UNIVERSITÀ DEGLI STUDI DI PADOVA

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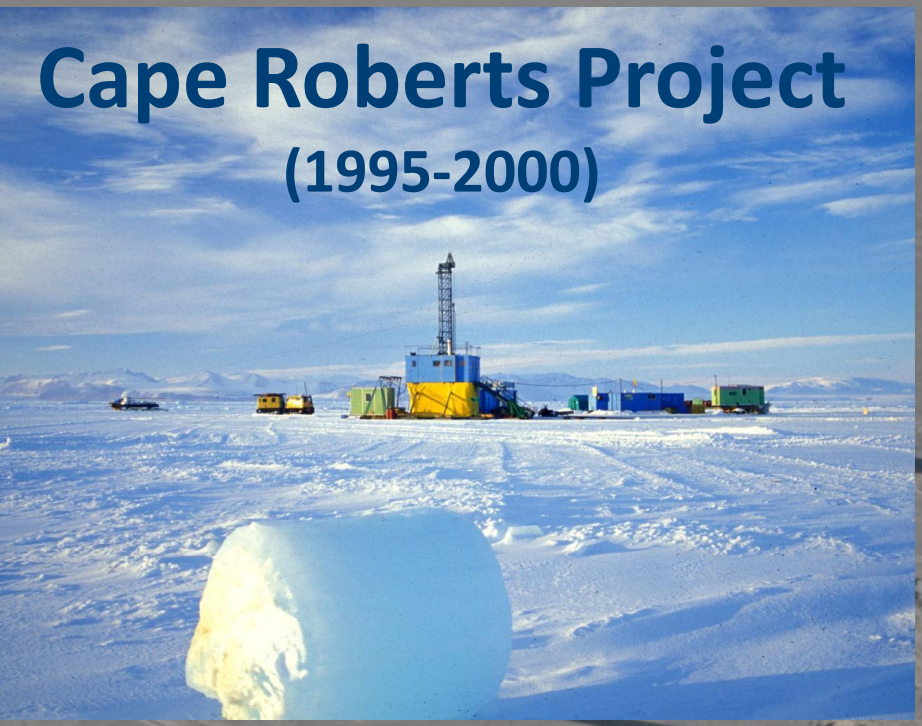
PROGRAMMA NAZIONALE DI RICERCHE IN ANTARTIDE
ITALIANTARTIDE

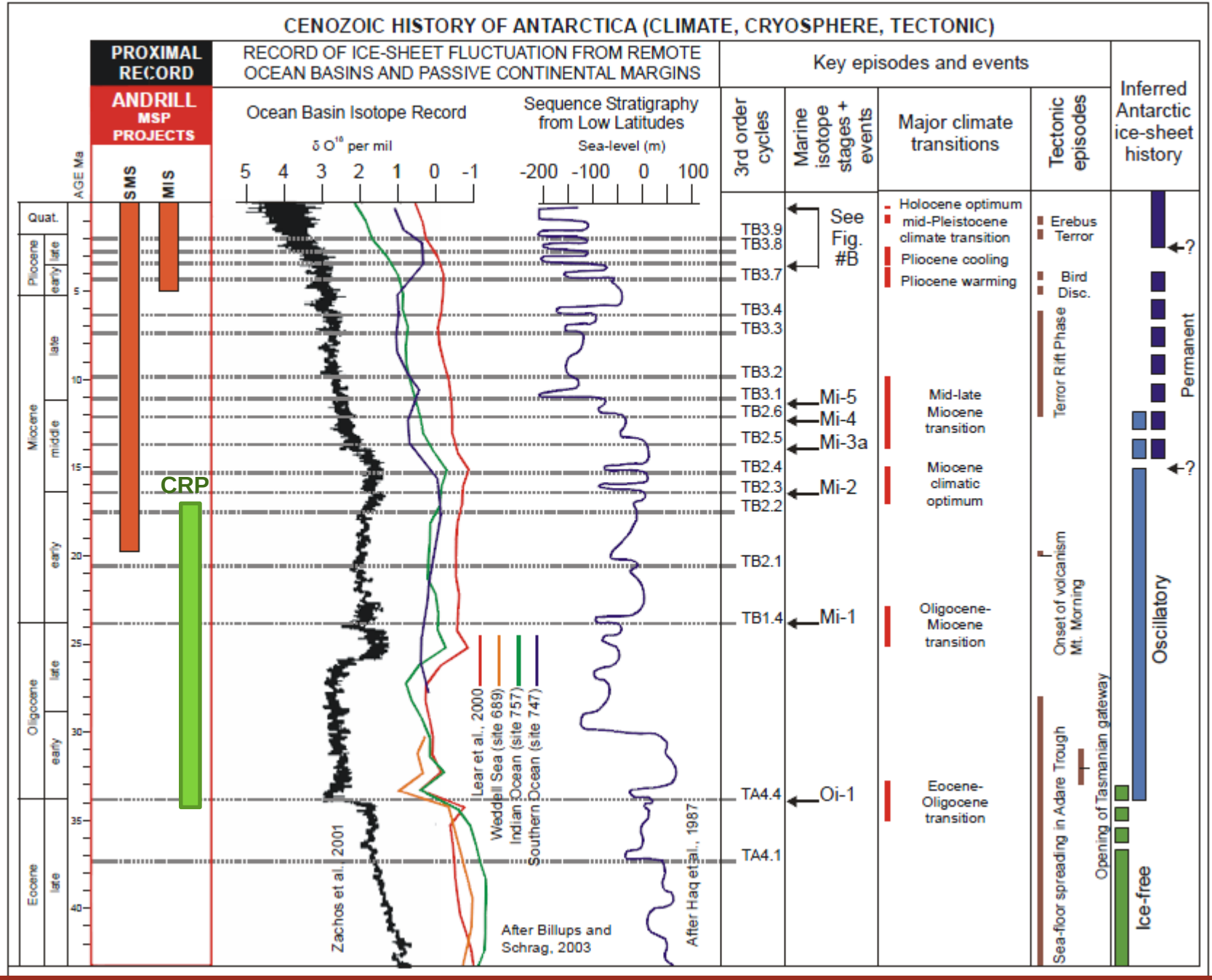
Ross Ice Sheet dynamics: clues from detrital thermochronology and sedimentary petrography

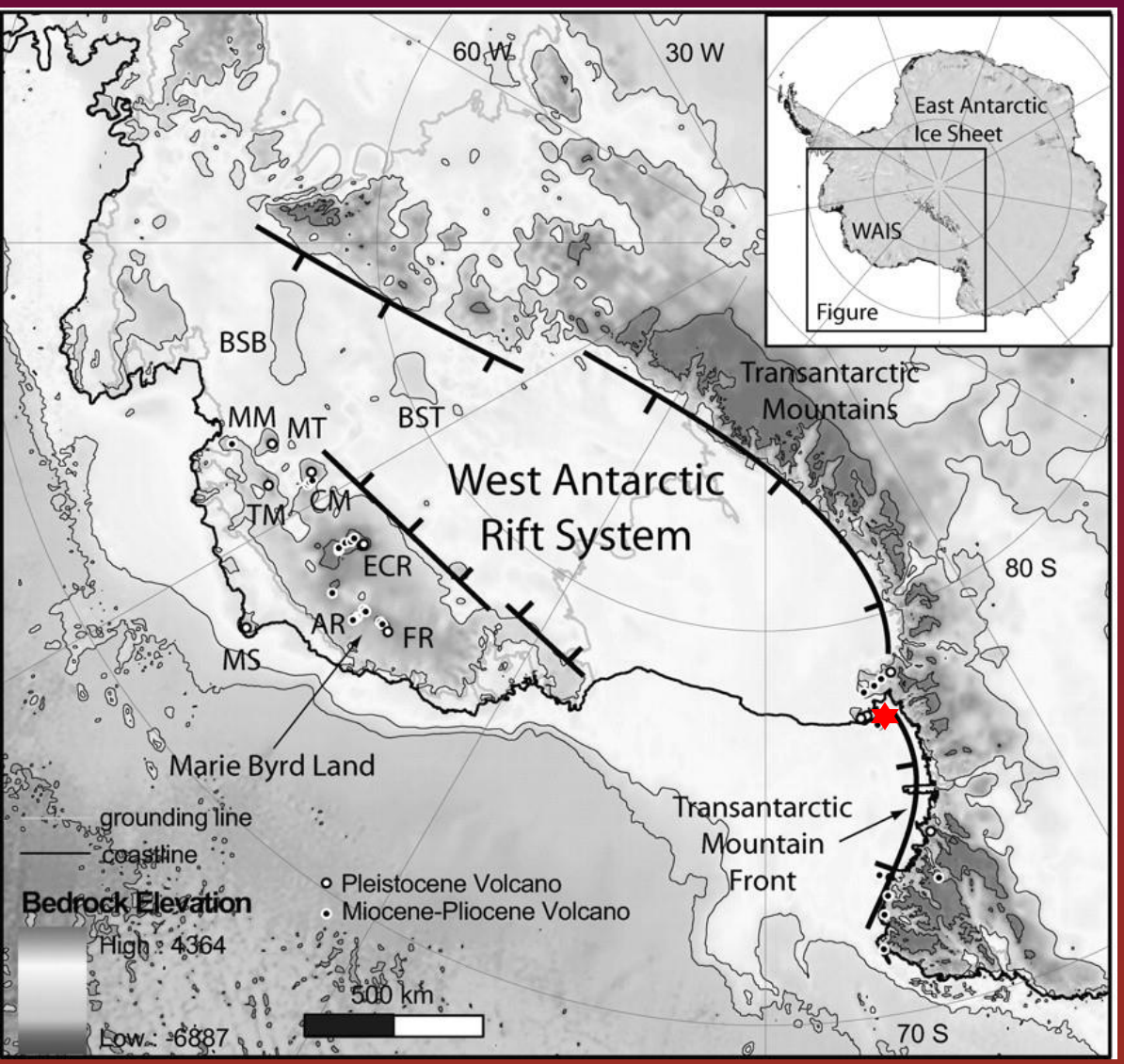
M. Zattin, B. Andreucci, M.L. Balestrieri, V. Olivetti, D. Pace, F. Talarico

