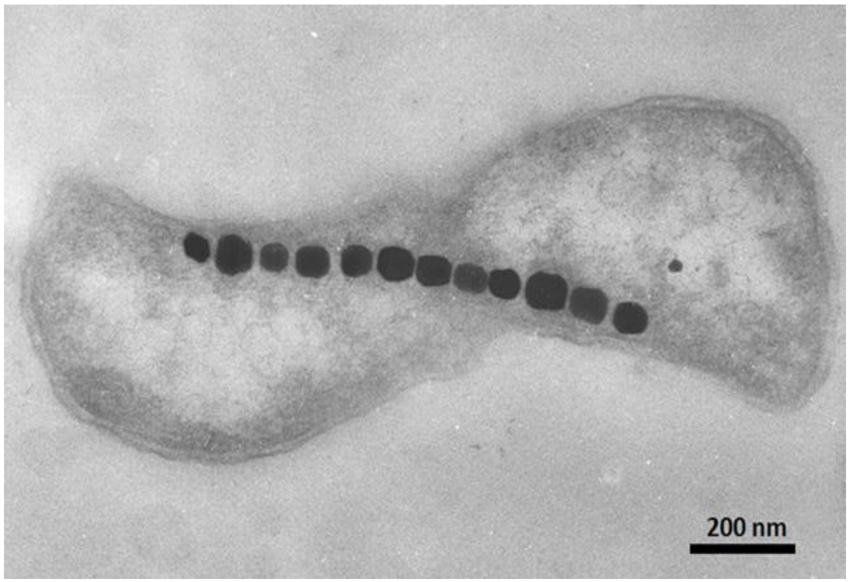
Quantifying magnetite magnetofossil contributions to sedimentary magnetizations

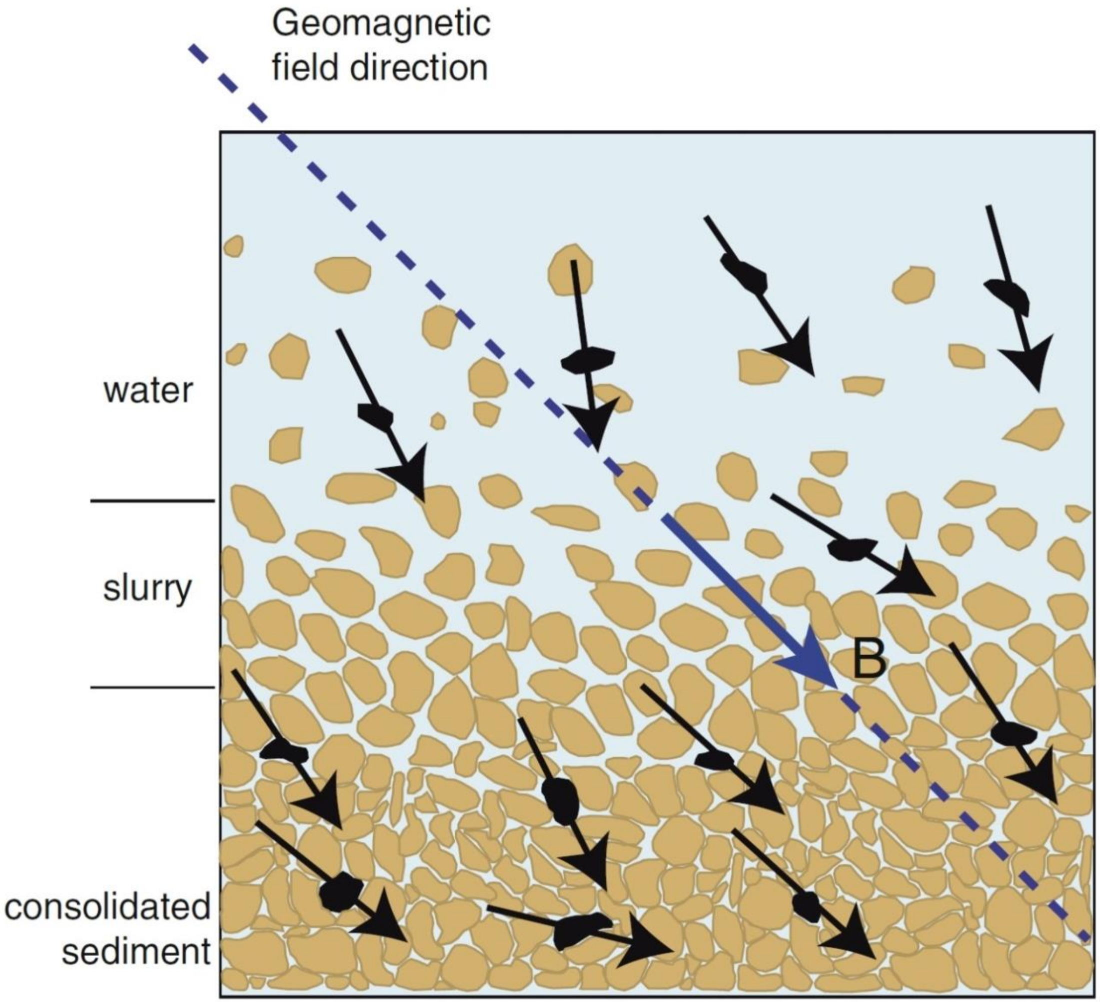


D. Heslop, A. P. Roberts, L. Chang, M. Davies,
A. Abrajevitch & P. De Deckker.
Research School of Earth Sciences, The Australian National University.

Outline

- Introduction
- Geological setting
- Results
- Interpretation
- Conclusions

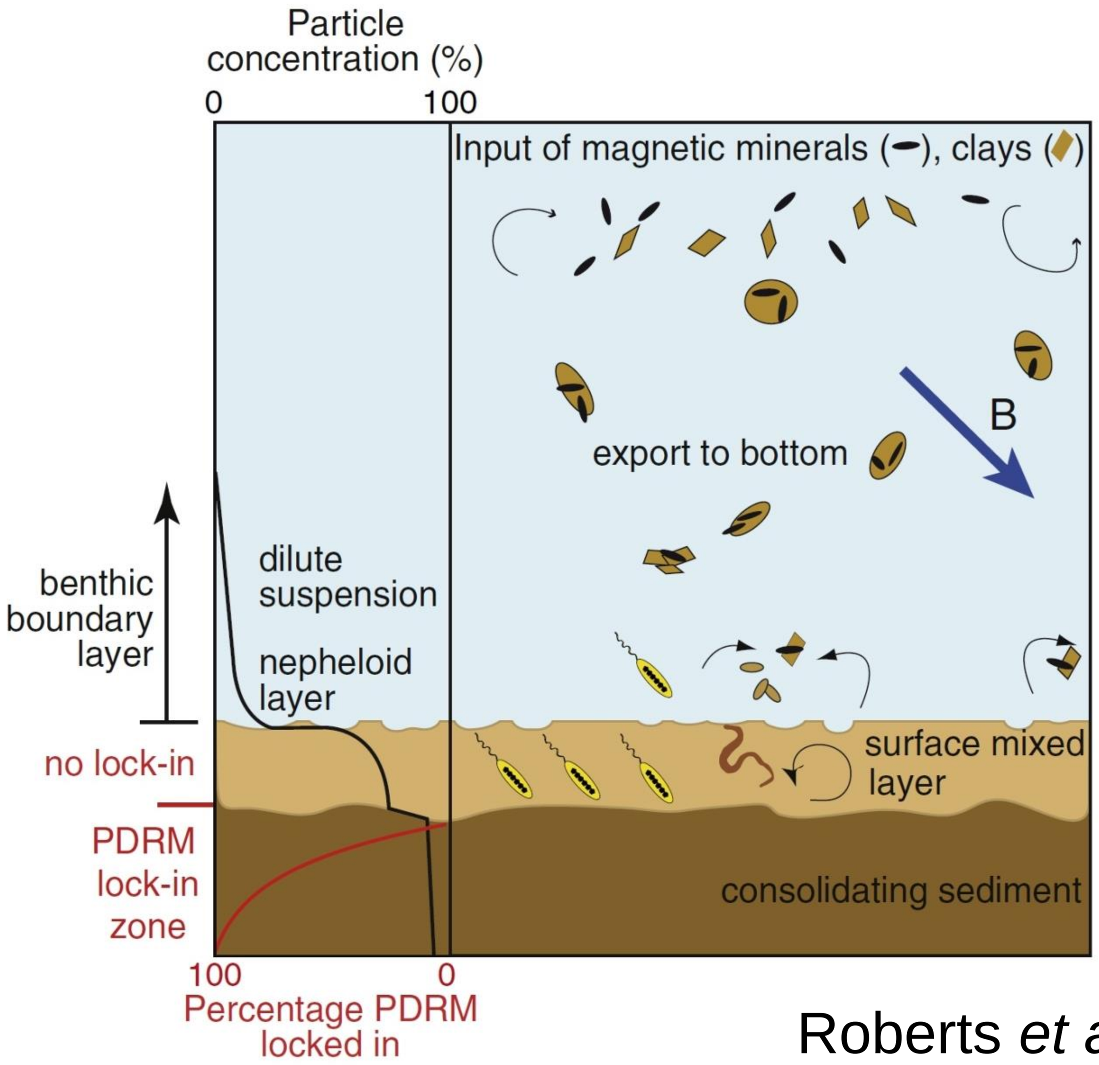
ARC Project: How do sediments become magnetized?



DRM
Depositional
Remanent
Magnetization

Roberts *et al. Quat. Sci. Rev. 2013*

ARC Project: How do sediments become magnetized?

