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INTERPRETATIVE STRATIGRAPHY and SANDSTONE PETROGRAPHY of the BURRA GROUP in the PORT GERMEIN GORGE AREA.

by

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ABSTRACT.

The stratigraphy of a clastic-dolomite sequence of the Burra Group and the unconformably overlying tillitic sequence of the Yudnamutana Sub-group, in the Nelshaby Anticline, are described and interpreted. A petrological study of arkosic and dolomitic arkosic sandstones of the Burra Group, indicate these sediments were derived from an igneous plutonic source. It is suggested the arkosic sediments accumulated in response to active tectonism in the source area, rather than aggradation on a peneplaned surface, under adverse climatic conditions. Field and petrological evidence indicated these sediments were deposited in a high energy environment. This has resulted in the tectonic arkoses being texturally mature and not immature as normally expected in tectonic arkoses.

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INTRODUCTION.

The Nelshaby Anticline is situated in the Southern Flinders Ranges 315 kilometres north of Adelaide. Routine geological mapping was carried out in the northern sector of the anticline, which covers an area of approximately 27 kilometres (see locality map Figure 1). Faulting along the western margin of the area has resulted in a striking contrast between flat lying plains to the west, and mountains to the east. The general topography of the map area is rugged and mountainous, with steep sided valleys. A greater stage of maturity is reached in the eastern section, where the relief is more subdued.

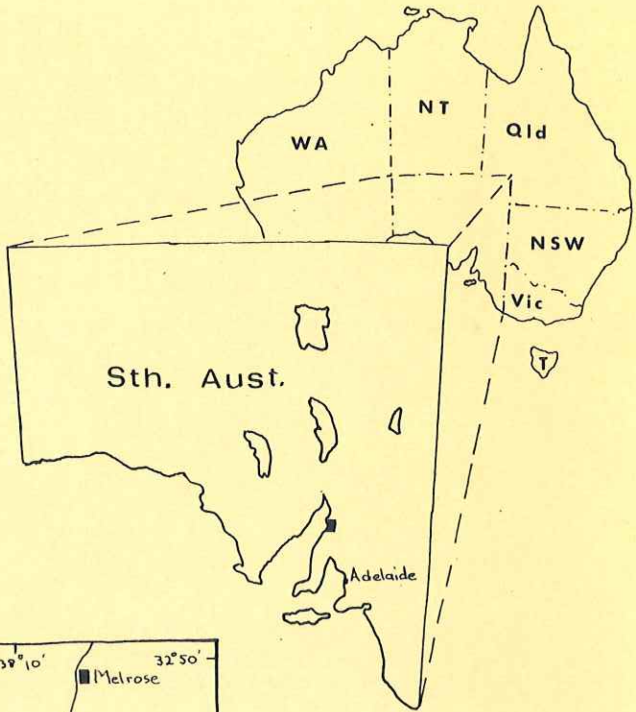
Type and density of vegetation varies greatly. The western and central sections are densely vegetated with dwarf eucalyptus, gums and yakkas. Grasslands with scattered wooded regions cover the eastern section. The closeness of the Spencer Gulf has a moderating effect on the climate. Average maximum temperatures of 27° - 32°C are reached in January, and average minimum temperatures of 2° - 4°C in July. The average rainfall is 380-510 millimetres and is precipitated mainly in the winter months. The area is dissected by small streams, most of which drain into Back Creek, which has carved a deep gorge. The gorge has provided an important historical link between the coast and the interior. All the streams are ephemeral.

The first reported geological investigation of the region was by Howchin in 1928, who studied the geology through the Port Germein Gorge. The region was first mapped by King (1953) to assess the magnesite reserves in the Skillogalee Dolomite for B.H.P. Later, Forbes (1959, 1961), as part of a Ph. D. Thesis at Adelaide University, studied magnesite deposits throughout the Adelaide Geosyncline, and included deposits within the map area. The South Australia Department of Mines have mapped this region as part of their regional mapping of the Orroroo 4 mile to the inch geological map (Binks, 1971).

Extremely poor exposure and the difficulty of penetrating many of the more rugged, vegetated regions, made this area extremely unsuited for detailed mapping and evaluation. The geological map (Figure 2) which accompanies this thesis has been based on limited outcrop and as such, lithological formations are accurate, but sub-division within these have only been tentatively made.

LOCALITY MAP

Pt. GERMEIN GORGE AREA



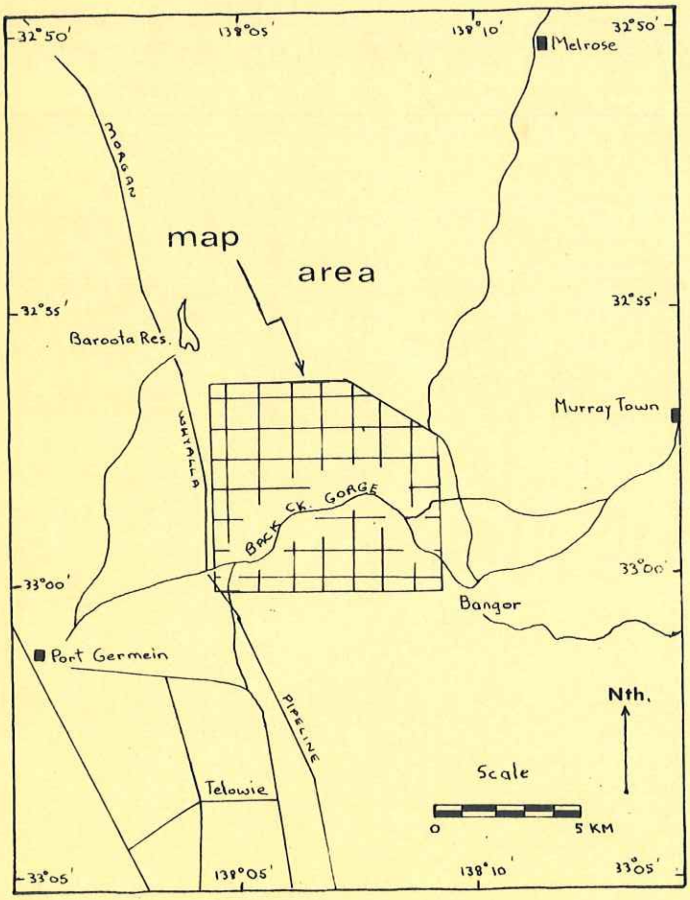
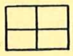


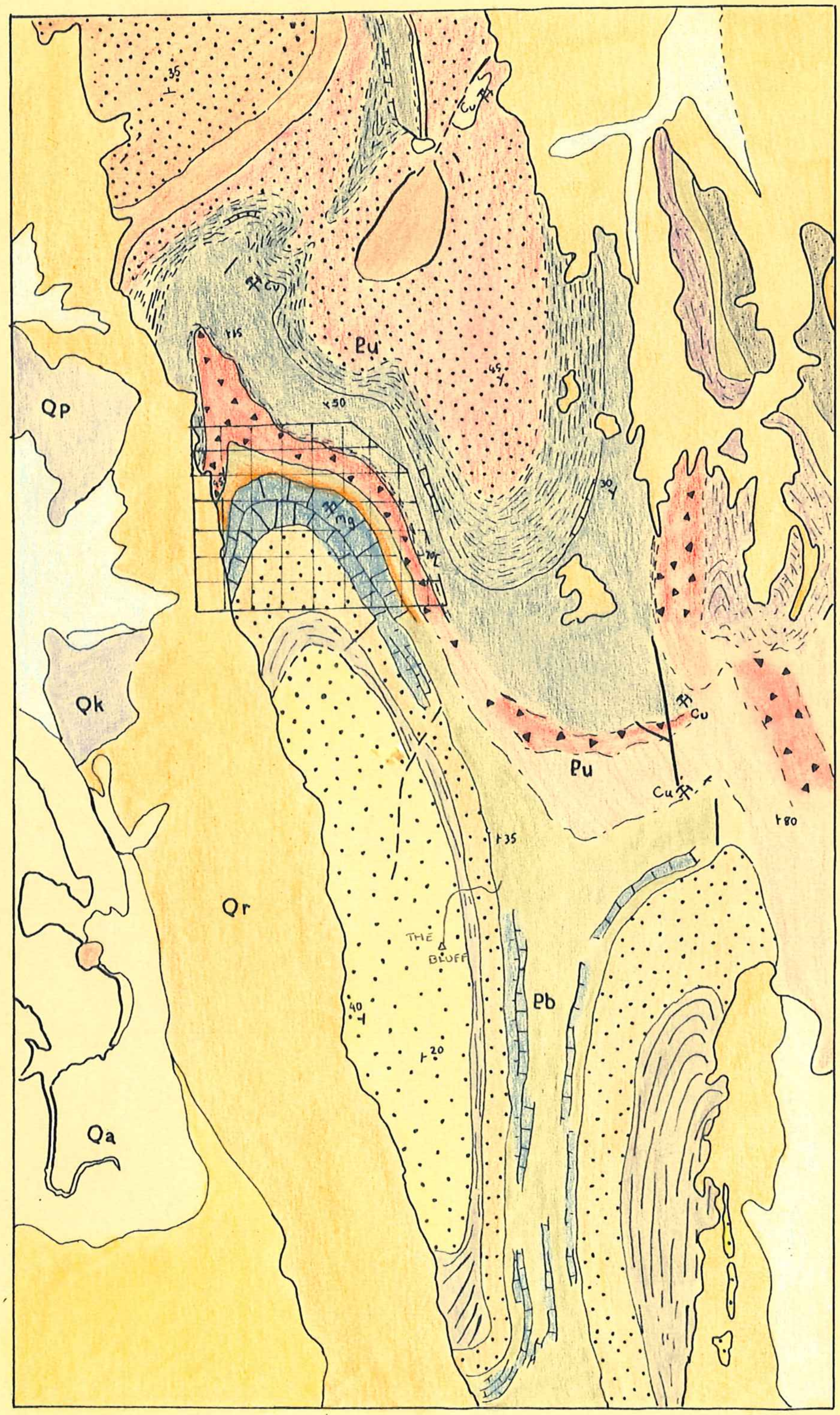
FIGURE 1.

REGIONAL GEOLOGY

For symbol notation see figure 4.



— map area



Modified from Burra and Orroroo 1:250,000 Geological Maps.

FIGURE 3.

The regional geological setting of the map area, is shown in Figure 3, which has been modified from the Burra (Mirams, 1964) and Orroroo (Binks 1971) 4 mile to the inch geological maps, published by the South Australia Department of Mines. The formation names used on these maps have been retained for use in this thesis.

DESCRIPTIVE AND INTERPRETATIVE STRATIGRAPHY.

General.

Relatively shallow water sediments of the Burra Group are unconformably overlaid by glaciogenic sediments of the Yudnamutana Sub-group. These have been folded into a broad, north pitching (15^o) anticline, trending north-south. The western limb of the fold has been down faulted beneath the coastal plains. From this anticline Mirams (1964) established two units in the Upper Callanna beds; the Nelshaby Sandstone and Wirrabara Formation. Binks (1971) has not differentiated these on the Orroroo 4 mile to the inch geological map, considering them to be local members of the Rhynie Sandstone. In this region the Nelshaby Sandstone and Wirrabara Formation are undoubtedly stratigraphically below the Rhynie Sandstone, and have been considered by the author as units of the Rhynie Sandstone.

For descriptive purposes, the various units of the lower AdelaideSystem are described in ascending stratigraphic order, (Figure 4).

Rhynie Sandstone.

The Rhynie Sandstone is a thick arenaceous sequence of predominantly pink feldspathic sandstones at the base of the Burra Group. It outcrops in the core of the Nelshaby Anticline forming the backbone of the Bluff Ranges. Due to the rugged topography and dense vegetation, entry into this region was virtually impossible. Traverses were limited to two roadways and a few tracks. Considering the Nelshaby Sandstone and Wirrabara Formation as units of the Rhynie Sandstone and not upper Callanna Beds, four distinct stratigraphic units can be recognised.

Nelshaby Sandstone (Unit 1): This unit outcrops south of the map area in a broad north trending belt (Figure 3). It was studied from the Telowie Gorge and on the road to the Bluff where outcrop was more accessible. On the Burra Sheet (Mirams, 1964) the Telowie Gorge is shown to be Wirrabara Formation, however, this is incorrect and should be Nelshaby Sandstone. This unit consists of light pink, medium to coarse grained, well-sorted feldspathic sandstones. Intense weathering of feldspars has given most outcrops a white mottled appearance. Bedding thickness varies from very thin (1-3 cm.) to beds 1 metre thick. Petrologically these arenites are well-sorted, texturely mature arkoses, consisting of quartz, microcline, orthoclase and minor rock fragments, cemented with authigenic quartz overgrowths. Grains are generally sub-rounded to rounded, and may have red hematite rims (TS 448/T.6)* indicating that oxidising conditions prevailed throughout the depositional and post-depositional history of this unit (Walker, 1967).

On the eastern limb of the Nelshaby Anticline, interbeds of weathered, sandy siltstones and siltstones are common. These are thinly flat-bedded, pink to red in colour, occasionally green. Their absence from the western limb suggests that they were deposited out of suspension, in quieter, deeper water, distal from a western shoreline. A 2 metre thick band of conglomerate outcrops near the top of this unit, composed of rounded pebbles of very weathered pink 'sandstone' material (possibly pink granite), in a feldspathic sandstone matrix. The largest pebble observed measured 9 centimetres in diameter.

Sedimentary structures in this unit are scarce, except for the rare development of coarse, tabular cross-beds. These outcrop as an individual set 1 to 3 metres thick, bounded by flat-bedded sandstones.

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*Reference prefixed by 448- or TS 448- refer to hand specimens and thin sections described in Appendix 111.

High angles up to 26° between top and fore-beds were recorded from the Telowie Gorge, (Plate 1, pA) but only low angles (7°) from the Bluff Road. Small, wedge-shape cross beds, with individual sets measuring 40 centimetres, were observed at one locality. Ripple marks were not observed. The development of coarse cross-beds of well sorted sandstones, and the absence of small scale sedimentary structures, suggest a highly energetic, agitated shallow marine environment, which prevented the preservation of small scale sedimentary structures.