Cape Roberts Project

(1995-2000)

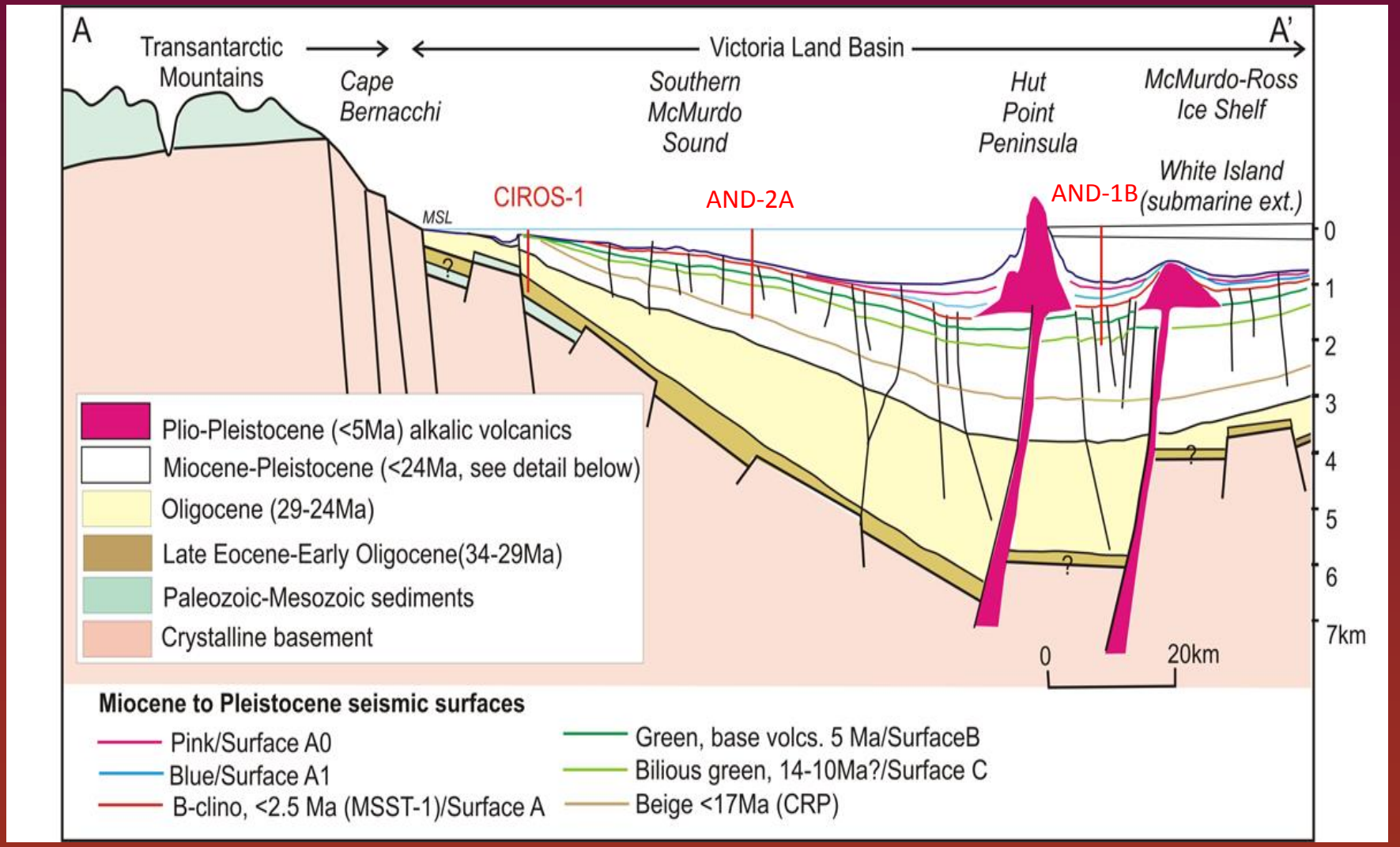



CENOZOIC HISTORY OF ANTARCTICA (CLIMATE, CRYOSPHERE, TECTONIC)
PROXIMAL RECORD
ANDRILL MSP PROJECTS
RECORD OF ICE-SHEET FLUCTUATION FROM REMOTE OCEAN BASINS AND PASSIVE CONTINENTAL MARGINS
Key episodes and events
Ocean Basin Isotope Record
δ O18 per mil
Sequence Stratigraphy from Low Latitudes
Sea-level (m)
AGE Ma
SMS
MIS
CRP
Quat.
Pliocene
Miocene
Oligocene
Eocene
early
late
middle
TB3.9
TB3.8
TB3.7
TB3.4
TB3.3
TB3.2
TB3.1
TB2.6
TB2.5
TB2.4
TB2.3
TB2.2
TB2.1
TB1.4
TA4.4
TA4.1
3rd order cycles
Marine isotope stages + events
See Fig. #B
Mi-5
Mi-4
Mi-3a
Mi-2
Mi-1
Oi-1
Major climate transitions
Holocene optimum
mid-Pleistocene climate transition
Pliocene cooling
Pliocene warming
Mid-late Miocene transition
Miocene climatic optimum
Oligocene-Miocene transition
Eocene-Oligocene transition
Tectonic episodes
Erebus
Terror
Bird Disc.
Terror Rift Phase
Onset of volcanism Mt. Morning
Opening of Tasmanian gateway
Sea-floor spreading in Adare Trough
Inferred Antarctic ice-sheet history
Permanent
Oscillatory
Ice-free
Zachos et al. 2001
Lear et al., 2000
Weddell Sea (site 689)
Indian Ocean (site 757)
Southern Ocean (site 747)
After Billups and Schrag, 2003
After Haq et al., 1987



The Transantarctic Mountains (TAM) form the western shoulder of the **Mesozoic-Cenozoic West Antarctic Rift System** (WARS). The rifting evolution is commonly considered polyphase and involves an Early Cretaceous phase followed by a major Cenozoic one, starting at c. 50-40 Ma.

The **Cenozoic rift reorganization** occurred concurrently with a major change in the global climate system and a global reorganization of plate motions.


