THE GEOLOGY EAST OF POTGIETERSRUS - COMPRISING THE SOUTHERN PORTION OF 1:50 000 SHEET NO. 2429AA.

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ABSTRACT

The geology exposed north and east of Potgietersrus consists largely of rock from the Pretoria and Chuniespoort Groups, with outcrops from the Swazian erathem. Intrusives of Bushveld origin are present north and west of Potgietersrus.

The Malmani Dolomite of the Chuniespoort Group has received particular attention in this survey. In the course of mapping the dolomite was sub-divided to five formations enabling a detailed structure to emerge.

CONTENTS

1. INTRODUCTION

1.1 Location of Area

The area under investigation was confined to the southern portion of Sheet 2429AA (Potgietersrus). The area stretches approximately 30 km to the east of Potgietersrus and 10 km to the north. It covers an area of about 250 square kilometres.

1.2 Physiography

East of Potgietersrus the dolomite crops out as a range of hills 1500 to 1800m in amsl, broken occassionally by faulting. North of Potgietersrus the dolomite, recrystalised by Bushveld intrusives, forms an area of low relief. Quartzites of the Boshoek Formation cap shales of the Timeball Hill formation, forming a steep-sided ridge some 12 km long, from Potgietersrus east to Buffelshoek.

Where the dolomite forms high relief, deep, vertical-sided gorges are produced by intermittent streams. A number of small, natural springs exist on the dolomite, owing their existance to the positions of fault planes, abrupt changes in lithology and/or the intrusion of diabase dykes.

Typical karstic scenery has been developed on the dolomite outcrop particularly in the Makapangat area.

1.3 Previous Work

The Potgietersrus area was first mapped (on a scale of 1:250,000) by the Geological Survey in 1911 by Kynaston, Mellor and Hall. A more recent investigation of the geology was carried out by De Villiers of the Geological Survey in 1965 which lead to the publication of a provisional geological map Sheet 2429AA. Parts of the area were also mapped by Dr. Porszasz of ~~the~~ Department of Water Affairs.

Work published by Button (1973) on the detailed subdivision of the Malmani Subgroup was applied with success to the dolomite exposed north and east of Potgietersrus.

1.4 Present Investigation

The purpose of this investigation was to prepare a detailed geological map of the southern portion of Sheet 2429AA (Potgietersrus) and forms part of a larger investigation embracing the whole of the dolomite exposure. Aerial photographs, scale 1:30,000, were used for mapping in the field. The geology was trans= ferred onto a base map, scale 1:50,000. Fieldwork was carried out between May and October 1978. With the mapping completed a more intensive groundwater survey, with particular reference to the dolomites, could then be instigated.

The geological mapping was requested by the Department of Water Affairs and carried out under the supervision of the Geological Survey.

2. GEOLOGICAL FORMATIONS

Recent to Tertiary			Soil, sand, alluvium and karstic cave deposits.
Pretoria Group		Lakenvallei Formation	Dolomite, marble shale and quartzite.
		Vermont Formation	Shale, quartzite and dolomite
		Magaliesberg Formation	Quartzite
		Silverton Formation	Shale and impure quartzite
		Daspoort Formation	Quartzite
		Strubenkop Formation	Shale
		Boshoek Formation	Quartzite
		Timeball Hill Formation	Shale and thin quartzites
Chunies=poort Group		Rooihoogte Formation	Massive, brecciated chert
		Duitschland Formation	Dolomite, shale, quartzite and lava
		Penge Formation	Shale and ironstone
	Malmani Sub=group	Frisco Formation	Dolomite, chert poor, carbona=ceous shale at base
		Eccles Formation	Dolomite, chert rich
		Lyttelton Formation	Dolomite, chert poor, shale and chert breccia at base
		Monte Christo Formation	Dolomite, chert rich
		Oaktree Formation	Dolomite, with shale and quartzite
		Black Reef Formation	Quartzite, shale, lava
Archean Complex		Grey Granite	
		Pietersburg Sequence	Quartzite, meta lava, amphibo=lite, ironstone quartz-porphyry, serpentinite.
Post-Pretoria Group		Sills and dykes of diabase	
		Bushveld norite	

3. ARCHEAN COMPLEX

The rocks of the Archean Complex consist of varying lithologies, namely quartzite, quartz-porphyry, shale, ironstone (banded and brecciated), acid and intermediate lava, tuff, amphibolite, serpentinite and granite. They are exposed north-east of Potgietersrus, north of the Ysterberg Fault.

The quartzite is coarse-grained and in places similar to the overlying Black Reef quartzite. It contains a number of thick conglomerates together with a thin layer of shale.

Small outcrops of quartz-porphyry, lava, ferruginous and sandy-shale are exposed west of the Makapans Syncline where the Ysterberg Fault throws the Archean complex against rock of the Chuniespoort group. Banded ironstone is exposed on Uitloop 3KS and Amatava 41 KS. An exposure on Uitloop 3 KS shows the ironstone containing thin, (1-2cm) banded and brecciated chert.

Amphibolite and serpentinite (locally altered to talc and talc schist) are exposed on Amatava 41 KS. Small outcrops of a medium-grained grey (Archean) granite were mapped both on Uitloop 3KS and Amatava 41 KS.

4. BLACK REEF FORMATION

The beginning of the Vaaliun erathem is marked by the deposition of the Black Reef quartzite on a clear angular unconformity above rocks of the Archean complex.

The quartzite is exposed striking north-west to south-east across Uitloop 3 KS and Amatava 41 KS thinning towards the north-west. It is again exposed south of the Ysterberg Fault, on the northern limb of the Makapans Syncline, and underlies the Malmani subgroup from Sukses 37 KS, south to Grootvalley 57 KS.

The lithology of the Black Reef consists largely of a whitish medium- to coarse-grained quartzite. In thin section this quartzite may be classed an ortho quartzite. It contains pebble beds, sandy shale and lava. Little variation is encountered within the quartzite. It is generally trough cross-bedded with foresets up to 1,2m in height, the bedding planes marked by conspicuous fine and corase layering. A lens of conglomerate containing sub-rounded pebbles (up to 10 cm in diameter), is exposed on Groot Valley 57 KS lying approximately 30m below the top of the formation. A light-coloured lava is exposed close to the top of the formation in the Makapans and Grootvalley areas. Thin beds of sandy shale are exposed on Spanje 36 KS and Zwartkrans 38 KS.

5. CHUNIESPOORT GROUP

5.1 Malmani Subgroup

The rocks of the Malmani subgroup rest conformably on the quartzite of the Black Reef formation. They are over= lain, again conformably, by iron-rich shale and ironstone of the Penge formation.

The main areas where the Malmani subgroup crops out are:

(a) Mogoto, comprising the farms Spanje 36 KS, Portugal 55 KS, De Hoop 54 KS, Grootvalley 57 KS and the eastern portions of both Makapansgat 39 KS and Buffelshoek 53 KS.

(b) Makapans, comprising the farms Makapansgat 39 KS, the western portion of Zwartkrans 38 KS and the southern portion of Sukses 37 KS.

(c) North of the main Potgietersrus-Pietersburg road comprising the farms Uitloop 3 KS, Amatava 41 KS, Weenan 40 KS and the northern portion of Planknek 43 KS.

The Mogoto area, although not stratigraphically complete, possesses the larger areal extent and the most complex struc= ture. This area has thus received most attention in this survey. The Makapans area shows an almost complete strati= graphy though much complicated by later deformation. The area north of the tar road gives a complete section through the dolomite, particularly well exposed in the eastern portion but poorly exposed and affected by Bushveld metamorphism in the west.

The Malmani subgroup could be subdivided into five formations according to a scheme given by Button (1973) and Geol. Survey (1978) using lithological differences (summarized in Fig. 1) and where possible, various marker horizons such as distinctive stromatolite zones. In the western most parts

SUBDIVISION OF THE MALMANI SUBGROUP

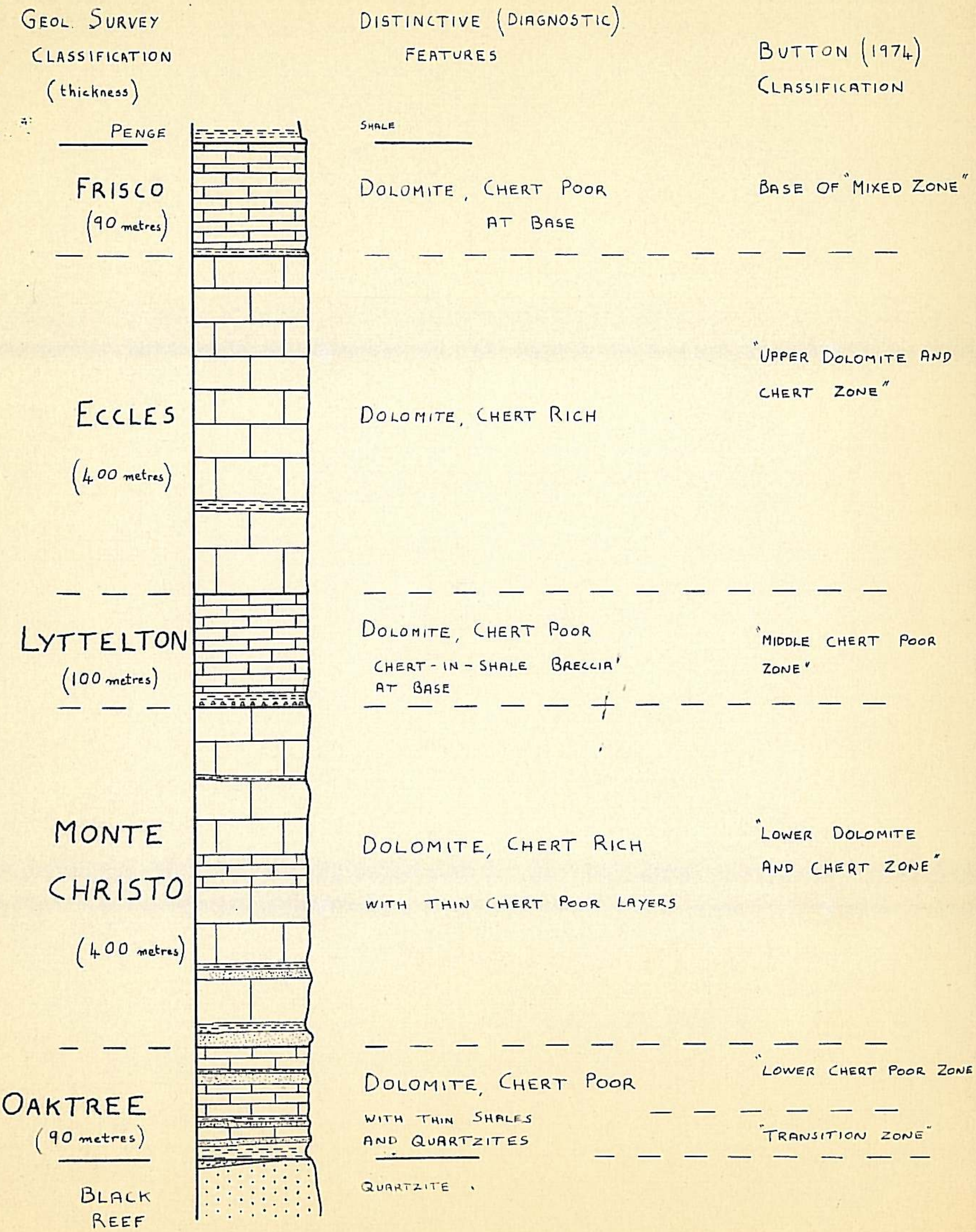

FIG. 1

of Amatava 41 KS and Uitloop 3 KS no subdivision of the Malmani subgroup could be made because of poor outcrop.

5.1.1. Oaktree Formation

This formation forms the base of the Malmani subgroup and rests conformably on Black Reef quartzite. A problem exists as to where the exact boundary should be placed between the two formations. De Villiers (1965) shows on his map a transition zone between the quartzite of the Black Reef formation and the massive dolomite of the Malmani subgroup. This zone consists of layers of quartzite, dolomite and shale. Button (1973) used a similar classification. For the present mapping the boundary between the two formations was taken at the base of the first carbonaceous shale overlying the quartzite or lava of the Black Reef formation. This boundary was chosen because of the close similarity of the shale with shales higher up the Malmani subgroup. This similarity extends to general appearance, microscopic features and chemistry (see Appendix). Dark chert-poor dolomite, similar to that described within Button's "Lower Chert Poor Zone" is present within the basal shale and quartzite. The upper contact of the formation has been placed at the top of the uppermost bed of chert-poor dolomite (10m thick) below a 4m thick layer of quartzite and shale.