Wirrabara Formation, (Unit 2): Feldspathic sandstones of unit 1 are conformably overlain by unit 2, which has a thickness of approximately 250 metres at the Bluff Road, where it was studied. This unit is composed of thickly laminated to thinly bedded siltstones and clay shales. These are flat-bedded and more rarely cross stratified. The blue-grey and green colour of most siltstones (448/N.5) and shales suggest these were deposited under reducing conditions, in contrast to oxidizing conditions for unit 1. Fine to medium grained, poorly sorted feldspathic sandstones occur interbedded with siltstones. Dark blue and grey laminae are common in both siltstones and sandstones. Straight and sinuous current bedded ripple marks, with wavelengths up to 5 centimetres occur on many siltstones and shales. These may have polygonal mudcracks superimposed on them indicating periods of subaerial exposure. Rare halite casts were observed. Sedimentary structures and textures indicate that this unit was deposited in a quiet, shallow, near shore, marine (possibly supratidal) environment, with a somewhat restricted circulation. A lagoon environment developed behind barrier sands would fit such conditions.

Rhynie Sandstone, (Unit 3): The only continuous exposure of this unit in the map area outcrops in the Port Germein Gorge. Lithologically and petrologically this unit is very similar to unit 1. It consists of approximately 800 metres of fine to coarse grained, well-sorted, flat-bedded feldspathic sandstones. Typically light pink to light maroon (448/Sc 1.19) and more rarely light grey in colour.

Thin beds of alternating fine and coarser grained sandstone are a common feature of this unit. Most outcrops have a white or light brown mottled appearance resulting from the alteration of feldspars. Petrologically, these weathered rocks could be described as orthoquartzites (TS 448/5.4). Less weathered samples have a sub-arkose to arkose composition (TS 448/Sc 1.16).

Thin flat or wavy bedded siltstones and sandy siltstone interbeds are common. These have been intensely weathered to white, yellow, orange and brown colours. Associated with the siltstones are Fe concretions, ranging in size from small nodules to large irregularly shaped lenses, developed along bedding planes.

Wavy and cross-bedded, black heavy mineral laminations were observed at two stratigraphic horizons, one near the top, the other approximately 350 metres below this. Coarse cross-beds similar to those described in unit 1 are frequent throughout this unit (Plate 2,pA). Cross-beds on a smaller scale were observed, but are not common, although very conspicuous when delineated by heavy mineral or silty laminations, (Plate 2, pB). This suggests that cross-beds of all sizes are probably more common than can be recognised. The well-sorted nature of the sandstones prevents their recognition, making this unit appear homogenously flat-bedded. Current bedded ripple marks are plentiful. They are either straight or sinuous crested, symmetrical or asymmetrical, (Plate 1, pB). Interference ripple marks were also observed. Variable orientations of ripple crests suggest that these formed in shallow water where current and tidal directions were changeable. The most dominant orientations are north-south and northeast-southwest. Periods of sub-aerial exposure are indicated by sand filled mudcracks, seen at one locality, (L 2). Structures and textures are compatible to a beach and tidal environment. A significantly less energetic environment than that in which unit 1 was deposited is indicated by the preservation of small scale sedimentary structures.

In the Port Germein Gorge, Unit 3 is comprised of pink Nelshaby (Unit 1) type sandstones, and is ilmenite poor. Wilson (1952, p135), describes this unit from the Riverton-Clare region as an "ilmenite rich feldspathic sandstone". This description also adequately applies to white feldspathic sandstones which outcrop north of the map area, at Mt. Remarkable, marked on the Orroroo 4 mile to the inch geological map, as Rhynie Sandstone. Considerable variation in colour and ilmenite content occurs along the lateral outcrop of this formation. This may be the result of breaking down of ilmenite to form microscopic specks of hematite, which gives the sandstones in the map area their characteristic red appearance.

The Upper Rhynie Sandstone (Unit 4): This unit conformably overlies pink feldspathic sandstones and is composed of 40 metres of poorly sorted weathered sandstones, siltstones and shales, (Appendix 1, Section A). These are well-bedded, show current ripple marks and are occasionally cross bedded. Small flame and soft sediment deformation structures are common. Near the top of the sequence, is a red-brown chert which has resulted from the local silicification of siltstones, (TS 448/4.3, 448/5.14) commonly accompanied by brecciation, (448/5.14a). This unit was deposited under milder conditions than the underlying sandstone. Current strength was insufficient to winnow out finer material, resulting in poorly sorted sediments. Coarse rounded ripples (Plate 2, pC) indicate that periods of storm activity were common.

Skillogalee Dolomite.

Carbonates of the Skillogalee Dolomite conformably overlie siliceous siltstones and silty sandstones of the Upper Rhynie Sandstone. This formation attains its maximum thickness of approximately 880 metres in the nose of the anticline. This is due to the relative incompetency of the dolomites, which have been squeezed from the limbs into the nose of the pitching anticline. Poor exposure of most carbonate rocks made study and detailed mapping of this formation difficult. Two distinctive units were recognised.

The lower unit consists of light brown, buff dolomites and can be correlated to the Castambul Dolomite, (Mawson and Sprigg, 1950). The upper unit comprises dark grey-blue dolomites and magnesites and is the equivalent to the Montacute Dolomite, (Mawson and Sprigg, 1950).

Unit 1. The contact between the lower unit 1 of the Skillogalee Dolomite and the underlying feldspathic sandstone sequence is graditional over a thickness of 25 metres. Siliceous red brown, yellow and orange siltstones progressively pass up into buff brown dolomites, (448/7.5). This unit consists of a mixed association of shaley dolomites, siltstones and feldspathic sandstones, totalling approximately 280 metres. The lower portion of this unit was studied in detail in the Port Germein Gorge, where outcrop, although highly weathered, was continuous enough to allow sectioning, (Appendix 2 Section A). From here three sub-lithofacies were recognised, but their lateral extent was impossible to determine.

Sub-lithofacies 1: consists predominantly of light grey to buff brown dolomites weathering to a light brown-cream colour. Dendrites are common. The dolomites are usually flat-bedded but occasionally wavy. Bedding thickness varies from thinly laminated to thin beds, but rare massive beds also occur. Partings on bedding planes give most outcrops a shaley appearance. Minor thin lenses and interbeds (less than 6 centimetres thick) of poorly-sorted sandstone and siltstone occur, commonly having a scoured basal contact. Dolomite intraclasts up to 10 centimetres in length are common within these (Plate 3, pA). Associated with one sandstone lens were small (less than 1 centimetre) ellipsoid vughs, lined with drusy dolomite, (Plate 4, pC). These are thought to be secondary solution voids. Some have been infilled with coarsely crystalline quartz of diagenetic origin.

Small dome shaped columnar stromatolites (Plate 4, pA & B) occur at one locality (L 2). These outcrop as a thin bed 15 centimetres thick, overlying a coarsely crystalline, pelletal siliceous rock of diagenetic origin (448/Sc 1.5). The texture of this rock is similar to that of pelletal magnesite, (448/Sc M) found in the Skillogalee Dolomite and may represent the silicification of such a rock, or possibly of dolomite pellets.

Alternatively, they may be of a similar origin as the silica infilling vughs, described above. It is surprising that stromatolites do not occur more abundantly in this region. This could be the result of the dolomites being deposited in a high energy environment which prevented their growth.

Sub-lithofacies 2: is characterised by brown, grey-green laminated shaley siltstones (TS 448/4.5), typically flat or wavy laminated, occasionally cross-laminated and finely rippled. Influxes of sand have given many siltstones a mottled appearance. Lenses up to 52 centimetres thick, of moderately sorted, fine to medium grained sandstones are common. (Plate 3, p 3). These are thinly bedded, straight or wavy and occasionally rippled. At many localities where this sub-lithofacies can be recognised, diagenetic silicification has converted the siltstones into a hard siliceous rock, preserving its original bedding form. (448/3.1, 448/4.10).

Sub-lithofacies 3: consists of poorly sorted, flat-bedded feldspathic sandstones (TS Sc 1.1). Light grey in colour, they weather to brown-yellow. Grain size varies from fine sand to pebble size, the latter commonly being concentrated in bands up to 4 centimetres thick. The largest pebble measured 9 millimetres. Coarser grain fractions are well rounded.

Unit 2: is a thick sequence (600 metres) of dark blue-grey dolomite, feldspathic sandstones, magnesites, siltstones and shales. The dolomites are flat to wavy bedded, rarely slump folded, and range from thinly laminated to massive beds, 1 metre thick. Generally, the dolomites are pure and free from arenaceous detritus. A thin bed of oolithic dolomite was observed at one location (L3: TS 448/2.7). Beds of fragmental dolomite, occasionally associated with magnesite pellets are common (448/3.13). Diagenetic silicification of these beds has occurred. Black chert, either forming beds of moderate length or nodules in dolomite, also occur (448/7.1b). Two kinds of chert can thus be recognised in this unit; one, the selective silicification of fragmental carbonate beds, the other, forming thin beds or nodules. The latter may cross-cut bedding, indicating that they are, in part, of diagenetic origin.

Interbedded with the dolomites are flat-bedded, poorly sorted, light to dark grey (weathering brown) feldspathic sandstone, similar to sub-lithofacies 3 of unit 1, (448/6.1). Petrologically, these are moderately sorted, medium to coarse grained, consisting of quartz, microcline, orthoclase, carbonate grains and minor plagioclase, cemented by a carbonate matrix, which may comprise up to 50 percent of the thin section, (TS 448/3.6).

The feldspathic sandstone interbeds have an average thickness of 2 metres and outcrop in a rhythmic pattern separated by 30-50 metres of dolomite. Boldly outcropping, in contrast to the dolomite, these form small ridges over the country-side and can be traced up to 1.6 kilometres along their strike. Rare, medium sized cross-beds and current ripple marks indicate these sediments had a westerly source. Sand filled polygonal mud cracks were seen at one location, (L 4).

Thin beds of white magnesite, commonly associated with black chert (Plate 1, pC), form a small but important part of this sequence, and have been used to correlate this unit throughout the Adelaide Geosyncline. Rare magnesites were observed in unit 1, but are not as extensive as in unit 2. Most magnesites have a pelletal structure (448/Sc M), although massive structureless magnesites do occur. The largest magnesite outcrop occurs at location L5 and is described in detail in Appendix 1, Section C. Forbes (1961) considers the magnesites to be the result of the reaction between alkaline water of continental origin and magnesium-rich seawater in marginal lagoons during transgressive phases. During regression, these sediments were eroded and reworked seaward.

Siltstones and shales outcrop very poorly, and are similar to sub-lithofacies 2 of unit 1. No chertified siltstones were observed.

The environment of deposition and palaeogeography of the Skillogalee Dolomite throughout the Adelaide Geosyncline has been well documented by Forbes, (1960, 1961), and more recently by Preiss (1973). To save space, the reader is directed to these publications. Forbes (1961, p 218) concluded 'that most dolomite is of marine, although perhaps shallow water origin'. Sedimentary features in the Port Germein Gorge are in accordance with this interpretation.

The occurrence of terrigenous sediments, interbedded with dolomites, are readily explained by using a similar model as that proposed by Forbes for magnesites. Detritus from highlands to the west accumulated in marginal lagoons during marine transgression. Dessication, subsequent erosion and reworking of these sediments into deeper water, occurred during regression. Repeated marine transgressions and regressions would account for the rhythmic outcropping pattern of these sandstones. Major sea level fluctuations would not be required, if the depositional basin was extremely flat and shallow as minor sea level changes would then result in drastic changes to the position of the coastline.

Undalya Quartzite.

"Undalya Quartzite is recognised as a sandy unit overlying the Skillogalee Dolomite" (Binks 1967, p 26.) Using this definition some 160 metres of 'Undalya Quartzite' is present in the map area, although not of the type originally described by Wilson (1952, p 140) from the Riverton-Clare region: "The rock is a well-bedded medium-grained feldspathic white and cream quartzite and occurs with numerous minor interbedded sandy, (?)carbonaceous and pyritic shales". In the map area, however, this formation consists predominantly of a green weathering brown dolomite-sandstone rock (448/9.4). Dolomite may comprise 70 percent or more of the total rock. The clastic framework grains are composed of poorly sorted, fine to coarse quartz, microcline, orthoclase and minor plagioclase, with sub-arkose to arkose composition, (TS 448/9.4). The coarser grain fractions are generally very well rounded. Rocks similar to these have been described by Preiss (1973) from the formation which overlies the Skillogalee Dolomite, at Depot Creek. This formation has not been correlated with the Undalya Quartzite, but left un-named on the Port Augusta 4 mile to the inch geological map. The formation in the Port Germein Gorge would be better correlated to this, than the Undalya Quartzite of Wilson's type area. Minor grey and green siltstones, quartzites and cream dolomites occur interbedded with the dolomite-sandstone rocks.

The Undalya Quartzite outcrops poorly in the map area. Best exposures are in the north-west, where dolomite-sandstone rocks comprise the total sequence. On the eastern limb virtually no outscrop occurs, where siltstones appear to be more dominant. This suggests a possible facies change from the north-west to the south-east. No sedimentary structures were observed. The extremely poor exposure of this formation prevents any accurate assessment of the depositional environment. Well rounded grains, rare broken 'rounds' and dolomite intraclasts suggest the dolomite-sandstone rocks were deposited in a highly energetic marine environment. Considerable fluctuations in current strength is indicated by banding of fine and coarse clastic grains, (plate 3, PC).

? lower Auburn Dolomite Equivalent.

Dolomite-sandstone rocks of the 'Undalya Quartzite' are overlain by non-calcareous, laminated, grey and green siltstones. These are best correlated with the lower Auburn Dolomite equivalent, but possibly are equivalent to the Saddleworth Formation. This formation outcrops very poorly over most of the map area. The best exposures occur in the north-west where it has a local thickness of approximately 195 metres (Appendix 1, Section D). From this region the formation has been sub-divided into three units, these have been mapped tentatively on Figure 2.

Unit 1: This basal unit consists of grey and green, fine-grained siltstones and shales, with a minor occurrence of thin lenses of sandy siltstones. The siltstones are flat laminated and occasionally cross-laminated.

