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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES
GEOLOGY AND GEOPHYSICS

RECORDS:

1966/136

GEOLOGY OF THE MOUNT ELIZABETH 1:250,000 SHEET AREA SE/52-1, WESTERN AUSTRALIA

by

H.G. Roberts and W.J. Perry

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Records No. 1966/136

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SUMMARY

This record gives an account of the geology of the Mount Elizabeth 1:250,000 Sheet area SE/52-1, a 7000-square-mile area lying between latitudes 16° and 17°S and longitudes 126° and 127°30'E in the Kimberley Division of northern Western Australia. The area contains rocks of Carpentarian and Adelaidean age, and rocks and unconsolidated sediments of Cainozoic age.

The oldest rocks - those of Carpentarian age - are gently dipping sedimentary rocks of the Kimberley Group. The Group is about 9,400 feet thick (base not exposed) and consists mainly of quartz arenites, with subordinate thicknesses of basic lavas and lutites, and minor thicknesses of carbonate rocks. It is conformably overlain by the Mendena Formation, which consists of an alternating sequence of arenites and lutites and is about 300 feet thick (top eroded); it is the only representative of the Bastion Group preserved in the area. The strata of the Kimberley Group are intruded by sills and dykes of dolerite (Hart Dolerite) which may be either upper Carpentarian or lower Adelaidean in age.

The older rocks are overlain unconformably by sub-horizontal strata of the upper Adelaidean Mount House Group. The basal unit of the Group is the Walsh Tillite, a product of the older of the two glaciations which are known to have affected the Kimberley region during late Precambrian times. Several glaciated pavements underlie the Tillite. The Tillite may be as thick as 200 feet and is conformably overlain by about 170 feet of arenites and lutites of the Traine Formation. The top of the sequence is eroded.

Surface water supplies are adequate for the present pastoral activity and the prospects of obtaining subsurface supplies appear to be good. Minor occurrences of copper minerals are present in the area.

INTRODUCTION

Location and Access

The Mount Elizabeth Sheet area lies between latitudes 16° and 17°S and longitudes 126° and $127^{\circ}30'$E, in the Kimberley Land Division in the northern part of Western Australia. A graded road from Derby provides access to Gibb River Homestead which is in the central-western part of the area; the road is at present being extended northwards to Kalumburu, on the north coast of the Kimberley region, and will replace an existing, poorly defined track. A rough track from Wyndham passes through the north-eastern part of the area and terminates at Gibb River Homestead. The only other established track in the area extends westwards from Gibb River Homestead to Mount Elizabeth Homestead.

Habitation and Industry

Gibb River and Mount Elizabeth Homesteads have a combined population of about 30 and are the only centres of permanent habitation in the area - Karunjie Homestead is at present unoccupied. Cattle raising is the only industry.

Climate and Vegetation

The area has a tropical savannah climate and is subject to distinct 'wet' and 'dry' seasons. The average annual rainfall at Gibb River is 29 inches; it probably increases slightly to the north-west and decreases to about 25 inches in the south-east (Slatyer, 1960). Most of the rain falls between November and March. The normal daily maximum temperature is about 95°F in January and 85°F in July. On rare occasions frosts occur at Gibb River Homestead.

Most of the area, in particular the sandstone country, is covered by open forests with a low shrubby undergrowth and spinifex. The vegetation tends to be sparse where rock exposures are good, but where soils have been developed, the vegetation is generally more dense. In areas underlain by volcanic rocks the undergrowth is not as dense as elsewhere and a good grass layer is present. The best grazing land is developed in the volcanic areas.

Previous Investigations

Probably the first geological work done in the map area was in 1901 when A. Gibb Maitland and G.C. Gibson accompanied the Brockman exploration expedition (Brockman & Crossland,

1901) on an examination of the Kimberley Plateau, but their findings were never published, although some references to the general area were made by Maitland in subsequent years. Hann (1901) also conducted exploration in the Kimberley Plateau, but little significant geological data was gathered. Rock samples were collected by the Crossland expedition of 1905 (Fitzgerald, 1907). Easton, a surveyor, wrote in broad terms on the geology of the region and Maitland (1928) discussed the volcanic rocks encountered during his visit to the area at the turn of the century. Edwards (1943) enlarged on the description of the volcanic rocks and gave the first detailed presentation of their petrology.

The first systematic work in the area was conducted by Harms (1959) on behalf of the Broken Hill Pty. Coy., as part of a reconnaissance of an area covering the Kimberley region and extending to the Victoria River district of the Northern Territory. Harms' work has provided a useful basis for the present work.

Present Investigations

The accompanying map (Plate 1) was compiled from field work which was carried out during June and July 1965 as part of a joint Geological Survey of Western Australia - Bureau of Mineral Resources project designed to complete the regional geological mapping of the Kimberley Plateau region. The adjoining Lissadell Sheet area (to the east) was mapped in 1963 (Dunnet & Plumb, 1964); the Lansdowne Sheet area (to the south) was mapped in 1964 (Gellatly, Derrick & Plumb, 1965) and the Ashton Sheet area (to the north) was mapped during the 1965 field season (Derrick, 1966). Mapping of the Charnley Sheet area (to the west) was begun in 1965 and is to be completed during 1966.

Due to the difficulties of ground access much of the area was reconnoitred by means of widely spaced helicopter traverses, which were supplemented by ground traverses along the three main tracks radiating from Gibb River Homestead.

Perry and Richard (1965) prepared a photogeological map of the area prior to the field work and their photo-overlays were available for use in the field. The present map embodies much of the original photo-interpretation, but has been supplemented and revised in the light of field data.

Air photographs and base maps covering the area and available during 1965 were: air photographs at a scale of 1:50,000 flown by the Royal Australian Air Force in 1949, and a planimetric map at a scale of 1:250,000 compiled in 1961 by the Royal Australian Survey Corps from photo-scale, slotted template assemblies. The geological plate of the accompanying map was compiled on the photo-scale assemblies which were then photographically reduced to a scale of 1:250,000.

PHYSIOGRAPHY

The Mount Elizabeth Sheet area lies within a broad area characterised by a general unity of elevation and topographic form, commonly known as the Kimberley Plateau. Plumb (in prep.) refers to the area as the Kimberley Plateau (physiographic) Province, and he recognizes a number of sub-provinces; parts of four of these sub-provinces - the Prince Regent Plateau, Gibb Hills, Karunjie Plateau and Glenroy Plains - occur in the Mount Elizabeth Sheet area (fig.1).

The Prince Regent Plateau extends into the map area from the north-west and occupies a large part of the north-western quarter of the Sheet area. An appendage of the Plateau - the Phillips Range - occurs in the south-western corner of the Sheet area.

In the north-western part of the area most of the Plateau lies above an elevation of 1700 feet above sea level and only locally do elevations exceed 2000 feet. The highest known point in the Sheet area is about 9 miles W 30°S of Mount Elizabeth Homestead and is 2229 feet above sea level. The area of the Plateau is underlain by horizontal or gently-dipping arenites of the King Leopold Sandstone; dissection of the arenites has, in places, led to the development of gorges, low cliffs and benches, but in general the topography is more subdued in the Mount Elizabeth Sheet area than in the extension of the Plateau further to the north-west; local relief rarely exceeds 100 feet. The margin of the Plateau is generally a gentle slope.

The Phillips Range is an east-west trending feature which rises to elevations of 1900 feet above sea level; steep slopes bound the range to the north and south, but its crest is relatively flat except near the main watercourses, which are deeply incised. In places the Range stands almost 500 feet above the adjoining country.

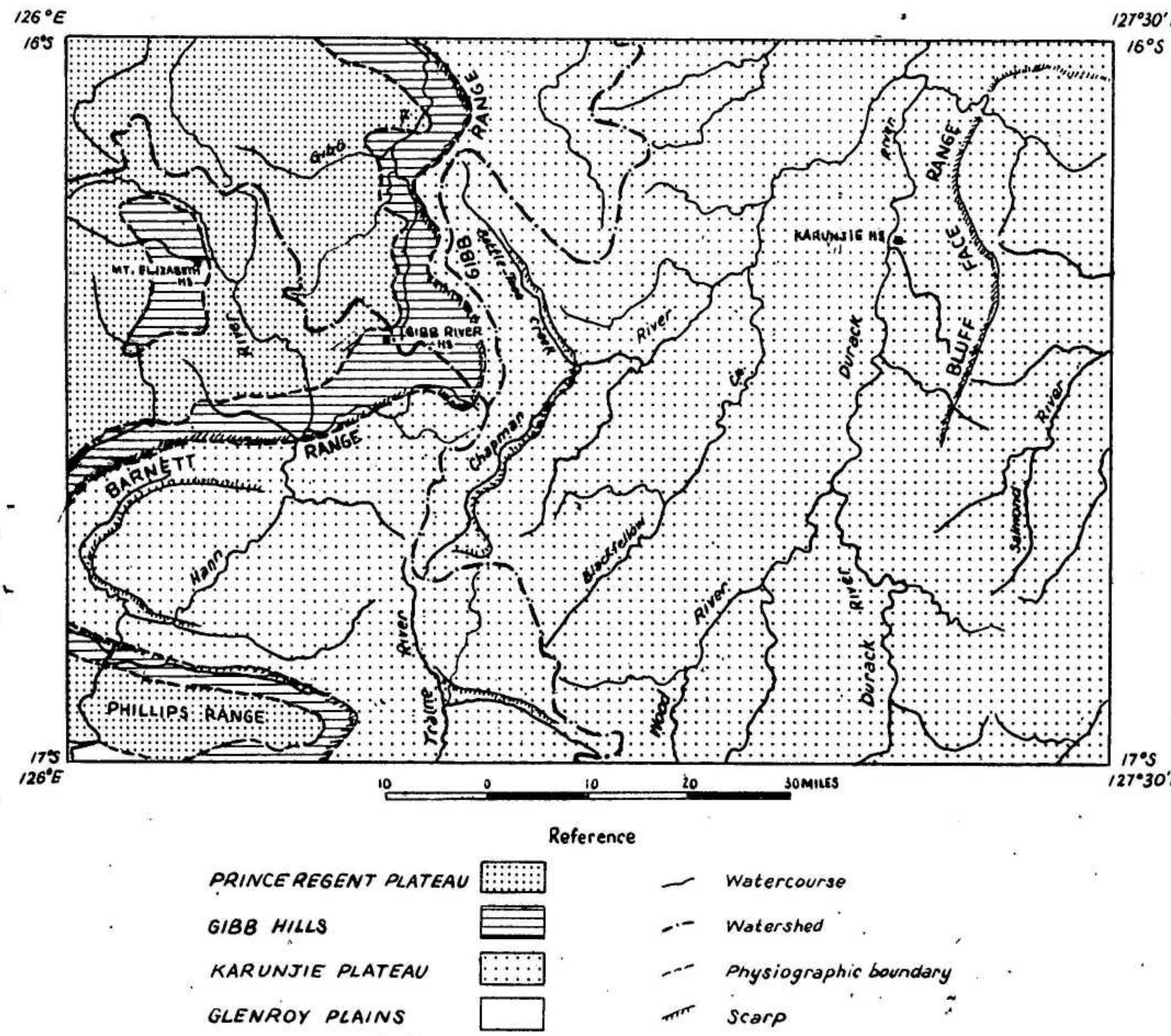
The Gibb Hills occupy a narrow, low-lying belt bounding the Prince Regent Plateau to the east. The Hills owe their distinctive topography to the underlying Carson Volcanics. The zone is characterised by gently undulating, rounded hills, commonly interspersed with wide, soil-covered areas. Soil is particularly widespread in the north, but it diminishes in its extent to the south. Elevations within the sub-province range from 1350 feet in the north to about 1700 feet near Gibb River Homestead. Local relief rarely exceeds 50 feet in most of the area but in the south, near the Phillips Range, some of the hills and ridges rise up to 100 feet above the surrounding country.

The Karunjie Plateau covers a large part of the Sheet area. It is bounded in the west by an almost continuous scarp (e.g. the Gibb and Barnett Ranges); the scarp rises from 200 to 300 feet above the general level of the adjoining Gibb Hills. Although there is no clear topographic evidence of the area having ever approached true peneplanation, there are some indications that a mature land surface, with much less than the existing relief may have been developed at elevations ranging from about 1700 to 2000 feet. This surface has been thoroughly dissected and relics are preserved in only two areas - in the west it forms a watershed between the Gibb and Chapman Rivers and the Chapman and Traine Rivers, and in the east it forms the Bluff Face Range.

The topography of the Plateau is profoundly influenced by the varying response to erosion of the underlying strata and by their structural attitude. Horizontal or gently-dipping arenites and lutites underlie most of the area; the arenites generally form broad mesas and plateaux, while the lutites form valleys. Where the lutites and arenites are closely interbedded the arenites tend to form benches, undercut by erosion of the less resistant lutites. Where the strata are dipping the arenites form prominent cuestas, such as the Barnett Range, and the lutites form long intervening valleys.

Elevations in the Plateau range from almost 2200 feet above sea level in the south-eastern corner of the area to about 1000 feet in the north-east, along the course of the Durack River. Local relief generally ranges from 100 to 200 feet, but in places, notably in the Bluff Face Range, the local relief is up to 500 feet;

FIG. 1 : PHYSIOGRAPHIC SKETCH MAP - MOUNT ELIZABETH SHEET AREA



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relief is also strong in the far south-eastern corner of the Sheet area.

A small part of the Glenroy Plains sub-province extends into the far south-western part of the Sheet area, to the south of the Phillips Range. This area is characterized by wide, flat, soil-covered tracts of country, supporting only low, sparse vegetation.

Drainage

The area is drained by three major river systems. The eastern half of the area is drained by the Durack and Salmond Rivers which join to the south of Wyndham and flow into Cambridge Gulf. The north-west is drained by the Gibb River and other tributaries of the Drysdale River system which flows northwards into the eastern part of Napier Broome Bay (on the north coast of the Kimberley region). The south-western part of the area is drained by the Hann and Traine Rivers; these are part of the Fitzroy River system which flows into King Sound, on the west coast.

