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The Precambrian Geology of the Oscar Range Inlier, Lennard River 1:250,000 Sheet Area, SE 51-8, Western Australia

by

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THE PRECAMBRIAN GEOLOGY OF THE OSCAR RANGE INLIER, LENNARD RIVER 1:250,000 SHEET AREA, SE 51-8, WESTERN AUSTRALIA

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(Accompanied by a geological map of the
Leopold Downs 1:100,000 Sheet area, No. 3962)

RECORD NO. 1971/61

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SUMMARY

The Oscar Range Inlier is a succession of probable Proterozoic rocks surrounded by limestones of a Devonian reef complex. It is situated in the Kimberley region, in the southern part of the Lennard River 1:250,000 Sheet area, about 330 km east of Derby and 45 km northwest of Fitzroy Crossing. Eight major units have been recognized in the succession, which dips and thickens to the southwest. These are, from base to top, the Mt Wilson Beds, Christophers Beds, Le Lievre Beds, Ellendale Beds, Linesman Beds, Elimberrie Beds, Ninety Seven Mile Beds and Spielers Volcanics. The Mt Wilson Beds are possibly equivalent to the Christophers Beds, but in most places contacts between the units are faulted and/or unconformable. The total thickness of the succession is about 11,500 metres.

Moderately to highly deformed quartzite, phyllite, and boulder to cobble conglomerate are characteristic of the succession. Limestone and dolomite characterize the basal Elimberrie Beds, and metabasalt occurs in the Ninety Seven Mile Beds. The Spielers Volcanics are possibly ash flow tuffs of either (?)Adelaidean or Devonian age. Many of the conglomerates appear glacigene, and the succession is tentatively correlated with Adelaidean glacial sequences elsewhere in the Kimberley. The metamorphic grade of the succession is low greenschist facies.

Deformation increases from the northeast to the southwest. All units are steeply dipping, tightly to isoclinally folded, locally overfolded, and strongly faulted. Younger units such as the Ninety Seven Mile Beds show less deformation than some older units. The style of deformation is similar to that found on the Yampi Sheet area, and is possibly a result of large-scale basement block movements in the Cambrian.

Small iron-rich gossans are common, particularly in the Elimberrie Beds, and some have anomalous zinc values. In places anomalous zinc, lead, copper, cobalt, nickel, and manganese values occur at the unconformity between the Oscar Range succession and Devonian limestone, and further investigation is suggested. Conglomerates in the area may contain gold, uranium, and thorium mineralization.

INTRODUCTION

The Oscar Range Inlier is a belt of mainly metasedimentary rocks of probable Proterozoic age exposed in the southern part of the Lennard River 1:250,000 Sheet area. These rocks, known as the Oscar Range Succession, were mapped in detail by the writers in 1966-67 during regional mapping of the Lennard River Sheet. This report presents the results of the detailed mapping, summary reports of which have been presented by Gellatly et al. (1968) and Derrick & Playford (in prep.). The map accompanying the report is the 1:100,000 Sheet of Leopold Downs, number 3962; the older Precambrian geology on this Sheet is taken from Gellatly et al. (1968) and the Palaeozoic geology is modified from Playford & Lowry (1966), and will not be described in this report. Some parts of the Oscar Range Succession, e.g. Mount Wilson, fall outside the eastern boundary of the Sheet; the geology of these areas is presented in text figure 3. The succession was mapped with the aid of 1:50,000 aerial photographs flown by the RAAF in 1950.

Access to the Oscar Range Inlier is from the Great Northern Highway, via a gravel road which runs through the southeast part of the Inlier to Leopold Downs station. A rough track runs along the southwest margin of the inlier parallel to the telegraph line connecting Derby with Fitzroy Crossing.

Climate and vegetation of the area are considered in detail by Gellatly et al. (1968). Most of the Inlier is covered with spinifex, grasses, stunted eucalypts, and acacia scrub; winter is warm and dry and summer hot and wet. In normal seasons spring-fed waterholes can be found in streams draining the northwest end of the Inlier, and along the southwest edge of the Devonian reef complex.

Physiography of the Inlier is shown in Figs 1 & 2. Hogbacks, strike ridges and narrow bevelled plateaux separated by narrow valleys are the characteristic land forms.

STRATIGRAPHY - PROTEROZOIC

Introduction

The oldest units of the Oscar Range Succession are considered to be those along the northeast margin (Mt Wilson Beds, Christophers Beds), because of predominant southwesterly dip and thickening of the Succession towards the southwest. Deformation of the Succession increases rapidly from the northeast to the southwest, and this, together with rapid facies changes, has complicated the stratigraphic relationships between units.

Fig. 1. Typical physiography of the Oscar Range: low hills of limestone (basal Elimberrie Beds - left), sandstone (basal Ellendale Beds - centre) and plateau-forming quartzite of the Le Lievre Beds (extreme right). Locality about 8 km. east of Stumpy's Soak. View looking east-southeast.

M 536/5 DCG

Fig. 2. Typical physiography of the Oscar Range: quartzite ridges of the Le Lievre and Ellendale Beds, with planated tops; black crags of Devonian limestone and soil plains in background. View looking southwest.

M 528/27 GMD

TABLE 1. STRATIGRAPHIC TABLE, OSCAR RANGE SUCCESSION

ERA	PERIOD		ROCK UNIT		THICKNESS (METRES)	LITHOLOGY	TOPOGRAPHY	DISTRIBUTION	STRATIGRAPHIC RELATIONSHIPS	REMARKS
PALAEOZOIC OR PROTEROZOIC	?ADELAIDEAN OR SILURIAN		Spielers Volcanics	Pzs	About 750	Dark grey and pale grey green quartz-feldspar porphyry	Plains and sediments with sparse low ridges	Southern flank of south-eastern part of Oscar Range	Overlies Elimberrie Beds concordantly. Overlain by Napier Formation	Probably ash-flow tuff
PROTEROZOIC	ADELAIDEAN OR CARPENTARIAN	OSCAR RANGE SUCCESSION	Ninety Seven Mile Beds	Bzn_6	270	Boulder and cobble beds, phyllite	Low strike ridges and plains	Northwest end of Oscar Range	Overlies Christopher Beds; faulted against Ellendale Beds; overlain unconformably by Devonian and Permian	Possible lateral equivalents of Elimberrie Beds. Boulder Beds of Bzn_3 and Bzn_6 possibly glacigene
				Bzn_5	400 to 510	Quartzite	High bevelled ridges			
				Bzn_4	14 to 100+	Phyllite, metabasalt.	Valley forming			
				Bzn_3	300	Boulder and cobble beds	Rounded hills			
				Bzn_2	220	Phyllite and boulder beds	Valleys and low hills			
				Bzn_1	300	Quartzite, conglomerate, ?tuff, phyllite, amygdaloidal basalt	Plains and low sediments			
			Elimberrie Beds	Bzb_7	140	Quartz sandstone, siltstone and ironstone	Valley forming, with low rises and interspersed strike ridges	Immediately southeast of Le Lievre Ridge, for about 15 km	Overlies the Ellendale Beds unconformably; overlain by Devonian limestone. In southeast overlain by Spielers Volcanics, and overlies Linesman Beds	Chert-quartzite breccias abundant in Bzb_1; parts of Bzb_3 and Bzb_6 possibly glacigene
				Bzb_6	40–170	?Tillite and phyllitic siltstone, tuff				
				Bzb_5	Up to 360	Phyllitic siltstone, minor quartz sandstone				
				Bzb_4	Up to 140	Quartzite, minor cobble beds				
				Bzb_3	120–170	Phyllite, minor boulder sandstone. ?tillite, limonitic sandstone.				
				Bzb_2	210	Dolomitic limestone, dololutite, feldspathic sandstone, siltstone				
				Bzb_1	220	Dolomitic limestone, doloarenite, quartzite, ironstone lenses, chert		Headwaters of Camarotoechia Creek; small outcrop 4 km southwest of Leopold Downs airstrip		
			Linesman Beds	Bzl_3	235	Siltstone with feldspathic sandstone interbeds	Narrow sinuous ridges and valleys; member Bzl_1 plain and valley forming	Southeastern end of Oscar Range	Overlain unconformably by and faulted against Elimberrie Beds; underlain by and probably faulted against Christopher Beds	High siltstone content characteristic. Tight folding precludes accurate thickness measurement towards base of unit
				Bzl_2	260	Siltstone and feldspathic sandstone				
				Bzl_1	ca. 800	Siltstone and shale; minor feldspathic sandstone				

ERA	PERIOD		ROCK UNIT		THICKNESS (METRES)	LITHOLOGY	TOPOGRAPHY	DISTRIBUTION	STRATIGRAPHIC RELATIONSHIPS	REMARKS
PROTEROZOIC	ADELAIDEAN OR CARPENTARIAN	SUCCESSION	Ellendale Beds	Bze_3	414	Siltstone	Strike ridges and low hogbacks, with intervening valleys	Northeast and southwest of Le Lievre Ridge	Overlies Le Lievre Beds; boundary unconformable and probably faulted. Overlain by limestone of Elimberrie Beds.	Most rudaceous member in Succession; siltstone and chert clasts in conglomerate unique
				Bze_2	360 to 650	Cobble and boulder conglomerate, quartz sandstone; minor feldspathic sandstone and siltstone				
				Bze_1	Up to 400	Quartz sandstone, feldspathic sandstone, siltstone, shale, conglomerate, hematite rock				
			UNCONFORMITY							
			Le Lievre Beds	Bzv_3	150	Dark grey-green magnetite phyllite	Quartzites form flat topped ridges, forming highest part of Oscar Range. Phyllites valley-forming	Central part of Oscar Range	Probably the oldest beds in the Oscar Range succession; overlain by Ellendale Beds	Thick sequence of massive pale grey quartzite diagnostic; ripple-marking and current-bedding abundant
				Bzv_2	450	White to grey quartzite				
				Bzv_1	200	Red-brown and grey phyllite, siltstone and minor sandstone interbeds				
			POSSIBLE UNCONFORMITY							
		RANGE		Bzc	1176	Undifferentiated: White to purple quartz sandstone, pebble to boulder conglomerate, phyllite.	Prominent strike ridges and hogbacks. Some low ground in northwest.	East, southeast and northwest of Christophers Bore; headwaters of Ninety Seven Mile Creek; Leopold Downs airstrip	Overlain unconformably by Devonian limestone, faulted and unconformable boundary with Linesman Beds. Possibly overlain conformably by Elimberrie Beds	Some sandstones epidote-rich; rapid thickness changes displayed by conglomerates, specular hematite widespread. Most conglomerates with coarse-grained sandy matrix.
			Christophers Beds	Bzc_3	650	White quartz sandstone				
				Bzc_2	500	Phyllitic siltstone, locally tuffaceous feldspathic sandstone, minor carbonate				
		OSCAR		Bzc_1	852 to 1150	Pale purple-grey to white quartz sandstone; minor siltstone, and pebble and cobble conglomerate				
			INFERRED UNCONFORMITY							
			Mount Wilson Beds	Bzw	666 measured	Grey to white granule sandstone, gritty feldspathic sandstone and arkose; buff, green and white quartz sandstone	Moderately rugged sandstone hills and ridges	At Mount Wilson and The Twins	Overlain unconformably by Devonian (Pillara Limestone). Overlies Halls Creek Group and Lamboo Complex unconformably. Possible correlative of Christopher Beds	Some beds possibly glauconitic in upper half of sequence. Source area granitic areas immediately to northeast.
			UNCONFORMITY							

Because of this complexity the major subdivisions of the Succession are named 'Beds'. These in turn have been divided into informal numbered but unnamed members. Stratigraphic nomenclature submissions for the newly named Beds are presented in Appendix 3, and the stratigraphy of the Succession in Table 1.

The age and correlations of the Succession with other units are still problematical. It is separated from the main Precambrian outcrops of the Lamboo Complex and Kimberley Basin by a large expanse of Devonian rocks, but is also considered to be Precambrian because -

(a) it is overlain unconformably by the Devonian reef complex;
(b) it contains no fossils;
(c) it is highly deformed;
(d) the deformation is probably of Cambrian age.

Such isotopic age determinations of the Succession as have been carried out are not unequivocal: one unit, the Spielers Volcanics, has given Silurian ages, but could well be Proterozoic because of its close structural association with other units in the Succession.

Certain features of the Adelaidean glacial sequences 150 km to the southwest resemble parts of the Oscar Range Succession, which is therefore tentatively considered to be of Proterozoic, possibly Adelaidean age and/or Carpentarian.

MOUNT WILSON BEDS (Bzw)

Introduction

The Mount Wilson Beds (new name) are named after Mount Wilson, lat. 17°55'S, long. 125°33'E, where the sequence is best exposed. Outcrops of the Mount Wilson Beds occur about 12 km and 16 km to the northeast of the southeastern end of the Oscar Range. Because of lithological and stratigraphical similarities and proximity to rocks of the Oscar Range Succession they have been included in this report. Their location is shown in Figure 3.

Stratigraphic Relationships

The Mount Wilson Beds lie unconformably on the Halls Creek Group at Mount Wilson, and on the Whitewater Volcanics at The Twins. At both localities the sequence is overlain unconformably by the Devonian Pillara

Limestone. The rocks at Mount Wilson and The Twins resemble those in the Oscar Range inlier, particularly the Christopher Beds, and they are tentatively correlated with them.

Lithology

The Beds are predominantly coarse-grained arenites containing quartz sandstone, feldspathic sandstone, and minor arkose. 666 m of section was measured by pacing at Mount Wilson and about 300 m at The Twins. A paced measured section at Mount Wilson (ZW1) is given in Appendix 2.

The basal part of the unit is a distinctive, very strongly cross-bedded, coarse-grained sandstone which contains abundant granule beds. Graded bedding is also present. Many of the quartz and feldspar grains are angular, and almost certainly have been derived locally from granitic terrain immediately to the northeast. The feldspar content of the sandstone decreases upwards in the sequence, as does the grain-size, though even in fine-grained ?glauconitic sandstone near the top of the sequence some coarse-grained beds are present. Fine-grained sediments forming the upper half of the sequence at Mount Wilson are micaceous, slightly ferruginous, and ripple-marked, and certain beds show overturned cross-beds and slump structures. Tourmaline is an abundant accessory, and in some hand specimens constitutes about 2 percent of the rock.

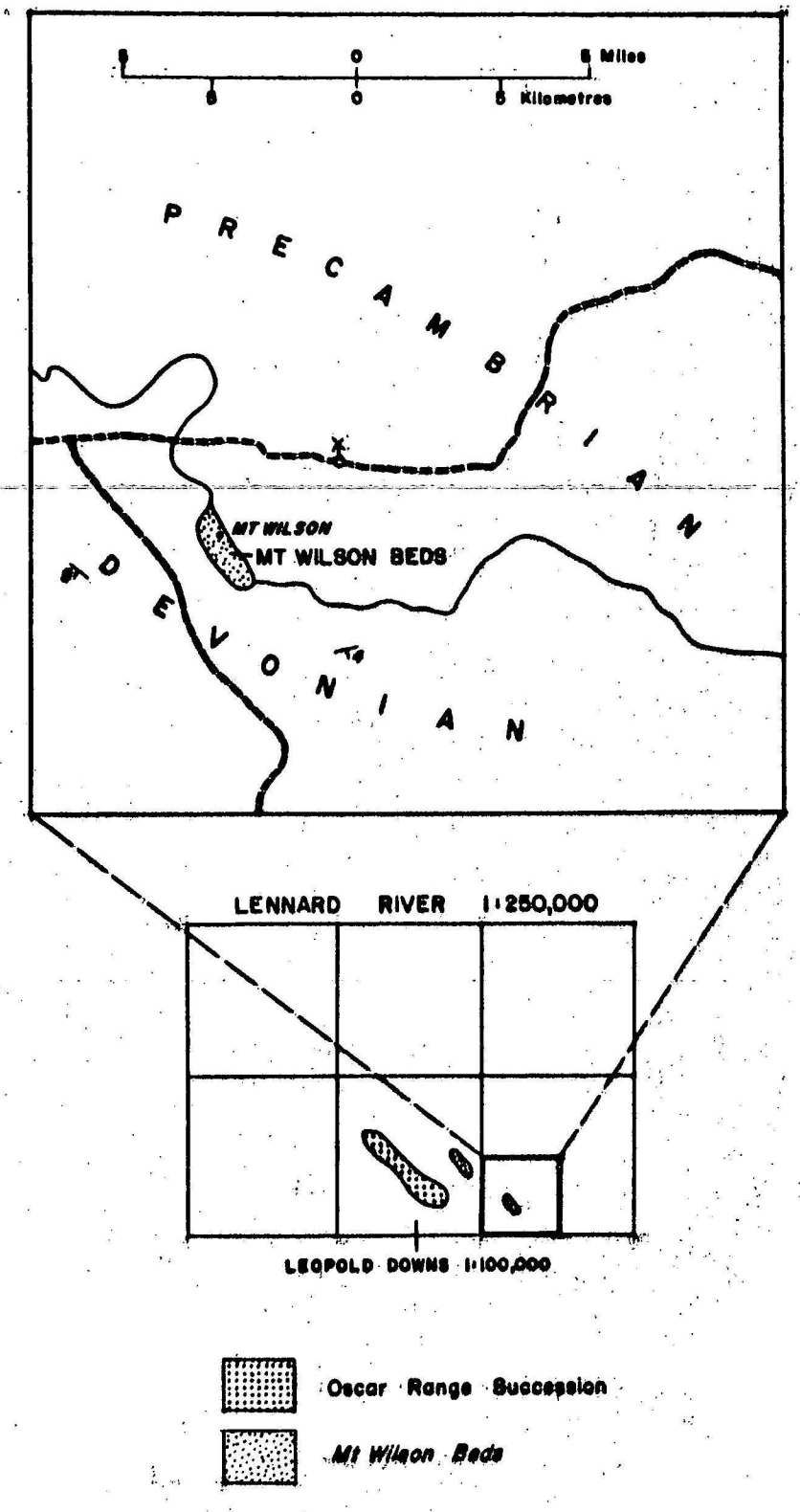
The sequence at The Twins appears less feldspathic than that at Mount Wilson, although coarse-grained sandstone is still dominant. Poorly sorted pebbly granule sandstone, showing cross-bedding and graded-bedding, is typical of the basal half of the Twins sequence.

Petrography

Four specimens were examined. Towards the base of the sequence the sandstone is slightly bimodal and coarse-grained, with rock fragments common but heavy minerals less so.

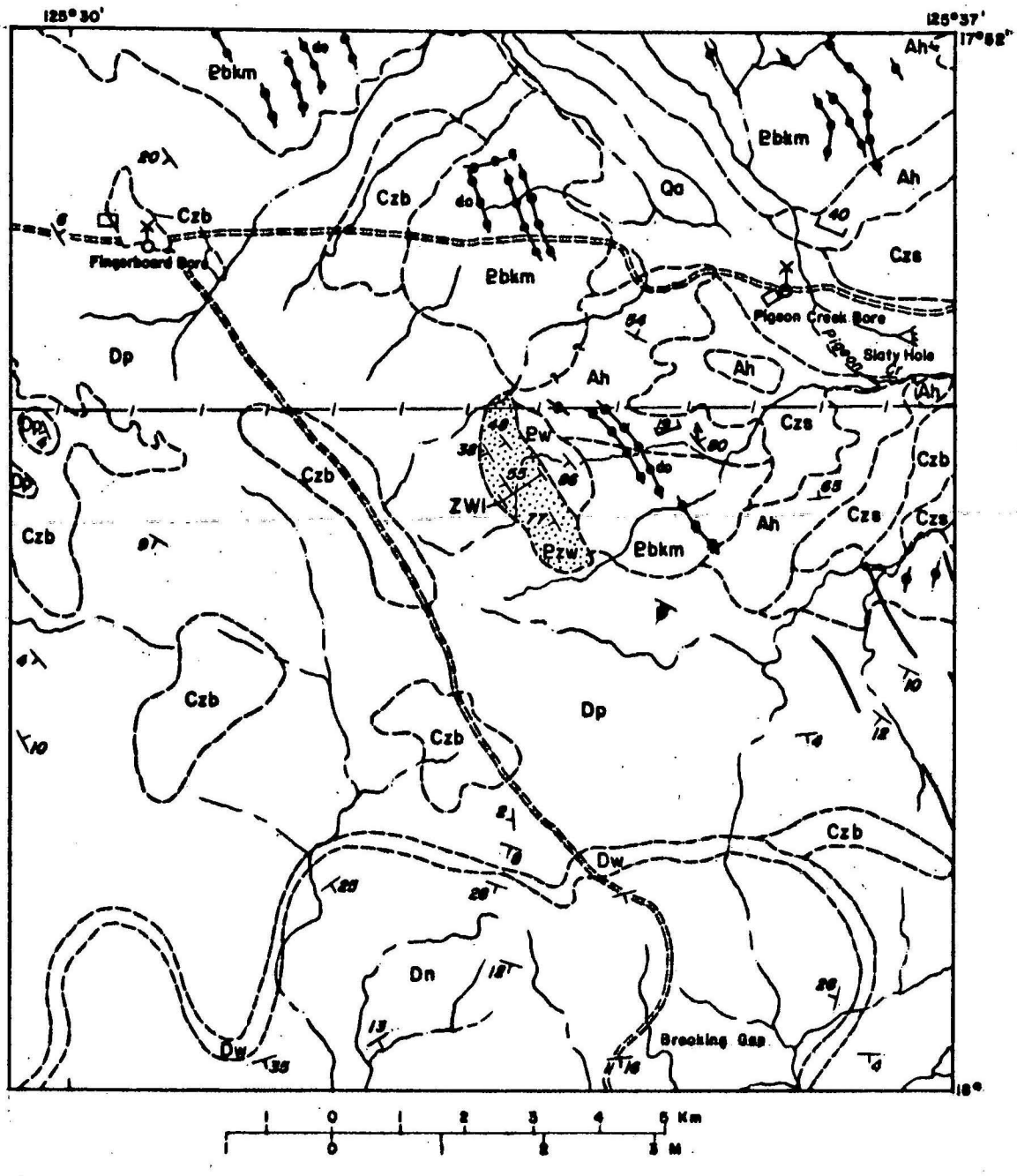
Towards the top of the sequence the sandstone becomes fine-grained, and contains mica and chlorite. It is also flattened slightly, and shows cleavage development and minor recrystallization.

Fig. 3a SKETCH SHOWING LOCATION OF MT WILSON BEDS RELATIVE TO OSCAR RANGE SUCCESSION



To accompany Record 1971/61

Fig. 3b. GEOLOGICAL SKETCH MAP OF MT WILSON BEDS (Pzw)



For reference, see accompanying geological map

Dispersed heavy minerals are very abundant, and characterize this unit. Tourmaline is an olive green/bluish-brown variety, and constitutes up to 2 percent of the sandstone. Zircon is fresh, pale pink and euhedral, and forms up to 1 percent of some specimens. The high heavy mineral content of the sequence probably reflects the proximity of granite basement, which probably contributed a large proportion of the sediment in the sequence.

Structure

At both Mount Wilson and The Twins the beds are generally uniformly dipping to the southwest at about 45° to 55°. Steeply dipping and near-vertical sandstone is present near the southern end of Mount Wilson, but folding and faulting appear to be absent. The overlying Devonian rocks show drape dips of up to 50° at the contact with the Mount Wilson beds, although dips of 10° or less are usual away from the contact.

Age and Correlations

The Mount Wilson Beds are tentatively considered to be of Proterozoic, possibly Carpentarian or Adelaidean, age. No fossils have yet been found in the sequence, which is at least pre-Devonian. The generally steep dips of the Mount Wilson Beds contrast with the generally flat-lying or gently-dipping arkosic rocks at Prairie Hill, which resemble the Mount Wilson Beds lithologically but which are considered to be a basal facies of the Pillara Limestone.

CHRISTOPHERS BEDS (Bzc)

Introduction

The Christophers Beds crop out on the northern flank of the Oscar Range. The reference area is that between Christophers Bore and Leopold Downs airstrip at the southeastern end of the Range. Extensive, discontinuous outcrops of sandstone at the northwestern end of the Oscar Range are tentatively assigned to the Christophers Beds because of similarities of lithology and stratigraphic position to the Christophers Beds in the type area. The name is derived from Christophers Bore, which is about 2 km west of the type area.

The Christophers Beds consists of three members and a sequence of undifferentiated rock. These four units, from top to bottom, are listed below:-

Bzc	1176 m.	Undifferentiated white to purple quartz sandstone, pebble to boulder conglomerate.
Bzc_3	650 m.	White quartz sandstone.
Bzc_2	500 m.	Phyllitic siltstone, locally tuffaceous; feldspathic sandstone; minor carbonate.
Bzc_1	852 to 1150 m.	Pale purple grey to white quartz sandstone; minor siltstone and pebble and cobble conglomerate.

Member Bzc_2 and possibly also the uppermost beds of member Bzc_1 are intruded by thin sills of dolerite.

Stratigraphic Relationships

The Christophers Beds are probably the oldest in the Oscar Range. They are lithologically similar to the Mount Wilson Beds and may be a lateral equivalent. However, the Christophers Beds occur up-dip from the Mount Wilson Beds (although separated from them by about 11 km of country obscured by a thin veneer of Devonian limestones) and could be younger.

The Christophers Beds are situated down-dip from the Linesman Beds which possibly overlie them. This suggested relationship is anomalous in that the overlying(?) Linesman Beds are more strongly folded than the Christophers Beds. The possibility of a major fault between these two units cannot be excluded. In the northwest, Christophers Beds are overlain by the Elimberrie Beds with apparent conformity.

Within the Christophers Beds stratigraphic relationships are uncertain. The linear nature of the southwest boundary of member Bzc_1 suggests the presence there of a major fault. Discordance of dips between members Bzc_2 and Bzc_3 suggests that the contact is either a fault or an unconformity.

Field Occurrence

The Christophers Beds crop out intermittently for a strike length of 20 km in the southeastern end of the Oscar Range and about 24 km in the northwestern part. They have a total outcrop area of around 20 km^2. In the southeast, sandstone members form two prominent strike ridges with an intervening valley formed by the more easily eroded member Bzc_2. In the northwest, where sandstone predominates, several narrow strike ridges are present. Extensive areas are obscured by soil cover or by a thin veneer of Devonian limestone.

The beds mostly trend west-northwest, and have steep dips mainly to the south. Cross-bedding indicates younging of the beds to the south, and current directions from the east.

In the reference area (section ZC1) the measured thickness of Bzc_1 is 852 m, and to the southeast it thickens by 300 m. The total thickness of the Christophers Beds in the southeast is estimated to be about 2300 m. In the northwest the section is 1176 m thick; all of this may belong to Bzc_1, but correlation is uncertain. Measured sections of the sequences near Christophers Bore and in the northwest are given in Appendix 2 (sections ZC1, ZC2).

Lithology

Member Bzc_1. In the reference area (measured section ZC1) the Christophers Beds grade upwards from well-sorted white to pale buff and pale grey-green medium to coarse-grained quartz sandstone and feldspathic sandstone, to poorly-sorted pale purple-grey coarse-grained quartz sandstone and pebble conglomerate. Interbeds of phyllitic siltstone are sporadically distributed throughout this sequence.

In the southeast, about 2 km west of Brooking Creek, beds of lithology similar to those listed above are present and are underlain by poorly exposed beds, which amount to a further 300 m of section. This section consists of pure white to pale grey coarse-grained quartz sandstone with thin interbeds of pale grey chert, dark grey medium-grained hematitic quartz sandstone, and grey to grey-brown arenaceous dolomitic limestone.

Further to the southeast, near Leopold Downs airstrip, a small inlier of Christophers Beds consists of coarse-grained quartz granule sandstone and pebble and cobble conglomerate, similar to those rock types in the upper part of the sequence near Christophers Bore.

Member Bzc_2. Beds of this member are very poorly exposed, and no complete section has been measured.

About 6 km southeast of Christophers Bore, scattered outcrops in a small stream gully consist of pale grey and grey-brown phyllite, strongly cleaved pale red-brown fine-grained silty feldspathic sandstone, buff medium to coarse-grained feldspathic sandstone, red-brown dolomite, and pebble conglomerate consisting of 1 cm to 6 cm pebbles of quartz sandstone in a dark red-brown limonitic matrix.