A
Transantarctic Mountains
Victoria Land Basin
A'
Cape Bernacchi
Southern McMurdo Sound
Hut Point Peninsula
McMurdo-Ross Ice Shelf
White Island (submarine ext.)
CIROS-1
AND-2A
AND-1B
MSL
?
0
1
2
3
4
5
6
7km
0
20km
Plio-Pleistocene (<5Ma) alkalic volcanics
Miocene-Pleistocene (<24Ma, see detail below)
Oligocene (29-24Ma)
Late Eocene-Early Oligocene(34-29Ma)
Paleozoic-Mesozoic sediments
Crystalline basement
Miocene to Pleistocene seismic surfaces
Pink/Surface A0
Blue/Surface A1
B-clino, <2.5 Ma (MSST-1)/Surface A
Green, base volcs. 5 Ma/SurfaceB
Bilious green, 14-10Ma?/Surface C
Beige <17Ma (CRP)

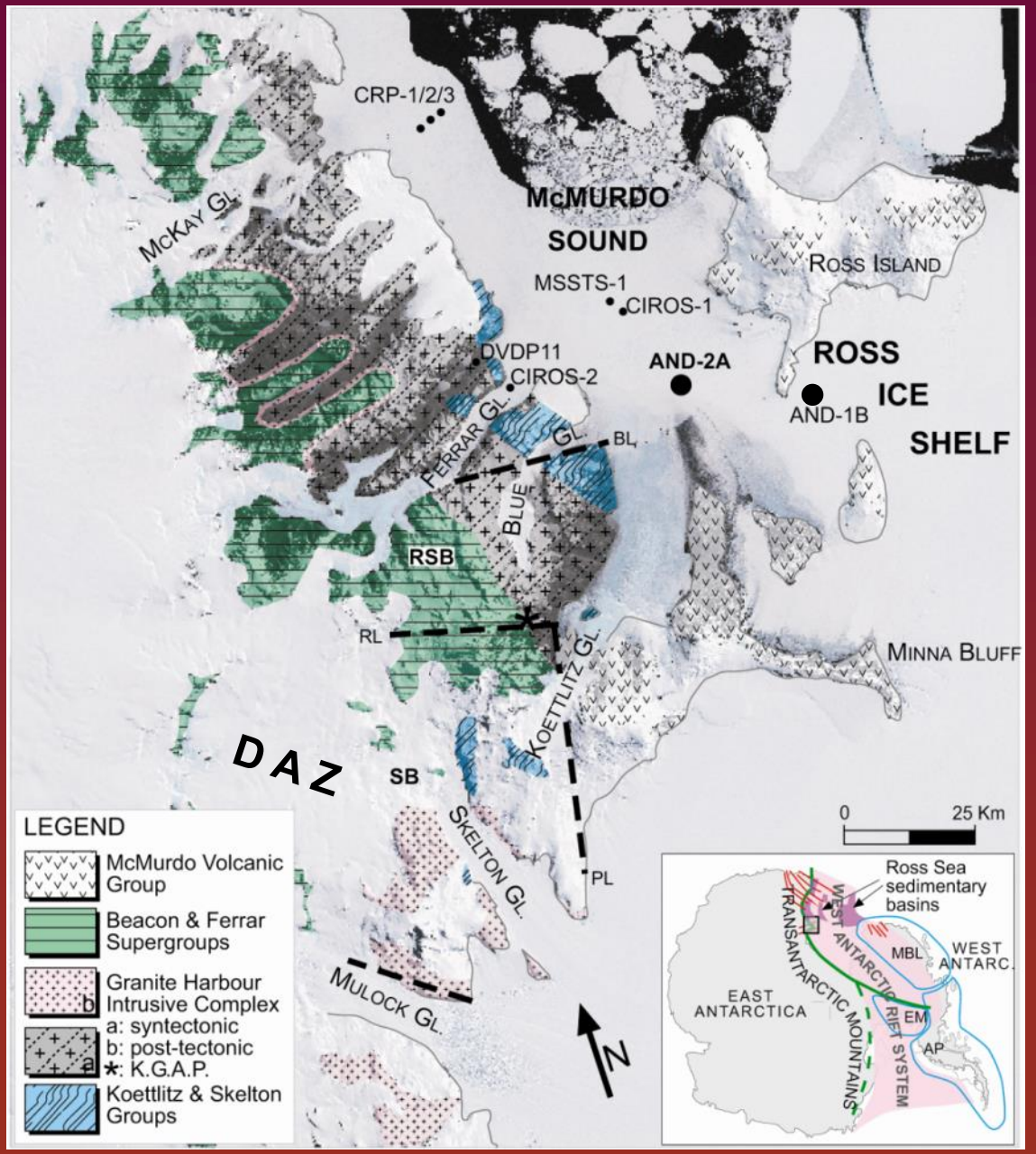
Miocene-Pliocene

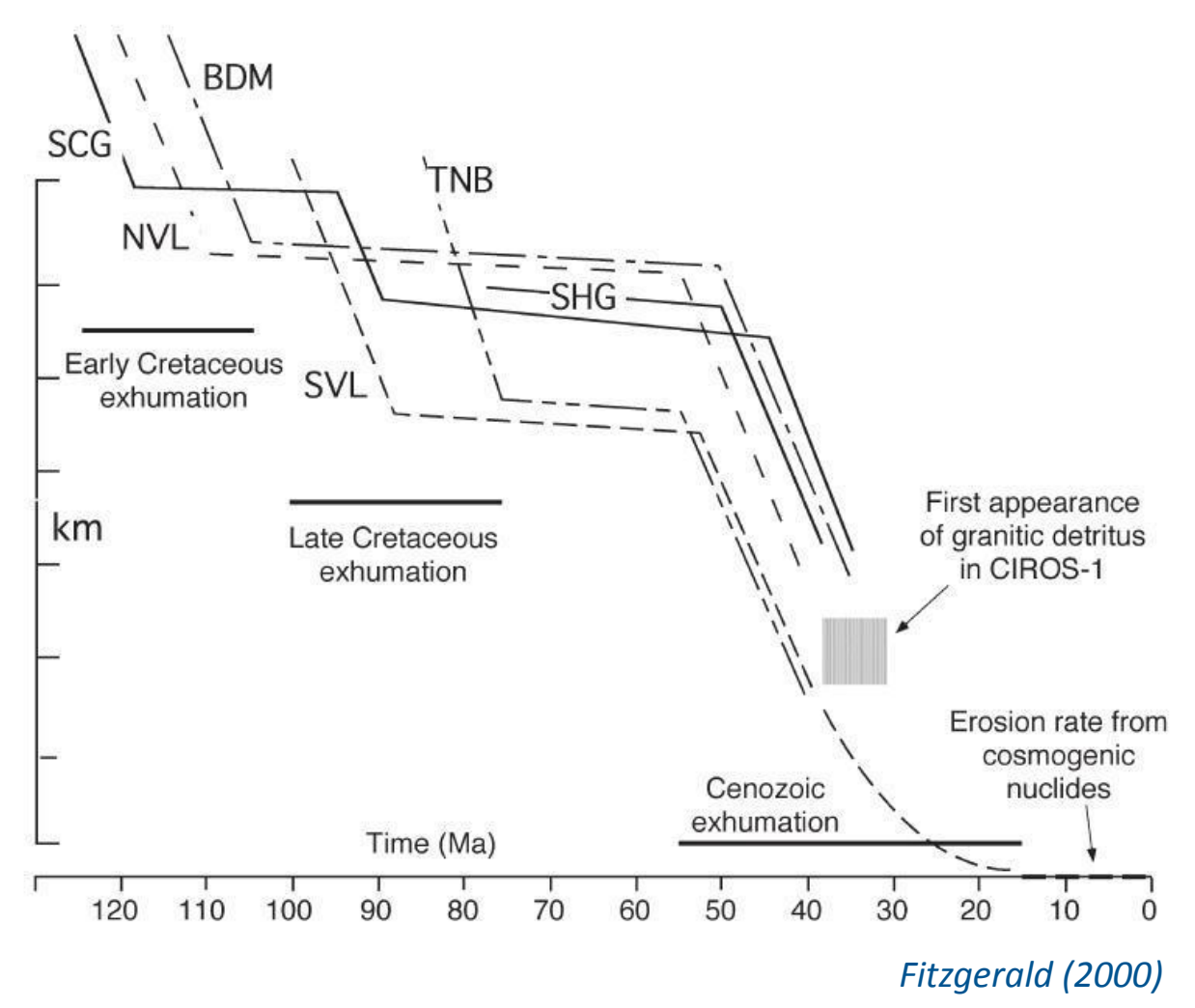
Devonian - Triassic

Cambrian-Ordovician

Jurassic

Proterozoic - Cambrian





Fitzgerald (2000)

SCG: Scott Glacier area; BDM: Beardmore Glacier area; SHG: Shackleton Glacier area; SVL: Southern Victoria Land; TNB: Terra Nova Bay; NVL: Northern Victoria Land.