This lowermost formation within the Malmani subgroup crops out in all three main areas of dolomite exposure. It is particularly well exposed on the northern limbs of both the Makapans and Mogoto Synclines (Section 2), although the outcrop is disrupted by north-east to south-west and north-south faulting respectively. The formation on Uitloop 3 KS appears to thin to the north-west but is to a large extent covered by superficial deposits. Surface deposits also partially obscure the

LITHOLOGY OF THE OAKTREE FORMATION

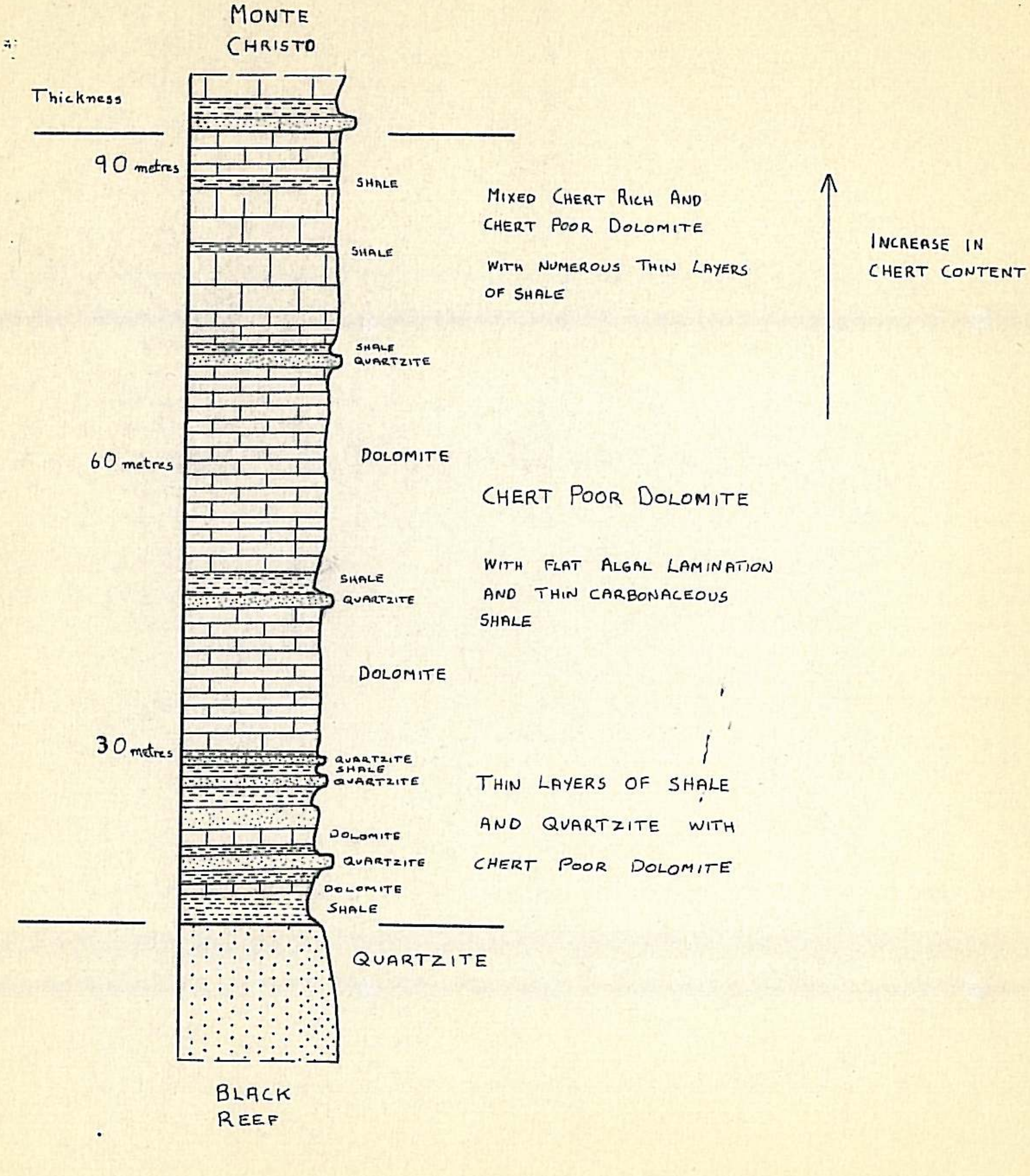

FIG. 2

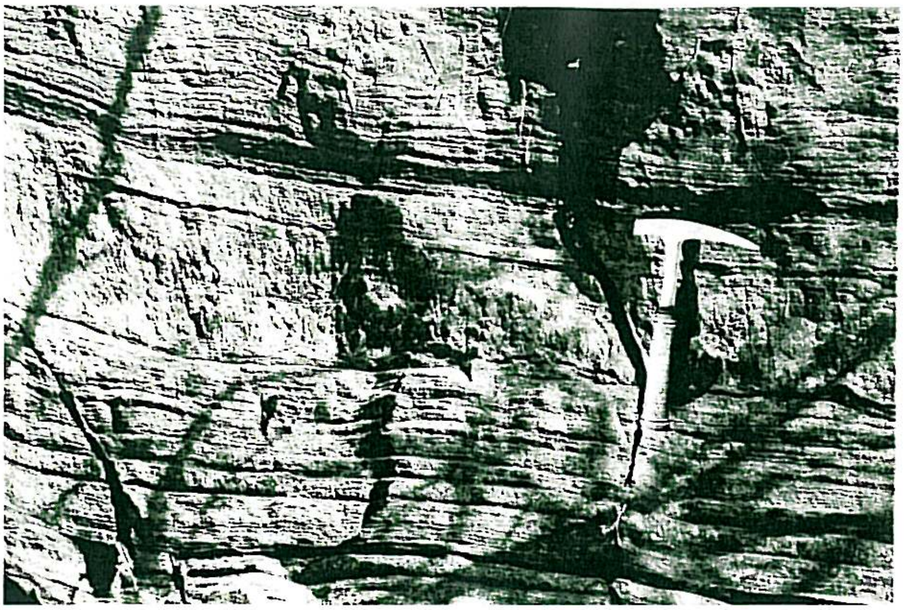

PHOTO 1

DOLOMITE (OAKTREE FORMATION), SHOWING FLAT "ALGAL MATS".

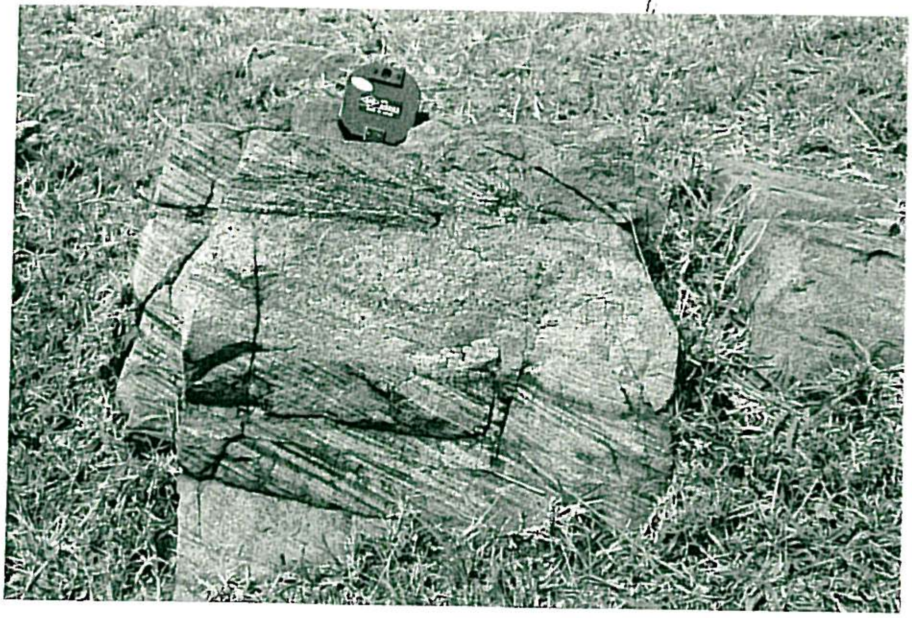

PHOTO 2

QUARTZITE (OAKTREE FORMATION) - CROSS-BEDDING STRUCTURE formation in the eastern most portion of Portugal 55 KS.

The relative abundance of quartzite and shale are characteristic of the Oaktree Formation. Chert is ubiquitous in fine laminations 0,5-3mm thick throughout the formation but the thick chert beds common higher up in the succession are rare in the Oaktree forma= tion. The crystalline dolomite is generally dark in colour when free of sizable chert layers (weathering to a light-brown or grey). The dolomite appears lighter in colour when associated with thick chert. The fine laminations have their origins in tightly-packed algal structures universally developed through= out the formation. The laminations appear to be characteristic of dolomite which is relatively poor in chert, and may be continuous of tens of metres, appearing completely flat on outcrop (Photo 1). How= ever, on close examination, the flat algal "mats" show a high degree of disruption giving a crinkled appearance. Stacked columnar stromatolite structures (up to 5mm in diameter) are visible together with small laterally-linked domical structures. Where relatively thick (up to 10cm) beds of chert are developed, larger structures are observed, usually in the form of domical stromatolites up to 50cmin diameter. These structures are rare close to the base of the forma= tion but increase in number, until quite common near to the top.

In the basal portion of the Oaktree formation up to four layers of quartzite are developed, each not exceeding three metres in thickness. Higher up in the formation another two layers of quartzite were encountered. No individual layer exceeds three metres in thickness and each is associated with a carbonaceous shale. In thin section they are shown to be ortho-quartzites containing small quantities (less than 5%) of feldspar, carbonate and sulphide - altering to limonite on weathered surfaces. They are typically light coloured, medium- to coarse-grained, well-sorted and often show cross-bedding structures (Photo 2).

The shales lie immediately above the quartzites, giving a cyclic appearance to deposition.

	dolomite	30 metres
II	shale	4m
	quartzite	3m
	dolomite	30 metres
I	shale	4m
	quartzite	3m

"Shearing" within the shales obliterates any bedding structures which is characteristic of most shales in the other formations of the Malmani subgroup. The "shearing" does not appear to be related to any later tectonic move= ment but is probably a penecontemporaneous deformation (intrastratal slip). Sulphides are common among the basal shales. The fine-grained shale often contains small (<1mm), rounded grains of quartz. On microscopic examina= tion the shale lamination is shown to consist of many thin "fining upwards" cycles, each less than 1mm thick. Shale bands may develop in the dolomite without the presence of a quartzite. But these bands do not usually attain the thickness of those related to the quartzite (varying in thickness from a few cm to metre dimensions) and have not been used as stratigraphic markers within the Oaktree formation.

5.1.2 Monte Christo Formation

The Monte Christo formation, characterised by an abundance of chert within the dolomite, lies conformably above the Oaktree formation and has a thickness of approximately 400 metres. The lower contact of the formation has been defined at the base of a band of quartzite and shale overlying the chert-poor dolomite of the Oaktree formation. This distinctive horizon may, with the exception of the Makapans area, be traced throughout the dolomite outcrop. Clearly exposed along the northern limb of the Mogoto Syncline and north of the tar road, but complicated by faulting on the Makapans exposure. The top of the formation is defined as the uppermost layer of dolomite and chert below a thick band of shale and chert breccia.

As in the Oaktree formation, the dolomite, where associated with pentiful chert assumes a grey-blue colour, weathering to a light grey. Similarly dolomite without the related chert shows a darker tone. The chert in fresh section is generally dark blue-grey to black, weathering white, with a chalk-like appearance. Beds of chert can commonly vary between less than 1mm and 50cm in thickness. One exceptional chert layer 2,5 metres thick is developed close to the base of the formation. Some individual chert layers are traceable over hundreds of metres. The beds may thin gradually or terminate abruptly. Photo 3 shows thin truncated chert layers. Chert may also develop along a horizon in nodular form, as can be seen in Photo 4.

Sedimentary structures within the chert include ripple marks, occassionally exhibiting an interference pattern (Photo 5). Oolites are exceptionally well preserved, outcrops showing a typical reverse grading.

