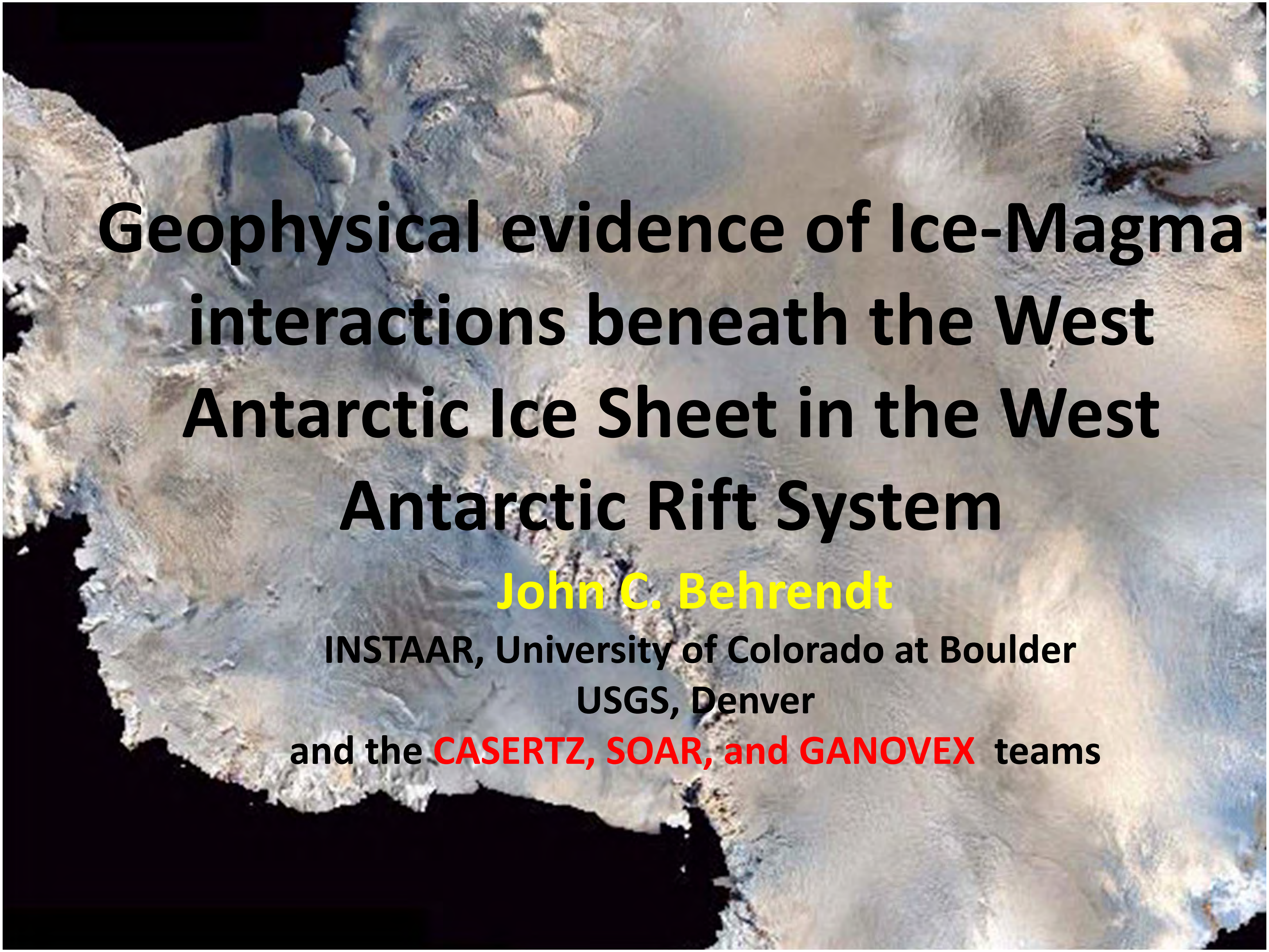


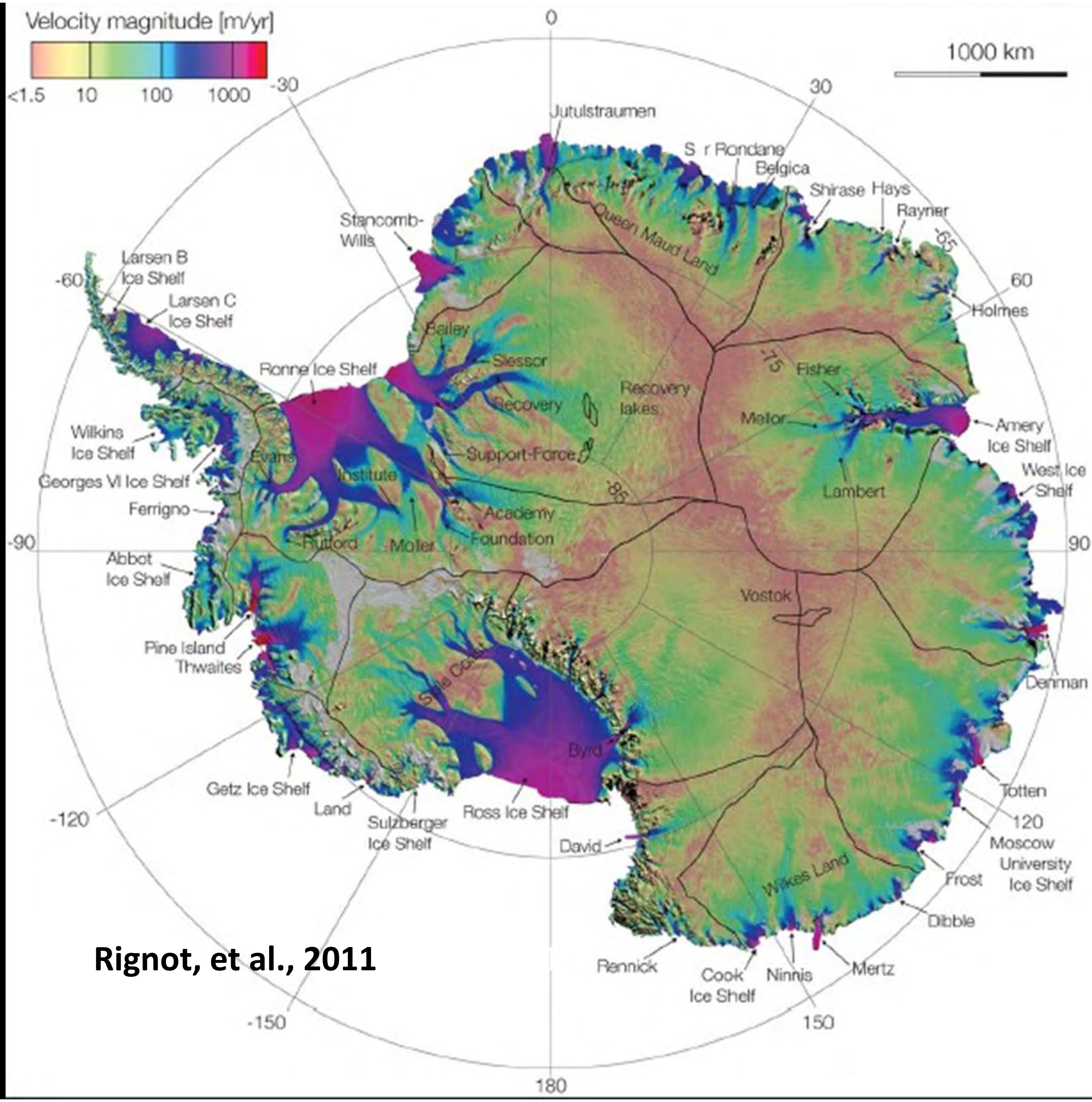
# Geophysical evidence of Ice-Magma interactions beneath the West Antarctic Ice Sheet in the West Antarctic Rift System


John C. Behrendt

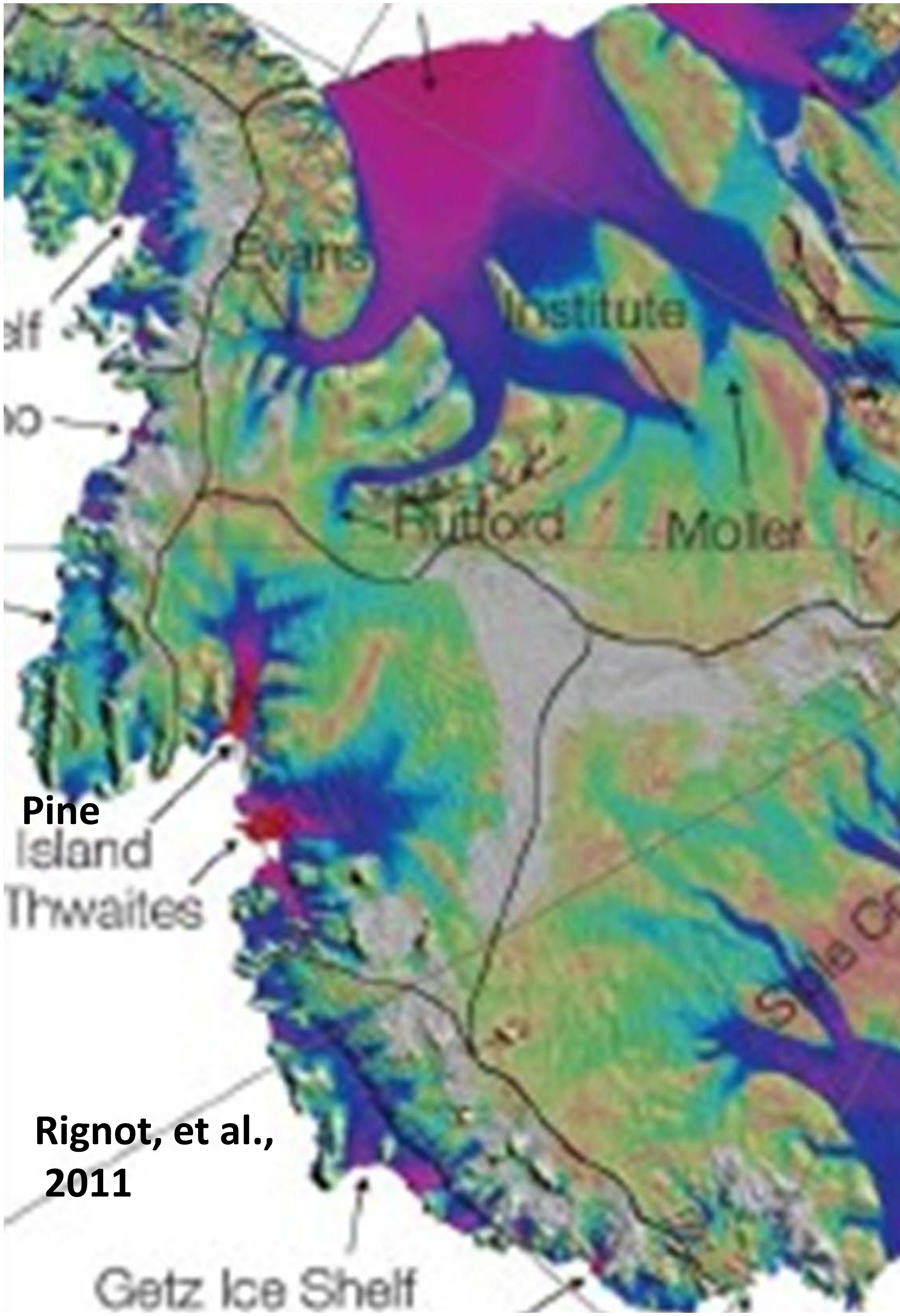
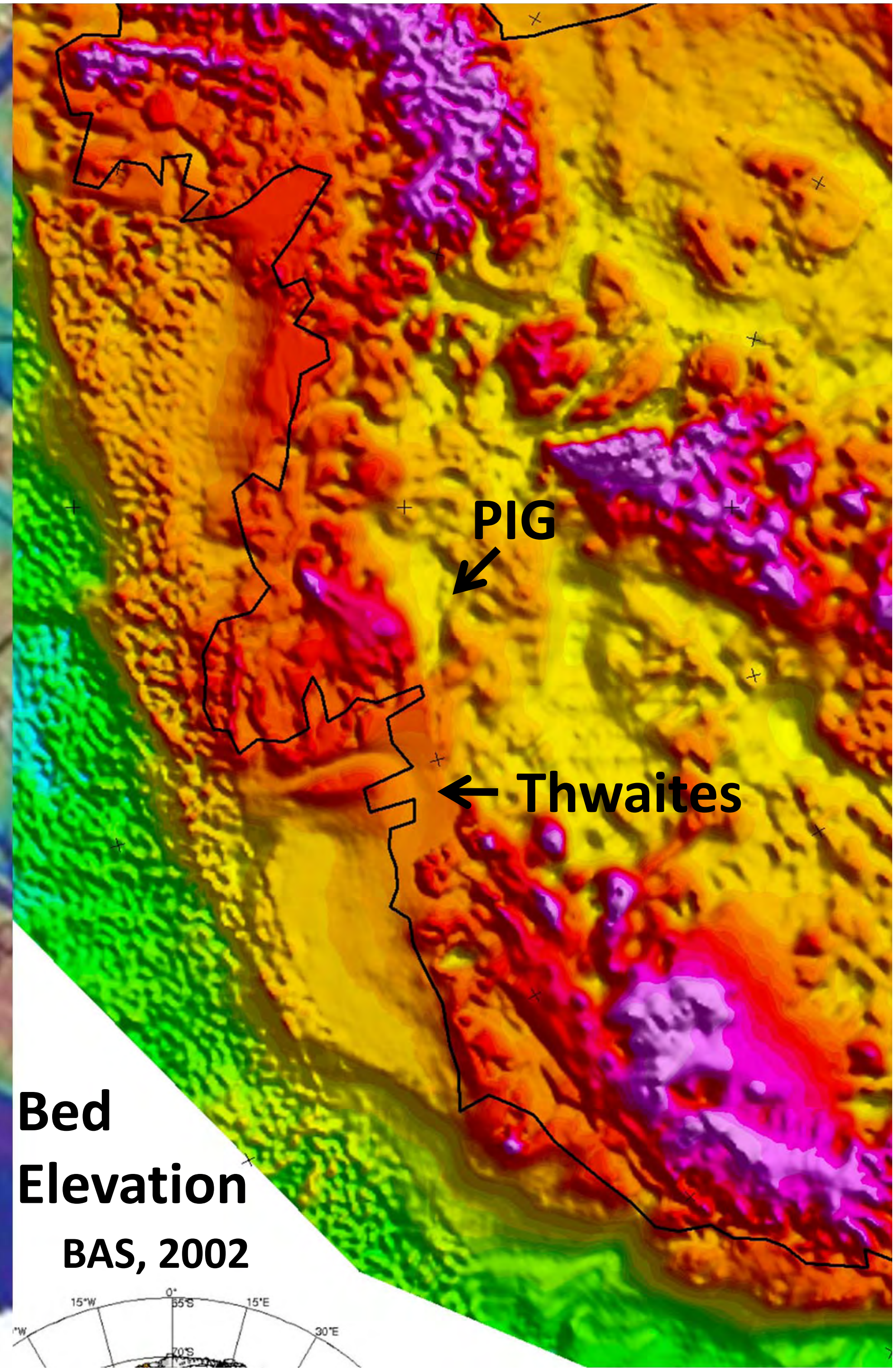
INSTAAR, University of Colorado at Boulder

