Lecture 16:

The magnetic time scale and magnetostratigraphy

- Review of geological time scale (GTS)
- Development of the geomagnetic polarity time scale (GPTS)
- Applications in geology (dates and rates)

Geological time scale

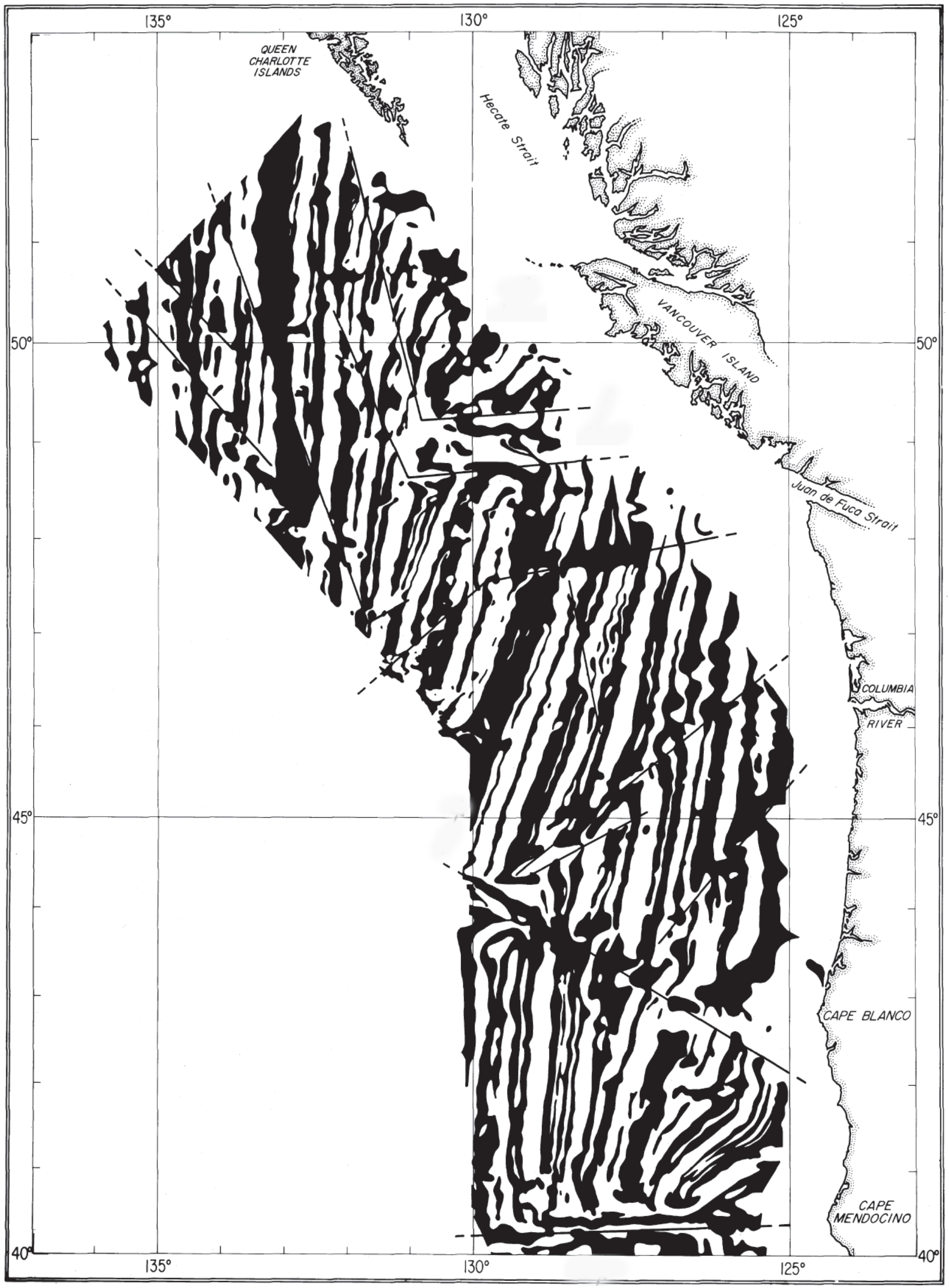
- list of ordered events placed in a temporal context
- Eons: Phanerozoic, Proterozoic,
- Eras: Mesozoic, Cenozoic, etc.
- Periods: Cretaceous, Paleogene, Neogene, etc.
- Series: Oligocene, etc.
- Stages: Maastrichtian, Messinian, etc.

