LOWER CAMBRIAN CARBONATE STRATIGRAPHY AND SEDIMENTOLOGY, OLD WIRREALPA SPRING, FLINDERS RANGES, SOUTH AUSTRALIA.

(VOLUME 2)

BY

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THIS THESIS IS SUBMITTED FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

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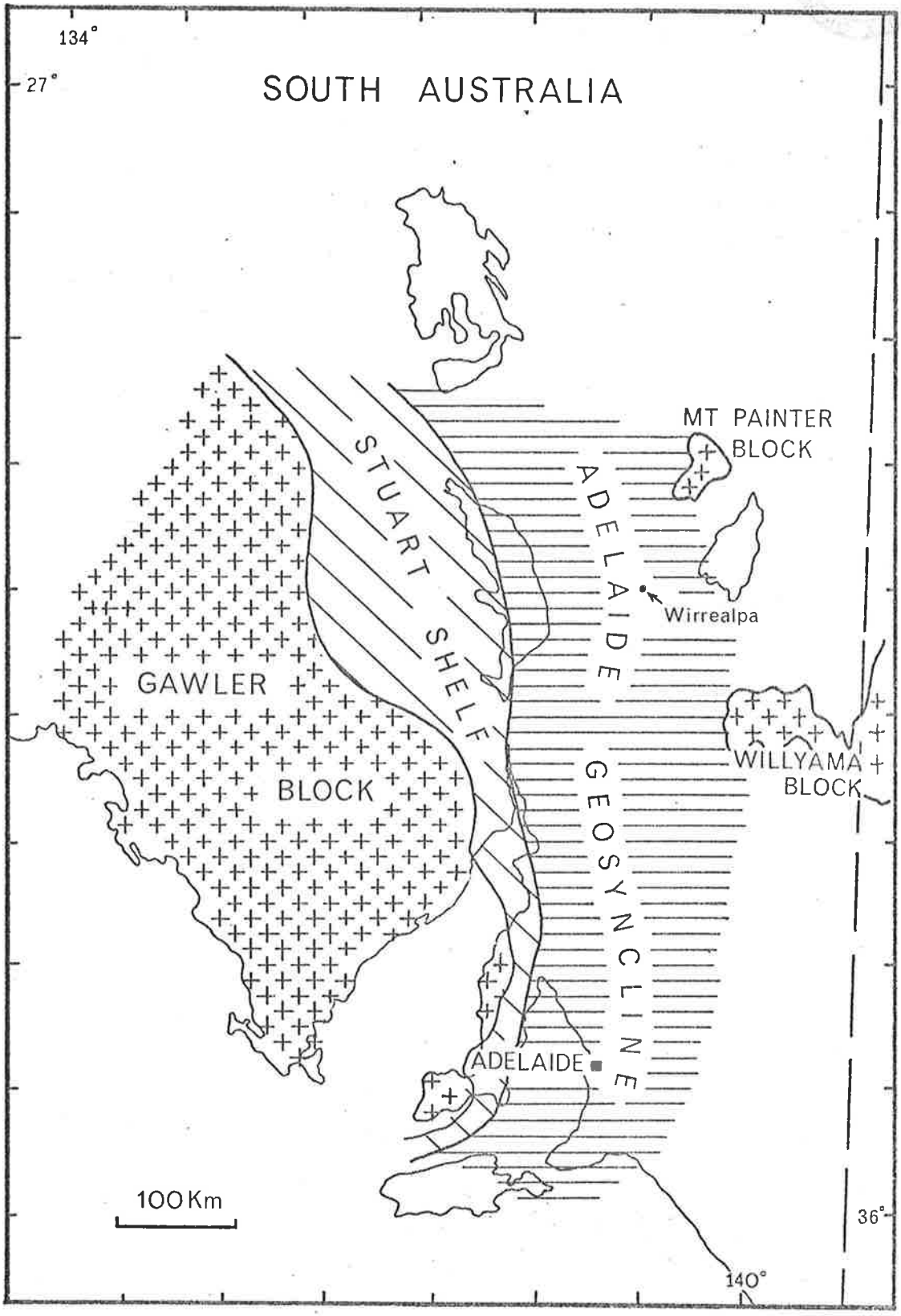


FIGURE 1: Major tectonic subdivisions of South Australia (after Tectonic Map of Australia and New Guinea, Geol. Soc. Aust. 1971).

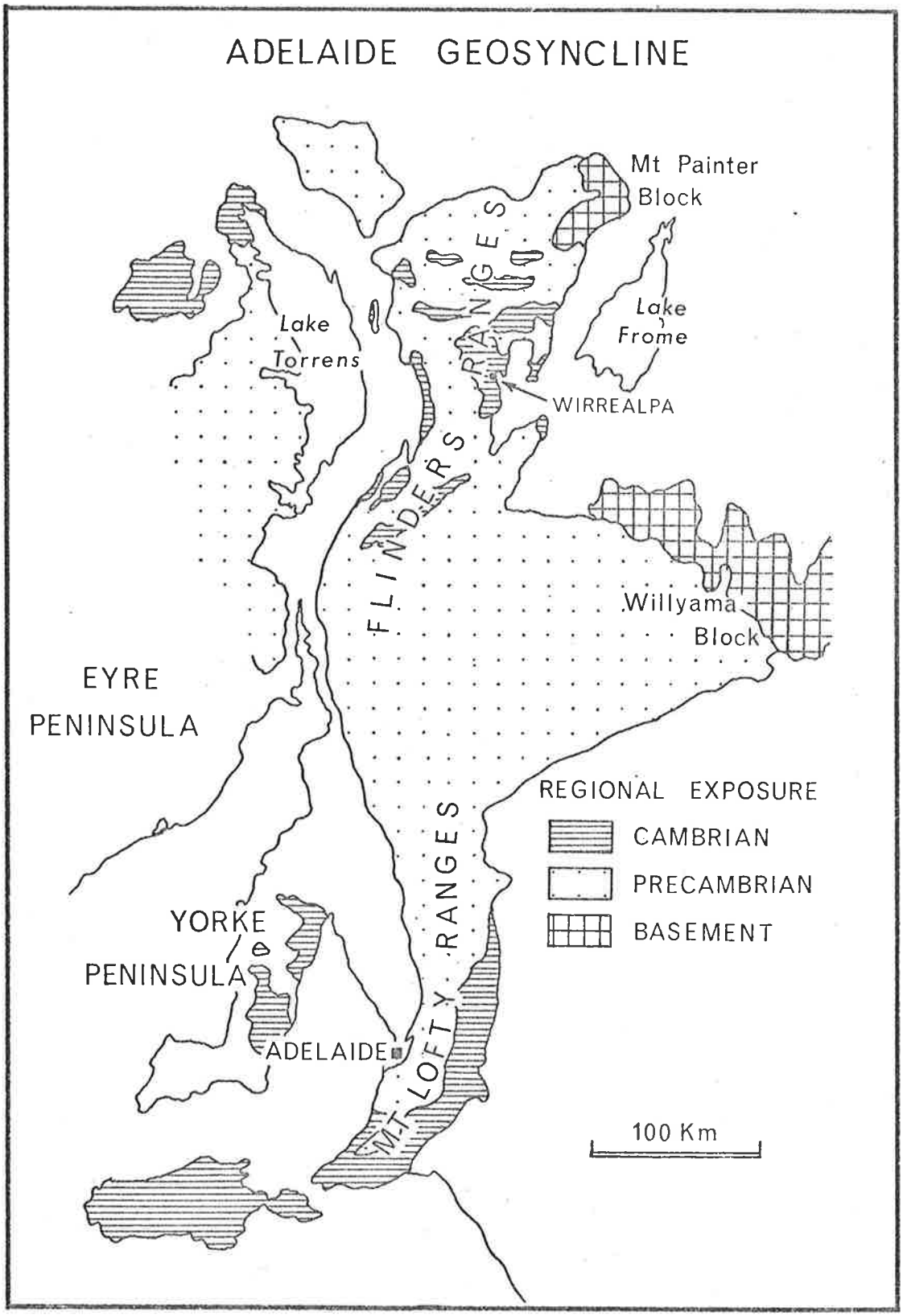


FIGURE 2: Generalized outcrop distribution in the Adelaide "Geosyncline"(after Wopfner, 1969).

FIGURE 3: In text, Volume 1, p. 2.

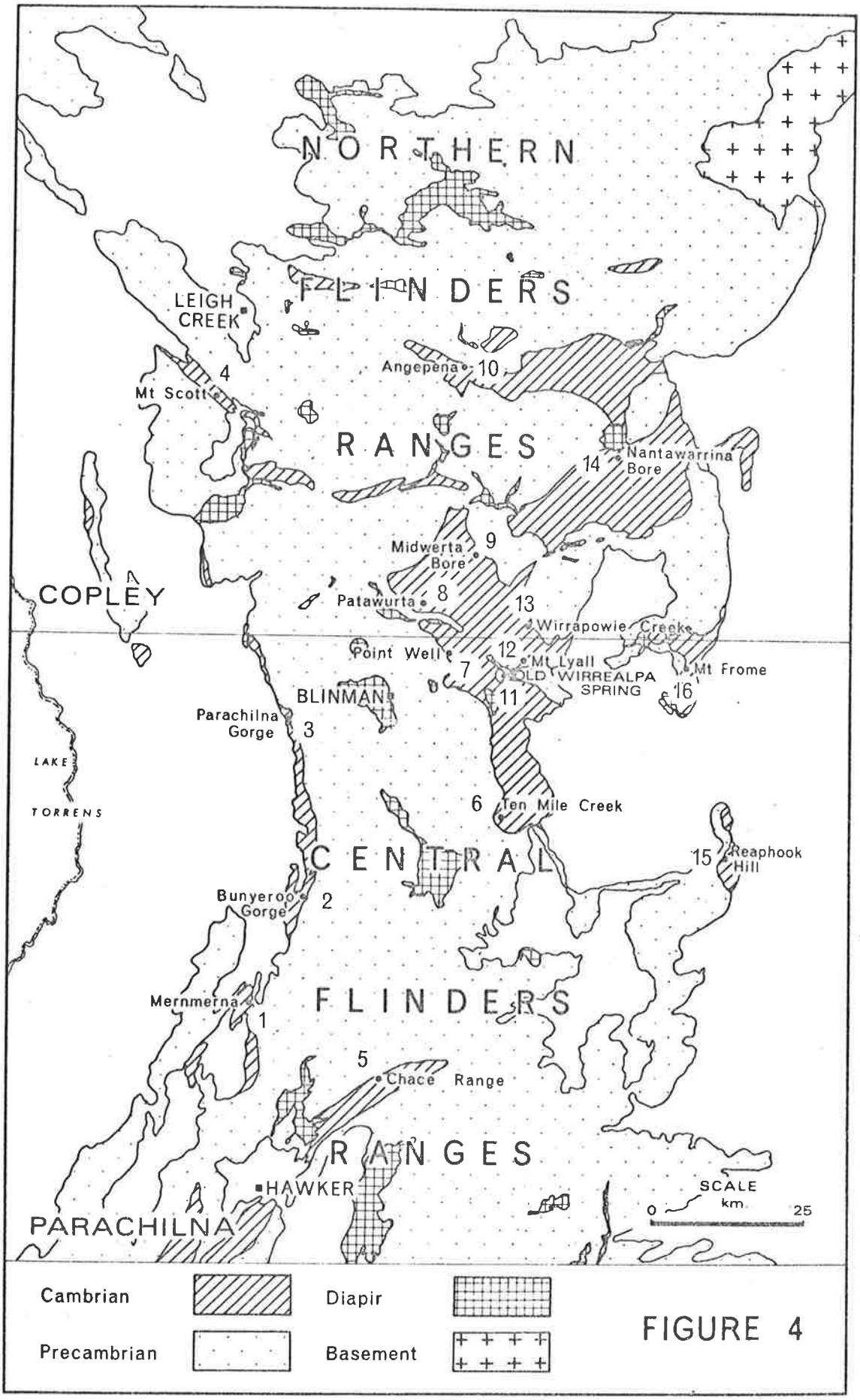


FIGURE 4

FIGURE 4: Outcrop distribution and measured Section locations, Central and Northern Flinders Ranges (from COPLEY and PARACHILNA 1:250,000 map sheets).

FIGURE 5: In pocket at the back of this volume.

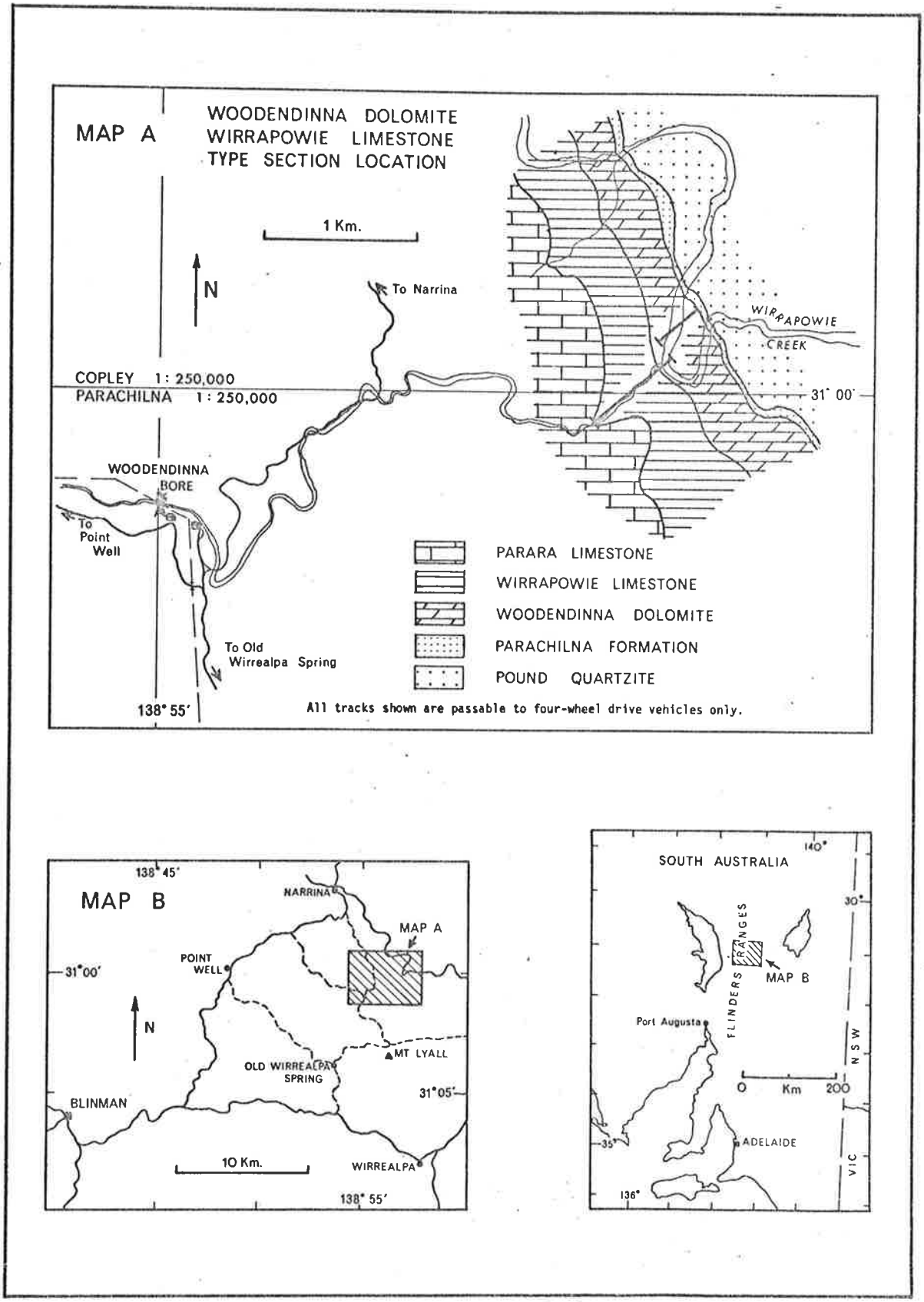


FIGURE 6: Type-section location maps, Woodendinna Dolomite and Wirrapowie Limestone (after Haslett, 1975).

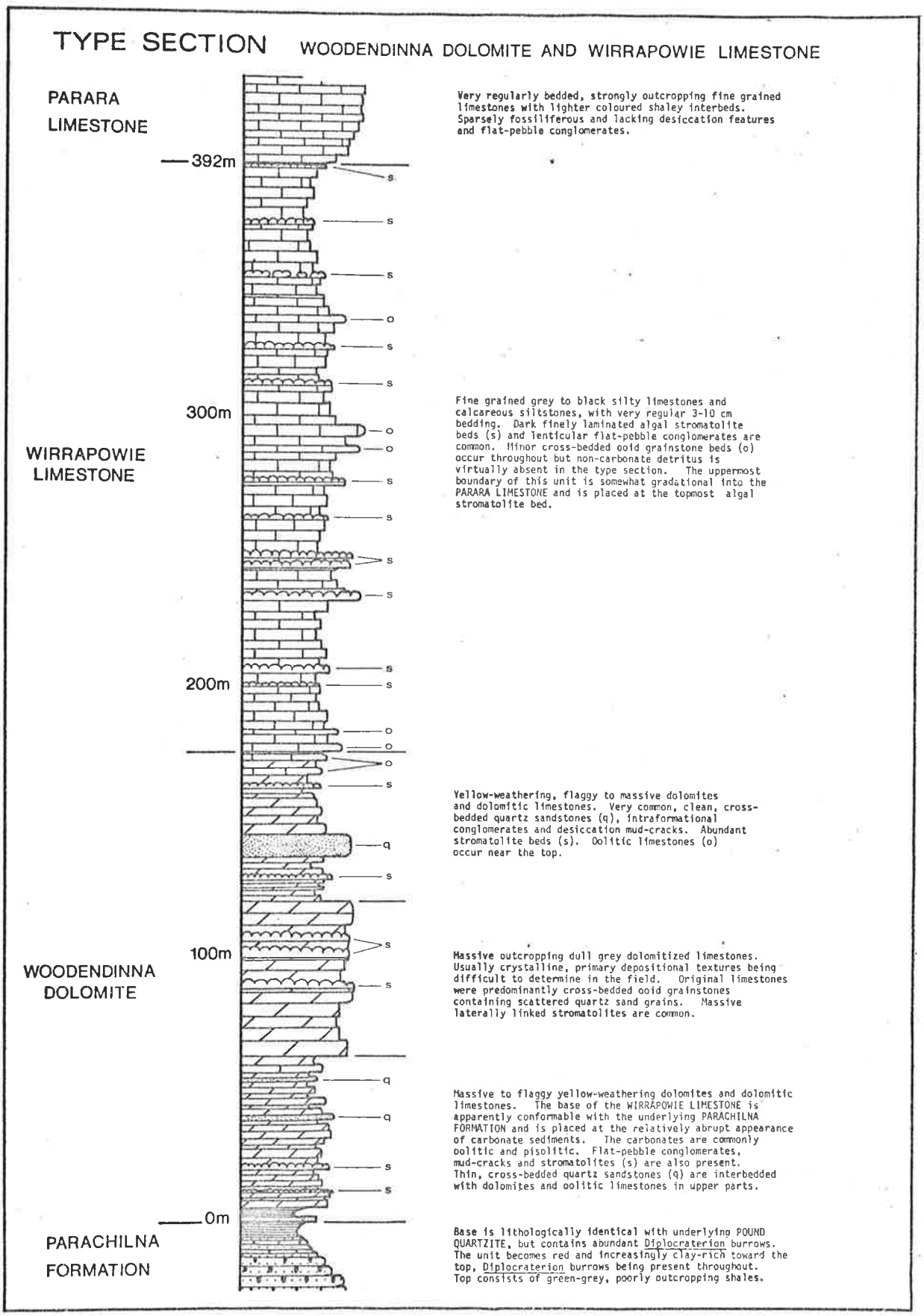


FIGURE 7: Type section, Woodendinna Dolomite and Wirrapowie Limestone (after Haslett, 1975).

