of the primary igneous texture of the rock.

Collectors Number: NCG017. **Registered Number:** N5334. **Location:** [N0 72730 66845] Brandshill, Strathmore. **Geological map sheet:** 57. **Rock Type:** weakly olivine microporphyritic basalt. **Formation:** uncertain. **Symbol:** omiB^{B}.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals

alteration – opaque minerals, bowlingite, chlorite, ?talc

Description: This thin section is of a relatively fresh, coarse-grained, weakly microporphyritic, inequigranular, hypocrystalline basalt which possesses a weakly developed pilotaxitic fabric. Anhedral, fractured olivine microphenocrysts and clusters of smaller granular olivine crystals are pseudomorphed by bowlingite, chlorite and possible talc.

The bulk of the rock is composed of randomly orientated to weakly aligned plagioclase laths, with plagioclase also occurring as an intergranular phase. Radiating (spherulitic) aggregates of plagioclase laths are also present. Plagioclase forms anhedral, twinned (simple and multiple) and zoned crystals which locally comprise a distinct core enclosed within an oscillatory zoned rim. Clinopyroxene is fresh and forms anhedral, interstitial ophitic to subophitic crystals ranging up to 0.7 mm in size. The remaining interstitial to intersertal areas are composed of a dusty looking (under plane polarised light) mesostasis containing very fine-grained opaque minerals.

Collectors Number: NCG018. **Registered Number:** N5335. **Location:** [N0 70698 67946] Craig of Garvock/Balmakelly, Strathmore. **Geological map sheet:** 57. **Rock Type:** amygdaloidal, weakly olivine-plagioclase microporphyritic basalt. **Formation:** uncertain. **Symbol:** oplmiB or B.

Mineralogy: major – plagioclase

minor – opaque minerals

alteration – opaque minerals, chlorite, bowlingite/iddingsite, carbonate, quartz

Description: This thin section is of a altered (hematised), fine-grained, inequigranular, originally glassy, hypocrystalline, amygdaloidal, weakly microporphyritic basalt. Small olivine microphenocrysts are pseudomorphed by opaque minerals, chlorite and bowlingite/iddingsite. The bulk of the rock is composed of anhedral, inequigranular, randomly orientated plagioclase laths set in a hematised, originally glass, matrix. Glomerophyric clusters of radiating, slightly coarser grained plagioclase crystals are also present. Plagioclase forms anhedral, twinned (simple and multiple) crystals which are variably replaced by cryptocrystalline chlorite.

Amygdales are variably zoned and composed of an outer rim of chlorite and/or quartz, with the remainder filled by sparry carbonate.

Collectors Number: NCG019. **Registered Number:** N5336. **Location:** [N0 72090 68231] Craig of Garvock, Strathmore. **Geological map sheet:** 57. **Rock Type:** quartzose litharenite. **Formation:** Deep Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a medium- to coarse-grained, poorly sorted, very closely packed, clast supported, immature, massive, matrix-poor, compact quartzose litharenite. Detrital grains are angular, subangular, to occasionally subrounded in shape with a low sphericity. A preferred shape alignment of elongate clasts and detrital micas is developed.

The mixed clast assemblage is dominated by monocrystalline quartz, lithic fragments and subordinate feldspar. The lithic clasts are variably degraded and typically composed of a very fine-grained felsitic volcanic rock. Other minor to accessory detrital components include polycrystalline quartz, opaque minerals, biotite, K-feldspar, muscovite, very fine-grained phyllitic metasedimentary rock, garnet, chlorite, epidote, altered very fine grained basaltic rock, microcline, tourmaline and possible ?pyroxene.

Traces of matrix are apparently secondary in nature and derived from degraded lithic clasts. Compaction resulted in pressure solution, kinking of detrital micas and plastic deformation of unstable lithic clasts. Pressure solution appears to have resulted in the main mode of cementation within this sandstone.

Collectors Number: NCG020. **Registered Number:** N5337. **Location:** [N0 72085 65553] Den of Morphie, Strathmore. **Geological map sheet:** 57. **Rock Type:** fine-grained micaceous sandstone. **Formation:** Dundee Flagstone Formation. **Symbol:** not applicable.