All of the major elements of the drainage systems have characteristics which show that they have been superimposed - e.g. the Hann River cuts through the Barnett and Phillips Ranges without regard for their comparatively great elevation, and streams such as the Durack and Wood Rivers have meandering courses, cutting across the geological grain, even in the most immature parts of their profiles. It is believed that these streams may have been developed in a relatively mature landscape. The striking parallelism of the Salmond River, Wood River, Blackfellow Creek and the Chapman River may be the result of their all having been initiated on a north-easterly dipping land surface. It is possible that very slight warping of an ancient peneplain along a north-west axis may have induced the present major stream pattern.

The tributaries of the major streams are subsequent and their courses are influenced to a great degree by the nature of the bedrock, e.g. Bottle Tree Creek flows along the strike of less resistant strata, and streams in the north-western part of the area are commonly incised in joint and fault planes.

STRATIGRAPHY

Rocks of Carpentarian+, Adelaidean and Cainozoic age are exposed in the Mount Elizabeth Sheet area. The older rocks - those of Carpentarian age - are sedimentary rocks and were deposited in a sedimentary basin (the Kimberley Basin) which extended over the entire Kimberley Plateau and probably far beyond. Sedimentation was initiated about 1800 million years ago and in a time span of less than 300 million years some 15,000 feet of sediment accumulated.

The sequence in the Basin was first subdivided by Guppy et al (1958) but Harms (1959, 1965) and Dow, Gemuts, Plumb and Dunnet, (1964) successively modified the nomenclature and erected further divisions. Gellatly, Derrick & Plumb (1965) made further modifications to the nomenclature, and it is their nomenclature (to be fully defined by Plumb (in prep.), that is followed in this report. They divide the sequence into three Groups - the Speewah, Kimberley and Bastion Groups. The Speewah Group is up to 6000 feet thick and consists of arenites and lutites, but it is exposed only around the margins of the Kimberley Plateau and does not crop out in the Mount Elizabeth Sheet area. It is overlain (generally conformably) by the Kimberley Group which consists of arenites, lutites, basic volcanic rocks and some carbonate rocks; the Group is up to about 10,000 feet thick and is extensively exposed in the map area. The Kimberley Group is conformably overlain by the Bastion Group which consists of arenites, and lutites, and is up to 4600 feet thick in its reference area (Dow et al,1964). Only the lowermost subdivision of the Bastion Group - the Mendena Formation - is exposed in the map area.

+ Current Bureau of Mineral Resources nomenclature is applied to subdivisions of the Precambrian time-scale throughout this report. It should be noted however that the Geological Survey of Western Australia has adopted subdivisions which differ in concept and nomenclature (Report of the Department of Mines, Western Australia for the year 1964) from those of the Bureau. The appropriate Western Australian terms are shown in the reference to the accompanying map.

The Carpentarian rocks are intruded by the Hart Dolerite which is either of upper Carpentarian or lower Adelaidean age. The Hart Dolerite and the older rocks are overlain unconformably by the upper Adelaidean Mount House Group which consists of tillite, arenites and lutites and is up to 370 feet thick. Its top is eroded.

The Mount House Group and the older rocks are overlain by a variety of thin Cainozoic deposits.

The stratigraphy is summarized in Table 3 (following p. 28).

CARPENTARIAN

KIMBERLEY GROUP

KING LEOPOLD SANDSTONE

Distribution of Exposures: the King Leopold Sandstone crops out in the north-western part of the map area; in the Phillips Range: in the south-eastern corner of the area; and in a small zone in the extreme south-east.

Stratigraphic Relationships: The base of the King Leopold Sandstone is not exposed in the map area, but to the south-east the unit is known to overlie the Luman Siltstone (the uppermost unit of the Speewah Group) with general conformity (Gellatly et al., 1965). In places, however, the unit rest unconformably on rocks of the Speewah Group (Gellatly et al., op.cit.; Roberts, Halligan and Gemuts, 1965). The Sandstone is conformably overlain by the Carson Volcanics.

Lithology and Thickness: In the Mount Elizabeth Sheet area only the upper part of the King Leopold Sandstone is exposed. It consists predominantly of brown or orange weathering, white or buff ubiquitously cross-bedded, massive, medium and coarse-grained quartz sandstone. Locally the sandstone is light purple-grey or brown when broken, and in places the massive sandstone beds are intercalated with blocky beds. The rocks are generally laminated (although very faintly), but in places the laminated strata are interbedded with thin-bedded and, rarely, thick-bedded strata. On the whole the sandstone is moderately well sorted, but in places scattered very coarse grains or granules of quartz are present and in rare localities pebbly bands occur.

The sandstone (R 65163001, 2, 3) consists of grains of quartz, cemented by secondary silica overgrowths, and varying amounts (0-5%) of clay. Traces of sericite are present in some of the rocks, and tourmaline, opaques and feldspar aggregates occur in accessory amounts. The quartz grains are generally either subrounded or rounded.

The sandstone is almost invariably cross-bedded; the thickness of the foreset beds varies from 1 inch to 10 feet but most fall within the range 6 inches to 2 feet. Simple and planar cross-beds (McKee & Weir, 1953) are the most common types, but trough types occur locally. Recumbently folded cross-beds are very common in the unit - of sixteen localities where observations were made in the King Leopold Sandstone, recumbently folded cross-beds were noted at five. Numerous examples occur at each of the five localities.

Ripple marks were observed at two of the sixteen localities and it is of note that these two localities were the only ones where fine-grained sandstone was recorded. Rare foresets 1 to 3 inches thick (very thin in the general context of the formation) were the only evidence of cross-bedding at either locality.

There is no way of accurately assessing the exposed thickness of the unit in the Mount Elizabeth Sheet area, but in the Phillips Range at least 2,800 feet of section is thought to be present. In the Lansdowne Sheet area estimates of the thickness range from 2,300 to 4,400 feet (Gellatly et al., 1965).

CARSON VOLCANICS

Distribution of Exposures: The Carson Volcanics crop out to the north and south-east of the Phillips Range and within a zone extending from north of the Barnett Range, through Gibb River Homestead to the northern boundary of the Sheet area. Exposures of the unit also occur in the extreme south-east. The volcanics are generally very poorly exposed.

Stratigraphic Relationships: The Carson Volcanics conformably overlie the King Leopold Sandstone and they are conformably overlain by the Warton Sandstone.

Lithology and Thickness: The Volcanics are about 2300 feet thick and consist predominantly of grey-green to black massive and amygdaloidal basalt. Thin flows of grey-green amygdaloidal spilite and beds of pyroclastic material are present locally and at least two interbeds of feldspathic sandstone are known in the sequence. The uppermost 100 feet of the unit consists essentially of micaceous siltstone.

The basalt which makes up the bulk of the unit occurs as numerous flows. In most places it is even-grained and it is difficult to distinguish the various flows. In some places however amygdales are abundant in the upper parts of some of the flows. No samples of the basalt from the Mount Elizabeth Sheet area have been thin-sectioned, but Gellatly et.al., (1965) describe the basalts of the adjoining Lansdowne Sheet area as being predominantly of tholeititic composition. The amygdales are characteristically filled by calcite, chlorite or epidote. Spilitic flows are not abundant.

Rare thin beds of pink tuffaceous claystone have been noted in about the middle of the unit. In thin section (R65163009) the rock can be seen to consist of volcanic lapilli set in a finer-grained tuffaceous claystone matrix. The larger fragments consist of a mass of feldspar laths which are commonly epidotized and/or dusted with opaques, including hematite. The fragments are generally well rounded. Fragments of quartz and chalcocite are also present.

A bed of volcanic agglomerate up to 100 feet thick occurs in an area south-east of the Phillips Range in the upper half of the unit, but agglomerates have not been noted elsewhere. Thin interbeds of chloritic clayey siltstone and fine-grained feldspathic sandstone occur in the agglomerate.

In an area south-east of the Barnett River Gorge two beds of fine to medium-grained, blocky, laminated, cross-bedded and ripple-marked feldspathic sandstone, each about 20 feet thick occur in the sequence. The lowermost bed lies about 800 feet above the base of the unit and the rock (R65163004) consists of grains of quartz (95%) and feldspar (5%) with minor amounts of clay, tourmaline, opaques and ? jarosite. The uppermost bed lies about 1500 feet above the base of the unit and consists (R65163006) of fine to medium grained quartz (70%) and feldspar (30%). Most of the feldspar is of the potash variety; opaques and rutile are present in accessory amounts.

The uppermost 100 feet of strata consist predominantly of micaceous siltstone, but fine-grained arenaceous interbeds are common, particularly near the base and near the top of the sequence. The micaceous siltstone is generally purple or green, finely laminated and fissile. In parts of the sequence the mica content is as high as 50% but generally it is only about 5%. The interbedded arenites are mostly red-brown feldspathic sandstones and characteristically occur as beds about 2 inches thick.

WARTON SANDSTONE

Distribution of Exposures: The Warton Sandstone crops out in a zone from 2 to 6 miles wide extending from the central-northern margin of the Sheet area southwards to the centre of the Sheet area, where it swings to the west and follows a paraboloid course around the western nose of the Mount Barnett Syncline. It is largely obscured by the unconformably overlying Mount House Group between the Phillips Range and the Traine River, but east of the Traine River it is exposed in an ESE - trending belt which intersects the southern margin of the Sheet area.

Stratigraphic Relationships: The Warton Sandstone conformably overlies the Carson Volcanics and is conformably overlain by the Elgee Siltstone. These relationships hold throughout the Kimberley Basin.

Lithology and Thickness: The thickness of the Warton Sandstone seems to be fairly consistent throughout the western part of the Sheet area - rough estimates of its thickness range from 1300 feet east of Gibb River Homestead to 1600 feet in the Barnett Range; a thickness of 1400 feet is thought to be present north of the Phillips Range. In the south-eastern corner of the Sheet area no observations have been made, but to the south-west (in the Lansdowne Sheet area) the thickness has been estimated (Gellatly et.al.) to be 900 feet, and to the north-east (in the Lissadell Sheet area) 700 feet (Dow et.al., 1964).

In the western part of the map area the lowermost 50 feet of the unit consists of poorly resistant, purple-grey or buff-weathering, pale purple-grey, flaggy, blocky massive, fine and medium-grained feldspathic sandstone.

The rocks (R65163018, 19, 20) are made up of subrounded to angular grains of quartz (75 to 90%) set in a cement made up predominantly of clay minerals, but also containing variable amounts of secondary silica, (in the form of overgrowths), sericite, detrital muscovite, and feldspar. Iron oxide dust occurs either in laminae or as fine coatings of the quartz grains. Rutile, zircon, tourmaline and opaques occur in accessory amounts.

The strata are commonly cross-bedded, the foresets being from 3 inches to 3 feet thick. The cross-beds are characteristically of the planar, tabular, shallow-dipping type. No ripple marks have been observed in the strata.

The overlying beds, which form the bulk of the Warton Sandstone are more resistant to erosion and form a scarp overlying the basal beds. White or orange weathering, white and buff, blocky, laminated to thick-bedded medium-grained quartz sandstone predominates but interbeds of feldspathic sandstone occur in the sequence.

The quartz sandstone (R65163021, 22) consists almost wholly of quartz, with only trace amounts of feldspar, clay, tourmaline, zircon, muscovite, rutile and iron oxides. The quartz grains are cemented by quartz overgrowths; they were originally subrounded to rounded, and, in general well sorted.

Cross-beds are fairly common in the sequence; most are of the planar, tabular type but trough types have been noted low in the sequence. Recumbently folded cross-beds have been noted at one locality (fig.12). Current ripple marks are present, but are extremely rare. Clay pellets are also comparatively rare.

ELGEE SILTSTONE

<u>Distribution of Exposures</u>: Intermittent exposures of the Elgee Siltstone occur in a zone extending northwards from the headwaters of the Chapman River; in a zone around the Mount Barnett Syncline and extending to the east of the Traine River with a wide gap where the beds lie unconformably below the Mount House Group; in an area surrounding a point about 10 miles south-west of Karunjie Homestead; and in the extreme south-eastern corner of the Sheet area.

Stratigraphic Relationships: The Elgee Siltstone conformably overlies the Warton Sandstone and is conformably overlain by the Pentecost Sandstone. These relationships hold throughout the Kimberley Basin.

Lithology and Thickness: The Elgee Siltstone is about 700 feet thick in the Phillips Range district and is thought to maintain this general order of thickness over most of the area, although there may be a slight thinning to the north.

Strata of the lower half of the unit are rarely exposed and no complete sections are available for study. A few isolated exposures of beds within this part of the unit occur along the Gibb River-Karunjie road. Here softer strata, including red-brown siltstone, alternate with more resistant arenaceous beds. The latter include beds of pink blocky, laminated, fine-grained feldspathic sandstone; buff, flaggy to blocky fine-grained quartz sandstone; and buff-weathering, pale grey-green, flaggy and blocky, laminated, fine-grained feldspathic sandstone. The latter (R65163017) consists of poorly sorted, subangular to subrounded grains of quartz (60%) with secondary overgrowths (15%) and feldspar (10%) cemented by chlorite (15%); tourmaline, zircon and apatite are present in accessory amounts.

In the south-eastern part of the Sheet area the lowermost beds of the unit have been mapped as belonging to the Teronis Member, which is recognised in the adjoining Lissadell Sheet area (to the east) where it is about 50 feet thick and consists of grey and green shale and micaceous shale with interbeds of flaggy, grey and green dolomite and minor algal dolomite (Dow et al, 1964).

The upper half of the Elgee Siltstone is reasonably well exposed, not because of its inherent resistance to erosion but because the strata are protected by the overlying, resistant, scarp-forming beds of the Pentecost Sandstone. Red-brown siltstone, and mudstone make up at least 90% of the stratigraphic column. These rocks are generally fissile and break up into a starchy scree. Laminations are apparent only in restricted parts of the sequence. Thin (1" to 2'), widely spaced interbeds of red-brown to grey-green and rarely pink, flaggy, laminated, fine and very fine-grained sandstone occur in the sequence and increase in abundance towards the top. Iron oxide-stained quartz sandstone is probably the most abundant type, but feldspathic sandstone and silty sandstone appear to be fairly common. The beds almost invariably bear oscillation or current ripple marks, and in places small-scale cross-beds are present. Load casts are very common at the base of the sandy beds, and scattered red-brown and green siltstone pellets, lithologically identical to the siltstone comprising the bulk of the sequence, are abundant in many of the beds.

