



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

(VOLUME 1)

BY

PETER GERALD HASLETT, B.Sc.(HONS.)(ADELAIDE)
DEPARTMENT OF GEOLOGY AND MINERALOGY
UNIVERSITY OF ADELAIDE

MAY 1976

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

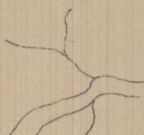
MAP SYMBOLS



ROADS — Passable for two-wheel drive vehicles.



TRACKS — Passable for four-wheel drive only.



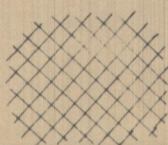
CREEKS — Usually dry.



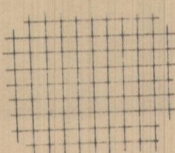
WINDMILL AND BORE



TOPOGRAPHIC FORM LINES
Intervals each 20m.



ZONE OF BRECCIATION



ZONE OF SECONDARY DOLOMITIZATION

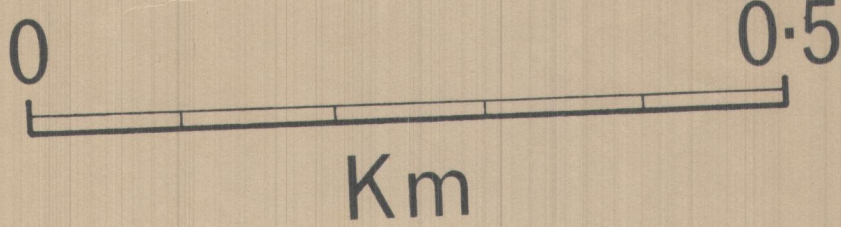
NOTE — Uncoloured areas without symbols represent Recent soils and alluvium.

MAP ORIENTATION

Vertical map grid parallels true North—South direction.

Magnetic North approx. 7° east of True North.

Scale



MAP LEGEND

Cambrian Carbonate Lithofacies

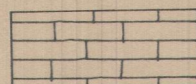
YOUNGER
CAMBRIAN
CARBONATES

CARBONATES
OF FAUNAL
ASSEMBLAGES
1 & 2
(Daily 1956)

UNDIFFERENTIATED LAYERED BRECCIA

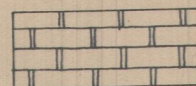
PARACHILNA FORMATION (LOWER CAMBRIAN)

PARARA LIMESTONE



POORLY FOSSILIFEROUS DARK GREY FLAGGY LIME MUDSTONES WHICH UNCONFORMABLY OVERLIE OLDER GRAINSTONES IN THE DONKEY BORE SEQUENCE. LENTICULAR CONGLOMERATES COMMONLY OCCUPY DEPRESSIONS IN THE EROSIONAL UNCONFORMITY SURFACE. THOSE IN THE BLACK DOG HILL SEQUENCE TEND TO BE SILICIFIED. HAVE THIN FOSSILIFEROUS AND CONGLOMERATIC INTERBEDS, AND ARE LITHOLOGICALLY SIMILAR TO UNDERLYING CARBONATES (SEE TEXT).

WILKAWILLINA LIMESTONE



PURE, CRYSTALLINE BIOCLASTIC GRAINSTONES WITH ABUNDANT ARCHAEOCYATHID REMAINS. THEY UNCONFORMABLY OVERLIE OLDER GRAINSTONES IN THE WIRREALPA HILL SEQUENCE. WELL SORTED AND WELL ROUNDED QUARTZ SAND GRAINS ARE COMMON ABOVE THE EROSIONAL UNCONFORMITY. FENESTRAL STRUCTURES AND LESS COMMON INTRAFORMATIONAL CONGLOMERATES ARE ALSO PRESENT. BIRDSEYE LIMESTONES MAY SIMILARLY BE WELL DEVELOPED WITHIN THIS UNIT.

LITHOCLAST
GRAINSTONES

BOULDER



GRAINSTONES IN WHICH NON-CARBONATE CLASTS PREDOMINATE. AN ESTIMATED 50% OR MORE OF THESE CLASTS ARE IN THE BOULDER OR GREATER GRAINSIZE RANGE OF FOLK (1969). THE BOULDERS ARE RELATED LITHOLOGICALLY TO ROCK TYPES OF THE 'DIAPIR'. MEDIUM TO WELL ROUNDED BOULDERS OF DOLERITE ARE PARTICULARLY ABUNDANT. DOLOMITE BOULDERS ARE CONSPICUOUSLY ABSENT. BEDDING IS USUALLY POORLY DEVELOPED, BUT BOULDER RICH UNITS SHOW A GROSS LENTICULAR SHAPE SUGGESTIVE OF CHANNELS. MINOR FINER GRAINED INTERBEDS MAY DELINEATE LESS COMMON LARGE SCALE CROSS-BEDS WITHIN THE BOULDER CONGLOMERATES.

