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DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

003

GEOLOGICAL SURVEY
NON METALLIC RESOURCES DIVISION

GEOLOGY OF THE BUNKERS GRABEN CENTRAL FLINDERS RANGES

By

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(Student - South Australian Institute of Techonology)

PREFACE

This thesis has been compiled from geological field work and ideas of my own, except for those parts acknowledged in the text. No part of this thesis has been submitted previously for a diploma or degree at this Institute or elsewhere.

Ross K. Forsyth.

ACKNOWLEDGEMENTS

I would like to acknowledge the cooperation of Jeff Olliver (Supervising Geologist) in development of the programme, and other personnel including L.C. Barnes (Senior Geologist), W.S.McCallum, I.J. Townsend, J.H. Oors, and P.P. Crettenden and R.J. Harris of the Non Metallics Resource Division, South Australian Department of Mines and Energy, for their assistance and guidance in the field.

I am grateful for the assistance from B. Dalgarno (Supervising Geologist), B. Forbes (Senior Geologist) and R. Coats of the Regional Mapping Division, of the South Australian Department of Mines and Energy. I record my thanks to Amdel for preparation and description of thin sections, and also to A. Francis for drafting of the geological map.

Thanks are due to Malcolm Nickels and Bernie Matthews (Australian Barytes Pty. Ltd.) for providing accommodation and other facilities whilst field work was carried out.

FRONTISPIECE.

Oraparinna Mine, in Bayley Range Siltstone Member (Brachina Formation). View to the north.

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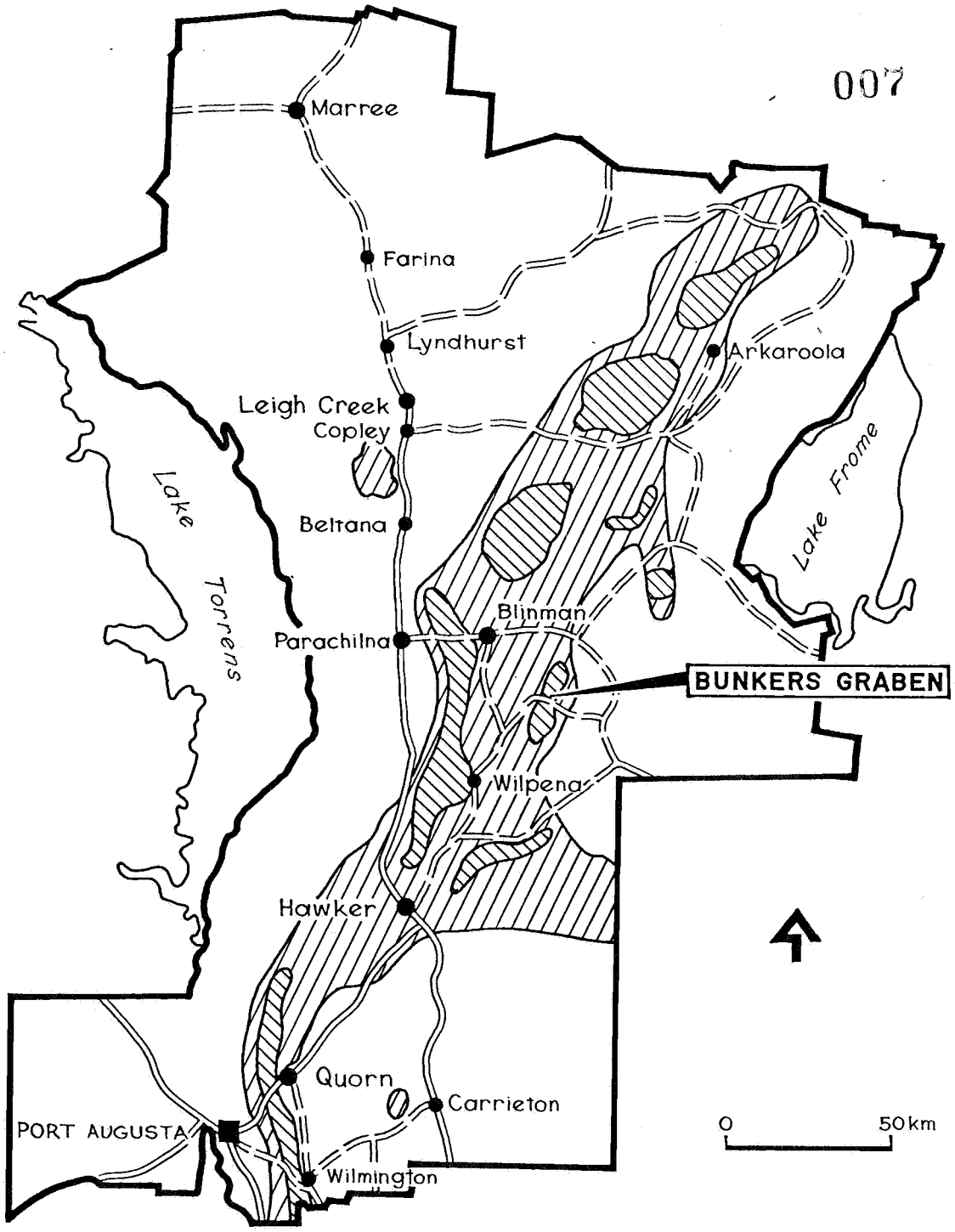

ENVIRONMENTAL AREAS

- Class A
- Class B
- Class C

- Country Township
- Special Township
- Main road
- Secondary road

Fig. 1

DEPARTMENT OF MINES — SOUTH AUSTRALIA

INDUSTRIAL MINERALS SECTION	Drn. R.F.	FLINDERS RANGES PLANNING AREA	SCALE: 1:2 000 000
	Tcd. A.F.	**BUNKERS GRABEN**	S 13724
	Ckd.	LOCALITY PLAN	
	Exd.		DATE: OCT. 1978

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

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GEOLOGY OF THE BUNKERS GRABEN CENTRAL FLINDERS RANGES

ABSTRACT

The sandstone, siltstone and shale facies of the Wilpena Group were deposited in a shallow marine environment, during the Middle to Late Marinoan. Development of the Bunkers Graben is structurally controlled by faulting related to diapiric activity between Middle Sturtion and Lower Palaeozoic. Barite in the Oraparinna, Roberts and Western Lodes is industrial grade quality.

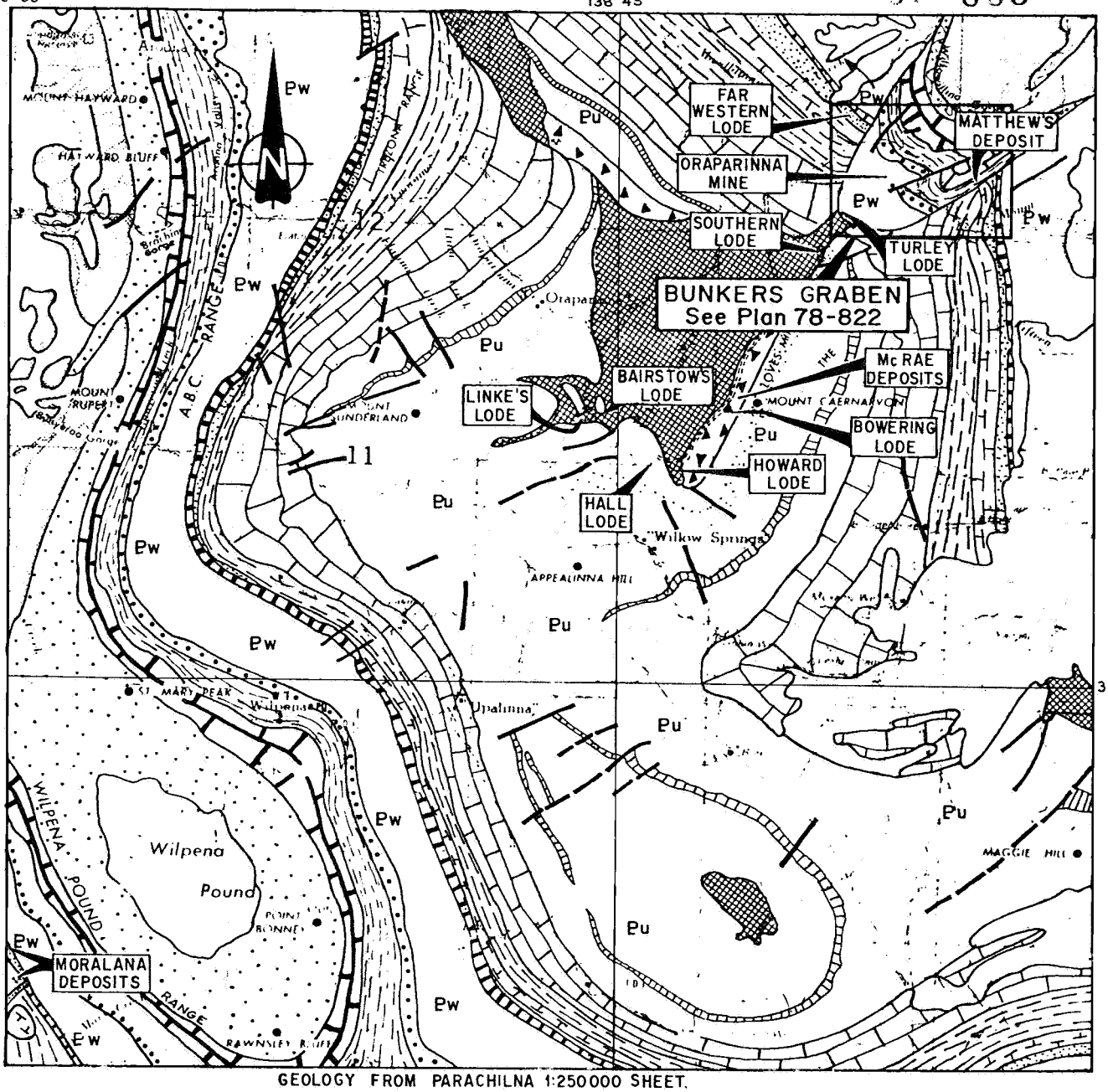
INTRODUCTION

The Bunkers Graben is approximately 40 km north east of Wilpena Chalet and is located within the County of Taunton. Well graded gravel roads make the area readily accessible, except after torrential rains. Situated in a Class A and Class B Environmental Area, mining must be in accordance with the Flinders Ranges Planning Area Development Plan (see Figure 1). 50 rock samples (P 204/78 - P 253/78) and 11 barite samples (P 460/78 - P 471/68) were collected, with thin sections prepared by Amdel.

Hot dry summers and cool dry winters with intermittent rainfall typify the climate of the area. Vegetation is characterised by sparse growth and large gums outlining the creek beds.

The aim of this project was to map the geology of the Bunkers Graben and record any potential barite deposits within the region.

For the purpose of this report the Oraparinna structure has been referred to informally as the Bunkers Graben. This project was carried out in accordance with the requirements of the Applied Geology course at the South Australian Institute of Technology, whilst employed at the South Australian Department of Mines and Energy, during the period January-February 1978.



GEOLOGY FROM PARACHILNA 1:250000 SHEET.

PALAEOZOIC QUAT. — Superficial deposits.

PALAEOZOIC Cambrian — UNDIFFERENTIATED: Wilkawillina Lst. Pardra Lst. Bunkers sst., Oraparinna Shale, Billy Creek Formation.

PROTEROZOIC Adelaide System

- POUND QUARTZITE: White quartzite and red feldspathic sandstone.
- WONOKA FORMATION: Calcareous shale and flaggy limestone.
- BUNYEROO FORMATION: Purple and green dolomitic shale.
- A.B.C. RANGE QUARTZITE.
- Pw — BRACHINA FORMATION: Greenish grey siltstone with lenticular sandstone interbeds.
- NUCCALEENA FORMATION: Brown weathering purple dolomite.
- ELLATINA FORMATION: Pink sandstone and feldspathic greywacke.
- TREZONA FORMATION: Grey shales with interbeds of purple limestone.

PROTEROZOIC Adelaide System

- ENORAMA SHALE: Purple weathering green shale.
- ETINA FORMATION: Sandy-limestone and grey shale.
- WOCKERAWIRRA DOLOMITE.
- Pu — TAPLEY HILL FORMATION: Blue grey laminated siltstone.
- Mount Caernarvon Greywacke Member.
- WILYERPA FORMATION: Arkosic quartzite and siltstone. Includes Holowilena Ironstone

Dolomites, dolomitic siltstones and breccias.

Fault.

TURLEY LODE — Barite Deposit.

SCALE 1:250,000

km. 5 0 5 10 km.

Fig. 2

	DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	SCALE 1:250000
COMPILED L. Barnes.	BARITE DEPOSITS — ORAPARINNA DIAPIR AND BUNKERS GRABEN LOCATION & REGIONAL GEOLOGY	DATE OCT. 1978
DRN G.J.T. | CKD		PLAN NUMBER S13725

REGIONAL GEOLOGY

Sediments within the Bunkers Graben are of Marinoan age and constitute part of the Umberatana and Wilpena Groups. Final formation of the cone shaped graben occurred in Early Cambrian times, during the last recorded phase of diapiric activity. The competent ABC Range Quartzite highlights the faulting and fracturing in the centre and structural flanks of the graben. The strata within the graben generally dip between 30^{o}-45^{o} to the northeast. However, the Nuccaleena Formation at the extreme south western tip of the Bunkers Graben dips 85^{o}-90^{o} to the northeast, due to intense deformation and recrystallisation during diapiric activity. Sandstone, siltstone and shale facies predominate throughout the region. Figure 2 depicts the regional geology of the Bunkers Graben.

STRATIGRAPHY

PROTEROZOIC

ADELAIDE SYSTEM

UMBERATANA GROUP (COATS, 1964) (See Figure 3)

TREZONA FORMATION. (DALGARNO AND JOHNSON, 1964)

The only Trezona Formation within the graben is a small fault bounded sliver on the north eastern margin. (see Figure 4).

The Trezona Formation consists of a light brown coloured recrystallised pelletal limestone with interbeds of grey green calcareous siltstone. Oolites (about .3mm in diameter) are disseminated throughout the limestone, with calcite constituting between 85-95% of the total rock (P 229/78). Calcite forms coarser grained vein and fracture fillings up to several millimetres in width. The siltstones show occasional cross laminations and Dalgarno and Johnson (1964), reported the presence of sand filled mudcracks and rain prints, in the upper section of the formation in Enorama Creek. Vegetation is stunted on

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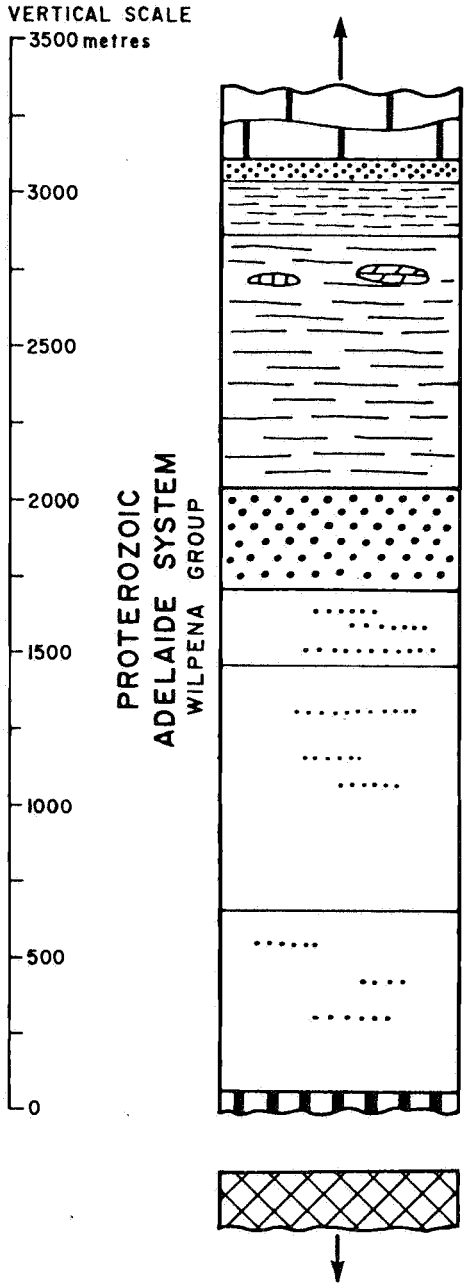

WONOKA FORMATION
Flaggy limestone with siltstone interbeds.

BUNYEROO FORMATION
UNIT III Purple siltstone

UNIT II Green shale with fine-grained sandstone interbeds.

UNIT I Fissile red shales with limestone and dolomite interbeds.

A B C RANGE QUARTZITE
Sandstone, siltstone, quartzite.

BRACHINA FORMATION
BAYLEY RANGE SILTSTONE MEMBER Siltstone and fine and medium grained sandstone and shale interbeds.
Olive-green

MOORILLAH SILTSTONE MEMBER Siltstone and fine grained sandstone interbeds.
Reddish-brown

grey to reddish brown - feldspathic

MOOLOOLOO SILTSTONE MEMBER Siltstone and fine grained sandstone interbeds.

NUCCALEENA FORMATION
Dolomite, siltstone.

CALLANNA BEDS
Diapiric breccia.

Note : All thicknesses were measured in the central axis of the graben.

Fig. 3

	DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	1:25 000 Vert.
COMPILED R. Forsyth		OCT. 1978
DRN. A.F.	BUNKERS GRABEN STRATIGRAPHIC COLUMN	S13726

the formation. The Trezona Formation crops out boldly in the form of cuestas, in the north east of the graben.

WILPENA GROUP (DALGARNO AND JOHNSON, 1964) (See Figure 3)

NUCCALEENA FORMATION (DALGARNO AND JOHNSON, 1964)

The Nuccaleena Formation is represented by two members. The basal member is a well bedded pink to purple dolomite, 10m thick, (P 252/78) and the upper member is represented by a series of purple siltstones with dolomite interbeds. The thickness of the Nuccaleena Formation within the graben is approximately 50m. Due to its persistence, it is a useful marker bed throughout the Flinders Ranges. Outcrop is poor to the north and east, outside the graben. However, at the extreme southern portion of the graben, outcrop is bold, marking the disconformable contacts between the Wilpena Group and Oraparinna Diapir.

Minor cross laminations 1 cm thick and laminae between 1-4 mm thick are present within the formation. The Nuccaleena Formation forms small prominent ridges within the surrounding topography. Contact between the Nuccaleena Formation and the Brachina Formation is gradational.

BRACHINA FORMATION (DALGARNO AND JOHNSON, 1964)

MOOLOOLOO SILTSTONE MEMBER. (LEESON, 1970)

The Mooloolloo Siltstone Member, the lowest member of the Brachina Formation, represents about one third of the total formation The Mooloolloo Siltstone Member consists of grey to reddish brown feldspathic siltstones (P 249/78) with fine grained sandstone interbeds. The presence of laminae, varying from 2mm-8mm thick and minor scale cross bedding were noted. The lower 200 m of this member consists entirely of reddish purple silstones. The thickness within the graben is about 600m. Due to the lack of

outcrop within the area and local intertonguing within the siltstone-sandstone facies, between the Mooloolo Siltstone Member and Moorillah Siltstone Member, the boundary was not clearly established.

MOORILLAH SILTSTONE MEMBER, (LEESON, 1970)

The Moorillah Siltstone Member consists of about 800 m of reddish brown unbanded and banded siltstones with fine grained feldspathic sandstone interbeds. Towards the top, sandstone interbeds are more frequent and rare medium grained quartzite interbeds are also present. Small scale cross bedding and abundant soft sediment deformation structures are commonly displayed. The Moorillah Siltstone Member crops out as moderately high hills. The contact between the Moorillah Siltstone Member and the Bayley Range Siltstone Member is transitional.