Unit 2: The basal unit is overlain by a thin sequence of brown siltstones, mottled sandy siltstones, (448/9.3) and poorly sorted, wavy-bedded dolomites and dolomitic feldspathic sandstones (448/10.14). Dolomite intraclasts are very common in the latter. Sandstones containing blue and cream intraclasts of dolomite occur in the nose of the anticline, (448/13.11). The largest intraclast observed measured 15 centimetres. The two most southerly outcrops, (L6 & L7) where this unit could be recognised, are composed almost entirely of cream dolomite.

Unit 3: This unit is very similar to unit 1 and is predominantly composed of grey and green siltstones (448/3.17) and shales. Minor beds of medium grained sandstones, dolomite and dolomitic rich sandstones occur. At the top of this unit, siltstones contain discontinuous thin sandstone beds resembling pinch and swell structures.

Any interpretation of the depositional environment for this formation must be questionable, due to its poor exposure. A rapid change in energy conditions, from the suggested highly energetic environment in which the 'Undalya Quartzite' was deposited, to flat and wavy laminated siltstones of unit 1 is indicated. Such a change may have been the result of a rapid marine transgression during the deposition of the 'Undalya Quartzite', and unit 1 was then deposited under quiet conditions, below wave base. Alternatively, a marine regression may have formed shallow lagoons, in which the siltstones were deposited. Unit 2 was deposited under a brief period of high energy conditions, which resulted in the breaking up of bedded dolomites to form dolomite intraclasts in sandstones and dolomitic sandstones. After the deposition of unit 2, there was a return to generally quiet conditions.

Appila Tillite.

Shallow water, marine sediments of the Burra Group are unconformably overlain by tillite of the Yudnamutana Sub-group. In the map area the Appila Tillite is composed of beds of boulder tillite separated by lithic sandstones and siltstones. This formation has a thickness of 350 metres. At all locations, except L8 where the base of the tillite is exposed, massive structureless boulder tillite overlies the lower Auburn Dolomite equivalent. At L8 however, a thin sequence of siltstones, sandy siltstones and sandstones occur beneath boulder tillite, (Appendix 1, Section E). Within the siltstones are sandy laminations which have been disrupted by drop pebbles. The largest pebble measured 5 centimetres in diameter (Plate 2, PD). Also recorded at this outcrop were sandstone beds 28 centimetres thick of reverse graded bedding.

The Appila Tillite can be sub-divided into five lithofacies by textural characteristics of the rock types. These are:

1). Very fine grained, slightly sandy siltstone, which is typically brown, rarely green, faintly bedded and may contain a few coarse erratics, (448/8.7).

2). Poorly sorted sub-litharenite with a fine grained dolomite matrix, which may comprise up to 70 percent of the total rock, (448/T).

3). Moderately sorted, medium grained sandstone, commonly cross bedded, (448/8.16).

4). Very poorly sorted, fluvioglacial, pebbly litharenite, (448/7.9).

5). Massive boulder tillite: sedimentary, igneous and metamorphic erratics of pebble to boulder size in a fine grained calcareous matrix. White and purple quartzite erratics are the most abundant. Other rock types include dolomite, granite, gneiss, quartz, porphyry, mica, schist and siltstone. The largest erratic observed was a rounded, 5 metre striated purple quartzite.

Lithofacies (5) is by far the most dominant type and is interpreted as being deposited from floating shelf ice into a low energy marine environment. Current strength was weak and little reworking occurred. Lithofacies 1) to 3) were deposited under higher energy conditions and are probably normal, shallow marine sediments with minor contributions from drifting icebergs.

PETROGRAPHY.

Introduction.

A detailed petrological study was carried out on sandstones from the Burra Group in the Nelshaby Anticline. Two different types of sandstones were analysed. Feldspathic sandstones from the Rhynie Sandstone and dolomite-sandstones from the Skillogalee Dolomite, Undalya Quartzite and lower Auburn Dolomite Equivalent. One sample from the Appila Tillite has been included.

The study was hampered by the highly weathered nature of the samples, all of which had to be impregnated with resins several times prior to grinding the thin sections. Many samples intended for study were so weathered that they had to be discarded. A total of 70 representative thin sections were studied, 58 of which were analysed using a Swift Automatic Point Counter. In the point counted samples, only grains with mean diameters between 0.25 and 0.50 millimetres were analysed. The apparent mean diameter of the grains was estimated by averaging the diameters of 25 grains. For every thin section 100 quartz grains were counted using a magnification of 80 times. A spacing of 0.6 millimetres between points ensured that no grain was counted twice. To obtain the operator error, 26 randomly chosen, thin sections were recounted. Variations between 5 and 10 percent were recorded. By using the table from van der Plas and Tobi (1965) the reliability of such counts varies from 2.7 to 8 percent. This is based on an average of 160 grains counted in most thin sections. While the study has been carried out using quantitative methods, it is considered to be only semi-quantitative. This is due to the inability of obtaining sandstones with similar sorting. Since the degree of sorting depends on current strength, the preserved composition of sandstones deposited under different conditions would vary. For example, poorly sorted sediments deposited in a low energy environment are more likely to preserve less stable grains than those deposited in a high energy environment. Other errors arising from local bed to bed variations and sampling errors, would also decrease the quantitative nature of this study. Bearing these in mind, the results are considered sufficiently accurate to allow general comparisons between compositional and textural properties of the sandstones, to be made.

Grain types analysed by point counting were:

1). *Quartz, monocrystalline grains with straight to slightly undulose extinction. This type is completely extinguished upon slight rotation (less than 2 degrees) of the flat microscope stage.

2). Quartz, monocrystalline grains with strongly undulose extinction. A rotation of greater than 2 degrees is required to extinguish the grain.

3). Quartz, semi-composite grains, comprising of two or more subgrains with very close optical orientations.

4). Quartz, composite grains consisting of two or more subgrains with widely differing optical orientations, each of which may have straight or undulose extinction. The boundaries between the subgrains may be planar, curved or sutured.

5). Microcline (6) orthoclase (7) plagioclase feldspars were identified by normal optical methods.

8). Rock fragments.

9). Mica.

Accessory minerals, inclusion types in quartz, type and percentage of matrix and silica overgrowths were also noted. The sorting of the framework grains were visually estimated using Folk's (1968, p 104) sorting comparison diagrams.

Details of sandstone composition.

The composition of the grain types point counted are essentially uniform throughout the Burra Group, in the Nelshaby Anticline. This is diagramatically shown in Figure 5. To obtain the diagram the compositions of sandstones from similar stratigraphic levels were averaged. This was found necessary because of the difficulty in arranging the samples in their correct stratigraphic level, due to poor exposure and the possibility of faulting, not recognisable in the field. Also by doing this,errors associated

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* Numbers (1) to (9) pertain to Figure 6 and Appendix 11.

VERTICAL VARIATION IN SANDSTONE COMPOSITION

BURRA GROUP

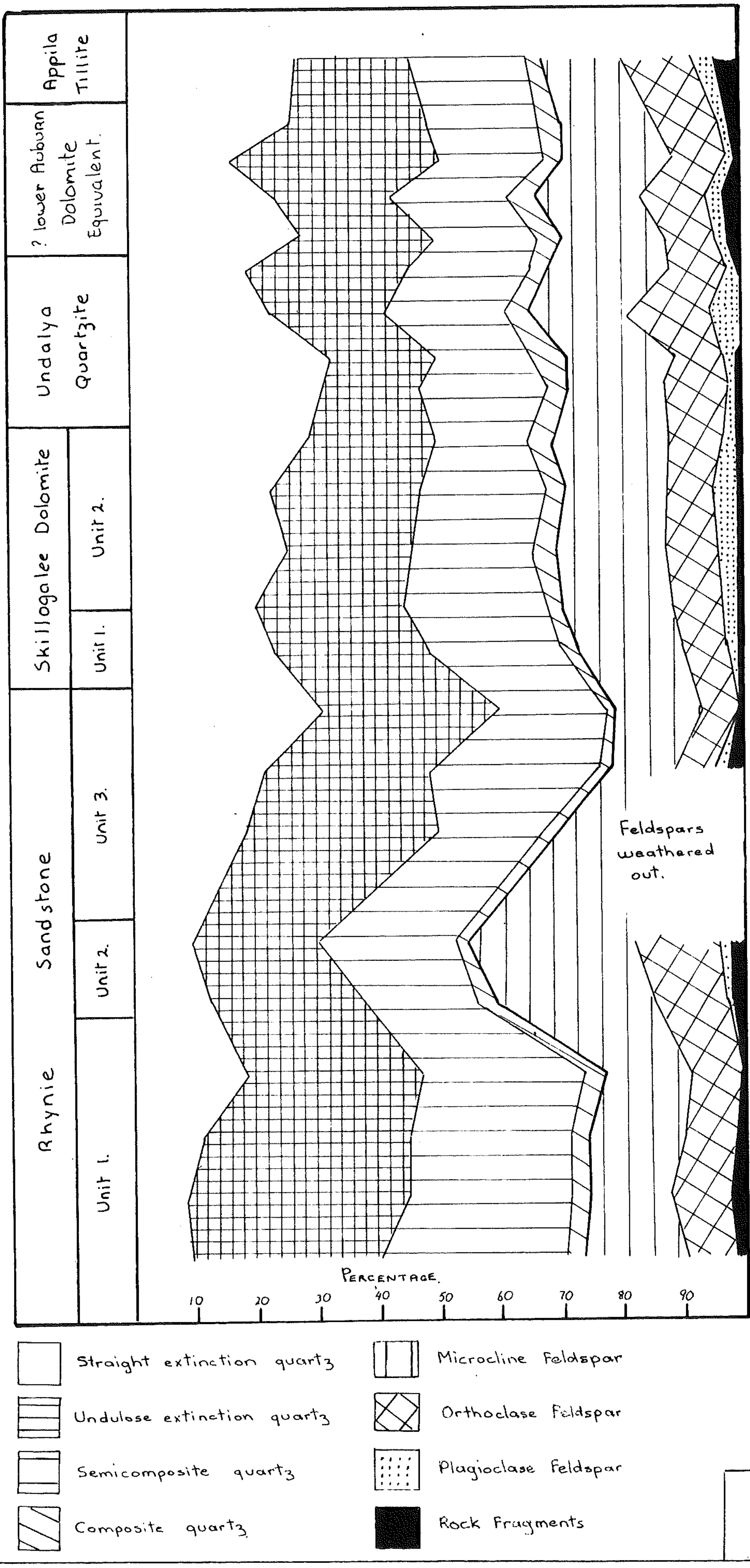

FIGURE 5

with bed to bed variations and operational procedure were minimised. While minor fluctuations do exist, no significance can be placed on these due to the small number of samples analysed compared with the total thickness of the sequence studied. The framework grains of all sandstones studied have a sub-arkose to arkose composition (Figure 6).

Quartz.

Quartz is the most abundant mineral in the sandstones studied, comprising up to 80 percent of the framework grains. Higher values were recorded in the Rhynie Sandstone, unit 3, where post-depositional alteration and weathering of feldspars has occurred. In all thin sections studied the degree and nature of strain of quartz grains is highly variable and has no apparent stratigraphic control. The presence of straight and undulose extinction in a single thin section, indicates these characteristics were inherited from the source rock. Some thin sections contain up to 99 percent strained quartz, *(TS+ 448/7.1, 6.1, Sc 2.1, L.2, B, 1.9, Sc 4.2, & Sc 4.1). This percentage increase is the result of post-depositional faulting and not regional folding. This is clearly the case for thin section TS 448/7.1, 6.1, L.2, B, where a large fault occurs along the western boundary of the map area where these samples were collected. Composite quartz grains are common, generally comprising between 1 and 4 percent, rarely as high as 10 percent, and are more abundant in the coarser grain fractions. Over 60 percent of composite grains counted were comprised of more than 5 sub-grains usually having a bi-modal size distribution. Blatt(1967a) has shown these features to be characteristic of gneissic or schistose rocks.

Mineral inclusions in quartz grains are similar throughout the vertical sequence. Dust and vacuoles are the most abundant inclusions, the latter commonly being arranged in rows, 'probably formed upon stressing of the parent rock and represent incipient healed fractures', (Folk, 1968, p 71). Acicular rutile needles are common, ranging in size from 0.02 to 20 millimetres. This type of inclusion is characteristic of granitic quartz, (Blatt et al. 1972, p 276). Rutile, rounded potassium feldspar (orthoclase and microcline), zircon, muscovite, rare biotite, green and brown tourmaline were also recorded.

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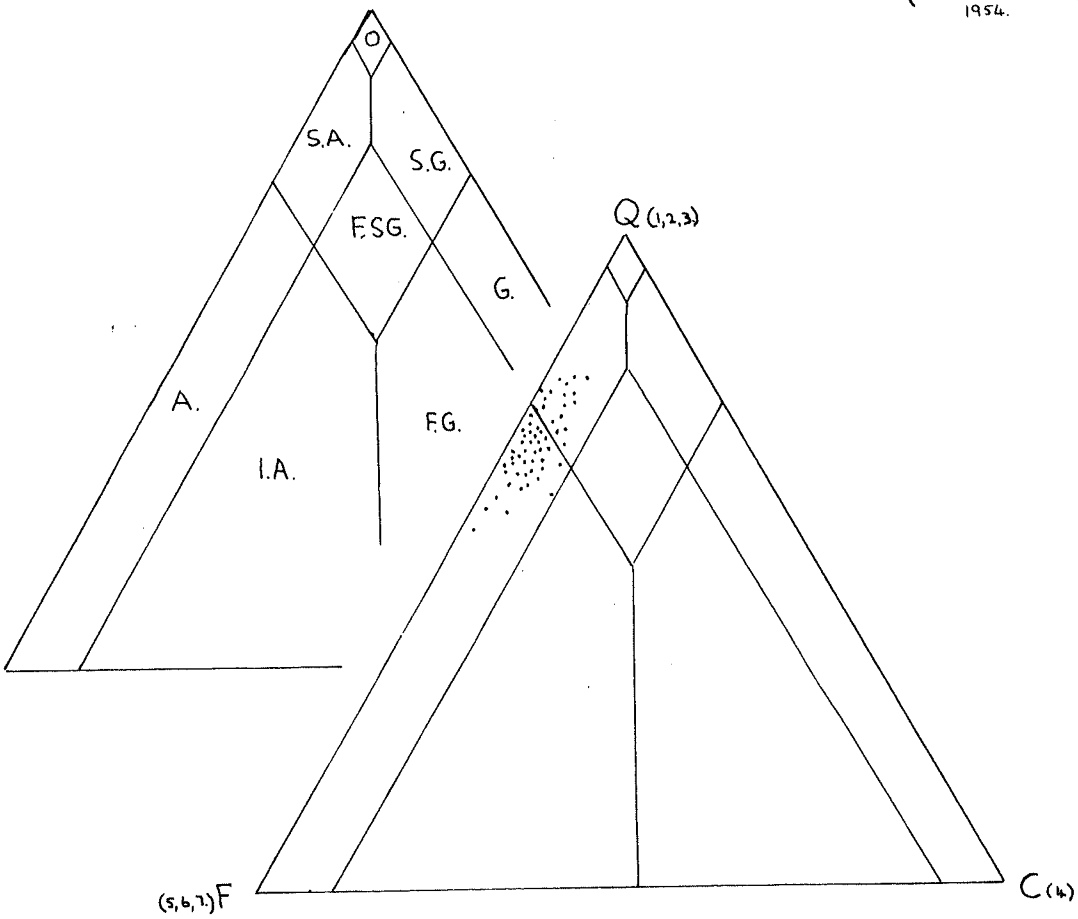
*Thin sections - denoted by TS+ - refer to Appendix 11.

