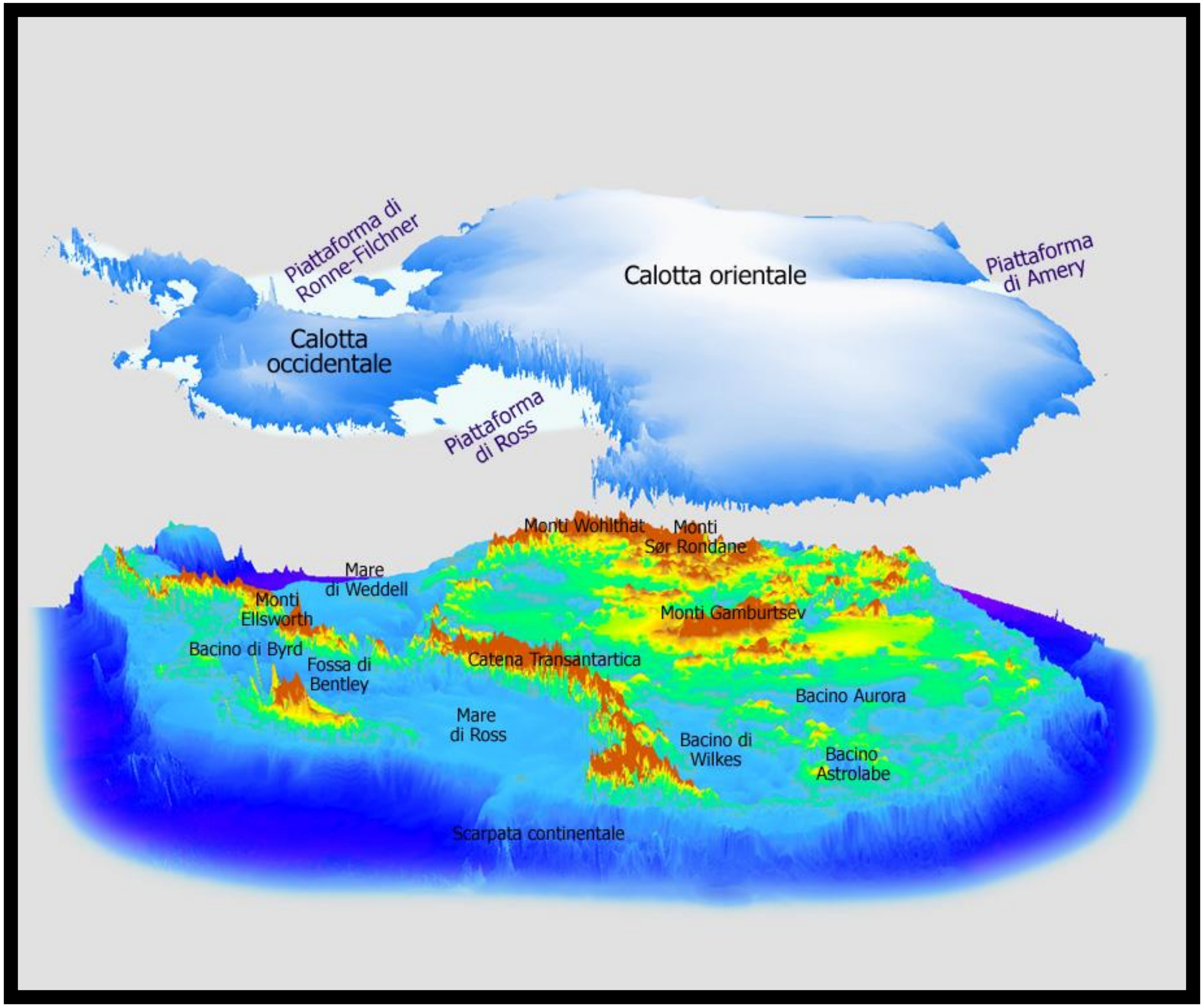
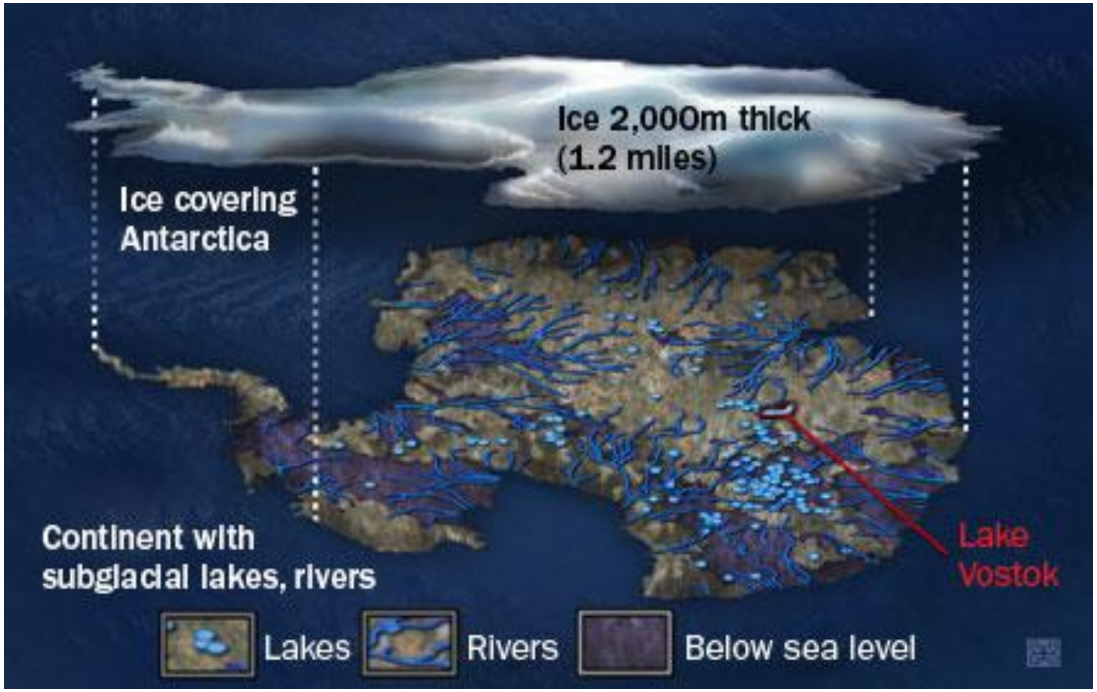
Subglacial topography

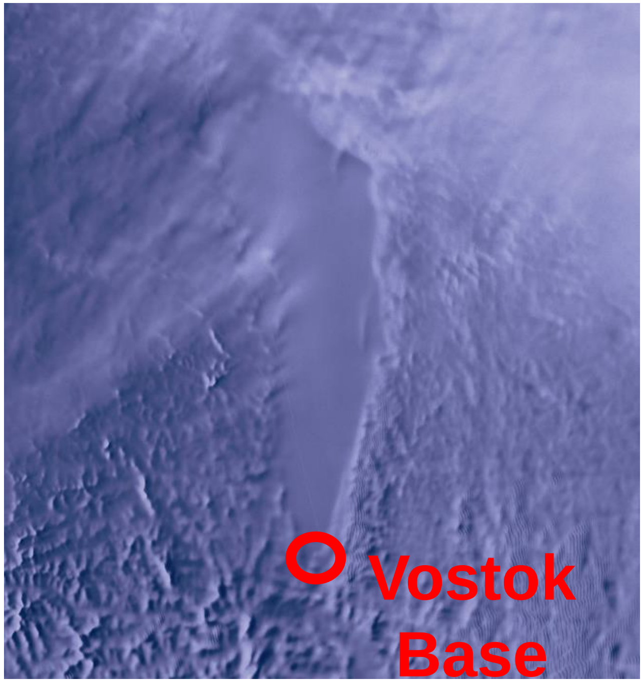



Northern Victoria Land
Figure is from Baroni


Western Italian Alps

RETE DI LAGHI SUBGLACIALI SOTTO LA CALOTTA





Vi e' l'evidenza scientifica di una fitta rete di laghi subglaciali sotto la calotta ghiacciata. Perche' si vogliono studiare:

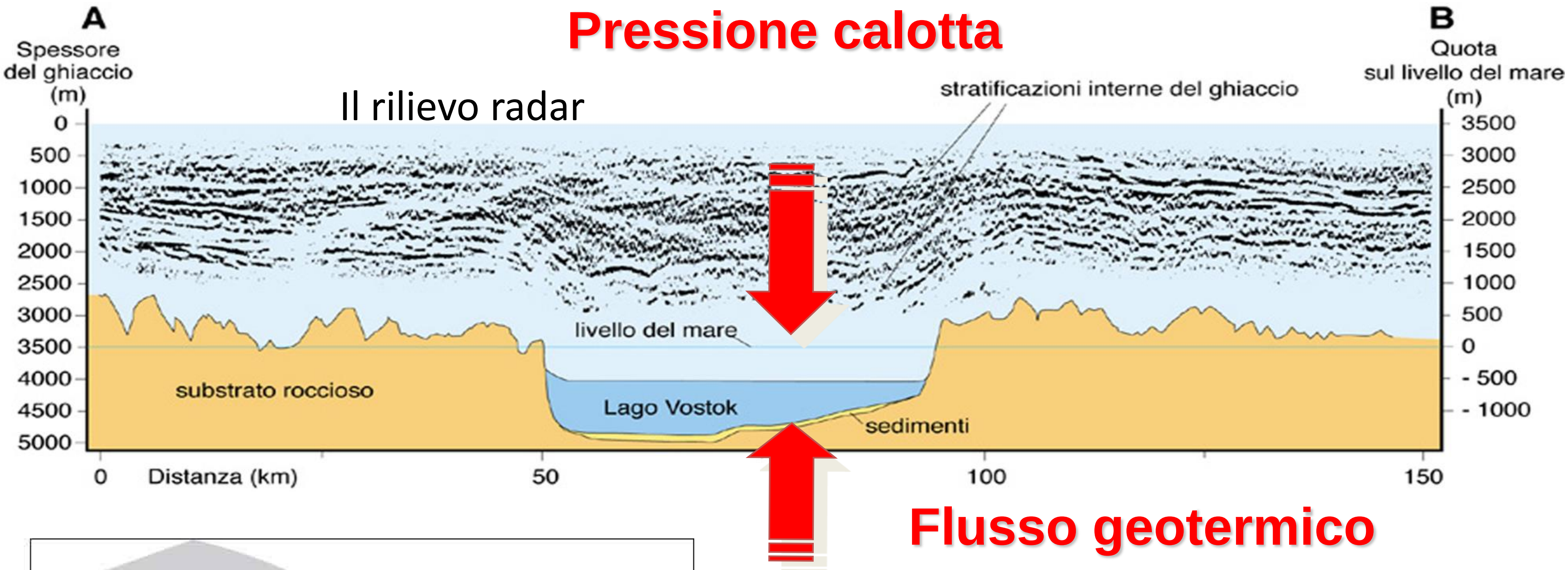
1- un'eventuale destabilizzazione della calotta comincierebbe proprio dalla sua base,

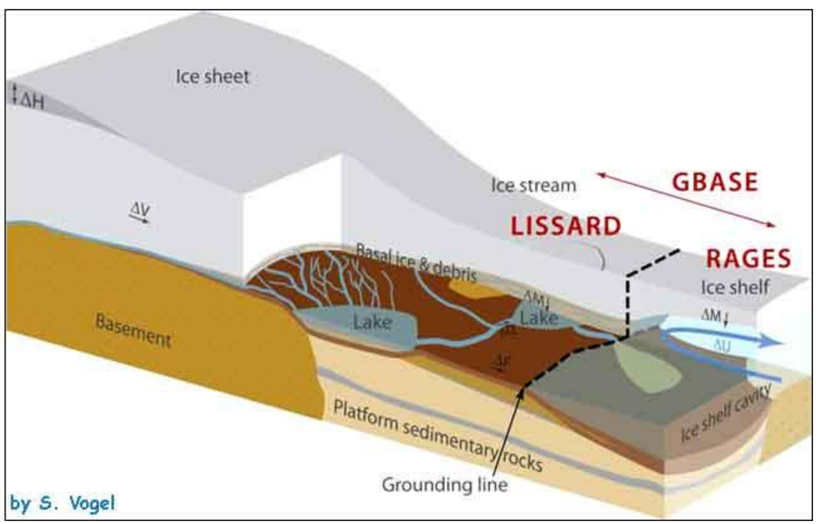
2- contengono la storia dell'Antartide antecedente a 800.000 anni fa,

3- contengono organismi isolati dal resto del mondo da molto tempo,

4- rappresentano l'habitat che si ha su alcuni satelliti di Giove.

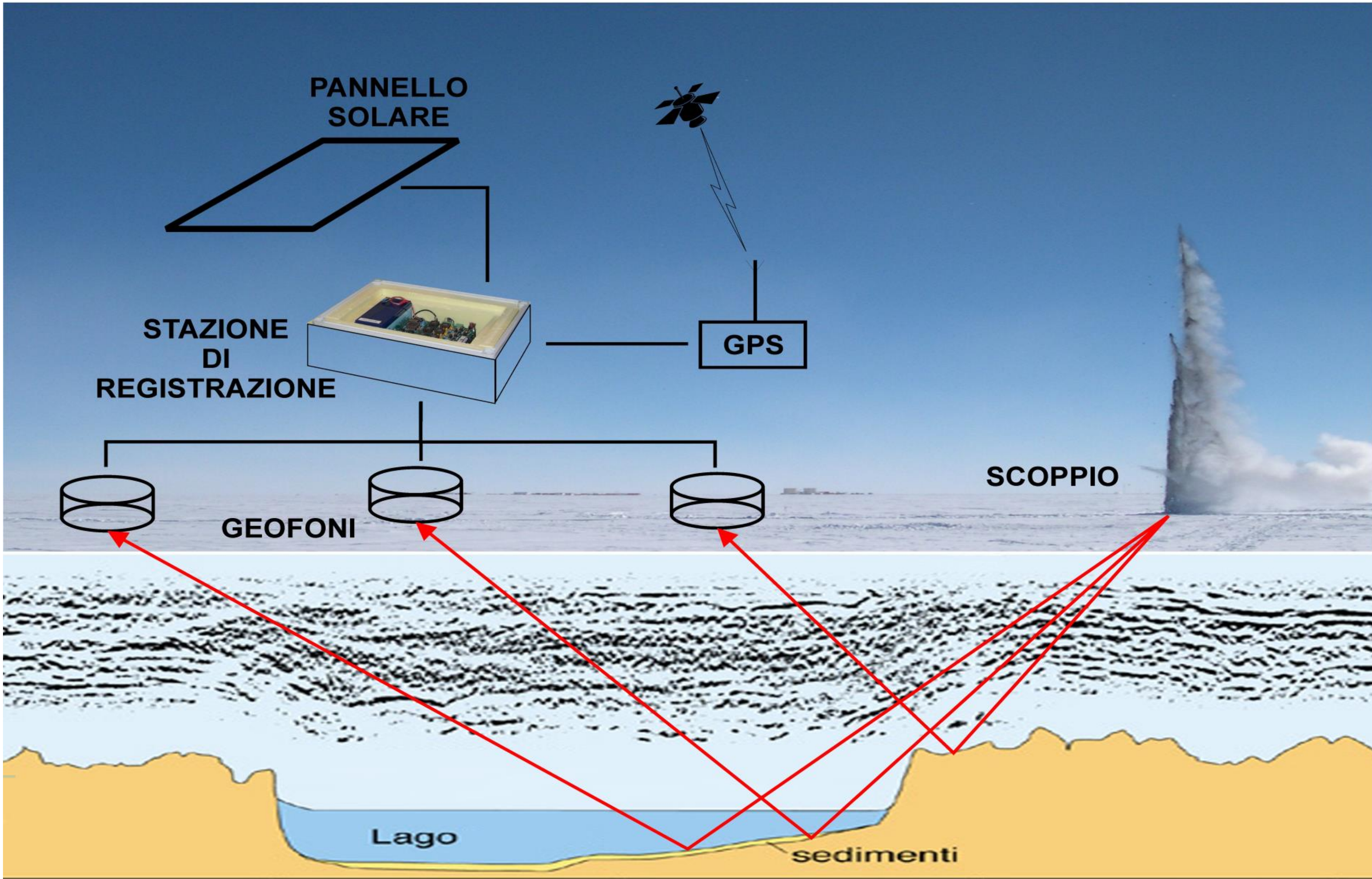
Che cosa sono i laghi subglaciali?