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LITHOLOGY OF THE MONTE CHRISTO FORMATION

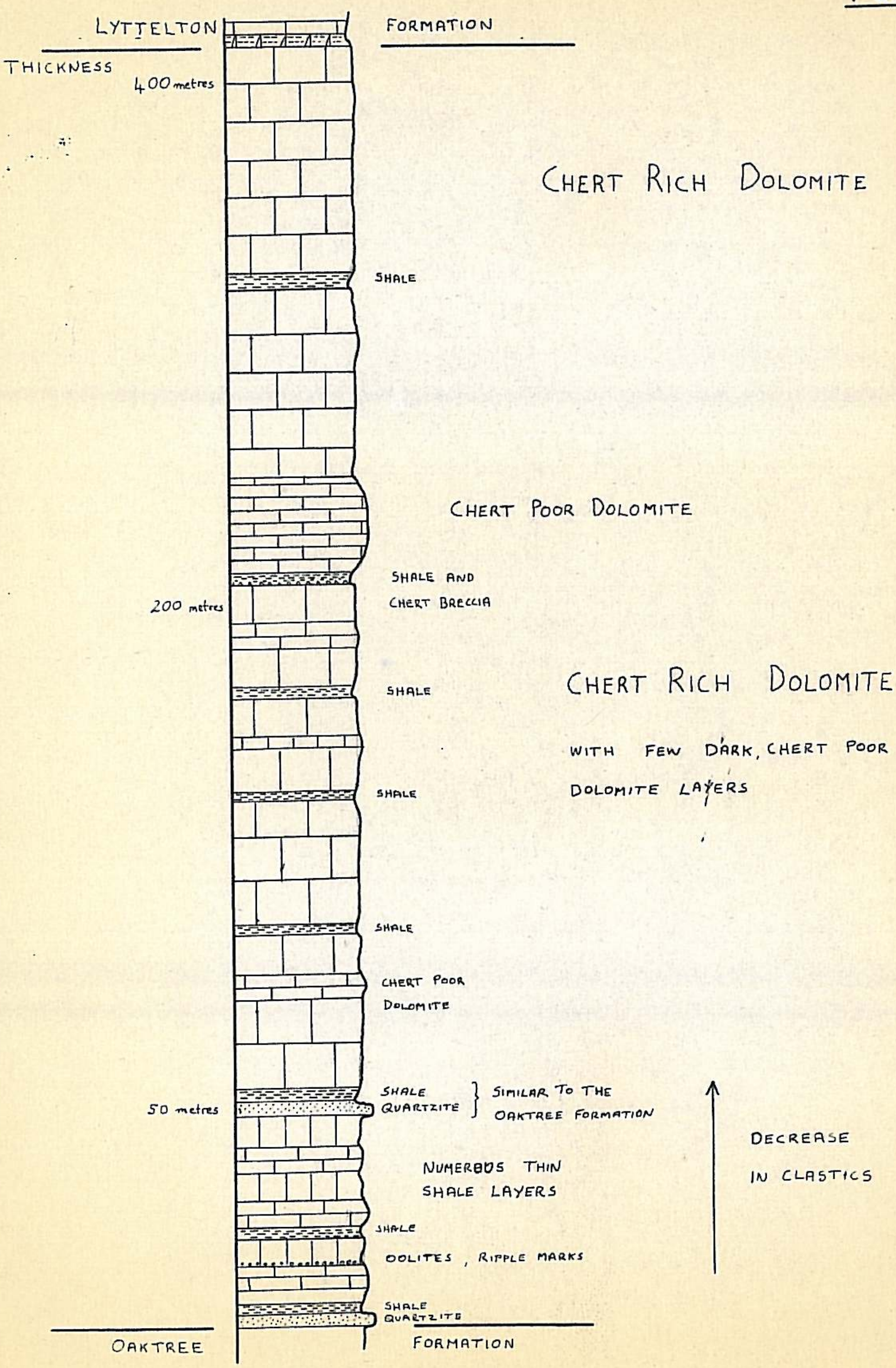

FIG. 3

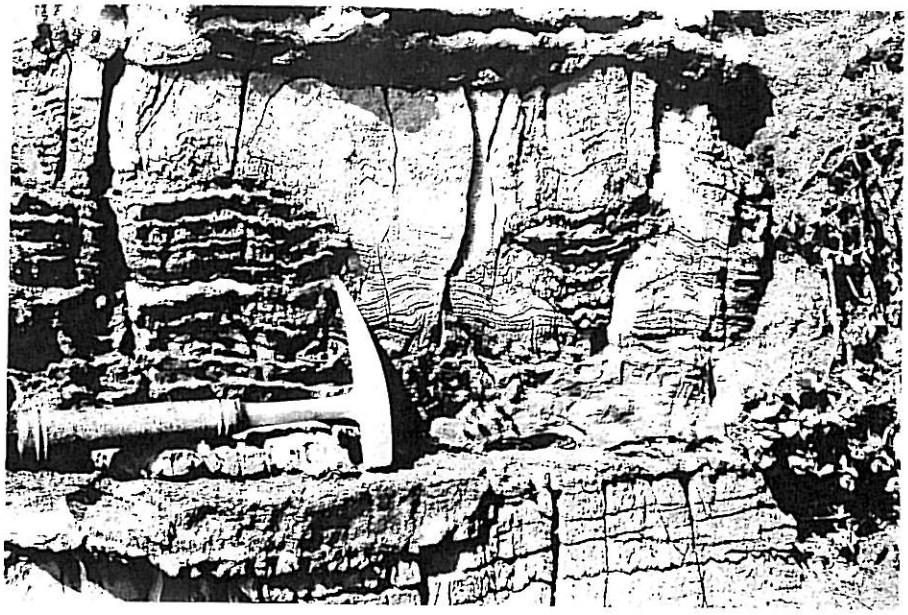

PHOTO 3: TRUNCATED CHERT LAYERS IN DOLOMITE FROM THE MONTE CHRISTO FORMATION

PHOTO 4: NODULAR CHERT (WHITE) IN DOLOMITE - MONTE CHRISTO FORMATION

The Monte Christo formation is defined as a zone of chert-rich dolomite. However, numerous thin layers of relatively chert poor dolomite are present throughout the formation. The largest, about 20 metres thick and overlain by dark shale, is developed approximately 200 metres above the base of the formation (fig. 3). The character of the dolomite is similar to the chert-poor dolomite of the Oaktree formation, that is, typically fine algal structures contained within a dark, finely crystalline dolomite.

Common algal structures within the chert-rich layers include*: (a) closely spaced globoidal, laterally linked stromatolites (Photo 6).

(b) linked and isolated domical structures (Photo 7).

(Dentate, angulate and corrugate (all linked) are common laminae shapes).

Small "parasite" stromatolites may form on larger domical structures and on the "mat" linking these structures (Photo 8). Less common are the encapsulated structures similar to large oncolites (Photo 9) and those similar to "storm rolled" mats of modern carbonate environments (Photo 10, centre)

Clastics similar in character to those developed in the Oaktree formation are intercalated in the Monte Christo formation. Quartzite is confined to the base, but layers of shale are encountered throughout the formation.

12./....

*Classification and description follows Trustwell and Eriksson (1972).

PHOTO 5.

AN INTERFERENCE PATTERN IN CHERT, FROM THE MONTE CHRISTO FORMATION.

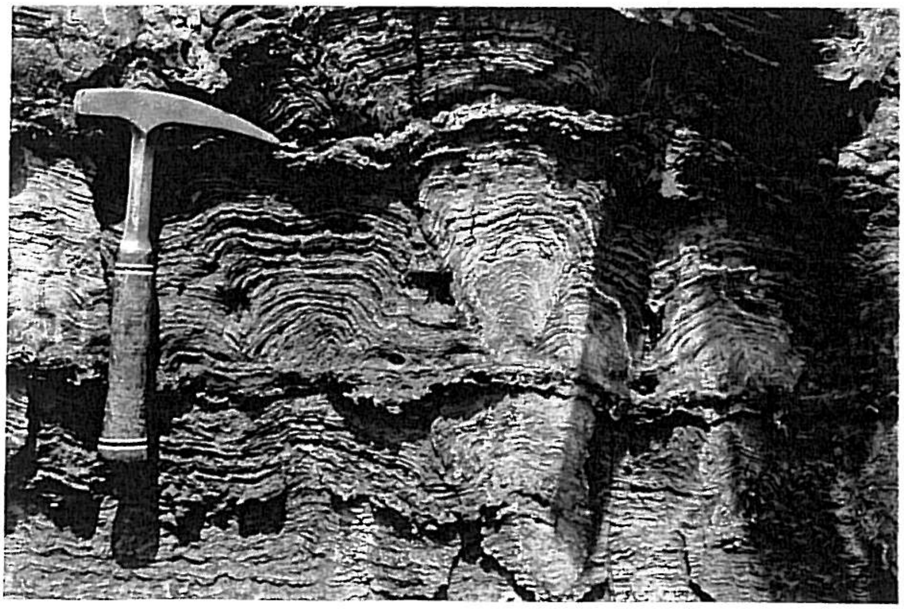

PHOTO 6.

STROMATOLITE STRUCTURES, FROM THE MONTE CHRISTO FORMATION.

CLASSED: LINKED (LATERAL), VERY CLOSE AND CONTIGUOUS, HIGH STACKED AND GLOBOIDAL.

NOTE: A SINGLE LAYER OF CHERT SEPARATES, OR DEFINES, EACH OF THE THREE LAYERS OF STROMATOLITES.

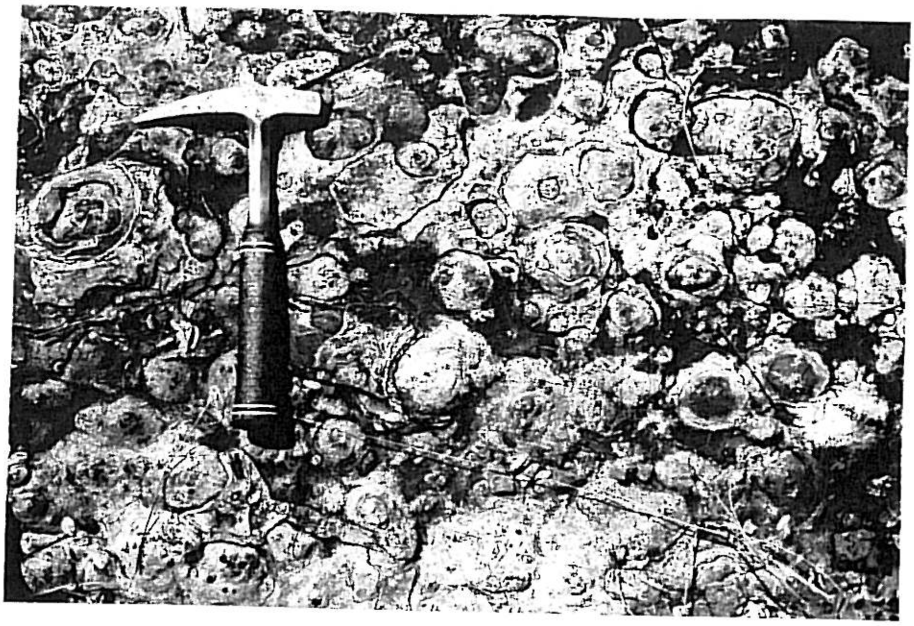

PHOTO 7.

PLAN VIEW OF DOMICAL STRUCTURES DEVELOPED IN THE MONTE CHRISTO FORMATION.

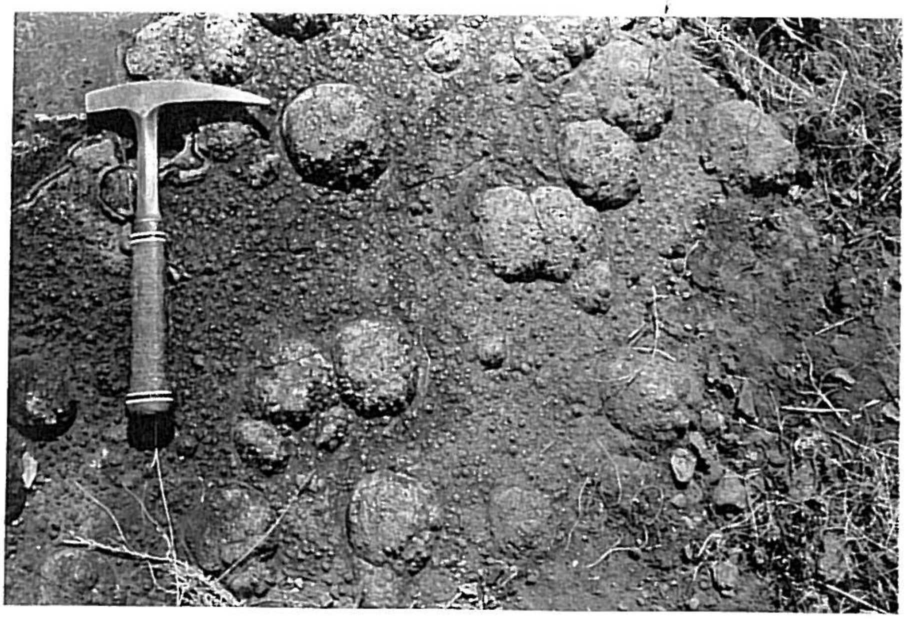

PHOTO 8.