About 2 km east of Christophers Bore phyllitic basic tuff and quartz sandstone intruded by dolerite are present. A partial measured section is as follows:

soil cover

8 metres Quartz sandstone: pink, thin-bedded poorly sorted slightly feldspathic quartz sandstone.

55 " Phyllite: dark grey feldspar and quartz-bearing phyllitic tuffaceous sandstone containing small magnetite psuedomorphs (Appendix 1, R68.16.0371).

2 " Metadolerite: dark grey-green, massive, coarse-grained.

35 " Phyllite: dark grey phyllitic basic tuff (as above).

Member Bzc_3. This member, which is confined to two outcrops between 5 and 10 km east-southeast of Christophers Bore, consists entirely of quartz sandstone. The sandstone is mostly white to very pale purple grey, coarse-grained, thin to thick-bedded, and blocky to massive. The topmost beds are fine to medium-grained white to pale green quartz sandstone. It is cross-bedded; cross-beds indicate currents from the east. One overturned cross-bed has been noted. This member differs from Bzc_1 in its lack of siltstone interbeds, and from the nearby Linesman Beds (Bzl_1) in both lack of siltstone and lack of feldspar.

Undifferentiated Christophers Beds. The extensive areas of sandstone, conglomerate, and phyllite in the northwest of the Oscar Range which are tentatively assigned to the Christophers Beds cannot be correlated with certainty with any particular member in the type area. The greatest thickness of this unit measured is 1176 m just north of the head-

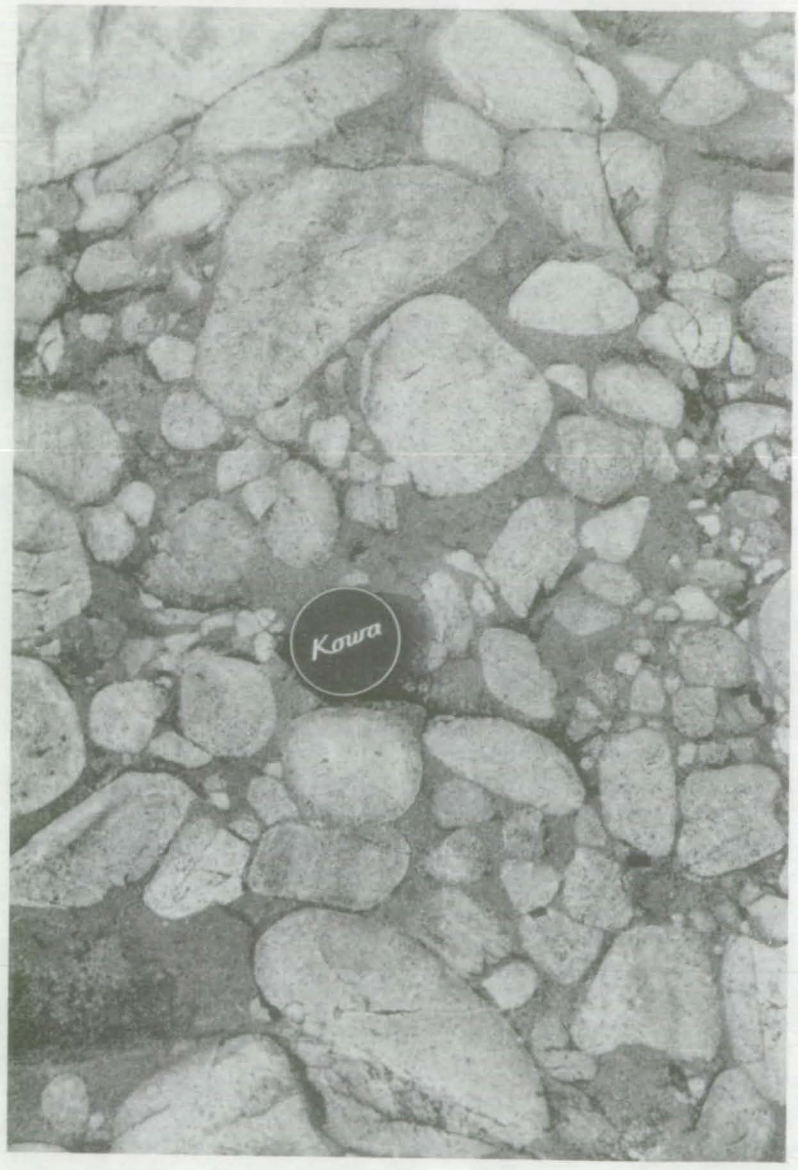


Fig. 4. Relatively undeformed cobble conglomerate with coarse-grained sand matrix in undifferentiated Christophers Beds, 6 km. north of Stumpys Bore.

M 457/20A GMD

waters of Ninety Seven Mile Creek. This is a minimum thickness. since both top and bottom of the sequence are overlain by Devonian limestone. This paced section is listed in Appendix 2.

Quartz sandstone predominates and is associated with lesser amounts of conglomerate, phyllite and phyllitic sandstone. Pale purple to brown quartz sandstone predominates over white to grey sandstone and quartzite, and all are generally medium to coarse-grained, cross-bedded, massive to blocky, thick to thin-bedded and relatively poorly bedded. They do not crop out as prominently as the quartzites of the Le Lievre Beds, partly because of their hematite, limonite, sericite and feldspar content.

Many sandstones contain specularite crystals, which are also well developed in small quartz veins which cut the sandstone. A small lenticular bed of fine-grained hematite sandstone contained 50% by volume of iron oxide.

Granule sandstone*, pebble, cobble, and boulder conglomerate, and phyllite are scattered through the sequence. The conglomerates characteristically contain quartzite megaclasts up to 15 cm long in a coarse-grained sand matrix (Fig. 4), in contrast to the phyllitic matrix in conglomerates from the Ninety Seven Mile Beds. The clasts are relatively undeformed, and clasts up to 2 cm diameter after hematite are developed at the clast-matrix interface, and in the matrix.

A feature of the conglomerate deposits in the sequence is the rapid lateral thickness variations, e.g. within 1200 m of strike length the thickness of a conglomerate lens ranged from zero to 60 m. Some quartzite beds display similar variation.

A characteristic of much of the quartz sandstone is the presence of blue-grey quartz grains, which resemble quartz found in many of the granitic rocks of the Lamboo Complex. Another feature is the cross-bedding, which forms units up to 25 cm thick with planar bases.

* Sandstones with abundant quartz granules 2 to 4 mm diameter.

LE LIEVRE BEDS (Bzv)

Introduction

The Le Lievre Beds (pronounced 'Le Veer' Beds) consist of quartzite and phyllite which occupy the central 'core' of the Oscar Range. They form an elongate fold belt 13 km long and up to 1 km wide which extends from Hardman Creek in the southeast to Camarotoechia Creek in the northwest. The reference area is Le Lievre Ridge, near 3081 E, 2758 N, a high elongate flat-topped ridge which extends from Hardman Creek northwestwards for about 3 km. It is the highest part of the Oscar Range.

Stratigraphic Relationships

The Le Lievre Beds are probably one of the oldest units in the Oscar Range Succession. They form an anticlinal core and are overlain by the Ellendale Beds with slight but faulted unconformity. Near the southeastern part of the Le Lievre Ridge the Le Lievre Beds are probably overlain unconformably by the Elimberrie Beds. Relations with the Linesman Beds and Christophers Beds are uncertain; the latter are possibly folded lateral equivalents of the Le Lievre Beds.

Field Occurrence

The Le Lievre Beds contain three members. The oldest, Bzv_1, is predominantly a valley-forming phyllite, and is overlain by the most prominent member, Bzv_2, which is a quartzite forming small rugged plateau, flat-top ridges and hogbacks. The topmost member consists of magnetite-bearing phyllite.

Lithology

Member Bzv_1: Little is known of this unit. It consists of red-brown to grey phyllite, which is flaggy and laminated, micaceous, and in rare instances, spotted. Minor sandstone interbeds are present. Since it is poorly exposed and forms the central parts of the anticline, thickness is difficult to estimate. An approximate thickness of 200 m was obtained from aerial photographs. A small 'window' of the phyllite occurs at the southeastern end of Le Lievre Ridge, probably resulting from gentle cross-folding on northeast axes.

Member Bzv_2: Quartzite is by far the most abundant rock type in this member, which is estimated from aerial photographs to be about 450 m thick. No complete section has been measured, although the uppermost 200 m along the northeastern flank have been paced. This section is described below.

Ellendale Beds

unconformity

Thickness (in metres)	
51	Quartzite, pale blue-grey, massive, thick-bedded, ripple-marked towards base.
24	Sandstone, phyllitic, with thin lamellae of talcose material. Pebbly towards base.
45	Quartz sandstone, pale grey, massive to blocky, thick-bedded, cross-bedded and ripple-marked. Overlapped by Ellendale Beds.
30	Sandstone and breccia, ferruginous and poorly bedded.
30	Quartz sandstone, white to pale fawn, massive, thick-bedded.
22	Quartzite, grey, medium-grained, thick-bedded, massive.

minor fold axis

202 (Total metres)

The quartzite throughout is typically white to pale grey, coarse to medium-grained, massive to blocky, thick-bedded, well-sorted and clean-washed. Tourmaline and specularite are rare accessories. Both cross-beds and ripple marks are present, the latter apparently more frequent near the top of the sequence. They are very nearly symmetrical, and are 0.8 cm high with a crest spacing of 6.2 cm. This gives a ripple index of about 8, which falls well within the range for ripples formed under water (Tanner, 1967). Jointing is very well developed, and is usually vertical or nearly so. Bedding has been almost completely obliterated during metamorphic recrystallization of the sandstone to quartzite. Only poorly preserved cross-bedding and some ripples indicate the facing in the sequence.

Quartzite from the Le Lievre Beds is very clean-washed, and contains only oblate quartz grains up to 1 mm diameter with granulated and recrystallized margins. Tourmaline, specks of black iron oxide, and rare flakes of muscovite are accessories. In some specimens the larger grains show silica overgrowths, which are outlined by dusty inclusions of fine-grained iron oxide. Sericite, present in some specimens as small oriented flakes, also occurs in rare fine-grained micaceous and ferruginous rock fragments.

Member Bzv_3: This unit is a magnetite-bearing phyllite, which could possibly be a sheared basic tuff similar to those in the Christophers Beds. It crops out only on the southwest flank of the Le Lievre Ridge, is very poorly exposed, and extends along strike for only 4.5 km. It is about 150 m thick; to the southeast it is truncated by quartzite of Bzv_2, and to the northwest is overlapped by and faulted against the Ellendale Beds.

ELLENDALE BEDS (Bze)

Introduction

The Ellendale Beds occur on the southwest and northeast flanks of the central 'core' of the Oscar Range, and extend from Hardman Creek in the southeast to Ninety Seven Mile Creek in the northwest. The reference area for the basal member Bze_1 is on the northeast flank of the Oscar Range, about 1.5 km southeast of the headwaters of Camarotoechia Creek, (3051E, 27603N). For Bze_2 the reference area is on the southwest flank of the range about 3 km southeast of Camarotoechia Creek (3030E, 27603N).

The Beds are named after Ellendale homestead, about 40 km west-southwest of the Oscar Ranges, near the Great Northern Highway. The name has been used because of the lack of suitable geographic names in the reference area.

The Ellendale Beds consist of three members:

Bze_3	414 m	Siltstone
Bze_2	ca 360 to 650 m	Cobble and boulder conglomerate, quartzite and quartz sandstone; minor feldspathic sandstone and siltstone.
Bze_1	up to 400 m	Quartz sandstone and feldspathic sandstone, quartzite,

minor phyllitic siltstone, shale, pebble conglomerate and hematite rock.

Stratigraphic Relationships

The disposition of the Ellendale Beds around the anticlinal core of Le Lievre Beds indicates they overlie them. Along the northeast flank the relationship is obscured by faulting, and the contact is probably also unconformable, while along the southwest flank a faulted contact predominates. Along the Le Lievre Ridge the Ellendale Beds appear to overlap phyllite (Pzv_3) of the Le Lievre Beds.

The basal member of the Ellendale Beds is overlain with probable unconformity by limestone of the Elimberrie Beds, which also overlaps the upper members of the Ellendale Beds near Hardman Creek.

Relations with the Christophers Beds and Ninety Seven Mile Beds are uncertain. The Ellendale Beds are possibly younger than or equivalent to parts of the Christophers Beds; they are separated from the Ninety Seven Mile Beds by faulting, and are probably older than them.

Stratigraphic relationships within the Ellendale Beds are not completely known. On the northern side of the Le Lievre Ridge conglomerate and sandstone at the base of Pze_2 lie directly on ferruginous phyllite of Pze_1. Only about 120 m of Pze_2 are present and this is overlain directly by siltstone of Pze_3, whereas on the southside of the Le Lievre Ridge about 650 m of Pze_2 are known. This suggests that siltstones of Pze_3 may lie unconformably on Pze_2.

Field Occurrence

Phyllite, quartzite, conglomerate, and shale are the major rock types of the Ellendale Beds. The basal member occurs along the northeast flank of the range 'core' and consists of older phyllitic sandstone and younger quartzite. The former is valley-forming, while the latter forms strike ridges and low hogbacks. The middle member Pze_2 occurs mainly in the southwest, but extends for about 3 km around to the northeast flank of the range core. It is basically a conglomerate-quartzite-phyllite sequence, and forms closely spaced folded

strike ridges with intervening valleys. The uppermost member is a shale unit restricted in extent to the southeast end of the Le Lievre Ridge.

The total measured thickness of the Ellendale Beds is around 1500 m, but this is a minimum value since the beds are strongly folded and it has not been possible to measure complete sections of the members. The base of the 400 m-thick sequence of Bze_1 measured is an anticlinal core and the top can be delineated only approximately because of detritus from the overlying basal conglomerate of Bze_2. Similarly both the top and bottom of Bze_2 are not exposed and where the greatest thickness is preserved there is repetition by folding. The base of Bze_3, although well exposed can be delineated with reasonable confidence on topographic grounds, but the location of the upper contact is uncertain; it is probably an unconformity, so the original thickness of this member could be in excess of that measured.

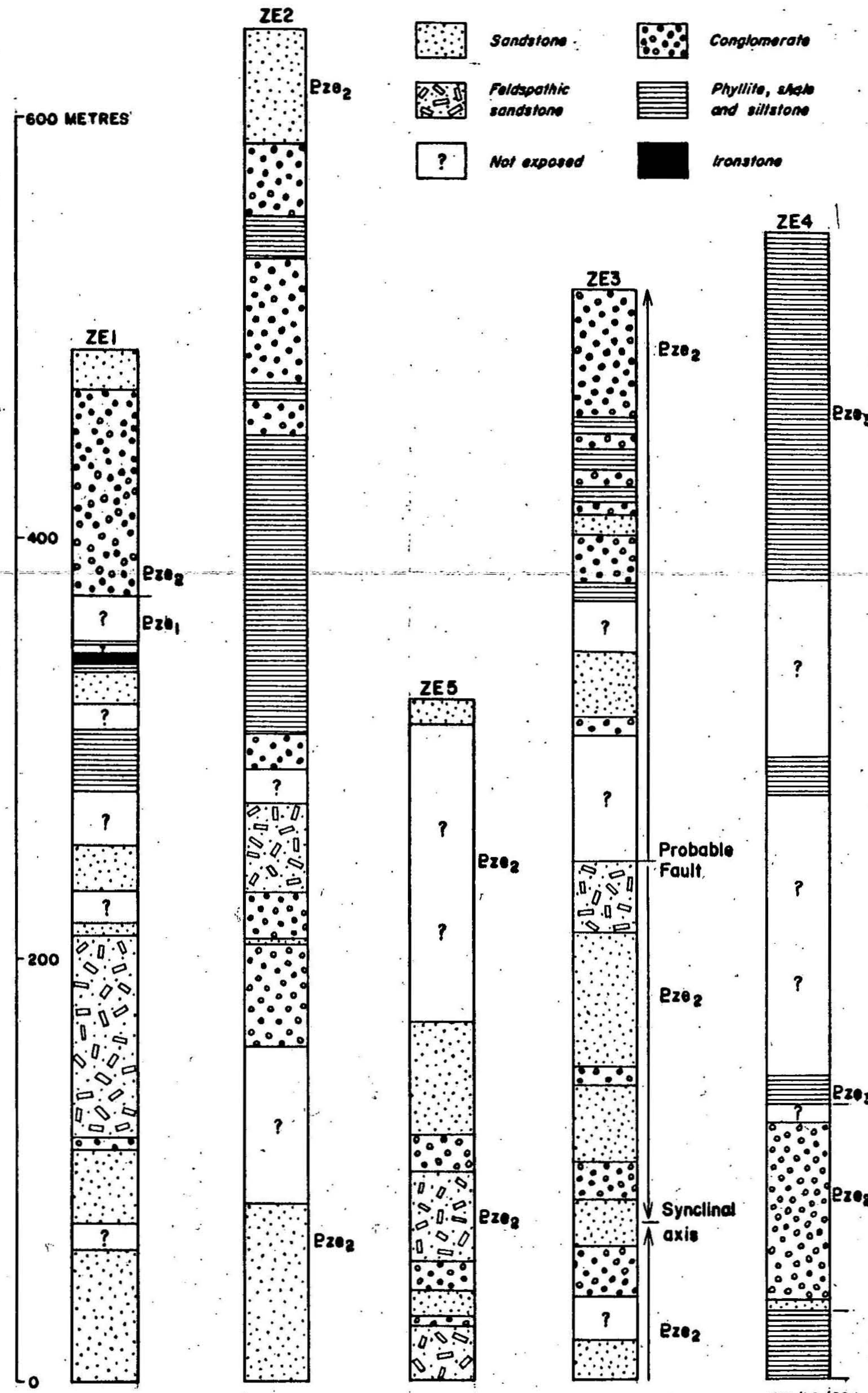
Lithology

Member Bze_1: The most complete section (about 400 m) of this unit has been examined, about 10 km west-northwest of Christophers Bore. It consists essentially of quartz sandstone and quartzite, sericitized feldspathic sandstone, phyllitic shale and siltstone, and minor ironstone and pebble conglomerate. A measured section (ZE1) is given in detail in Appendix 2, and the major rock types are shown diagrammatically in Figure 5.

A few kilometres farther to the northwest, where the sequence is complicated by tight folding, only about 250 m can be delineated but a much greater thickness may be present. There the unit consists of phyllitic sandstone and quartz sandstone, with minor shale and siltstone. The basal part of the member is a pale cream-green medium-grained phyllitic sandstone, which is thin-bedded to laminated and slightly fissile. It is slightly feldspathic, and contains some tourmaline.

Overlying this phyllitic sandstone sequence is quartz sandstone, which is typically white to grey, medium to coarse-grained, massive to blocky and thick-bedded. It is poorly bedded and very clean-washed. Minor tourmaline and rare spots of limonite are evident

Fig. 5 STRATIGRAPHIC SECTIONS OF ELLENDALE BEDS



To accompany Record 1971/61

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in hand specimen. On weathered surfaces solution pits are common, owing to preferential weathering of sericitized feldspar.

Cross-beds are present throughout, but are partly obscured by recrystallization. They occur in sets up to 30 cm thick, with planar lower surfaces, and in one place are overturned.

Towards the base of the quartz sandstone and quartzite the colour is pale blue-grey, and ripple marks are present. A bed of cobble and pebble conglomerate has also been noted. At the top of the quartzite good sorting, which is characteristic of most of the unit, is not evident. Fine to coarse-grained quartzite with stringers of granule and pebbly sandstone is present, and is generally massive, thick-bedded and cross-bedded. Rapid reversals in the facing of these beds indicates that they are folded almost isoclinally. As a result a near-vertical cleavage and quartz veining in axial regions are well developed.

At one locality a coating on a joint plane in white quartz sandstone may be malachite; it is associated with small veins containing quartz and hematite.

Member Pze_2: The most distinctive features of this member are the diverse nature of the rock types and their rapid alternation throughout the sequence, and the abundance of conglomerate. The ratio conglomerate:sandstone:siltstone for this unit is approximately 2:3:1, and it is the most rudaceous rock unit in the Oscar Range. The basal 100 m consists almost entirely of conglomerate, and thinner conglomerate bands are sporadically distributed throughout the rest of the sequence. The conglomerates contain flattened pebbles, cobbles, and boulders of quartzite, generally in a coarse-grained phyllitic quartzite matrix. Some conglomerates, apparently unique to this member, contain scattered fragments of black siltstone, chert, and laminated siltstone, but quartzite clasts predominate (Fig. 6). The megaclasts are flattened parallel to the cleavage, which is subparallel to bedding, and only departs from it in fold axial regions. Rapid variations in thickness of the conglomerate along strike are very common. Measured sections ZE2, ZE3, and ZE5 are listed in Appendix 2.

The sandstones are mostly fawn to pale grey, thin-bedded, flaggy, medium-grained well-sorted varieties. Massive white quartz sandstone is rare. Much of the sandstone is phyllitic, or contains very thin interbeds (1 to 3 cm) of phyllite. The mica is white to golden brown, and appears slightly ferruginous in the hand specimen. Rare examples of sandstone are dark coloured because of an abundance of tourmaline (up to 30%) and, to a lesser extent, specularite. Some specimens contain sericitized feldspar. Cherty quartzite, found at the top of this member on the southwest flank of the Oscar Range, is probably a result of silica enrichment by leaching of the overlying Permian sandstones of the Grant Formation.

Phyllite forms valleys between the strike ridges of conglomerate and quartzite. It is red-brown to pale green, and is usually laminated, well cleaved, and sporadically conglomeratic, or with some coarse quartz grains. It mainly forms interbeds from 0.5 to 6 m thick, and in places is highly folded (Fig. 7).

Member Pze_3: Pale purple and pale grey-green laminated siltstone make up the entire section, which is about 400 m thick. It is phyllitic in parts but is less highly cleaved than siltstone elsewhere in the Oscar Range Inlier. Measured section ZE4 is listed in Appendix 2.

LINESMAN BEDS (Bzl)

Introduction

The Linesman Beds form a tightly folded sequence of mainly siltstone and sandstone near the southeastern end of the Oscar Range, immediately west and south of Christophers Bore.

They contain three members:

Bzl_3	235 m	Siltstone with interbeds of feldspathic sandstone.
Bzl_2	260 m	Siltstone and feldspathic sandstone.
Bzl_1	ca 800 m	Siltstone and shale; minor feldspathic sandstone and cobble siltstone.

Fig. 6. Conglomerate in member Pze_2 of Ellendale Beds, showing clasts of quartzite, chert, black siltstone and laminated siltstone; locality about 4 km. east-southeast of Stumpys Bore.

M 457/29A GMD

Fig. 7. Folded conglomeratic phyllite in member Pze_2, 4 km. east-southeast of Stumpys Bore.

M 457/11A GMD

Stratigraphic Relationships

The Linesman Beds occur up-dip from the Christophers Beds and are possibly younger, but the contact could possibly be faulted: there is an apparent overlap northwestwards of the Linesman Beds on to progressively older members of the Christophers Beds, and the Linesman Beds are more intensely folded than the Christophers Beds.

The tightly folded Linesman Beds are truncated to the south-southwest by a major fault from which the Elimberrie Beds dip to the south-southwest. The difference in intensity of folding between the Linesman Beds and the Elimberrie Beds indicates that Linesman Beds have undergone a period of intense deformation that has not affected the Elimberrie Beds. It is probable that an unconformity exists between the two units but has been faulted out of the sequence at the present level of erosion.

The basal siltstone member of the Linesman Beds is lithologically similar to the siltstone unit at the top of the Ellendale Beds and is separated from it by only about 1 km of no outcrop. Correlation of these two siltstone members is suggested. If this correlation is valid then the presence of an unconformity between the Linesman Beds and the Elimberrie Beds is established, since the limestone of member Bzb_2 of the Elimberrie Beds directly overlies siltstone of the basal member of the Linesman Beds. The Linesman Beds are overlain unconformably by Devonian Limestone. Within the Linesman Beds there is an overlap west-northwestwards of Bzl_3 on to Bzl_1. This suggests the presence of a minor intraformational unconformity between Bzl_3 and the underlying Bzl_2 and Bzl_1. However, detailed measurement of dips and strikes of Bzl_3 and Bzl_1 beds about 2 km due west of Christophers Bore has failed to indicate any detectable difference of dip between the two members and any initial discordance of dip has presumably been destroyed by the near isoclinal folding which has affected the unit. Fig. 8b illustrates diagrammatically the suggested stratigraphic relations within the Linesman Beds prior to folding.

Field Occurrence

The Linesman Beds extend more or less continuously for a total strike length of about 14 km at the southern end of the Oscar Range and have a total outcrop area of about 25 km^2. The Beds trend northwest

and exhibit very tight, near-isoclinal folding about steeply-plunging, southeast-trending fold axes. Sandstone beds in the sequence form prominent sinuous strike ridges which are well displayed on air photographs. The basal member lacks sandstone interbeds, and shows low relief, a smooth-toned photo-pattern, and dendritic minor drainage.

Lithology

The Linesman Beds consist predominantly of siltstone and thus differ from other rock units of the Oscar Range which consists mostly of quartzite or conglomerate. Even the most arenaceous member of the Linesman Beds, Bzl_2, which appears on rapid inspection to be mainly feldspathic sandstone, has been proved on detailed examination to contain a slight predominance of siltstone. The conglomerate:sandstone:siltstone ratio for the whole unit is 1:18:88. Measured sections of members Bzl_2 and Bzl_3 and a partly measured, partly estimated section of member Bzl_1, are given in Appendix 2; diagrammatic sections of members Bzl_2 and Bzl_3 are shown in Fig. 8a.

Member Bzl_1: The basal 100 m of member Bzl_1 consists of siltstone and feldspathic sandstone with thin intercalated boulder beds. These boulder beds contain well rounded ellipsoidal cobbles, boulders, and pebbles of quartzite and quartz sandstone. Most of the clasts are moderately well polished and some are facetted. The matrix ranges from red-brown micaceous siltstone to poorly sorted quartz sandstone. Above this basal 100 m the member consists entirely of siltstone and shale.