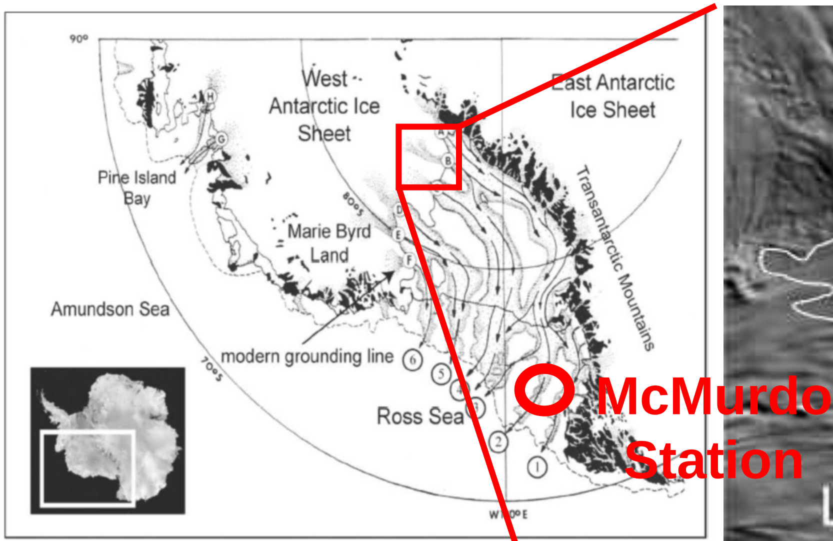


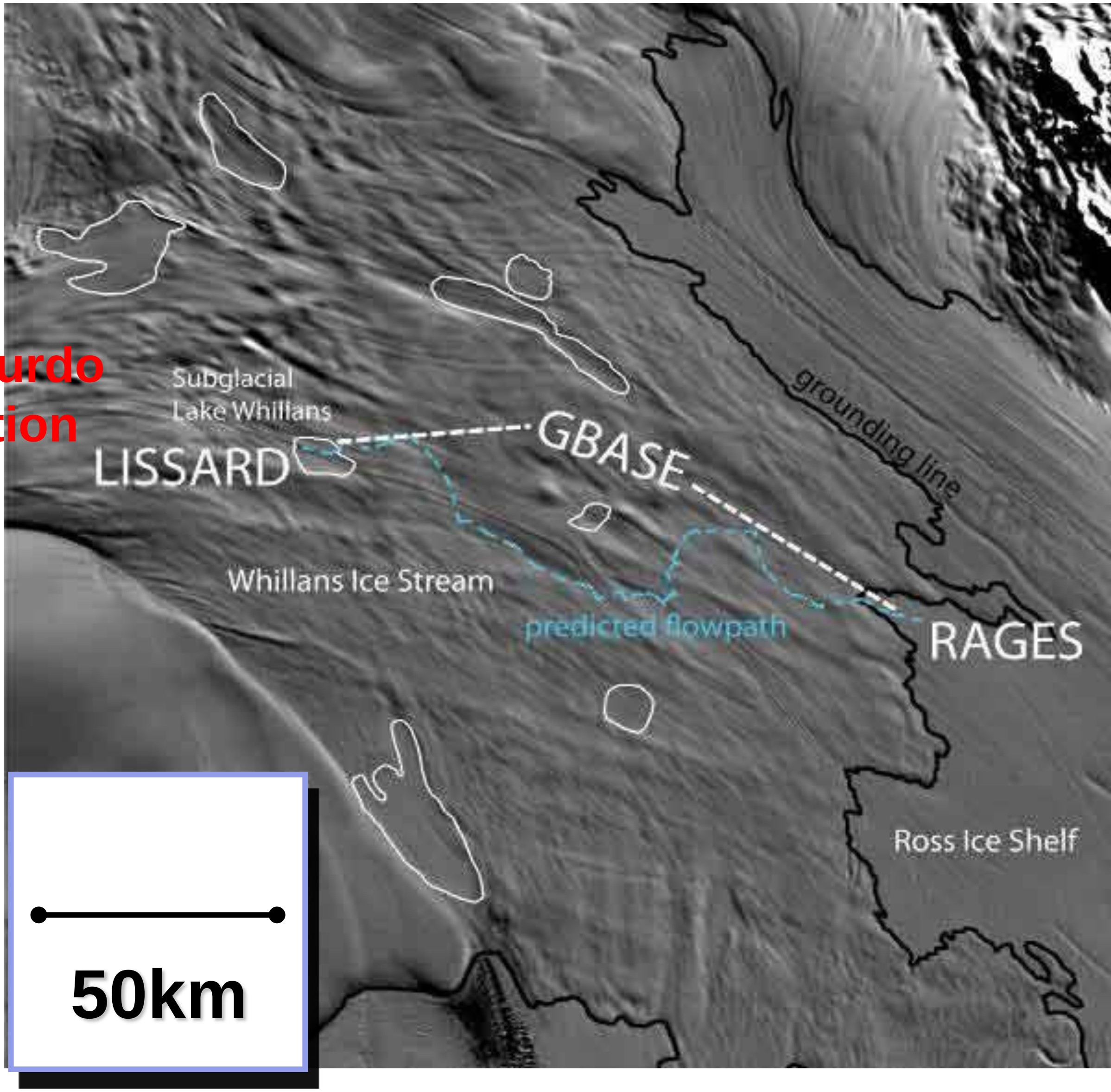
I laghi subglaciali possono essere comunicanti con il mare, oppure completamente isolati rispetto al resto del mondo

La sismica a riflessione permette di conoscere il tipo del substrato roccioso e sedimentario sotto la calotta glaciale



GHIACCIAIO WHILLANS DA SATELLITE

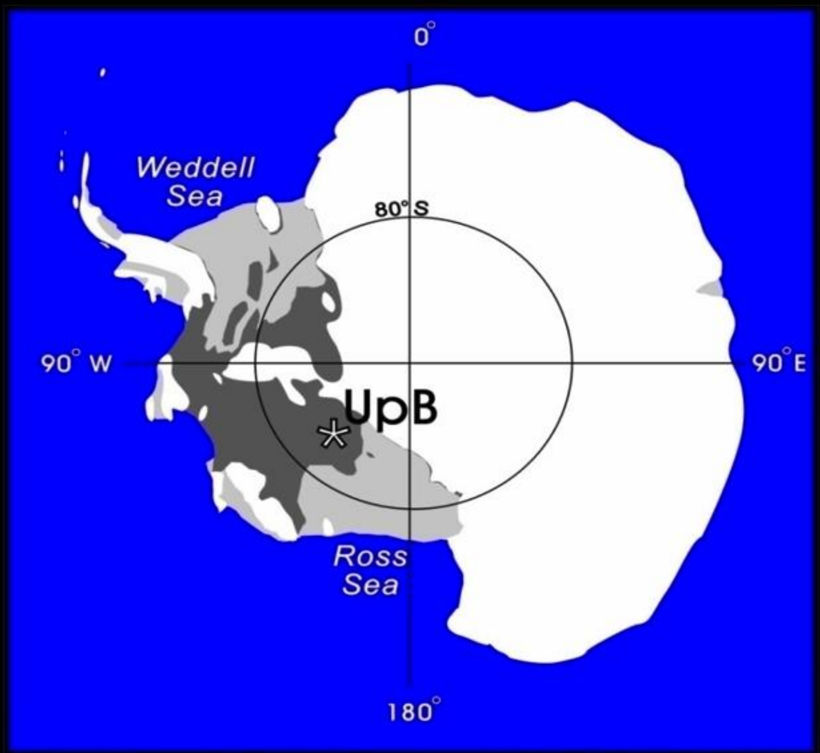




Il ghiacciaio Whillans è largo 150km, lungo 500km e si sposta ad una velocità di 3m al mese!!!

Sediments recovered from beneath the ice provided the only direct evidence of marine events in the West Antarctic interior

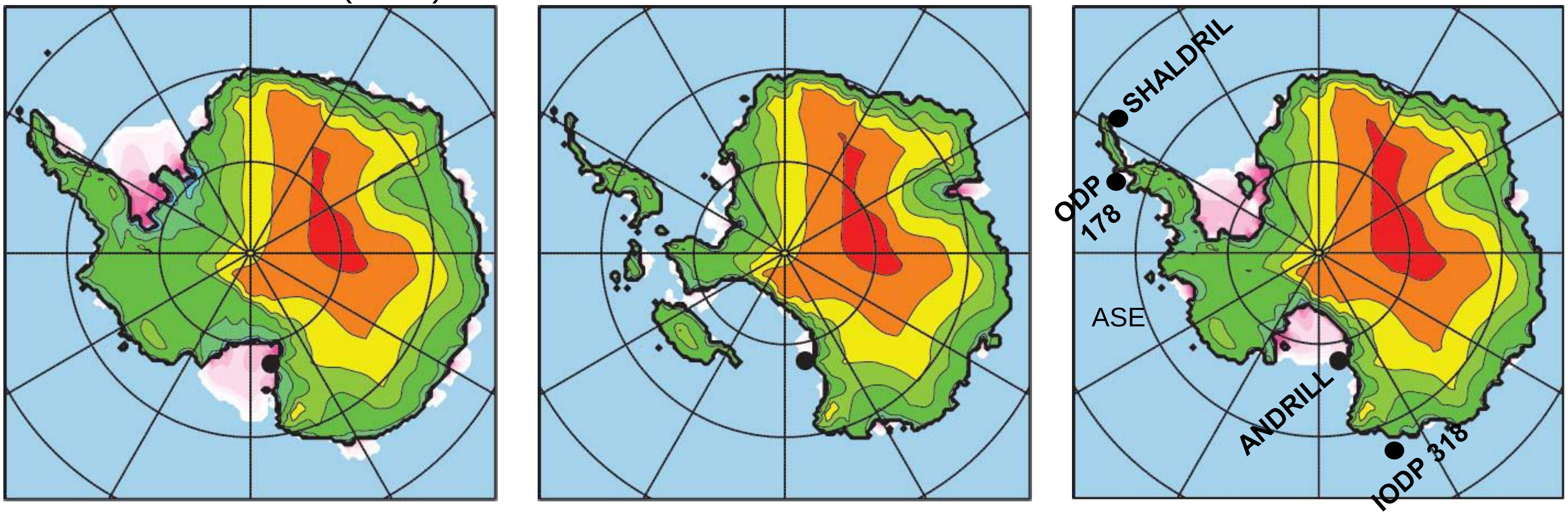
Caltech hot water drill at Upstream B, Antarctica, 1991



Scherer

Caltech system refurbished for WISSARD

Pollard & DeConto (2009)



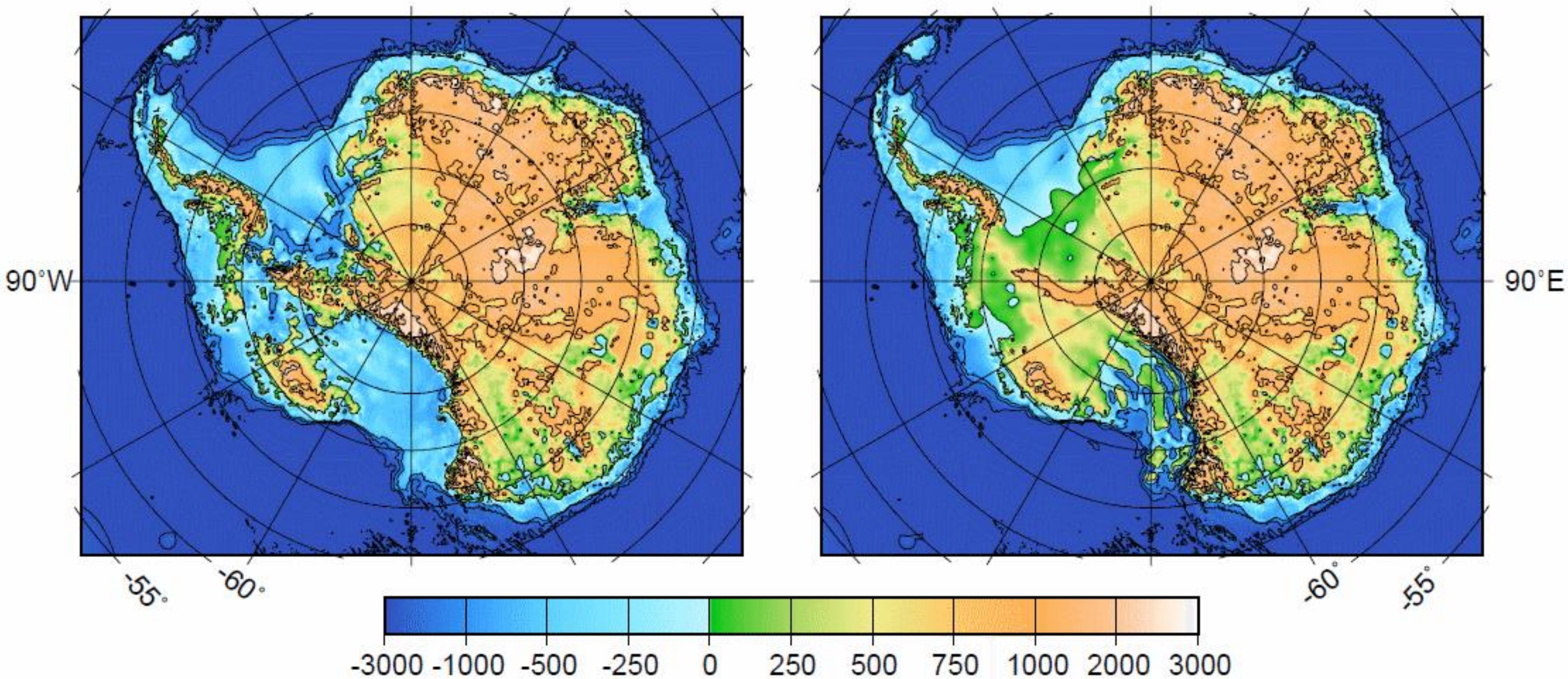
at 1,094 Ma   at 1,079 Ma   present

- Repeated phases of collapsed WAIS are predicted by modelling under global warming
- ANDRILL AND IODP Exp. 318 show evidence for repeated grounded ice, ice-shelf and open water conditions (superinterglacials) in Ross Sea embayment from Late Miocene to Pliocene
- **Past retreat/collapse processes, causes, rates remain unclear**
- CO2 and SST estimate to lose WAIS. Threshold for irreversible meltdown?
- Other proximal drill data do not exist to verify past partial or full collapses of **marine-based Antarctic Ice Sheet** >> large modelling/prediction uncertainty

Paleo – bathymetric reconstructions

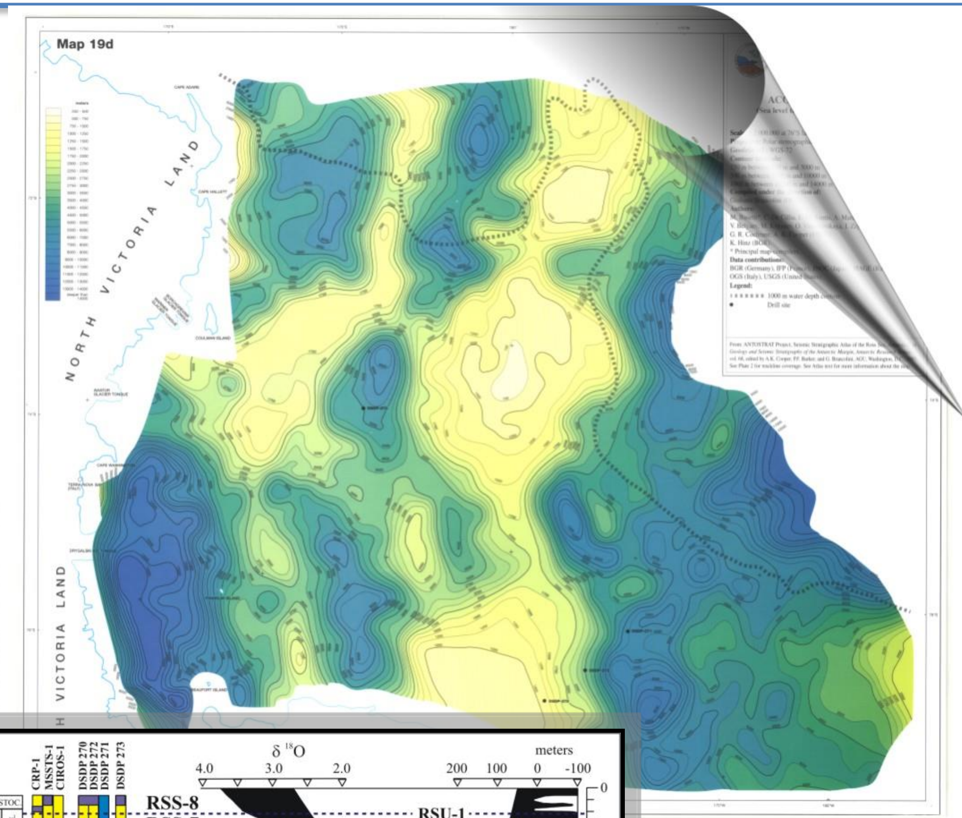
Static view of Antarctica with only the ice sheet removed