PEBBLE



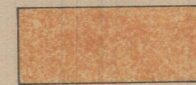
GRAINSTONES IN WHICH NON-CARBONATE CLASTS PREDOMINATE. AN ESTIMATED 50% OR MORE OF THESE CLASTS ARE BETWEEN THE SAND AND BOULDER GRAINSIZE LIMITS. (FOLK 1969). LARGER FRAGMENTS ARE WELL ROUNDED AND OF 'DIAPIRIC' LITHOLOGIES, MOST BEING SANDSTONES. CALCAREOUS SKELETAL FRAGMENTS AND OOLIDS FORM SUBORDINATE CLASTIC COMPONENTS. MEDIUM SCALE CHEVRON CROSS-BEDDING IS PARTICULARLY COMMON IN THE BLACK DOG HILL SEQUENCE. ELSEWHERE BEDDING TENDS TO BE PLANAR, OR SHOW LOW ANGLE CROSS BEDS. CURRENT RIPPLES ARE RELATIVELY COMMON.

SAND



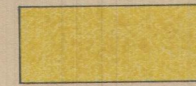
GRAINSTONES CONTAINING SAND-SIZE CLASTS, AN ESTIMATED 50% OR MORE OF WHICH ARE NON-CARBONATE, USUALLY ROUNDED QUARTZ GRAINS. CARBONATE CLASTS ARE MOSTLY OOLIDS. SORTING IS GENERALLY GOOD. MEDIUM SCALE CROSS-BEDDING OF CHEVRON TYPE IS VERY COMMON, AS ARE ASYMMETRIC SINUOUS CURRENT RIPPLES.

OOLID GRAINSTONES



ESSENTIALLY IDENTICAL TO THE ABOVE, EXCEPT THAT OOLIDS ARE THE DOMINANT CLASTS. MINOR CALCAREOUS AND PHOSPHATIC SKELETAL REMAINS ALSO OCCUR. IN THE WIRREALPA HILL AND DONKEY BORE SEQUENCES THE UNIT INCLUDES PISOLITIC GRAINSTONES, SOME OF WHICH HAVE WELL SORTED PISOLITHS UP TO 4 MM IN DIAMETER. PARTS OF THESE BEDS IN THE WIRREALPA HILL SEQUENCE HAVE BEEN EXTENSIVELY SILICIFIED.

SKELETAL GRAINSTONES



GRAINSTONES WHICH ARE DOMINANTLY COMPOSED OF SKELETAL CLASTS, USUALLY ARCHAEOCYATHID FRAGMENTS. OOLIDS AND/OR QUARTZ SAND GRAINS MAY BE PRESENT, BUT IN MINOR AMOUNT. SOMETIMES CROSS-BEDDED BUT MORE COMMONLY PLANAR CURRENT BEDDED OR WITH LOW ANGLE CROSS-BEDS. SORTING IS VARIABLE, USUALLY MODERATE BUT SOMETIMES POOR. SKELETAL REMAINS ARE CONSIDERABLY FRAGMENTED.

WACKESTONES



MASSIVE TO FLAGGY DARK COLOURED CARBONATES OF LIMITED DISTRIBUTION. LARGER CLASTS MAY BE SKELETAL FRAGMENTS. COMMON UNDIFFERENTIATED 'PELLETS', OR RARELY OOLIDS, PELLETS, AND SOMETIMES SKELETAL CLASTS MAY SHOW PREFERENTIAL DOLOMITIZATION. A WIDESPREAD 'SPRY' MOTTLING IS ALSO APPARENT (SEE TEXT).

MUDSTONES



DARK GREY TO BLACK, FLAGGY, FETID MUDSTONES. COMMONLY PYRITIC AND POORLY BEDDED. THOSE ENRICHED IN QUARTZ SILT MAY SHOW SMALL SCALE CROSS-BEDS. SPARSELY FOSSILIFEROUS BUT WITH INTERBEDS CONTAINING TRILOBITE, HYOLITHID, BRACHIOPOD AND RARE ARCHAEOCYATHID FRAGMENTS, MOST OF WHICH ARE PRESUMABLY ALLOCHTHONOUS. RARE MUDSTONES OF THE WIRREALPA HILL SEQUENCE ARE LIGHTER IN COLOUR. 'SILICIFICATION AND DIAGENETIC "MOTTLING" ARE COMMON THROUGHOUT.