Member Bzl_2: This member consists almost entirely of siltstone and feldspathic sandstone. Siltstone predominates, but the sandstone:siltstone ratio is close to 1:1. Thin conglomerate beds containing pebbles and cobbles of quartz sandstone, quartzite, and vein quartz in a feldspathic sandstone matrix make up about 2 percent of the total thickness. In addition to the succession given in Appendix 2 (section ZL_1) the topmost beds of the sequence have been measured about 1 km west-southwest of Christophers Bore near the overlap of member Bzl_3 on to Bzl_1. These are as follows:

Fig. 8 (a) STRATIGRAPHIC SUCCESSION OF MEMBERS Pzl_2 AND Pzl_3 OF LINESMAN BEDS

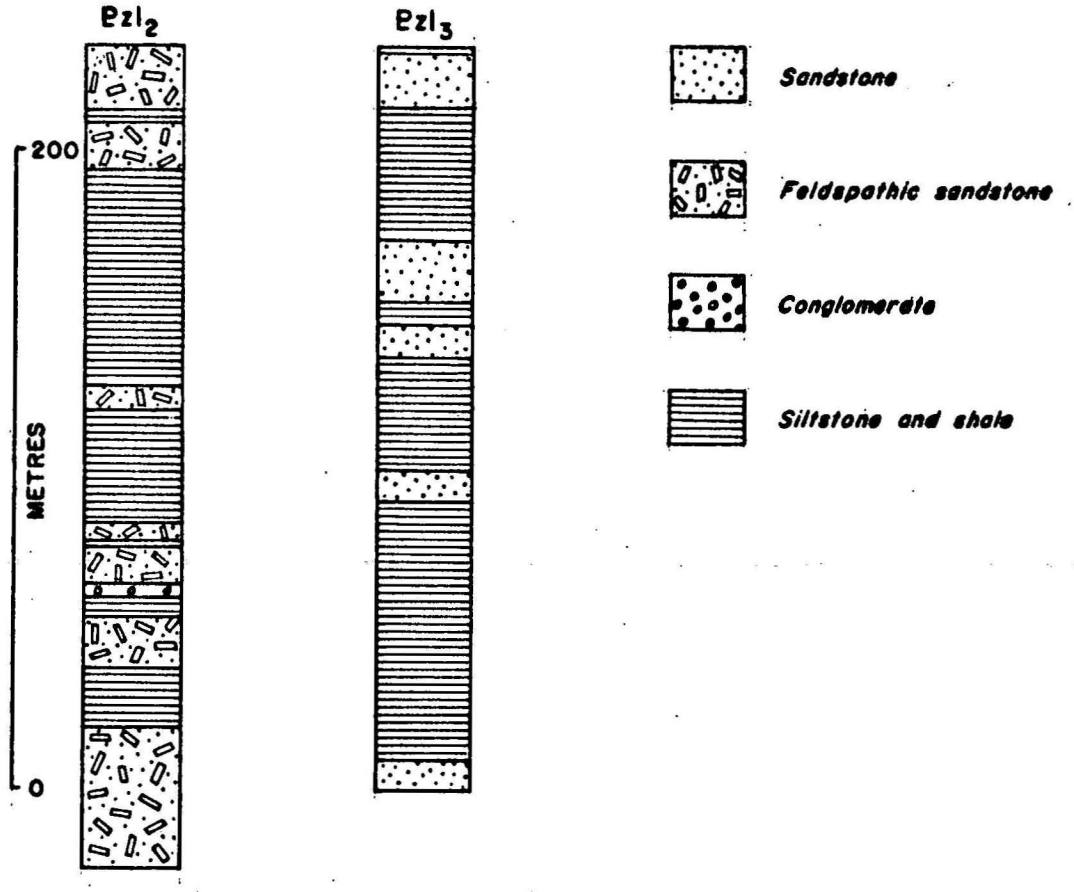
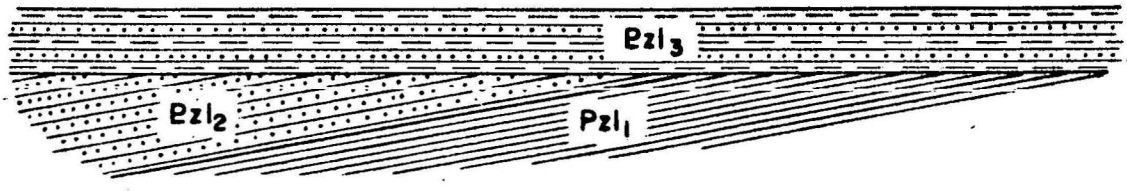


Fig. 8 (b) SUGGESTED STRATIGRAPHIC RELATIONSHIPS OF MEMBERS OF THE LINESMAN BEDS PRIOR TO FOLDING



Thickness (metres)	(Overlain by basal sandstone of Bzl_3) Topmost beds of Member Bzl_2
40	Siltstone: red brown (weathered) laminated, flaggy.
5	Feldspathic sandstone: white to pale green, coarse-grained thick-bedded blocky feldspathic sandstone.
6	Siltstone and shale: red brown, laminated, fissile.
6	Quartz sandstone and feldspathic sandstone: very pale pink, coarse-grained.

The relationship of this partial sequence to that given in the measured section is unknown, but the two thin sandstones and their thin siltstone interbeds form a distinctive unit which can be traced through several fold closures for more than 1 km on the ground.

Although original feldspar grains in these sandstones are readily discernible in hand specimen, examination of a thin section (R68. 16.0365) indicates that the feldspar has been entirely converted to sericite during metamorphism. Also quartz has been extensively recrystallized.

Member Bzl_3: This member differs from Bzl_2 in having a lower sandstone:siltstone ratio (ca. 1:2) and in containing mostly fine to medium-grained feldspathic sandstone rather than coarse-grained as in Bzl_2. The basal white feldspathic sandstone is a distinctive marker bed which can be traced for about 16 km. The immediately overlying siltstone is characteristically banded, showing alternating very pale grey green and pale purple bands 0.5 to 1 cm thick. The siltstone is massive in creek gorges but fissile in outcrop elsewhere. The colour of the purple laminae is due to the presence of minute specks of hematite (thin section R68.16.0364). Symmetrical cuspate ripple marks have been noted in thin fine-grained feldspathic sandstone interbeds in phyllite near the top of the sequence. At least part of the unit, therefore, was laid down in shallow water.

ELIMBERRIE BEDS (Bzb)

Introduction

The Elimberrie Beds crop out on the northern flank of the central part of the Oscar Range and on the southern flank of the southeastern part. Most of the sequences is preserved only in the southeast.

The name is derived from Elimberrie Spring, about 14 km northwest of the northwesterly extremity of outcrop of the Elimberrie Beds.

The Elimberrie Beds are characterized by the presence of several hundred feet of dolomite at the base of the sequence and by the occurrence of probable glacigene* rocks in the middle and upper parts. Seven members are recognized.

Two reference areas are proposed - around the headwaters of Camarotoechia Creek (3040E, 27640N) for the basal member, and about 5 km northeast of Twelve Mile Bore (3185E, 27500N) for the rest of the unit.

The members of the Elimberrie Beds are:

Bzb_7	140 m	Quartz sandstone and siltstone; thin ironstone interbeds.
Bzb_6	40 to 170 m	(?)Tillite and phyllitic siltstone, tuff.
Bzb_5	Up to 360 m	Phyllitic siltstone; minor quartz sandstone.
Bzb_4	Up to 140 m	Quartzite; quartz sandstone and feldspathic sandstone, minor cobble beds.
Bzb_3	120 to 170 m	Phyllite, siltstone and shale, minor limestone, quartz sandstone and tillite(?).
Bzb_2	210 m	Dolomitic limestone, dololutite, feldspathic sandstone, siltstone.
Bzb_1	220 m	Dolomitic limestone, dolarenite, quartzite, ironstone lenses, chert.

Stratigraphic Relationships

On the northern flank of the Oscar Range the Elimberrie Beds overlie the Ellendale Beds unconformably. The unconformity is well displayed about 4½ km north of Stumpys Bore, where the basal limestone of the Elimberrie Beds lies on member Bze_1 of the Ellendale Beds with

* "Glacigene" is used to describe sequences of possible glacial affinity (e.g. containing boulder beds, boulder phyllite, poor sorting, crescentic percussion marks) for which direct evidence of glaciation (striated pavements) is lacking.

Fig. 9 STRATIGRAPHIC SECTIONS OF ELIMBERRIE BEDS

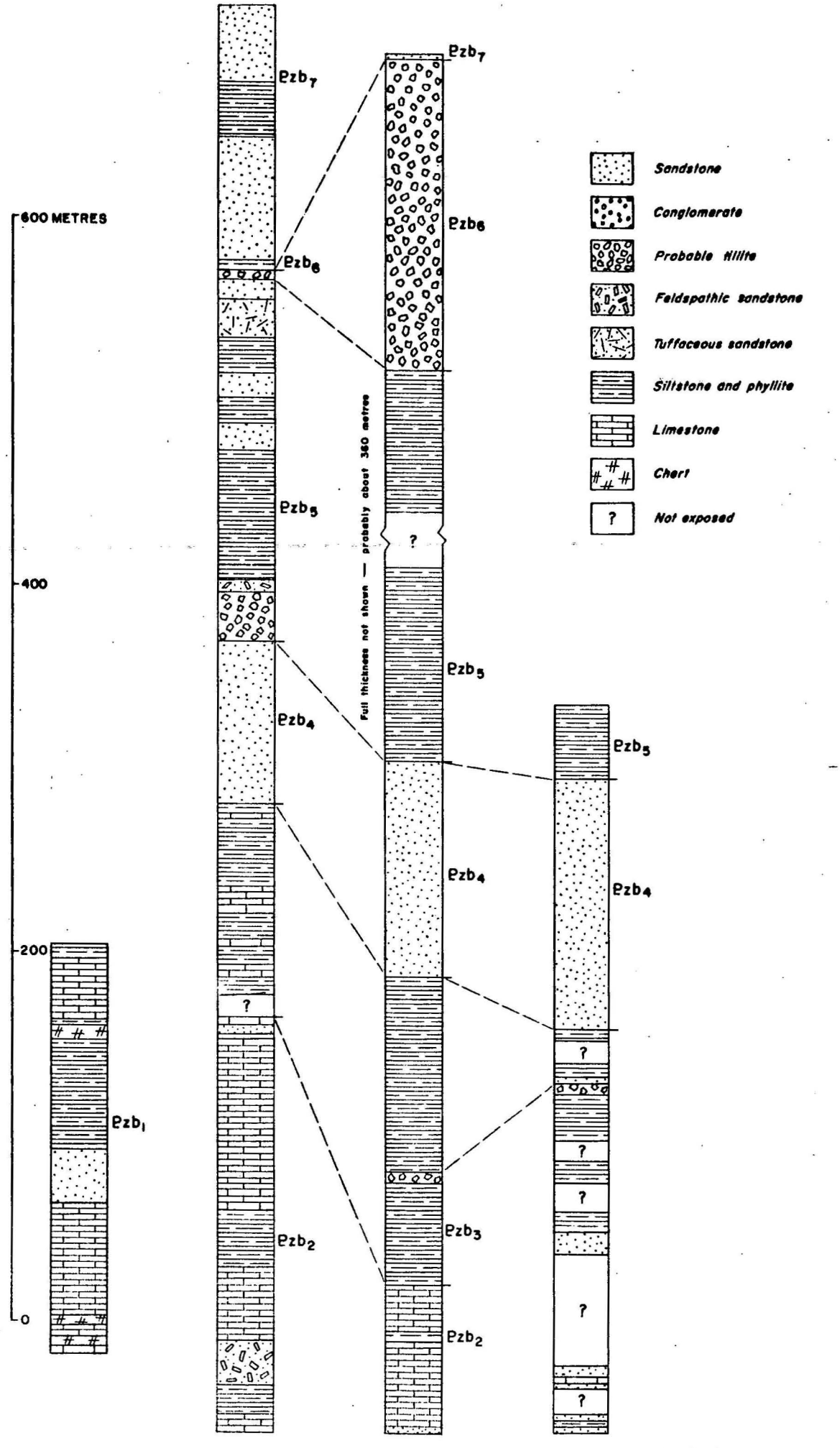


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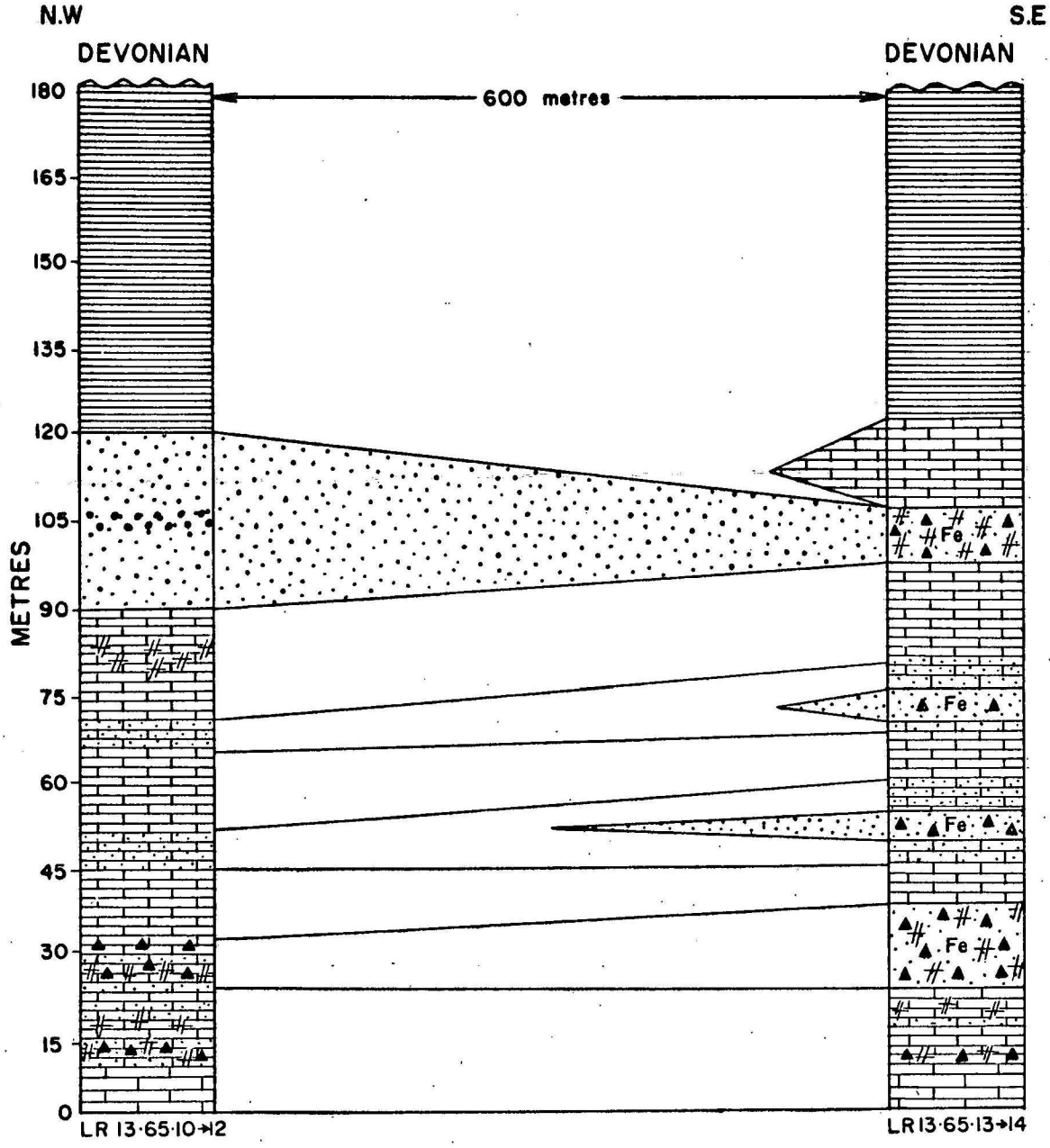
Fig. 10 FACIES AND THICKNESS VARIATIONS ELIMBERRIE BEDS BASAL MEMBER Pzb1



Phyllite

Quartzite, quartz sandstone, conglomerate

Thin-bedded limestone

Massive limestone

Sandy limestone

Chert

Breccia

Fe *Iron*

To accompany Record 1971/61

E51/A8/29

angular discordance. Farther to the southeast, in the headwaters of Spielers Creek, limestone at the base of the Elimberrie Beds overlies member Bze_3. Although the contact in this locality is not exposed these relationships demonstrate overlap of the Elimberrie Beds northwestwards on to progressively older members of the Ellendale Beds.

The relationship of the Elimberrie Beds to the Linesman Beds has been described in the section on the latter unit. In the northwestern part of the Oscar Range the Elimberrie Beds are in contact with the Christophers Beds and apparently overlie them.

The Elimberrie Beds are overlain, apparently concordantly, by the Spielers Volcanics. Strong shearing parallel to the contact in both units suggests that the contact may be a high-angle thrust. The Ninety Seven Mile Beds are also overlain by Spielers Volcanics(?) and, like the Elimberrie Beds, contain glacigene boulder beds in their upper parts; these two units are thought to be lateral equivalents in part, but dissimilarities between the lower parts of the sequence of each unit preclude more than partial correlation between them.

The Elimberrie Beds are overlain unconformably by the Devonian Pillara Limestone and by boulder conglomerate of probable Permian age.

Within the Elimberrie Beds relationships between the sequences mapped as Bzb_1 and Bzb_2 are uncertain. Both consist predominantly of limestone, but are separated by an area of no outcrop northwest of Spielers Creek. The limestones of Bzb_1 appear to be coarser grained and less arenaceous than those of Bzb_2; member Bzb_1 has no top and Bzb_2 has no bottom and there may be some overlap between the two members. Poorly exposed beds immediately west of Spielers Creek probably include limestones of both these units.

Field Occurrence

The Elimberrie Beds form a semi-continuous belt from a point about 4 km north of Stumpys Bore to 9 km east-northeast of Twelve Mile Bore, a distance of about 31 km. A further small isolated outcrop forms an inlier farther to the east, about 4 km southwest of Leopold Downs airstrip. West of Spielers Creek the Elimberrie Beds flank the northern side of the Oscar Range whereas to the east of Spielers Creek they flank the southern side.

The Elimberrie Beds form mostly low, discontinuous strike ridges and hogbacks with intervening pediments and narrow alluvium-floored valleys. With only minor exceptions it forms lower ground than the adjacent Ellendale and Linesman Beds which together constitute the main topographic core of the Oscar Range.

The total area of outcrop is about 50 km^2; about two-fifths of this is accounted for by the basal member.

The maximum thickness of the Elimberrie Beds amounts to some 1400 m. Most of the members are very variable in thickness. For example member Bzb_5 ranges from 40 m to 370 m, being thickest where boulder beds predominate. The thickness variations are recorded in Appendix 2 (measured sections) and are shown diagrammatically on Figures 9 and 10.

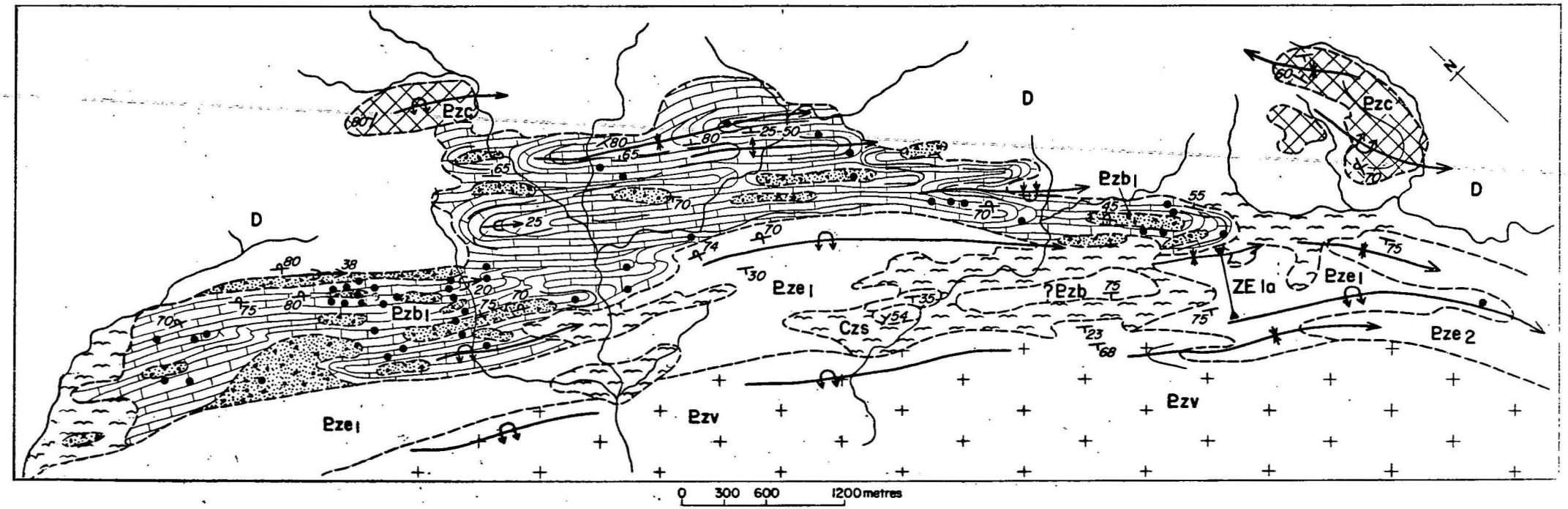
Lithology

Member Bzb_1: Figure 11 is a sketch map showing the detailed geology of the member, which contains massive well-bedded dolomitic limestone, flaggy sandy dolomite, and dolomitic quartz sandstone, quartzite, phyllite and ferruginous chert-quartzite breccia.

Two types of dolomitic limestone predominate. One is massive, fine to coarse-grained, light grey-brown, thick-bedded, and shows bulbous weathering surfaces which in places are rough and irregular on a small scale. It is upstanding relative to the other type, which is thin-bedded, fine-grained, generally brown on weathered surfaces and dark grey to black on fresh surfaces. It is finely interbanded with chert and sandy dolomite, and locally has well developed small-scale folds (Fig. 12) in contrast to the massive type. Boudin structures, chert nodules, and quartz veins are widespread throughout both types (Fig. 14).

Sandy dolomite (or dolomitic quartz sandstone) is a common interbed within the limestone units (Fig. 13). It shows a grey-brown weathered surface and a pale pink-fawn fresh surface. The beds are flaggy and thin-bedded, and are 2 to 4 cm thick. The quartz grains in the sandstone are most evident on the weathered surface, where they

Fig.11 DETAILED GEOLOGICAL SKETCH OF BASAL MEMBER Pzb1 OF THE ELIMBERRIE BEDS



Czs — Soil and alluvium

Pzb1 — Elimberrie Beds: Limestone, calcarenite, phyllite and quartzite (stippled). Basal member.

D — Devonian: Limestone

Pze2 / Pze1 — Ellendale Beds: Cobble and boulder conglomerate, quartz and feldspathic sandstone, phyllite.

Pzv — Le Lievre Beds: Massive grey-white quartzite

Ferruginous chert breccia, gossan, hematite lenses

Pzc — Christophers Beds: Grey to purple quartz sandstone, minor boulder conglomerate.

ZE Ia — Measured section

To accompany Record 1971/61

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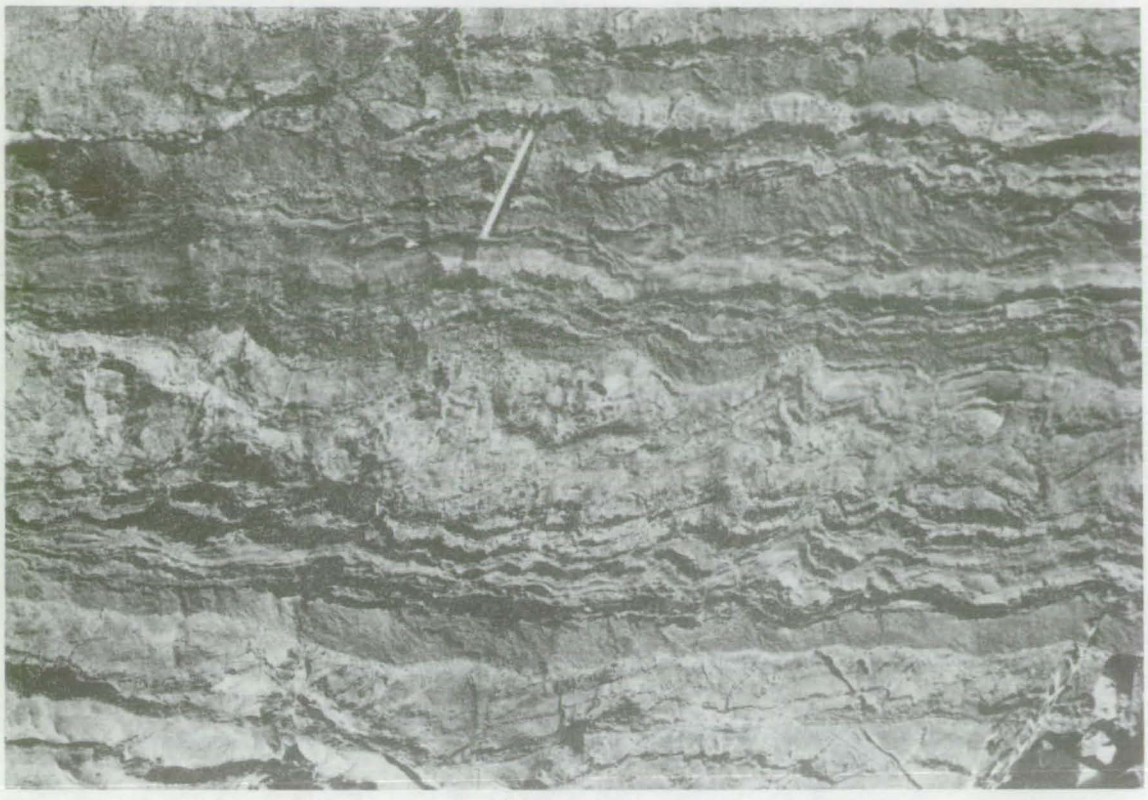


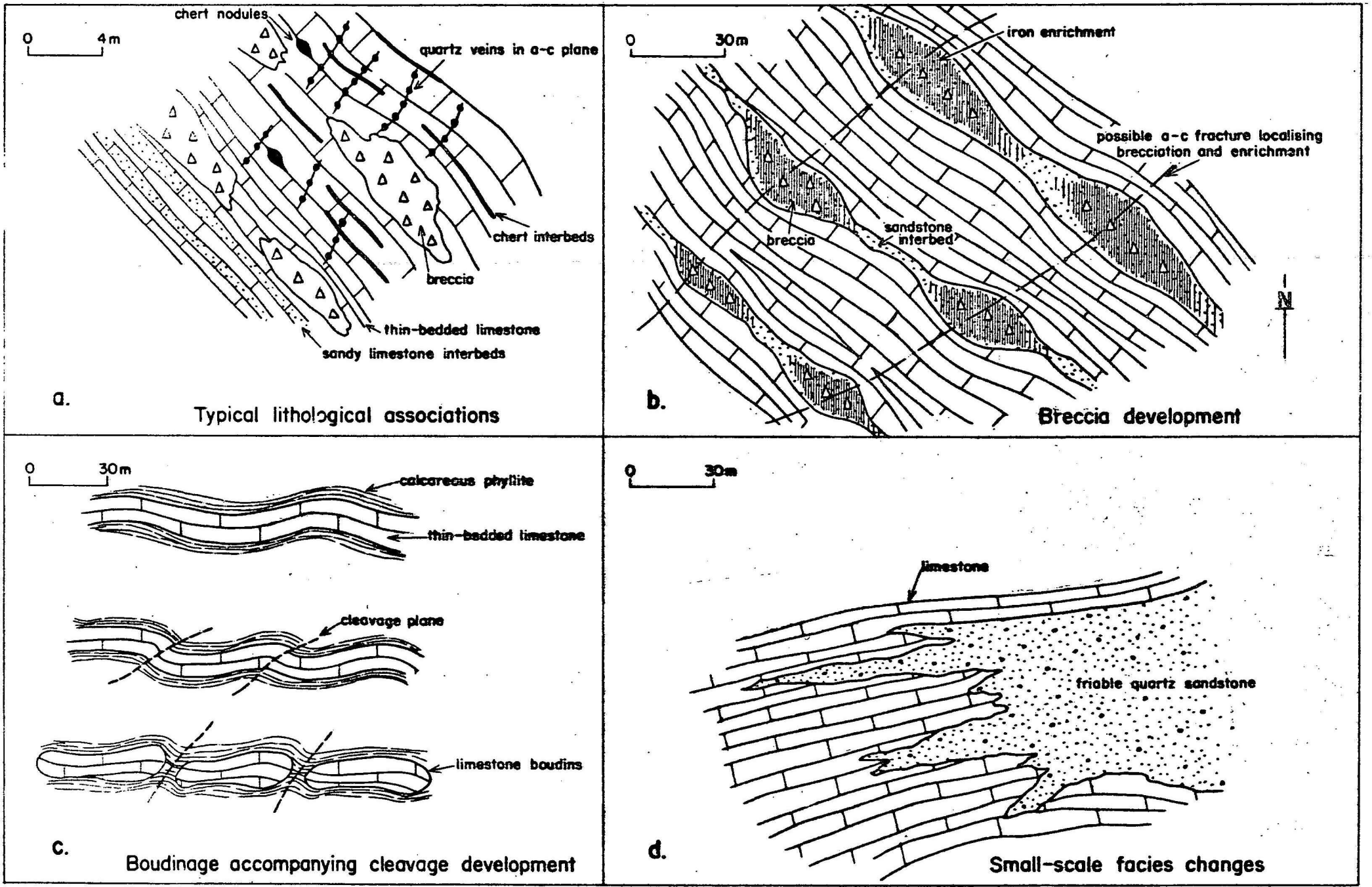
Fig. 12. Small-scale folding in bedded limestone, Elimberrie Beds, member Pzb_1. Match parallel to incipient axial plane cleavage. Locality 7 km. east-northeast of Stumpys Bore.

M 457/24A GMD

Fig. 13. Sandy dolomite in Pzb_1; locality about 8 km. east of Stumpys Soak.