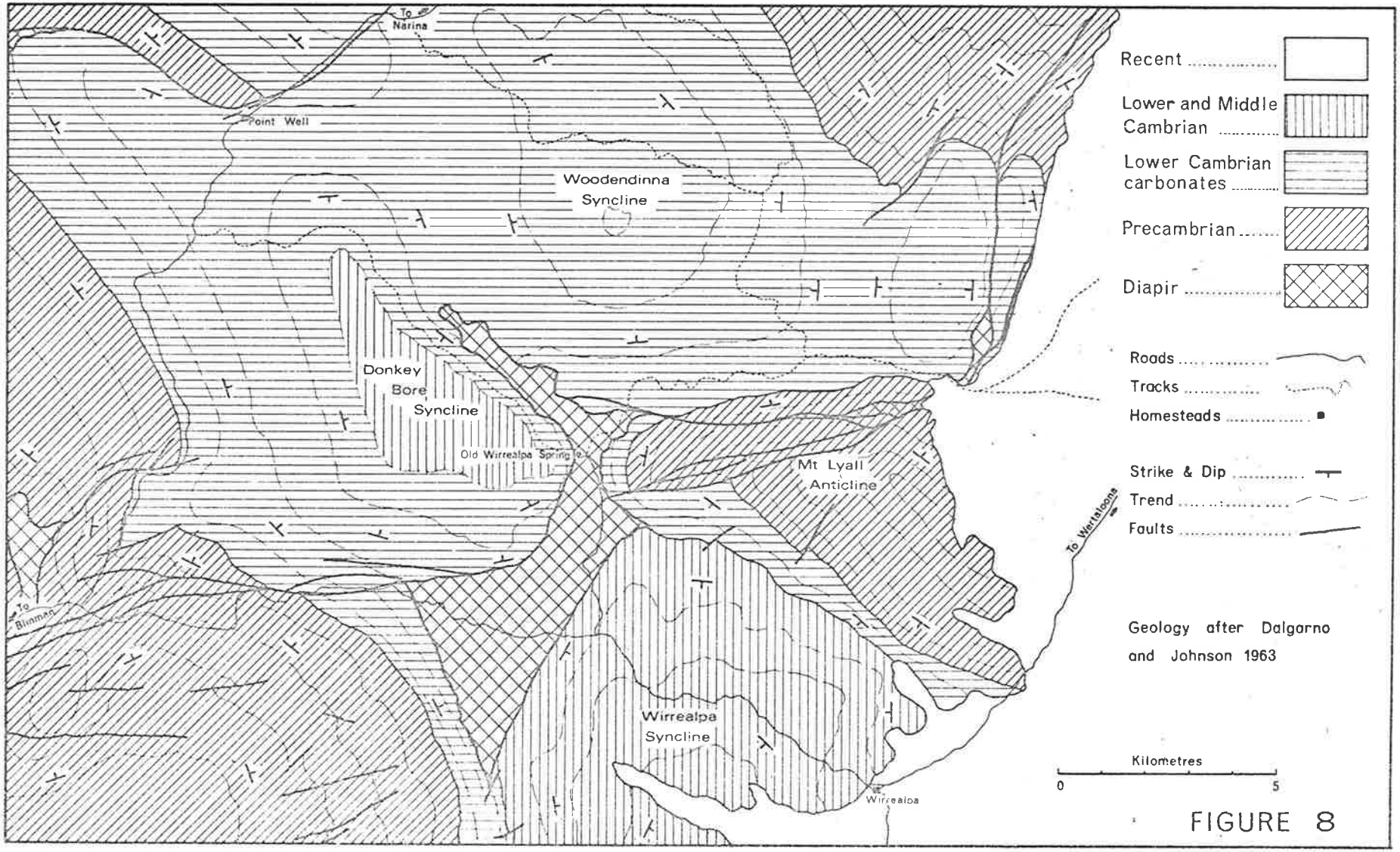

To Narina
Point Well
Woodendinna Syncline
Donkey Bore Syncline
Old Wirrealpa Spring
Mt Lyall Anticline
To Wertaloona
To Blinman
Wirrealpa Syncline
Wirrealpa
Recent
Lower and Middle Cambrian
Lower Cambrian carbonates
Precambrian
Diapir
Roads
Tracks
Homesteads
Strike & Dip
Trend
Faults
Geology after Dalgarno and Johnson 1963
Kilometres
0
5

FIGURE 8

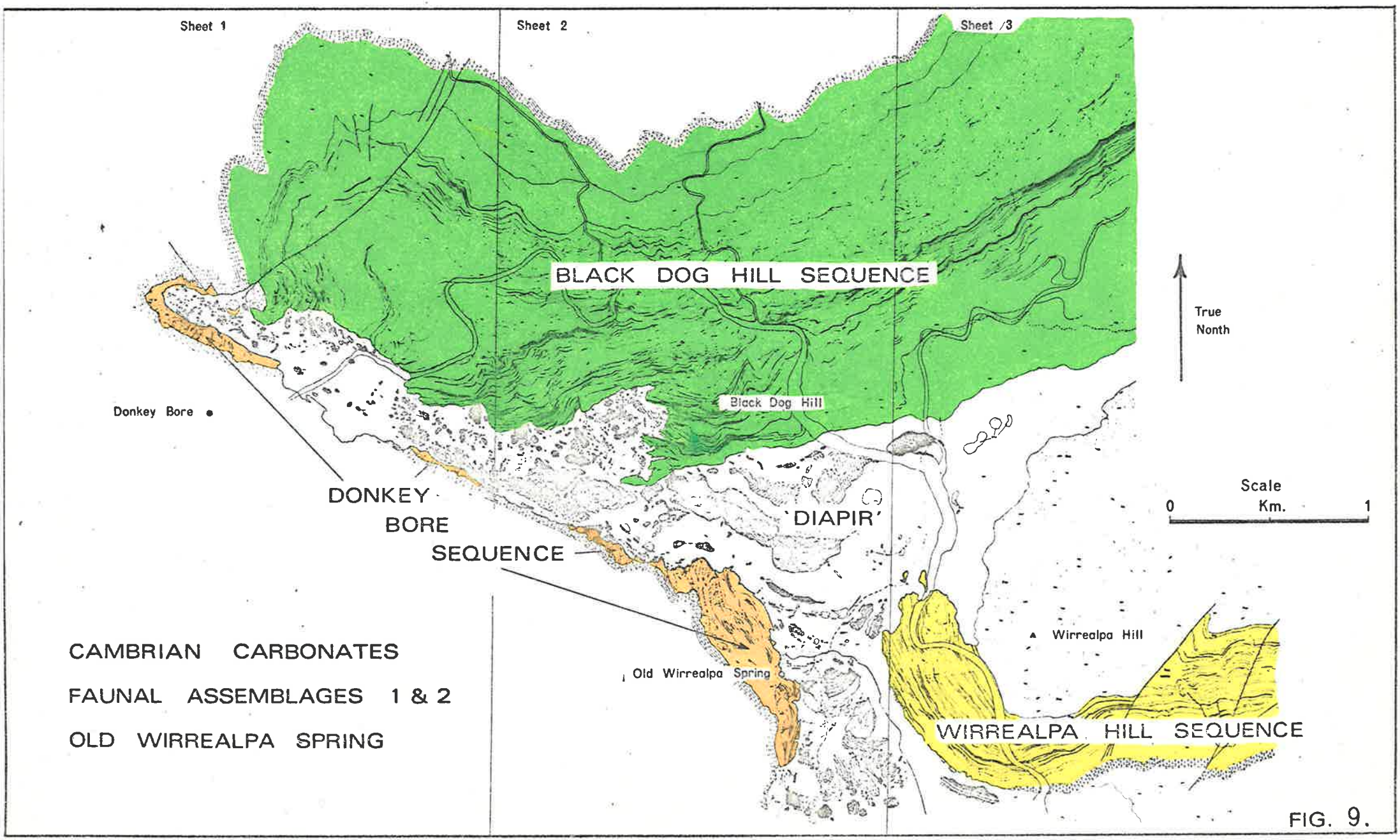

Sheet 1
Sheet 2
Sheet /3
BLACK DOG HILL SEQUENCE
Black Dog Hill
Donkey Bore
DONKEY BORE SEQUENCE
'DIAPIR'
Old Wirrealpa Spring
Wirrealpa Hill
WIRREALPA HILL SEQUENCE
True North
Scale
0 Km. 1
CAMBRIAN CARBONATES
FAUNAL ASSEMBLAGES 1 & 2
OLD WIRREALPA SPRING

FIG. 9.

FIGURE 10: Map sheets 1, 2, and 3 in pocket at the back of this volume.

FIGURE 11: In pocket at the back of this volume.

FIGURE 12: In pocket at the back of this volume.

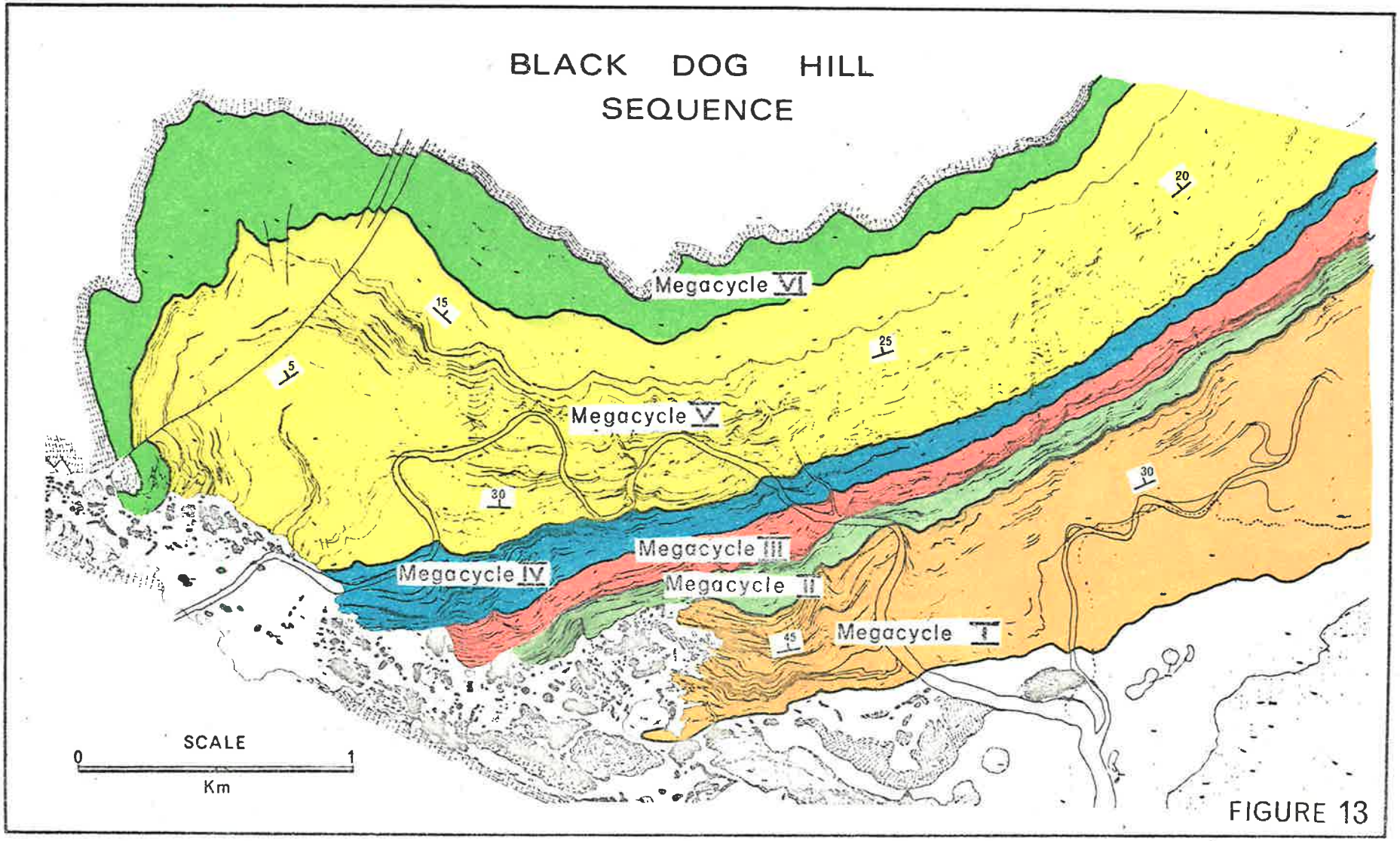
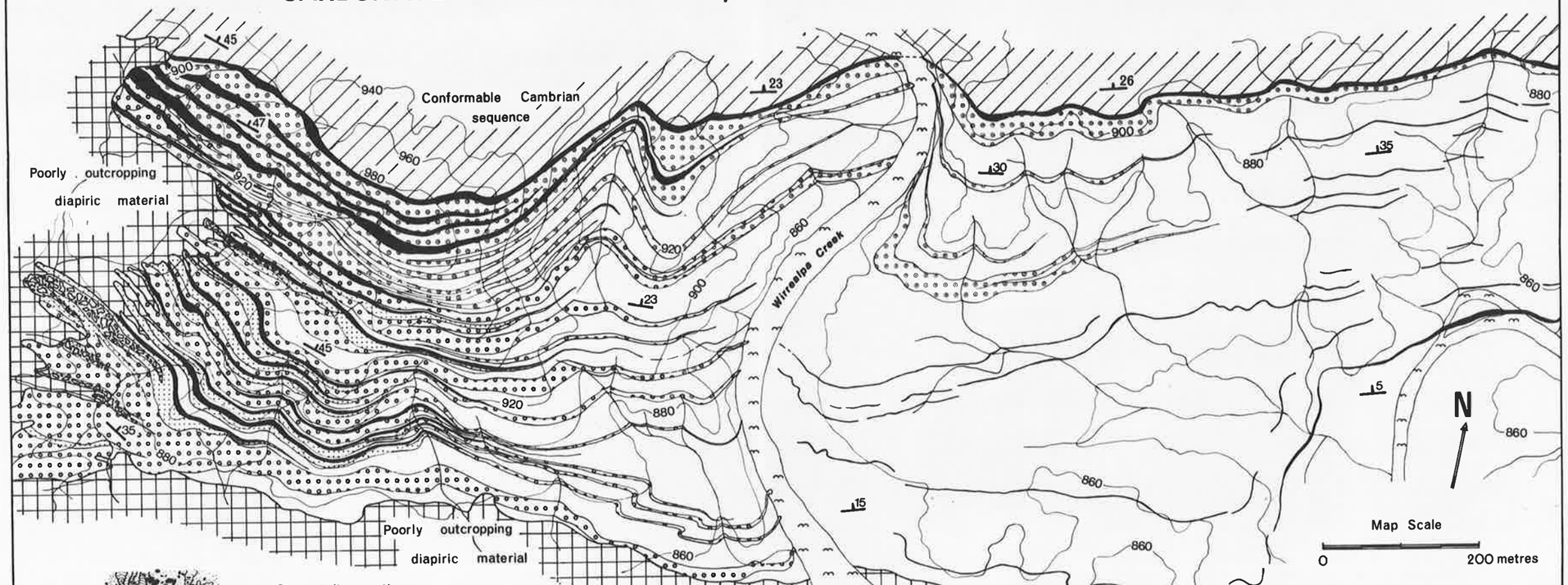
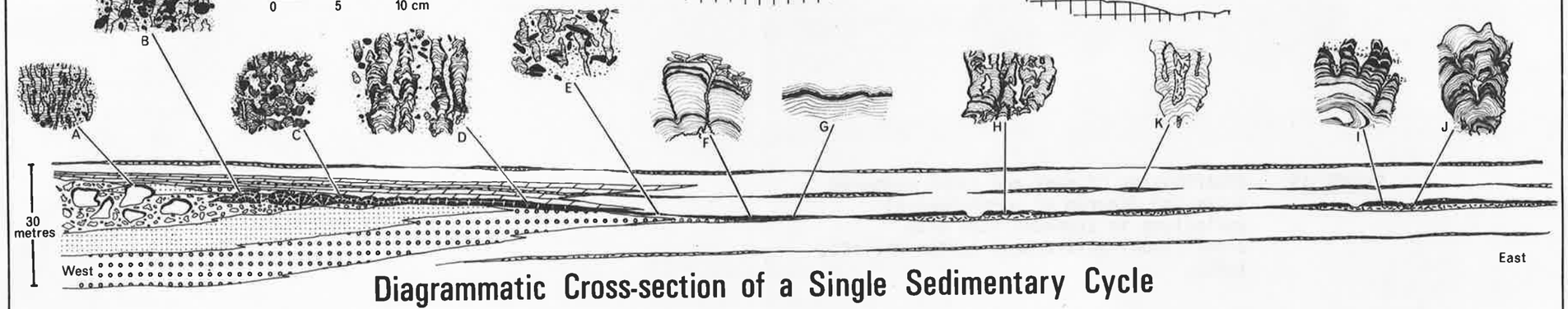

BLACK DOG HILL
SEQUENCE
Megacycle VI
Megacycle V
Megacycle IV
Megacycle III
Megacycle II
Megacycle I
15
5
30
20
25
30
45
SCALE
0
1
Km

FIGURE 13

FIGURE 14: In text, Volume 1, p. 38.

CARBONATE LITHOFACIES MAP, LOWER CAMBRIAN, OLD WIRREALPA, S.A.





Diagrammatic Cross-section of a Single Sedimentary Cycle

Gravelly Lithoclast Grainstones

Sandy Lithoclast Grainstones

Carbonate Mudstones

Stromatolites

Dark Colored Ooid Grainstones

Light Colored Ooid Grainstones

Flat Pebble Conglomerates

Dolomitic Mudstones

P.G.H. '74

FIGURE 15: Distribution of dark and light coloured ooids and diagram of morphological variations in stromatolites with depositional environment (after Haslett, 1976).

FIGURE 16: IN text, Volume 1, p. 52.