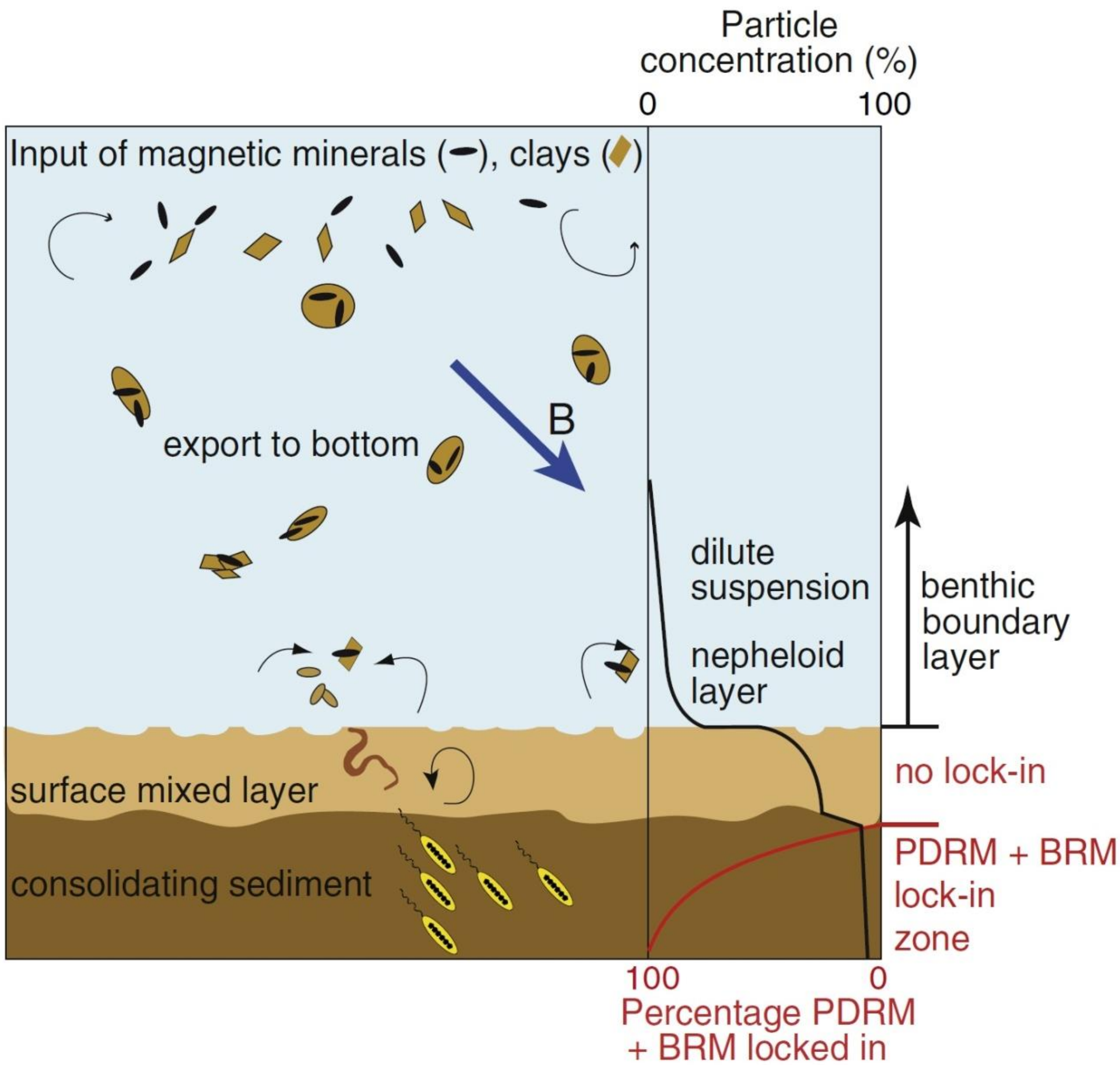


PDRM

Post-depositional Remanent Magnetization

Roberts *et al. Quat. Sci. Rev. 2013*

Introduction



Roberts *et al. Quat. Sci. Rev. 2013*

PDRM + BRM

PDRM & Biogenic Remanent Magnetization

BRM could offset palaeomagnetic recording

Introduction

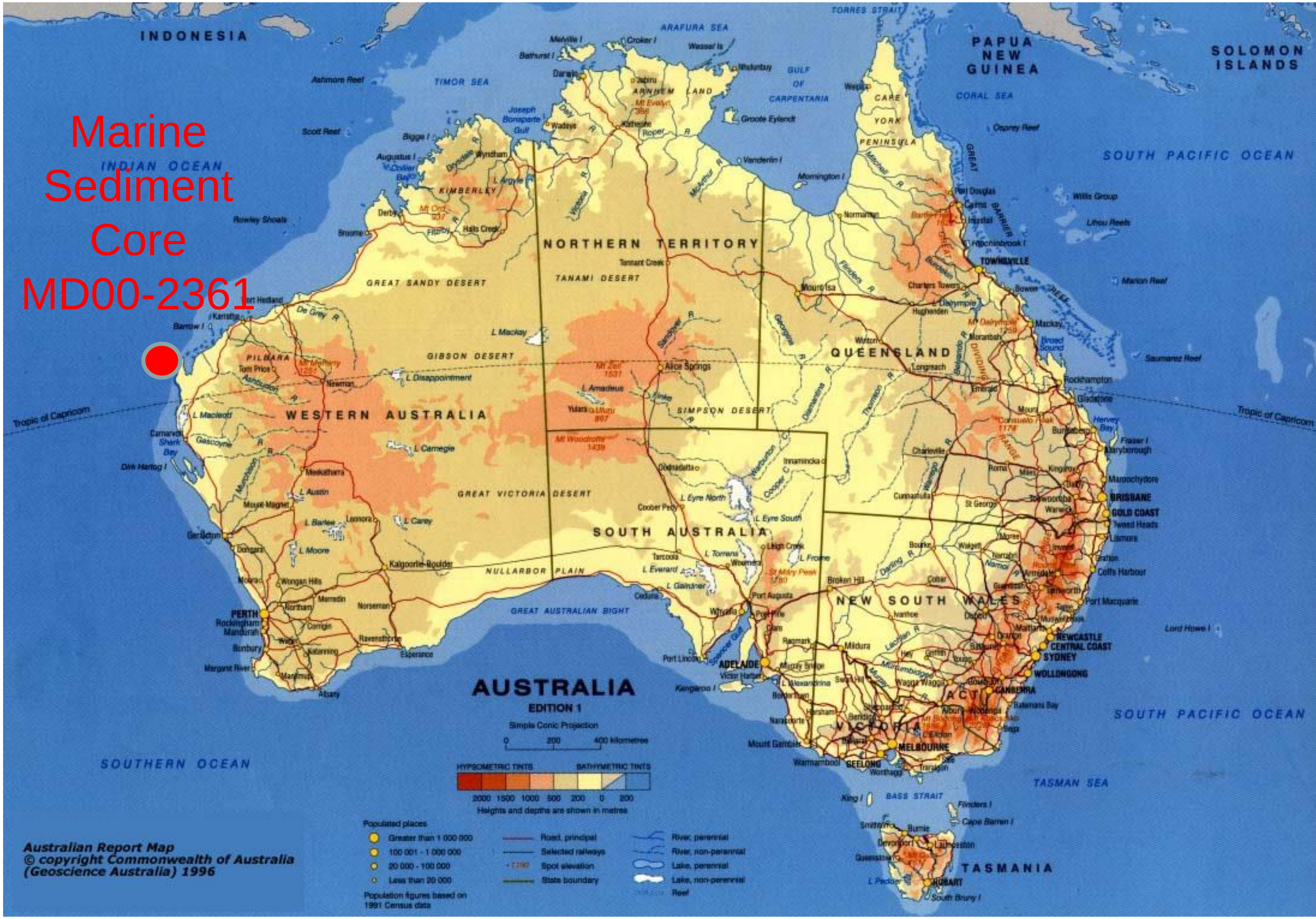
Primary hypothesis

Do magnetofossils (inorganic remains of magnetotactic bacteria) make a significant contribution to recording the palaeomagnetic field?

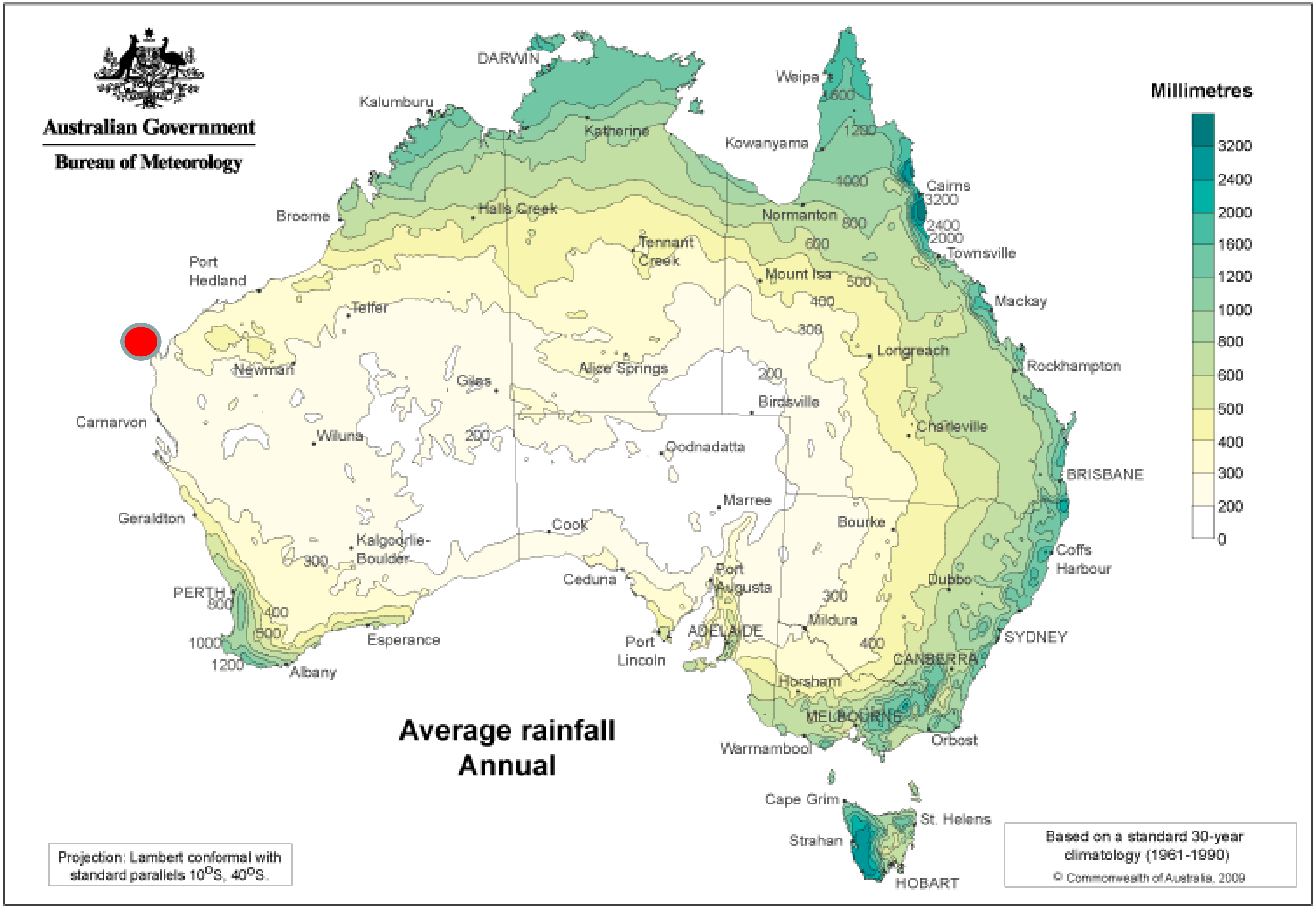
Secondary hypothesis

Is there any evidence that magnetofossils carry a BRM rather than a PDRM?