M 536/6 DCG

Fig.14. SOME LITHOLOGICAL ASSOCIATIONS IN THE BASAL MEMBER Pzbl OF THE ELIMBERRIE BEDS



form a friable crust. The quartz grains constitute up to 50 percent of the rock, and in some cases outline micro-cross-bedding. Ripple marks occur in the sequence near Leopold Downs airstrip, but have not been seen elsewhere.

Quartzite is scattered through the unit, but most exposures are probably part of one, possibly two, interbeds repeated by folding. It is grey-white, massive, thick to thin-bedded, and cross-bedded, with some tourmaline evident. It is fine to coarse-grained, although in places granule sandstone and pebble conglomerate occur. Cross-bedding in this unit and in the sandy limestone provides the only control over attitude of the sequence. In one instance the quartzite shows up to 45° of overturning. The quartzites are strongly jointed and cleaved, and bedding is obscure. Some quartzite is laminated and yellow-brown, and commonly appears in breccias.

Breccia is widespread in the member. The least abundant breccias contain phyllite fragments in a carbonate matrix. These are restricted in extent, and appear to be intraformational. Chert-quartzite breccias are widespread, and are characterized by their yellow-brown colour. They generally occur along ridge crests, are laterally discontinuous, and extend over areas of up to 180 m^2. The fragments of quartzite are laminated and yellow-brown, and are veined and replaced by dense siliceous orange-brown chert. Vughs lined with calcite, chalcedony, and hematite are common, as are quartz veins and vein quartz fragments. The more arenaceous parts of most of the breccias are enriched in iron; any massive limestone within the breccias is unaffected. Hematite forms veins, coatings, and solid blocks up to 50 cm across, and hematite pods are common throughout the member (Fig. 11). They are too small and too variable in grade to be economic.

Breccia 'pods' are shown diagrammatically in Fig. 14b. The brecciation and iron enrichment occurs where northeast-trending linear features intersect zones of thickening in relatively brittle laminated and calcareous quartzite bands. This northeast linear feature is not well defined, but could be an ac joint system.

Such breccia deposits could have been contemporaneous with Proterozoic or Cambrian folding and deformation, but equally they could be part of a Tertiary weathering profile in which leaching of carbonate

has resulted in autocollapse, followed by silicification. Significantly most of the breccia forms at high points along ridges, and may represent remnants of a breccia surface, of uncertain age.

Chert interbeds in limestone are generally dark grey, dense, and thin-bedded. They are locally stratiform, and may be very fine-grained quartzite.

Phyllite is poorly exposed. It is red-brown to grey, and both quartzitic and calcareous types occur, generally strongly deformed.

The exact thickness of the member is uncertain since no complete section is preserved. A composite paced section 219 m thick is listed in Appendix 2. A minimum thickness of about 140 m was paced over a relatively undeformed inlier of this member 4 km west of Leopold Downs airstrip, and about 32 km from the section listed above. In general the tight folding, rapid thickness variations, and poor exposures within the member prevent accurate thickness measurement.

Member Bzb_2: This member may be equivalent in part to Member Bzb_1, but differs from it lithologically in the scarcity of arenaceous dolomite, the absence of chert and ironstone lenses, and the presence of feldspathic sandstone.

Dolomites are mottled brown and grey-brown in hand specimen and locally rubbly and cellular, with small cavities containing powdery dark brown limonite. Some specimens have a 1 cm weathered crust of powdery limonite suggesting a moderate iron content. Some samples are friable and arenaceous, others are tough and porcelaneous. The friable types are commonly rudaceous and contain 1 cm to 3 cm fragments of phyllite and tough porcelaneous dolomite. Finely banded dololutite is present locally and is interbedded with shale and more massive dolomite. The presence of rare ellipsoidal quartzite pebbles up to 8 cm long suggest a possible association with the probable glacigene rocks higher in the Elimberrie Beds.

Feldspathic sandstone in this member is pale buff, medium-grained, thin-bedded, and well sorted. Associated siltstone is finely laminated and dark grey.

The greatest thickness measured is about 215 m; but the base of the exposed sequence is faulted. Immediately west of Spielers Creek the maximum possible thickness of limestone between the top of the Ellendale Beds and the base of member Bzb_3 is about 240 m. This could represent the combined thickness of Bzb_1 and Bzb_2. If so, then either the sequence there is abnormally thin or else this is the true combined thickness of the two members (which would then by inference be largely equivalent) and differences in the lithological succession between them must be accounted for by facies changes.

Member Bzb_3: This member consists principally of pale grey-brown finely laminated fissile phyllite. In three separate localities beds of boulder sandstone or phyllitic cobble or boulder siltstone have been noted, although in one locality (Section ZB1) they are apparently absent. The boulder sandstone consists of ellipsoidal cobbles and boulders of medium to coarse-grained white quartzite in a matrix of coarse-grained, very friable white to pale rust-brown phyllitic quartzite. The boulders and cobbles are smooth and faintly striated, but the striation could be of tectonic origin.

Interbedded with the boulder and cobble beds are beds and lenses of medium to coarse-grained, very friable cellular limonitic sandstone and sericitic quartzite, which contain ellipsoidal cavities 1 to 2 mm long containing powdery limonite. Similar cellular sandstone has been found associated with possible glacigene boulder and cobble beds in member Bzb_6 of the Elimberrie Beds.

Thin dolomitic limestone interbeds have been found in a predominantly siltstone sequence of member Bzb_3 near the eastern end of the Oscar Range but are apparently absent farther west.

Measured thicknesses of member Bzb_3 range from 120 m to 170 m.

Member Bzb_4: This member consists almost entirely of quartzite and quartz sandstone, minor feldspathic sandstone, and highly sheared boulder phyllite of possible glacial origin. The thickness ranges from 120 m to 140 m.

The relatively uniform lithology of member Bzb_4 and its resistance to erosion make it a distinctive marker unit in the Elimberrie Beds.

Member Bzb_5: This poorly exposed member consists almost entirely of phyllitic siltstone and shale. Quartz sandstone and quartzite locally make up about 20 percent of the succession. The thickness ranges from 160 m up to about 360 m.

The top is locally difficult to define since phyllite is common in the overlying member Bzb_6. The boundary is mostly mapped at the base of the lowest boulder beds in the sequence, but they are lenticular, and the boundary may be diachronous.

Member Bzb_6: Boulder beds of possible glacial origin are diagnostic of member Bzb_6, and are dominant, but phyllitic siltstone, quartzite, basic tuff, and minor hematitic ironstone are also present.

The boulder beds contain cobbles and boulders of white, medium to coarse-grained quartzite in a sandy to silty phyllitic matrix (Fig. 15). Megaclasts are up to 1 m long and are moderately well polished. Most are striated, but in many examples this is a tectonic striation. A few large undeformed boulders have crescentic percussion marks, but in most places the clasts have been stretched and flattened during folding and no trace of original surface marks remain. Cobbles are extremely flattened in places: some platy cobbles are up to 60 cm long but only around 10 cm thick (compare Fig. 16). Sandstone lenses within the boulder beds consist of friable cellular limonitic sandstone (described above) that is also characteristic of member Bzb_3. Quartzite immediately below the boulder beds in section ZB1, however, is non-limonitic.

The basal part of member Bzb_6 is a grey-green tuff of tholeiitic composition, which shows traces of original eutaxitic textures, including cuspate quartz shards. It consists mainly of clinopyroxene, altered plagioclase, and a little altered titanomagnetite. Although this tuff is close in the stratigraphic sequence to the rhyolitic ash-flow tuffs of the Spielers Volcanics, it is considered unlikely, because of compositional differences, that the two volcanic sequences represent closely related phases of volcanic activity.

The thickness of member Bzb_6 ranges from 40 m to 170 m; this varies according to the number of boulder beds.

Fig. 15. Deformed cobbles in possible tillite in member Pzb_6 of Elimberrie Beds, about 3½ km. west-wouthwest of Christophers Bore. Flattened and elongated cobbles up to 20 cm. across are set in a phyllitic matrix.

M 999/4 DCG

Fig. 16. Undeformed boulder conglomerate in member Pze_2 of Ellendale Beds, 1 km. north-east of Le Lievre Ridge.

GA 9696 DCG

Member Bzb_7: Quartzite and phyllitic siltstone are the dominant rocks of this member. Minor limonitic ironstone beds have also been noted. The quartzite is white to pale grey and pale red brown, medium to coarse-grained, thin-bedded, flaggy, and locally phyllitic. In places it is brecciated and ferruginous. The phyllitic siltstone is grey-brown, laminated and fissile. The sequence is poorly exposed and has a maximum exposed thickness of 140 m. In most localities the exposed thickness is much less than this.

NINETY SEVEN MILE BEDS (Bzn)

The Ninety Seven Mile Beds are confined to the northwest end of the Oscar Range, near Ninety Seven Mile Creek.

Boulder beds, phyllite, quartzite, basic volcanics, and minor(?) tuff are the main rock types in the Ninety Seven Mile Beds. Six members are recognized; these are:

Bzn_6	270 m	Boulder and cobble beds, phyllite.
Bzn_5	400 m to 510 m	Quartzite
Bzn_4	14 m to 100 m	Phyllite,? metabasalt
Bzn_3	300 m	Boulder and cobble beds.
Bzn_2	220 m	Phyllite and boulder beds.
Bzn_1	300 m	Conglomerate, quartzite, phyllite, amygdaloidal metabasalt, ?tuff.

Stratigraphic Relationships

The Ninety Seven Mile Beds probably overlie the Christophers Beds, although separated from them by Devonian cover. They are separated from the Ellendale Beds by faulting, but possibly overlie them unconformably. The topmost part of the Ninety Seven Mile Beds contains acid tuff similar to the Spielers Volcanics, and it is possible that most of the Ninety Seven Mile Beds are lateral equivalents of the Elimberrie Beds 18 km to the southeast, though they cannot be correlated in detail. Permian Grant Formation and Devonian strata overlie the Ninety Seven Mile Beds unconformably.

The only irregularity in the succession of members is the apparent overlap of member Bzn_4 by quartzite of member Bzn_5.

Field Occurrence

Boulder beds of member Bzn_3 form a belt of characteristically rounded hills with relief of up to 60 m. Quartzite forms prominent strike ridges, but phyllite, conglomerate, and amygdaloidal basalt forming the remainder of the sequence are poorly exposed and generally lie in valleys. The total area of outcrop is about 15 km^2.

Lithology

Member Bzn_1: This member is predominantly a phyllite-quartzite-conglomerate sequence characterized by thin amygdaloidal basic lavas and acid tuff at and near the top. A composite paced section is listed in Appendix 2. Conglomerates have a coarse sand matrix, unlike those higher in the Ninety Seven Mile Beds.

The calcareous tuff is pale fawn and flaggy, with grains of glassy quartz prominent on weathered surfaces. It is possibly a carbonated acid flow or sill, and underlies green chloritic phyllite and epidosite which form the base of the amygdaloidal lavas. Calc-silicate (calcite-quartz-chlorite-epidote) nodules up to 8 cm diameter occur in the phyllite.

The amygdaloidal lavas are metabasalt. They are deuterically altered and epidotized, with quartz and epidote the most common vesicle filling. A metabasalt-quartzite 'breccia' is a common associate of the lavas. It consists of irregular blocks of altered basalt in a fine-grained quartzite matrix (Fig. 17); some of the blocks show flowage. It is possibly a flow-top breccia, or a product of lava flowing over wet unconsolidated sand.

Member Bzn_2: This member overlies Bzn_1 conformably, and is about 217 m thick. It is predominantly a phyllite/boulder bed sequence, in the proportions 5:2. A section of the member is listed in Appendix 2.

The base of the sequence is well defined by a hematite-bearing quartz sandstone. It is fawn to grey, medium-grained, and contains up

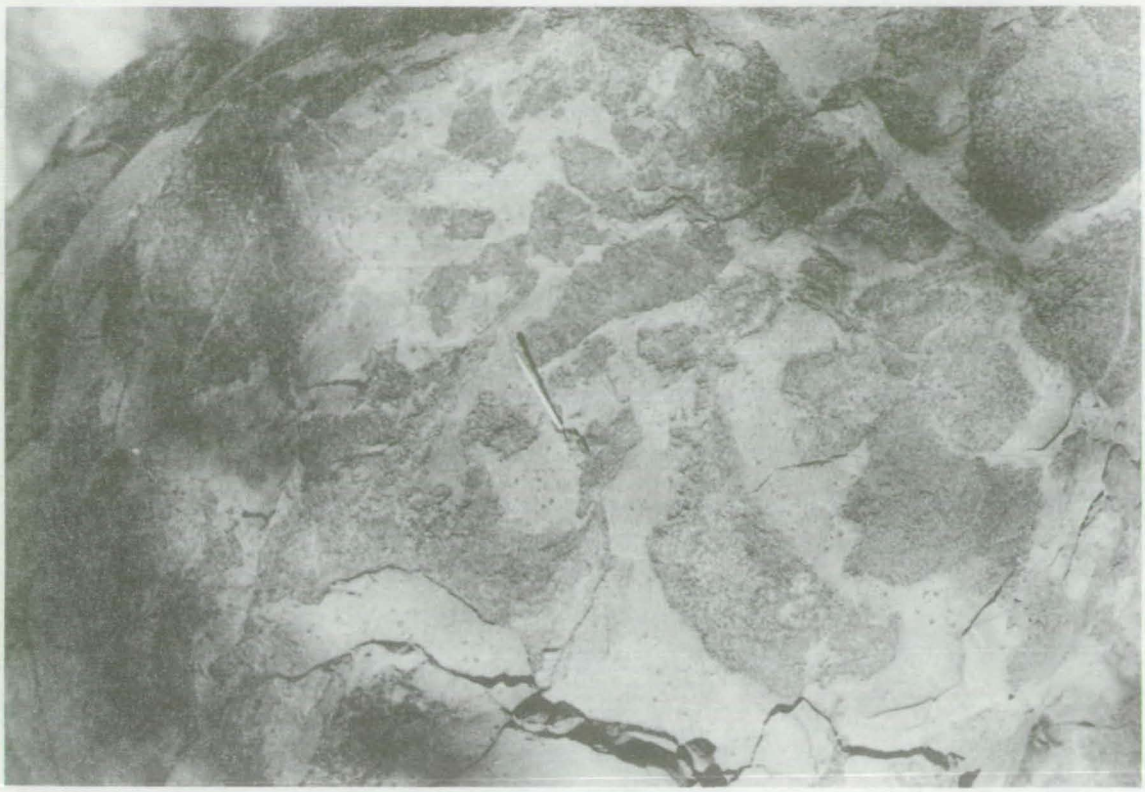


Fig. 17. Boulder surface of volcanic-quartzite breccia, showing irregular darker patches of metabasalt, member Pzn_1, 97-Mile Beds; locality 3-5 km. north of angle teleline.
M 457/18A GMD

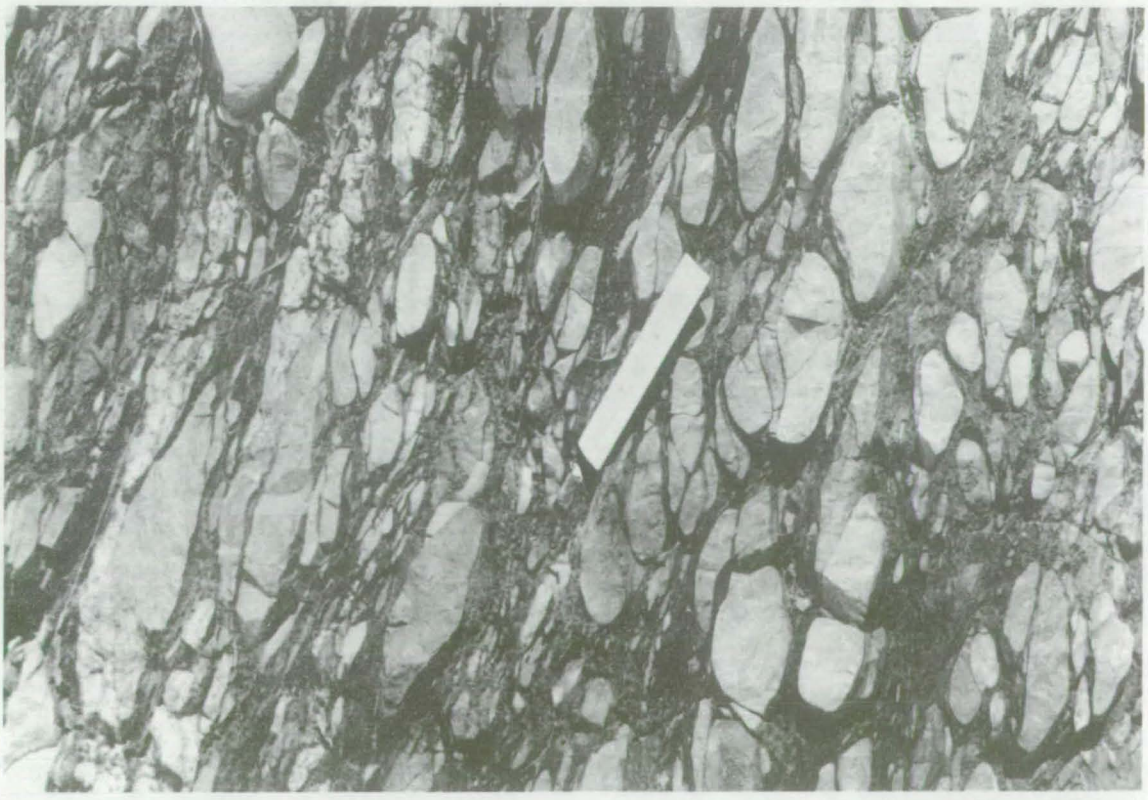


Fig. 18. Flattened cobble beds, member Pzn_2 of 97-Mile Beds; quartz veins at top right. Locality 3.5 km. north of angle teleline.
M 457/8A GMD

Fig. 19. Boulder-cobble beds, member Pzn_3, 97-Mile Beds. locality 3 km. north-northeast of angle teleline.

M 457/6A GMD

to 2 percent of shiny hematite crystals. Lenses of quartz sandstone and pebbly sandstone occur in the phyllite. The boulder and cobble beds contain up to 70 percent of quartzite megaclasts in a phyllitic matrix (Fig. 18): they are variably flattened, the average length-breadth ratio being 5:1 with extremes of up to 12:1. Specularite flakes up to 1 cm diameter occur in quartz veins which cut boulder beds near the base of the member.

Member Bzn_3: This member is the most striking unit of the Ninety Seven Mile Beds. It consists almost entirely of boulder, cobble, and pebble beds (Fig. 19); boulders are up to 0.5 m diameter. Megaclasts form up to 85 percent of the rock, and the matrix is a kaolinitic sandy phyllite. The flattened megaclasts are striated and grooved, and locally polished. Thin quartzite beds and phyllite occur interbanded with the boulder and cobble beds.

Member Bzn_4: Overlying the boulder beds of Bzn_3 is a predominantly phyllitic unit which varies in thickness from 100 m in the southeast to about 14 m in the northwest. The phyllite is variously grey, red-brown, and deep green, and is apparently overlapped by massive grey quartzite of member Bzn_5. The green phyllite is chloritic, and possibly volcanic in origin; on cleavage planes radiating clusters of chlorite and actinolite up to 4 m long occur. No complete section of this unit has been measured because of poor exposure. The following section is partly paced and partly estimated from photos.

Top	Bzn_5 massive quartzite
	disconformity
15	Interbedded phyllite and cobble beds
4.0	Grey quartzite, blocky to flaggy
6.0	Grey granule sandstone
75	Chlorite phyllite (?metabasalt), phyllite
100 metres	
	Bzn_3 - boulder beds.

Member Bzn_5: This member is a grey-white, medium to coarse-grained quartzite which is massive and generally thick-bedded. It is strongly jointed, and zones of quartzite breccia 2 m wide are common. Clay pellets and black tourmaline grains are also widespread. Feldspathic quartzite, with up to 10 percent feldspar, is present towards the base of the member. Cross-bedding is present, but is partly obscured by intense recrystallization.

Member Bzn_6: A paced measured section of this member is listed in Appendix 2. Cobble beds are the dominant rock type; the megaclasts are solely quartzite, and the matrix phyllitic. The sequence appears rhythmic, showing a gradation from cobble beds to phyllite to further cobble beds. Some of the phyllites contain only sporadic, partly flattened boulders of quartzite (Fig. 20). In cobble beds with little phyllitic matrix the clasts show extreme flattening, with up to 12:1 length/breadth ratios (Fig. 21).

Near the middle of the member a green phyllite is present, with augens of quartz; this is possibly an acid volcanic equivalent to the Spielers Volcanics to the southeast.

STRATIGRAPHY - PROTEROZOIC TO PALAEOZOIC

SPIELERS VOLCANICS

The Spielers Volcanics are found mainly on the southern margin of the southeastern part of the Oscar Range. Minor outcrops of (?)ashflow tuff near Ninety Seven Mile Creek have been tentatively assigned to them. They are porphyritic acid ashflow tuffs that resemble the Whitewater Volcanics lithologically, but can be distinguished by their stratigraphic position. The Spielers Volcanics are apparently lithologically homogeneous and have not been subdivided into members.

Stratigraphic Relationships

The Spielers Volcanics overlie the Elimberrie Beds concordantly but are extensively sheared, and the possibility of a low-angle fault-contact cannot be discounted. In the northwest they overlie and possibly interfinger with the Ninety Seven Mile Beds. They are overlain unconformably by the Devonian Napier Formation, Windjana Limestone, and Pillara Limestone.

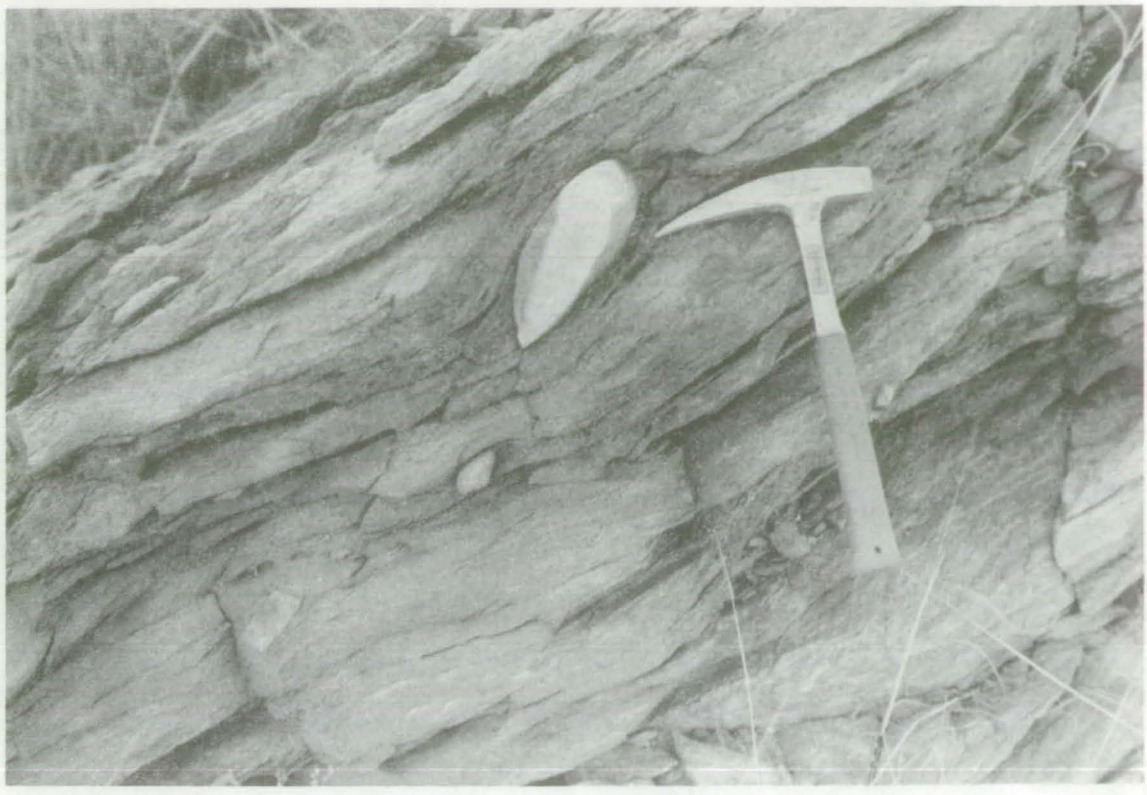


Fig. 20. Quartzite cobble in phyllitic matrix, member Pzn_6; possibly glacigene; locality 4 km. east of angle teleline.

M 754/15A GMD

Fig. 21. Highly flattened cobble beds, member Pzn_6, 97-Mile Beds; locality 4 km. east of angle teleline.

M 754/11A GMD

Because of their similarity to the Whitewater Volcanics and because of the possibility of a faulted contact with the underlying Elimberrie Beds, the Spielers Volcanics were submitted for Rb-Sr age determination. The results of this work (Bennett & Gellatly, 1970) indicate an approximate age of 365 m.y., i.e., middle Devonian. As this age is less than that of the strong deformation that has affected the Precambrian rocks of the Oscar Range (580 to 600 m.y.), and the Devonian rocks themselves are undeformed, it is probably too low, but it eliminates the possibility of correlation of the Spielers Volcanics with the Whitewater Volcanics (1950 m.y.). If correlations with green phyllitic volcanics in the top-most Ninety Seven Mile Beds are correct, the Spielers Volcanics are almost certainly Proterozoic in age.

Field Occurrence

The Spielers Volcanics crop out mainly on the southern flank of the Oscar Range from near the road metal quarry (3 km north-north-east of 12-Mile Bore) to near Spielers Creek. Extensive areas of the Volcanics are obscured by soil cover and outcrop is confined mainly to scattered thin slabs of foliated volcanics protruding through the soil. The total area underlain by the Volcanics is about 15 km^2.

The trend of the Volcanics is west-northwest, with foliation dips of around 40° to 50°, and is everywhere sub-parallel to the underlying Elimberrie Beds.

Lithology

In hand specimen, fresh samples of the Spielers Volcanics are dark grey, fine-grained, well-foliated, and porphyritic, containing phenocrysts of clear quartz and pale pink K-feldspar up to 5 mm across. Quartz phenocrysts are mostly lenticular owing to shearing, but a few undeformed bipyramids remain. Locally the Volcanics are pale grey-green owing to alteration of matrix K-feldspar to a clear mica (muscovite or phengite) (LR14-07-2). In altered rocks such as this K-feldspar phenocrysts have recrystallized to aggregates of quartz, muscovite, and sericite. Thin veinlets of limonitic material fill fractures in the altered rocks.

The matrix of these rocks is strongly foliated, and lacks the typical eutaxitic textures found in some ashflow tuffs. However, some sinuous trains of quartz granules could represent deformed and recrystallized glass shards and quartz phenocryst splinters.

INTRUSIVE ROCKS

Metadolerite and banded amphibolite form sills or dykes in the Christophers Beds, member Bzc_2, about 2 km east-southeast of Christophers Bores. They are symbolized Bzd on the accompanying map. Detrital boulders of metadolerite have been found 500 m to the northeast of this, and also 5 km to the east-southeast.

REGIONAL CORRELATIONS

Correlation of the Oscar Range Succession with other areas must be tentative, since distances between exposures are large. The possible glacigene rocks in the Elimberrie and Ninety Seven Mile Beds suggest a relationship with the Adelaidean units on the Mount Ramsay Sheet area 140 km to the southwest (viz. the Kuniandi and Louisa Downs Groups, which contain the Landrigan and Egan Tillites respectively). These latter rocks have been dated at 740 $\pm$ 30 m.y. by Bofinger (1967). Age determinations of phyllite and volcanics (Spielers Volcanics) in the Oscar Range indicate an age of deformation of about 600 m.y., and Bennett & Gellatly (1970) suggest that the Spielers Volcanics, occurring near the top of the Oscar Range Succession, could possibly be as old as late Precambrian. Thus the suggested correlation between the Oscar Range Succession and the Kuniandi-Louisa Downs Group is not precluded by the age determination results.

Another possible but less likely correlation is of basic lavas in the Ninety Seven Mile Beds with basic lavas of the Carson Volcanics, in the Kimberley Group, the nearest exposures of which are about 80 km to the north. The age of the Carson Volcanics is about 1800 m.y. (Carpentarian), which is possibly older than Oscar Range Succession; however the absolute age of the latter has still to be determined.