BAYLEY RANGE SILTSTONE MEMBER (LEESON, 1970)

The Bayley Range Silstone Member is distinguished from the Moorillah Siltstone Member by the increase in grain size and frequency of the sandstone interbeds. The Bayley Range Siltstone Member consists of olive green laminated siltstone with common fine and medium grained sandstone and shale interbeds. The Bayley Range Siltstone Member is the youngest member of the Brachina Formation and has a thickness of about 250 m. Near the upper boundary of the Bayley Range Siltstone Member and the overlying ABC Range Quartzite, abundant medium grained sandstone lenses and small scale sedimentary structures are present. This rock unit tends to form foothills to the more resistant ABC Range Quartzite. Abundant intertonguing between the Brachina Formation and ABC Range Quartzite depict a gradational conformable contact.

ABC RANGE QUARTZITE (DALGARNO AND JOHNSON, 1964)

The ABC Range Quartzite within the graben displays a variable range of lithologies. At the base of the formation, intertonguing with the Bayley Range Siltstone Member is prevalent. Lenses of medium grained quartzite and green siltstone interbeds mark the base of the ABC Range Quartzite. These are overlain by purple coloured argillaceous siltstones, which become micaceous towards the southeast, with minor interbeds of pebble rich siltstone at the top. These in turn are overlain by lenticular beds of fine to medium grained heavy mineral laminated reddish brown sandstones, often exhibiting cross bedding and ripple marks. Massive coarse grained milky white quartzites and interbeds of granule sandstone overlie the finer grained sandstones. Within the central region of the graben, lenses of granule sandstone cap the upper portion of the formation. Approximately 70% of the granule sandstone consists of well rounded detrital quartz pebbles ranging in size from 1m to 6m, with 20% chert (P 215/78). Abundant sedimentary structures including trough cross bedding, heavy mineral laminations, rain drop impressions, mud cracks and ripple marks are present throughout the formation.

The thickness of the ABC Range Quartzite in the central section of the Bunkers Graben is about 320 m.

At the north western side of the graben, intertonguing between the ABC Range Quartzite and the Bayley Range Siltstone Member is less evident. Here, a coarse grained pink feldspathic sandstone and minor siltstone interbeds constitute the major portion of the formation. The ABC Range Quartzite thins considerably on the south eastern side of the graben to a minimum thickness of about 50 m. The massive quartzite beds are less evident here, with medium grained reddish brown sandstones and interbeds of siltstone comprising the principal part of the formation.

Being reasonably competent, the ABC Range Quartzite crops out boldly as dip slopes within the Bunkers Graben. Fracturing and faulting is pronounced within the unit. The Bunyeroo Formation conformably overlies the ABC Range Quartzite.

BUNYEROO FORMATION (DALGARNO AND JOHNSON, 1964).

The Bunyeroo Formation consists of 3 members with the lower member comprising about three quarters of the total formation. Yellow, grey and green shales with occasional siltstone interbeds mark the base of the lower member. However, the major portion of this member is a partly calcareous fissile red shale. The red colour can be attributed to the presence of hematite. Diverse lithofacies relationships are indicated by the presence of lenticular sandstone, grey dolomitc sandstone, dolomite and grey blue limestone interbeds within the middle to upper section of this member. These interbeds are generally between 3-4 m in thickness and usually extend laterally less than 200m. The yellow grey green shales at the base contain secondary malachite within the sheared zones of faults. The thickness of the lower member is approximately 820m and outcrop is poor and generally confined to the creeks. The contact between the lower and middle members is transitional.

The middle member consists of approximately 150m of grey green shales with fine grained sandstone interbeds. It is characterised by the abundance of soft sediment deformation structures. Sedimentary structures include flute casts, ripple marks and small scale cross bedding. This member forms small rounded hills within the graben. There is a gradual contact between the middle and upper members.

The upper member consists of about 30 m of purple calcareous siltstones with occasional grey green shale and rare limestone interbeds. Sedimentary structures within the member are rare.

The upper member generally forms a depression between the middle member of the Bunyeroo Formation and the Wonoka Formation. There is a gradational and conformable contact between the Bunyeroo and Wonoka Formations.

WONOKA FORMATION (DALGARNO AND JOHNSON, 1964)

(Only the lower section of the formation was studied).

The base at the Wonoka Formation is marked by the appearance of frequent boldly outcropping flaggy limestone beds. The lower section of the Wonoka Formation consists of light grey flaggy limestones followed by silty limestones, siltstones with occasional dolomite, and sandstone interbeds. Rare intraformational breccias and frequent soft sediment deformational structures are also present. The Wonoka Formation boldly outcrops as moderately high hills within the surrounding topography.

GEOLOGICAL HISTORY

Conditions in the Adelaide Geosyncline during the deposition of the Upper Umberatana Group, (Middle Marinoan) appear to have been generally shallow marine. The commencement of the Wilpena Group is marked by a notable increase in the size of area of sedimentation within the Flinders Ranges area. This has been attributed to a slightly warmer climate resulting in the rise of the sea level following glaciation (Thomson, 1969). However, the general trend of the overall regional pattern of sedimentation throughout the deposition of the Wilpena Group, is regressive. This is suggested by sedimentological and textural features present within the Group. With movement of the Oraparinna Diapir in Sturtian and Middle Marinoan times, the structure of the Bunkers Graben was now well defined.

Carbonate comprising the lower member of the Nuccaleena Formation was deposited within a low energy, shallow (sub tidal) marine environment. Following carbonate deposition, an influx of fine grained clastics was incorporated within the basin. Cyclic deposition of carbonate and silt in an oxidising environment followed.

Deposition of the Brachina Formation followed, with similar conditions prevailing. The deposition of carbonate was phased out in the initial stages of the Mooloolooloo Siltstone Member, with silt deposition continuing in a shallow oxidising sub tidal marine environment. The presence of small scale cross laminations and graded bedding, (Plummer, 1978, also recorded ripple marks and flute casts) within the purple siltstones, imply that high energy traction currents were periodically active, within an overall protected shallow marine environment.

Plummer (1978), stated that the end of the Mooloolooloo Siltstone Member in the Central and Northern Flinders Ranges area is depicted by pulses of coarser detritus (i.e. medium grained

quartzite and intraformational conglomerate interbeds). However, these interbeds are not evident within the graben, possibly because they are diminished in size, or due to the lack of outcrop, were not identified.

The abundance of soft sediment deformation structures and pulses of coarser detritus within the Moorillah Siltstone Member indicate the shallowing of water in the depositional environment. Furthermore, the presence of flat top ripple marks infer a mud flat intertidal marine environment.

As shallowing continued, the intertidal mud flat environment continued to exist with pulses of coarser detritus and green silt marking the transition to the Bayley Range Siltstone Member. The green colours are possibly due to organic activity and not depth of water. The increase in sand content in the Bayley Range Siltstone Member reflects the continued regression, contemporaneous with uplift of the source.

The sand tends to form cyclic channel like bodies within the Bayley Range Siltstone Member, suggesting a barrier bar arrangement outlining the intertidal mud flat environment. As regressiion and uplift of the source continued, the increase in sand supply is noticeable within the system.

The previous facies is replaced by a cyclical facies, consisting of heavy mineral laminated and cross bedded sand with green sandy silt interbeds marking the start of the ABC Range Quartzite. This is in turn overlain by purple silt followed by interbeds of pebble rich silt. The pebble rich silt grades into ripple marked medium grained sands, which are overlain by a coarse grained white sand. From the sedimentary structures and other evidence available it appears that the depositional environment was a sand injected, intertidal environment. Furthermore, the ABC Quartzite exhibits a general upward coarsening grain profile, which is typical of many ancient

barrier bars. The most diagnostic feature of the sand in this case, is that it possibly formed sheet sand bodies running parallel to the local shoreline. The top of the ABC Range Quartzite is marked by the deposition of a granule sandstone derived from a high energy fluviatile environment, from a westerly source. A westerly source is suggested because of an overall coarsening of the grain size in the ABC Range Quartzite from the south east to the north west of the Bunkers Graben, and also due to the fact that the thickness of the formation increases substantially to the west.

The barrier bar, intertidal mudflat environment, was succeeded by a marine incursion depositing yellow, green and grey clay representing the base of the Bunyeroo Formation. Red clay above this sequence indicates that a highly oxidising environment had evolved, possibly within a shallow marine environment. Lenticular beds of sand, dolomitic sand, dolomite and grey blue limestone are also present in this transgressive phase. Following deposition of the red beds, a regression took place, producing a shallow marine tidal flat environment. This is supported by the presence of ripple marks and other sedimentary structures within the middle member. The absence of shallow water sedimentary structures in the upper member of the Bunyeroo Formation infers that a marine incursion followed, creating a shallow marine oxidising environment.

The Bunyeroo-Wonoka boundary is marked by the termination of the influx of fine grain clastics and rapid growth of limestones. However, a sporadic influx of fine grained sand and silt continued after the initial growth of the limestone beds. The presence of flute casts, current bedding, intraformational breccias and other slump structrues infer a sloping shallow marine shelf, subjected to slight local tectonic movement. Dalgarno and Johnson (1965) have stated that movement of the

Oraparinna Diapir occurred in the Marinoan, which could explain the above phenomenon. This movement was one of a series of movements of the Oraparinna Diapir from Sturtian to Early Cambrian times, creating a cone shaped graben.

Marine conditions continued to prevail within the Adelaide Geosyncline during the deposition of the upper part of the Wilpena Group (Late Marinoan). Rejuvenated erosion and marine regression, prior to the Cambrian followed, resulting in widespread deltaic and shallow marine conditions. In the Early Cambrian, there was renewed transgression of the sea and continued local movement of the Oraparinna Diapir producing the final phase of the Bunkers Graben. The upthrust of diapiric material appear also to be responsible for local faulting and fracturing within the graben during this period.

Following the deposition of red beds and other clastics of the Lake Frome Group, the Adelaide Geosyncline was folded during the Delamerian Orogeny. Renewed upward doming of the ranges during the Pleistocene gave rise to the formation of a fluvial conglomerate (overlying parts of the Bunyeroo Formation) and widespread creek bed silts. Erosion of the graben has continued to the present day, producing low angle slope deposits on the down dip slope of the ABC Range Quartzite hills and the present topography of the area.

STRUCTURE

The structure within the area is controlled by movement of the Oraparinna Diapir. It is believed movement within the Oraparinna Diapir was initiated before the Sturtian Glacial phase, with subsequent diapiric activity following in the Upper Sturtian, Middle Marinoan and finally Early Cambrian. Dalgarno and Johnson (1968) dated the graben using thickness and facies in the Hawker Group to the north east of the structure.

The Bunkers Graben was completed with the final phase of diapiric activity creating a cone shaped graben, an apparent characteristic of buried diapiric bodies. With subsequent folding and erosion, the graben has now been exposed in an obligue cross sectional view. Dalgarno (1964) noted the similarity between the fault pattern of the graben and that obtained experimentally by Currie (1956). Using Curries' experimental results, the following hypothesis is proposed for the formation of the Bunkers Graben.

FORMATION OF THE BUNKERS GRABEN

During diapiric activity, it appears that deposition of sediments exceeded the rate of domal uplift. Initial movement of the Oraparinna Diapir prior to the Sturtian Glacial Period would have produced stretching of the sedimentary overburden. Uplift during this period could have been associated with the formation of the fault system defining the boundary of the Bunkers Graben (see Figure 5).

Further diapiric activity in the Upper Sturtian, Middle Marinoan and Early Cambrian produced the younger faults within the graben. Upon rupture of the sedimentary overburden by action of upthrust as discussed, a cone shaped graben block was produced. Contemporaneous deposition and deformation of the Wilpena Group within the graben, has resulted in a greater thickness of sediments in the centre, than on the structural flanks.

This feature is particularly pronounced in the ABC Range Quartzite. The upper section of the Bunkers Graben has since been eroded, producing an oblique cross sectional view.

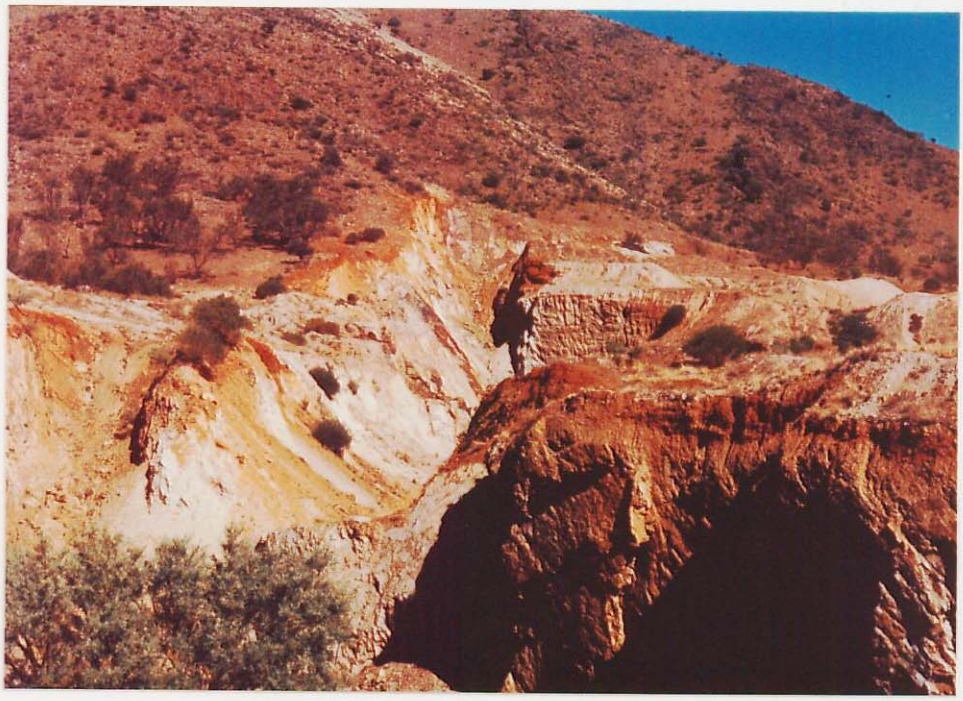

PLATE II

Belsen Lode. Open cut in Unit I of Bunyeroo Formation, with ABC Range Quartzite in hill in background.
View to the south-west.

ECONOMIC GEOLOGY

The Bunkers Graben lies within Class A and Class B Environmental areas as defined in the Flinders Ranges Planning Area Development Plan. All mining operations should thus be assessed to ensure minimum impact on physical and biological environments.

BARITE DEPOSITS

1. LOCATION.

Apart from the major barite lodes discussed in Table I, minor barite veins occur sporadically in the Bayley Range Siltstone Member (Brachina Formation) and ABC Range Quartzite, (rarely in the lower unit of the Bunyeroo Formation) throughout their entirety in the graben. No new deposits of any potential within the above formations were located. Location of major barite deposits are shown in Figure 2.

2. ORAPARINNA MINE.

The Oraparinna Mine is the only deposit being currently worked. The operating company is Australian Barytes Pty. Ltd.

(A) SITE GEOLOGY

The Oraparinna Barite Lode complex forms one of the many barite deposits within the Brachina - ABC Range Quartzite Formations. The barite occurs in a series of steeply dipping lodes in the sandstone, siltstone and shale facies of the Bayley Range Siltstone Member and the lower transitional portion of the ABC Range Quartzite.

(B) ORIGIN OF BARITE

The barite deposits show structural affinities to faulting and fracturing within the Bunkers Graben. It is suggested that the barite lodes have formed by migration of barium sulphate from the surrounding sandstone, siltstone, shale sequence of the Adelaide System, with diapiric activity in the Middle Marinoan and Early Cambrian producing a graben complex, enabling the deposition of barium sulphate solutions

in open fissures and fracture zones.

The epigenetic origin and geology of barite, as described above, are typical of deposits found in the Bayley Range Siltstone Member and the ABC Range Quartzite.

3. QUALITY AND SUITABILITY OF THE BARITE

Barite today is used for a variety of purposes. Approximately 75% is used in petroleum drilling operations, with the remainder being consumed in chemical, paint and rubber industries. The American Society for Testing Material Specification D602-42 requires barite for use in pigments to be white and to contain -

- at least 94% $BaSO_4$
- not more than 0.05% Fe_2O_3
- not more than 0.2% Soluble salts
- not more than 0.5% moisture and volatiles
- not more than 2% quartz, clays and foreign materials.

Barite from Oraparinna, Roberts and Western lodes meet the specifications for barite to be used as a white paint pigment. The Matthews Deposit barite falls into the above chemical specifications, however the colour of the barite is a mottled grey. Due to the lack of whiteness, the barite from this deposit is generally used in the glass industry. Barite from Turleys and Belsen was used as a weighting agent in drilling muds. Less stringent specifications are required for barite used in drilling mud, i.e. :-

- contain at least 92% $BaSO_4$
- have a specific gravity of at least 4.2
- contain less than 250 ppm soluble alkaline earths, expressed as calcium
- several percent of iron oxide is permitted.

PLATE III

Oraparinna Mine, underground. Barite lodes in roof of tunnel in Bayley Range Siltstone Member.

TABLE I

DEPOSIT	FORMATION	RESERVES (TONNES) MEASURED	INDICATED	INFERRED	AVERAGE GRADE (%) $BaSO_4$	$SrSO_4$	SiO_2	Fe_2O_3	S.G.	REFERENCE
ORAPARINNA (underground)	Bayley Range Silt/s Member (BRACHINA FM)	2 000	72 000	135 000	95	2.0	2.7	.1	4.4	Hiern, Olliver, 1973; Reid 1969
MATTHEWS	UNIT II (BUNYEROO FM)	-	6 000	8 000	91.4	3.8	4.03	.12	4.37	Olliver, 1975
ROBERTS	Bayley Range Silt/s Member (BRACHINA FM)	5 000		20 000						Hiern, Olliver, 1973; Reid, 196
WESTERN	Bayley Range Silt/s Member (BRACHINA FM)	IN PRESS								
TURLEYS	Mooloolo Silt/s (BRACHINA FM)	IN PRESS								

PLATE IV

Matthews Lode. Sample of black, grey and white mottled barite.

SUMMARY

Wilpena Group sediments within the Bunkers Graben were deposited in a predominantly low energy shallow environment in the Midde to Upper Marinoan. The graben is structurally controlled by faulting related to diapiric activity between Middle Sturtian and Early Cambrian times.

Carbonate comprising the Nuccaleena Formation at the base of the Wilpena Group was deposited in oxidising shallow marine conditions. This was followed by an influx of fine grained clastics forming the Brachina Formation. A marine regression followed and coarse sands of the ABC Range Quartzite were laid down. The overlying Bunyeroo Formation comprising sands, silts and clays were deposited following a marine incursion. Similar marine conditions prevailed during deposition of the Wonoka Formation, marked by the growth of limestones and a temporary decrease in the influx of clastics within the basin.

All the major barite deposits are situated within the sandstone, siltstone and shale facies of the Brachina and Bunyeroo Formations. Many minor veins of barite are dispersed throughout the Bayley Range Siltstone Member and the ABC Range Quartzite. Higher priced industrial grade barite is obtainable from Oraparinna, Roberts and Western lodes. Barite from Turleys and Belsen, and Matthews is suitable for oil drilling mud and glass respectively.