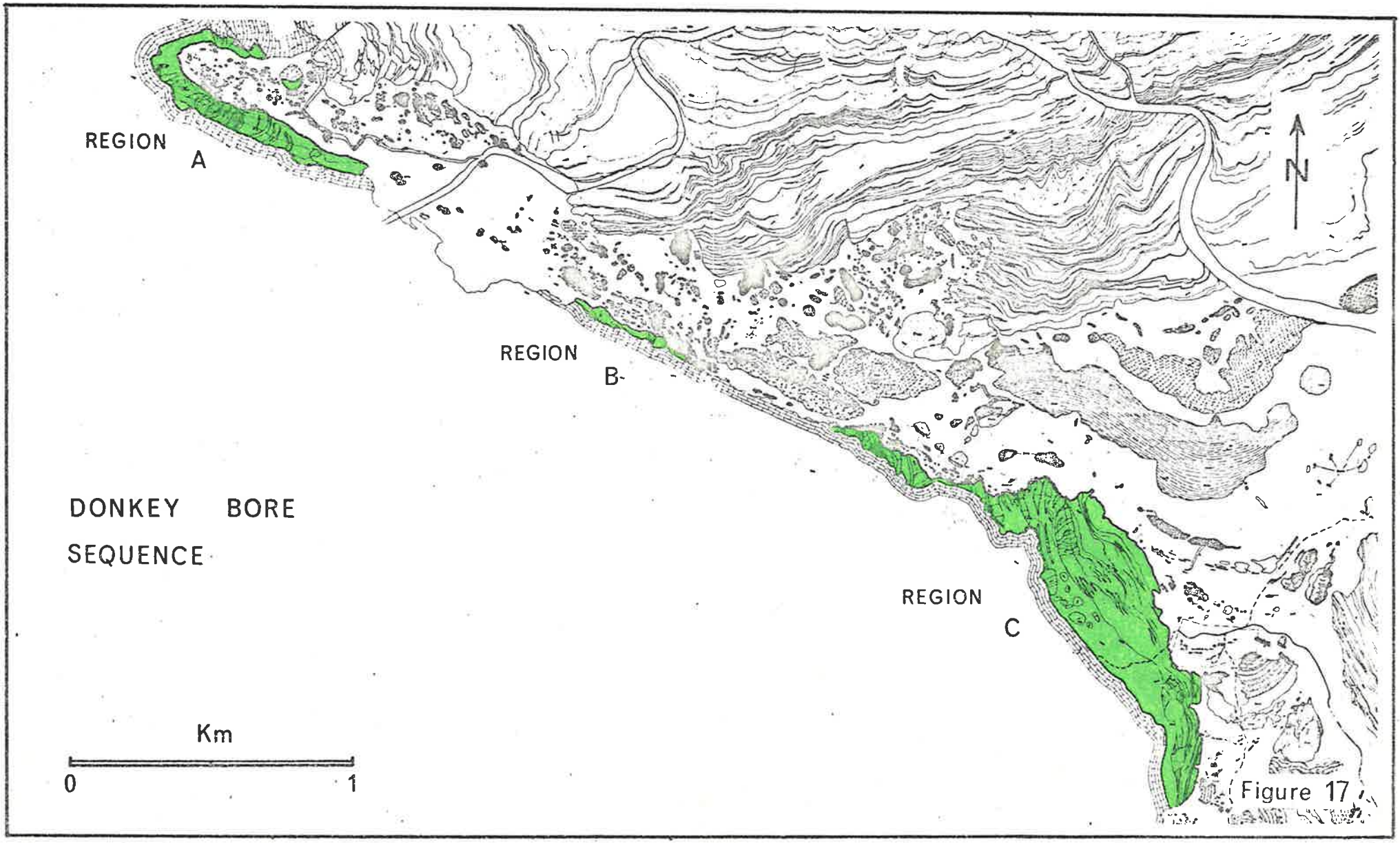


Figure 17

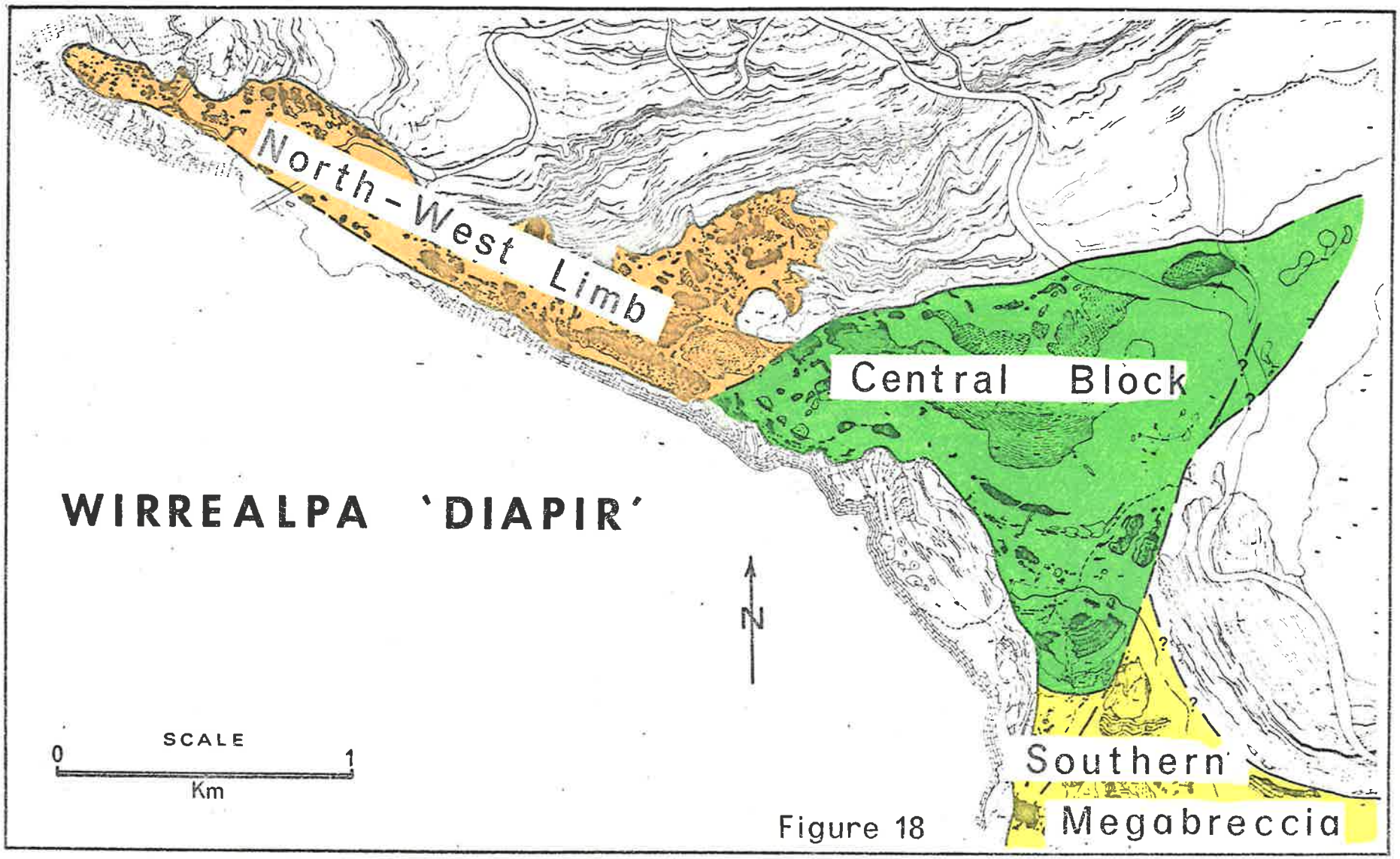

North-West Limb
Central Block
Southern
Megabreccia
WIRREALPA 'DIAPIR'
N
SCALE
0
1
Km

Figure 18

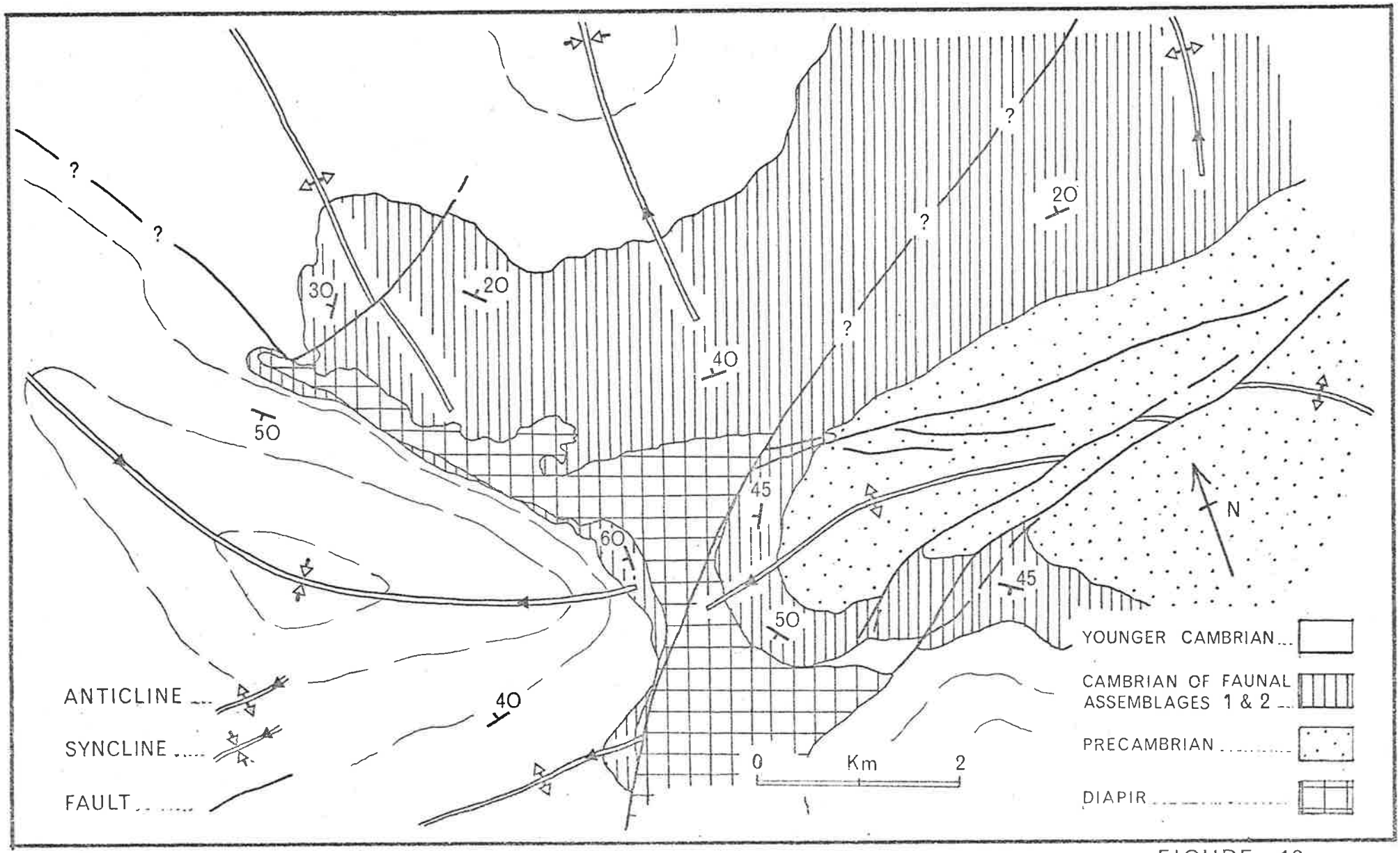

?
?
30
20
?
?
20
40
50
45
60
45
50
40
N
0
Km
2
ANTICLINE
SYNCLINE
FAULT
YOUNGER CAMBRIAN
CAMBRIAN OF FAUNAL ASSEMBLAGES 1 & 2
PRECAMBRIAN
DIAPIR

FIGURE 19

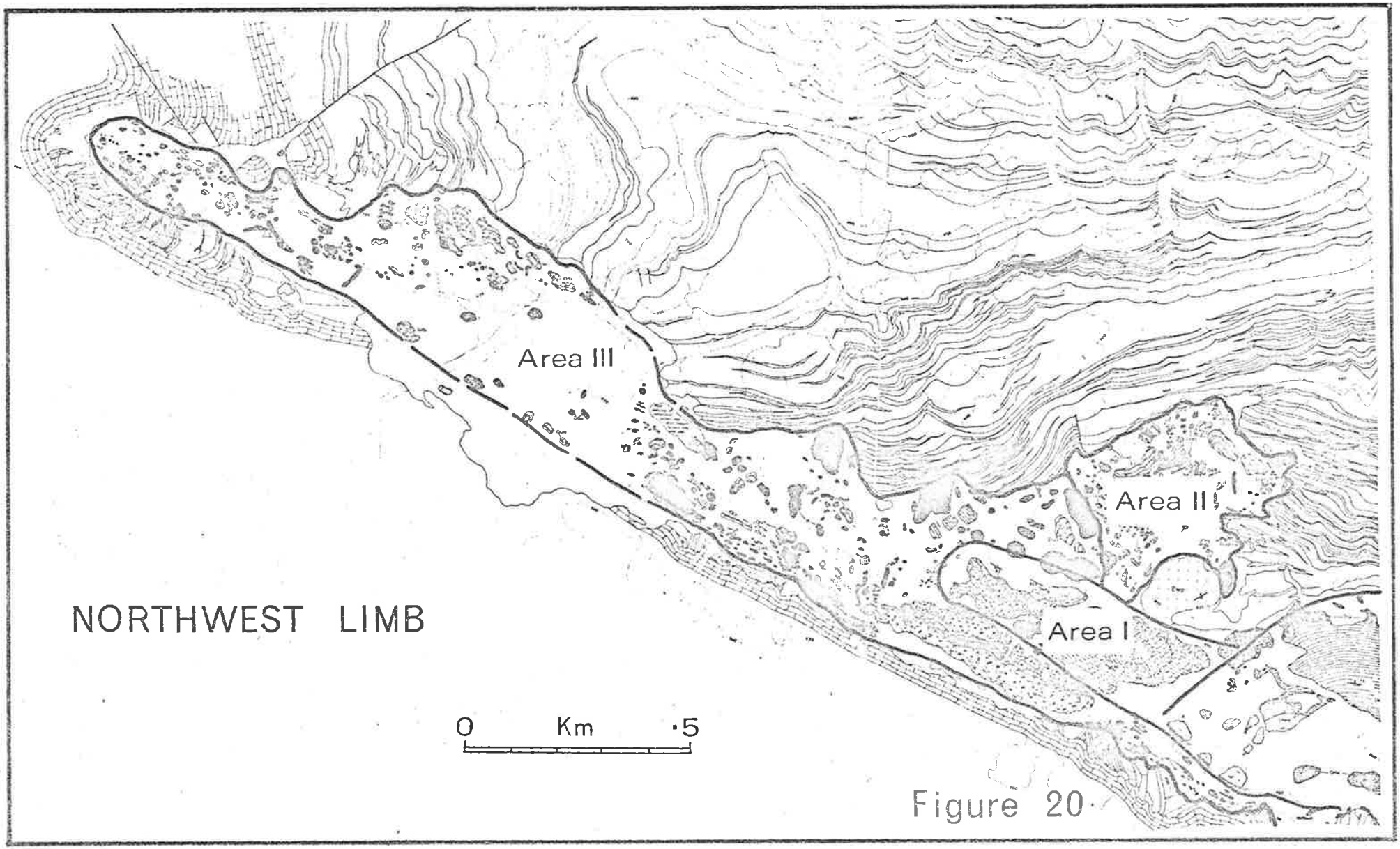


Figure 20

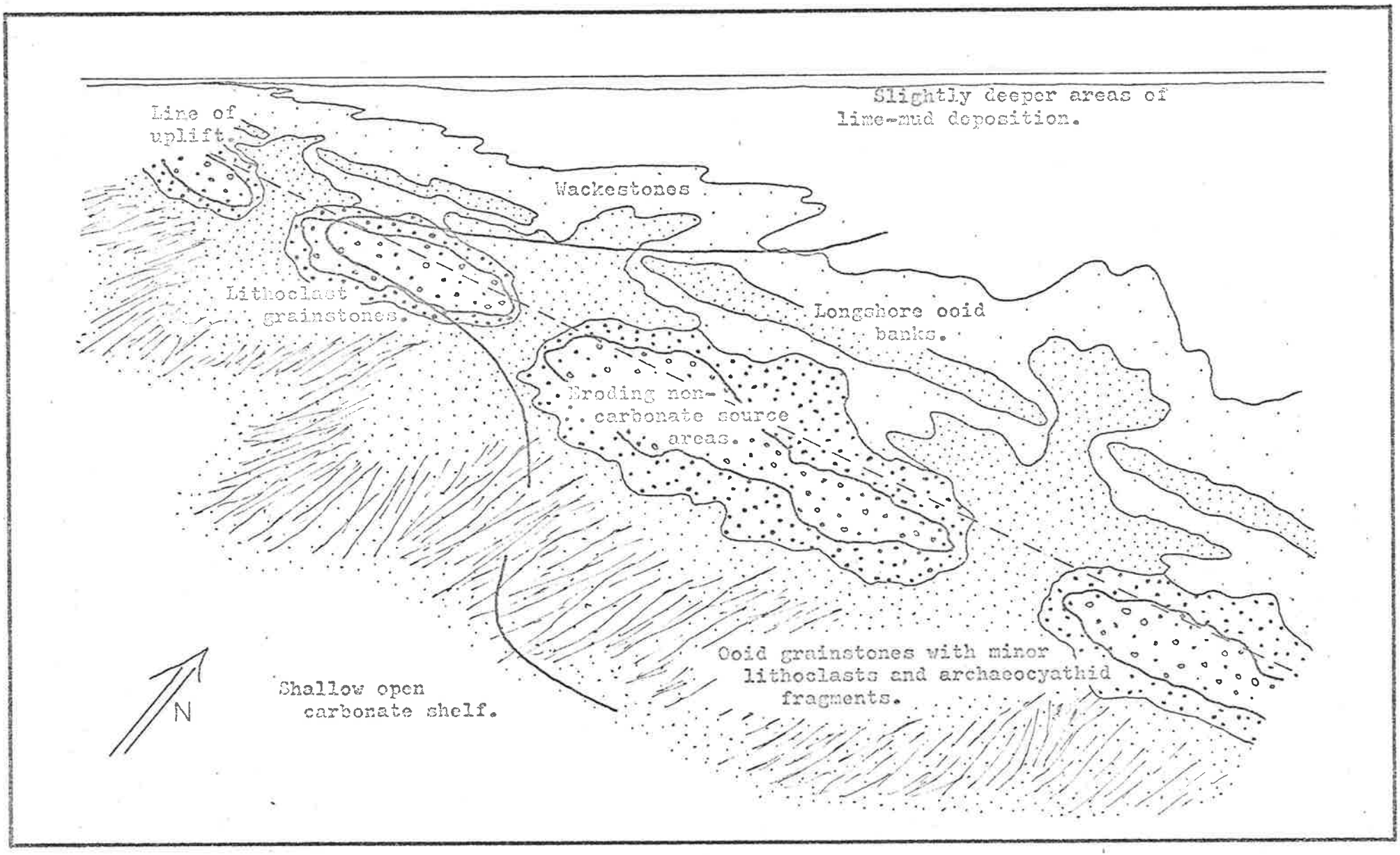

Line of uplift.
Slightly deeper areas of lime-mud deposition.
Wackestones
Lithoclast grainstones.
Longshore ooid banks.
Eroding non-carbonate source areas.
Ooid grainstones with minor lithoclasts and archaeocyathid fragments.
N
Shallow open carbonate shelf.

FIGURE 26

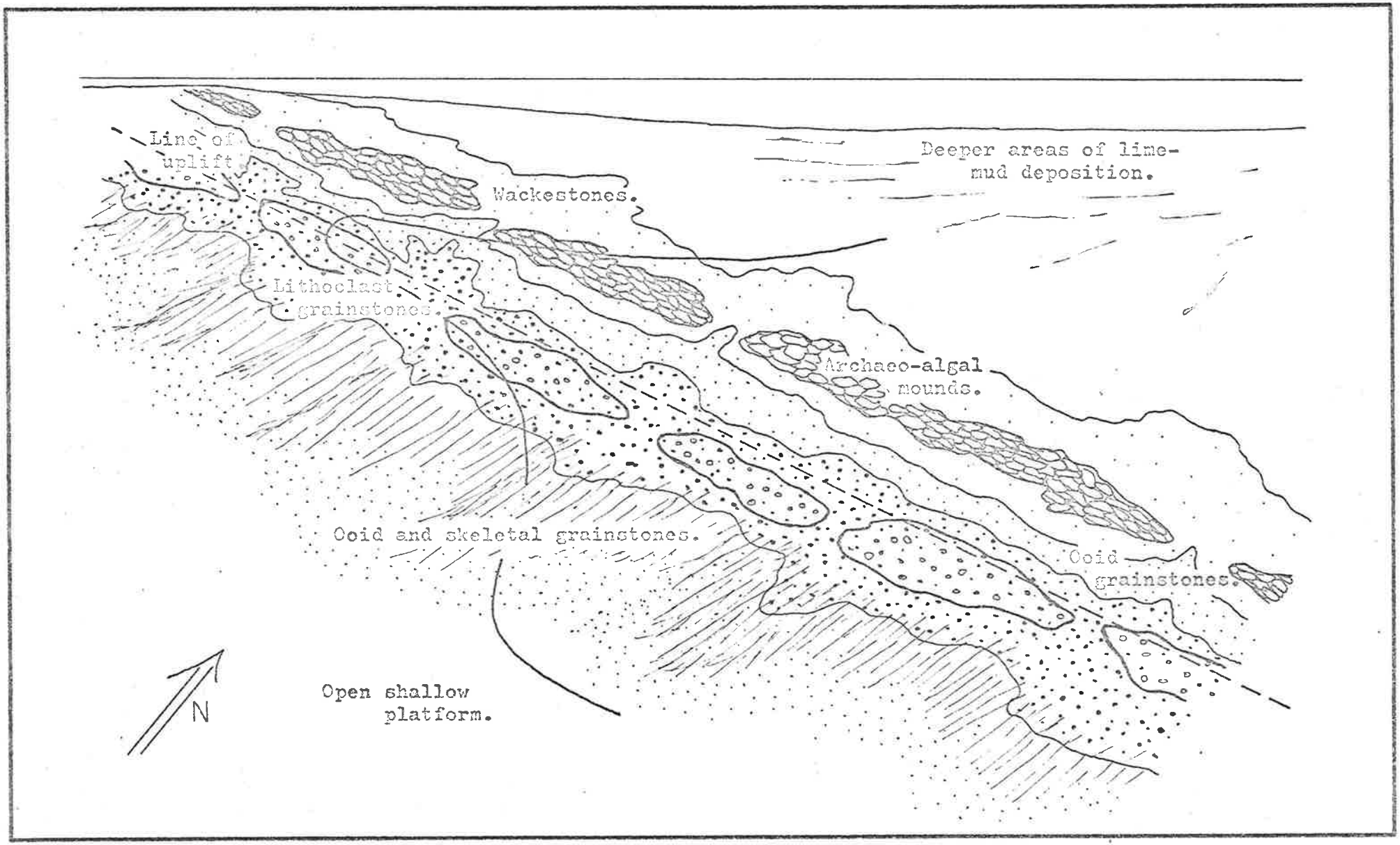

Line of uplift.
Wackestones.
Deeper areas of lime-mud deposition.
Lithoclast grainstones.
Archaeo-algal mounds.
Ooid and skeletal grainstones.
Ooid grainstones.
N
Open shallow platform.