"PARASITE" STRUCTURES ON LARGER STRUCTURES AND ON THE LINKING MAT. THESE MAY REPRESENT GAS ESCAPE STRUCTURES.

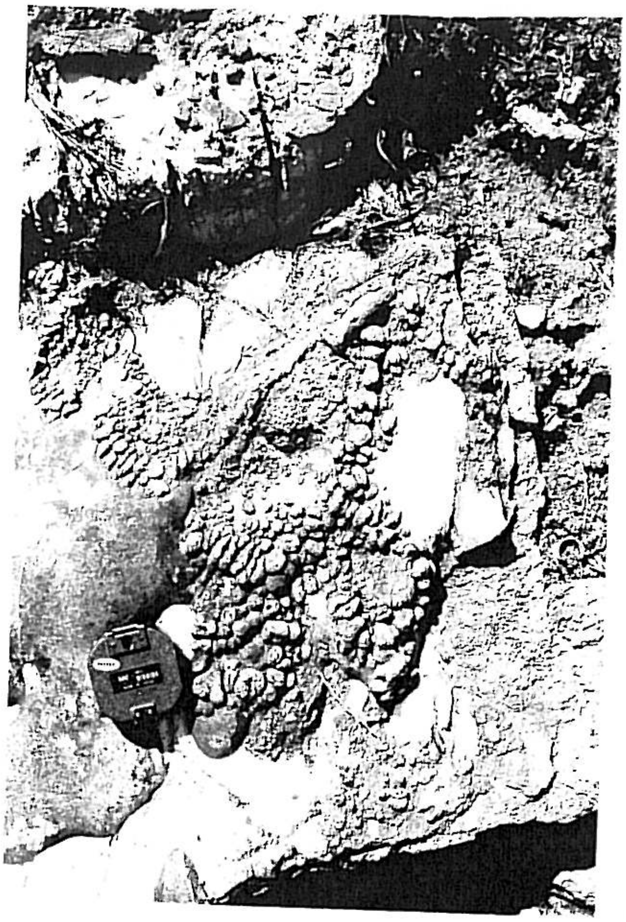

PHOTO 9:

A "CLUSTER" OF SMALL ENCAPSULATED STRUCTURES (DOLOMITE), FROM THE MONTE CHRISTO FORMATION.

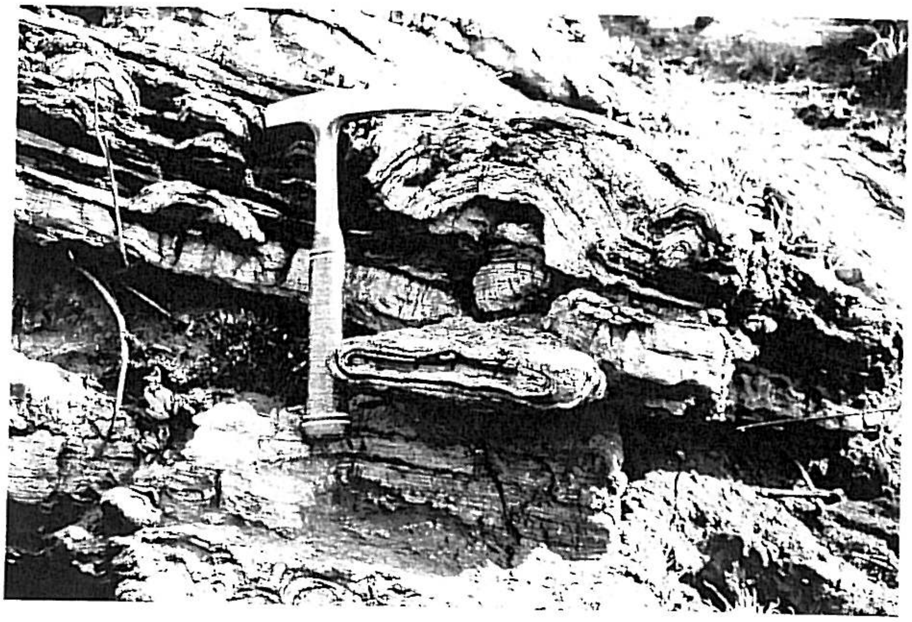

PHOTO 10:

A CONCENTRIC "MAT" PROTRUDING FROM A CHERT LAYER WITHIN THE MONTE CHRISTO FORMATION.

The quartzite is usually cross-bedded and shows ripple marks with interference patterns. The argillaceous rocks exhibit some variation, i.e. thickness, varying between a few centimetres up to 2,5 metres, and grainsize. On outcrop they range between mudstones - quartzwackes and argillaceous quartzites. Many of the argillaceous beds may carry pyrite or limonite. No sedimentary features, such as ripple marks or cross-bedding were observed in the shale. Original bedding planes are exscinded by "shearing".

A chert-in-shale breccia, 0,5-1 metre thick, is developed approximately 15 metres above the base of the formation. This breccia is similar to one developed at the base of the Lyttelton formation, which is described in the following section.

5.1.3 Lyttelton Formation

This formation is comprised of chert-poor dolomite with a few intercalated beds of shale and attains a thickness of 90m. The lower contact is defined as the base of the lower=most shale above the chert-rich dolomite of the Monte Christo formation (fig. 4). The top of the formation was taken as the first appearance of light-coloured chert-rich dolomite. The contact between chert-rich and chert-poor dolomite can be clearly observed in the field. The Lyttelton formation is exposed on the northern limb of the Mogoto Syncline, the southern limb of the Makapans Syncline, and forms a north-west to south-east striking outcrop on Amatava 41 KS.

Deposition generally begins with a blue-grey siltstone (0-3m thick) containing some limonite. It is followed by a dark sandy-shale or quartz-wacke (1-4m thick) carrying ubiquous tiny quartz grains. Dark chert-poor dolomite (0-3m thick) may be developed above the shale. A chert breccia with=in a mudstone matrix overlies the dolomite or shale. This breccia may represent an intraformational conglomerate

LITHOLOGY OF THE LYTTELTON FORMATION

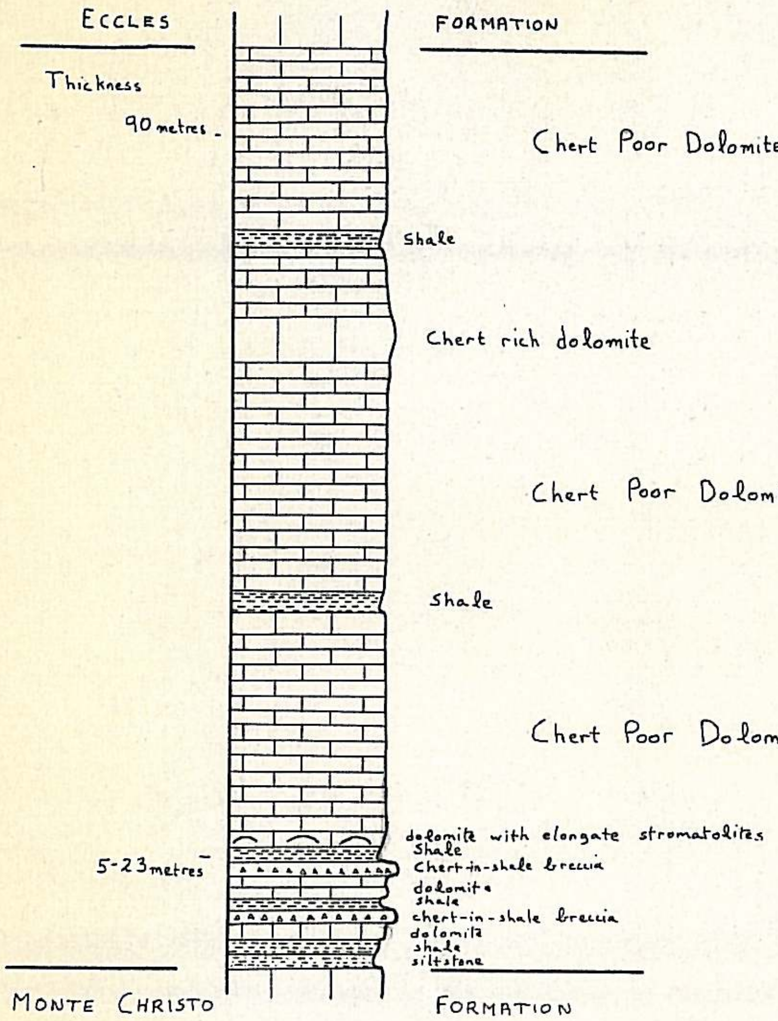

FIG. 4

PHOTO 11:

PLAN VIEW OF THE CHERT-IN-SHALE BRECCIA AT THE BASE OF THE LYTTELTON FORMATION.

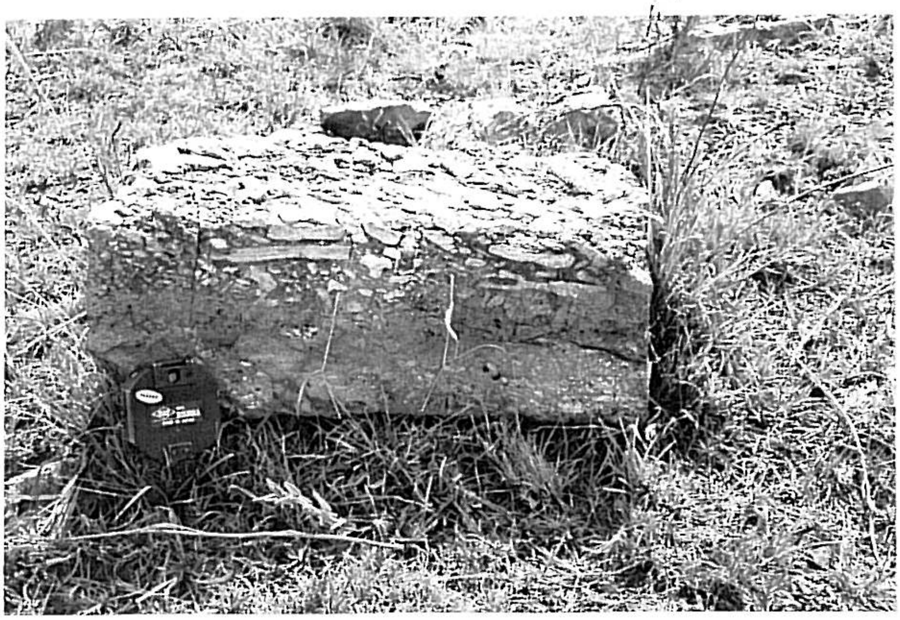

PHOTO 12.

SECTION THROUGH THE CHERT-IN-SHALE BRECCIA.

NOTE: THE SHORT AXES OF THE CHERT CLASTS ARE PERPENDICULAR TO BEDDING.

NOTE ALSO THAT THE SMALLER CLASTS ARE CONCENTRATED TO THE BASE OF THE SECTION.

(Photo's 11 and 12). The clasts of chert are plate-like and range in size from a fraction of a millimetre up to about 30cm. In general the smaller clasts have a more random orientation than the larger, which are arranged such that the shortest axes are perpendicular to bedding. The clasts are contained within a matrix of mudstone. On the whole the chert fragments are poorly sorted, (however, some layers within the member, Vℓs, show chert-rich and chert-poor layers), - (Photo 12). In the south of the area mapped this unit is overlain by alternating beds of dolomite and shale and a second, similar breccia is developed approximately 10m above the first. Here thin shales overlie the uppermost breccia, followed by a distinctive horizon of dark (matt black) dolomite exhibiting large (up to 3m in long axis) elongate, domical stromatolites (Photo 13). This horizon together with the chert-in-shale breccia serves as an excellent marker for the base of the Lyttelton formation.

Above the basal unit the lithology is remarkably uniform. Dark chert-poor dolomite typifies the formation. How= ever a few thin chert-rich layers are present. Thin dark shale is encountered throughout the formation.