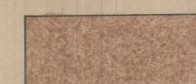
BOUNDSTONES

ALGAL



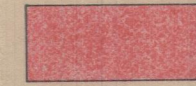
ALGAL STROMATOLITES AND CRYPTALGAL LAMINATES. COMMONLY DARK COLOURED BIOHERMS OR BIOSTROMAL BEDS. MORPHOLOGICAL TYPES ARE EXTREMELY VARIED, RANGING FROM COLUMNAR THROUGH DOMAL TO PLANAR ALGAL LAMINITES. STROMATOLITES ARE FREQUENTLY DOLOMITIZED IN THE WIRREALPA HILL SEQUENCE.

ARCHEO/
ALGAL



DARK COLOURED ARCHAEOCYATHID BIOHERMS, WITH INDIVIDUALS IN APPROXIMATE GROWTH POSITIONS AND SURROUNDED BY BLACK CUMULATE MASSES OF APPARENT ALGAL ORIGIN. ARCHAEOCYATHIDS ARE FROM A NUMBER OF DIFFERENT GROUPS, BUT ALL FORMS TEND TO BE ELONGATE AND CYLINDRICAL. THEIR CENTRAL CAVITIES ARE COMMONLY SPAR-FILLED, FREQUENTLY PRESERVING GEOPETAL STRUCTURES. RELATED FAUNA INCLUDES BRACHIOPODS NOTABLY KUTOGINA SP. AND PROBLEMATICA EG. MICROMITRA SP. RECOGNISABLE ALGAL REMAINS INCLUDE RENALCIS SP.

BIRD'S-EYE LIMESTONES



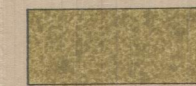
WELL LAMINATED PELLETAL AND OOLITIC WACKESTONES AND PACKSTONES WITH ABUNDANT SPAR-FILLED LAMINOID FENESTRAE. INDIVIDUAL FENESTRAE ARE UP TO 2 CM LONG. THE ROCKS ARE PALE PINK TO CREAM COLOURED IN WEATHERED OUTCROP. IN PLACES A CRYPTALGAL LAMINATION MAY BE SEEN. OTHER PARTS MAY HAVE THIN, LITHOCLAST RICH INTERBEDS.

CALCRETES



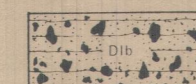
A LITHOLOGICALLY DIVERSE UNIT, THE COMPONENT LITHOLOGIES OF WHICH ARE RELATED TO CARBONATE DEPOSITION UNDER GENERALLY SUB-AERIAL CONDITIONS. BODIES ARE DISCORDANT WITH AND YOUNGER THAN HOST SEQUENCES. LITHOLOGIES INCLUDE PINK TO RED FINELY LAMINATED FLOWSTONES, LARGE IRREGULAR PISOLITHS AND VERY REGULAR CARBONATE PISOLITHS REMINISCENT OF MODERN CAVE PEARLS, BUT HAVING FRAGMENTS OF LOWER CAMBRIAN BRACHIOPODS AS NUCLEI. NODULAR LIMESTONES AND PALE, 'REWELED' CARBONATE BRECCIAS ARE COMMON. LARGE DISORIENTED BLOCKS OF YOUNGER SEQUENCES MAY BE SURROUNDED BY CARBONATE MUDSTONES OF INDISTINCT CHARACTER.

DOLOMITIC MUDSTONES



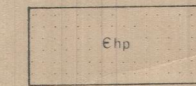
PALE YELLOW, FINE GRAINED DOLOMITES WHICH SHOW COMMON DESICCATION MUDCRACKS. INTERBEDDED INTRAFORMATIONAL CONGLOMERATES, AND THIN WELL SORTED QUARTZ SANDSTONES ARE FREQUENTLY PRESENT. THE SANDSTONES SHOW SMALL SCALE CROSS-BEDDING. PISOLITIC INTERBEDS, AND LITHOCLAST ENRICHED HORIZONS ARE RARE COMPONENTS OF THIS UNIT.

UNDIFFERENTIATED LAYERED BRECCIA



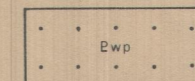
VERY ILL-SORTED BRECCIAS AND CONGLOMERATES. OUTCROP IS CHARACTERISTICALLY POOR. CLASTS ARE GENERALLY ANGULAR AND OF 'DIAPIRIC' LITHOLOGIES. THE VERY IMPURE CARBONATE MATRIX MATERIAL MAY BE SECONDARILY DOLOMITIZED AND/OR SILICIFIED. RARE FINE GRAINED DOLOMITES AND QUARTZ SANDSTONES OCCUR AS INTERBEDS. SOME BEDS ARE RICH IN HEMATITE BOULDERS. A CRUDE LAYERING, PRESENT THROUGHOUT, PARALLELS THE BEDDING OF OVERLYING SEQUENCES. IN THE MOST GENERAL TERMS, THE ANGULARITY AND GRAINSIZE OF LITHOCLASTS DECREASE UPWARDS.

