Magnetostratigraphy of Frasnian-Fammenian (Devonian) Carbonates of the Canning Basin, Western Australia: Evaluating the Potential for Regional and Global Correlations*

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Abstract

Correlation of carbonate sequences is bedevilled by heterogeneous facies that reflect a diversity of depositional, faunal, and isotopic settings. This diversity presents some challenges for detailed correlation, even at a regional scale. The Canning Basin of Western Australia presents world-class exposures of a carbonate-dominated shelf from Devonian times, where a highly irregular coastline created a variety of depositional environments: carbonate platforms and reefs, slope deposits, and hemipelagic basins, along with deposition around atoll-like blocks that were detached from the main coastline. Magnetostratigraphic correlation is based on the globally synchronous record of geomagnetic reversals, and can provide a temporal reference frame.

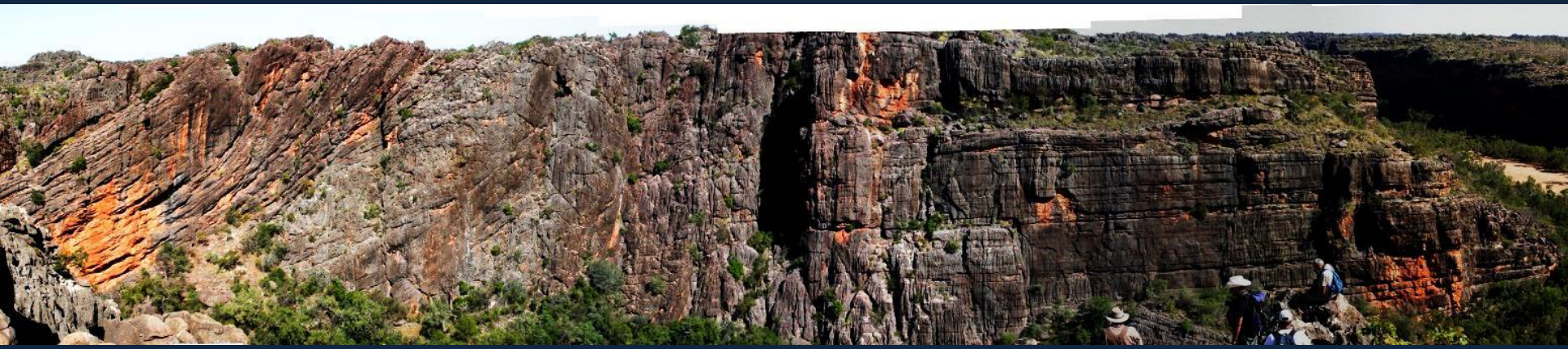
In this contribution, we present the results of four magnetostratigraphic profiles from four different environments along the Lennard Shelf covering Givetian to end-Fammenian (Middle to end-Devonian) times. Paleomagnetic results were obtained from thermal demagnetization of individual, oriented samples taken at the meter scale over approximately 2500 meters of composite section. Magnetite and hematite are inferred to be the principal magnetic carriers, and primary remanences are recovered from

roughly 25% of all samples. A relatively high reversal rate is observed in all sections, consistent with previously obtained results from the Canning Basin (Hurley and Van der Voo, Geology, 1990). Comparison of the primary magnetic polarity record from these different environments will allow cross-checks on the correlation between different environments, as well as a providing a template for assessing other potential correlation schemes, including biostratigraphy, isotope chemostratigraphy, and magnetic susceptibility. The compiled results from this study will constitute the first systematic contribution to the construction of a Global Polarity Timescale for Middle to Late Devonian times.

Reference Cited

Hurley, N.F., and R. Van der Voo, 1990, Magnetostratigraphy, Late Devonian iridium anomaly, and impact hypotheses: Geology, v. 18/4, p. 291-294.

Magnetostratigraphy of Frasnian-Fammenian (Devonian) Carbonates of the Canning Basin, Western Australia: Evaluating the Potential for Regional and Global Correlations



Eric Tohver[1], T.E. Playton[2], S. Pisarevsky[1], Maodu Yan[2], J. Hansma[1], B. Roelofs[3], Kate Trinajstic[3], J. Kirschvink[4], P. Haines[5], R. Hocking[5], Paul Montgomery[2]

1 – University of Western Australia, 2 – Chevron, 3 – Curtin University, 4 – Caltech, 5 – Geological Survey of Western Australia

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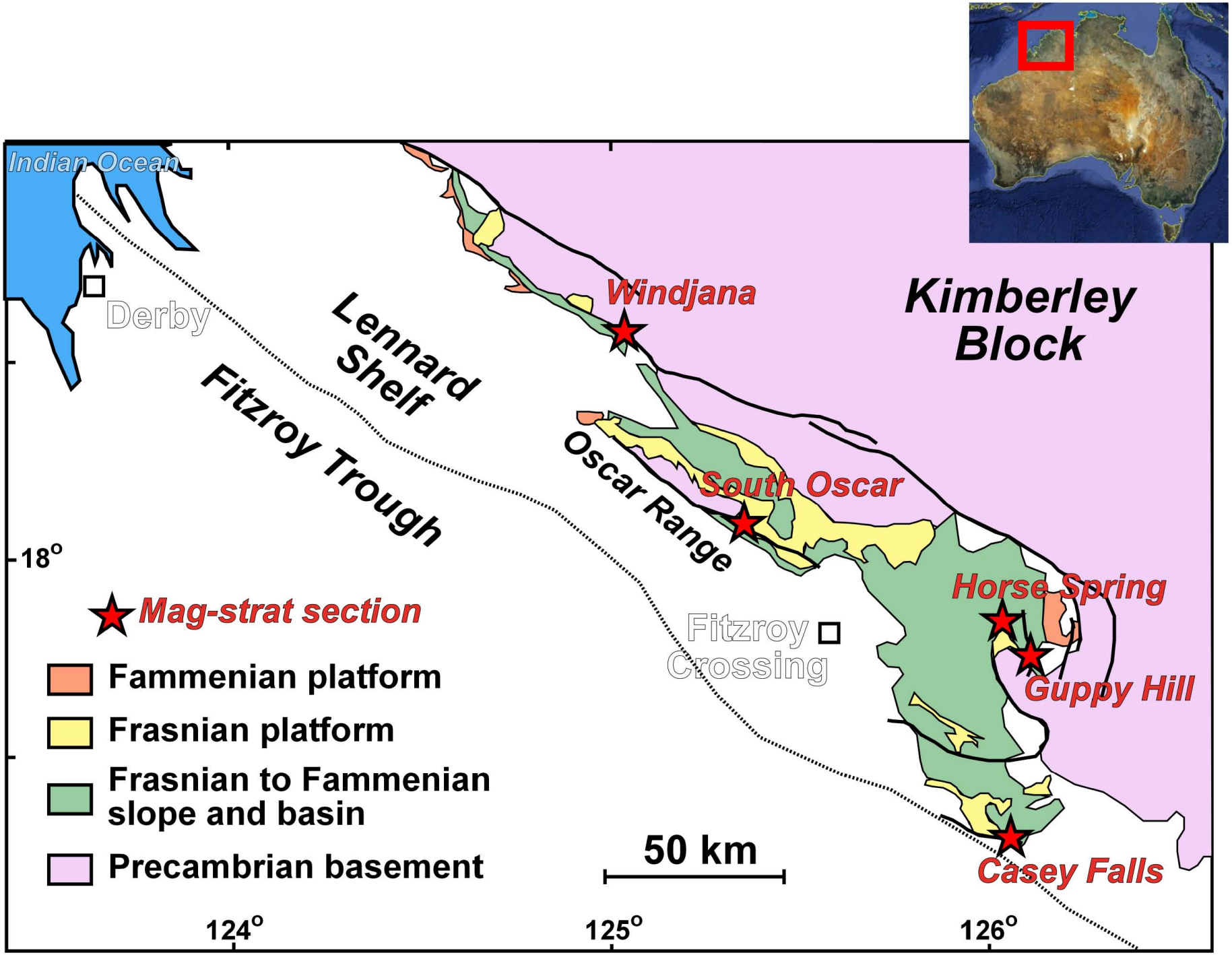
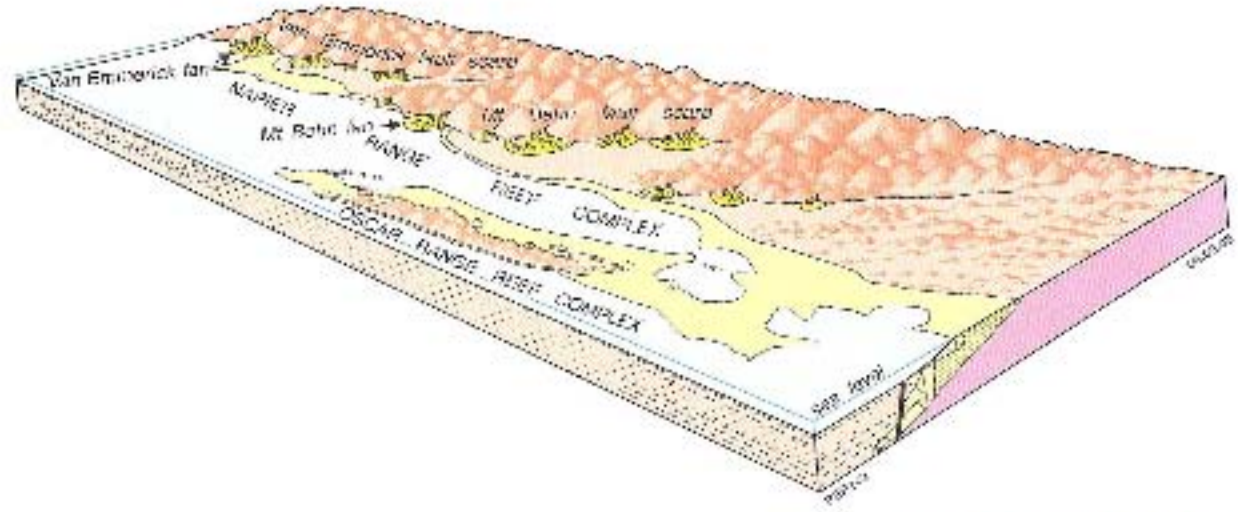
Outline

1. Canning Basin Overview – Correlation challenges across heterogeneous reef / platform / slope / basin environments
2. Multi-pronged correlation – workflow and comparison of different techniques
3. Quick introduction to magnetostratigraphy
4. Two worked examples –
    a. Windjana sites
    b. South Oscar slope versus Horse Springs Basin
5. Overview of correlation

Summary and Conclusions


Indian Ocean
Derby
Lennard Shelf
Fitzroy Trough
Windjana
Kimberley Block
Oscar Range
South Oscar
Horse Spring
Guppy Hill
Fitzroy Crossing
Casey Falls
18°
Mag-strat section
Fammenian platform
Frasnian platform
Frasnian to Fammenian slope and basin
Precambrian basement
50 km
124°
125°
126°



South Oscar Range

Windjana

Casey Falls

Guppy Hills

Horse Spring

Frasnian/Famennian boundary

Sequence 4

Sequence 3

Sequence 2

Sequence 1

Frasnian

Givetian

basement?