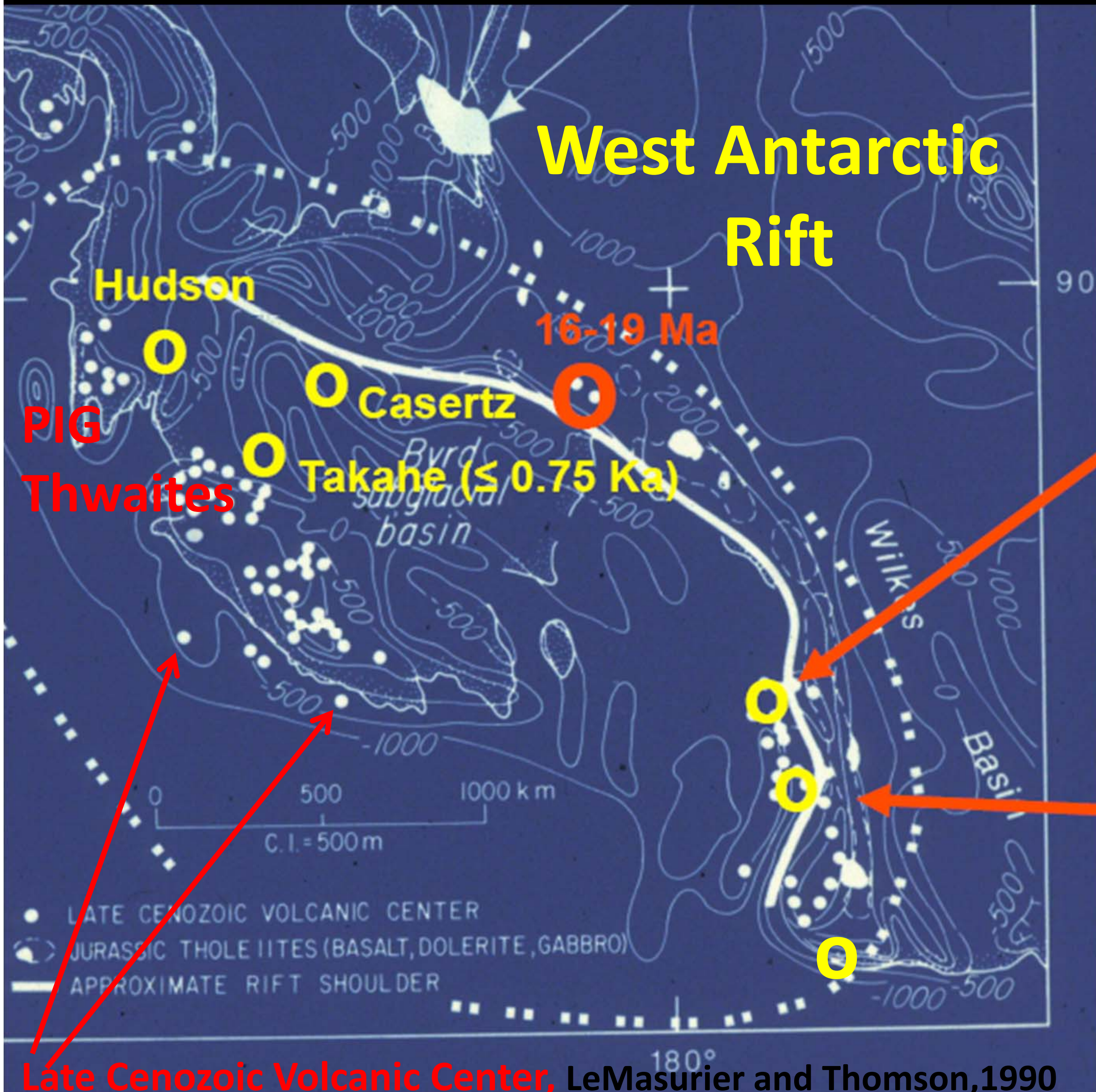
USGS, Denver

and the CASERTZ, SOAR, and GANOVEX teams



Rignot, et al., 2011


Evans
Institute
Rutford
Moller
Pine
Island
Thwaites
Rignot, et al.,
2011
Getz Ice Shelf

PIG
Thwaites
Bed
Elevation
BAS, 2002

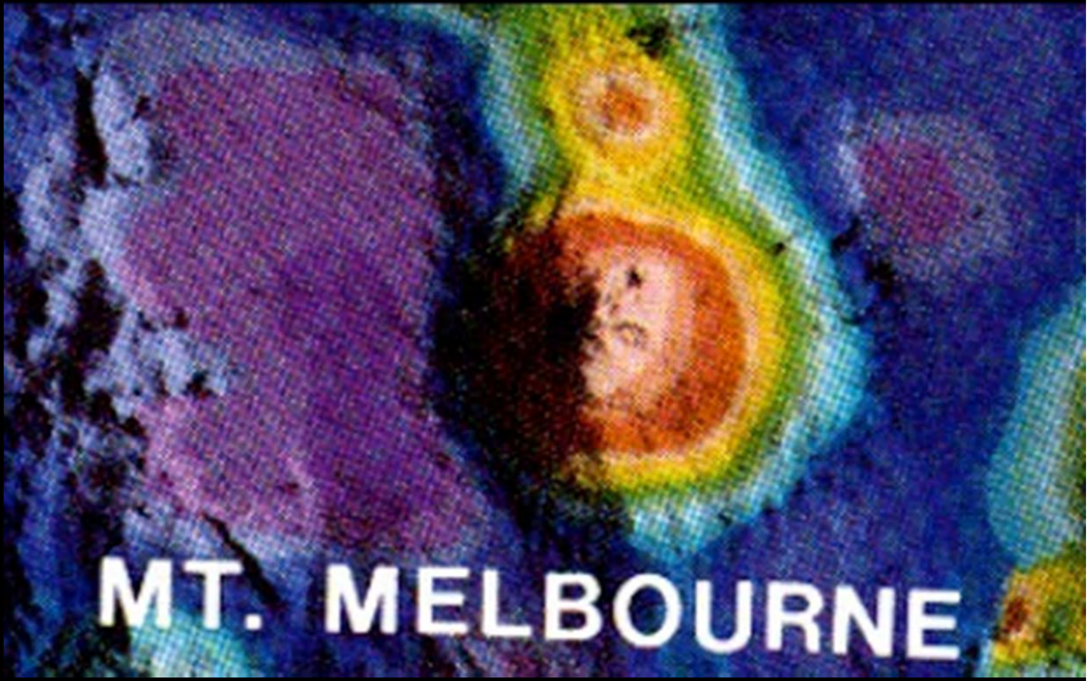



Mt Erebus (0-1 Ma)

Mt Melbourne (≤ 0.26 Ma)

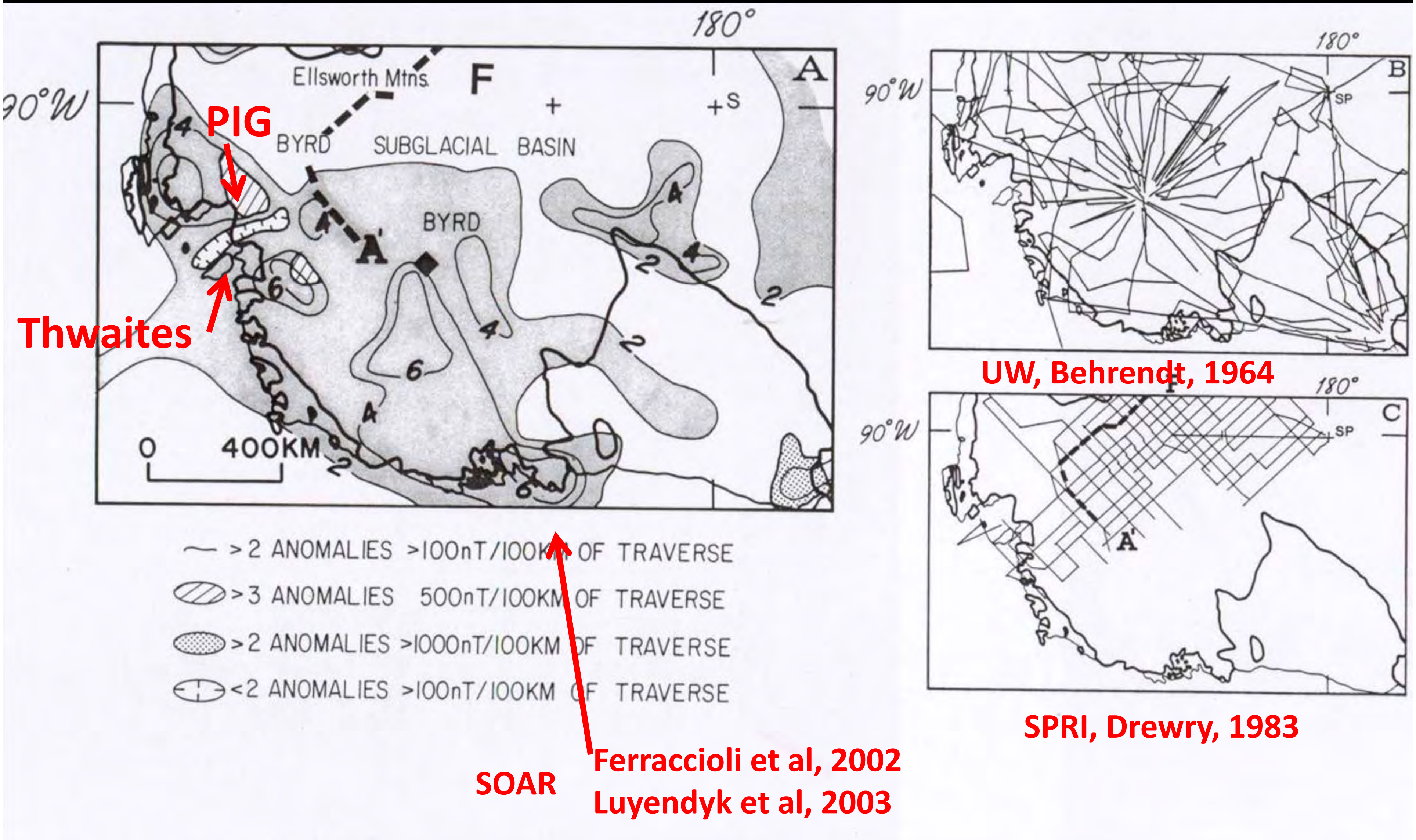
**O** Active volcanic centers

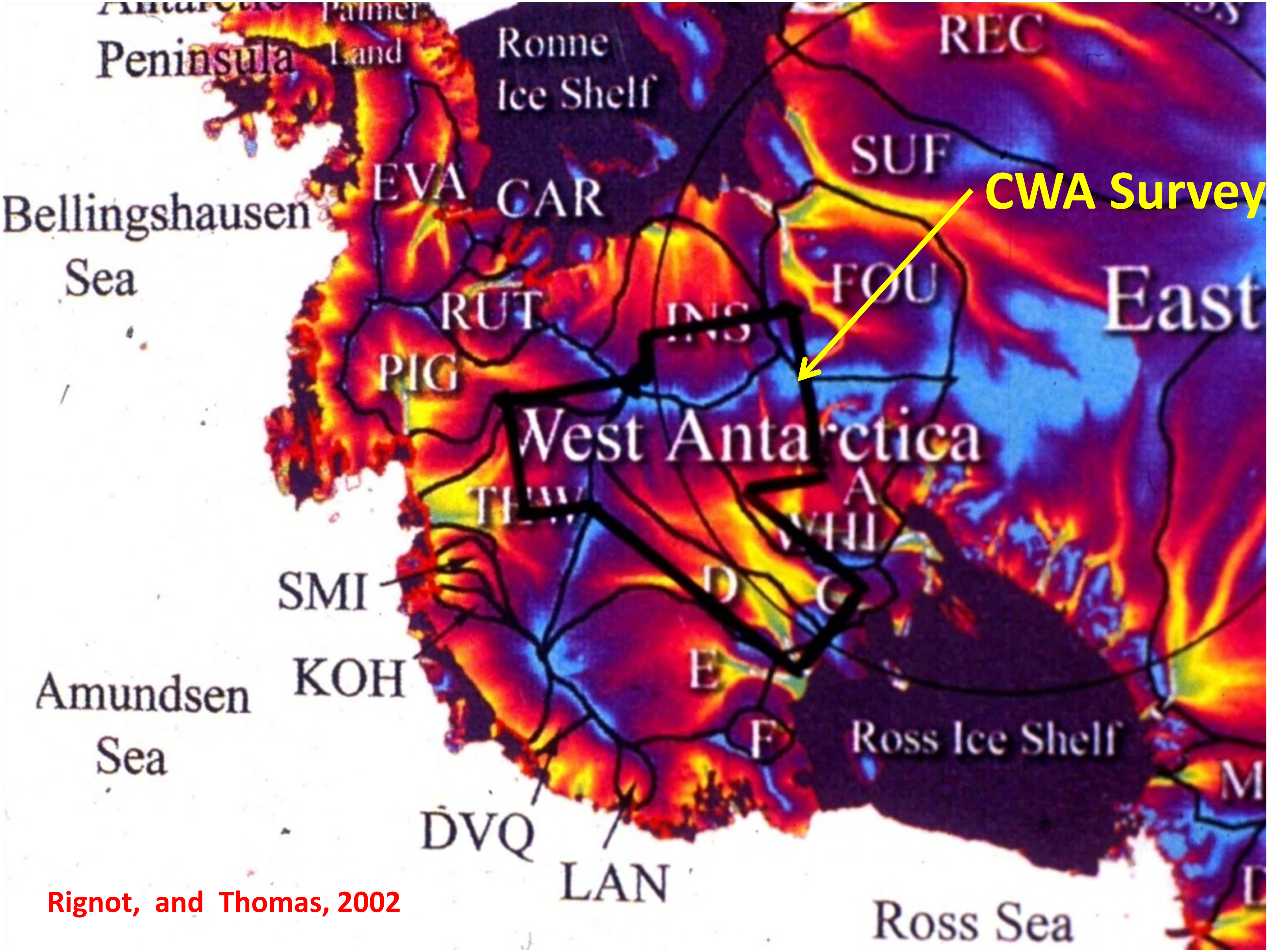
Mt Melbourne (≤ 0.26 Ma)