COMPOSITION OF FRAMEWORK GRAINS.

(after R.L. Folk.) 1954.



O. _ Orthoquartzite

S.A. _ Sub-arkose

A. _ Arkose

I.A. _ Impure Arkose

S.G. _ Sub-graywacke

F.S.G. _ Feldspathic Sub-graywacke

G. _ Graykwacke

F.G. _ Feldspathic Graywacke

FIGURE 6

The clear nature of the quartz grains and the inclusion types suggest that granitic source rocks contributed more quartz than did gneisses and schists.

Two types of authigenic quartz in the form of detrital grain overgrowths were recorded.

(a). Quartz Overgrowths are more common in the Rhynie Sandstone, and may comprise up to 6 percent of the thin section (TS+ 448/5 1.19). Trace amounts were also recorded in the carbonate-rich sandstones from the upper part of the sequence. Quartz overgrowths occur on all grain sizes and may be developed on most grains (TS+ 448/S 1.19), a few (TS+ 448/T.4) or on none (TS 448/T2). They are generally clear (Plate 5, p A), and may be distinguished from their detrital cores by the presence of red hematite rims or by the concentration of vacuoles or dust. Original detrital grain boundaries in highly strained samples could notbe recognised, quartz overgrowths in these were inferred from the sheared, interlocking texture of the grains, (TS+ 448/B). Quartz overgrowths on feldspar grains were also recorded, (Plate 5, p B).

(b). Chalcedony Overgrowths are the most dominant type of authigenic quartz in the carbonate-rich sandstones. Authigenic quartz of this type does not occur in samples from the Rhynie Sandstone. This suggests that the presence of carbonate is important, if not vital, to their development. The chalcedony overgrowths are of a fibrous nature, developed perpendicular to the grain boundary. They do not form around the complete grain, but are restricted to the direction paralleling the regional cleavage, (Plate 5, p C). During folding and cleavage development, quartz was dissolved from grain boundaries perpendicular to the principal shortening direction and redeposited in the form of chalcedony overgrowths, in the direction of least strain, the cleavage direction. Like quartz, chalcedony overgrowths occur on all grain sizes, although more easily recognised on larger grains. Generally only a few grains have overgrowths, however, the complete range from most grains having chalcedony overgrowths (TS+ 448/9.4) to none (TS+ 448/1.9) was observed. Overgrowths may also be developed on feldspar grains. Chalcedony is also present in forms other than detrital grain overgrowths, forming small irregular shaped patches or thin fibres normal to cracks developed in carbonate grains.

Feldspar.

Feldspar grains are the second most abundant mineral in any thin section, contributing 15-35 percent of the medium grain size fraction. In any thin section the degree of feldspar weathering and alterations is extremely variable. The association of fresh and weathered grains of similar feldspar type indicates most of the alteration was pre-depositional. (Plate 5, p D). Vacuolisation, replacement by carbonates, and sericitisation are the main types of feldspar alteration. Quartzification, ferruginisation and kaolinisation are less common.

Microline grains indentified by their characteristic gridiron twinning are the most abundant single variety of feldspar, usually comprising over half of the total feldspar count. A higher percentage of these grains are fresh, compared with orthoclase and plagioclase. This indicates that microcline is more stable in the pre-depositional environment, as well as the diagenetic environment and is less affected by surface weathering.

The difficulty of distinguishing untwinned orthoclase from straight extinction quartz necessitated the staining of some thin sections with sodium cobaltinitrite. It was then possible to distinguish quartz (unstained), microcline (stained, with gridiron twinning) and orthoclase (stained, no twinning). Orthoclase generally forms 6-12 percent of the medium grain size fraction, although values as high as 17 percent were recorded, (TS^+ 448/6.1). String, microperthite grains are common in many thin sections, especially in the coarse to very coarse grain size.

Plagioclase is the least abundant variety of feldspar generally comprising less than 5 percent of the grain size fraction analysed. Most plagioclase grains have been altered by sericitisation, although the degree of alteration is extremely variable; from relatively fresh grains containing a few sericite flakes, randomly orientated or along cleavage planes, to highly altered grain which have been completely transformed into a confused aggregate of sericite flakes. The latter appear so structurally weak that it is difficult to imagine these being transported any distance, without complete disassociation. It is therefore concluded that alteration continued to some degree after deposition.

Rock Fragments.

Rock fragments, if present, form only a small percentage of the frame-work grains. The mineralogy of these grains may be used to determine the source rock type. The most abundant rock fragment type consists of quartz, opaque minerals and micaceous (sericite?) material probably of schistose origin. Grains consisting of quartz and feldspar crystals are common, and are either of plutonic igneous or gneissic origin. Rare grains of muscovite schist were observed. There is no apparent stratigraphic control on the occurence of these rock fragment types.

Mica.

Detrital mica flakes occur in many thin sections, in trace amounts (less than 1 percent). Muscovite is by far the most common detrital mica. Small, rare flakes of biotite were observed. Sericite, formed as a result of feldspar alteration, was not included in the total mica count.

Accessory Minerals.

The most common type of non-opaque heavy minerals is small, sub-rounded grains of green and brown tourmaline. Colourless and pink zircon grains are less frequent. These types of accessory minerals are most commonly associated with granitic or pegmatitic source rocks. Opaque heavy minerals occur, but were difficult to identify from thin section.

Matrix.

Two distinct types of primary matrix can be recognised: firstly, a confused association of fine sericite flakes, quartz and feldspar granules, and secondly, a very fine grained carbonate mud matrix. The first type is solely confined to the Rhynie Sandstone, the latter type occurs in all carbonate-rich sandstones from the upper part of the sequence.

The sericite flakes, quartz and feldspar granules comprising the first type of primary matrix are identical to the products resulting from the complete alteration and weathering of feldspar grains. It is suggested this matrix is the result of in-situ feldspar decay and remobilisation of these products during compaction. The rounded to well rounded nature of the detrital grains indicate that the decayed feldspar remains and coarser clastic grains could not have been co-precipitated. If they were, the fine grained feldspar remains would have been winnowed out during rounding of the coarser grains. In thin sections with this type of matrix authigenic quartz overgrowths are rare or absent, (TS^{+} 448/T.2), suggesting the matrix inhibits their formati: This matrix type does not occur in all thin sections from the Rhynie Sandstone, most are cemented by quartz overgrowths, resulting in a mosaic of quartz and feldspar grains, (TS^{+} 448/Sc 1.19).

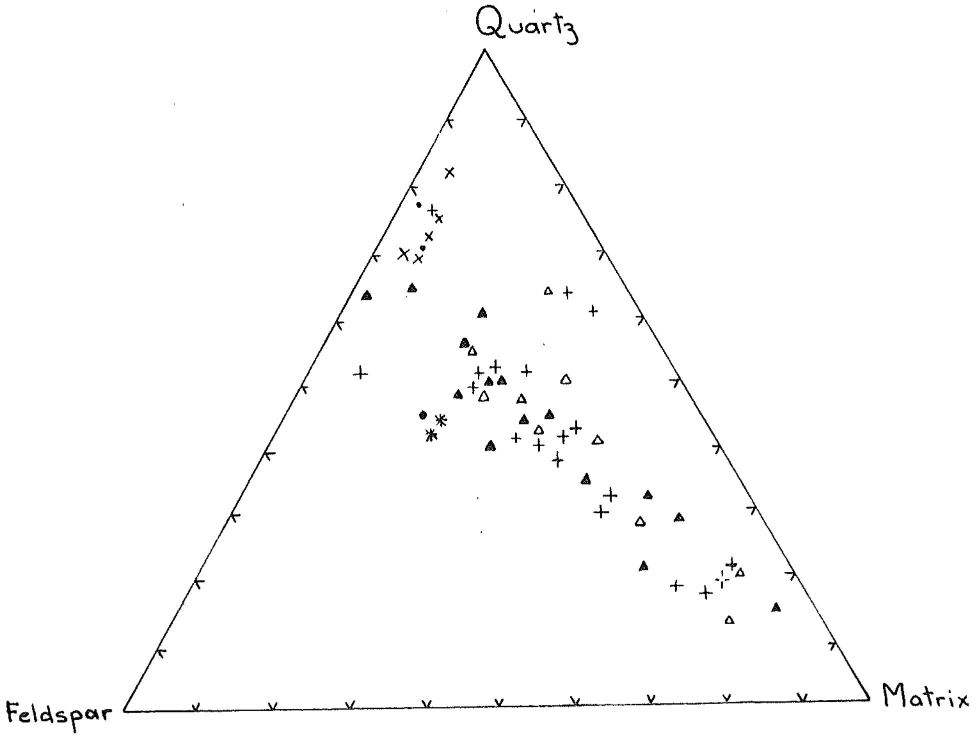
The second type of primary matrix consists of a very fine grained carbonate-mud matrix. It may be patchy or form continuous or discontinuous bands (2 cm thick) and may comprise up to 80 percent of the thin section. This type of rock would be better termed an arenaceous calcarenite, rather than a sandstone. The primary origin of the matrix is indicated by irregular shaped carbonate grains (TS^{+} 448/8.16), intraclasts (TS^{+} 448/12.1c) and thick laminations, (TS^{+} 448/7.1c). In most thin sections the original shape of the carbonate grains have been completely destroyed by compaction forming a fine grained mud matrix, enclosing detrital clastic grains. Subsequent partial recrystallisation of carbonate mud grains has resulted in a coarsely crystalline, carbonate mosaic of subhedral grains. Many of the recrystallised grains have a well developed rhombohedral cleavage and may be twinned. The texture of these thin sections consists of floating clastic grains in a coarsely crystalline mosaic of carbonate rhombehedra. Staining of the rocks from which thin sections were cut, with Alizarine Red S, showed that the carbonate matrix was comprised completely of dolomite. Dolomite is not considered to be the primary carbonate, but the result of dolomitisation of calcite during diagenesis.

Many of the clastic grains incorporated in the matrix have been intensely sutured, obscuring their original shape, (Plate 6, p A). All stages of corrosion can be seen in a single thin section: from well rounded grains to grains with irregular boundaries, to grains reduced to 'spongy' masses, whole cavities are filled by dolomite. Corrosion in some thin sections has resulted in elongated grains orientated in the cleavage plane. During folding, increase strain on grain boundaries perpendicular to the principal shortening direction would increase the amount suturing on these boundaries, thus forming elongated grains (Plate 6, p B). Because of post-depositional corrosion, the degree of sorting in these thin sections listed in Appendix 11, will not be the sorting of the sediments at the time of their deposition.

In many thin sections the dolomite matrix has been partly (Plate 6, p C) or wholly (TS^{+} 448/7.11) replaced by fine-grain chert.

The estimated percentages of quartz, feldspar and matrix in the thin sections studied have been plotted on a triangular diagram in Figure 7.

COMPOSITION OF SANDSTONES



-¦- . . . . . . Appila Tillite.

Δ . . . . . . ? lower Auburn Dolomite Equivalent.

▲ . . . . . . Undalya Quartzite.

\+ . . . . . . Skillogalee Dolomite.

• . . . . . . Unit 3 ⎫

✳ . . . . . . Unit 2 ⎬ Rhynie Sandstone.

× . . . . . . Unit 1 ⎭

FIGURE 7

INTERPRETATION.

An igneous plutonic source contributed most of the clastic grains in the sandstones studied. This is suggested by the abundance of microcline feldspar, the clear nature of the quartz grains, and inclusion types in quartz. Accessory minerals (green and brown tourmaline, zircon) are also more characteristic of this type of source rock. Contributions from gneissic and schistose rocks are indicated by the bimodal nature of the composite quartz grains (Blatt, 1967a) and rock fragment types. There is no evidence to suggest any recycling of older un-metamorphosed sediments. The restricted mineralogy of the sand-stones implies a single source area supplied the detritus to the depositional basin throughout the Burra Group. A preliminary study of direction structures: asymmetric ripple marks and cross-beds in the Rhynie Sandstone and feldspathic sandstones of the Skillogalee Dolomite, indicate the sediments were derived from the west and north-west : the Gawler Platform.

The association of fresh and weathered feldspar grains of the same variety, suggest the accumulation of arkosic sands was due to tectonism in the source area. Active tectonism resulted in granite rocks being brought into the weathering and erosional environment. The high relief created and subsequent large stream run off (and erosion) transported the granitic debris into the depositional basin. The thick sequence of arkosic sands accumulated is more compatible with active tectonism in the source area, rather than simple aggradation on a peneplaned surface, under adverse climatic conditions. The climatic influence on the source rocks and sediments during deposition could not be determined, but is thought to be minimal.