MATERIALS AND METHODS

DETRITAL APATITE FISSION-TRACK ANALYSIS

- 23 samples from CRP well
- 33 samples from AND-2A well
- 7 samples from AND-1B well

DETRITAL APATITE U-Pb ANALYSIS

- 326 ages from 14 samples from AND-2A well
- 30 ages from 5 samples from CRP well

DETRITAL APATITE U-Th/He ANALYSIS

- 27 ages from 4 samples from AND-2A well

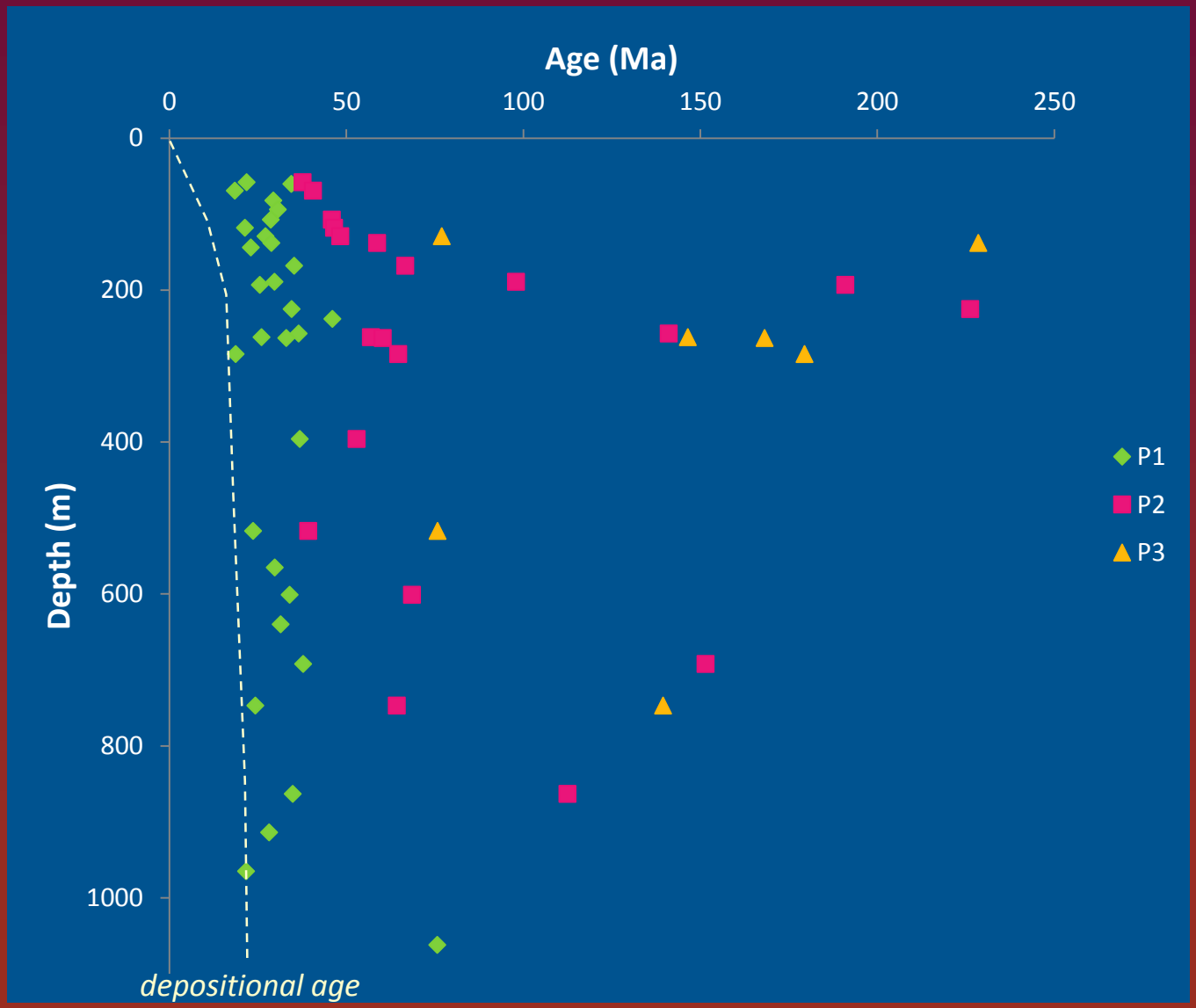
BEDROCK APATITE FISSION-TRACK ANALYSIS

- 20 ages from the region between the Royal Society Range and the Britannia Range

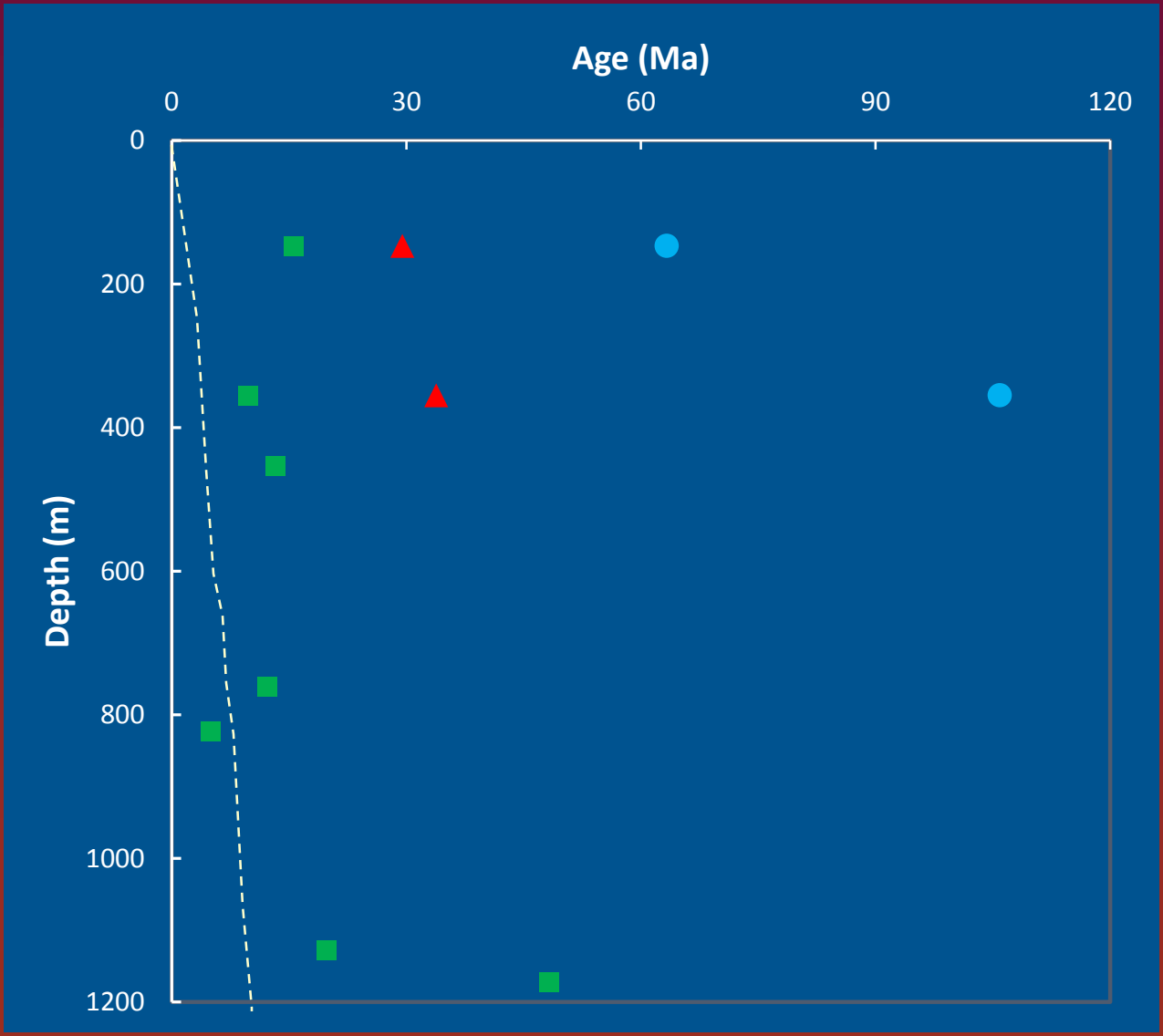
PETROGRAPHY OF GRAVEL FRACTION

Several thousands of clasts ranging in size from boulder- to granule-class (>2 mm) were logged and counted on the basis of lithology and occurring depth on the cut surface of the wells working-half core.

