Updated tectonic framework of West Antarctica and legacy of formation within the complex convergent margin of Gondwana

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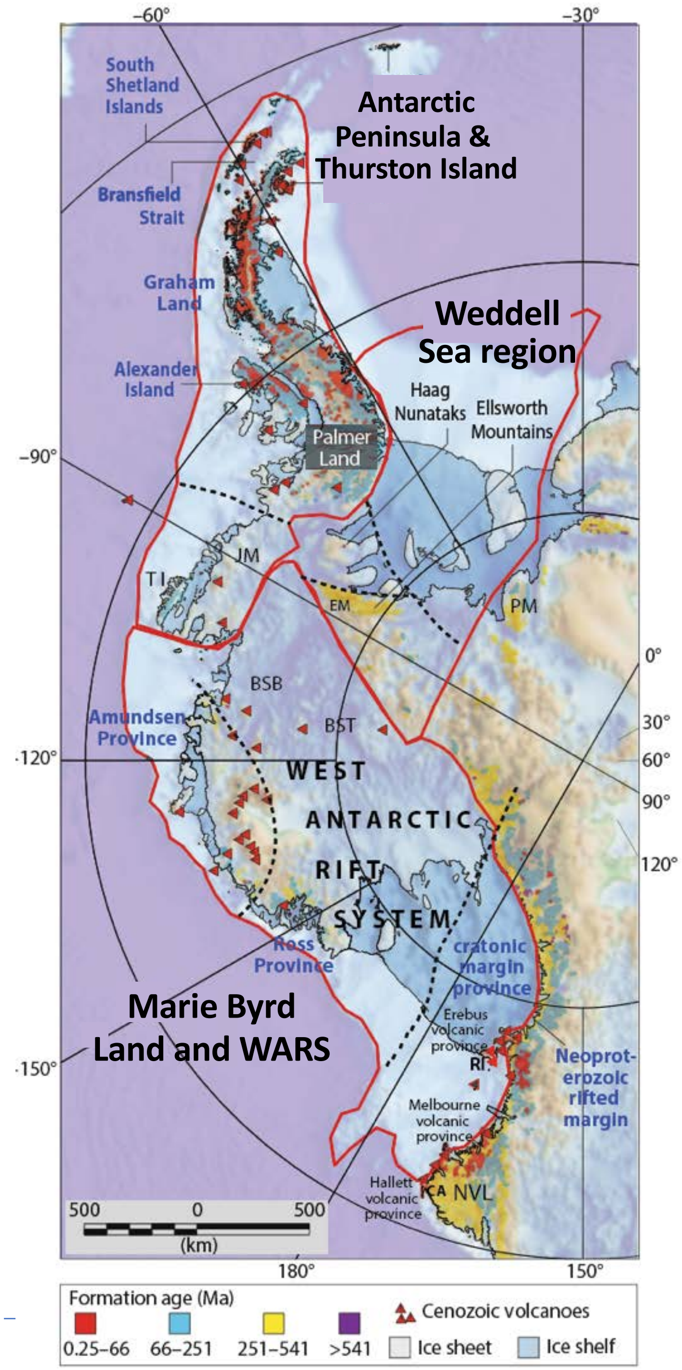
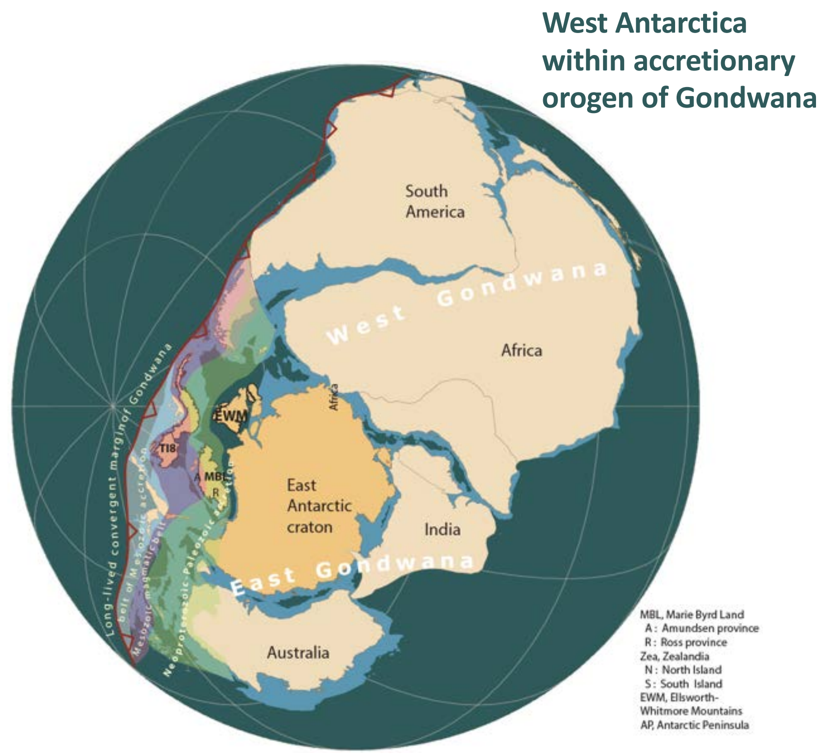
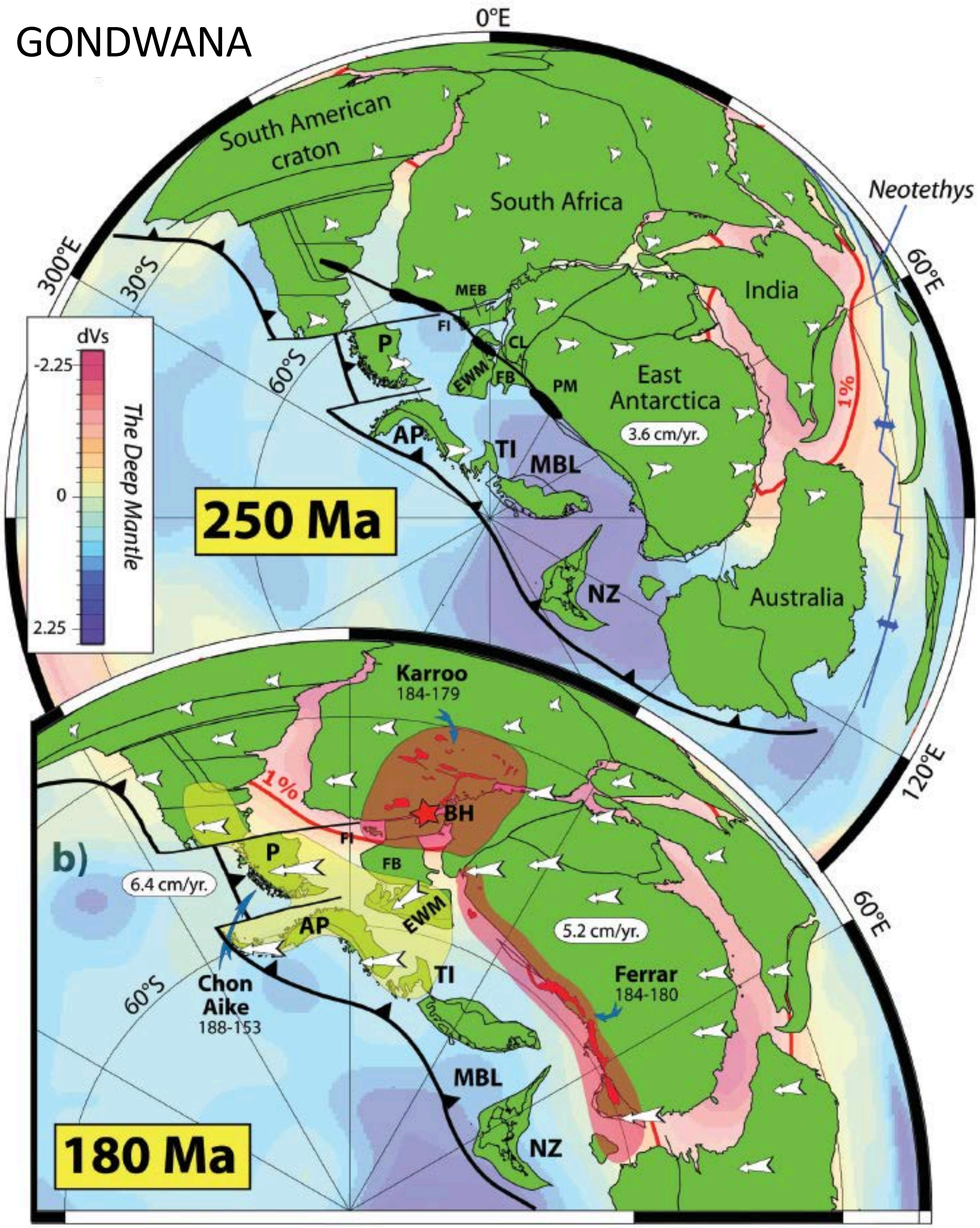




GONDWANA



Torsvik et al. 2008, doi:10.3133/of2007-1047.kp11

Longstanding view of West Antarctica

Discrete tectonic entities: *Terranes*
(character of intervening crust, not known)

Developed along the active margin of Gondwana

This presentation explores both distinctions and commonalities between three provinces of West Antarctica.

AP, Antarctic Peninsula
P, Patagonia
TI, Thurston Island
EWM, Ellsworth-Whitmore Mountains
> paleomagnetic evidence for large vertical axis rotation

MBL, Marie Byrd Land
NZ, Zealandia

Ferrar – Large Igneous Province

Presentation Outline

Part I.

I. Geological/geophysical/ geochronological evidence of a shared history for West Antarctica tectonic provinces along a complex accretionary margin

II. Geophysical remote sensing reveals the subglacial extent of geological provinces; new tectonic scenarios emerge.

- Ellsworth-Whitmore province (*Jordan et al. 2017*)
- Antarctic Peninsula (*Burton-Johnson & Riley, 2015*)
- Ross Embayment cratonic margin province (*Tinto et al. 2019*)

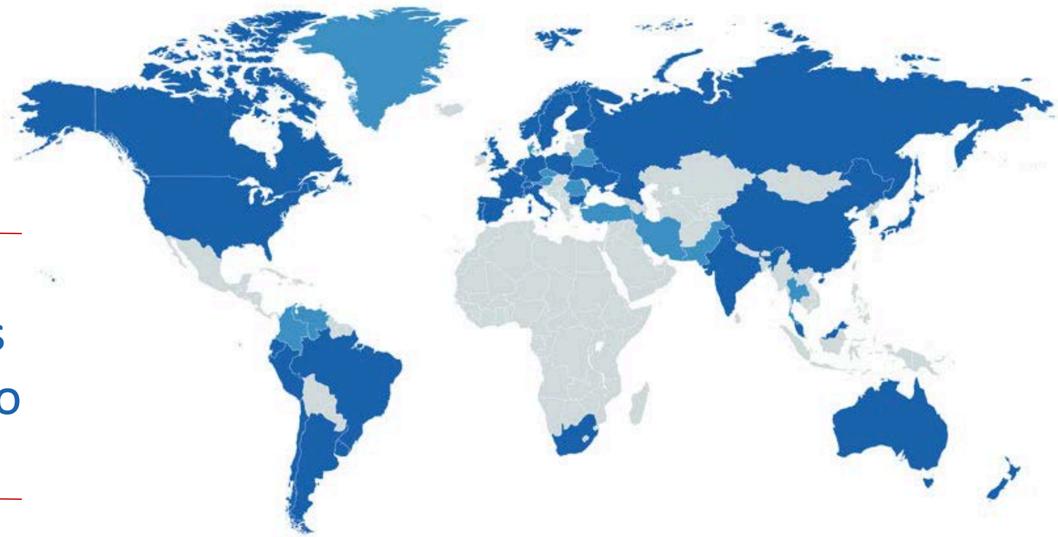
Part II.

III. The inboard limit of West Antarctica in Ross Embayment

- Defined by physiography or crustal geology?
- Transantarctic Mountains or Central High / boundary of cratonic margin province?

IV. Utility of updated crustal geology and tectonic framework

Relevant to many areas of contemporary research: paleotopography, glacial processes, subglacial hydrology, heat flux, glacial isostatic response



SCAR members and programmes that contribute to this work

Geosciences Scientific Research Programmes

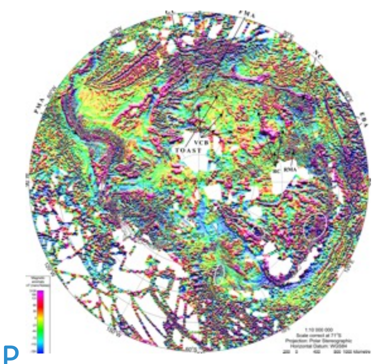
- Past Antarctic Ice Sheet Dynamics – PAIS
- Solid Earth Responses & influences on Cryospheric Evolution– SERCE
- Antarctic Offshore Stratigraphy Project - ANTOSTRAT

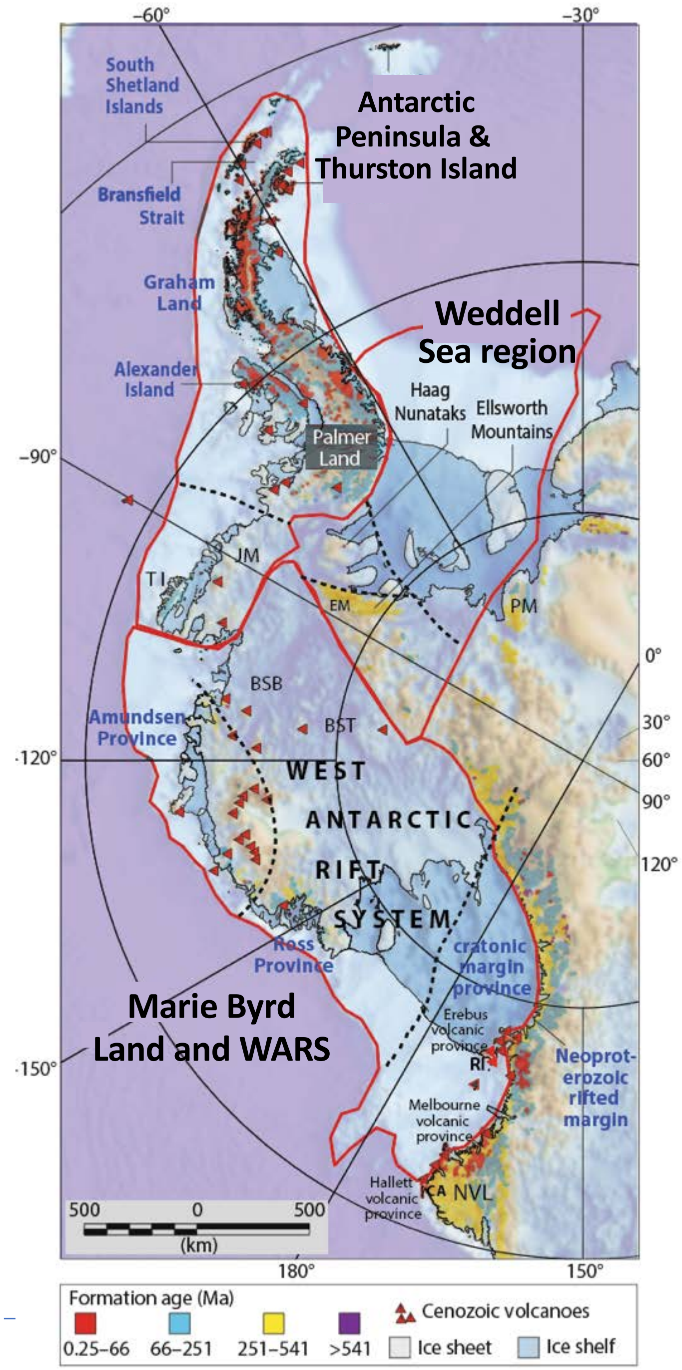
Geosciences Expert Groups

- Antarctic Digital Magnetic Anomaly Map Project – ADMAP
- Antarctic Volcanism – AntVolc
- Geodetic Infrastructure of Antarctica – GIANT
- International Bathymetric Chart of the Southern Ocean – IBCSO

Geosciences Action Groups

- Connecting Geophysics with Geology – CGG
- Geological Mapping Update of Antarctica – GeoMap





Updated tectonic framework of West Antarctica and legacy of formation within the complex convergent margin of Gondwana

Weddell Sea region and continental highlands

(Ellsworth-Whitmore Mountains, Haag Nunataks)

Structural trend of EWM is orthogonal to Pensacola and Transantarctic Mountains

Antarctic Peninsula (AP) – Thurston Island (TI) province

Marie Byrd Land (MBL) and West Antarctic rift system

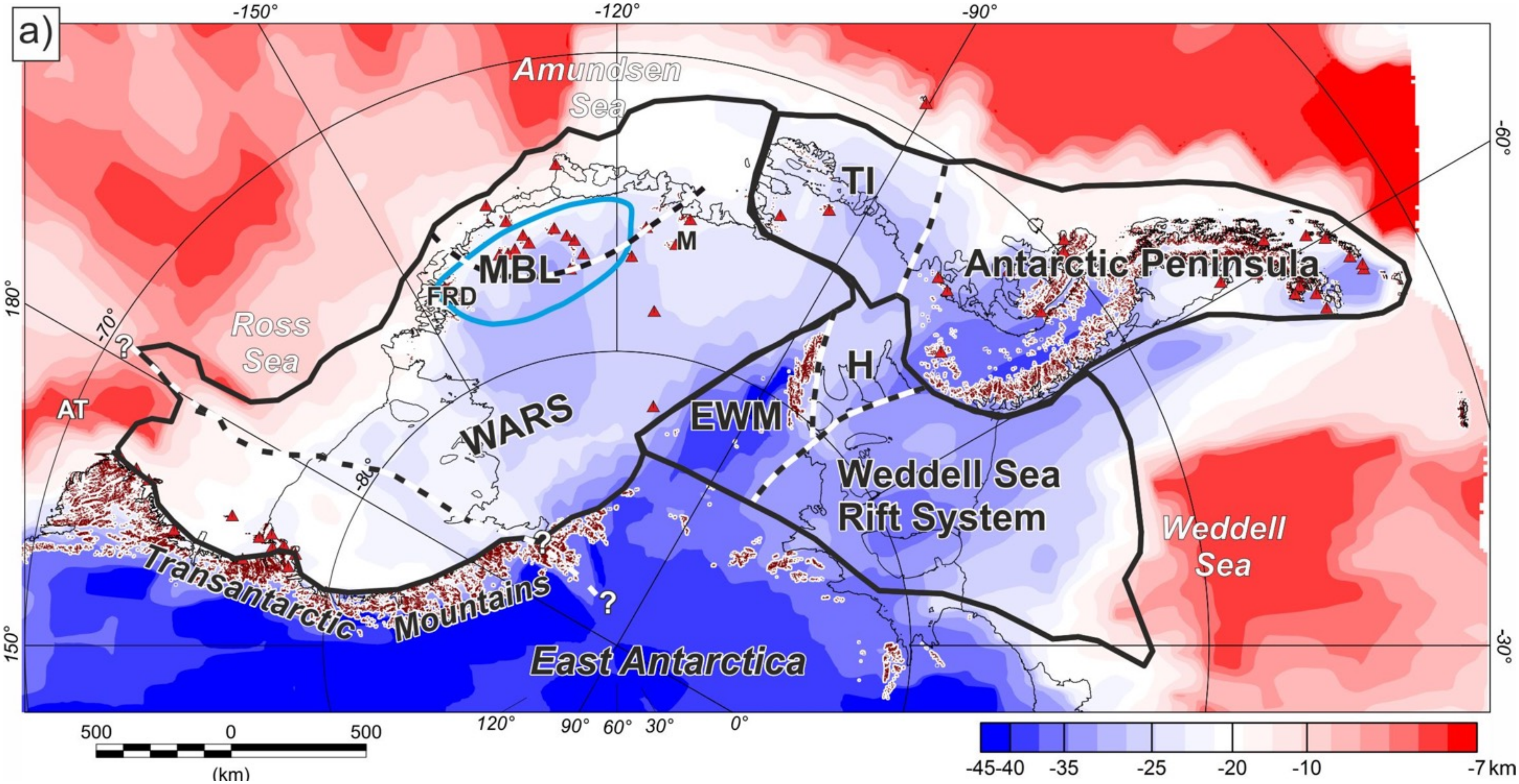
Geophysical remote sensing provides new understanding of the subglacial extent

lithospheric characteristics

locations ± kinematics of crustal structures

Geology, geochronology, and thermochronology has led to discovery of common elements shared among the three provinces.