Description: This thin section is of a fine-grained, moderately to poorly sorted, moderate to open packed, clast to matrix supported, micaceous sandstone with a well developed lamination and cross lamination. Detrital micas are shape aligned parallel to this sedimentary lamination and cross lamination, and are concentrated along the tops of the foresets.

Clastic grains are angular to subangular in shape with a low sphericity, and mainly composed of monocrystalline quartz and variably hematised biotite. Other minor to accessory detrital components present include plagioclase, K-feldspar, micrographic intergrowth, garnet, tourmaline, opaque minerals, zircon and epidote.

he clay-grade matrix to the sandstone appears to have been partially derived from degraded lithic clasts and is apparently lacking in clay minerals. Compaction resulted in the kinking of detrital micas.

Collectors Number: NCG021. **Registered Number:** N5338. **Location:** [N0 73316 65764] North Snadon, Strathmore. **Geological map sheet:** 57. **Rock Type:** altered, plagioclase-olivine microporphyritic basaltic rock. **Formation:** Montrose Volcanic Formation. **Symbol:** plomiB.

Mineralogy: major – plagioclase

minor – opaque minerals

alteration – opaque minerals, chlorite, bowlingite/iddingsite, sericite, biotite

Description: This thin section is of a altered (hematised), fine-grained, inequigranular, massive, amygdaloidal, microporphyritic, originally glassy, hypocrystalline basalt which possesses a crudely developed seriate texture. Microphenocrysts are composed of anhedral, weakly aligned plagioclase laths and chloritic pseudomorphs (± opaque minerals) after finer-grained olivine. Plagioclase is fractured and variably altered to sericitic white mica.

The groundmass is composed of randomly orientated to very weakly aligned plagioclase laths set in a variably hematised, red-brown originally glass matrix. Rounded to irregular amygdales are composed of a very fine-grained to cryptocrystalline, colourless to yellow-green chloritic assemblage.

Collectors Number: NCG022. **Registered Number:** N5339. **Location:** [N0 72897 69715] Hill of Garvock, Strathmore. **Geological map sheet:** 57. **Rock Type:** altered, coarse-grained, weakly olivine microporphyritic basalt. **Formation:** Arbuthnot-Garvock Group undifferentiated. **Symbol:** omiB^B or B^B.

Mineralogy: major – plagioclase, clinopyroxene

minor – opaque minerals

alteration – chlorite, opaque minerals, bowlingite/iddingsite, ?talc

Description: This thin section is of a altered (chloritised), coarse-grained, inequigranular, massive, aphyric to weakly olivine microporphyritic, hypocrystalline basalt which contains occasional pseudomorphs of chlorite and opaque minerals (± ?talc) after olivine microphenocrysts. The rock is mainly composed of randomly orientated to radiating plagioclase laths with intergranular ophitic to subophitic, pale pink clinopyroxene. Larger plagioclase crystals possess a well-developed oscillatory zonation. Plagioclase forms an open crystal framework with the remaining interstitial to intersertal areas are filled by a cryptocrystalline chloritic assemblage. Radiating, spherulitic clusters of plagioclase are locally partially included within an aggregate of intergranular pyroxene and feldspar.

Collectors Number: NCG023. **Registered Number:** N5340. **Location:** [N0 72926 65473] South Snadon, Strathmore. **Geological map sheet:** 57. **Rock Type:** altered, plagioclase-olivine-clinopyroxene microporphyritic basalt. **Formation:** Montrose Volcanic Formation. **Symbol:** plopmiB.