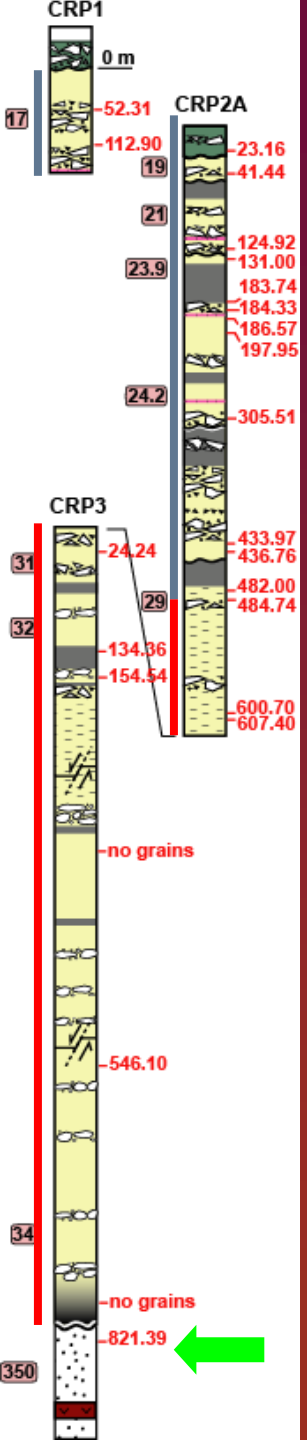
AFT data from well AND-2A

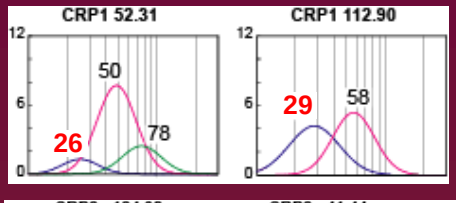


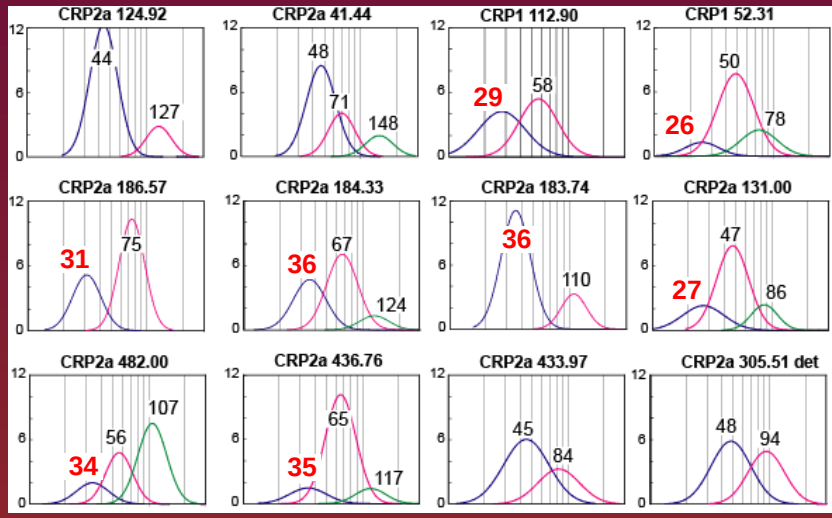
AFT data from well AND-1B



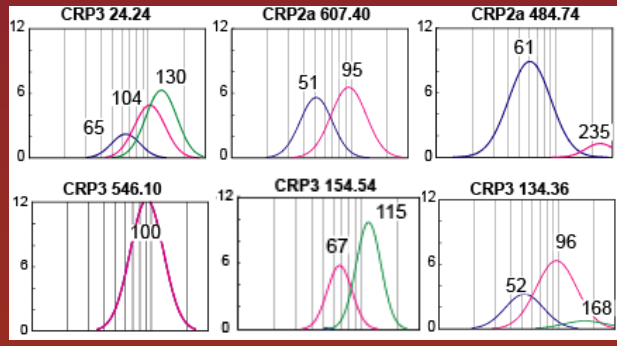
AFT from CRP wells







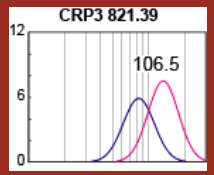
Dep. age: 29 to 17 Ma
- three peaks
- **episodic** young peak P1 < 40 Ma



Dep. Age: 34 to 29 Ma
- 2 or 3 peaks
- No peak < 40 Ma

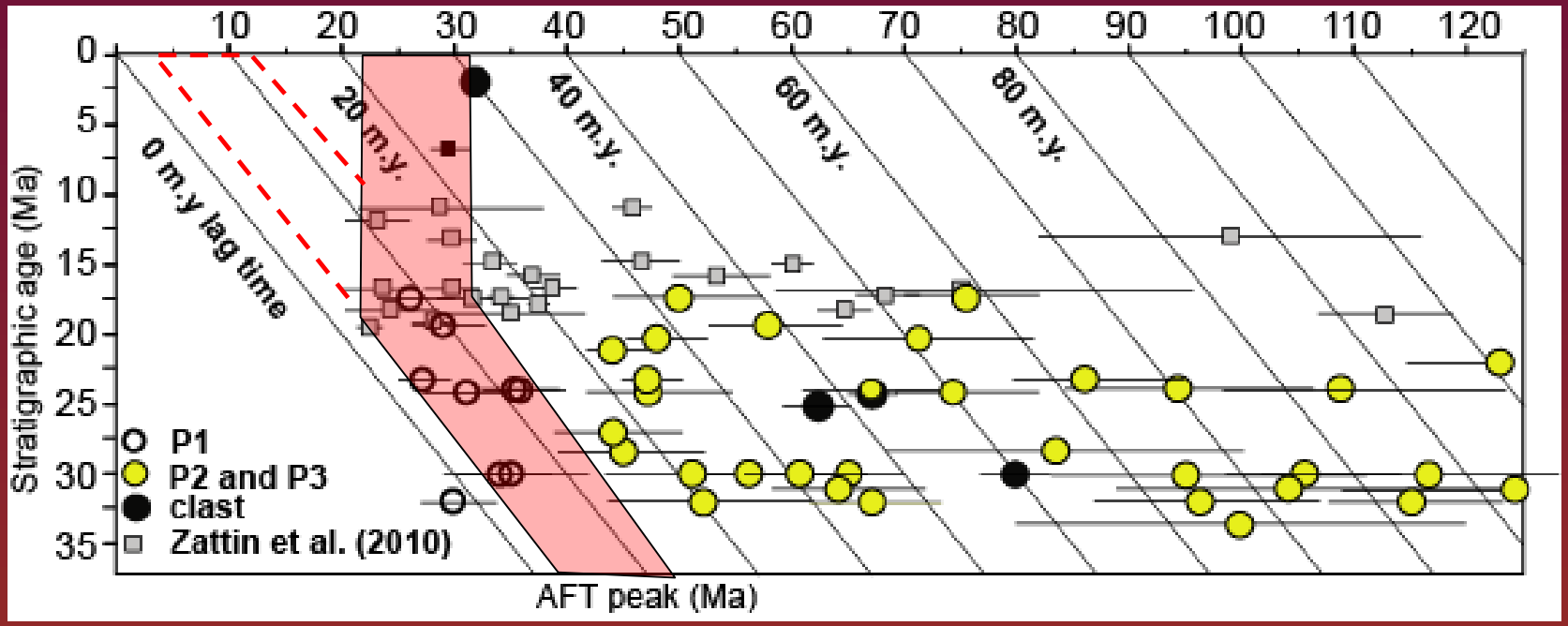
Beacon sandstone (Devonian)

Substratum
106.5 Ma



Lag time

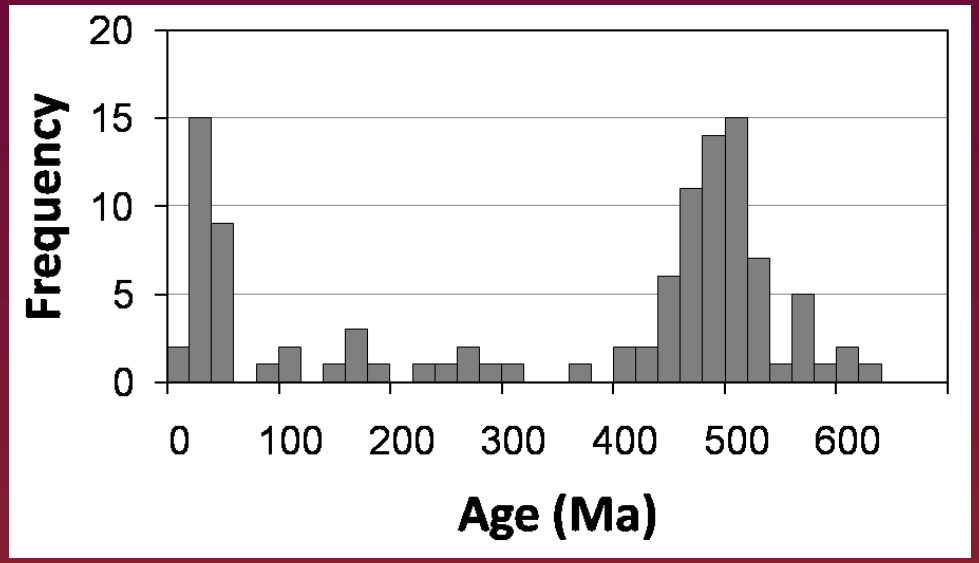
(peak age – depositional age)



Are AFT ages <40 Ma related to the **rapid cooling of volcanic** products or is their meaning to be interpreted in terms of **exhumation** of source rocks?