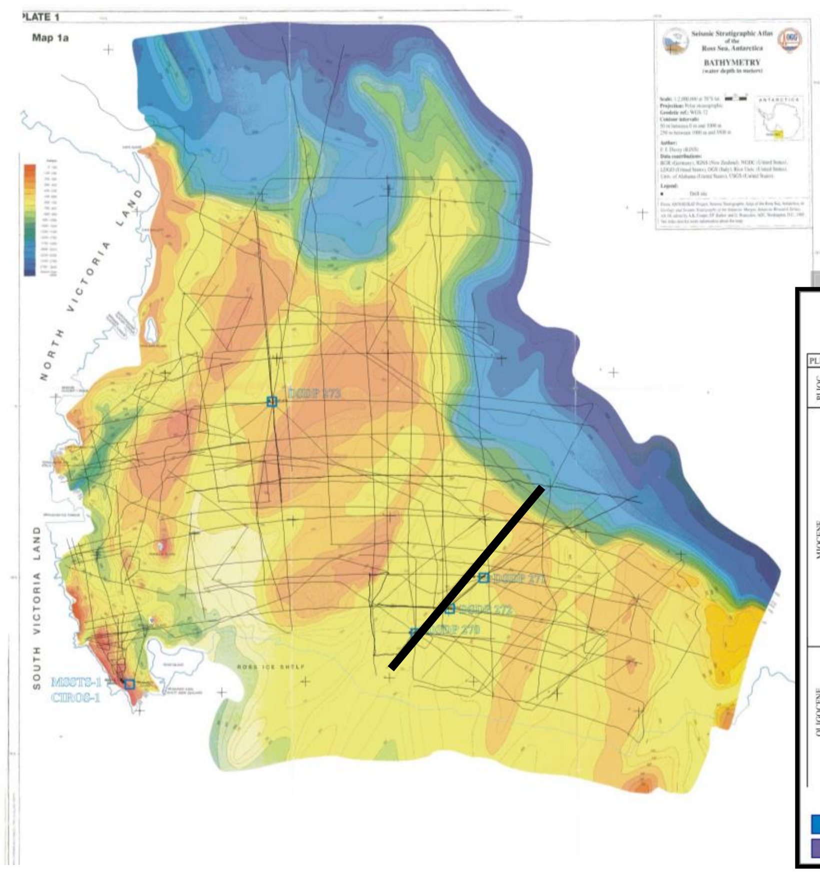
New reconstruction (34 Ma) with the additional landmass.

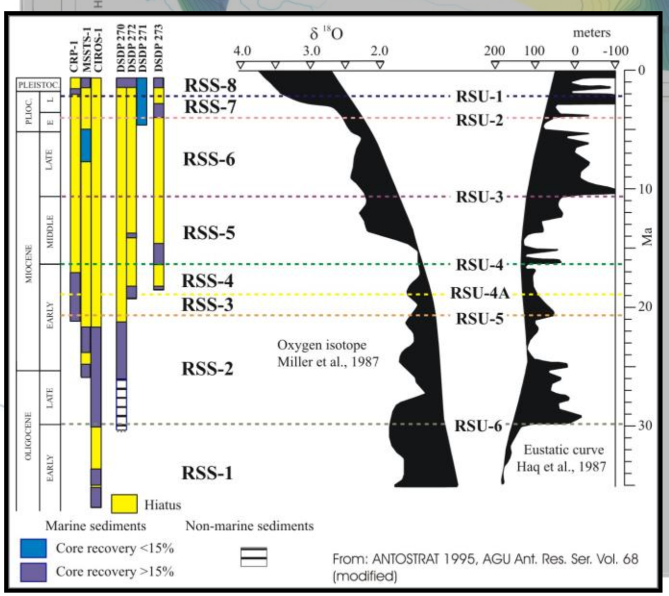


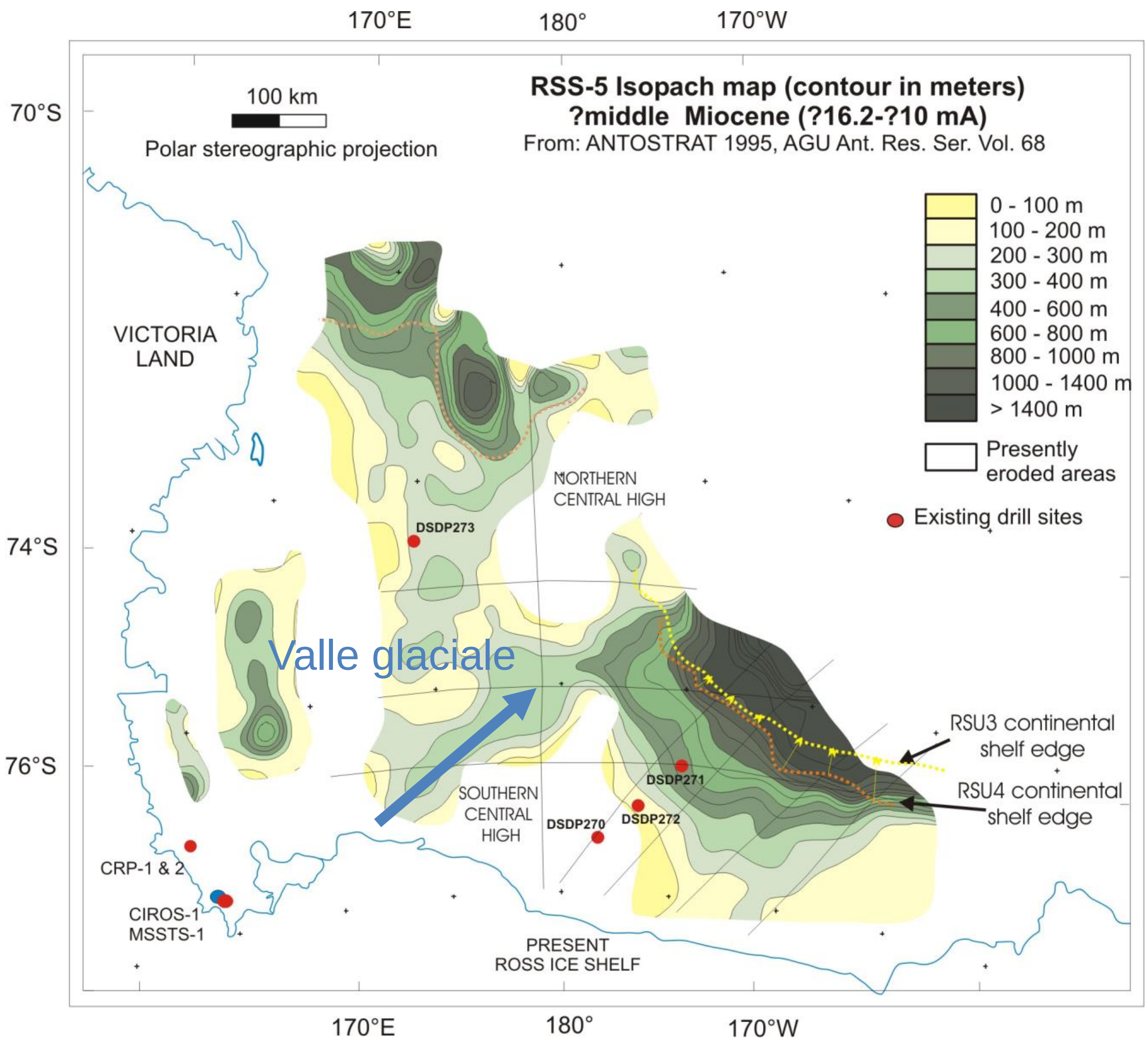
Wilson Luyendyk, 2009. Geophysical Research Letters

Geology and Seismic Stratigraphy of the Antarctic Margin
Alan K. Cooper, Peter. F. Barker, and G. Brancolini, Editors
Antarctic Research Series, Volume 68, 1995. 303 pages, 22 fold-out maps, two CD ROMs

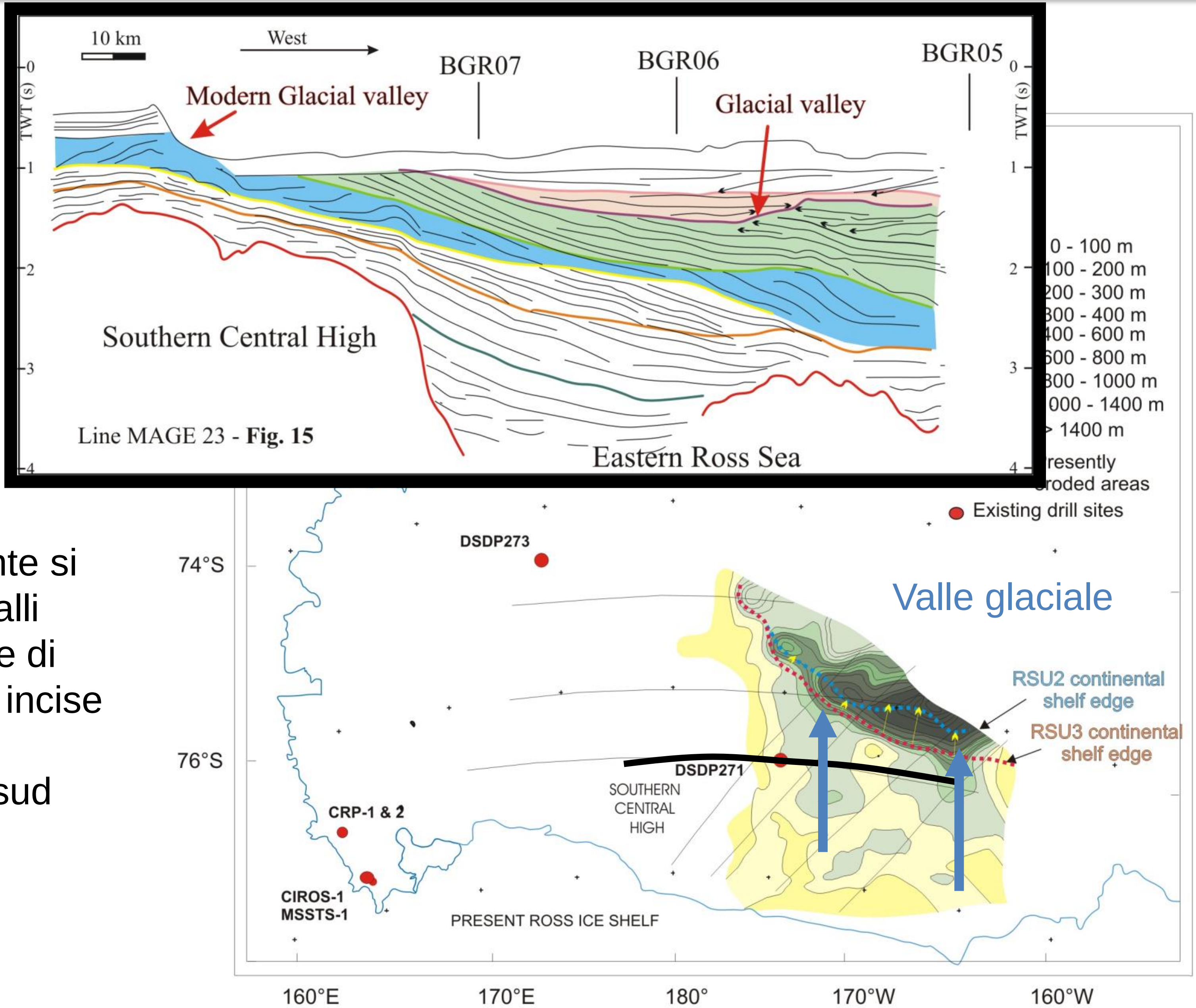




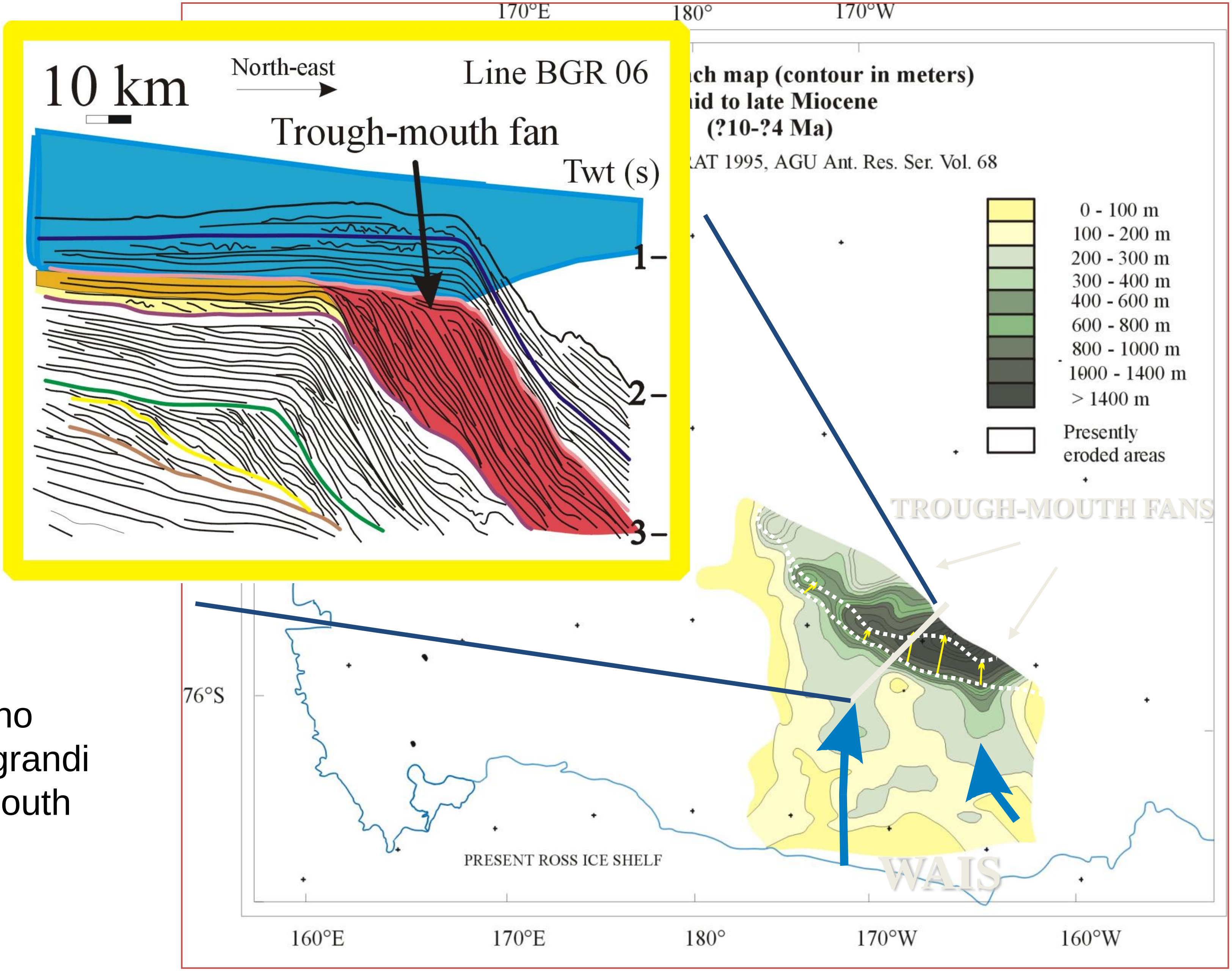




Tra 16 e 10 milioni di anni fa nel Mare di Ross esisteva un ghiacciaio che si estendeva attraverso la piattaforma e che si è poi riempito di sedimento.