The majority of the thick Rhynie Sandstone sequence is comprised of moderately sorted, texturally mature arkoses. Tectonic arkoses described in the literature from other localities are typically poorly sorted, clayey, immature sands. The increase maturity in the suggested tectonic arkose studied is the result of the granitic debris being deposited in a high energy environment. The detritus supplied would certainly have contained more fine grained material than is preserved in the sediments. Winnowing of the fines during sorting would account for their absence. The final texture of the sediments is therefore not controlled by tectonism, but by the depositional environment. Sedimentary structures in the arkosic sandstones of the Rhynie Sandstone are also suggestive of a high energy, shallow, near shore, marine environment. The similarities in composition and texture throughout the vertical sequence of this formation imply these conditions prevailed for a long time. Throughout this period of sedimentation, a balance was maintained between the rate of supply of debris into the basin and the effectiveness of the depositional environment to sort and destroy unstable grains. The rate of debris supply was sufficient to prevent feldspar grains being subjected to prolonged abrasion and subsequent destruction. If this were not the case, super-mature orthoquartzites would have resulted. Oxidising conditions for the depositional and post-depositional history are indicated by the presence of hematite rims on many of the clastic grains. It is suggested that ilmenite, which is common in the Rhynie Sandstone in other regions outside the area studies, may have been destroyed under certain oxidising conditions (possibly during diagenesis), to form red hematite rims.

Following the sedimentation of the Rhynie Sandstone a thick sequence of dolomites were precipitated. The change from the clastic Rhynie Sandstone sequence to chemical sediments may be the result of a gradual infilling of the depositional basin during the accumulation of unit 4 of the Rhynie Sandstone, or the peneplanation of the source area and consequent decrease in supply of detritus. The dolomitic arkoses interbedded with the dolomite, are interpreted as having accumulated during marine transgressive phases in lagoons, marginal to the coastline and having been reworked seaward during regressive phases. Repeated marine regressions and transgressions, possibly the result of intermittent subsidence of an extremely flat, shallow basin would explain the rhythmic outcropping pattern of these arenites. In so much as the dolomitic arkoses were deposited during marine regressive phases, the expenditure of high energy on these sediments was brief. This is reflected in these sediments being less sorted than those in the Rhynie Sandstone. Time was however, sufficient to winnow out most of the fine grained material and round coarser grains, but these textural characteristics may have occurred en route from a distant source to the depositional basin.

Well-rounded clastic grains and dolomite intraclasts in the dolomite arkosic sandstones (or arenaceous calc-arkoses) of the Undalya Quartzite are evidence that these sediments were also deposited under high energy conditions. Possibly resulting from the ripping up of bedded dolomite and arkosic sands in a near-shore marine environment, and then being redeposited together. Considerable fluctuations in energy are suggested by the banding of fine and coarser grains. Sorting within bands is generally good.

The bulk lithology and textures of the dolomitic arkosic sandstones of the ? lower Auburn Dolomite Equivalent,unit 2, are similar to the Undalya Quartzite. Clastic sediments are not common in units 1 and 3. The influx of arkosic sands into the basin during the deposition of unit 2 could be the result of increase tectonic activity in the source area. Alternatively, these sediments may have been deposited in a similar way as the arkosic sands of the Skillogalee Dolomite.

In as much as this area was unsuited for a detailed study of this kind, due to poor exposure, and that only a small number of thin sections were analysed compared to the thickness of the sequence, these interpretations are only tentative. Further field and petrological investigations in other regions are required to test the validity of these interpretations.

CONCLUSION.

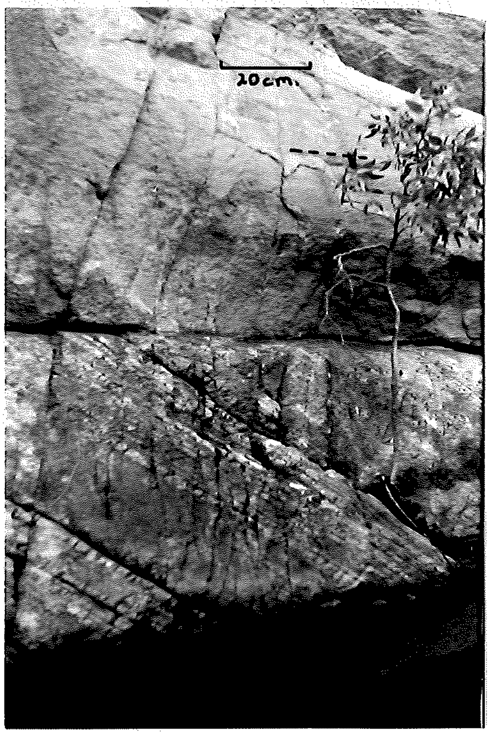
From field and petrological investigations it is concluded that sandstones of sub-arkosic to arkosic composition were derived from a dominantly igneous plutonic source to the west and north-west of the map area. The arkoses have been interpreted as being the result of active tectonism in the source area, rather than aggradation on a peneplaned surface, under adverse conditions. The departure from texturally immature sands cited in the literature for tectonic arkoses, to the texturally mature arkoses studied, is due to granite debris being deposited in a high energy environment. Textural characteristics of the arkoses therefore reflect the environment of deposition rather than the active tectonism in the source area.

PLATE 1.

A. Coarse cross-beds: Rhynie Sandstone, unit 1.
Telowie Gorge

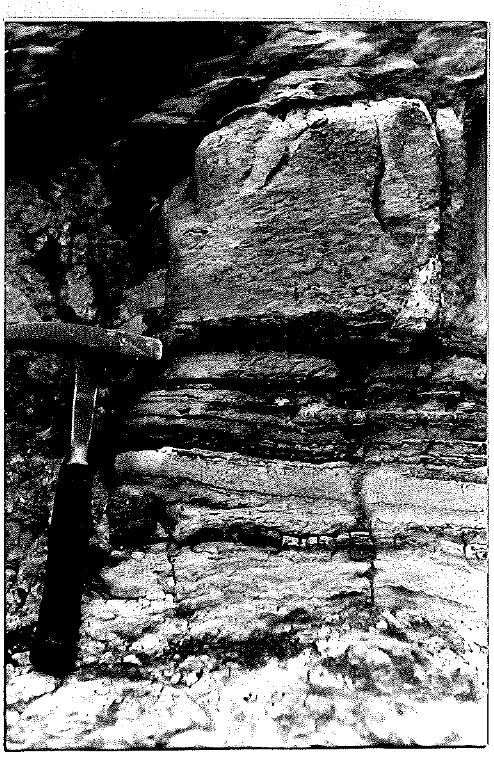
B. Straight, slightly sinuous ripple marks: Rhynie Sandstone, unit 3.

C. Bedded black chert and pelletal magnesite: Skillogalee Dolomite, unit 2.



A

B



C

PLATE I

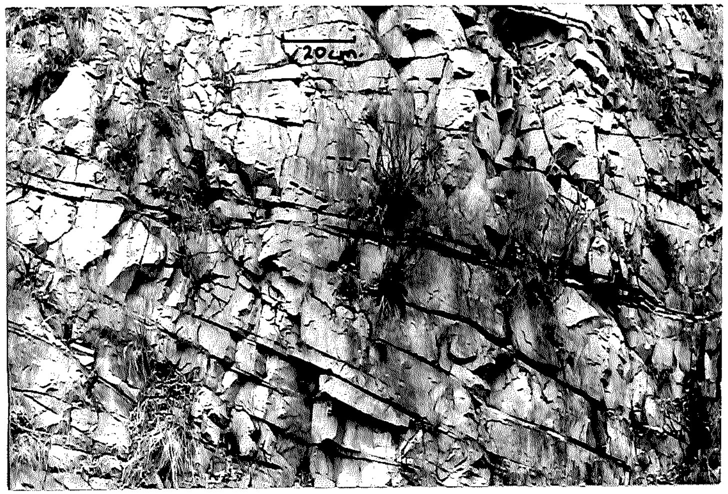
PLATE 2.

A. Coarse cross-beds: Rhynie Sandstone, unit 3.

B. Cross-bedded, heavy mineral laminations:
Rhynie Sandstone, unit 3.

C. Coarse ripple marks: Rhynie Sandstone, unit 4.

D. Drop pebble: Appila Tillite.



A

PLATE 2

B

C

D

PLATE 3.

A. Scoured basal contact between dolomite and Sandstone interbed. Note: dolomite intraclasts in sandstone (arrows): Skillogalee Dolomite, unit 1, sub-lithofacies 1.

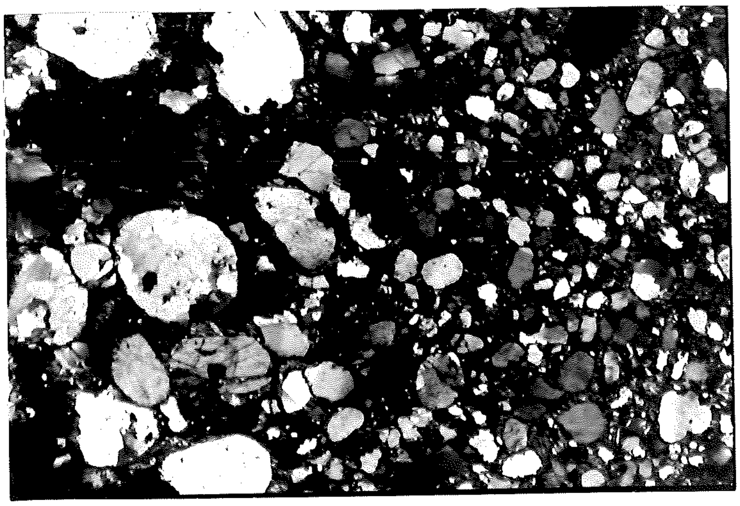
B. Sandstone lense within grey-green laminated siltstone: Skillogalee Dolomite, unit 1, sub-lithofacies 2.

C. Sharply banded fine and coarse clastic grains: Undalya Quartzite, TS 448/9.4., Nicols crossed X 10.

PLATE 3

A

B



C

PLATE 4.

A. Small dome shaped columnar stromatolites: Skillogalee Dolomite, unit 1, sub-lithofacies 1.

B. Cut section of stromatolites. Note: pelletal, siliceous material underlying stromatolites: Skillogalee Dolomite, unit 1, sub-lithofacies 1.

C. Weathered dolomite with irregular shaped sandstone lenses. Note: small, ellipsoid vughs, (arrows). Skillogalee Dolomite, unit 1, sub-lithofacies 1.

A

B

PLATE 4

C

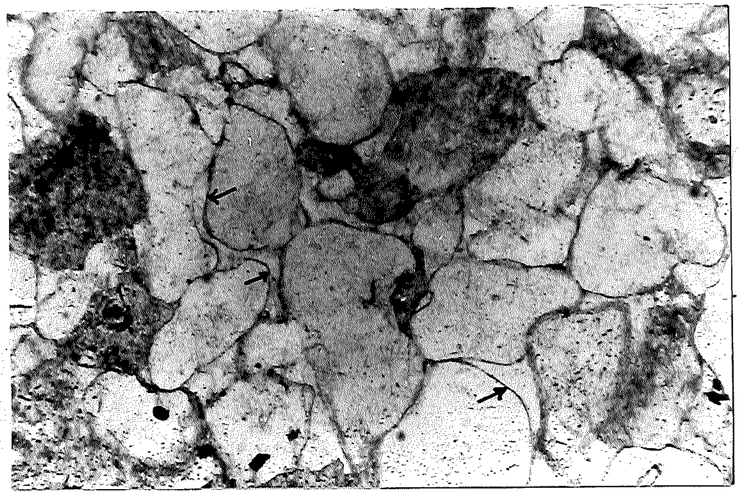
PLATE 5.

A. Quartz overgrowths distinguished from detrital cores by hematite rims (arrows): Rhynie Sandstone, unit 3, TS 448/5.11. Nicols not crossed, X 40.

B. Quartz overgrowth on microcline feldspar (m) grain: Rhynie Sandstone, unit 3, TS 448/Sc 1.19. Nicols crossed, X 100.

C. Chalcedony overgrowths on quartz (qtz) and feldspar (f) grains: Undalya Quartzite, TS 448/9.4. Nicols crossed, X 40.

D. Fresh (f) and weathered (w) microcline feldspar grains: Undalya Quartzite, TS 448/7.11. Nicols crossed, X 40.

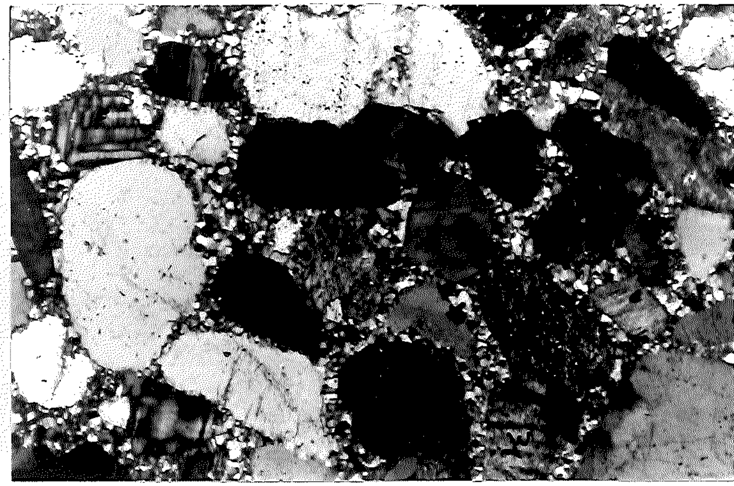


A

PLATE 5

B

C



D

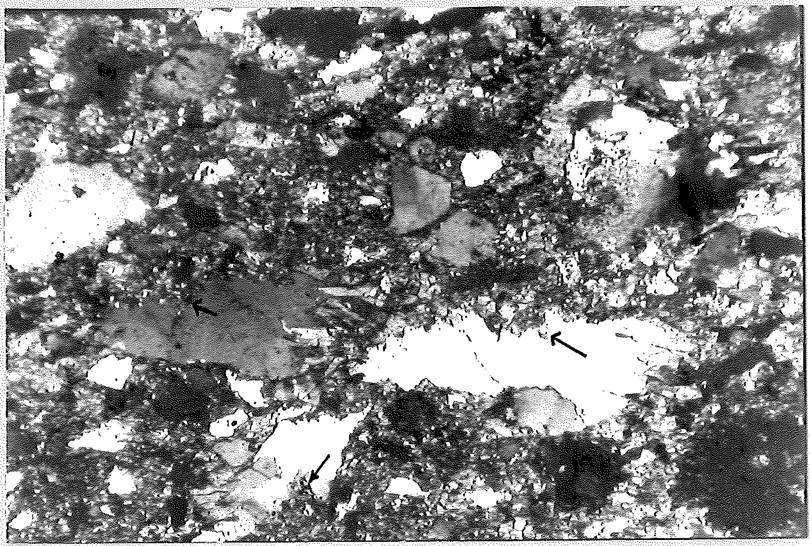
PLATE 6.