FIGURE 27

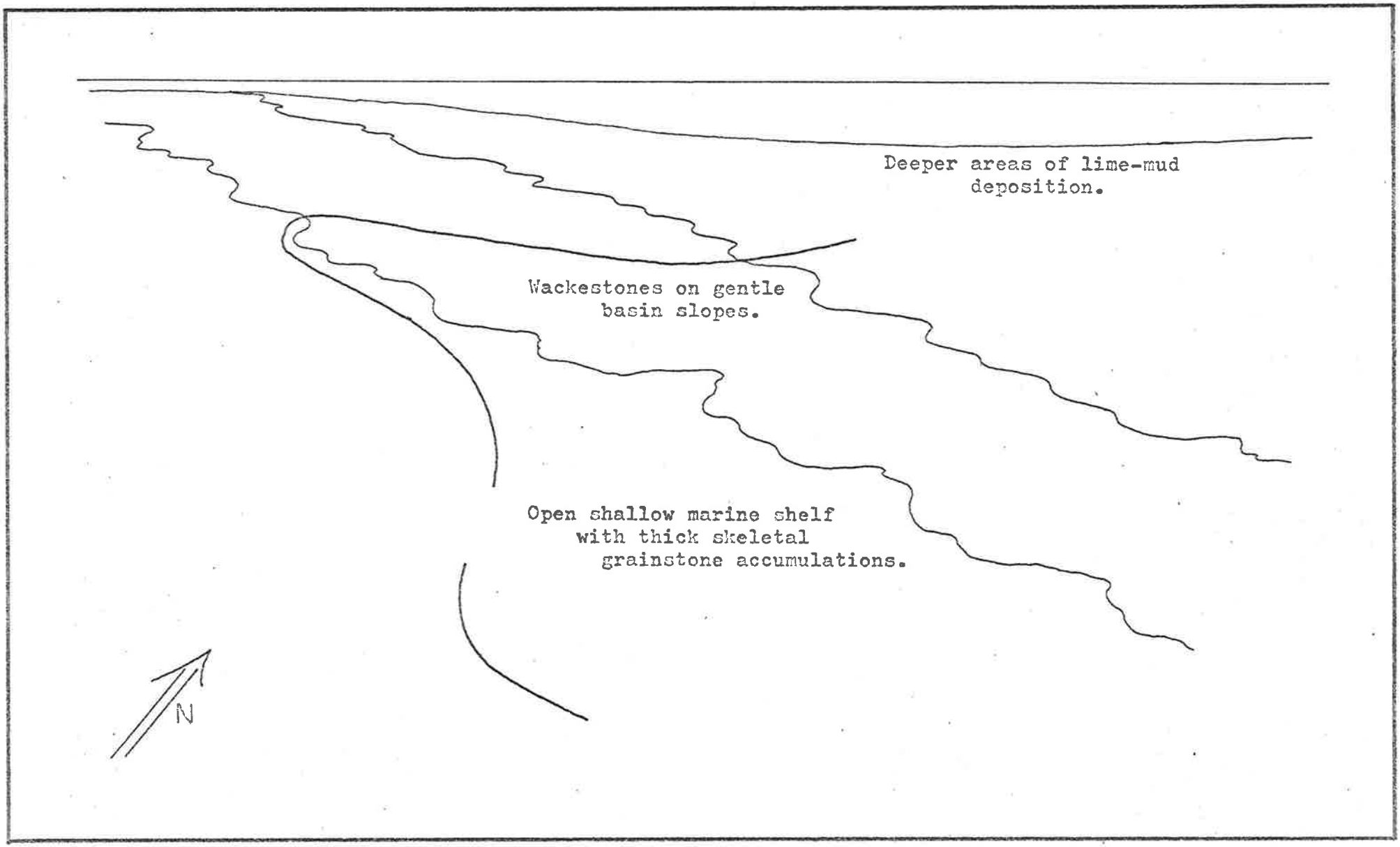

Deeper areas of lime-mud deposition.
Wackestones on gentle basin slopes.
Open shallow marine shelf with thick skeletal grainstone accumulations.
N

FIGURE 28

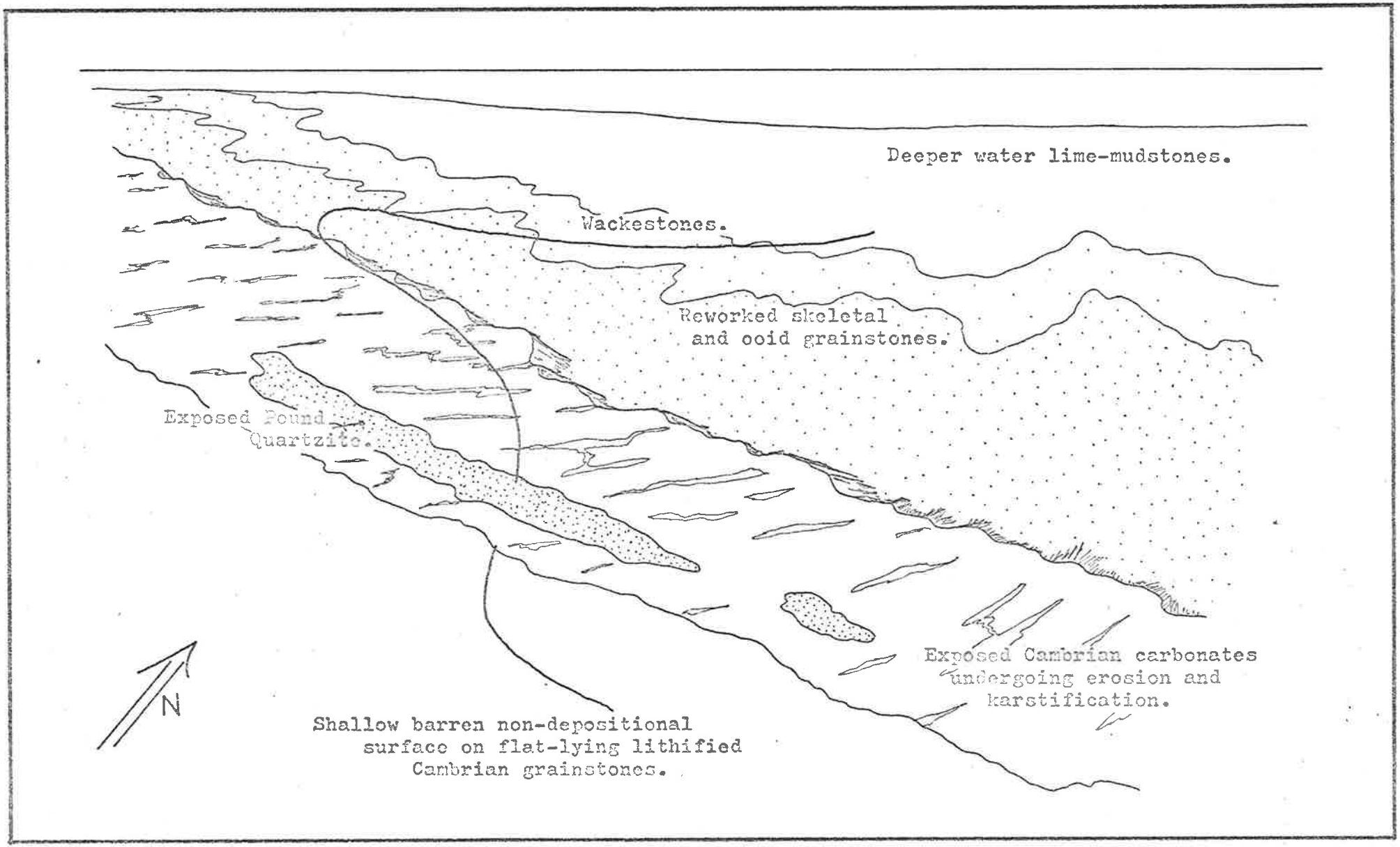

Deeper water lime-mudstones.
Wackestones.
Reworked skeletal and ooid grainstones.
Exposed Pound Quartzite.
N
Shallow barren non-depositional surface on flat-lying lithified Cambrian grainstones.
Exposed Cambrian carbonates undergoing erosion and karstification.

FIGURE 29

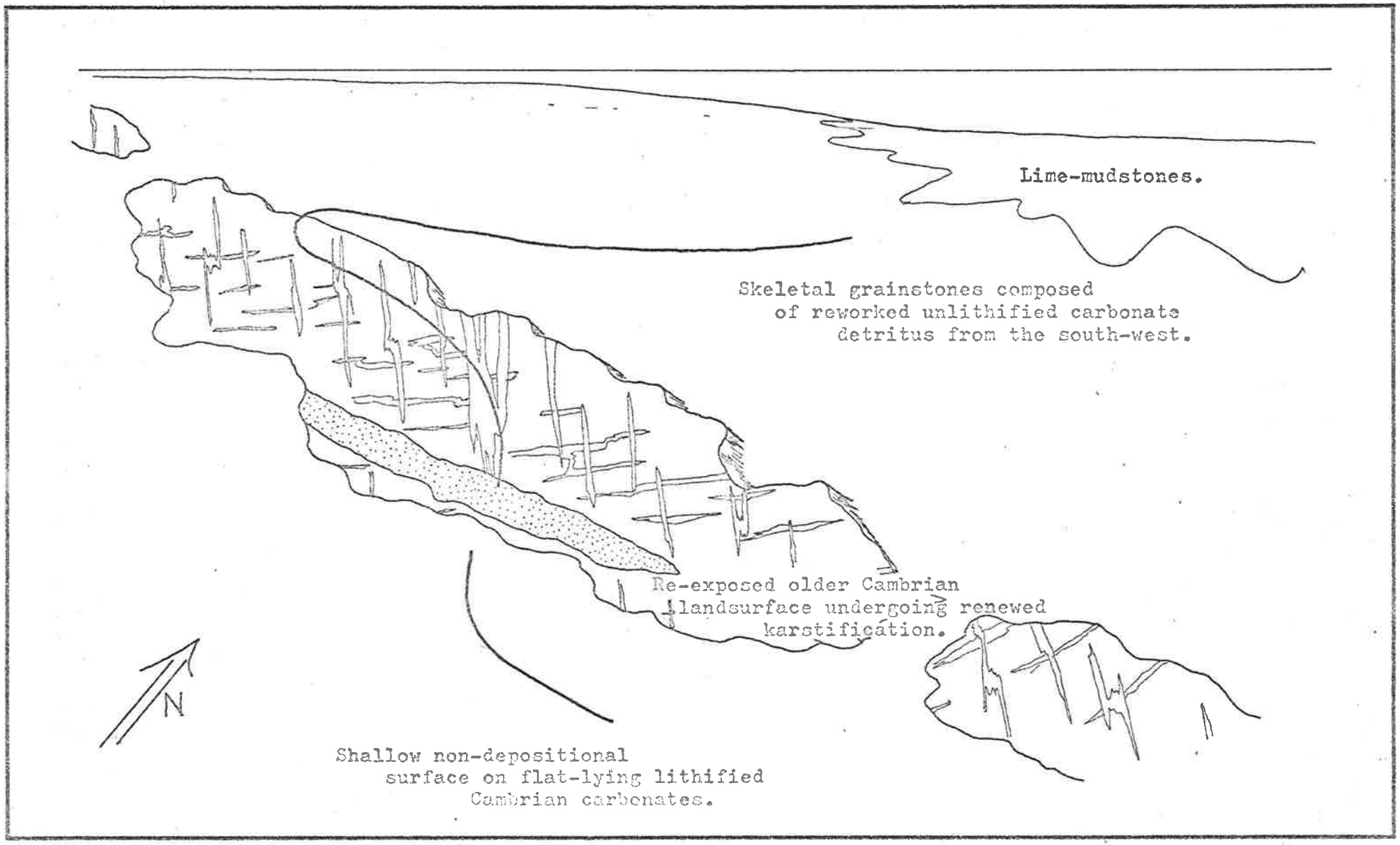

Lime-mudstones.
Skeletal grainstones composed of reworked unlithified carbonate detritus from the south-west.
Re-exposed older Cambrian landsurface undergoing renewed karstification.
N
Shallow non-depositional surface on flat-lying lithified Cambrian carbonates.

FIGURE 30

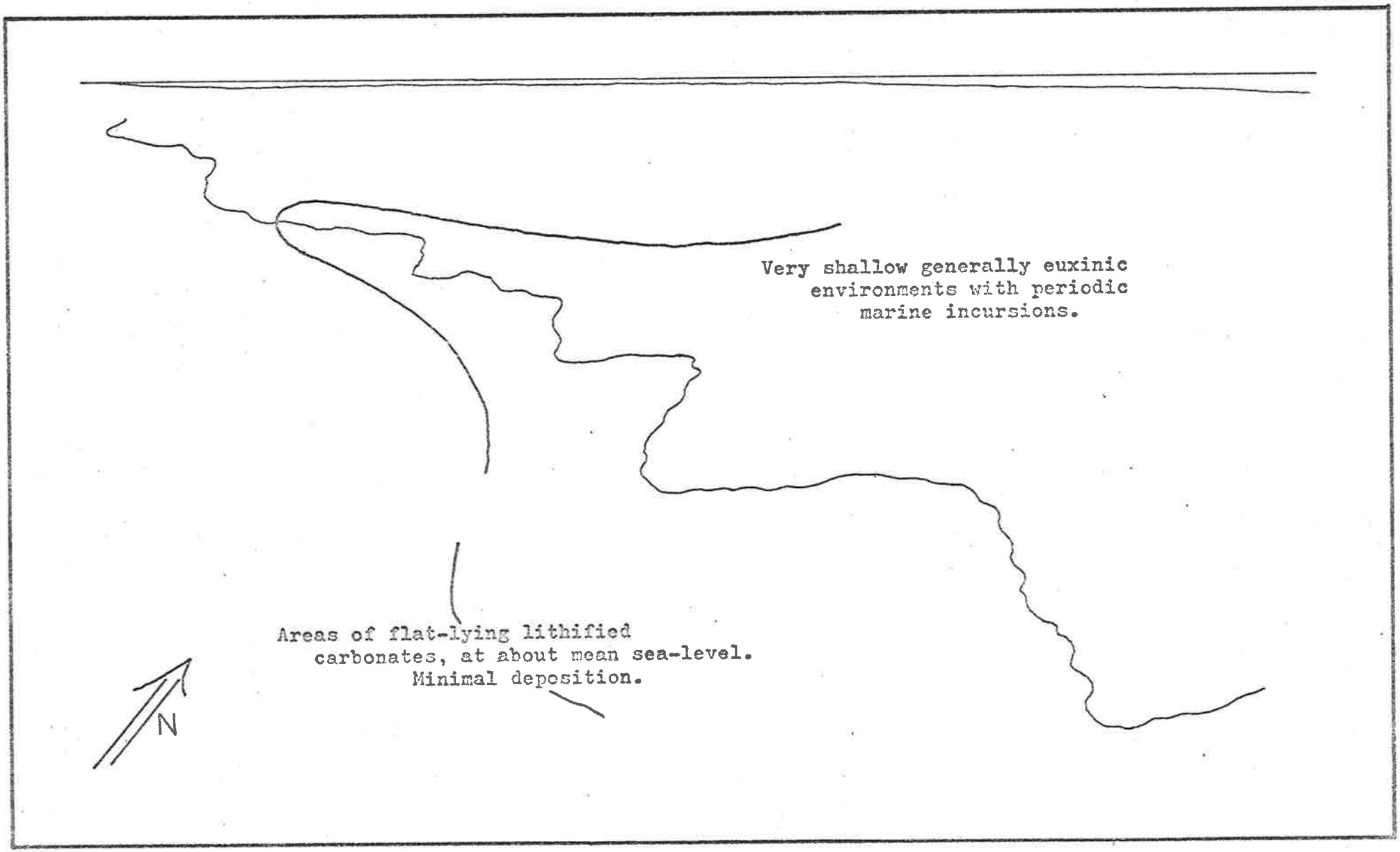
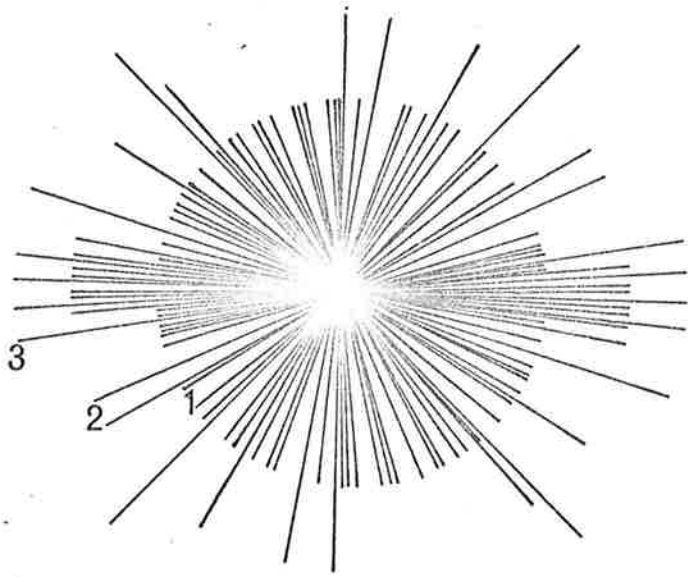

Very shallow generally euxinic
environments with periodic
marine incursions.
Areas of flat-lying lithified
carbonates, at about mean sea-level.
Minimal deposition.
N

FIGURE 31

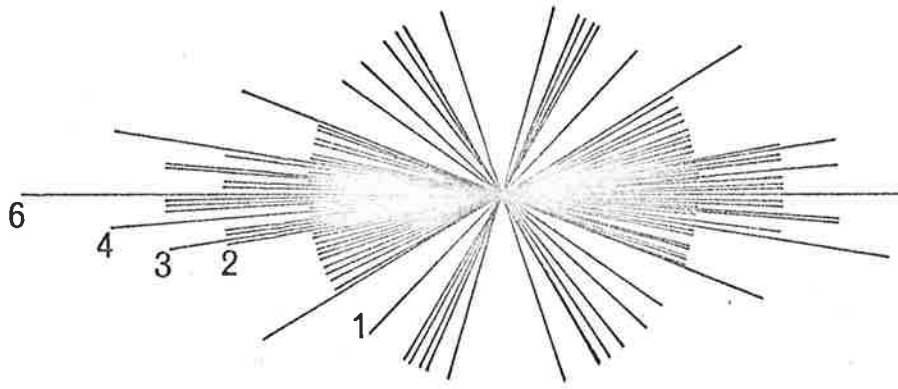
FIGURE 32: In text, Volume 1, p. 104.