Givetian bank

Frasnian

L M U

1 2 3 4 5 6 7

Frasnian 3rd-order sequences

500m

500m

no VE

Workflow

SUMMARY: BIOZONES ARE BEST FOR LARGE SCALE CORRELATION, BUT LESS USEFUL AT FINER SCALES, I.E., <10-100S METERS OF STRATIGRAPHIC THICKNESS

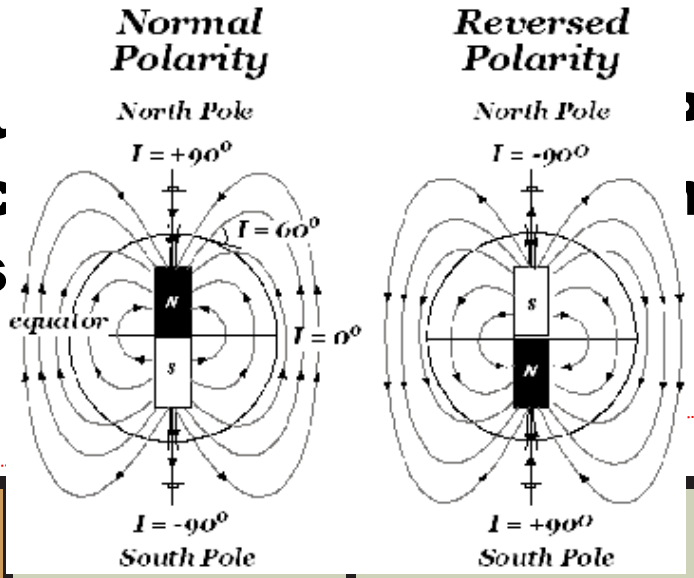
SUMMARY: MAGNETOZONES ARE EXCELLENT FOR MESOSCALE CORRELATION, BUT ABSENCE OF GPTS IS PROBLEMATIC WITHOUT BIOSTRATIGRAPHY. LOW RECOVERY IN WEAKLY MAGNETIZED CARBONATES CAN LEAD TO GAPS IN POLARITY ASSIGNMENT.

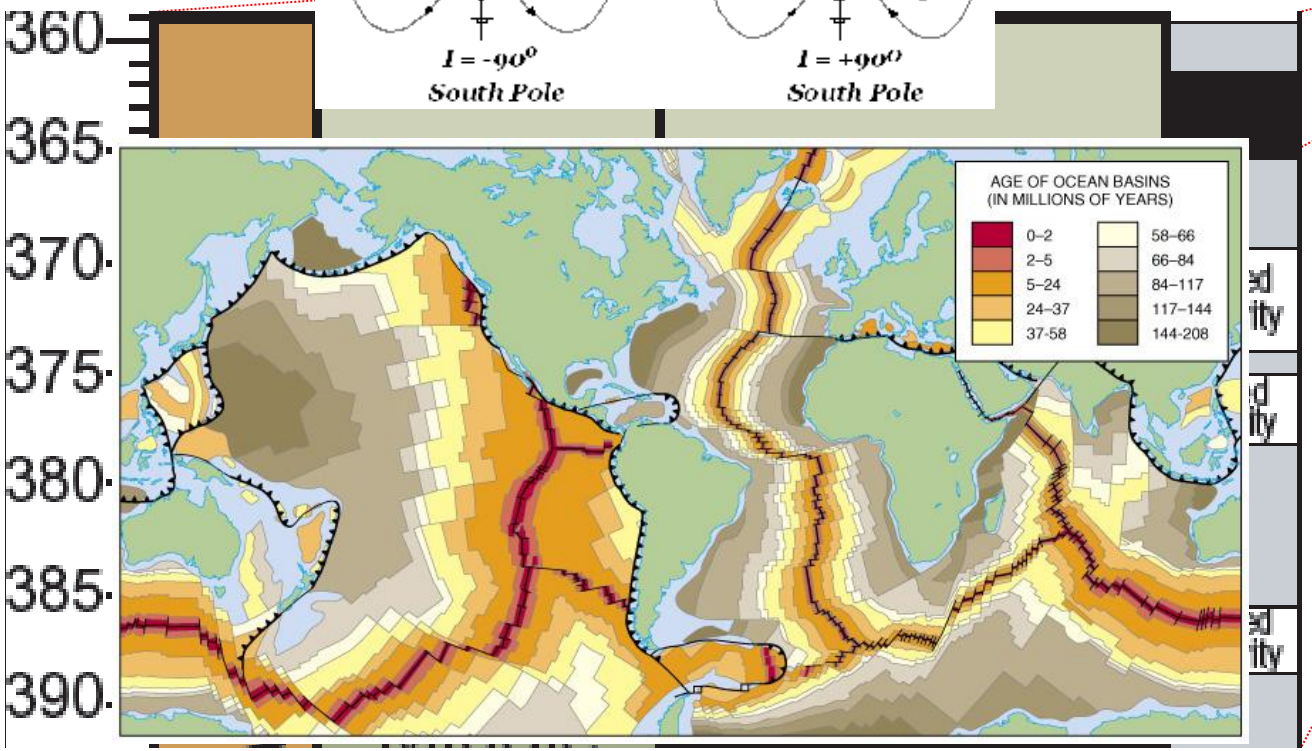
SUMMARY: ISOTOPE STRATIGRAPHY CAN FUNCTION FOR GLOBAL CORRELATIONS AS WELL AS ENVIRONMENTAL RECONSTRUCTIONS. LOCAL VARIATIONS CAN BE COMMON, AND THE EFFECTS OF POST-DIAGENETIC PROCESSES MUST BE ELIMINATED.

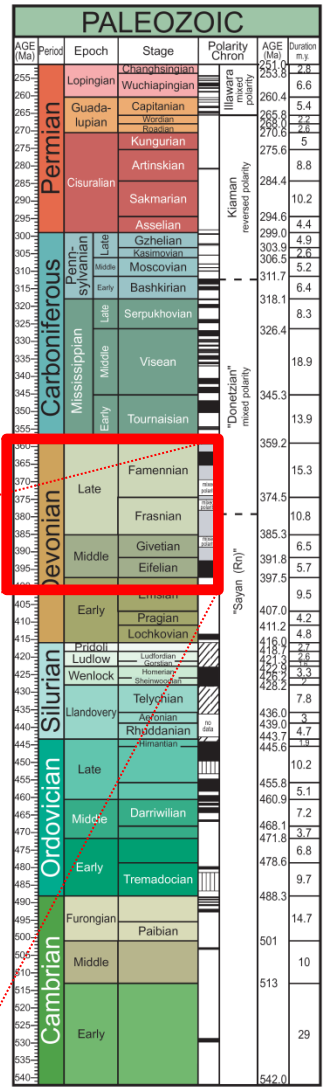
GEOLOGIC TIME SCALE

PHANEROZOIC

Unfortu **olarity**
Timesc **nexistent**
for this







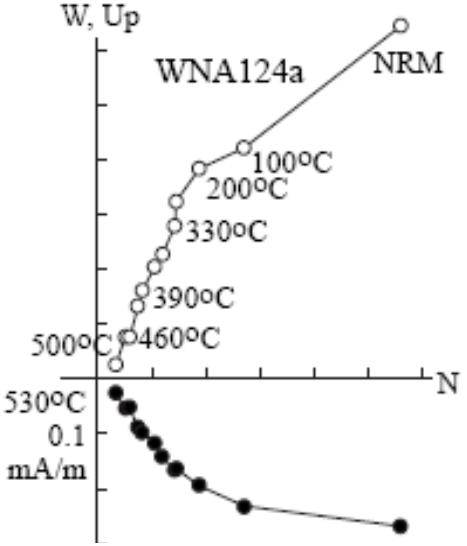
For details see "A Geologic Time Scale 2004" by F. M. Gradstein, J. G. Ogg, A. G. Smith, et al. (2004) with Cambridge University Press, and the official website of the International Commission on Stratigraphy (ICS) under *www.stratigraphy.org* .