STRUCTURE

The Oscar Range Succession is highly deformed; most rocks are folded and faulted, but some show only strong cleavage and upturned bedding. Over most of the area faulting is difficult to trace because of poor or discontinuous outcrop, and the similarity of rock types in the various members. Minor and major structures are described below, and shown in Figures 22 and 23 respectively.

Minor structures

These include minor fold plunges, bedding attitudes, lineations, and cleavages. A summary of the attitudes shown in Figure 22 is as follows:

(a) Poles to bedding: a great majority of bedding planes show variable dips (30°-85°) to the southwest.

(b) Fold plunges: about 75 percent plunge at 30° to 50° to the southwest and 25 percent at 30° to 50° to the northwest. This possibly indicates refolding about northeast-trending axes.

(c) Lineation plunges: most lineations are contained in a southwest-dipping girdle plane. In this plane 50 percent of lineations plunge at 30° to 50° to the southeast; 30 percent plunge northwest at 30° to 50°; and 20 percent plunge to the southwest.

(d) Poles to axial planes: all planes dip to the southwest at 30° to 80°.

(e) Poles to cleavages: show some cleavages dip to the northwest, but most dip to the southwest at 50° to 80°.

Major structures (Fig. 23)

Four major structural divisions or blocks are recognized. These are:

a) Le Lievre Block
b) Linesman Block
c) Christophers Block
d) Elimberrie-Ninety Seven Mile Block

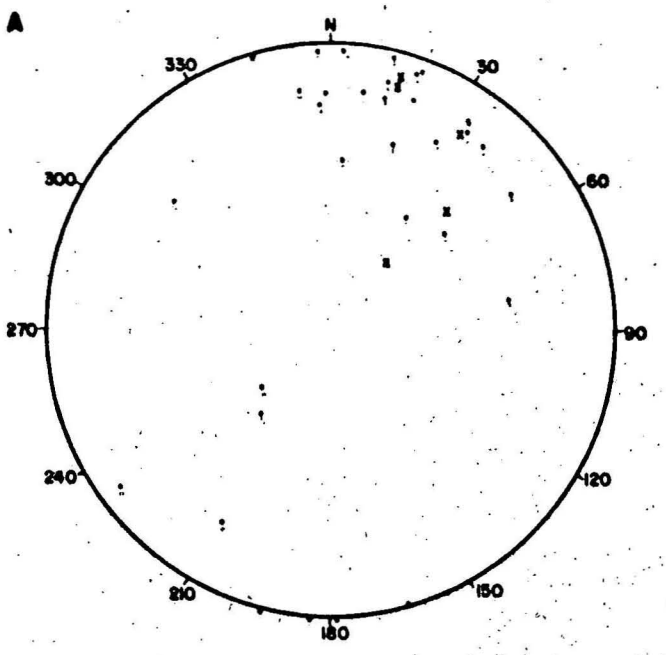
The Le Lievre Block forms the central core of the Oscar Range. It is basically an anticline plunging steeply southeast, and folded about a northwest axis. Slight cross-folding about northeast axes is also evident. Parts of the fold structure are overturned, with both limbs dipping to the southwest. Some single folds show a change from normal to overturned limbs along the bedding strike. Strong drag-folding is displayed on both limbs of the major anticline, and normal faulting occurs parallel to the fold axial plane. On the northeast limb the fault sense is northeast block down, and on the southwest limb southwest block down. This pattern of drag folding and faulting is consistent with compressional shear folding.

The Linesman Block is a fault-bounded fold belt. Folding is tight, with moderate plunges (35°-45°) to the south-southeast. Traces of the fold axes trend about 350°, in contrast to the 330° trends in the Le Lievre Block. This divergence of trends could be a result of sinistral rotation between the bounding faults; the southwestern bounding fault shows some normal movement in the sense southwest block down. The Linesman Block is tentatively considered to be originally a part of the Le Lievre Block affected by subsequent major faulting. This fault zone does not appear to affect the rest of the Oscar Range Succession, and its possible extension under Devonian cover is shown in Figure 23.

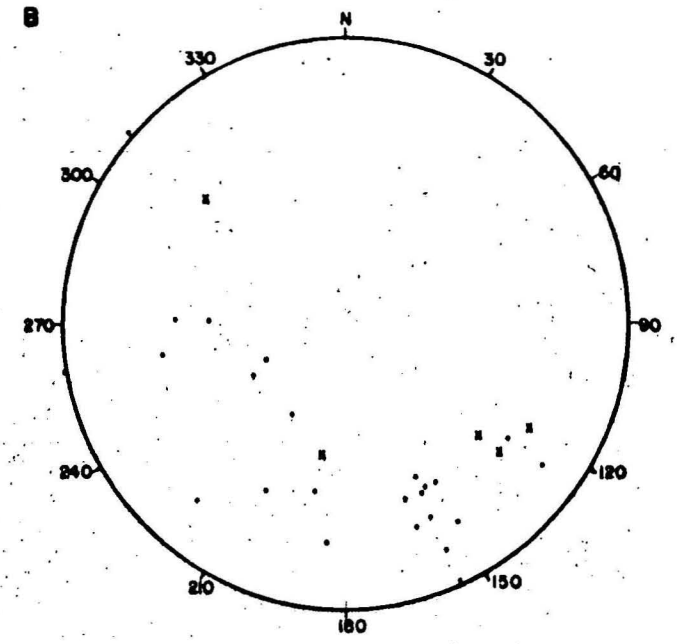
Christophers Block contains older rocks along the northeast edge of the Oscar Range. The block shows steep to vertical bedding and strong cleavage, but folding is generally absent. It is faulted against the Linesman Block in the southeast. The relatively less deformed Christophers Block probably reflects a rapid diminution northeastwards of the effects of major folding and faulting in the core of the Oscar Range.

Elimberrie-Ninety Seven Mile Block. This block is underlain by the Elimberrie and Ninety Seven Mile Beds, and is characterized by a relative absence of major deformation (i.e. in both units nearly all the beds dip uniformly to the southwest, and show only small scale folding, cleavage and some faulting, despite their coincidence with axes of major deformation in the older Le Lievre Block).

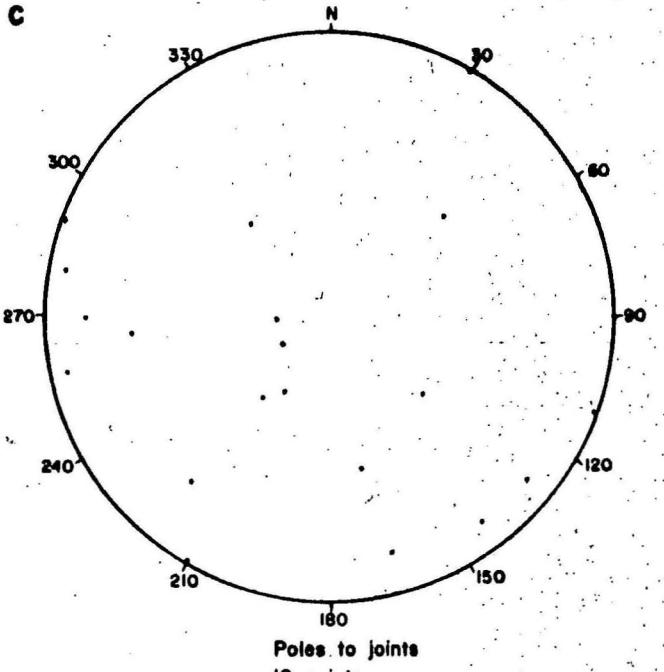
Fig. 22 PLOTS OF MINOR STRUCTURAL ELEMENTS, OSCAR RANGE SUCCESSION



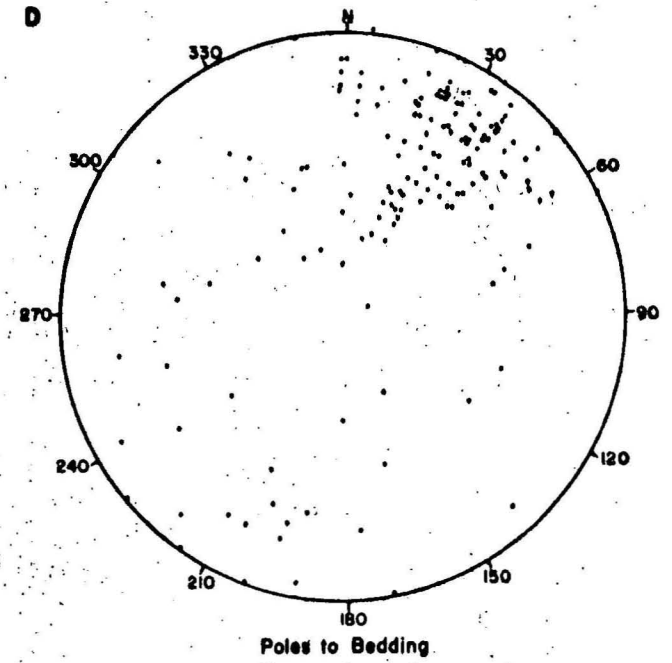
• Poles to cleavage
30 points
x Poles to axial planes



• Lineation plunges
21 points
x Fold plunges



Poles to joints
18 points

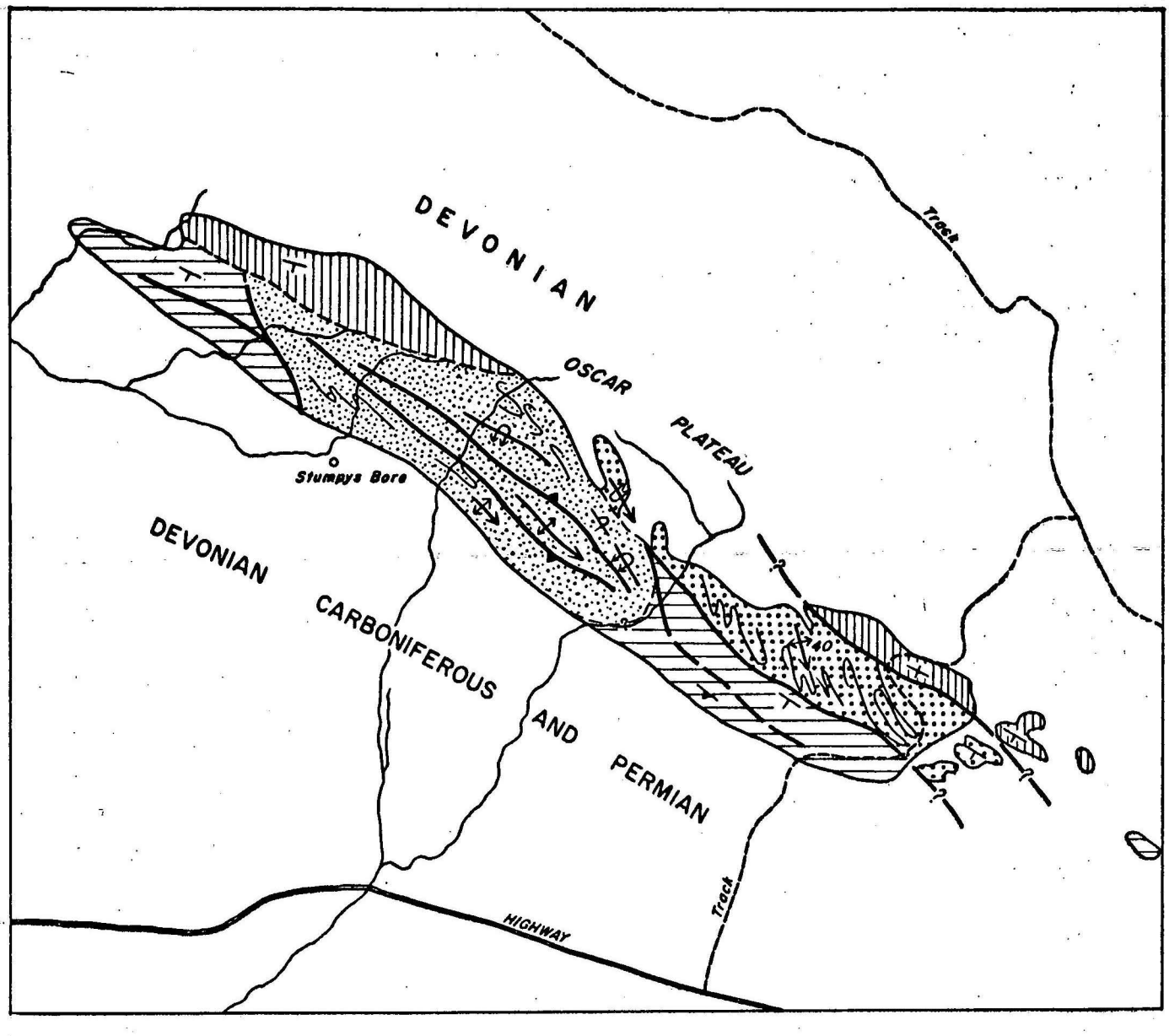


Poles to Bedding
Bottom hemisphere
155 points

To accompany Record 1971/61

E51/AF

Fig. 23 STRUCTURAL DIVISIONS - OSCAR RANGE SUCCESSION



To accompany Record 1971/61

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A possible explanation for the apparent lack of major deformation is the unconformable relationship between the Elimberrie Beds and the Ninety Seven Mile Beds and older rocks. The unconformity might have been a decollement surface inhibiting the transmission of deformation upwards throughout the sequence.

Discussion

The overall pattern of deformation in the Oscar Range Succession is probably a result of compression, induced by large-scale block movement. These blocks are the Kimberley Basin-Mobile Belt Block to the north and northeast, and a crystalline block in the southwest, now forming the basement in the Fitzroy-Canning Basin. The absolute movements of these blocks are not known, but overfolding in the Oscar Range suggests a relative movement northwards of the southwest block. A similar style of deformation has affected the Yampi area, broadly coaxial with the Oscar Range. In both cases the age of the deformation is about 600 million years (Bennett & Gellatly, 1970).

METAMORPHISM

In the Oscar Range Succession only dynamic metamorphism in the greenschist facies is evident. The indicator minerals include biotite, muscovite, chlorite, and epidote, which are widespread in basalt and phyllite, and to a lesser degree in quartzite. Metadolerite and basaltic tuff in the southeast part of the Oscar Range contain altered plagioclase, typical of greenschist facies metamorphism; they also contain relict clinopyroxene and (?)cummingtonite, which suggests that the dynamic metamorphism affecting the area was relatively anhydrous. Most quartzites show secondary silica overgrowths, and some contain tourmaline, also showing overgrowths. These could be either metamorphic or diagenetic changes. Spotted phyllites are rare in the Succession; where present the spots are limonitic, probably after pyrite.

The low grade dynamic metamorphism in the Oscar Range contrasts with the structurally similar Yampi area, where andalusite and chloritoid indicate a higher but still low grade dynamothermal metamorphism.

ECONOMIC GEOLOGY

No workable mineral deposits have been found so far in the Oscar Range. However, lenses of sedimentary ironstone have been noted in the Ellendale Beds, and several gossans are present, mainly in the limestone of the Elimberrie Beds; some contain anomalous concentrations of base metals, especially zinc. Pebble conglomerates of the Christophers Beds are similar to the radioactive conglomerates of the Kimberley Basin, and are possibly prospective.

There is only one water bore in the Precambrian, but the Oscar Range and the immediately surrounding area could provide further supplies of underground water.

Metals

As part of the recent survey several representative chip samples of gossans and several grab samples of rocks were analysed to provide a guide to possible mineralization in the area, and to the background values of the host-rocks. Anomalous, but subeconomic, concentrations of zinc, manganese, cobalt, nickel, lead, and copper have been noted. Analytical results are given in Table 2.

Zinc and Lead

A small outcrop of pale pink-brown quartz sandstone on the northern margin of the ridge of Napier Formation about 3 km west-northwest of the limestone quarry is cut by a lens of gossanous limonitic material. This lens, which crops out for a length of 100 m, and width of 15 m, widens eastwards and disappears under soil cover. A few small scattered gossanous lenses are present to the southwest of the main one.

The limonite is cellular, and contains 0.5 cm to 1 cm vughs lined with powdery white, yellow-brown, rusty-brown, and deep purple-brown ferruginous alteration products. A few concentrically banded ferruginous pisolites are also present.

A representative chip sample across the full width of the gossan (Table 2, 66.16.0938) contained 1% zinc, 500ppm lead and small amounts of other base metals. A further sample from the same area contained 0.5% zinc and 300ppm lead (Table 2, 66.16.0935).

Table 2a: Index of Geochemical Samples

Field No.	Reg'd No.	Co-ordinates X	Co-ordinates Y	Formation	Rock Type
LR14.07.53a	915*	3180E	27530N	Bzb_2	Pale grey limestone
LR14.07.53h	916	3180	27530	Bzb_2	Brown siliceous gossan
LR14.07.10c	917	3200	27531	Bzb_2	Dolomitic limestone
LR14.05.25a	918	3130	27549	Bzb_2	Ferruginous cellular sandstone
LR14.05.53	919	3120	27550	Bzb_4	Slightly calcareous quartzite
LR14.07.53c	920	3180	27530	Bzb_2	Brown limestone
LR14.07.53d	921	3180	27530	Bzb_2	Brown limestone
LR14.07.53g	922	3180	27530	Bzb_2	Brown limestone
LR14.07.53i	923	3180	27530	Bzb_2	Gossan
LR14.05.11	925	3130	27531	Bzb_5	Limonitic siltstone
LR14.05.7	926	3182	27510	Bzb_3	Gossanous brecciated phyllite
LR14.07.53b	927	3180	27530	Bzb_2	Pink-grey limestone
LR14.07.72	928	3197	27510	Dp**	Limonitic carbonate
LR14.05.25b	929	3130	27549	Bzb_2	Impure dolomite
LR14.05.1	930	3140	27500	Dn**	Slightly ferruginous limestone
LR14.07.53f	931	3180	27530	Bzb_2	Dolomite
LR14.07.4c	932	3170	27510	Bzb_7	Brecciated ferruginous siltstone
LR14.05.8	933	3140	27542	Bzb_3	Limonitic phyllite
LR14.05.10	934	3140	27542	Bzb_3	Limonitic phyllite
LR14.05.50a	935	3100	27560	Bzb_2	Gossan
LR14.05.52a	936	3100	27560	Bzb_2	Gossan
LR14.07.44	937	3200	27516	Bzb_2	Ferruginous dolomite
LR14.05.50b	938	3100	27560	Bzb_2	Gossan (chip sample)
LR14.05.52b	939	3100	27560	Bzb_2	Gossan
LR14.07.53e	940	3180	27530	Bzb_2	Ferruginous limestone
LR14.05.25c	941	3100	27560	Bzb_2	Impure dolomite
LR14.07.28	942	3180	27530	Bzl_3	Sericite phyllite
LR14.07.4b	943	3170	27510	Bzb_7	Ferruginous siliceous siltstone
LR14.07.13	944	3202	27539N	Bzc_1	Pebble conglomerate
OR 5	945	3348	27575	Bzc_1	" "
LR14.07.4d	946	3278	27500	Bzb_7	Brecciated ferruginised phyllite

Table 2a (Continued)

Field No.	Reg'd No.	Co-ordinates		Formation	Rock Type
LR14.05.55a	947	3079E	27595N	Bze_1	Massive goethite
LR14.07.72	948	3180	27495	Dev**	?Manganese oxide
LR14.05.53	949	3100	27565	Bze_3	Brown earthy limon. sst.
LR13.36.87	950	3056	27616	Bze_1	Brown limonitic sandstone
LR13.65.93	951	3032	27637	Bze_1	(?)Cupriferous quartzite
LR14.07.39	952	3155	27520	Bzb_4	Brecciated vugghy quartzite
LR12.15.27	953	2916	27694	Bzn_3	Conglomeratic phyllite matrix
LR13.67.25	954	2942	27661	Bzn_6	Phyllitic quartzite
LR13.65.94a	955	3045	27638	Bzb_1	Earthy limonitic phyllite
LR13.65.94b	956	3045	27638	Bzb_1	Brown cherty sandstone
LR13.65.96	957	3034	27643	Bzb_1	Limonite gossan
LR13.65.9	958	3010	27660	Bzb_1	Calcareous limonitic sst.
LR13.65.98	959	3026	27649	Bzb_1	Massive limonitic sst.
LR13.65.99	960	3027	27649	Bzb_1	Limonitic gossan
LR13.65.21	961	3036	27644	Bzb_1	Gossan with limestone
LR13.65.1c	962	3008	27621	Bze_2	Orange-brown cherty sst.
LR12.15.41	963	2906	27700	Bzn_3	Quartz-hematite vein
LR13.65.45	311	3066	27625	Bzb_1	Chert-phyllite breccia
LR12.15.44b	313	2949	27692	Bzc	Ferruginous pebble quartzite matrix.
LR12.15.39b	319	2919	27700	Bzn_1	Volcanic-quartzite breccia

* R67 or 68160915 etc

** From the Devonian-Proterozoic unconformity

Y Transverse Mercator Grid; positions of samples 915 to 943 approximate because of loss of aerial photos.

Table 2b: Semi-quantitative Spectographic Analysis of samples listed in Table 2a.

(in ppm)

Sample No.	Cu	Pb	Zn	Co	Ni	Sn	Ag	Au	Mo
915	15	6	-20	3	15	4	0.1	-3	3
916	12	10	25	8	60	5	0.1	"	60
917	12	10	25	5	5	2	0.2	"	2
918	12	3	50	40	200	6	0.1	"	3
919	15	6	40	2	5	1	0.3	"	2
920	12	3	-20	3	5	1	0.2	"	1
921	15	6	50	30	150	2	0.1	"	3
922	20	3	30	50	200	6	0.3	"	3
923	20	3	60	60	100	3	0.3	"	3
925	150	50	200	1	15	2	1.0	"	2
926	70	3	100	5	15	2	0.1	"	2
927	25	3	-20	5	15	1	0.2	"	3
928	15	30	1000	70	200	-1	0.1	"	5
929	15	8	20	5	5	3	0.1	"	1
930	150	25	150	100	200	1	0.2	"	5
931	15	8	20	40	200	8	0.1	"	30
932	80	10	120	50	30	-1	0.3	"	-1
933	80	5	100	60	80	5	-0.1	"	2
934	80	6	200	5	8	-1	0.4	"	1
935	25	300	5000	60	50	-1	0.3	"	8
936	400	200	150	50	80	1	2.0	"	5
937	120	5	200	15	50	-1	0.2	"	2
938	15	500	10,000	30	50	-1	0.2	"	3
939	6	6	30	3	10	1	0.2	"	1
940	30	10	-20	500	300	4	0.3	"	4
941	3	5	-20	3	3	-1	0.4	"	-1
942	30	6	30	3	10	-1	0.6	"	3
943	40	3	120	15	60	1	0.4	"	4
944	6	3	X*	10	15	1	0.2	X	3
945									
946	50	3	120	30	60	x	0.1	"	X
947	6	2	120	100	30	x	0.1	"	3
948	10	6	300	1000	250	x	0.3	"	5
949	100	10	200	200	1000	1	0.1	"	3

Table 2b (continued)

Sample No.	Cu	Pb	Zn	Co	Ni	Sn	Ag	Au	Mo
950	100	6	500	15	50	x	0.2	"	3
951	20	6	x	5	15	1	0.2	"	5
952	15	4	x	15	40	2	0.4	"	5
953	6	3	x	15	40	1	0.2	"	x
954	10	3	x	50	50	3	0.1	"	x
955	80	12	200	20	150	1	0.1	"	x
956	25	4	100	40	80	x	0.2	"	5
957	250	15	1500	30	40	1	0.2	"	20
958	30	10	40	30	15	x	0.2	"	x
959	120	20	1000	30	60	x	0.2	"	3
960	60	12	120	30	60	x	0.2	"	3
961	15	30	120	10	40	x	x	"	x
962	100	6	x	10	40	x	x	"	5
963	6	10	x	10	10	x	0.1	"	x
311	50	10	x	15	40	2	0.2	"	x
313	20	10	x	5	20	x	0.2	"	3
319	20	8	x	5	10	1	0.4	"	3

X = not detected

The age of the sandstone host-rock is unknown. It overlies the Spielers Volcanics, and underlies the Napier Formation, and could be of any age between late Precambrian and middle Devonian. The mineralization likewise could lie within this range, or could be of later origin. If of Devonian age or later it could possibly be related to lead-zinc mineralization of the Devonian limestone reef complex, and could possibly be a useful indicator of more extensive mineralization within the reef complex.

Manganese, Cobalt and Zinc

About 3 km east of the road-metal quarry the unconformity between the Elimberrie Beds and the Devonian limestone is marked by thin beds and lenses of brown (?)sideritic carbonate containing manganese oxide nodules. One specimen of a manganiferous nodule contained 1000ppm zinc and 200ppm nickel (Table 2, 66.16.0929): another contained 300 ppm zinc and 1000ppm cobalt and 250ppm nickel (67.16.0948). Although the content of these metals is subeconomic they indicate the presence of mineralization at the unconformity between the Devonian and the underlying Precambrian.

Nickel

In most of the rocks nickel concentrations are below 300ppm. One exception is a dark brown, mostly limonitic sandstone from member Bze_3 of the Ellendale Beds. This specimen contained 1000ppm nickel (Table 2, 68.16.0949), an unusually high value for a sedimentary rock. Although the chances of finding an economic nickel deposit in such an environment are poor this anomaly warrants further investigation.

Copper

Malachite-stained quartzite from the Ellendale Beds, was found to contain only 20ppm copper.

A cellular limonitic sandstone forming a small lens in the boulder beds (?glacials) of the Elimberrie Beds contains 400ppm copper, an unusually high amount for a sandstone. None of the minor copper anomalies found appear to warrant further investigation, but copper should nevertheless be sought in any future geochemical programme.

Uranium, Thorium and Gold

The quartz pebble conglomerates of the Christophers Beds, particularly in the southeastern part of the Oscar Range, are lithologically similar to conglomerates in the O'Donnell Formation of the Speewah Group, in the northern part of the Lennard River 1:250,000 Sheet area, in which radiometric anomalies due almost entirely to thorium have been noted. The conglomerates of the Christophers Beds may warrant examination for uranium and thorium mineralization, but as yet no reports of radiometric anomalies have been reported from this unit. These conglomerates are also worth investigating for their possible gold content.

Other conglomerates in the area are mainly sandstone cobble and boulder conglomerates, and are less likely to contain significant mineralization.

Iron Ore

The presence of small lenses of sedimentary ironstone in member Bze_1 of the Ellendale Beds and of gossanous goethite in member Bzb_1 of the Elimberrie Beds has been noted. All of them are small, and are unlikely to contain economic quantities of iron. Some of the gossans (which have probably been derived through oxidation of pyrite) could contain significant concentrations of other base metals.

Ironstone lenses in the Ellendale Beds are about 300-400 m long and from 6 m to 60 m thick. Only a little of the ironstone is high-grade, much is low-grade hematitic or goethitic sandstone.

Lenses of gossanous material in the Elimberrie Beds are similar to those in the Ellendale Beds. Ironstone lenses are associated with chert and siliceous breccia; no other base-metal mineralization is evident, but the breccia and associated limestone could provide favourable host rocks for metal concentrations at depth beneath the gossans.

Discussion

All the base metal mineralization of the Oscar Range is in sedimentary rocks far removed from any ignous rocks, and is probably of syngenetic origin. Mineralization at the unconformity with the

overlying Devonian could be epigenetic, but redistributed from syngenetic sedimentary deposits in the Precambrian, or could possibly be of primary sedimentary origin. Although the analysis of the manganese nodules appears to be encouraging economically, such base metal concentrations are not unusual in sedimentary manganese nodules. For example, Young (1968) has reported values of 2000ppm cobalt and 4000 ppm nickel from a manganese nodule from the Pacific Ocean.

Construction Materials

Most of the quartzites, especially those of the Le Lievre Beds, would be suitable for use as rock-fill (dimension-stone) for construction projects, and would also be suitable for road-metal for bitumen-sealed roads if an alternative should be required to the limestone currently quarried from the Napier Formation, at the southeastern end of the Oscar Range.