PARACHILNA FORMATION (LOWER CAMBRIAN)



POORLY OUTCROPPING CLAYEY SANDSTONES AND MINOR, THINLY INTERBEDDED LIMESTONES. GREEN SHALES ARE EXPOSED AT ONE LOCALITY IN THE WIRREALPA HILL SEQUENCE. DIPLOCATERION BURROWS ARE COMMON FEATURES OF THE CLAYEY SANDSTONES.

POUND QUARTZITE
UPPER PROTEROZOIC

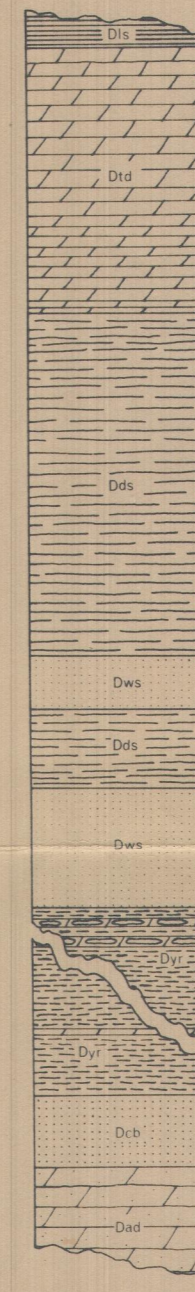


WELL INDURATED FELDSPATHIC, QUARTZ SANDSTONES. UPPERMOST UNIT IS LIGHT COLOURED, CROSS-BEDDED, AND HAS NUMEROUS CLAY GALLS AND INTERBEDDED COARSER PEBBLE BANDS. THE SMALL PODS OUTCROPPING ON SHEET ARE HIGHLY BRECCIATED AND CONTAIN STYLOLITES AND QUARTZ-FILLED TENSION GASHES.

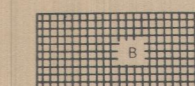
Rock Types Of The 'Diapir'

ESTABLISHED
STRATIGRAPHIC
SEQUENCE

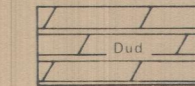
THICKNESS AND
STRATIGRAPHIC
RELATIONSHIPS
INDETERMINATE



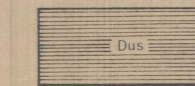
COLUMN SCALE 1:9000



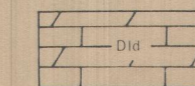
UNDIFFERENTIATED BASIC INTRUSIVES. GREEN HIGHLY ALTERED, EPIDOTE RICH DOLERITES IN THE MAIN. MOST ARE COARSELY CRYSTALLINE WITH FELTED TEXTURES - RARELY AMYGDALOIDAL.



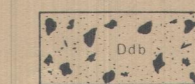
UNDIFFERENTIATED DOLOMITES. WIDE VARIETY OF TYPES IN THE FIELD, REFLECTING BOTH A PRIMARY VARIABILITY AND, POSSIBLY MORE IMPORTANT, WIDELY DIFFERENT DIAGENETIC HISTORIES. NONE CAN BE LITHOLOGICALLY CORRELATED WITH DOLOMITES OF THE CENTRAL BLOCK SEQUENCE. BRECCIATION, SILICIFICATION AND FERRUGINIZATION ARE ABUQUOUS.



UNDIFFERENTIATED SHALES AND SILTSTONES. USUALLY GREEN TO GREY IN COLOUR WITH VARIOUS BEDDING TYPES. COMMONLY STRUCTURALLY DEFORMED AND POORLY OUTCROPPING.



FINELY INTERBEDDED DOLOMITES AND LIMESTONES. REGULARLY BEDDED WITH ALTERNATING 1 CM TO 5 CM DOLOMITES AND LIMESTONES.



IMPURE BRECCIA BEDS. VERY POORLY SORTED, OFTEN ANGULAR FRAGMENTS, OF A WIDE VARIETY OF SEDIMENTARY ROCKS. GENERALLY MASSIVE, ALTHOUGH A CRUDE IRREGULAR LAYERING MAY INFREQUENTLY BE FOUND.

HIGHLY LEACHED, WELL LAMINATED SILTSTONE. UPPERMOST CONTACT IS NOT EXPOSED.