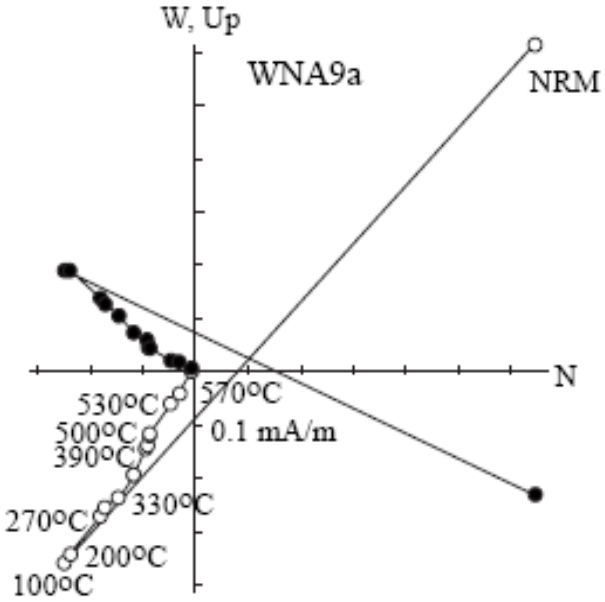
Devonian | Silurian | Ordovician | Cambrian

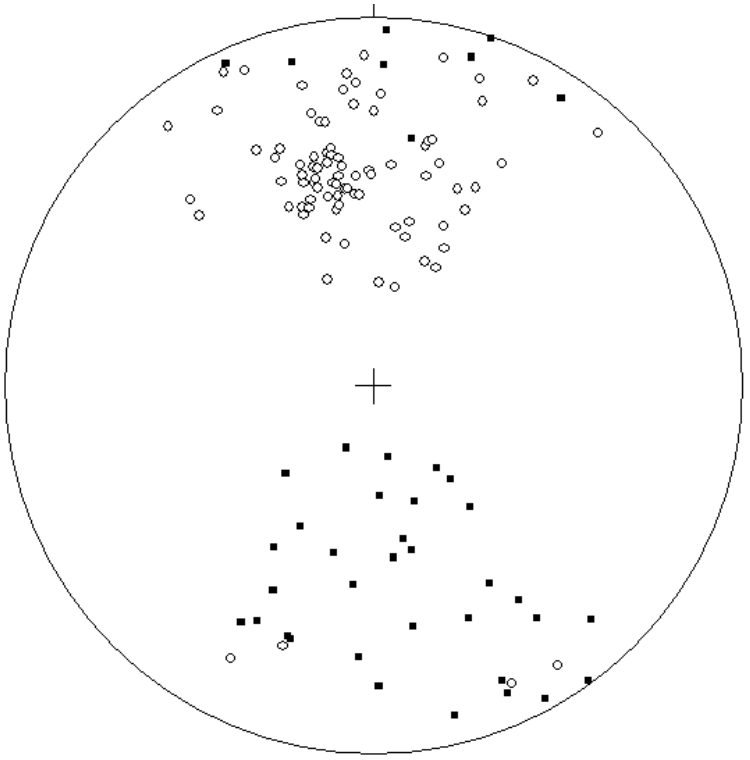
2 416 443.7 488.3 542 Ma


~1.3 m

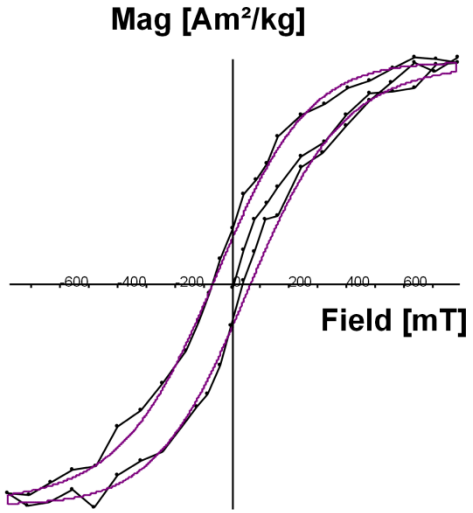
Thermal Demagnetization (12-15 steps)