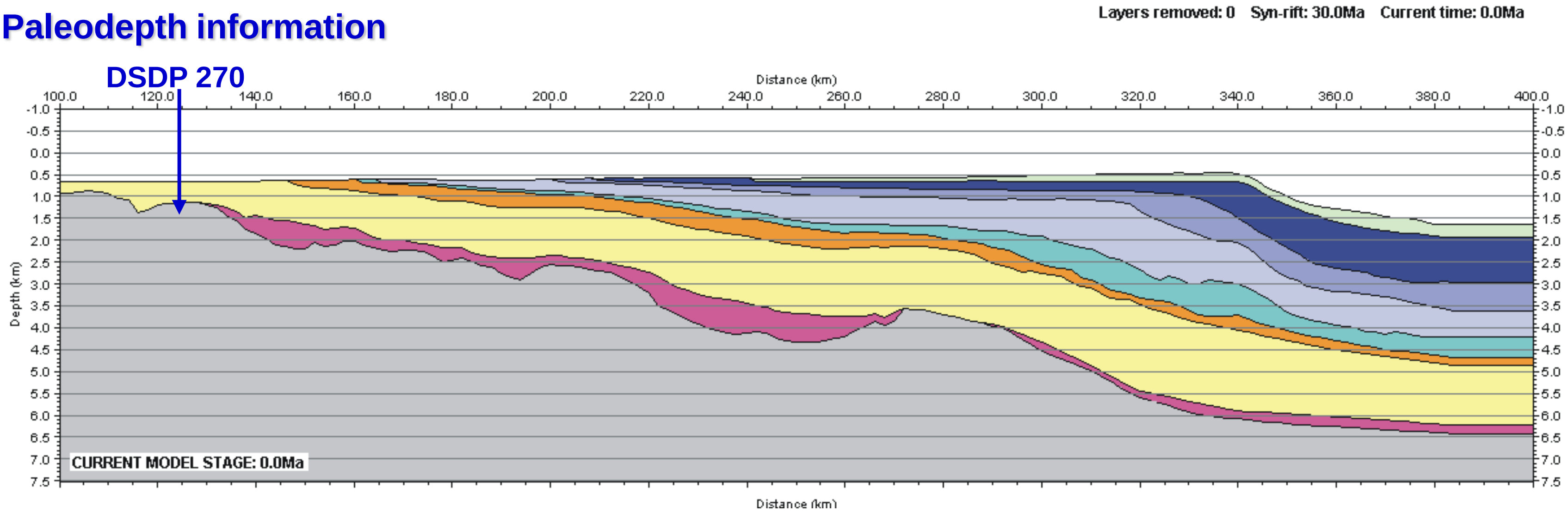
Successivamente si sono formate valli glaciali nel Mare di Ross orientale, incise da ghiacciai provenienti da sud



Che hanno formato grandi trough-mouth

Flexural backstripping of depth converted profile BGR80-07 (Ross Sea) (De Santis et al., 1999)

Paleodepth information

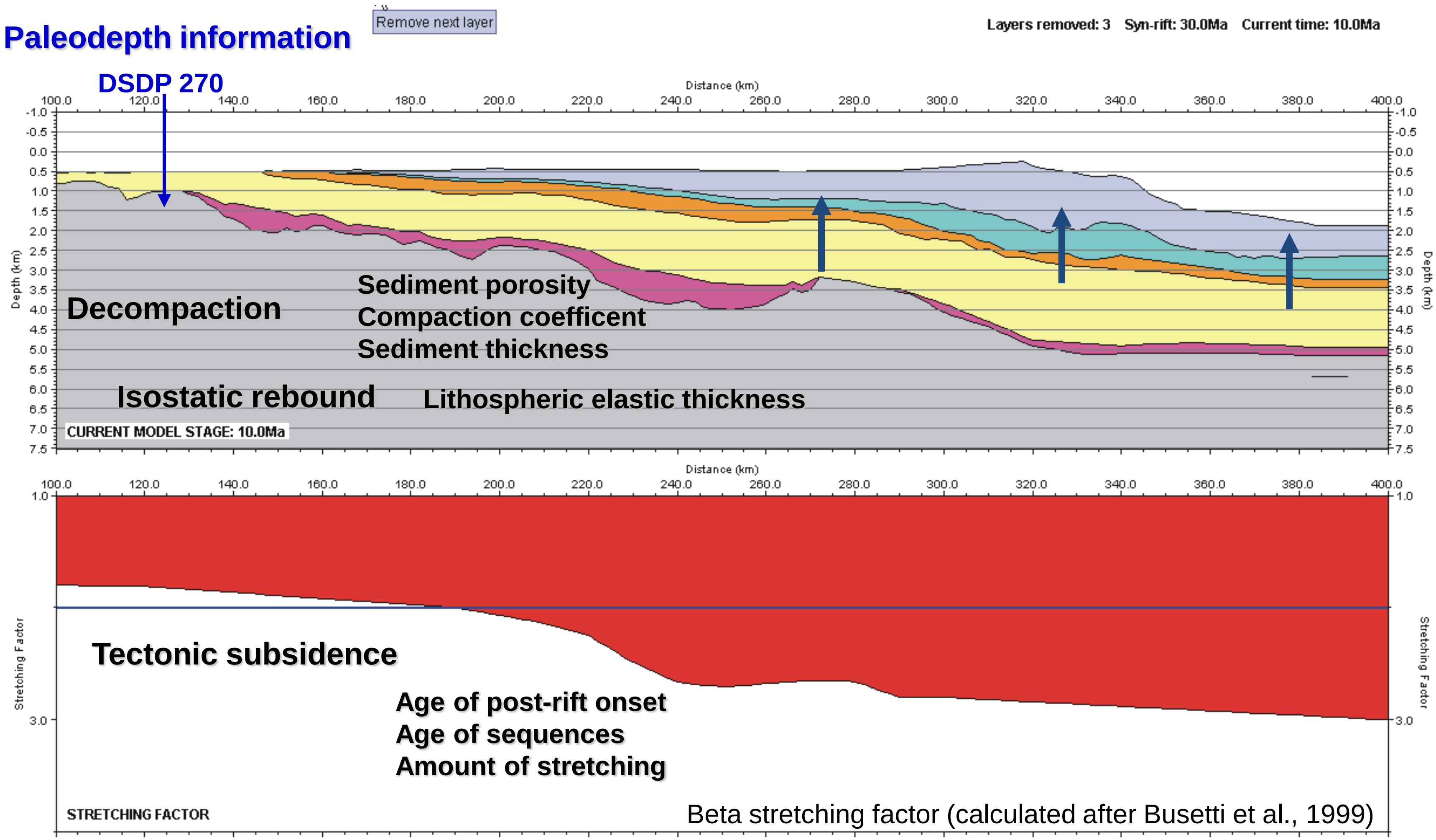


Per ricostruire la paleomorfologia di una zona, ad un certo tempo del passato, oltre a mappare la distribuzione nello spazio degli orizzonti sepolti, occorre anche calcolare di quanto questi orizzonti sono sprofondati per effetto del:

- Peso dei sedimenti sovrastanti
- Della subsidenza tettonica

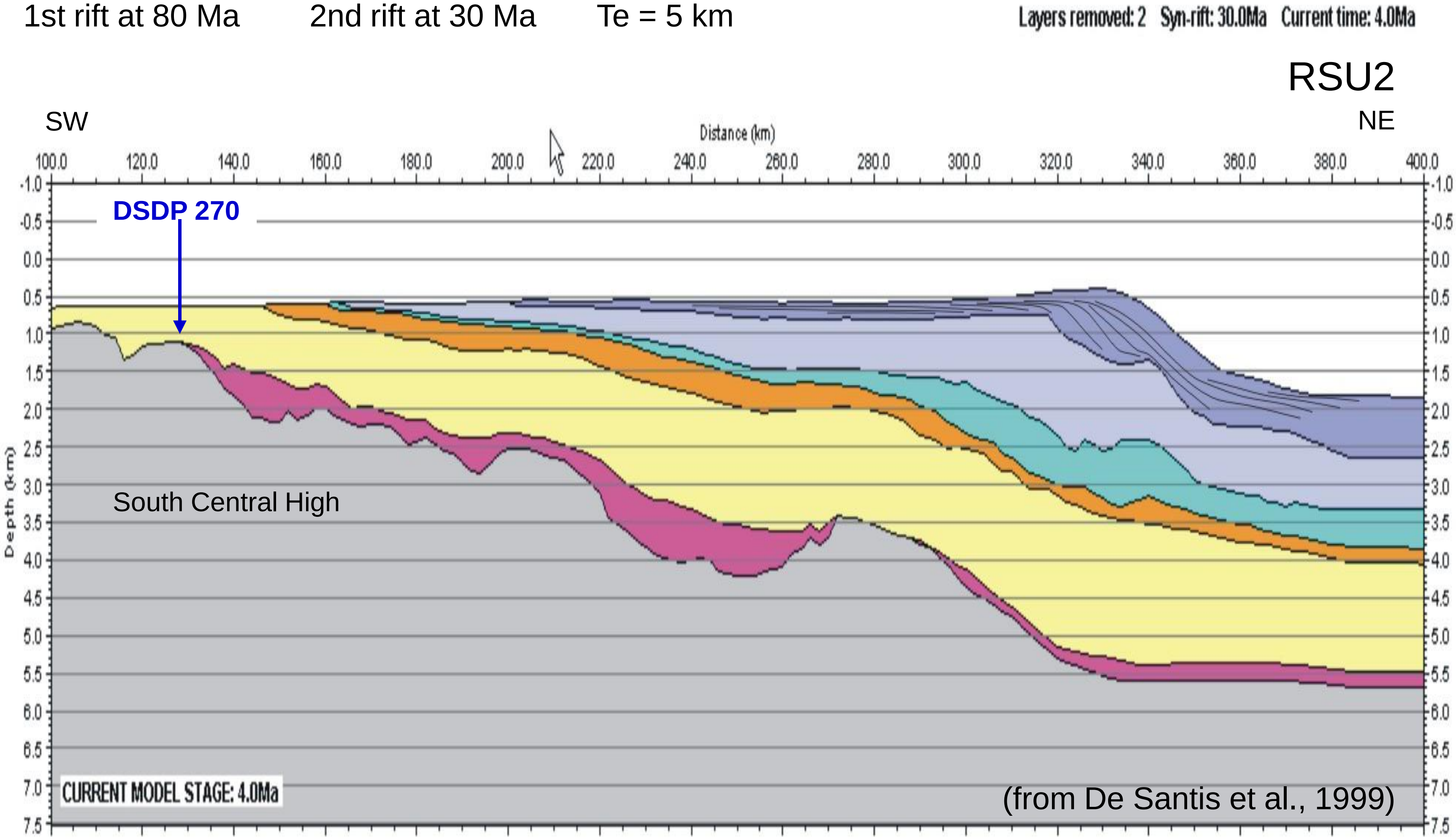
Flexural backstripping of depth converted profile BGR80-07

(De Santis et al., 1999)



Flexural backstripping of depth converted profile BGR80-07

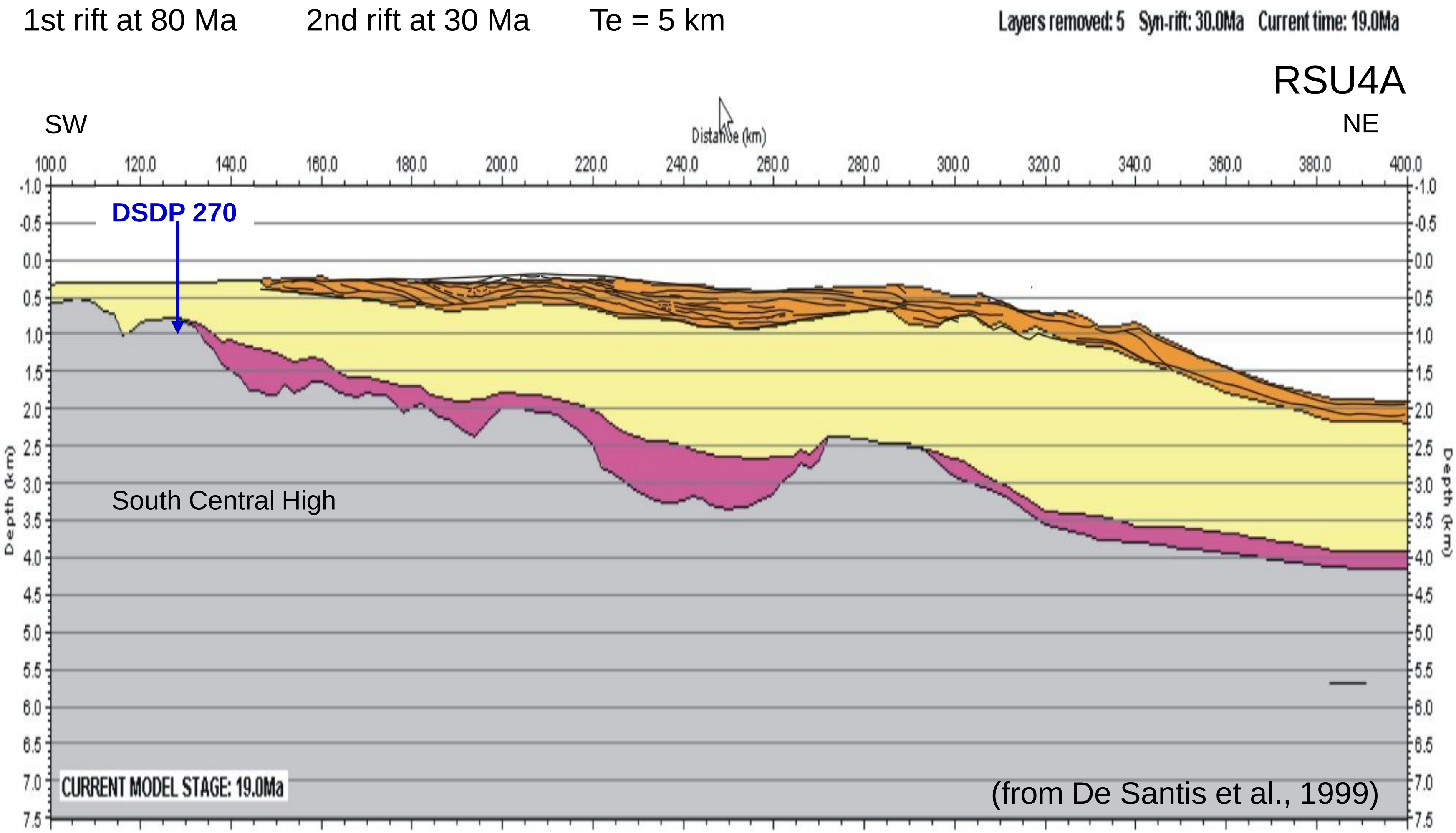
1st rift at 80 Ma   2nd rift at 30 Ma   Te = 5 km



(from De Santis et al., 1999)

Flexural backstripping of depth converted profile BGR80-07

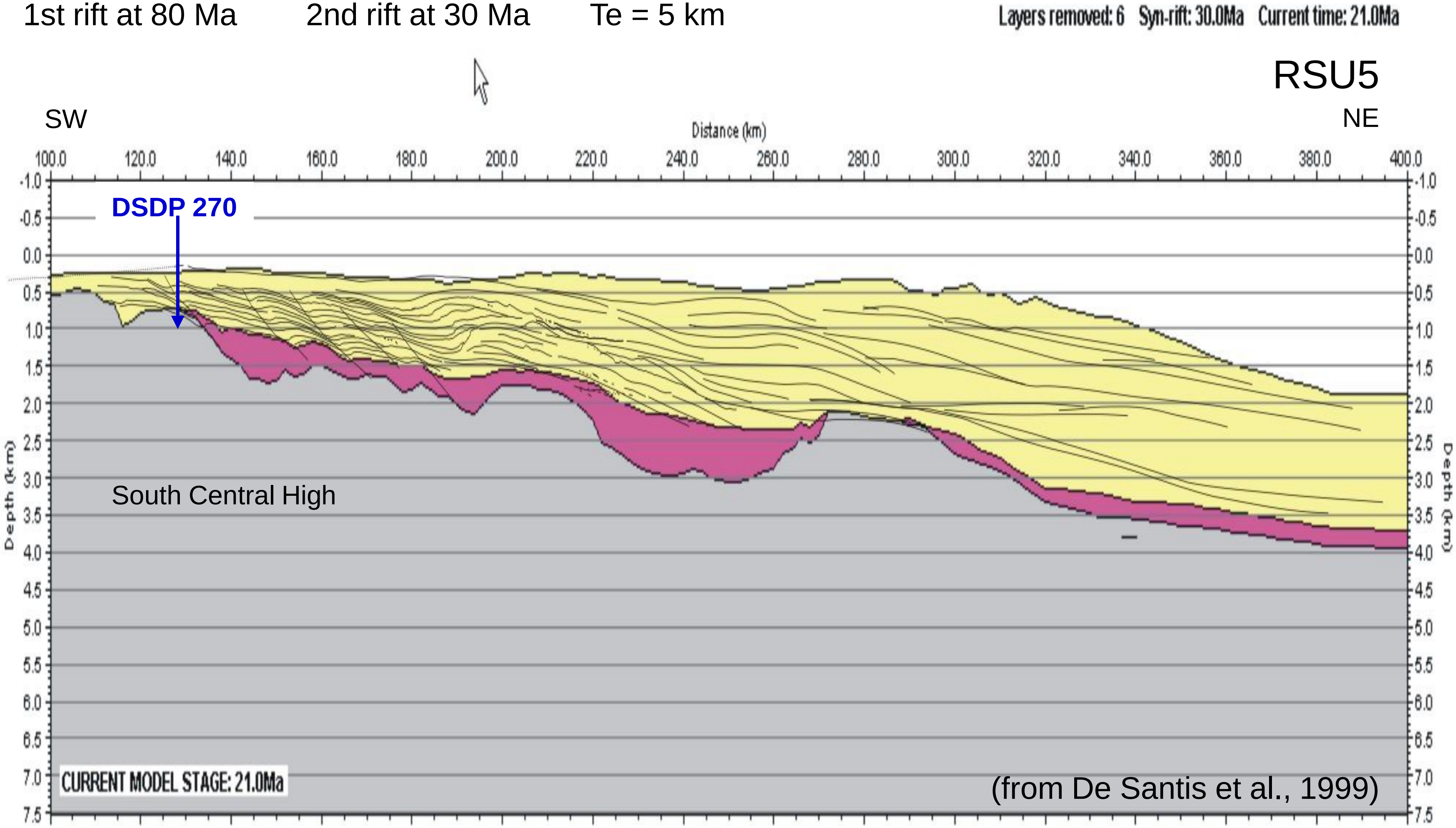
1st rift at 80 Ma 2nd rift at 30 Ma Te = 5 km