Water

Only one bore (Christophers) is currently pumping water from the Precambrian rocks. The water is drawn from cleaved siltstone of the basal member of the Linesman Beds. Considerable potential exists for the development of underground water in the Precambrian rocks along the northern margin of the Oscar Range, where non-perennial springs occur along the contact between Devonian and Precambrian rocks. This zone lies to the south of an extensive area of good pasture developed on soils overlying the Devonian rocks. To the south of the Oscar Range a line of springs is present in the Devonian rocks associated with a major fault, and there is little need for the development of supplementary water supplies.

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APPENDIX 1

PETROGRAPHIC DESCRIPTIONS

OSCAR RANGE SUCCESSION

PETROGRAPHIC DESCRIPTIONS

Christophers Beds

R 68.16.0367[Y] LR - OR - 5 (two slides) 3297E 27491N[*]

Phyllitic quartz pebble conglomerate: Pebbles of vein quartz up to 1 cm across are enclosed in a matrix consisting of about equal amounts of finely crystalline sericite and small sutured quartz grains. Pebbles are rounded and partly sheared, recrystallized, and fractured. The matrix is of very variable composition; some patches are very sericite-rich; others consist almost entirely of small interlocking quartz grains. Minor constituents are red-brown elongate crystals of ?goethite; rounded detrital zircon and tourmaline; and a turbid pale brown to pale brown yellow mineral (?rutile after leucoxene?).

Christophers Beds

R 68.16.0367 LR 14-07-19 (c)[**] 3202E 27544N

Fine grained phyllitic sandstone: Consists mainly of 0.1 mm sub-angular to ellipsoidal quartz grains (60%) in a fine grained sericitic matrix (30%). Small sinuous lenticles of opaque material possibly indicate original glass shards. Discrete flakes of muscovite, irregular patches and disseminated specks of goethite, and rare rounded grains of tourmaline are also present.

Christophers Beds

R 68.16.0366 LR 14-09-5 3272E 27510N

Granule quartzite: a metamorphosed quartz granule conglomerate - consists of 2 mm rounded quartz granules and a matrix of interlocking small sutured quartz grains. Matrix includes small flakes of sericite and various detrital minerals zircon, ?monazite, rutile; and abundant minute specks of indeterminate opaques.

Altered Dolerite (Bzd)

R 68.16.0370 LR 14-07-80 (a) 3200E 27530N

Altered dolerite: contains highly altered plagioclase, partly altered pyroxene, magnetite-ilmenite partly altered to leucoxene, and minor amounts of micropegmatite. Plagioclase is completely altered to turbid albite, chlorite, clinozoisite, and rare epidote. Fresh pyroxene present is pale pink titanaugite. It is bordered by ?cummingtonite.

* transverse mercator grid
** field number, using aerial photographs
Y BMR registered number

Christophers Beds

R 68.16.0371 LR 14-07-80 (b) 3200E 27530N

Tuffaceous phyllitic sandstone: consists mainly of large fractured and polygonized quartz grains (up to 2 cm) and abundant minute flakes of chlorite which locally make up discrete monomineralic areas. Large particles of subophitic altered pyroxene are scattered throughout the rock. These now consist of turbid chlorite arranged in two almost perpendicular directions outlining original pyroxene cleavages. These pyroxene pseudomorphs are densely studded with minute grains of goethite and ?hematite. Rare acicular grains of apatite also suggest a basic igneous provenance. There is no identifiable feldspar - all leucocratic material is quartz.

Christophers Beds

R 68.16.0368 LR 14-09-3 (b) 3271E 27506N

Magnetite-bearing quartzite: consists of discrete rounded to subrounded quartz grains with silica overgrowths (75%) and with grain margins that are commonly granulated; scattered euhedral magnetites (red-brown thin edges indicate alteration to hematite); and anastomosing cleavage films and ragged patches of chlorite and biotite (only just up to biotite grade). A few scattered grains of rounded detrital tourmaline are also present.

Christophers Beds

R 66160205 LR 12.15.37b

Epidote-bearing quartz sandstone: Quartz (70%) is relatively undeformed with a.g.d.* 0.09 mm. Epidote (30%) forms distinct anhedral grains, and also narrow veinlets through the rock. The sandstone adjacent to these veinlets is devoid of epidote in a zone about 1.5 mm wide, suggestive of epidote migration from sandstone to vein. In this depleted zone actinolite is developed as small prisms intergrown with quartz, and indicates very local exchange of alumina and iron.

* average grain diameter

Christophers Beds

R 67160313 LR 12.15.44b

Arenaceous conglomerate matrix: This contains quartz, typically with granulated margins. The quartz is clear and slightly strained, and shows silica overgrowths outlined by iron ore inclusions. Iron oxide occurs in grain boundaries, and as ferruginous matrix in sandstone and siltstone rock fragments. Accessories are grey chlorite, tourmaline, and zircon.

Christophers Beds

R 67160315 LR 12.17.4

Quartz sandstone: Quartz grains are slightly flattened, with granulated margins. A finer grained quartz mosaic occurs interstitially. Green biotite, pale green chlorite, and muscovite form thin discontinuous laminae through the rock. Accessories are tourmaline, iron oxide, epidote, and zircon.

Le Lievre Beds

R 68.16.0358 LR 14-05-4 6800E 27576N

Quartzite: Consists almost entirely of quartz. Grains are mostly ca 0.2 mm, subangular and partly interlocking; many grains have granulated margins and show preferential dimensional and lattice orientation due to recrystallization and deformation. Minor amounts of interstitial sericite, black opaque oxides, and very rare zircon are also present.

Ellendale Beds

R 68.16.0360 LR 14-05-42 3086E 27595N

Hematite quartzite: A fine-grained rock consisting of scattered 0.1 mm sutured quartz grains and abundant smaller quartz granules, and irregular hackly patches of hematite (ca 10%) and goethite (ca 15%). Hematite tends to be confined to discrete iron-rich bands whereas the goethite occurs both in iron-rich bands and as disseminated grains. A few scattered grains of tourmaline are also present.

Ellendale Beds

R 68.16.0359 LR 14-05-38(b) 3089E 27590N

Quartzite: The rock is a highly deformed quartzite and represents the matrix of a sheared cobble conglomerate. All quartz grains are lenticular, some are sinuous, and most have intricately interlocking sutured boundaries. Lenticular grains and trains of grains that have common optical orientation are common and are probably derived from sheared-out quartz granules and pebbles. Rare sinuous band of sericite and small enclosed granules of an opaque oxide (at least partly hematite) and of tourmaline constitute about 5% of the rock.

Ellendale Beds

R 68.16.0361 LR 14-05-55 3082 27595

Quartzite: A deformed inequigranular quartzite. Ellipsoidal quartz grains 0.2 to 0.5 mm across with irregular sutured margins and intergranular bands of 0.02 to 0.05 mm quartz grains make up about 95% of the rock. Sparse films of sericite and a pale brown chlorite, and scattered grains of a black opaque oxide and of pale brown turbid material (?leucoxene) make up the rest of the rock.

Ellendale Beds

R66160210 LR 12.17.27b

Hematite quartzite: Quartz (55%) is flattened, with irregular grain boundaries; a.g.d. 0.3 mm. Most grains are clear, but show undulose extinction. Hematite (45%) forms continuous streaks between quartz grains.

Ellendale Beds

R 66160209 LR 13.65.80a

Phyllitic quartzite: Quartz forms oblate, highly strained, and broken grains, rotated in places, in a finer grained granular quartz mosaic. Lenticles of clay-sericite aggregates wrap around quartz grains. Accessories are large muscovite flakes and subhedral grains of green tourmaline.

Ellendale Beds

R 66160211 LR 13.67.10

Tourmaline-bearing quartzite: Quartz occurs as flattened oriented strained grains, the margins of which are severely granulated. The large grains (0.8 x 0.3 mm) form 50% of the rock, and the granular material 30%. Tourmaline (20%) has a.g.d. 0.1 to 0.2mm, and forms single grains or aggregates pleochroic from fawn-pink to deep olive green. Deformation of some tourmaline prisms suggest post-tourmaline movement in the rock. The angularity of the tourmaline indicates recrystallization during diagenesis. Accessories are pale yellow-grey ?chlorite, and leached hematite.

Ellendale Beds

R 66160208 LR 12.15.18

Quartzite: Quartz is oblate, a.g.d. 0.4 mm, with granular margins; sericite flakes occur along incipient cleavage planes. Green-brown tourmaline is an abundant accessory, with rare zircon and iron ore. A small fragment of spotted phyllite is present.

Linesman Beds

R 68.16.0364 LR 14-07-32 3182E 27528N

Phyllitic siltstone: A conspicuously banded siltstone consisting of alternating very pale grey-green and very pale purple-brown bands. The rock is essentially a fine-grained siltstone consisting of 0.01 mm subangular grains of quartz and abundant sericite showing both bedding lamination and strain-slip cleavage. The colour of the purple bands is imparted by minute scattered specks of hematite which are absent from the grey-green bands. A few small grains of tourmaline and rare flakes of muscovite are the only other minerals present.

Linesman Beds

R 68.16.0362 LR 14-07-21(9) 3192E 27532N

Phyllitic siltstone: A rather inequigranular poorly-sorted, sandy, cleaved siltstone. Most of the rock consists of 0.01 to 0.02 subangular grains of quartz and interstitial films of sericite, and scattered grains of goethite, tourmaline, and turbid pale grey-brown leucoxene (or sphene?). Part of the thin section contains scattered subrounded to subangular quartz grains (up to 0.2 mm) and rare flakes of detrital muscovite. The thin section shows graded bedding and micro-cross-bedding.

Linesman Beds

R AN4 LR 14-07-30 3183E 27528N

Phyllitic siltstone (age determination specimen): A quartz-rich phyllitic siltstone consisting of subrounded grains of quartz (ca. 55%) up to 0.2 mm and abundant small flakes of sericite showing two dominant orientations - a bedding or early cleavage direction and a superimposed strain-slip cleavage direction. Small grains of tourmaline, a black opaque oxide, and rare zircon are accessories.

Linesman Beds

R 68.16.0357 LR 14-07-29(e) SE51-8 3183E 2728N

Ironstone: A highly ferruginous rock (ironstone) perhaps best described as a goethite-rich phyllitic siltstone. The rock is finely banded and consists of alternating 1 to 8 mm bands consisting of (a) sericite and orange-brown ferruginous chloritic material showing prominent strain-slip cleavage (1 mm bands) and (b) scattered 0.02 mm subangular quartz grains, discrete granules of goethite, and orange-brown ferruginous chlorite in approximately equal proportion (5 mm to 8 mm bands).

Linesman Beds

R 68.16.0365 LR 14-07029(b) SE51-8 3183E 27528N

Sericitic quartzite (metamorphosed feldspathic sandstone): Consists principally (55%) of 0.2 mm to 0.5 mm subrounded quartz grains which have been recrystallized marginally to give grain boundaries which are intricately sutured on a small scale. Small interstitial quartz granules,and patches and films of sericite (probably replacing original feldspar) each constitute about 20% of the rock. Scattered flakes of muscovite, and rare grains of tourmaline, and small specks of a black opaque oxide are the only other minerals present.

Elimberrie Beds

R 67160311 LR 13.65.45

Breccia: Contains fine-grained siltstone fragments in a siliceous matrix. The siltstone is laminated and sericitic. Disseminated through it is ?limonite, which probably imparts the orange-brown colour typical of the breccias. The matrix is a random intergrowth of quartz of various grainsize and limonitic material, with coarse-grained muscovite aggregates. Comb quartz lines chert-filled vughs.

Elimberrie Beds

R 66160215 LR 13.65.11a

Calc- or dolo-arenite: A fine-grained equigranular mosaic of carbonate (98%), with a.g.d. 0.04 mm. Quartz (2%) grains with a.g.d. 0.3 mm are anhedral, with slightly strained extinction.

Elimberrie Beds

R 66160214 LR 13.65.36a

Massive dolomite or limestone: Contains carbonate grains (99%) speckled with fine iron oxide (1%). Some coarse-grained dolomite rhombs with a.g.d. 2 mm are scattered through the rock.

Elimberrie Beds

R 66160213 LR 12.17.22c

Banded dolomite or limestone: Contains 0.3 to 0.1 mm carbonate in bands of varying grain size; coarse-grained calcite (1-2 mm) is associated with comb-structured quartz in subparallel veinlets. Small ragged grains of iron oxide are accessory.

Elimberrie Beds

R 66160212 LR 12.17.15c

Quartzose doloarenite or calcarenite: Contains a subhedral fine-grained mosaic of carbonate (70%), through which are scattered subrounded strained quartz grains (30%). Rare lenticular fragments of micaceous siltstone and shale are present. Accessories include muscovite, tourmaline, zircon, and scattered iron oxide.

Elimberrie Beds

67.16.0300 LR 14-05-55 3134 27537N

Phyllite: A fine-grained, conspicuously layered phyllite. Consists of alternating layers of quartz and muscovite from 0.2 mm to 1 mm thick. Quartz makes up about 65% of the rock and muscovite about 30%. Quartz-rich layers consist of an interlocking aggregate of small equidimensional 0.02 mm quartz grains and small decussate intergranular flakes of muscovite, and minor biotite, green-brown goethite(?), and tourmaline. The muscovite layers consist almost entirely of a felted aggregate of small parallel muscovite flakes and minor disseminated grains of tourmaline, goethite(?), and turbid sphene(?).

Elimberrie Beds

R 68.16.0356 LR 14-07-6 3177E 27500N

Ferruginous phyllitic quartzite: A fine-grained sericitic/limonitic slightly phyllitic quartzite. Consists of interlocking irregularly shaped 0.05 to 0.02 mm quartz grains, sinuous bands and discrete anhedral patches of very fine-grained sericite, and disseminated specks of orange-brown limonite. Rare tourmaline zircon, pale brown turbid sphene(?), and black opaque magnetite(?) are also present.

The sericite in this rock has probably been derived from original feldspar grains, and has locally been concentrated into bands as a result of deformation.

Elimberrie Beds

R 68.16.0372 LR-OR-8a 3323E 27442N

Doloarenite: A coarse to medium-grained poorly sorted dolomite containing subrounded fragments of fine-grained dolomite up to 1.5 mm in a matrix of anhedral 0.1 mm dolomite grains and anhedral 0.1 mm to 0.2 mm grains of quartz (ca. 70%) and potash feldspar (ca. 2-3%). Rare small grains of tourmaline, zircon, muscovite, ?magnetite, and goethite are associated with the quartz-rich areas.

Elimberrie Beds

R 68.16.0373 LR-OR-8b 3323E 27442N

Doloarenite: A coarse to medium-grained pale rusty brown quartz-bearing doloarenite. Contains lenticular fragments of fine-grained dolomite up to 3 mm long and concentrically-zoned rounded dolomite grains in a fine to medium-grained matrix of anhedral dolomite, quartz, and K-feldspar. Some of the quartz grains were originally rounded but are now irregularly shaped due to secondary overgrowth. Specks of carbonate outline the original grain boundaries. Minor amounts of zircon, tourmaline, muscovite, goethite and hematite(?) are also present.

Elimberrie Beds

R 68.16.0374 LR 14-07-10a 3193E 27504N

Doloarenite: A coarse-grained moderately homogeneous rock consisting essentially of anhedral 0.1 to 0.2 mm grains of dolomite (ca. 95%) and quartz (ca. 5%). Minor accessory minerals present are tourmaline, muscovite, hematite, K-feldspar, and calcite.

Patches of the rock are stained with limonite, which forms small specks in the dolomite,

Elimberrie Beds

R 68.16.0375 LR 14-07-42(a) 3199E 27502N

Dololutite: A very fine-grained finely-banded dolomite rock. Small (ca. 0.01 mm) anhedral to euhedral grains of dolomite make up about 85-90% of the rock. Scattered subangular quartz grains, rare small flakes of muscovite, and patches and grains of goethite are the only other minerals present.

The banding is inconspicuous in thin section and results from the dolomite in certain thin bands being more turbid than in the rest of the rock.

Elimberrie Beds

R 68.16.0376 LR 14-05-54a 3102E 27570N

Pebbly dolomite: A coarse-grained fragmental dolomite. Contains subangular pebbles of fine-grained dolomite and fine-grained subgreywacke up to 8 mm in a coarse-grained recrystallized matrix consisting mainly of dolomite, calcite, and quartz. The matrix dolomite is mainly limonite-stained and has been recrystallized and overgrown to form rhombohedral crystals in places. Calcite fills interstices between dolomite rhombs and locally completely encloses them. Quartz has been extensively recrystallized and overgrown and now forms perfect euhedral crystals, but original rounded grain boundaries are outlined by rings of minute inclusions. Rare opaques, tourmaline, muscovite, and zircon are also present.

Elimberrie Beds

R 68.16.0377 LR 14-05-18 SE 57-8 3131E 27550N

Sericite quartzite: Consists of irregular interlocking quartz grains up to 1 mm but mostly around 0.2 to 0.3 mm, and patches and grains of fine-grained sericite aggregates probably derived from original feldspar.

Minor amounts of magnetite(?), tourmaline, pale yellow turbid (?)rutile, and small disseminated specks of limonite are also present.. Sericite makes up around 25% of the rock, which is probably a metamorphosed feldspathic sandstone.

Elimberrie Beds

R 68.16.0378 LR 14-07-73.2 3183E 27504N

Dolomite: A fine-grained rock consisting of about 85% of carbonate which stain tests show to be entirely dolomite. Irregular bands lenticles and irregularly-branching patches of fine-grained quartz mosaics make up around 10-12% of the rock. Thin films of a colourless to very pale brown mica (1-2%) are also present. Minerals present in trace amounts are tourmaline and black opaque ?graphite.

The shape and texture of the quartz patches is curious and could result from deformation of thin lamellae of detrital quartz or could represent relict organic structures.

Elimberrie Beds

R 68.16.0379 LR 14-05-10 3109E 27547N

Limonitic phyllite: Consists of approximately equal amounts of sericite occurring in thick (0.5 mm) sinuous and lenticular bands and lenticles of fine-grained aggregates of interlocking, locally sutured, quartz grains. Most lenticles of quartz are around 2 mm long and 1 mm across and consist mainly of 0.03 mm quartz grains. Limonite-rich lenticles about 2 mm long constitute 15% to 20% of the rock. Minor amounts of tourmaline, zircon, and pale yellow-grey turbid ?rutile are also present.

Elimberrie Beds

R 68.16.0380 LR 14-05-4 3104E 27564N

Limonite-spotted siltstone: A finely laminated siltstone consisting of subhedral 1 mm patches of limonite (probably pseudomorphing original pyrite) in a fine-grained matrix consisting principally of sericite, subangular 0.01 to 0.02 mm quartz grains, and finely disseminated indeterminate turbid or opaque grains. Rare zircon and tourmaline are also present.

The lamination, which is not particularly conspicuous in thin section, results from the alternation of quartz-bearing laminae with laminae almost free from quartz.

Elimberrie Beds

R 68.16.0381 LR 14-07-73.6 3180E 27504N

Basaltic tuff: A partly altered medium to coarse-grained rock showing traces of original eutaxitic textures. Consists mainly of pale green, turbid, partly altered clinopyroxene (ca. 35%) and rare anhedra of magnetite and associated leucoxene, in a fine grained turbid altered matrix. The matrix consists of turbid altered feldspar (?) fine-grained pyroxene, chlorite, sericite and quartz. The quartz commonly occurs as cuspate shards.

The rock is apparently of tholeiitic composition.

Elimberrie Beds

R 68.16.0382 LR 14-07-9 3180E 27504N

Phyllitic siltstone: Consists almost entirely of minute, well-oriented flakes of colourless to very pale brown mica (?phengite) and small scattered ellipsoidal to lenticular quartz grains and aggregates. Minor tourmaline, zircon, muscovite, and specks of goethite are also present. Veinlets of goethite-rich material traverse the rock.

Elimberrie Beds

R 68.16.0383 LR 14-07-73.4 3180E 27504N

Pebbly phyllite (forms matrix of a boulder bed): Consist of lenticles of finely granular mosaic-textured quartzite in a matrix of very fine-grained well-oriented colourless to very pale brown mica with rare

thin laminae of interlocking quartz granules. Scattered grains of tourmaline and zircon, flakes of muscovite, and thin films, flakes, and lenticles of goethite are also present.

Most of the quartzite lenticles consist of fine-grained interlocking quartz, but some contain isolated subrounded grains up to 0.5 mm. Small isolated subrounded to angular quartz grains in the phyllitic matrix indicate extremely poor sorting of the original sediment and support the suggestion of a possible glacigene origin for the deposit.

Elimberrie Beds

R 68.16.0384 LR 14-05-28(m) 3125E 27535N

Phyllitic quartzite (forms matrix of a boulder bed): A fine-grained micaceous quartzite, consisting of an inequigranular mosaic of anhedral equidimensional interlocking 0.07 mm quartz grains, scattered ellipsoidal quartz grains up to 1.5 mm long, and thin intergranular films and small scattered flakes of a colourless mica which makes up about 2% of the rock. Scattered grains of tourmaline, well rounded zircon, and minute grains of black opaque and grey-brown turbid material (Fe and Ti oxides?) are also present.

Elimberrie Beds

R 68.16.0394 LR 14-05-15

Quartzite: A fine-grained highly sheared quartzite. Small (0.3 mm) equidimensional to lenticular quartz grains showing moderately good preferred orientation (tested with 1 wavelength plate) make up about 97% of the rock.

Thin flakes and trains of muscovite (ca. 2%), scattered grains of tourmaline, and small patches of turbid grey to clear colourless grains with moderately high relief are also present.

Ninety Seven Mile Beds

R 66.16.0202, 203, 204 LR 12-15-30 Bzn_1

Epidotized amygdaloidal basalt: Epidote forms large prisms in amygdales, and small microlites in areas adjacent to the amygdales. Quartz forms euhedral coarse-grained intergrowths with epidote, microlites in the groundmass and thin veinlets through the rock. Abundant specks of

iron oxide form the rest of the groundmass. Small bundles and acicular prisms of actinolite are common, and chlorite is a minor accessory. The microlitic form of quartz and epidote suggests they have replaced feldspar of the original lava.

Ninety Seven Mile Beds

R 67.16.0317 LR 12-15-31b Bzn_1

Chlorite phyllite: Contains porphyroblasts of plagioclase and epidote in a fine-grained mosaic of quartz, chlorite, biotite, and muscovite. The plagioclase is simply twinned, and occurs as relict single laths up to 1.5 mm long, with composition An_{19}, and as subophitic aggregates intergrown with large patches of epidote. Magnetite subhedra form 8% of the rock; lenticular patches of quartz and epidote could be flattened amygdales.

Ninety Seven Mile Beds

R 67.16.0314 LR 12-15-33

Quartz sandstone: This is the matrix of Bzn_1 basal conglomerate; larger quartz grains 1-2 mm diameter are subangular to subrounded, and show strained extinction. Finer grained quartz forms a granular mosaic. Rock fragments are common, and include fine-grained quartz sandstone, coarse-grained siltstone and, less commonly, micaceous siltstone. Accessories are tourmaline, zircon, and some iron oxide.

Ninety Seven Mile Beds (Bzn_1)

R 67.16.0319a,b

Volcanic - quartzite breccia: Contains rounded blocks of epidote-rich lava in a quartzite matrix. The former contains iron oxide, epidote, and quartz; the latter is a fine to medium-grained mosaic of quartz, with some larger grains showing granulated margins. Accessories include calcite and clay minerals.

Ninety Seven Mile Beds (Bzn_1)

R 66.16.0201 LR 12-15-31a

Calcareous ?tuff: Contains distinctive quartz augen to 3 mm diameter. The quartz is clear and partly embayed, and is marginally fractured. Narrow stringers of granular quartz associated with the augen are derived from them by cataclasis. Randomly oriented granular quartz streaks also occur. Calcite forms a fine-grained anhedral aggregate in which spheroids of calcite to 1 mm diameter occur. Accessories are hematite flakes, fine-grained muscovite, and rare zircon.

Ninety Seven Mile Beds (Bzn_2)

R 66.16.0207 LR 12-15-41a

Magnetite quartzite: Contains fine-grained aggregates of quartz derived from larger grains by cataclasis. The larger grains are flattened and oblate. Muscovite forms thin discontinuous laminae, associated with apple green chlorite. Magnetite forms 1 mm subhedra, A few shaly siltstone fragments are present. Accessories are blue-green tourmaline and pink zircon.

Ninety Seven Mile Beds (Bzn_4)

R 67.16.0316 LR 12-15-23

Chlorite schist (?metabasalt): Contains abundant felted aggregates of chlorite, pleochroic from apple green to pale yellow-green. Two cleavages S_1 and S_2 are present, at a slight angle to one another.

Porphyroblasts include epidote-limonite, forming subhedral shapes mainly in S_2. These are possibly altered feldspar. Apatite (1-2%) forms subhedral porphyroblasts up to 0.2 m diameter oriented in the major foliation S_1. Specks and streaks of iron oxide are accessory.

Ninety Seven Mile Beds (Bzn_5)

R 66.16.0206 LR 12-15-4b

Sheared quartzite: Highly flattened, with cataclasis producing aggregates of fine-grained quartz from coarser grains. A few flakes of muscovite and hematite are accessory.

Ninety Seven Mile Beds (Bzn_6)

R 66.16.0200 LR 12-15-12

Pale green phyllite: Contains 2 mm strained, embayed quartz augen, with fine-grained granular aggregates in the matrix. Muscovite (20%) forms aggregates of short stubby flakes, and shows a faint green pleochroism (?phengite). Two grains of untwinned potash feldspar were noted. Accessories are hematite and rare zircon. The rock is probably an altered acid volcanic, equivalent to the Spielers Volcanics.

Spielers Volcanics

R 67.16.0302 LR 14-07-2 3170E 27495N

Altered acid ash-flow tuff: A highly altered acid volcanic. Consists of sheared lenticular quartz grains and aggregates and tightly altered porphyroclasts of feldspar in a very fine-grained quartz-mica matrix. Feldspar porphyroclasts are now altered to aggregates of quartz, muscovite, and sericite, which form pale brown microcrystalline aggregates. Patches of opaque brown material are probably Fe and Ti oxide after original ferromagnesian minerals. Biotite is absent and the clear mica locally has a very faint green coloration suggesting that it is a phengite.

Spielers Volcanics

R 66.16.0251 LR 14-05-51 2139E 27517N

Porphyritic acid ashflow tuff: A sheared rhyolitic acid volcanic containing moderately abundant phenocrysts of quartz and K-feldspar and rare phenocrysts of plagioclase and altered ferromagnesian minerals in a fine-grained quartzo-feldspathic matrix. Phenocrysts are up to 3 mm across and make up about 20% of the rock. K-feldspar phenocrysts are euhedral to subhedral and consist of turbid, locally perthitic microcline. Some phenocrysts have overgrowths of clear microcline. Some are patchy owing to the presence of two distinct K-feldspar phases. Quartz phenocrysts are mostly lenticular owing to shearing but a few undeformed bipyramids remain. Plagioclase has $X \wedge c = 13^{\circ}$. The matrix consists of quartz, K-feldspar, and plagioclase, and minor biotite, epidote, and tourmaline.