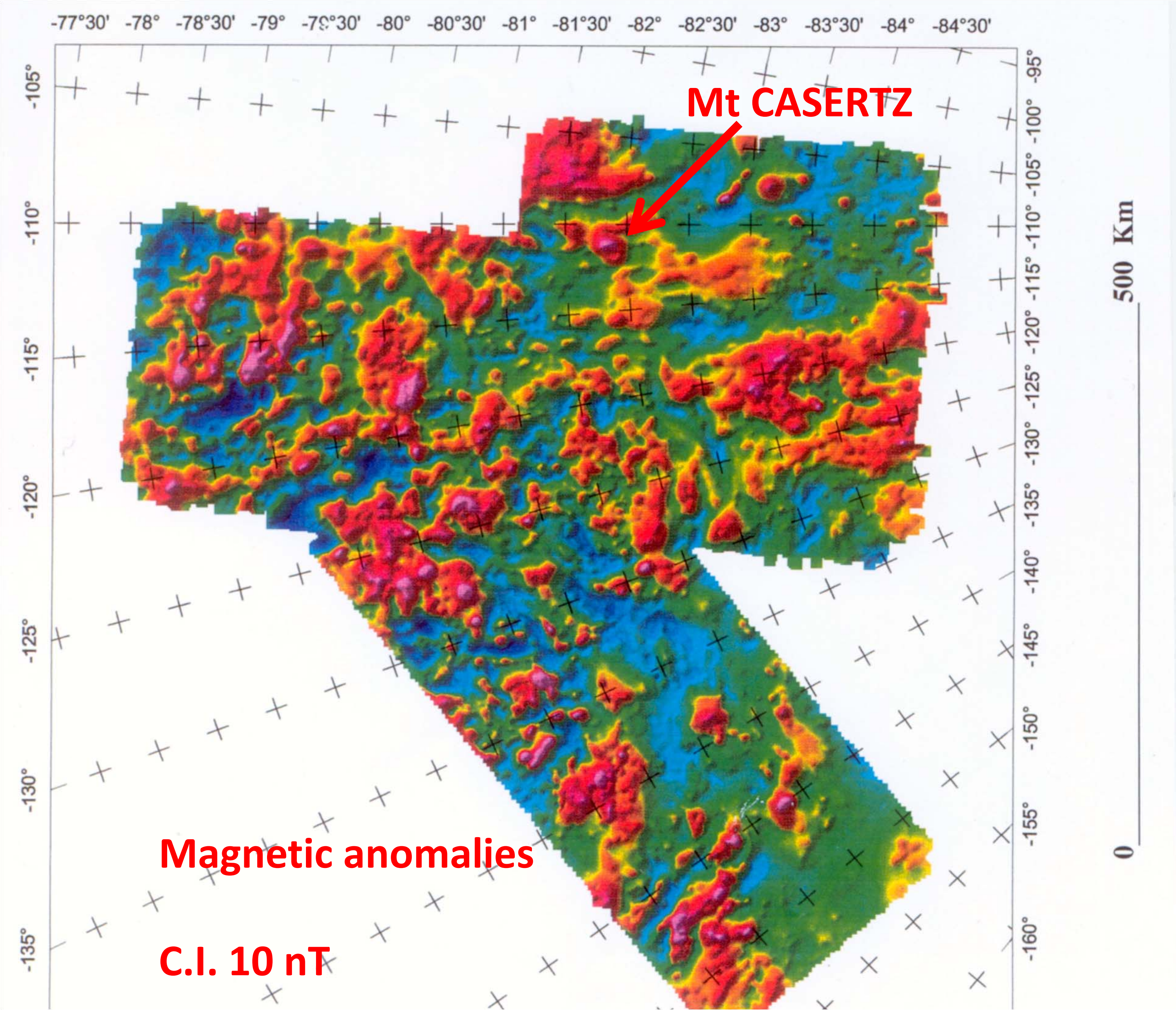

Aeromagnetic anomaly superposed on enhanced Landsat image

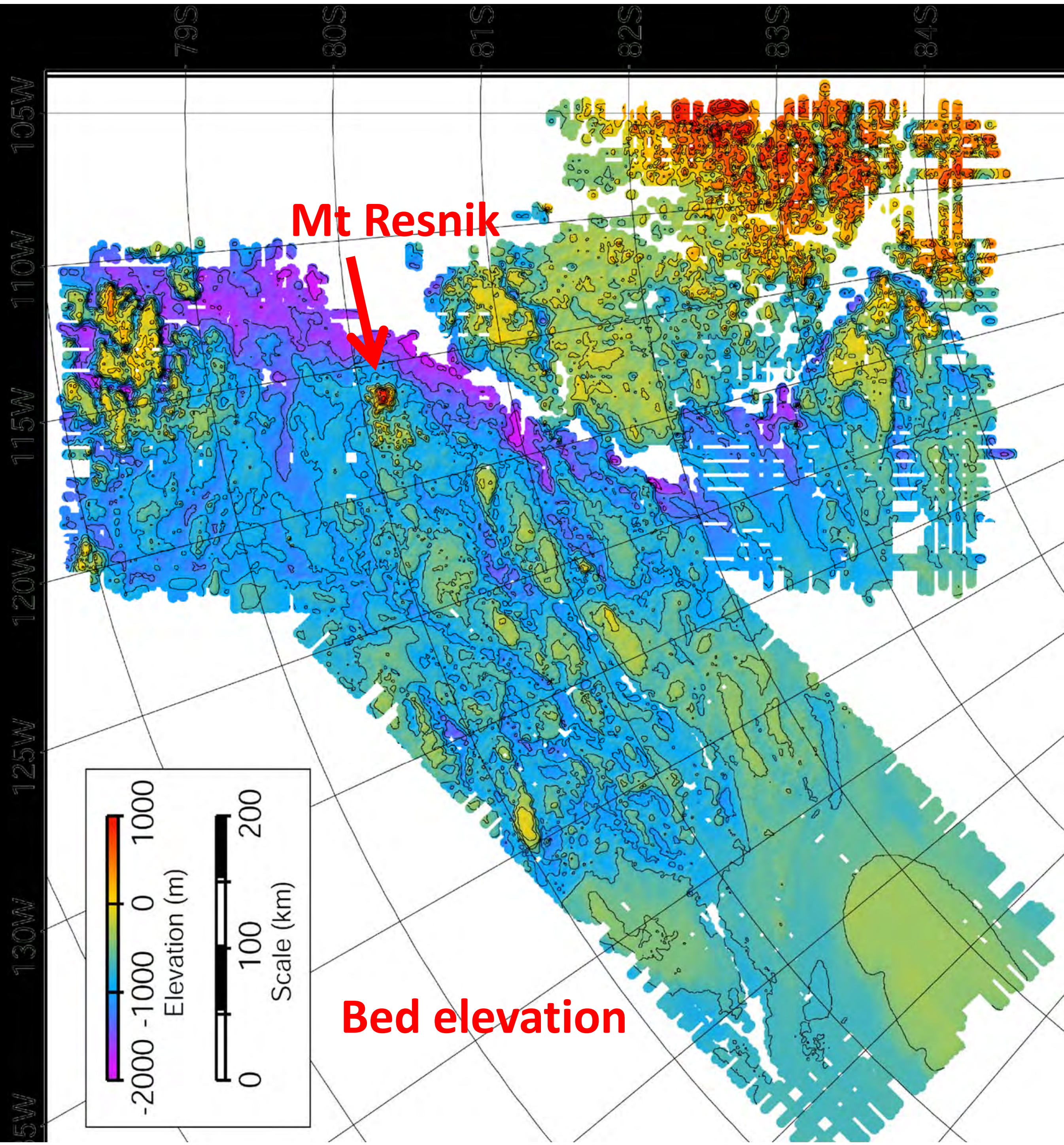
# Frequency of occurrence of short-wavelength, high-amplitude magnetic anomalies 1958-61, 1978-79, 2002-03