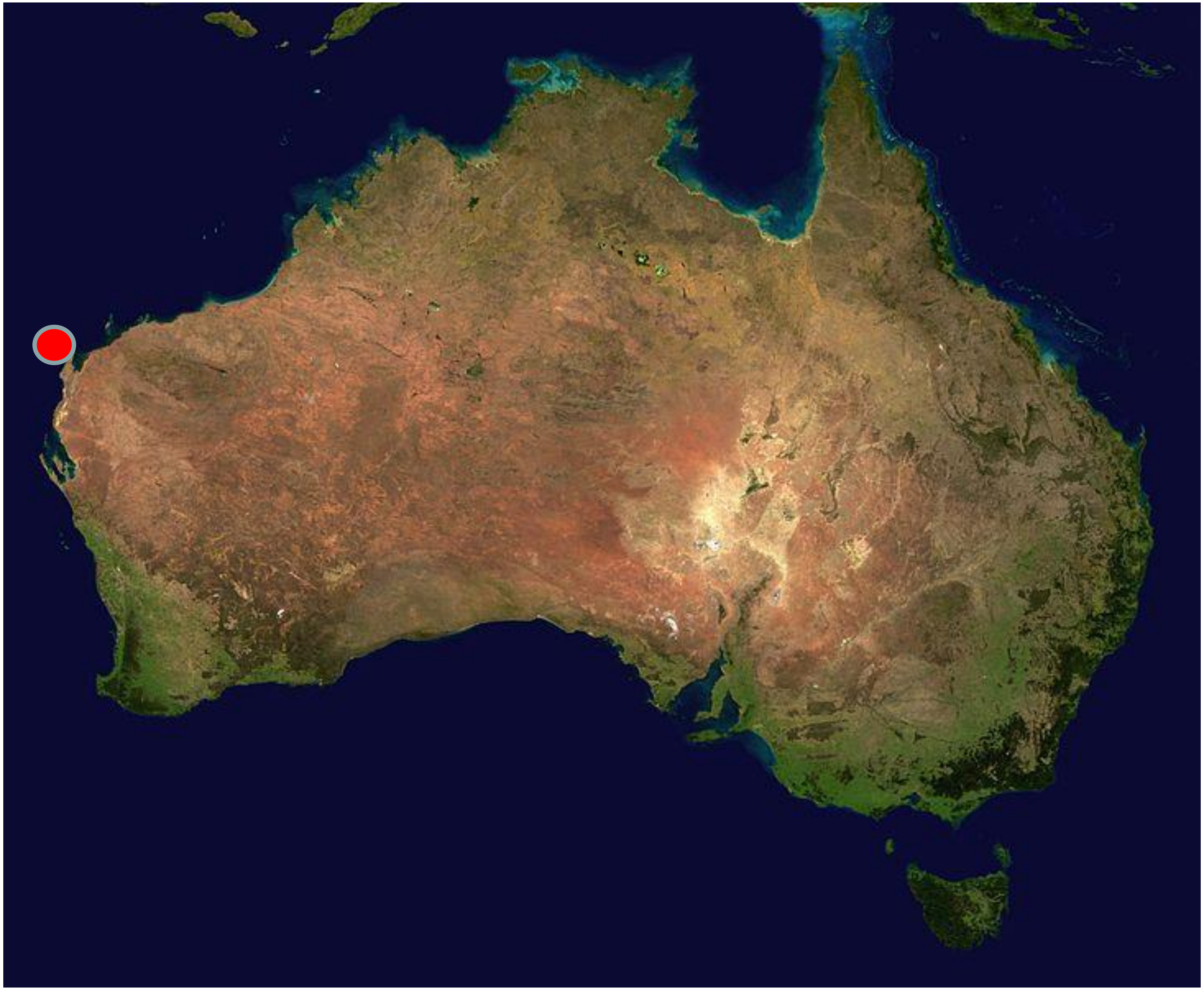
Geological setting



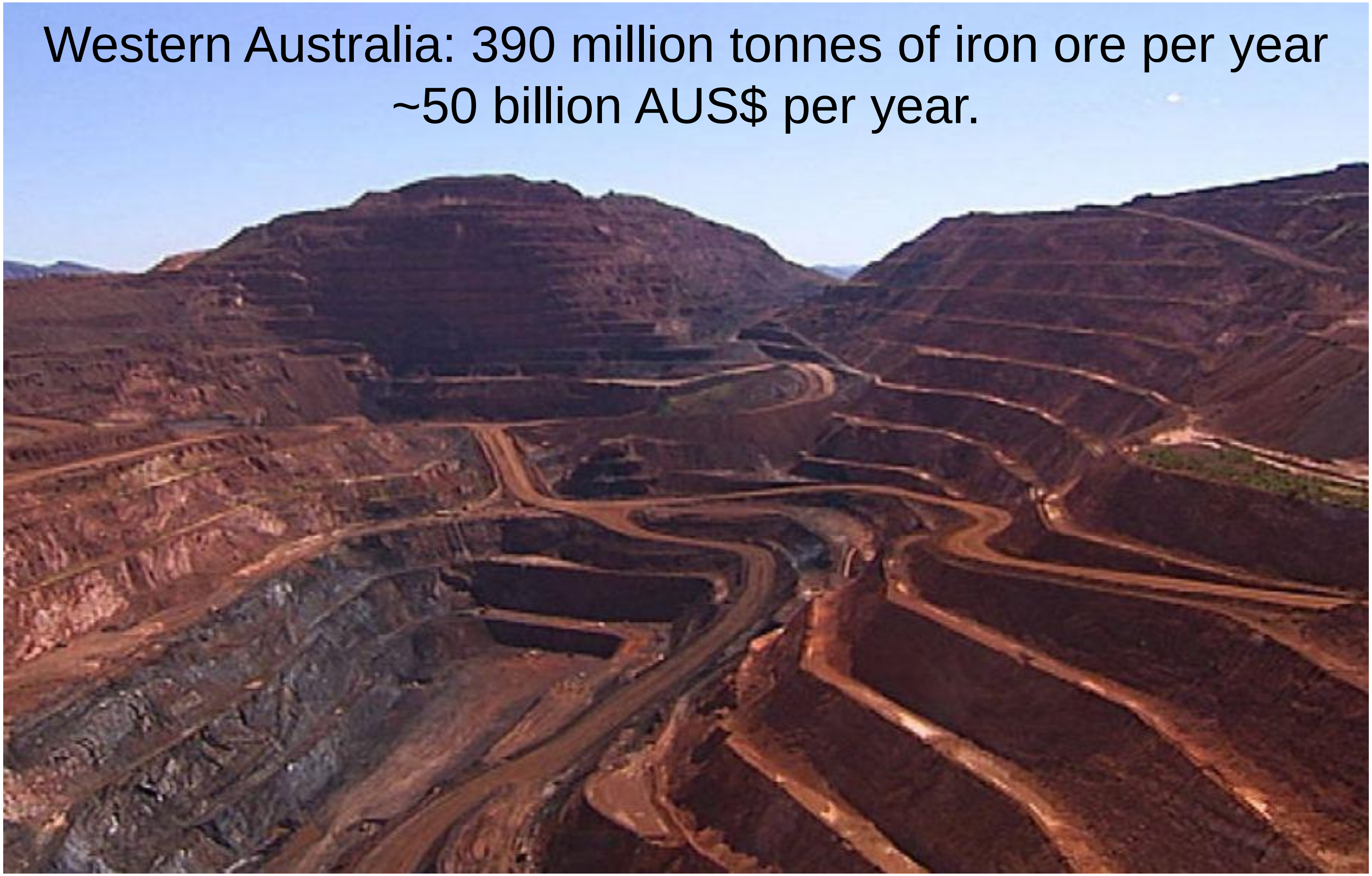
Geological setting



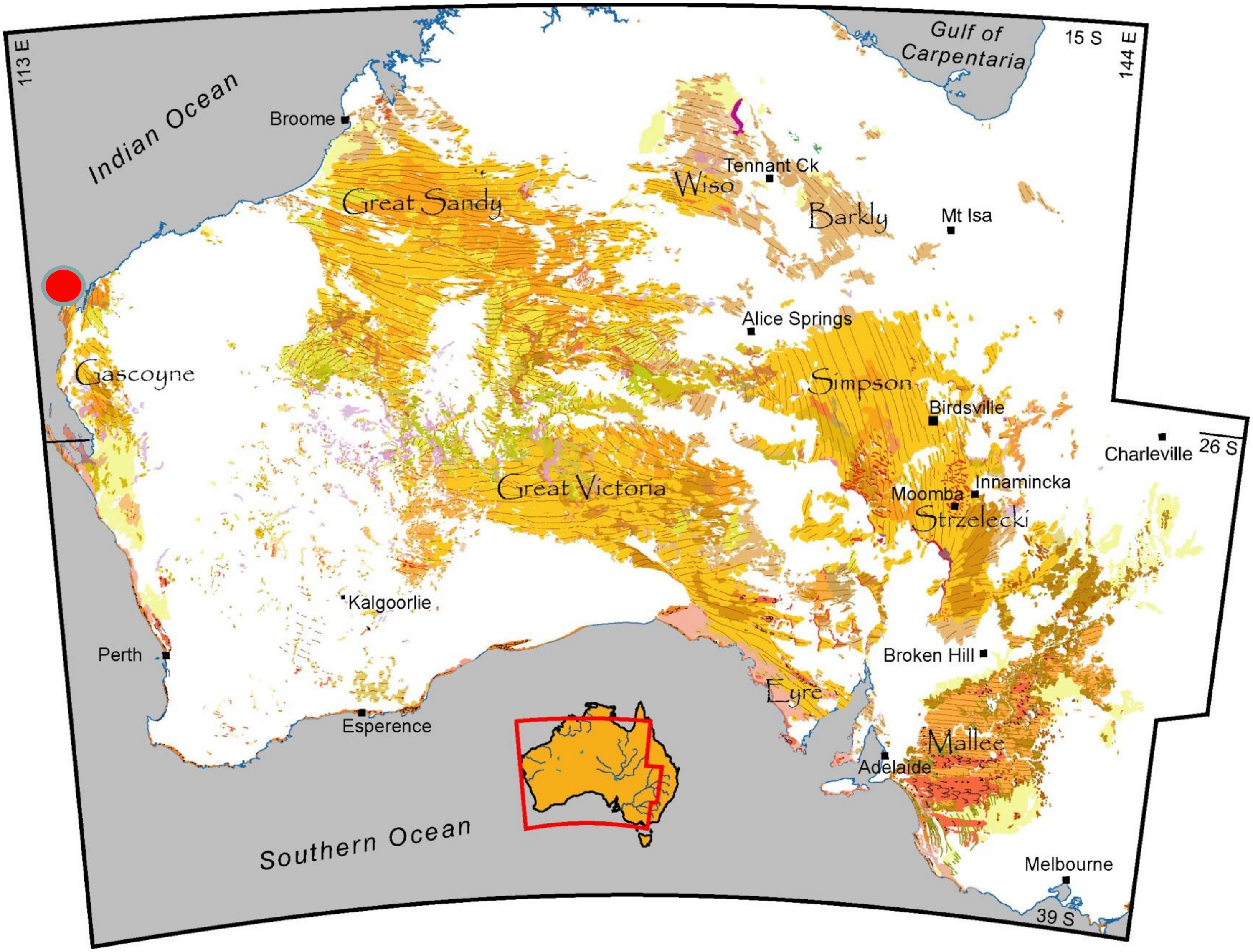
Geological setting



Geological setting



Geological setting

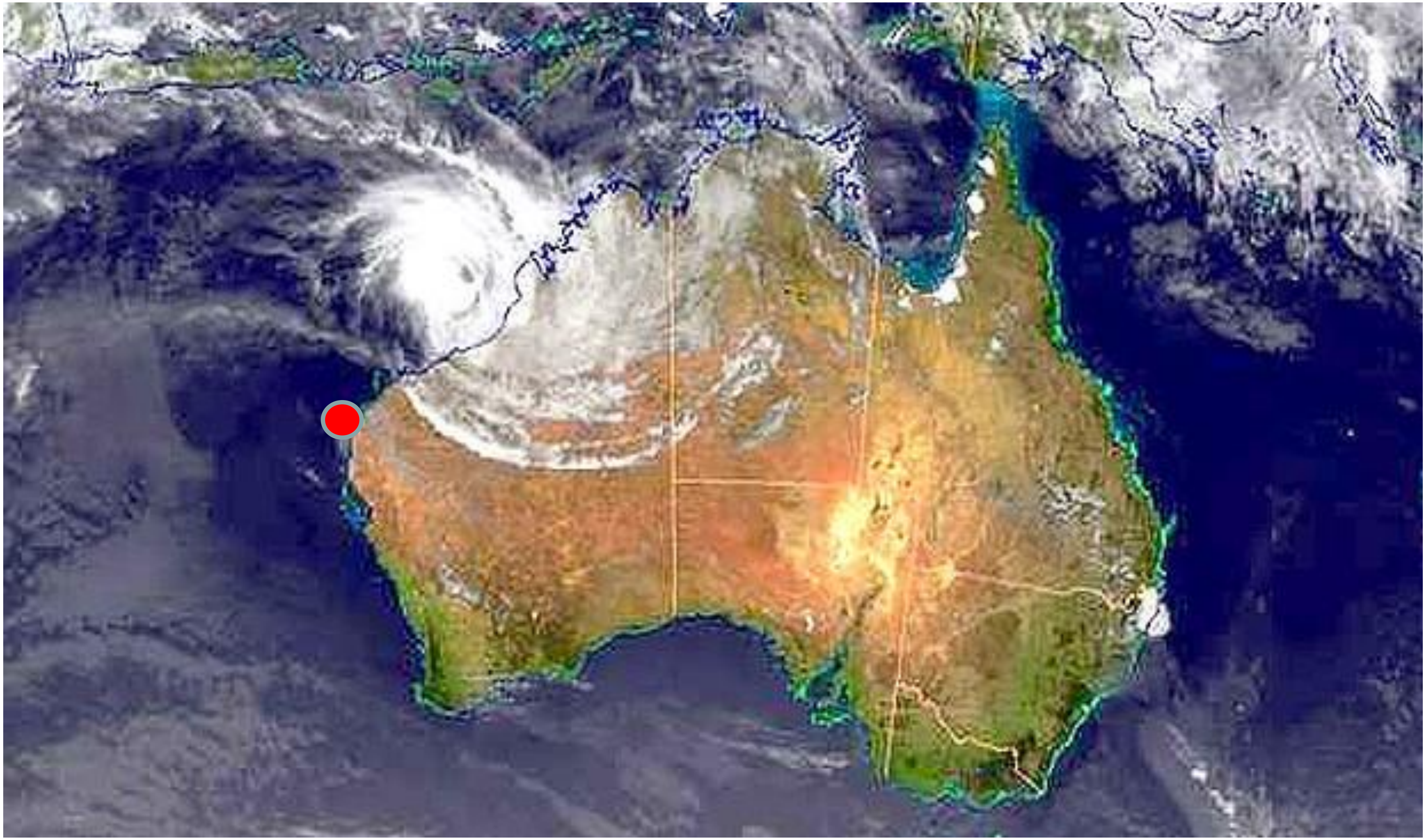


Hesse (2010), Geological Society, London, Special Publications.