FIGURE 33: In pocket at the back of this volume.

MOTTLED LIMESTONES —— ORIENTATION OF LONG-AXES OF LITHOCLAST PEBBLES, MEASURED IN A PLANE PERPENDICULAR TO BEDDING.



PEBBLES FROM CARBONATE NODULES (n=84).



PEBBLES FROM CLAYEY MATRIX (n=79).

FIGURE 34.

PLATES

PLATE : 1

a. Stromatolites within flaggy lime mudstones of the stromatolite/intraclast mudstone lithofacies. (Wirrapowie Limestone), from within Wirrapowie Creek.

b. Desiccation mudcracks on underside of bedding plane in mudcrack dolomite lithofacies. (Woodendinna Dolomite), Wirrapowie Creek section.

c. Dolomite clasts in intraformational conglomerate, mudcrack dolomite lithofacies (Woodendinna Dolomite). The matrix is enriched in coarse-grained, quartz sand.

a

b

c

PLATE : 2

a. Cobbled bedding plane surface on ooid grainstone bed, mudcrack dolomite lithofacies. (Woodendinna Dolomite), Wirrapowie Creek section.

b. Basal lithoclast grainstone beds. Note the large proportion of lithoclasts and their angular to sub-angular shapes. Megacycle I, Black Dog Hill sequence.

c. Grey flaggy lime mudstones, characteristic of the eastern parts of megacycle I in the Black Dog Hill sequence.

a

b

c

PLATE : 3

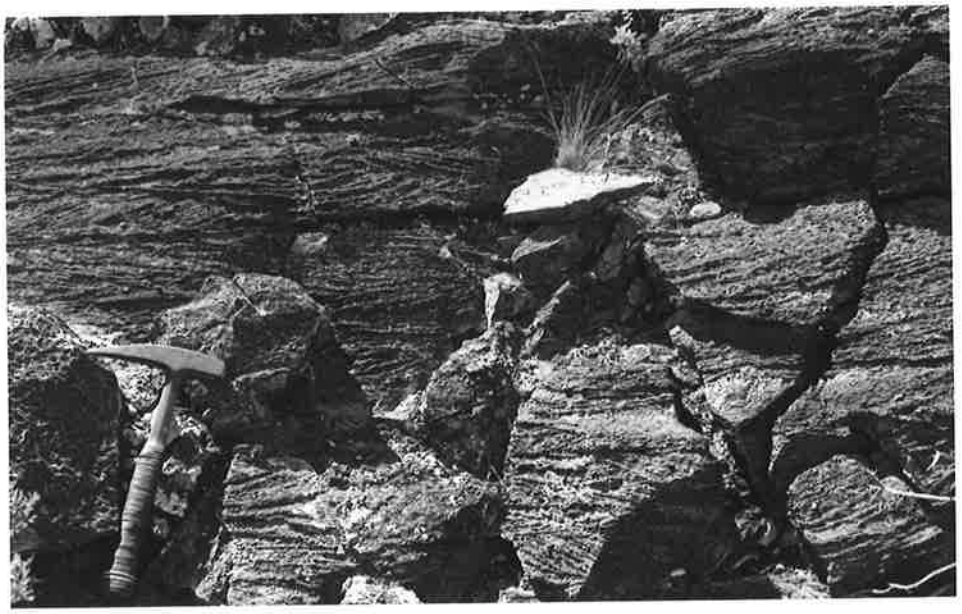
a. Ripple marks on the upper surface of an ooid grainstone bed, Black Dog Hill sequence.

b. Cross-bedded, quartz sand-rich lithoclast grainstones, Black Dog Hill sequence.

c. Bedded pebble grainstones, western parts of megacycle I, Black Dog Hill sequence.

a

b



c

PLATE : 4

a. Poorly bedded, ill-sorted boulder lithoclast grainstones, Black Dog Hill sequence.

b. Biostromal stromatolites associated with ooid grainstones, Black Dog Hill sequence.

c. Narrow, pebble-floored channel cutting thick stromatolite beds, Black Dog Hill sequence. The hammer rests upon rounded lithoclasts in the base of the channel. of the stromatolitic layering can best be seen at centre right.

a

b

c

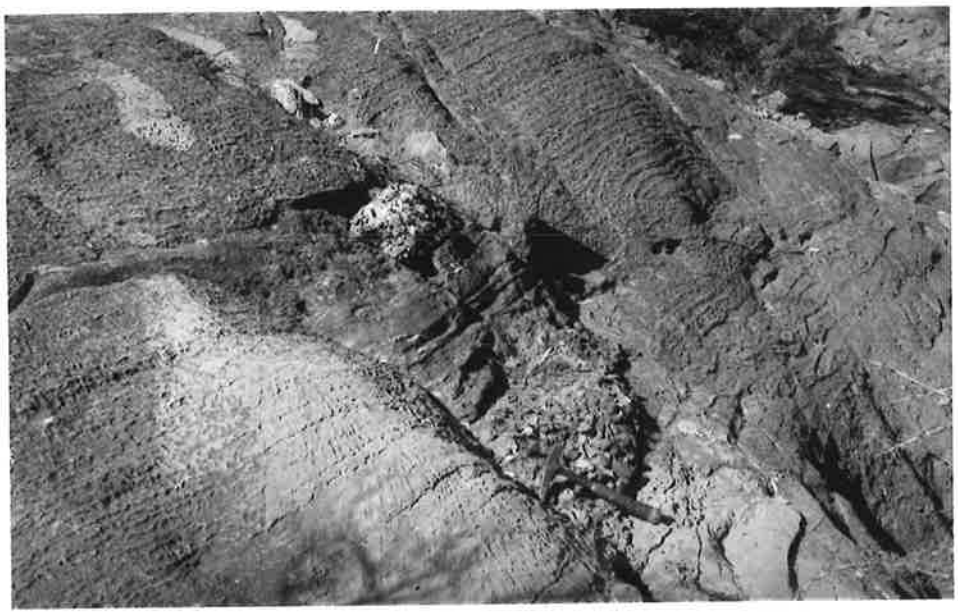


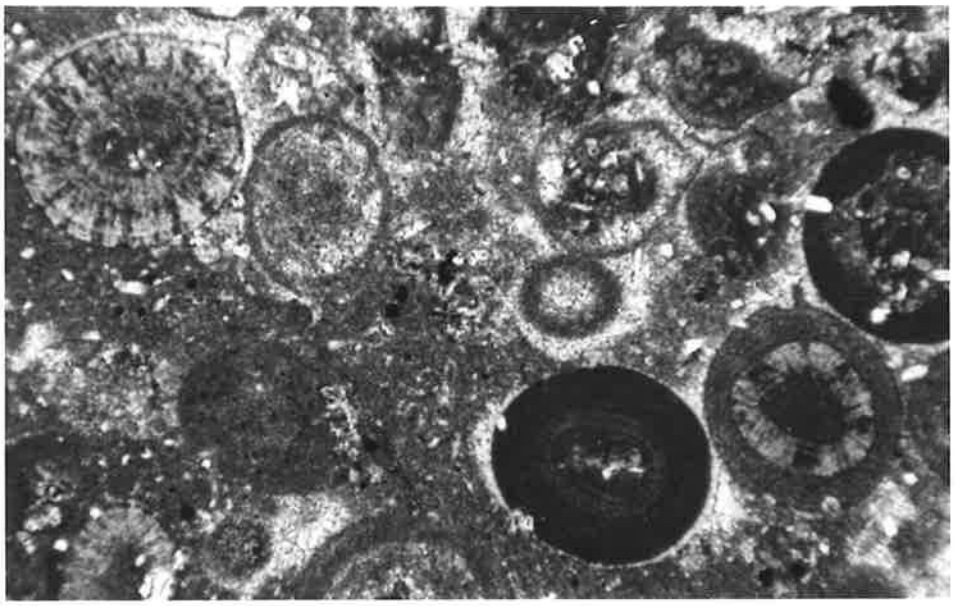
PLATE : 5

a. Photomicrograph of ooid types. The ooids with strong radial and concentric structures appear black in colour in hand specimen. The light-coloured variety are dark and dense in thin section with good concentric structure which may be seen in the dark micritic ooid at bottom-right. The micritic type in most cases in this thin section show evidence of recrystallization. A good composite ooid can be seen on the bottom-right hand corner. Average size of ooids shown would be .75-1.0 mm.

b. Typical poor outcrop of sedimentary megabreccia beds as the "diapir" is approached, megacycle I, Black Dog Hill sequence. Some of the larger boulders are outlined.

c. Large boulder with its uppermost surface encrusted with digitate stromatolites, Black Dog Hill sequence.

a



b

c

PLATE: 6

a. Cambrian ooid grainstone lenses which fill depressions in underlying, non-layered breccia material, basal megacycle II, Black Dog Hill sequence. The grainstones may contain small chips of breccia material. Lens cap is approximately 5 cm across.

b. Partially silicified, current oriented hyolithids on a wackestone bedding surface, Black Dog Hill sequence.

c. Cobbles and boulders predominatly of dolerite, in a boulder lithoclast grainstone of the Black Dog Hill sequence. Cement is entirely calcite.

a

b

c

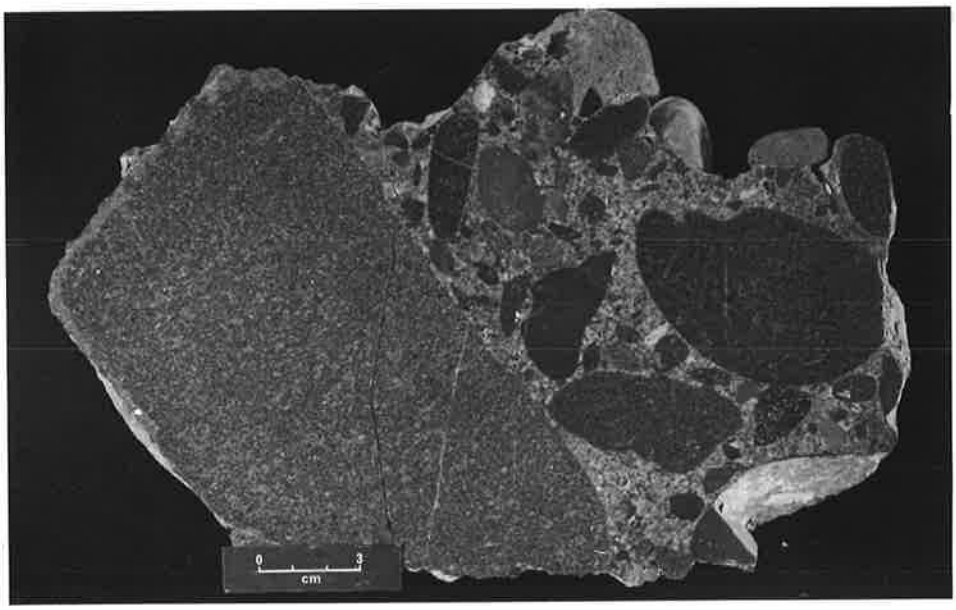


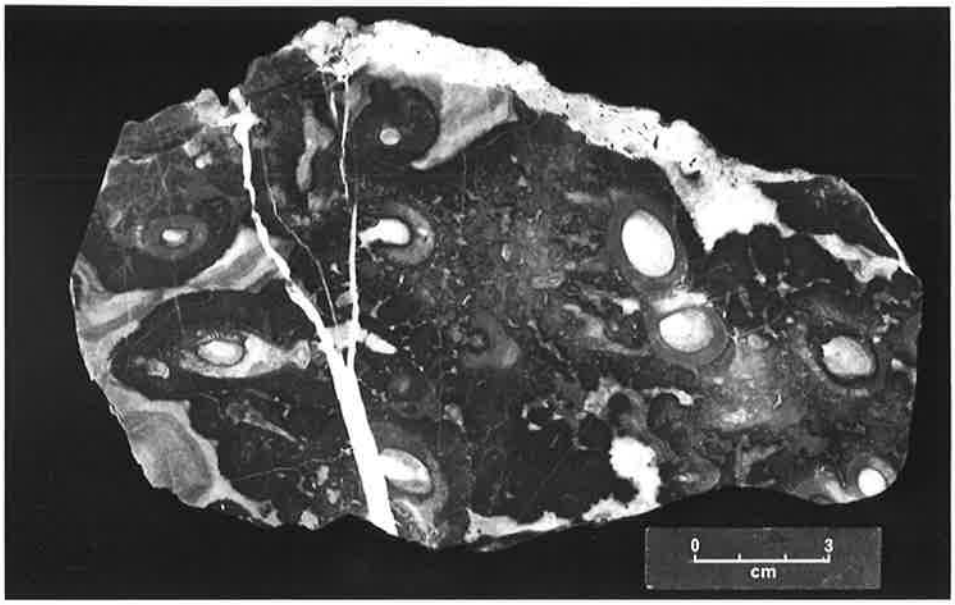
PLATE : 7

a. Photograph of rock-slab showing preferred orientation of preserved archaeocyathid remains. Irregular dark cumulate masses of algal remains are also present. Section cut parallel to bedding, Black Dog Hill sequence.

b. Bioherm of columnar, hematitic stromatolites. Individual columns and branching may be seen. The stromatolites are bright red in colour. Black Dog Hill sequence.

c. Vertical cyclicity which characterizes megacycle VI of the Black Dog Hill sequence. In the photograph massive, poorly fossiliferous lime mudstones (a) are overlain by intraformational conglomerates (b). Rubbly fossiliferous mudstones (c) follow, to be in turn overlain by the laminated, cherty mudstones (d) before a gradual return once again to massive poorly fossiliferous lime mudstones.

a



b

c

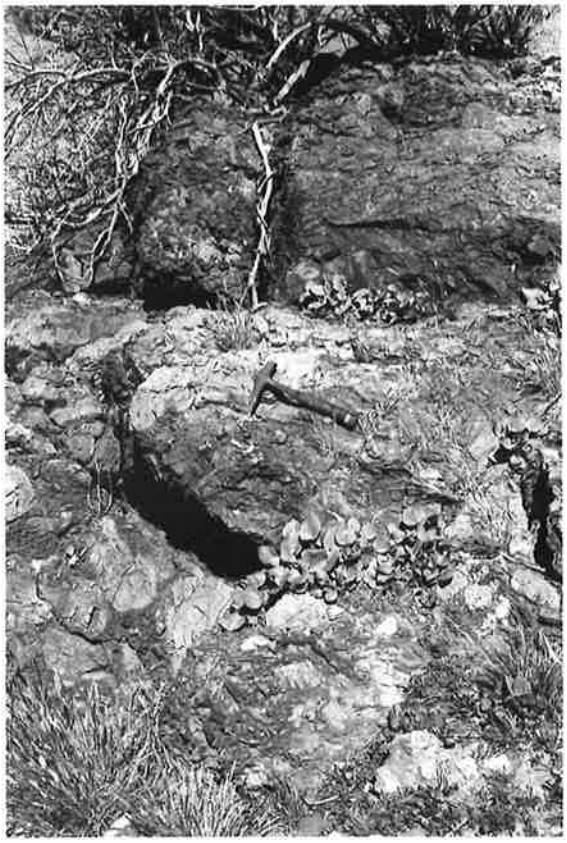
PLATE : 8

a. Coarse intraclast conglomerates from a thick lens in the Donkey Bore sequence. Clasts are mainly calcareous mudstones, impure dolomitic shales and minor sandstones.

b. Poorly sorted angular clasts in layered breccia unit (Dlb). Layering is not well developed in this particular outcrop. Donkey Bore sequence.

c. Gradational boundary from breccia material (Dlb, near hammer) upward into sandy and pebbly grainstones, Donkey Bore sequence.

a



b

c

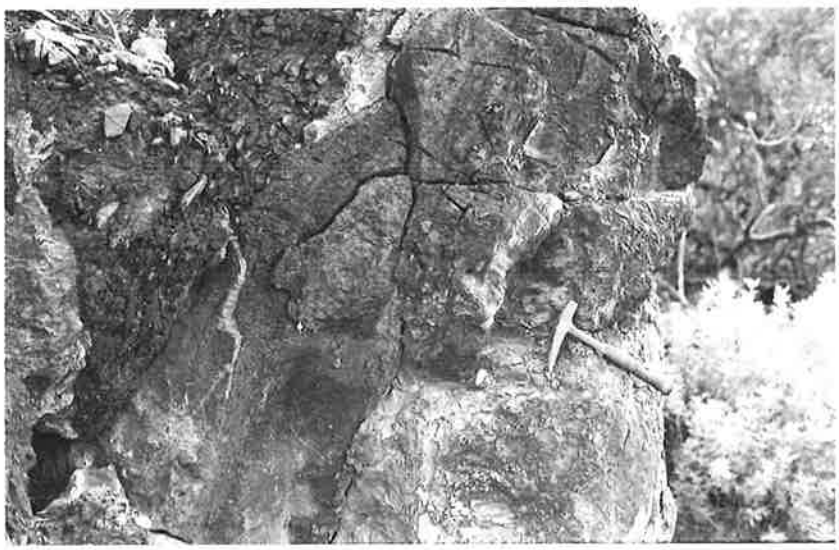


PLATE : 9

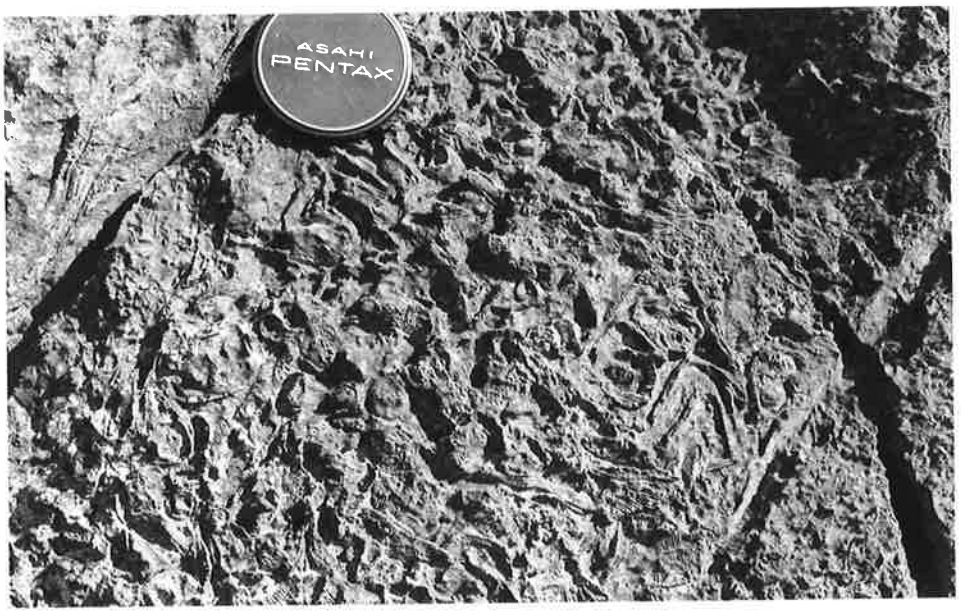
a. Ooid grainstones (under hammer) which sit upon and contain boulders of layered breccia, are themselves cut by channels which are later filled by coarse, boulder-lithoclast grainstones, Donkey Bore sequence. Note the irregular upper and lower surfaces of the grainstone bed, and the boulders within the grainstones just to the left of the hammer.

b. Archaeocyathid fragments in rich skeletal grainstones of the Donkey Bore sequence. Fragments are relatively unbroken and bedding features absent.

c. Layered archaeocyathid grainstones, Donkey Bore sequence. Note the white sparry cements in some narrow intervallum areas and geopetal structures in the central cavities of some archaeocyathid tests.