A. Quartz grains sutured (arrows) by dolomite matrix: Skillogalee Dolomite, unit 2, TS 448/12.2. Nicols crossed, X 40.

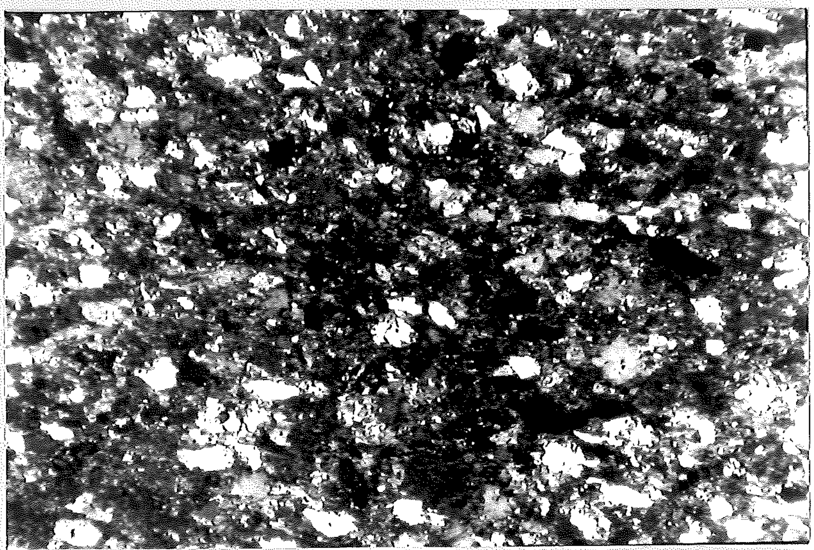
B. Corrosion of clastic grains by dolomite matrix, to form elongated grains, parallel to the cleavage direction: Skillogalee Dolomite, unit 2, TS 448/12.8. Nicols crossed, X 10.

C. Carbonate grain replaced by fine grained chert (arrow): Skillogalee Dolomite, unit 1, TS Sc 3.4. Nicols crossed, X 40.

PLATE 6



A



B

C

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APPENDICES.

APPENDIX 1.

DESCRIPTIONS OF MEASURED STRATIGRAPHIC SECTIONS.

The scarcity of continuous outcrop in the map area, limited the number and length of sections that could be made. Sections were measured by using a 3 metre tape, held at right angles to the bedding. These are diagrammatically shown in Figures A1-1,2,3. The location of sections are shown in Appendix lV.

Section A. Total length of section 435 metres, measured through the upper part of the Rhynie Sandstone, unit 3, unit 4 and the lower part of the Skillogalee Dolomite, unit 1. Actual length of section calculated from Figure 2 is 410 metres.

Section B. Total length of section 57 metres, measured through the upper part of the Skillogalee Dolomite, unit 1.

Section C. Total length of section 10.4 metres, measured at disused B.H.P. mine, (Locality L5) in Skillogalee Dolomite unit 2.

Section D. Total length of section 146 metres, measured through the ? lower Auburn Dolomite Equivalent, unit 1, 2, 3, up to the Appila Tillite. Actual length of section calculated from Figure 2 is 165 metres.

Section E. Total length of section 180 metres measured from the base of the Appila Tillite at locality L8, through the lower half of this formation. Actual length of section calculated from figure 2 is 160 metres.

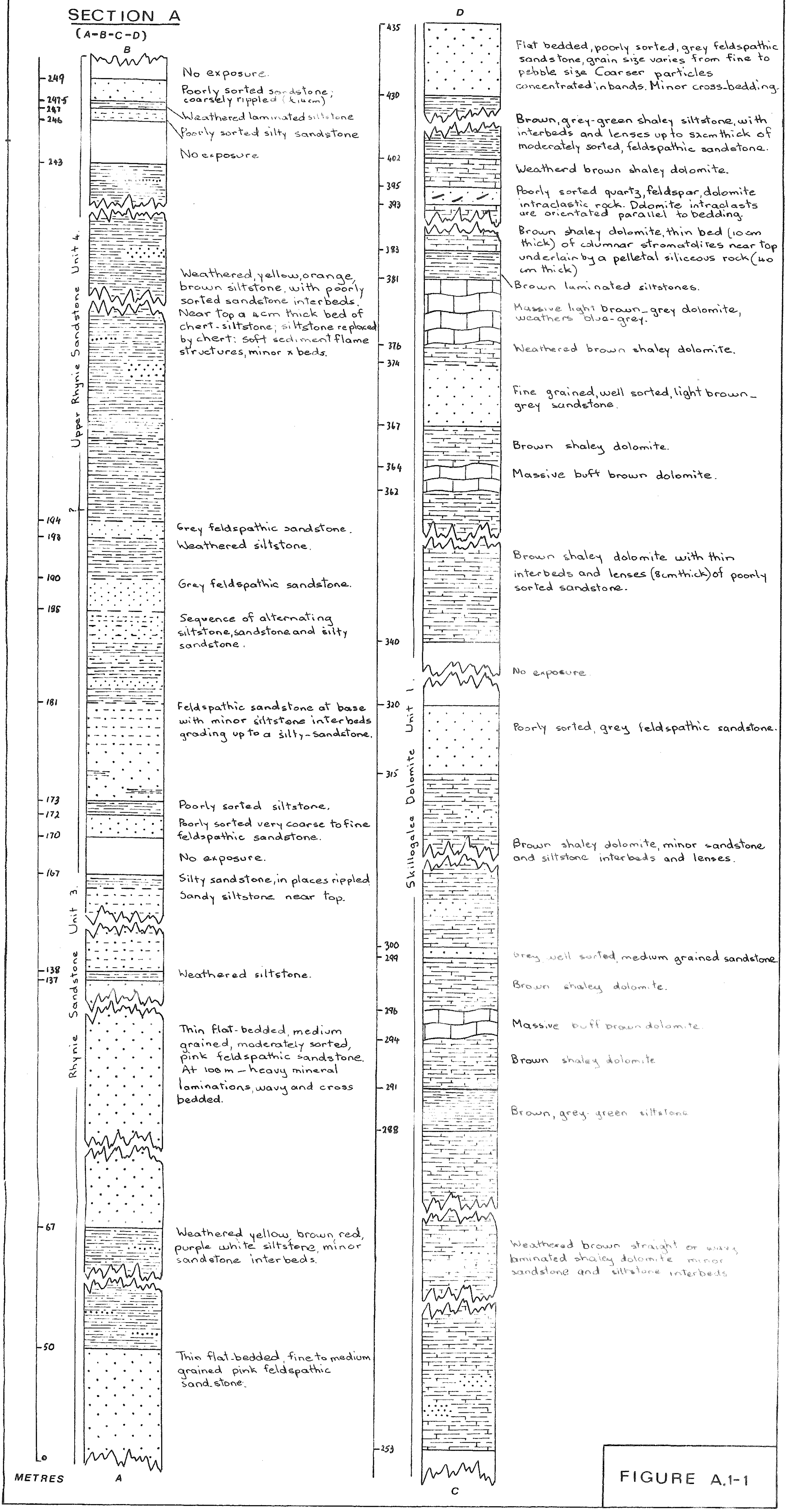
SECTION A
(A-B-C-D)
B
249
247.5
247
246
243
No exposure.
Poorly sorted sandstone; coarsely rippled (λ 14cm)
Weathered laminated siltstone
Poorly sorted silty sandstone
No exposure
Upper Rhynie Sandstone Unit 4.
Weathered, yellow, orange, brown siltstone, with poorly sorted sandstone interbeds. Near top a 4cm thick bed of chert-siltstone; siltstone replaced by chert: soft sediment flame structures, minor x beds.
194
193
190
185
181
173
172
170
167
Grey feldspathic sandstone.
Weathered siltstone.
Grey feldspathic sandstone.
Sequence of alternating siltstone, sandstone and silty sandstone.
Feldspathic sandstone at base with minor siltstone interbeds grading up to a silty-sandstone.
Poorly sorted siltstone.
Poorly sorted very coarse to fine feldspathic sandstone.
No exposure.
Silty sandstone, in places rippled
Sandy siltstone near top.
Rhynie Sandstone Unit 3.
138
137
Weathered siltstone.
Thin flat-bedded, medium grained, moderately sorted, pink feldspathic sandstone. At 100m – heavy mineral laminations, wavy and cross bedded.
67
Weathered yellow, brown, red, purple, white siltstone, minor sandstone interbeds.
50
Thin flat-bedded, fine to medium grained pink feldspathic sand stone.
0
METRES
A
D
435
430
402
395
393
383
381
376
374
367
364
362
Flat bedded, poorly sorted, grey feldspathic sandstone, grain size varies from fine to pebble size. Coarser particles concentrated in bands. Minor cross-bedding.
Brown, grey-green shaley siltstone, with interbeds and lenses up to 5x2cm thick of moderately sorted, feldspathic sandstone.
Weatherd brown shaley dolomite.
Poorly sorted quartz, feldspar, dolomite intraclastic rock. Dolomite intraclasts are orientated parallel to bedding.
Brown shaley dolomite, thin bed (10 cm thick) of columnar stromatolites near top underlain by a pelletal siliceous rock (40 cm thick)
Brown laminated siltstones.
Massive light brown-grey dolomite, weathers blue-grey.
Weathered brown shaley dolomite.
Fine grained, well sorted, light brown-grey sandstone.
Brown shaley dolomite.
Massive buff brown dolomite.
Brown shaley dolomite with thin interbeds and lenses (8cm thick) of poorly sorted sandstone.
340
No exposure.
320
315
Skillogalee Dolomite Unit 1.
Poorly sorted, grey feldspathic sandstone.
Brown shaley dolomite, minor sandstone and siltstone interbeds and lenses.
300
299
296
294
291
288
Grey well sorted, medium grained sandstone.
Brown shaley dolomite.
Massive buff brown dolomite.
Brown shaley dolomite
Brown, grey-green siltstone
Weathered brown straight or wavy laminated shaley dolomite minor sandstone and siltstone interbeds
253
C

FIGURE A.1-1

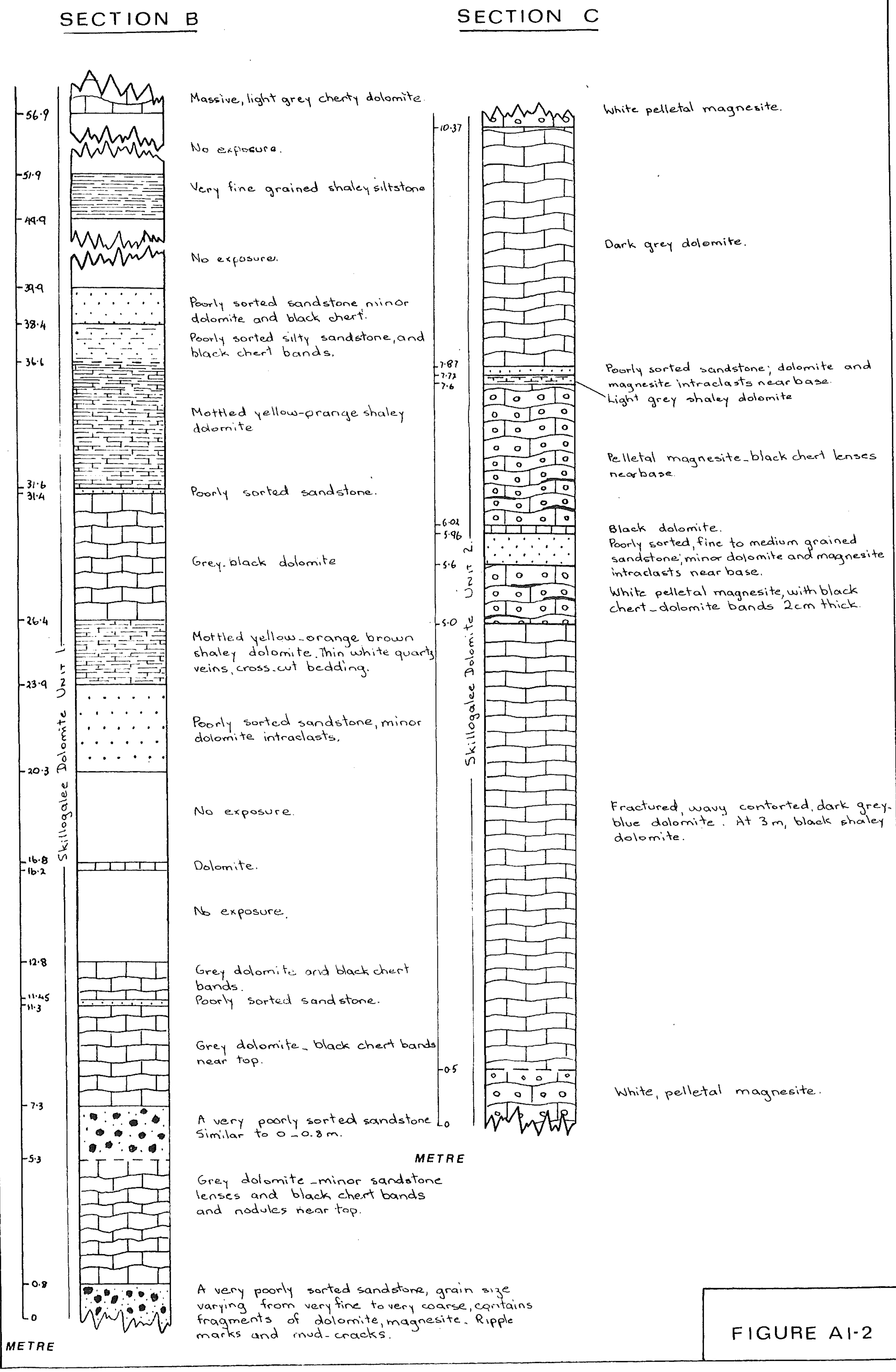
SECTION B
SECTION C
56·9
51·9
49·9
39·9
38·4
36·6
31·6
31·4
26·4
23·9
20·3
16·8
16·2
12·8
11·45
11·3
7·3
5·3
0·8
0
METRE
Skillogalee Dolomite Unit 1
Massive, light grey cherty dolomite.
No exposure.
Very fine grained shaley siltstone
No exposure.
Poorly sorted sandstone minor dolomite and black chert.
Poorly sorted silty sandstone, and black chert bands.
Mottled yellow-orange shaley dolomite
Poorly sorted sandstone.
Grey-black dolomite
Mottled yellow-orange brown shaley dolomite. Thin white quartz veins, cross-cut bedding.
Poorly sorted sandstone, minor dolomite intraclasts.
No exposure.
Dolomite.
No exposure.
Grey dolomite and black chert bands.
Poorly sorted sandstone.
Grey dolomite - black chert bands near top.
A very poorly sorted sandstone Similar to 0 - 0.8 m.
Grey dolomite - minor sandstone lenses and black chert bands and nodules near top.
A very poorly sorted sandstone, grain size varying from very fine to very coarse, contains fragments of dolomite, magnesite. Ripple marks and mud-cracks.
10·37
7·87
7·72
7·6
6·02
5·96
5·6
5·0
0·5
0
METRE
Skillogalee Dolomite Unit 2
White pelletal magnesite.
Dark grey dolomite.
Poorly sorted sandstone; dolomite and magnesite intraclasts near base.
Light grey shaley dolomite
Pelletal magnesite - black chert lenses near base.
Black dolomite.
Poorly sorted, fine to medium grained sandstone; minor dolomite and magnesite intraclasts near base.
White pelletal magnesite, with black chert - dolomite bands 2cm thick.
Fractured, wavy contorted, dark grey-blue dolomite. At 3 m, black shaley dolomite.
White, pelletal magnesite.