Mineralogy: major – plagioclase, clinopyroxene, olivine

minor – opaque minerals

alteration – chlorite, bowlingite/iddingsite, opaque minerals, quartz

Description: This thin section is of a altered, fine- to very fine-grained, inequigranular, originally glassy, hypocrystalline, massive, weakly amygdaloidal, microporphyritic basalt. Phenocrysts are mainly composed of plagioclase and chlorite (± opaque minerals) pseudomorphs after olivine, as well as rare clinopyroxene microphenocrysts. Plagioclase forms anhedral, twinned (simple and multiple), prismatic to laths shaped crystals which may possesses a well-developed oscillatory compositional zonation. Olivine formed anhedral to weakly subhedral crystals. Traces of relict olivine are present. Clinopyroxene is pale brown in colour and forms anhedral, rounded partially resorped crystals.

The groundmass is fine- to very fine-grained and mainly composed of randomly orientated anhedral plagioclase laths set within an originally glassy matrix. Interstitial to intersertal glass has been replaced by a dusty looking (under plane polarised light) mesostasis, as well as fine-grained chlorite and quartz. Fine-grained, granular clinopyroxene occurs intergranular to plagioclase.

Amygdales are zoned and composed of an outer rim of cryptocrystalline quartz with the remainder filled by very fine-grained to cryptocrystalline chlorite.

Collectors Number: NCG024. **Registered Number:** N5341. **Location:** [N0 70937 66136] Grange Hall Farm, Strathmore. **Geological map sheet:** 57. **Rock Type:** quartzose litharenite. **Formation:** Deep Conglomerate Formation. **Symbol:** not applicable.

Description: This thin section is of a medium- to coarse-grained, moderately to poorly sorted, immature, closely to very closely packed, clast supported, massive quartz arenite which is characterised by the common occurrence of detrital epidote and garnet. Clastic grains are angular to subangular in shape with a low sphericity. Grain shape has, however, been modified during compaction due to localised pressure solution and the growth of trace amounts of a quartz rim cement. Traces of a carbonate cement replacing unstable detrital grains and/or matrix have been noted within this sandstone.

The mixed clast assemblage is dominated by monocrystalline quartz, lithic fragments and subordinate feldspar. Lithic clasts are mainly composed of fragments of a very fine-grained basaltic to andesitic volcanic rock. Other minor to accessory detrital components include plagioclase, opaque minerals, muscovite, epidote, garnet, phyllitic to cleaved metasedimentary rock, biotite, chlorite, polycrystalline quartz, siltstone, zoisite, mudstone, very fine-grained metasedimentary rock, metamafite and microcline.

Collectors Number: NCG025. **Registered Number:** N5342. **Location:** [N0 74381 66500] Woodstone Hill, Strathmore. **Geological map sheet:** 57. **Rock Type:** siltstone with mudstone rip-up clasts. **Formation:** Montrose Volcanic Formation. **Symbol:** not applicable.

Description: This thin section is of a red-brown coloured siltstone containing plastically deformed, finely laminated mudstone lithic clasts. The mudstone clasts are folded to contorted indicating that this finely laminated sediment was unlithified at the time of disruption. The style of deformation recorded by the mudstone lithic clasts and relatively homogeneous nature of the siltstone s reminiscent of soft-sediment deformation associated with liquefaction and water escape. The mudstone clasts occur within one horizon within the siltstone giving it an overall graded appearance with a lithic-rich pebbly base.

The siltstone is massive to very weakly laminated. Angular to subangular, low sphericity detrital grains within the siltstone are mainly composed of monocrystalline quartz. Other minor to accessory detrital components present include opaque minerals, muscovite, very fine-grained volcanic rock, biotite, epidote, tourmaline, zircon and titanite.

Collectors Number: NCG026. **Registered Number:** N5343. **Location:** [N0 70248 63887] Den or Morphie, Strathmore. **Geological map sheet:** 57. **Rock Type:** laminated quartzose litharenite. **Formation:** Scone Sandstone Formation. **Symbol:** not applicable.

Description: This thin section is of a medium- to coarse-grained, poorly sorted, immature, laminated, closely to very closely packed, clast supported, matrix-poor, quartzose litharenite containing distinct heavy mineral bands composed of opaque minerals, garnet and epidote. The quality of this thin section is relatively poor due to 'plucking' during manufacture.