Geological setting

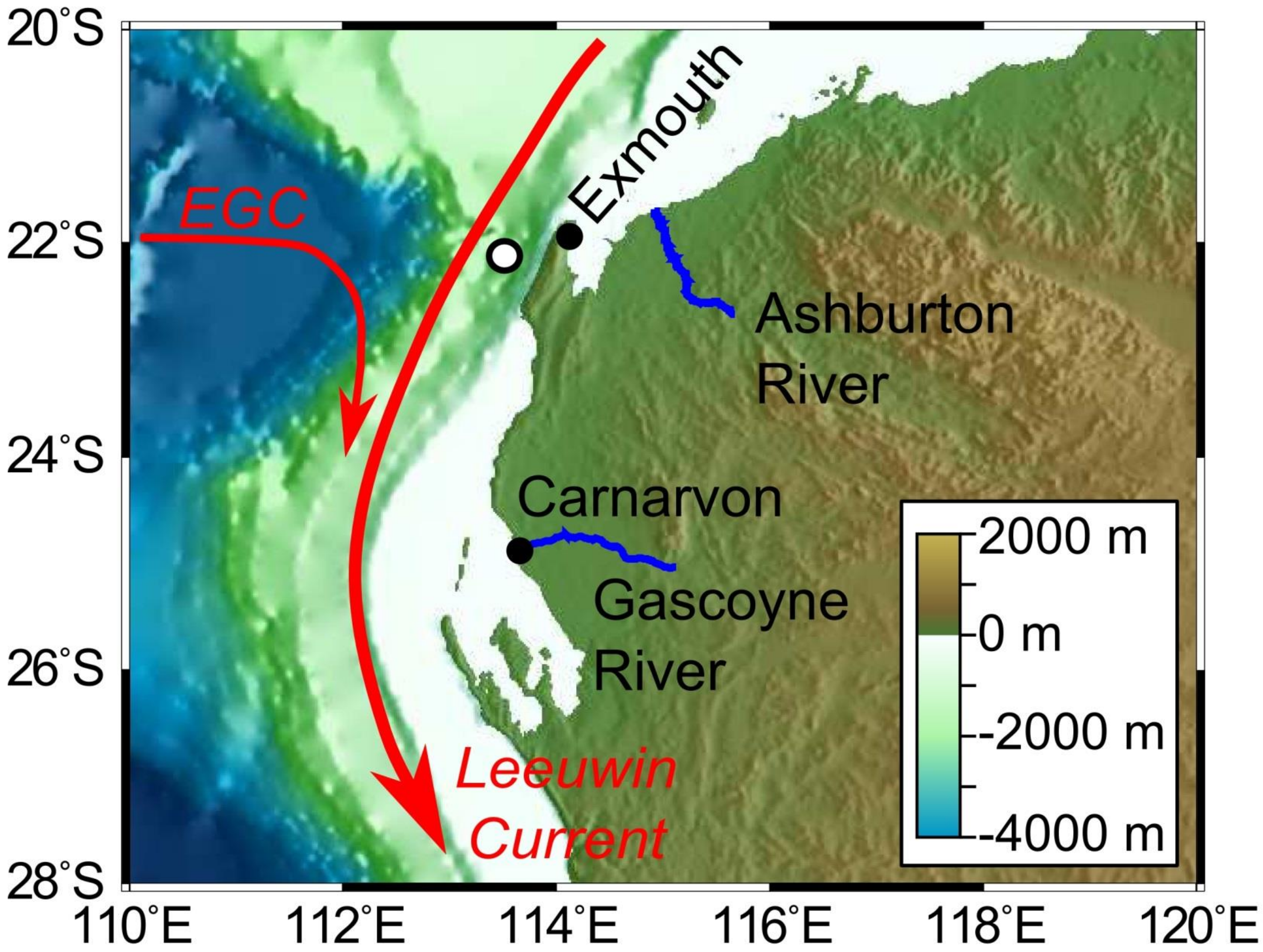
Geological setting

Tropical Cyclones also transport moisture southwards from the WPWP



Geological setting

Geological setting

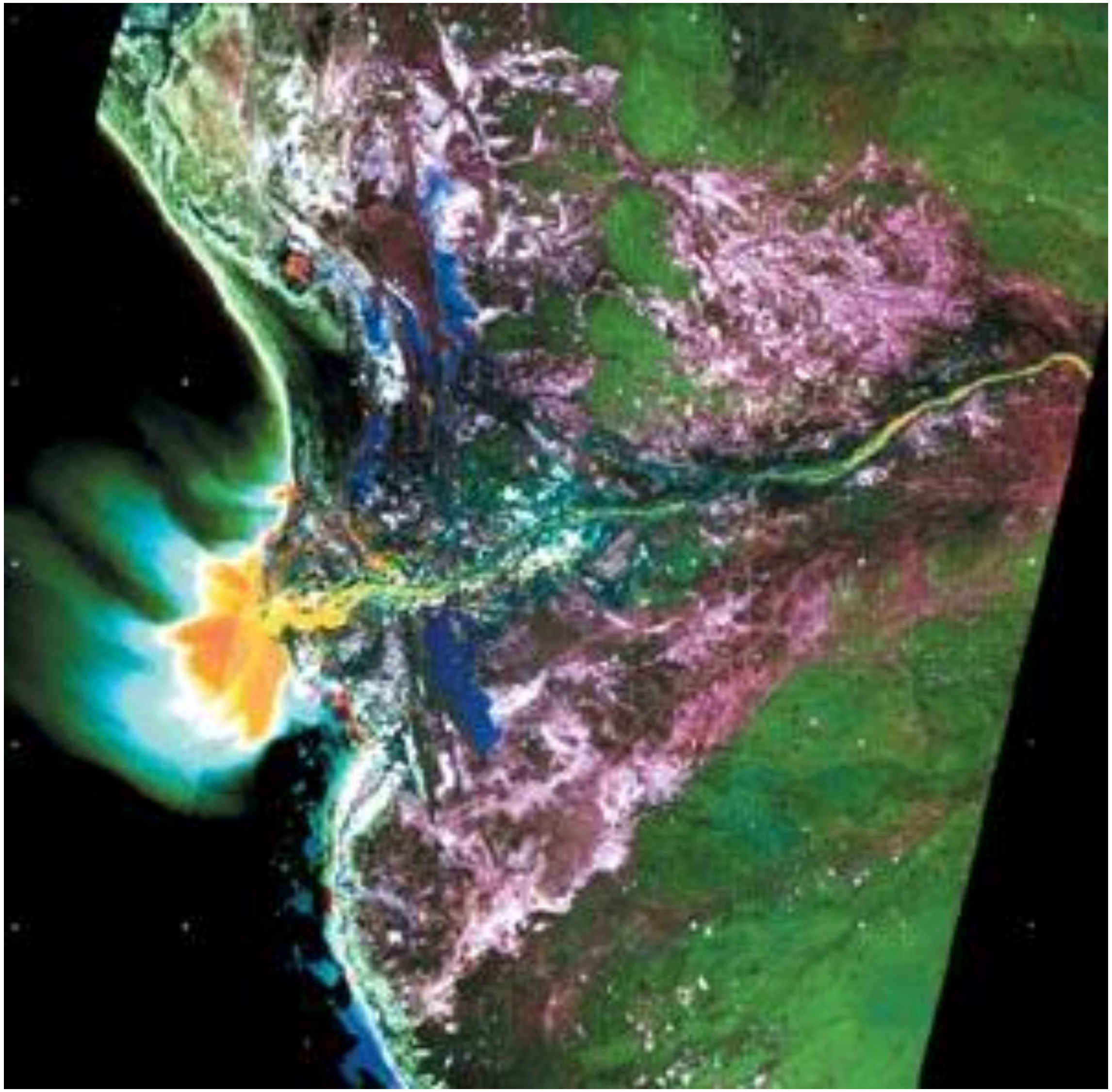


Geological setting

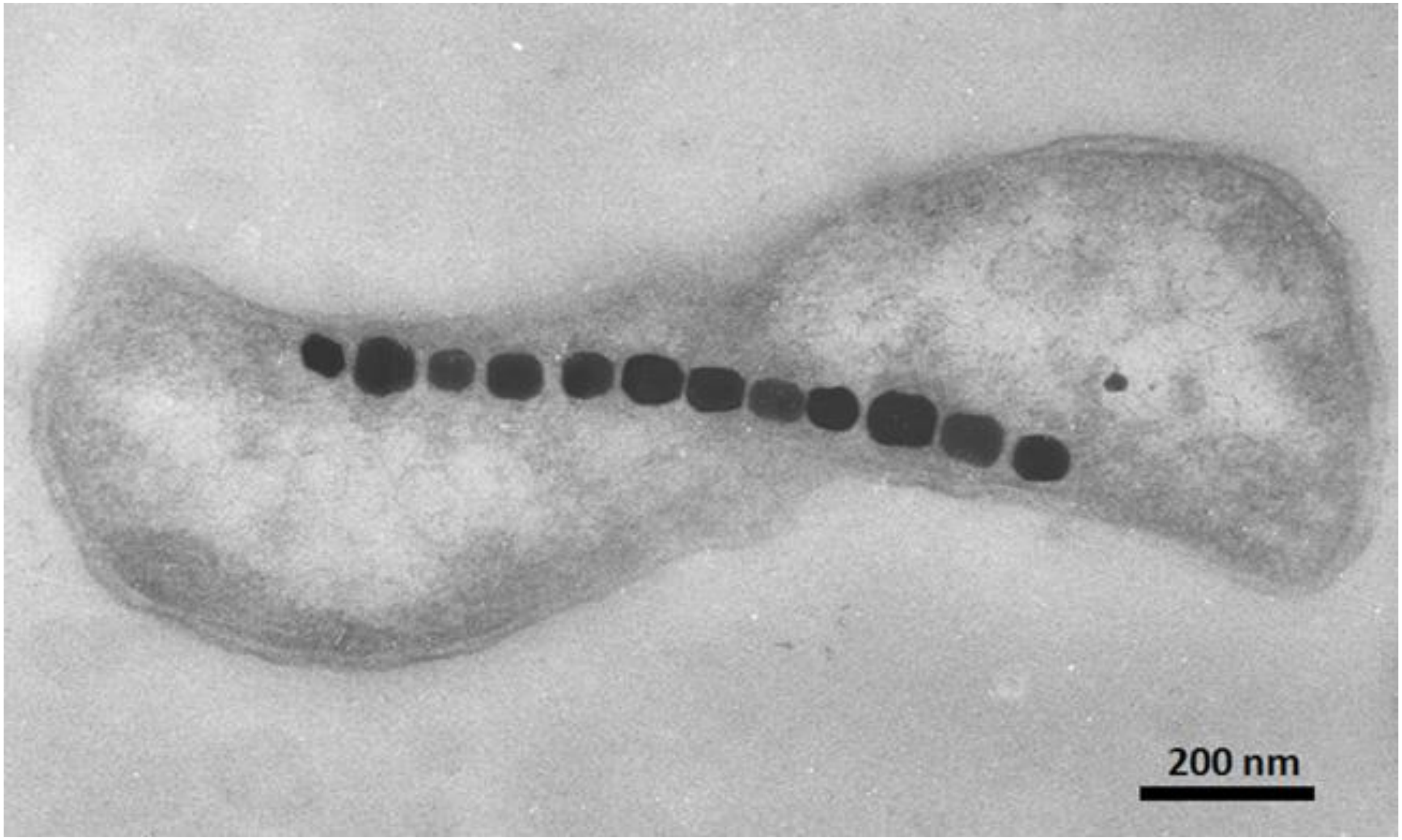
Massive flood plumes carry iron-rich sediments.

Ashburton River - southward flowing Leeuwin Current.

Gascoyne River - northward flowing Ningaloo Current.