APPENDIX 2

MEASURED SECTIONS,

OSCAR RANGE SUCCESSION

Mount Wilson Beds - Section Bzw_1

Measured Section of Mount Wilson Beds at Mount Wilson
350 E. 275 N. Distances paced. Measured by G.M. Derrick

(Overlain unconformably by Devonian Limestone)

Thickness (metres)	Mt. Wilson Beds
38	White, pale green and pale grey quartz sandstone, well sorted, massive to blocky, thick-bedded, well cross-bedded.
102	Pale purple to pale green quartz sandstone, coarse to fine-grained, blocky to flaggy, thin-bedded to laminated, cross-bedded, medium-grained sandstone, possibly glauconitic or chloritic. Minor fine-grained sandstone with irregular slump balls.
88	Pale fawn quartz sandstone, blocky and thin-bedded, alternating with slightly ferruginous quartz sandstone; possibly glauconitic.
234	Pale purple-brown to pale fawn quartz sandstone, blocky, thin to thick-bedded, coarse-grained and poorly sorted, with some granule bands; well cross-bedded. Minor variations in iron content.
57	Scree; no outcrop. Mainly sandstone rubble.
27	Pale green to green-grey quartz sandstone and feldspathic sandstone, fine to medium-grained, cross-bedded and ripple-marked. Abundant tourmaline.
49	Pale purple to buff quartz sandstone, with minor feldspar; coarse to very coarse-grained, cross-bedded, massive to blocky, thick-bedded, with pale pink to brown limonitic cement.
11	No outcrop; ferruginous soil and ferruginous sandstone rubble.
60	Grey to white coarse-grained to granule quartz sandstone, feldspathic sandstone, and arkose, slightly gritty. Minor medium-grained sandstone. Well graded and strongly cross-bedded. Black tourmaline abundant.
	unconformity
666 total	(Sheared acid volcanics of Whitewater Volcanics and Halls Creek Group phyllites)

CHRISTOPHER BEDS SECTION ZC1

Composite measured section 4 km east (ZC 1-a) and 3 km east-northeast (ZC 1-b) of Christophers Bore, (3200E, 27535N and 3191E, 27551N). Measured with tape and abney, by D.C. Gellatly.

Thickness (metres)	Higher beds obscured by alluvium
ZC 1a	
18	Phyllite; grey-brown to red-brown fissile micaceous phyllite.
28	Sandstone; purple-grey and purple-brown, fine-grained, thin-bedded, flaggy well-sorted quartz sandstone.
57	Quartz sandstone; pale purple-grey and pale grey, coarse-grained, thin to thick-bedded, poorly-sorted, silica-cemented.
2	Conglomerate; 2 cm to 8 cm pebbles of vein quartz and grey fine-grained siliceous phyllite, in a coarse-grained pale purple-grey quartz sandstone matrix.
10	Conglomerate; 1 cm to 2 cm pebbles of vein quartz in a pale purple-grey coarse-grained quartz sandstone matrix: includes 15 cm interbeds of quartz sandstone.
75	Quartz sandstone and quartz granule sandstone; pale purple-grey very coarse-grained, thin to thick-bedded blocky to flaggy; sporadic 15 cm to 30 cm interbeds of pebble conglomerate containing 1 cm to 2 cm pebbles of vein quartz.
ZC 1b	
49	Quartz sandstone; grey to pale grey-brown very coarse-grained, thin bedded, phyllitic, silty; topmost beds have scattered pebbles and cobbles of fine-grained quartz sandstone.
6	No exposures
6	Quartz sandstone; pale rust-brown medium-grained thin-bedded flaggy.
18	Quartz sandstone; pale purple-grey phyllitic medium-grained, silty: poorly exposed.

23	Quartz sandstone; white to very pale grey-green coarse-grained thin to thick-bedded, blocky, silica-cemented.
3	No exposures
43.5	Quartz sandstone; cream to buff, very coarse-grained thick-bedded, poorly-sorted; cross-bedded: has 10 cm bed of pebble conglomerate at top containing pebbles of vein quartz, siltstone, and quartz sandstone.
47	Quartz sandstone; pale purple-grey, very coarse-grained, thick to thin-bedded, blocky to flaggy, schistose.
2	Quartz sandstone; white fine-grained thin-bedded flaggy.
46	No exposures
2.5	Quartz sandstone; pale grey-green coarse-grained thick-bedded micaceous.
4	No exposures
9	Siltstone; purple grey, laminated, flaggy, micaceous, with rare interbeds of fine-grained grey-green quartz sandstone.
3	No exposures
17	Quartz sandstone; pale grey-green to buff, fine to coarse-grained thick-bedded, blocky to massive.
19	No exposures
15	Feldspathic sandstone; pale buff to pale purple-brown, coarse-grained, thick-bedded, blocky.
7	No exposures
9	Quartz sandstone; buff to pale grey-green, coarse to fine-grained, thick-bedded, blocky.
6	Siltstone; pale grey-green to buff, laminated, fissile to flaggy, siliceous; and fine-grained feldspathic sandstone.
23	Quartz sandstone; buff to pale red-brown, coarse-grained, thick-bedded, blocky, well-sorted, moderately friable, with well-rounded grains.
13	Quartz sandstone; buff, coarse-grained, thin-bedded, flaggy to blocky, well-sorted, slightly feldspathic.

180	No exposures
12	Quartz sandstone; pale grey and pale buff, coarse-grained, thick-bedded, blocky to massive, well-sorted, silica-cemented; cross-bedded.
35	Quartz sandstone and feldspathic sandstone; pale buff to white, coarse to medium-grained thin-bedded, flaggy to blocky, well-sorted, silica-cemented.
7	Quartz sandstone; white to pale buff, coarse-grained thick-bedded blocky, poorly-sorted; cross-bedded.
54	No exposures
3	Quartz sandstone; pale purple-brown and rust-brown, thin-bedded, flaggy, coarse-grained, slightly ferruginous.
852 total	

Lower beds obscured by soil cover and by Devonian Limestone.

CHRISTOPHER BEDS SECTION ZC2

Paced section, Member Bzc, 2970E, 27690N, headwaters of Ninety Seven Mile Creek, measured by G.M. Derrick.

Overlain by Devonian Limestone

Thickness (metres)	
	_____ unconformity
135	Quartz sandstone; pale pink to off-white, friable, blocky, thin-bedded and poorly bedded, with feldspar and sericitic laminae.
12	Quartz sandstone; white, coarse-grained and blocky. Minor feldspar. Slightly silicified.
300	Quartz sandstone; hematite-bearing, grey-white, coarse-grained massive and thick-bedded, with limonitic and sericitic laminae.
144	Quartz sandstone; grey-white, medium to coarse-grained, massive, thin-bedded to laminated.
330	Quartz sandstone; pale purple, thin-bedded and blocky.
39	Boulder and cobble conglomerate in phyllitic quartzite matrix.
8	Granule sandstone; deep pink, massive, poorly bedded. Friable, sericitic, with pebbles common and cobbles sporadic.
126	Quartz sandstone; pale brown to dark purple-brown, massive to blocky, thick-bedded, with some phyllitic sandstone interbeds.
8	Boulder conglomerate
33	Quartz sandstone; pale purple to white.
6	Boulder conglomerate
120	Quartz sandstone; flaggy to blocky, medium-grained, thin-bedded, with minor lenses of boulder conglomerate.
15	Quartzite; grey-white, massive to blocky, thick-bedded.
1176 total	_____ unconformity

Devonian Limestone

ELLENDALE BEDS - SECTION ZE1

Measured section of Member 1 of Ellendale Beds (Bze_1) 10 km east of Stumpys Bore (3080E, 27597N). Distances paced. Measured by D.C. Gellatly. (Overlain by cobble conglomerate - Member 2 of Ellendale Beds).

Thickness (metres)	Ellendale beds - Member 1 (Bze)
7.5	No exposures (debris slope of conglomerate detritus)
1	Siltstone; white, very fine-grained, phyllitic, with thin interbeds of very pale grey feldspathic quartzite.
4.2	No exposures
5.4	Hematite; dark grey-brown massive hematite rock and thin-bedded, blocky sandy hematite.
3	Siltstone; white, very fine-grained, phyllitic, with thin interbeds of very pale grey feldspathic quartzite.
16.5	Quartz sandstone; white to very pale grey, medium-grained, thick-bedded, massive, well sorted.
12	No exposure
5.4	Shale; silver-grey, very fine-grained, laminated, fissile, phyllitic.
6	No exposures
5.4	Shale; silver-grey, very fine-grained, laminated, fissile, phyllitic.
5.1	No exposures
6.9	Shale; silver-grey, very fine-grained, laminated, fissile, phyllitic; red-brown when weathered.
27	No exposure.
21	Quartz sandstone; white to pale buff, coarse-grained, thin to thick-bedded, blocky to massive; forms a prominent ridge.
15.9	No exposure
5.7	Quartz sandstone; pale pink medium-grained, friable; grades downwards into rubbly pale yellow to pale rust brown, medium-grained, slightly ferruginous quartz sandstone.

Thickness (metres)	
15.9	No exposure
5.7	Quartz sandstone; pale pink medium-grained, friable; grades downwards into rubbly pale yellow to pale rust brown, medium-grained, slightly ferruginous quartz sandstone.
51	Feldspathic sandstone; buff to pale-grey, medium to coarse-grained, thin-bedded, friable, phyllitic.
1.5	Feldspathic sandstone; pale grey, very fine-grained, laminated, fissile.
42	Feldspathic sandstone; pale buff to pale pink-brown, medium-grained, thin-bedded, flaggy.
5.4	Conglomerate; purple-brown platy pebbles of sheared quarta sandstone in a matrix of pale grey flaggy sericitic phyllitic sandstone.
17.4	Quartz sandstone; pale grey, fissile, sericitic phyllitic.
17.4	Quartz sandstone; pale grey, coarse-grained, massive, blocky, silica-cemented.
12.3	No exposure.
17.4	Quartz sandstone; yellow-brown, medium-grained, thin-bedded, blocky silica-cemented.
.6	Conglomerate; pebbles of yellow brown quartz sandstone up to 2½ cm in a matrix of yellow brown quartz sandstone.
43.5	Quartz sandstone; yellow-brown, medium-grained, thin-bedded, blocky, silica-cemented.
356.5total	Core of anticline: lower beds not exposed.

ELLENDALE BEDS - SECTION ZE2

Paced measured section Bze_2, locality 3010E, 27613N, 2.4 km east of Stumpys Bore. Measured by G.M. Derrick.

Thickness (metres)	
	(Overlain unconformably by Devonian limestone and Permian Grant Formation)
37.5	Cherty quartzite; fine-grained, laminated. Quartz sandstone, fine to medium-grained, grey to white, flaggy to blocky, with some rough columnar jointing.
17.1	Brecciated sandstone; with incorporated phyllite fragments. Dull grey-green fine-grained phyllitic sandstone. Silicified and quartz-veined sandstone, with specks of chalcopyrite and specularite.
35.1	Boulder and cobble conglomerate rubble - poorly exposed.
18.9	Phyllite; with some massive quartz veining.
5.4	Boulder bed rubble
23.7	Boulder and cobble conglomerate, slightly flattened.
30.6	Boulder and cobble conglomerate rubble.
7.5	Phyllite
8.1	Boulder and cobble conglomerate rubble.
9	Boulder and cobble conglomerate; quartz veins contain specularite.
139.5	Phyllite; grey-brown, well-bedded and cleaved, with interbeds up to 3 feet thick of cobble conglomerate near top.
15.6	Boulder and cobble conglomerate, with phyllite interbeds at top.
14.7	Boulder bed rubble.
42	Phyllitic quartz sandstone; grey to red-brown, medium to coarse-grained, tourmaline and ?hematite accessories.
9.6	Boulder conglomerate, with quartz-specularite veins.
9.6	Phyllitic quartz sandstone; grey, flaggy to blocky. Contains numerous lenses of quartz with hematite. Passes along strike into boulder beds.

Thickness (metres)	
13.2	Boulder conglomerate with phyllitic matrix.
1.8	Phyllitic quartzite.
48.9	Boulder conglomerate.
74.7	Boulder and cobble rubble.
90	Quartz sandstone; grey-blue, medium-grained, with phyllitic interbeds.
612.5 total	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ possibly fault-bounded Le Lievre Beds

ELLENDALE BEDS - SECTION ZE3

Measured section of Member 2 (Bze_2) of Ellendale Beds 8 km east-southeast of Stumpys Bore. (3052E, 2761N) Distances paced: measured by D.C. Gellatly.

Thickness (metres)	Lithology
	(Overlain by soil and alluvium)
20.7	Quartz sandstone; buff, coarse-grained, poorly sorted, thin-to thick-bedded, silty; contains thin conglomerate beds with pebbles of white quartz sandstone up to 8 cm in diameter.
22.2	No exposure.
23.7	Conglomerate; pebble and cobble conglomerate with thin interbeds of tuff coarse-grained poorly-sorted quartz sandstone.
22.8	Quartz sandstone; pale grey-green, fine to medium-grained, thin-bedded, flaggy, poorly sorted.
19.2	Conglomerate; pebbles and cobbles (up to 30 cm) in a pale grey sandy matrix.
37.5	Quartz sandstone; dark grey, fine to coarse-grained, thin-bedded, laminated, flaggy to blocky, poorly-sorted.
9	Conglomerate; cobbles and boulders of white to grey quartz sandstone up to 50 cm in a coarse-grained sandstone matrix.
63	Quartz sandstone; grey, fine to coarse-grained, thick-bedded, blocky, well-sorted, silica-cemented, slightly feldspathic.
33	Quartz sandstone; white to purple-brown, medium-grained, thick-bedded, blocky, well-sorted, slightly feldspathic.
37.5	No exposure.
1.5	(brecciated quartz reef - possible fault).
21	No exposures.
7.5	Conglomerate; cobbles and boulders of white quartz sandstone in a pale buff coarse-grained poorly sorted sandstone matrix.

Thickness (metres)	
30	Feldspathic sandstone; pale cream to pale buff, fine to medium-grained, thin-bedded, flaggy to blocky, well-sorted.
18	Conglomerate
25.2	No exposures
10.2	Siltstone
21.6	Conglomerate
8.4	Quartz sandstone; poorly sorted, phyllitic, silty, with scattered ½ inch pebbles.
4.5	Conglomerate
7.2	Siltstone
8.1	Conglomerate
10.8	Phyllitic silty sandstone
8.1	Conglomerate
8.1	Silty quartz sandstone
61.5	Conglomerate
540.3 total*	Fault
	(Faulted against Member 1 (Bzv_1) of Le Lievre Beds)

* Includes probable repetition of beds by folding. True thickness 300 m +.

ELLENDALE BEDS - SECTION ZE4

Measured section of Member 3 of Ellendale Beds (Bze_3) (3098E, 2756N) 7½ km west-northwest of Christophers Bore.

Thickness (metres)	
	Overlain by limestone of Elimberrie Beds Bzb_2
	Ellendale Beds - (Bze_3)
3	Siltstone; pale purple and pale grey-green, mottled.
12.9	No exposures.
150	Siltstone; pale purple and pale grey-green mottled, laminated. Lowermost 6 m contain thin beds of limonitic siltstone.
84	No exposures
18	Siltstone; pale buff; only scattered outcrop.
131.6	No exposures.
13.2	Siltstone; grey, flaggy, red-brown when weathered.
413.7 total	
	Overlies sandstone and conglomerate of Member 2 of Ellendale Beds (Bze_2).

ELLENDALE BEDS - SECTION ZE5

Paced measured section of part of Bze_2, locality 3029E, 27603N, 5 km east-southeast of Stumpys Bore. Measured by G.M. Derrick.

Thickness (metres)	(Overlain unconformably by Devonian limestone and Permian Grant Formation)
12	Cherty quartzite; grey-white, laminated.
136.8	No exposure; cobble conglomerate and tourmaline quartzite along strike.
52.8	Phyllitic quartz sandstone; pale purple, medium-grained, blocky, poorly bedded, well foliated and cleaved.
7.5	Boulder and cobble conglomerate rubble.
10.5	Cobble conglomerate, unflattened.
42.6	Feldspathic sandstone; phyllitic, grey-white, blocky, well-bedded and cleaved. Some altered hematite. Interbeds of massive quartz sandstone, cross-bedded.
14.7	Cobble and boulder conglomerate.
12.3	Quartz sandstone; grey, blocky to flaggy, laminated; rare pebbles; thin phyllitic bands 1 to 2 mm thick.
4.8	Cobble conglomerate.
27	Feldspathic sandstone; phyllitic, pale grey-green to white, blocky to flaggy, poorly bedded, with limonitized specks of feldspar and hematite
	- - - - - - - - - - - - - - minor fold axis
324.0 total	

LINESMAN BEDS - SECTION ZL1

Measured section of Member 2 (Bzl_2) of Linesman Beds.
Locality 4 km southeast of Christophers Bore (3203E, 27509N).
Measured with tape and abney by D.C. Gellatly.

Thickness (metres)	
	(Faulted contact with Elimberrie Beds)
6	Feldspathic sandstone; pale pink-brown, coarse to medium-grained, thick-bedded, blocky.
0.3	Conglomerate; pebbles of vein quartz and quartzite up to 2 cm in a matrix of coarse-grained pale grey slightly feldspathic poorly-sorted quartz sandstone.
16.2	Feldspathic sandstone; pale pink to buff, coarse to medium-grained, thick-bedded, blocky, well-sorted.
3.6	Siltstone; buff, thin-bedded, flaggy, siliceous.
15.6	Feldspathic sandstone; white to buff, medium to coarse-grained, thick-bedded, blocky, moderately well sorted.
67.5	Siltstone; pale grey to pale green-grey, laminated, flaggy, to fissile; minor interbedded laminae of pale purple-grey siltstone.
7.2	Feldspathic sandstone; pale grey to pale grey-brown, fine-grained, thin-bedded to laminated, blocky to flaggy, silty.
33.3	Siltstone; grey and purple-grey, laminated, flaggy to fissile.
5.1	Feldspathic sandstone; pale grey, fine-grained, laminated, flaggy.
2.7	Siltstone; pale grey and pale purple-brown, laminated, flaggy.
12	Feldspathic sandstone; white to pale brown, medium to coarse-grained, thick-bedded, blocky.
3.9	Conglomerate; pebbles and cobbles up to 10 cm, in a coarse-grained poorly-sorted slightly feldspathic quartz sandstone matrix.

Thickness (metres)	
6.0	Siltstone; pale grey-brown and purple-grey, laminated, fissile.
16.5	Feldspathic quartz sandstone; cream to pale grey, medium-grained, thick-bedded, blocky, slightly feldspathic.
18.0	Siltstone; pale brown and purple-grey, thin-bedded to laminated, flaggy; has rare laminae of fine-grained sandstone.
43.5	Feldspathic sandstone; white to pale brown and pale grey, coarse to medium-grained, thick-bedded, blocky.
257.4 total	

Overlies siltstone (Bzl_1) - mainly soil covered.

LINESMAN BEDS - SECTION ZL2

Measured section member 3 (Bzl_3) of Linesman Beds. Locality 1 km, west of Christophers Bore, 3159E, 27542N). Measured with tape and abney; measured by D.C. Gellatly.

Thickness (metres)	
ZL2(a)	Faulted against Elimberrie Beds
7	Siltstone; pale grey laminated flaggy.
56	Feldspathic sandstone; pale grey-green and maroon-grey, fine-grained, laminated, flaggy; and siltstone.
18	Siltstone; pale grey-green and pale pink-brown, laminated, blocky to massive, micaceous.
116	Siltstone; pale grey-green, pink-brown and grey-brown, laminated, flaggy.
63	Feldspathic sandstone; buff, medium-grained, thick-bedded, blocky, well-sorted.
30	Siltstone; pale grey-green and pale purple-grey, laminated, flaggy.
29	Feldspathic sandstone; white to pale buff, coarse-grained, thick-bedded, blocky to massive, well-sorted.
30	Siltstone; pale grey-green and pale cream-pink, laminated, flaggy.
5	Feldspathic sandstone; pale grey-green and pale purple-grey, fine-grained, laminated, flaggy to blocky, well-sorted.
86	Siltstone; pale grey-green and pale purple-grey, laminated, flaggy.
32	Feldspathic sandstone; grey and pink-brown, medium to coarse-grained, thick-bedded, blocky.
19	Siltstone; pale grey-green and pale purple-grey, laminated, flaggy.
14	Siltstone; purple-brown and grey-green, laminated, flaggy, feldspathic.

Thickness (metres)	
104	Siltstone; pale grey-green and cream-pink, laminated, flaggy.
3	Siltstone; yellow-brown, laminated, flaggy, limonitic.
120	Siltstone; pale green-grey and pale purple-grey, laminated, flaggy.
35	Feldspathic sandstone; off-white, medium-grained, thick-bedded, blocky, silica-cemented.
767 total	

Overlies grey-green phyllitic siltstone of Member 1 of Linesman Beds.

LINESMAN BEDS - SECTION ZL3

Estimated (a) and measured (b) section of Member 1 (Bzl_1) of Linesman Beds, 0.8 km northeast of Christophers Bore. Distance paced, measured by D.C. Gellatly.

Thickness (metres)	(Overlain by Member Bzl)
ca 480 (a)	Siltstone; pale grey and brown, laminated, flaggy to fissile.
ca 240 (a)	No exposures (phyllite occurs along strike)
ca 51.3 (b)	Siltstone; dark purple-brown and red-brown, phyllitic, with thin interbeds of pink-brown, fine-grained, thin-bedded, flaggy, feldspathic sandstone.
12 (b)	'Boulder beds'; well-rounded boulders, cobbles, and pebbles of grey to pale brown quartzite in a phyllitic sandy matrix.
14.4(b)	Siltstone; dark purple-brown and red-brown, phyllitic, with thin interbeds of pink-brown, fine-grained, thin-bedded, flaggy, feldspathic sandstone.
7.2 (b)	Boulder beds; rounded and ellipsoidal cobbles and boulders of quartz sandstone in a matrix of poorly sorted quartz sandstone.
30 (b)	Feldspathic sandstone; buff to pale brown, coarse-grained, thin-bedded, flaggy to blocky, well-sorted; poorly exposed phyllite interbeds.
	(Lower beds obscured by soil cover)
ca 824	**total**

ELIMBERRIE BEDS - SECTION ZB1

Measured section of Members 3 (Bzb_3) to 7 (Bzb_7), 4 km south-southeast of Christophers Bore. (3186E, 27503N). Measured by D.C. Gellatly.

Lithology

Thickness (metres)	Overlain by Spielers Volcanics (Bzs)
	Elimberrie Beds - Member 7 (Bzb_7)
24.6	Shale and siltstone; pale red-brown, medium-grained, laminated, fissile, phyllitic.
18.3	Quartzite; white, coarse-grained, flaggy, phyllitic.
30	Shale and siltstone; pale grey-brown, laminated, fissile, phyllitic.
12.3	Quartzite; pale grey to pale red-brown, medium-grained, thin-bedded, blocky.
17.1	Quartzite; white to pale buff, medium-grained, flaggy.
12.6	No exposure; phyllitic quartzite detritus.
24.0	Quartzite; pale buff, medium-grained, thin-bedded, flaggy; locally brecciated and ferruginous.
138.9 total	

ELIMBERRIE BEDS - MEMBER 6 (Bzb_6)

5.1	Siltstone; purple-grey, laminated, fissile, phyllitic.
2.4	Tillite(?); boulder sandstone - cobbles and boulders of medium to coarse-grained quartzite in a sandy and silty phyllitic matrix. Megaclasts are up to 1 m long, and moderately well polished. Most are striated and a few have crescentic percussion marks.
10.5	Quartzite; white to very pale grey, laminated, phyllitic.
21.6	Tuff; green and grey-green, mottled, coarse-grained.
.6	Hematitic ironstone.
40.2 total	

ELIMBERRIE BEDS MEMBER 5 (Bzb_5)

Thickness (metres)	
18	Shale; grey, laminated, very fissile, phyllitic.
13.5	Quartz sandstone; pale grey and pale red-brown, medium-grained thin-bedded, flaggy to blocky.
15.6	Siltstone; pale grey, fissile, laminated, phyllitic; with thin interbeds of phyllitic quartzite.
15.0	Quartzite; pale grey, laminated, flaggy, phyllitic.
70.2	Shale and siltstone; pale grey, laminated, phyllitic.
132.3 total	

ELIMBERRIE BEDS - MEMBER 4 (Bzb_4)

5.7	Quartzite; white, medium-grained, flaggy, slightly feldspathic, phyllitic.
27.6	Tillite(?); highly sheared, pebbles, cobbles and boulders of white quartzite (up to 0.6 m long by 0.15 m thick) in a phyllitic siltstone matrix.
32.4	Quartzite; white, flaggy, phyllitic.
9.0	Quartz sandstone; white to pale purple-brown, fine to medium-grained, thick-bedded, blocky.
27.9	Quartzite; pale silver-grey, fine-grained, fissile, phyllitic.
7.5	Quartz sandstone; white, fine to medium-grained, thin to thick-bedded. Forms narrow ridge.
6.3	Quartz sandstone; white to pale buff, fine-grained, thin-bedded, blocky.
7.5	Quartz sandstone; pale grey, medium-grained, thin-bedded, flaggy, feldspathic.
123.9 total	

ELIMBERRIE BEDS - MEMBER 2 (Bzb_2)

Thickness (metres)	
28.2	Limestone; mottled grey-brown, poorly bedded, pebbly, cellular; some beds are arenaceous and friable; others are tough and porcellaneous; contain abundant phyllite fragments in places.
.9	Shale; grey-brown, laminated, fissile.
48.0	Limestone; as above.
2.4	Sandstone; pale rust-brown, ferruginous.
	Probable faulted unconformity
79.5 total	

Faulted against Linesman Beds.

ELIMBERRIE BEDS - SECTION ZB3

Measured section of part of Elimberrie Beds. Locality 3128E, 27549N, 5 km west of Christophers Bore. Distances taped; measured by D.C. Gellatly.

Thickness (metres)	
	ELIMBERRIE BEDS - MEMBER 4 (Bzb_4)
ca 60	Quartzite; white phyllitic, flaggy (not measured - estimated from air photos)
.6	Ironstone; yellow-brown, limonitic.
77.4	Quartzite; pale purple-grey, flaggy, phyllitic.
138 total	
	ELIMBERRIE BEDS - MEMBER 3 (Bzb_3)
18	No exposure (phyllite)
1.8	Phyllite; purple and pale green-grey, laminated, fissile.
5.7	Phyllite; pale grey, sandy.
3.0	Sandstone; rusty brown, coarse-grained, very friable, cellular.
6.0	Tillite(?); boulder sandstone - ellipsoidal boulders and cobbles of white quartzite in a matrix of coarse-grained, very friable; white to pale rusty brown, phyllitic quartz sandstone.
.6	Sandstone; pale cream-white, thin-bedded, medium-grained, friable, cellular, calcareous.
9.6	Phyllite; pale pink-grey, fissile.
15.6	Phyllite; grey-brown and purple-grey.
9.9	No exposure.
12.3	Phyllite; grey and purple-grey, finely laminated, very fissile.
15.3	No exposures.
4.2	Phyllite; grey.
5.4	Phyllite; pale red-brown and grey, finely laminated, fissile, bedded; yellow-brown on weathered surface.
3.0	No exposures.

Thickness (metres)	
5.1	Sandstone; buff to pale brown, brecciated, sericitic, with scattered pebbles of quartz sandstone and sideritic ironstone; friable and ferruginous in places.
3.0	Sandstone; pale grey, medium to coarse-grained, thick-bedded, blocky, well-sorted, slightly feldspathic.
118.5 total	
30	No exposure - possible fault. (Part of Bzb_2)
6.0	Quartz sandstone; pale yellow-brown brecciated, medium-grained, slightly feldspathic, silica-cemented.
2.1	Limestone; pale grey.
3.0	Quartz sandstone; rust-brown, coarse-grained, cellular, feldspathic.
15.0	No exposure.
2.4	Quartz sandstone; rust-brown, coarse-grained, cellular, feldspathic.
3.0	Siltstone; pale grey-brown, phyllitic.
1.5	Quartz sandstone; pale rust-brown, friable, cellular, pebble-bearing.
63.0 total	

ELIMBERRIE BEDS - MEMBER Bzb_1

SECTION ZB4

Composite paced section, 3030E, 27640N. Measured by G.M. Derrick.

Thickness (metres)	
	Overlain unconformably by Devonian Limestone.
	Elimberrie Beds - Member Bzb_1
9	Phyllite; grey, calcareous, laminated.
3	Limestone; massive, well-bedded, grey-buff; interbedded chert bands and quartz veins; minor phyllite-limestone breccia.
2.4	Limestone; dull grey-brown, poorly bedded, massive.
30	Limestone; thin-bedded, with interbeds of calcareous coarse-grained sandstone.
3.0	Chert-quartzite breccia.
60	Phyllite; red-brown, laminated, fine-grained, strongly deformed; rare medium-grained quartz sandstone interbeds.
30	Quartzite; white to pale grey, fine to medium-grained, massive to blocky, thin-bedded.
57	Limestone; flaggy, well-bedded, with interbeds of coarse-grained calcareous quartz sandstone.
3.0	Limestone-phyllite breccia.
6.0	Chert-quartzite breccia.
7.5	Limestone; flaggy, with thin interbeds of fine-grained grey chert and sandy limestone.
3.6	Chert-quartzite breccia, yellow-brown to pale green.
4.5	Limestone; massive, grey-brown and well-bedded.
	_ _ _ _ _ _ _ _ _ _ anticlinal fold core, base not exposed.
219.0 total	

ELIMBERRIE BEDS - MEMBER 2 (Bzb_2)

SECTION ZB5

Composite measured section (distances paced): Locality 3195E, 27506N, 3.2 km southeast of Christophers Bore. Measured by D.C. Gellatly.