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FAR WESTERN BARITE LODE

FLINDERS RANGES NATIONAL PARK

BELSEN LODE

MATTHEW'S BARITE LODE

WESTERN LODE

Orraparinna Mine

ROBERTS LODE

BUNKERS GRABEN

TURLEY'S BARITE LODE

Tommy Gunyah Bore

Fifteen Mile Creek

Fifteen Mile Bore

SOUTHERN BARITE LODE

N

PROTEROZOIC

ADELAIDE SYSTEM

RECENT

Low angle slope deposits.

WILPENA GROUP

UMBERATANA GROUP

WONOKA FORMATION : Light grey flaggy limestones, silty limestone, siltstone and occasional dolomite and sandstone interbeds. Intraformational breccias and soft sediment deformational structures.

BUNYEROO FORMATION:

UNIT III Purple calcareous siltstone with occasional green-grey shales and rare dolomite interbeds.

UNIT II Green grey shales with fine grained sandstone interbeds. Frequent soft sediment deformational structures.

UNIT I Fissile red shales with yellow, grey and green shales near base. Dolomite and limestone interbeds near top.

ABC RANGE QUARTZITE : Ripple-marked and cross-bedded feldspathic sandstones with heavy mineral laminae. Massive quartzite and rare granular sandstone at top.

BRACHINA FORMATION

BAYLEY RANGE SILTSTONE MEMBER Olive green siltstone with fine and medium grained sandstone and shale interbeds.

MOORILLAH SILTSTONE MEMBER Redish-brown siltstone with fine grained sandstone interbeds. Soft sediment deformation structures.

MOOLOOLOO SILTSTONE MEMBER Grey to reddish brown feldspathic siltstone with fine grained sandstone interbeds.

NUCCALEENA FORMATION: Well bedded purple dolomite at base. Siltstone and dolomite interbeds follow.

ELATINA FORMATION: Pale-reddish feldspathic sandstone and pebbly siltstone.

TREZONA FORMATION : Tan colored re-crystallised pelletal limestone with interbeds of grey-green calcareos siltstone. Oolites common.

ENORAMA SHALE Purple weathering, grey-green very thinly bedded silty shale. Slightly dolomitic

ETINA FORMATION: Blue and grey-green shales and siltstones with boldly outcropping sandy and oolitic limestones

WOCKERAWIRRA DOLOMITE : Fine grained buff dolomite and dolomitic siltstone. Becomes sandy in upper part

Diapir

Fault

Geological boundary

Strike and dip of bedding 35

Graded road

Track

National Park boundary

Open cut mine

Sample location P210/78 x 210

Creek

Diagrammatic cross section A — A' See drawing no. S13729 A A'

3424-1

METRES 200 0 200 400 600 800 1000 METRES

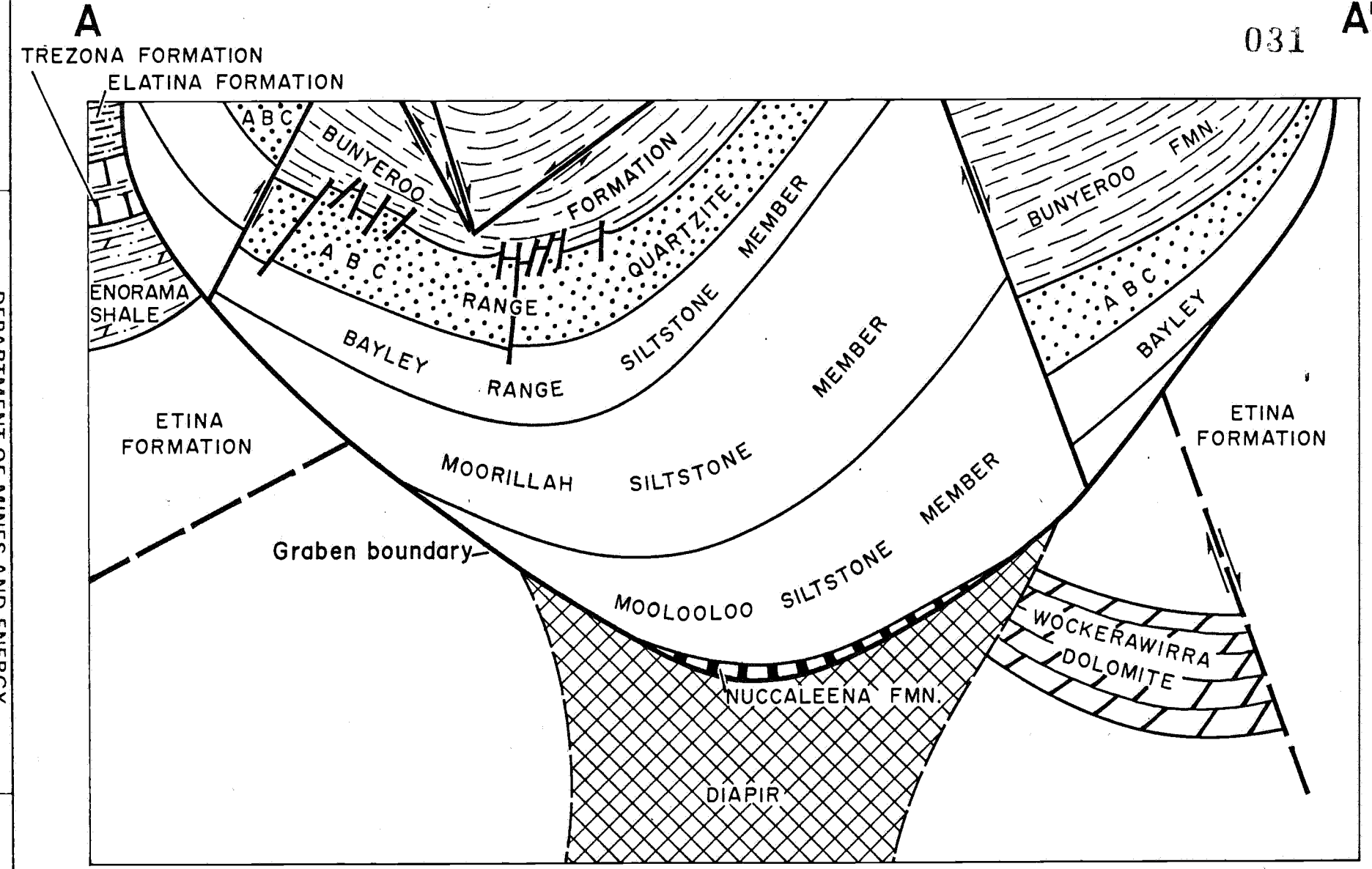
Fig. 4

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA

GEOLOGY OF THE BUNKERS GRABEN

NON METALLIC RESOURCES DIV. R Forsyth A.F. 1:10000 OCT. 1978

78-822



For location see drawing no. 78–822

Fig. 5

BUNKERS GRABEN
GEOLOGICAL SECTION A–A'
(DIAGRAMMATIC)

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

COMPILED R. Forsyth
DRN A.F.
CKD

SCALE 1:2000 V=H
DATE OCT. 1978
PLAN NUMBER
S13729

APPENDIX I

Petrographic Description of Rock Samples.
From Amdel reports GS 2917/78, GS 3453/78 and GS 1751/79
by F. Radke.

TABLE II

Sample No.	Thin Section No.	Rock Unit Name	Rock Type	Stained with Alizarin red-S
P204/78	TSC 19032	ABC Range Quartzite	Sandstone	
P205/78	TSC 19033	ABC Range Quartzite	Laminated, Fine Grained Sandstone	
P206/78	TSC 19034	ABC Range Quartzite	Ferruginous Sandstone	
P207/78	TSC 19035	ABC Range Quartzite	Argillaceous Siltstone	
P208/78	TSC 19036	ABC Range Quartzite	Quartz Sandstone	
P209/78	TSC 19037	ABC Range Quartzite	Sandstone	
P210/78	TSC 19038	Bunyeroo (Unit II)	Impure Limestone	
P211/78	TSC 19039	Bunyeroo (Unit II)	Silty Shale	Yes
P212/78	TSC 19040	Bunyeroo (Unit II)	Silty Shale	Yes
P213/78	TSC 19041	ABC Range Quartzite	Sandstone	
P214/78	TSC 19042	ABC Range Quartzite	Sandstone	
P215/78	TSC 19043	ABC Range Quartzite	Granule Sandstone	
P216/78	TSC 19044	Bunyeroo (Unit II)	Sandstone	Yes
P217/78	TSC 19045	Bunyeroo (Unit III)	Calcareous Shale (Marl)	Yes
P218/78	TSC 19046	Bunyeroo (Unit II)	Dolomitic Sandstone	Yes
P219/78	TSC 19047	Bunyeroo (Unit II)	Calcareous Sandstone	Yes
P220/78	TSC 19048	Bunyeroo (Unit II)	Calcareous Siltstone	Yes
P221/78	TSC 19049	Bunyeroo (Unit II)	Sandstone/siltstone	Yes
P222/78	TSC 19050	Wonoka Fm.	Impure Limestone	Yes
P223/78	TSC 19051	Bunyeroo (Unit I)	Dolomite	Yes
P224/78	TSC 19052	Bunyeroo (Unit I)	Limestone	
P225/78	TSC 19053	Bunyeroo (Unit I)	Brecciated and Silicified Argillite	Yes
P226/78	TSC 19054	ABC Range Quartzite	Deformed Barite	
P227/78	TSC 19055	ABC Range Quartzite	Iron Oxide Rock	

Sample No.	Thin Section No.	Rock Unit Name	Rock Type	Stained with Alizarin red-S
P228/78	TSC 19056	Trezona Fm.	Limestone	Yes
P229/78	TSC 19057	Trezona Fm.	Recrystallized Pelletal Limestone	Yes
P230/78	TSC 19058	Trezona Fm.	Limestone Breccia.	Yes
P231/78	TSC 19059	ABC Range Quartzite	Fine grained sandstone	
P232/78	TSC 19060	Brachina Fm. (Bayley Range)	Dolomite Siltstone	Yes
P233/78	TSC 19061	Trezona Fm.	Limestone Breccia	Yes
P234/78	TSC 19062	Trezona Fm.	Recrystallized Pelletal Limestone	Yes
P235/78	TSC 19063	Wonoka Fm.	Shale	Yes
P236/78	TSC 19064	Wonoka Fm.	Ferruginous, Silty Argillite	Yes
P237/78	TSC 19065	Elatina Fm.	Argilaceous Siltstone	Yes
P238/78	TSC 19066	Nuccaleena Fm.	Dolomite	Yes
P239/78	TSC 19067	Brachina (Bayley Range)	Silty/sandy shale	
P240/78	TSC 19068	Brachina (Bayley Range)	Argillaceous Siltstone/Sandstone	
P241/73	TSC 19069	Brachina (Moorillah)	Feldspathic Siltstone	
P242/78	TSC 19070	Brachina (Moorillah)	Ferruginous Sandstone	
P243/78	TSC 19071	Brachina (Moorillah)	Sandstone	
P244/78	TSC 19072	Brachina (Moorillah)	Feldspathic siltstone/sandstone	
P245/78	TSC 19073	Brachina (Moorillah)	Ferruginous Sandstone	
P246/78	TSC 19074	Brachina (Moorillah)	Feldspathic Siltstone	

Sample No.	Thin Section No.	Rock Unit Name	Rock Type	Stained with Alizarin red-S
P247/78	TSC 19075	Brachina (Moorillah)	Feldspathic Siltstone	
P248/78	TSC 19076	Brachina (Moorillah)	Feldspathic Siltstone	
P249/78	TSC 19077	Brachina (Mooloolloo)	Recrystallized Feldspathic Siltstone	
P250/78	TSC 19078	Brachina (Mooloolloo)	Feldspathic Sandstone	
P251/78	TSC 19079	Brachina (Mooloolloo)	Arkosic Sandstone	
P252/78	TSC 19080	Nuccaleena Fm.	Dolomite	Yes
P253/78	TSC 19081	Nuccaleena Fm.	Carbonate Rock.	
P460/78	TSC 39954	Wonoka Fm.	Dolomitic Sandstone	
P461/78	TSC 39955	Bunyeroo (Unit II)	Sandstone	
P462/78	TSC 39956	Bunyeroo (Unit II)	Dolomite	
P463/78	TSC 39957	Bunyeroo (Unit II)	Dolomite	
P464/78	TSC 39958	Brachina (Mooloolloo)	Barite	
P465/78	TSC 39959	Brachina (Mooloolloo)	Barite	
P466/78	TSC 39960	Brachina (Bayley Range)	Barite Mylonite	
P467/78	TSC 39961	Brachina (Bayley Range)	Barite Mylonite	
P468/78	TSC 39962	Bunyeroo (Unit I)	Deformed Barite	
P469/78	TSC 39963	Bunyeroo (Unit I)	Barite	
P470/78	TSC 39964	Bunyeroo (Unit II)	Deformed Barite	
P471/78	TSC 39965	Brachina (Bayley Range)	Deformed Barite.	

Some of the thin sections described in this section were stained with alizarin red-S solution to distinguish calcite from other carbonate by staining it pink. In the petrographic descriptions the following terminology is used for the carbonates in these samples:

Carbonate - Used for any carbonate in unstained thin sections and does not distinguish between calcite and other carbonates.

Calcite - Used for carbonate in stained thin sections which is stained pink by the alizarin red-S solution.

Dolomite - Used for carbonate in stained thin sections which is not stained by the alizarin red-S solution. Although this carbonate is most likely dolomite it has not been positively identified by X-ray diffraction or detailed examination of optical properties.

PETROGRAPHY OF SAMPLES FROM
THE ORAPARINNA BARITE MINE AREA

037

Sample: P204/78; TSC19032

Rock Name:
Sandstone

Hand Specimen:
A massive, grey-coloured rock with extensive limonitic fillings and staining along fractured surfaces.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	80
Feldspar	10
Sericite-clay	4
Tourmaline	1
Zircon	1
Opaques and semi-opaques	4

This samples consists mainly of quartz grains with modified sub-rounded shapes. The quartz grains have a somewhat bimodal character with most of them being between 0.1 and 0.2 mm in size, although a smaller proportion of larger grains generally about 0.5 mm in size are also present. The larger quartz grains generally have slightly more rounded shapes than the finer grained quartz. A small amount of feldspar is intergrown with the quartz, mainly as crystals approximately 0.1 to 0.2 mm in size. The most common feldspar is an untwinned orthoclase, although small amounts of polysynthetically twinned plagioclase and gridiron twinned microcline are also present. The untwinned feldspar can generally be distinguished from the quartz by its slightly more altered character reflected both in finely divided sericite-clay and more intensely fractured character of the grains with linings of translucent, reddish-brown limonite.

The rock has a well indurated character due to the formation of quartz overgrowths and mild recrystallization of the quartz.

Locally interstitial areas between the detrital quartz grains are filled with finely divided phyllosilicates with a pale yellow to reddish-brown iron-stained colour. Traces of muscovite are also present as small flakes below 0.1 mm long located between the detrital quartz grains.
Tourmaline and zircon are disseminated through the rock as small crystals generally about 0.05 to 0.1 mm in size. Most of the detrital tourmaline grains have rounded to sub-rounded shapes and a pleochroic green colour, while the zircon crystals tend to have prismatic shapes. Opaques are disseminated through the rock as anhedral grains generally about 0.1 mm in size. Translucent, reddish-brown limonitic material is concentrated as narrow fracture fillings below 0.1 mm wide. Some on these limonitic fracture fillings exhibit a weakly-banded, colloform texture. Some limonite is also disseminated through the rock as irregular patches up to 0.2 mm in size.

This is a very fine-grained, quartz-rich standstone which has suffered minor recrystallization.

Sample: P205/78; TSC19033

Rock Name:
Laminated, fine-grained sandstone

038

Hand Specimen:
A brown coloured rock with a weakly laminated character best seen on a freshly cut surface.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	65
Feldspar	10
Phyllosilicates	10
Zircon	4
Tourmaline	1
Volcanic rock fragments	Trace
Rutile	Trace
Opaques and semi-opaques	10

This sample consists mainly of detrital quartz grains cemented by an interstitial, phyllosilicate-rich cement. The quartz grains have a bimodal character with most of them being about 0.1 mm in size and a smaller proportion of disseminated quartz grains being about 0.3 to 0.5 mm in size. The smaller quartz grains exhibit angular to sub-angular shapes while the larger quartz grains generally exhibit sub-rounded shapes. The interstitial matrix consists mainly of a greenish-yellow phyllosilicate which could be either a stained clay or sericite or possibly a chlorite-like phyllosilicate.

Detrital feldspar grains are also present in the rock and exhibit a similar shape and size to the quartz. The most common type of feldspar is an untwinned orthoclase, although smaller amounts of polysynthetically twinned plagioclase and gridiron twinned microcline are also present. A few detrital grains which appear to represent devitrified rhyolites were also noted in the sample. Zircon is disseminated through the rock as prismatic to sub-rounded detrital grains generally about 0.05 to 0.1 mm in size. Minor pleochroic green tourmaline and traces of yellow rutile are also disseminated through the rock as detrital grains generally about 0.1 mm in size. Opaques are also disseminated through the rock as anhedral grains between 0.05 and 0.1 mm in size. The opaques, in particular, tend to be concentrated in narrow bands generally about 0.5 mm wide, which should account for the lamellar character of the rock in hand specimen. These bands also contain concentrations of zircon and are believed to represent detrital heavy mineral-rich bands.

This is a relatively fine-grained detrital sediment cemented by an intergranular phyllosilicate-rich matrix.

Sample: P206/78; TSC19034 039

Rock Name:
Ferruginous, fine-grained sandstone

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	65
Feldspar	10
Sericite-clay	7
Chlorite	2
Tourmaline	Trace-1
Opaques & semi-opaques	15

This sample consists mainly of angular quartz grains generally about 0.1 mm in size which tend to form a recrystallized, granular mosaic cemented by interstitial iron-stained phyllosilicates. The rock also contains a significant proportion of detrital feldspar as grains with a similar size and shape to the detrital quartz grains. A significant proportion of the feldspar consists of polysynthetically twinned plagioclase although at least some grid-iron twinned microcline and probably some orthoclase are also present. Most of the feldspar grains are moderately fresh showing only incipient alteration to finely divided sericite.

The interstitial matrix is comprised mainly of finely divided phyllosilicates which generally have a translucent, reddish-brown colour due to intimately intergrown limonitic material. Locally the argillaceous matrix appears to have been completely replaced by limonitic material. In addition opaques are disseminated through the rock as anhedral grains generally about 0.1 mm in size which could be of detrital origin. A pale greeen, weakly pleochroic chlorite is intergrown with the matrix and traces of a bright green phyllosilicate form small pellets below 0.1 mm in size.

Minour tourmaline is disseminated through the rock as small detrital grains below 0.1 mm in size which exhibit a pleochroic green colour.

This a fine-grained detrital sediment cemented by an argillaceous and ferruginous matrix.

Sample: P207/78; TSC19035

Rock Name:
Argillaceous Siltstone

040

Hand Specimen:
A pale brown coloured rock with a vague, very finely laminated character.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz and feldspar	45
Argillaceous matrix	40
Muscovite-Sericite	10
Tourmaline	Trace
Bright green phyllo-silicate	Trace
Opaques and semi-opaques	5

This sample consists mainly of very fine-grained (typical grain size below 0.05 mm) detrital quartz and feldspar cemented by an iron-stained, argillaceous matrix. Quartz is the major detrital component, although some detrital feldspar grains were noted. The exact proportion of feldspar is impossible to determine optically because of the very fine grain size of the detrital particles. Muscovite-sericite flakes below 0.1 mm long are also disseminated through the rock and exhibit a well developed lepidoblastic foliation oriented parallel to the vague laminations noted in hand specimen. Traces of pleochroic green tourmaline form small detrital grains below 0.05 mm in size. A few small grains of a bright green mineral believed to represent a bright green phyllosilicate were also noted in thin section.