(from De Santis et al., 1999)

Flexural backstripping of depth converted profile BGR80-07

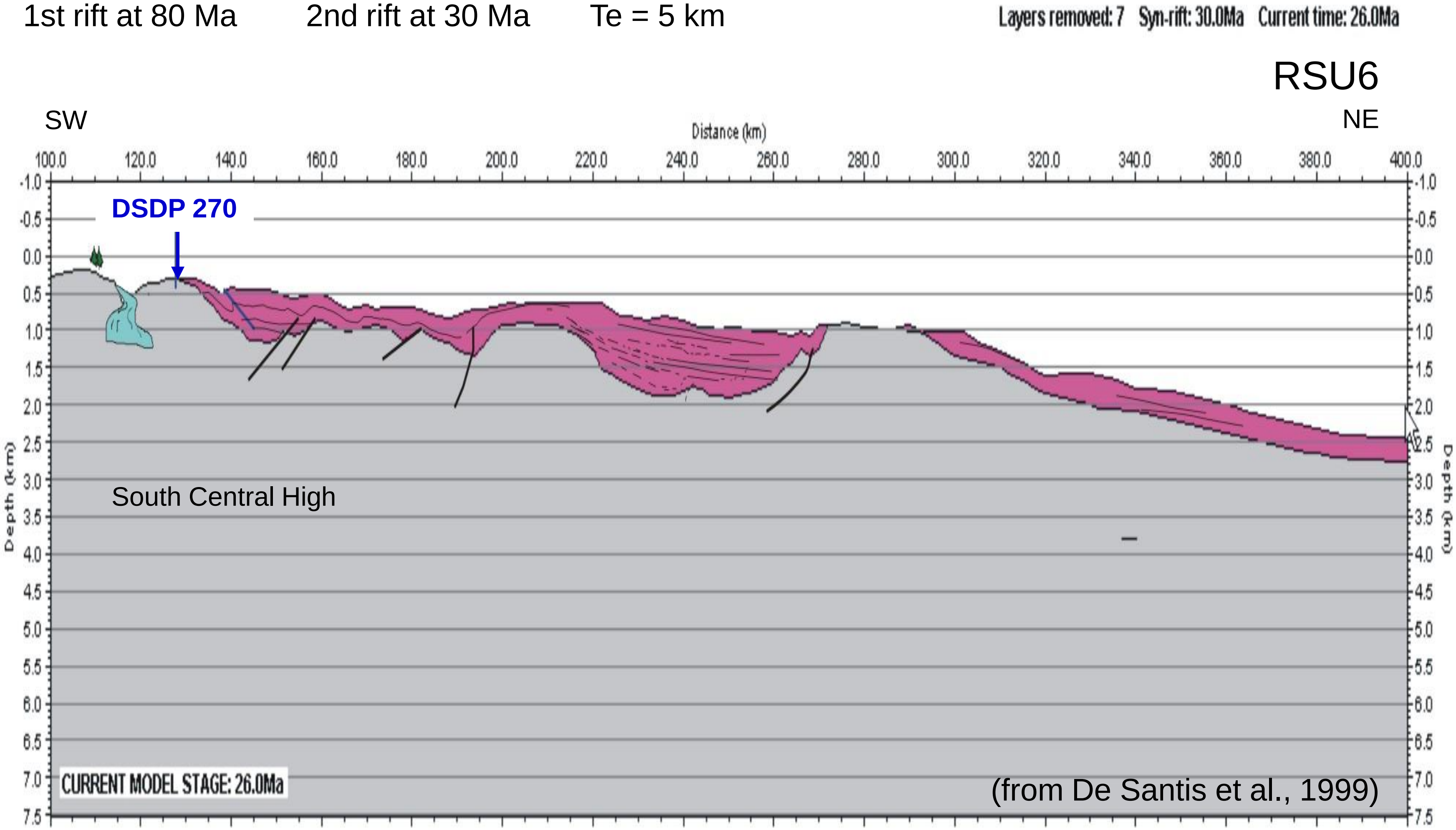
1st rift at 80 Ma 2nd rift at 30 Ma Te = 5 km



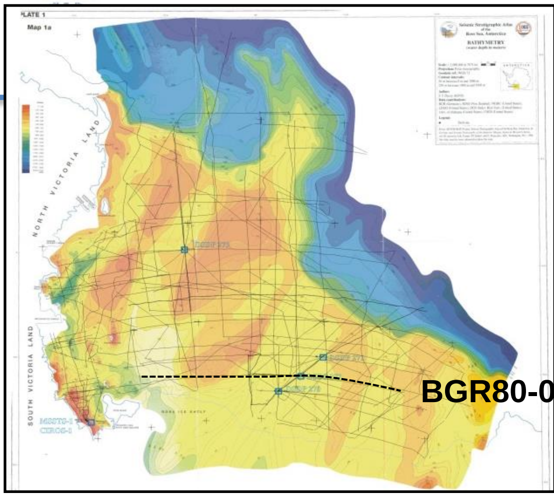
(from De Santis et al., 1999)

Flexural backstripping of depth converted profile BGR80-07

1st rift at 80 Ma 2nd rift at 30 Ma Te = 5 km

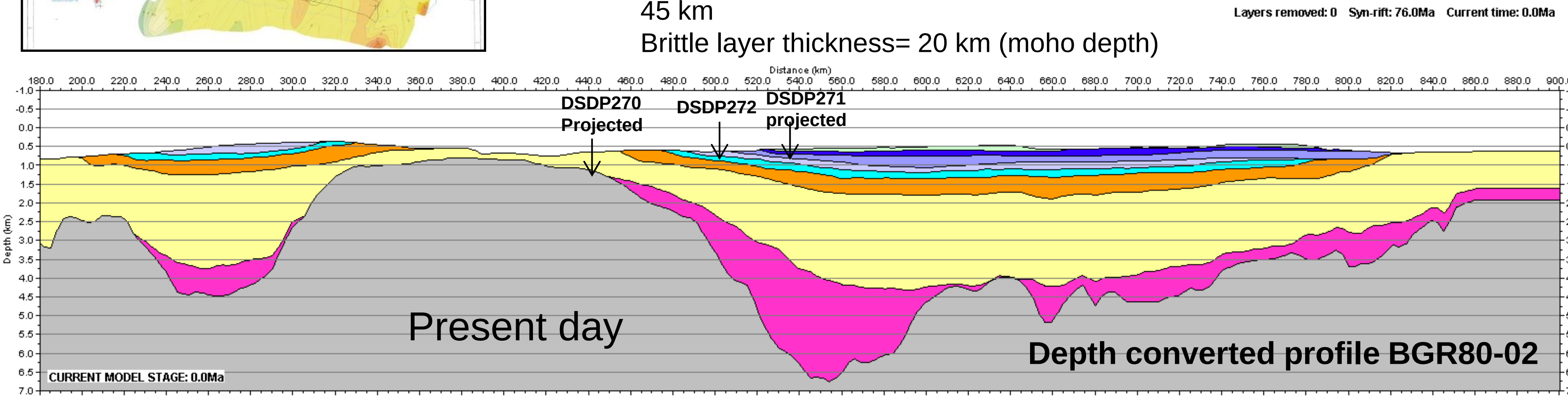


(from De Santis et al., 1999)

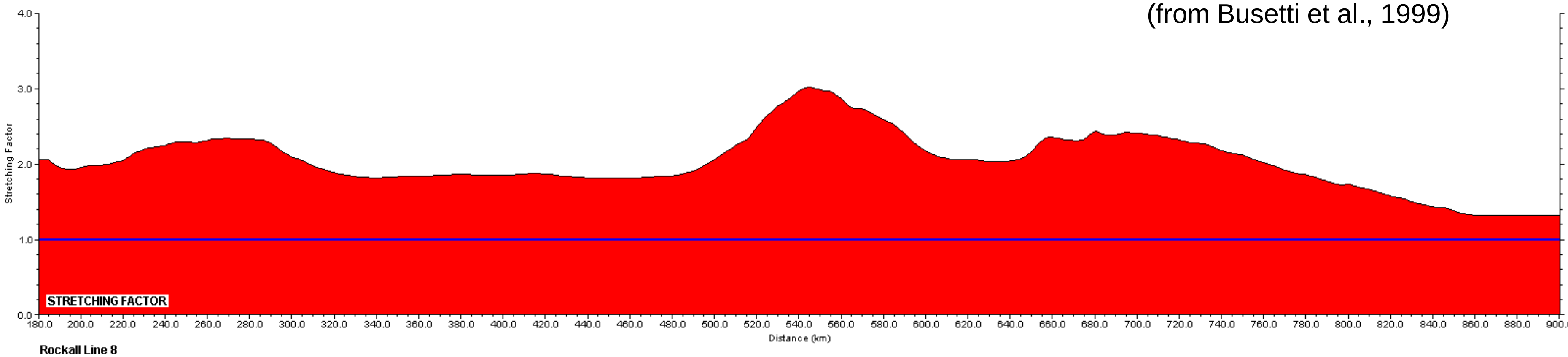


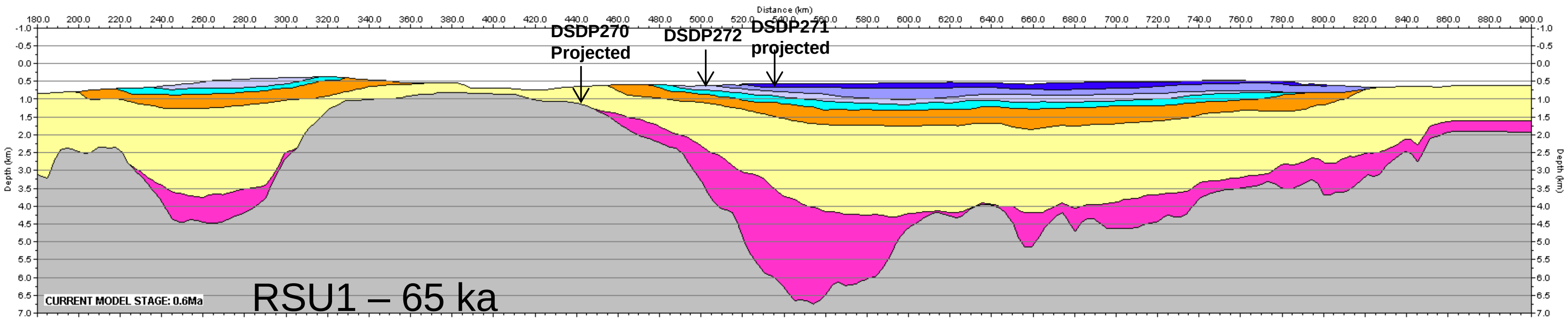
#	Poros (%)	Dec con (1/km)	Dens (g/cc)	Age base (Ma)	Vel (km/s)	Name
1	45.0	0.45	2.6800001	0.6	0.0	Layer_1
2	45.0	0.45	2.6800001	4.0	0.0	Layer_2
3	45.0	0.45	2.6800001	10.0	0.0	Layer_3
4	45.0	0.45	2.6800001	16.5	0.0	Layer_4
5	45.0	0.45	2.6800001	19.0	0.0	Layer_5
6	45.0	0.45	2.6800001	21.0	0.0	Layer_6
7	45.0	0.45	2.6800001	26.0	0.0	Layer_7
8	49.0	0.27	2.6800001	30.0	0.0	Layer_8

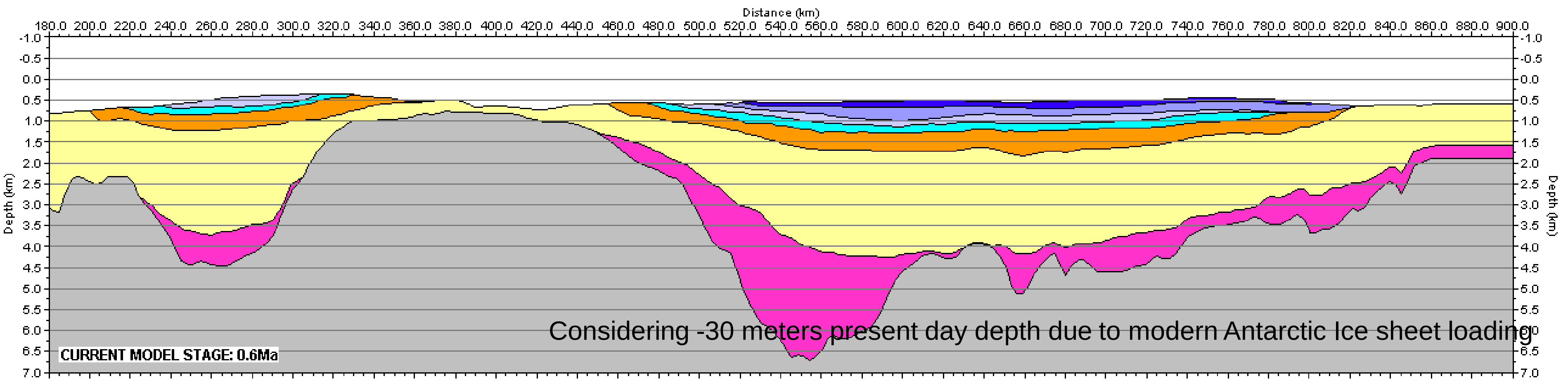
Rift age = 76 Ma
Effective elastic thickness of the Lithoshere = 45 km
Brittle layer thickness= 20 km (moho depth)