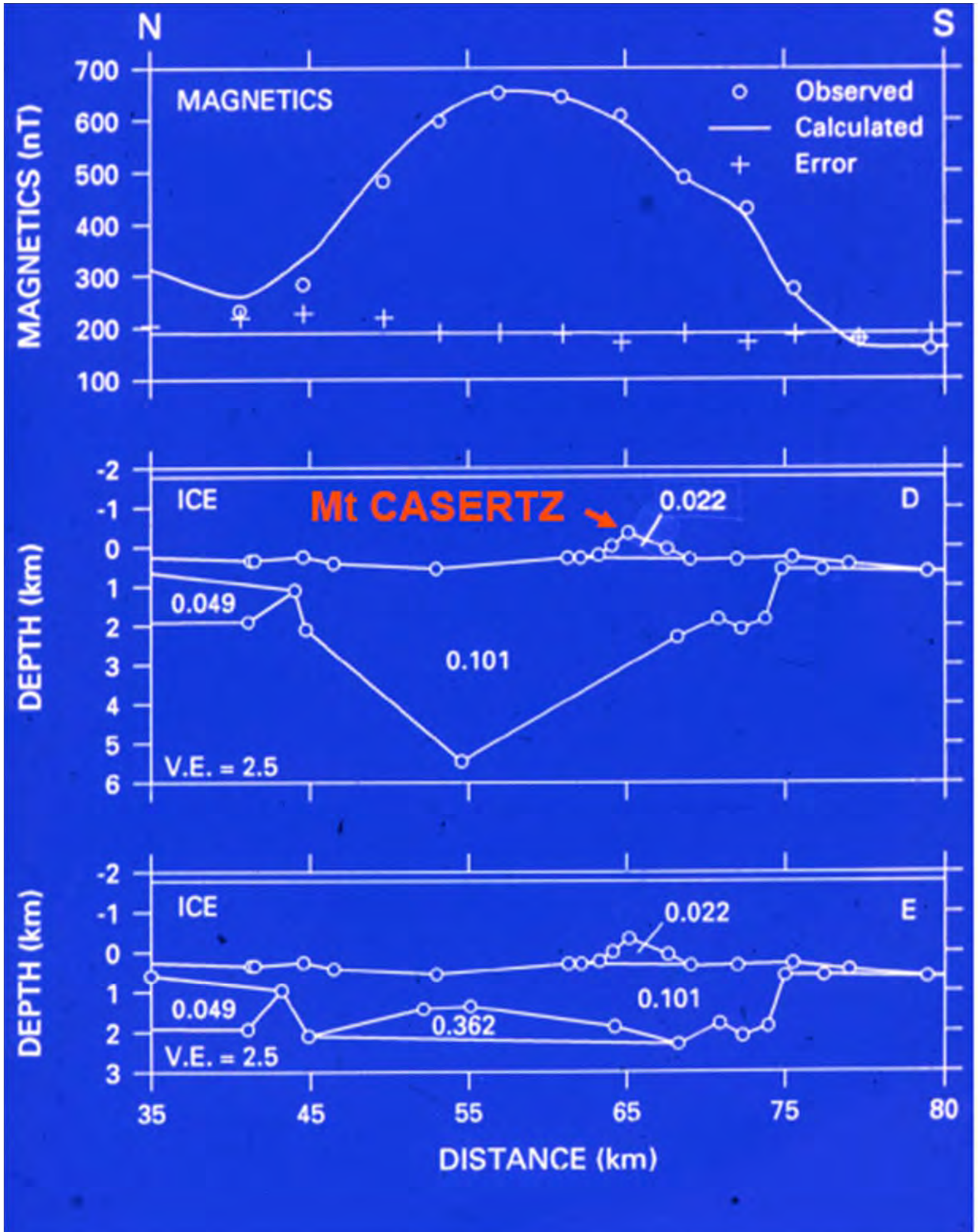




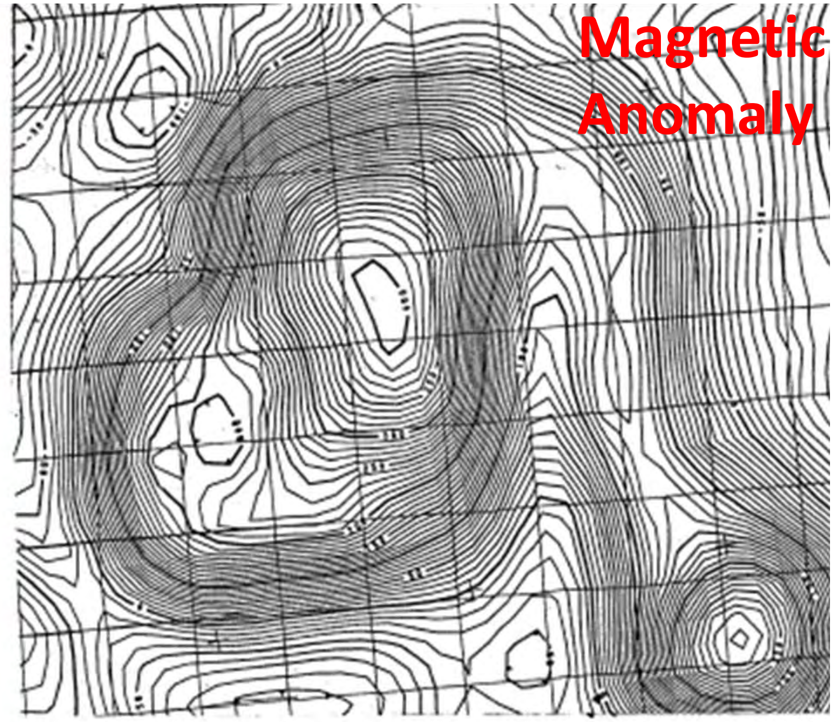

Rignot, and Thomas, 2002

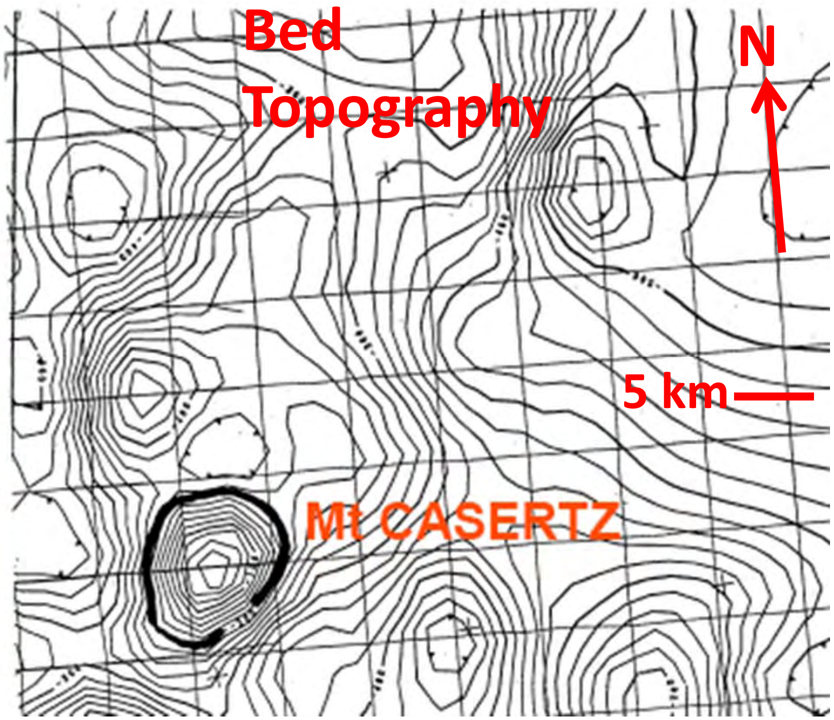

Mt CASERTZ
Magnetic anomalies
C.I. 10 nT
-77°30' -78° -78°30' -79° -79°30' -80° -80°30' -81° -81°30' -82° -82°30' -83° -83°30' -84° -84°30'
-105° -110° -115° -120° -125° -130° -135°
-95° -100° -105° -110° -115° -120° -125° -130° -135° -140° -145° -150° -155° -160°
500 Km
0

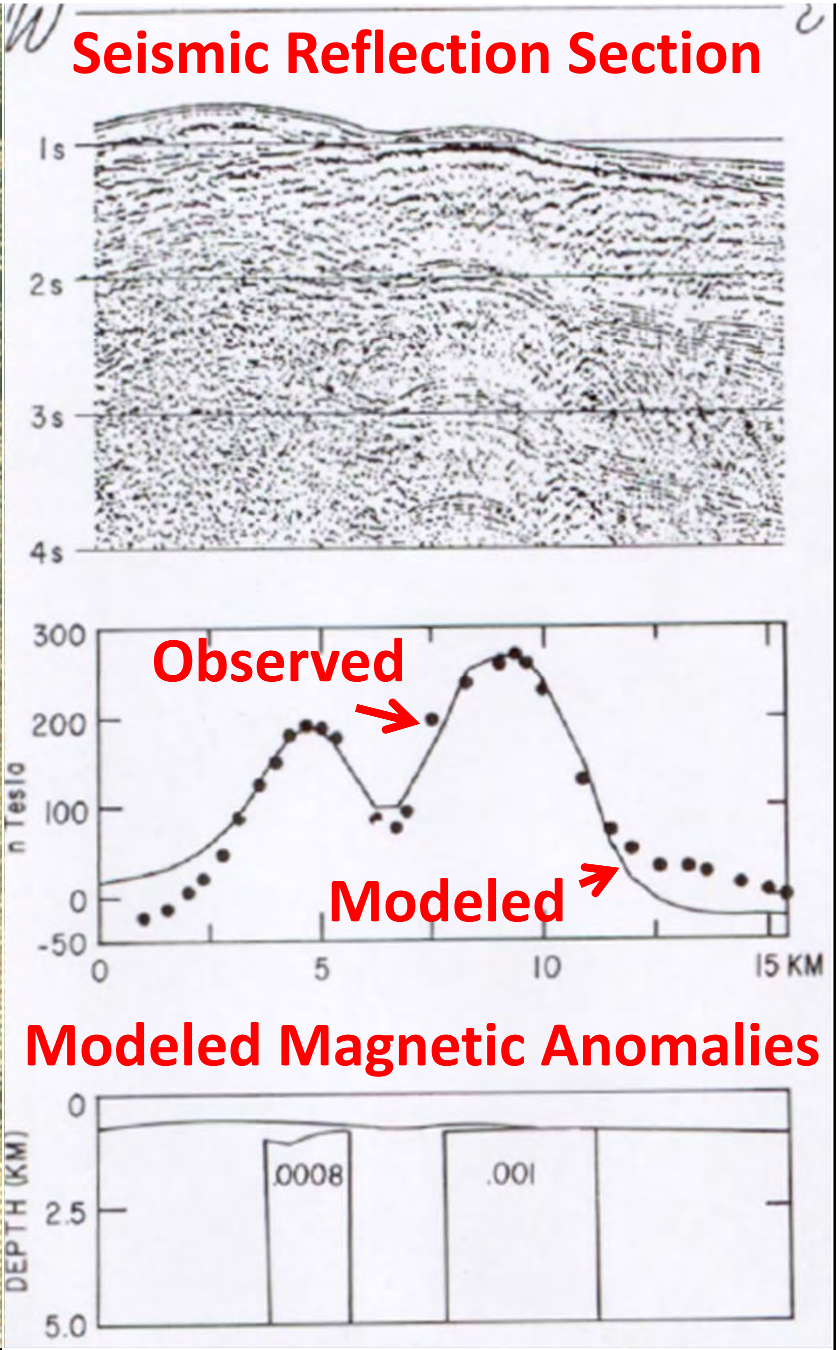

Mt Resnik
Bed elevation
79S
80S
81S
82S
83S
84S
105W
110W
115W
120W
125W
130W
-2000 -1000 0 1000
Elevation (m)
0 100 200
Scale (km)