Crustal thickness derived from passive seismic observations



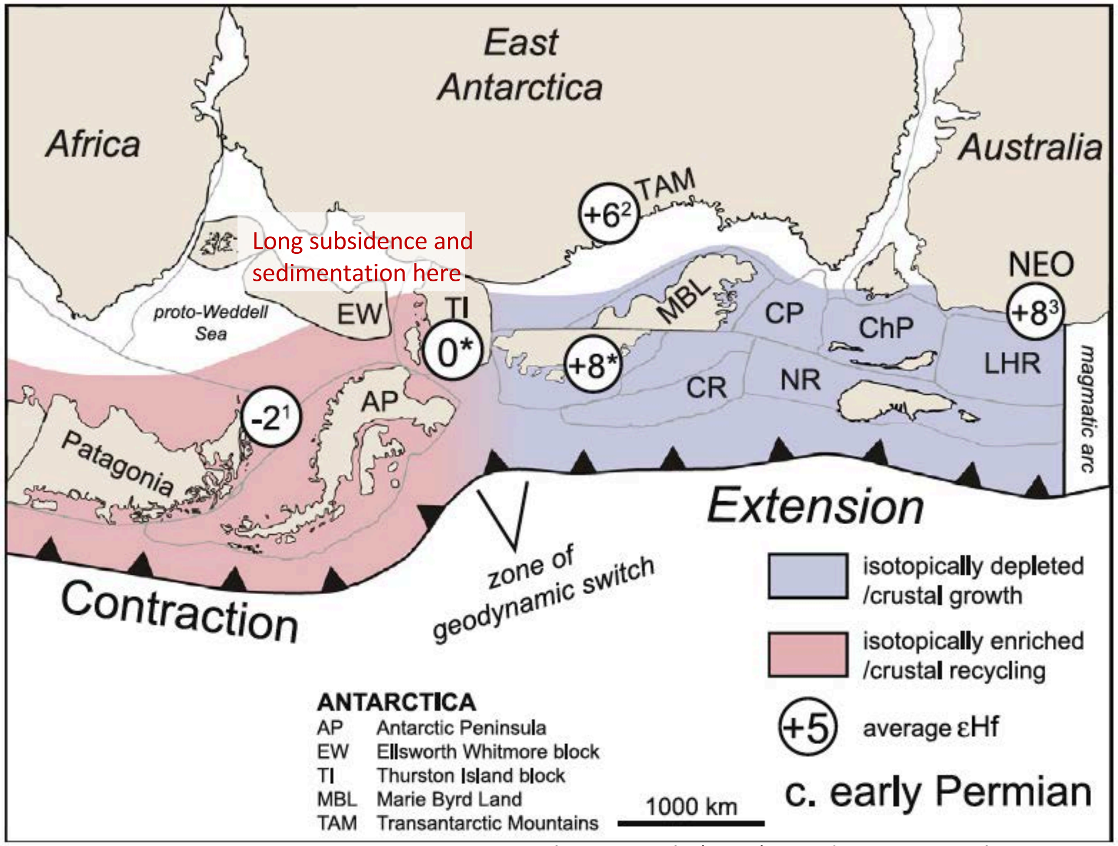
West Antarctic crust has a mean thickness of just 25 km, in contrast to East Antarctica 's cratonic crust, 35–45-km-thick. The crustal thickness domains, together with aeromagnetic anomaly patterns, allow the subglacial extent of West Antarctic provinces to be determined. The geophysical characteristics aid the interpretation of the geological makeup of the crust.

Thicker crust in the Peninsula - Weddell Sea region, compared to MBL, signifies contraction and tectonic thickening in the 'advancing' orogen.

Figure draws upon POLEnet contributions, including Chaput et al. 2014; An et al. 2015 and other POLEnet works

Gondwana accretionary orogen –

West Antarctica, Zealandia and Patagonia developed along this margin



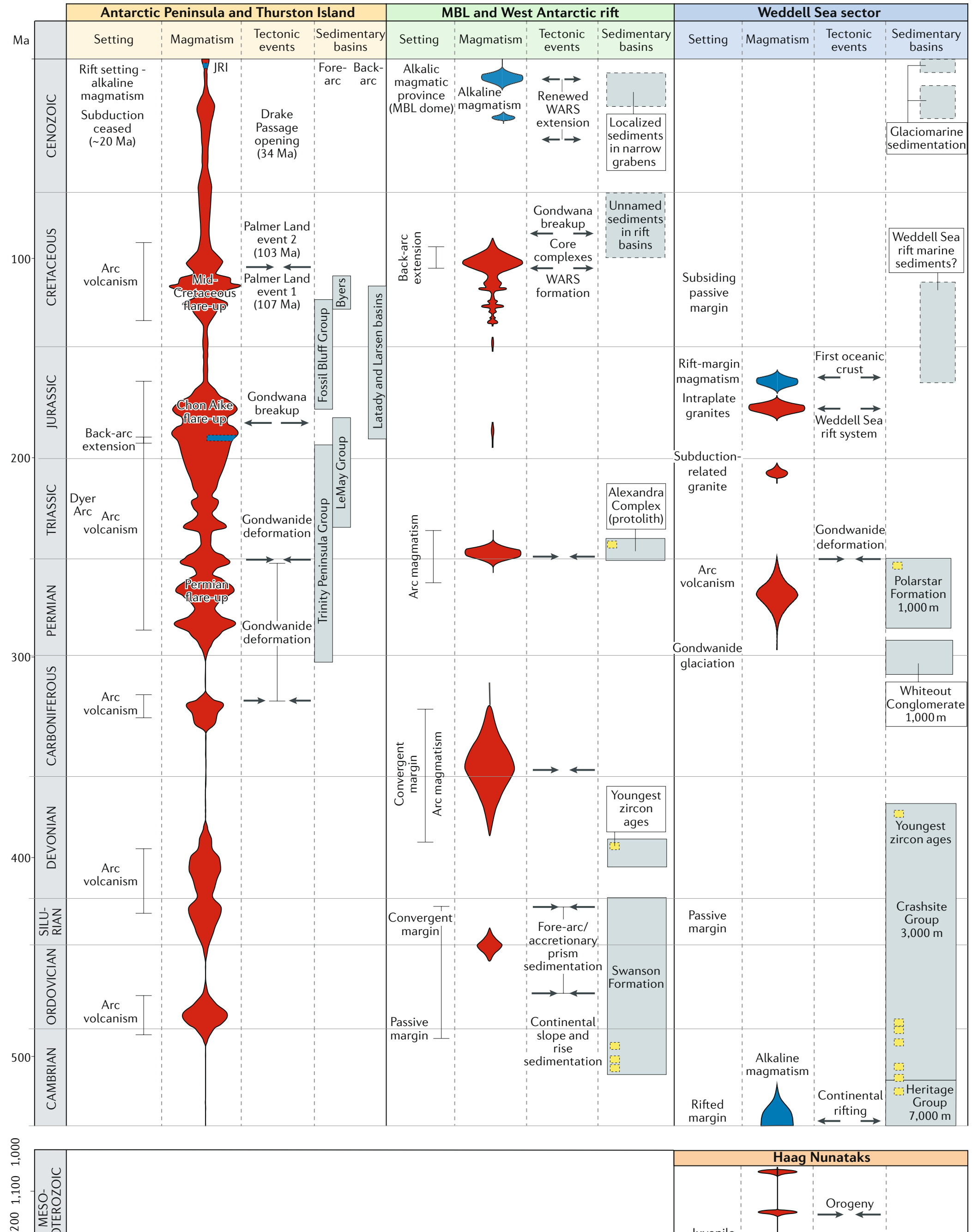
Nelson & Cottle (2018), Gondwana Research 63, 15–33

! There is a shift in the reference North direction for this diagram. North is down.

Accretionary orogens

- form at intraoceanic and continental margin convergent boundaries
- comprise supra-subduction zone forearc, magmatic arc and back-arc
  - Retreating mode: marked by long-term extension, with development of back-arc basins. Subducting lower plate retreats with respect to overriding plate. Example: western Pacific, today.
  - Advancing mode: marked by contraction and crustal thickening, with development of foreland fold and thrust belts. Overriding plate advances towards the downgoing plate (e.g. Andes)

See Cawood et al. 2009, GSL-SP 318



Jordan, Riley & Siddoway, 2020, [*https://rdcu.be/b0OL8*](https://rdcu.be/b0OL8)

Timeline of tectonic – magmatic events

Antarctic Peninsula – Thurston Island

Long continuous record of magmatism

Weddell Sea sector / Ellsworth-Whitmore Mountains

Long complete sedimentary record

Weddell Sea province

Generally long-wavelength magnetic features.

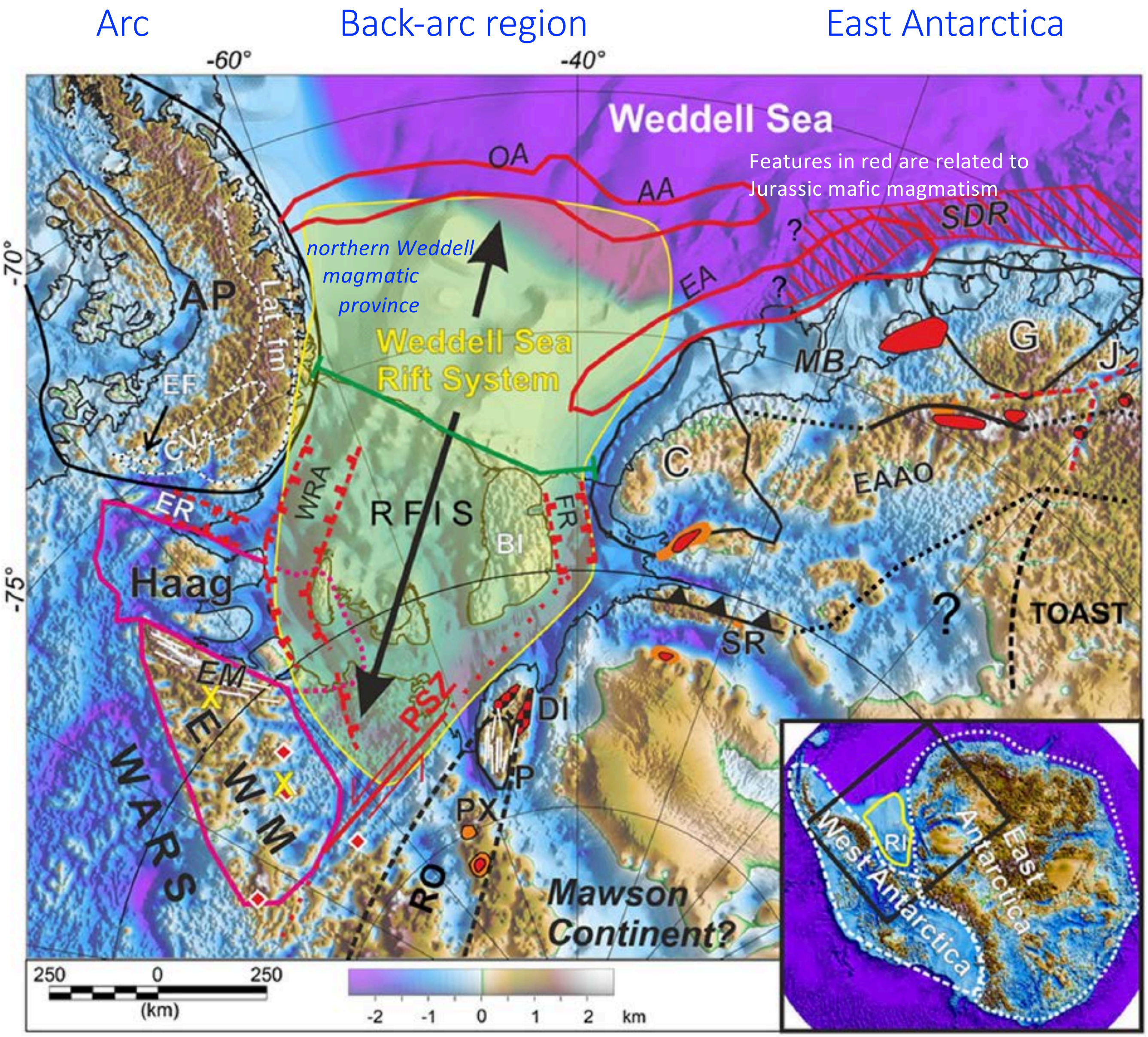
Northern Weddell Magnetic Province, offshore **Southern Weddell Magnetic Province** beneath Ronne Filchner ice shelf (RFIS)

crust ~30 km thick

Jurassic rift fabric

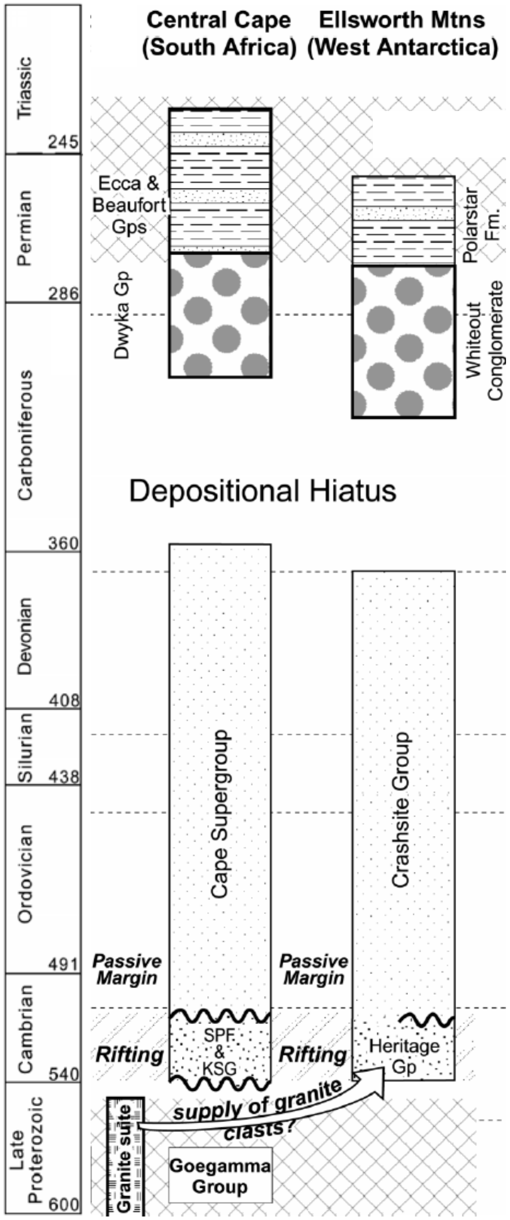
Subsequent subsidence allowed thick sediment accumulation.

Key features:
EM: Ellsworth Mountains
EWM: Ellsworth-Whitmore block
PSZ: Pagano Shear Zone
RFIS: Ronne Filchner Ice Shelf, overlies
Southern Weddell magmatic province



Jordan et al. 2017, doi: 10.1016/j.gr.2016.09.009

EWM Paleozoic sedimentary record, structural trend, and paleomagnetic data

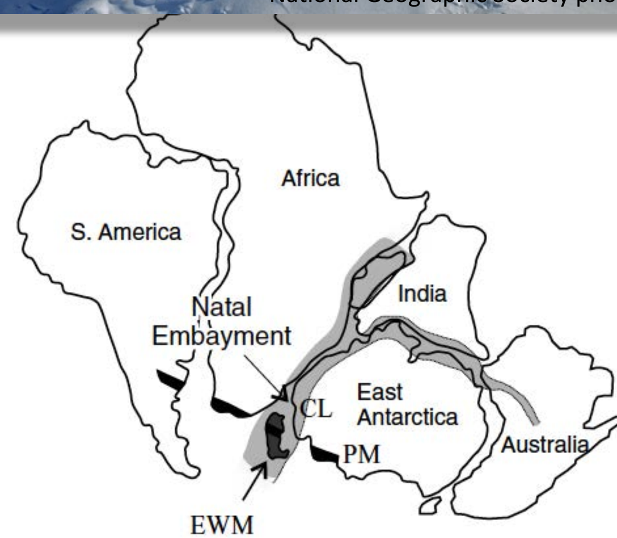


Curtis, 2001, doi: 10.1130/0016-7606(2001)113<0939:THOTEM>2.0.CO;2

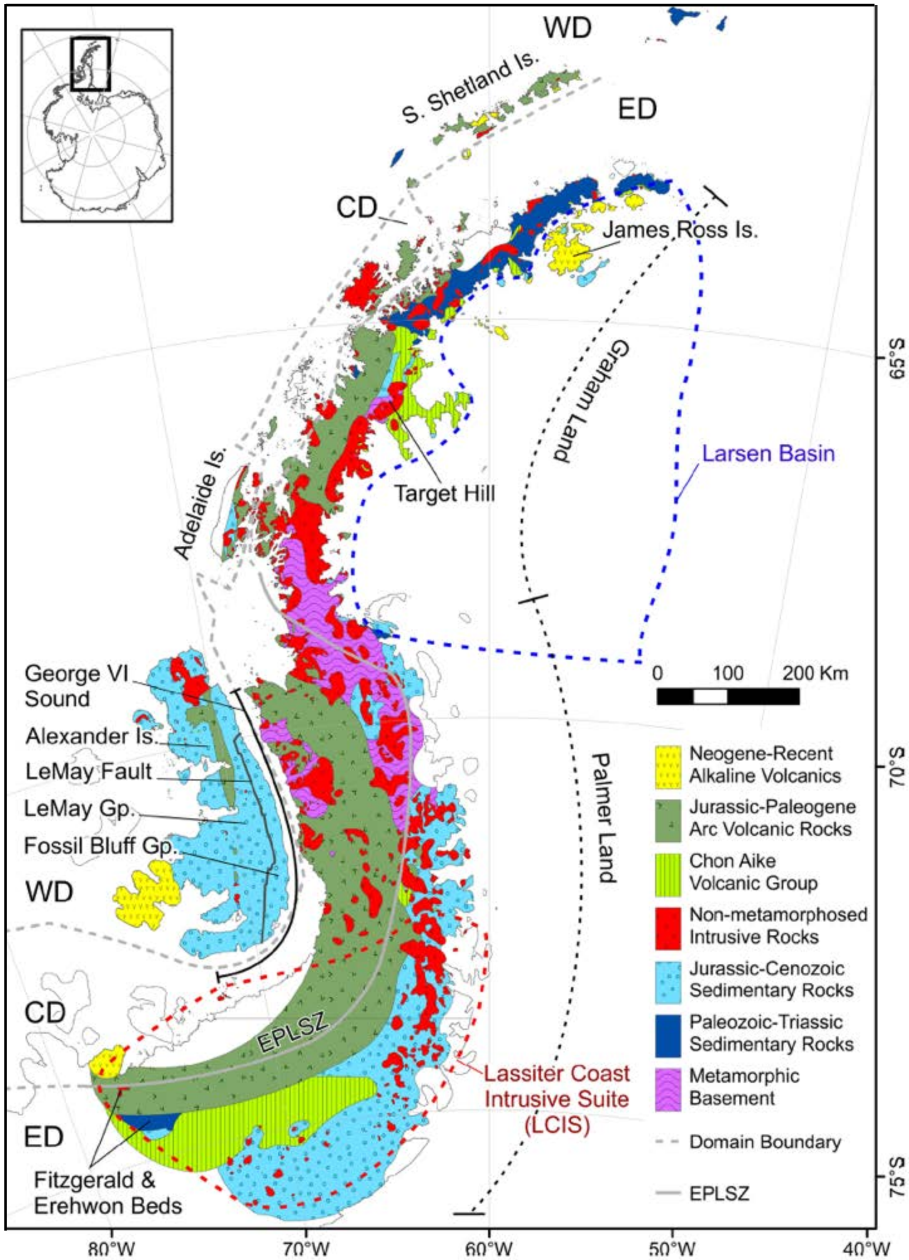
Mt. Vinson

National Geographic Society photo

Cambrian Heritage Group: convergent margin silicilastics deposited in back arc, in an extensional to transtensional basin receiving sediment from continental sources.