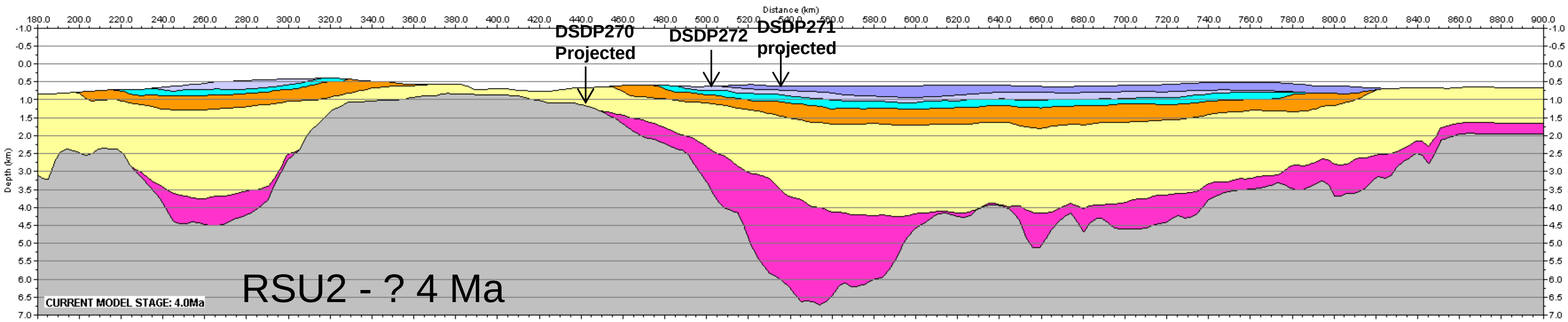


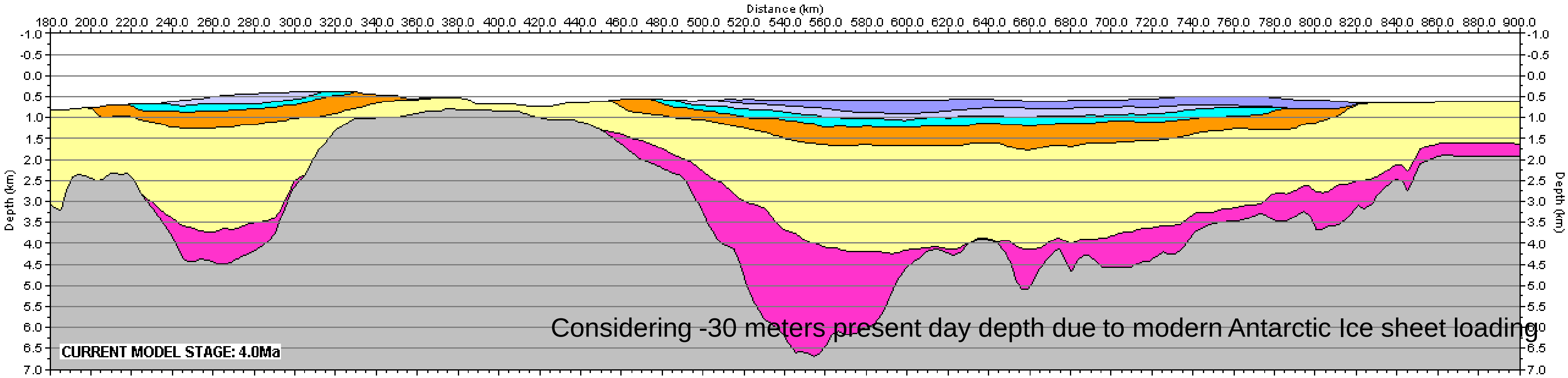
(from Busetti et al., 1999)




Distance (km)
DSDP270
Projected
DSDP272
DSDP271
projected
Depth (km)
CURRENT MODEL STAGE: 0.6Ma
RSU1 – 65 ka


Distance (km)
Depth (km)
CURRENT MODEL STAGE: 0.6Ma
Considering -30 meters present day depth due to modern Antarctic Ice sheet loading


Distance (km)
180.0 200.0 220.0 240.0 260.0 280.0 300.0 320.0 340.0 360.0 380.0 400.0 420.0 440.0 460.0 480.0 500.0 520.0 540.0 560.0 580.0 600.0 620.0 640.0 660.0 680.0 700.0 720.0 740.0 760.0 780.0 800.0 820.0 840.0 860.0 880.0 900.0
Depth (km)
-1.0 -0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0
DSDP270
Projected
DSDP272
DSDP271
projected
RSU2 - ? 4 Ma
CURRENT MODEL STAGE: 4.0Ma


Distance (km)
180.0 200.0 220.0 240.0 260.0 280.0 300.0 320.0 340.0 360.0 380.0 400.0 420.0 440.0 460.0 480.0 500.0 520.0 540.0 560.0 580.0 600.0 620.0 640.0 660.0 680.0 700.0 720.0 740.0 760.0 780.0 800.0 820.0 840.0 860.0 880.0 900.0
Depth (km)
-1.0 -0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0
Considering -30 meters present day depth due to modern Antarctic Ice sheet loading
CURRENT MODEL STAGE: 4.0Ma

Sample (number)	Depth below sea floor (meters)	Depth below sea floor (milliseconds)	Seismic facies
1 - 12 13 - 24 25 - 30	4.8 - 27 27 - 99 109 - 149	ca. 0 - 20 20 - 100 100 - 150	facies A facies B facies C

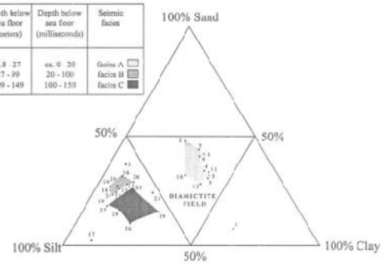


Figure 2. Triangular plot of sand/silt/clay distribution for DSDP Site 272 lithologic units from top of hole to 149 meters below sea floor. Grain size data are from Balshaw [1981]. Shading is same as interpretations in Fig. 1.

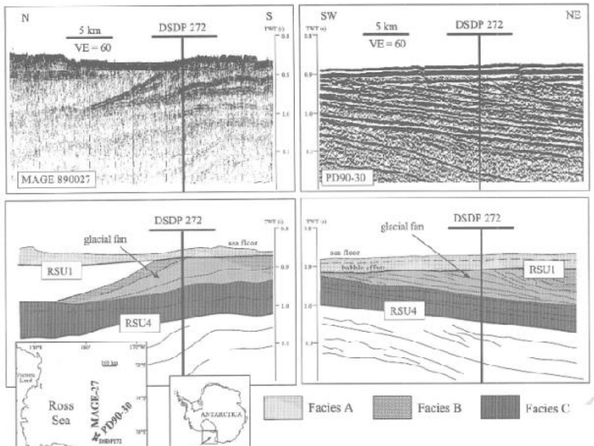
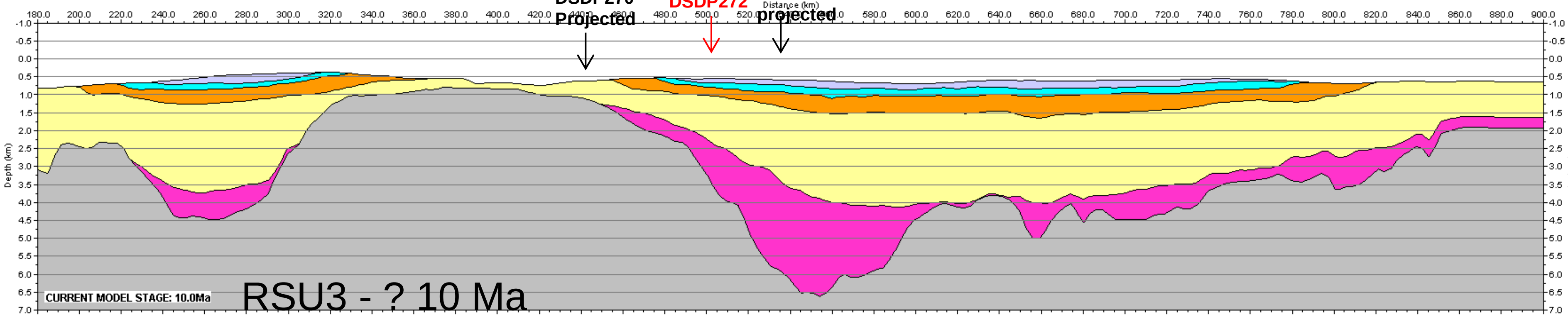


Figure 1: Seismic profiles with interpretations across DSDP Site 272 in the Ross Sea.

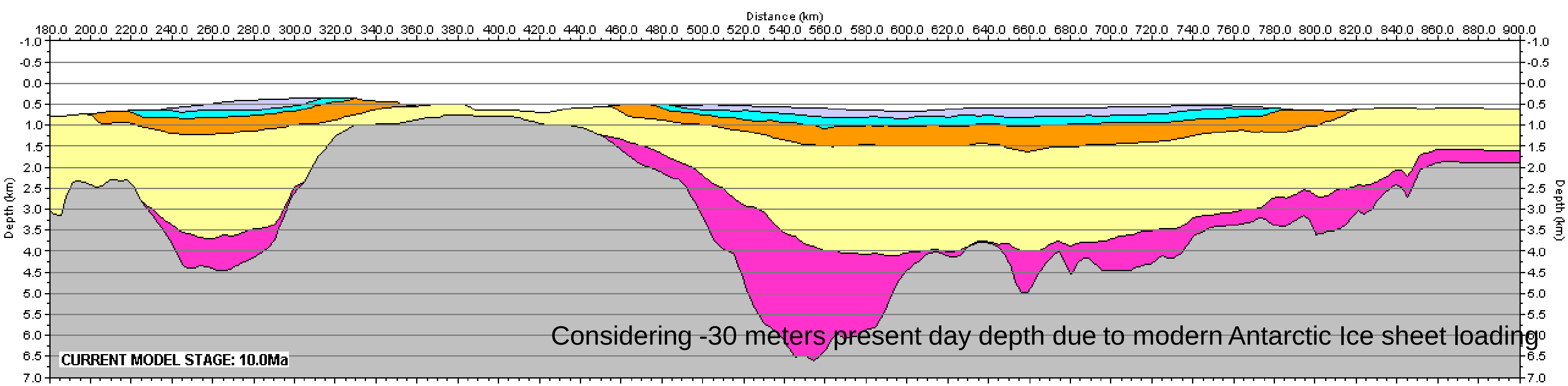
TABLE 1. Seismic Data

Type of survey	Seismic source	Seismic source frequency (hertz)	Receiver bandwidth (hertz)	Vertical resolution (meter)	Penetration depth (second)	Scientific institution and year	Seismic survey (km)
single-channel	Sparker 100 J	50-800	no filter	ca. 1.5	0.2	MAGE[1] 1989	3,100
single-channel	Air gun 2.46 l	20-600	50-140	ca. 5	1.5-2.0	Rice University[2] 1990	2,600

[1]Joint Stock Company Marine Arctic Geological Expedition (Russia)
[2]Rice University (USA)

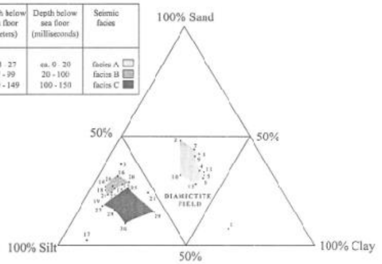


RSU3 - ? 10 Ma



Considering -30 meters present day depth due to modern Antarctic Ice sheet loading

Sample (number)	Depth below sea floor (meters)	Depth below sea floor (milliseconds)	Seismic facies
1 - 12	4.8 - 27	ca. 0 - 20	facies A
13 - 24	27 - 99	20 - 100	facies B
25 - 30	109 - 149	100 - 150	facies C



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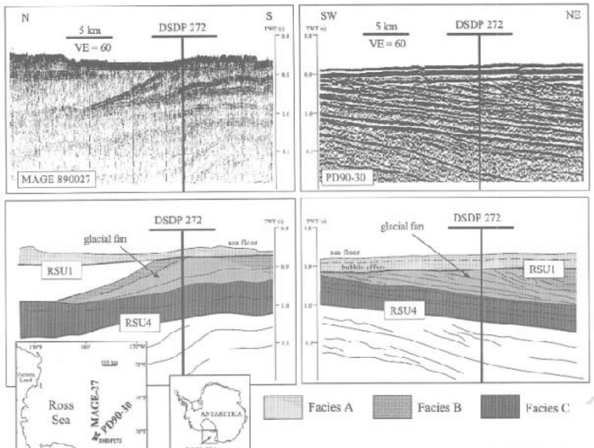

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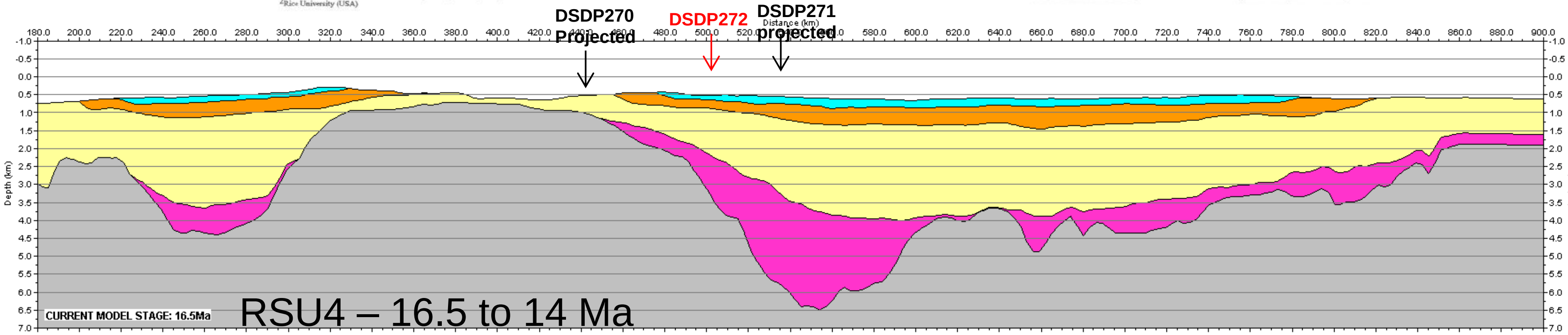
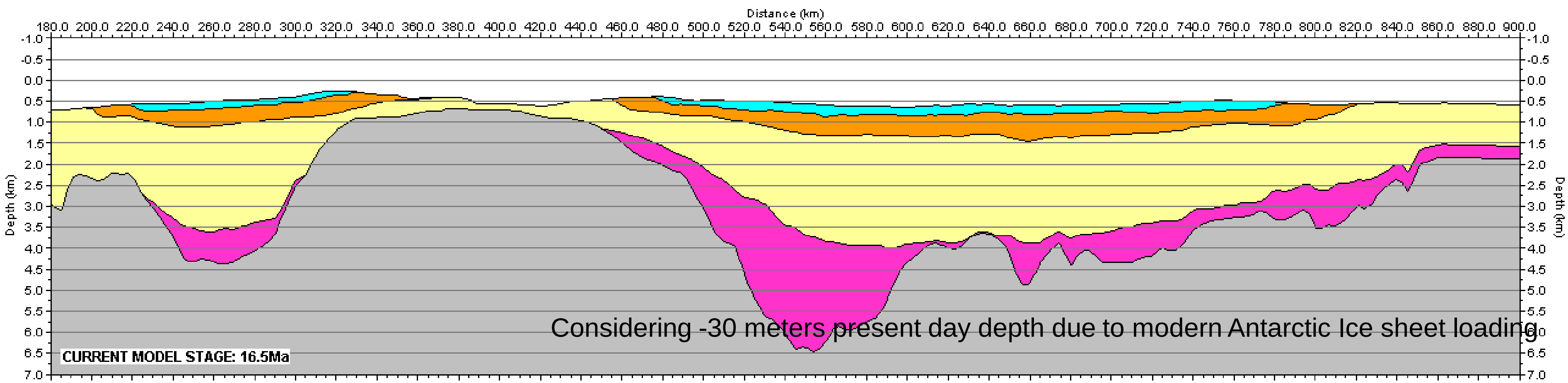
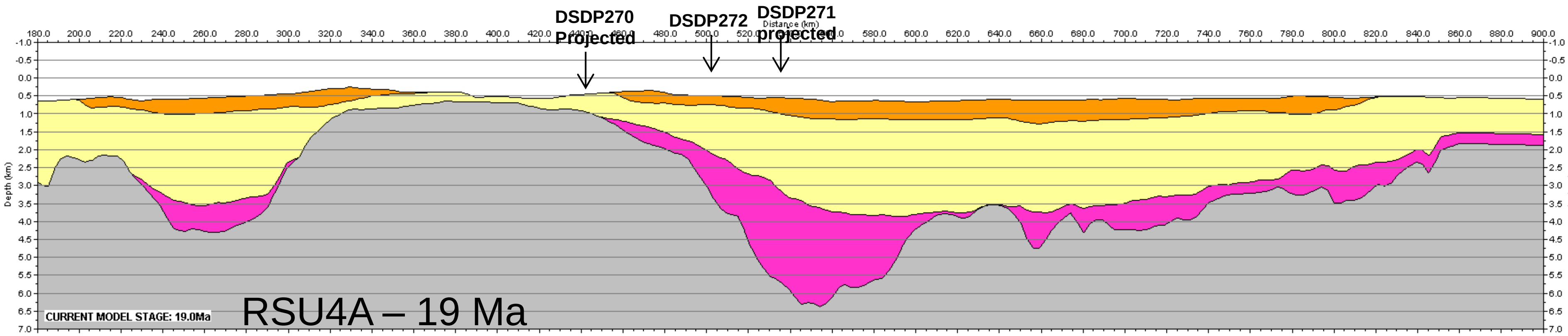
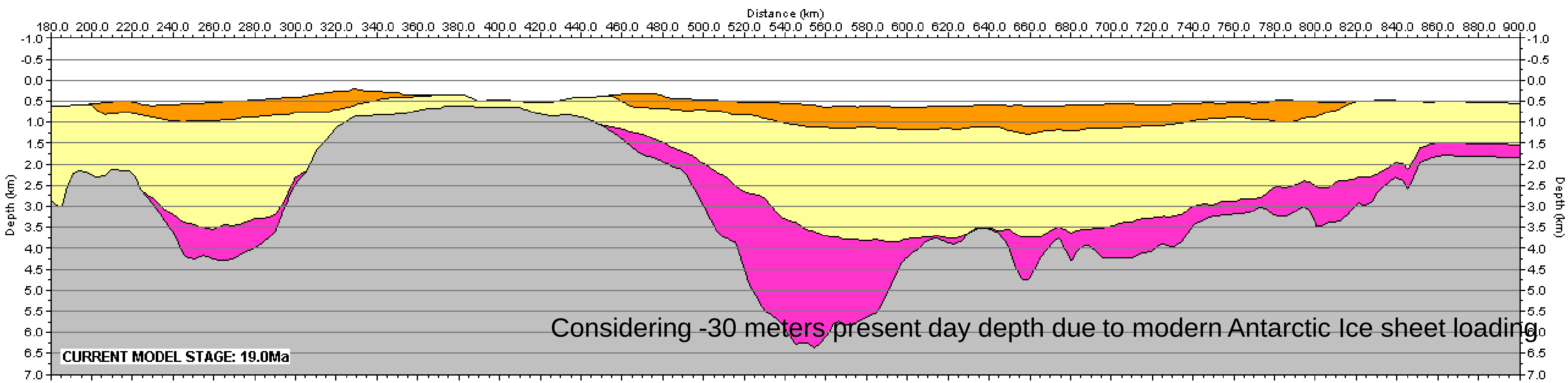