**Surveyed in 1991**



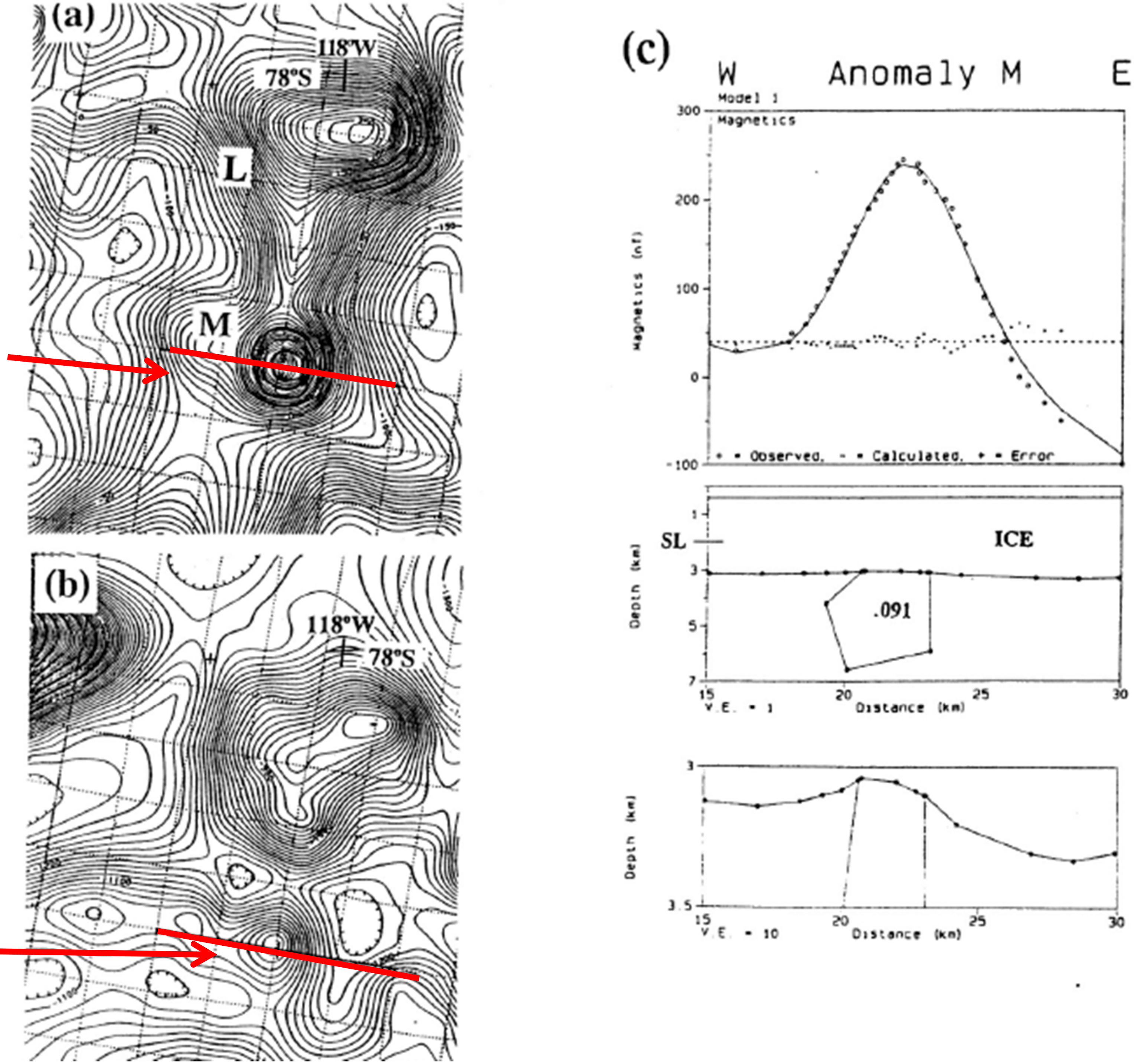




**Victoria Land Basin, Ross Sea shelf**

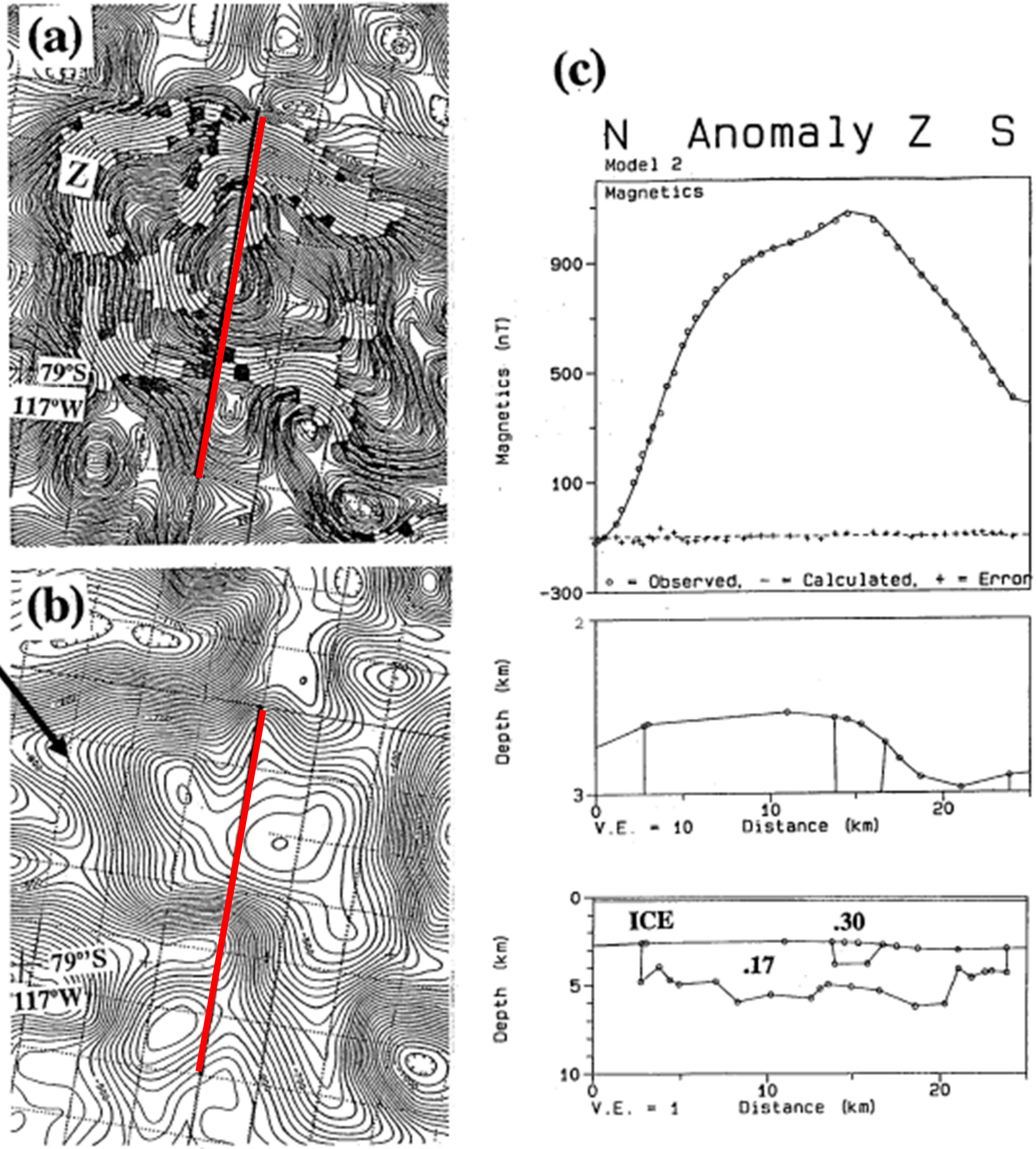
Magnetic Anomaly

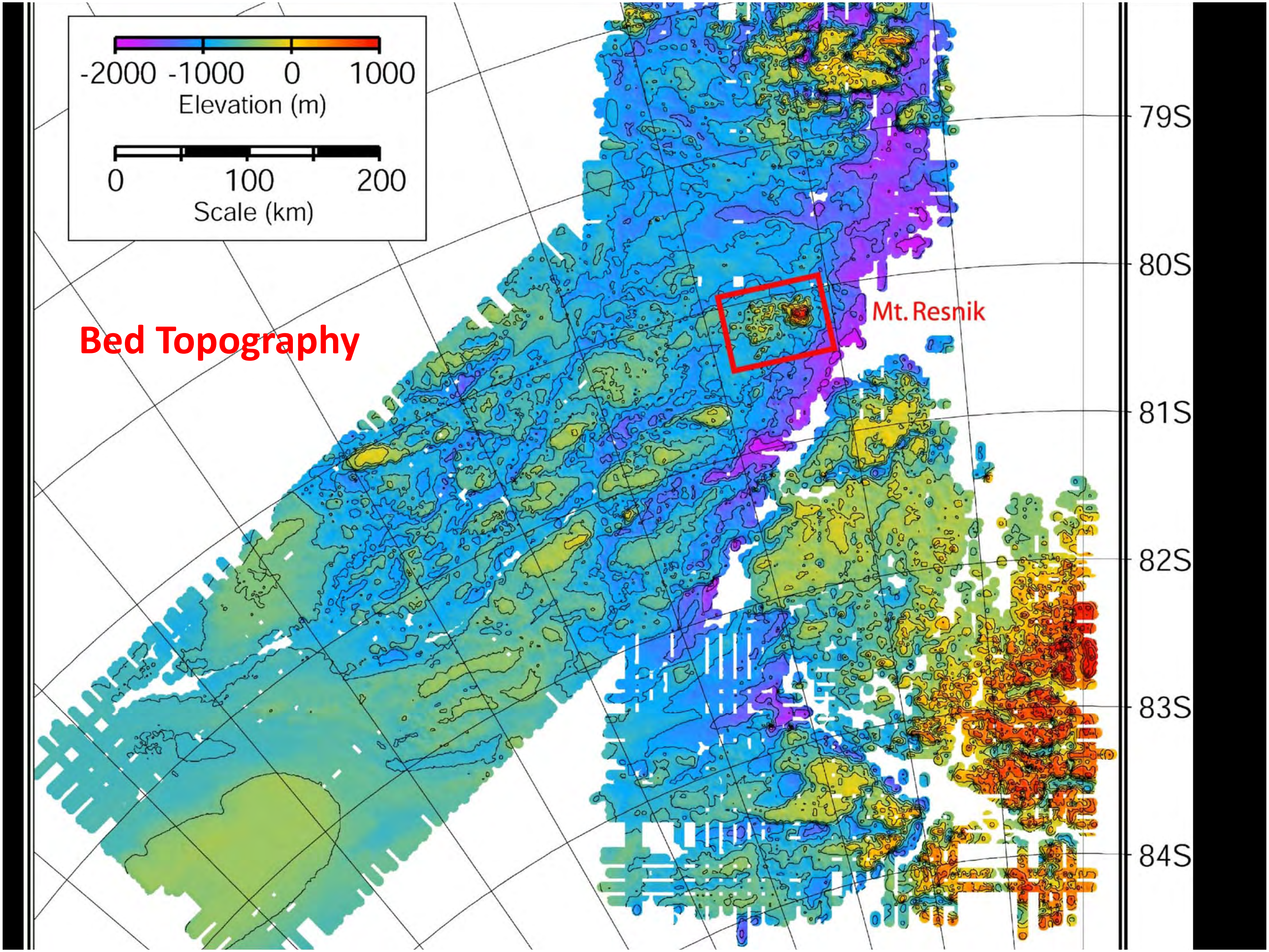
Bed Topo

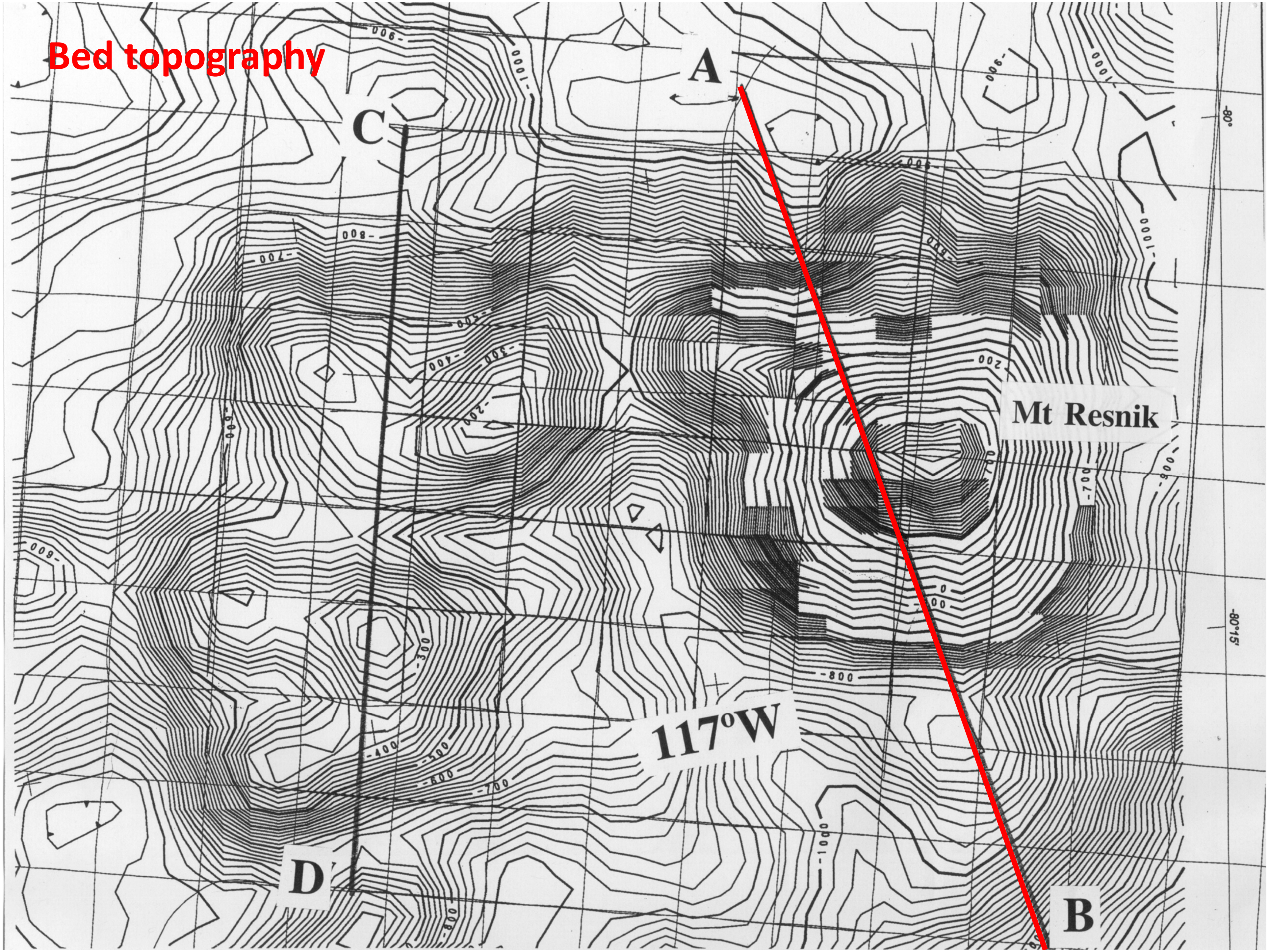


Mag Anomaly

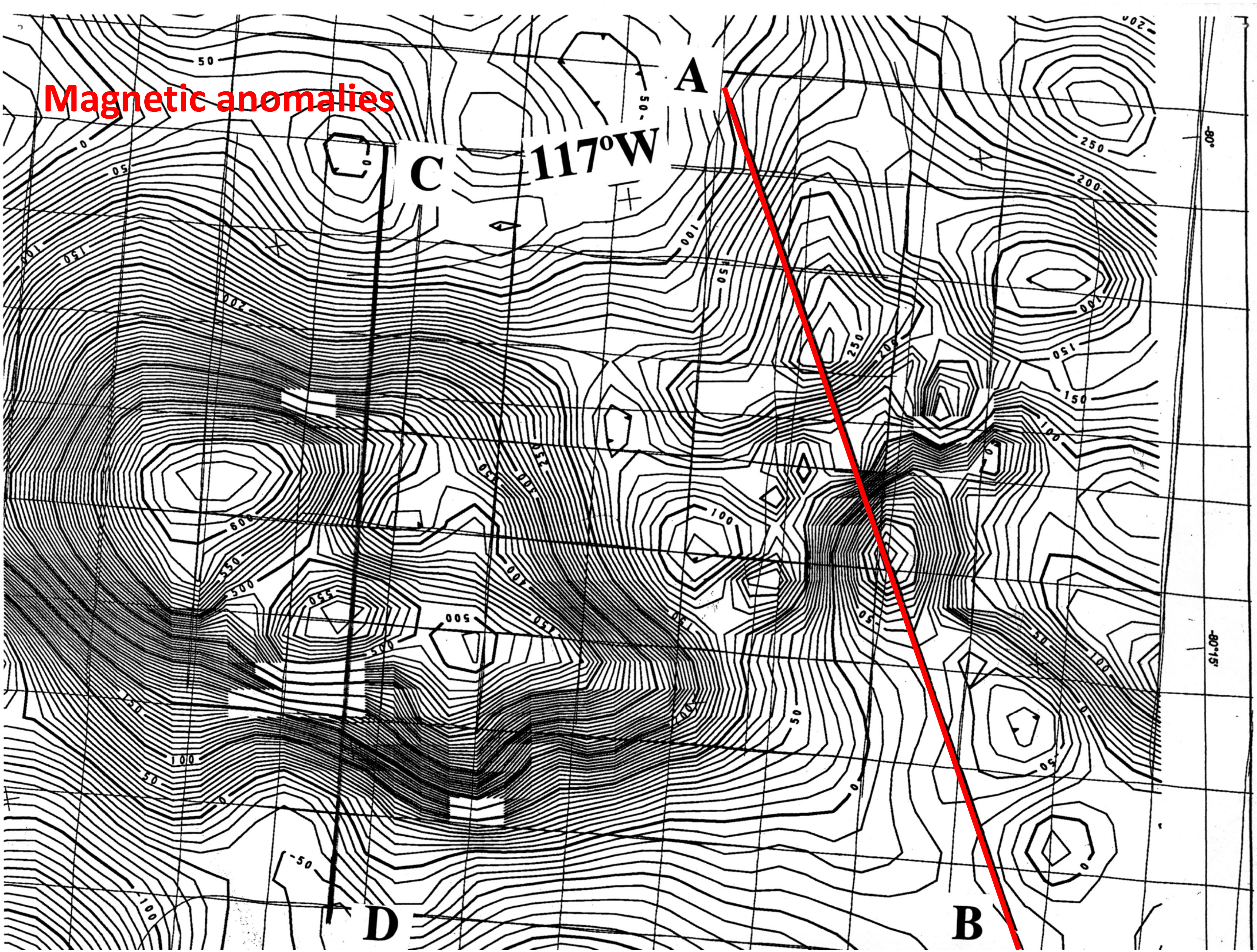
Bed Topo



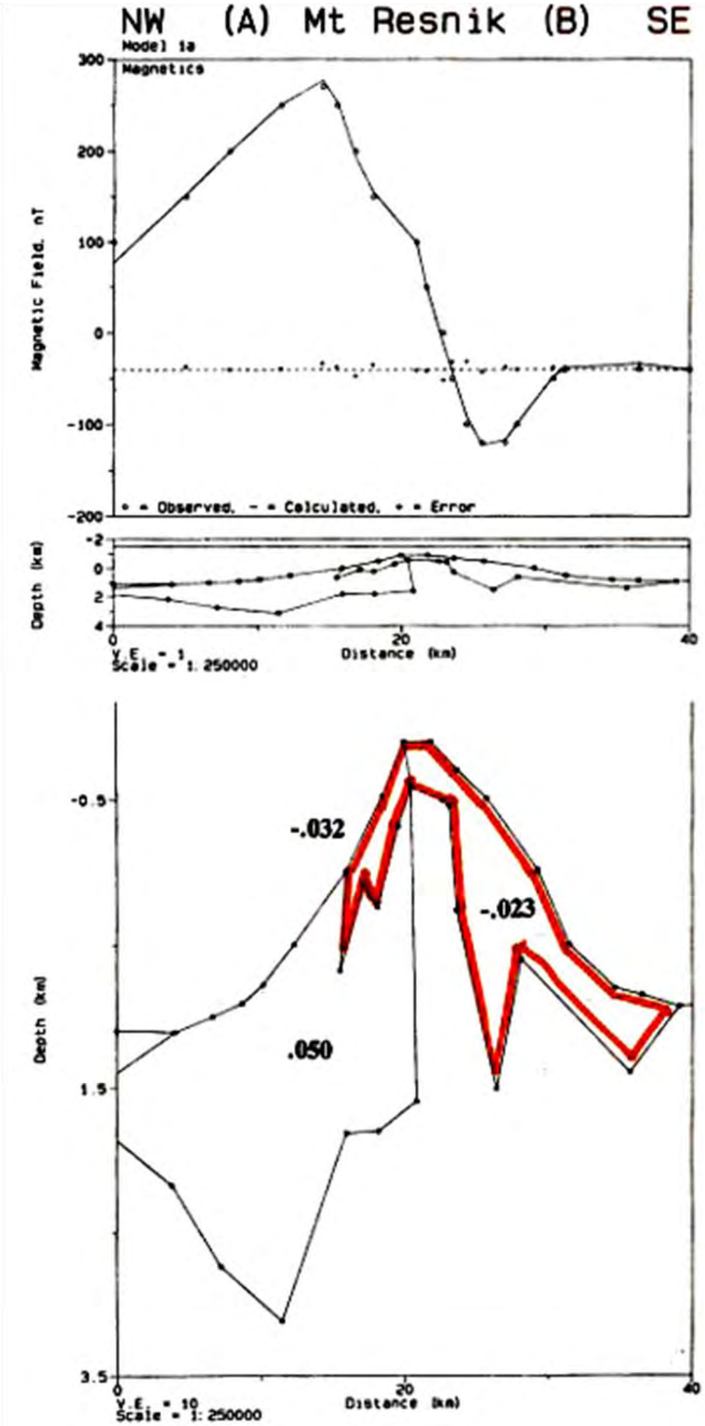

-2000 -1000 0 1000
Elevation (m)
0 100 200
Scale (km)
Bed Topography
Mt. Resnik
79S
80S
81S
82S
83S
84S