FIGURE A1-2

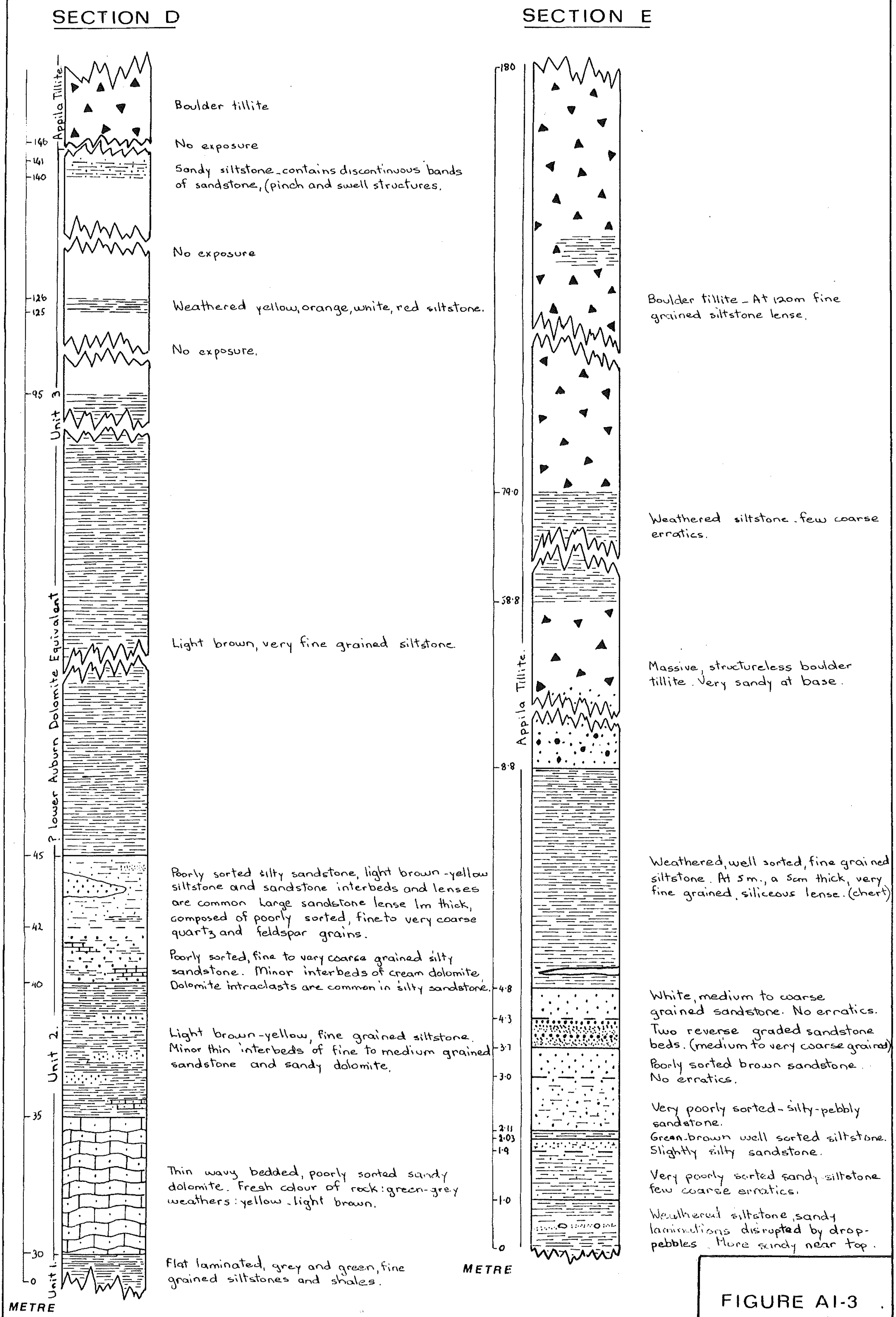
SECTION D
Appila Tillite
Unit 3
? lower Auburn Dolomite Equivalent
Unit 2.
Unit 1.
METRE
146
141
140
126
125
95
45
42
40
35
30
0
Boulder tillite
No exposure
Sandy siltstone - contains discontinuous bands of sandstone, (pinch and swell structures.
No exposure
Weathered yellow, orange, white, red siltstone.
No exposure.
Light brown, very fine grained siltstone.
Poorly sorted silty sandstone, light brown - yellow siltstone and sandstone interbeds and lenses are common. Large sandstone lense 1m thick, composed of poorly sorted, fine to very coarse quartz and feldspar grains.
Poorly sorted, fine to very coarse grained silty sandstone. Minor interbeds of cream dolomite. Dolomite intraclasts are common in silty sandstone.
Light brown - yellow, fine grained siltstone. Minor thin interbeds of fine to medium grained sandstone and sandy dolomite.
Thin wavy bedded, poorly sorted sandy dolomite. Fresh colour of rock: green-grey weathers: yellow - light brown.
Flat laminated, grey and green, fine grained siltstones and shales.
SECTION E
Appila Tillite.
METRE
180
79.0
58.8
8.8
4.8
4.3
3.7
3.0
2.11
2.03
1.9
1.0
0
Boulder tillite - At 120m fine grained siltstone lense.
Weathered siltstone - few coarse erratics.
Massive, structureless boulder tillite. Very sandy at base.
Weathered, well sorted, fine grained siltstone. At 5m., a 5cm thick, very fine grained, siliceous lense. (chert)
White, medium to coarse grained sandstone. No erratics.
Two reverse graded sandstone beds. (medium to very coarse grained)
Poorly sorted brown sandstone. No erratics.
Very poorly sorted - silty - pebbly sandstone.
Green-brown well sorted siltstone.
Slightly silty sandstone.
Very poorly sorted sandy siltstone few coarse erratics.
Weathered siltstone, sandy laminations disrupted by drop-pebbles. More sandy near top.

FIGURE A1-3.

APPENDIX 11.

RESULTS OF POINT COUNTING.

The quantitative results of sandstones analysed using a Swift Automatic Point Counter are listed in table form in the two following pages.

Abbreviations used:

1. Straight extinction quartz.
2. Undulose extinction quartz.
3. Semi-composite quartz.
4. Composite quartz.
5. Microcline feldspar.
6. Orthoclase feldspar.
7. Plagioclase feldspar.
8. Rock fragments.
9. Mica.

tr - trace = less than 1 percent.
% - percent.

Stratigraphic Formation	Thin Section	Sorting	Grain size in m.m.	Matrix Percent	Authigenic Silica	Percentage of medium size framework grains. Quartz 1	Quartz 2	Quartz 3	Quartz 4	Feldspar 5	Feldspar 6	Feldspar 7	Rock Frag. 8	Mica 9	Accessory Minerals: Tourmaline	Accessory Minerals: Zircon	Inclusions in Quartz: Vacuoles	Rutile Needles	Rutile	Feldspar	Zircon	Mica	Tourmaline
Appila Tillite	448/16.1	POOR	·37	70	tr. Ch.	27·5	17·5	18·6	2·3	13·0	12·4	3·4	4·0	–	–	–	X	–	–	–	–	–	–
? lower Auburn Dolomite Equivalent	448/12.8	POOR	·28	75	–	35·7	14·3	20·2	2·4	16·0	9·2	1·2	–	tr	X	–	X	–	–	–	–	–	–
	448/8.14	POOR	·41	35	tr	16·5	34·6	27·1	3·0	12·0	3·7	–	2·2	tr	–	–	X	X	–	–	–	–	–
	448/1.14	POOR	·42	35	–	19·6	35·1	12·8	2·7	18·2	6·8	2·0	2·0	tr	–	–	X	X	X	–	–	X	–
	448/8.18	POOR	·34	40	–	12·8	28·2	26·5	3·4	18·8	9·4	0·8	–	tr	–	–	X	X	–	–	–	–	X
	448/Sc4.1	MODERATE	·39	18	tr.	5·5	30·9	29·8	1·7	16·0	15·5	–	–	–	–	–	X	–	X	–	X	–	–
	448/Sc4.2	POOR - MODERATE	·38	8	–	6·9	34·5	26·6	2·1	17·2	6·9	4·8	–	–	X	X	X	X	–	–	–	–	–
	448/Sc4.3	BIMODAL ?	·47	35	Ch. common	17·8	21·3	20·1	6·5	18·9	8·9	4·1	1·2	tr	X	–	X	X	–	X	–	–	–
	448/8.6	BIMODAL ?	·39	70	ch. common	28·7	17·8	13·8	9·7	17·8	7·4	2·9	1·1	tr	X	–	X	X	–	–	–	–	–
	448/13.4	POOR	·36	30	tr. Ch.	26·7	17·4	9·2	4·6	19·2	7·3	3·4	1·0	–	X	–	X	X	–	–	–	–	–
	448/1-9	POOR - MODERATE	·39	20	–	4·1	25·4	30·1	1·2	21·4	15·0	2·9	–	–	X	–	X	X	–	–	–	–	–
	448/9.18	POOR	·34	45	–	25·9	24·6	14·3	4·5	20·0	6·5	1·3	2·0	tr	X	X	X	X	–	–	–	X	–
Undalya Quartzite	448/10.21	POOR - MODERATE	·48	18	–	13·6	27·9	27·9	3·4	16·8	6·7	2·5	–	–	X	–	X	X	–	–	–	–	–
	448/3.15	POOR	·40	35	–	21·4	15·3	19·8	3·8	22·9	13·7	3·1	–	–	X	–	X	X	–	–	–	–	–
	448/7.11	MODERATE	·46	25	–	21·1	21·1	17·5	3·0	21·7	9·0	6·6	–	–	–	–	X	X	–	–	–	–	–
	448/9.19b	MODERATE	·42	25	tr. Ch.	24·5	16·0	20·9	4·3	15·0	14·1	1·8	1·2	–	–	–	X	X	X	X	–	X	–
	448/1.12	POOR	·43	40	–	34·8	19·3	9·1	5·5	18·3	10·1	2·8	–	–	X	–	X	X	–	–	–	–	–
	448/9.5	POOR	·46	60	Ch common	28·2	19·4	11·8	8·2	19·4	9·4	1·2	1·2	–	–	–	X	X	–	–	X	–	X
	448/9.6	POOR	·31	40	–	2·5	34·2	20·3	2·5	21·5	15·2	2·5	1·3	–	–	X	X	X	–	–	–	X	X
	448/β	–	·47	10	8%	0·6	17·1	45·6	3·2	15·8	15·2	0·3	–	tr	–	–	X	X	–	–	–	X	–
	448/9.7	POOR	·35	80	–	27·1	27·2	15·1	6·3	12·5	10·6	–	0·6	tr	–	–	X	X	–	–	–	–	–
	448/9.14	POOR	·37	47	–	37·9	12·6	16·8	3·2	17·9	9·5	2·1	–	–	X	–	X	X	–	–	–	–	–
	448/1.10	POOR	·27	63	–	47·7	10·2	12·5	3·4	15·9	9·0	1·0	–	–	–	–	X	X	–	–	–	–	–
	448/1.11b	POOR	·36	25	–	16·0	21·8	25·2	5·9	15·9	6·3	3·1	–	–	–	–	X	X	–	–	X	–	–
	448/8.46	POOR	·31	55		24·4	25	14·7	1·2	21·2	9·6	2·0	·6	–	–	–	X	X	–	–	–	–	–