East of Gibb River, on the road to Karunjie two beds of red-brown, flaggy to blocky, fine and medium-grained quartz sandstone, each about 20 feet thick, separated by 2 feet of red-brown siltstone represent the top of the unit. The beds are cross-bedded on a small scale, and contain abundant oscillation ripple marks; clay pellets are very common.

PENTECOST SANDSTONE

Distribution of Exposures: Exposures of the Pentecost Sandstone cover most of the eastern half of the Sheet area. The unit is also exposed in the south-western quarter of the area, in the 'core' of the Mount Barnett Syncline.

Stratigraphic Relationships: The Pentecost Sandstone conformably overlies the Elgee Siltstone and is conformably overlain by the Mendena Formation (the lowermost unit of the Bastion Group). In the Mount Ramsay Sheet area the Sandstone is overlain conformably by the Hilfordy Formation, the lowermost unit of the Crowhurst Group (Roberts et. al. 1965).

Lithology and Thickness: The Pentecost Sandstone consists predominantly of quartz sandstone, but contains beds of feldspathic sandstone, glauconitic sandstone, siltstone and shale. Within the map area the unit has a thickness of about 2000 feet.

On the accompanying map the unit has been divided into three un-named members. These will be discussed in turn.

Lower: The lower subdivision of the Pentecost Sandstone is about 500 feet thick and consists entirely of blocky, medium-grained quartz sandstone. The sandstone is generally cream or white in outcrop, but in parts of the sequence purple-grey beds are interbedded. It is characteristically moderately well sorted and contains ubiquitous planar cross-beds.

The sandstone (R65163028) consists of well rounded quartz grains cemented by secondary silica overgrowths. Traces of sericite are present around some of the grain boundaries and rare aggregates of clay and accessory tourmaline are also present.

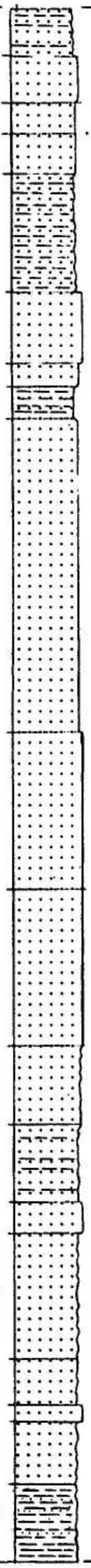
Middle: The middle subdivision of the Pentecost Sandstone is about 1000 feet thick and consists mainly of quartz sandstone, but persistent beds of siltstone, silty sandstone and sandy siltstone occur in the sequence. A generalized stratigraphic column, drawn from several geographically separated localities is set out in Table 1, and shown diagrammatically in figure 2.

Table 1: Generalized stratigraphic sequence - middle subdivision of the Pentecost Sandstone.

		Overlain by upper subdivision
	30'	Purple-weathering, purple, flaggy, laminated fine-grained quartz sandstone (R65163041) interbedded with purple and green siltstone and micaceous silty sandstone
	30'	White and buff-weathering, white, friable, massive and blocky, medium-grained quartz sandstone. Cross-bedded. Contains scattered clay pellets.
A +	20'	White and orange-weathering, white to buff blocky, fine-grained quartz sandstone (R65163037) with pitted weathering surfaces. Scattered clay pellets.
	25'	Pink-brown-weathering, pink, fairly friable, flaggy to blocky, laminated, fine-grained quartz sandstone (R65163040). Forms scarp and bench. Contains light coloured "oxidation" spots. Cross-beds present but not conspicuous. Interbedded with white quartz sandstone of essentially the same composition.
	75'	Brown-weathering, white to brown, friable, flaggy, laminated, fine-grained quartz sandstone (R65163034) interbedded with brown-weathering thinly flaggy to fissile, "papery" micaceous siltstone, sandy siltstone and silty sandstone. Also interbeds of purple, flaggy, laminated, fine-grained sandstone (R65163035) and silt-pellet granule conglomerate (R65163036).

FIGURE 2 : GENERALIZED COLUMNAR SECTION – 'MIDDLE' PENTECOST SANDSTONE

Conformably overlain by 'upper' subdivision



30'	Purple quartz sandstone, siltstone, silty sandstone, f. grained
30'	White quartz sandstone, m. grained
20'	White quartz sandstone, f. grained
25'	Pink quartz sandstone, f. grained
75'	White to brown quartz sandstone, f. grained; siltstone, sandy siltstone, silty sandstone
45'	White to buff quartz sandstone, f. grained
15'	Purple-pink quartz sandstone, f. grained
20'	Purple siltstone, micaceous sandstone
200'	White to buff quartz sandstone, f.-m. grained
100'	Pink feldspathic sandstone, f. grained
100'	White to buff quartz sandstone and feldspathic sandstone, f. grained
50'	White quartz sandstone, m. grained
50'	Pink quartz sandstone; siltstone (?)
20'	White quartz sandstone, f. grained
80'	White, pink, purple quartz sandstone; siltstone (?)
30'	Purple-grey sub-greywacke
10'	Pink quartz sandstone, f. grained
40'	Purple-grey sub-greywacke, f. grained
50'	Grey-green siltstone; sandstone, f. grained

Conformably underlain by 'lower' subdivision

To accompany Record 1968/136
E52/A1/6

45' White-to-brown-weathering, white to buff blocky and flaggy, fine-grained, silicified quartz sandstone. Rare current ripple marks present.

15' Purple-grey-weathering, purple-pink, blocky, laminated to thick-bedded, fine-grained quartz sandstone.

20' Purple, fissile, laminated siltstone interbedded with purple-brown, thinly flaggy, fine-grained micaceous sandstone. Oscillation and current ripple marks common.

B +

?200' White to buff, friable, fine to medium-grained quartz sandstone. Cross-bedded. Jointed.

100' Pink-weathering, flaggy, laminated, fine-grained, well sorted feldspathic sandstone. Some mica along bedding planes. Current ripple marks present.

100' Buff-weathering, white to buff blocky to flaggy, laminated to thin-bedded, fine-grained quartz sandstone and feldspathic sandstone. Cross-beds common, including recumbent types.

C +

50' White friable, blocky to massive, medium-grained quartz sandstone. Abundant dark minerals scattered throughout. Some cross-beds present.

50' Mainly scree-covered, but consists in part at least of pink weathering, pink, blocky and flaggy, fine-grained, very well sorted quartz sandstone with a silica matrix. May be interbedded with softer rocks. Some cross-beds, occasional clay pellets.

20' White-to-pink-weathering, white, flaggy and blocky, fine-grained quartz sandstone with a silica matrix. Contains scattered purple siltstone pellets. Weak laminations, some cross-beds. Top forms bench.

80' Rubbly outcrop of blocky and flaggy, fine-grained, pink, mauve and orange-weathering, white, pink and purplish, well sorted quartz sandstone. Current ripple marks, some cross-beds. Probably interbedded with siltstone, but this does not crop out. Top forms bench.

30' Purple-weathering, purple and purple-grey flaggy, laminated, friable, fine-grained ferruginous sub-greywacke. Contains some mud-cracks.

10' Pink-weathering, pink, silicified fine-grained quartz sandstone: massive, weakly laminated to thin-bedded. Small-scale cross-beds present. Forms bench.

40' Purple-weathering, purple and grey, flaggy to blocky, laminated fine-grained, friable to silicified ferruginous sub-greywacke or quartz sandstone. These beds are generally glauconitic but no glauconite was seen in this locality.

50' Green to grey, thinly flaggy to fissile, finely laminated to thinly bedded, micaceous and non-micaceous siltstone. Micro-cross-beds present. Interbedded with green, flaggy, fine-grained sandstone.

Underlain by Lower subdivision

A+ Measured by Abney Level in vicinity of Long. 126°57'E, Lat. 16°08'S. (Photo-reference 3-61-1)

B+ Roughly estimated at and to west of Long. 126°54'E, Lat. 16°36'S. (Photo-reference 9-62-1)

C+ Estimated in vicinity of Long. 126°48'E, Lat. 16°34'. (Photo-reference 9-60-1)

D+ Measured by Abney Level few hundred yards to East of Karunjie Homestead.

The quartz sandstone which forms the bulk of the unit is characteristically blocky, white, buff or pink, fine to medium-grained and in thin section (65163032, 34, 37) can be seen to consist of well sorted subangular to well rounded quartz grains cemented by secondary silica overgrowths.

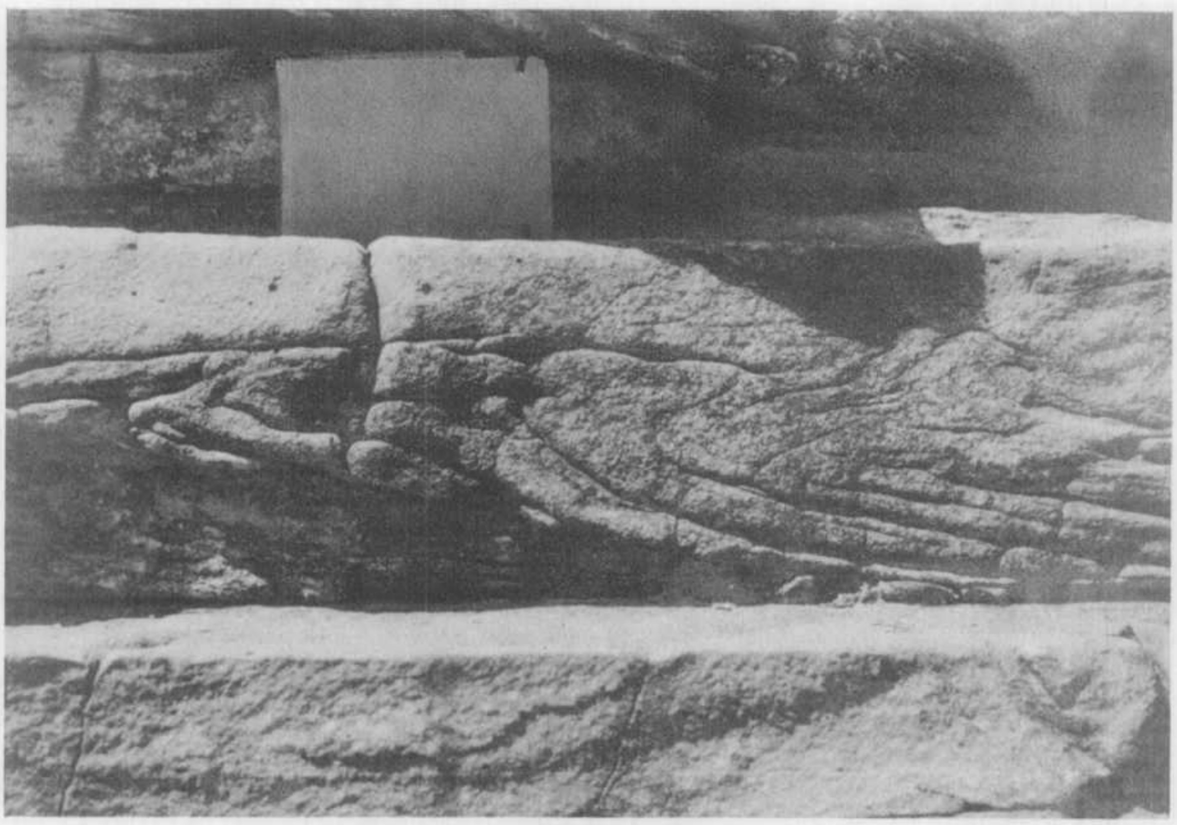


Figure 3: Recumbently folded cross-laminae-middle Pentecost Sandstone, locality P2, figure 12.

Cross-beds of the planar type are very common in the quartz sandstones and recumbently folded cross-laminae have been noted (fig. 3). Many of the beds are "spotted" due mainly to limonite concentrations - in some cases the limonite weathers out to give the rock a pitted appearance in outcrop, but in other cases the limonite is more resistant than the enclosing rock and small protrusions are developed.

Some of the quartz sandstone beds are red-brown or purple due to the presence of iron oxides as grain coatings (65163040) and in the matrix. In places white bleached "spots" occur in these beds.

In the lower part of the subdivision glauconitic sandstone is generally present. The sandstone (65163031,33) consists of moderately well sorted subangular to well rounded grains of quartz, feldspar and glauconite, cemented by quartz overgrowths. Accessory tourmaline and opaques are present. Derrick (1966) has found in the Ashton Sheet area that the glauconite is locally replaced by apatite.

In the lowermost part of the unit green siltstone is interbedded with green fine-grained sandstone. In thin section (65163026,27, 29) these rocks can be seen to consist of quartz, feldspar, chlorite, and muscovite, cemented by secondary quartz overgrowths. Accessory amounts of rutile, apatite, tourmaline zircon and opaques are present. In part of the Ashton Sheet area these beds contain copper minerals (Roberts, Derrick and Ivanac, 1966).

<u>Upper</u>: The upper subdivision of the Pentecost Sandstone crops out extensively in the eastern and south-eastern part of the map area. The lowermost beds generally lie at the top of a prominent scarp (e.g. Bluff Face Range). The thickness of the subdivision is thought to be about 500 feet.

The subdivision consists of white, medium and coarse-grained quartz sandstone, with minor beds of fine-grained quartz sandstone. The sandstones are characteristically blocky and weakly laminated. Cross-beds are ubiquitous and purple clay pellets are common, particularly in the coarse-grained beds. The fine-grained beds are more abundant high in the sequence than in the lower part.

In thin section (65163039) the sandstone consists of quartz grains cemented by secondary silica overgrowths; tourmaline and zircon are present in accessory amounts.

BASTION GROUP

MENDENA FORMATION

Distribution of Exposures: The Mendena Formation is exposed in the Salmond River district (along the eastern margin of the Sheet area), and near the Durack River in the far southern part of the area.

Stratigraphic Relationships: The Formation conformably overlies the Pentecost Sandstone. In the Mount Elizabeth Sheet area the unit is the youngest preserved part of the Kimberley Basin succession but to the east, in the Lissadell Sheet area (Dunnet & Plumb, 1964) the unit is conformably overlain by the Wyndham Shale.

Lithology and Thickness: Only the lower part of the Mendena Formation is preserved in the map area. Exposures are very poor and little can be said about the sequence except that it consists of a series of resistant beds (mainly quartz sandstone) alternating with less resistant beds which are made up in part of purple siltstone.