U-Pb dating is needed!

U-Pb data

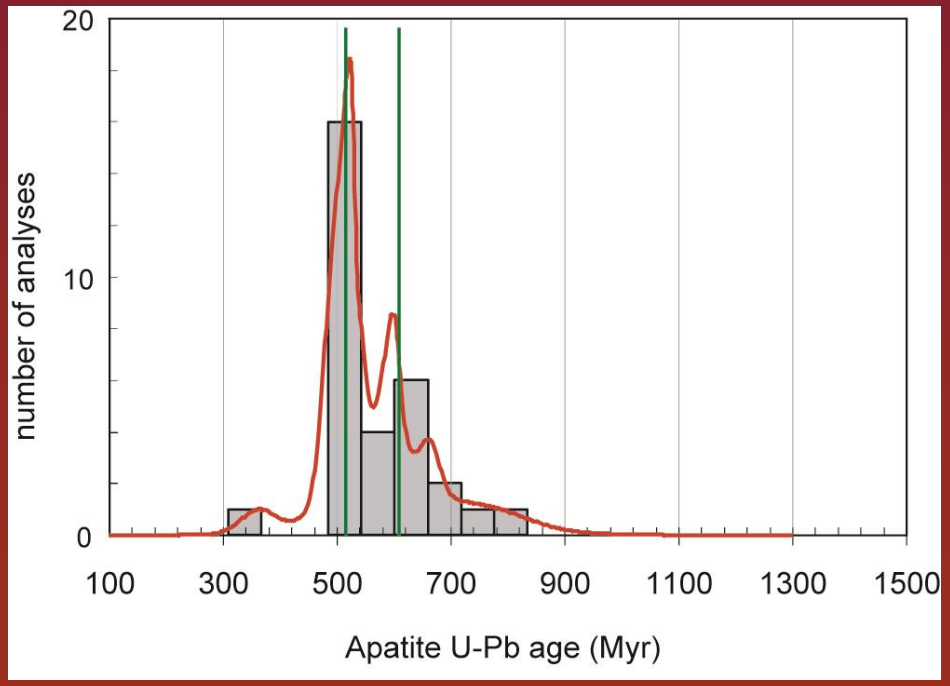


AND-2A well

Age values span from 18 to 690 Ma with two main peaks (<ca. 45 Ma and around 500 Ma).

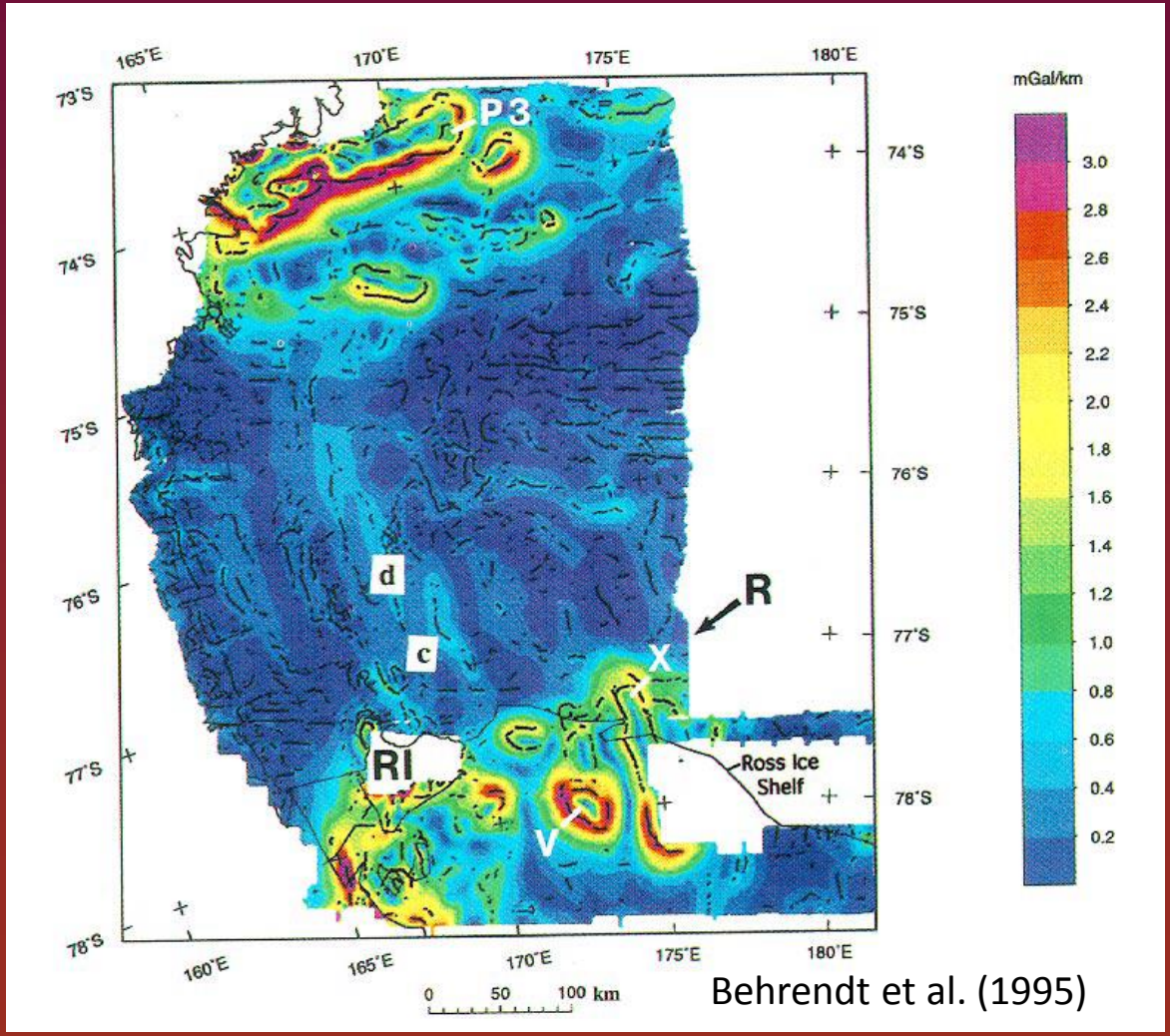
CRP well

Age values span from 360 to 799 Ma with two main peaks (ca. 530 Ma and around 610 Ma).