a

b



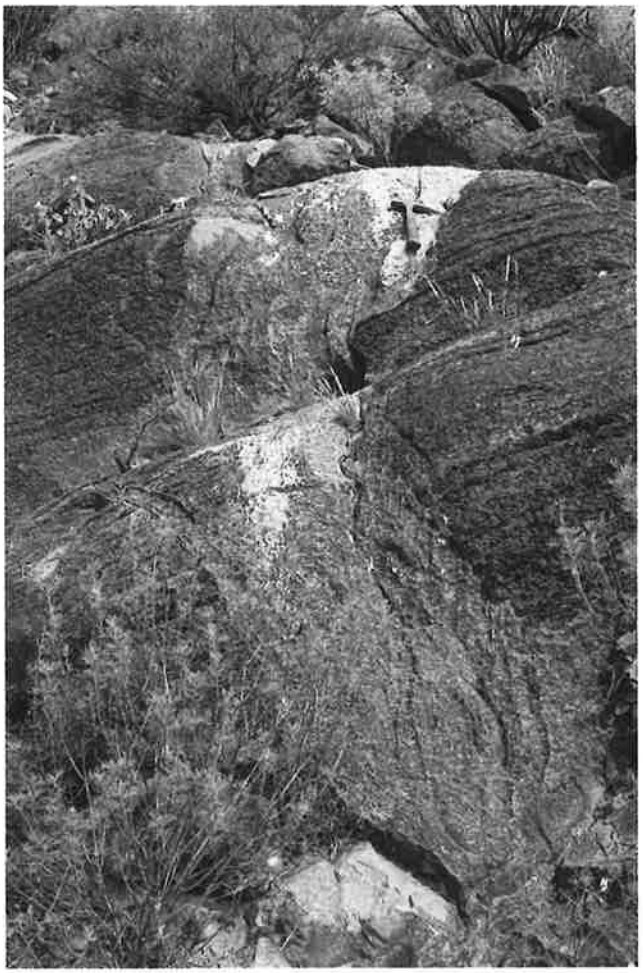
c

PLATE : 10

a. Irregular dyke-like structure cutting through pebbly host-rocks of the Donkey Bore sequence at a high angle. The host sequences are dipping away from the camera.

b. Dyke-like fissure filled with pisoliths and lime mud. (Upper centre) Note the downward bifurcation of the structure. Donkey Bore sequence.

a



b

PLATE : 11

a. Vertically layered fissure-fill debris, much of which consists of skeletal remains. Note the undulose layering of flowstone material near the hammer handle. Karst fissure, Donkey Bore sequence.

b. Boulder and pebble fill in large fissure, Donkey Bore sequence. Bedding orientation in the boulders is random. The rubbly matrix (under hammer) is pinkish coloured, fine-grained carbonate.

c. Boulder-filled fissure cutting obliquely across the host-rock layering, Donkey Bore sequence. The hammer is along the margin of the structure, where clasts in the fissure may be seen adjacent to, or below their source in the host-rock sequence. The host dips fairly steeply toward the right-hand side of the photograph.

a

b

c

PLATE : 12

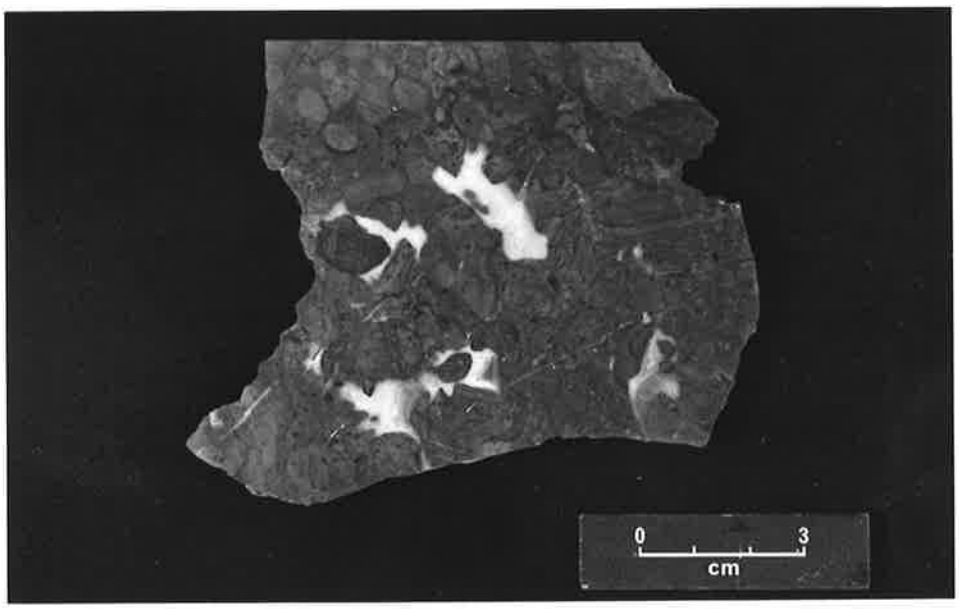
a. Fissure fill consisting of pisoliths within a pink lime mudstone matrix, Donkey Bore sequence. Pebbly host-rock sequence can be seen on the extreme right of the photograph.

b. Photograph of slab of reddened pisoliths. Note the poor sorting and the absence of layering in the sample. Lighter patches are later-stage sparry cements in cavities. At right-centre of the slab, darker secondary hematitic laminae may be seen. Although not clear in the photograph, these laminae may cross-cut pisoliths.

c. Photograph illustrating the radial and concentric structures, and close packed nature of the polyhedral pisoliths from karst fissures in the Donkey Bore sequence. Plane surfaces of contact of growth cement between pisoliths are the planes of fracture along which the rock breaks to form individual polyhedra. The largest pisolith in the photograph is 1.5 cm in diameter.

a

b



c

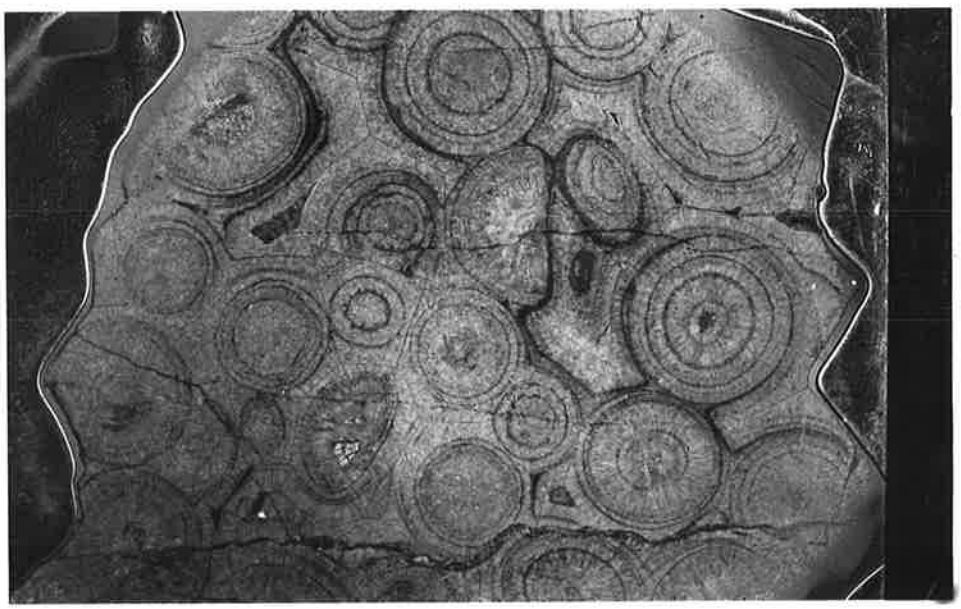


PLATE : 13

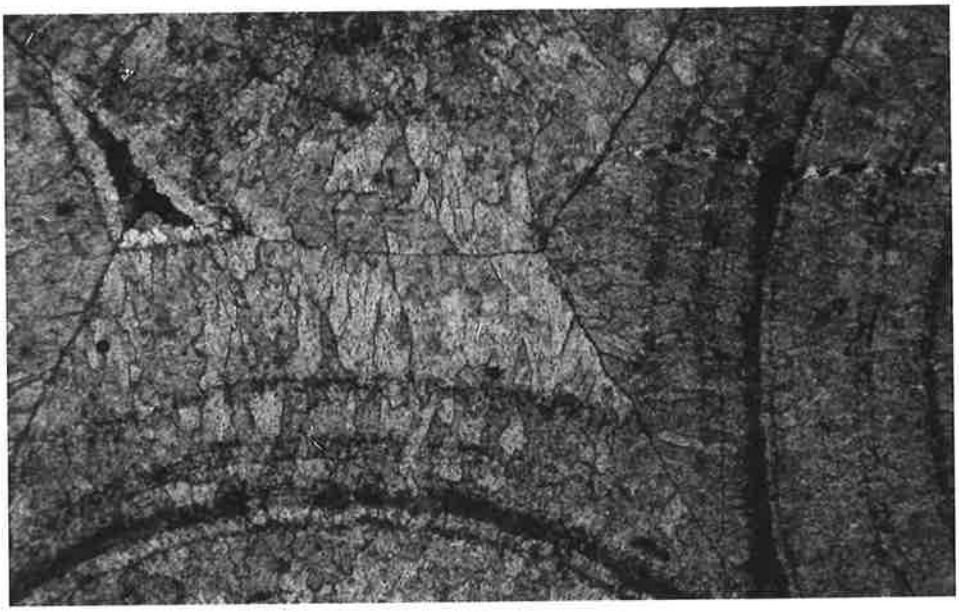
a. Polyhedral pisolitic rock within karst fissures, Donkey Bore sequence, showing the weathering characteristics.

b. Photograph showing a triple-junction of interstitial cements formed by the regular additions of fibrous cements between spherical pisoliths, Donkey Bore sequence. The junction on the left has not been completely filled by calcite cement. Such junctions are commonly later filled with coarse dolomite rhombs.

c. Samples illustrating the range in size of well shaped polyhedral pisoliths, Donkey Bore sequence.

a

b



1mm

c

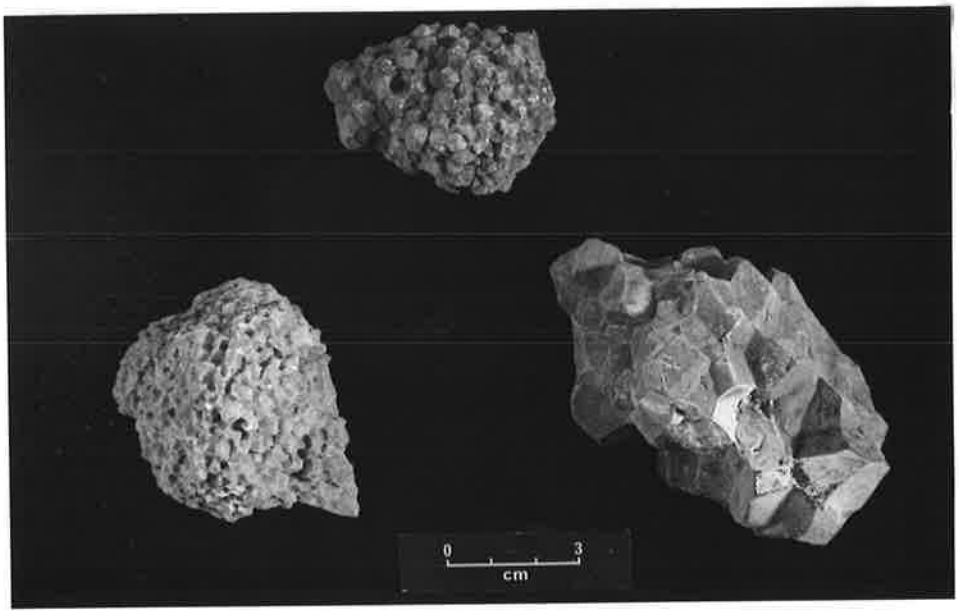


PLATE : 14

a. Pisolith from within Cambrian karst fissure, Donkey Bore sequence. Note the phosphatic brachiopod fragment as the pisolith nucleus. Triple-point (bottom-right) is junction of growth cements on adjacent close-packed pisoliths.

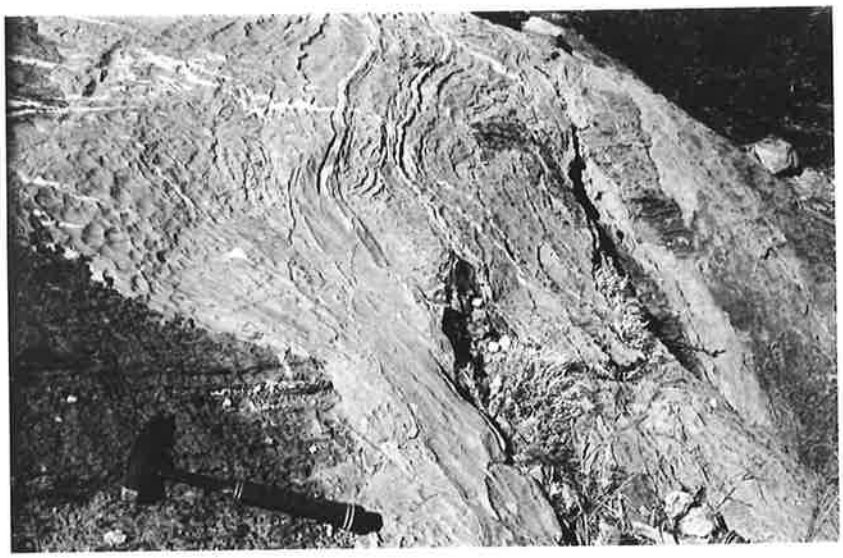
b. Good flowstones from within Cambrian cave-features. Note later spar-filled tension gashes cutting both host-rock and flowstone material, top left-hand side of photograph. Donkey Bore sequence.

c. Birdseye limestone, Wirrealpa Hill sequence. Note the abundant small laminal fenestrae and small well rounded lithoclasts (centre and left-centre of thin section).

a

2mm

b



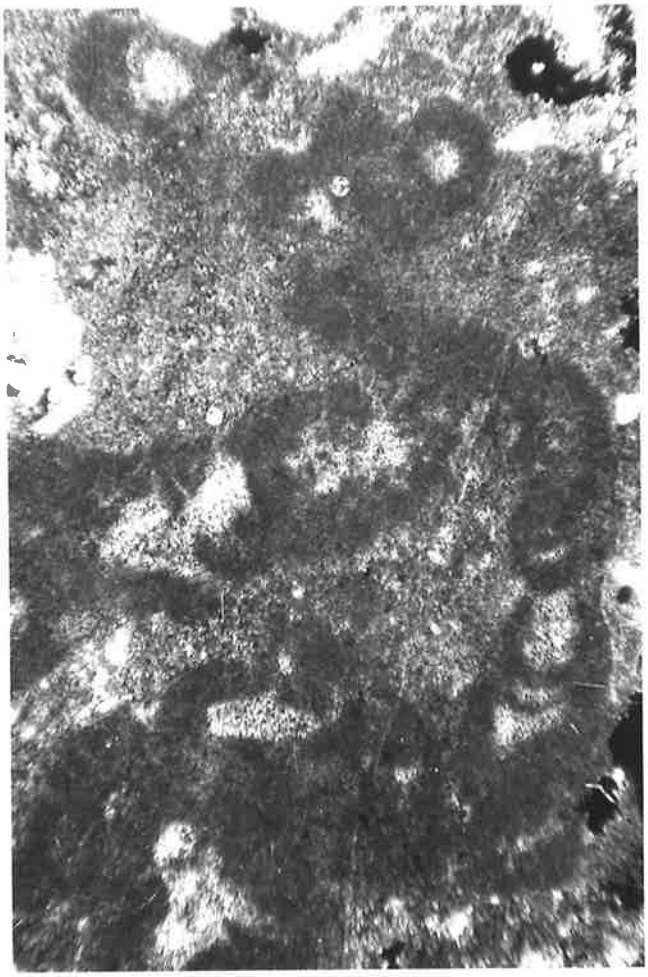
c

1.5cm

PLATE : 15

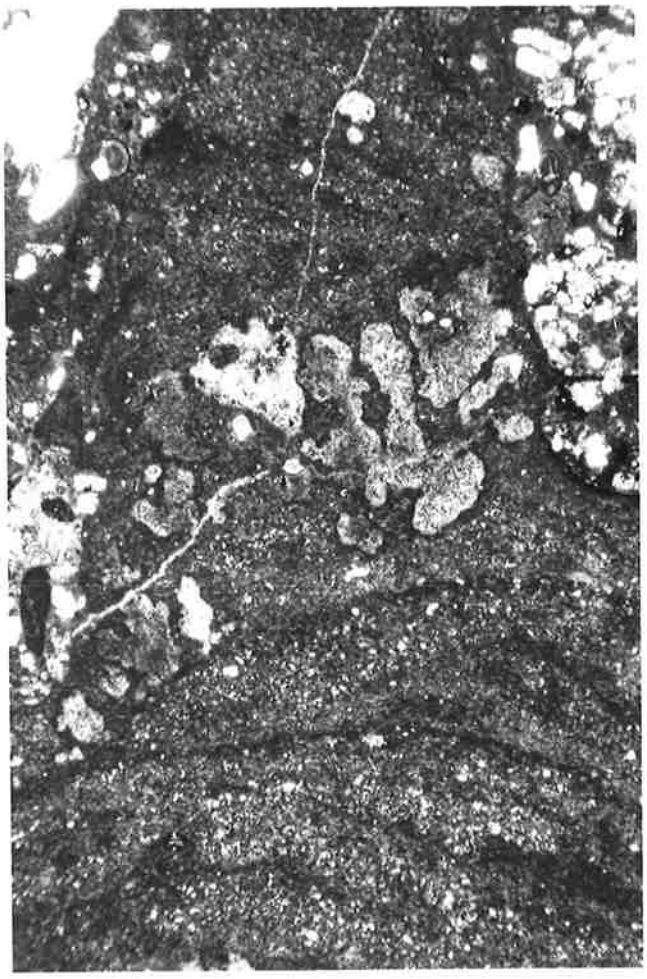
a. Preserved Renalcis-like algal remains from stromatolite in the grainstone lithofacies, megacycle I, Black Dog Hill sequence. (Thin section)

b. Globular patches of pseudospar within a stromatolite column in the grainstone lithofacies, megacycle I, Black Dog Hill sequence. Note the tendency of the patches to branch upward. (Thin section)



a

.3mm



b

1mm

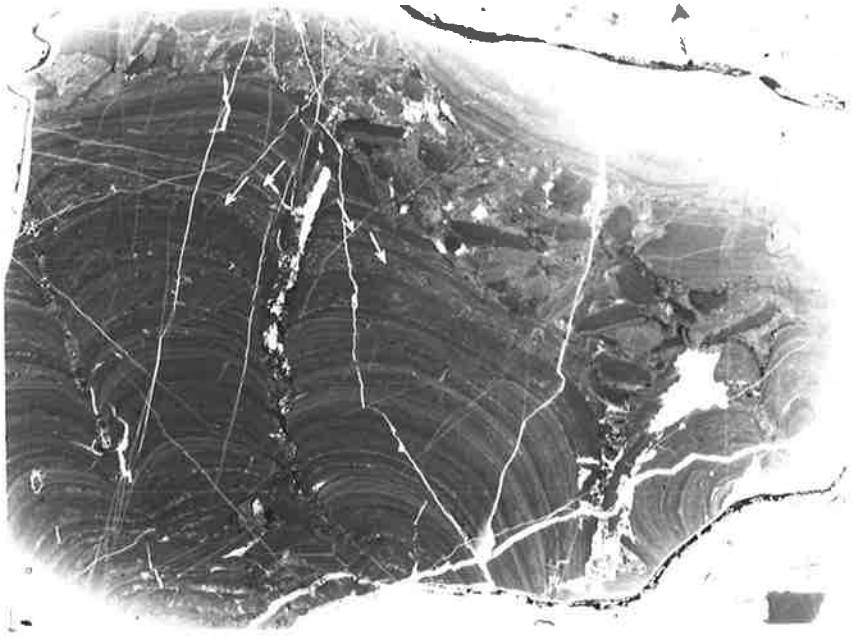
PLATE : 16

a. Stromatolites with highly pigmented column margins, grainstone lithofacies, Black Dog Hill sequence. Note the tendency for the laminae to cloak the column margins. (Rock slab).