The dominant algal structure in the dolomite is flat laminated, or "crinkly" mats. Small domical structures are outlined at times by relatively chert-rich horizons.

5.1.4 Eccles Formation

This formation consists of chert-rich dolomite with subordinate layers of chert-poor dolomite and attains a thickness of approximately 400 metres. The base of the Eccles formation is defined as the lowermost band of chert-rich dolomite overlying chert-poor dolomite of the Lyttelton formation. The upper contact of the formation is placed at the base of a carbonaceous shale overlain by relatively chert-poor dolomite. (Fig. 5).

PHOTO 13:

AN ELONGATE STROMATOLITE IN DARK DOLOMITE, FORMED AT THE BASE OF THE LYTTELTON FORMATION.

PHOTO 14:

A TYPICAL "MEGA-DOME" STRUCTURE FOUND WITHIN THE ECCLES FORMATION.

NOTE, SMALLER DOMES ON THE OUTERMOST LAYER – BOTTOM RIGHT OF HAMMER (CENTRE).

LITHOLOGY OF THE ECCLES FORMATION

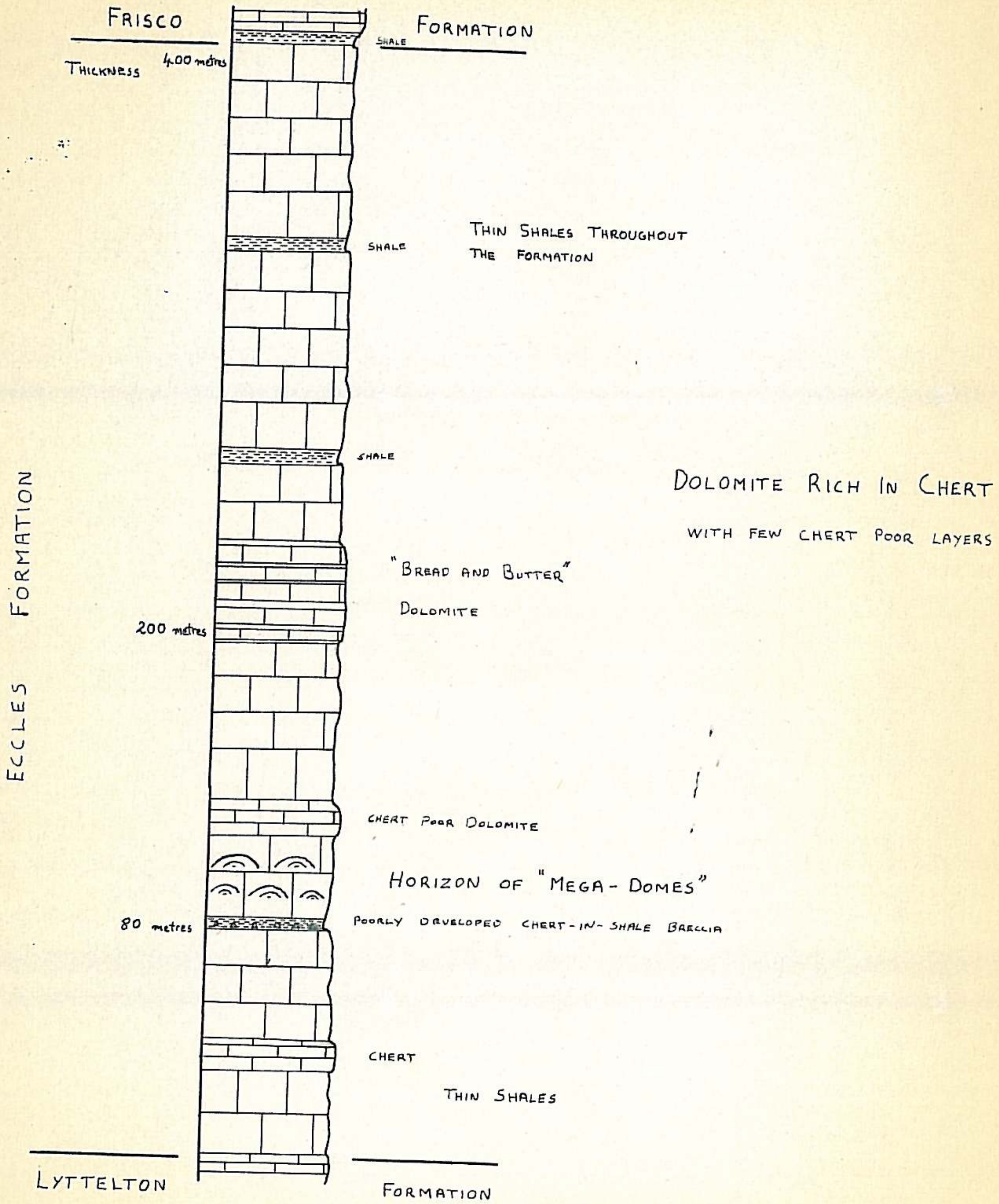

FIG. 5

15(a)

15(b)

PHOTO 15

A LAYER OF DOLOMITE COVERED BY SMALL STROMATOLITES - "ALGAL PAVEMENT" FORMED WITHIN THE ECCLES FORMATION, BUT COMMON THROUGHOUT CHERT RICH DOLOMITE.

The lithology of the Eccles formation is similar to that of the Monte Christo formation but lacks the abundance of clastics. As in the Monte Christo formation the dolomite is typically light-coloured and finely-crystalline. The layered and nodular chert is similar both in occurrence and colour to that in the Monte Christo formation

A 2 metre thick unit of chert-in-shale breccia is encountered approximately 80 metres above the base of the formation. This breccia is similar to that found at the base of the Lyttelton formation, but is poorly developed and not laterally persistent. Thin layers of carbonaceous shales are also present in the Eccles formation. The shale may contain chert layers preserving algal structures, with the shale "draped" over the chert. Again, distinctive bedding within the shales has been destroyed by intrastratal slip.

A distinct horizon of large stromatalite structures ("Mega-domes") is present overlying the chert-in-shale breccia. These structures may be circular or elongate. Diameters up to 7 metres were recorded (Photo 14). Smaller domes are usually scattered on the larger structure.

As in the Monte Christo formation, several units of relatively chert-poor dolomite are developed throughout the Eccles formation. They rarely exceed 5 metres in thickness. The dolomite is finely crystalline and generally darker than the surrounding dolomite containing layered chert. Thin ($<$ 2mm) laminae of

15./.....

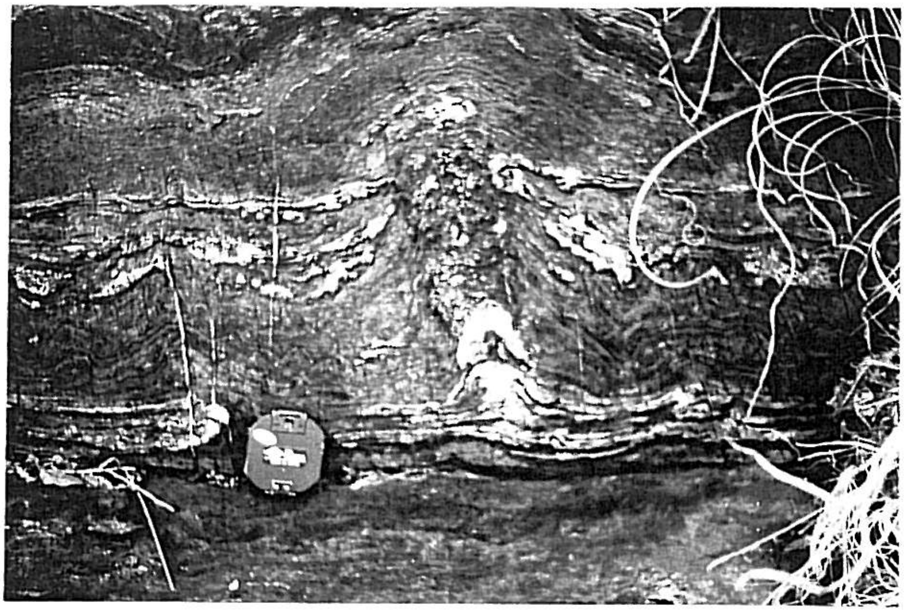

PHOTO. 16:

ISOLATED COLUMNAR STROMATOLITE. ECCLES FORMATION.

NOTE. STROMATOLOITE IS NOT CONFINED BY CHERT LAYERS BUT APPEARS TO "PUSH" THROUGH OVERLYING LAYERS.

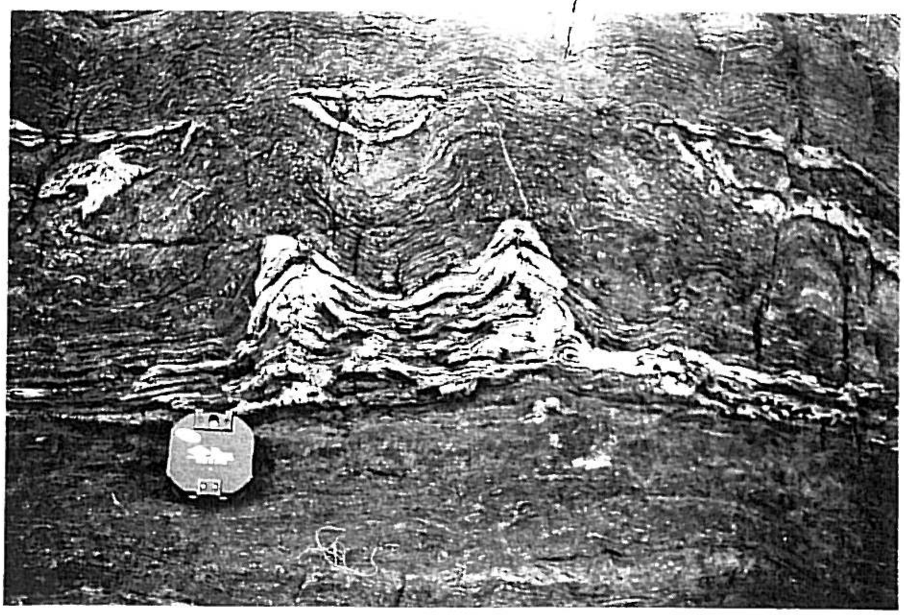

PHOTO. 17.

BRANCHING STROMATOLØTE (RARE). FOUND WITHIN THE ECCLES FORMATION.

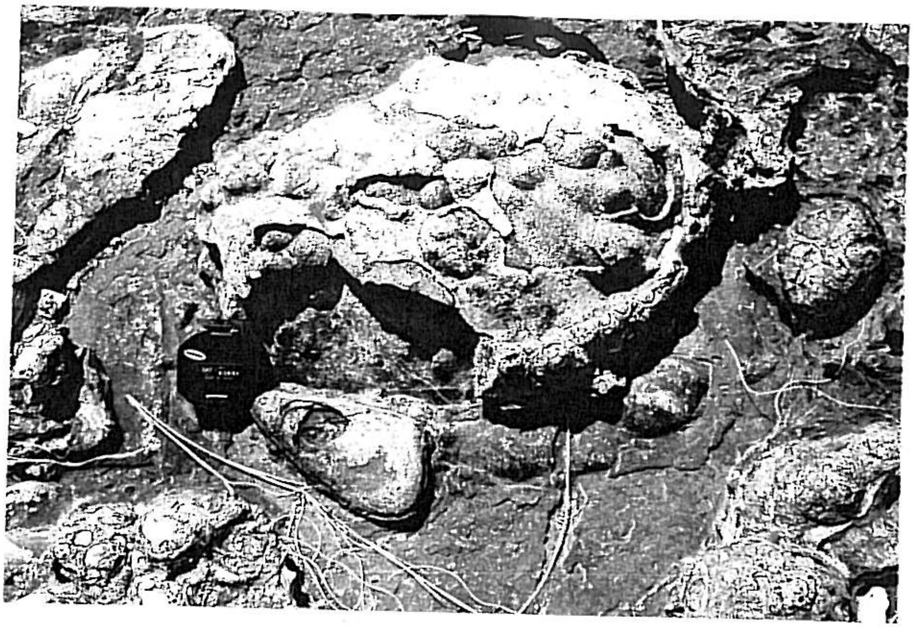

PHOTO 18

STRUCTURE PHOTOGRAPHED IMMEDIATELY RIGHT OF COMPASS IS COMPLETED ENCLOSED. FORMED IN DOLOMITE BY CONCENTRIC LAYERING. STRUCTURE ABOVE AND RIGHT OF COMPASS IS A STROMATOLITE ERODED IN PRECAMBRIAN TIMES. ECCLES FORMATION.