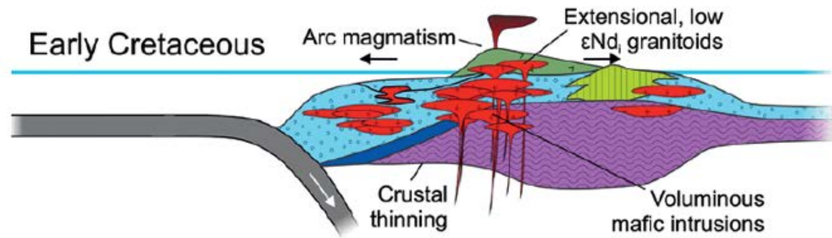


Randall & Mac Niocaill 2004 GJI



Burton-Johnson & Riley, 2015, JGS, doi:10.1144/jgs2014-110

Main phase of continental margin arc magmatism in AP and TI : Cretaceous



Debated geology:
Amalgamation of far-travelled terranes that accreted to the Gondwana margin?
Or not far travelled? (Patagonia is coherent)

The geological record includes well-preserved fore-arc, back-arc and magmatic successions of a continental margin arc. The accretionary continental margin has been long-lived in this sector (Ordovician to present), with especially high magma addition rates during the Cretaceous and Permian. The Permian granite magmatism, ca. 280-250 Ma, affected the AP, north Patagonian Massif and Choiyoi province.

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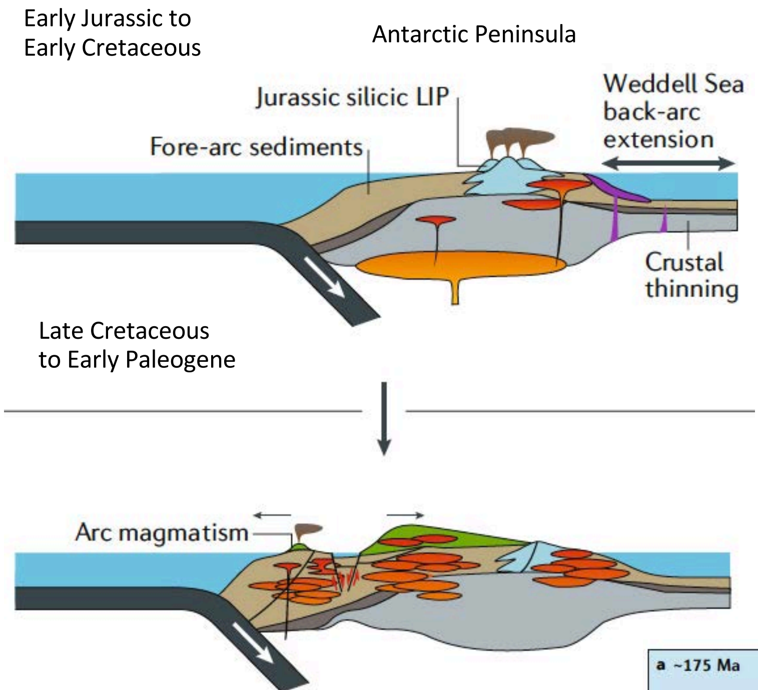
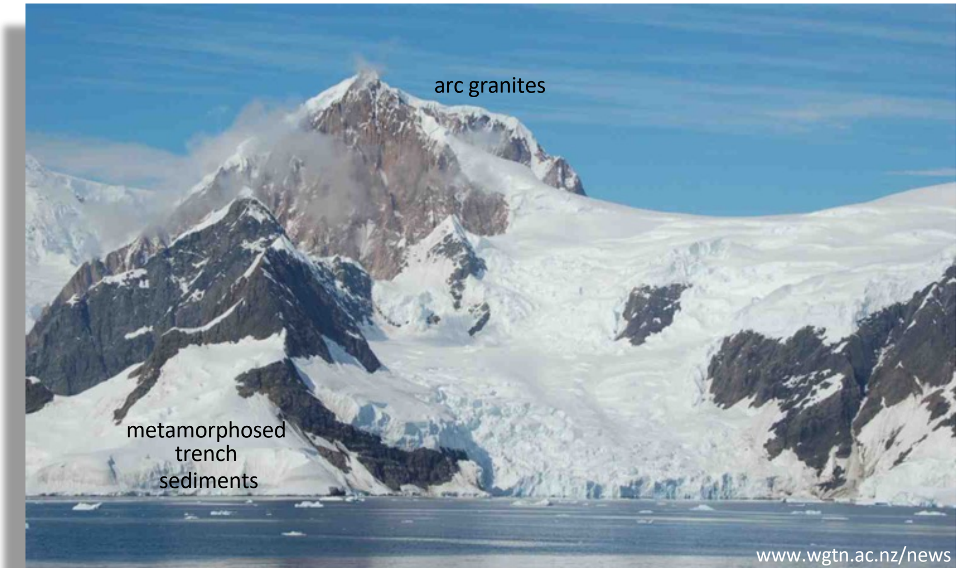
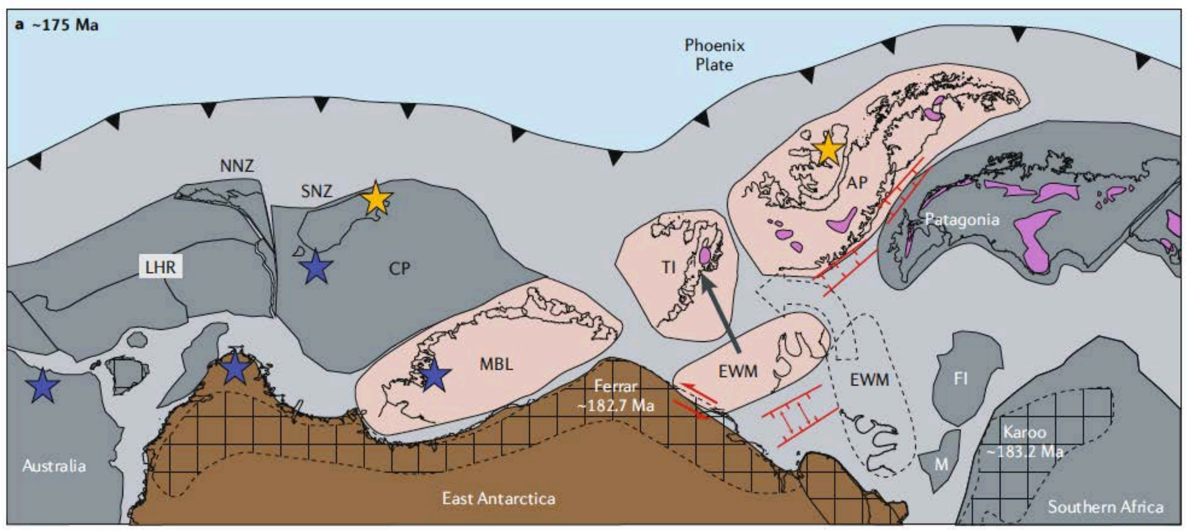
Ongoing subduction and magmatism in Antarctic Peninsula, with only limited extension across the arc.





In the **back-arc region**: tectonism in southern Weddell magmatic province

- wrench and ~30° tectonic rotation?
- >90° tectonic rotation?



Cambr-Ordov marginal turbidites. Triassic fore-arc sediments

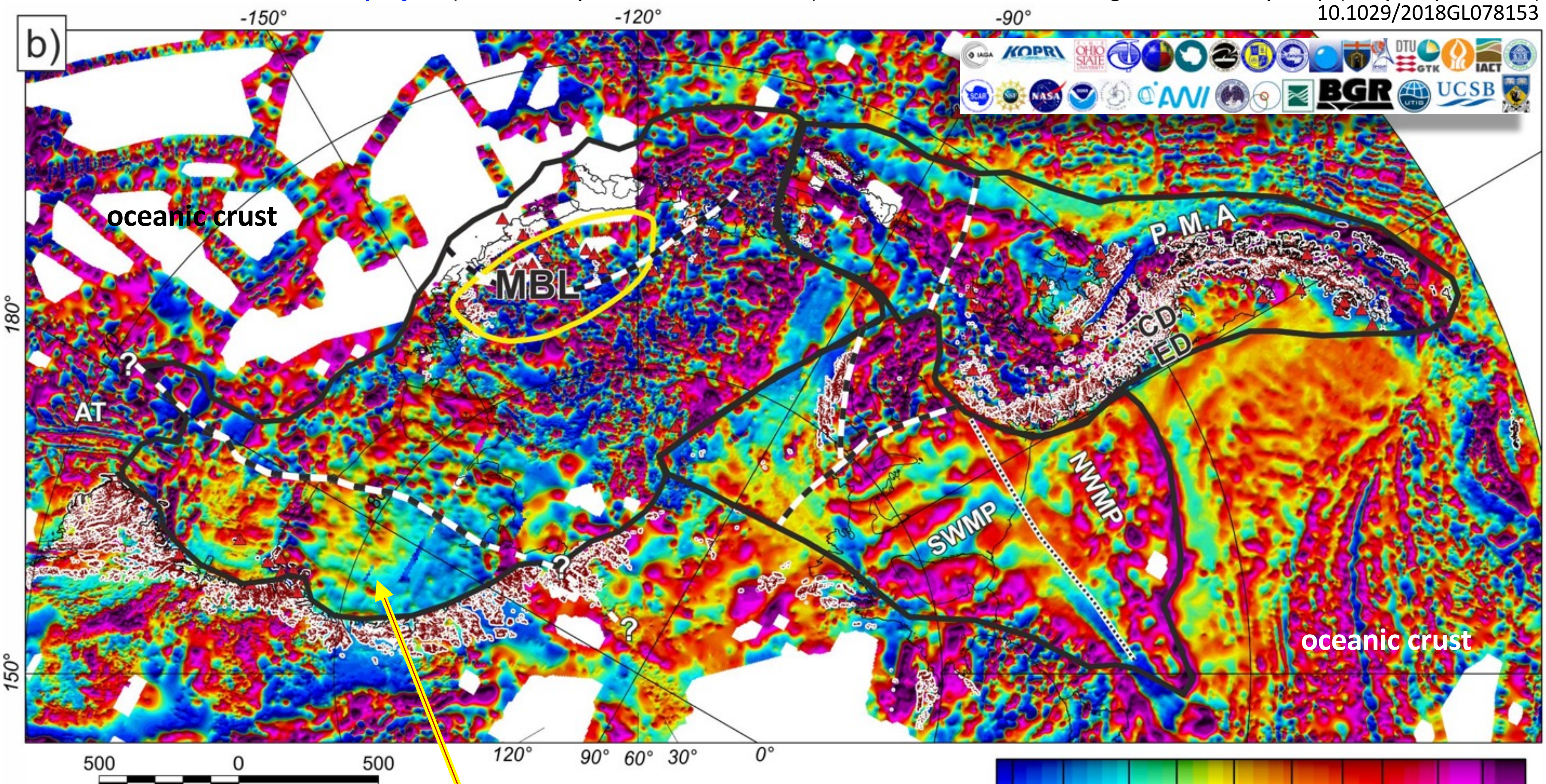
EWM: Ellsworth Mountains province

Jordan et al., 2020, https://rdcu.be/b0OL8

New geophysical datasets – subglacial extent of geotectonic provinces

ROSETTA-Ice project (Ross Embayment, Tinto et. 2019) // **SCAR ADMAP2** aeromagnetic anomaly map (Golynsky et 2018)

10.1029/2018GL078153



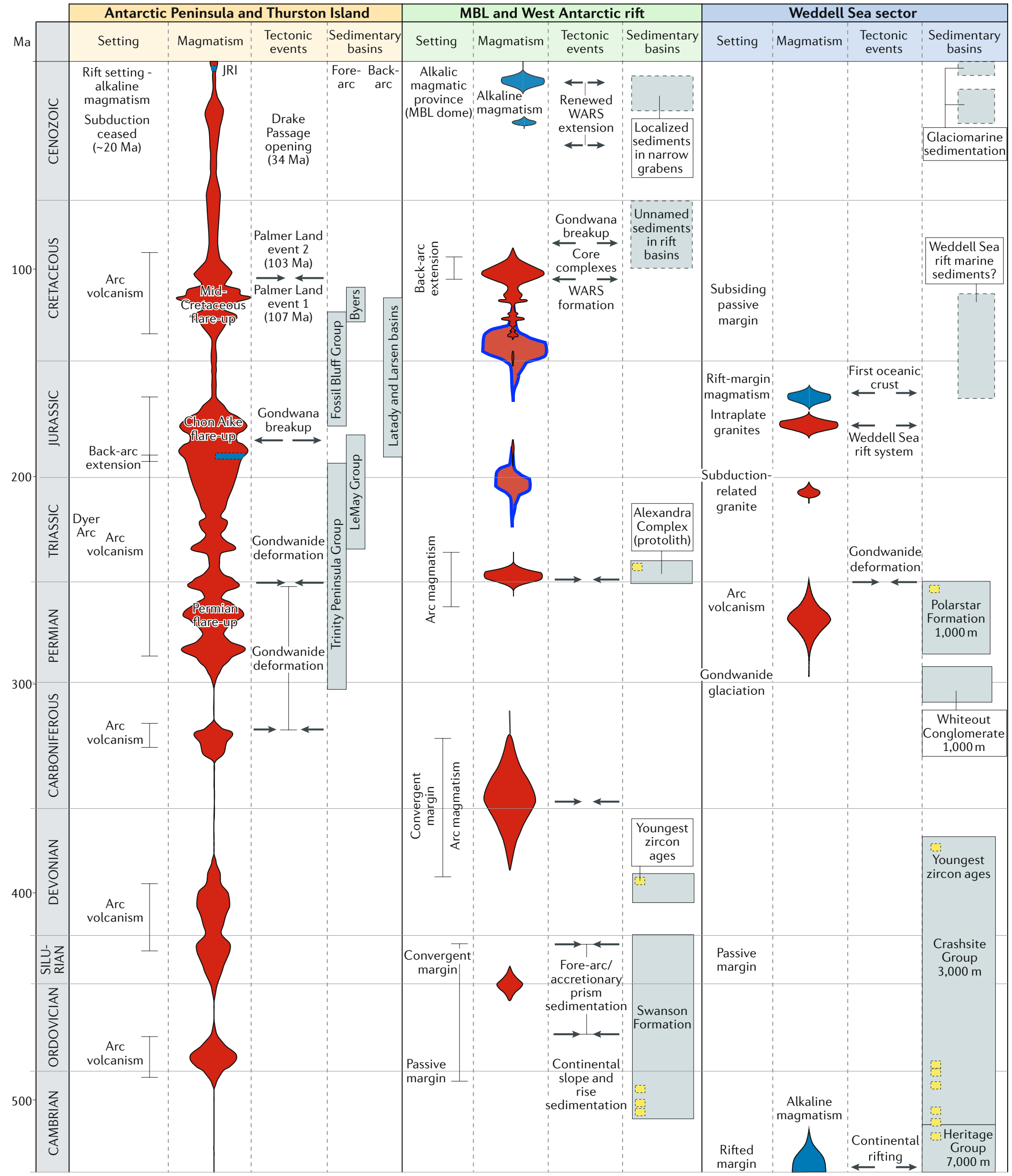
cratonic margin province: magnetically quiet (excluding anomalies related toMcMurdo Volcanic province); signature resembles that of Neoproterozoic – Cambrian passive margin seds of central TAM

Marie Byrd Land (MBL) and West Antarctic rift system (WARS) are characterized by broad areas of crust 20–25 km thick, a product of Cretaceous to Cenozoic extension. The disordered high-amplitude magnetic patterns are attributed to wide-spread plutonic centers and volcanoes.

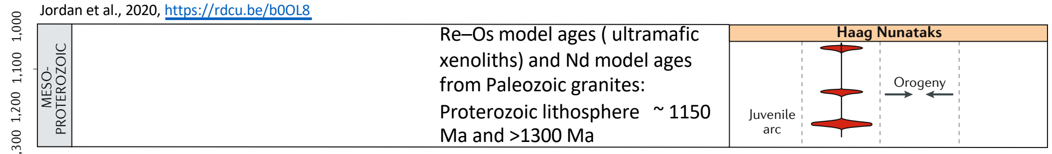
Pacific-margin Magnetic Anomaly (PMA), ~2,600-km-long: attributed to well-preserved magmatic arc. There is detailed structure within the magnetic anomalies, attributable to periods of contraction and crustal thickening.