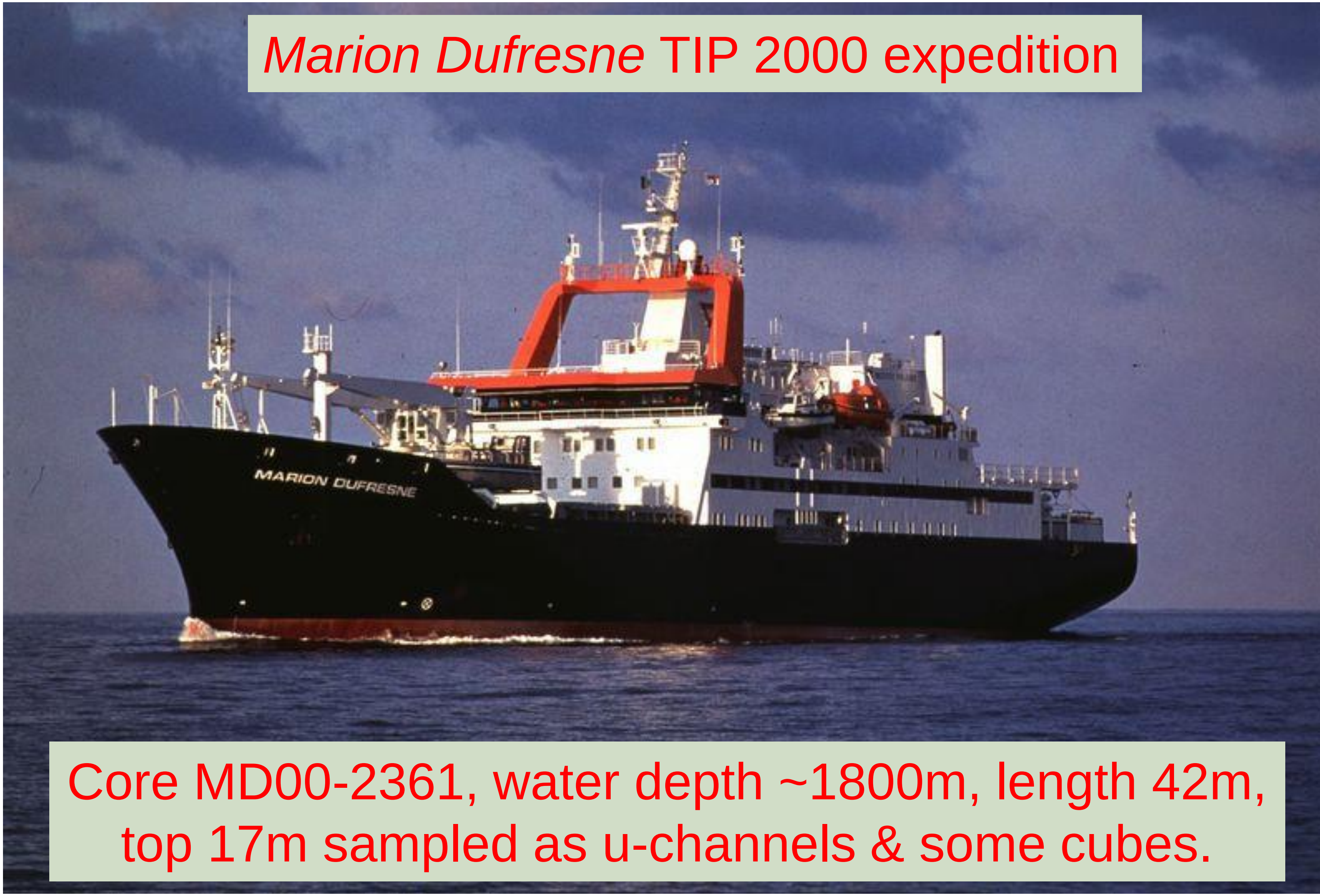


The magnetic mineral assemblage is not limited to aeolian & riverine particles



Sampling

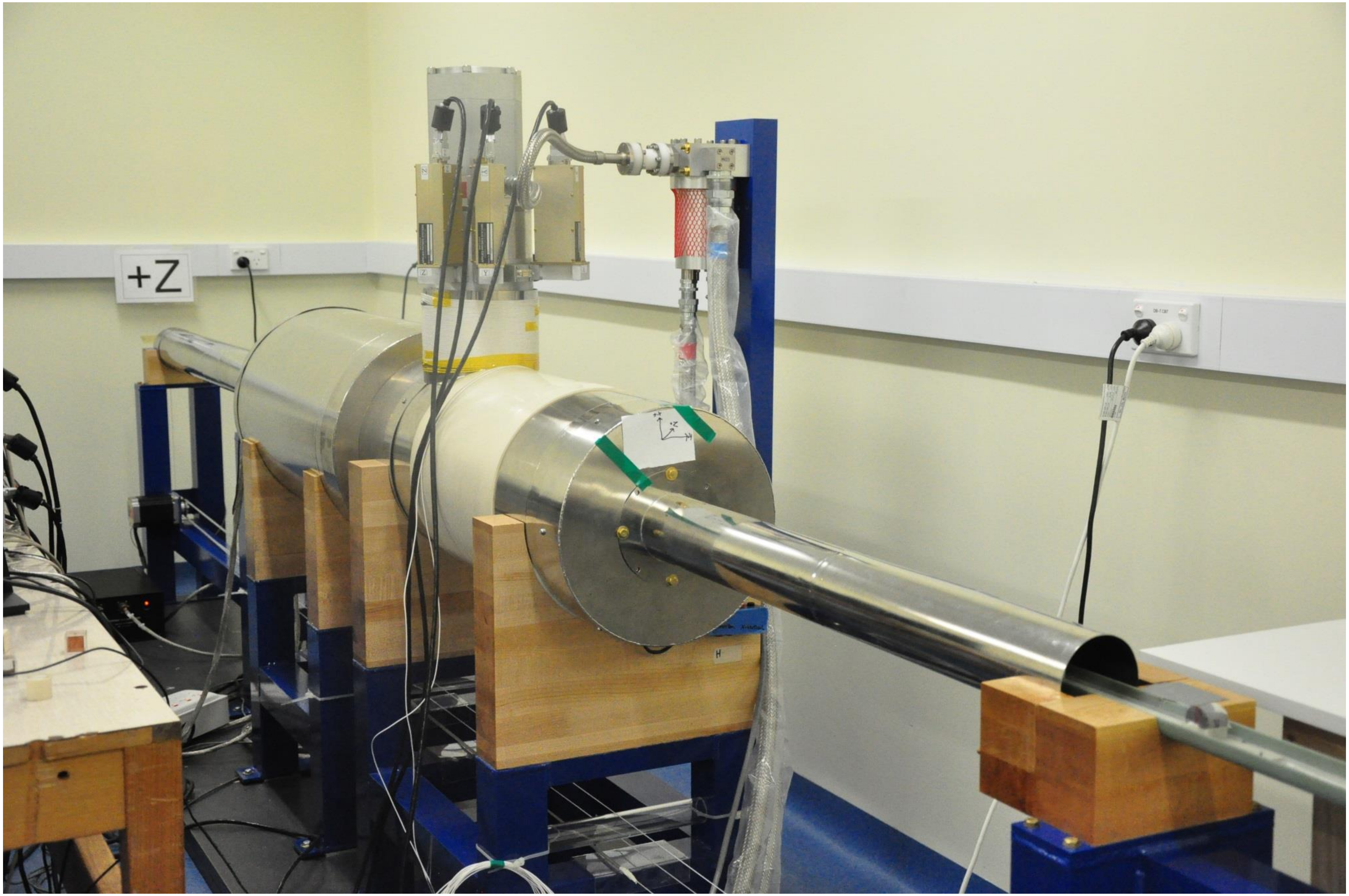
Marion Dufresne TIP 2000 expedition



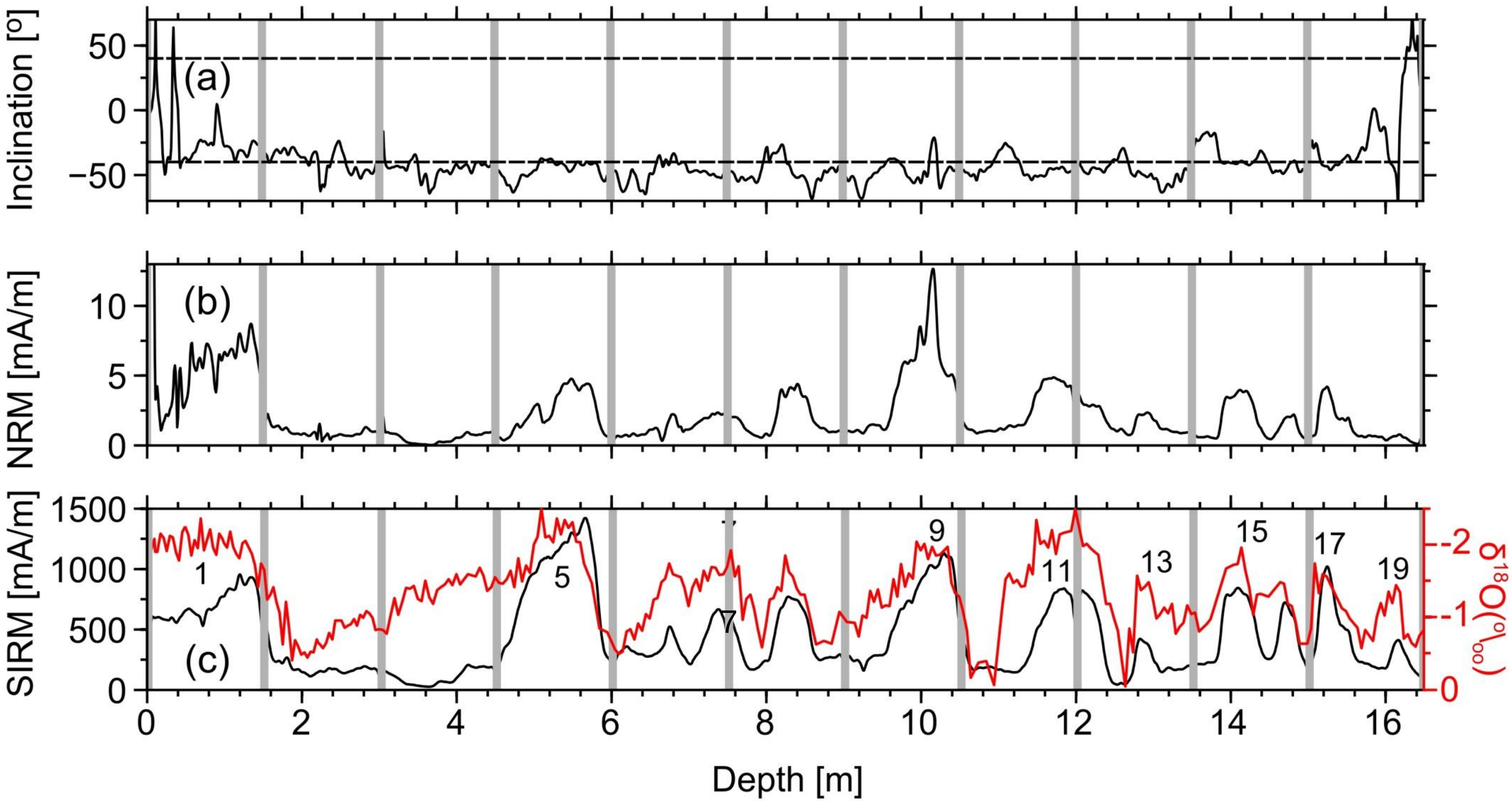
Core MD00-2361, water depth ~1800m, length 42m, top 17m sampled as u-channels & some cubes.

Black Mountain Palaeomagnetism Laboratory (established 1964)

Results



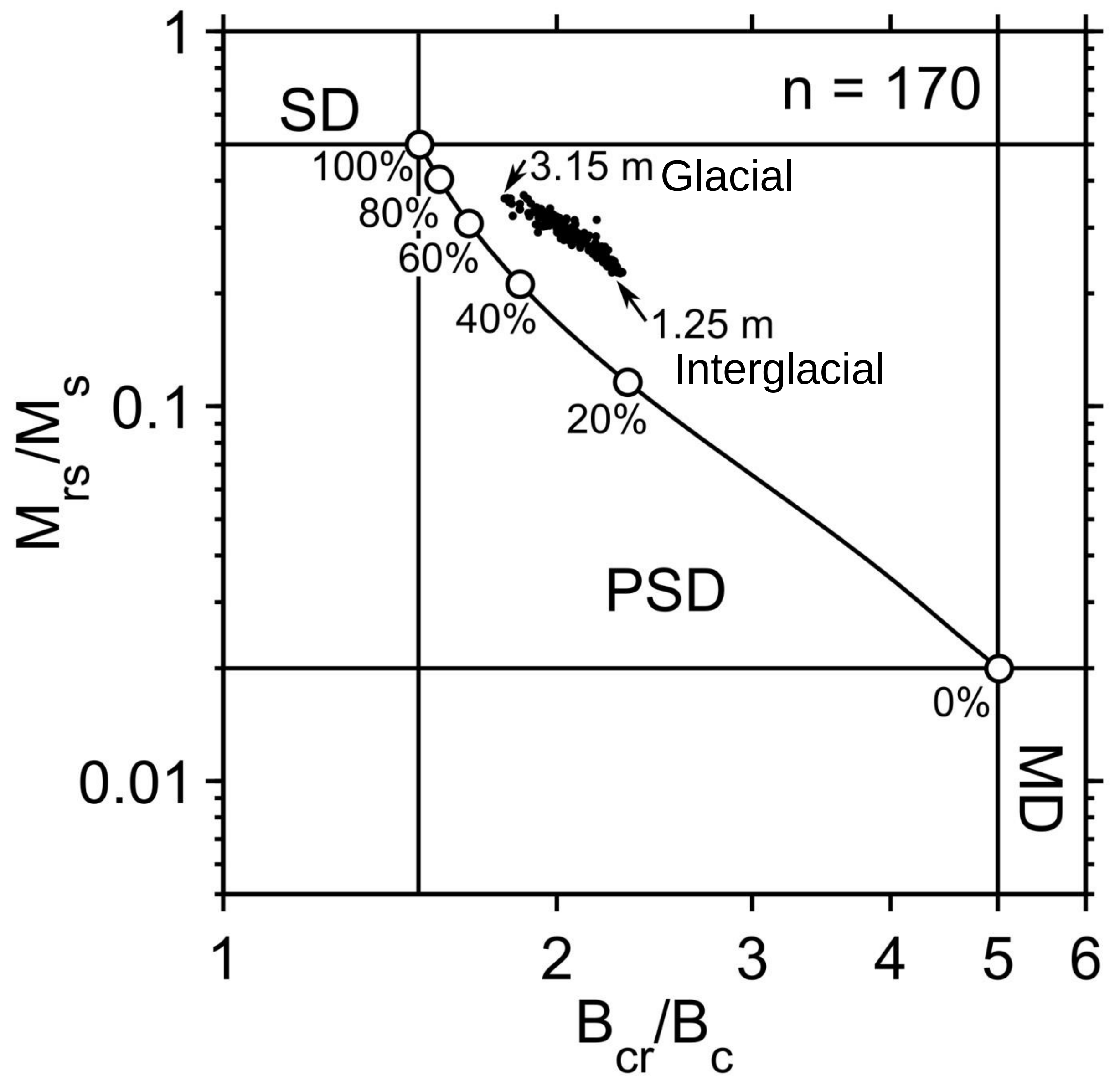
Results



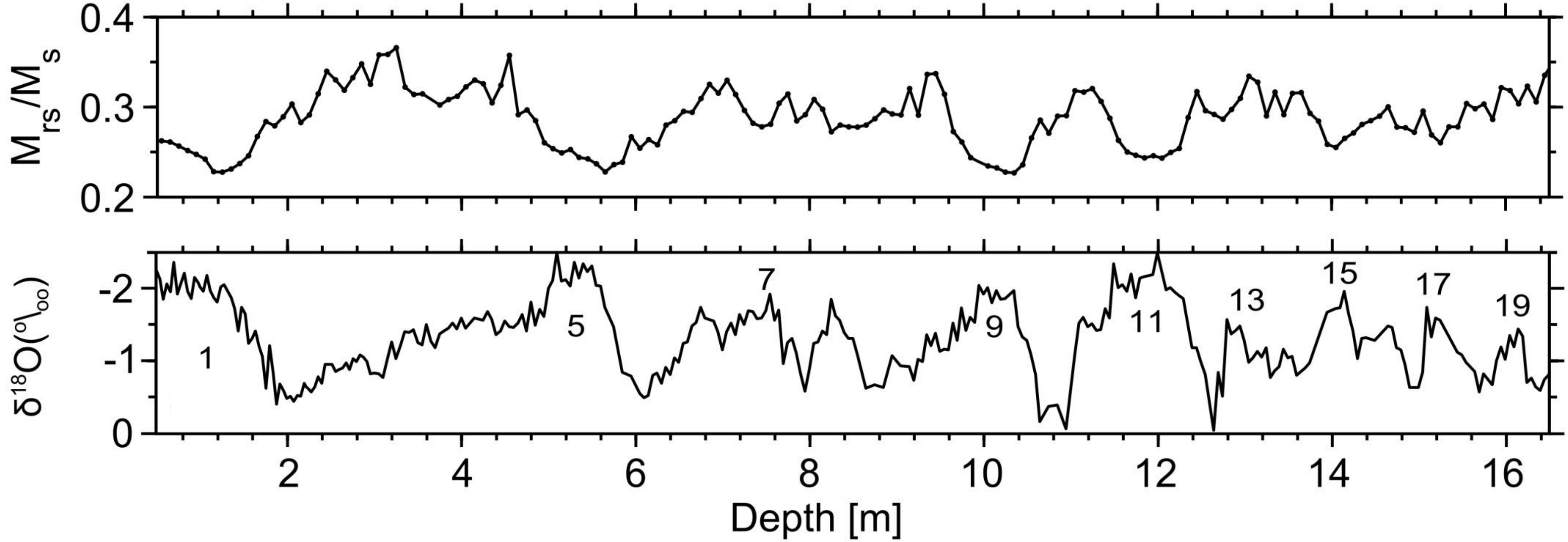
Glacials → magnetically weak

Interglacial → magnetically strong

Results


1
0.1
0.01
M_{rs}/M_s
n = 170
SD
100%
80%
60%
40%
20%
0%
3.15 m Glacial
1.25 m
Interglacial
PSD
MD
1
2
3
4
5
6
B_{cr}/B_c