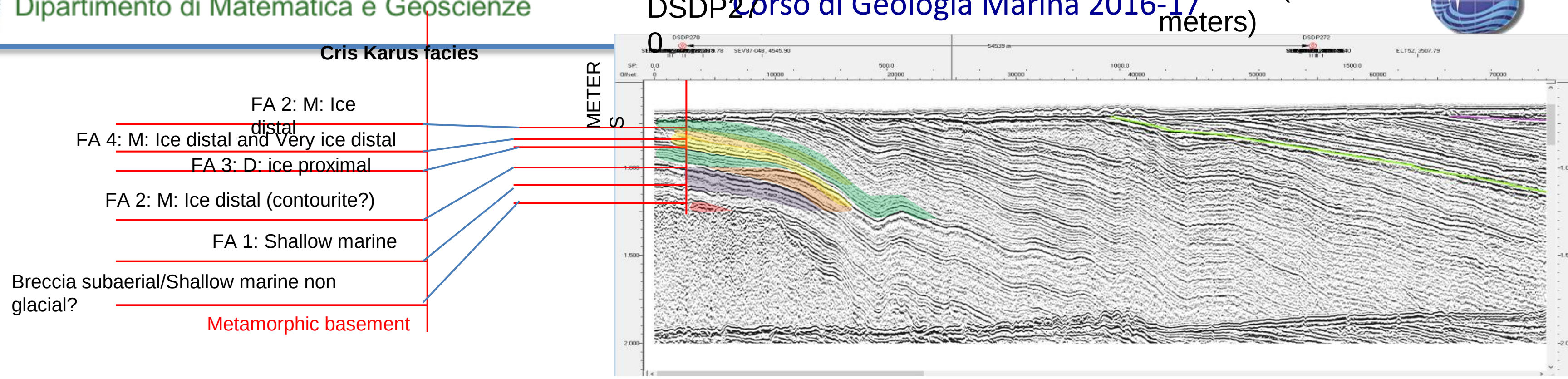
RSU4 – 16.5 to 14 Ma

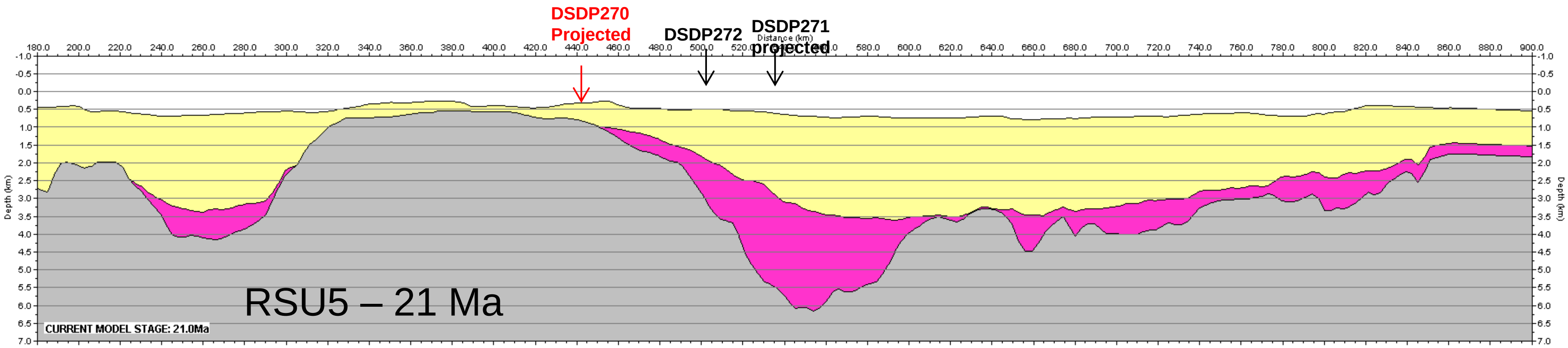


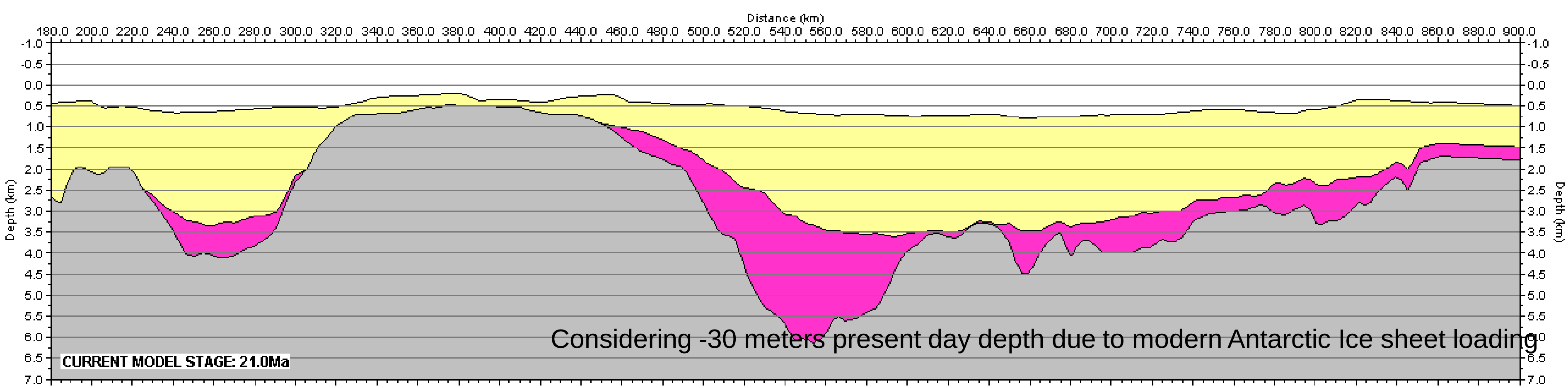
Considering -30 meters present day depth due to modern Antarctic Ice sheet loading

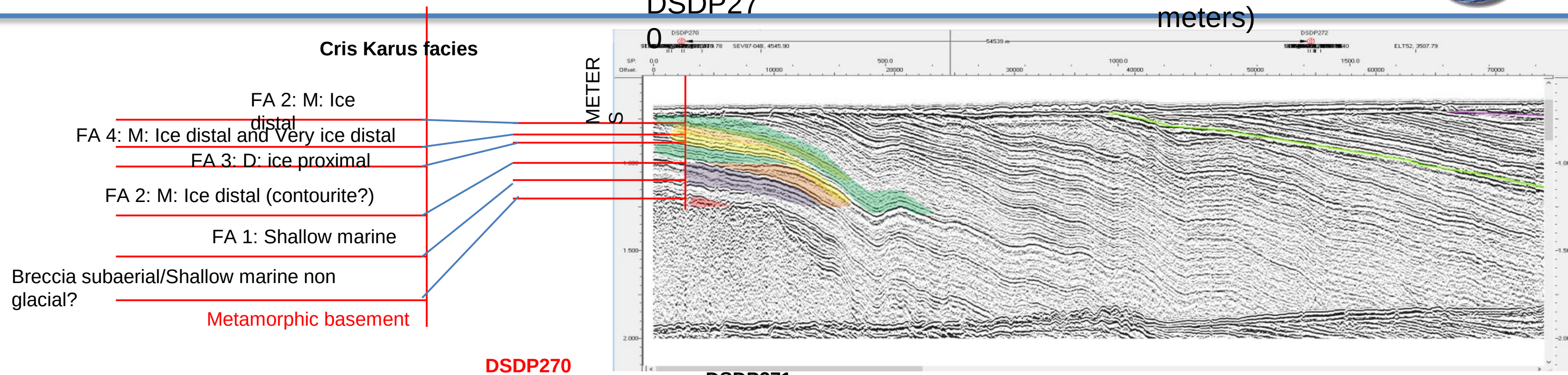

DSDP270
Projected
DSDP272
DSDP271
projected
Distance (km)
Depth (km)
CURRENT MODEL STAGE: 19.0Ma
RSU4A – 19 Ma


Distance (km)
Depth (km)
CURRENT MODEL STAGE: 19.0Ma
Considering -30 meters present day depth due to modern Antarctic Ice sheet loading


Cris Karus facies
FA 2: M: Ice distal
FA 4: M: Ice distal and Very ice distal
FA 3: D: ice proximal
FA 2: M: Ice distal (contourite?)
FA 1: Shallow marine
Breccia subaerial/Shallow marine non glacial?
Metamorphic basement
METERS
DSDP270
PD90-30 (converted in meters)


DSDP270 Projected
DSDP272
DSDP271 projected
Distance (km)
Depth (km)
RSU5 – 21 Ma
CURRENT MODEL STAGE: 21.0Ma


Distance (km)
Depth (km)
CURRENT MODEL STAGE: 21.0Ma
Considering -30 meters present day depth due to modern Antarctic Ice sheet loading


PD90-30 (converted in meters)
DSDP270
METERS
Cris Karus facies
FA 2: M: Ice distal
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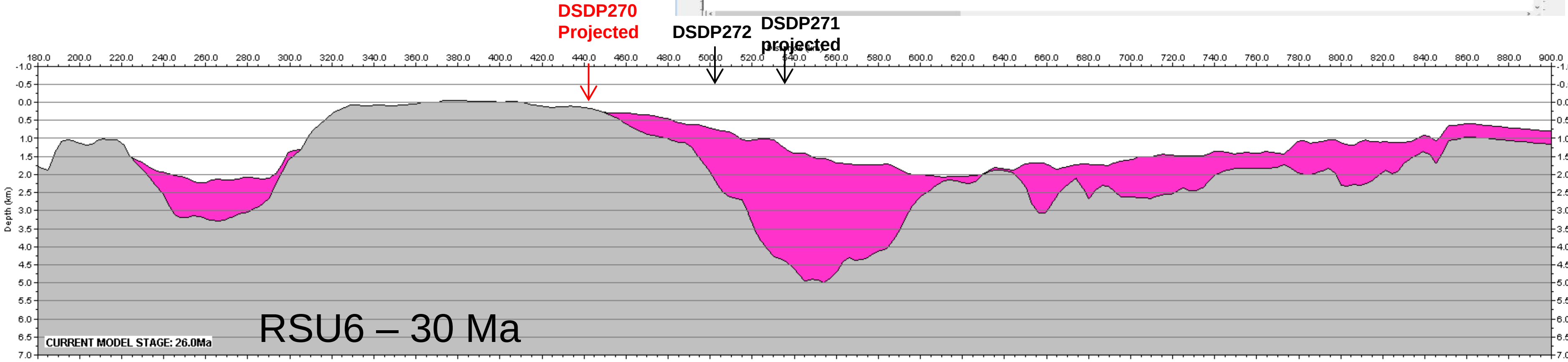
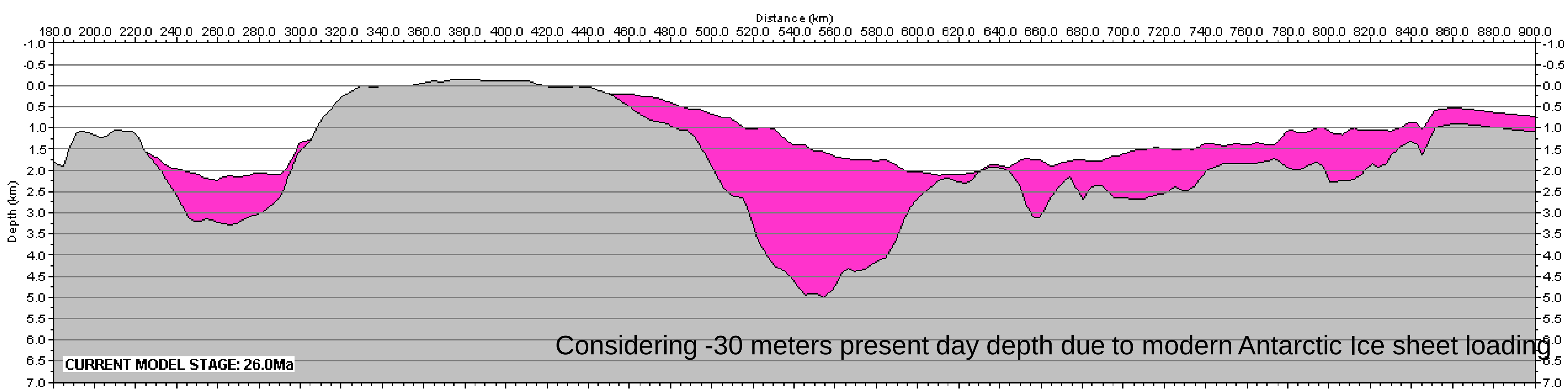
Metamorphic basement

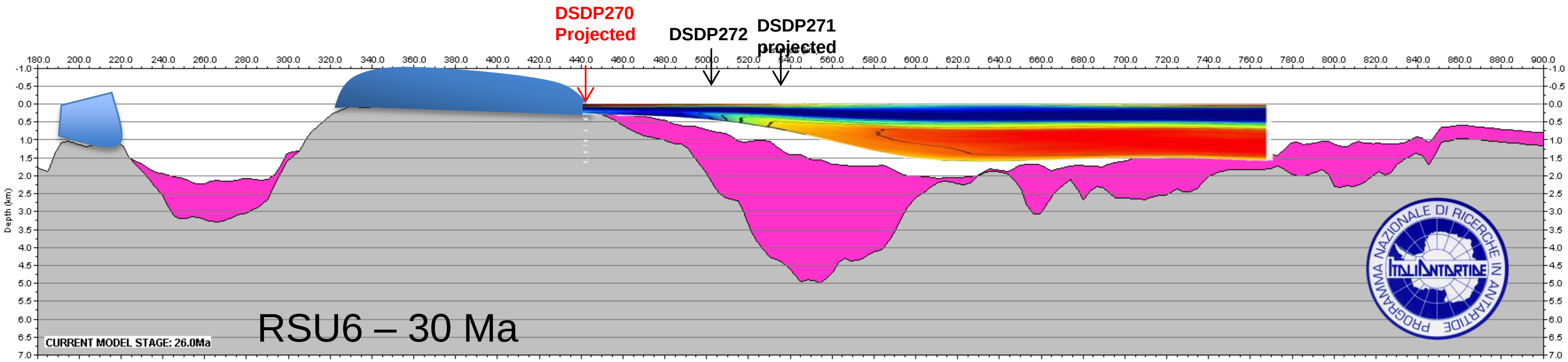

DSDP270 Projected
DSDP272
DSDP271 projected
Depth (km)
CURRENT MODEL STAGE: 26.0Ma
RSU6 – 30 Ma

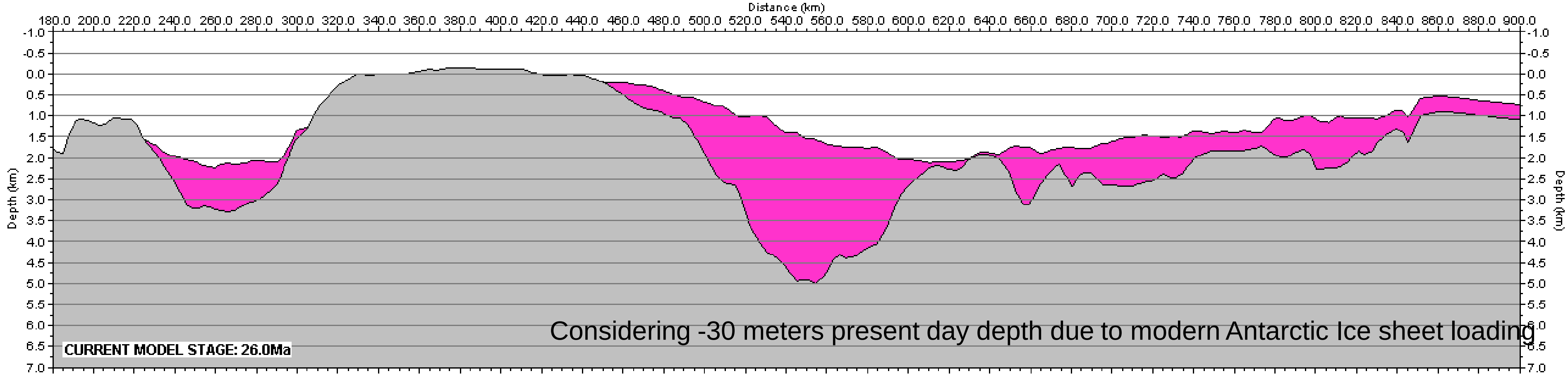

Distance (km)
Depth (km)
CURRENT MODEL STAGE: 26.0Ma
Considering -30 meters present day depth due to modern Antarctic Ice sheet loading

How much (thickness and volume) terrestrial ice existed already?