Thickness (metres)	Overlain by Member Bzb_3
	Elimberrie Member Bzb_2
89.4	Limestone and dolomite; grey and brown, rubbly, cellular, porcellaneous; commonly brecciated; finely laminated dark grey calcilutite; quartz-pebble-bearing limestone; lenses of coarse-grained friable limonitic sandstone.
34.5	Siltstone; grey and grey-green, thin-bedded, flaggy, with rare 6 mm calcareous laminae; interbedded with grey and grey-brown laminated fissile shale.
26.1	Feldspathic sandstone; pale buff, medium-grained, thin-bedded, blocky, well-sorted.
13.5	Siltstone and shale; grey-brown, laminated, flaggy to fissile, grey-brown.
23.1	Feldspathic sandstone and arkose; buff, medium-grained, thick-bedded, blocky, well-sorted, silica-cemented.
18.0	Siltstone; grey-brown, thin-bedded, flaggy grey-brown; and fine-grained feldspathic sandstone.
9.0	Limestone; dark grey to pale grey, thick-bedded, brecciated.
213.6 total	fault contact

Faulted against Linesman Beds.

NINETY SEVEN MILE BEDS - SECTION ZN1

Composite paced measured section of Bzn_1, locality 2945E, 27688N, 5.6 km northwest of Stumpys Bore. Measured by G.M. Derrick.

Thickness (metres)	Bzn_2 - Specularite-bearing quartzite with interbedded phyllite
39	Amygdaloidal epidote-bearing lavas, epidosite, quartzitic epidosite, volcanic-quartzite breccia.
12	Phyllite; green and chloritic.
7.5	(?)Tuff; pale brown to grey, calcareous, with quartz augen.
26.4	Cobble and boulder conglomerate, with coarse-grained sandy matrix. Sericitic films common on grains.
160.5	Phyllite; green-brown, laminated, with regular sandy lenses.
7.5	Quartzite; white to pale buff, medium-grained, sericitic in part.
39	Quartz sandstone; white to buff, medium-grained, blocky, interbedded with phyllitic sandstone, brown-buff, fine-grained.
6	Phyllite; red-brown, laminated.
297.9 total	Base overlapped by Devonian limestone.

NINETY SEVEN MILE BEDS - SECTION ZN2

Paced measured section, Bzn_6, locality 2941E, 27622N, 3 km northwest of Stumpys Bore. Measured by G.M. Derrick.

Thickness (metres)	
	Overlain unconformably by Devonian limestone.
75	Cobble conglomerate, with sporadic boulders and abundant pebbles, mainly of quartzite, set in contorted phyllitic groundmass.
10.5	Phyllite; green-grey, sericitic, well-cleaved. Small lenses of quartzite.
30	Boulder and cobble conglomerate, with phyllitic matrix. Cobble content decreases down sequence.
24	Phyllite; with rare pebbles of quartzite.
9	?Acid volcanic; pale green, highly sheared.
25.2	Boulder and cobble conglomerate, massive, becoming more phyllitic down-sequence.
23.1	Phyllite; with sporadic quartzite pebbles, grading downwards to fine-grained, red-brown, phyllitic sandstone.
10.5	Cobble conglomerate, with phyllitic matrix.
28.2	Subgreywacke; phyllitic, medium to coarse-grained, dark red-brown.
33	Quartzite; white to grey, fine to medium-grained, blocky.
268.5 total	

Massive white quartzite Bzn_5

ELIMBERRIE BEDS - MEMBER 3 (Bzb_3)

Thickness (metres)	
7.8	Shale and siltstone; grey, laminated, fissile to flaggy.
1.2	Limestone; grey-brown, laminated, flaggy.
9.9	Siltstone; grey-brown, laminated, fissile to flaggy.
.2	Limestone; laminated grey and grey-brown.
.6	Shale; fissile grey-green.
.6	Limestone; pale brown, laminated, blocky.
21.6	Shale and siltstone; pale grey, laminated, fissile.
14.4	Limestone; pale brown, thin-bedded, massive.
16.8	Shale and siltstone; pale grey and grey-green, laminated.
3.0	Limestone; pale grey-brown and rusty yellow-brown, laminated, flaggy.
10.5	Shale; pale grey, laminated, fissile.
6.0	Limestone; laminated, grey and grey-brown.
9.0	Shale and siltstone; pale grey, fissile.
12.0	No exposure.
9.3	Shale; pale grey and grey-green.
3.0	Limestone; pale grey, brecciated, with abundant small angular pebbles of vein quartz.
.6	Quartz sandstone; rust-brown, coarse-grained, friable, cellular.
3.9	Quartzite; fine-grained white, sericitic.
2.4	Shale and siltstone; pale grey-green, fissile.
123.7 total	

Elimberrie Beds - Member 2 (Bzb_2) - Section ZB5

ELIMBERRIE BEDS - SECTIONS ZB2a, b

Measured and estimated sections of Elimberrie Beds. Members 4 and 5 have been estimated from air photographs; member 2 was measured with tape and abney, and members 3 and 6 by pacing distances. Locality 3½ km west of Christophers Bore. (3040E, 27536N; and 3028E, 27535N). Measured by D.C. Gellatly.

Thickness (metres)	Higher beds observed by soil cover
ZB2b	Elimberrie Beds - Member 7 (Bzb_7)
2.4	Sandstone; very pale grey to pale buff, thick-bedded, blocky, medium to coarse-grained, silica-cemented
	Elimberrie Beds - Member 6 (Bzb_6)
171.0	Boulder beds; probably tillite: abundant pebbles, cobbles, and boulders of quartzite in a sheared phyllitic quartzite matrix. Intercalations of phyllite and lenses of cellular limonitic quartz sandstone.
	Elimberrie Beds - Member 5 (Bzb_5)
ca 360	Phyllite; pale grey, fissile, micaceous; poorly exposed.
ZB2a	Elimberrie Beds - Member 4 (Bzb_4)
117.0	Quartzite; white to very pale grey-brown, fine-grained, laminated, flaggy, phyllitic, and minor feldspathic sandstone.
	Elimberrie Beds - Member 3 (Bzb_3)
108.9	Siltstone; pale grey, laminated, flaggy to fissile, phyllitic.
4.5	Tillite(?); cobbles of quartz sandstone in a matrix of phyllitic siltstone.
54.0	Siltstone: grey-brown, laminated, flaggy, phyllitic.
167.4 total	

APPENDIX 3

STRATIGRAPHIC NOMENCLATURE SUBMISSIONS

Name of Unit — Christophers Beds

Sheet area — Lennard River 1:250,000
Leopold Downs 1:100,000

Derivation of Name — From Christophers Bore (3170E; 27562N) in the southeastern part of the Oscar Range.

Lithology — Mainly pale purple-grey and white quartz sandstone with minor siltstone and pebble conglomerate. Christopher Beds are subdivided into three members. Because of lack of outcrop it is not certain that these constitute a conformable sequence.

Unit	Thickness (Metres)	Lithology
undifferentiated	1176	Sandstone and conglomerate
member 3	650	White quartz sandstone
member 2	500	Shale and siltstone
member 1	852	Purple-grey quartz sandstone; minor siltstone and pebble conglomerate.

Distribution — In southeastern part of Oscar Range, to east of Christophers Bore; also scattered outcrops to northwest of Christophers Bore, for about 20 km.

Topography — Prominent strike ridges and rounded hogbacks.

Reference Sections — (3198E, 27540N) and (3231E, 27510N), east and southeast of Christophers Bore respectively.

Stratigraphic Relationships — Unconformably overlain by Devonian rocks. Relationships with other Precambrian rock units not displayed in type area. Possible equivalents to northwest overlain apparently conformably by basal member of Elimberrie Beds. Older than Linesman and Elimberrie Beds and possibly as old as Le Lievre Beds.

Age — Proterozoic

Thickness — The siltstone member is poorly exposed and may be much thicker than indicated.

Diagnostic features — The thick sequence of pale purple-grey coarse-grained quartz sandstone and associated quartz pebble conglomerate is unique in the Oscar Range.

Remarks — The basal member is lithologically similar to the O'Donnell Formation in the King Leopold Ranges to the north.

Name of Unit — Elimberrie Beds

Sheet area — Lennard River 1:250,000
Leopold Downs 1:100,000

Derivation of Name — From Elimberrie Spring on the northern margin of the Oscar Plateau (2898E, 27783N).

Lithology — A varied succession consisting of dolomitic limestone, phyllitic siltstone, quartzite and quartz sandstone, boulder beds, and acid volcanics. The Elimberrie Beds are provisionally subdivided into the following seven members:

Member	Thickness (metres)	Lithology
7	140	Quartz sandstone and siltstone; thin ironstone beds.
6	40-170	Cobble and boulder beds (?tillite) with silty matrix
5	Up to 360	Phyllitic siltstone
4	Up to 140	Quartzite, feldspathic sandstone
3	120-170	Cobble conglomerate, siltstone, and cellular limonitic sandstone
2	210	Limestone and dolomite; feldspathic sandstone and shale interbeds.
1	220	Dolomite, limestone, quartzite, ironstone lenses, chert.

Distribution — In the Oscar Range. Forms northern flank of western end of range and southern flank of eastern end.

Topography — Forms low lying country with low strike ridges.

Reference Section — Near southeastern end of Oscar Range (3185E, 27500N).

Stratigraphic Relationships — Apparently forms topmost part of Oscar Range Succession. Contact with underlying Linesman Beds is probably a faulted unconformity. Relations with underlying Ellendale Beds in west uncertain, but may be unconformable.

Age — Proterozoic (?Adelaidean)

Name of Unit Ellendale Beds

Sheet area Lennard River 1:250,000
Leopold Downs 1:100,000

Derivation of Name Ellendale Homestead

Lithology Cobble conglomerate, sandstone, and siltstone. The Ellendale Beds may be subdivided into three members. Thicknesses of these members are uncertain because of tight folding.

Member	Approx. Thickness (metres)	Lithology
3	414	Siltstone and shale
2	120-620	Cobble and boulder conglomerate with sandstone interbeds
1	Up to 400	Sheared feldspathic sandstone, minor siltstone and hematite lenses, quartz sandstone

Distribution In central part of Oscar Range, flanking central anticline formed by Le Lievre Beds.

Topography Mostly low, sharp-crested strike ridges. Conglomerate crops out as gently rounded ridges.

Reference Sections In central part of Oscar Range, near Le Lievre Ridge (3088E, 27565N), (3047E, 27592N).

Stratigraphic Relationships Overlie Le Lievre Beds. Contact mostly faulted but may in part be unconformable. Overlain unconformably by basal member of Elimberrie Beds, which overlaps from topmost member of Ellendale Beds to lowest. Siltstone at top of Ellendale Beds may possibly be a correlative of basal member of Linesman Beds.

Age Proterozoic

Thickness Uncertain, apparently about 1400 m. A reliable thickness has been obtained only for the conglomerate member, and this apparently shows lateral thickness variations, so that the determined thickness may not be representative.

Diagnostic Features The thick conglomerate is characteristic. The conglomerates in the Ellendale Beds differ from those of the Elimberrie Beds in having an arenaceous matrix rather than a silty one. The presence of lenses of primary sedimentary hematite in the basal member is also characteristic.

Remarks No correlations are possible with other areas. The coarse conglomerates contain only sandstone cobbles and boulders and may have been derived locally from the underlying Le Lievre Beds.

Name of Unit — Le Lievre Beds

Sheet area — Lennard River 1:250,000
Leopold Downs 1:100,000

Derivation of Name — From Le Lievre Ridge (newly named) in the central part of the Oscar Range.

Lithology — Pale grey massive quartz sandstone and quartzite; minor phyllitic siltstone and grey-green chlorite phyllite. The Le Lievre Beds are divided into three members. The Beds are strongly cleaved and stratigraphic relationships between these members are uncertain.

Member	Approx. Thickness (metres)	Lithology
3	150	Dark grey-green magnetite phyllite.
2	450	White to grey quartzite
1	200	Red-brown phyllite, siltstone, minor sandstone.

Distribution — In central part of Oscar Range, forming narrow median belt around Le Lievre Ridge.

Topography — A high flat topped ridge, which forms the highest part of the Oscar Range. The phyllites form narrow valleys within and bordering this ridge.

Reference Section — Near Le Lievre Ridge (3070E, 27580N).

Stratigraphic Relationships — Apparently the lowest beds in the Oscar Range Succession. Overlain by the Ellendale Beds. Contacts are mostly faulted and therefore relationships uncertain but may in part be unconformable. Because of tight folding the sequence of members within the Le Lievre Beds is uncertain. Overlapped on north-eastern margins by Ellendale Beds.

Age — Proterozoic

Thickness — Probably not less than 800 m. Exact thickness uncertain since the base of the succession is not exposed.

Diagnostic features — The thick sequence of massive pale grey, even-grained quartzite and quartz sandstone is unique in the Oscar Range.

Proposed Name:	Mount Wilson Beds
Sheet area:	Lennard River 1:250,000 Leopold Downs 1:100,000
Derivation of Name	From Mount Wilson, 3485E, 27488N, at which the sequence is best exposed.
Lithology	Basal very coarse-grained gritty arkose and granule feldspathic sandstone, quartz sandstone and medium-grained glauconitic and ferruginous quartz sandstone.
Distribution	Discontinuous inliers around Mount Wilson and The Twins, about 13 km northwest of Mount Wilson.
Topographic Features	Forms prominent hills up to 100 m high projecting through Devonian calcareous sediments. Probably basement ridges.
Reference Section	At Mount Wilson.
Stratigraphic Relationships	Unconformable over Halls Creek Group (Archaean) at Mount Wilson, and Whitewater Volcanics (Carpentarian) at the Twins. Overlain unconformably by Pillara Limestone (Devonian).
Age	Proterozoic: Tentatively correlated with sediments of Oscar Range (Christophers Beds).
Thickness	At Mount Wilson, 666 m (measured); At The Twins, 330 m (estimated).
Diagnostic Features	The basal coarse-grained arkose and generally very coarse-grained and cross-bedded sandstone throughout. Steep dips ($>45^{\circ}$) and topographic setting help distinguish these beds from the arkosic facies of the Pillara Limestone.

Name of Unit — Ninety Seven Mile Beds

Sheet area — Lennard River 1:250,000
Leopold Downs 1:100,000

Derivation of Name — From Ninety Seven Mile Creek in northwestern part of Oscar Range.

Lithology — Mainly cobble conglomerate with some phyllite, white to pale brown quartzite, minor rhyolite, and amygdaloidal basic volcanics. The following members are recognized:

Member	Thickness (metres)	Lithology
6	270	Cobble conglomerate, phyllite
5	400-510	White to grey quartzite, quartz sandstone, minor phyllite and cobble conglomerate.
4	100+	Green chlorite, phyllite (?metabasalt)
3	300	Cobble conglomerate
2	220	Phyllite, phyllitic sandstone, minor cobble conglomerate.
1	300	Amygdaloidal, epidotised basic volcanics, epidotised quartzite, chlorite, phyllite, minor tuff.

Distribution — Confined to extreme northwestern end of Oscar Ranges.

Topography — The quartzite forms moderately rugged ridges and small plateaux; the conglomerate forms a series of rounded hills; and the lavas crop out poorly from soil cover and low-lying Devonian rocks.

Reference Section — 5 km northeast of the 'angle teleline' (2910E, 27690N).

Stratigraphic Relationships — Separated from Christophers Beds to the north by Devonian cover and from the Ellendale Beds to the east by a fault. The Ninety Seven Mile Beds may be equivalent in part to the Ellendale Beds, or may possibly be younger. Overlain unconformably by the Grant Formation(Permian).

Age — Proterozoic

Thickness — Approximately 1600 m.

Diagnostic Features — The thick sequence of cobble conglomerate and phyllite, together with basic and acid lavas at base, is diagnostic. The sequence also appears to be unfolded and relatively unfaulted.

Name of Unit	Spielers Volcanics
Sheet area	Lennard River 1:250,000 Leopold Downs 1:100,000
Derivation of Name	Spielers Creek, which drains areas underlain by Spielers Volcanics.
Lithology	Dark grey and pale grey-green 'quartz-feldspar porphyry' - probably ashflow tuff; contains phenocrysts of quartz and K-feldspar up to 5 mm. Mostly strongly foliated.
Distribution	Southern flank of southeastern part of Oscar Range, southeast of Spielers Creek.
Topography	Mostly spinifex covered plans and pediments with sparse low outcrops of foliated volcanics.
Reference area	3166E, 27490N (about 19 km northwest of Twelve Mile Bore).
Stratigraphic Relationships	Overlies Elimberrie Beds (?Adelaidean) concordantly. Overlain probably unconformably by Napier Formation (Devonian).
Age	Late Precambrian or Palaeozoic; possibly Devonian. Rb/Sr age determinations (two specimens only) indicate an isotopic age of 365 m.y.
Thickness	About 750 metres.
Diagnostic Features	The Spielers Volcanics closely resemble ashflow tuffs of the Whitewater Volcanics (Lower Proterozoic) but are distinguished by their stratigraphic position.
Remarks	The Spielers Volcanics were previcusly the topmost member of the Elimberrie Beds.

LEOPOLD DOWNS

WESTERN AUSTRALIA

1:100,000 GEOLOGICAL MAP

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Reference

- Geological boundary
- Anticline, showing plunge
- Syncline, showing plunge
- Overturned anticline, showing plunge
- Fault, attitude unknown (D,U indicate relative movement down, up)
- Normal fault, teeth on downthrown side
- Transcurrent fault

Where location of boundaries, folds and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes

- Plunge of minor anticline
- Plunge of minor syncline
- Plunge of minor drag fold
- Plunge of fold axis
- Shear zone
- Shear zone – inclined
- Fault Breccia
- Strike and dip of strata
- Prevailing strike and dip of strata
- Strike and dip of strata with plunge of lineation
- Vertical strata
- Vertical strata with plunge of lineation
- Horizontal strata
- Strike and dip of overturned strata
- Trend line
- Strike and dip of joint
- Vertical joint
- Joint pattern – air-photo interpretation
- Top of bed, from cleavage/bedding relationship
- Top of bed, from cross-bedding
- Current direction from cross-bedding
- Strike and dip of foliation
- Vertical foliation
- Vertical foliation with plunge of lineation
- Strike and dip of foliation with plunge of lineation
- Direction and plunge of lineation
- Strike and dip of cleavage
- Strike and dip of cleavage and bedding coincident
- Strike and dip of cleavage with plunge of lineation
- Strike and dip of cleavage and bedding coincident with plunge of lineation
- Vertical cleavage
- Vertical cleavage and bedding coincident

- Fossil locality
- Specimen locality
- Age determination sample locality
- Type section locality
- Measured section locality
- Dykes and veins; do-dolerite, q-quartz, ap-aplite, p-pegmatite; unless stated otherwise, all dykes are dolerite

- Open cut or quarry
- Prospect
- Mineral occurrence
- Au Gold
- Cu Copper
- Fe Iron
- Mn Manganese
- Rc Crushed rock aggregate
- Sb Antimony
- Sn Tin
- Zn Zinc

- Bore
- Bore – salinity < 2500 ppm
- Windpump
- Equipped with pump engine
- Spring
- Waterhole

- Highway
- Road
- Vehicle track
- Landing ground
- Fence
- Telephone line
- Homestead
- Yard
- Elevation in metres – approximate

Reference

CAINOZOIC	QUATERNARY		Qa Alluvium
			Qs Windblown sand
			Czt Travertine, tufa(calcrete)
			Czb Residual black soil
			Czs Other residual soils
	TERTIARY		Tp Laterite; pisolitic ironstone; ferruginous sandstone
MESOZOIC	JURASSIC	Fitzroy Lamproite	Jf Leucite-rich lamprophyre
PALAEOZOIC	PERMIAN	Noonkanbah Formation	Pn Shale, siltstone, limestone, intraformational conglomerate
		Poole Sandstone	Pp Micaceous silty sandstone and quartz sandstone
		Grant Formation	Pg Massive aqueoglacial, unsorted silty sandstone, conglomeratic sandstone, tillite, siltstone, shale, varved rocks
	PERMIAN ?		Pc Boulder and cobble conglomerate
	CARBONIFEROUS	Laurel Formation	Cll Calcarenite, sandy and silty limestone
	DEVONIAN	FAMENNIAN-FRASNIAN	Windjana Limestone — Dw Reef facies: yellow to white massive algal and stromatoporoid limestone, dolomitized in part
			Pillara Limestone — Dp Back-reef facies: yellow to light grey, bedded stromatoporoid limestone, birdseye limestone, oolite; calcarenite and calcilutite, arkosic sandstone
			Napier Formation — Dn Fore-reef and inter-reef facies: grey to red calcarenite, calcirudite and megabreccia, in part sandy and silty
		FRASNIAN-GIVETIAN	Behn Conglomerate — Db Boulder, pebble, and cobble conglomerate with arkosic matrix
	DEVONIAN TO/OR ADELAIDEAN	Spielers Volcanics	Pzs Porphyritic rhyolite ashflow tuff
			Pzd Dark grey-green altered dolerite
	ADELAIDEAN ?	Oscar Ranges Succession — Ninety-seven Mile Beds	Pzn$_6$ Cobble conglomerate with phyllite matrix, highly sheared locally; minor acid tuff
			Pzn$_5$ Pale grey to white quartzite; minor feldspathic quartzite
			Pzn$_4$ Grey-green chlorite phyllite
			Pzn$_3$ Cobble and boulder conglomerate with phyllite matrix
			Pzn$_2$ Grey phyllite; cobble and boulder conglomerate with phyllite matrix
			Pzn$_1$ Green-brown phyllite, cobble and boulder conglomerate with sandstone matrix, amygdaloidal spidotised lava and tuff
		Elimberrie Beds	Pzb$_5$ White quartz sandstone and quartzite; siltstone, thin ironstone beds
			Pzb$_4$ Grey cobble and boulder tillite with phyllite matrix, highly sheared locally; minor siltstone, sandstone, basic tuff
			Pzb$_3$ Grey phyllitic siltstone and shale, minor quartz sandstone and quartzite
			Pzb$_2$ White to pale buff quartzite; quartz sandstone and feldspathic sandstone; minor cobble beds
			Pzb$_1$ Grey cobble and boulder (?) tillite with phyllite matrix; phyllite; minor friable limanitic sandstone
		Linesman Beds	Pzl$_3$ Grey to brown dolomitic limestone; dolarenite, feldspathic sandstone, siltstone
			Pzl$_2$ Pale-grey to pink limestone; dolarenite, quartzite, ironstone lenses
			Pzl$_3$ Pale purple-grey siltstone; minor feldspathic sandstone and quartzite
			Pzl$_2$ Pale buff feldspathic sandstone and quartzite; siltstone; minor pebble conglomerate
			Pzl$_1$ Grey-brown siltstone and shale; minor feldspathic sandstone and cobble and boulder conglomerate
		Ellendale Beds	Pze$_3$ Grey-brown siltstone and shale
			Pze$_2$ Pale grey cobble and boulder conglomerate, quartz sandstone and quartzite; minor feldspathic sandstone and siltstone
			Pze$_1$ Pale buff quartz sandstone and feldspathic sandstone; minor shale, siltstone, pebble conglomerate; hematite lenses
		Le Lievre Beds	Pzv$_3$ Grey phyllite
			Pzv$_2$ Pale grey quartzite and quartz sandstone
			Pzv$_1$ Grey phyllite and siltstone
		Christophers Beds	Pzc Pale purple to white quartz sandstone and quartzite; pebble to boulder conglomerate; phyllite
			Pzc$_3$ White quartzite and quartz sandstone
			Pzc$_2$ Dark-grey phyllite; minor feldspathic sandstone and dolomite
			Pzc$_1$ Purple grey quartz sandstone and quartzite; minor siltstone, phyllite, feldspathic sandstone, hematitic sandstone, pebble and cobble conglomerate
		Mount Wilson Beds	Pzw Grey to white coarse-grained quartz sandstone and grit; feldspathic sandstone and arkose
	CARPENTARIAN	Hart Dolerite	Pdh Dark-grey tholeiitic dolerite
	LOWER PROTEROZOIC*	Lamboo Complex — Mount Amy Granite	Pbka Pale grey to pink medium-grained biotite granite, muscovite granite, aplite, pegmatite
		Dyasons Granite	Pbky Pale grey to pink medium-grained leucocratic biotite granite; Gneissic contact-zone with xenoliths and net-veining
		Lennard Granite	Pbkl Leucocratic coarsely porphyritic biotite granite and adamellite
		McSherrys Granodiorite	Pbkm Mesocratic biotite-and hornblende granodiorite and tonalite
		Bickleys Porphyry	Pbb Grey quartz-feldspar porphyry, and porphyritic microgranite with hipiramidal quartz phenocrysts
		Whitewater Volcanics	Pw Rhyodacite crystal-rich and crystal-poor ashflow tuff
			Pws Bedded rhyodacite tuff; tuffaceous siltstone, sandstone, and conglomerate
		Richenda Microgranodiorite	Pbkr Grey medium-grained biotite microgranodiorite; Rhyolite cone sheet
		Woodward Dolerite	Pbd Dark-grey-green amphibolitized
	ARCHAEAN OR LOWER PROTEROZOIC*	Halls Creek Group	Ah Grey phyllitic siltstone and greywacke; andalusite, staurolite and garnet-mica schist
			Grey-blue pebbly sericitic quartzite

* Subdivision of Precambrian time-scale used by the Geological Survey of Western Australia, shown in brown

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. R.W. Swartz M.B.E., E.D., Minister for National Development.
Base map compiled by the Royal Australian Survey Corps from aerial photography at 1:50,000 Scale. Transverse Mercator Projection

Geology 1955 by D.J. Guppy, A.W. Lindner, J.H. Rattigan, J.N. Casey
1963 by P.E. Playford and D.C. Lowry (GSWA)
1966-67 by D.C. Gellatly, G.M. Derrick, C.M. Morgan
Compiled 1968-69 by D.C. Gellatly, G.M. Derrick, A. Tatarow, D. Brentnall
Cartography by Geological Branch BMR
Drawn by D. Brentnall

Scale 1:100,000

BROWN NUMBERED GRID LINES ARE 10,000 METRE INTERVALS OF THE AUSTRALIAN MAP GRID, ZONE 51

GEOLOGICAL RELIABILITY DIAGRAM

Geology A Detailed mapping
B$_1$ Detailed reconnaissance and air-photo interpretation
B$_2$ General reconnaissance: some traverses, mainly air-photo interpretation

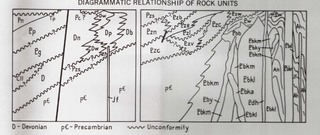
RELATIONSHIP TO 1:250,000 SERIES

Showing Magnetic Declination 1970

Yampi	Charnley	Mt. Elizabeth
Derby	Lennard River	Lansdowne
Mt Anderson	Noonkanbah	Mt Ramsay

ANNUAL CHANGE 1°5'W

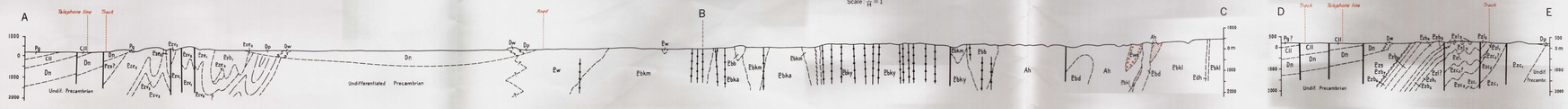
DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Sections

Cainozoic sediments omitted

Scale: V/H = 1



PRELIMINARY EDITION, 1971

SUBJECT TO AMENDMENT

LEOPOLD DOWNS

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