Timeline of tectonic – magmatic events

Marie Byrd Land, West Antarctic rift system and Zealandia *

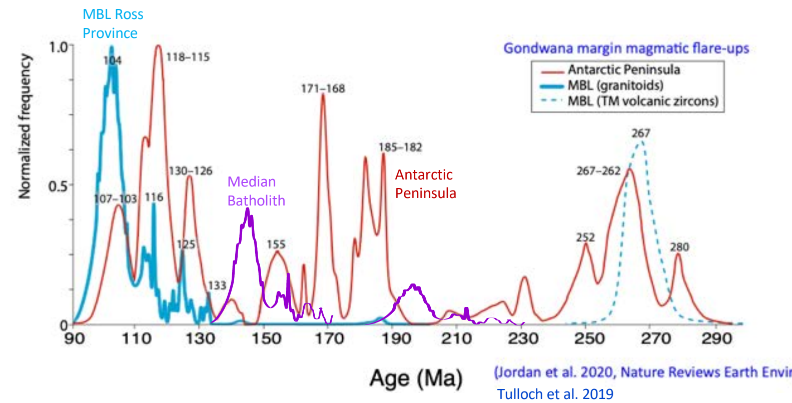


Jordan et al., 2020, https://rdcu.be/b0OL8



Re–Os model ages (ultramafic xenoliths) and Nd model ages from Paleozoic granites: Proterozoic lithosphere ~ 1150 Ma and >1300 Ma

Re-Os: Handler et 2003, doi:10.1016/S0009-2541(02)00410-2



(Jordan et al. 2020, Nature Reviews Earth Envir)
Tulloch et al. 2019

* ***Zealandia***: New Zealand plus submerged continental crust (Mortimer, 2017, doi: 10.1130/GSATG321A.1

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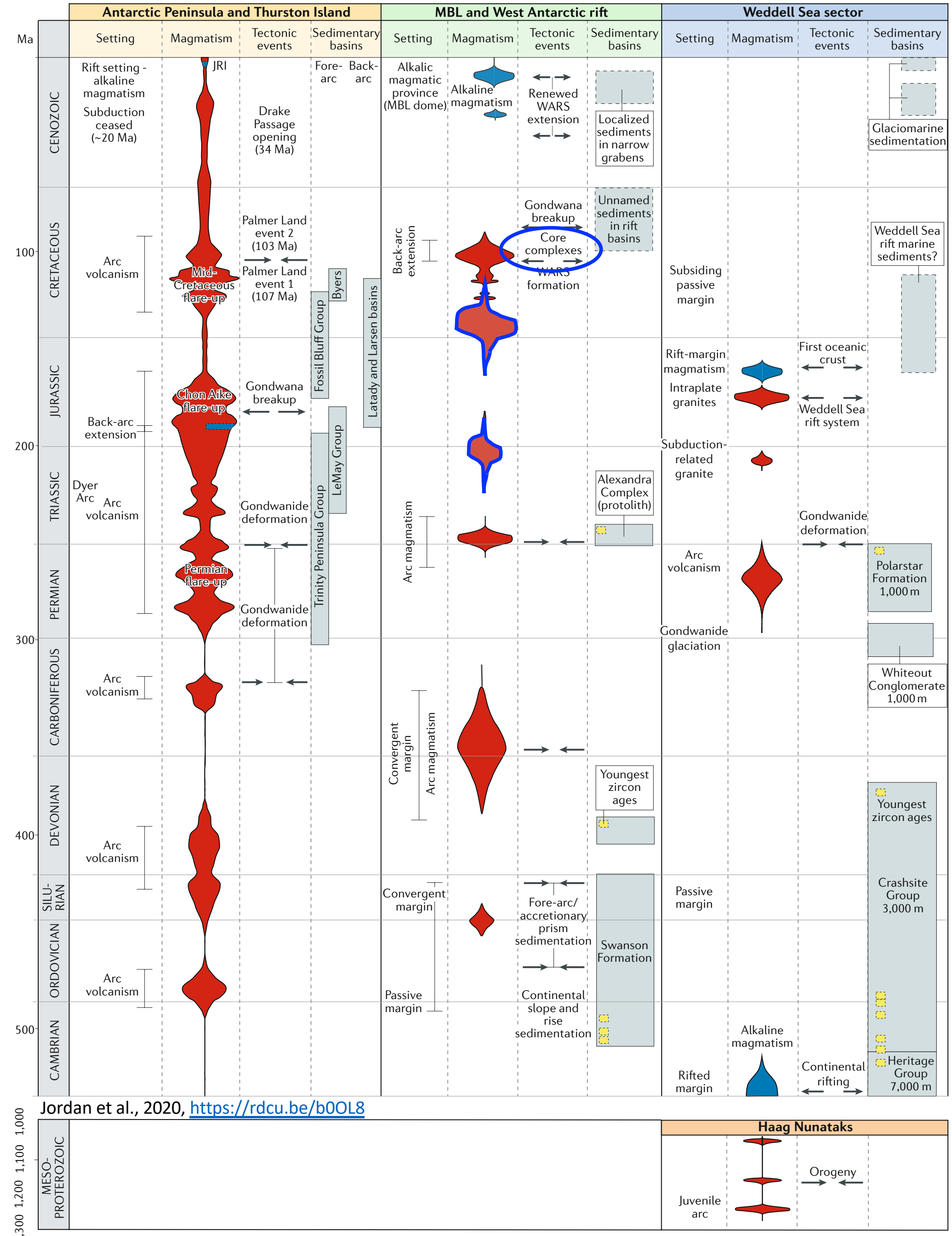
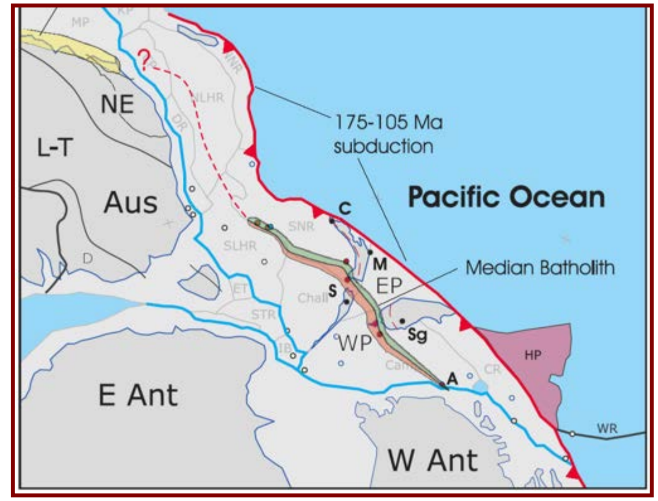
Timeline of tectonic – magmatic events

Marie Byrd Land + Zealandia



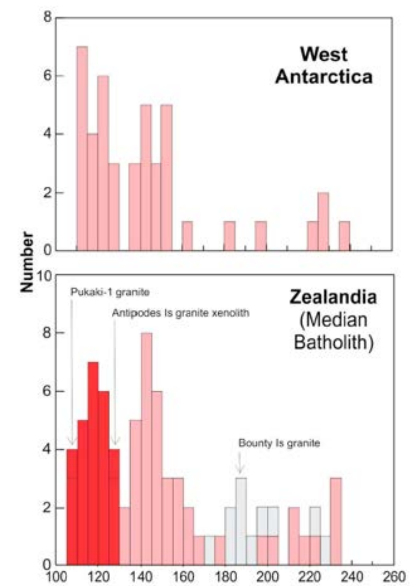
Jordan et al., 2020, https://rdcu.be/b0OL8



Base map: reconstruction of Tulloch et al. 2006

Broad margin with Mesozoic magmatic arc traversing Zealandia in the outboard position

Flareup with short voluminous magmatism is recorded in Median Batholith, Zealandia



Tulloch et al. 2019, 10.1029/2018TC005116

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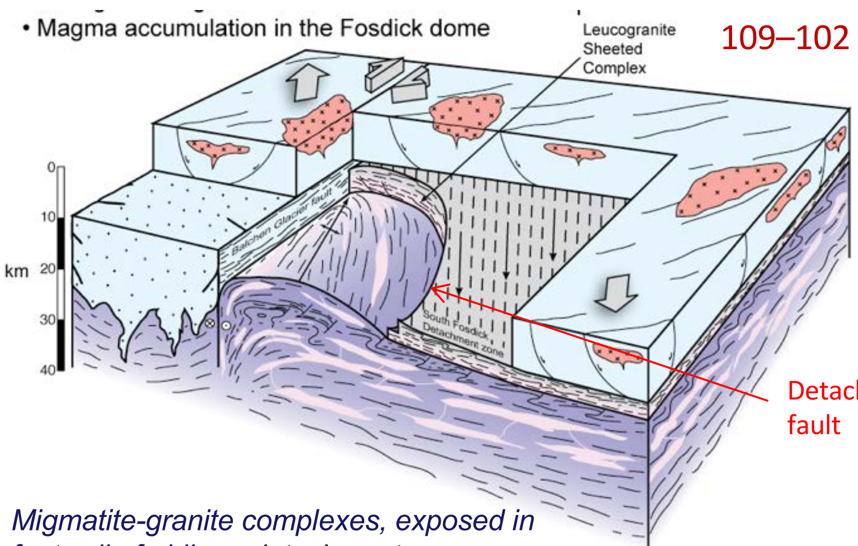
MBL magmatic flare-up:

Granulite facies metamorphism, crustal melting, core complexes formed and cogenetic granites emplaced. Dramatically rapid cooling of footwall rocks and granites.

MBL flare-up: migmatization and mafic dyking



Melting and weakening of of mid-crust, migration to form granites. Folding and flow of melt-rich middle crust. Rapid exhumation upon detachment zones and wide extension.

Migmatite-granite complexes, exposed in footwall of oblique detachment zones
McFadden et al, Tectonics, 2010, 2015
Brown et al. 2015.

Comparison of sectors

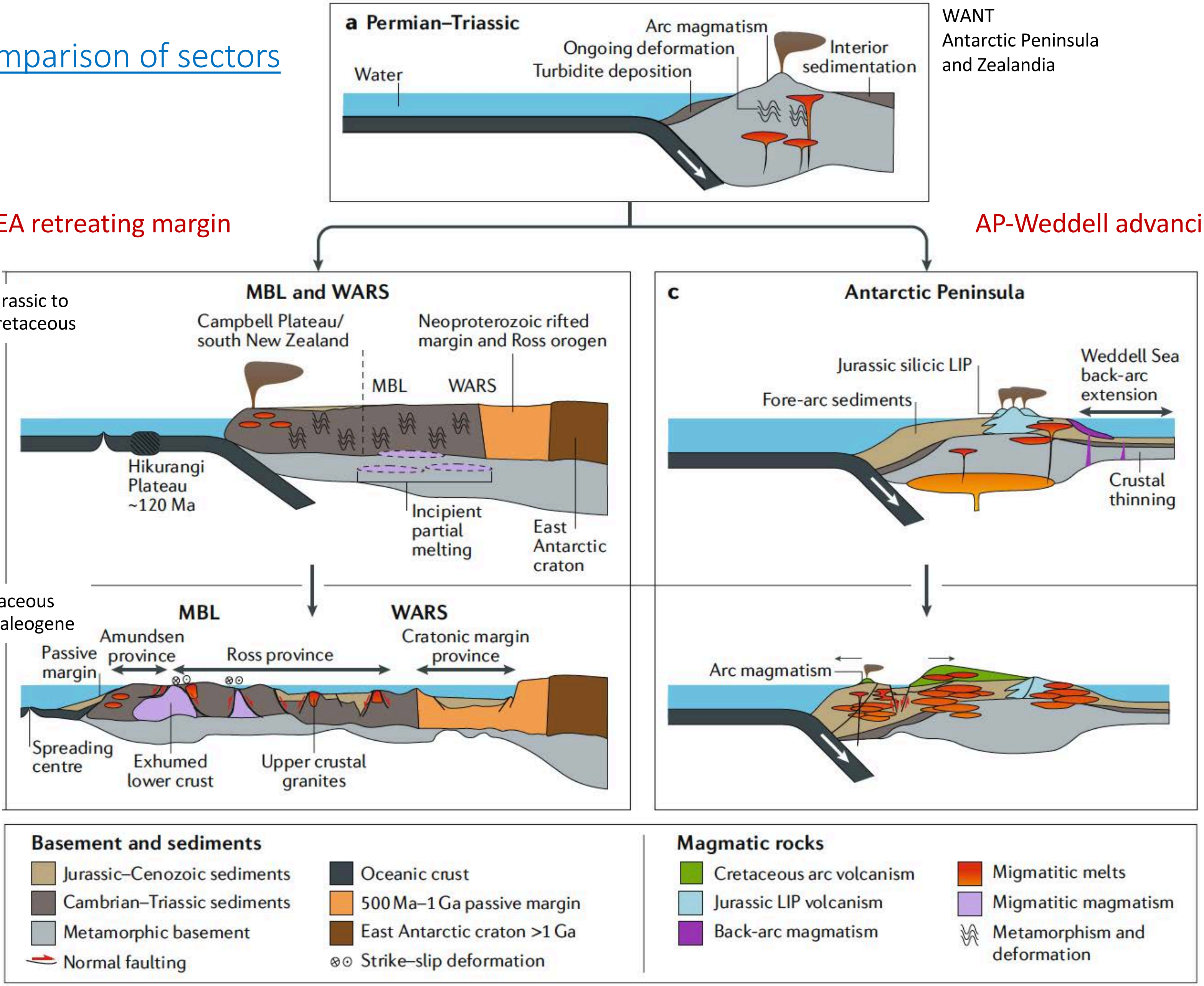
WANT
Antarctic Peninsula
and Zealandia

MBL-ZEA retreating margin

AP-Weddell advancing margin

Early Jurassic to
Early Cretaceous

Late Cretaceous
to Early Paleogene



What of the active volcanism ?

Thin crust of the retreating-mode margin has undergone repeated tectonic reworking with development of enduring crustal scale structures; underlain by anomalous mantle.

Pictured here: Basanite-trachyte flows, ~1.4 to 1.1. Ma, containing ultramafic xenoliths of varied composition

See Gaffney & Siddoway, ISAES 2007

Marie Byrd Land volcanic province, 13 Ma to present (plus few older centers).

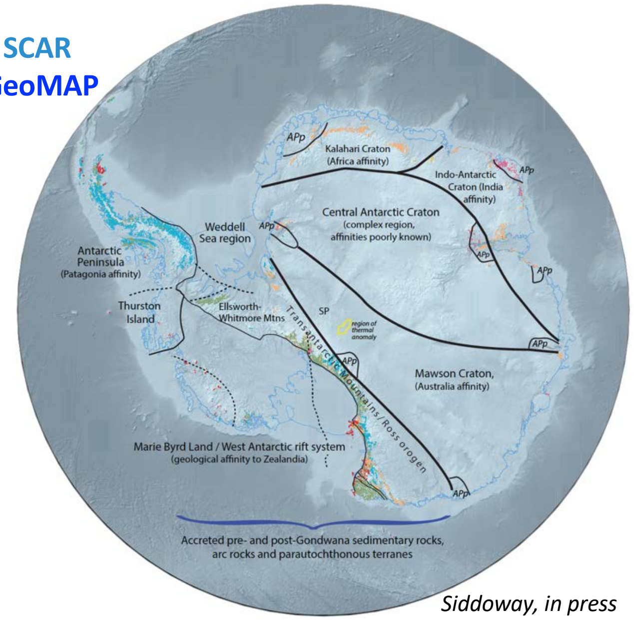
Credit: Tim Ivanic & Chris Yakumchuk

PHOTO: Demas Bluff, Fosdick Mountains – lavas containing deep sourced, diverse assemblage of ultramafic xenoliths

Conclusions (Part I)

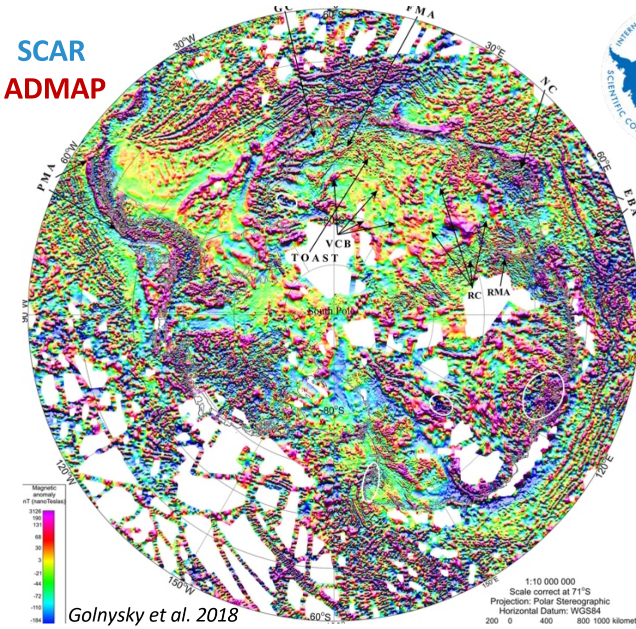
Geological analysis of the exposed rocks and geophysical observations together provide the means to unveil more of the region's complex history.

SCAR
GeoMAP



Siddoway, in press

SCAR
ADMAP



Golnysky et al. 2018

The updated framework presented here is a product of this joint approach. Key elements are:

1) the broader subglacial extent of WANT tectonic provinces (terranes)
2) varied tectonic-magmatic processes led to creation and stabilization WANT-Zealandia continental crust along an accretionary margin, tectonically active since 500 Ma
3) thin crust and extensive magmatism are a sign of repeated tectonic reworking that created a) distinctions between terranes and b) a common geotectonic history.
4) available for testing and refinement, and evaluation in the context of new research initiatives, including the new Lithosphere of East Antarctica program.

First meeting
12 Aug. 21:00 UTC

Base map: Smith Lyttle & Cox, GeoMAP

Acknowledgements

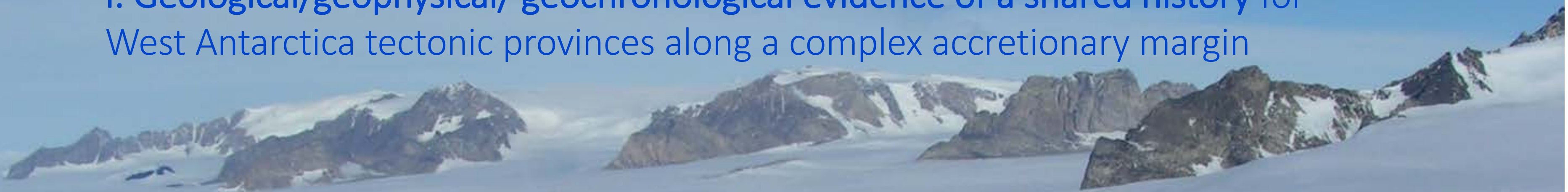
Updated tectonic framework of West Antarctica

Siddoway, Jordan, Riley, Tinto & Tankersley

Place in the Presentation: beginning of Part II

Part I, completed

I. Geological/geophysical/ geochronological evidence of a shared history for West Antarctica tectonic provinces along a complex accretionary margin



II. Geophysical remote sensing reveals the subglacial extent of geological provinces; new tectonic scenarios emerge.

- Ellsworth-Whitmore province (*Jordan et al. 2017*)
- Antarctic Peninsula (*Burton-Johnson & Riley, 2015*)
- Ross Embayment cratonic margin province (*Tinto et al. 2019*)

Part II, ahead

III. The inboard limit of West Antarctica in Ross Embayment

- **Defined by crustal geology or physiography**?
- Transantarctic Mountains or Central High as boundary of cratonic margin province?