The resistant beds are generally from 10 to 20 feet thick and consist of brown, green, purple or white fine to medium-grained quartz sandstone. The beds are flaggy or blocky and are generally well laminated. Current and oscillation ripple marks are common in the strata and clay pellets are abundant.

The less resistant strata are rarely exposed, but purple siltstone crops out at several localities and much of the sequence may be made up of this rock type. The less resistant beds range from 10 to 50 feet in thickness.

The total thickness of Mendena Formation preserved in the map area is thought to be about 300 feet.

CARPENTARIAN OR ADELAIDEAN

HART DOLERITE

Distribution of Exposures: The Hart Dolerite is exposed at widely scattered localities throughout the Sheet area.

Stratigraphic Relationships: The Hart Dolerite intrudes (mainly in the form of sills) rocks of the Kimberley Group. The highest stratigraphic position at which the Dolerite has been noted is in the middle subdivision of the Pentecost Sandstone. It is thought to have been intruded after the deposition of the Kimberley Basin Succession, but before its structural deformation and certainly before the deposition of the Mount House Group.

Lithology: In hand specimen the dolerite is most commonly dark-grey-green or black, tough, and generally medium to coarse-grained. It weathers into rounded tors and typically forms low, black-soil-covered flats and valleys. Granophyre is present at one locality 25 miles east of Gibb River Homestead but elsewhere the Dolerite is fairly uniform in appearance.

The main constituents of the most common type of dolerite (65163015, 16) are plagioclase (An_{60}) and augite which occur as sub-ophitic intergrowths associated with minor interstitial micrographic intergrowths of quartz and potash feldspar (3% of rock). Some ilmenite is present. Most of the primary constituents of the rock are altered to some degree. Alteration products include chlorite, carbonate and sericite, the latter being especially evident in the feldspars. Leucoxene is commonly associated with the ilmenite. Accessory apatite crystals and traces of amphibole are present.

One specimen (65163014) contains olivine. The olivine occurs in association with sub-ophitic intergrowths of pyroxene and labradorite. As well as minor amounts of opaques there are aggregate patches of biotite and green amphibole, the latter often rimming pyroxene. Cloudy ?epidote and sericite alteration is most common in the feldspar. Olivine is altered to serpentine minerals and opaques, but the pyroxenes are mainly fresh.

The 'granophyre' (65163013) is a chloritised rock of granitic composition. The potash feldspar occurs as "feathery" radial intergrowths with minor amounts of quartz. On a slightly increased scale these minerals have a micrographic texture but they do not form obvious radial groups. Simple grains of clouded potash feldspar are common in the rock and in the few interstitial areas grains of quartz are intergrown with potash feldspar crystals. Chlorite, with spherulitic texture commonly occurs in these interstices; Sericite is also a common alteration product. Accessory leucoxene, sphene, apatite, rutile and opaques are present in the rock.

ADELAIDEAN

MOUNT HOUSE GROUP

The four formations of the Mount House Group were first described by Gellatly, Derrick and Plumb (1965) in an area of excellent exposure in the scarp on the south-eastern side of the Clifton Plateau (Lat. 17 24'S; Long. 126°E) in the adjoining Lansdowne Sheet area to the south. The Clifton Plateau is 35 miles from the nearest exposure of the Group on the southern margin of the Mount Elizabeth Sheet area and, as might be expected, the sequence differs slightly from that in the type area. The Walsh Tillite and the Traine Formation are the only units recognised.

WALSH TILLITE

Distribution of Exposures: The Walsh Tillite crops out in a north-south zone about 10 to 15 miles wide extending from about 5 miles south-east of Gibb River Homestead, to the southern margin of the Sheet area.

Stratigraphic Relationships: The Tillite rests unconformably on strata of the Kimberley Group and may be inferred to post-date the Hart Dolerite and rocks of the Bastion Group. The unit is conformably overlain by the Traine Formation.

Lithology and Thickness: The Walsh Tillite, as its name implies, consists mainly of tillite, but thin beds of dolomite cap the tillite and have, for mapping purposes, been included in the unit. Rare beds of pebbly sandstone occur within the tillite.

Fresh outcrops of tillite are very rare and much of the area mapped as Walsh Tillite on Plate 1 is covered by bouldery soil; the fresh exposures are restricted to steep creek banks. The best exposures

Figure 4: Outcrop of tillite (Walsh Tillite)
at locality 3.

of tillite to be found are in the main western tributary of the Traine River near Knob Yard (localities 4 and 5, Plate 1) and in a creek bed about 4 miles to the north-west (locality 3).

The tillite consists typically of a dull greyish-purple to red brown, unstratified, poorly sorted mixture of clay and silt-sized grains in which well rounded to angular megaclasts (pebbles, cobbles and boulders), principally of quartzite are embedded (fig. 4). Sand-sized grains are scattered through the matrix. Many of the megaclasts are polished, some are both polished and striated and rare ones are faceted. The largest megaclast found in situ is 7 feet across; at a point about 3 miles east of locality 7 a boulder 18 feet long and 10 feet wide protrudes 6 feet above the soil in which it is embedded - the boulder is almost certainly glacial.

The section exposed at locality 3 is shown in figure 5. The tillite is overlain by a bed, 2 feet thick, of grey silty limestone or dolomite, which in some places shows wavy bedding and in others is contorted. It contains pebbles of silicified sandstone, and is overlain by dark brown silty, possibly chloritic, shale some 25 feet thick; the actual contact was not observed, but it is assumed to be conformable, as the whole sequence is in general flat-lying. The shale is closely fractured and readily breaks into small fragments when struck with a hammer; it contains rare scattered pebbles up to half an inch across and grades upwards into pinkish-brown banded dolomite with a platy parting ranging from $\frac{1}{8}$" to 2", and a thickness of about 15 feet.

In a creek bank near Knob Yard (locality 5) about 30 feet of tillite is exposed. Here the matrix is predominantly silty and the erratics are mainly silicified quartz sandstone and quartzite. Round some of the megaclasts the matrix has a pale green colour. The base of the section is not exposed and the top is soil covered; near the top of the creek bank the matrix shows thin ($\frac{1}{2}$ inch) stratification.

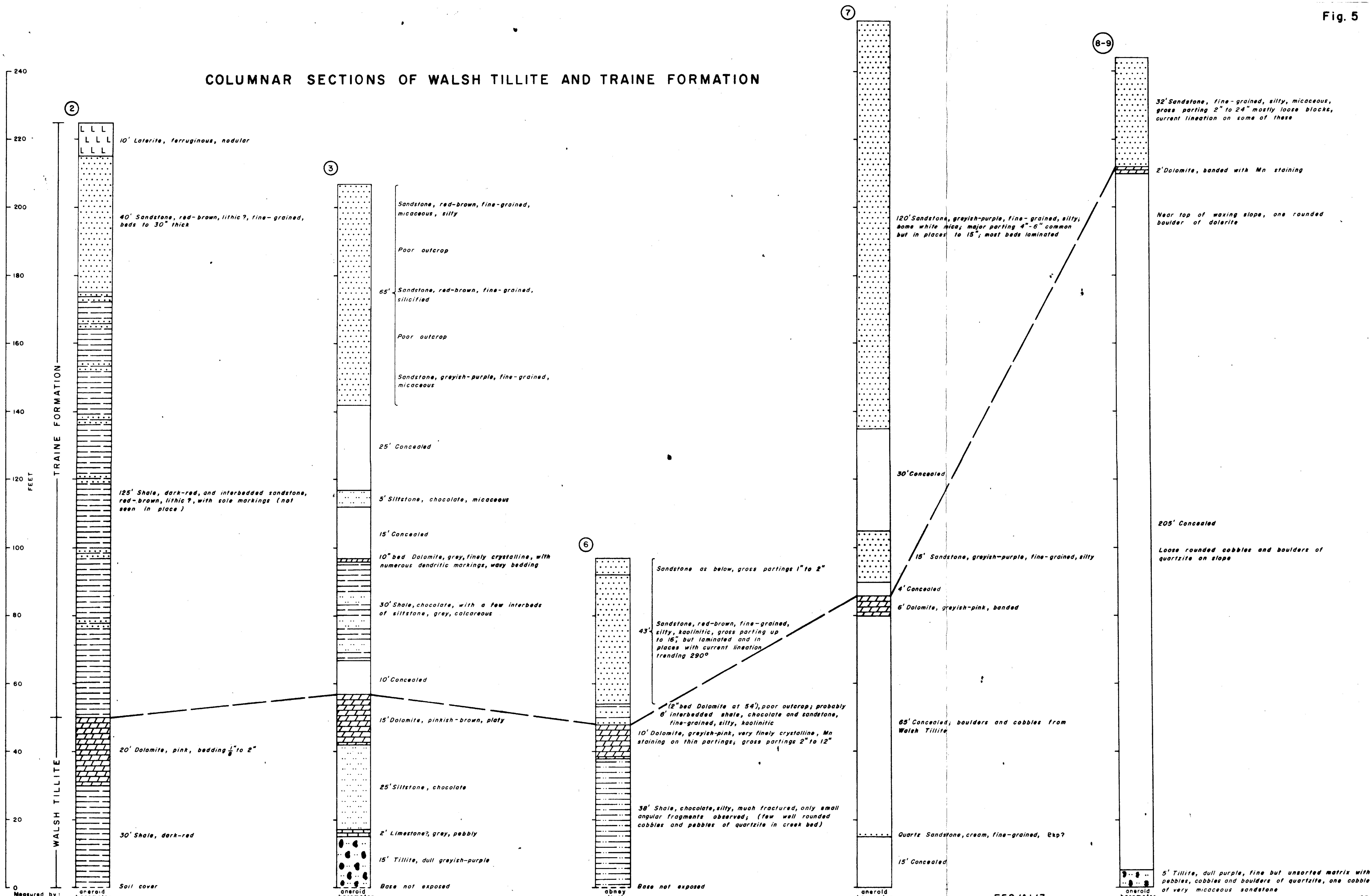
At locality 4 (about half a mile upstream of locality 5) about 20 feet of tillite is exposed. Towards the top of the creek bank the characteristic purplish colour is altered to a pale grey, perhaps due to leaching by ground water of some of the iron content in the tillite matrix. Nearby a strongly cemented, coarse-grained sandstone contains pebbles, cobbles and boulders of silicified sandstone typical of the Walsh Tillite. The sandstone is roughly bedded. A similar outcrop occurs near Nap's Yard (locality 1), where 20 feet of very coarse pebbly sandstone and pebble conglomerate is exposed; the pebbles, as well as the scattered cobbles and small boulders present in the beds are all composed of silicified sandstone. As at locality 4, the pebbly sandstone is roughly bedded and poorly sorted. It rests with slight unconformity on a very coarse-grained sandstone that may be part of the Warton Sandstone.

At locality 6 the tillite is not exposed; dark silty shale occurs at the base of the section. The shale is overlain by very finely crystalline greyish pink dolomite 10 feet thick; manganese staining in the form of dendritic films is evident on fractures and thin partings. Gross parting ranges from 2 to 12 inches. The rock weathers to a grey colour with a fluted and fretted surface. A similar section occurs at locality 2.

At locality 8 tillite crops out in a creek bed and at locality 9, some 200 feet higher in elevation, beds of dolomite crop out. The intervening hill slope is covered with pebbles, cobbles and boulders indicating that tillite lies beneath and thus could possibly be over 200 feet thick. However the tillite may only be mantling a 'basement' slope and could be much thinner than 200 feet.

The dolomite bed which caps the tillite is a good "marker" unit both on the ground and on air photographs, on which it is visible in many places as a light-toned bench. It contrasts strongly with the dark tone of the overlying sandstone of the Traine Formation. The bed is 15 feet thick at locality 3, 6 feet thick at locality 7 and 2 feet thick at locality 9. It is not present in the southern part of the Sheet area, and the fact that the southern limits of the outcrop appear to coincide

Fig. 5


COLUMNAR SECTIONS OF WALSH TILLITE AND TRAINE FORMATION
FEET
240
220
200
180
160
140
120
100
80
60
40
20
0
TRAINE FORMATION
WALSH TILLITE
Measured by:
2
10' Laterite, ferruginous, nodular
40' Sandstone, red-brown, lithic ?, fine-grained, beds to 30" thick
125' Shale, dark-red, and interbedded sandstone, red-brown, lithic ?, with sole markings (not seen in place)
20' Dolomite, pink, bedding 1/8" to 2"
30' Shale, dark-red
Soil cover
aneroid barometer
3
Sandstone, red-brown, fine-grained, micaceous, silty
Poor outcrop
65'
Sandstone, red-brown, fine-grained, silicified
Poor outcrop
Sandstone, greyish-purple, fine-grained, micaceous
25' Concealed
5' Siltstone, chocolate, micaceous
15' Concealed
10" bed Dolomite, grey, finely crystalline, with numerous dendritic markings, wavy bedding
30' Shale, chocolate, with a few interbeds of siltstone, grey, calcareous
10' Concealed
15' Dolomite, pinkish-brown, platy
25' Siltstone, chocolate
2' Limestone?, grey, pebbly
15' Tillite, dull greyish-purple
Base not exposed
aneroid barometer
6
Sandstone as below, gross partings 1" to 2"
43'
Sandstone, red-brown, fine-grained, silty, kaolinitic, gross parting up to 16", but laminated and in places with current lineation trending 290°
(2" bed Dolomite at 54'), poor outcrop; probably 6' interbedded shale, chocolate and sandstone, fine-grained, silty, kaolinitic
10' Dolomite, greyish-pink, very finely crystalline, Mn staining on thin partings; gross partings 2" to 12"
38' Shale, chocolate, silty, much fractured, only small angular fragments observed; (few well rounded cobbles and pebbles of quartzite in creek bed)
Base not exposed
abney level
To accompany Record 1966 / 136
7
120' Sandstone, greyish-purple, fine-grained, silty; some white mica; major parting 4"-6" common but in places to 15"; most beds laminated
30' Concealed
15' Sandstone, greyish-purple, fine-grained, silty
4' Concealed
6' Dolomite, greyish-pink, banded
65' Concealed; boulders and cobbles from Walsh Tillite
Quartz Sandstone, cream, fine-grained, Ekp?
15' Concealed
aneroid barometer
E52/A1/3
8-9
32' Sandstone, fine-grained, silty, micaceous, gross parting 2" to 24" mostly loose blocks, current lineation on some of these
2' Dolomite, banded with Mn staining
Near top of waxing slope, one rounded boulder of dolerite
205' Concealed
Loose rounded cobbles and boulders of quartzite on slope
5' Tillite, dull purple, fine but unsorted matrix with pebbles, cobbles and boulders of quartzite, one cobble of very micaceous sandstone
aneroid barometer
JF

with the extrapolated crest-line of the Warton Sandstone cuesta in the Barnett Range, suggests that the crest line may have been exposed during the deposition of the dolomite.