Minor opaques are disseminated through the rock as anhedral to subhedral grains generally about 0.05 mm in size. Translucent reddish-brown limonite also forms disseminated grains and crystals, many of which have euhedral shapes indicating that they are pseudomorphs after pyrite. This limonitic material is concentrated in a lenticular-shaped area oriented parallel to the general foliation and banding. In thin section the banding is defined mainly by slight variations in the degree of iron-staining of the phyllosilicate-rich matrix.

This is a very fine-grained detrital sediment consisting mainly of silt to fine sand-sized detrital grains in an iron-stained, argillaceous matrix.

Sample: P208/78; TSC19036

Rock Name:
Quartz Sandstone

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	80
Sericite-clay	10
Feldspar	5
Tourmaline	Trace
Opaques	5

This sample is comprised mainly of detrital quartz grains between 0.2 and 0.8 mm in size disseminated through a much finer-grained matrix comprised mainly of quartz, opaques and finely-divided phyllosilicates. The quartz which was in a finer-grained matrix could also be of detrital origin but has a very fine grain size, typically below 0.1 mm.

The larger quartz grains generally exhibit rounded to subrounded shapes although a few grains with subangular shapes are also present. Most of the quartz grains are separated from each other by an interstitial matrix but where they are in contact they have a somewhat recrystallized, concavo-convex boundary. In addition a small proportion of detrital feldspar is disseminated through the rock as subrounded to subangular grains up to 0.7 mm in size. A few lithic clasts which appear to represent fine-grained metasedimentary rocks were also noted. These clasts consist mainly of fine-grained quartz intergrown with finely divided muscovite flakes which exhibit a lepidoblastic foliation. In addition a few clasts of finely divided sericitic and argillaceous material are also disseminated through the rock.

The matrix is comprised mainly of finely divided phyllosilicates many of which have a translucent, reddish brown colour due to limonitic staining. Opaques are intimately intergrown with the argillaceous matrix mainly as finely granular aggregates although a significant proportion of the opaques form elongate, bladed crystals up to 0.3 mm long. These well developed crystals could represent hematite crystals but positive identification is impossible in thin section. Very fine-grained quartz is also disseminated through the matrix and generally has angular to subangular shapes.

Traces of tourmaline are disseminated through the rock as small crystals up to 0.2 mm in size which exhibit a pleochroic green colour.

This is a quartz-rich detrital sediment containing rounded quartz grains as well as a smaller proportion of relatively fresh feldspar set in a finely divided argillaceous matrix.

Sample: P209/78; TSC19037

Rock Name:
Sandstone

042

Hand Specimen:
A reddish-brown coloured rock with a somewhat "slabby" character most likely reflecting a weakly developed foliation. Small white mica flakes are easily visible on the vague foliation planes.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	70
Feldspar	10
Clay-chlorite	7
Muscovite	3
Biotite	Trace
Tourmaline	Trace
Opaques and semi-opaques	10

This sample consists essentially of detrital, fine sand-sized (typical grain size about 0.1 mm) quartz grains cemented by interstitial opaque to translucent, reddish-brown iron oxide. The quartz grains generally exhibit sub-angular shapes. Minor feldspar is also present in the rock as detrital grains similar in size and shape to the detrital quartz grains. Most of the feldspar is an untwinned orthoclase, but smaller amounts of polysynthetically twinned plagioclase and gridiron twinned microcline are also present. Aggregates of finely divided clay with rounded to sub-rounded shapes are also disseminated through the rock and could represent either detrital clay pellets or altered feldspar grains. Finely divided aggregates of a greenish-yellow phyllosilicate believed to represent chlorite aggregates are also disseminated through the rock and are most likely of detrital origin.

Well developed muscovite flakes generally below 0.2 mm in length are evenly distributed through the rock and exhibit a preferred orientation defining a lepidoblastic foliation. Traces of pleochroic, reddish-brown biotite are also locally present as flakes approximately 0.2 mm in length, which are oriented parallel to the muscovite flakes. Many of the muscovite flakes have bent and contorted shapes produced by compaction around detrital quartz and feldspar grains. Traces of pleochroic green tourmaline are disseminated through the rock as small detrital grains below 0.1 mm in size.

This sample is a fine-grained, quartz-rich detrital sediment with a ferruginous cement.

Sample: P210/78; TSC19038

Rock Name:
Impure limestone

Hand Specimen:
A pale brown weakly laminated rock containing limonite pseudomorphs after pyrite up to a few millimetres in size which weather out in relief. The sample reacts strongly to dilute (10%) hydrochloric acid, indicating a high calcite content.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Carbonate (calcite)	50
Quartz and feldspar	40
Muscovite	3
Limonite	5
Opaques	1

This sample consists essentially of fine-grained carbonate (typical grain size about 0.1 to 0.2 mm) intergrown with detrital quartz and feldspar grains which have a general grain size of about 0.1 mm. The thin section has not been stained, but microchemical tests on the hand specimen indicate that most, if not all, of the carbonate is calcite. The detrital quartz and feldspar grains have angular to sub-angular shapes and locally show a recrystallized, granular character. The exact proportion of feldspar in this rock is hard to determine because of the fine grain size of the quartz and feldspar and the very fresh character of the feldspar, making it hard to distinguish from quartz, except where it exhibits twinning. Minor amounts of polysynthetically twinned plagioclase are present in the sample and untwinned orthoclase could also be present.

Well developed muscovite flakes below 0.3 mm long are disseminated through the rock and exhibit a weakly developed preferred orientation defining a vague lepidoblastic foliation. Minor small opaque grains approximately 0.1 mm in size are also disseminated through the rock. Large euhedral to subhedral limonite crystals considered to be pseudomorphic after pyrite are also disseminated through the rock. Minor translucent, reddish-brown limonite also forms narrow fracture and vein fillings below 0.03 mm wide.

This sample has suffered at least some recrystallization which modified the detrital character of the quartz and feldspar grains and produced an equigranular calcite. This rock has been called an impure limestone and could represent a carbonate sediment with a significant detrital component, but it is also possible that it could represent a fine-grained detrital rock which has suffered later partial replacement by granular calcite.

Sample: P212/78; TSC19040

Rock Name:
Silty shale

Hand Specimen:
A greenish-grey coloured rock with a very weakly developed foliation which produces a 'platy' character.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Argillaceous matrix	65
Quartz and feldspar	30
Carbonate (dolomite)	3
Opaques and semi-opaques	1

This sample is fundamentally very similar to sample P211/78 (TSC19039), consisting essentially of a clay-rich matrix which is intergrown with very fine sand to silt-sized (typical grain size below 0.05 mm) detrital quartz and feldspar grains. This sample also exhibits a discontinuous lamellar banding due mainly to elongate, lenticular concentrations of detrital quartz and feldspar grains which are separated by somewhat undulose clay-rich bands. The major difference between this rock and sample P211/78 is that this sample has a higher proportion and slightly coarser-grained detrital quartz and feldspar grains. As with sample P211/78, the proportion of quartz and feldspar present is hard to determine because of the fine grain size.

This sample also contains very small disseminated carbonate crystals, some of which exhibit well developed rhomb shapes. These carbonate crystals do not appear to be affected by an alizarin red-S stain and are believed to represent dolomite. Most of these carbonate crystals have narrow rims of translucent, reddish-brown iron oxide and it is believed that sample P211/78 also contained similar carbonate, but the carbonate in that rock has been completely replaced by iron oxides. This has produced a slightly higher proportion of translucent, reddish-brown iron oxides in sample P211/78 and no evidence of dolomite, although a trace of calcite was noted in sample P211/78.

This sample is very similar to sample P211/78 in mineralogy, texture and origin, but still contains small dolomite rhombs which have not been replaced by translucent, reddish-brown iron oxides.

Sample: P211/78; TSC19039

Rock Name:
Silty shale

Hand Specimen:
A massive, greyish-brown coloured rock. A very vague foliation or bedding is defined mainly by a tendency for the rock to fracture into 'platy' fragments.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Argillaceous matrix	80
Quartz and feldspar	17
Calcite	Trace
Opaques and semi-opaques	3

This sample consists essentially of a clay-rich matrix intergrown with silt-sized (typical grain size below 0.04 mm) detrital quartz and feldspar grains. There is a vague banded character produced mainly by a tendency for the detrital quartz and feldspar to be concentrated in elongate lenses and discontinuous bands separated by discontinuous bands richer in clay. The matrix also exhibits a very vague foliation defined mainly by small, birefringent muscovite-sericite flakes. Most of the argillaceous matrix has a translucent brownish character due mainly to iron staining. In addition, finely divided opaque to translucent reddish-brown semi-opaque iron oxides are disseminated through the rock as small crystals below 0.05 mm in size.

Traces of calcite were noted as small crystals generally about 0.03 mm in size which are intergrown with the argillaceous matrix. The calcite was identified by its positive reaction to the alizarin red-S stain.

This is a very fine-grained argillaceous sediment with a significant silt-sized detrital component comprised mainly of quartz and feldspar.

Sample: P213/78; TSC19041

Rock Name:
Sandstone

Hand Specimen:
A reddish-brown, weakly banded rock with localised well-developed liesegang structure. The sample shows no reaction to dilute hydrochloric acid, indicating no calcite is present.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	65
Feldspar	10
Clay-chlorite	10
Muscovite	3
Carbonate (dolomite)	2
Biotite	Trace
Bright green phyllosilicates	Trace
Tourmaline	Trace
Opaques and semi-opaques	10

This samples consists mainly of detrital quartz grains with a typical grain size between 0.1 and 0.2 mm cemented mainly by translucent semi-opaque to opaque iron oxides. The quartz grains exhibit angular to sub-angular shapes which have been slightly modified by recrystallization and minor overgrowth quartz. Detrital feldspar grains with a similar grain size and shape to the quartz grains are also disseminated through the rock. The feldspar is comprised of untwinned orthoclase, polysynthetically twinned plagioclase and gridiron twinned microcline, and for the most part has a very fresh character. Traces of pleochroic green tourmaline are disseminated through the rock as sub-rounded, detrital grains below 0.1 mm in size.

Small granules generally about 0.1 mm in size of clay and a fibrous yellowish-green phyllosilicate, believed to represent a chlorite mineral, are also disseminated through the rock. Both the clay and chlorite appear to represent detrital phyllosilicate flakes although some of the clay-rich patches could represent completely altered feldspar grains. The muscovite forms well developed flakes up to 0.2 mm in length, which exhibit a preferred orientation defining a lepidoblastic foliation. This foliation is oriented parallel to a vague banding defined mainly by variations in opaque to translucent reddish-brown iron oxides. Traces of a bright green phyllosilicate are also disseminated through the rock as small grains generally below 0.05 mm in size.

Some of the opaque and translucent, reddish-brown iron oxides contain intergrowths of carbonate which appear to represent remnants which have been almost completely replaced by the iron oxides. Although the sample has not been stained with an alizarin red-S solution, this carbonate is not believed to be calcite since the hand specimen does not react to dilute hydrochloric acid and in other samples which are stained the calcite generally does not show replacement by iron oxides. Although the carbonate has not been positively identified by X-ray diffraction, it is believed to be dolomite.

This is a fine-grained detrital sediment very similar in mineralogy, grain size and origin to sample P209/78 (TSC19037) and probably comes from the same formation as that sample. The main difference between this sample and sample P209/78 is that this sample contains remnants of carbonate which have not been completely replaced by opaque to translucent, reddish-brown iron oxides. It is thus concluded that both this sample and sample P209/78 originally contained a dolomite cement which has been completely replaced by iron oxides in sample P209/78 and partially replaced by iron oxides in this sample.

Sample: P214/78; TSC19042

Rock Name:
Sandstone

Hand Specimen:
A massive, dark grey coloured rock with localised ocherous staining, particularly along fracture surfaces.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	65
Feldspar	10
Chlorite	10
Sericite-clay	5
Muscovite	1
Zircon	1
Tourmaline	Trace
Opaques and semi-opaques	8

This sample consists mainly of detrital quartz grains approximately 0.1 mm in size which have only slightly modified angular to sub-angular shapes. Detrital feldspar grains of a similar size and shape to the detrital quartz grains are also disseminated through the rock and, for the most part, have a very fresh character. The feldspar consists of untwinned orthoclase with some polysynthetically twinned plagioclase and minor gridiron twinned microcline. Accessory zircon and traces of pleochroic green tourmaline are also present as small, detrital grains below 0.1 mm in size. Most of the zircon grains have rounded to sub-rounded shapes, although a few with prismatic shapes were noted.

A green to reddish-coloured phyllosilicate, believed to be chlorite, forms irregular patches up to 0.5 mm in size. The reddish colour of many of these patches is considered to be due to iron staining, although it could represent the actual colour of the mineral. These phyllosilicate patches contain moderately well-developed flakes with an interlocking felted texture. Minor finely-divided sericite-clay also occurs between the detrital quartz and feldspar grains as very finely-divided flakes below 0.05 mm in size. Muscovite flakes up to 0.3 mm long are disseminated through the rock and appear to have a random orientation.

Opaque to translucent reddish-brown semi-opaque iron oxides occur interstitially between the detrital quartz and feldspar grains and would represent the major cementing medium. Minor opaques also form somewhat rounded, disseminated grains which are most likely of detrital origin. Opaque and translucent reddish-brown iron oxides also form narrow fracture and vein fillings below 0.2 mm wide.

This sample is a relatively fine-grained sandstone somewhat similar to samples P209/78 and P213/78 (TSC19037,41) but this sample contains detrital zircon grains which were not observed in either samples P209/78 or P213/78.

Sample: P215/78; TSC19043

Rock Name:
Granule sandstone

Hand Specimen:
An obviously detrital rock consisting of rounded, granule-sized milky-grey quartz grains and a small proportion of darker grey chert grains. The sample has an indurated character despite moderate amounts of void spaces between the detrital grains.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	70
Chert	20
Sericite-clay	3
(?)Jarosite	3
Feldspar	Trace-1
Muscovite	Trace
Zircon	Trace
Opaques	2

This sample consists essentially of rounded granule-sized (typical grain size between 1 and 4 mm) quartz and chert grains. The interstitial areas between these detrital quartz and chert grains are filled with finer-grained quartz (typical grain size about 0.2 mm) intergrown with finely divided sericite-clay and a flaky yellowish-brown mineral with high birefringence which is tentatively identified as jarosite. Minor amounts of feldspar also form small grains between the larger quartz and chert grains. These smaller grains generally have sub-angular shapes which have been modified by recrystallization and possibly marginal replacement by phyllosilicates.

Most of the detrital quartz granules have a polycrystalline texture which shows evidence of deformation in the form of sutured grain margins, strained extinction and, in some grains, foliation produced by elongate quartz crystals.

The detrital chert grains show a variety of textures ranging from very fine-grained up to medium-grained (maximum grain size about 0.1 mm) cherty textures to localised fibrous or chalcedonic textures. A few chert granules contain ovoid structures of much finer-grained chert in a coarser-grained chert matrix which appear to be either pisolitic structure, or possibly ovoid organic structures. These structures are considered typical of limestone and it is considered that at least the chert fragments with this structure represent silicified limestone.

Traces of zircon and muscovite were noted mainly as inclusions within detrital quartz granules. Opaques occur mainly as anhedral disseminated grains intergrown with the matrix, although some chert granules contain small disseminated opaque grains below 0.05 mm in size.

This is a detrital sediment consisting mainly of granule-sized quartz and chert grains. There is textural evidence that at least some of the chert fragments in this rock actually represent fragments of silicified limestone.

Sample: P216/78; TSC19044

Rock Name:
Fine-grained sandstone

Thin Section:
An optical estimate of the constitutents gives the following:

	%
Quartz	65
Feldspar	10
Carbonate (dolomite)	10
Muscovite	5
Calcite	3
Sericite-clay	3
Chlorite	1
Tourmaline	Trace
Opaques & semi-opaques	3

This rock is comprised mainly of very fine sand sized (typical grain size between 0.05 and 0.1 mm) detritus intergrown with carbonate and muscovite flakes. The muscovite flakes are up to 0.1 mm in length and exhibit a well developed lepidoblastic foliation which most likely represents a bedding direction. Minor detrital feldspar is also present in the rock although its exact proportion is difficult to estimate due to the fine grain size and lack of twinning of at least some of the feldspar. At least some polysynthetically twinned plagioclase was positively identified and most if not all of the feldspar has a very fresh character showing only incipient sericitization.

Most of the carbonate in this rock forms small rhombs below 0.1 mm in size which are unaffected by the alizarin red-S staining suggesting they are dolomite. Calcite identified by its positive reaction to the alizarin red-S stain occurs interstitially between the detrital grains as irregular aggregates up to 0.05 mm in size. Many of the carbonate rhombs show incipient alteration to translucent, reddish-brown iron oxides particularly along their margins.

Minor finely divided sericite-clay occurs interstitially between the quartz grains. Chlorite is also present as small flakes up to 0.1 mm in size which exhibit a pale green, pleochroic colour and a preferred orientation parallel to the lepidoblastic foliation defined by the muscovite flakes. Traces of pleochroic green tourmaline form small grains below 0.1 mm in size. Some opaques are disseminated through the rock as euhedral crystals up to 0.2 mm in size which have translucent, red margins suggesting that they represent limonitic pseudomorphs after pyrite. Minor opaques also form anhedral disseminated grains below 0.1 mm in size and narrow fracture and vein fillings.

This is a very fine-grained detrital sediment containing a moderate carbonate content mainly as dolomite rhombs.

Sample: P217/78; TSC19045

Rock Name:
Calcareous Shale (Marl)

Thin Section:
An optical estimate of the constituents gives the following:

	%
Argillaceous matrix	40
Carbonate	40
Quartz	10
Muscovite	5
Tourmaline	Trace
Opaques & semi-opaques	5

This is a very fine-grained rock comprised mainly of intimately intergrown argillaceous material and carbonate. Most of the carbonate appears to be unaffected by the alizarin red-S stain and is most likely dolomite but approximately 20% of the carbonate is stained indicating that it is calcite. The argillaceous material consists mainly of weakly birefringent clay although some pale green chlorite and finely divided sericite are also intergrown with this matrix. Well developed muscovite flakes up to 0.1 mm long are disseminated through the rock and exhibit a well developed, lepidoblastic foliation.

Detrital quartz grains generally below 0.03 mm in size are disseminated through the rock. Some detrital feldspar could also be present but the very fine grain size makes positive identification difficult. Traces of pleochroic green tourmaline were also noted as small grains below 0.05 mm in size.

Opaque to translucent, reddish-brown iron oxides are concentrated along narrow bands and fracture surfaces which are oriented parallel to the lepidoblastic foliation and would represent a remnant bedding texture. In some cases opaques are concentrated in lenticular shaped bodies up to 0.3 m wide. Minor opaques are also disseminated through the rock as small grains generally below 0.5 mm in size.

This is a very fine-grained detrital sediment consisting mainly of carbonate and argillaceous material and could be termed a marl.

Sample: P218/78; TSC19046

Rock Name:
Dolomitic Sandstone

Hand Specimen:
A pale grey-coloured rock with a weakly developed foliation best seen on a weathered surface.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz and feldspar	55
Dolomite	25
Muscovite-sericite	12
Calcite	3
Tourmaline	Trace
Opaques and semi-opaques	5

This thin section was stained with alizarin red-S solution so that in the petrographic description calcite is used for any carbonate which is stained pink and dolomite for any unstained carbonate.