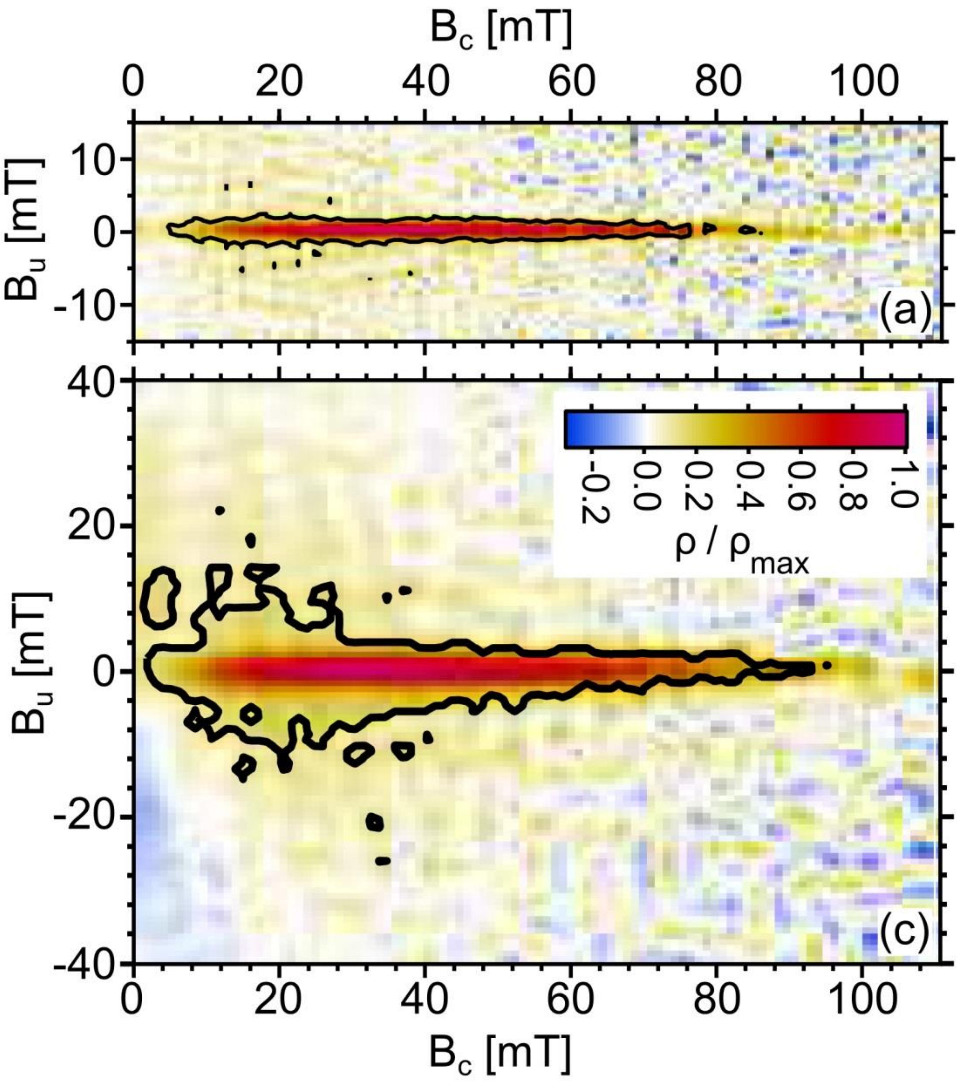
Results



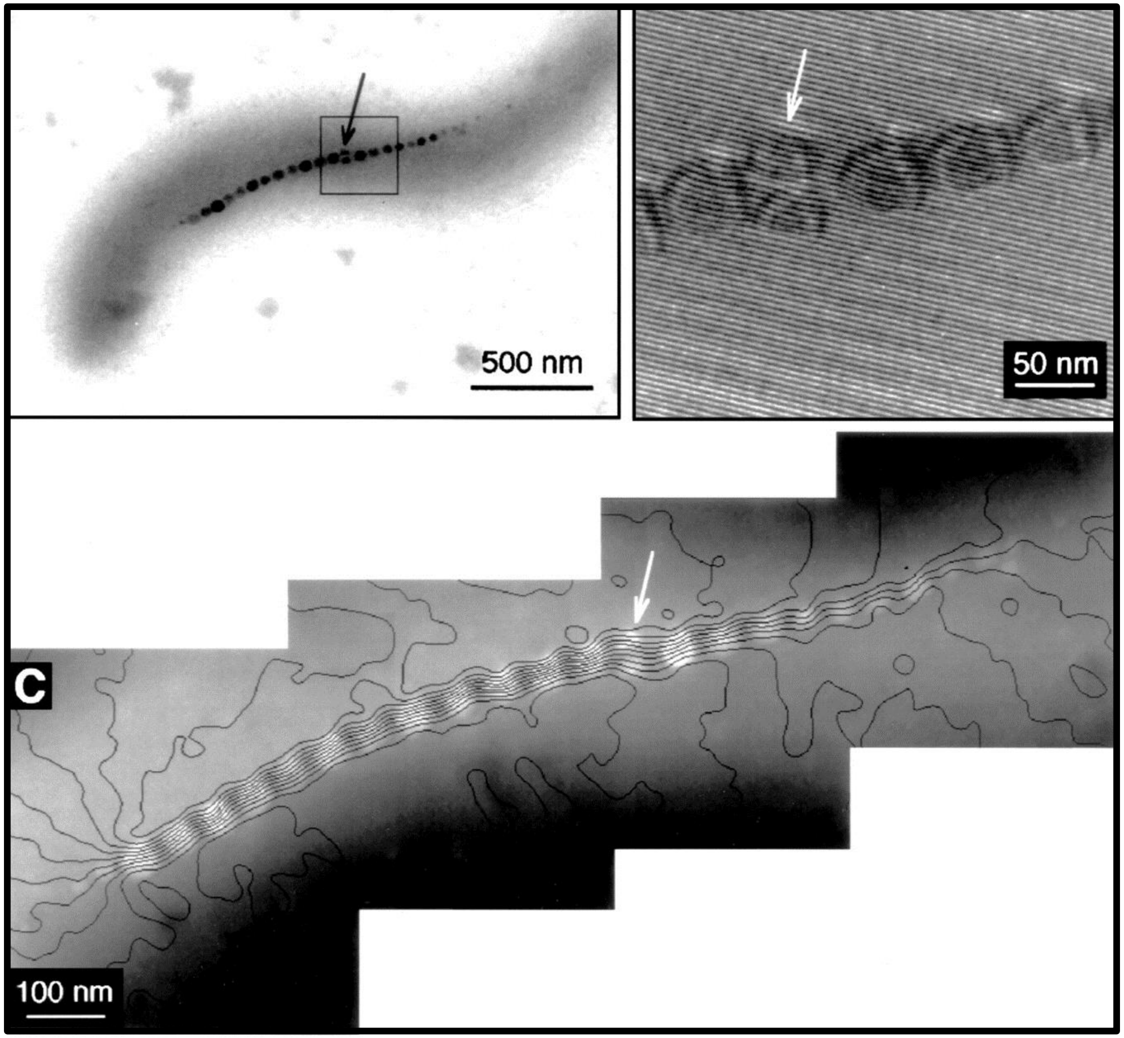
Glacials → Magnetically weak, finer grained

Interglacials → Magnetically strong, coarser grained

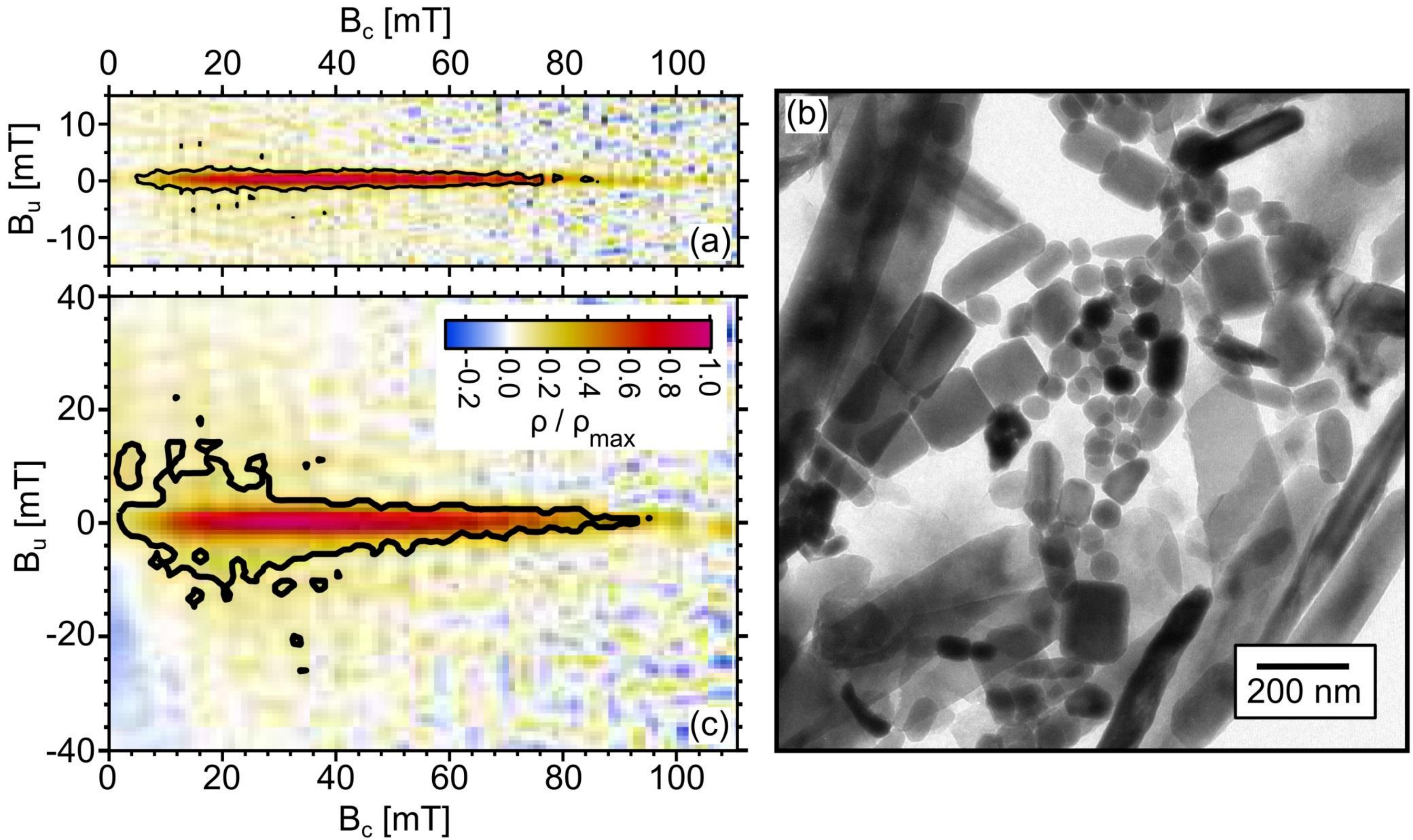
Glacial sediment (3.15 m)