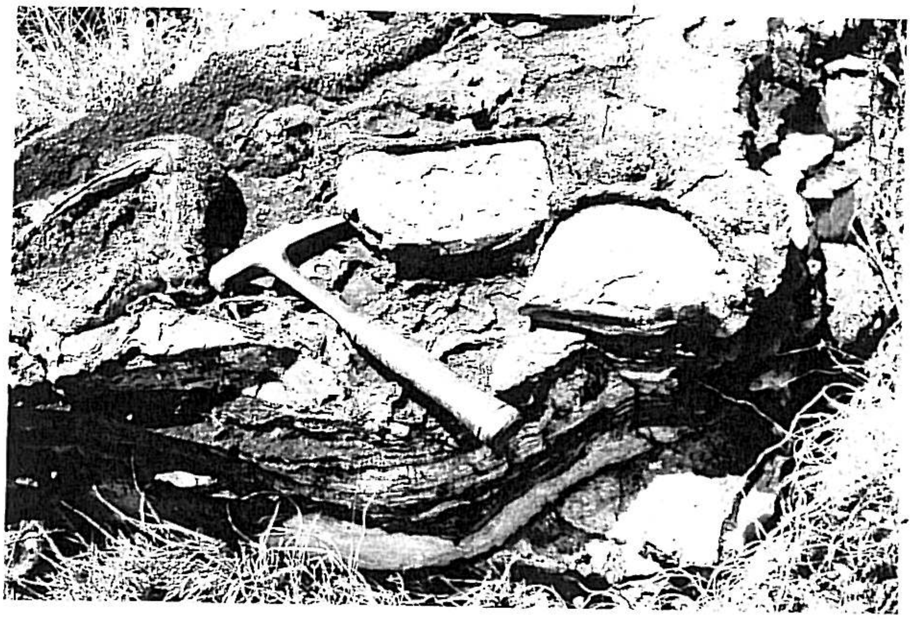

PHOTO 18 A.

TWO STRUCTURES (SHOWING WHITE AGAINST DARK DOLOMITE) , TO THE RIGHT OF HAMMER, ARE SIMILAR TO THAT SHOWN COMPLETE IN PHOTO 18, BUT HERE, BROKEN IN HALF, IN PRE CAMBRIAN TIMES.

NOTE: THE GROWTH OF A NEW ALGAL MAT OVER THE BROKEN HALVES - ON THE FAR SIDE.

ECCLES FORM.

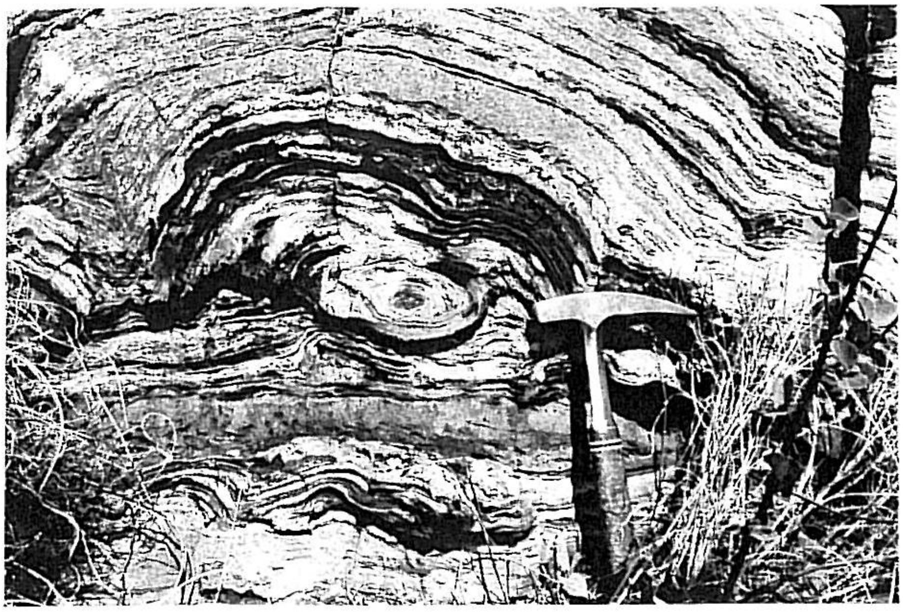

PHOTO 19 A

A "ROLLED MAT" PROVIDING A NUCLEUS FOR A STROMATOLITE

ECCLES FORMATION

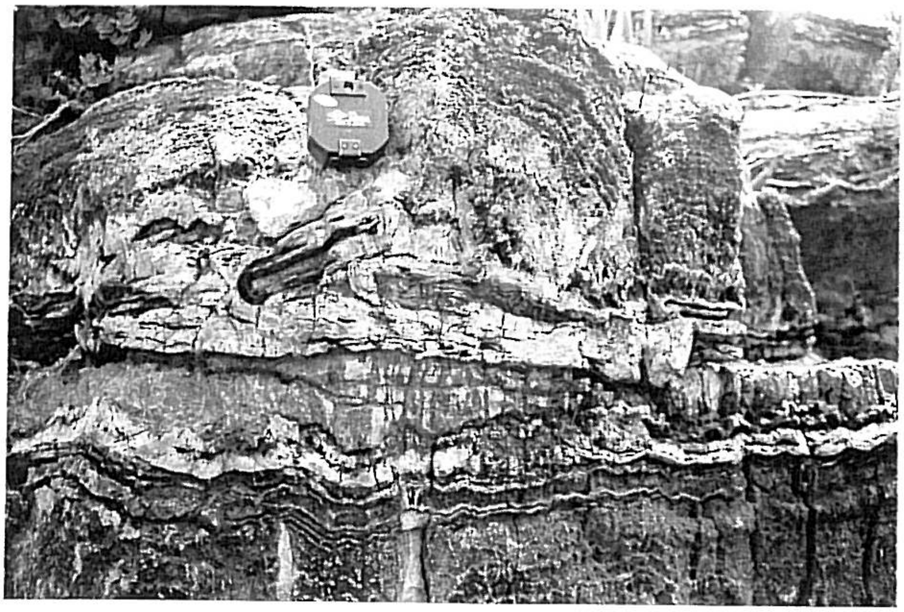

PHOTO 19 B

SIMILAR STRUCTURE TO 19 A, BUT ONE MAT IS INCLINED AGAINST ANOTHER.

ECCLES FORMATION.

chert may outline delicate algal structures, typical of chert-poor dolomite.

The Eccles formation is particularly rich in differing algal types e.g. the algal "pavement" (Photo 15), the columnar stromatolite (Photo 16) and the branching type of stromatolite (Photo 17). Enclosed concentric structures (Photo 18) were observed. The origin of these structures, which may form a nucleus to a stromatolite (Photo 19), is not understood. Mechanical sedimentary structures include ripple marks, development of edge-wise breccias and weak cross-bedding in oolite beds.

A distinctive horizon of "bread and butter" dolomite was observed approximately 200 metres above the base of the formation. It is particularly well developed on Amatava 41 KS. This horizon consists of a regular alternation of dolomite (10-50 cm thick) and chert (1-20cm thick). North of the tar road, faint algal structures are preserved within the chert layers.

5.1.5 Frisco Formation

The lower contact of the Frisco formation is placed at the base of a carbonaceous shale (absent in the Makapans area) lying above the relatively chert-rich dolomite of the Eccles formation. The top of the formation is the uppermost dolomite overlain by a ferruginous shale. The Frisco formation is well exposed north of the tar road striking north-west to south-east then on the north-west and south east-limbs of the Makapans Syncline and on Buffelshoek 53 KS, where the outcrop is truncated by the north-south trending De Hoop Fault.

The formation is composed of dolomite which is essentially chert-poor, particularly in the basal portion. Beds relatively rich in chert are encountered more than 50 metres above the base. Where chert-poor, the dolomite is similar to the dark dolomite described in the lower formations. The chert, where present, often forms discontinuous layers and nodules. Thin beds of carbonaceous shale occur throughout the formation. Towards the top of the formation the shale becomes sandy, grading into a quartz-wacke. These lithologies are parti= cularly well developed north of the tar road.

5.2 Penge Formation

The base of the Penge formation in the Potgietersrus area is taken as the base of a ferrugineous shale overlying chert-poor dolomite of the Frisco formation. The upper contact of the formation is taken as the top of a thick layer of green shale. Only the basal and upper portions of the formation are exposed in the Potgietersrus area, the middle is either covered by superficial deposits or faulted out.

The base of the Penge formation crops out a few kilo= metres north-east of Potgietersrus, striking north-west to south-east. It can also be seen in the exposed core of the Makapans Syncline. The top of the formation is exposed in the northeastern portion of De Hoop 54 KS. Here the remaining Penge is truncated by the north-south trending De Hoop Fault.

The base consists largely of iron-rich sediments (approximately 10 metres thick) deposited conformably on dolomite of the Frisco formation (fig. 6). Bedding

LITHOLOGY OF THE PENGE FORMATION

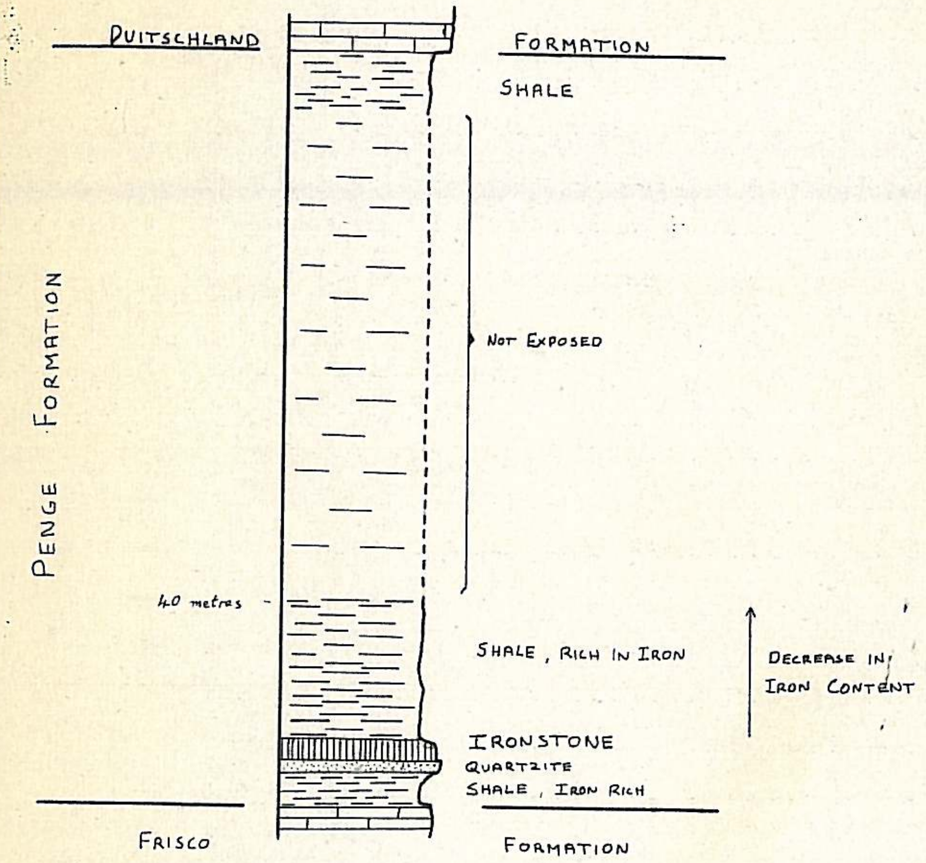

FIG. 6

Bedding in the basal shale is generally obscured by penecontemperaneous shearing or slipping (similar to that encountered within the Malmani Subgroup), but where preserved, the bedding is flat and finely laminated. The composition of the argillaceous rocks varies between mudstone and sandy shale. In fresh section they are coloured black, grey to mauve. They assume a rust colour upon weathering.

Quartzite or ironstone rests above this shale. The quartzite thins to the north-west and is not developed north-west of Uitloop 3 KS. The matrix contains both silica and carbonate cement. Small quantities of iron were observed within the quartzite. The ironstone (3-6 metres thick) may or may not be banded with chert layers, which can be continuous or brecciated. Where free of chert the ironstone is dark brown or black, weathering to a rust colour. The matrix contains small (up to 5mm) nodules of limonite. The brecciated ironstone closely resembles the structure of the chert-in-shale breccia encountered at the base of the Lyttelton formation. The larger clasts of "striped" chert are generally orientated with their long axes parallel to bedding. The origin of this structure may be similar to that suggested for the chert breccia of the Lyttelton formation, that is, a penecontemperaneous brittle deformation of the chert within a soft, ductile mudstone matrix. But a problem exists as to when and how the iron was introduced to the matrix. Shales similar to that at the base overlie the ironstone. The iron content of these shales appears to decrease with thickness above the ironstone.