		Sample	Sorting				1	2	3	4	5	6	7	8	9									
Skillogalee Dolomite.		448/12.4b	MODERATE	·45	40	—	17·9	29·3	19·5	4·1	18·7	8·1	0·8	0·8	—	—	—	X	X	—	—	—	X	—
		448/9.1b	MODERATE	·47	35	COMMON	14·9	25·9	27·7	1·7	16·7	12·6	1·2	1·2	—	—	X	X	X	—	—	—	X	—
		448/12.2	POOR-MODERATE	·31	65	—	39·6	13·9	10·4	4·2	20·8	9·0	2·1	—	tr.	X	—	X	X	—	—	—	—	—
		448/L.2	MODERATE	·45	20	tr.	1·6	37·9	24·2	2·4	16·1	11·3	6·5	—	tr.	—	—	X	X	—	X	—	X	X
		448/12.1c	POOR	·29	50	—	29·0	19·1	12·7	2·4	18·1	9·3	6·2	1·0	—	—	—	X	X	—	—	—	X	—
		448/12.1	POOR-MODERATE	·37	40	—	16·8	23·1	25·9	1·6	17·6	9·7	4·9	0·7	tr.	X	X	X	X	X	—	X	X	—
		448/12.18	MODERATE	·39	35	—	13·7	33·8	24·4	4·3	15·0	7·2	7·2	0·7	—	X	—	X	X	—	—	—	—	—
		448/3.9	POOR-MODERATE	·39	70	G. Ch.	32·5	20·6	18·1	4·5	14·2	7·7	0·7	0·7	tr.	X	—	X	X	—	—	—	—	X
		448/Sc2.2	MODERATE	·32	25	—	18·2	27·8	23·2	3·7	17·7	7·8	—	—	tr	—	—	X	X	—	—	—	—	—
		448/3.6	MODERATE	·30	52	—	31·6	12·9	14·8	2·6	20·0	10·3	7·1	0·6	tr	X	—	X	X	—	—	—	X	X
		448/3.5	MODERATE	·31	70	—	29·7	19·4	14·2	1·9	20·6	7·7	6·5	—	—	X	X	X	—	—	—	—	X	—
		448/Sc2.1	MODERATE - WELL	·48	12	—	2·9	22·4	35·8	2·9	19·4	13·4	—	2·9	—	—	—	X	X	—	—	—	—	—
		448/10.11b	POOR	·37	80	—	22·8	22·8	24·4	5·5	13·4	8·7	0·8	—	—	—	—	X	X	—	—	—	—	—
		448/10.9	MODERATE	·37	20	—	11·4	27·2	33·3	1·7	17·5	8·8	—	—	—	X	X	X	X	—	—	—	X	—
		448/6.1	POOR-MODERATE	·38	8	—	0·6	23·5	29·4	1·6	23·0	17·1	3·7	—	tr	—	—	X	—	—	—	X	—	—
		448/Sc3.4	WELL	·46	40	—	30·1	17·3	17·3	4·5	17·9	7·7	4·5	0·6	—	X	—	X	X	—	—	—	—	X
		448/Sc3.2	MODERATE	·47	26	—	19·5	28·0	20·0	1·9	18·2	8·2	1·9	0·6	tr	—	—	X	X	X	—	—	X	—
		448/7.3c	POOR-MODERATE	·35	35	—	27·6	15·3	18·3	3·7	19·0	12·3	3·7	—	tr	X	X	X	X	—	—	—	—	—
		448/7.1	MODERATE	·32	3	tr	1·9	30·4	29·8	2·5	19·8	12·4	3·1	—	tr	X	X	X	X	—	—	—	—	—
		448/7.1b	—	·27	90	—	30·5	20·6	21·1	2·8	13·8	6·5	2·1	1·4	tr	X	—	X	X	—	X	X	—	—
		448/Sc1.1	POOR-MODERATE	·40	7	tr	25·4	34·6	16·9	—	16·2	6·9	—	—	tr	X	—	X	X	—	—	X	X	—
Rhynie Sandstone.	UNIT 3	448/Sc1.19	WELL	·42	6	6%	31·5	28·2	16·9	0·8	14·5	6·4	—	—	—	—	—	X	X	—	—	—	—	—
		448/Sc1.16	POOR-MODERATE	·36	3	1-2%	21·5	26·9	28·5	1·5	11·5	6·2	1·5	2·3	tr	X	X	X	X	—	X	—	—	—
		448/5.4	MODERATE	·31	15	1-2%	31·0	41·5	21·7	5·7	—	—	—	—	tr	—	X	X	X	—	—	X	—	—
		448/5.11	WELL	·34	5	5%	21·2	48·1	26·9	3·8	—	—	—	—	tr	X	—	X	X	—	—	—	—	—
		448/N.6	MODERATE - WELL	·43	6	4%	13·1	36·1	50·8	—	—	—	—	—	tr	X	—	X	X	—	—	—	—	—
	UNIT 2	448/N.4	POOR-MODERATE	·28	20	tr	9·1	21·0	22·8	1·7	27·1	13·7	2·0	3·1	tr	X	X	X	X	—	—	—	—	—
		448/N.2	MODERATE	·28	20	—	12·6	24·1	18·7	2·1	26·5	12·7	1	2	tr	X	—	X	X	—	—	—	—	—
	UNIT 1	448/T.1	WELL	·48	4	4%	24·2	26·6	27·3	3·1	9·4	7·0	—	1·5	cr	X	—	X	X	X	X	X	—	—
		448/T.2	WELL - V.WELL	·34	6	—	13·5	29·8	27·4	2·8	18·4	7·8	—	—	tr	X	—	X	X	—	—	—	X	—
		448/T.3	MODERATE	·46	5	4%	8·8	39·4	24·8	2·2	12·4	10·2	—	2·2	tr	—	—	X	X	—	—	X	X	—
		448/T.4	WELL	·43	5	tr	7·1	36·2	27·7	3·6	13·5	9·2	—	2·8	—	X	—	X	—	—	—	—	—	—
		488/T6	MODERATE - WELL	·37	4	4%	11·7	23·4	33·1	2·0	19·5	9·7	—	0·7	tr	—	—	X	X	—	—	—	—	—

APPENDIX 111.

ROCK AND THIN SECTION DESCRIPTIONS.

Rock and thin section (TS) descriptions of specimens to which reference has been made in the text, held under the accession number 448- by the Geology Department, Adelaide University. Locations of samples collected within map area are shown in Appendix 1V.

448/T.6 Rhynie Sandstone, unit 1, (Nelshaby Sandstone). A light pink, well sorted, medium grained feldspathic sandstone. Grains are generally rounded.

TS 448/T.6 A medium grained, texturally mature, moderate to to well-sorted arkose. Most grains are rounded and have thick red hematite rims.

Contains: 66% sub-rounded to rounded quartz.
20% twinned, microcline feldspar.
10% orthoclase feldspar.
4% authigenic quartz overgrowths.
trace - muscovite and rock fragments.

448/N.5 Rhynie Sandstone, unit 2, (Wirrabara Formation). A very fine grained, well-sorted, wavy laminated, blue-grey siltstone.

448/Sc. 1.19 Rhynie Sandstone, unit 3. A light maroon, medium grained, well-sorted feldspathic sandstone. Stratification is indicated by darker laminae.

TS 448/Sc. 1.19 A medium grained, texturally mature, moderate to well-sorted arkose. Most grains are rounded, some have thin red hematite rims. The rock is cemented by clear, authigenic quartz overgrowths.

Contains: 73% rounded quartz.
15% twinned microcline feldspar.
6% orthoclase feldspar.
6% authigenic quartz overgrowths.

448/5.4 Rhynie Sandstone, unit 3. A highly weathered, pink, moderately-sorted fine to medium grained sandstone. Composed of rounded quartz and white weathered feldspar specks.

TS 448/5.4 A weathered, medium grained, moderately-sorted sandstone. Feldspar grains have been post- depositionally weathered out, giving the rock an orthoquartzite composition.

Contains: 95% strained and unstrained quartz.
5% weathered feldspar remains.
Accessory mineral - 1 rounded zircon grain.

448/Sc 1.16 Rhynie Sandstone, unit 3. A pink to purple, moderately-sorted, fine to medium grained feldspathic sandstone.

TS 448/Sc 1.16 A medium grained, poor to moderately sorted sub-arkose, cemented by authigenic quartz overgrowths.

Contains: 77% quartz.
11% microcline feldspar
6% orthoclase feldspar.
2% plagioclase feldspar.
1% rock fragments: muscovite schist and quartz-feldspar.
2% authigenic quartz overgrowths.
Accessory minerals - muscovite rounded green tourmaline and zircon.

TS 448/4.3 Rhynie Sandstone, unit 4.
A red-orange, laminated chert (jasper) siltstone. The rock is the result of silicification of siltstones.

Contains: 90% chert-jasper.
5% very fine grained quartz
5% fine grained muscovite.
trace - feldspar.

448/5.14 Rhynie Sandstone, unit 4.
A red, laminated chert (jasper).

448/5.14a Rhynie Sandstone, unit 4.
A brecciated, red-brown chert.

448/7.5 Skillogalee Dolomite, unit 1, sub-lithofacies 1.
A light brown, weathered, fine-grained, laminated shaley dolomite.

448/4.5a Skillogalee Dolomite, unit 1, sub-lithofacies 1.
A buff brown, laminated, dendritic dolomite. Post-depositional pressure solution has resulted in formation of stylolites.

448/Sc 1.5 Skillogalee Dolomite, unit 1, sub-lithofacies 1.
A siliceous pelletal rock. Individual pellets are round to oval shaped, average size 4 mm. These are cemented by a silica or clayey matrix.

448.4.5 Skillogalee Dolomite, unit 1, sub-lithofacies 2.
A grey-green, brown, shaley siltstone. Flat and wavy laminated, finely rippled.

TS 448/4.5 A very fine grained, laminated and finely rippled siltstone. Minor amounts of fine clastic material concentrated in laminations.
Contains: 90% very fine grained, grey-brown matrix: red Fe stained in places.
10% fine grained clastics - quartz and microcline feldspar.
Opaques - common.

448/3.1 Skillogalee Dolomite, unit 1, sub-lithofacies 2.
A laminated fine grained grey siltstone: which has been diagenetically replaced by chert to form a hard siliceous chert-siltstone. Small red specks (? hematite) are common on lamination planes.

448/4.10 Skillogalee Dolomite, unit 1, sub-lithofacies 2.
A flat-laminated, very fine grained chert-siltstone.

448/Sc 1.1 — Skillogalee Dolomite, unit 1, sub-lithofacies 3.
A weathered, brown to grey, poorly-sorted fine to coarse grained feldspathic sandstone.

TS 448/Scl.1 — A poor-moderately-sorted, sub-arkose.

Contains:
- 77% sub-round to rounded quartz.
- 16% microcline feldspar.
- 6% orthoclase feldspar.
- 1% muscovite.

Accessory Minerals - green tourmaline and pink zircon.

448/2.7 — Skillogalee Dolomite, unit 2.
Dark grey-black oolithic chert-dolomite.

TS 448/2.7 — Oolithic Dolomite. Some oolites have grown around quartz or microcline feldspar grains, few show concentric growth rings. Average size of round and oval shaped oolites is 0.75 mm. Fine grained dolomite and chert comprise 20% of thin section.

448/3.13 — Skillogalee Dolomite, unit 2.
A fragmental dolomite and magnesite rock. Diagenetic silicification has converted the rock into a chert.

448/7.16 — Skillogalee Dolomite, unit 2.
Sandy laminated dolomite, with a thin band of black chert parallel to bedding.

448/7.16 — Skillogalee Dolomite, unit 2.
A light brown-grey, faintly graded bedded feldspathic sandstone. Grain size varies from very coarse to fine. Very coarse grains are angular to sub-rounded and concentrated in thin beds.

TS 448/6.1 — A poor to moderately-sorted, fine to medium grained arkose.

Contains:
- 54% strained quartz.
- 21% microcline feldspar.
- 15% orthoclase feldspar.
- 2% plagioclase feldspar.
- 8% carbonate matrix.

TS 448/3.6 — Skillogalee Dolomite, unit 2.

A moderately-sorted, dolomite cemented arkose. Quartz and feldspar grains have been intensely sutured by the carbonate matrix. Small dolomite lathes and grains are common.

Contains: 45% carbonate matrix- partly recrystallised and replaced by very fine grained chert.
30% quartz.
12% microcline feldspar.
5% orthoclase feldspar.
5% carbonate grains and lathes.
3% plagioclase feldspar.

Accessory Minerals - Muscovite, green and red tourmaline.

448/ScM — Skillogalee Dolomite, unit 2.

Light grey weathering to white pelletal magnesite.

448/9.4 — Undalya Quartzite.

A reverse graded bedded, brown-green dolomite-sandstone. Fine to coarse grained, sub-rounded to rounded quartz and feldspar grains comprise 50% of the rock.

TS 448/9.4 — Poor to moderately-sorted, dolomitic sub-arkose. Sub-rounded to well-rounded quartz, and feldspar grains in a very fine grained dolomite matrix. Chalcedony overgrowths occur on most grains.

Contains: 45% dolomite matrix.
40% quartz.
10% microcline feldspar.
5% orthoclase feldspar
trace - plagioclase feldspar.

448/9.3 — ? lower Auburn Dolomite, unit 2.

Sandy mottled, brown siltstone. Sand lenses are fine to medium grained, moderately-sorted.

448/10.14 ? lower Auburn Dolomite, unit 2.
A brown-green dolomitic feldspathic sandstone. Poorly sorted, fine to coarse quartz and feldspar grains comprise 50% of rock, in a fine grain dolomite matrix. Green dolomite intraclasts are common.

448/13.11 ? lower Auburn Dolomite, unit 2.
A medium grained, well-sorted sandstone contains intraclasts of dark green dolomite.

448/3.17 ? lower Auburn Dolomite, unit 3.
A dark to light green, laminated, fine-grained siltstone.

448/8.7 Appila Tillite, lithofacies 1
A very fine grained, laminated brown siltstone. Contains one pebble-sized, fine grained quartzite erratic.

448/T Appila Tillite, lithofacies 2.
Poorly sorted, arenaceous, calcarenite. Clastic quartz, feldspar and rock fragment grains total 40% of the rock, in a very fine grain dolomite matrix.

TS 448/T Poorly sorted, arenaceous calcarenite.
Contains:
- 60% dolomite-fine-grained mud, in places recrystallised.
- 23% quartz.
- 8% microcline feldspar.
- 6% orthoclase feldspar.
- 2% rock fragments.
- 1% plagioclase feldspar.
- trace - chalcedony overgrowths and chert.

448/8/16 Appila Tillite, lithofacies 3.
Medium grained, moderately sorted, cross-bedded, slightly feldspathic, quartz sandstone.

448/7.9 Appila Tillite, lithofacies 4.
Very poorly-sorted, pebbly litharenite

APPENDIX IV.

LOCATION OF SAMPLES AND SECTIONS.

See Figure A4 in folder at the back of the thesis.