TALCOSE DOLOMITE SEQUENCE. MASSIVE COARSELY CRYSTALLINE DOLOMITES WITH ABUNDANT TALC SEGREGATIONS, PARTICULARLY AT THE TOP. BASAL PARTS OF THE SEQUENCE, AND LATERAL EXTREMITIES OF THE LARGE CENTRAL BLOCK CONSIST OF FLAGGY BUFF YELLOW DOLOMITES WITH QUARTZ SAND INTERBEDS AND ABUNDANT TEEPEE STRUCTURES. BOTH TOP AND BOTTOM CONTACTS WITH SILTSTONES SHOW EXTENSIVE SILICIFICATION AND FERRUGINIZATION.

DOLOMITIC GREEN SILTSTONES WHICH ARE GENERALLY WELL LAMINATED. SOME WELL DEVELOPED FLAME STRUCTURES AND LOAD FEATURES ARE PRESENT. SILTSTONES ARE STRONGLY LEACHED NEAR THEIR UPPER BOUNDARY.

CROSS-BEDDED DOLOMITIC GREEN SILTSTONES WITH INTERBEDDED MASSIVE LIMESTONE AND THIN QUARTZ SANDSTONES. RIPPLE MARKS AND MUD FLAKES ARE COMMON. PYRITE PSEUDOMORPHS AND SLUMP BEDDED UNITS ARE LESS FREQUENTLY PRESENT.

SLIGHTLY DOLOMITIC GREEN SILTSTONES. MASSIVE TO FLAGGY BEDDING AND MINOR CROSS BEDDING.

POORLY OUT-CROPPING SEQUENCE OF HIGHLY WEATHERED SANDSTONES.

GREEN TO GREY FINELY LAMINATED MICACEOUS SHALE. SOME SANDY INTERBEDS AND COMMON V₂-1 METRE THICK LIMESTONE BEDS WITH SMALL SCALE SLUMPS AND SEDIMENTARY BRECCIAS.

HIGHLY WEATHERED AND DISRUPTED QUARTZ SANDSTONE SEQUENCE. SANDSTONES ARE CLAYEY, USUALLY FRIABLE, AND HAVE ABUNDANT CARBONATE CONCRETIONS. SILTSTONES, SLUMP BRECCIAS AND CONGLOMERATES ARE COMMON.

YELLOW AND RED WEATHERING SILTSTONES WITH REGULAR LAMINATIONS AND SMALL SCALE SLUMP STRUCTURES. THIN LENTICULAR BEDS OF COARSE CRYSTALLINE CALCITE, SOMETIMES CROSS-BEDDED AND WITH MUD FLAKES BECOME MORE COMMON TOWARD THE TOP. SILTSTONES BECOME SANDIER TOWARD THE SOMEWHAT GRADATIONAL UPPER BOUNDARY INTO OVERLYING SANDSTONES.

YELLOW AND RED WEATHERING SILTSTONES WITH GOOD SMALL SCALE CROSS-LAMINATIONS. REMNANT CROSS-BEDDED DOLOMITE NODULES ARE ALSO PRESENT.

YELLOW AND RED WEATHERING FINELY LAMINATED SILTSTONES. ABUNDANT HALITE CASTS AND FINE QUARTZ SANDSTONE INTERBEDS NEAR THE BASE. THIN NODULAR CARBONATE INTERBEDS NEAR THE TOP. THESE BEDS ARE COARSELY CRYSTALLINE, OCHROUS, WITH HIGHLY DISRUPTIVE BEDDING STRUCTURES. CROSS-CUTTING QUARTZ HEMATITE VEINS ARE COMMON.

PALE PINK TO CREAM-COLOURED, HEAVY MINERAL CROSS-BEDDED QUARTZ SANDSTONES. GENERALLY MEDIUM TO COARSE GRAINED BUT WITH FINE SAND AND SILTSTONE INTERBEDS. HALITE CASTS ARE COMMON.