18./......

The top of the formation exposes dark green shale and siltstone.

Duitschland Formation

The Duitschland formation (200m thick) is exposed on De Hoop 54 KS, Weenan 40 KS and Planknek 43 KS. The most complete section is seen 2 km south-east of the De Hoop homestead. The base of the formation is defined as the base of a thick (20 metre) layer of dolomite overlying green shale of the Penge Formation. The upper contact of the Duitschland Formation is taken at the base of a massive brecciated chert.

The basal dolomite, exposed on De Hoop 54 KS and on the eastern portion of Weenan 40 KS is essentially chert free. The weathered surface is coloured dark grey-blue. In fresh section, however, it is light coloured and coarsely crystalline. The source of the recrystallization, which is similar to that observed close to the Bushveld intrusives on Uitloop 3 KS, is not clear. Carbonaceous shale (10 metres thick) overlies the dolomite. This shale conforms to the description given for the shale within the Malmani subgroup. Coarsely recrystallized, chert-poor dolomite again overlies the shale. A bed of light-coloured lava (1,5 metres thick) is exposed on the De Hoop outcrop, 80 metres above the base of the formation. This lava bed is not exposed on the fault repeated Duitschland formation outcrops west of De Hoop 54 KS. Chert-rich dolomite with carbonaceous and sandy shale (containing pyrite) and quartzite overlie the chert-free dolomite to the top of the formation. The dolomite immediately underlying the chert of the Rooihoogte formation is often dissolved, by groundwater, and the resulting void filled by recent deposits of travertine and calcite, "fissure infill", up to 2 metres thick.

5.4 Rooihoogte Formation

The Rooihoogte formation is exposed underlying the uppermost dolomite of the Duitschland formation on De Hoop 54 KS, Weenan 40 KS and Planknek 43 KS. The formation consists entirely of a massive brecciated chert. It varies in thickness between 4 and 15 metres thinning to the north-west.

The clasts of chert are generally sub-angular, contained within a siliceous matrix. They vary in size between a few millimetres to several tens of centimetres. In some outcrops (notably north-east of De Hoop 54 KS) the chert appears to have escaped brecciation. In one case, on Planknek 43 KS, a clast of shale (much sheared) was encountered within the breccia.

20./.....

6. PRETORIA GROUP

6.1 Timeball Hill Formation

The Timeball Hill formation (approximately 1500 metres thick) is exposed in an arc shaped outcrop, from the farm Buffelshoek 53 KS, striking north to south, to Potgietersrus striking west-north-west to east-south-east. The base of the formation is exposed above the massive chert of the Rooihoogte formation south of the De Hoop homestead. It consists largely of light-grey siltstone which is finely laminated and cross-bedded. This basal unit is overlain by dark grey-green shale, sandy shale and flaggy mudstone with small lenses of quartzite. Sedimentary features are common within the shale and include ripple marks, cross-bedding, desiccation cracks and scour (flute) structures (Photo 20). The quartzite is fine- to medium-grained, often green in colour and rarely exceeds 3 metres in thickness. In places it exhibits faint cross-bedding. At one place a ferrugineous quartzite (2 metres thick) was encountered approximately 500 metres above the base of the formation on Buffelshoek 53 KS.

A distinctive dark mudstone unit close to the base of the formation contains scattered andalusite crystals. This unit is quarried locally for "flagstone". Small pyrite crystals are contained with in dark shales higher in the formation.

Many of the shale units in the vicinity of Potgietersrus are strongly recrystallized by the intrusion of the Bushveld Complex.

Lithologies above the Timeball Hill formation were mapped just east of Potgietersrus. These formations, however, fall outside the scope of the present investigation and thus have received less attention.

They are the following formations:

PHOTO 20

CASTS OF FLUTE MARKS FORMED IN SHALE, FROM THE TIMEBALL HILL FORMATION.

(CURRENT DIRECTION - FROM BOTTOM LEFT TO TOP RIGHT)

6.2 Boshoek Formation

The Boshoek formation lies conformably above the Timeball Hill formation, forming the crest of a conspicuous ridge which stretches from Maribashoek 50 KS, west to Potgietersrus. It consists largely of white, medium- to coarse-grained quartzite. (In thin section shown to be an orthoquartzite). It contains thin conglomerates close to the base of the formation. Sedimentary structures are common, cross-bedding is ubiquous, both large scale trough cross-bedding and smaller cross-lamination. Convolute lamination, formed by soft sediment deformation, was encountered approximately 20 metres above the base of the formation on Planknek 43 KS.

6.3 Strubenkop Formation

Similar to the Timeball Hill lithology, that is, shale (largely recrystallised because of proximity to the Bushveld norite intrusions) and mudstones with sub=ordinate sandy shale and thin quartzite.

6.4 Daspoort Formation

This is comprised of white quartzite exhibiting cross-bedding and ripple marks. In thin section the quartzite contains greater than 95% silica.

6.5 Silverton Formation

Shale and meta-shale is dominant, with some thin, impure quartzite.

6.6 Magaliesberg Formation

This formation consists of a medium-grained, white quartzite, again with cross-bedding and ripple struc=tures. It is locally quarried for building material.

22./.....

6.7 Vermont Formation

Shale and meta-shale with impure quartzite and thin layers (less than 2 metres thick) of dolomite is developed.

6.8 Lakenvallei Formation

Dolomite and marble, the latter coarsely recrystallised by the intrusion of the Bushveld Complex, with fine, dark chert laminations and recrystallised shale beds. A quartzite is exposed overlying the dolomite on the railway section east of Potgietersrus.

7. SUPERFICIAL DEPOSITS

Alluvial deposits are found throughout the area, obscuring the solid geology. At one locality immediately east of Potgietersrus (29°01,5'; 24°11') a deposit of fairly pure quartz sand, which is a direct product of weathering of quartzite of the Boshoek formation, is quarried and used for building material.

Deposits of surface calcrete are common on the low-lying dolomite on Uitloop 3 KS. Here, thick deposits of surface lime have been quarried throughout the century, ("Northern Lime Works", 29°02', 24°07'). Similarly, surface lime overlying the dolomite of the Lakenvallei formation is worked immediately north of Potgietersrus. Thick lime deposits are also found overlying dolomite near Makapaangrot.

Extensive karstic deposits are found within the dolomite. Voids created by preferential solution along zones of weakness, related to faulting and jointing, are filled by "cave-earth" and the precipitation of travertine and calcite (Photo's 21 and 22). With the falling water table, large caverns have been exposed, and sink holes developed, for example, near Makapaangrot (29°12',24°08.5'). Here numerous small "chimney" structures have been developed in a recently cemented dolomite and chert breccia (Photo's 23 and 24). These deposits have yielded important Lower Pleistocene faunal and hominid remains.

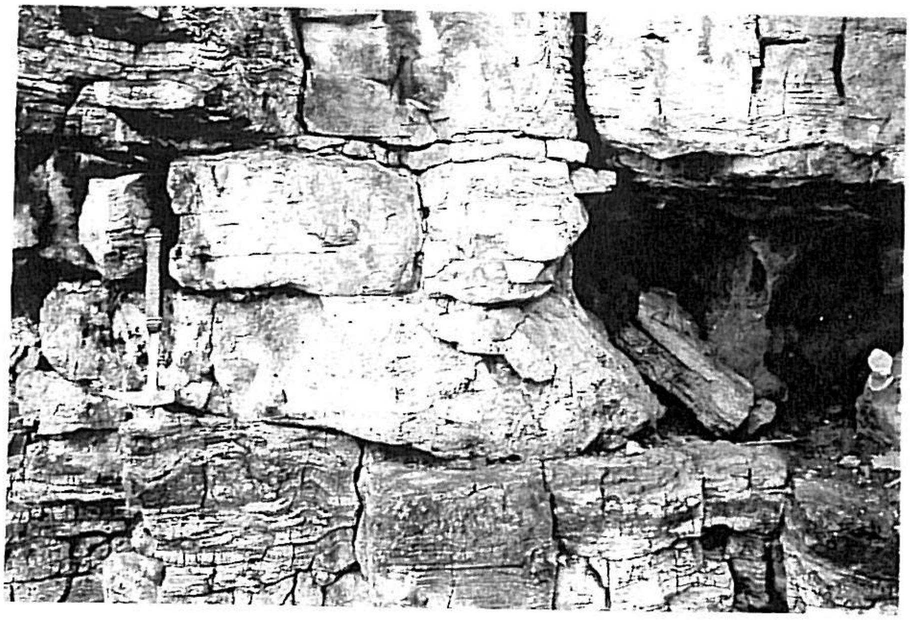

PHOTO. 21.

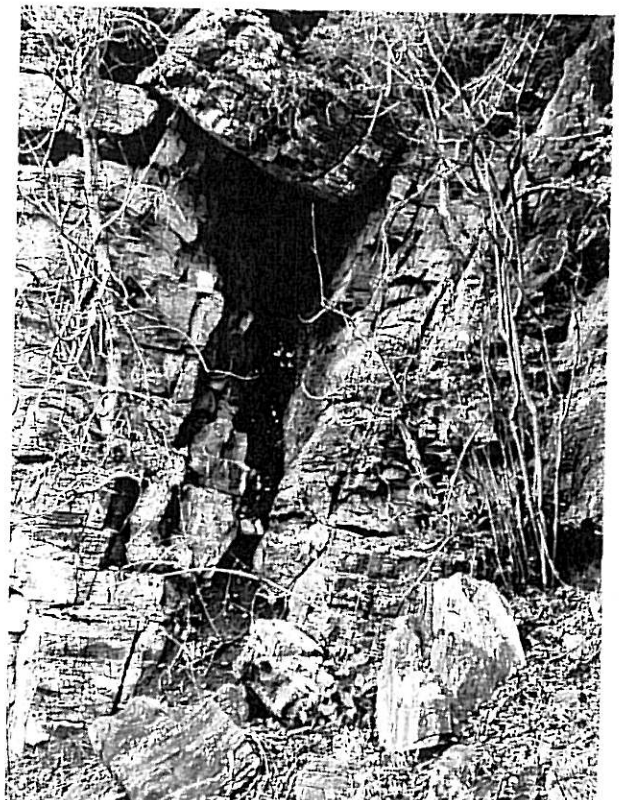

PHOTO 22.

HORIZONTAL (PHOTO 21) AND VERTICAL (PHOTO 22) JOINTS FILLED AND CEMENTED BY "CAVE EARTH" - LATER ERODED, LEAVING LARGE VOIDS IN THE DOLOMITE OAKTREE FORMATION.

PHOTO 23.

PHOTO 24.

A RECENTLY CEMENTED DOLOMITE AND CHERT BRECCIA, WITH CHIMNEY STRUCTURES. (MAKAPANSGAT)

8. INTRUSIVES

The Potgietersrus area has been intruded by diabase dykes and sills. Two episodes of intrusive activity are recognised:

(a) sill type ; then extensive faulting, followed by

(b) the intrusion of dykes.

Two extensive sill structures were mapped. The larger of the two extends from Buffelshoek 53 KS, west to Planknek 43 KS. The sill shows mostly a concordant relationship with the country rock, intruded within the uppermost beds of shale within the Timeball Hill formation. Close to Potgietersrus, however, it is found 10 metres above the base of the overlying Boshoek Quartzite. The second sill structure transgresses rock from the Black Reef to the Monte Christo formation in the Mogoto area.

The dykes show no preferred orientation. They could be followed over distances up to 10 km. Where exposed, the contacts of the dykes are vertical. The dyke rock is usually a medium-grained black to grey diabase. On Portugal 55 KS, the dykes have a common centre, shared also with a steeply-dipping sill structure. This centre of activity also produces a radiating system of small irregular dykes following local fractures within the dolomite.

Norite of the Bushveld Complex is exposed on Uitloop 3 KS. Shallow drilling (up to 80 metres) has also located norite under= lying the sediments immediately east of Potgietersrus (Oorlogs= fontein 45 KS). The Bushveld intrusives are responsible for exten= sive recrystallisation of dolomite and shale on Uitloop 3 KS and Planknek 43 KS.