This sample is comprised mainly of fine sand-sized (typical grain size between 0.05 and 0.1 mm) detrital quartz grains intergrown with granular dolomite and muscovite flakes. The muscovite flakes are generally about 0.1 mm long and exhibit a preferred orientation defining a lepidoblastic foliation. A small amount of feldspar is also present in this rock as detrital grains similar in size and shape to the detrital quartz grains, but the exact amount of feldspar is hard to determine optically. Traces of very fresh, polysynthetically twinned plagioclase were noted in this sample.

The dolomite forms small grains generally about 0.1 mm in size which show some marginal replacement by translucent, reddish-brown iron oxides. Some of the muscovite flakes also show weakly developed marginal alteration to translucent, reddish-brown iron oxides, and a few phyllosilicate flakes of translucent, reddish-brown colour could represent completely altered muscovite, or possibly completely altered biotite flakes, were also noted. Calcite is concentrated as narrow vein and fracture fillings below 0.4 mm wide.

A trace of pleochroic green tourmaline forms detrital grains below 0.1 mm in size. A small proportion of the opaques in this rock also form disseminated crystals below 0.1 mm in size, some of which exhibit euhedral to subhedral shapes.

This is a fine-grained detrital sediment containing a high dolomite content and moderate amounts of muscovite. The dolomite shows some marginal replacement by translucent, reddish-brown iron oxides.

Sample: P219/78; TSC19047

Rock Name:
Fine-grained calcareous sandstone

Hand Specimen:
A massive, pale brown to tan coloured rock containing dark brown limonite pseudomorphs after pyrite. These pseudomorphs tend to be concentrated along a discontinuous band or fracture zone but also locally form aggregates up to about 1 cm in size which retain a pseudomorphic polycrystalline character after pyrite. The limonite pseudomorphs include both cubes and pyritohedrons with some cubic faces showing fine striations.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz and feldspar	70
Calcite	15
Sericite-clay	5
Dolomite	5
Chlorite	2
Opaques and semi-opaques	3

This sample consists essentially of fine-grained (typical grain size between 0.03 and 0.1 mm) quartz and feldspar intergrown with a smaller amount of carbonate (calcite and dolomite) and muscovite-sericite. The feldspar includes at least some polysynthetically twinned plagioclase but the exact proportions of quartz and feldspar present in the rock are hard to determine since most of the feldspar is untwinned and has a relatively unaltered character. Only where the feldspar exhibits either twinning or incipient alteration along cleavage traces is it easily distinguishable from the quartz.

The calcite forms irregular patches up to 0.3 mm in size which have a polycrystalline, fine-grained (typical grain size below 0.1 mm) character. Minor dolomite (i.e., unstained carbonate) is intergrown with the calcite-rich patches. A small proportion of the calcite exhibits euhedral, prismatic shapes and these euhedral crystals generally contain marginal intergrowths of translucent reddish brown iron oxide.

Small flakes of muscovite-sericite up to 0.2 mm long are disseminated through the rock and exhibit a random orientation. Some clay is also present as rouleaux or fibrous flakes. Disseminated chlorite flakes with a pale green colour are also present. Opaques are disseminated through the rock as anhedral grains and granular aggregates up to 0.1 mm in size. Larger euhedral to subhedral opaque and translucent, reddish-brown crystals are also disseminated through the rock and would represent the limonitic pseudomorphs after pyrite noted in hand specimen. Many of these pseudomorphs exhibit translucent, reddish-brown margins and opaque cores.

This is a fine-grained detrital sediment which has suffered recrystallization under advance diagenesis or low grade metamorphic conditions. Euhedral pyrite crystals have been completely replaced by secondary iron oxides.

Sample: P220/78; TSC19048

Rock Name:
Calcareous siltstone

Hand Specimen:
A dark grey coloured rock with a vague, finely laminated character.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz and feldspar	45
Calcite	35
Muscovite	8
Biotite	5
Chlorite	2
Dolomite	2
Opaques and semi-opaques	3

This sample consists essentially of a fine-grained (typical grain size between 0.05 and 0.1 mm) intergrowth of quartz, feldspar and calcite. Well developed phyllosilicate flakes in the form of muscovite, biotite and chlorite are disseminated through the rock and exhibit a well developed preferred orientation defining a lepidoblastic foliation. A vague banding oriented parallel to the lepidoblastic foliation is also evident in thin section and defined mainly by slight concentrations of translucent, reddish-brown iron oxides as interstitial fillings in bands up to 0.5 mm wide.

The detrital quartz and feldspar grains have a somewhat recrystallized, angular character and although some polysynthetically twinned plagioclase is present most of the feldspar is untwinned and very fresh making it hard to determine the proportions of quartz and feldspar present. The phyllosilicate flakes are up to 0.15 mm long and the biotite in particular tends to form somewhat fibrous appearing flakes. The biotite has a dark brown, intensely pleochroic colour while the chlorite flakes have a pale green, weakly pleochroic colour and anomalous blue interference colours.

Calcite is disseminated through the rock as grains and granular aggregates intergrown with the detrital quartz and feldspar. Minor dolomite is locally intergrown with the calcite as small crystals below 0.05 mm in size. Most of the rock contains a significant proportion of calcite although a few slightly coarser grained bands containing a somewhat smaller proportion of calcite are present. Minor calcite also occurs as narrow fracture fillings below 0.05 mm wide which are oriented approximately perpendicular to the general foliation and banding.

Opaques occur mainly as anhedral disseminated grains and granular aggregates below 0.1 mm in size. Translucent, reddish-brown iron oxide tend to be concentrated interstitially between the detrital felsic mineral grains and to some extent are intergrown with the calcite.

This is a fine-grained detrital sediment with a significant carbonate content which has undergone recrystallization in response to advanced diagenes or low grade metamorphism to produce a well foliated texture.

Sample: P221/78; TSC19049

Rock Name:
Fine-grained sandstone/siltstone

Hand Specimen:
A massive, pale brown coloured rock with a very fine-grained texture.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz and feldspar	80
Biotite	7
Muscovite	5
Sericite-clay	5
Chlorite	1
Opaques	2

This sample consists essentially of angular quartz and feldspar grains up to 0.1 mm in size intergrown with well developed mica (biotite and muscovite) flakes. The muscovite and biotite flakes are below 0.15 mm long and exhibit a well developed lepidoblastic foliation. The biotite is moderately pleochroic in shades of brown. Minor chlorite is also disseminated through the rock as small flakes below 0.1 mm in length which exhibit a similar preferred orientation to the muscovite and biotite. This chlorite has a pleochroic green colour and anomalous blue interference colours.

The quartz and feldspar has a somewhat recrystallized character but still retains a well developed detrital texture. The exact proportions of quartz and feldspar present are hard to determine since most of the feldspar is untwinned and similar in appearance to quartz. A small proportion of the feldspar exhibits polysynthetic twinning typical of plagioclase. Some of the feldspar also exhibits alteration to finely divided sericite-clay. The sericite-clay also tends to be concentrated interstitially between the detrital quartz and feldspar grains.

Minor opaques are disseminated through the rock as anhedral grains and granular aggregates generally below 0.05 mm in size.

This is a fine-grained detrital sediment consisting mainly of quartz and feldspar which has suffered recrystallization under advanced diagenetic or low grade metamorphic conditions.

Sample: P222/78; TSC19050

Rock Name:
Impure limestone

Hand Specimen:
A massive, pale grey rock.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Calcite	75
Quartz	15
Muscovite	4
Biotite	3
Sericite-clay	1
Feldspar	1
Chlorite	Trace
Opaques	1

This is a calcite-rich rock consisting mainly of fine-grained calcite (typical grain size about 0.05 mm) which contains disseminated quartz grains and mica flakes. The mica flakes exhibit a well-developed preferred orientation defining a lepidoblastic foliation.

The detrital quartz grains are generally between 0.05 and 0.1 mm in size and exhibit angular to sub-angular shapes which may have been slightly modified by marginal replacement with carbonate. Minor feldspar is also present in this rock and at least traces of polysynthetically twinned plagioclase were noted.

The mica flakes are up to 0.2 mm in length and consists of both muscovite and pleochroic brown biotite. Traces of pale green, weakly pleochroic chlorite are also noted as small flakes below 0.1 mm in length, which are also oriented parallel to the foliation direction. Minor amounts of sericite-clay are concentrated in very small aggregates below 0.1 mm in size, which most likely represent small clay pellets. Minor opaques are disseminated through the rock as anhedral grains generally below 0.05 mm in size.

This is an impure limestone containing a significant proportion of detrital quartz within well developed mica flakes which are also most likely of detrital origin.

Sample: P223/78; TSC19051

Rock Name:
Dolomite

Hand Specimen:
A massive, dark grey to black rock with a ferruginous, reddish-brown weathering rind up to about 2 mm wide. The carbonate in this rock was positively identified as dolomite by X-ray diffraction.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Dolomite	95
Quartz	1
Muscovite	trace-1
Calcite	trace
Opaques and semi-opaques	5

This is an essentially monomineralic sample comprised of very fine-grained, almost micritic dolomite with a typical grain size of about 0.05 mm. The dolomite forms a granular matrix through which minor opaques and minor detrital quartz and muscovite are disseminated. A very vague lamellar banded character is produced mainly by concentrations of opaque to semi-opaque iron oxide along narrow bands below 0.2 mm wide. Most of the carbonate has a somewhat turbid brown colour most likely due to very finely divided inclusions possibly of iron oxides.

The disseminated quartz grains are below 0.05 mm in size and generally have subrounded to subangular shapes. The muscovite forms small disseminated flakes below 0.1 mm in length which are generally oriented parallel to the vague banding.

Opaques and translucent, reddish brown semi-opaque material are disseminated through the rock as anhedral grains and granular aggregates up to 0.3 mm in size. Most of the disseminated opaque grains have marginal coronas consisting of finely granular dolomite with a reddish-brown iron-stained character.

A few narrow dolomite veinlets below 0.1 mm wide transect the rock approximately perpendicular to the vague lamellar banding. A single calcite veinlet approximately 0.05 mm wide is also present in the rock.

Sample: P224/78; TSC19052

Rock Name:
Limestone (?)calcrete

Hand Specimen:
A fragmental-appearing rock consisting of pale grey fragments cemented by interstitial pale tan-coloured vein-like structures. The sample reacts strongly to dilute hydrochloric acid, indicating it is rich in calcite.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Carbonate (calcite)	95
Quartz	3
Muscovite	1
Tourmaline	Trace
Opaques	1

This rock is comprised mainly of calcite which has a very fine, almost micritic grain size. The pale grey fragments noted in hand specimen consist almost exclusively of fine-grained (typical grain size about 0.03 mm) calcite intergrown with small amounts of quartz and muscovite. The quartz forms small grains below 0.03 mm in size, while the muscovite forms very small flakes below 0.05 mm long. A single grain of pleochroic green tourmaline approximately 0.3 mm long was also noted in one of these fragments.

The pale tan, interstitial vein-like structures also consist mainly of very fine-grained calcite similar to that in the fragments, except that this calcite has a somewhat turbid, brown character most likely due to finely-divided iron oxides. Locally, these vein-like structures contain irregular patches of coarser-grained calcite (typical grain size about 0.05 to 0.1 mm) of a somewhat 'sparry' character. This turbid iron-stained calcite also contains some intergrown quartz grains and muscovite flakes.

Minor opaques are disseminated through the rock as anhedral grains below 0.02 mm in size.

This is a limestone which has a well-developed fragmental texture suggesting that it in fact represents a surface cemented rock (i.e. calcrete).

Sample: P225/78; TSC19053

Rock Name:
Brecciated and silicified argillite

Hand Specimen:
A massive rock with an irregular, somewhat mottled colouration varying from milky-grey to dark reddish-brown.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	40
Argillite fragments	25
Calcite	15
Opaques and semi-opaques	20

This sample consists mainly of secondary minerals in the form of quartz, calcite and opaque to translucent reddish-brown iron oxide through which angular fragments of a fine-grained sediment (argillite). The argillite fragments are up to about 2 mm in size and consist mainly of finely divided phyllosilicate with minor detrital quartz. The detrital quartz grains are below 0.05 mm in size and are generally pretty evenly distributed through the argillite. Locally the argillite shows extensive replacement by granular quartz and some areas consist of granular, secondary quartz containing finely divided phyllosilicate flakes which appear to be remnants of argillite.

Quartz forms irregular patches up to several millimetres in size which have a highly variable grain size and texture. Some of the quartz forms moderately coarse-grained regions (grain size up to 0.5 mm) with a granular mosaic texture. Some coarse-grained quartz with euhedral to subhedral crystal shapes are also present. Other areas are comprised of much finer grained quartz generally intergrown with finely divided phyllosilicates which appear to be remnants from the original argillite.

Other areas of this rock are comprised of finely intergrown calcite and opaque to translucent reddish-brown iron oxide. Within some of these areas the iron oxides occur along remnant cleavage traces which have a prismatic character typical of amphibole suggesting that at least some of these areas could represent altered amphibole-rich zones. In other regions the limonite and calcite form irregular intergrowths with highly variable proportions of calcite and iron oxide. Within these regions euhedral quartz crystals up to 0.3 mm in size are locally present.

This sample is considered to represent a very fine-grained detrital sediment comprised mainly of clay with a minor proportion of silt-sized quartz which has suffered brecciation and replacement by secondary minerals in the form of quartz, calcite and iron oxide.

Sample: P226/78; TSC19054

Rock Name:
Deformed barite

Hand Specimen:
A massive, dull white rock with limonitic void fillings and narrow limonite-lined veinlets. Much of the barite tends to form elongate, 'platy' structures which are best seen on a weathered surface.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Barite	95
Carbonate	Trace-1
Opaques and semi-opaques	3

This sample consists mainly of large barite crystals several millimetres in size which form a coarse-grained mosaic. The barite shows extensive evidence of deformation with the formation of strained lamellae which locally have a 'kinked' character. Localised granulation of barite to form very fine-grained aggregates (typical grain size below 0.1 mm) has occurred along grain boundaries and some fractures. Most of the large barite crystals also show undulose extinction. The barite contains abundant, finely-divided inclusions, at least some of which represent opaque to translucent reddish-brown iron oxides which impart a turbid character to the barite. Translucent, reddish-brown iron oxides also occur as narrow fracture and vein fillings and localised, interstitial patches up to 3 mm in size.

Traces of carbonate are included within a few barite crystals as small grains and granular aggregates generally below 0.1 mm in size. This sample has not been stained with alizarin red-S solution so the carbonate has not been further identified.

Sample: P227/78; TSC19055

Rock Name:
Iron Oxide rock

Hand Specimen:
A dark grey rock with a somewhat nodular character. Examination of a freshly cut surface shows that it has a colloform texture. The rock shows no evidence of being magnetic when tested with a hand magnet.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	5
Iron-stained clay	1
Carbonate	Trace
Opaques	95

This sample consists mainly of opaque material which is believed to represent an iron oxide such as hematite or goethite. In hand specimen well developed colloform textures are evident, but in thin section it has a completely opaque character.

The quartz is intergrown with this opaque material as irregular patches up to a few millimetres wide and as euhedral to subhedral, prismatic crystals. The quartz patches have a very fine-grained, 'cherty' character which could have been produced by granulation of coarser-grained quartz. The individual prismatic crystals are generally included within the opaque material and typically have a size of about 0.3 mm. Minor carbonate is included within some of these well developed quartz crystals. This sample has not been stained with alizarin red-S solution, so the carbonates cannot be further identified.

A translucent, reddish-brown fibrous mineral locally partially fills void spaces or narrow fractures. This material is believed to represent an iron-stained clay and some of the larger patches contain small (generally about 0.1 mm in size) sub-angular quartz grains which appear to be of detrital origin.

This sample is comprised mainly of opaque, colloform iron oxides (probably goethite). It also contains some intergrown quartz which, at least locally, shows some evidence of granulation and deformation.

Sample: P228/78; TSC19056

Rock Name:

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Limestone

Thin Section:

An optical estimate of the constituents gives the following:

	%
Calcite	70
Quartz	15
Clay	10
Carbonate	3
Opaques & semi-opaques	3

This rock is comprised mainly of very fine-grained (typical grain size between 0.05 and 0.1 mm), microcrystalline calcite intergrown with quartz and argillaceous material. The quartz grains are up to 0.1 mm in size and exhibit somewhat irregular characters. At least some of the quartz grains appear to be of detrital origin but other quartz appears to be of secondary origin and tends to be concentrated along fractures. Minor detrital feldspar could also be present in the rock and masked by the detrital quartz but its proportions would be low.

Finely divided clay minerals tend to form small patches up to 0.1 mm in size and fine intergrowths with granular quartz.

Locally the rock contains carbonate rhombs(possibly dolomite) which show moderate to extensive replacement by translucent, reddish-brown iron oxides. Opaque to translucent reddish-brown iron oxides are also concentrated as discontinuous vein in fracture fillings below 0.1 mm wide. Some of these fracture fillings have an undulous, incipiently microstylolitic character.

This is a fine-grained, impure limestone consisting mainly of calcite intergrown with quartz and argillaceous material.

Sample: P229/78; TSC19057

Rock Name;
Recrystallized pelletal limestone

Hand Specimen:
A massive, pale grey coloured rock with some irregular vein-like structures up to 3 mm wide which have a white colour.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Calcite	95
Quartz	2
Clay-chlorite	2
Opaques and semi-opaques	1

This rock is comprised mainly of calcite which forms a recrystallized granular mosaic with a typical grain size of 0.1 to 0.2 mm. Ovoid structures generally about 0.3 mm in diameter are disseminated through the rock and generally consist of much finer grained, somewhat turbid appearing calcite. Most of these structures are comprised of an outer fine-grained, turbid band with an inner clear, coarser grained calcite intergrowth. These ovoid structures are considered to represent recrystallized pellets or oolites. Some calcite also forms coarser grained vein and fracture fillings up to several millimetres wide which are comprised of granular mosaic calcite with a typical grain size between 0.3 and 1 mm. These coarser grained calcite veins would represent the white veins noted in hand specimen.

Finely divided phyllosilicates with a yellowish-green colour (probably chlorite and clay) tend to be concentrated in irregular patches and vein-like structures. A few of these patches have angular shapes and textures similar to the argillite fragments in sample P225/78 (TSC19053). Finely granular quartz (typical grain size about 0.1 mm) is locally intergrown with these phyllosilicates.

Quartz is also disseminated through the rock as well developed prismatic crystals up to 0.5 mm in length. These crystals commonly exhibit hexagonal cross sections and small inclusions of calcite and are considered to represent authigenic quartz.

Opaques and translucent, reddish-brown semi-opaque material form disseminated grains and narrow fracture and vein fillings. Most of the opaque grains are below 0.1 mm in size although a few up to 0.4 mm in size are present. There is some tendency for the opaque grains to be concentrated in the phyllosilicat rich areas or locally in the cores of a few recrystallized pelletal structures At least one patch of translucent reddish-brown iron oxide exhibits a lamellar remnant cleavage structure.

This is a limestone which has suffered recrystallization but still contains ovoid structures considered to represent recrystallized pellets or oolites.

Sample: P230/78; TSC19058

Rock Name:
Limestone breccia

Hand Specimen:
A massive, reddish-brown coloured rock with an irregular, fragmental texture. In hand specimen the fragments have a darker reddish-brown colour and often an elongate, undulose character. On a weathered surface a fine, almost filigree texture is produced by differential weathering.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Calcite	85
Quartz	10
Plagioclase	1
Clay-chlorite	1
Muscovite	trace-1
Tourmaline	trace
Opaques and semi-opaques	3

This sample consists essentially of irregular fragments of fine-grained calcite which have elongate shapes and generally a subparallel orientation separated a matrix of slightly coarser grained (typical grain size approximately 0.1 mm) calcite. The angular fragments contain abundant translucent reddish-brown iron oxide which accounts for their darker colour in hand specimen. These fragments often have highly undulose, contorted characters suggesting that they were deformed in a plastic state. These fragments also contain very small angular quartz grains generally below 0.05 mm in size. One or two of these fragments contain intergrown phyllosilicates (clay and chlorite) similar to the phyllosilicates in the argillite fragments of sample P225/78 (TSC19053).