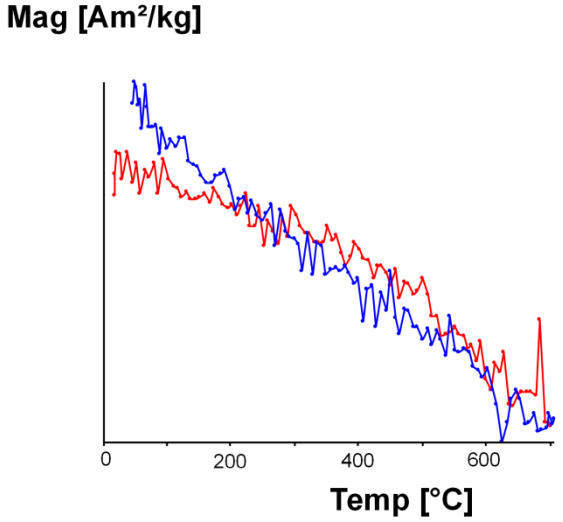


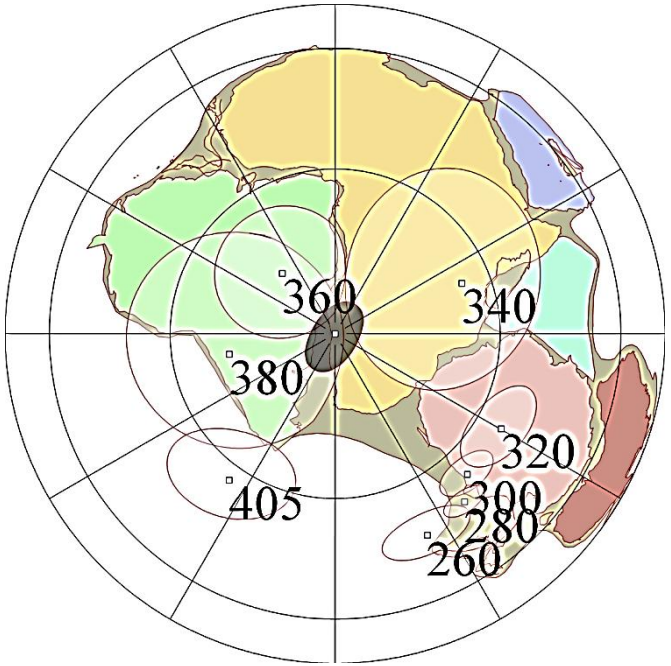




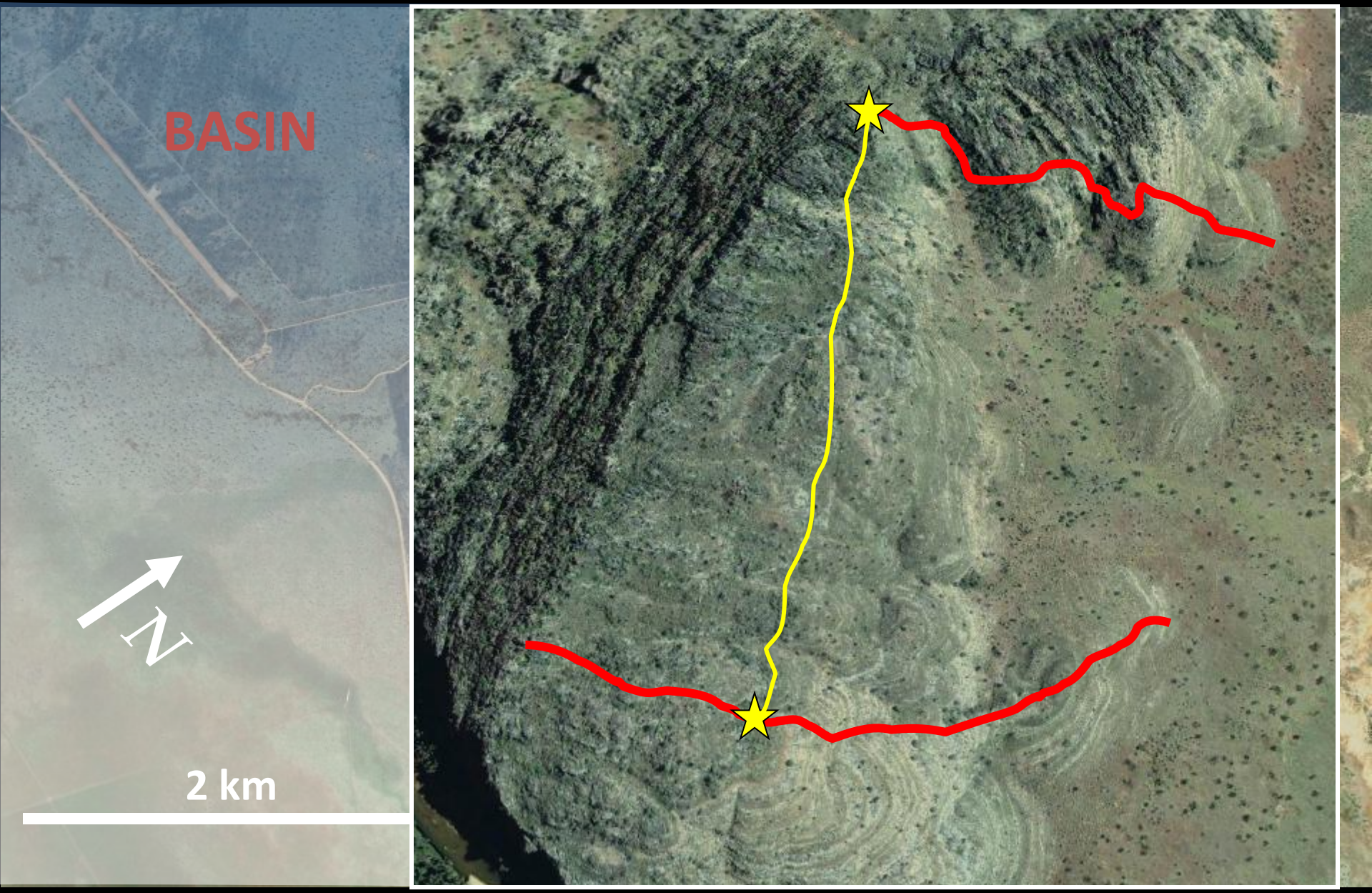
Rock Magnetism

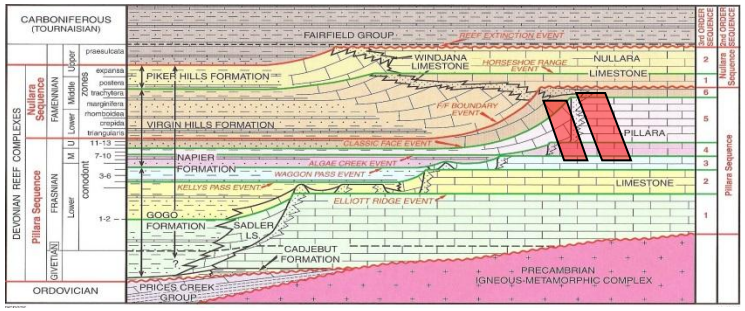






Upper Frasnian platform to slope – Windjana Gorge





Great circle/PCA MAD>15 direction

Unstable direction

Reversed polarity

PCA, MAD <15 direction

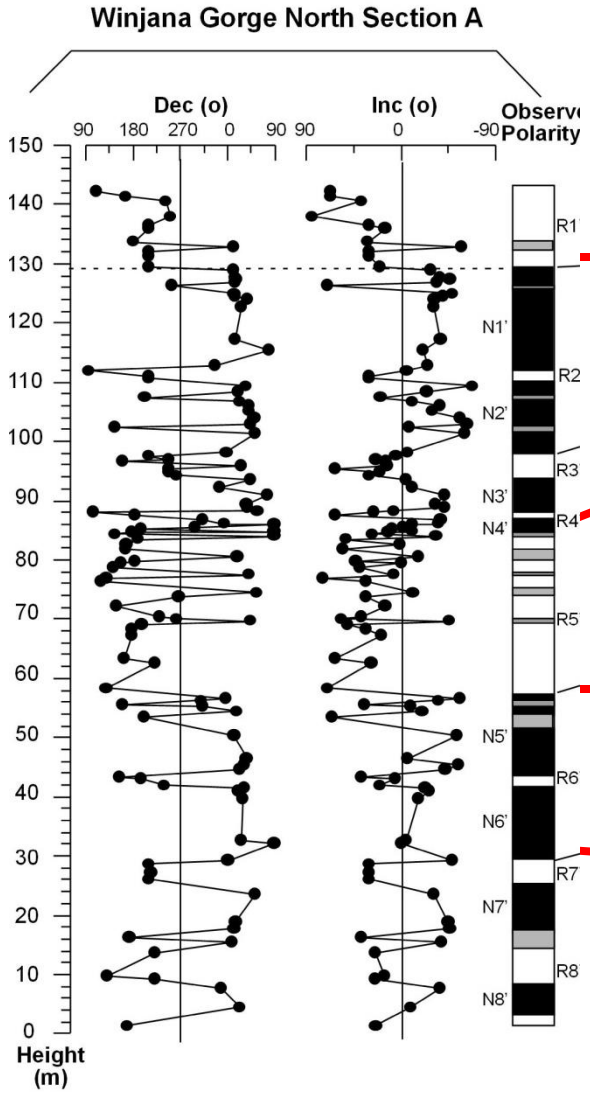
Vague polarity

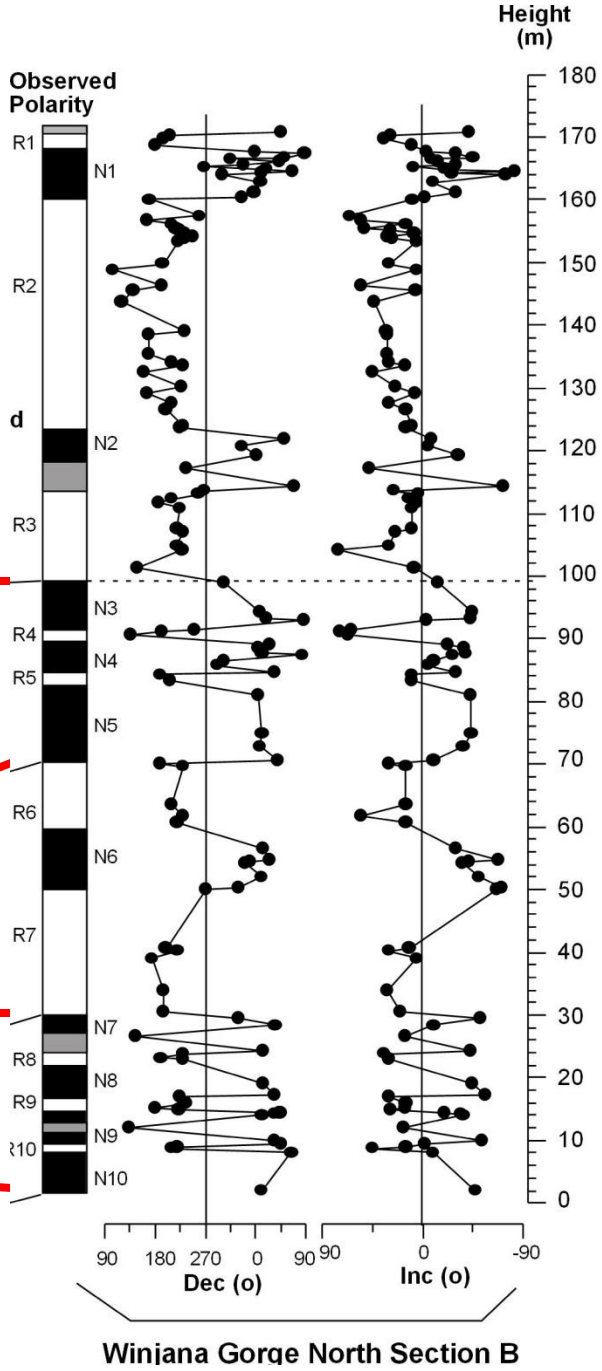
Normal polarity

25% recovery of ~500 samples from 220 m of composite section