b. Broad columnar stromatolite with associated flat-pebble conglomerates from the mudstone lithofacies, Black Dog Hill sequence. Arrows indicate several of the irregularly laminated zones, traceable from one column to the next. (Thin section).

a

3cm



b

3cm

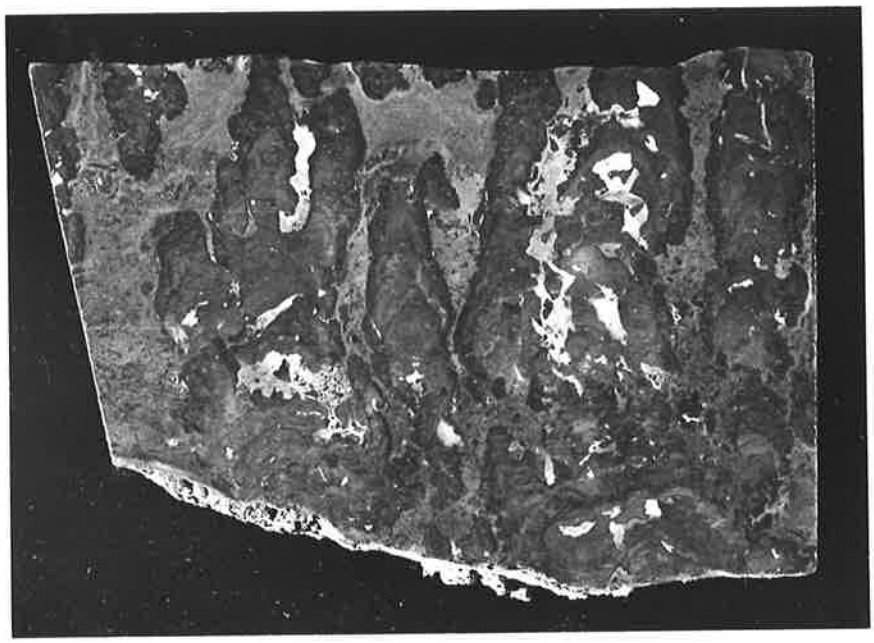
PLATE : 17

a. Walled columnar stromatolite from the mudstone lithofacies, showing spar-filled cavities within columns. (Rock slab). Black Dog Hill sequence.

b. Branched columnar stromatolite from the mudstone lithofacies, showing irregular porous laminations within parts of the columns. Megacycle I, Black Dog Hill sequence. (Thin section).

a

1cm



b

3cm

PLATE : 18

a. Stromatolites from the margin of a tidal channel within the mudstone lithofacies. The effect of rare irregular laminae on the shape of later laminations with high inheritance may be seen. (Thin section). Megacycle I, Black Dog Hill sequence.

b. Ribbon limestones of the lime mudstone unit of megacycle V, Black Dog Hill sequence. The dog in the photograph is .8 m high.

a

b

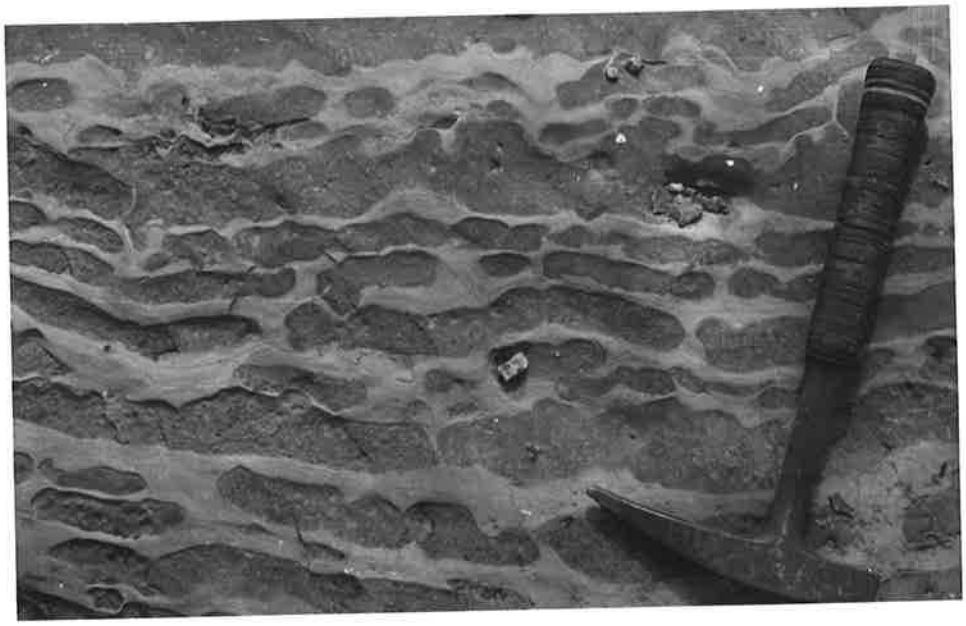
PLATE : 19

a. Nodular limestone from lime mudstone unit, megacycle V, Black Dog Hill sequence. Note that carbonate-depleted zones (lighter colour) may form broad or narrow (lower-centre) breaks in the darker, carbonate-enriched zones.

b. General illustration of the folding of matrix laminae about the carbonate-enriched nodules. At centre left several laminae may be seen passing into the central nodule. Lime-mudstones, Black Dog Hill sequence.

c. Mottled limestone from the lime mudstone unit of megacycle V, Black Dog Hill sequence. Plane of photograph is perpendicular to the expected bedding, of which there is little to no trace in the outcrop. Note the irregularity of the lamination in the carbonate-deficient zones (lighter coloured areas).

a



b

c

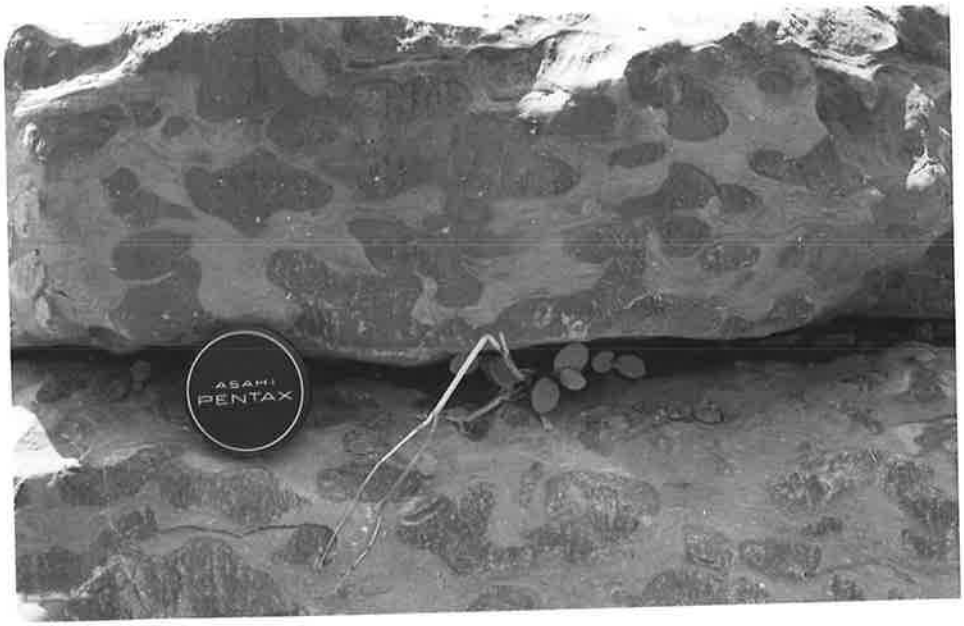


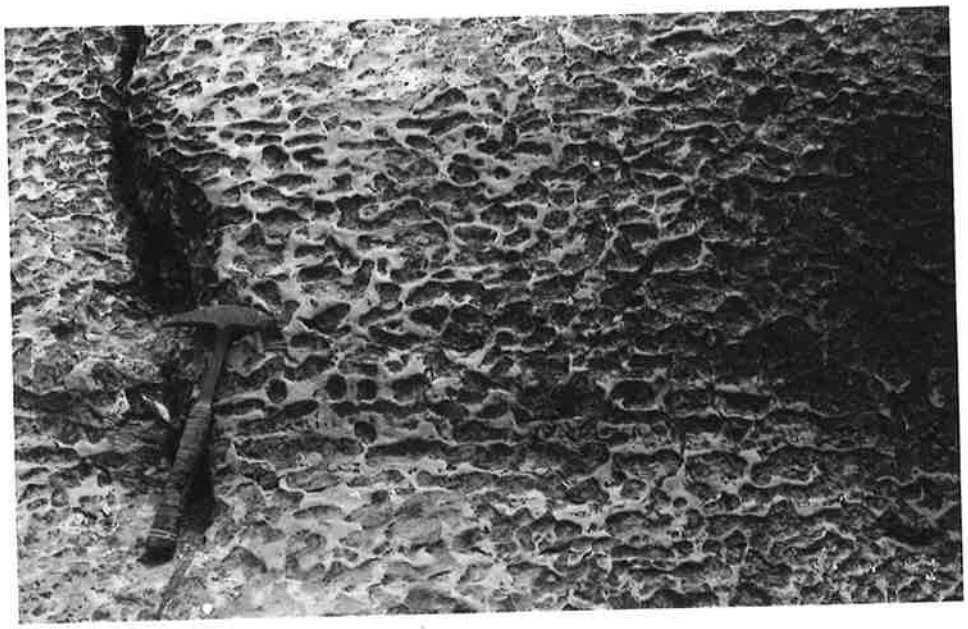
PLATE : 20

a. Mottled limestones with a tendency to show nodular textures toward the bottom of the photograph, Black Dog Hill sequence.

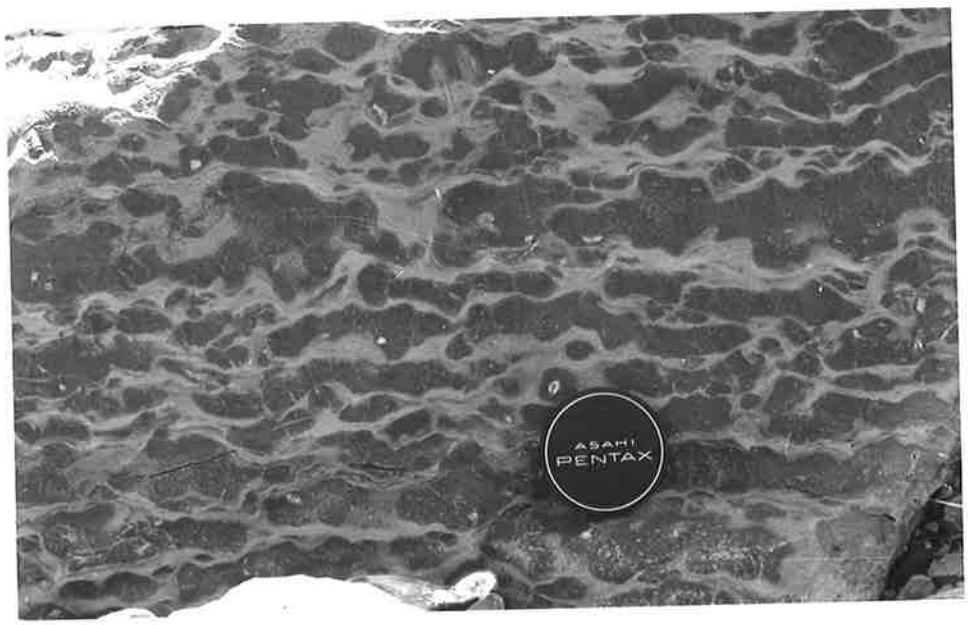
b. Somewhat diffuse lighter clayey laminae which converge and intensify in narrower gaps between dark coloured, carbonate-enriched nodules, Black Dog Hill sequence.

c. Ribbon limestones (under hammer) passing progressively upward into nodular then mottled limestones in the lime mudstone unit, Black Dog Hill sequence.

a



b



c

PLATE : 21

a. Vertical gradation of textural types from ribbon to nodular to mottled lime mudstones, Black Dog Hill sequence.

b. Massive outcrop of interbedded nodular and mottled limestones, Black Dog Hill sequence. Note the presence of several thin regular ribbon limestone beds within units of the other textural types.

a

b

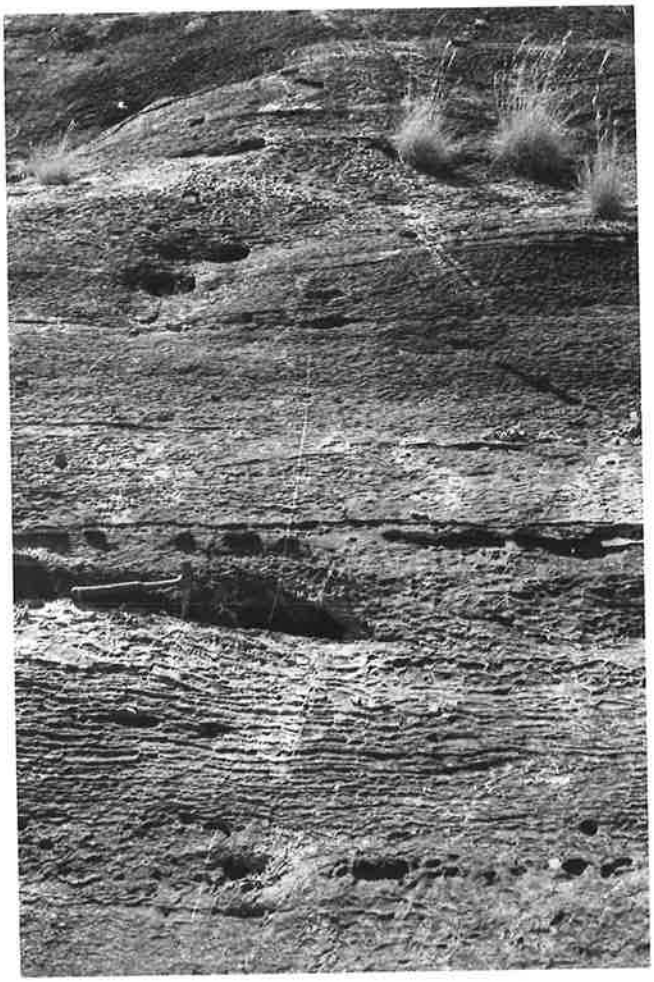


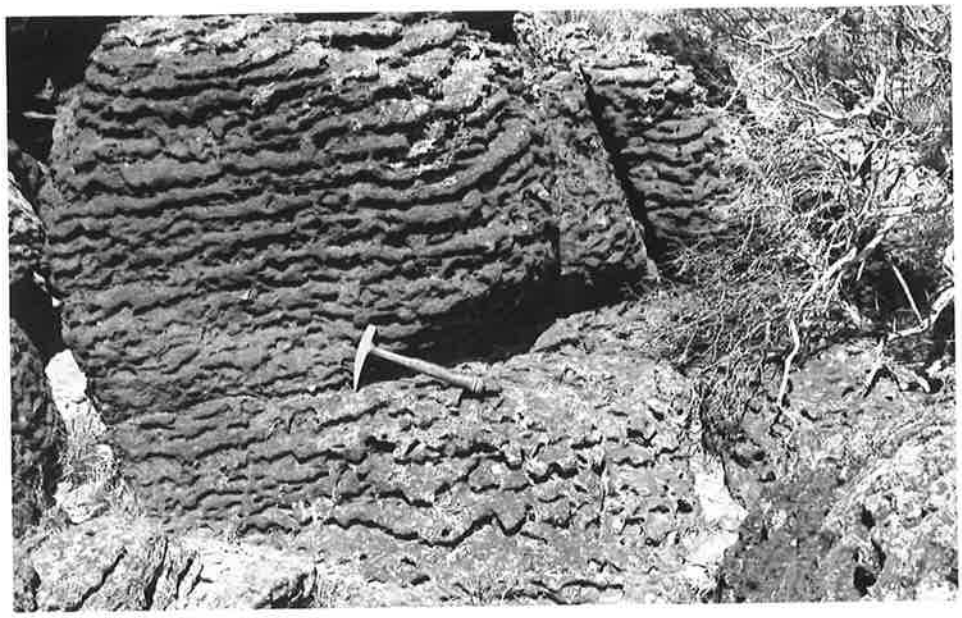
PLATE : 22

a. Honey-combed appearance of weathered outcrops of nodular-textured, pebbly lithoclast conglomerates of megacycle IV, Black Dog Hill sequence. The carbonate-enriched zones weather away, leaving the carbonate-deficient zones standing in positive relief.

b. Laminations within the lighter coloured clay-rich zones folded both upward and downward into depressions in carbonate-enriched nodules, Black Dog Hill sequence.

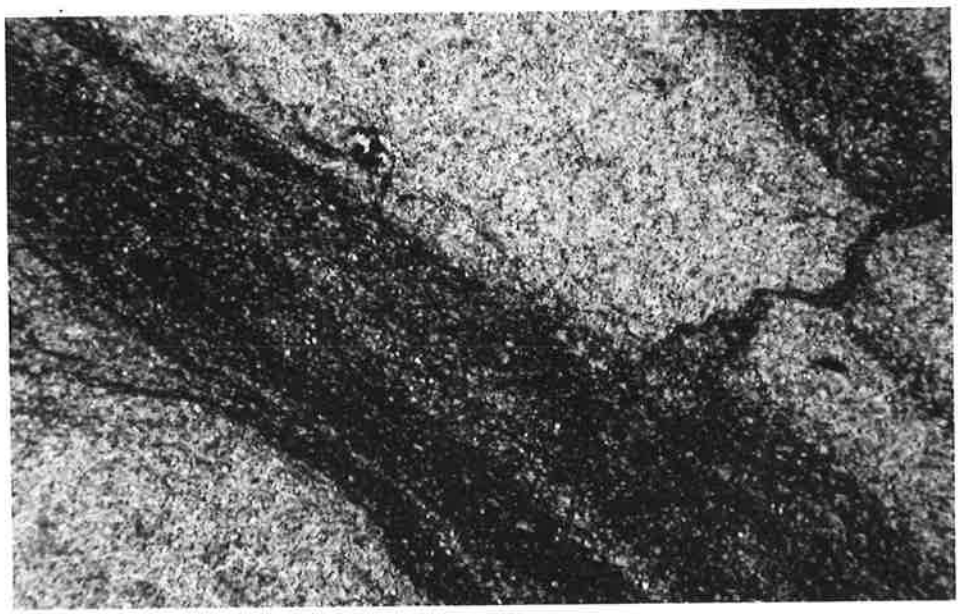
c. Fine clayey laminae (dark colour) and zones of carbonate-enrichment (lighter colour). Note the penetration of clay-rich material into a break in the carbonate zone (centre left). The clayey laminae are concentrated in this zone, which is stylolitic in appearance. Black Dog Hill sequence. (Positive print from acetate peel)

a



b

c



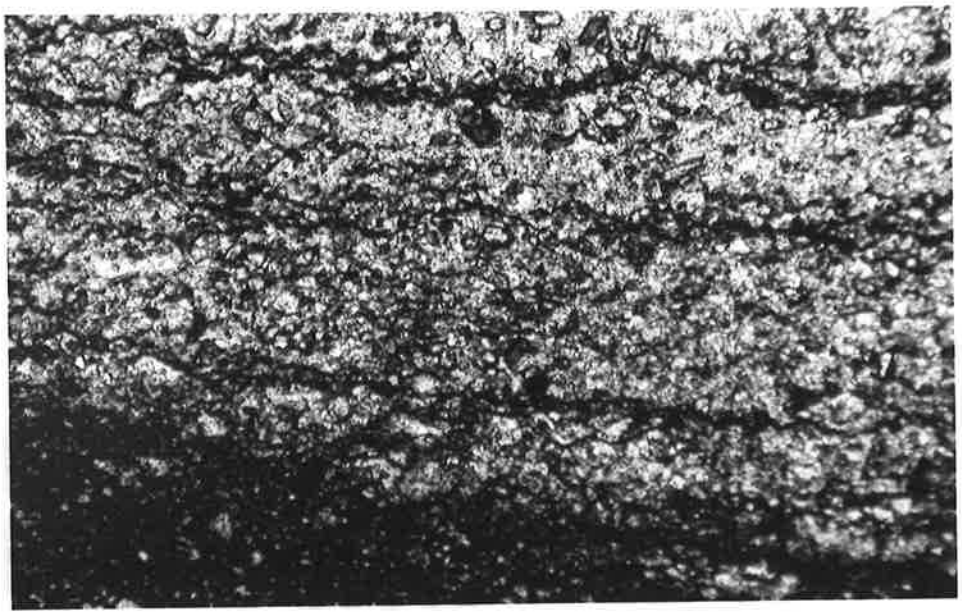
.5mm

PLATE : 23

a. Microstylolitic laminations (arrowed) within carbonate-enriched zone adjacent to a zone of carbonate depletion (bottom of photograph). Thin section, Black Dog Hill sequence. (Positive print of acetate peel).