IV. Utility of updated crustal geology and tectonic framework, and hypothesis testing

Relevant to many areas of contemporary research: paleotopography, glacial processes, subglacial hydrology, heat flux, glacial isostatic response

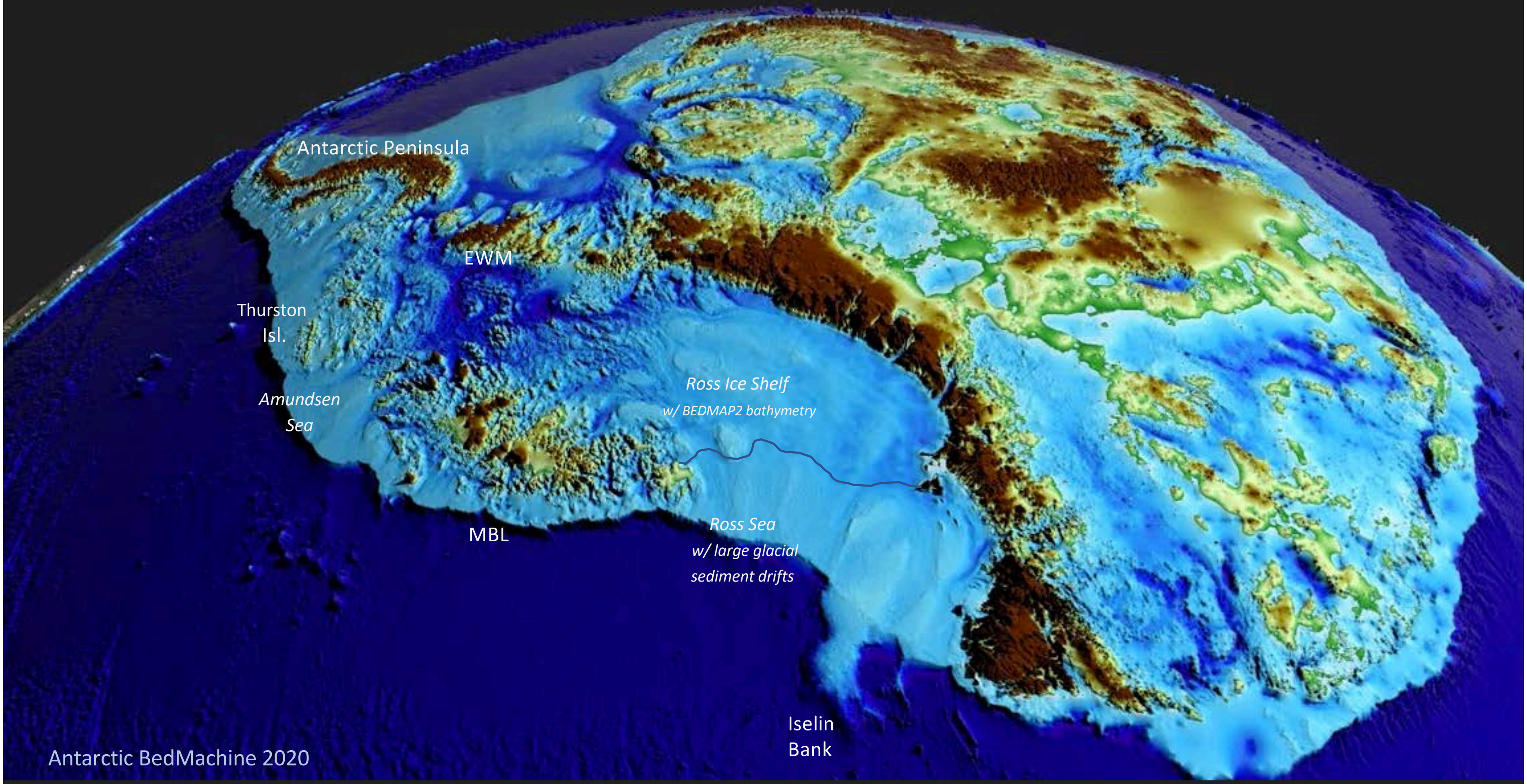
PHOTO: Fosdick Mountains granite-migmatite complex, exposed in footwall of a crustal detachment

The inboard limit of West Antarctica in Ross Embayment

- **Defined by crustal geology or** physiography?
- Transantarctic Mountains or Central High as boundary of cratonic margin province?

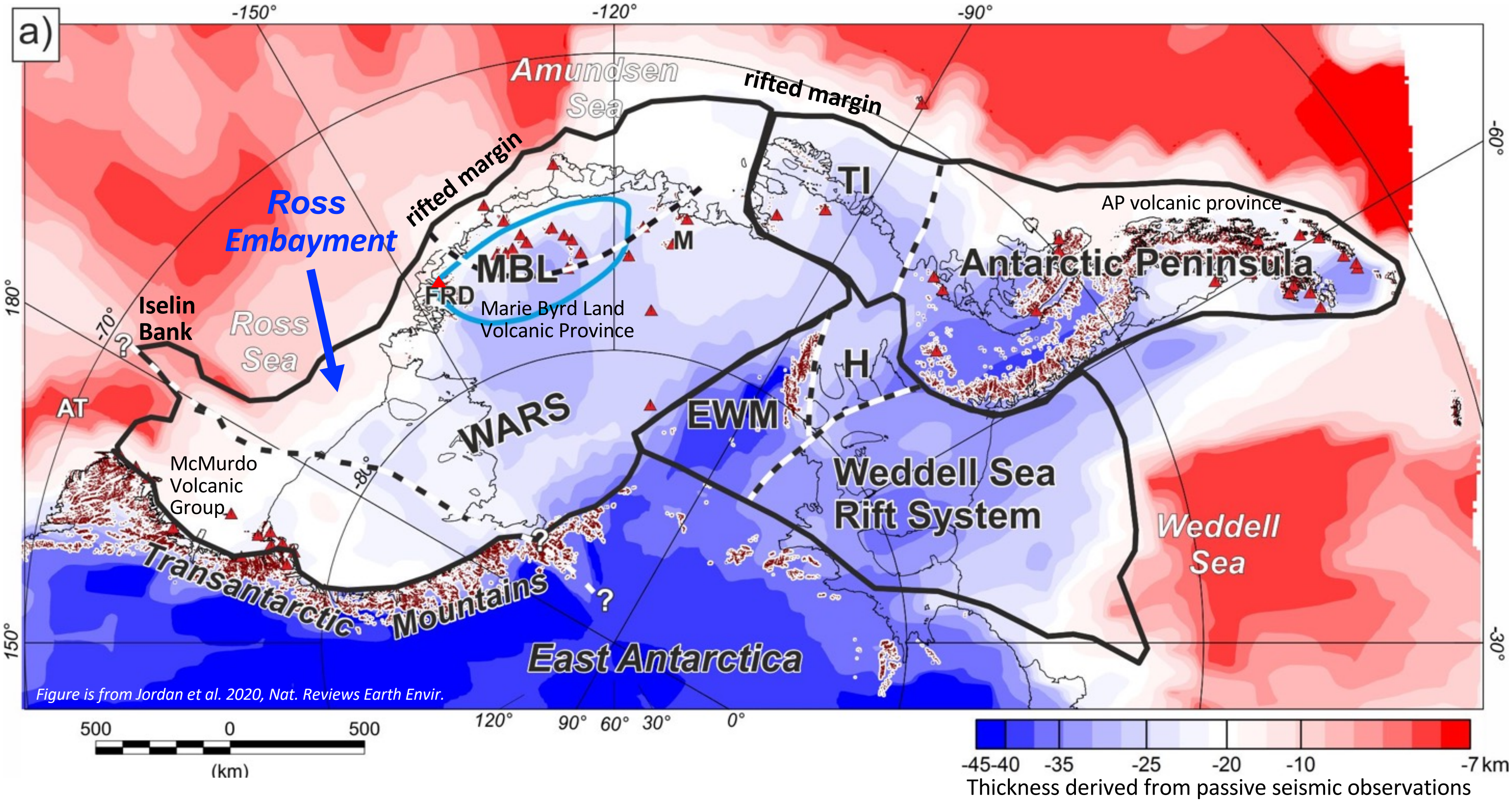
Transantarctic Mountains form the physiographic boundary of East Antarctica.

Antarctica subglacial topography



Where is the inboard limit of West Antarctica within the Ross Embayment ?

Are there cues from the crustal thickness map and the distribution of Cenozoic volcanic provinces ?



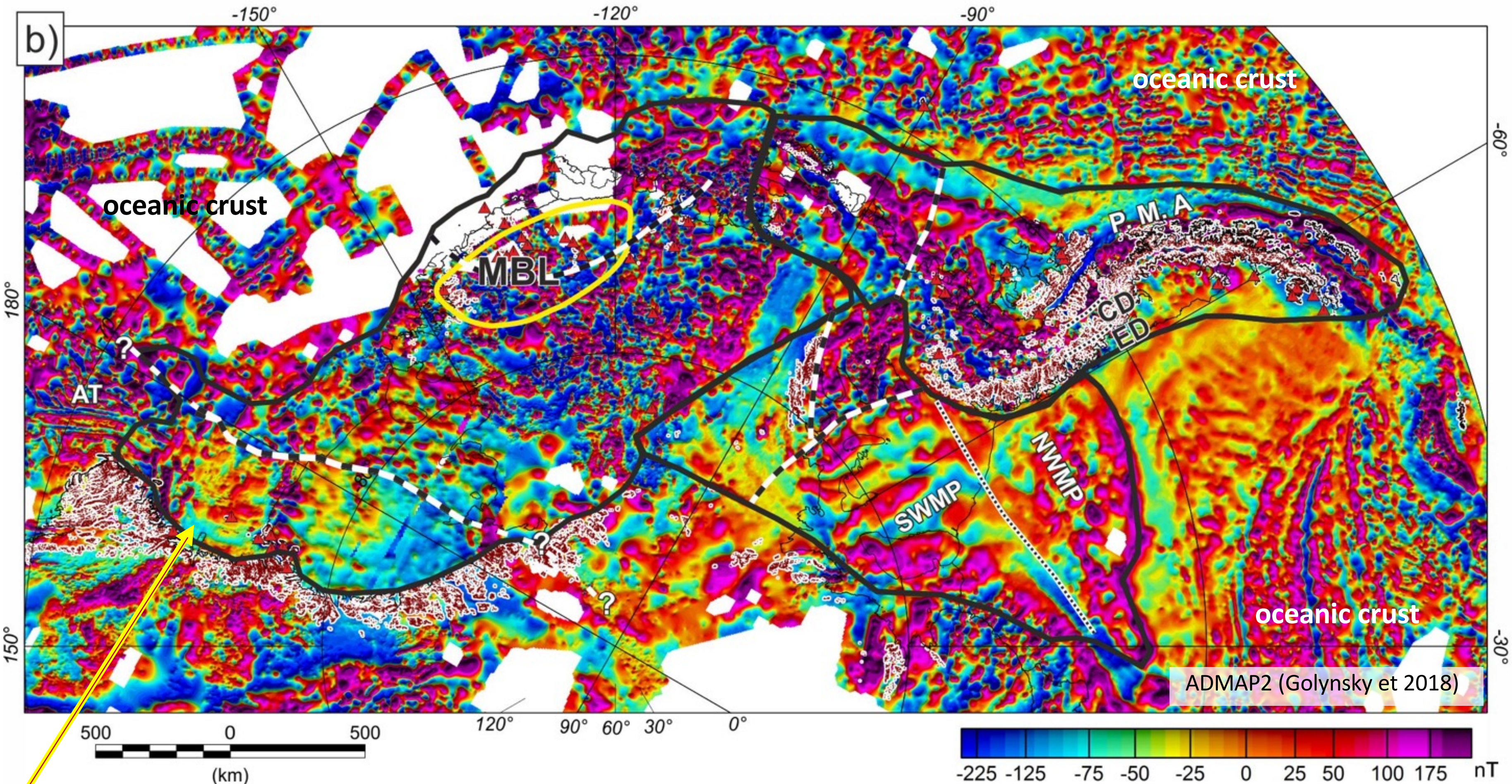
Major volcanoes formed 13 Ma to present, with isolated instances of Oligocene or earlier activity.

Heat flow measurements: 83 to 126 mW/m^2, some localities >250 mW/m^2

Crustal thickness: EANT, 35–45-km. Ross Embayment, 15-28 km, and WANT, 22-32 km (Chaput et al. 2014).

A linear 'ridge' of thicker crust, ~28 km, is apparent along the midline of the Ross Embayment. It trends ~ N-S, parallel to the trend of the Iselin Bank 'promontory' upon the rifted margin. There are no known centers of volcanism along the ridge nor the bank.

Magnetic character of MBL+ eastern Ross Embayment vs. western Ross Embayment



Cratonic Margin Province: magnetically quiet
Signature resembles that of Neoprot. – Cambrian passive margin seds of CTAM (Goodge & Finn 2010) and the western Ellsworth Mountains block (which lacks outcrops).
High gradient anomalies attributed to McMurdo Volcanic province stand out from the characteristic pattern for west half of Ross Embayment.

MBL characterized by short wavelength, high-amplitude magnetic anomalies, reflect the regional geology: wide-spread plutonic centers and volcanoes.

See next slides: **ROSETTA-Ice project** (Ross Embayment, Tinto et. 2019)

Higher resolution data for southern Ross Embayment collected by
ROSETTA-Ice Project: Ross Ocean and Shelf Environment, and Tectonic setting Through Aerogeophysical surveys

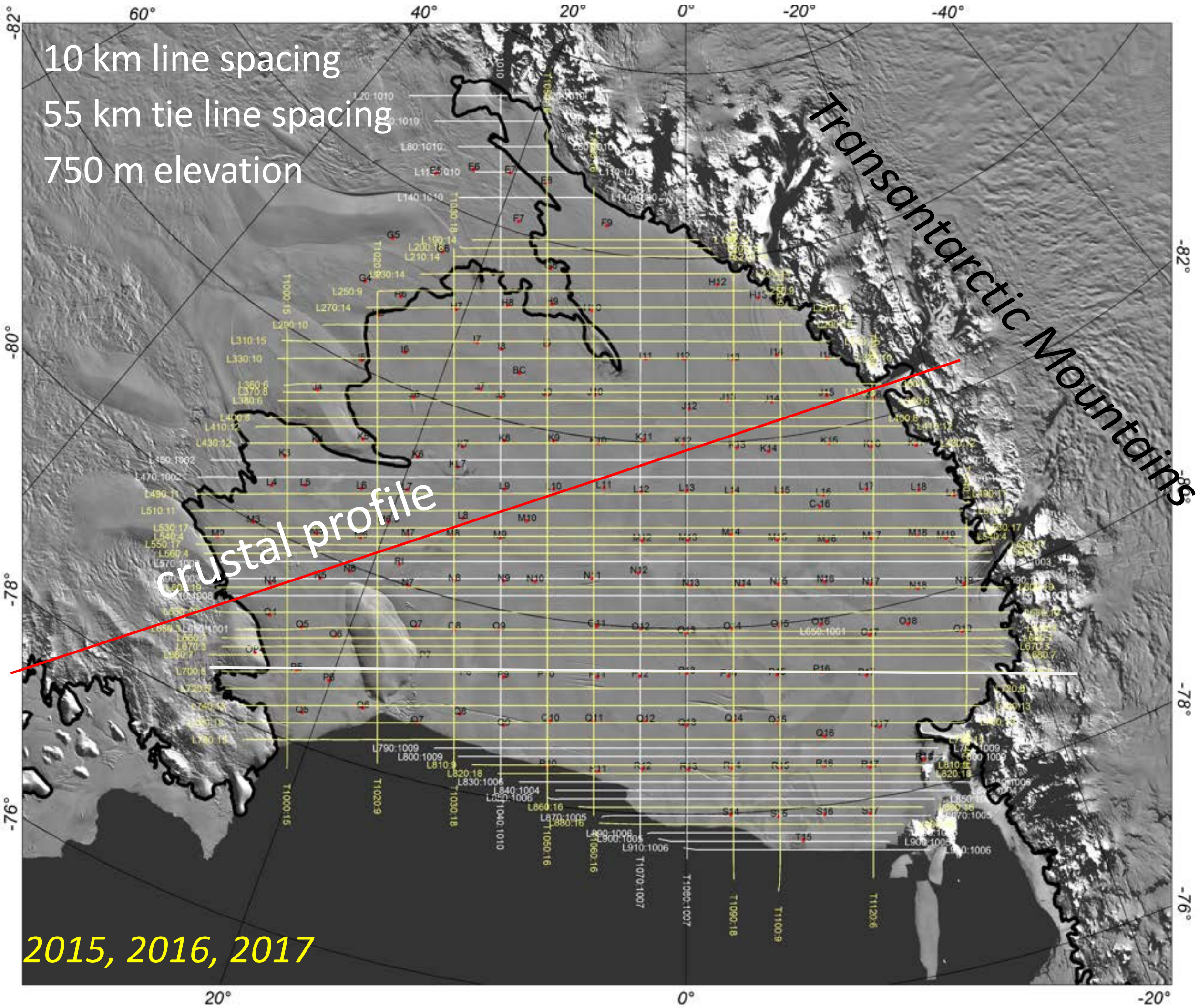
Airborne survey 2015-2017

Ross Ice Shelf : 476,000 km^2 area

Ice sheet 400 to >1000 m thick

Scintrex Cesium CS-3 magnetometer
DGS gravity meter
GNS gravity meter
Shallow ice sounding radar
Depth sounding radar
RIEGL VQ-580 Swath scanning laser
IMPERX Bobcat 29MP visible camera
SOFRADIR IRE640L infrared camera
Heitronics KT15-IIP Pyrometer

Two lines parallel to Operation IceBridge flight lines



Note the lines of longitude.
North is down, in this figure.

GORDON AND BETTY MOORE FOUNDATION
SCAR 2020 ONLINE

Prominent contrast

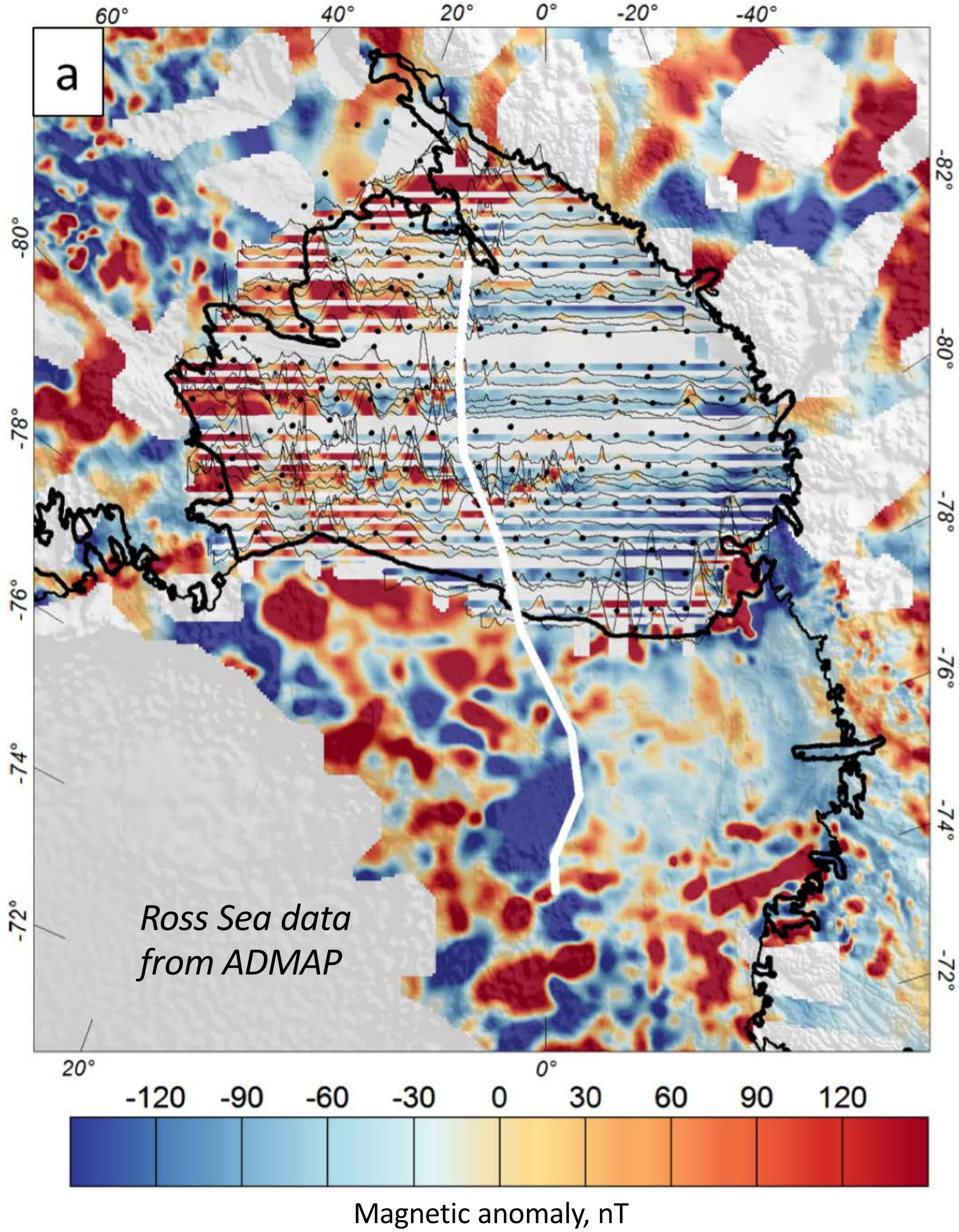
Magnetic Anomalies

high amplitude

wavelength ~20 km

Shallower depth to mag basement

High amplitude anomalies continue North across Ross Sea



low amplitude

wavelength ~50 to 70 km

subdued *magnetics continu*
across Ross Sea

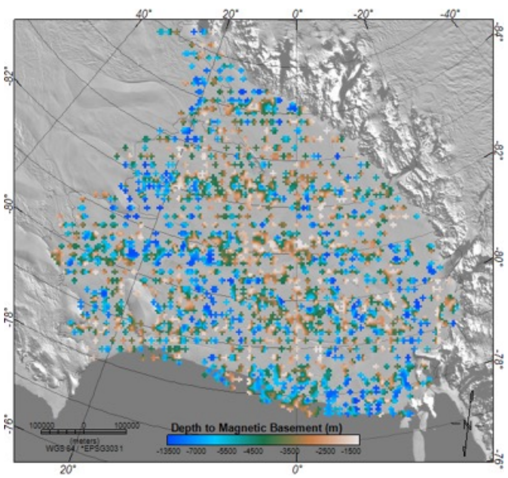
Note the lines of longitude. North is down, in this figure.