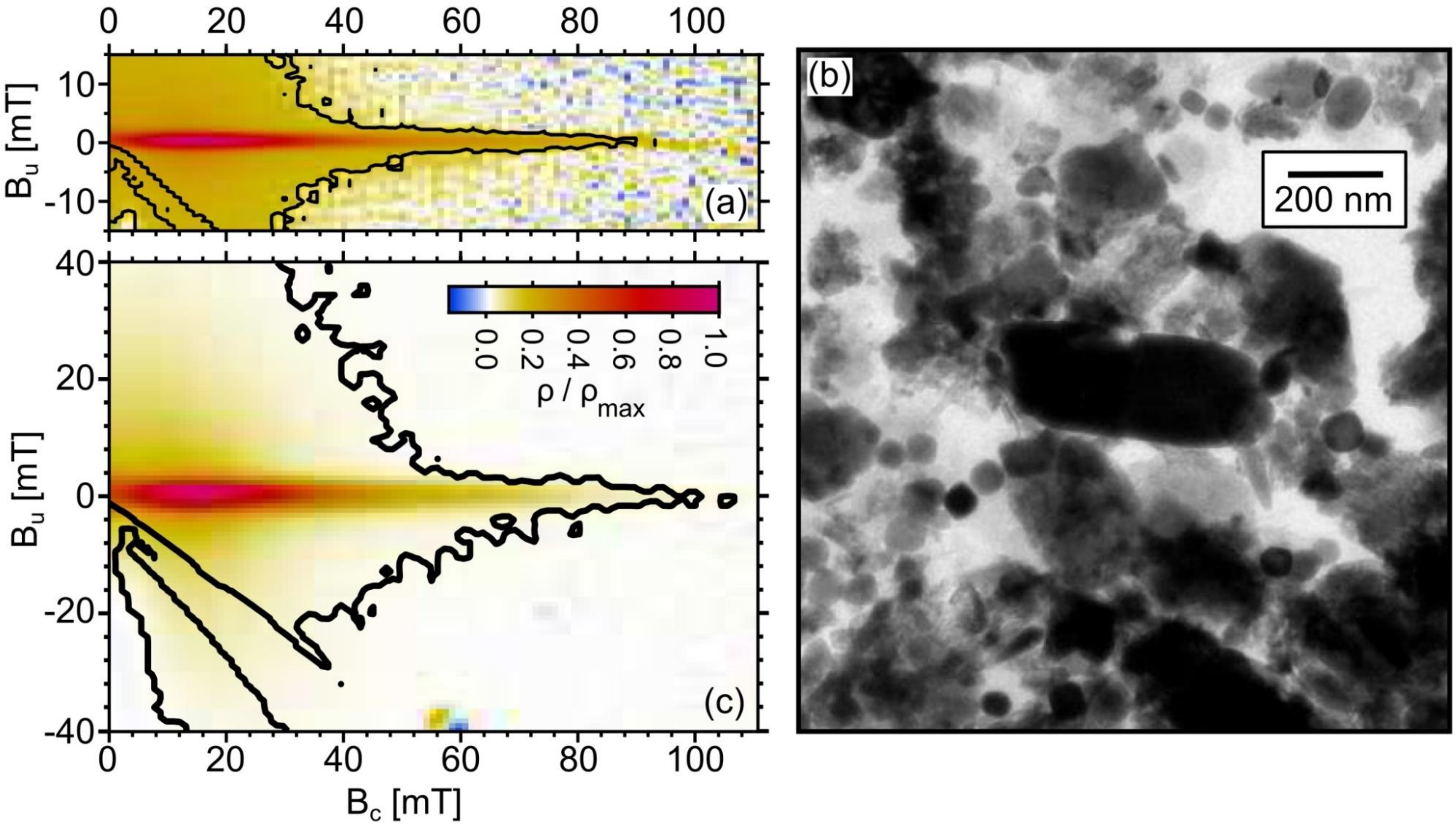
Magnetic Microstructure of Magnetotactic Bacteria by Electron Holography
Dunin-Borkowski *et al.* Science 1998.



Glacial sediment (3.15 m)

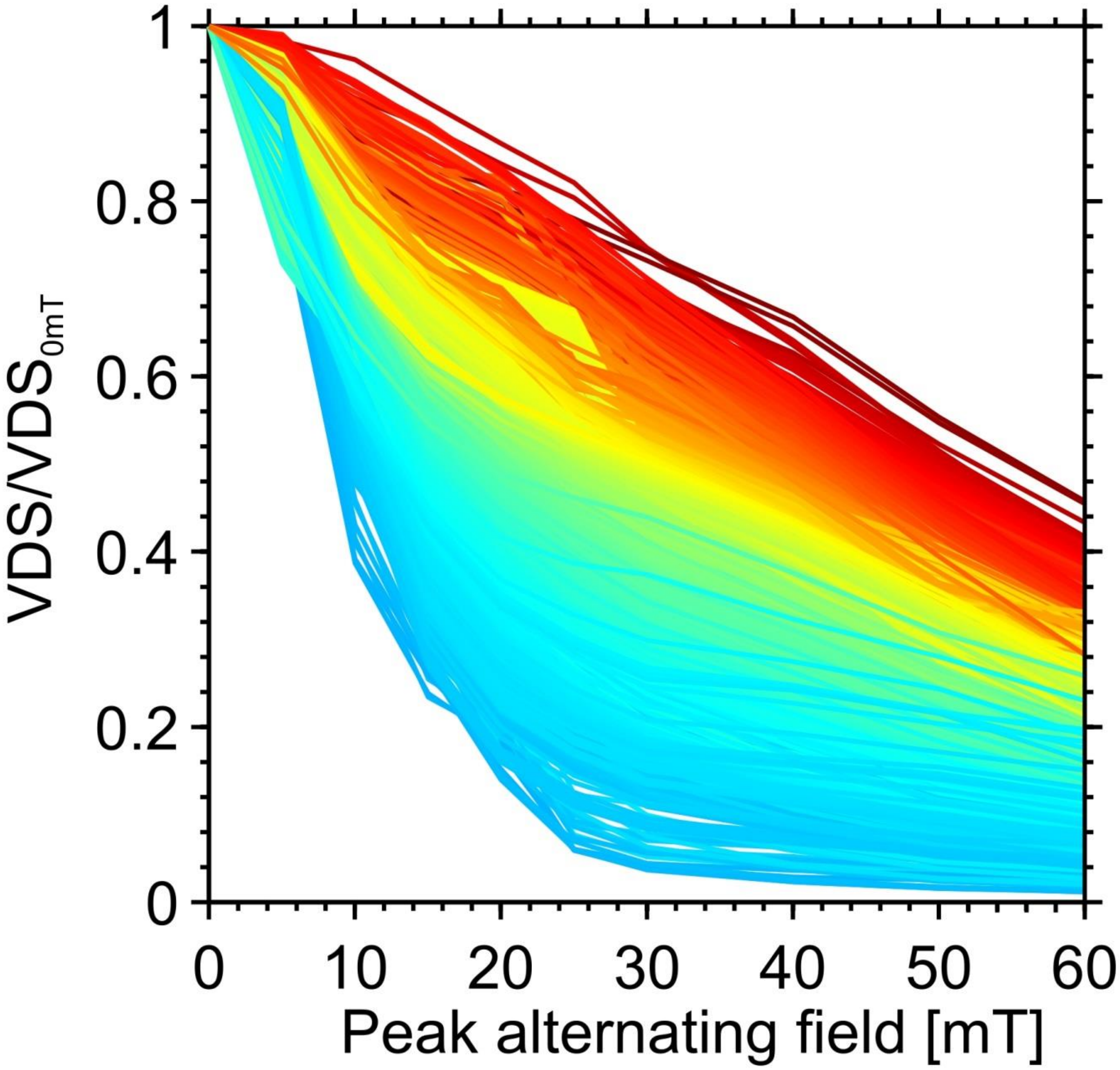


Interglacial sediment (1.25 m)



Glacials → Magnetically weak, magnetofossil dominated
Interglacials → Magnetically strong, detrital dominated

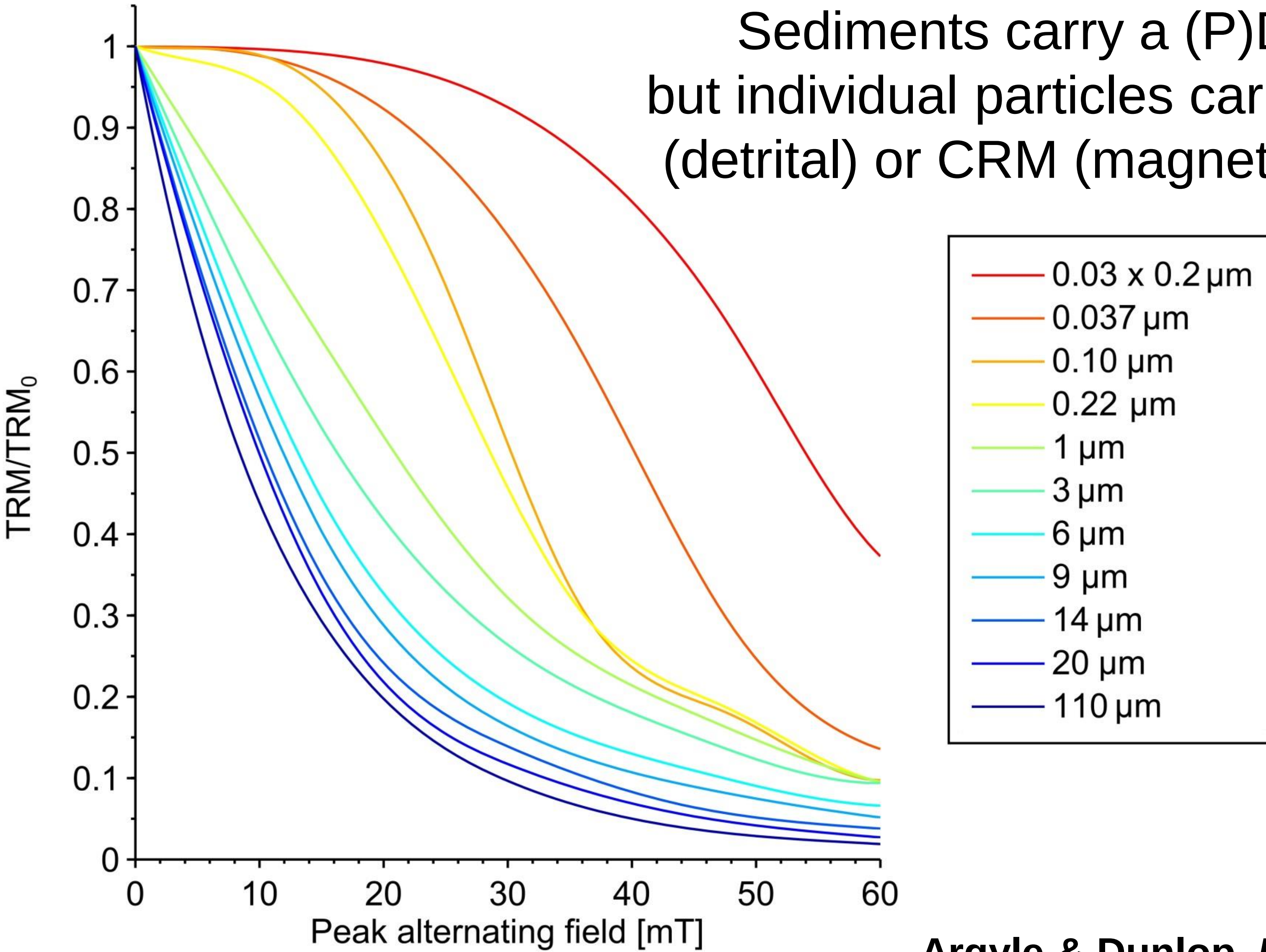
Results



NRM demagnetization spectra exhibit a wide distributions of shapes.

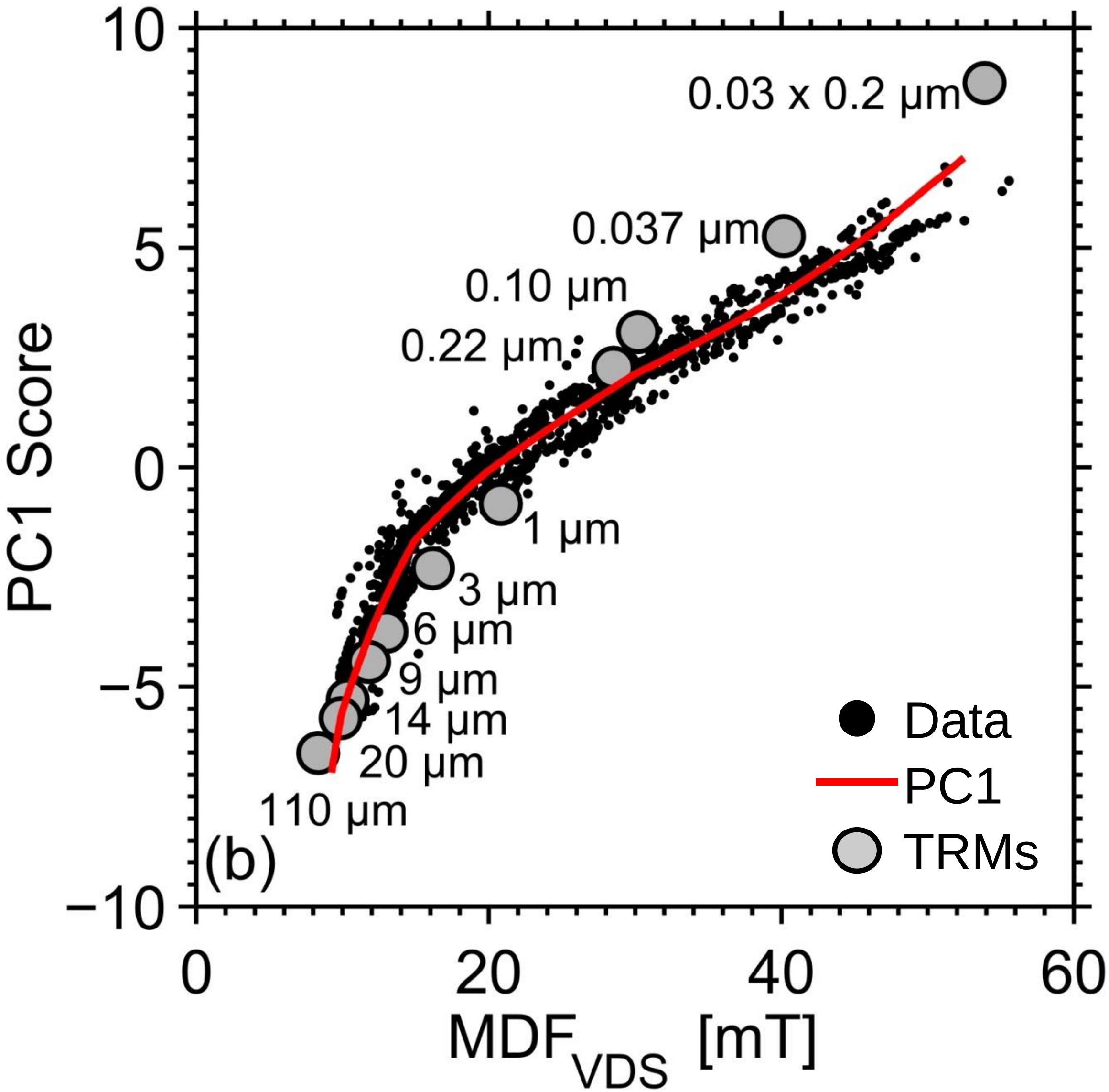
Results

Sediments carry a (P)DRM,
but individual particles carry a TRM
(detrital) or CRM (magnetofossils)