Glaciated Pavements

West of Morris Range seven exposures of polished, grooved and striated bedrock have been observed at seven main localities. These features are considered to be due to the abrasive action of subglacial moraine material as it was moved along close to or in contact with the surface of the bedrock by its enclosing ice.

At each exposure the bedrock is composed of silicified quartz sandstone of the lower subdivision of the Pentecost Sandstone.

The pavement localities are shown on Plate 1 where they have been numbered P1 to P7. Details of their location are given in Table 2.

Table 2 : Location Details - glaciated pavements

Map Symbol	Air Photo Reference	Grid Reference	Latitude (S)	Longitude (E)
P1	11-61-7	446894	16°40'45"	126°21'50"
P2	11-61-8	447894	16°41'00"	126°21'45"
P3	11-61-9	442898	16°42'20"	126°23'20"
P4	11-61-2	442897	16°42'35"	126°23'40"
P5	11-61-4	445895	16°42'30"	126°24'10"
P6	13-02-2	441879	16°50'15"	126°21'10"
P7	13-08-6	449876	16°51'30"	126°25'30"

Pavement P1 extends over an area about 50yards wide and 50 yards long, but large parts of the surface have been destroyed by recent erosion. In places the pavement retains a bright polish but over most of the area parallel grooves and striae are the only vestiges of glaciation. Along the north-western part of the pavement a brightly polished north-dipping surface bears deep crescentic gouges (Harris, 1943, p249; Flint, 1957, p64) and well developed parallel grooves and striae. The distribution of polished and unpolished areas within the crescentic gouges gives good evidence of ice-flow from the north. Fine crescentic fractures are present on this surface; most are concave downstream, but some are concave upstream. The grooves and striae are consistently oriented throughout the entire area of the pavement; they trend at 195°.

Pavement P2 is about 20 by 20 yards in area and although polishing is rare (due to recent weathering) grooves and striae remain conspicuous. Crescentic gouges are developed on north-dipping slopes within the pavement and again give evidence of ice flow from the north. The grooves and striae have trends ranging from 187° to 195°.

Pavement P3 covers an area of about 10 by 5 yards and although it is well polished and grooves and striae are abundant, there is no clear evidence of the sense of ice movement. The grooves and striae trend at 195°.

Pavement P4 (fig. 6) is of similar extent and the polish and grooves and striae are generally well preserved. The grooves and striae have trends ranging from 190° to 197°. In one part of the pavement a small ledge standing 3 inches above the general level of the pavement provides evidence of ice flow from the north. The lower, northern surface is polished and striated to within a few inches of the ledge, which itself has a brightly polished vertical wall, but no striae. The intersection between the wall and the higher, southern surface is rounded and pitted with numerous small crescentic gouges (concave to the south). This combination of features is most unlikely to have developed if the ice flow had been from the south.

Pavement P5. At locality P5 several beds of sandstone, displaying polishing and striations over an area of a few square yards, are exposed on the northern side of a low hill of quartzite rubble derived from the Walsh Tillite. The direction of the striations on the relatively flat bedding surfaces ranges from 170° to 190°, and the northern edges of the beds are rounded and polished, strongly suggesting ice movement from the north.

Pavement P6. occurs on an elongate north-trending, mound-like ridge of quartz sandstone. To the east, west and north the ridge dips beneath bouldery soil (tillite residue); it appears to have formed an elevated area in

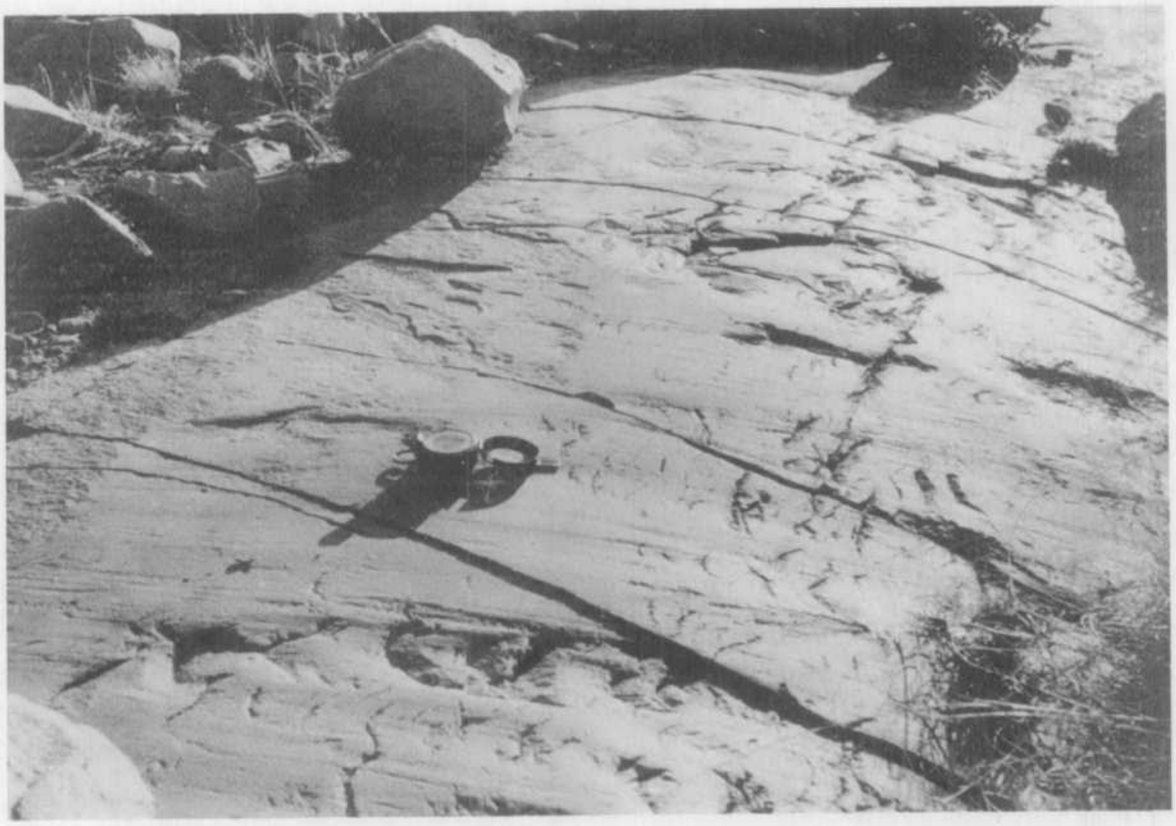


Figure 6: Part of glaciated pavement P4. Note deep crescentic gouges (foreground); parallel grooves and striae; bright polish and crescentic fractures. Long arm of compass points north.

Figure 7: North-eastern part of glaciated pavement P6. Note deep grooves, bright polish and abundant striae on upper surface in contrast to patchy polish on lower surface. Long arm of compass points north.

the pre-tillite terrain. The ridge is about 500 yards long and 100 yards across and rises to 20 feet above the surrounding level. Polished, grooved and striated surfaces occur along the western margin of the ridge (at the foot of the ridge slope), and in the north-east. Less well preserved grooves and striae also occur on the crest of the ridge. Along the western margin and on the crest the grooves and striae have trends ranging from 187° to 197°, but in the north-east they trend at 165°. In the latter area it is probable that the ice flow was deflected by the north-easterly dipping ridge face.

Good evidence of the sense of movement of the ice occurs on the north-dipping, northern parts of the ridge surface. At one locality, in the extreme north-east, deep grooves have been cut into the bedrock; they are terminated southwards by a broken, patchily polished, south-dipping face (fig.7). The patchy polish on the southern face indicates that the breakage occurred either before or during the glaciation. The contrast in the degree of polishing on the broken and grooved surfaces leaves little doubt that ice flow was from the north.

Crescentic gouges (concave northwards) and crescentic fractures (concave southwards) are common on the northern ridge slopes and although Flint (1957, P64) regards these features as unreliable indicators, the general consistency of orientation, (particularly of the gouges) in the Mount Elizabeth Sheet area can be taken as supporting evidence of ice flow from north to south.

Pavement P7, which covers an area of approximately 60 x 25 yards was found by Harms (1959) and is by far the best preserved glaciated surface yet known in the Kimberley region. Virtually the e ntire surface is brightly polished and is traversed by long parallel grooves and striae. Some of the grooves are several inches deep (fig. 8) and 20 yards long but most are shallow and less than an inch across. Chatter-marks (concave southwards) are common in the grooves and crescentic gouges occur on north-dipping parts of the surface. Taken overall the pavement surface is slightly arched; the central part of the surface is 5 feet or so higher in elevation than the northern extremity.

No conclusive evidence of the ice-flow direction was found on the pavement but the crescentic gouges are oriented as in the other pavements of the Sheet area and suggest ice flow from the north.

The grooves and striae have trends ranging from 173^{o} to 177^{o}.

TRAINE FORMATION

Distribution of Exposures: The Traine Formation crops out within a belt extending about 20 miles northwards from the southern margin of the Sheet area between the Phillips Range and the Traine River.

Stratigraphic Relationships: The Formation rests conformably on the Walsh Tillite. The top of the unit is eroded.

Lithology and Thickness: The best section of the Traine Formation in the Mount Elizabeth Sheet area is exposed to the south of locality 3 (Plate 1). The sequence is shown diagramatically on figure 5. Chocolate (dark brown) shale (with a few interbeds of grey calcareous siltstone occurs at the base of the unit but the section becomes more silty upwards and some 85 feet above the base it grades into fine-grained micaceous sandstone. At this level the sandstone is greyish-purple, but higher it is red-brown, and it is the latter colour that seems to be responsible for the strikingly dark tone on the air photos. Many of the hill slopes are mantled with loose

Figure 8: Grooves and striae on glaciated pavement P.7.

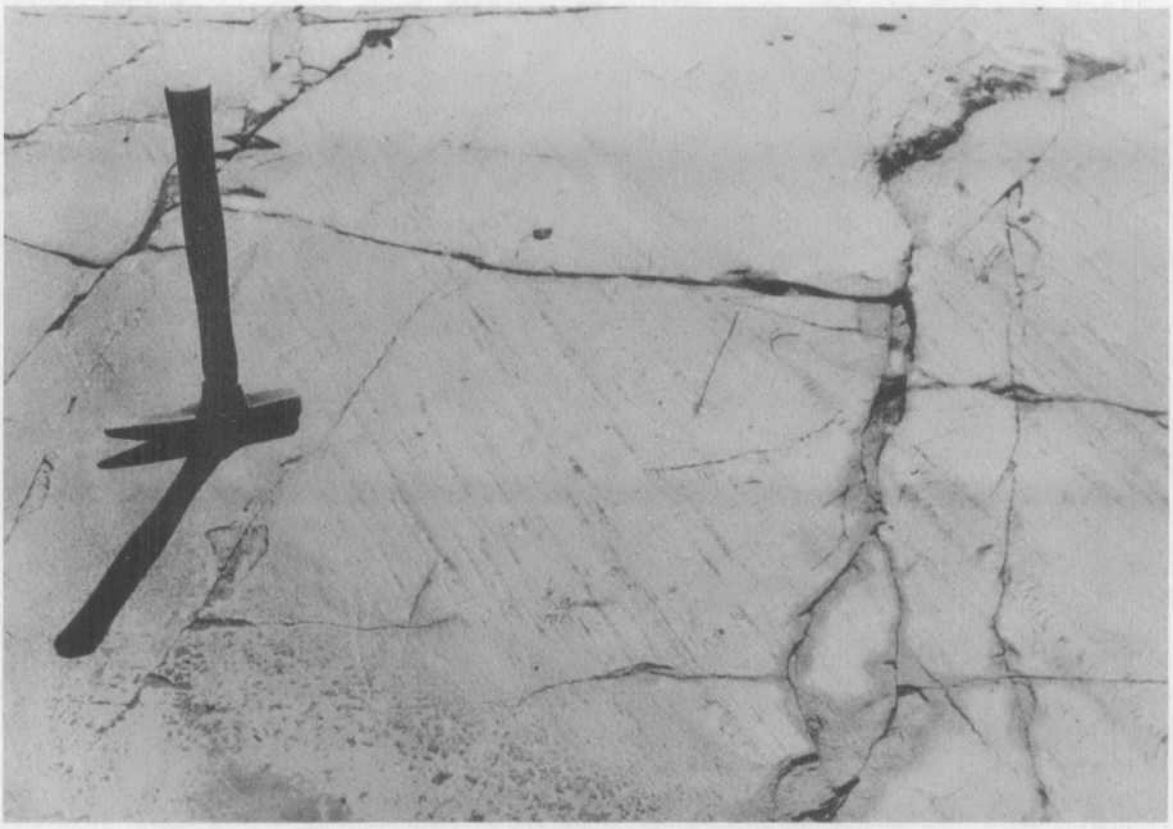


Figure 9: Grooves and striae on glaciated pavement P7. Note trains of chatter-marks (in shallow grooves - centre of photo) and crescentic fractures (right).