Ministero degli Affari Esteri e della Cooperazione Internazionale

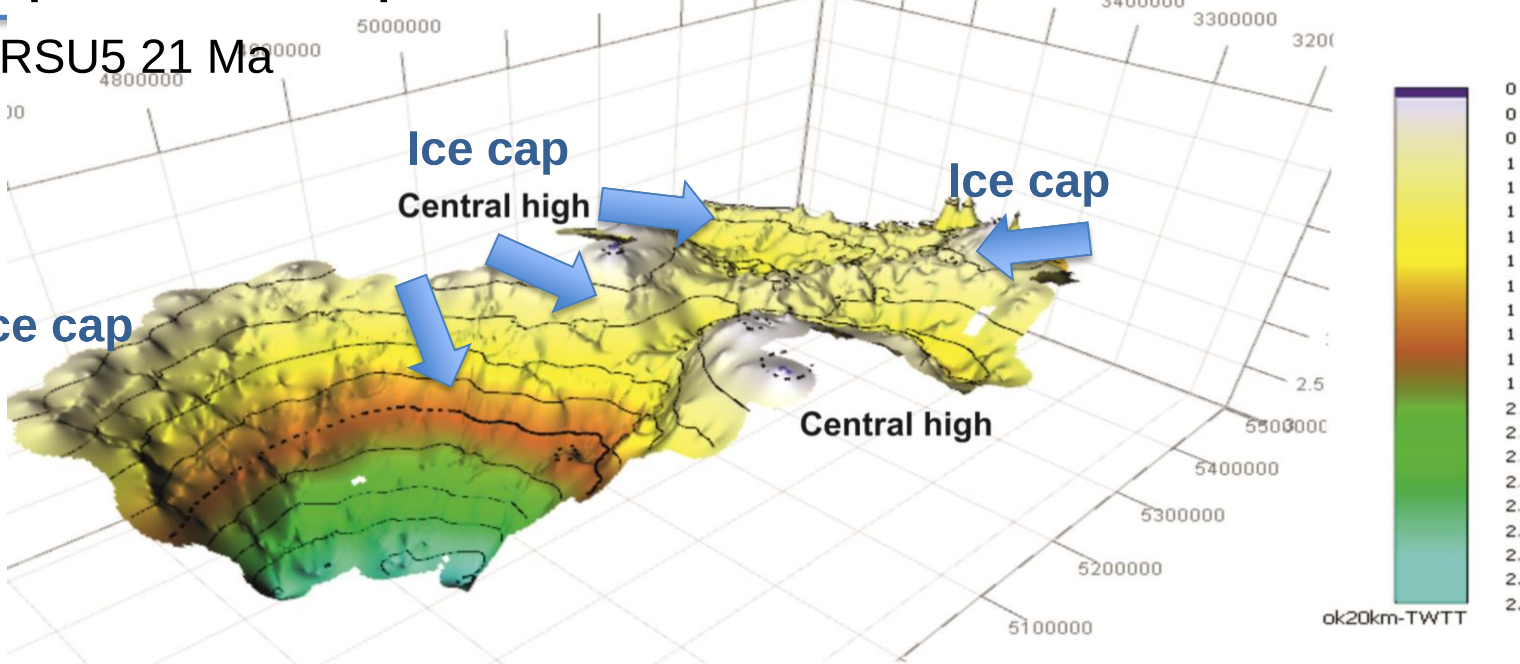
How was the water masses stratification? And circulation?





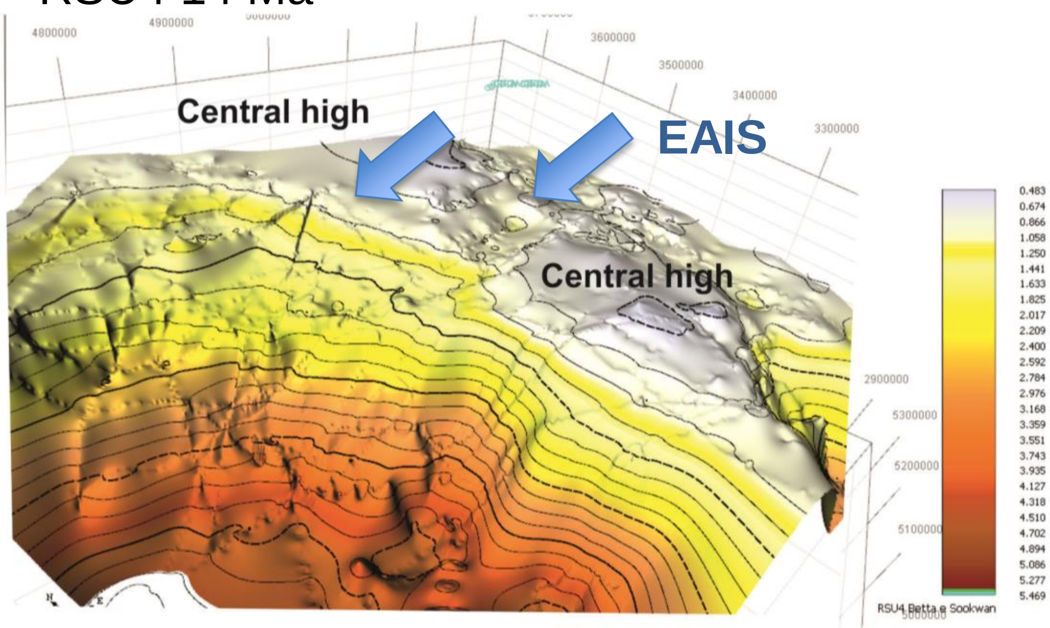
Depth contour maps in time twt

RSU5 21 Ma

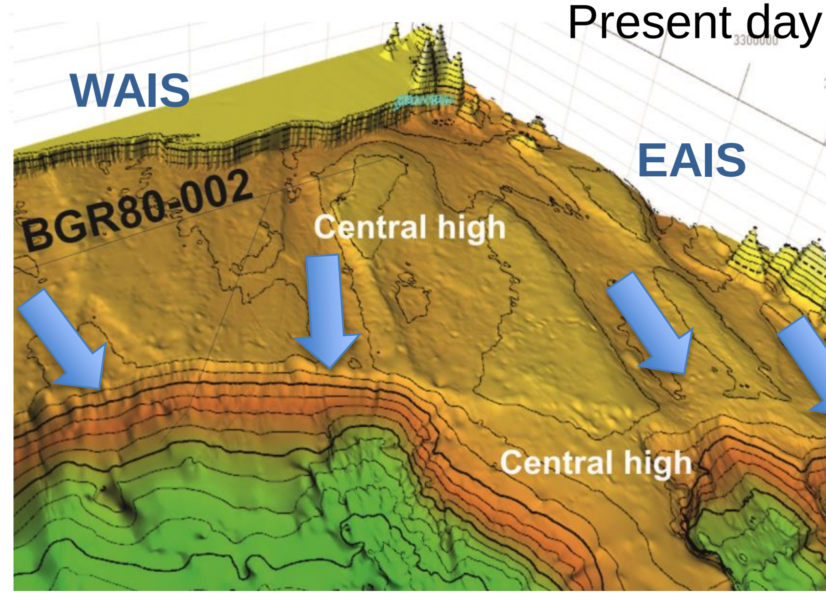


New Italian geophysical cruise in the Ross Sea in 2017

RSU4 14 Ma



Present day



PAIS - Past Antarctic Ice Sheet Dynamics conference
Trieste, Italy
September 10th (Sunday) to 16th (Saturday) 2017

http://www.scar.org/pais/pais-news

PAIS-conference-2017.inogs.it

pais-conference2017@inogs.it

Promoting committee

- L. De Santis (OGS, Trieste, Italy) – co-chair of PAIS and *organizing chairperson* *ldesantis@ogs.trieste.it*
- Tim Naish (Univ. of Victoria, NZ) – co-chair of PAIS and *scientific committee chairperson*
- Carlota Escutia (CSIC-Univ. Granada, Spain) former co-chair of PAIS
- Rob DeConto (University of Massachusetts, MA, USA), former co-chair of PAIS
- Anna Wåhlin (co-chair of SOOS www.soos.aq , univ. of Göteborg, Sweden)
- Valerie Masson-DeMotte (co-chair of IPCC-WG1, LSCE (CEA-CNRS-UVSQ/IPSL), Gif-sur-YveWe, France)

Plenary talks and posters
Workshops
half-day and 2-days field excursions

Theme - 1: Advances in Antarctic ice-sheet reconstructions from geological and ice core archives. 1A: Deep time reconstructions. 1B: Recent reconstructions (LIG to present)

Theme - 2: Advances in understanding the drivers, processes, and rates of past and future Antarctic ice-sheet change from models and data.

Theme – 3: Teleconnections, far-field responses to Antarctic ice sheet change.

Theme – 4: Co-evolution of climate and life in the Antarctic & Southern Ocean.

Theme – 5: Emerging research priorities of societal relevance

- Topic 1 - Science-logistics-management opportunities and challenges (e.g. in the COMNAP Antarctic Roadmap Challenges https://www.comnap.aq/Projects/SitePages/ARC.aspx
- Topic 2 – PAIS Policy-relevant research outcomes for IPCC AR6-
- Topic 3 - Improving engagement and reach.

Papers addressing the following topics will be welcomed

PAIS Past Antarctic Ice Sheet Dynamics

- Contribution of Antarctic ice sheets to sea level changes, past, present and future.
- The role of geodynamics on ice sheet and sea-level changes
- Thresholds and processes for ice shelf/ice sheet stability
- Attribution of cryospheric changes to natural and anthropogenic climate changes.
- Ice sheet dynamics: processes, uncertainties, boundary conditions, field and laboratory experiments and modelling.
- Coupling of global climate models to ice sheet and sea-ice models.
- Ice–ocean interactions
- Atmosphere-ice-ocean interactions: Ice cores, marine cores and climate
- Antarctic feedbacks in climate change, including carbon cycle and processes of polar amplification.
- Paleogeographic reconstructions
- Climate/ocean proxy development
- Improvements in geochronology and age control: how to better constrain rates of change
- Identifying future drilling and data acquisition priorities and opportunities
- Past regional climate variability records
- Global and hemispheric scale teleconnections
- Biotic response to changes in paleoceanography and Antarctic ice sheet change
- Antarctic ecosystem responses on orbital and longer timescales
- Policy relevance of Antarctic ice sheet research
- Improving engagement and reach

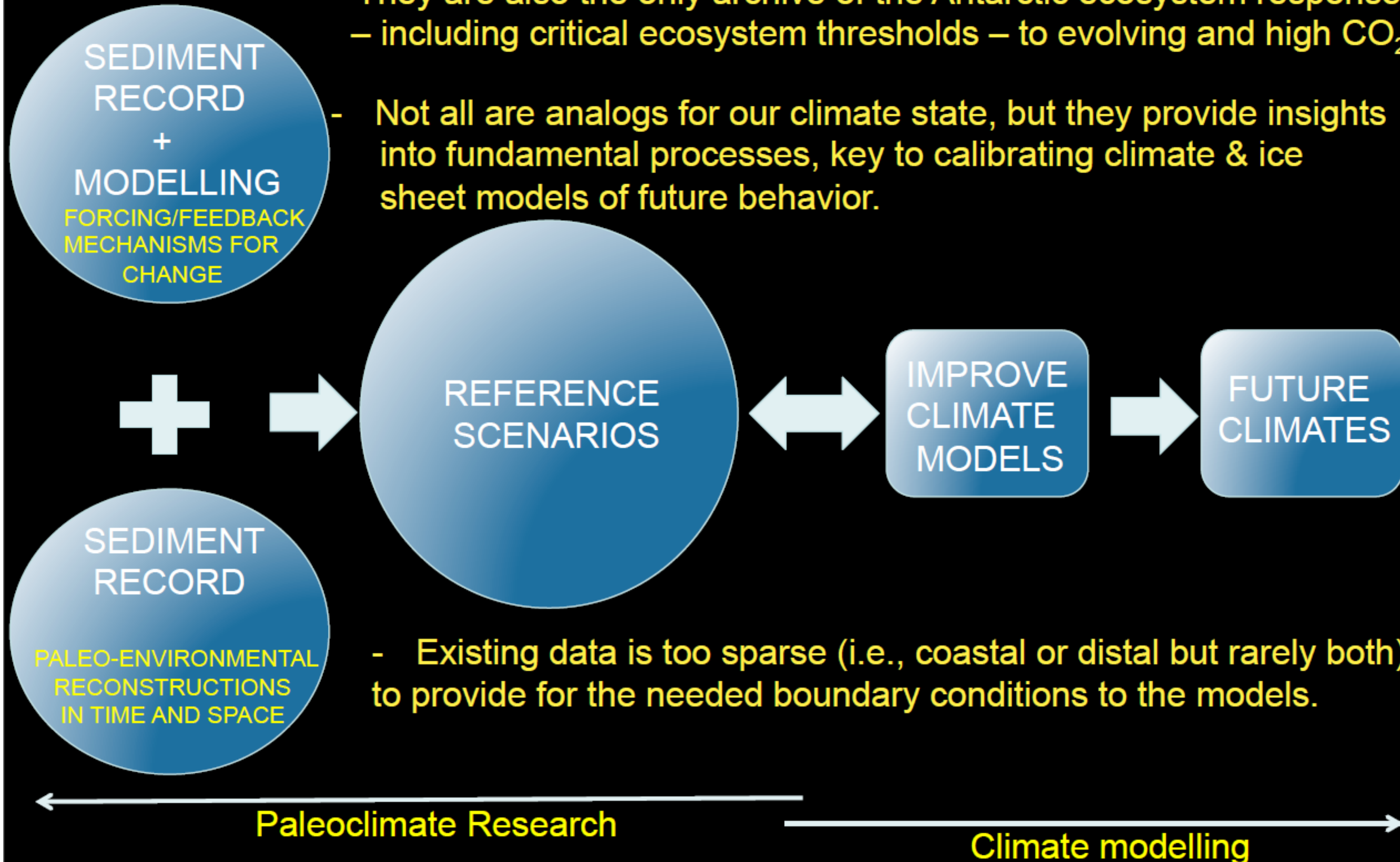
PAIS Past Antarctic Ice Sheet Dynamics

Day 3 – Workshops and half-day field excursion (optional)

- PRAMSO (Palaeoclimate Records from the Antarctic Margin and Southern Ocean)
- Paleotopography and paleobtahymetry/CASP/ANTscape
- Antarctic Seismic Data Library System SDLS
- High-resolution (last 1Ma) ice core and marine record synthesis?
- APECS
- Subglacial and paleoceanographic community
- Rates of retreat over the last deglaciation (particularly in the Ross and Amundsen Seas), reconstructing paleo ice-stream dynamics, modes of past grounding line behavior
- Others?

SUMMARY

- Deep-time sedimentary records from Antarctica are unique archives of paleoclimate and ice sheet behavior.
- They are also the only archive of the Antarctic ecosystem response – including critical ecosystem thresholds – to evolving and high CO_2
- Not all are analogs for our climate state, but they provide insights into fundamental processes, key to calibrating climate & ice sheet models of future behavior.



- Existing data is too sparse (i.e., coastal or distal but rarely both) to provide for the needed boundary conditions to the models.