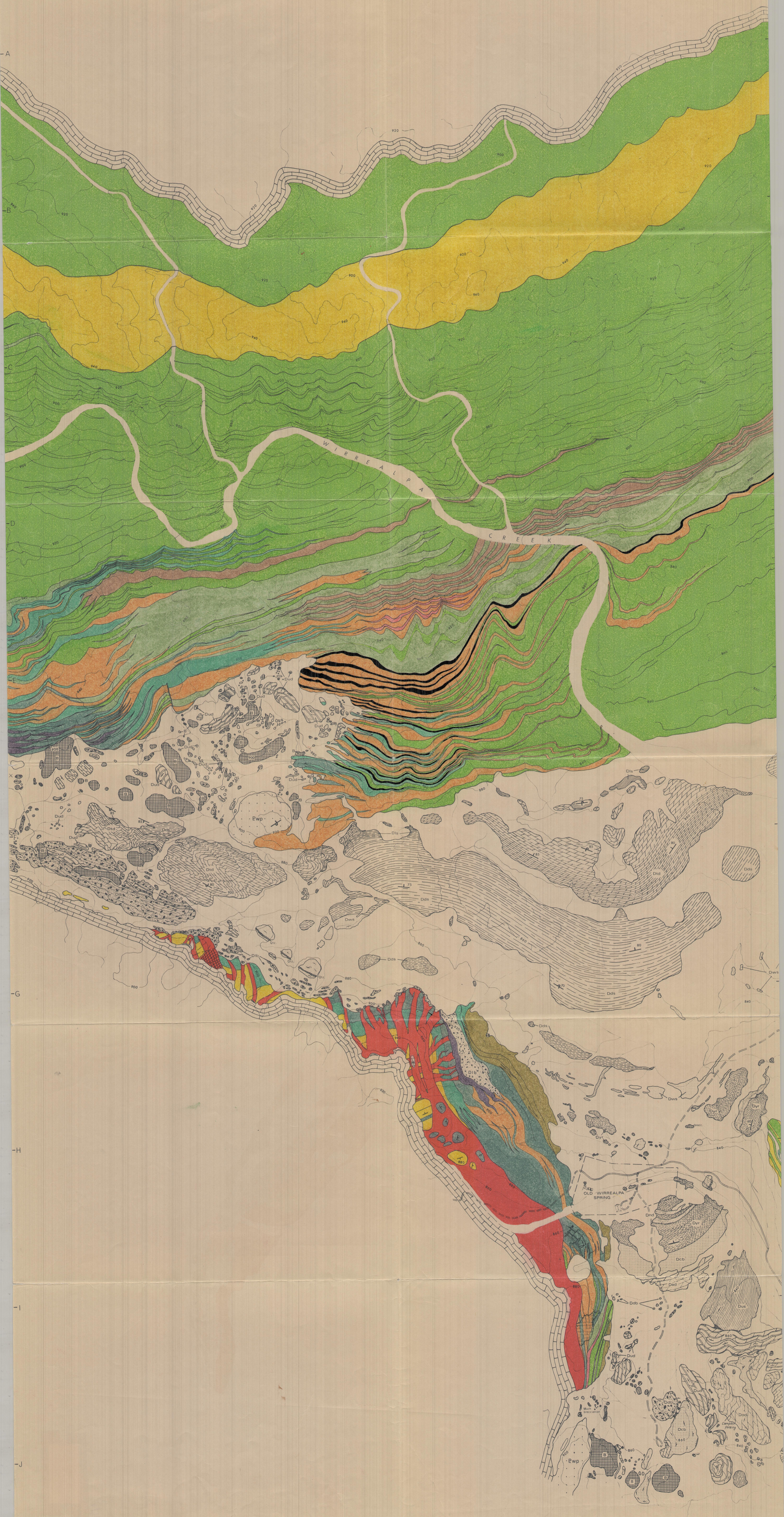
INTERBEDDED WELL LAMINATED LIMESTONES AND DOLOMITES. UPPERMOST UNIT IS COARSE, CROSS-BEDDED CALC-SAND WITH MINOR SLUMP STRUCTURES AND CARBONATE BRECCIAS.

WEATHERED YELLOW SILTSTONES WITH THIN CRYSTALLINE LIMESTONE INTERBEDS. MOSTLY WELL LAMINATED BUT SOME DISRUPTED BEDDING IS PRESENT.