Detrital quartz grains are locally present in the calcite matrix. These grains have angular to subangular shapes and are between 0.05 and 0.2 mm in size. Polysynthetically twinned plagioclase similar in shape and size to the quartz grains are also disseminated through the slightly coarser grained calcite matrix and other, untwinned feldspar may also be present although none could be positively identified. Traces of muscovite form well developed flakes up to 0.5 mm in length which are considered to be of detrital origin. Rounded detrital tourmaline grains up to 0.2 mm in size were also noted and exhibit a pleochroic green colour. The angular detrital quartz and feldspar grains commonly exhibit marginal concentrations of opaque to translucent reddish-brown iron oxides. Minor opaques are also disseminated through the rock as anhedral grains and granular aggregates up to 0.3 mm in size.

This sample is considered to represent a banded rock which has undergone deformation in a partially plastic state to produce the present brecciated character. The fragments most likely represent plastic, argillite bands similar to the argillite in sample P225/78 which have been almost completely replaced by fine-grained calcite leaving only minor remnant small quartz grains and localized traces of phyllosilicate. The detrital quartz and minor feldspar, mica and tourmaline are intergrown with the granular calcite matrix which separates the fragments of deformed and carbonatized argillite.

Sample: P231/78; TSC19059

Rock Name:
Fine-grained sandstone

Hand Specimen:
A somewhat mottled brown to pale tan-coloured rock. The pale tan-coloured areas react weakly to dilute hydrochloric acid, but the darker brown areas are non-reactive.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	80
Feldspar	5
Carbonate (calcite)	5
Sericite-clay	5
Muscovite	1
Tourmaline	Trace
Zircon	Trace
Opaques and semi-opaques	5

This sample consists mainly of detrital quartz grains disseminated through a matrix comprised mainly of carbonate and opaque to translucent reddish-brown iron oxides. The detrital quartz grains exhibit angular to sub-angular shapes and are generally about 0.1 mm in size. Minor detrital feldspar is also present, although the exact proportion is hard to determine. At least some polysynthetically twinned plagioclase and gridiron twinned microcline is present in this rock and both forms of feldspar show very little alteration.

The interstitial carbonate is believed to consist mainly of calcite because of the reactive nature of the hand specimen to hydrochloric acid. This carbonate forms anhedral grains up to 0.25 mm in size, some of which show partial replacement by translucent, reddish-brown iron oxides. The darker coloured brown areas noted in hand specimen are areas where the carbonate has been completely or almost completely replaced by iron oxides, while the paler coloured areas contain carbonate which is only partially replaced by iron oxides. Minor opaques also form narrow fracture and vein fillings below 0.1 mm wide and disseminated grains, probably of detrital origin, generally about 0.1 mm in size.

Clay is disseminated through the rock as interstitial material intergrown with the iron oxides and small, rounded pellets generally about 0.05 mm in size. A few well developed muscovite flakes up to 0.2 mm long are also disseminated through the rock. Traces of detrital tourmaline and zircon form disseminated grains below 0.1 mm in size. The tourmaline has a pleochroic green colour and forms rounded to sub-rounded grains, while the zircon generally forms prismatic crystals.

This is a fine-grained detrital sediment with some intergrown carbonate which has been partially replaced by limonitic material.

Sample: P232/78; TSC19060

Rock Name:
Dolomitic siltstone

Hand Specimen:
A massive, pale brown to tan coloured rock. Black manganese oxides line fracture surfaces and locally have a dendritic character.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz and feldspar	40
Dolomite	20
Muscovite-sericite	20
Chlorite	10
Calcite	5
Translucent iron oxides	5
Opaques	1

This sample consists essentially of silt-sized quartz and feldspar grains intergrown with finely divided phyllosilicates and altered dolomite rhombs. The quartz and feldspar have a recrystallized character and forms grains up to 0.05 mm in size. The relative proportions of quartz and feldspar are hard to determine because of the fine grain size and lack of twinning in the feldspar. Muscovite flakes up to 0.1 mm in length are disseminated through the rock and exhibit a preferred orientation defining a vague lepidoblastic foliation. Finely divided sericite and clay are also intergrown with the quartz and feldspar as are small flakes of pleochroic green chlorite.

Dolomite is disseminated through the rock as crystals up to 0.05 mm in size which generally exhibit a rhomb-shape. These dolomite crystals have been largely replaced by translucent reddish-brown iron oxide particularly around their margins and to a lesser extent by calcite. The abundance of iron oxides intergrown with the rhombs would account for the brown colour of the sample in hand specimen. Minor calcite is also locally present as narrow fracture and vein fillings particularly adjacent to opaque filled veins.

Opaques form anhedral disseminated grains up to 0.1 mm in size and narrow fracture and vein fillings. The opaques which occur as fracture and vein fillings would represent the manganese linings noted in hand specimen.

This is a fine-grained detrital rock with a high carbonate content.

Sample: P233/78; TSC19061

Rock Name:
Limestone breccia

Hand Specimen:
A massive dark reddish-brown rock with a variegated, somewhat fragmental appearing texture best seen on a freshly cut surface.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Calcite	90
Quartz	4
Clay-chlorite	1
Muscovite	trace
Opaques and semi-opaques	5

This sample consists essentially of limestone fragments with a granular texture cemented by a limestone matrix with a similar, granular texture. The fragments are defined mainly by concentrations of translucent, reddish-brown iron oxides around their margins although finely divided translucent iron oxides are also disseminated through some of the fragments and most of the matrix material. In some cases the iron oxides form opaque to semi-opaque intergranular concentrations up to 0.5 mm in size, but for the most part they have a finely divided, intergranular texture with a translucent reddish-brown colour. The calcite shows quite a variation in grain size with some fragments containing large calcite crystals up to 1 mm in size while the matrix generally had the finest grain size with a typical grain size of about 0.05 mm.

Detrital quartz grains are disseminated through the rock as angular fragments approximately 0.15 mm in size which occur within the calcite matrix and to a lesser extent within some fragments. Traces of yellow to reddish-brown iron-stained phyllosilicates (probably chlorite and/or clay) are locally present as small patches up to 0.5 mm in size. A few small muscovite flakes up to 0.1 mm in length are also disseminated through the rock and most likely represent small detrital muscovite flakes.

Locally the margins of the fragments have suffered pressure solution to produce irregular,stylolitic contacts. Some of the fragments also have highly undulose characters suggesting that they had suffered deformation in a plastic state.

This rock is considered to be very similar to sample P230/78 (TSC19058) in origin but has suffered somewhat extensive replacement of fragments by calcite and recrystallization of this calcite to produce a more coarsely granular texture.

Sample: P234/78; TSC19062

Rock Name:
Recrystallized pelletal limestone

Hand Specimen:
A massive, pale tan coloured rock.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Calcite	90
Quartz	5
Barite	2
Clay-chlorite	1
Opaques and semi-opaques	1

This is an essentially a monomineralic rock consisting of a recrystallized granular (typical grain size between 0.1 and 0.2 mm) calcite intergrowth. Despite the recrystallization, round to ovoid structures similar to that in sample P229/78 (TSC19057) are disseminated through the rock and defined mainly by margins of finer grained, turbid appearing carbonate. Internally these structures generally consist of more coarsely granular carbonate similar to the bulk of the matrix carbonate.

Quartz is disseminated through the rock as prismatic crystals up to 0.5 mm long with well developed hexagonal cross sections. These well developed quartz crystals are considered to represent authigenic quartz and locally they contain inclusions of calcite. Minor finely granular quartz is also present as small, irregular patches up to 0.3 mm in size. Traces of finely divided phyllosilicates are locally intergrown with this finely granular quartz but most of the phyllosilicates in this rock form small, irregular patches up to 0.5 mm in size.

Barite is also present locally as crystals up to 0.8 mm in size which are intergrown with the finely granular calcite.

Minor translucent, reddish-brown iron oxides locally occur interstitially between the granular calcite. Opaques are disseminated through the rock as anhedral grains and interstitial fillings up to 0.1 mm in size.

Although most of the rock consists of relatively fine-grained calcite with a remnant pelletal texture few fragments of finely intergrown calcite and quartz were also noted. These fragments have angular shapes and are up to 3 mm long.

This is a recrystallized pelletal or oolitic limestone very similar to sample P229/78 although this sample also contains some fragments of very fine-grained calcite-quartz intergrowths.

Sample: P235/78; TSC19063

Rock Name:
Shale

Thin Section:
An optical estimate of the constituents gives the following:

	%
Argillaceous matrix	85
Quartz	10
Opaques & semi-opaques	5

This rock is comprised mainly of a very fine-grained argillaceous matrix with a translucent, reddish-brown colour due to limonitic staining. The matrix is comprised mainly of weakly birefringent clay intergrown with finely divided sericite-muscovite flakes. Some of the muscovite flakes are up to 0.1 mm in length although most have a much finer size. A very vague and weakly developed foliation is evident within the matrix defined largely by phyllosilicate flakes.

Detrital quartz grains are disseminated through the rock and are rarely over 0.05 mm in size although a few larger grains up to 0.1 mm in size are present. Minor detrital feldspar could also be present but the fine grain size makes positive identification difficult.

Translucent, reddish-brown to opaque iron oxides form small disseminated grains and granular aggregates up to 0.1 mm in size. Finely divided limonitic material is disseminated through the rock and produces a translucent, reddish-brown character to much of the argillaceous material.

This is a very fine-grained detrital sediment consisting mainly of argillaceous material.

Sample: P236/78; TSC19064

Rock Name:
Ferruginous, silty argillite

Hand Specimen:
A tan to pale brown coloured rock with a very finely laminated bedding. Some fracture surfaces contain fillings and encrustations of calcite which locally form bladed crystals intergrown with reddish-brown iron oxides but in other places form a somewhat drusy coating. The calcite was identified by examination in temporary oil mounts and testing with dilute hydrochloric acid.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Argillaceous matrix	55
Quartz and feldspar	30
Muscovite-sericite	5
Bright green phyllosilicate	trace
Translucent iron oxides	10

This sample consists essentially of a phyllosilicate-rich matrix through which angular fine sand to silt-sized (typical size between 0.03 and 0.08 mm) detrital quartz grains are disseminated. The argillaceous matrix consists mainly of fibrous clay and chlorite and generally has somewhat reddish-brown iron-stained character.

Although the iron-staining of the matrix makes identification difficult a significant amount of chlorite is believed to be intergrown with the argillaceous matrix. Well developed muscovite flakes up to 0.1 mm in length are disseminated through the rock and exhibit a weakly developed preferred orientation defining a vague lepidoblastic foliation. A few very small (below 0.05 mm in size) flaky aggregates of a bright green phyllosilicate which locally has a somewhat pelletal character are also disseminated through the rock.

The detrital quartz grains generally have angular shapes and at least some grains of detrital feldspar similar in size and shape to the quartz grains were also noted. The feldspar which was postively identified consists of polysynthetically twinned plagioclase and a higher proportion of feldspar could be present and due to its lack of twinning and grain size difficult to distinguish from quartz.

Translucent reddish-brown opaques are disseminated through the rock as small patches generally below 0.2 mm in size. Similar translucent reddish-brown iron oxides also occur locally as narrow fracture fillins below 0.1 mm wide. These disseminated, translucent iron oxides are considered to be a replacement product of dolomite and locally exhibit prismatic shapes typical of dolomite. In sample P232/78 (TSC19060) dolomite rhombs partially replaced by similar iron oxide are disseminated through the rock and in this sample it is believed that the dolomite has been completely replaced by iron oxides.

The fine lamellar banding noted in hand specimen is not as easily visible in thin section but appears to be reflected mainly in variations in proportion of detrital quartz and variations in the proportion of translucent iron oxides in various bands.

This is a very fine-grained detrital sediment similar to sample P232/78 although this sample appears to have a smaller proportion of detrital quartz and suffered complete replacement of dolomite by iron oxides.

Sample: P237/78; TSC19065

Rock Name:
Argillaceous siltstone

Hand Specimen:
A reddish-brown, finely laminated rock.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	60
Argillaceous material	25
Calcite	10
Tourmaline	Trace
Opaques and semi-opaques	5

This sample consists mainly of very fine-grained, detrital quartz and feldspar grains disseminated through an iron-stained argillaceous matrix. Quartz is by far the most abundant of the detrital components and the exact proportions of feldspar present is hard to determine, but at least some was positively identified. These detrital grains are below 0.04 mm in size and exhibit sub-angular shapes. Most of the argillaceous matrix is a reddish-brown, iron-stained colour, although some unstained, finely divided muscovite-sericite flakes are also present.

Calcite is disseminated through the rock as small grains below 0.05 mm in size. Traces of detrital tourmaline form small, pleochroic green grains and opaques are disseminated through the rock as anhedral grains up to 0.1 mm in size.

The sample contains several discontinuous clay-rich bands with a deep, reddish-brown translucent colour. One large argillaceous clast several millimetres in size is also present in the rock.

This is a fine-grained detrital sediment with a significant calcite content.

Sample: P238/78; TSC19066

Rock Name:
Dolomite

Thin Section:
An optical estimate of the constituents gives the following:

	%
Carbonate (dolomite)	80
Quartz	10
Calcite	5
Sericite-clay	2
Opaques and semi-opaques	5

This rock is comprised mainly of a very finely granular, dolomite mosaic with a typical grain size below 0.05 mm. The dolomite contains disseminated quartz grains generally below 0.1 mm in size as well as irregular patches of opaque to translucent, reddish-brown iron oxides. The iron oxide patches are up to 1 mm in size and limonitic material tends to be concentrated interstitially between the highly granular dolomite within these patches.

The rock contains a few narrow (below 1 mm wide) calcite-rich bands which also contain localized concentrations of granular quartz and finely divided sericite-clay. Some of the granular quartz within these bands has a slightly coarser grain size (up to 0.15mm) than the quartz disseminated through the microcrystalline dolomite. Opaques also tend to be concentrated within these bands as anhedral grains as well as marginal concentrations with a vein-like character. These bands probably represent a remnant bedding and the rock also contains other localized bands with concentrations of translucent iron oxides and finely granular quartz and finely divided sericite-clay. A few very narrow veinlets (below 0.05 mm wide) filled with calcite and opaques transect this general banding.

Minor opaques are disseminated through the rock as anhedral grains up to 0.1 mm in size.

This is a very fine-grained carbonate rock believed to consist mainly of dolomite although the unstained carbonate has not been positively identifiec either optically or with X-ray diffraction.

Sample: P239/78; TSC19067

Rock Name:
Silty/Sandy Shale

Thin Section:
An optical estimate of the constituents gives the following:

	%
Argillaceous matrix	65
Quartz and feldspar	25
Tourmaline	Trace
Opaques & semi-opaques	10

This sample is comprised mainly of an argillaceous matrix consisting of sericitic material intergrown with weakly birefringent clay. The argillaceous matrix has a very vague foliation and contains concentrations of intimately intergrown translucent, reddish-brown iron oxides. These iron oxides form irregular patches up to 0.1 mm in size and are locally concentrated along narrow fractures and veins up to 0.05 mm wide. The matrix also contains some small muscovite flakes up to 0.1 mm long which are oriented parallel to the general foliation direction.

Angular to subangular quartz and feldspar grains with a very fine sand to silt size (typical grain size below 0.1 mm) are disseminated through the matrix. Most of this detritus appears to be comprised of quartz although at least a small proportion of feldspar including polysynthetic twinned plagioclase is present. The fine grain size and probable lack of twinning of much of the feldspar makes mineral proportions difficult to estimate. The feldspar which can be identified generally has a very fresh character with some grains having a slightly reddish-brown colour due to finely divided iron oxides with other grains showing only incipient sericitization.

Tourmaline is disseminated through the rock as small crystals below 0.1 mm in size which exhibit a pleochroic green colour. Traces of a bright green phyllosilicate form small pellets below 0.1 mm in size. Minor opaques are disseminated through the rock as anhedral grains with angular aggregates up to 0.15 mm in size.

This is an argillaceous sediment containing a significant proportion of very fine sand to silt sized detritus.

Sample: P240/78; TSC19068

Rock Name:
Argillaceous siltstone/very fine-grained sandstone

Hand Specimen:
A pale greenish-grey coloured rock with a finely banded character and localized scour and fill textures.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz and feldspar	45
Argillaceous matrix	40
Muscovite-sericite flakes	5
Chlorite flakes	2
Tourmaline	trace
Bright green phyllosilicate	trace
Translucent iron oxides	5
Opaques	3

This sample consists essentially of angular fine sand to silt-sized (typical grain size between 0.03 and 0.1 mm) detrital quartz and feldspar particles distributed through an interstitial phyllosilicate-rich matrix. The matrix is comprised mainly of greenish brown phyllosilicate and contains at least some fibrous pleochroic brown biotite. Well developed muscovite flakes up to 1.5 mm in length are disseminated through the rock and exhibit a well developed lepidoblastic foliation. This foliation is oriented parallel to the banding noted in hand specimen which is reflected in thin section by variations in grain size and proportions of detrital particles. Minor chlorite is also disseminated through the rock as well developed flakes up to 0.1 mm long which have a pleochroic green colour. Traces of a bright green phyllosilicate form small aggregates below 0.05 mm in size.

The exact proportions of detrital quartz and feldspar in this rock are hard to determine because of the fine grain size and lack of twinning in the feldspar. Some feldspar exhibits polysynthetic twinning typical of plagioclase but most of the feldspar is untwinned and only a portion of this has a somewhat turbid character due to finely divided micron-sized inclusions. It is believed that a significant proportion of the detrital felsic mineral grains (probably about 30%) is comprised of feldspar. Traces of detrital tourmaline are also present as rounded, pleochroic green grains up to 0.1 mm in size.

Translucent, reddish-brown iron oxides form irregular aggregates up to 0.2 mm in size. These iron oxides are believed to represent a replacement product of dolomite and locally exhibit prismatic shapes typical of carbonate although no remnants of dolomite, such as are present in sample P232/78 (TSC19060), were observed. Opaques are disseminated through the rock as anhedral grains below 0.1 mm in size.

This is a fine-grained detrital rock similar to the previously described argillites and siltstones.

Sample: P241/78; TSC19069

Rock Name:
Feldspathic siltstone

Hand Specimen:
A dark reddish-brown weakly laminated rock with a vague, platy foliation.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Feldspar	40
Quartz	35
Muscovite-sericite	12
Chlorite	5
Translucent iron oxides	5
Opaques	3

This sample consists essentially of small (generally below 0.05 mm) detrital quartz and feldspar grains with an interstitial ferruginous matrix. The quartz and feldspar grains exhibit angular to subangular, recrystallized shapes and the feldspar can generally be distinguished from the quartz by its slightly turbid character produced by finely divided micron-sized inclusions. Well developed muscovite flakes up to 1.5 mm in length are disseminated through the rock and exhibit a well developed lepidoblastic foliation. A vague banding is oriented parallel to this foliation direction and defined mainly by slight variations in the proportion of opaque to semi-opaque iron oxides. Minor pleochroic green chlorite forms well developed flakes below 0.1 mm in size which are also generally oriented parallel to the foliation and banding.