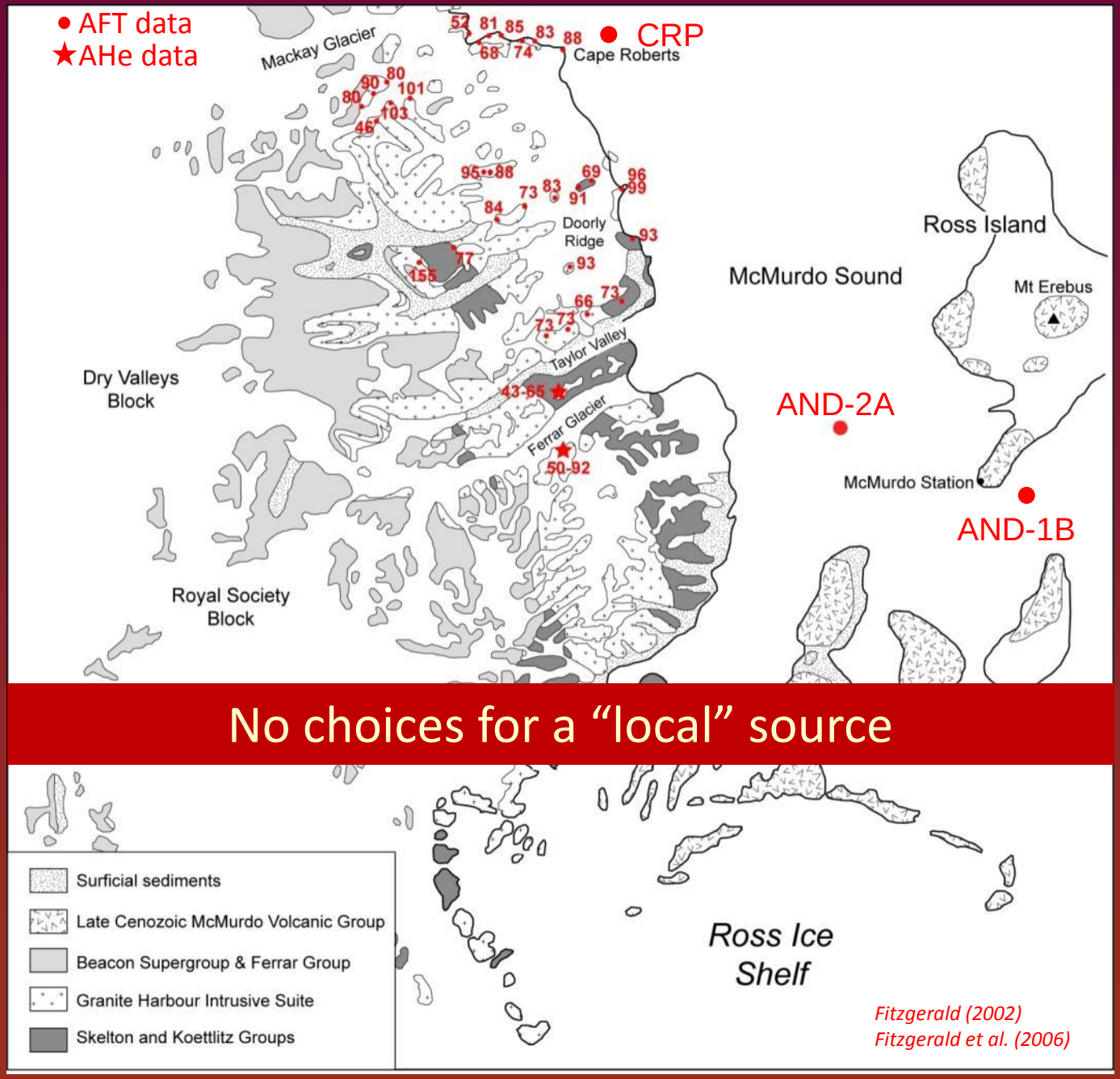
CONCLUSIONS - 1

The finding of **volcanic apatites** with a late Eocene/Oligocene age documents the existence of a so far undetected **volcanic source** well before the Mount Morning magmatic province. The location of the volcanic center is unknown but aeromagnetic anomalies and the lack of the signal in the CRP well suggest the presence of **subglacial volcanic centers** beneath the Ross Ice Shelf and the WAIS.



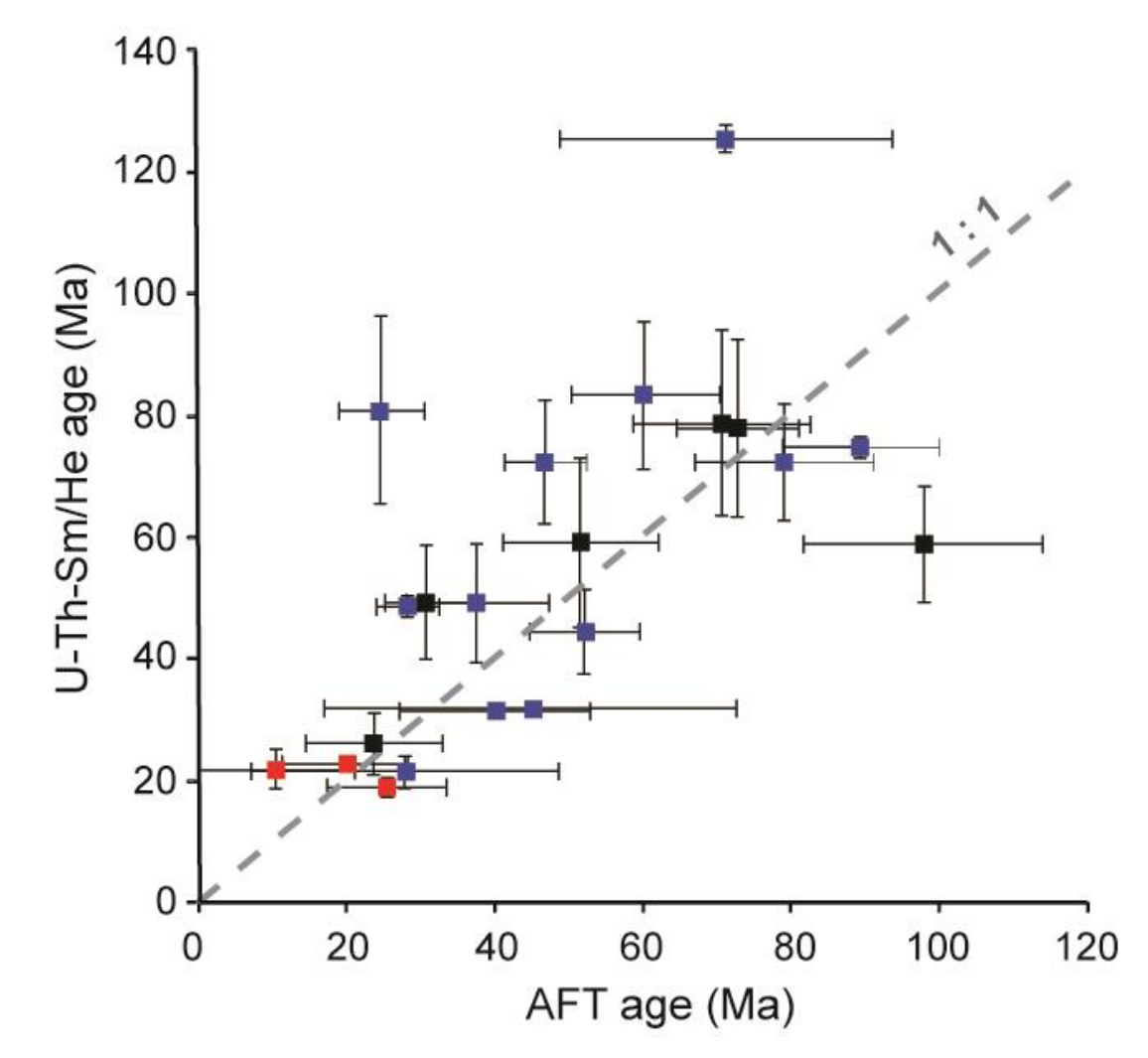
Behrendt et al. (1995)


Where do the sediments
come from?