SHEET 1



SHEET 2



SHEET 3



A

B

C

D

E

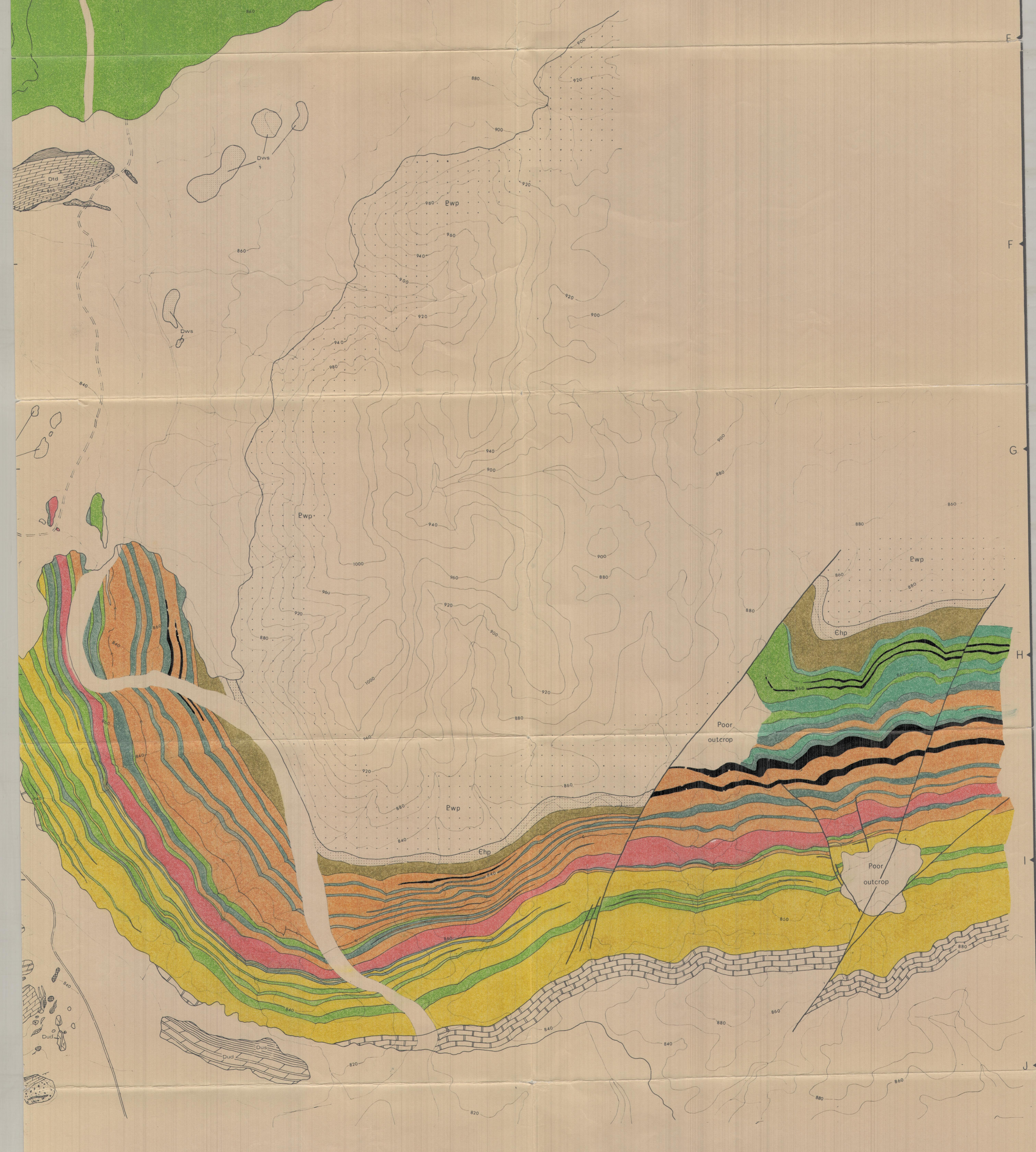
F

G

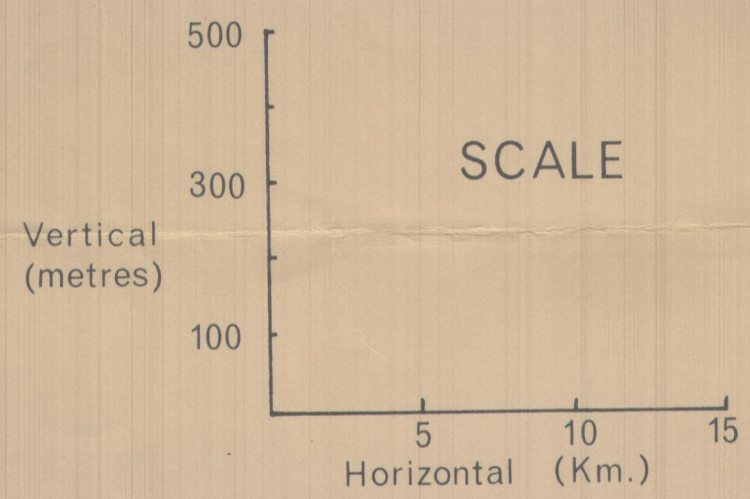
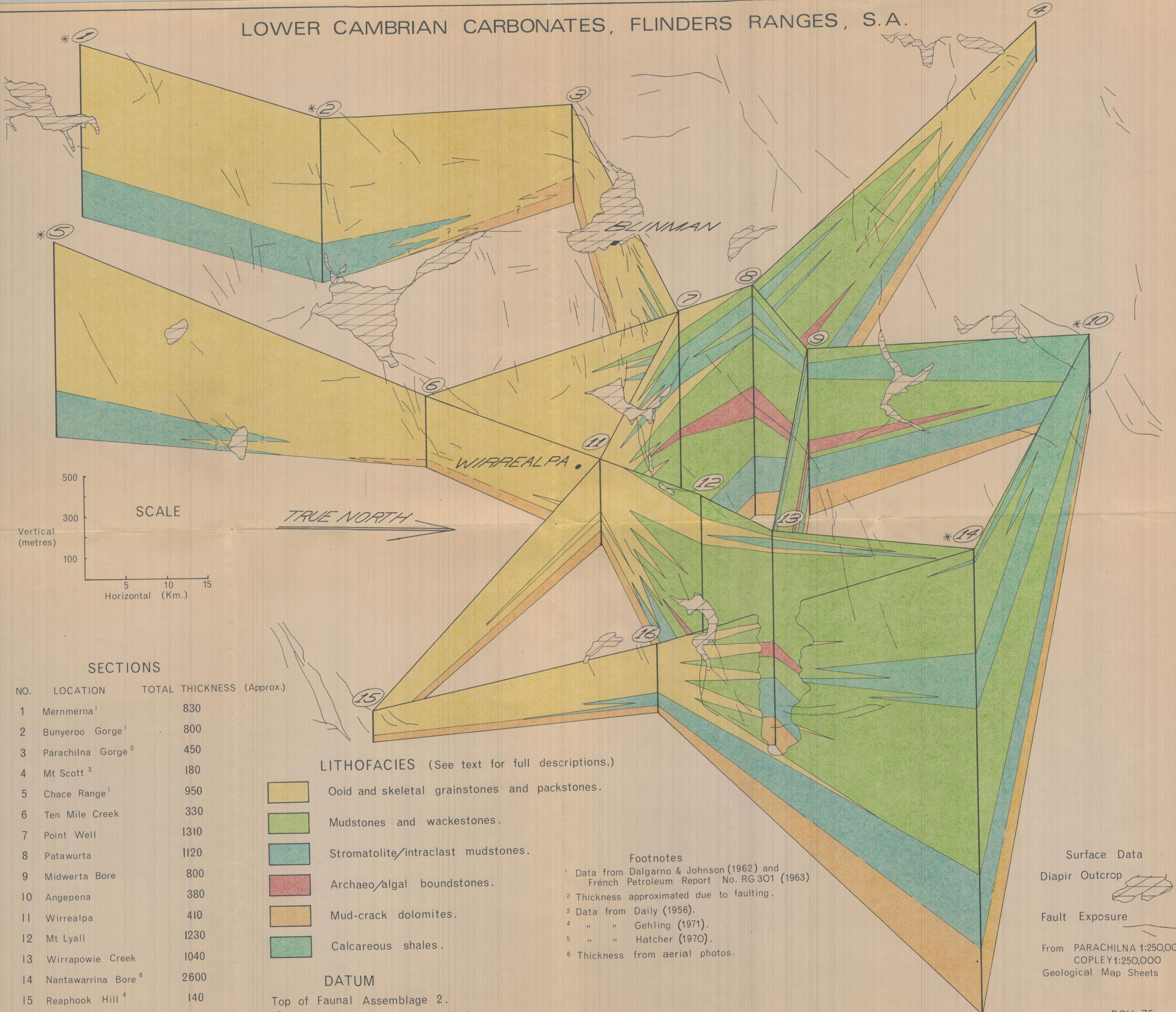
H

I

J



LOWER CAMBRIAN CARBONATES, FLINDERS RANGES, S.A.



SECTIONS

NO.	LOCATION	TOTAL THICKNESS (Approx.)
1	Mernmerna ¹	830
2	Bunyeroo Gorge ¹	800
3	Parachilna Gorge ²	450
4	Mt Scott ³	180
5	Chace Range ¹	950
6	Ten Mile Creek	330
7	Point Well	1310
8	Patawurtia	1120
9	Midwerta Bore	800
10	Angepena	380
11	Wirrealpa	410
12	Mt Lyall	1230
13	Wirrapowie Creek	1040
14	Nantawarrina Bore ⁶	2600
15	Reaphook Hill ⁴	140
16	Mt Frome ⁵	330

LITHOFACIES (See text for full descriptions.)

- Ooid and skeletal grainstones and packstones.
- Mudstones and wackestones.
- Stromatolite/intraclast mudstones.
- Archaeo/algal boundstones.
- Mud-crack dolomites.
- Calcareous shales.

DATUM

Top of Faunal Assemblage 2.
(* Denotes approx. position only.)

Footnotes

- ¹ Data from Dalgarno & Johnson (1962) and French Petroleum Report No. RG 301 (1963).
- ² Thickness approximated due to faulting.
- ³ Data from Daily (1956).
- ⁴ " " Gehling (1971).
- ⁵ " " Hatcher (1970).
- ⁶ Thickness from aerial photos.

Surface Data

Diapir Outcrop

Fault Exposure

From PARACHILNA 1:250,000
COPLEY 1:250,000
Geological Map Sheets