The grain margins between the detrital quartz and feldspar grains contain concentrations of finely divided translucent, reddish-brown iron oxides but these iron oxides are also disseminated through the rock as irregular patches up to 0.2 mm in size. By comparison with sample P232/78 (TSC19060) these patches could represent replaced dolomite although the textural evidence to support such an interpretation is weak. Opaques are disseminated through the rock as anhedral grains below 0.08 mm in size.

This is a fine-grained detrital rock consisting largely of quartz and feldspar cemented by an iron oxide-rich matrix.

Sample: P242/78; TSC19070

Rock Name:
Ferruginous fine-grained sandstone

Hand Specimen:
A massive, dark reddish-brown rock.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	45
Feldspar	20
Ferruginous matrix	20
Muscovite-sericite	5
Chlorite	5
Tourmaline	trace-1
Opaques	5

This sample consists essentially of angular fine sand-sized (typical grain size approximately 0.1 mm) detrital quartz and feldspar grains cemented by a translucent reddish-brown, ferruginous matrix. Well developed muscovite flakes up to 0.1 mm in length are disseminated through the rock and generally exhibit a random orientation. A fibrous muscovite-sericite is also intergrown with the ferruginous matrix. Pleochroic green chlorite also forms flakes up to 0.08 mm in size.

Most of the feldspar is untwinned although a small proportion exhibits polysynthetic twinning typical of plagioclase. The untwinned feldspar can usually be distinguished from quartz by its slightly turbid character (due to finely divided micron-sized inclusions) although some limpid feldspar is also present making the exact proportions of quartz and feldspar somewhat indefinite. Although most of the detrital grains have angular to subangular shapes and are approximately 0.1 mm in size, a few larger detrital quartz grains up to 0.4 mm in size with subrounded shapes are also disseminate through the rock.

The ferruginous matrix is believed to be comprised mainly of translucent reddish-brown iron oxides intergrown with finely divided phyllosilicates. The phyllosilicates are largely masked by the translucent character of the iron oxides. Opaques are also disseminated through the rock as anhedral grains up to 0.1 mm in size. Traces of detrital tourmaline form angular grains below 0.1 mm in size which have a pleochroic green colour.

This is a fine-grained detrital sediment consisting mainly of quartz and feldspar in a ferruginous matrix.

Sample: P243/78; TSC19071

Rock Name:
Fine-grained sandstone

Hand Specimen:
A well banded rock consisting of alternating dark reddish-brown and pale grey bands ranging in width between 0.5 and 3 mm.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	55
Feldspar	20
Muscovite-sericite	10
Chlorite	5
Bright green phyllosilicate	trace
Tourmaline	trace
Opaques and semi-opaques	10

This sample consists essentially of a granular mosaic comprised of angular to subangular, fine sand-sized (typical grain size about 0.1 to 0.15 mm) quartz and feldspar. The well developed banding noted in hand specimen is due mainly to variations in the proportion of opaque to semi-opaque iron oxides located interstitially between the detrital felsic mineral grains.

Authigenic quartz is present as overgrowths over quartz grains and more rarely as fine void fillings which have a radial, slightly banded texture. The exact proportion of authigenic quartz is hard to determine although in most cases the overgrowths can be seen by a narrow band of opaque to semi-opaque iron oxides between the detrital quartz grain and the quartz overgrowth. At least some of the authigenic quartz has a slightly turbid reddish-brown colour due to finely divided iron oxide inclusions making it particularly hard to determine the proportion of feldspar since the feldspar also commonly has a similar turbidity. Most of the feldspar is untwinned but some detrital feldspar grains with polysythetic twinning typical of plagioclase, or gridiron twinning typical of microcline are also present. Most of the feldspar is quite fresh although some feldspar grains show incipient alteration to finely divided sericite-clay.

Muscovite flakes up to 0.1 mm in length are disseminated through the rock and exhibit a preferred orientation defining a lepidoblastic foliation. Many of the muscovite flakes have contorted or broken shapes where they are bent around detrital felsic mineral grains. A bright green phyllosilicate is disseminated through the rock as very fine flaky aggregates up to 0.05 mm in size.

Traces of pleochroic green tourmaline form angular detrital grains up to 0.1 mm in size.

This is a fine-grained detrital sediment consisting mainly of quartz and feldspar with some iron oxide-rich bands.

Sample: P244/78; TSC19072

Rock Name:
Feldspathic siltstone/very fine-grained sandstone

Hand Specimen:
A massive, dark reddish-brown coloured rock.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	35
Feldspar	30
Muscovite	10
Sericite-clay	5
Chlorite	5
Carbonate	5
Tourmaline	trace
Bright green phyllosilicate	trace
Opaques and semi-opaques	10

This sample is comprised mainly of very fine sand to silt-sized (typical grain size below 0.05 mm) detrital quartz and feldspar grains intergrown with phyllosilicates and somewhat altered carbonate. The detrital quartz and feldspar grains have angular to subangular shapes and although the exact proportions of these two minerals is hard to determine. They are considered to be about equally abundant. Most of the feldspar is untwinned and can be distinguished from the quartz by a slightly turbid character produced by finely divided micron-sized inclusions. A small proportion of the feldspar exhibits polysynthetic twinning typical of plagioclase. Much of the feldspar also shows incipient alteration to finely divided sericite-clay and some highly altered feldspar grains would be hard to distinguish from matrix phyllosilicates.

Well developed muscovite flakes up to 0.1 mm in length are disseminated through the rock and exhibit a well developed lepidoblastic foliation. Flakes of pleochroic green chlorite up to 0.5 mm in length are also oriented parallel to this foliation direction. Traces of a bright green phyllosilicate forms small pelletal appearing bodies below 0.05 mm in size.

Carbonate is disseminated through the rock as crystals up to 0.1 mm in size which show moderate to extensive replacement by translucent, reddish brown iron oxides. By analogy with sample P232/78 (TSC19060) the bulk of this carbonate is considered to be dolomite although some calcite could also be present.

Opaques are disseminated through the rock as anhedral grains below 0.05 mm in size. Traces of detrital tourmaline form angular, pleochroic green fragments up to 0.05 mm in size.

The rock is cut by a vein approximately 0.3 mm wide consisting of slightly coarser grained granular quartz (typical grain size about 0.1 mm) intergrown with carbonate.

This is a very fine-grained detrital sediment containing some carbonate which has been partially replaced by iron oxides. Both recrystallization and the formation of a well developed lepidoblastic foliation are due to either advanced diagenesis or very low grade metamorphism.

Sample: P245/78; TSC19073

Rock Name:
Ferruginous fine-grained sandstone

080

Hand Specimen:
A massive, dark reddish-brown rock.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz and feldspar	65
Ferruginous matrix	15
Carbonate	10
Muscovite	5
Chlorite	2
Tourmaline	trace
Opaques	5

This sample consists essentially of angular, fine sand-sized (typical grain size approximately 0.1 mm) detrital grains of quartz and feldspar cemented by a translucent, reddish-brown iron-stained matrix. The detrital quartz and feldspar are considered to be in approximately sub-equal proportions although the lack of twinning in the feldspar makes distinction between these two minerals difficult. Only a small proportion of the feldspar exhibits polysynthetic twinning typical of plagioclase but a high proportion of the untwinned feldspar has a turbid, reddish-brown colour produced by finely divided micron-sized inclusions.

The interstitial ferruginous matrix is believed to consist of finely divided phyllosilicates intergrown with translucent, reddish-brown iron oxides. Well developed muscovite flakes up to 0.1 mm in length are disseminated through the rock and exhibit a vague lepidoblastic foliation. Minor green chlorite also forms disseminated flakes and flaky aggregates up to 0.1 mm in size.

Carbonate is disseminated through the rock as irregular grains up to 0.1 mm in size which form granular intergrowths with the detrital quartz and feldspar Only a small proportion of this carbonate exhibits minor marginal replacement by translucent, reddish-brown iron oxides.

Opaques are disseminated through the rock as anhedral grains up to 0.1 mm in size. Traces of pleochroic green tourmaline form small (below 0.05 mm), rounded grains with a pleochroic green colour.

This is a fine-grained detrital rock consisting mainly of quartz and feldspar cemented by a translucent, reddish-brown iron-stained matrix.

Sample: P246/78; TSC19074

Rock Name:
Feldspathic siltstone

Hand Specimen:
A dark reddish-brown coloured rock with a vague, somewhat flaggy foliation.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Feldspar	40
Quartz	30
Sericite-clay	20
Muscovite	5
Chlorite	1
Tourmaline	trace
Bright green phyllosilicate	trace
Opaques and semi-opaques	5

This sample consists essentially of very fine-grained quartz and feldspar detritus cemented by an argillaceous, iron-stained matrix. Most of the detritus has a grain size below 0.05 mm although some larger quartz grains up to about 0.1 mm in size are disseminated through the rock. The detrital quartz and feldspar grains have angular to subangular shapes which have been mildy modified by recrystallization and alteration. The feldspar in particular tends to show moderate to extensive alteration to finely divided phyllosilicates (sericite-clay) with some feldspar grains being almost completely replaced by phyllosilicates. The unaltered feldspar has a turbid reddish-brown colour due to finely divided micron-sized inclusions which distinguishes it from the detrital quartz. Only a very small proportion of the feldspar exhibits polysynthetic twinning typical of plagioclase.

Well developed muscovite flakes up to 0.1 mm in size are disseminated through the rock and exhibit a well developed lepidoblastic foliation. Traces of pleochroic green chlorite also forms small, somewhat fibrous shapes also oriented parallel to this foliation direction. A bright green phyllosilicate forms small aggregates below 0.05 mm in size.

Opaques are disseminated through the rock as anhedral grains below 0.08 mm in size. Traces of tourmaline form small pleochroic green crystals. crystals below 0.05 mm in size.

This is a very fine-grained detrital sediment consisting largely of feldspar and quartz in which the feldspar has suffered a moderate alteration to secondary phyllosilicates.

Sample: P247/78; TSC19075

Rock Name:
Feldspathic siltstone

Hand Specimen:
A dark reddish-brown coloured rock with a vague, somewhat flaggy foliation.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Feldspar	40
Quartz	30
Sericite-clay	20
Muscovite	5
Chlorite	1
Tourmaline	trace
Opaques and semi-opaques	5

This sample is basically very similar to sample P246/78 (TSC19074) consisting essentially of silt-sized (typical grain size below 0.5 mm) detrital quartz and feldspar grains cemented by an iron-stained phyllosilicate-rich matrix. The feldspar grains show varying degrees of alteration to secondary phyllosilicates with some feldspar grains being almost completely replaced by secondary phyllosilicates. Well developed muscovite flakes are disseminated through the rock and exhibit a well developed lepidoblastic foliation.

The main difference between this sample and sample P246/78 is that this sample has a banded character which is not evident in hand specimen but can be easily seen by the naked eye in thin section. This banding is due mainly to fine concentrations of anhedral opaque grains in bands approximately 0.3 mm wide. Although opaques are disseminated through the rock these narrow bands contain slight concentrations of these opaque grains.

This is a fine-grained detrital sediment similar in mineralogy, texture and origin to sample P246/78 except that it has a slightly banded character due to concentrations of disseminated opaques.

Sample: P248/78; TSC19076

Rock Name:
Feldspathic siltstone

Hand Specimen:
A reddish-brown coloured rock with a fine, lamellar banding consisting of alternating dark reddish-brown to pale, greyish-brown bands. The bands reach a maximum width of about 2 mm.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	35
Feldspar	30
Sericite-clay	20
Muscovite	5
Chlorite	1
Tourmaline	trace
Opaques and semi-opaques	10

This sample is very similar to samples P246/78 and P247/78 (TSC19074-5) and consists essentially of detrital quartz and feldspar grains disseminated through a translucent, reddish-brown iron-stained matrix. Most of the detrital grains are below 0.05 mm in size although some larger quartz grains up to about 0.15 mm in size are disseminated through the rock. The feldspar generally has a turbid character produced by finely divided micron-sized inclusions and also shows moderate alteration to sericite-clay. Well developed muscovite flakes up to 0.1 mm in length are disseminated through the rock and exhibit a lepidoblastic foliation oriented parallel to the banding.

The banding noted in hand specimen is due mainly to concentrations of opaques and bands up to about 1 mm wide. Unlike sample P247/78 the opaques in this sample tend to form irregular aggregates up to about 0.3 mm in size and discontinuous, elongate bodies rather than anhedral grains. Anhedral opaque grains below 0.1 mm in size are disseminated through the rock but do not show any concentration in these opaque-rich bands. These irregular patches of opaques could represent carbonate which has been completely replaced by translucent to opaque iron oxides but there is no textural evidence to support this suggestion.

This is a fine-grained detrital sediment similar in mineralogy, texture and origin to the previously described feldspathic siltstones.

Sample: P249/78; TSC19077

Rock Name:
Recrystallized feldspathic siltstone

Hand Specimen:
A massive, reddish-brown coloured rock with a vague, somewhat flaggy foliation. On a freshly cut surface irregular liesegang structure is evident. The rock also contains small dark reddish brown limonite crystals below 1 mm in size which have euhedral shapes and are considered to represent pseuodmorphs after disseminated pyrite.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Feldspar	40
Quartz	35
Sericite-caly	10
Muscovite	5
Tourmaline, zircon	trace
Opaques and semi-opaques	10

This sample consists essentially of silt to very fine sand-sized (typical grain size about 0.05 mm) quartz and feldspar grains which form a granular mosaic intergrown with translucent iron oxides and phyllosilicates. The feldspar for the most part is untwinned with only a small proportion exhibiting polysynthetic twinning typical of plagioclase. Most of the feldspar shows at least some alteration to finely divided sericite and invariably has a turbid character due to finely divided micron-sized inclusions.

Well developed muscovite flakes up to 0.1 mm long are disseminated through the rock and exhibit a lepidoblastic foliation. Finely divided sericite-clay occurs interstitially between the quartz and feldspar grains and as an alteration product of feldspar. Translucent, brown iron oxides occur interstitially between the quartz and feldspar as irregular patches up to 0.15 mm in size. There is some tendency for these interstitial iron oxides to be concentrated in narrow bands. Small anhedral opaque grains below 0.1 mm in size are also disseminated through the rock. Large opaque to weakly translucent red grains generally between 0.4 and 1 mm in size are also disseminated through the rock and exhibit euhedral to subhedral shapes. These large opaque grains represent the limonite pseudomorphs after pyrite noted in hand specimen. Traces of tourmaline and zircon are disseminated through the rock as small crystals below 0.05 mm in size. The tourmaline has a pleochroic green colour.

This is a feldspathic siltstone similar to the previously described feldspathic siltstones (sample P246/78 to P248/78; TSC19074-6) except that this sample has suffered more intense recrystallization to produce a better developed granular mosaic texture and a tendency to concentrate the translucent iron oxides into larger, interstitial areas.

Sample: P250/78; TSC19078

Rock Name:
Very fine-grained feldspathic sandstone

Hand Specimen:
A grey to reddish-brown coloured rock with a vague, undulose character due to irregular darker coloured bands up to about 1 mm wide. The sample exhibits a darker reddish-brown coloured weathering rind approximately 1 cm thick. Similar reddish-brown alteration occurs marginal to fractures within the rock.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	45
Feldspar	30
Carbonate (?dolomite)	10
Sericite-clay	5
Muscovite	trace-1
Tourmaline, zircon, apatite	trace
Opaques and semi-opaques	10

This sample consists essentially of recrystallized, detrital quartz and feldspar grains approximately 0.1 mm in size which produce a granular mosaic locally intergrown with carbonate or translucent iron oxides. The feldspar can generally be distinguished from the quartz by a slightly turbid, reddish-brown colour which is produced by finely divided micron-sized inclusions. The feldspar also shows incipient alteration to finely divided sericite-clay. Most of the feldspar is untwinned although a small proportion with polysynthetic twinning typical of plagioclase is present. Most of the finely divided phyllosilicate (muscovite-sericite) occurs along the grain boundaries between quartz and feldspar.

The carbonate forms small crystals and granular aggregates up to 0.15 mm in size which generally have irregular shapes although a few exhibit prismatic shapes. In the weathering rind the carbonate has been completely or almost completely replaced by translucent, brown iron oxides which for the most part lack any prismatic pseudomorphic shapes indicating their original mineralogy. This alteration also occurs marginal to narrow fractures. Such replacement of carbonate (particularly dolomite) by translucent iron oxides is considered to be a common feature of these rocks and has been described in sample P232/78 (TSC19060). In most samples the carbonate has been completely replaced leaving only the translucent iron oxides which only very rarely show textural evidence indicating they have replaced carbonate.

Anhedral to subhedral opaque grains up to 0.15 mm in size are disseminated through the rock but are locally concentrated in narrow bands up to about 1 mm wide which would represent the darker coloured bands noted in hand specimen.

Traces of tourmaline, zircon and apatite are also disseminated through the rock as small crystals below 0.05 mm in size which also tend to be concentrated in the opaque-rich mineral bands. Most of the tourmaline has a pleochroic green colour similar to the tourmaline in the previously described samples although one tourmaline grain with a pleochroic greenish

brown colour was noted.

This is a fine-grained detrital sediment containing a significant carbonate content which has suffered recrystallization and mild alteration of feldspar. The carbonate has been completely replaced by translucent iron oxides within the weathering rind and marginal to fine fractures along which weathering and alteration by solutions could proceed.

Sample: P251/78; TSC19079

Rock Name:
Arkosic sandstone

Hand Specimen:
A grey to tan-coloured rock with small, reddish-brown limonite patches. The rocks shows a mild reaction to dilute hydrochloric acid.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	55
Feldspar	35
Carbonate (calcite)	3
Apatite	1
Muscovite	Trace-1
Tourmaline	Trace
Zircon	Trace
Opaques and semi-opaques	5

This sample consists mainly of relatively fine-grained (typical grain size about 0.1 mm) quartz and feldspar which form an equigranular mosaic. The feldspar can be distinguished from the quartz by its slightly turbid character produced by finely-divided micron-sized inclusions and is a significant component in this rock. Both the quartz and feldspar grains have sub-angular shapes which have been slightly modified by recrystallization. A small proportion of chert grains are also present in the rock. The feldspar consists mainly of untwinned orthoclase but smaller proportions of gridiron twinned microcline and polysynthetically twinned plagioclase are also present. Small amounts of detrital apatite, tourmaline and zircon are also present in the rock. The apatite in particular tends to form relatively large (about 0.1 mm in size) prismatic crystals. Both the tourmaline and zircon generally form smaller crystals (about 0.05 mm in size) and the tourmaline exhibits a pleochroic green colour.

Some interstitial carbonate is disseminated through the rock as irregular shaped crystals up to 0.1 mm in size. The mild reaction of the hand specimen to hydrochloric acid suggests that most, if not all, of the carbonate is calcite. Most of this carbonate shows some replacement by opaque to translucen reddish-brown iron oxides, although some carbonate grains with no evidence of replacement are present. Opaques are also disseminated through the rock as irregular patches up to 0.15 mm in size, at least some of which could represent completely replaced carbonate. Minor opaque to translucent reddish-brown iron oxides also form narrow fracture and vein fillings. Traces of muscovite are disseminated through the rock as small well-developed flakes up to 0.15 mm in length.

This is a relatively fine-grained detrital sediment which is somewhat different from the previously described sediments in that it has a significant feldspar content and also contains accessory detrital apatite.

Sample: P252/78; TSC19080

Rock Name:
Dolomite

Hand Specimen:
A massive, tan coloured rock with some narrow white veinlets. On a weathered surface the veinlets preferentially weather to produce deep incisions into the rock.