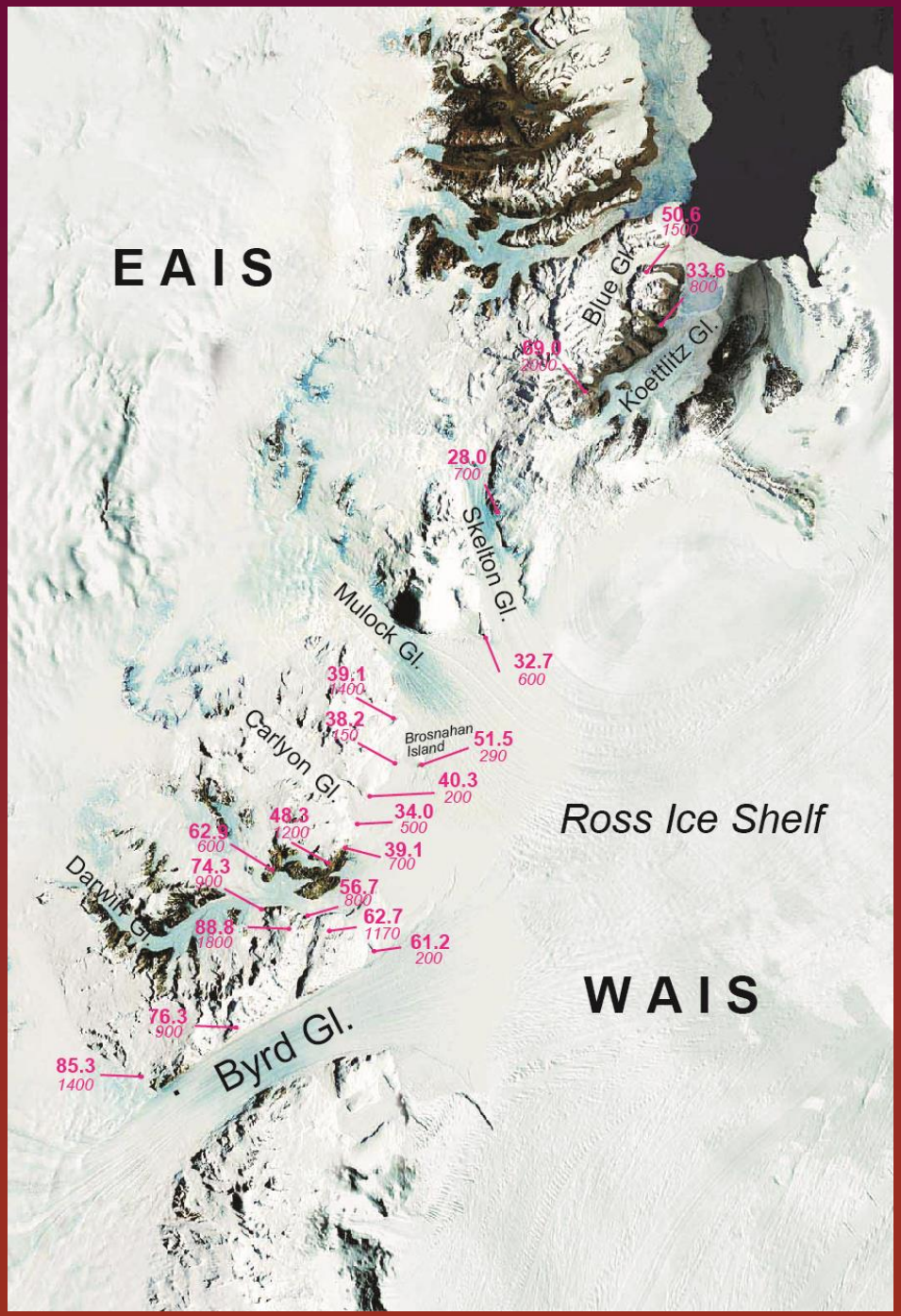


No choices for a “local” source

U-Th-Sm/He data



- Apatites with U/Pb<40 Ma
- Apatites with U/Pb>400 Ma
- Apatites not dated with U/Pb



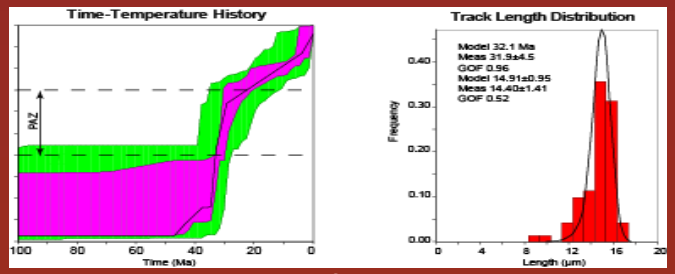
New AFT data from bedrock

(elevation in brackets)

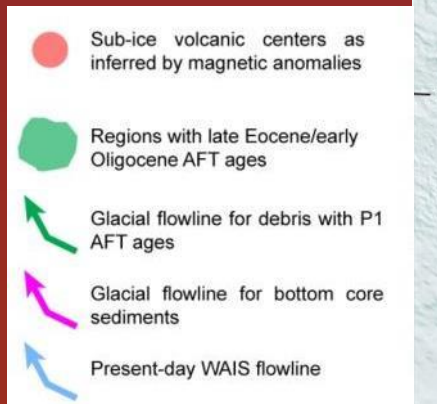
CONCLUSIONS - 2

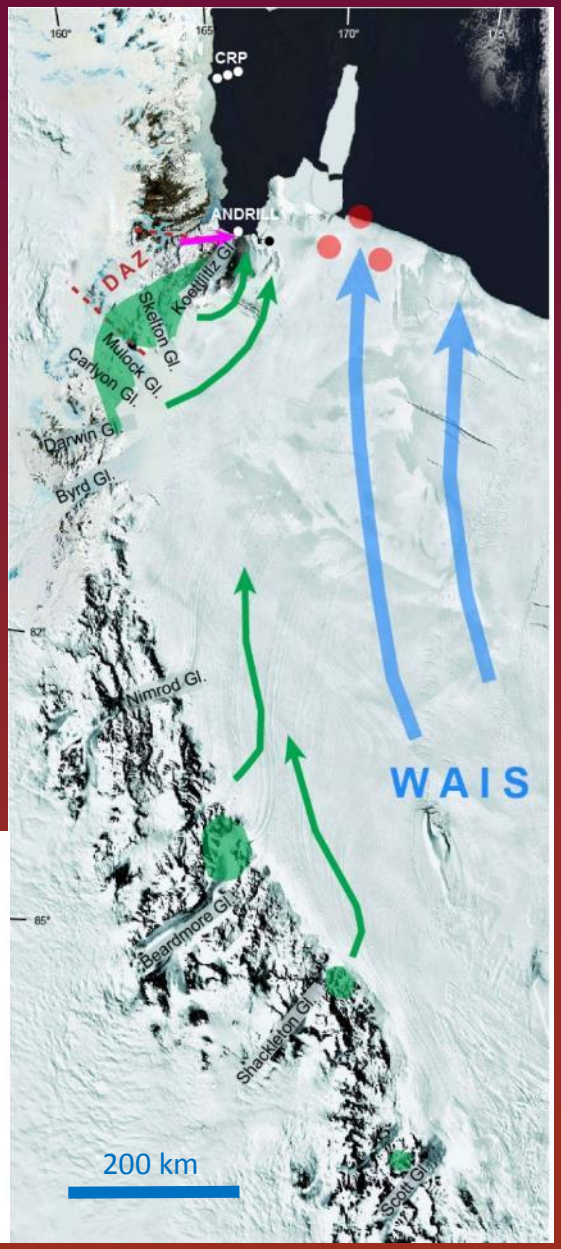
- Most of the sediments derived from the **region south of the Discovery Accommodation Zone** with only a minor contribution from the much closer glaciers of the Royal Society Range

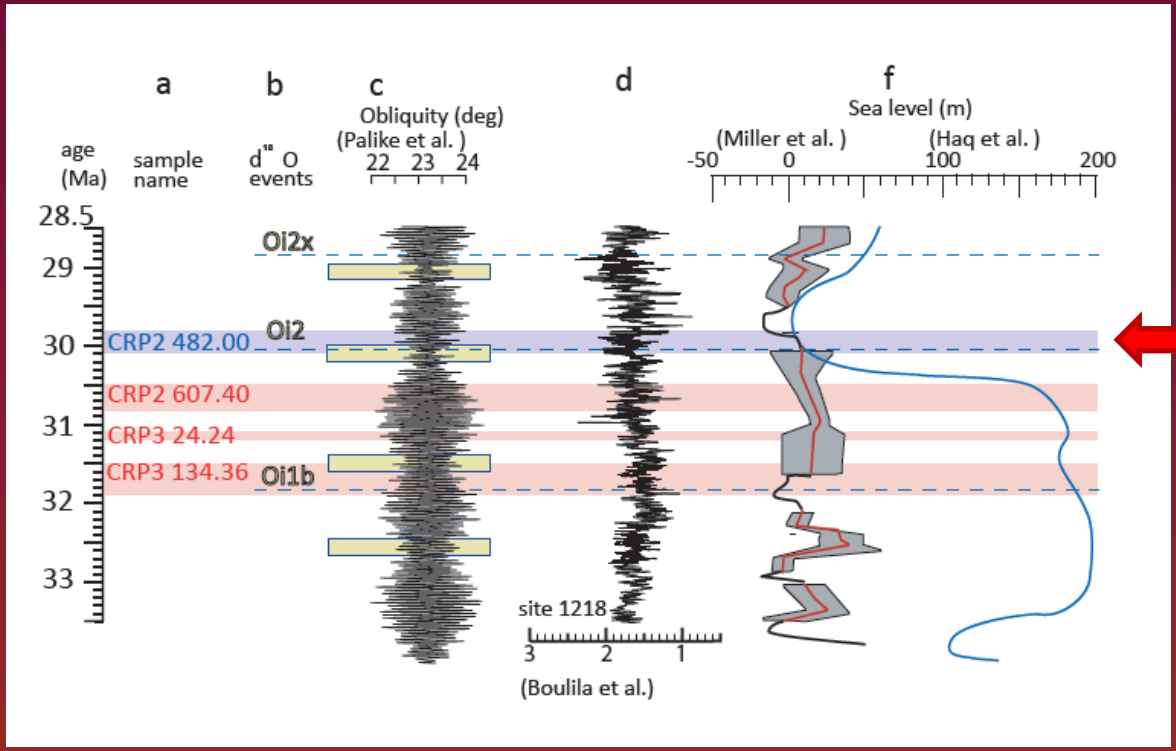
- The small gap between AFT and AHe ages indicates that a moderate-to-fast cooling event occurred along this region of the TAM during the **Oligocene**, after which the chain was in a post-orogenic decay, with cooling rates of the order of 0.1 km/Ma.



Thermal modelling of a granite clast in CRP2







Appearance of P1 grains

Is it related to formation of WAIS?

P1 peak age occurrence within the CRP drill core is episodic.

- colder periods: north directed ice-flow pattern brought far-travelled apatites (P1)
- warmer periods: an almost W-E directed flow formed by EAIS outlet glaciers resulted in a predominant sourcing of more proximal apatite (P2 and P3).