The Central High –prominent structure

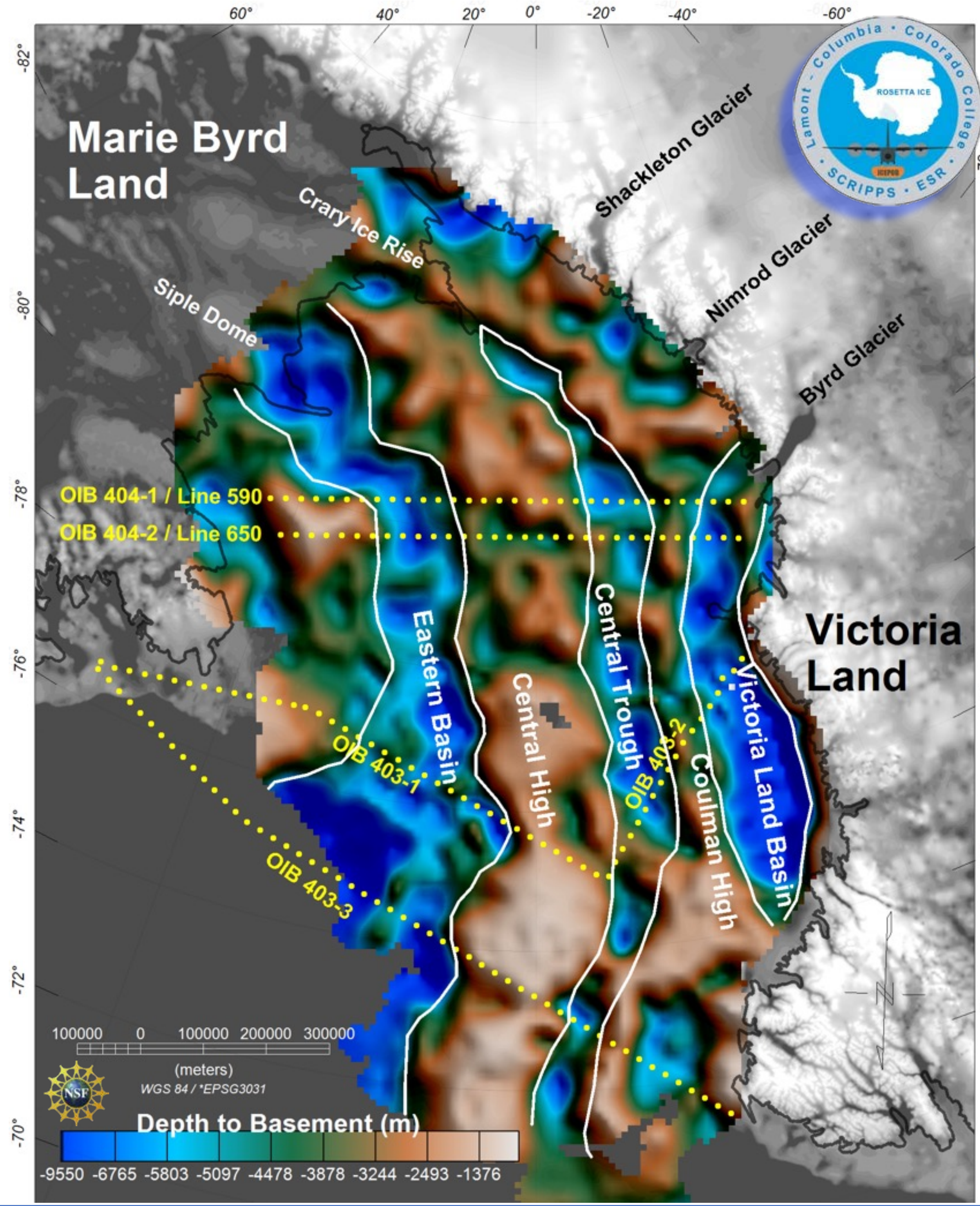
Southward continuation defined in this map of ROSETTA-Ice magnetic basement

Structures identified from seismic acoustic basement in Ross Sea, outlined in white. The major features are observed to continue southward beneath Ross Ice Shelf.

Rosetta-Ice Ross Ice Shelf data leveled to ANTOSTRAT acoustic basement, and joined to form a continuous surface.
Line pattern outlines the southward continuation of Ross Sea basement features.
Two ROSETTA-Ice flight lines coincide with Operation Ice Bridge flight lines (yellow dotted pattern).



Werner deconvolution solutions with depth limits between sea level and 20km (Tankersley et 2018 AGU)



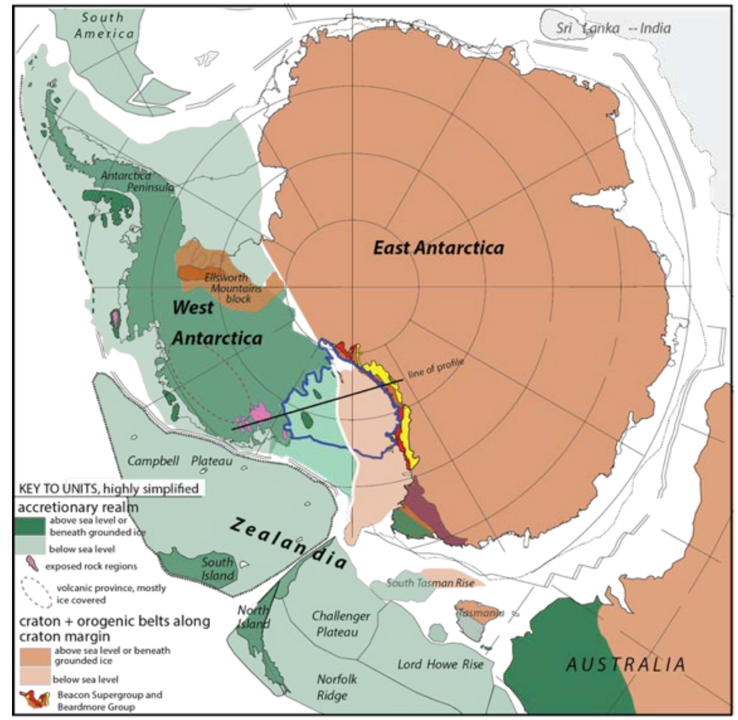
Work in progess:

M. Tankersley, Victoria Univ. Wellington, in progress; and 2018 AGU Fall Meeting.

Our RIS crustal profile – portrays extended "EANT-type" crust beneath Ross Embayment

Ice sheet 400 to >1000 m thick, upon ocean

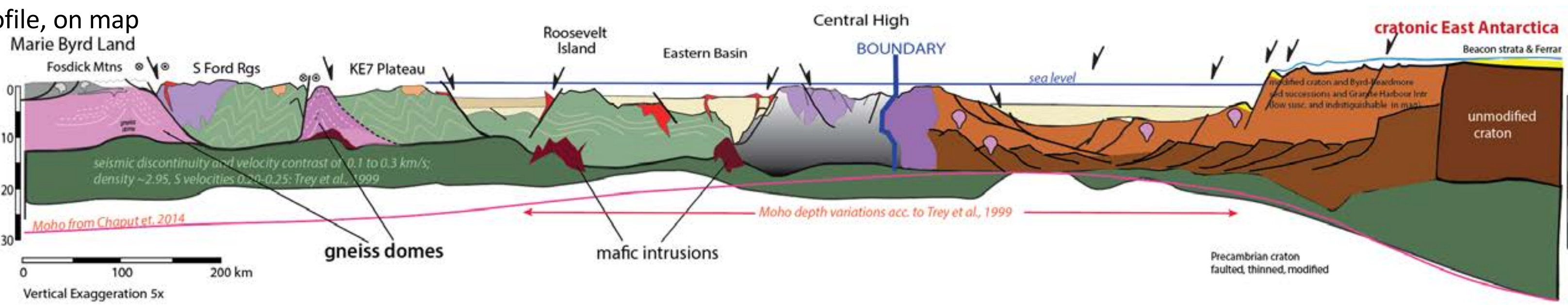
1) *Geophysically defined: Magnetics & gravity*



Future opportunity to rigorously test
Lithosphere of East Antarctica program.

First meeting
12 Aug. 21:00 UTC

Line of profile, on map

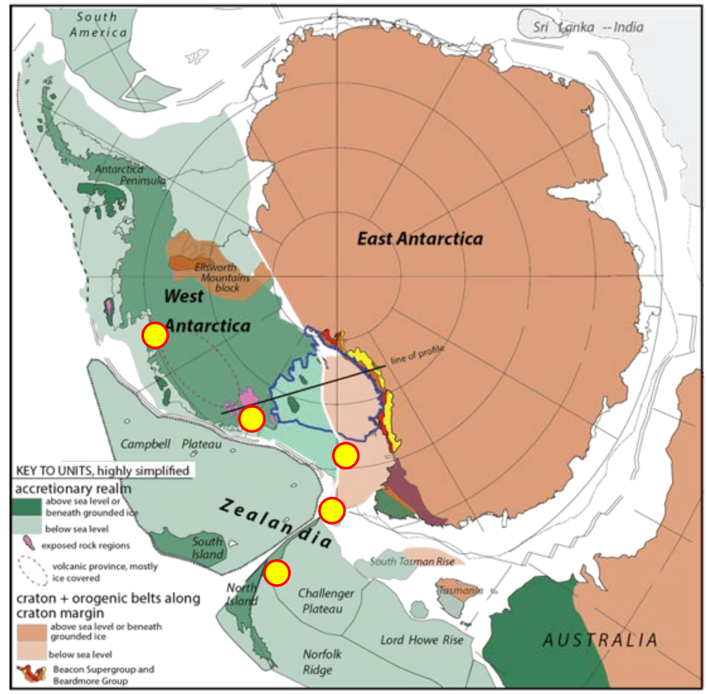


Tinto et al. 2019, Nature Geoscience, doi 10.1038/s41561-019-0370-2

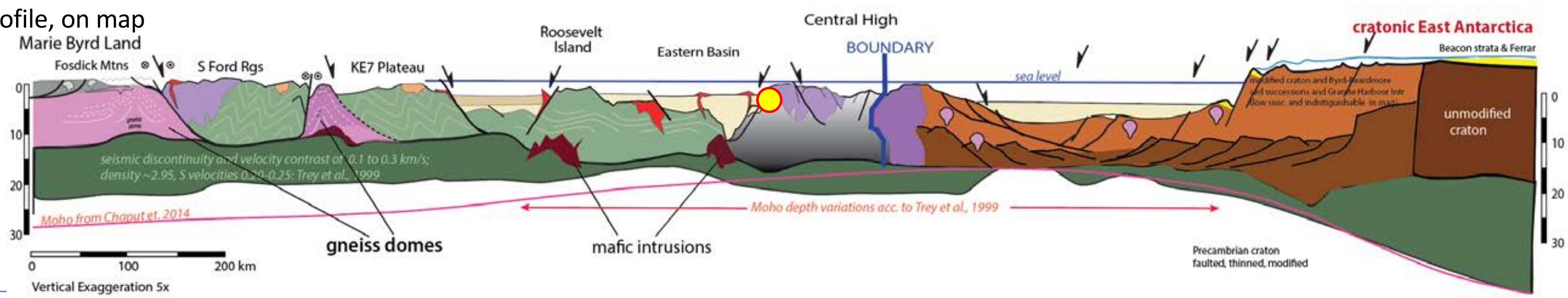
Our RIS crustal profile – portrays extended "EANT-type" crust beneath Ross Embayment

Reasons why the interpretation is geologically valid

1) *Geophysical characteristics: Magnetics & gravity (Tinto et al., 2019)*
2) Zealandia (once contiguous with MBL, see map) restores to MBL, with edge of Campbell Plateau 'tipping out' at Iselin Bank. *Logically, the RIS "MBL-side" is Campbell Plateau-type crust, and the TAM-side is not Campbell Plateau type-crust.*
3) Continental extension is achieved through displacements on arrays of faults throughout the extended region, each of which accommodate a portion of the deformation. (not an individual fault that abruptly truncates the crustal geology - see next slide)
4) The TAM do not form a 'hard' boundary: Ross Orogen-type (~TAM)
   plutonic and metamorphic rocks exist outboard of the TAM (Ross Embayment, MBL, and ZEA Western Province)
   • overlap sequence of Cambrian-Ordov. siliciclastic sediment links CTAM and MBL
5) As recently as Oligocene, the Central High formed the prominent physiographic edge of Antarctica; see slide (not the TAM, as today)

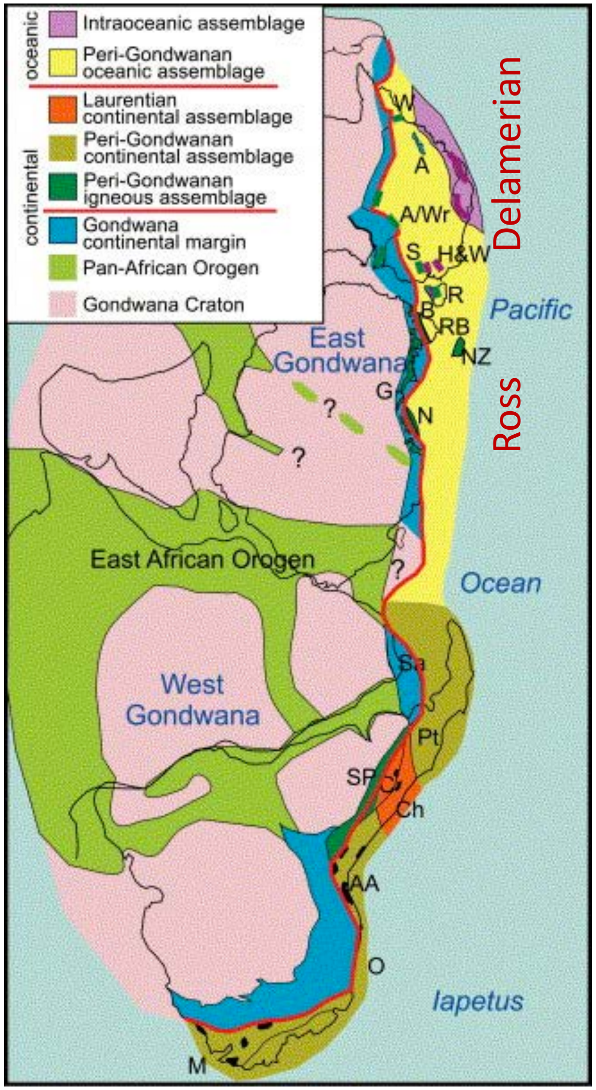


Line of profile, on map



Tinto et al. 2019, Nature Geoscience, doi 10.1038/s41561-019-0370-2

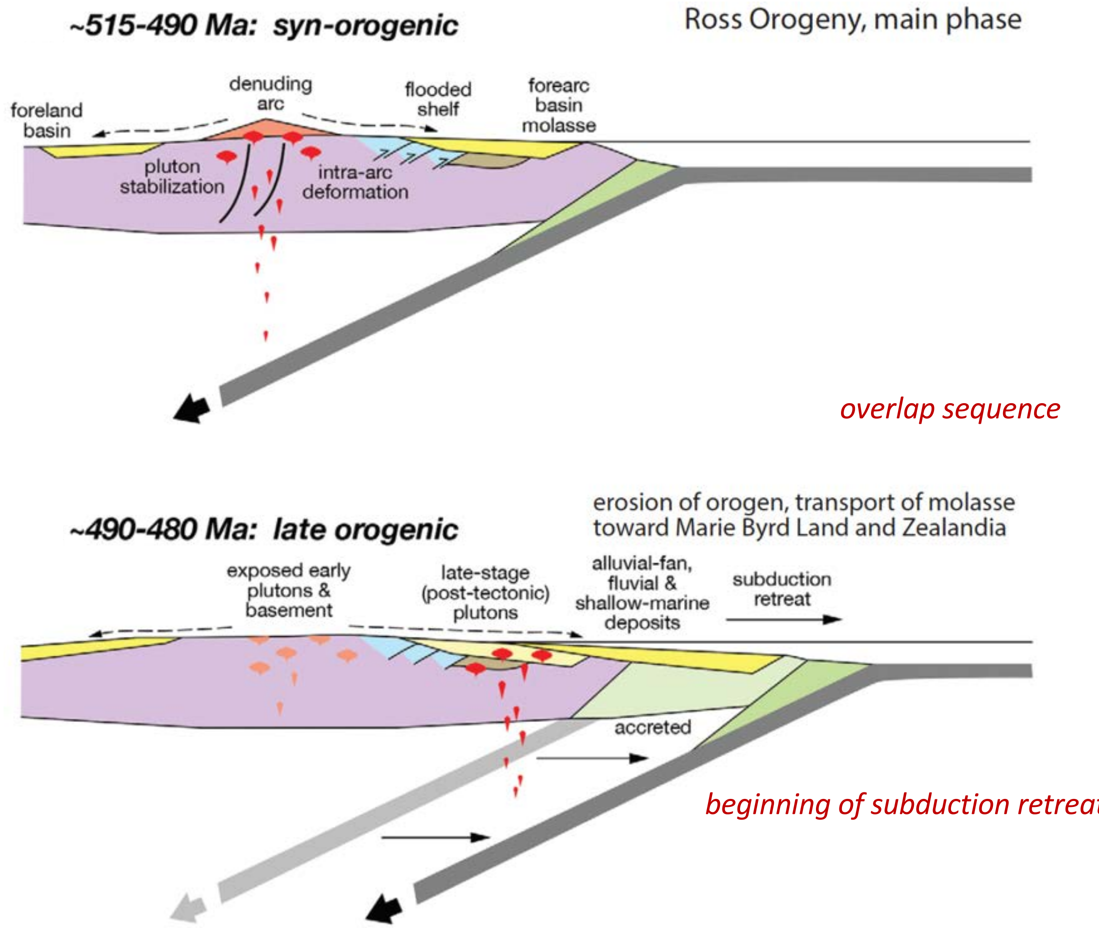
Cambrian – Ordovician Ross – Delamerian Orogen