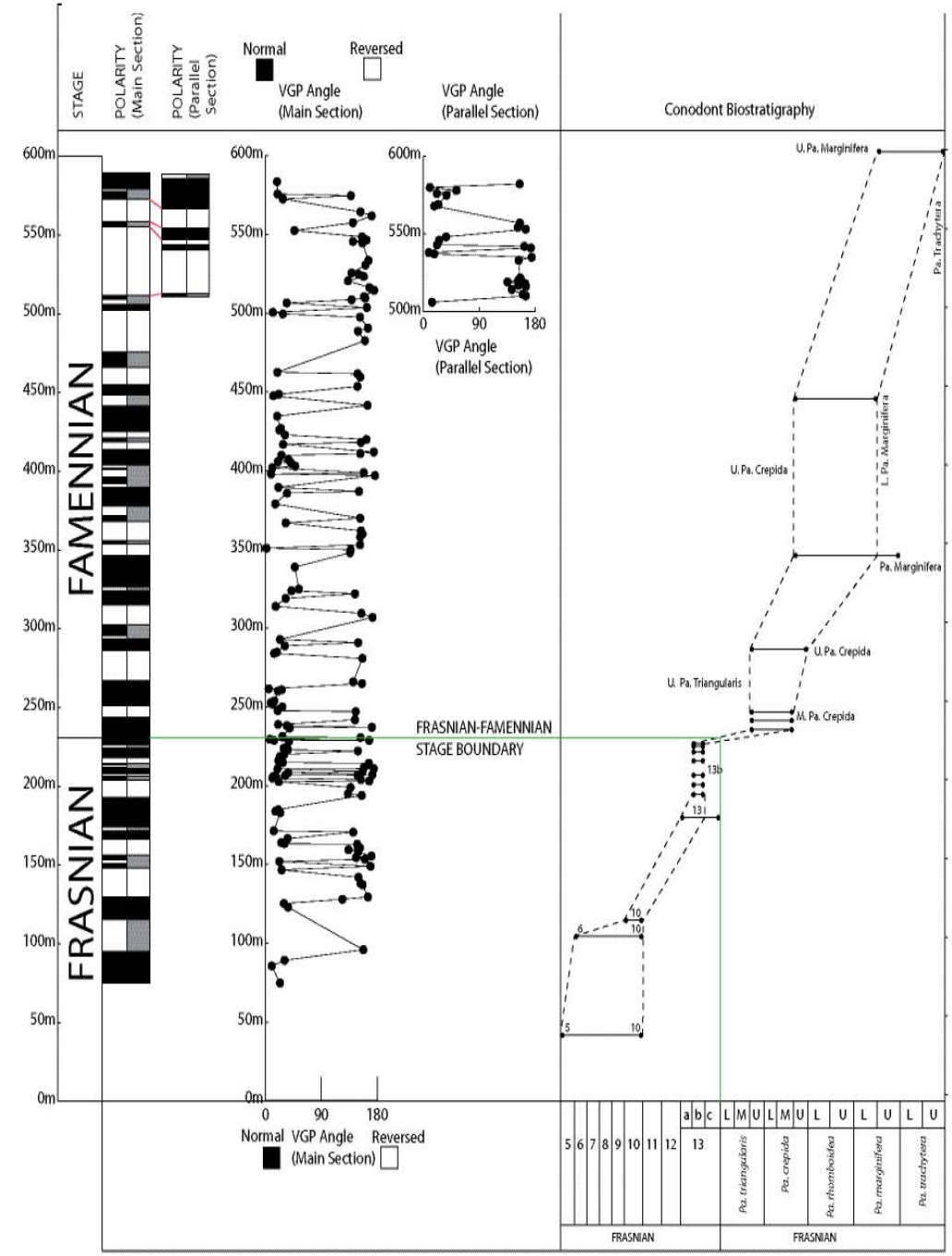
~20 reversals over 5-10 Ma interval

2-4 reversals/Ma

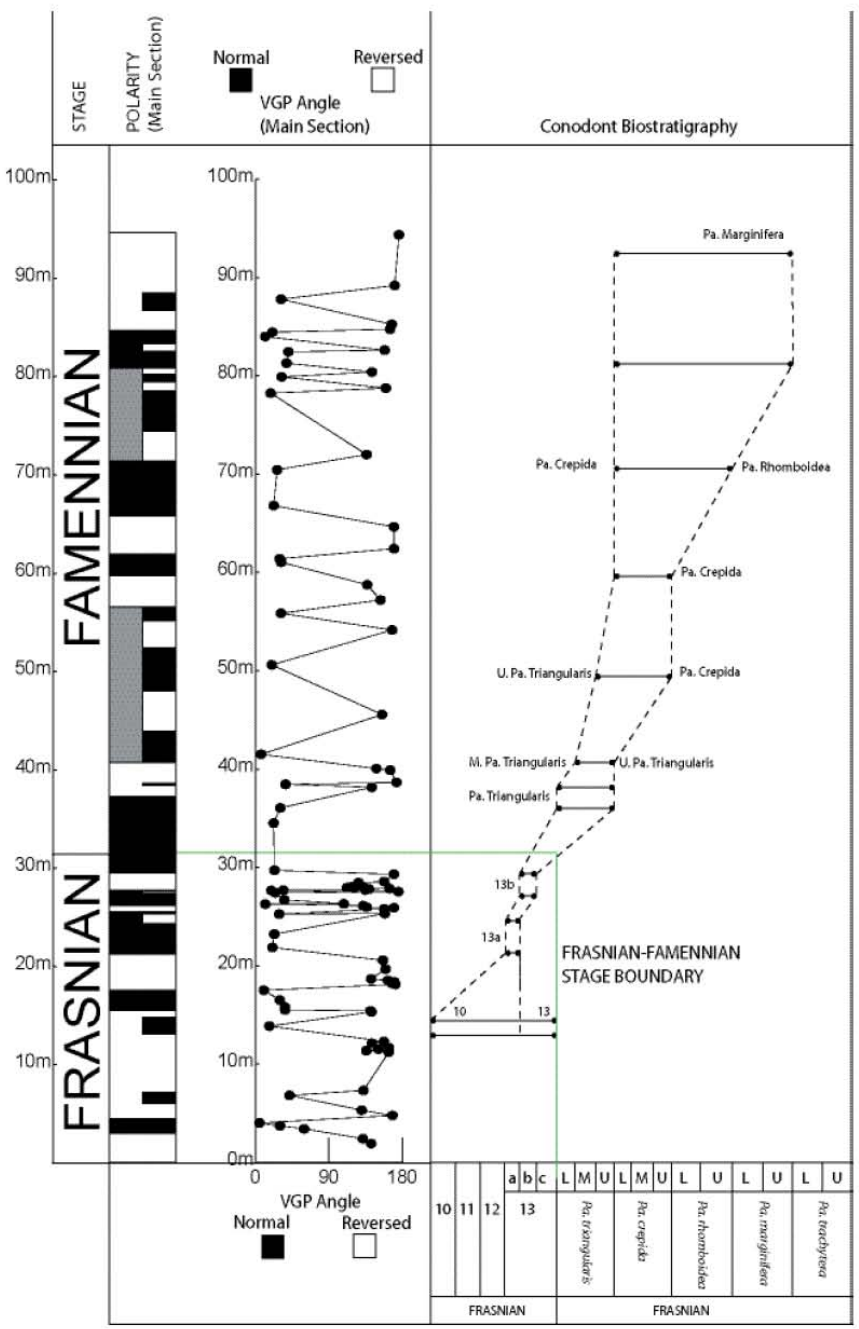


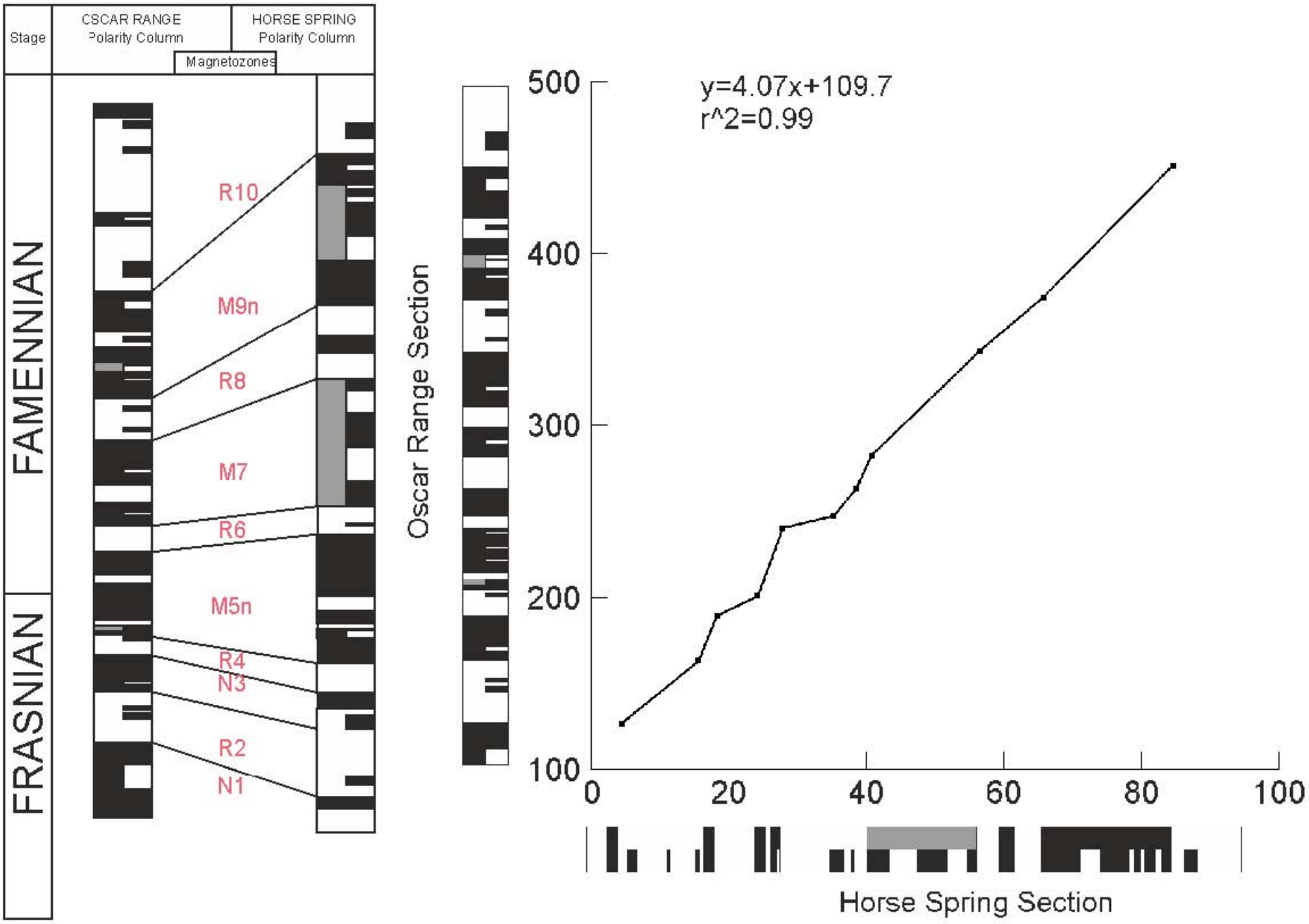


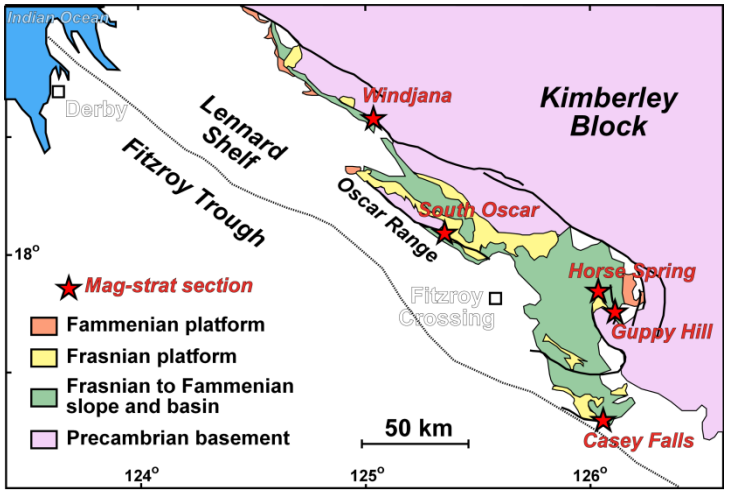
South Oscars – Slope



Virgin Hills – Basin




Stage
CSCAR RANGE
Polarity Column
HORSE SPRING
Polarity Column
Magnetozones
FAMENNIAN
FRASNIAN
R10
M9n
R8
M7
R6
M5n
R4
N3
R2
N1
Oscar Range Section
y=4.07x+109.7
r^2=0.99
500
400
300
200
100
0
20
40
60
80
100
Horse Spring Section