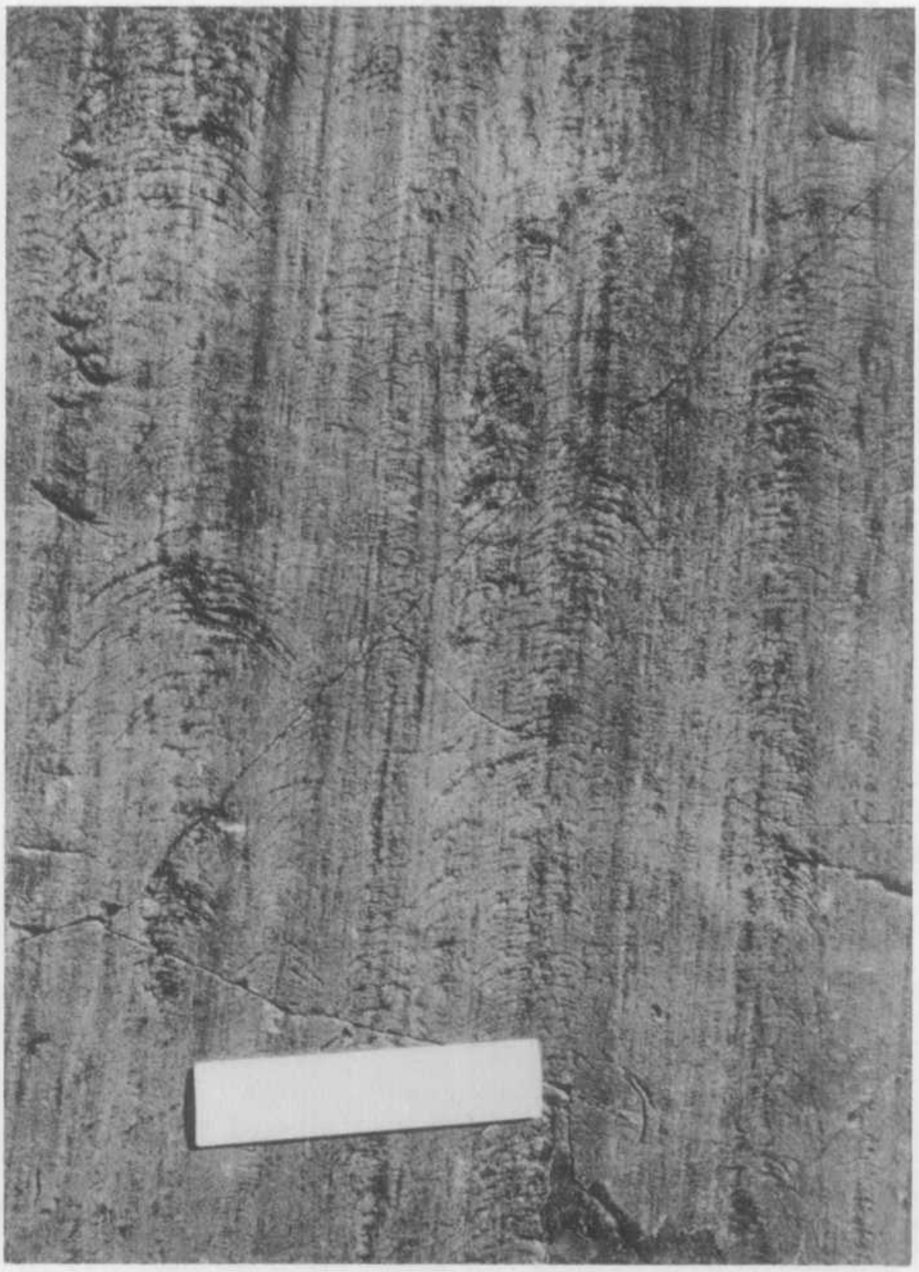


Figure 10: Crescentic fractures on glaciated pavement P7; top of photo towards north; scale 6 inches long.

fragments of the red-brown sandstone, and this accounts for the variation -- in detail -- of the edge of the dark toned area. The unit is 150 feet thick at this locality, but its top has been eroded.

At locality 2 dark red shale overlies the dolomite of the Walsh Tillite; only small angular fragments of shale are seen, and the hill slope is littered with angular blocks of red-brown, fine-grained sandstone showing current lineation (Stokes, 1947). Some of this sandstone may be interbedded with the shale, or it may derive from the upper part of the section where 40 feet of red-brown sandstone is seen in place. At this locality, some 10 feet of ferruginous nodular laterite caps the sandstone; the preserved thickness of the Formation is 165 feet.

At locality 7 a 4-foot interval above the dolomite may be underlain by shale, but the first definite outcrop is of thickly bedded, greyish-purple, fine-grained silty sandstone 15 feet thick. The next 30 feet is concealed and is succeeded by flaggy to blocky, laminated sandstone that continues to the top of the hill. In places it is well jointed. Current lineation was seen on many loose blocks, but only rarely in place. The thickness of the Traine Formation at this locality is 170 feet, but its top is eroded.

Less than 50 feet of the Formation is present in the section at locality 6. Immediately above the dolomite the outcrop is poor but the sequence is thought to consist of interbedded chocolate (dark brown) shale and fine-grained silty sandstone. This is succeeded by medium to thick-bedded, red-brown, fine-grained sandstone.

CAINOZOIC

Thin deposits of laterite and unconsolidated materials of probable Cainozoic age are widely distributed within the Sheet area. Although we have no means of accurately determining the age of any of these deposits it is thought that the laterite may be of Tertiary age, and that the alluvial deposits may be Quaternary.

Laterite (Tp). Only a few small outcrops of laterite are known in the map area - a group of exposures occurs to the east of Gibb River Homestead and further scattered exposures occur some 20 to 30 miles north of the Homestead. All the known deposits have been developed on the Carson Volcanics, and in most cases both a mottled zone and a pisolitic zone are present. The laterite is typically open-textured and yellow, orange or brown in colour.

Lateritic soil (Czl) In an area 20-40 miles north of Gibb River Homestead strongly ferruginous and pisolitic soils are present and have been mapped with the symbol Czl. They are believed to be residual soils developed on laterite.

Black soil (Czb) Small scattered deposits of grey or black clayey soil occur in areas underlain by basic igneous rocks and have been mapped as "Black Soil" (Czb).

Soil, sandy soil and eluvium (Czs) The most extensive of the Cainozoic deposits are the soils and eluvium developed on gentle hill slopes and on plateaux. A great variety of soil types are present but two broad classes can be recognized -

(i) the reddish, fine, even-textured soils developed on the Carson Volcanics, and

(ii) the light coloured sandy soils developed on the arenites.

The Carson Volcanics, Elgee Siltstone and Mendena Formation are less resistant to erosion than the other units in the sequence and they are extensively soil-covered.

Alluvium (Qa). Deposits of alluvium are common along the major watercourses but in general they have little areal extent - the flood plains are typically narrow. The alluvium is generally composed of fine sand and reddish mud.

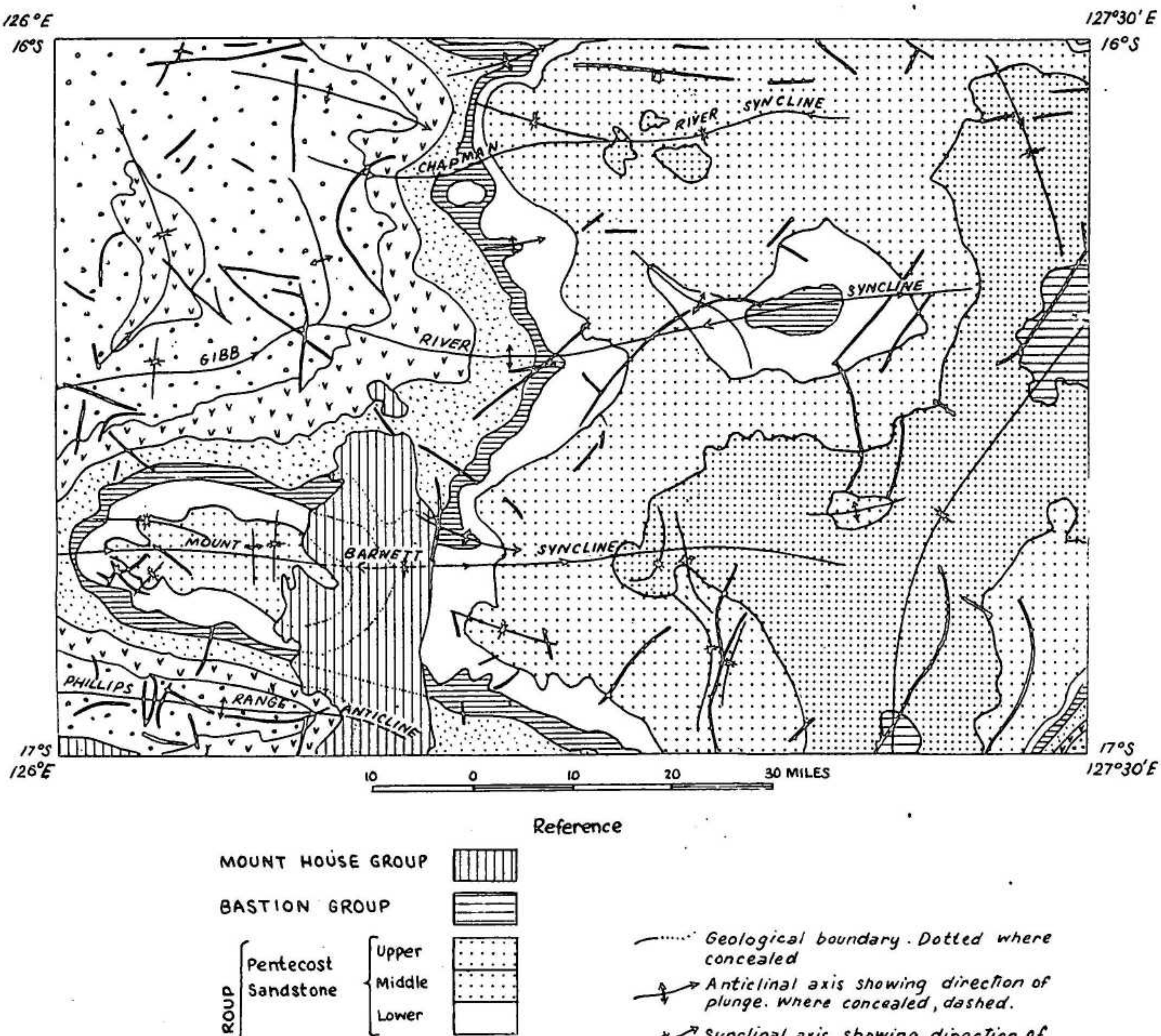
TABLE 3: SUMMARY OF STRATIGRAPHY - MOUNT ELIZABETH 1:250,000 SHEET AREA

Era	Age	Group	Rock Unit and Symbol	Lithology	Maximum Thickness in Feet	Physiographic Expression	Distribution	Remarks
CAINOZOIC	QUATERNARY (?)		Qa	Alluvium	20	Flood-plains along major watercourses	Widespread; occurs in small areas flanking major watercourses	Shown on Plate 1 only where of comparatively large extent.
CAINOZOIC	UNDIFFERENTIATED		Czs	Soil, sandy soil, eluvium	20	Flats, gentle slopes	Widespread	Developed principally on Carson Volcanics, Elgee Siltstone and Mendena Formation
CAINOZOIC	UNDIFFERENTIATED		Czb	Black or grey clayey soil	10(?)	Low-lying flats	Restricted to small, isolated areas in the Gibb River Homestead district and near Karunjie	Developed only on the Carson Volcanics and the Hart Dolerite
CAINOZOIC	UNDIFFERENTIATED		Czl	Ferruginous, pisolitic, lateritic soil	10(?)	Flat areas or very gentle slopes	Restricted to small, isolated areas in the Plain Creek district	Confined to areas underlain by laterite
CAINOZOIC	TERTIARY (?)		Tp	Laterite	30+	Mesas	Confined to small, isolated areas east of Gibb River Homestead and west of Gibb Range	Mottled and pisolitic zones generally well developed
				U N C O N F O R M I T Y				
PROTEROZOIC	ADELAIDEAN	MOUNT HOUSE GROUP	TRAINE FORMATION (Bha)	Red-brown, greyish-purple fine-grained silty micaceous sandstone; dark red shale and micaceous siltstone; minor fine-grained silty kaolinitic sandstone	170+	Resistant and poorly resistant-arenites form scarps and plateaux; lutites form underlying hill slopes	Confined to north-south trending zone south of Gibb River Homestead	Top of unit eroded; conformable on Walsh Tillite
PROTEROZOIC	ADELAIDEAN	MOUNT HOUSE GROUP	WALSH TILLITE (Bhw)	Dull greyish-purple, red brown, tillite; clay and silt matrix with mainly quartzite megaclasts; flaggy pink dolomite	200(?)	Poorly resistant-forms rounded, boulder-strewn hills		Unconformable on rocks of Kimberley Group; dolomite forms good marker horizon
				U N C O N F O R M I T Y				
PROTEROZOIC	ADELAIDEAN OR CARPENTARIAN		HART DOLERITE (Bdh)	Dark grey-green, medium to coarse-grained dolerite; granophyre	-	Poorly resistant-forms valley and low-lying soil-covered areas	Widespread, small areas	Intrudes Kimberley Group as sills, and rarely as dykes. Unconformably overlain by Walsh Tillite. Contains copper minerals near Karunjie
PROTEROZOIC	CARPENTARIAN	BASTION GROUP	MENDENA FORMATION (Btm)	Fine to medium-grained quartz sandstone, purple siltstone	300+	Poorly resistant - forms undulating, soil-covered country, broken by rare strike-ridges and benches	South-east of Karunjie and in an area near the southern margin	Very poorly exposed. Probably pre-dates Hart Dolerite. Unconformably pre-dates Walsh Tillite

TABLE 3 (Contd)