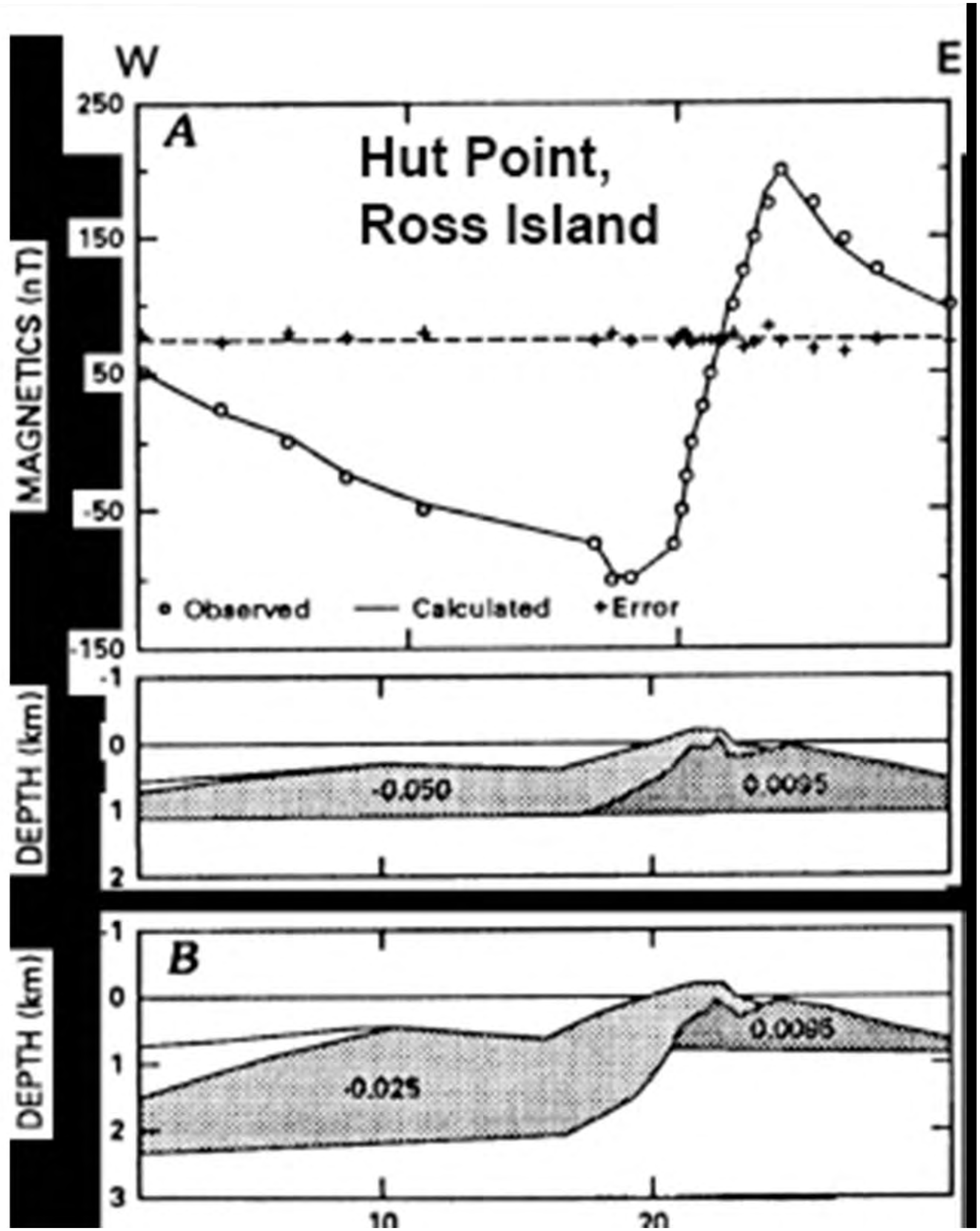
Bed topography
A
B
C
D
Mt Resnik
117°W
-80°
-80°15'
-800
-700
-400
-500
-600
-300
-1000



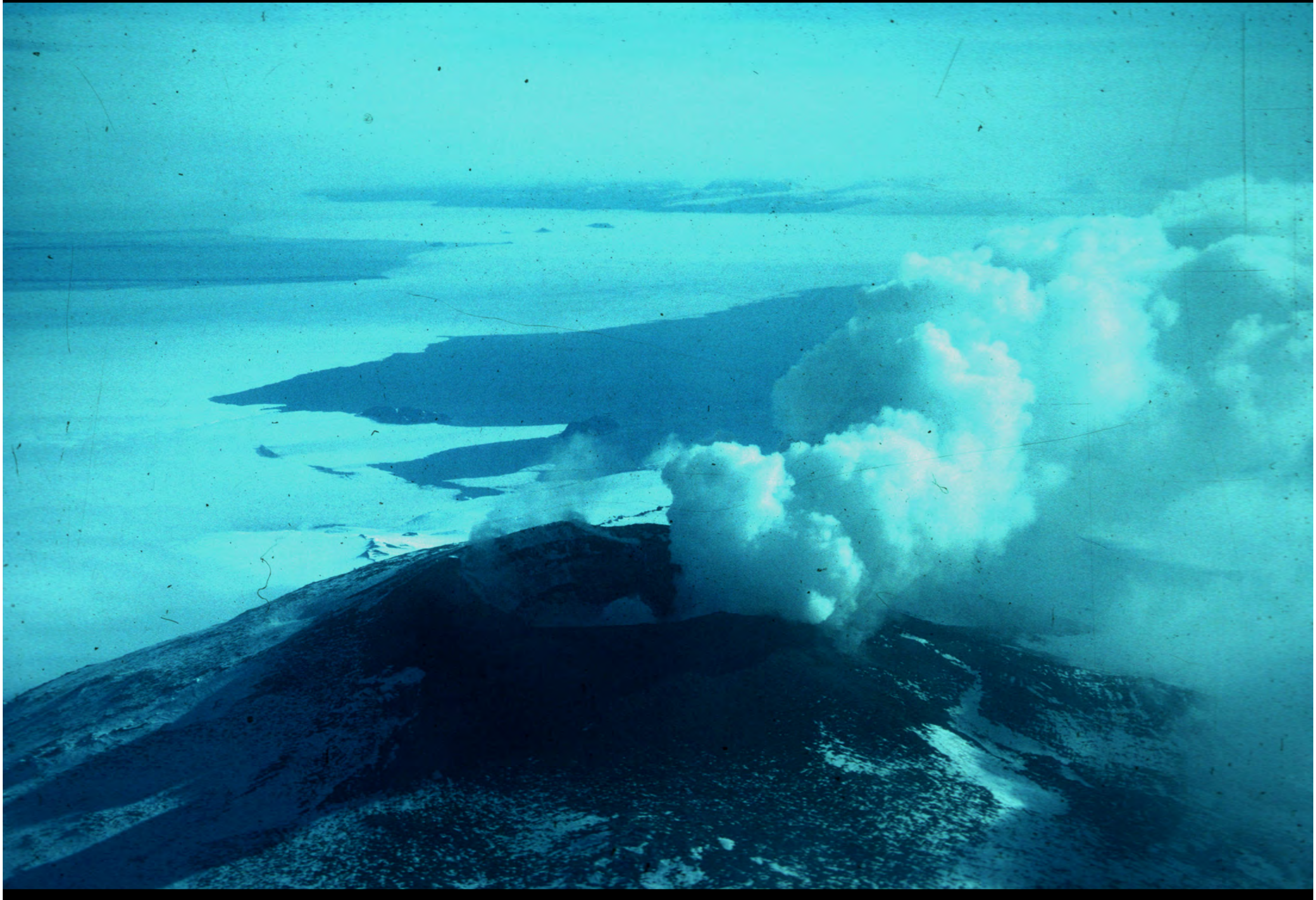
Magnetic anomalies
A
B
C
D
117°W
-80°
-80°15'



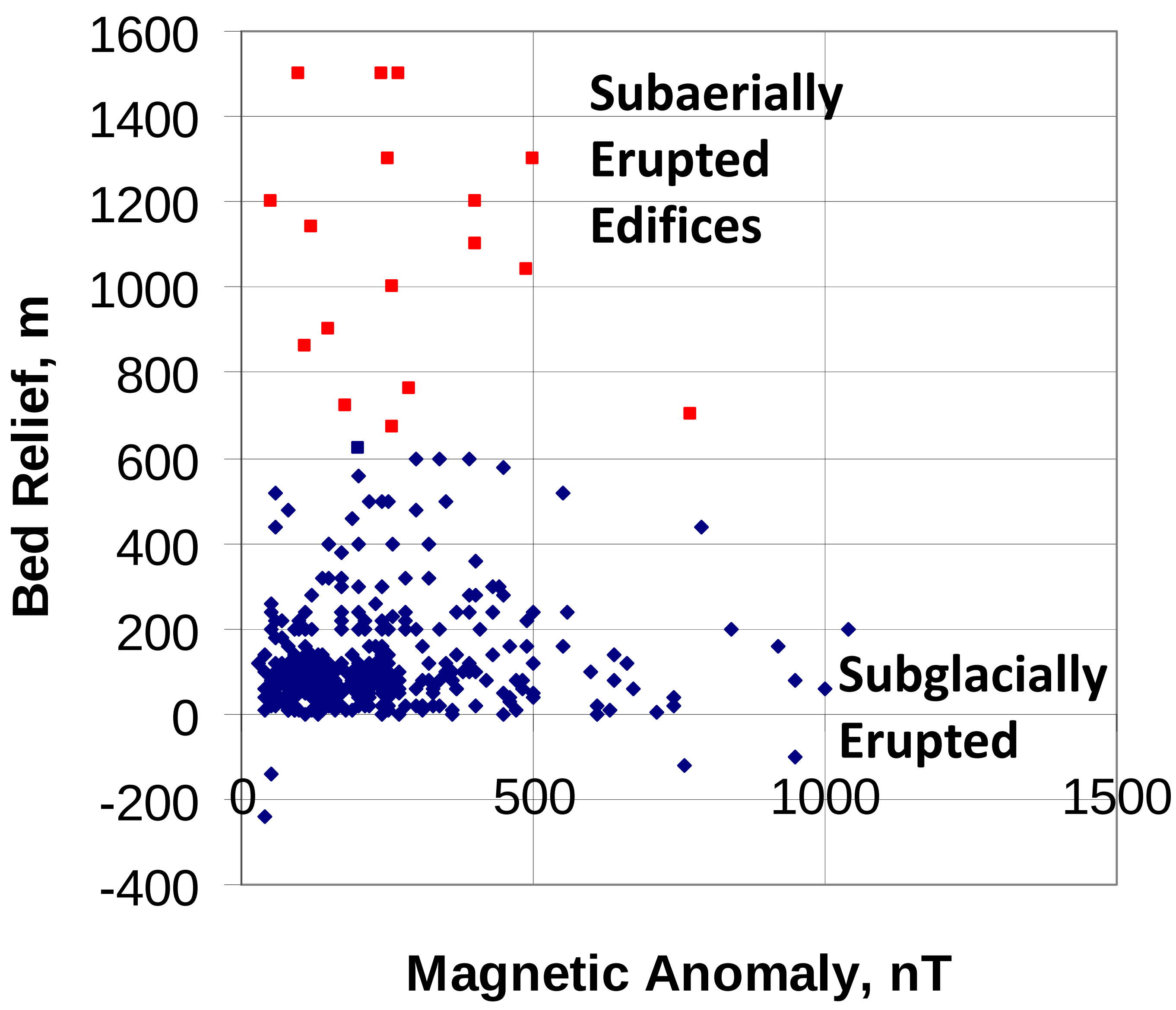
NW (A) Mt Resnik (B) SE
Model 1a
Magnetics
Magnetic Field, nT
300
200
100
0
-100
-200
○ = Observed, — = Calculated, + = Error
Depth (km)
-2
0
2
4
0
20
40
V.E. = 1
Scale = 1:250000
Distance (km)
-.032
-.023
.050
Depth (km)
-0.5
1.5
3.5
0
20
40
V.E. = 10
Scale = 1:250000
Distance (km)