Indian Ocean
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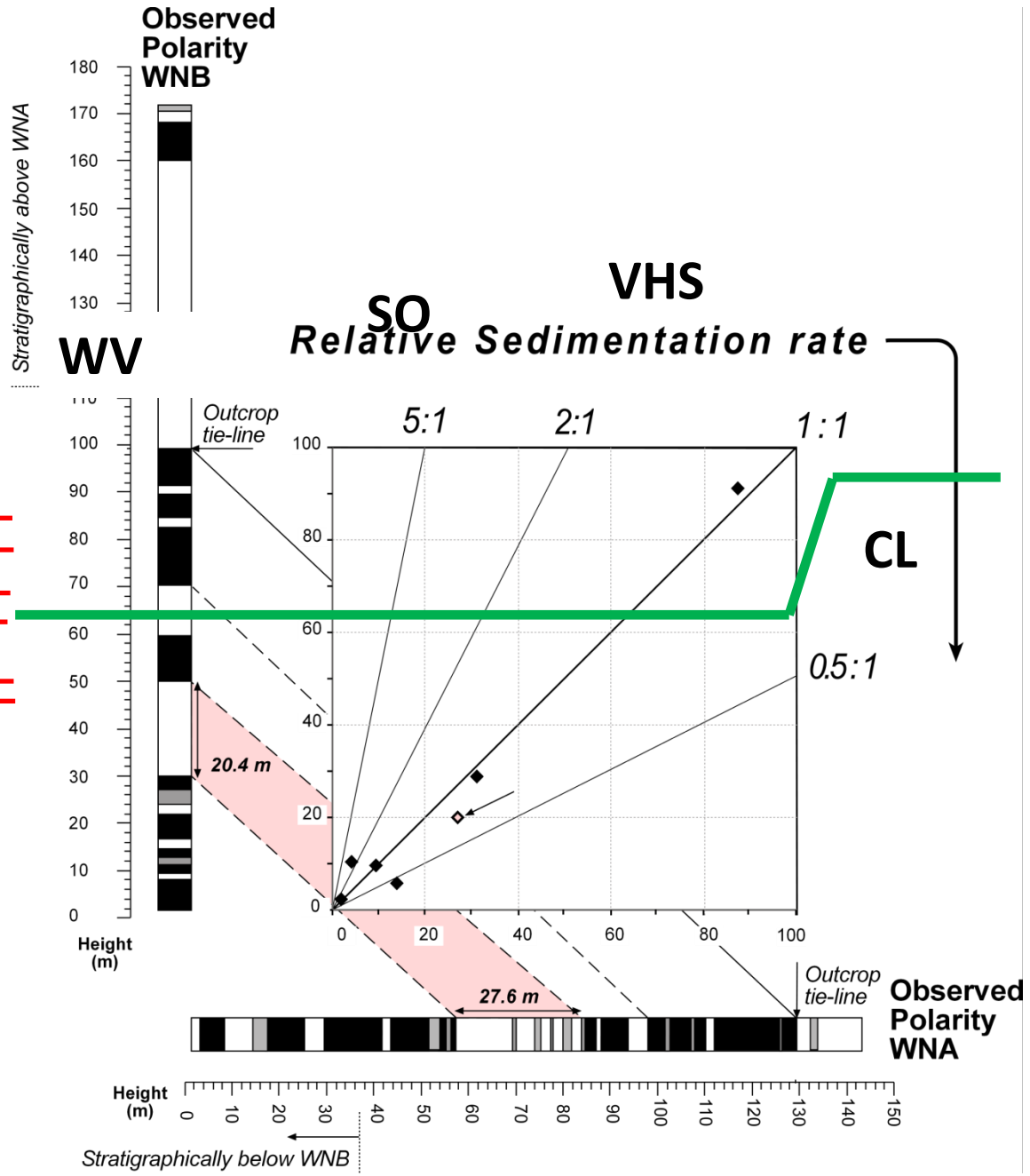
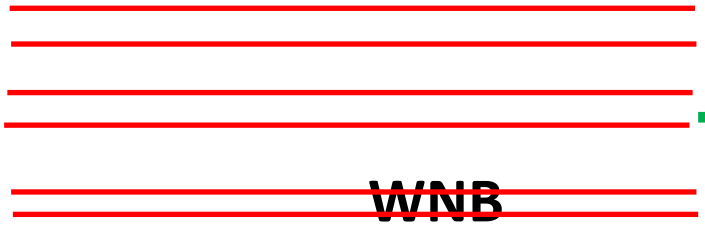
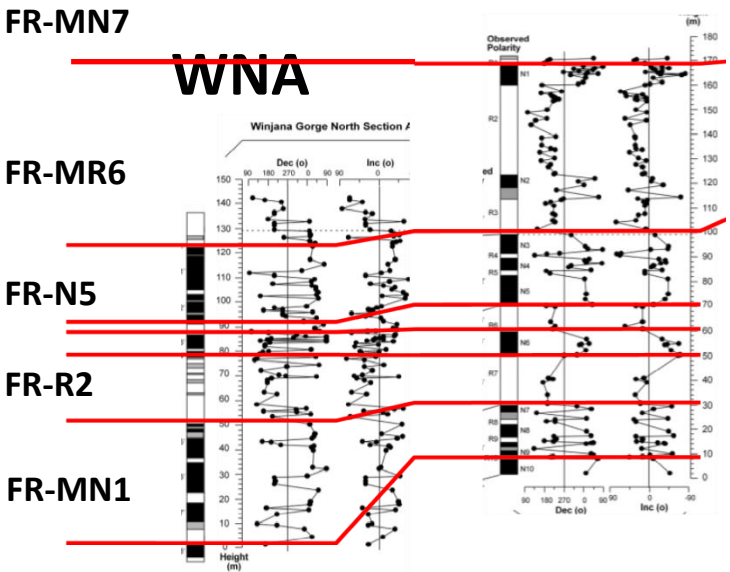
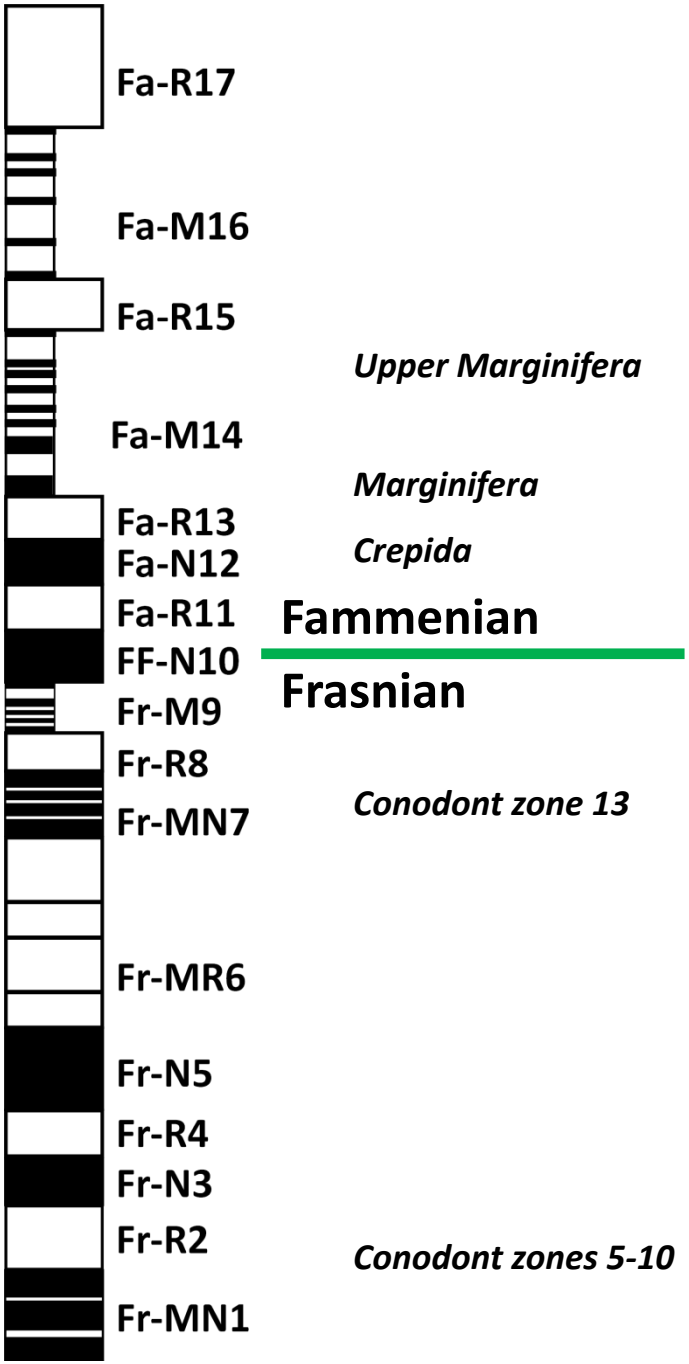
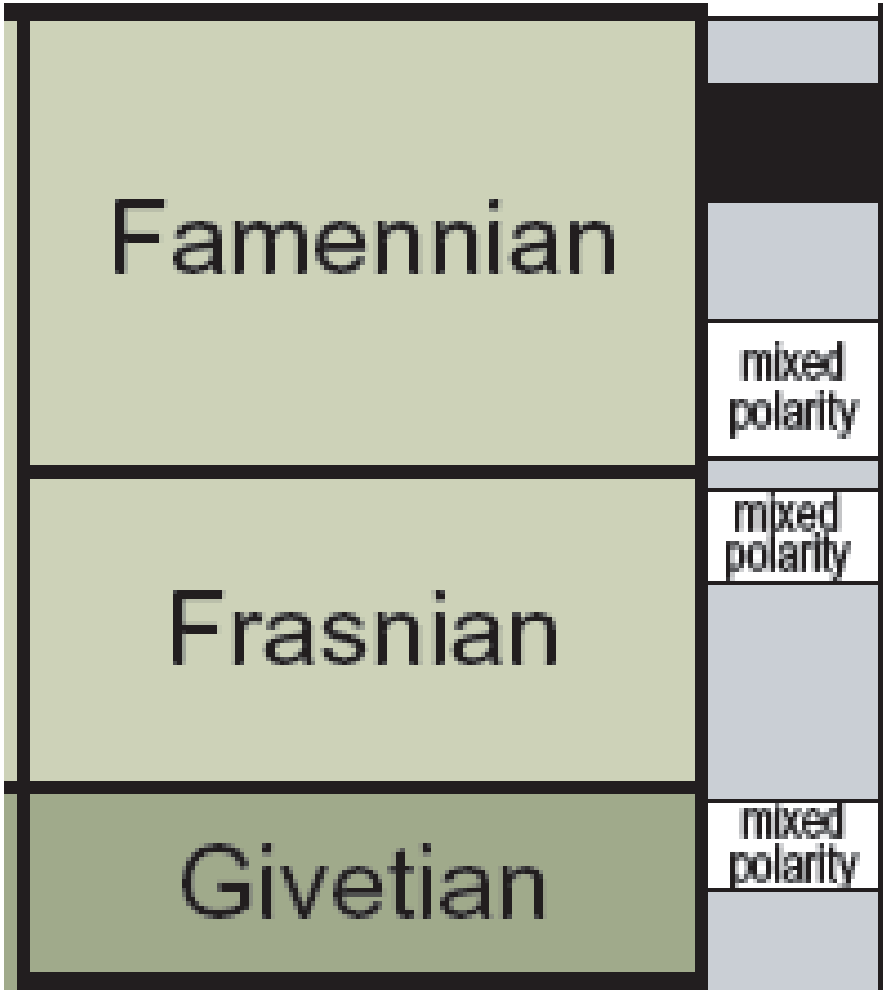
Casey Falls
18°
Mag-strat section
Fammenian platform
Frasnian platform
Frasnian to Fammenian slope and basin
Precambrian basement
50 km
124°
125°
126°


Observed Polarity WNB
Stratigraphically above WNA
180
170
160
150
140
130
WV
SO
VHS
Relative Sedimentation rate
Outcrop tie-line
5:1
2:1
1:1
0.5:1
CL
100
90
80
70
60
50
40
30
20
10
0
20.4 m
27.6 m
Height (m)
Outcrop tie-line
Observed Polarity WNA
Stratigraphically below WNB