AGE		ROCK UNIT AND SYMBOL			LITHOLOGY	MAXIMUM THICKNESS IN FEET	PHYSIOGRAPHIC EXPRESSION	DISTRIBUTION	REMARKS
PROTEROZOIC	CARPENTARIAN	KIMBERLEY GROUP	PENTECOST SANDSTONE	upper (BKpu)	White, medium and coarse-grained quartz sandstone, minor fine-grained quartz sandstone	500	Resistant - forms elevated rugged terrain. Basal beds cap a prominent scarp	Extensive in east and south-east	Conformably overlain by Mendena Formation
				middle (BKpm)	White, buff and pink fine and medium-grained quartz sandstone; glauconitic sandstone; grey-green micaceous siltstone	1000	Resistant and poorly resistant - where dipping resistant beds form cuestas, where horizontal form mesas, plateaux and benches. Less resistant strata form valleys and bench-cappings	Extensive in north-east, centre, central-south. Also in Barnett Range and in far south-east	Glauconitic beds occur near base. Copper minerals occur in lower part of subdivision in the Ashton 1:250,000 Sheet area (Derrick, 1966)
				lower (BKpl)	White, medium-grained quartz sandstone	500	Strongly resistant - forms cuestas	Continuous north-trending belt through centre of area. Also extensive to south-west of Karunjie and in Barnett Range. Small areas in extreme north-east and south-east	Basal contact somewhat transitional
			ELGEE SILTSTONE (Bke)		Red-brown siltstone and mudstone; red-brown to grey-green fine and medium-grained quartz sandstone and feldspathic sandstone	700	Poorly resistant - forms valleys and steep hill slopes beneath capping of Pentecost Sandstone	Semi-continuous north-trending belt through centre of area and in Barnett Range. Small areas south-west of Karunjie and in extreme south-east	Lower half of unit rarely exposed
				TERONIS MEMBER (Bkt)	Grey and green shale; flaggy grey and green dolomite	50	Poorly resistant - forms low rises	Confined to small areas in extreme south-east	Dolomite beds locally stromatolitic. Member lies at base of formation
			WARTON SANDSTONE (Bkw)		White and buff, medium-grained quartz sandstone; pale purple-grey medium-grained feldspathic sandstone	1600	Resistant - forms cuestas	Semi-continuous belt through Gibb and Barnett Ranges. Also in south-centre and south-east	Upper contact probably transitional
			CARSON VOLCANICS (Bkc)		Grey-green to black, massive and amygdaloidal basalt; amygdaloidal spilite, feldspathic sandstone, micaceous siltstone	2300	Poorly resistant- forms gently undulating country with rounded hills interspersed with wide soil-covered areas	Discontinuous belt flanking Gibb and Barnett Ranges. Isolated areas around Mount Elizabeth Homestead and in extreme south-east	Disseminated copper minerals present locally.
			KING LEOPOLD SANDSTONE (Bkl)		White and buff, medium and coarse-grained quartz sandstone	2800+	Strongly resistant - forms elevated craggy hills and plateaux	Large area in north-west; smaller areas in Phillips Range and in extreme south-east	Base of unit not exposed. Strongly jointed

FIG. II : STRUCTURAL SKETCH MAP — MOUNT ELIZABETH SHEET AREA



To accompany Record 1966/136
E52/A1/4

STRUCTURAL GEOLOGY

The Mount Elizabeth Sheet area lies in the central part of the Kimberley structural Basin. The Basin is bounded to the south-east and south-west by strongly folded and faulted zones, but the central part of the Basin (including the Mount Elizabeth Sheet area), has suffered only mild deformation. The main phase of deformation occurred prior to the deposition of the Mount House Group and most, if not all of the structures present in the Mount Elizabeth Sheet area, are thought to have been developed during this phase. In parts of the Basin, notably in the Lennard River Sheet area, a second phase of deformation occurred after the deposition of the Mount House Group.

Folds: The structure of the Sheet area is dominated by four long, parallel, west-trending folds. The southernmost - the Phillips Range anticline (fig. 11) - has limbs which dip at from 10° to 20°; the limbs of the Barnett Range syncline dip at about 8° in the west but the dips become lower in the east; the Gibb River anticline is a less well defined structure with flanks which dip at 5° or less and the Chapman River syncline has very gently dipping limbs. Thus there is a progressive diminution northwards in the amplitudes of the folds. All the folds have a gentle overall plunge to the east. Numerous minor folds roughly parallel the major folds but they are generally of only local significance.

A second set of important folds trends about north-north-west. Two such folds lie in the Gibb River - Mount Elizabeth district and others occur in the north-eastern and south-central parts of the Sheet area.

A major syncline in the south-eastern segment of the Sheet area trends about north-east and is roughly parallel to the Basin margin. Its limbs are very gently dipping.

Faults: Numerous faults up to 5 miles long and several up to 15 miles long are present in the Sheet area, but few are believed to have throws of more than a few tens of feet. In the eastern half of the Sheet area north-easterly trending faults are predominant, while in the western half north-striking faults are the most abundant.

Easterly and north-westerly trending faults are common in the northern and western parts of the Sheet area. Most of the faults have linear surface traces, but some are arcuate, suggesting perhaps that they were developed during the operation of the stress field responsible for the folding.

Joints: Joints are very numerous in most of the arenites of the area. The most prominent sets trend at 120^{o}, 90^{o}, 60^{o} and 30^{o}.

GEOLOGICAL HISTORY

The oldest rocks exposed in the map area are strata of the King Leopold Sandstone, the basal unit of the Kimberley Group. The sedimentary basin in which the Kimberley Group was deposited began to develop about 1800 million years ago, at the beginning of the Carpentarian Period. At this time acid lavas (Whitewater Volcanics) were extruded onto an eroded surface made up of folded geosynclinal strata and igneous intrusive rocks. The lavas were submerged and the arenites and lutites of the Speewah Group were laid down on them, probably in a shallow marine environment. It is not known if the Whitewater Volcanics or the Speewah Group occur in the subsurface in the Mount Elizabeth Sheet area.

The King Leopold Sandstone was apparently deposited in a shallow marine environment marked by persistent, strong current activity.

The deposition of the King Leopold Sandstone was followed by the extrusion of the flood basalts and the deposition of the clastic and pyroclastic materials which make up the Carson Volcanics. The basalts are believed to have been extruded mainly onto a land surface, but some may have been extruded onto a sea floor. The interbedded sediments were certainly laid down in water.

The succeeding Warton Sandstone is regarded as a shallow marine deposit, as are the overlying units - the Elgee Siltstone and Pentecost Sandstone. During the initial stages of the deposition of the Elgee Siltstone stromatolite colonies and associated carbonate-rich strata were developed in the south-eatern part of the Sheet area.

The Mendena Formation (the lowermost unit of the Bastion Group) is also thought to have been laid down in a shallow marine environment. Although the Mendena Formation is the only unit of the Bastion Group preserved in the Mount Elizabeth Sheet area it is likely that several thousand additional feet of sediment were laid down conformably on it. After the deposition of these beds the succession was intruded by the Hart Dolerite. Subsequently the area was folded, faulted, uplifted and subjected to prolonged erosion; these events occurred either in late Carpentarian or early Adelaidean times. Erosion appears to have bevelled the area to a point approaching the present general levels prior to the deposition of the Mount House Group - glaciation may have played an important role in the denudation.

The Walsh Tillite is thought to have been laid down in a terrestrial environment. The wide distribution of glaciated pavements beneath the tillite, though not ruling out a marine environment, is more suggestive of terrestrial conditions. The dolomite beds at the top of the unit are restricted in their distribution to the north of the extrapolated crest-line of the Warton Sandstone ridge in the southern Barnett Range, and this suggests that the crest-line may have remained subaerially exposed during the deposition of the dolomite. The fine, regular laminations in the dolomite and the nature of its association with the tillite, together with the evidence that it was deposited over a restricted area suggest that it was laid down in a lake during the initial stages of ice retreat. If this interpretation is valid it provides further evidence of a terrestrial origin for the tillite.

Following the deposition of the dolomite the ice probably retreated further and normal clastic sedimentation appears to have begun in a shallow, transgressive sea. The Traine Formation is the only preserved record of this sedimentation in the Mount Elizabeth Sheet area. Further strata were probably deposited but they were eroded following a marine regression.

The next recorded event was the development of a laterite profile, probably in Tertiary times. Erosion of the laterite, and the development of various soils and alluvial deposits are the most recent events to have effected the area. The development of the present drainage system possibly post-dates the establishment of the laterite profile, but the evidence in this regard is inconclusive.

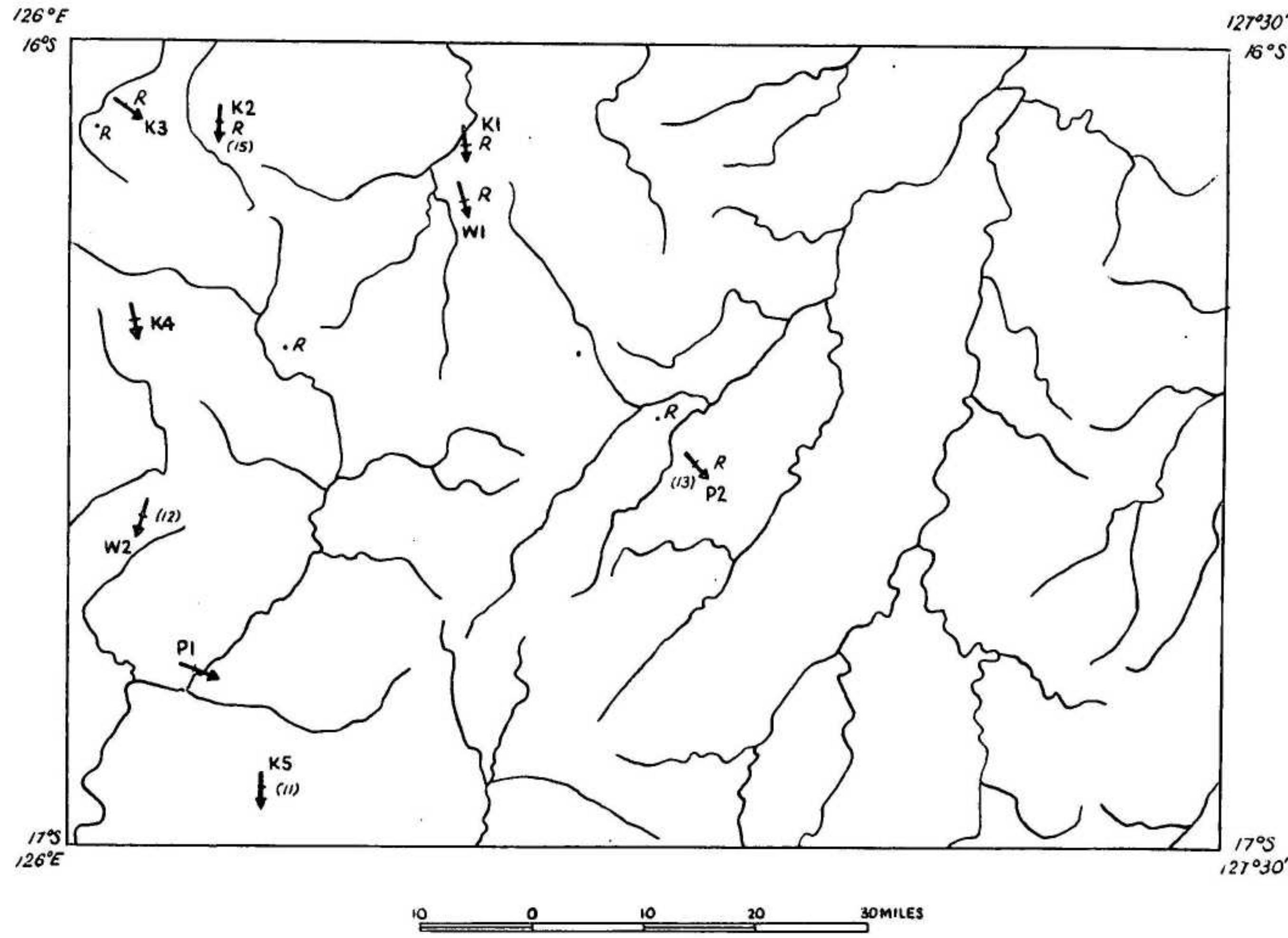
Cross-bed Orientations - Kimberley Group

The arenites of the Kimberley Basin succession are ubiquitously cross-bedded and as part of a wider, regional study, cross-bed orientations were measured at 9 localities in the Mount Elizabeth Sheet area (fig. 12).

At each of 5 of these localities 25 separate, randomly chosen, sets of cross-strata were measured; at the other 4 localities between 11 and 15 measurements were made. Five localities are in the King Leopold Sandstone, two are in the Warton Sandstone and two are in the Pentecost Sandstone.

The results are summarized in Table 4. The directions of dip of the cross-strata studied range from 31° to 255°, but 67% lie within the arc 136° to 210°, and it may be concluded that the most important direction of current flow was from the north-north-westerly quadrant.

FIGURE 12 : CROSS-BED ORIENTATIONS — MOUNT ELIZABETH SHEET AREA



Reference

Mean direction of dip of cross beds

2 Locality number. Prefix K = King Leopold Ss ; W = Warton Ss ; P = Pentecost Ss

(13) Number of measurements where less than 25

R Recumbent cross bed locality

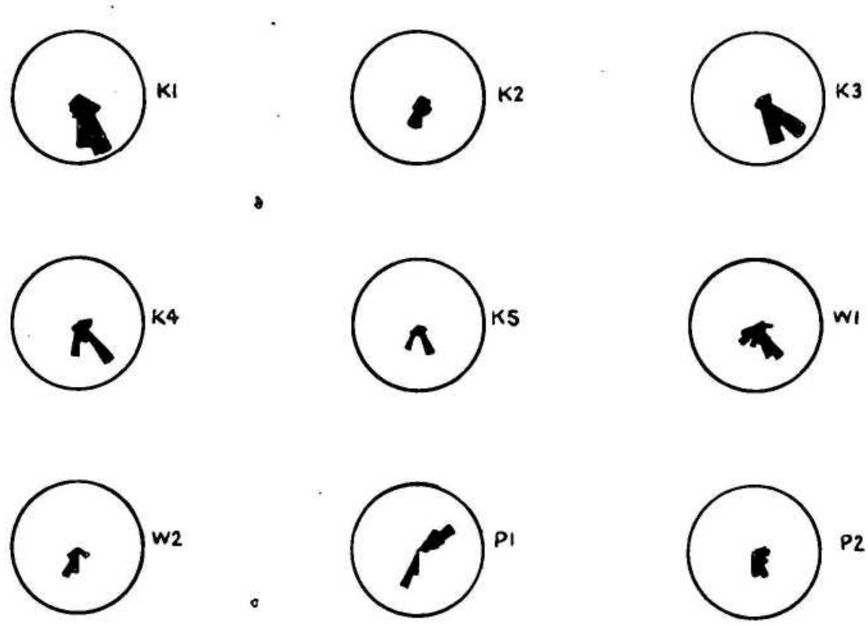


Table 4: Analysis of cross-bed dip directions measured in the Mount Elizabeth Sheet area. The numbers of readings at each locality falling within specified 15° intervals of arc are indicated by numerals.