Cawood, 2005, ESR, 10.1016/j.earscirev.2004.09.001

Transantarctic Mountains

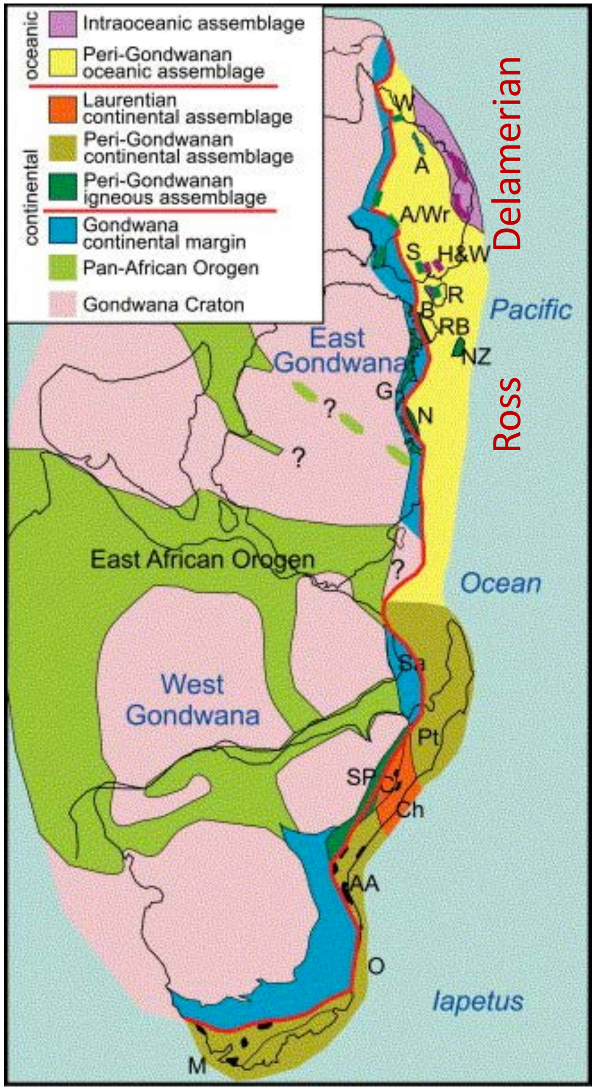
Ross Orogeny, main phase



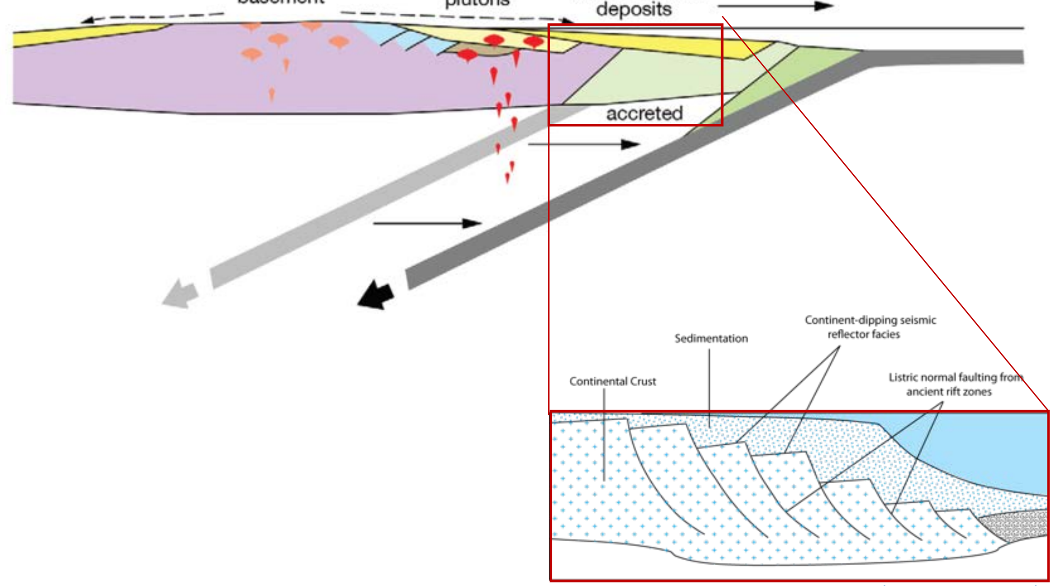
Goodge, 2020, Gondwana Research, 10.1016/j.gr.2019.11.001

Comparisons of detrital zircon U-Pb data for CTAM – Pensacola versus Ford Ranges (MBL) suggest common sources from some units

Cambrian – Ordovician Ross – Delamerian Orogen



Cawood, 2005, ESR, 10.1016/j.earscirev.2004.09.001



en.wikipedia.org/Passive_margin#/

Crust thinned and subsided. If magnetic, source is at greater depth.
Sediment cover, thicker: continentally derived, non/low magnetism due to subaerial weathering and transport

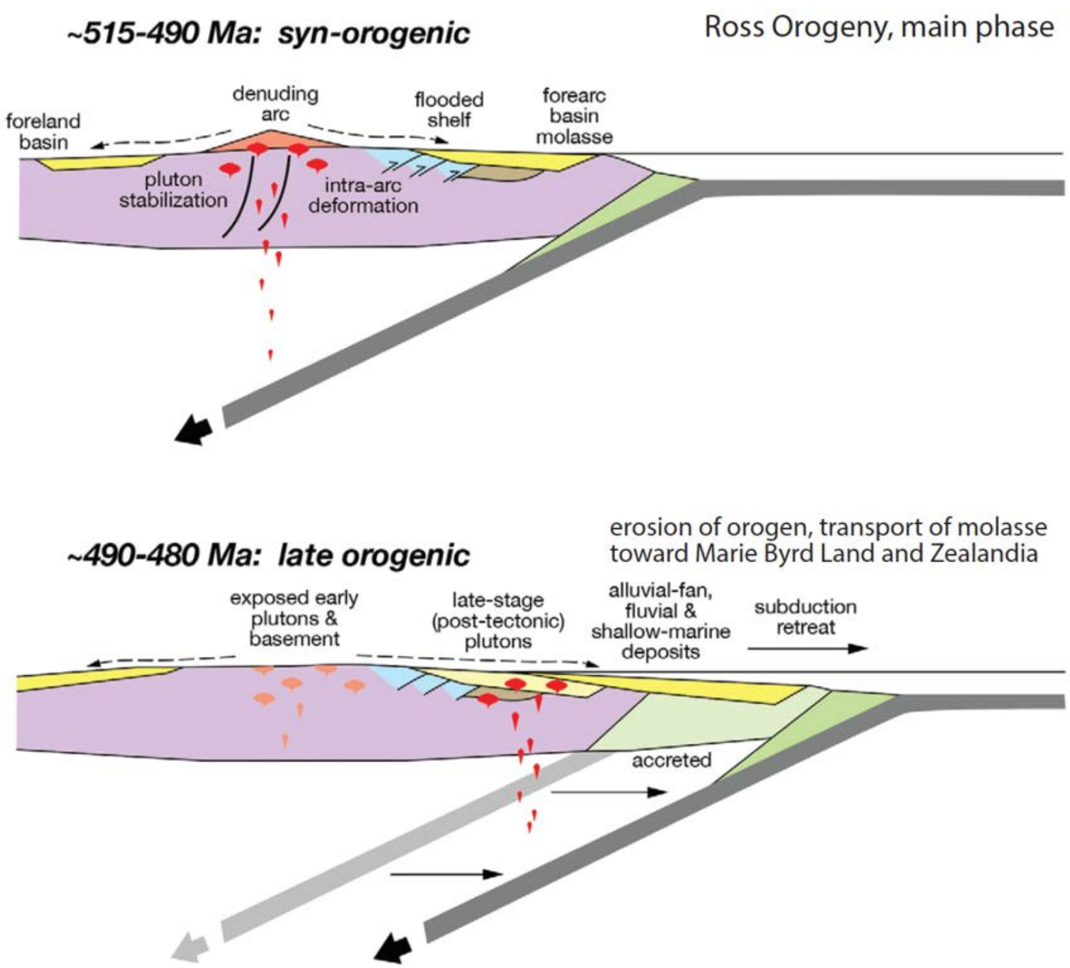
Future opportunity to test location: Lithosphere of East Antarctica program.

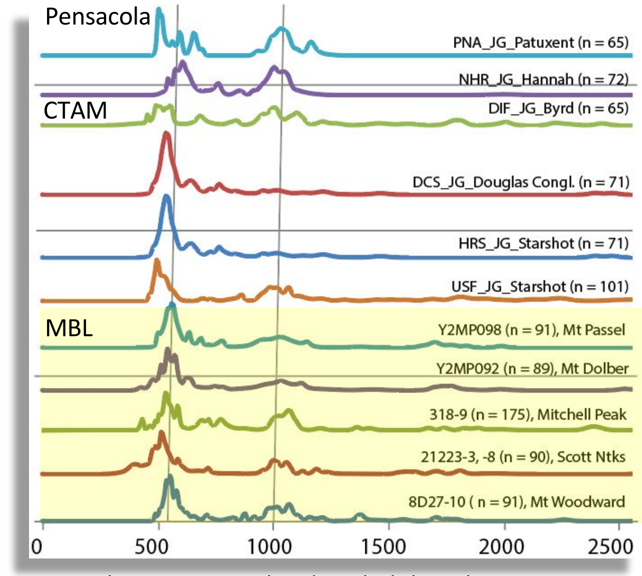
First meeting 12 Aug. 21:00 UTC

Comparisons of detrital zircon U-Pb data for CTAM – Pensacola versus Ford Ranges (MBL) suggest common sources from some units

Upper profile: Goodge, 2020, Gondw.Res., 10.1016/j.gr.2019.11.001

Cambrian – Ordovician Ross Orogen in Transantarctic Mountains





Detrital zircon normalized probability plots

MBL data: Yakymchuk et al. 2015. TAM data: Goodge et al. 2004

From J. Goodge, Gondwana Research 80 (2020), 10.1016/j.gr.2019.11.001

Latest Neoproterozoic to Cambrian orogenic sediment (molasse) shed from Ross Orogen

Normalized probability plots of detrital zircon U-Pb age data

Probability of correlation,
P: MBL samples to others

P values determined from Kolmogorov-Smirnoff (K-S) statistical comparison

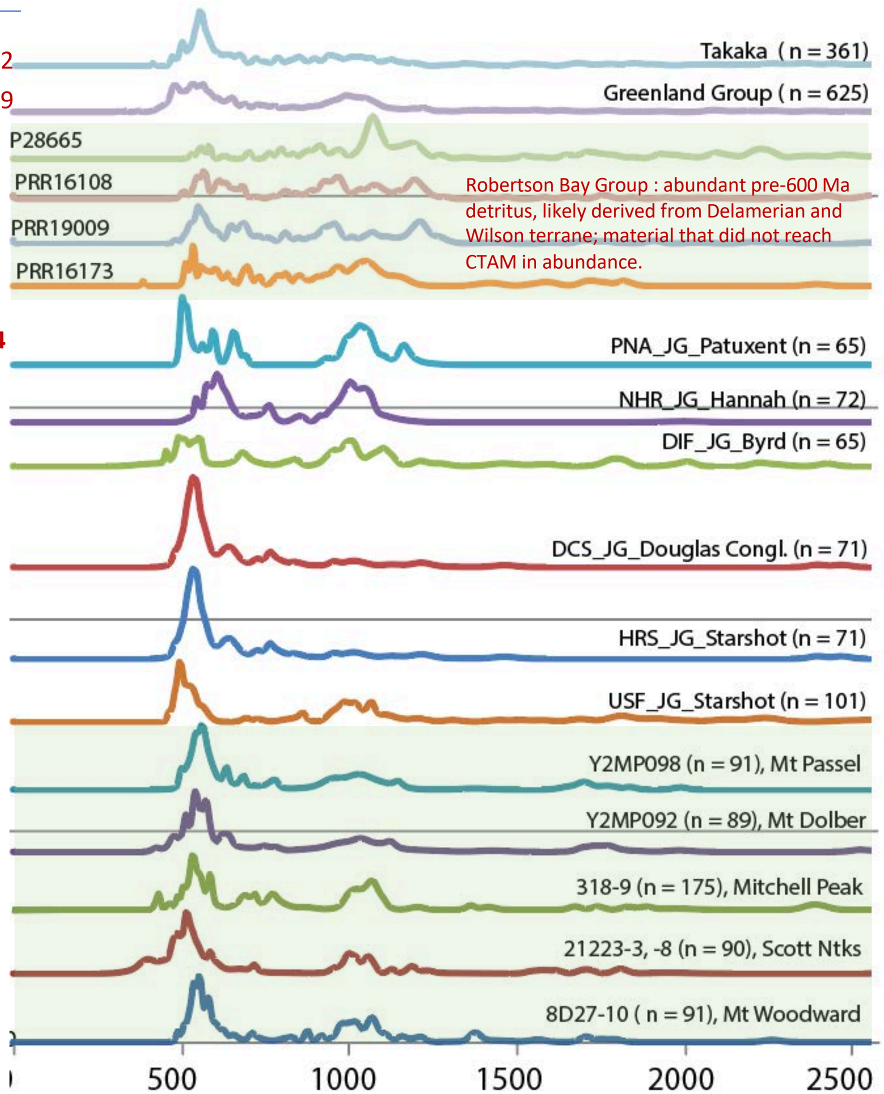
P 0.10 to 0.32

P 0.38 to 0.99

P 0.41 to 0.74

P 0.36

P 0.87 to 0.99 <u>within</u> this group



Iv. New Zealand data from Adams & Mortimer 2015

III. Robertson Bay Group, north Victoria Land
four samples reported by Paulsen et al. 2016 GR

Lesser abundances of 480-520 zircons “Granite Harbour Intrusives”

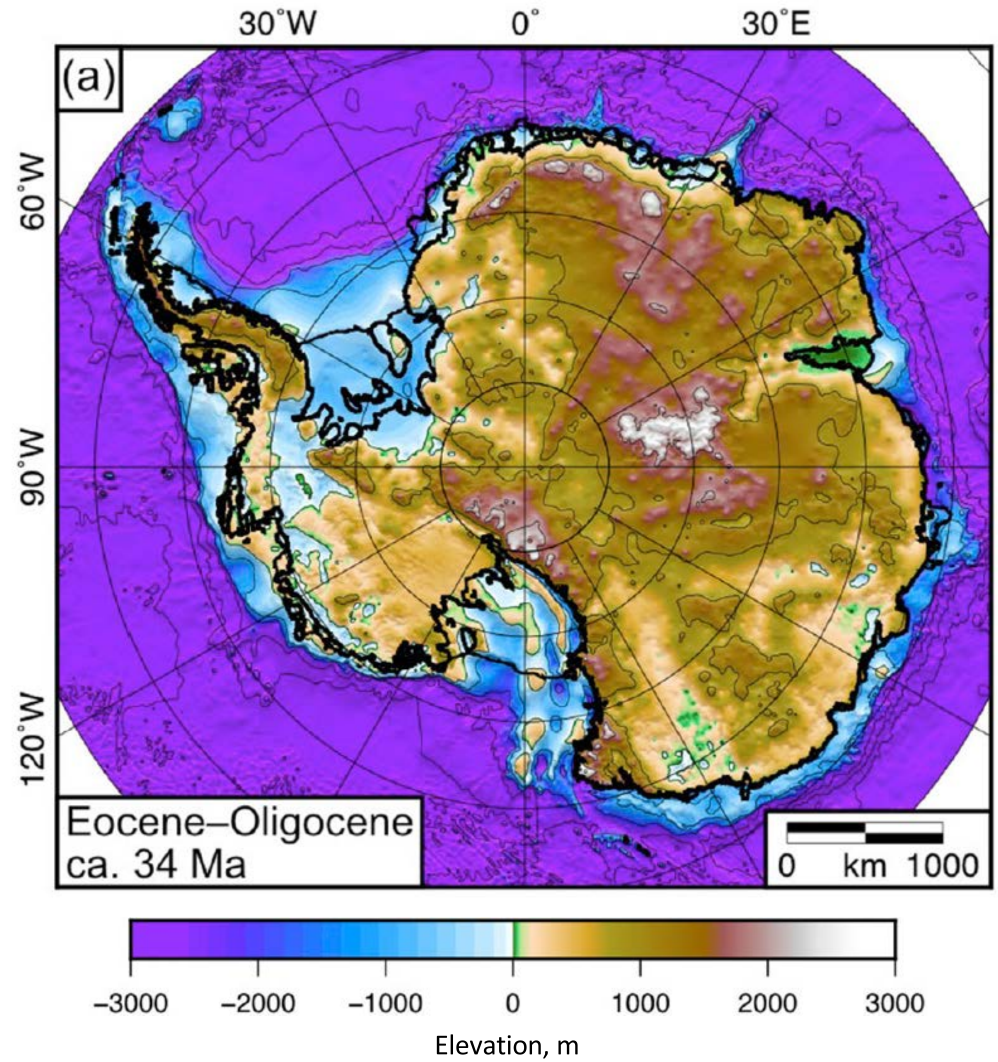
Broader span of ~580 to 1200 Ma zircons, reflecting input from ‘Wilson’ type, EANT or AUS sources

II. CTAM and Pensacola:
Goodge et al. 2004 GSAB

I. Ford Ranges, MBL:
Siddoway and Yakymchuk data
Swanson Fm and metamorphosed equivalents

K-S test incorporates ages with analytical uncertainty, plus the proportion of analyses constituting each age peak, to compute a **probability of correlation factor, P**. Statistical similarity is shown by P values ≥0.05, up to P = 1.0 (indistinguishable age distributions)

5) As recently as Oligocene, the Central High formed the formed the prominent physiographic edge of Antarctica



Paxman et al. 2019, P[3], doi:10.1016/j.palaeo.2019.109346

Bed corrected for ice load, thermal contraction, sedimentation, erosion, and horizontal motion

What defines the tectonic boundary and what is the geological character of the Central High?