WNB

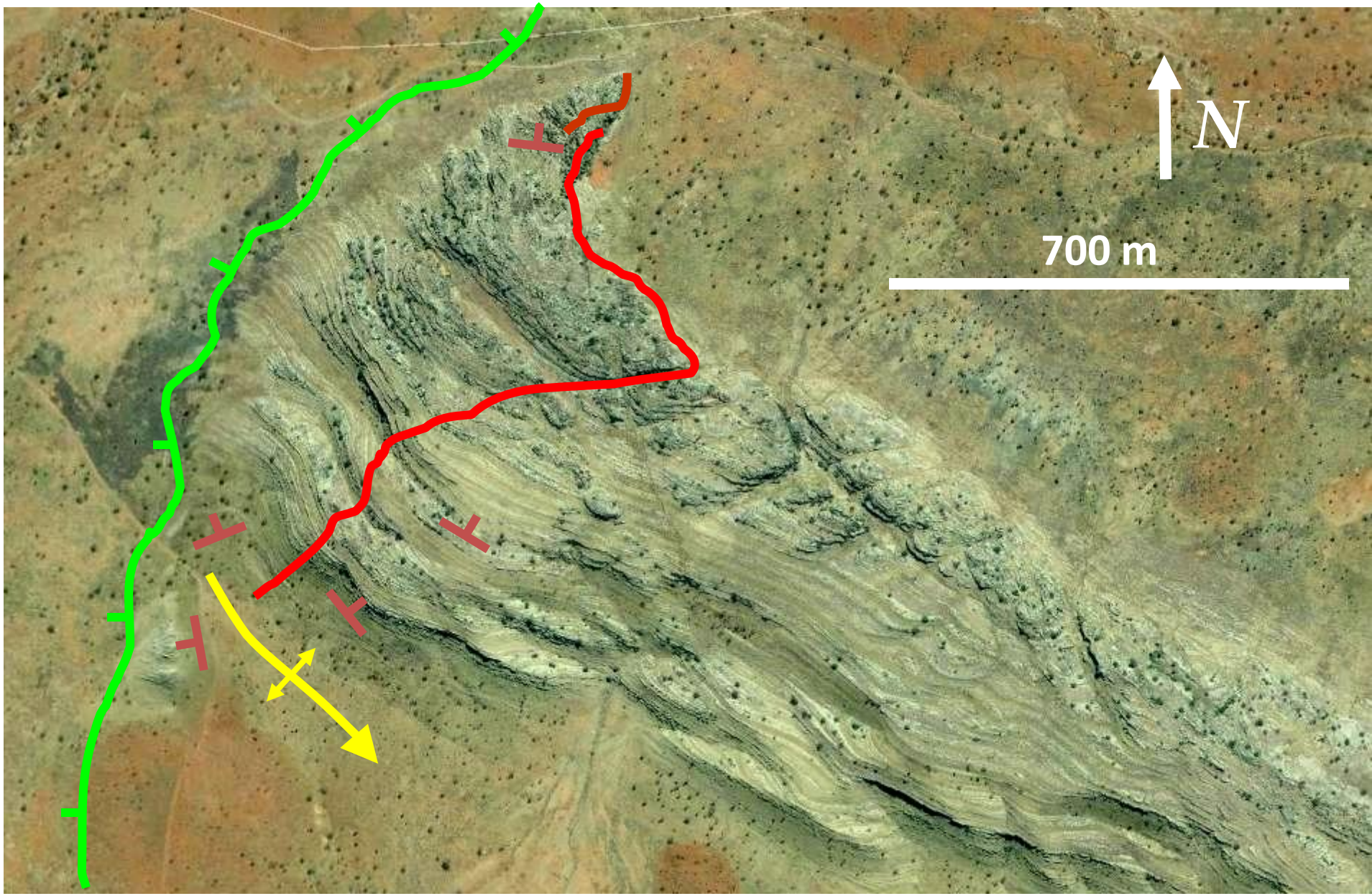

FR-MN7
WNA
FR-MR6
FR-N5
FR-R2
FR-MN1
Winjana Gorge North Section A
Dec (o)
Inc (o)
Observed Polarity
Height (m)


Fa-R17
Fa-M16
Fa-R15
Upper Marginifera
Fa-M14
Marginifera
Fa-R13
Crepida
Fa-N12
Fa-R11
Fammenian
FF-N10
Frasnian
Fr-M9
Fr-R8
Conodont zone 13
Fr-MN7
Fr-MR6
Fr-N5
Fr-R4
Fr-N3
Fr-R2
Conodont zones 5-10
Fr-MN1


Famennian
Frasnian
Givetian
mixed polarity
mixed polarity
mixed polarity

Conclusions

1. **Primary paleomagnetic remanences were recovered from ~25% of ~5000 samples taken from 7 separate sections of the Canning Basin of Western Australia.**
2. **Magnetostratigraphic results were integrated with biostratigraphy (conodonts) to provide a global reference frame.**
3. **The integrated chronostratigraphy provides a robust correlation scheme across different depositional environments, allowing the identification of heterogeneities in accumulation rates.**
4. **This study provides the first report of the Global Polarity Timescale of magnetic reversals for the Middle Devonian.**

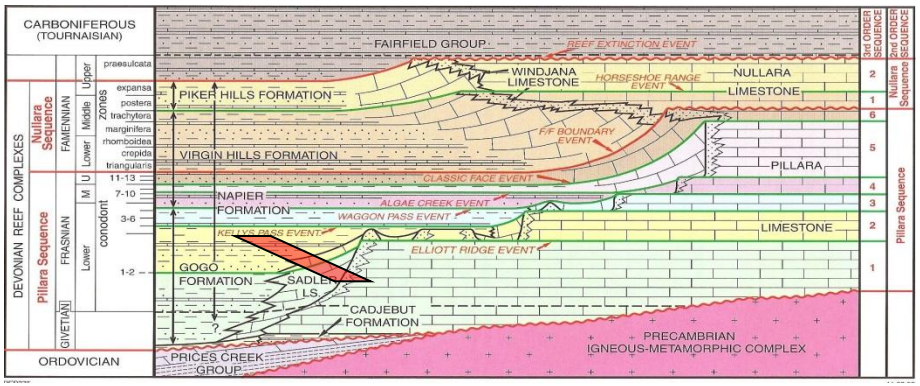

N
700 m

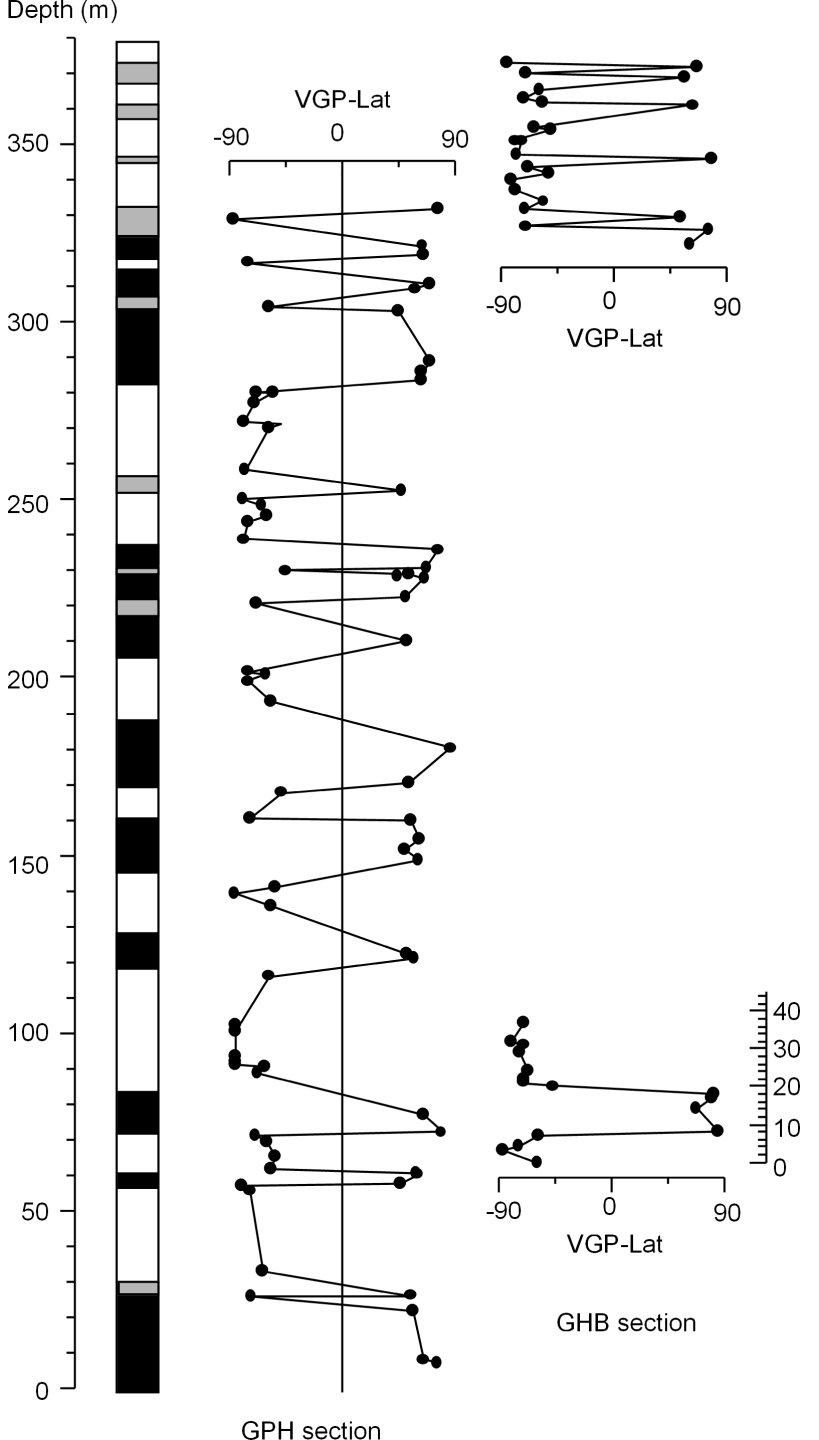
Mag-strat results from the Givetian (late middle Devonian)