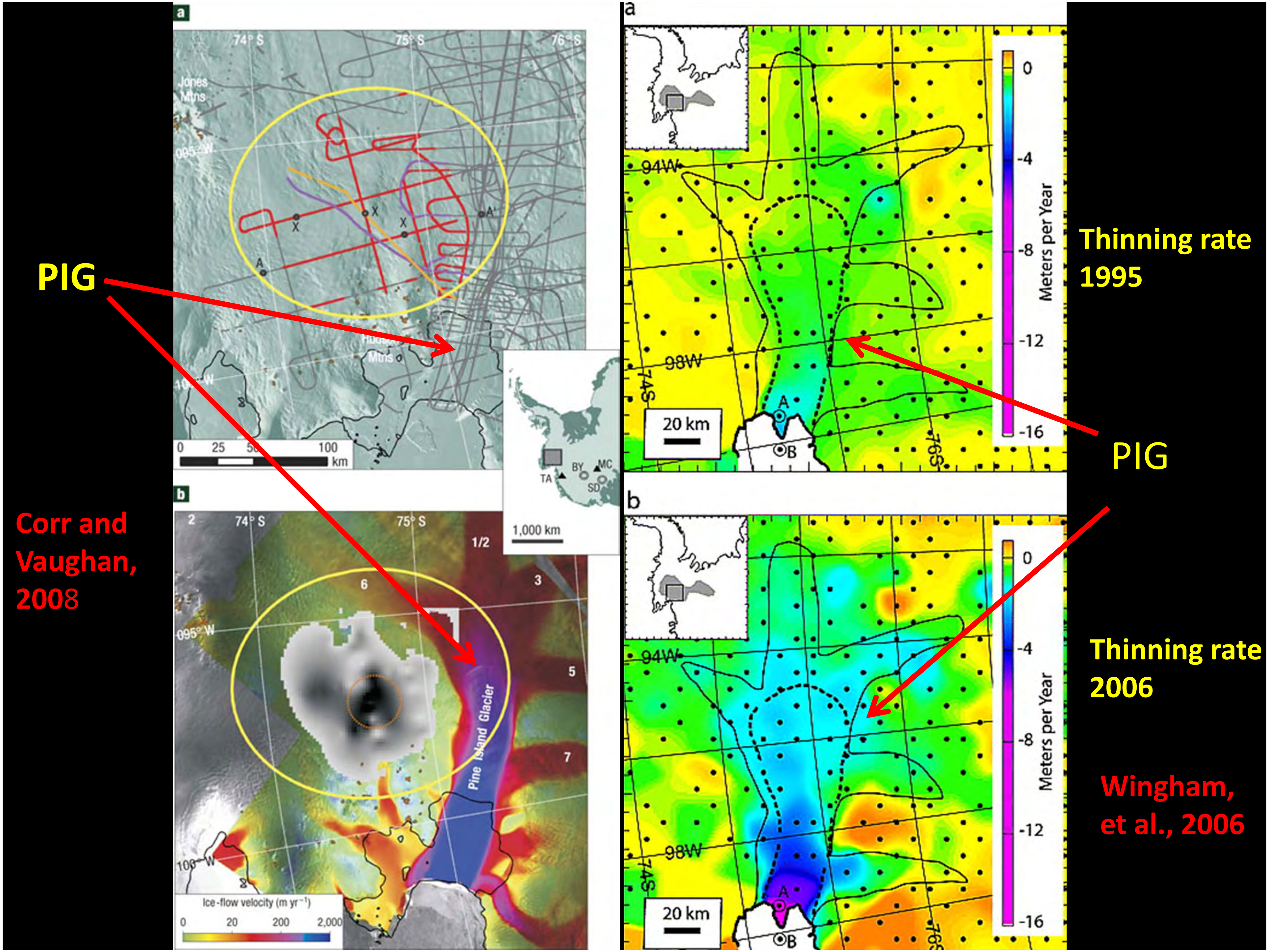



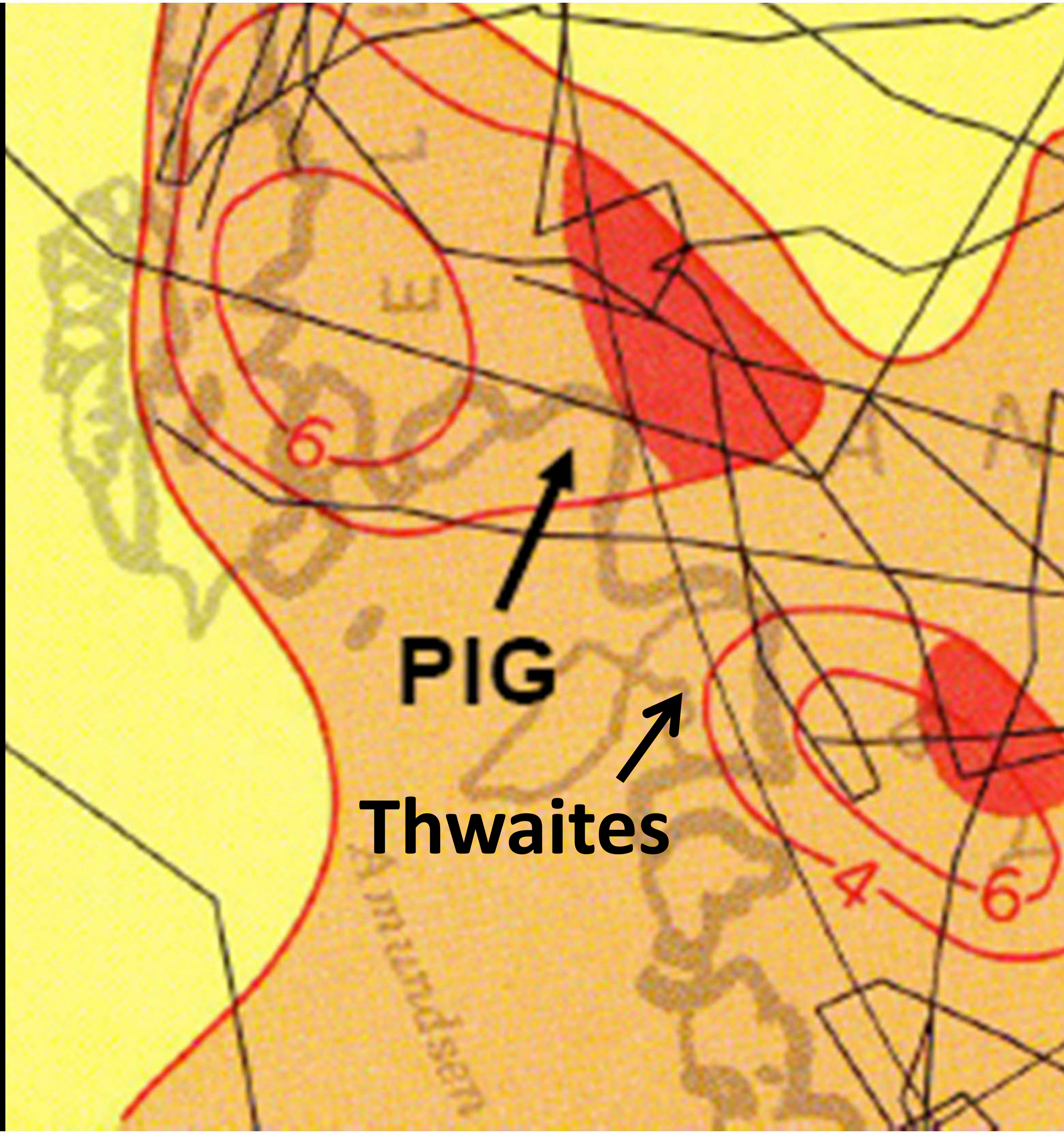
W
E
A
Hut Point, Ross Island
MAGNETICS (nT)
250
150
50
-50
-150
○ Observed
— Calculated
+ Error
DEPTH (km)
-1
0
1
2
-0.050
0.0095
B
DEPTH (km)
-1
0
1
2
3
-0.025
0.0095
10
20



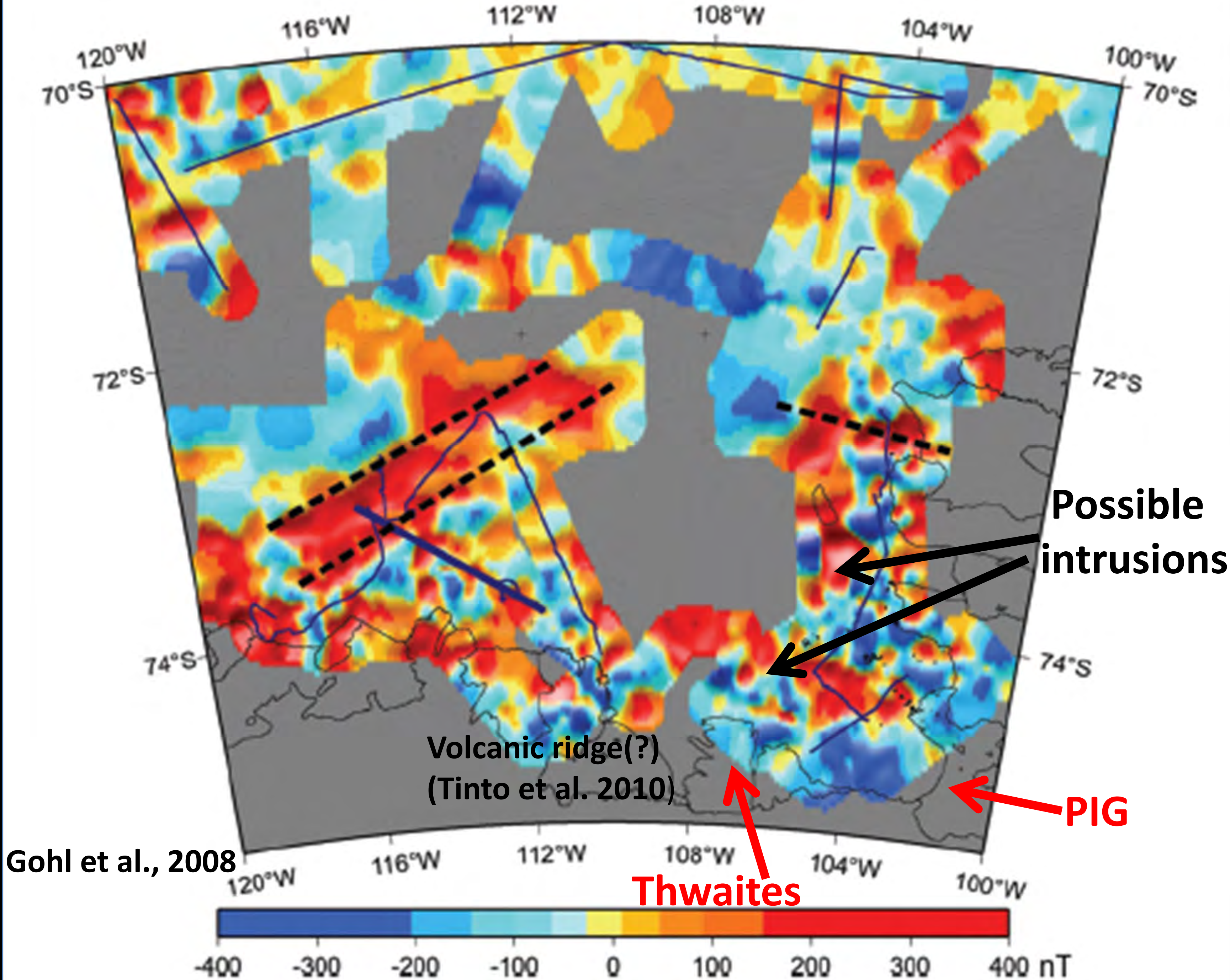
# Subglacial Volcanic Centers

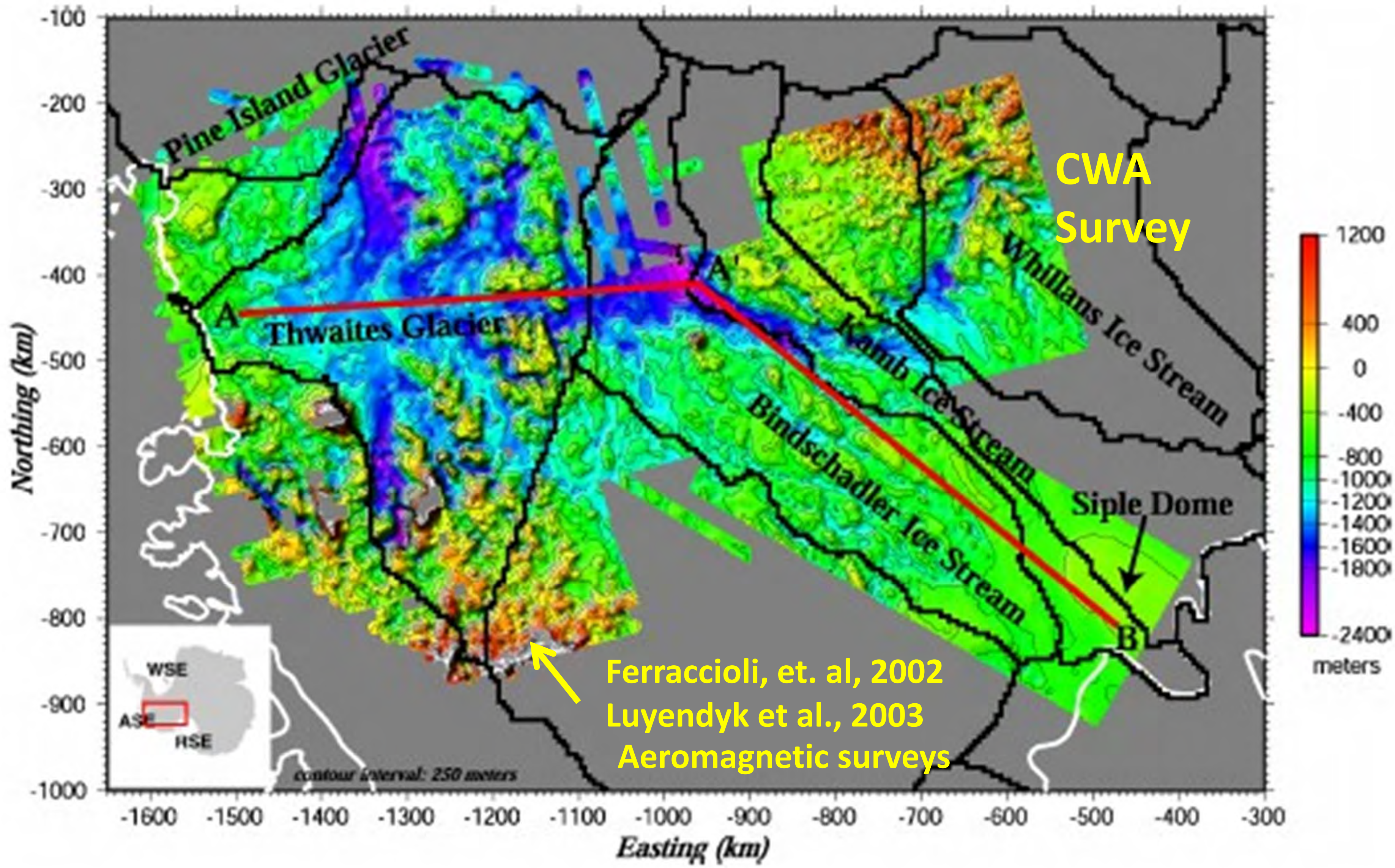



PIG
Corr and Vaughan, 2008
a
74° S
75° S
76° S
Jones Mtns
095° W
Hudson Mtns
100° W
0 25 50 100 km
1,000 km
TA
BY
MC
SD
b
2
1/2
3
6
5
7
Pine Island Glacier
Ice-flow velocity (m yr⁻¹)
0 20 200 2,000
Thinning rate 1995
94W
98W
74S
76S
20 km
A
B
0
-4
-8
-12
-16
Meters per Year
PIG
Thinning rate 2006
Wingham, et al., 2006