Detrital grains are angular to subangular in shape with a low sphericity. Weak preferred alignment of elongate grains and detrital micas has been recognised within this sandstone. The mixed clast assemblage is dominated by monocrystalline quartz, lithic fragments and subordinate plagioclase. The lithic clasts are mainly composed of a very fine-grained andesitic to dacitic rock. Other minor to accessory detrital components present include muscovite, biotite, K-feldspar, very fine-grained metasedimentary rock, garnet, epidote, zoisite, chlorite, staurolite, perthite, polycrystalline quartz and serpentinite.

Traces of a clay-grade matrix, chloritic rim cement and replacive carbonate cement have been noted within this sandstone.

Collectors Number: NCG027. **Registered Number:** N5344. **Location:** [N0 72750 66832] Brandshill, Strathmore. **Geological map sheet:** 57. **Rock Type:** coarse-grained, weakly plagioclase microporphyritic basalt. **Formation:** uncertain. **Symbol:** plmiB^B or B^B.

Mineralogy: major – plagioclase, clinopyroxene, olivine

minor – opaque minerals

alteration – bowlingite/iddingsite, chlorite, opaque minerals

Description: This thin section is of a coarse-grained, inequigranular, aphyric to weakly microporphyritic basalt with a weakly developed pilotaxitic fabric defined by variably shape-aligned plagioclase laths. The bulk of the rock is composed of anhedral to subhedral, randomly orientated to weakly aligned, twinned (simple and multiple) plagioclase laths. Plagioclase also forms occasional to rare microphenocrysts. The larger plagioclase laths are zoned.

Very pale brown clinopyroxene forms small (≤ 0.6 mm in size), anhedral to irregular, ophitic to subophitic intergranular crystals. Intergranular olivine originally formed clusters of small granular crystals which have largely been replaced by honey brown iddingsite. However, traces of relict olivine are present. The remaining interstitial to intersertal areas are filled by a dusty looking (under plane polarised light) mesostasis which contains needle-like to granular opaque minerals.

Collectors Number: NCG028. **Registered Number:** N5345. **Location:** [N0 72926 65473] South Snadon, Strathmore. **Geological map sheet:** 57. **Rock Type:** intercalated siltstone and hematised plagioclase microporphyritic basalt. **Formation:** Montrose Volcanic Formation. **Symbol:** not applicable.

Description: This thin section is of a intercalated siltstone and hematised plagioclase microporphyritic basalt. The siltstone is essentially massive with a variably developed preferred alignment of detrital micas and opaque mineral grains. This foliation is sigmoidal to arcuate in form and occurs at a high angle to the contacts with the adjacent basalt. A number of thin clay-grade veinlets are 'injected' along this foliation. Angular, low sphericity detrital grains within the siltstone are mainly composed of monocrystalline quartz. Other minor to accessory detrital components present include biotite, opaque minerals, muscovite, epidote, zircon, titanite and

chlorite. Although clay-grade material is present within the siltstone it is lacking in any obvious clay minerals.

The basalt is a very fine-grained, originally glassy, altered (hematised), microporphyritic rock which contains randomly orientated microphenocrysts of variably altered plagioclase. Rare chloritic pseudomorphs after possible olivine microphenocrysts are also present. The groundmass is mainly composed of fine- to very fine-grained plagioclase laths set in a turbid, brown coloured mesostasis. Minor to trace clinopyroxene occurs intergranular to plagioclase. Rounded to irregular amygdales are mainly composed of cryptocrystalline quartz. However, fine siltstone was also noted forming geopetal-like infills to one or two of the amygdales.

The boundary between the basalt and siltstone is sharp and irregular in form, apparently consistent with hot rock-wet sediment interaction. However, no obvious amygdales or fine grained fragments of basalt have been recognised within the siltstone. A thin (≤ 0.3 mm thick) layer of very fine silt to clay-grade material occurs along this lithological boundary. Very fine detrital micas within this clay-grade layer are aligned parallel to the basalt-siltstone contact. No obvious chilled margin, perlitic cracking or fracturing have been recognised within the basalt immediately adjacent to the contact.

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.