9. STRUCTURAL GEOLOGY

Deformation of the lithologies east of Potgietersrus may be divided chronologically into four phases.

(a) Swazian
(b) Post-Pretoria Group Folding
(c) Normal and Transcurrent Faulting
(d) Jointing

(a) Swazian deformation

The area mapped, of Swazian age, was small and outside the scope of the present investigation, thus a detailed structure was not interpreted. However, an isoclinal synform structure was mapped within the quartzite and shale of the Pietersburg sequence on Mt. Robert (Amatava 41 KS), folded along an axis trending east-north-east to west-south-west.

(b) Fold structures within the Chuniespoort and Pretoria Groups

South of the Makapans Fault and east of the De Hoop Fault folding in the main dolomite mass is along axes trending east to west. The major fold structure is the open syncline plung= ing gently to the west, the vertical axial plane located approximately along the common boundary of De Hoop 54 KS and Makapansgat 39 KS. The eastern portion of the axis is displaced to the south by the dextral movement of a transcurrent fault trending north to south. A corresponding open anticlinal structure is developed to the south. The exposed core (on Portugal 55 KS) shows an outcrop of chert-in-shale breccia belonging to the base of the Lyttelton formation (Section 2).

East of the Makapans Fault, in the vicinity of the Makapans Cave, a small open anticlinal structure is developed. The axial trace trends north-east to south-west. The anti= cline is developed in the basal formation of the Malmani subgroup and the core exposes quartzite of the underlying Black Reef formation. Further north, tight folding on east-west axes is observed within the Black Reef Formation.

West of the Makapans Fault, rocks of the Chuniespoort group have been folded to a tight syncline. The axial trace of which trends north-east to south-west. The axis plunges gently to the south-west and the axial plane dips to the north-west. Iron-rich shale of the Penge formation crops out in the exposed core. The Makapans and Mogoto Synclines are terminated by the north-east to south-west Makapans Fault resulting in the absence of a corresponding anticlinal structure.

Large scale folding in the Timeball Hill and Boshoek formations is expressed as a marked strike swing of 80°. The formations appear to form part of a very broad syncline stretching from Buffelshoek 53 KS (dipping west) to Planknek 43 KS (dipping south-south-west).

Local folding within the shale is encountered on Weenan 40 KS (29°07,5', 24°10,5') and Planknek 43 KS (29°04,5', 24°11'). These fold structures, which have a different style to those described above, are very tight, in places isoclinal and are invariably folded on axes parallel to the general strike of the beds (Photo 25). These local structures may be related to later, brittle deformation.

(c) Faulting

A number of fault systems affect the area east of Potgietersrus. The area is dominated by the north-east to south-west Ysterberg Fault extending from Pietersburg, south to near Potgietersrus. The exact nature and age of this fault is not known. It may have been active over a number of periods from Swazian times. On a regional scale it gives a sinstral displacement, with an apparent displacement east of Potgietersrus of 4 km. A single outcrop of fault breccia was encountered on Weenan 40 KS (29°08', 24°08,5') where dolomite of the Monte Christo formation is faulted

PHOTO 25

TIGHT FOLDING WITHIN SHALE OF THE TIMEBALL HILL FORMATION.
(PLANKNEK.)

against meta-lava of the Pietersburg sequence. North-west of the Ysterberg Fault, faulting is dominantly normal, north-east to south-west orientated, with downthrows to the south-east. Brittle deformation south-east of the Ysterberg Fault is orientated north-south and north-east to south-west. The Malmani subgroup is cut by numerous north to south normal faults in a step-like pattern. The De Hoop Fault (dipping to the west, with an apparent displacement of 400-500 metres) terminates the Malmani subgroup in the west, faulting it against the Penge, Duitschland, Rooihoogte and Timball Hill formations successively to the south. The system of north-south normal faulting is continued west, repeating the Duitschland and Rooihoogte formations on De Hoop 54 KS and Weenan 40 KS. In the extreme eastern portion of the area mapped (on Grootvalley 57 KS) the Black Reef quartzite is faulted (north-south) against the Monte Christo formation. The dextral north-south orientated transcurrent fault, which displaces the axis of the Mogoto Syncline, also shows some normal movement, dipping to the west. Small north-east to south-west normal faults disrupt the outcrop of the lower formation of the Malmani subgroup on Spanje 36 KS.

(d) Later Deformation:

Zones of brecciation, without displacement, within the Boshoek quartzites are common east of Potgietersrus, often producing gaps on the ridge on Planknek 43 KS. One such zone (29°04',24°11') may be related to movement on the Ysterberg Fault.

A uniform, regional system of jointing is superimposed on the geology, affecting rock of the Swazian to Pretoria age. The major joint direction deviates little from north-north-east to south-south-west. (fig. 7). A minor joint pattern is developed perpendicular to the major.

10. APPENDIX

A major element analysis of some lithologies within the Malmani Subgroup

(See Table I and figure 8)

Sample Number	Description
52, 53, 54	Dolomite (Oaktree formation). Dark, crystalline with fine algal structures. Collected from a chert poor layer at 3 metre intervals above sample 65.
55	Shale. From the Monte Christo formation. Collected approximately 150 metres above sample 60. Note: relatively small changes in TiO_2, Fe_2O_3, MgO, K_2O and SiO_2 content, but overall composition is very similar to the basal shales 60 and 61.
56	Dolomite. (Monte Christo formation). Dark, finely crystalline and showing plentyful algal structures. Collected immediately above a thin shale bed.
57	Dolomite. (Monte Christo formation). Lighter colour than previous dolomite. Collected between thick chert layers (see fig. 8).
58	Chert. (Monte Christo formation). Associated with sample 57.
60	Shale. Collected 10 metres above sample 61. Note: no significant change in composition.

61 .... <u>Shale</u>. Collected at the base of the Malmani Subgroup overlying the Black Reef formation.

64 .... <u>Dolomite</u>. (Oaktree formation). Dark, finely crystalline with very fine laminae of chert outlining small algal structures. Sample was collec= ted 1 metre above a layer of dark shale.

65 .... <u>Dolomite</u> (Oaktree formation). Similar to sample 64 but collected 0.5 metre above an isolated layer of chert.

Note (a) The composition of the basal shale is very similar to shale higher in the succession.

(b) The position of a dolomite bed relative to a shale or chert layer appears to have a profound effect on the amount of silica within the dolomite e.g. The dolomite samples 64, 65 and 55 were collected above shale or chert. Each sample has a relatively high SiO_2 content when compared to the dolomite samples 52, 53 and 54, which were taken at an increasing distance from shale or chert.

A notable exception to this is sample 57. Although collected close to layered chert, the SiO_2 content is very similar to that found in the dolomite samples 53 and 54.

(c) Similarly, the Fe_2O_3 content is increased were the dolomite is associated with shale or chert. Again with the exception of the dolomite sample 57.

(d) With increasing values of SiO_2 in the dolomite, the CaO, P_2O_5 and CO_2 content diminishes.

Sample Positions

for Major Element Analysis

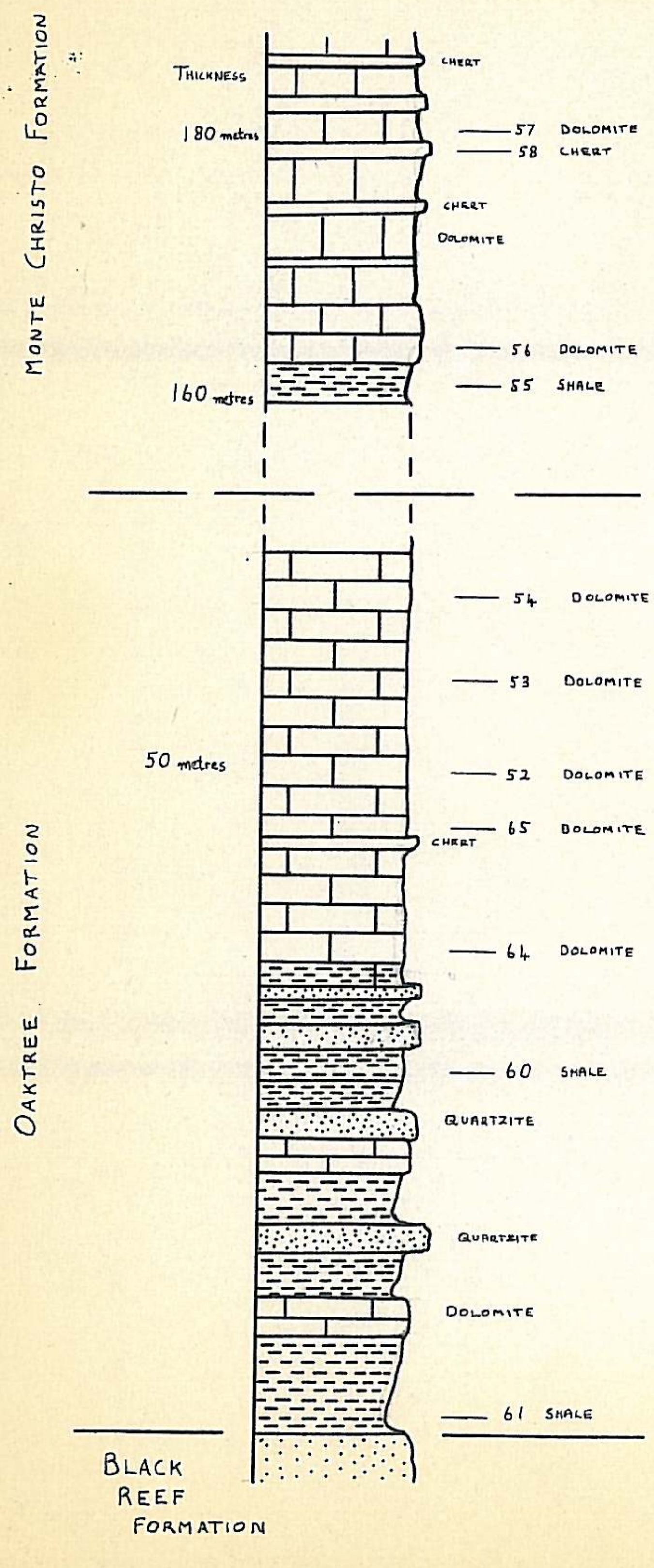

Fig. 8

GSO Project No. 78/197

GEOLOGICAL SURVEY LABORATORY
MAJOR ELEMENT ANALYSES

Requested by: .. S. [illegible]
Institution : ... Water Affairs

NO SAMPLE NUMBER		SG 52	53	54	55*	56	57	58*	60*	61*	64	65
SiO_2	(a)	5,12	2,08	2,74	71,03	14,25	1,78	94,5	59,60	59,5	46,16	46,10
TiO_2	(a)	0,03	< 0,01	< 0,01	0,53	0,07	< 0,01	< 0,01	0,70	0,77	0,02	0,03
Al_2O_3	(a)	2,14	0,54	1,25	> 10	6,21	< 0,10	2,82	> 10,0	> 10,0	4,15	4,15
Fe_2O_3	(a)	0,71	0,64	0,62	0,77	1,49	0,29	0,21	4,20	4,14	1,44	1,46
FeO	(b)											
MnO	(a)	0,56	0,69	0,52	0,05	0,57	0,26	0,08	0,06	0,07	0,32	0,31
MgO	(a)	19,26	20,10	20,03	1,08	18,82	20,56	< 0,1	5,62	5,76	12,12	11,08
CaO	(a)	26,66	28,66	29,93	< 1,0	18,87	30,09	< 1,0	< 1,0	< 1,0	11,65	10,93
Na_2O	(a)	—	—	—								
K_2O	(a)	0,78	0,19	0,18	6,16	1,40	0,08	0,15	4,33	3,94	0,47	0,54
P_2O_5	(a)	0,11	0,10	0,11	< 0,01	0,06	0,11	< 0,01	< 0,01	< 0,01	< 0,01	< 0,01
Cr_2O_3	(a)											
H_2O^+	(c)											
H_2O^-	(c)											
CO_2	(d)	42,20	44,73	44,59	1,98	35,35	47,09	1,69	2,60	2,60	24,35	24,13
Loss Ign.	(e)											
Totaal		97,57	97,74	99,98		97,09	100,37	100.57			100.69	98.74

a Energy dispersive XRF
b Volumetric titration
c Evolution analysis
d Gaschromatography
e Gravimetric 700°C

* Out of Calibration Range for Si, Al, Mg and Ca

TABLE I

Analyst: GSO, 21.9.78

12. FARM NAME INDEX