A portion of this sample was stained with alizarin red-S solution which did not appear to affect the bulk of the rock although its pale tan colour could mask the staining effect. Most of the narrow white veinlets were stained pink indicating they are calcite.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Carbonate	95
Quartz	1
Opaques and semi-opaques	5

This is essentially a monomineralic rock comprised of small carbonate grains below 0.05 mm in size which form a fine-grained granular mosaic. The rock is cut by veins of coarser grained carbonate which exhibit a maximum grain size of about 0.3 mm. Staining of the hand specimen suggests that the matrix of the rock is dolomite and most of the coarser grained carbonate veins are calcite.

Traces of quartz are disseminated through the rock as small crystals below 0.1 mm in length which generally exhibit prismatic shapes suggesting they are of authigenic origin. Locally quartz is also intergrown with coarser grained carbonate bands as small grains and granular aggregates up to 0.3 mm in size.

Translucent reddish-brown iron oxides are disseminated through the rock as interstitial fillings below 0.03 mm wide. Similar translucent iron oxides are also concentrated as narrow vein and fracture fillings and along the contacts between the coarser grained carbonate veins and finer grained matrix.

Sample: P253/78; TSC19081

Rock Name:
Carbonate rock

089

Thin Section:
An optical estimate of the constituents gives the following:

	%
Carbonate	90
Quartz	3
Opaques & semi-opaques	7

This sample is comprised mainly of fine-grained carbonate which forms a granular mosaic with varying grain sizes. Most of the carbonate forms a mosaic with a grain size of about 0.05 mm although this is transected by carbonate veinlets up to 0.5 mm wide which have a coarser grain size (typically about 0.3 mm). In addition some of the carbonate forms even finer grained, almost micritic appearing aggregates.

One portion of the thin section also contains carbonate intergrown with limonitic material which tends to form elongate, prismatic shaped aggregates with a radial texture indicating it has replaced a pre-existing mineral. The cores of some of these limonitic aggregates contain fine-grained secondary quartz fillings. The shapes of these pseudomorphs suggest that the original mineral could be an amphibole although these shapes are not well developed and such an interpretation is highly speculative. On a finer scale some of these pseudomorphs contain smaller, rhomb shaped pseudomorphs suggesting that they represent ferruginized carbonate crystals. It is possible that the original mineral was partially replaced by dolomite or siderite which has since suffered ferruginization to produce the limonitic material. The carbonate which comprises the bulk of the rock is probably calcite but no microchemical tests were made to confirm its identity.

In addition to the limonitic pseudomorphs opaque to translucent, reddish-brown iron oxides form narrow fracture and vein fillings below 0.1 mm wide which transect the microcrystalline carbonate mosaic. Locally these limonite filled fractures are common producing a brecciated texture.

This is a very fine-grained rock comprised mainly of microcrystalline carbonate .

Sample: P462/78; TS39956

Rock Name:
Dolomite

Hand Specimen:
A massive, grey-coloured rock with a narrow reddish-brown weathering rind.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Carbonate (dolomite)	85
Quartz and feldspar	7
Muscovite	5
Chlorite	2
Opaques and semi-opaques	1

This sample consists mainly of a very fine-grained (typical grain size below 0.05 mm), almost micritic carbonate intergrown with minor amounts of granular quartz and feldspar and phyllosilicate flakes. Locally, irregular patches up to 0.2 mm in size consisting of slightly coarser-grained carbonate are present in the rock. The carbonate has not been affected by the alizarin red-S stain, indicating that it is most likely a dolomite.

The quartz and feldspar grains are generally about 0.3 mm in size and exhibit somewhat irregular shapes. Quartz is the dominant mineral, but the exact proportion of feldspar present is hard to determine due to its fine grain size and lack of twinning. Traces of polysynthetically twinned plagioclase were noted.

The phyllosilicate flakes consist mainly of muscovite with a smaller proportion of chlorite. Both minerals form well developed flakes up to 0.1 mm in length which exhibit a sub-parallel orientation defining a foliation direction. Most of the chlorite has a pleochroic green colour although some pleochroic brown chlorite, which exhibits low birefringence, was also noted and could represent a degraded biotite.

Minor opaques are disseminated through the rock as anhedral grains up to 0.2 mm in size. Translucent, reddish-brown iron oxides are concentrated along the weathering rind which accounts for its reddish-brown colour in hand specimen. Minor opaque and translucent reddish-brown iron oxides are also concentrated as narrow, discontinuous fracture and vein fillings. A significant proportion of these fracture fillings are oriented at high angle to the foliation direction.

This is a very fine-grained carbonate-rich rock with only a minor detrital component.

Sample: P461/78; TS39955

Rock Name:
Sandstone

Hand Specimen:
A massive, brown-coloured rock.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	60
Feldspar	15
Clay	10
Carbonate (dolomite)	5
Muscovite	1
Zircon, (?)monazite	1
Muscovite	1
Tourmaline	Trace-1
Apatite	Trace
Opaques and semi-opaques	8

This sample consists essentially of detrital quartz and feldspar grains cemented by argillaceous material and carbonate which has been partially replaced by iron oxides. The quartz and feldspar detritus has a bimodal character with most having a grain size of about 0.1 mm, although larger grains, generally about 0.4 mm in size, are also disseminated through the rock. The smaller grains exhibit angular to sub-angular shapes, while the larger grains generally exhibit sub-angular to sub-rounded shapes. The exact proportion of feldspar present in the rock is hard to determine since untwinned orthoclase is often hard to distinguish from quartz. The feldspars identified in this rock include untwinned orthoclase, polysynthetically twinned plagioclase and gridiron twinned microcline. Virtually also of the feldspar is very fresh, showing only localised incipient alteration.

The interstitial matrix is comprised mainly of finely-divided clay, although locally significant amounts of carbonate and/or translucent, reddish-brown iron oxides also form a cementing medium. At least some of the translucent iron oxides are a replacement product of carbonate and occur intergrown around the margins of carbonate grains. The carbonate is not affected by the alizarin red-S stain and is believed to be dolomite.

Detrital zircon is disseminated through the rock as small crystals up to 0.1 mm in size. A few crystals believed to represent detrital monazite were also observed in the sample. Pleochroic green tourmaline forms detrital grains up to 0.1 mm in size. A trace of apatite was also noted as small grains believed to be of detrital origin.

This is a relatively fine-grained detrital sediment with a well developed bimodal character.

Sample: P460/78; TS39954

Rock Name:
Dolomitic, fine-grained sandstone

Hand Specimen:
A medium-grey, weakly laminated rock with a reddish-brown weathering rind.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz and feldspar	65
Carbonate (dolomite)	20
Chlorite/biotite	6
Muscovite	5
Tourmaline	Trace-1
Opaques and semi-opaques	3

This sample consists mainly of angular to sub-angular detrital quartz and feldspar grains typically about 0.05 mm in size. Feldspar is much less abundant than quartz, but the exact proportion of feldspar present in the rock is hard to determine since a large proportion of the feldspar appears to be untwinned orthoclase. Minor amounts of polysynthetically twinned plagioclase were also noted. Well developed muscovite and chloritized biotite flakes are disseminated through the rock and exhibit a well developed, preferred orientation defining a lepidoblastic foliation. This foliation is oriented parallel to a very vague banding produced mainly by mineralogical variations.

Carbonate (probably dolomite) occurs as anhedral grains and granular aggregates up to 0.1 mm in size. The carbonate is not evenly disseminated through the rock, some narrow bands having a lower carbonate content than other Also, the weathering rinds contain very little of any carbonate, but do contain concentrations of translucent iron oxides which are believed to represent an alteration product of carbonate produced by weathering. The carbonate throughout the rock also shows incipient alteration to translucent reddish-brown iron oxides, particularly around grain margins.

The muscovite and chloritized biotite flakes are generally below 0.1 mm in length. The biotite has a pleochroic brown colour but in most cases it has been completely or almost completely replaced by a weakly pleochroic, green chlorite. Traces of pleochroic green tourmaline are also disseminated through the rock as small, angular grains below 0.05 mm in size. Opaques also form anhedral disseminated grains generally below 0.03 mm in size.

This is a very fine-grained detrital sediment with a carbonate-rich matrix.

Sample: P463/78; TS39957

Rock Name:
Dolomite

Hand Specimen:
A grey to purple-coloured rock with a brownish weathering rind.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Carbonate (dolomite)	90
Quartz and feldspar	5
Muscovite	2
Opaques and semi-opaques	2

This sample is similar to sample P462/78 (TS39956), consisting essentially of granular dolomite intergrown with minor amounts of quartz and feldspar grains and muscovite flakes. This sample also exhibits a weakly banded texture due to slight variations in carbonate grain size within different bands and concentrations of finely-divided opaque to semi-opaque iron oxides within narrow bands generally below 0.2 mm wide. Slightly coarser-grained carbonate forms narrow vein-like structures up to 0.1 mm wide which are generally oriented perpendicular to the weak banding.

The quartz and feldspar grains are generally about 0.05 mm in size and quartz appears to be dominant, although the fine grain size makes the exact proportions of these two minerals hard to determine. Muscovite forms small flakes below 0.1 mm in length. Unlike sample P462/78, no chlorite or altered biotite flakes were noted in this sample. Opaques form anhedral disseminated grains up to 0.1 mm in size and translucent reddish-brown iron oxides tend to be concentrated in the weathering rind. Opaque and semi-opaque material forms discontinuous, undulose fracture fillings oriented perpendicular to the general banding direction. These fracture fillings are similar to those noted in sample P462/78.

This is a very fine-grained carbonate-rich rock with a weakly developed bedding defined largely by variations in carbonate grain size and slight concentrations of opaque material.

Sample: P464/78; TS39958

Rock Name:
Barite

Hand Specimen:
A milky-white rock containing several sub parallel veinlets or fractures filled with dark brown iron oxides. These fractures have a somewhat undulous character and at least locally appear to be incipiently stylolitic.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Barite	85
Carbonate	5
Opaques and semi-opaques	10

The major mineral in this rock is barite which forms a granular mosaic with a typical grain size between 0.5 and 4 mm. The barite contains finely divided inclusions (at least some is probably opaque to semi-opaque material) which impart a somewhat turbid character to it. The barite also shows some evidence of deformation in the form of weakly developed sutured grain margins and localised undulous extinction.

Carbonate is concentrated as discontinuous vein fillings up to 1 mm wide which exhibit a polycrystalline character. The carbonate is not affected by the alizarin red-S solution and is most likely dolomite. The carbonate also shows some evidence of deformation with localised granulation and the formation of twin lamellae believed to be of deformational origin. Most of the polycrystalline carbonate aggregates contain concentrations of translucent, reddish-brown iron oxides around their margins. Most of the opaque to semi-opaque iron oxides in this rock are concentrated in an irregular patch several millimetres in size. Smaller amounts form narrow fracture fillings or disseminated anhedral grains generally about 0.2 mm in size.

This is virtually a monomineralic rock which shows evidence of mild deformation.

Sample: P465/78; TS39959

Rock Name:
Barite

Hand Specimen:
A milky-white coloured rock with sub-parallel mildly undulous bands filled with black to dark brown iron oxides. Large patches up to several centimetres in size with an ocherous reddish brown colour occur locally through the rock. Locally the sample also contains very dark grey to black patches which could be either iron oxides or manganese oxides. The thin section contains some of the ocherous patches but none of the dark grey to black patches.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Barite	65
Carbonate	20
Quartz	10
Opaques and semi-opaques	5

Most of this thin section is comprised of barite which forms a granular mosaic with a grain size between 1 and 5 mm. This rock shows evidence of only very mild deformation in localised sutured grain boundaries and weakly developed strained extinction. The barite has a slightly turbid character due to finely divided inclusions some of which could represent opaque material.

Quartz forms euhedral to subhedral crystals up to several millimetres in size which generally contain irregular barite inclusions.

Carbonate is concentrated in irregular patches up to several centimetres in size mainly as euhedral to subhedral crystals up to 3 mm wide. The carbonate has suffered pervasive replacement by translucent, reddish-brown iron oxides particularly along cleavage traces and would represent the ocherous, reddish-brown patches noted in hand specimen. Opaque to translucent reddish-brown limonitic material also forms intergranular fillings between the barite crystals and discontinuous vein and fracture fillings. Minor opaque to translucent reddish-brown iron oxides also forms disseminated grains up to .2 mm in size some of which are included within large barite crystals.

This is an essentially monomineralic rock comprised mainly of barite with a smaller proportion of carbonate which exhibits pervasive replacements by iron oxides. This is the least deformed of the barites examined for this report.

Sample: P466/78; TS39960

Rock Name:
Barite Mylonite

Hand Specimen:
A milky-white to very pale tan coloured rock with localised concentrations of reddish-brown iron oxides.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Barite	75
Quartz	10
Calcite	10
Opaques and semi-opaques	5

This rock is comprised mainly of barite which shows evidence of extensive deformation. Locally the barite has a highly granulated character to produce bands of fine-grained (typical grain size about 0.1 mm) barite but in other places the barite has a somewhat coarser-grain size (up to 3 mm) but still exhibits marginal granulation to produce a well-developed mortar texture. The larger barite crystals also exhibit strained extinction as well as a lamellar twinning also believed to be produced by deformation.

Euhedral to subhedral quartz crystals up to 0.3 mm in size are disseminated through the rock but tend to be concentrated in the most highly granulated portions of the barite. These quartz crystals show no evidence of deformation indicating they have grown after fairly intense granulation. A few of these crystals exhibit a vague radial to subsectoral texture in cross section.

Calcite is concentrated in the coarser-grained portions of this rock as angular, interstitial fillings up to 0.1 mm in size. The calcite was identified by it's positive reaction to the alizarin red-S stain. Minor calcite also forms narrow fracture and vein fillings. The calcite shows some replacement by translucent, reddish-brown iron oxides particularly along cleavage traces and locally the calcite is almost completely replaced by iron oxides. The extensively replaced calcite would represent the reddish brown patches noted in hand specimen. Although most of the iron oxides in this rock are a replacement product of calcite minor iron oxides form anhedral disseminated grains up to 0.1 mm in size or discontinuous vein and fracture fillings.

This is a barite rich rock which shows extensive deformational effects to produce completely granulated areas. Both the quartz and calcite in this rock show no evidence of deformation indicating they have been introduced after the granulation has occurred.

Sample: P467/78; TS39961

Rock Name:
Barite Mylonite

Hand Specimen:
A milky-white rock with localised ocherous iron staining along fractures.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Barite	99
Opaques and semi opaques	1

This is an essentially monomineralic rock comprised of barite which forms large crystals up to 3 mm long which have suffered extensive deformation. Locally the large barite crystals have been completely granulated to produce finely-granular aggregrates with a typical grain size of 0.1 to 0.3 mm but elsewhere large barite crystals show only marginal granulation to produce a well developed mortar texture. The large barite crystals also show undulous extinction and a few of these crystals also exhibit a lamellar twinning believed to be produced by deformation. Although this rock has also been called a barite mylonite it appears to have suffered a slightly lesser degree of granulation than in sample P466/78 (TS39960).

The only other mineral present in this rock other than barite is opaque to semi opaque limonitic material which forms anhedral disseminated grains up to 0.1 mm in size and locally irregular void fillings or narrow fracture and vein fillings.

Sample: P468/78; TS39962

Rock Name:
Deformed Barite

Hand Specimen:
A milky-white rock with localised orange to reddish brown limonitic staining particularly along fractures.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Barite	98
Opaques and semi opaques	2

This is also an essentially monomineralic rock comprised mainly of barite which locally shows extensive granulation although for the most part it has a very relatively coarse-grain size. The coarse-grained barite forms a granular mosaic with typical grain sizes ranging between 0.5 and 8 mm. Within this region the barite exhibits a somewhat deformed character showing granulation along grain margins to produce an incipient mortar texture as well as localised strained extinction. In one portion of the thin section the barite has a highly deformed character showing extensive granulation to produce a fine-grained mosaic with a typical grain size of about 0.1 mm. This granulation is as intense as that in the two previously described barite mylonites (samples P466/78 and P467/78; TS39960-1) but has occurred on a much more localised scale. Most of the barite contains abundant finely divided inclusions at least some of which could represent opaque material which impart a turbid character to the barite. A few of the large barite crystals contain clear cores which essentially lack inclusions. These cores have irregular, ragged shapes.

Minor opaque and translucent brown iron oxides are disseminated through the rock mainly as small anhedral grains below 0.1 mm in size.

This rock shows evidence of extensive deformation but only locally has suffered the intense granulation evident in samples P466/78 and P467/78.

Sample: P469/78; TS39963

Rock Name:
Barite

Hand Specimen:
A coarsely crystalline, milky-white rock with localised black vein fracture fillings.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Barite	96
Quartz	2
Zircon	Trace
Opaques	2

This is also an essentially monomineralic rock comprised mainly of barite which forms a coarse-grained (typical grain size between 1 and 4 mm) mosaic. The barite shows some evidence of deformation particularly along grain margins where granulation has occurred and localised suturing is evident. Most of the large barite crystals also exhibit strained extinction and a few have a lamellar twinned character. The barite exhibits a slightly turbid character to do finely divided inclusions at least some of which could represent iron oxides.

Quartz is present locally as subhedral prismatic crystals approximately 1 mm in length. Most of the quartz crystals exhibit concentric growth bands. A few small, prismatic crystals of zircon approximately 0.1 mm in length were also noted as inclusions within large barite crystals. Opaques occur mainly as anhedral disseminated grains below 0.1 mm in size and narrow fracture and vein fillings.

Sample: P470/78; TS39964

Rock Name:
Deformed Barite

Hand Specimen:
A massive, coarsely crystalline rock with a mottled grey to dull white colour.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Barite	95
Quartz	2
Calcite	2
Opaques and semi-opaques	1

This is an essentially monomineralic rock consisting mainly of barite which forms a mosaic with a variable grain size. There is evidence of two generations of barite formation with one generation showing variable degrees of deformation and the other generation showing no evidence of deformation. The older, deformed barite has localised granulated areas with a very fine grain size (typically about 0.1 mm) and larger bladed crystals with undulose, strained extinction and marginal granulation to produce well developed mortar texture. The younger, undeformed barite tends to form euhedral to subhedral crystals up to 1 to 2 mm in size. The older barite has a somewhat turbid character with a finely divided inclusions at least some of which could represent opaque material while the younger barite tends to form clearer crystals with a much smaller number of inclusions.

Minor quartz is disseminated throughout the rock as subhedral crystals up to 1 mm in size. The calcite is also disseminated through the rock as anhedral grains and granular aggregates, generally about 0.2 mm in size which are included within some of the barite crystals. Minor calcite also forms intergranular fillings between the barite crystals. Much of the calcite shows some replacement by translucent, reddish-brown iron oxides. Opaque and semi-opaque iron oxides also form narrow fracture and vein fillings and anhedral disseminated grains up to 0.2 mm in size.

Sample: P471/78; TS39965

Rock Name:
Deformed Barite

Hand Specimen:
A coarsely crystalline, milky-white rock. The joint surface along which the barite is broken shows some brown, ocherous staining.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Barite	99-100
Opaques and semi-opaques	Trace

This sample consists almost exclusively of barite which forms deformed crystals up to several millimetres in size. The larger barite crystals exhibit strained extinction and localised plumose characters as well as strain induced twin lamella. Granulation has occurred along the margins of the large barite crystals to produce a well developed mortar texture. The barite crystals contain varying amounts of finely divided inclusions most of which appear to be opaque material. Many barite crystals contain regions with a concentration of these finely divided inclusions but most of the barite contains only a small number of such inclusions.

Only traces of opaque to translucent semi-opaque iron oxides were noted as small anhedral grains below 0.05 mm in size.