Direction of dip of cross-beds	Localities (See Fig. 11)									total number of measurement
	K1	K2	K3	K4	K5	W1	W2	P1	P2	
1- 15										
16- 30										
31- 45								4		4
46- 60								6		6
61- 75						1		3		4
76- 90			2	2		2		2	1	9
91-105			1						2	3
106-120			8			2		1	1	12
121-135	1	1	5	1		1				8
136-150	3	1	7	7	1	4	1		2	26
151-165	9	2	1	3	4	4	1		4	28
166-180	7	2		5	1	2			3	20
181-195	3	4	1	5	1	3	2	3		22
196-210	2	4		1	3	1	5	6		22
211-225	1	1			1		2			5
226-240				1		3				4
241-255						2	1			3
256-270										
271-285										
286-300										
301-315										
316-330										
331-345										
346-360										
Total number of measurements	25	15	25	25	11	25	12	25	13	176

ECONOMIC GEOLOGY

Apart from water no mineral deposits of economic value are known in the Mount Elizabeth Sheet area. Occurrences of copper minerals are known and bauxite has recently been discovered in adjoining areas.

Water: Surface water supplies are plentiful and reasonably widely distributed over the Sheet area. There are no permanently flowing watercourses but large waterholes persist in the major streams throughout the dry season. The Hann, Chapman and Durack Rivers are notable in this regard.

The prospects of obtaining underground water supplies appear to be good. No bores have yet been sunk but a spring issuing from the King Leopold Sandstone supplies Gibb River Homestead and provides evidence that the Sandstone is capable of acting as a water reservoir. Many of the other arenites may also be sufficiently porous and permeable to act as useful reservoirs, although deep silicification may in some places have effectively sealed the rocks.

An account of the hydrology and hydrogeology of the Kimberley region is given by Allen (1966).

Copper: Harms (1959) has drawn attention to occurrences of copper minerals in the Hart Dolerite near Karunjie Homestead and in the Carson Volcanics.

Near Karunjie chalcocite and chalcopyrite occur in loose boulders of Hart Dolerite scattered through black soil. Only a small proportion of the boulders contain visible copper minerals. The minerals occur as disseminated discrete crystals or, less commonly, in small clots.

Chalcopyrite and malachite have been noted in lavas of the Carson Volcanics near the Barnett River Gorge. The minerals occur as scattered, discrete crystals and in small vughs. Similar occurrences are common in the Carson Volcanics elsewhere in the Kimberley region but nowhere have concentrations of economic interest been found.

Roberts, Derrick and Ivanac (1966) have described copper occurrences in the extreme south-eastern part of the Ashton and the south-western part of the Cambridge Gulf Sheet areas. The occurrences are 25 miles apart, but they occupy identical positions in the stratigraphic column - both occur in green micaceous siltstone about 30 feet above the base of the middle subdivision of the Pentecost Sandstone. Although the grade is low (0.36% Cu in one instance) the beds are worthy of detailed examination.

Bauxite: During 1965 bauxite was discovered by K. Malcolm of U.S. Metals in the adjoining Ashton 1:250,000 Sheet area (Derrick, 1966). Small outcrops of laterite overlie the Carson Volcanics in the Mount Elizabeth Sheet area and although some may have an above-average alumina content no bauxite has been found and the area is regarded as being unprospective.

Construction materials: Deposits of sand and gravel suitable for building purposes are available at numerous localities throughout the area. Deposits of laterite suitable for road surfacing occur to the east of Gibb River Homestead and may underlie a thin sand or soil cover in a zone extending north from the Homestead to the Sheet margin. The Carson Volcanics and Hart Dolerite provide a potential source of "blue-metal" for road surfacing.

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PRELIMINARY EDITION, 1966

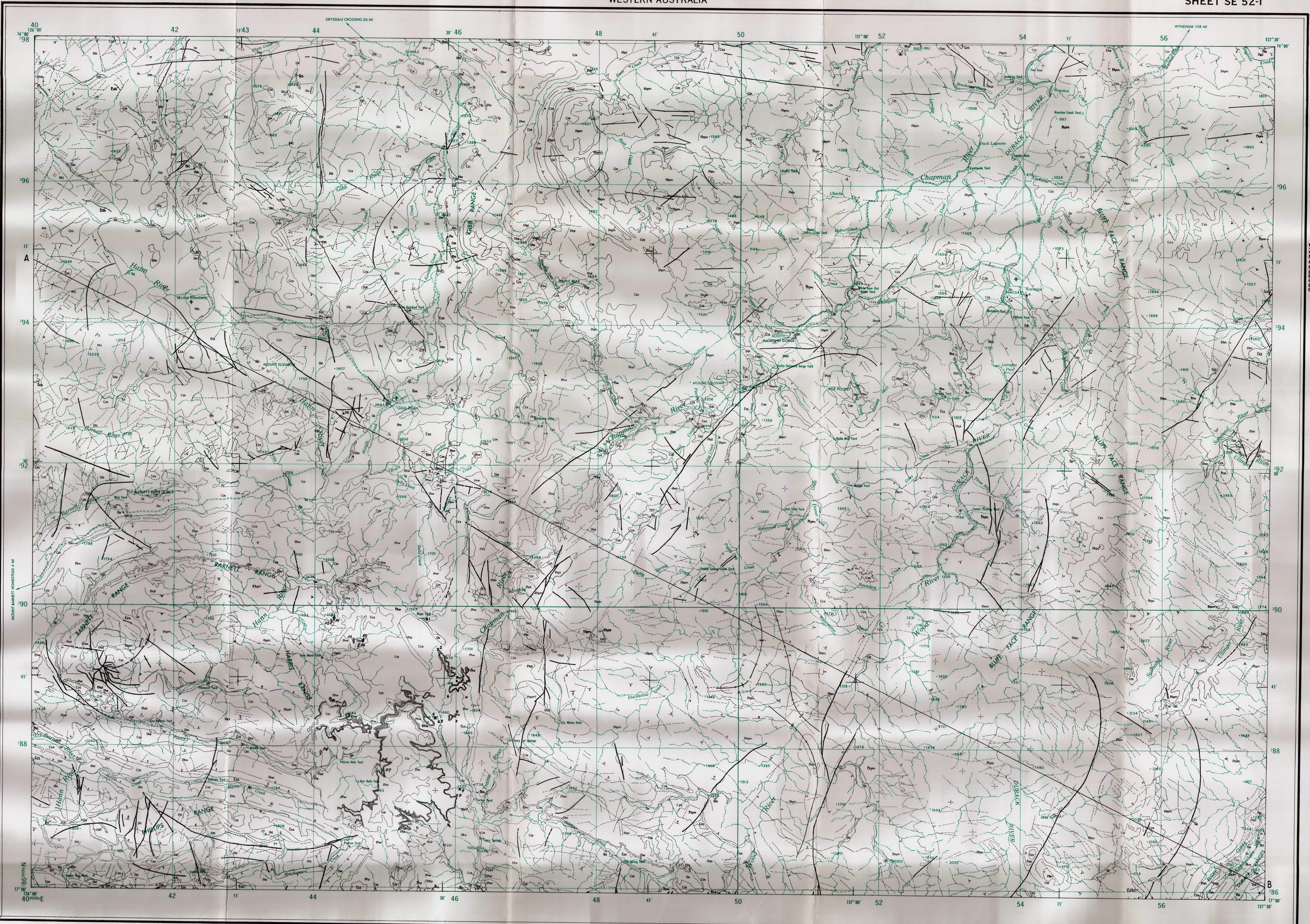
SUBJECT TO AMENDMENT

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

MOUNT ELIZABETH

WESTERN AUSTRALIA

SHEET SE 52-1



Reference

CAINOZOIC	QUATERNARY		Qa	Alluvium
	UNDIFFERENTIATED		Czs	Soil, sandy soil, eluvium
			Czb	Black soil.
			Czl	Ferruginous pisolitic lateritic soil
	TERTIARY		Tp	Laterite
PROTEROZOIC	ADELAIDEAN	Traine Formation (UNDIFF. UPPER PROT.*)	Ꝑha	Red-brown, fine-grained silty micaceous sandstone, dark red shale and micaceous siltstone
		Walsh Tillite	Ꝑhw	Flaggy pink dolomite; Greyish-purple to red-brown tillite
	ADELAIDEAN OR CARPENTARIAN	Hart Dolerite	Ꝑdh	Dark grey-green medium to coarse-grained dolerite; granophyre.
	CARPENTARIAN	Bastion Group: Mendena Formation (MID. & LOW. PROT.)	Ꝑtm	Fine to medium-grained quartz sandstone; purple siltstone
		Kimberley Group: Pentecost Sandstone, upper	Ꝑkpu	White, medium and coarse-grained quartz sandstone; minor fine-grained quartz sandstone
		Pentecost Sandstone, middle	Ꝑkpm	White, buff and pink fine and medium-grained quartz sandstone. Minor feldspathic sandstone; glauconitic sandstone; green-grey micaceous siltstone
		Pentecost Sandstone, lower	Ꝑkpl	White, medium-grained quartz sandstone
		Elgee Siltstone (LOWER PROTEROZOIC)	Ꝑke	Red-brown siltstone and mudstone; red-brown to grey-green, fine and medium-grained quartz sandstone and feldspathic sandstone
		Teronis Member	Ꝑkt	Grey and green shale; flaggy grey and green dolomite
		Warton Sandstone	Ꝑkw	White and buff, medium-grained quartz sandstone; pale purple-grey, medium-grained feldspathic sandstone.
		Carson Volcanics	Ꝑkc	Grey-green to black, massive and amygdaloidal basalt, grey-green amygdaloidal spilite, feldspathic sandstone, micaceous siltstone
		King Leopold Sandstone	Ꝑkl	White and buff, medium and coarse-grained quartz sandstone

* Subdivisions of the Precambrian time-scale used by Geological Survey of Western Australia, shown in grey.

Geological boundary

Fault

Anticline, showing plunge

Syncline, showing plunge

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

3 Strike and dip of strata

Horizontal strata

Dip < 5°

Dip < 15°

Dip 15°-45°

Horizontal strata

Trend line

Joint pattern

(Dip < 5° to Joint pattern: air-photo interpretation)

P2 Glacial striae, showing direction of movement

×5 Text reference locality

Measured section

Dyke

•Cu Minor mineral occurrence

Cu Copper

Vehicle track

Fence

"Mt Elizabeth" Homestead

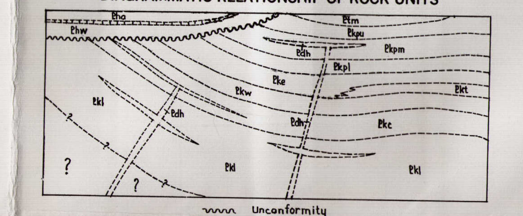
Landing ground

Yd Yard

JMA1 Astronomical station

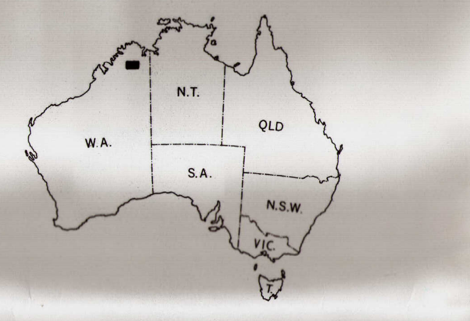
•1848′ Height in feet, instrument levelled; datum; mean sea level.

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Unconformity

Compiled and issued by the Bureau of Mineral Resources, Geology and Geophysics Department of National Development, in conjunction with the Geological Survey of Western Australia. Topographic base compiled by the Royal Australian Survey Corps. Aerial photography by the Royal Australian Air Force; complete vertical coverage at 1:50,000 scale. Transverse Mercator Projection



INDEX TO ADJOINING SHEETS

Showing Magnetic Declination

BROWSE ISLAND SD 51-11	MONTAGUE SOUND SD 51-12	DRYSDALE SD 52-9	MEDUSA BANKS SD 52-10	PORT KEATS SD 52-11
CAMDEN SOUND SD 51-15	PRINCE REGENT SD 51-16	ASHTON SD 52-13	CAMBRIDGE GULF SD 52-14	AUVERGNE SD 52-15
YAMPI SE 51-3	CHARNLEY SE 51-4	MOUNT ELIZABETH SE 52-1	LISSADELL SE 52-2	WATERLOO SE 52-3
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MOUNT ANDERSON SE 51-11	NOONKANBAH SE 51-12	MOUNT RAMSAY SE 52-9	GORDON DOWNS SE 52-10	BIRRINDUDU SE 52-11

ANNUAL CHANGE -30″W

Scale 1:250,000

5 0 5 10 15 MILES

5 0 5 10 15 20 25 KILOMETRES

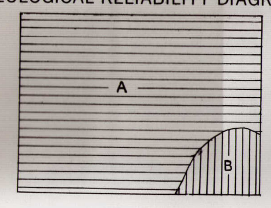
Section

Attitude of faults not known

Cainozoic sediments omitted from section

Scale: V/H = 2

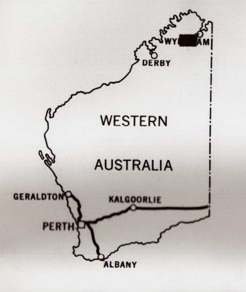
GEOLOGICAL RELIABILITY DIAGRAM

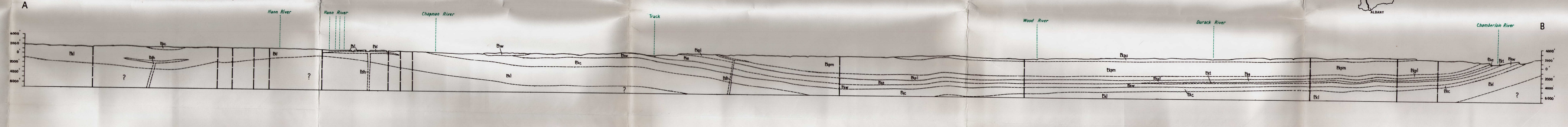


A Helicopter traverses, some ground traverses and air-photo interpretation

B Air-photo interpretation

Geological Photo Interpretation 1965 by: W.J. Perry
Geology 1965 by: H.G. Roberts, W.J. Perry (B.M.R.)
Compiled 1966 by: H.G. Roberts, W.W. Webb, J.L. McGovern
Cartography by: Geological Branch B.M.R.





MOUNT ELIZABETH

SHEET SE 52-1