Argyle & Dunlop, *EOS*, (1994)

Results



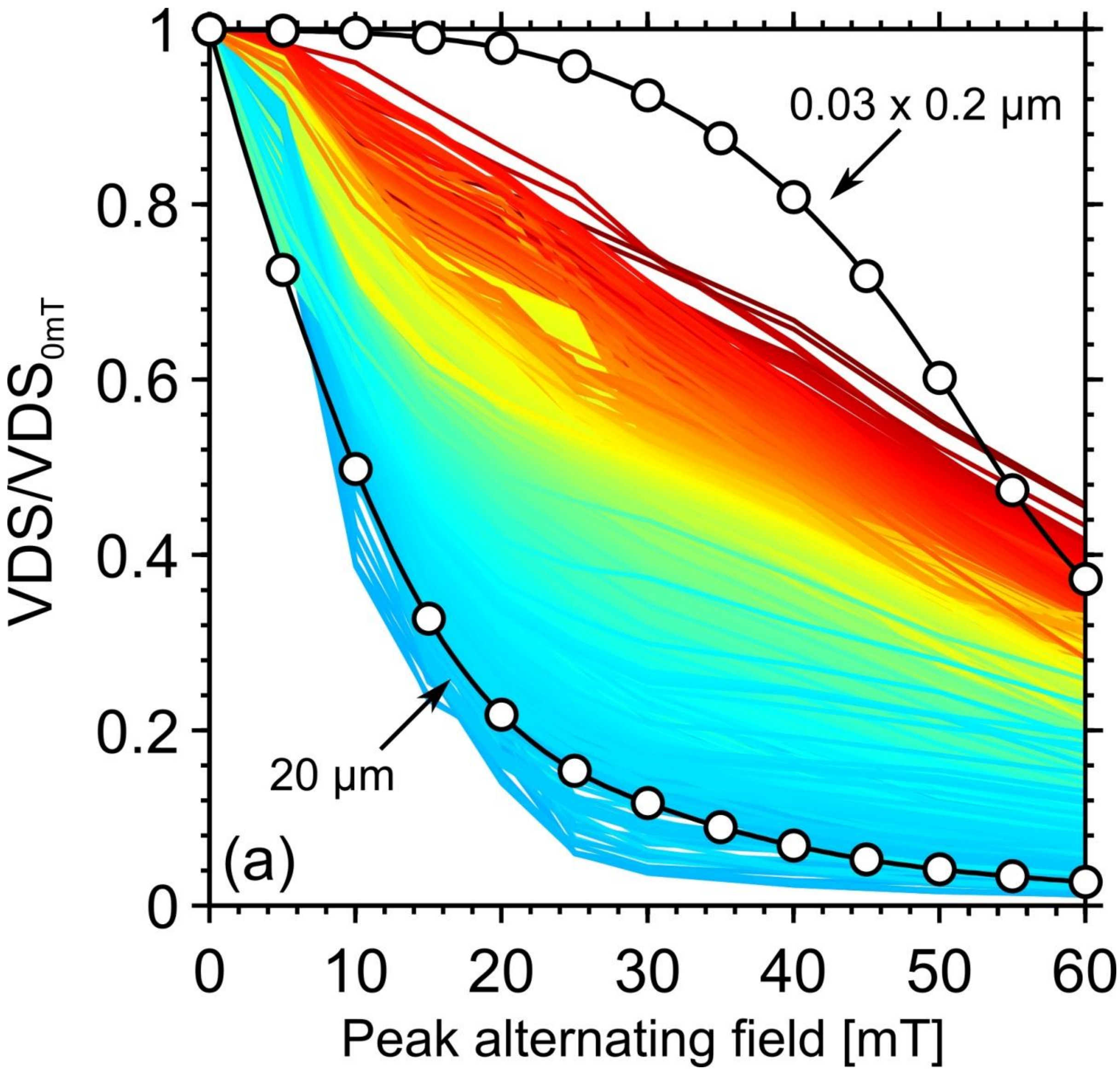
PCA

~90% of the VDS/VDS$_0$ variability is explained by the leading PC.

We interpret this to imply a 2 component mixture.

Select 2 end-members:
0.03 x 0.2 µm (biogenic)
20 µm (detrital)

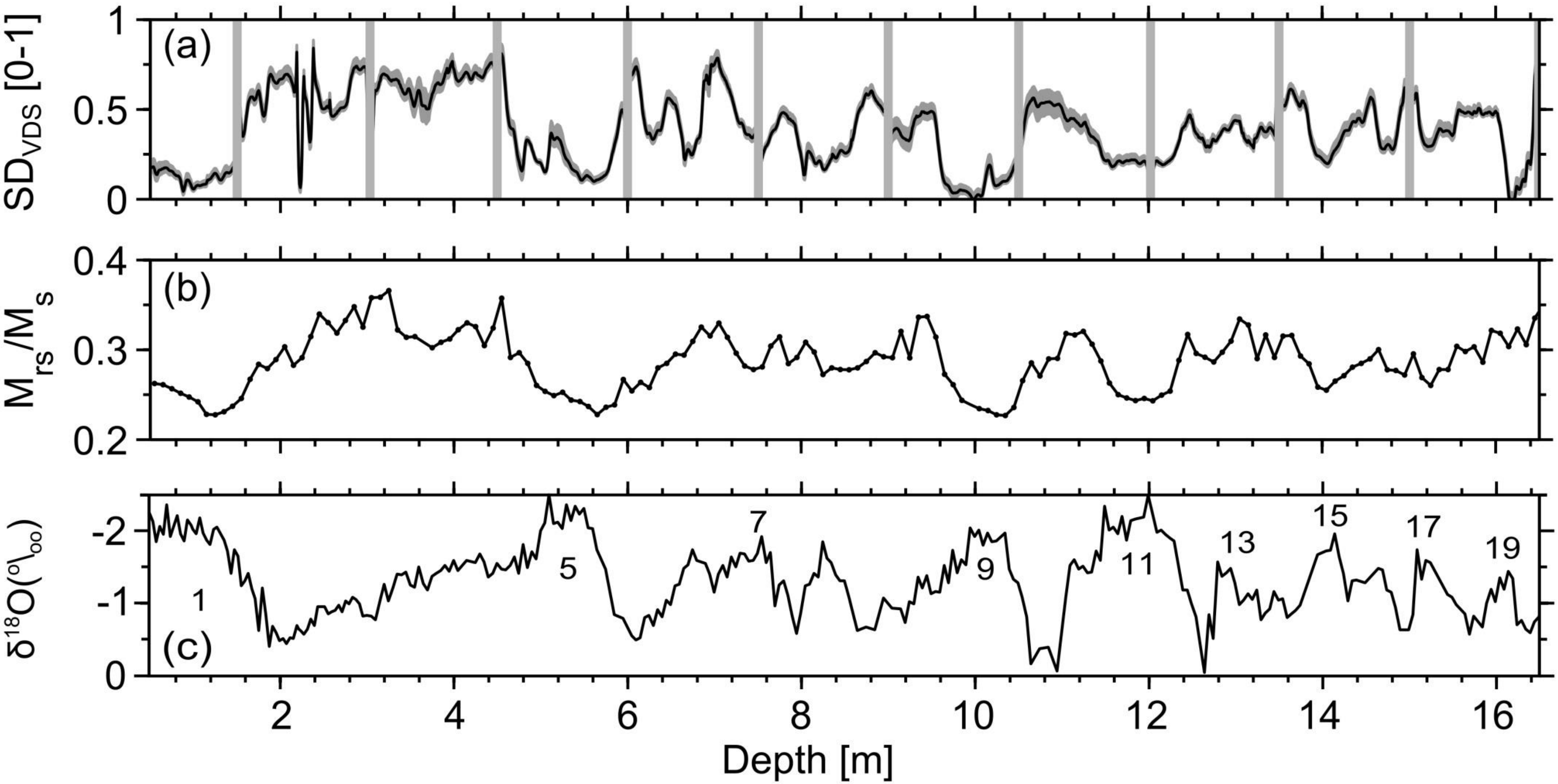
Results



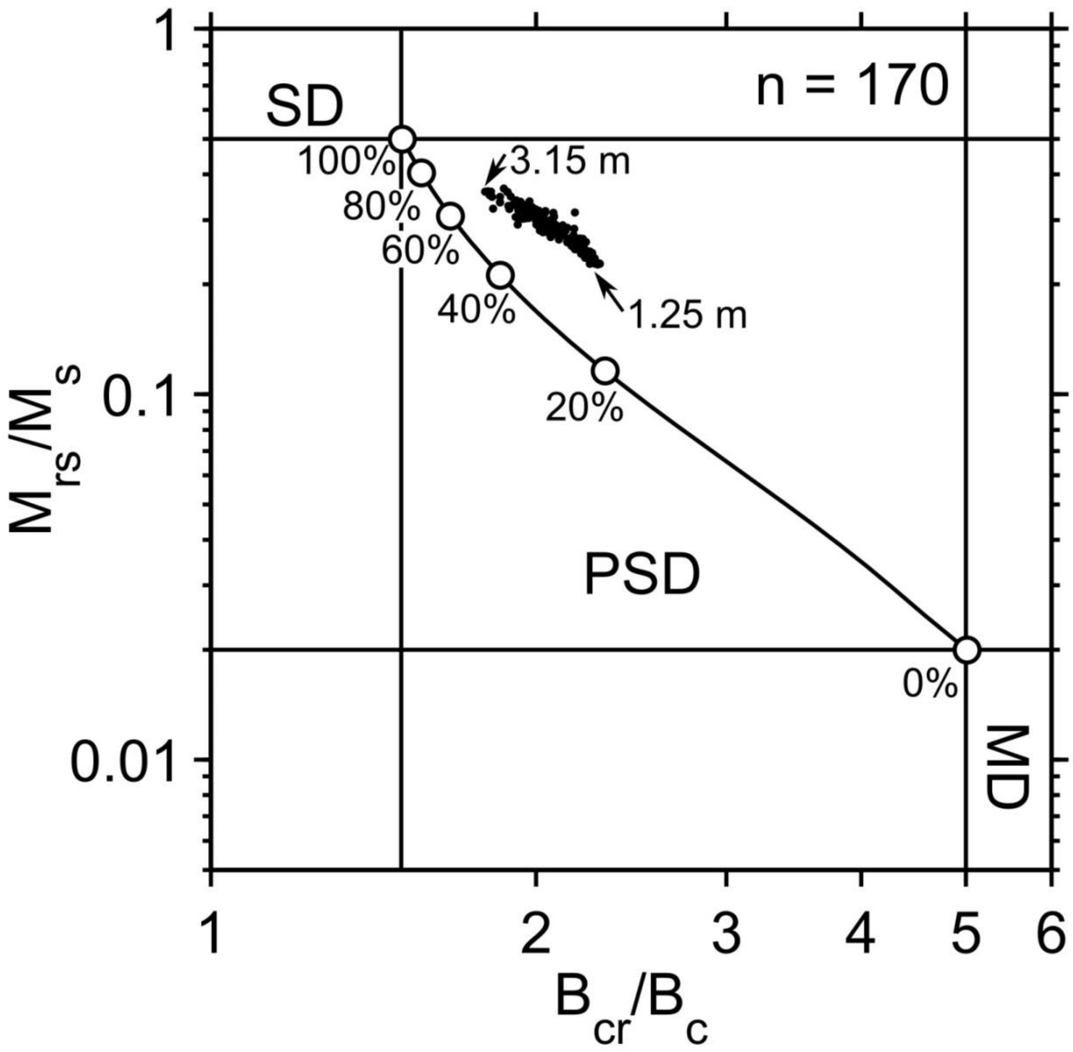
Apply constrained least-squares to determine the proportions in which the *0.03 x 0.2 µm* (biogenic) and *20 µm* (detrital) end-members need to be mixed together to fit the measured VDS/VDS_0 curve for each depth.

Interpretation

The biogenic contribution to the NRM is high (60-80%) during glacials and low (~10%) in interglacials.



Are we seeing a true BRM or a magnetofossil PDRM?



Don't have enough information, but the relative NRM contribution is close to the relative SD composition.

This implies biogenic and detrital components are acquiring NRMs with similar efficiencies.

Conclusions

- Under suitable preservation conditions, magnetofossils can make the dominant contribution to sedimentary NRMs.

- We don’t have enough evidence to demonstrate a BRM, but to a first-order, magnetofossil and detrital NRM formation efficiencies appear to be similar.