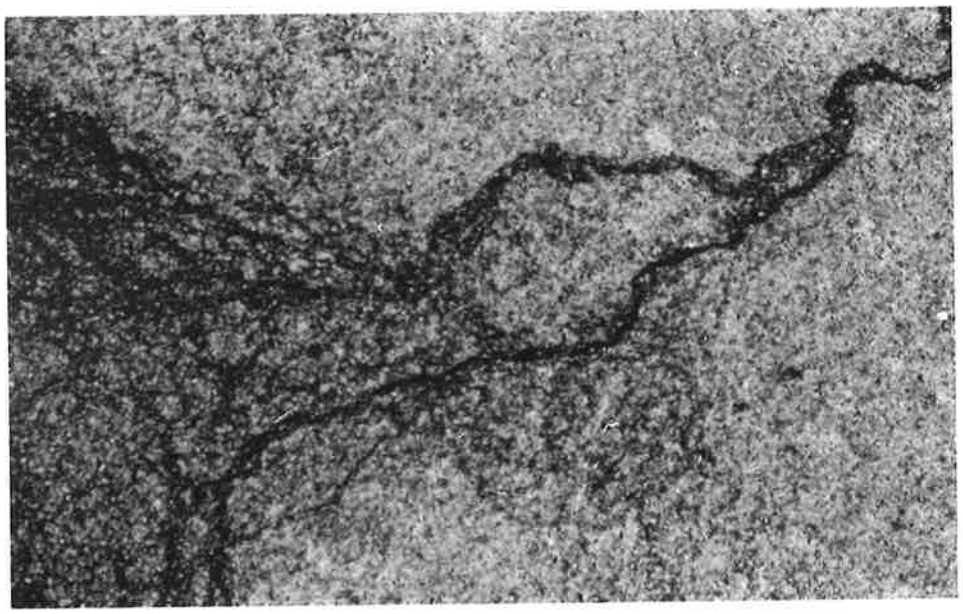
b. Microstylolitic clay seams which converge as horse-tail stylolites forming a single, dense stylolitic clay seam. (Positive print of acetate peel).

c. Fine clay and iron oxide build-up along bands of micro-stylolitic structures. Note the convergence and divergence of microstylolites (lower centre) and the general gradational contacts between carbonate-enriched and carbonate-depleted zones. Positive print of acetate peel, Black Dog Hill sequence, (White spots are bubbles in the peel).



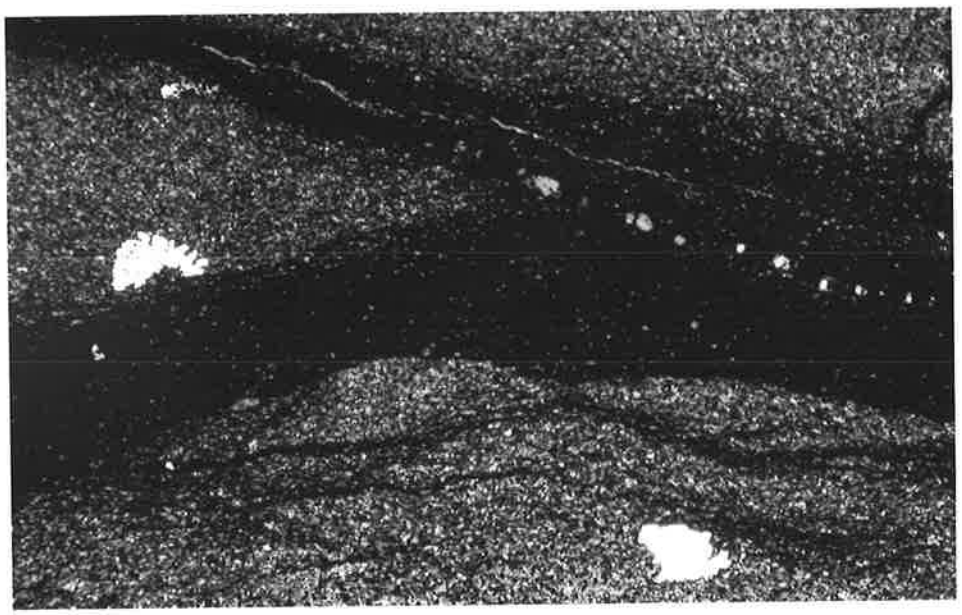
a

.25mm



b

.25mm



c

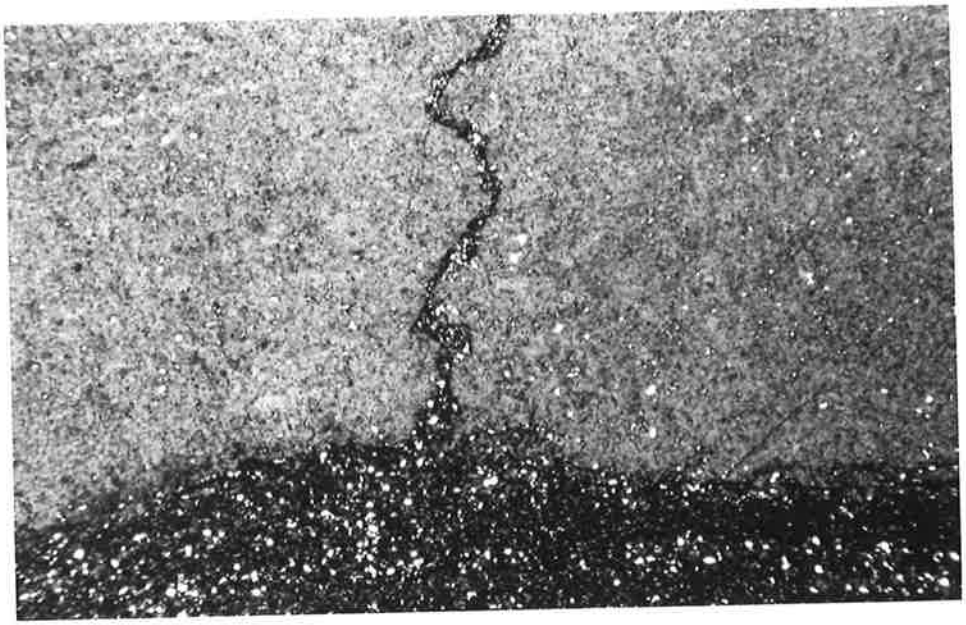
.25mm

PLATE : 24

a. Contact between carbonate-enriched (light colour) and carbonate-deficient zones. Note the stylolitic form of the cross-cutting clay and quartz-rich seam. The detrital quartz grains (bright spots) are concentrated in the darker carbonate-deficient areas. Black Dog Hill sequence.

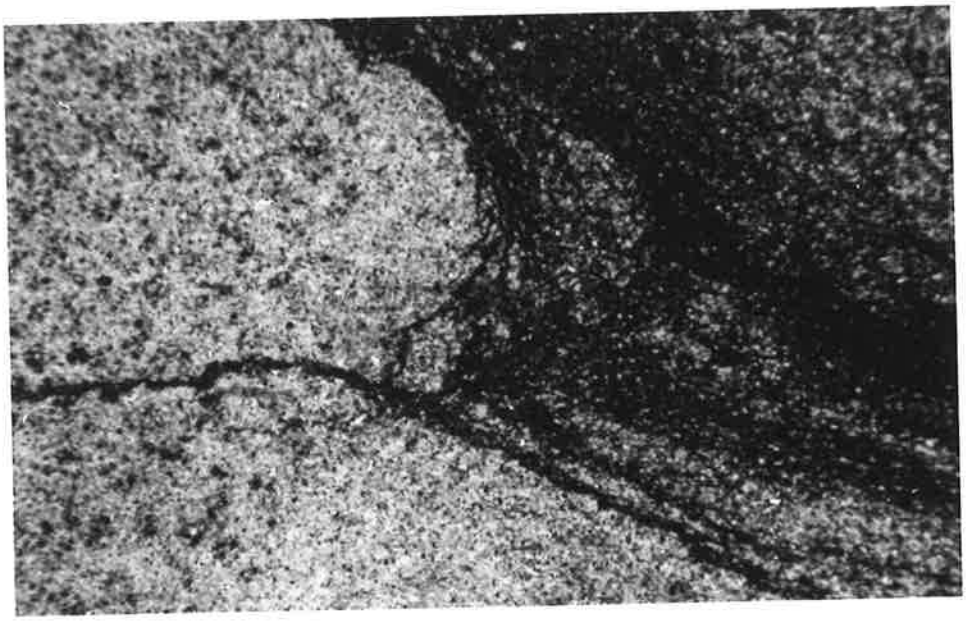
b. Darker microstylolitic laminae curved around a carbonate-enriched nodule margin. Note the convergence of the microstylolites into the denser lateral break in the nodule (centre-left). Black Dog Hill sequence.

c. Darker clay- and iron oxide-rich horsetail stylolites, Black Dog Hill sequence.



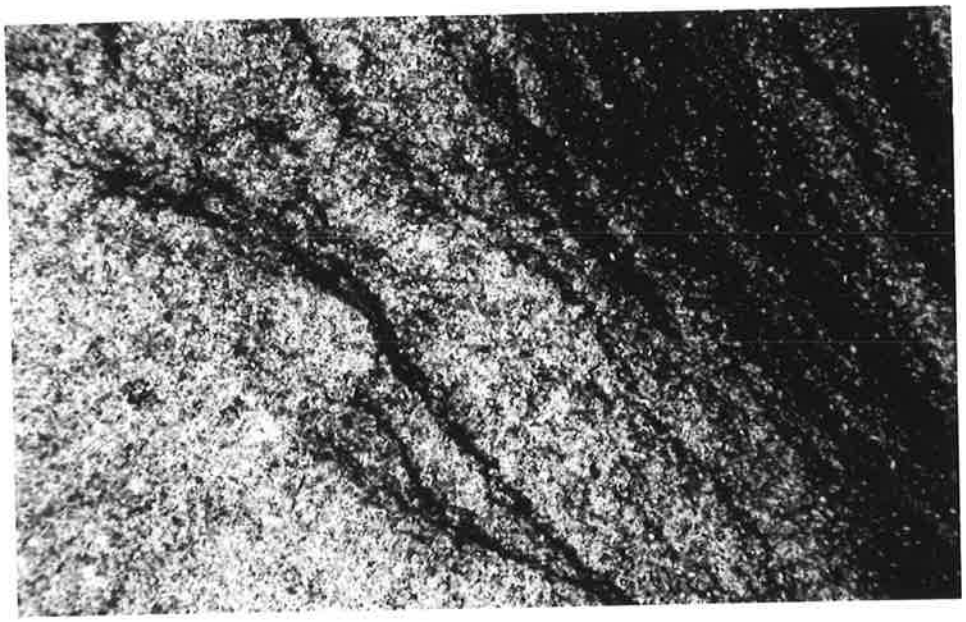
a

1cm



b

.25mm



c

.25mm

PLATE : 25

a. Weathered surface of a mottled pebbly lithoclast wackestone, megacycle IV, Black Dog Hill sequence. Note the tendency for the platey clasts to be oriented parallel to bedding which is parallel to the length of the photograph.

b. Polished slab of the same specimen as above, showing the mottled textures more clearly. Carbonate-enriched zones are darker in colour. The concentration of non-carbonate lithoclasts can be seen within the carbonate-deficient zones.

a

b

PLATE : 26

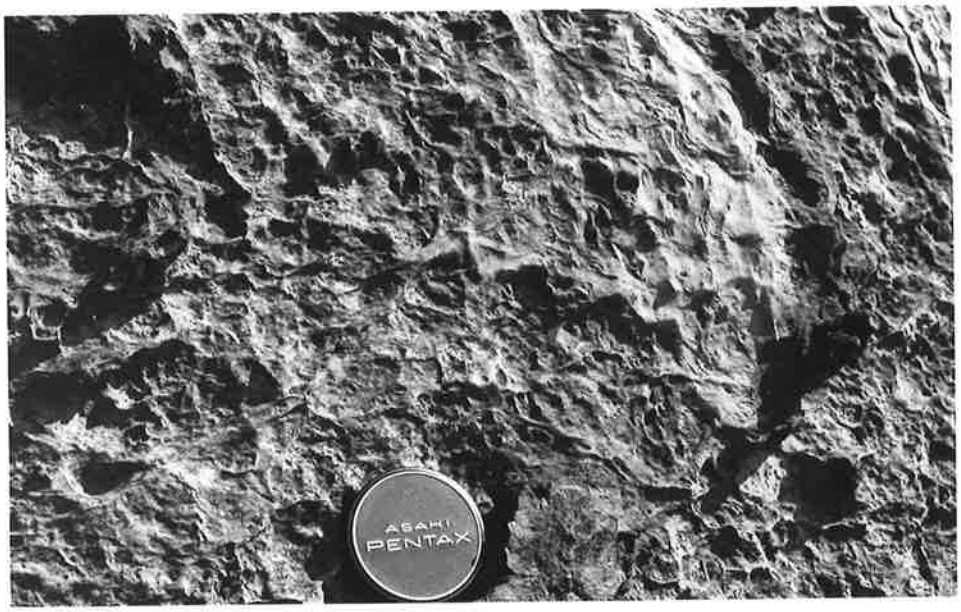
a. View of slump fold in nodular limestones, looking north, megacycle V, Black Dog Hill sequence. The bands standing out in relief are partly silicified.

b. Close-up view of the above slump fold closure, showing silicified material curving around the fold. Note the tendency for a number of the wavey stylolitic or clay-enriched bands to pass across the closure of the fold (upper left to lower right) as well as those which are folded around the nose (upper right).

c. Mudflow breccia unit, Black Dog Hill sequence. The darker, elongate carbonate clasts are randomly oriented within the lighter clayey matrix material. Hammer centre-left for scale.

a

b



c

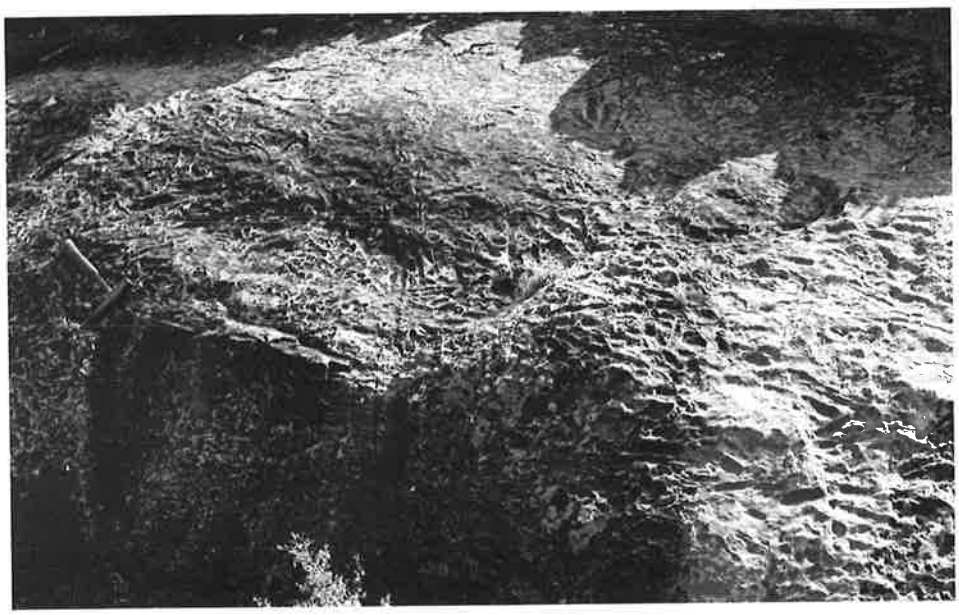


PLATE : 27

a. Large block of nodular lime-mudstone (outlined) from within a mudflow unit, megacycle V, Black Dog Hill sequence. The block is surrounded by reworked dark lime-mud clasts "floating" in a lighter-coloured clayey matrix. (Best seen at bottom-centre of photograph)

b. Chert nodules within a mottled limestone, Black Dog Hill sequence. The limestone immediately beneath the chert nodules (e.g. beneath the hammer) show a nodular to ribboned texture.

c. Massive mottled limestone unit, Black Dog Hill sequence. The dog is sitting slightly above a thin, very regular ribbon limestone band which traverses the exposure, and can be seen continuing, undisturbed, on the far side of the small creek.

a

b

c

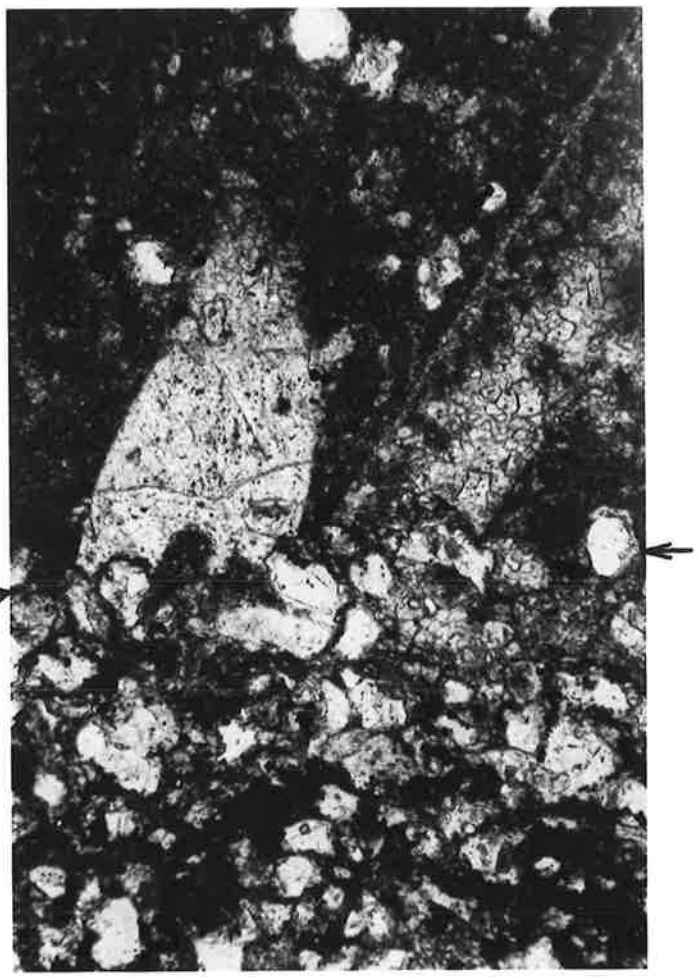
PLATE : 28

a. V-shaped crack in a carbonate-enriched nodule (lighter area) which is filled with coarse sparry calcite cement (white). The clayey matrix material (black) penetrates only a small distance into the crack. Black Dog Hill sequence. (Thin section)

b. Fossil fragments in carbonate-enriched zone (above arrows) which are truncated at the boundary with the carbonate-depleted zone by a microstylolitic suture. Note the great concentration of quartz grains (white clasts) in the microstylolitic matrix in contrast to the lower concentrations in the carbonate nodule (above arrows).

a

1mm



b

.5mm