370 m of composite section

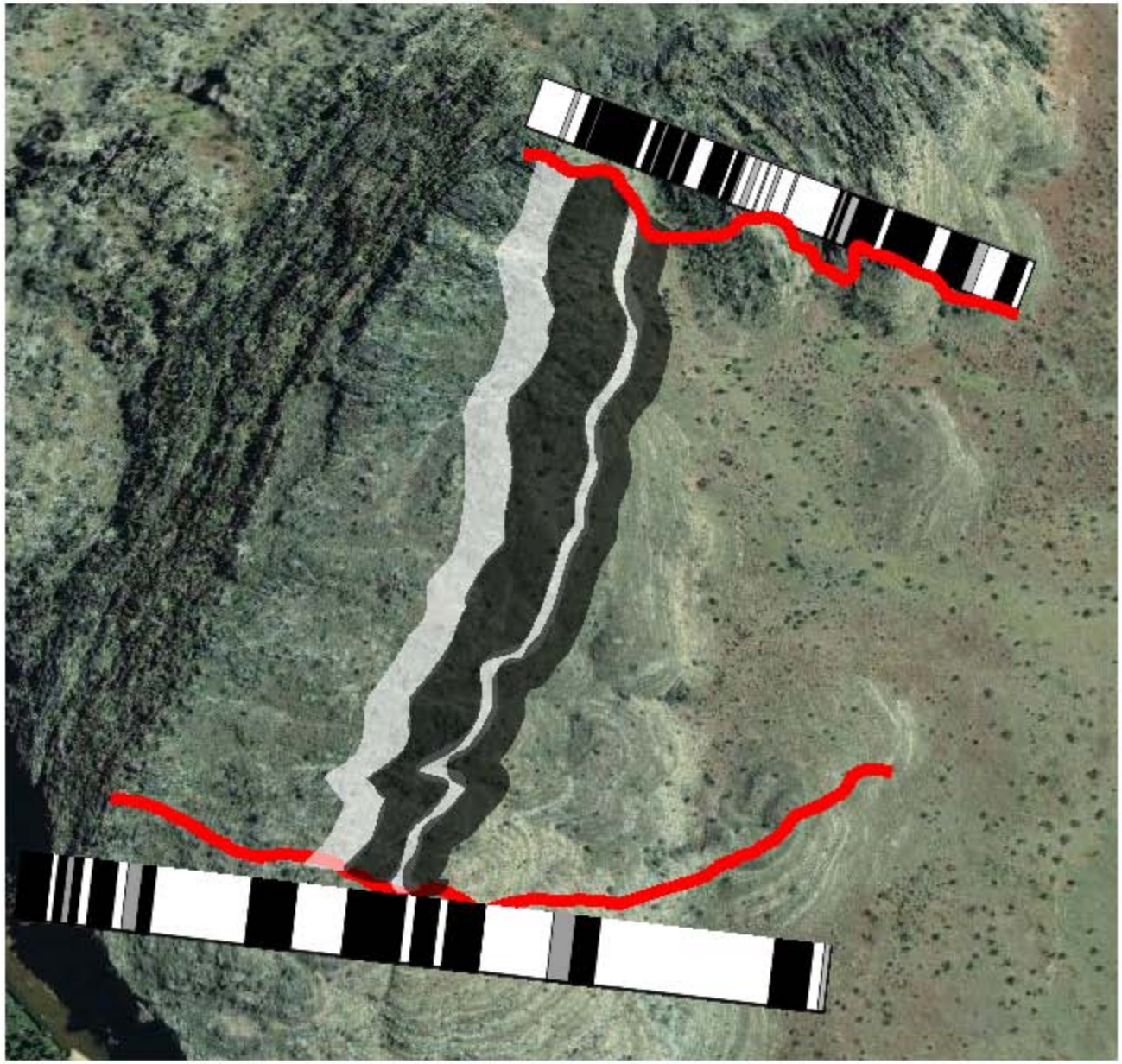
~15 reversals in ~5 Ma

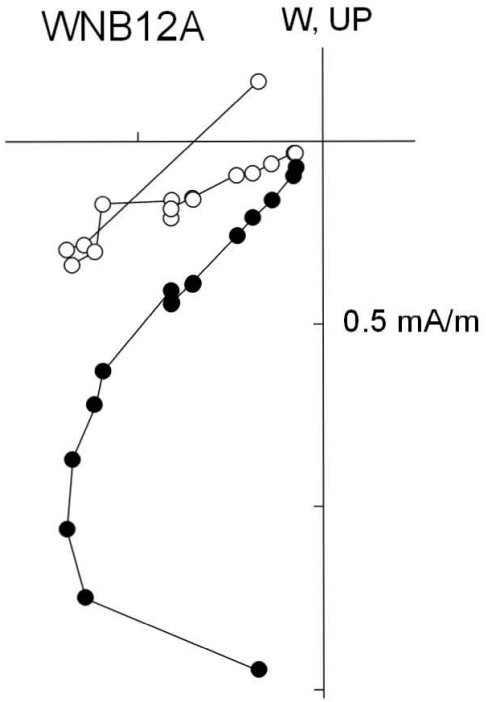
~3 reverals / Ma

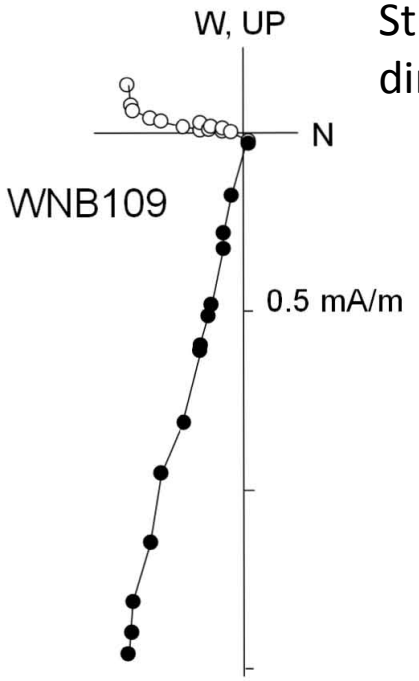




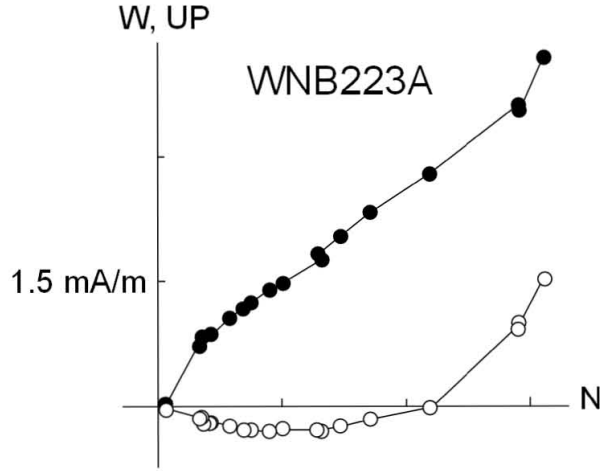
Geopetals indicate tectonic tilt <10 degrees

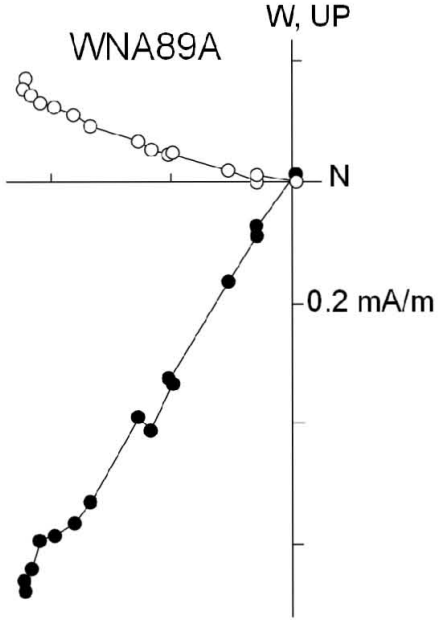


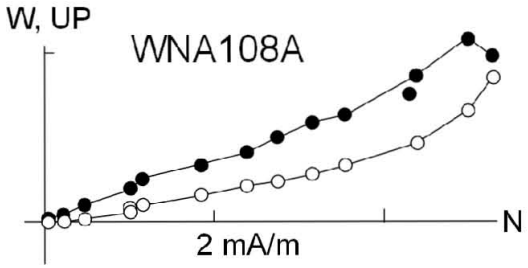


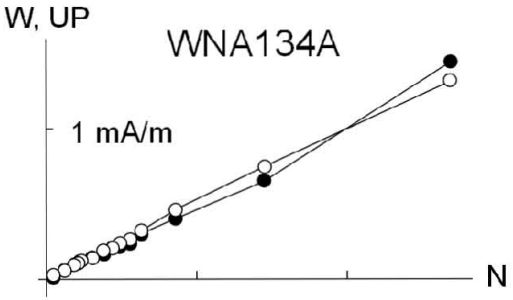


Strong magnetizations, random directions, remagnetizations





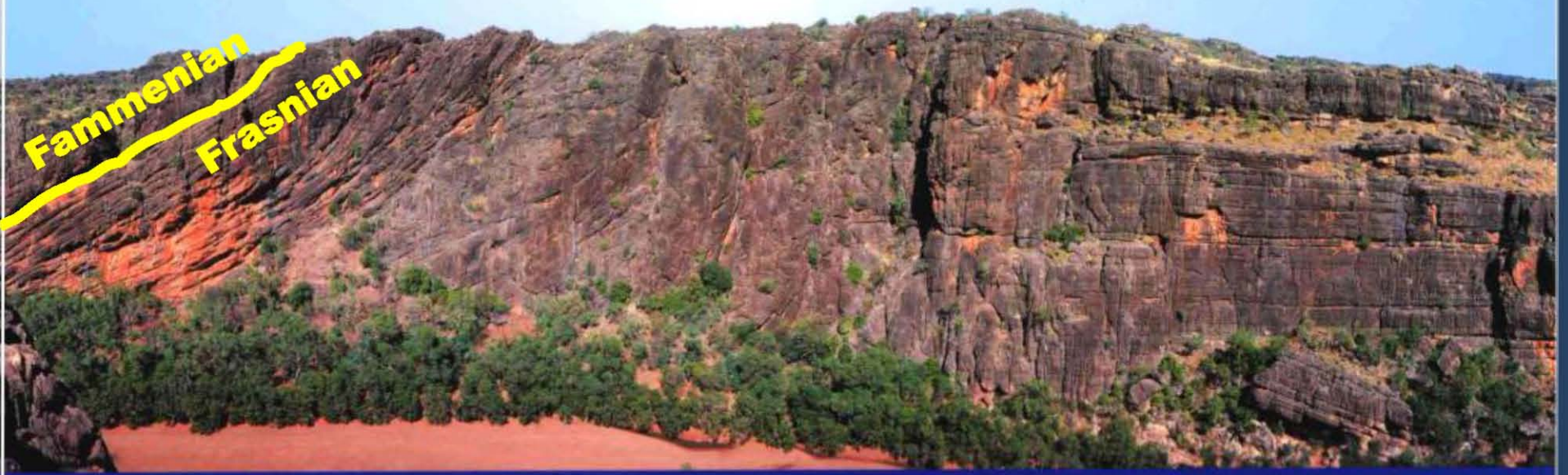




DEVONIAN REEF COMPLEXES
OF THE CANNING BASIN, WESTERN AUSTRALIA

Geological Survey of Western Australia
Bulletin 145

Phillip E Playford, Roger M Hocking and Anthony E Cockbain



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