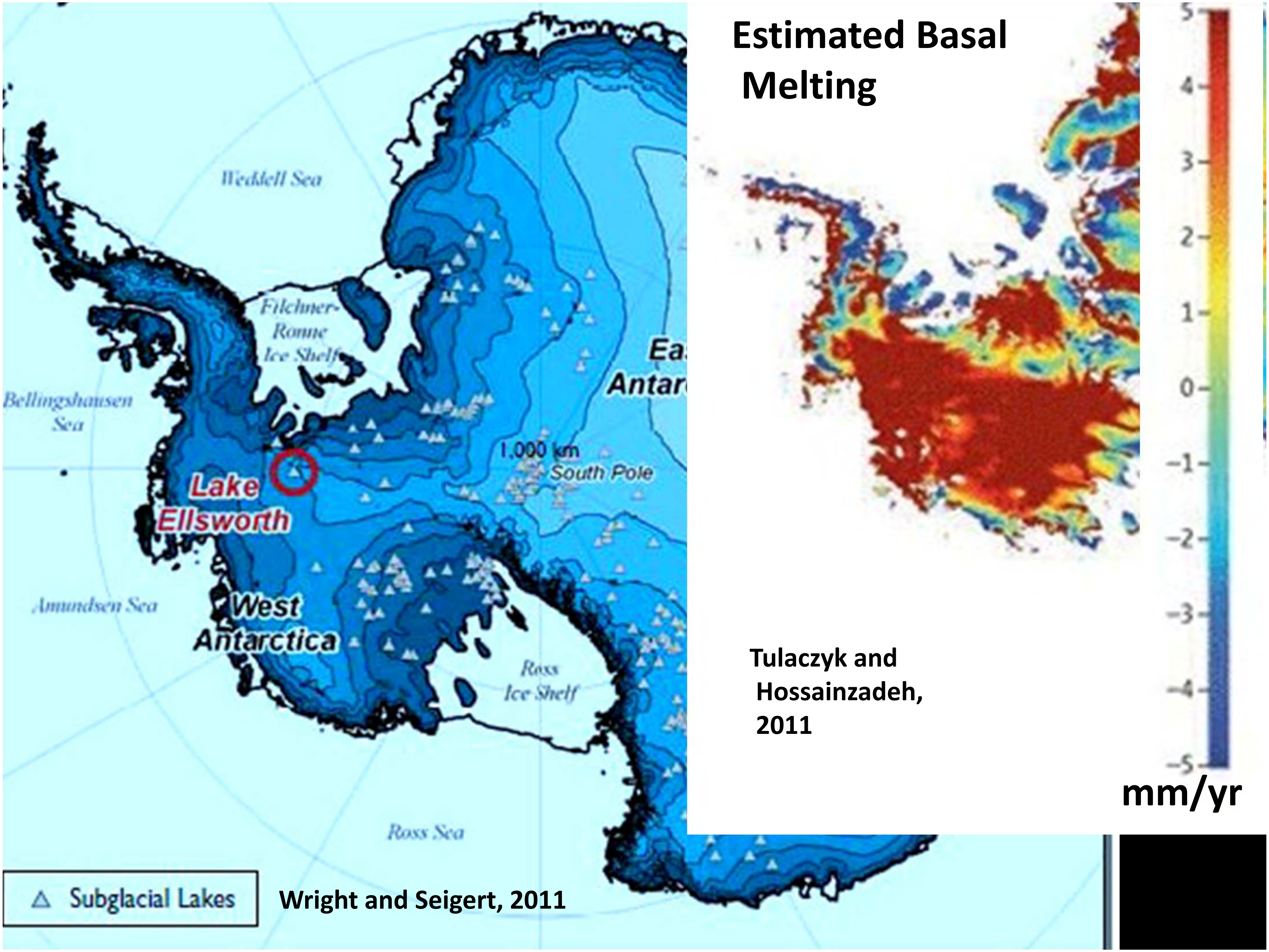
6
PIG
Thwaites
4
6


120°W
116°W
112°W
108°W
104°W
100°W
70°S
72°S
74°S
Possible
intrusions
Volcanic ridge(?)
(Tinto et al. 2010)
PIG
Thwaites
Gohl et al., 2008
-400
-300
-200
-100
0
100
200
300
400 nT



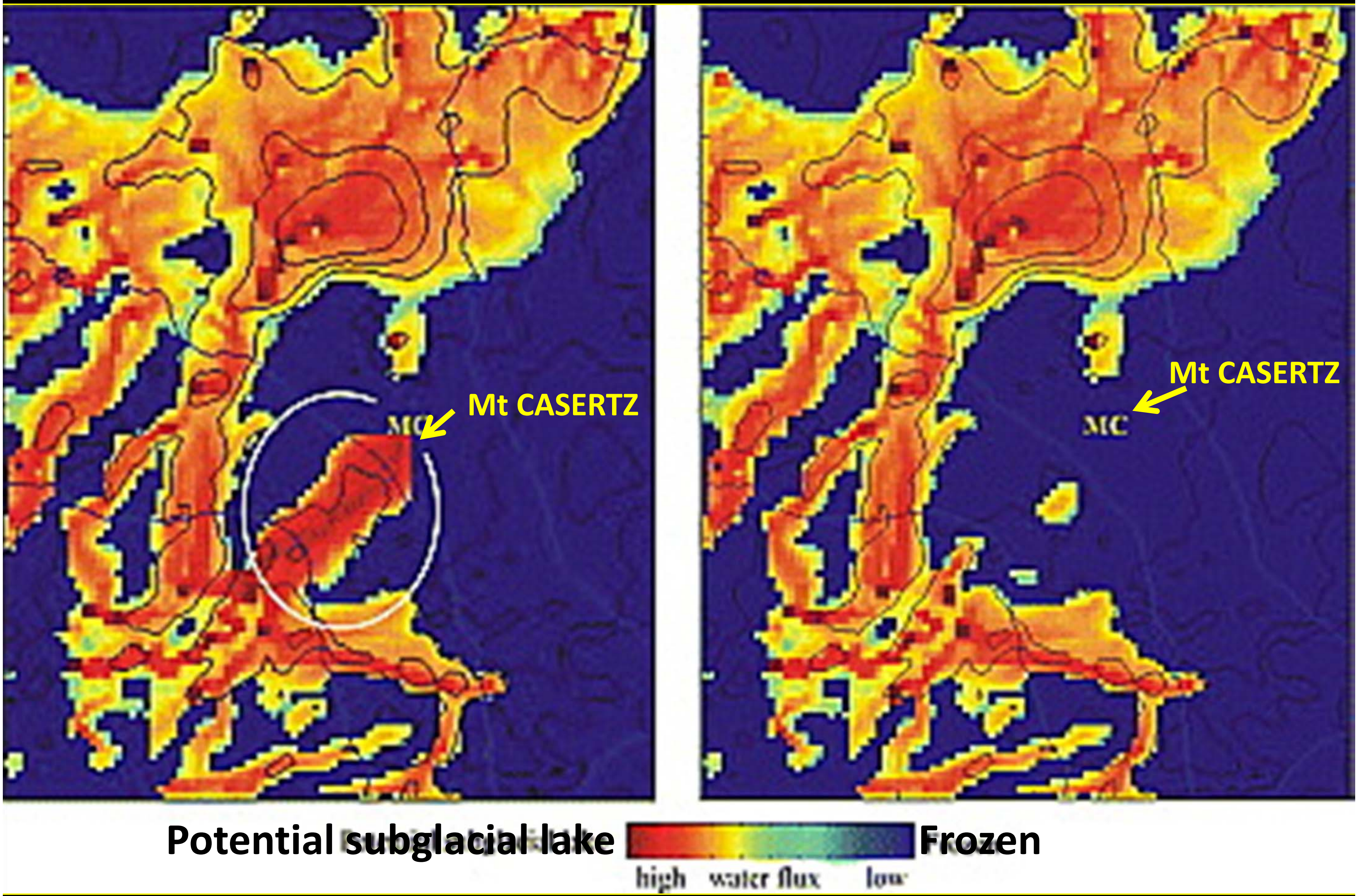

Bed Topography CWA and AGASEA (Airborne Geophysical Survey of the Amundsen Sea Embayment Antarctica) Holt et al., 2006; Diehl, et al., 2008)

# Estimated Basal Melting




Wright and Seigert, 2011

Tulaczyk and Hossainzadeh, 2011




Vogel and Tulaczyk, 2006

# Conclusions

The aeromagnetic method has proven the most useful geophysical tool for studying subglacial volcanic rocks since early surveys in the 1950s. The Central West Antarctica (CWA) aerogeophysical survey covering ~50,000 $km^2$ over the WAIS, consisting of 5-km orthogonal line spaced aeromagnetic, radar ice sounding and aerogravity measurements is a unique Antarctic data set.

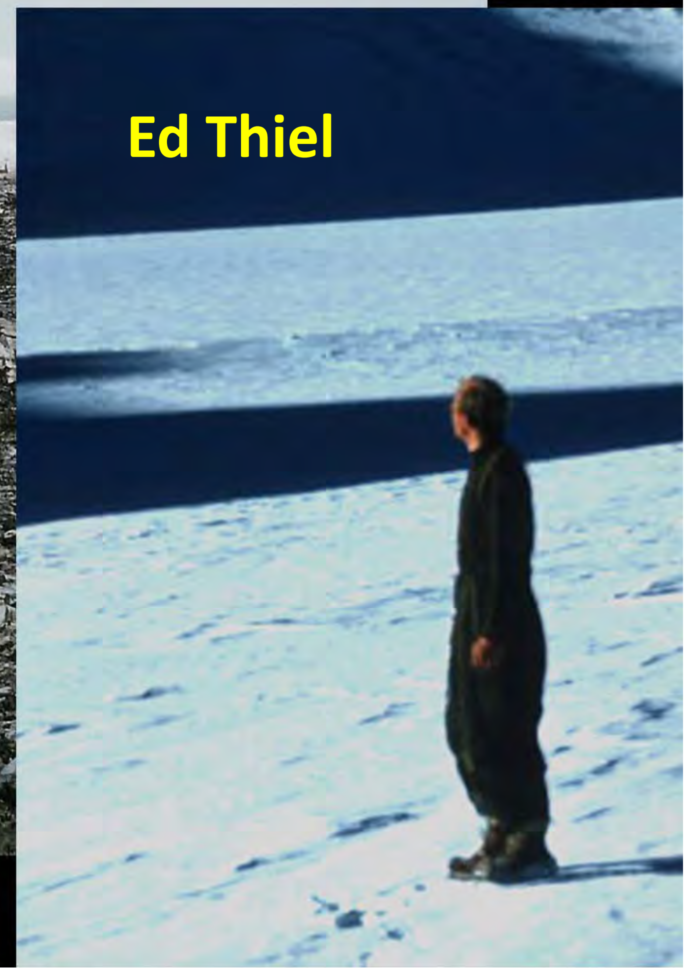
These data indicate numerous high-amplitude (100->1000 nT), 5-50km width, shallow-source, magnetic anomalies over a very extensive area (>500,000 $km^2$) mostly resulting from subglacial volcanic eruptions. I previously interpreted these anomalies in the CWA survey as ~1000 "volcanic centers" requiring high remanent normal magnetizations in the present field direction; >80% of these anomaly sources at the bed of the WAIS, appear modified by moving ice, requiring a younger age than the WAIS (~25 Ma).

Exposed volcanoes in the WR are <34 Ma, but at least four are active today. Most "volcanic centers" are buried beneath the WAIS; if a few of these are active today, subglacial volcanism may well have a significant effect on the WAIS regime.

Aerogeophysical data (Blankenship et al., 1993, Mt. CASERTZ; Corr and Vaughan, 2008, near Hudson Mts.) indicated active subglacial volcanoes and suggested volcanic effects on WAIS dynamics. Wingham et al. (2009) reported increasing volume loss from 2.6 to 10.1 $km^3$/yr from 1995 to 2006 for the Pine Island Glacier. This may be partly from Hudson Mts subglacial-volcanism.

The present rapid changes in stability of the WAIS resulting from global warming, could be accelerated by subglacial volcanism.


November, 1961
Bill Burch


Ed Thiel