HYPOTHESES to be tested:

Siddoway, Tankersley & Tinto, in progress

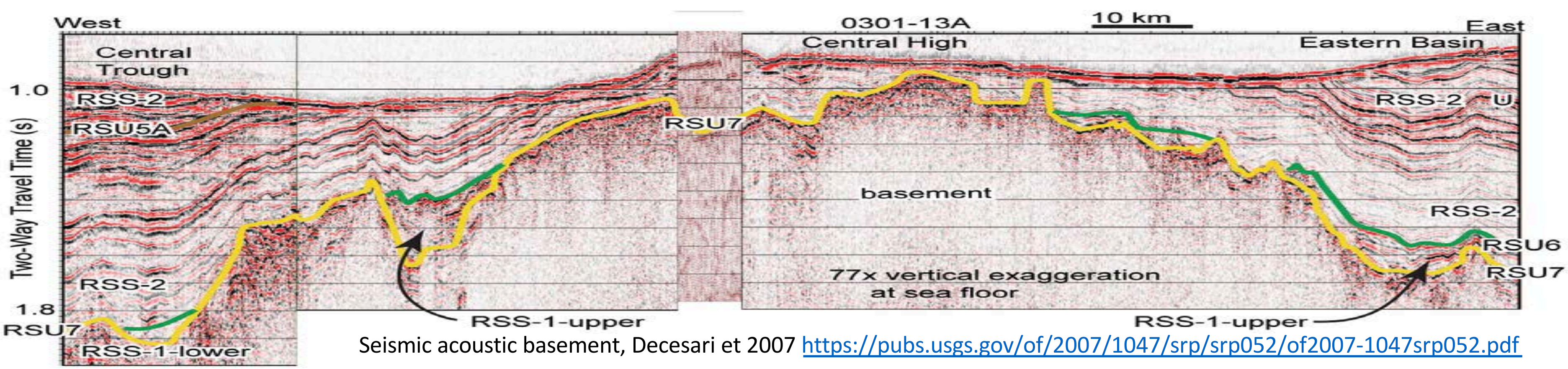
1) Faulted thinned edge of continental crust of EANT character -- outer limit of evolved lithosphere. Analogy: USA Great Basin, and $^{87}Sr/^{86}Sr$ line. (" the .706 line"). *Possible that all major normal faults dip the same way , toward MBL.*

2) Fault-dissected continental block (ribbon) within a 'failed' volcanic passive margin . "Passive margin" in this case means the region of broad intracontinental extension formed in the Cretaceous. *Opposite dip directions in major crustal detachment faults on either side of the continental block.* Analogy: Voring margin, Norway

3) Thick crust bordering ancestral transform boundary that was active during Gondwana breakup, circa 85 Ma [see Lamb et al. 2016 – Alpine Fault origins]

4) Microcontinent detached from continent (TAM) [Rey & Muller 2009 model]. Analogy: western USA terranes, NVL terranes

5) Linear plutonic belt (intermed to felsic magmatic arc) competent/coherent because is ~isotropic (previously unfaulted and not internally deformed) *during or after Ross Orogen.* Analogy: Andean type magmatic arc



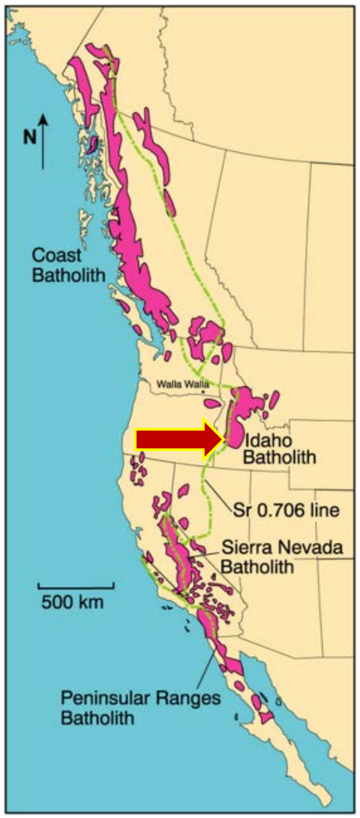
Seismic acoustic basement, Decesari et 2007 https://pubs.usgs.gov/of/2007/1047/srp/srp052/of2007-1047srp052.pdf

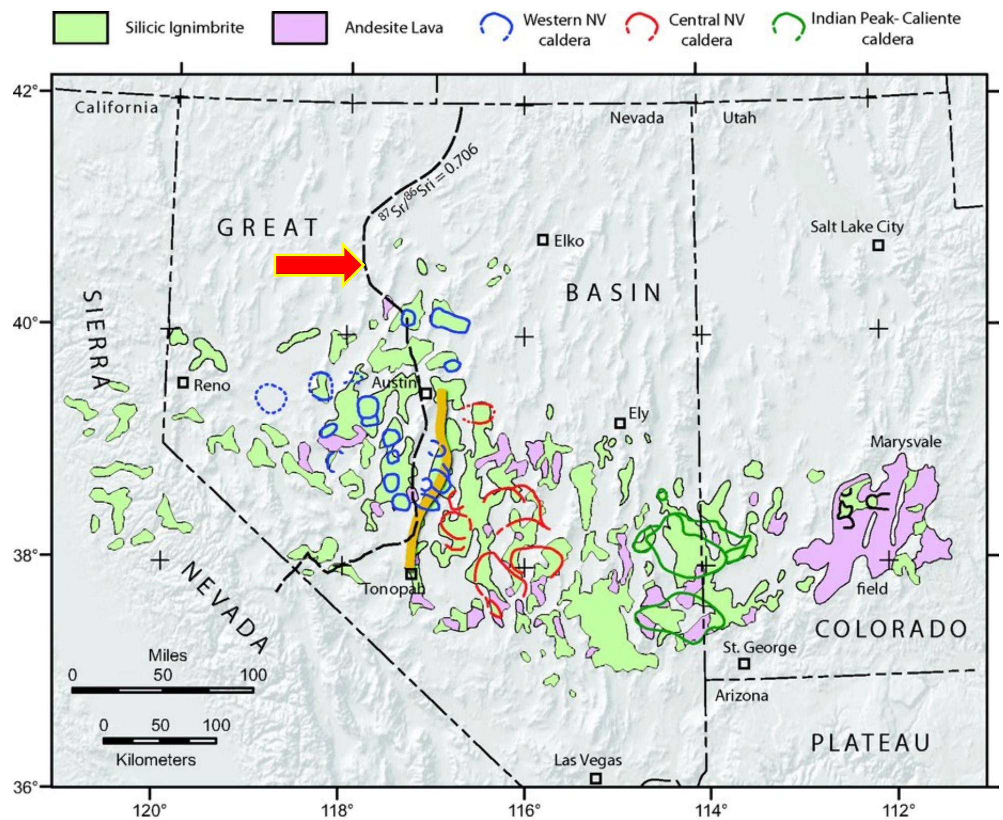
Five Hypotheses to be tested: TWO viable analogs illustrated here

Hypothesis 1: **North America – Great Basin** as WARS analog

the 0.706 line : $^{87}Sr/^{86}Sr$-delineated western edge of North American craton (Laurentia)

within faulted, thinned, ancient passive margin of Rodinia





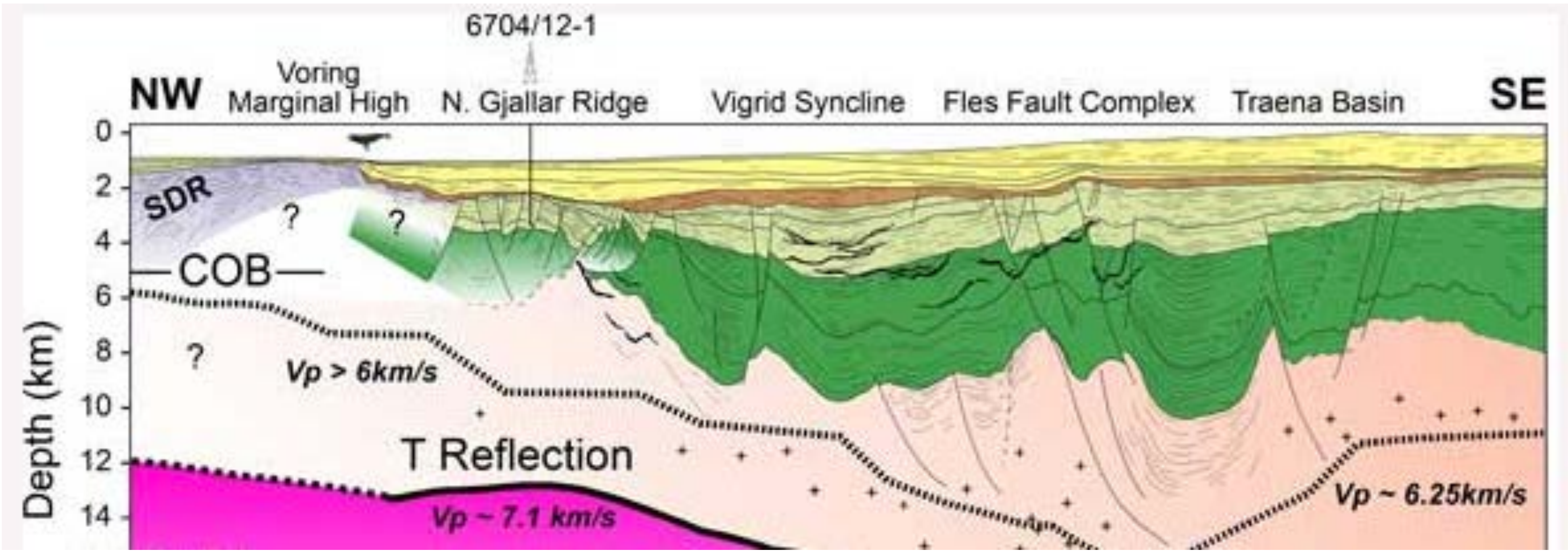
Black line: isotopic shift. Yellow band: approximate position of inferred topographic barrier on the western lip of the Nevadiplano “middle Cenozoic.” Red and blue: calderas localized along the 0.706 line

From: Best et al. Geosphere. 2013;9(2):260-274. doi:10.1130/GES00870.1
Introduction: The 36–18 Ma southern Great Basin, USA, ignimbrite province and flareup: Swarms of subduction-related supervolcanoes

Five Hypotheses to be tested: TWO viable analogs illustrated here

Hypothesis 2: Fault-dissected continental block (ribbon)
North Atlantic continent-ocean boundary and 'failed' volcanic passive margin as analog

Norway: Voring marginal high (e.g. *Gernignon et al ESR 2020*)



Ross Embayment – 'failed volcanic passive margin ?

Evidence of structurally controlled mafic bodies: sills and steep, narrow zones

Steep zones have trends orthogonal to rifted margin (subparallel to TAM)

Geophysics: **ANTOSTRAT** and **ACRUP** marine geophysics (e.g. Busetti et al. 1999; Della Vedova et al. 1994- 98, Davey et al. 1995, Cooper et al. 1991, 1997)

ROSETTA-Ice (Tinto et al. 2018)

Concluding thoughts: Updated crustal geology and tectonic framework

Bedrock geology and tectonic context are directly relevant to contemporary research in many areas:

- modeling the Cryosphere – Geosphere – Ocean system
- paleotopography for past climate reconstructions
- bedform influences upon glacial processes
- subglacial hydrology
- heat flux
- glacial isostatic response

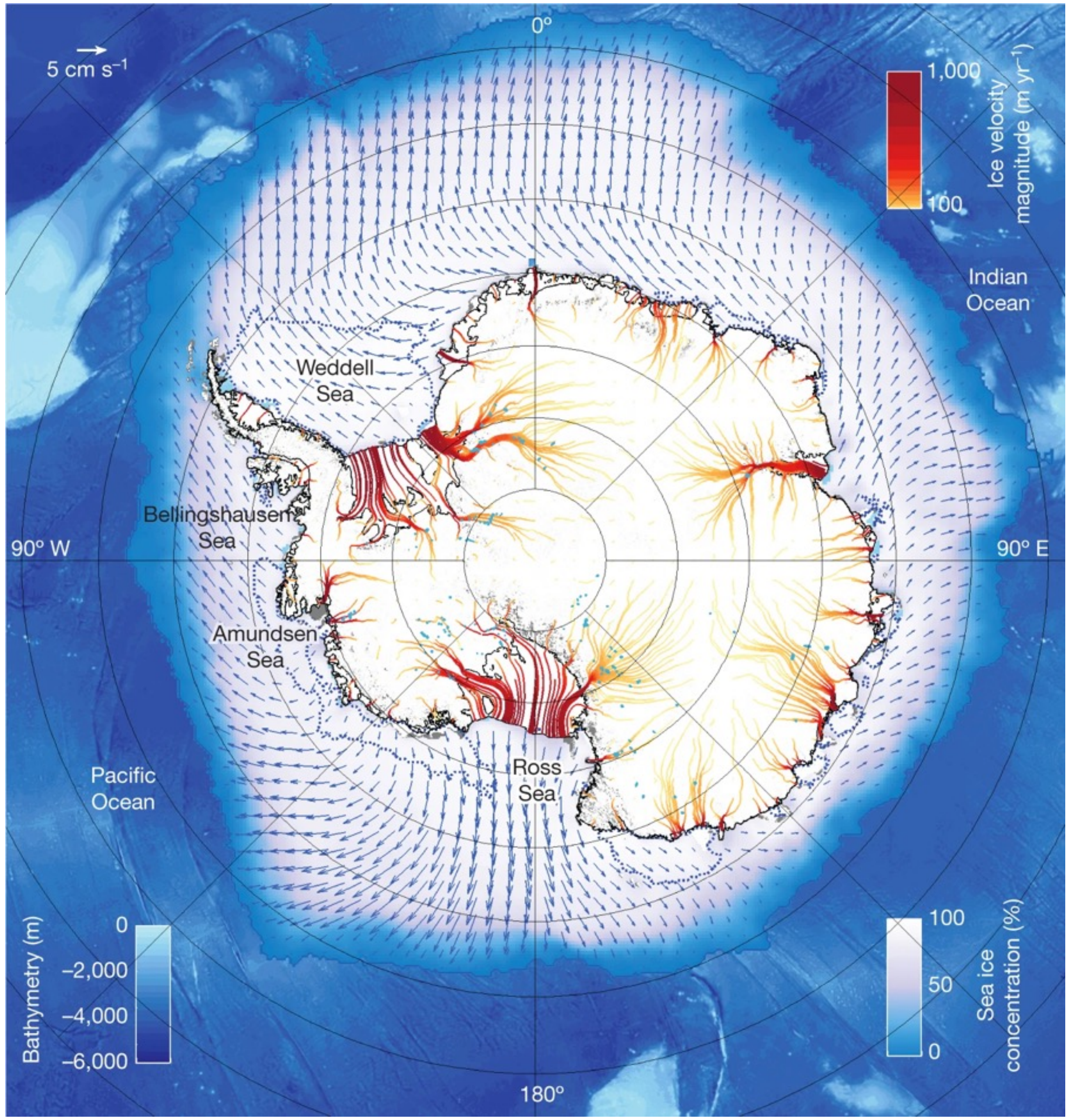


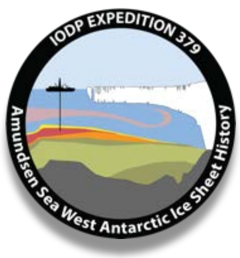
Figure: Ice sheet motion flowlines superimposed on MODIS mosaic of Antarctica Sea ice motion vectors

Shepherd, Fricker & Farrell, 2018, https://www.nature.com/articles/s41586-018-0171-6/figures/1

Concluding thoughts: Updated crustal geology and tectonic framework

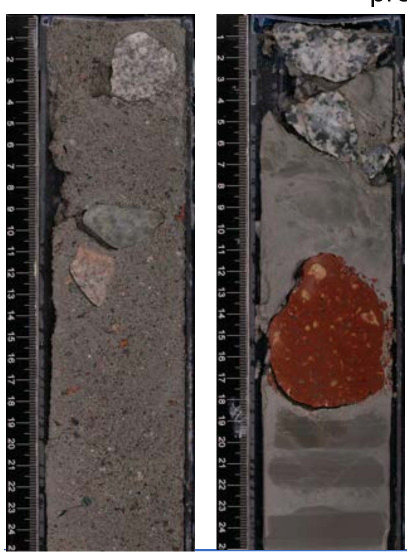
Synergistic links: International Ocean Discovery Program circum-Antarctica drilling

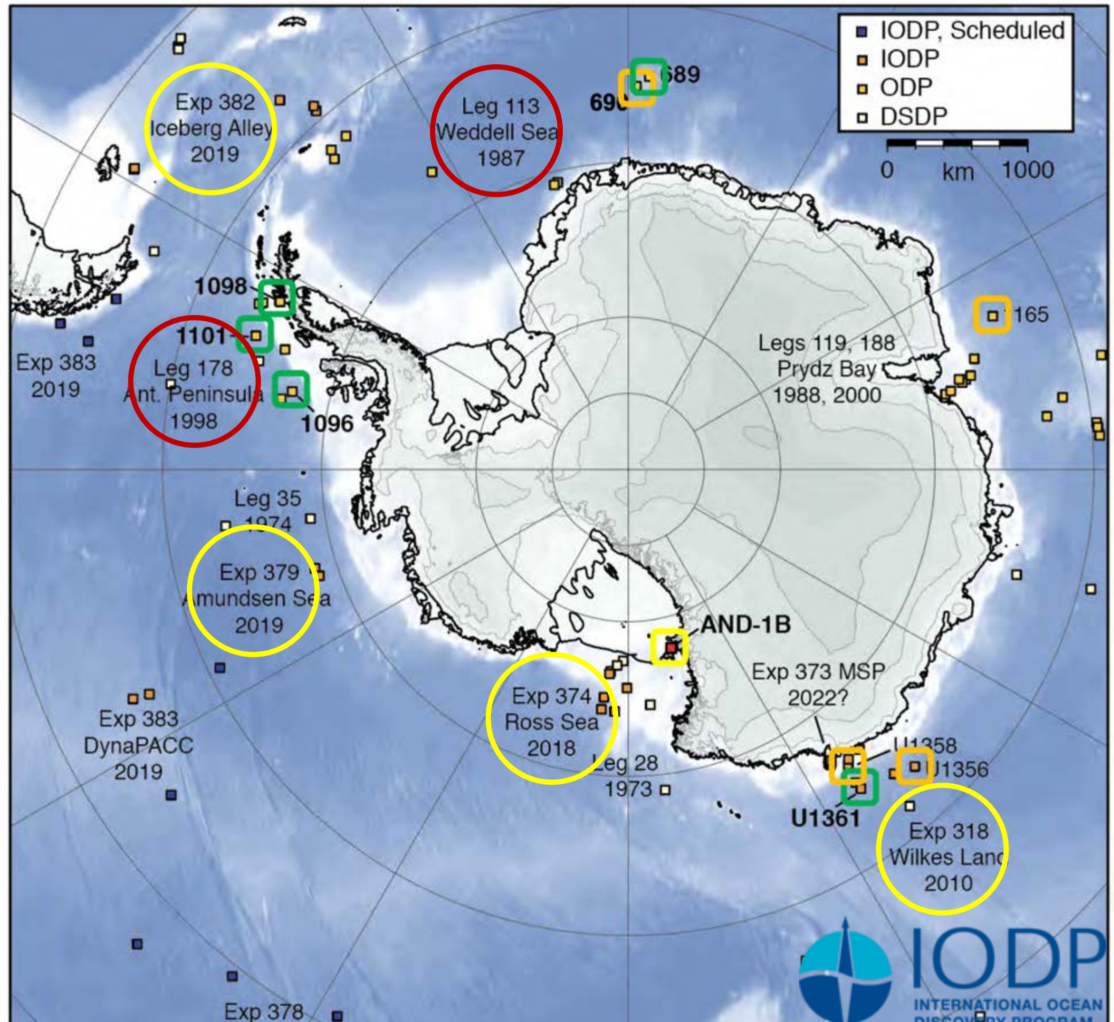
Opportunity to further characterize subglacial bedrock and WANT geological evolution using iceberg-rafted detritus, including clasts of rock, derived from WANT and EANT



IODP379 Shipboard Party

Geo/thermochronology data (multi-chronometry upon individual grains, to further refine tectono-magmatic development and landscape evolution of WANT e.g. NSF ICI-Hot project, Siddoway et al. 2018





Map: IODP, Kulhanek & Williams 2019

Igneous clasts within cores, IODP379

Acknowledgements