- Stage is the fundamental unit
- Defined by its base at a particular place (global standard section and point - GSSP)
- Attach a chronology using a lot of different dating techniques (radioisotopic decay, climatic variations with known age dependence, magnetic stratigraphy, progression of fossil sequences)
- Most often dates are estimated by correlation, interpolation and/or extrapolation.
- Constant revision (the official website is stratigraphy.org)

The GPTS and the GTS

- Identification of a particular polarity reversal allows direct correlation and/or dating of events globally
- Increasingly, stages are defined on the basis of magnetic reversals.
- Development of GPTS and GTS have gone hand in hand

- Reversely magnetized rocks found in early 1900s (see Chapter 14)
- But only systematic study of K-Ar dates combined with polarities on global collection of lava flows demonstrated reversal of geomagnetic field



Mason & Raff, 1961

Cox et al. (1963)

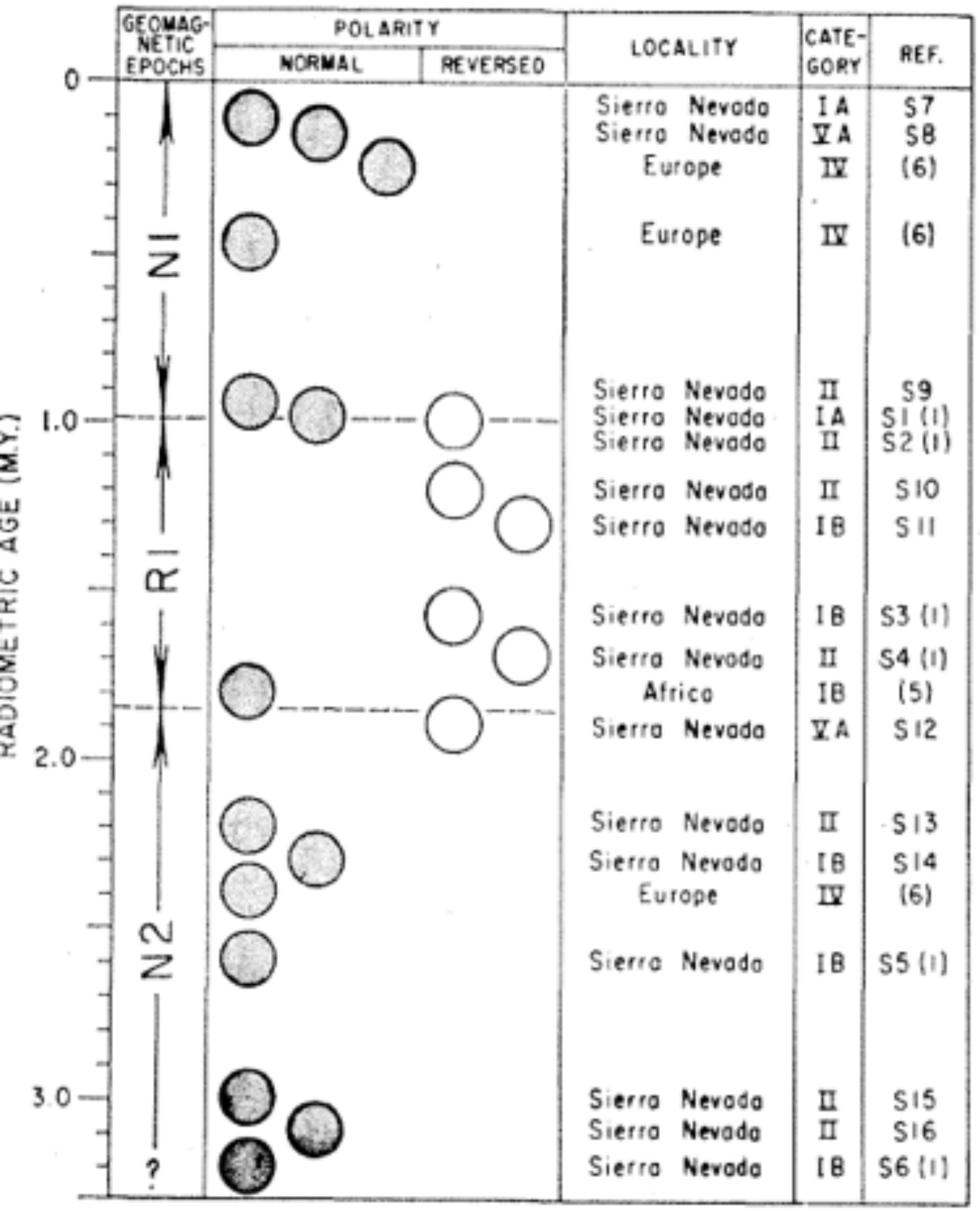
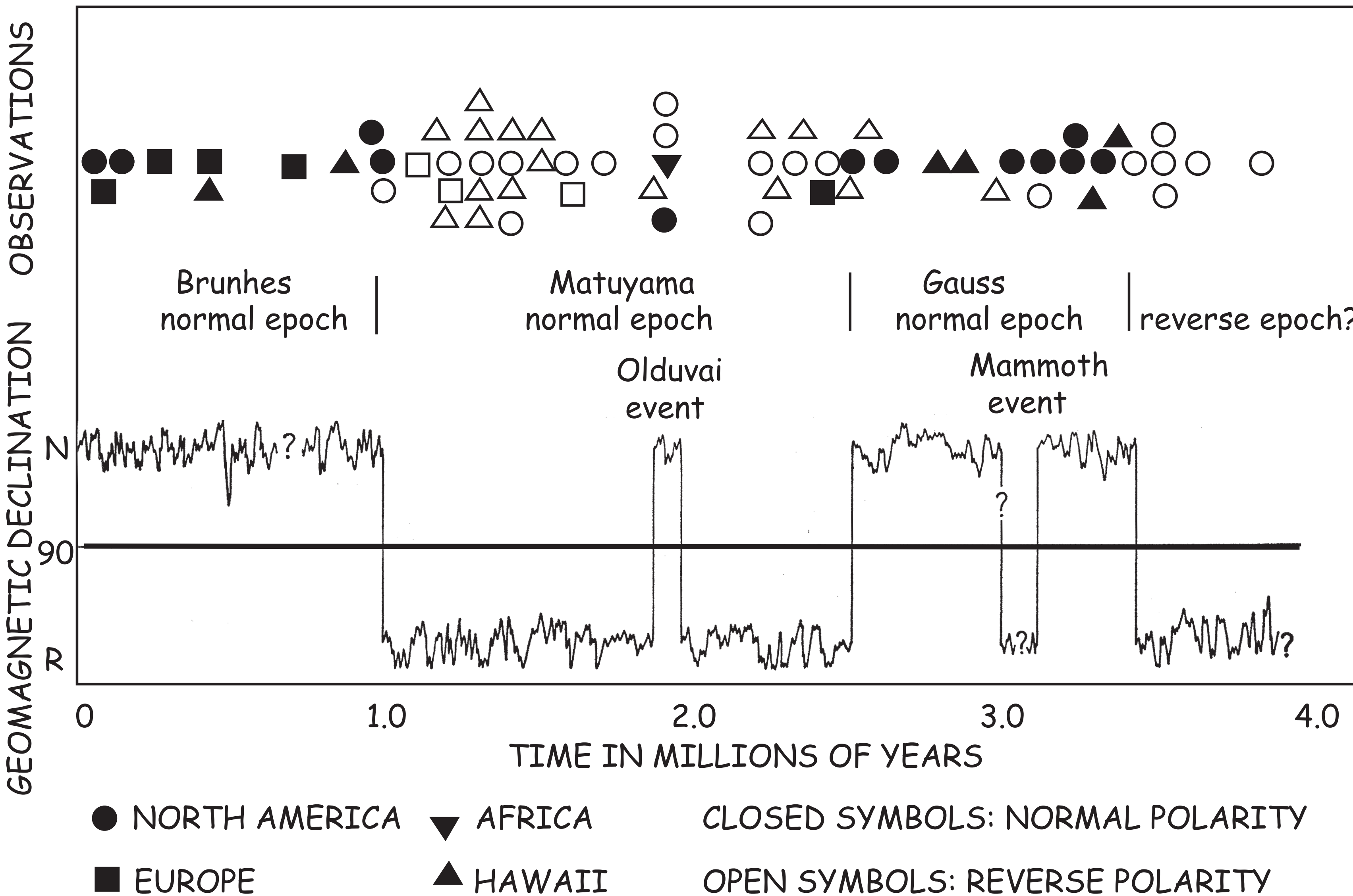


Fig. 1. Time scale for geomagnetic polarity epochs. Categories IA and IB designate determinations where there is evidence that self reversal has not occurred. For category II laboratory experiments indicate that self reversal is unlikely. For categories IV, VA, and VB, there either is evidence relevant to the possibility of self reversal or it is ambiguous. (Further details in text.)

Cox et al. (1964)

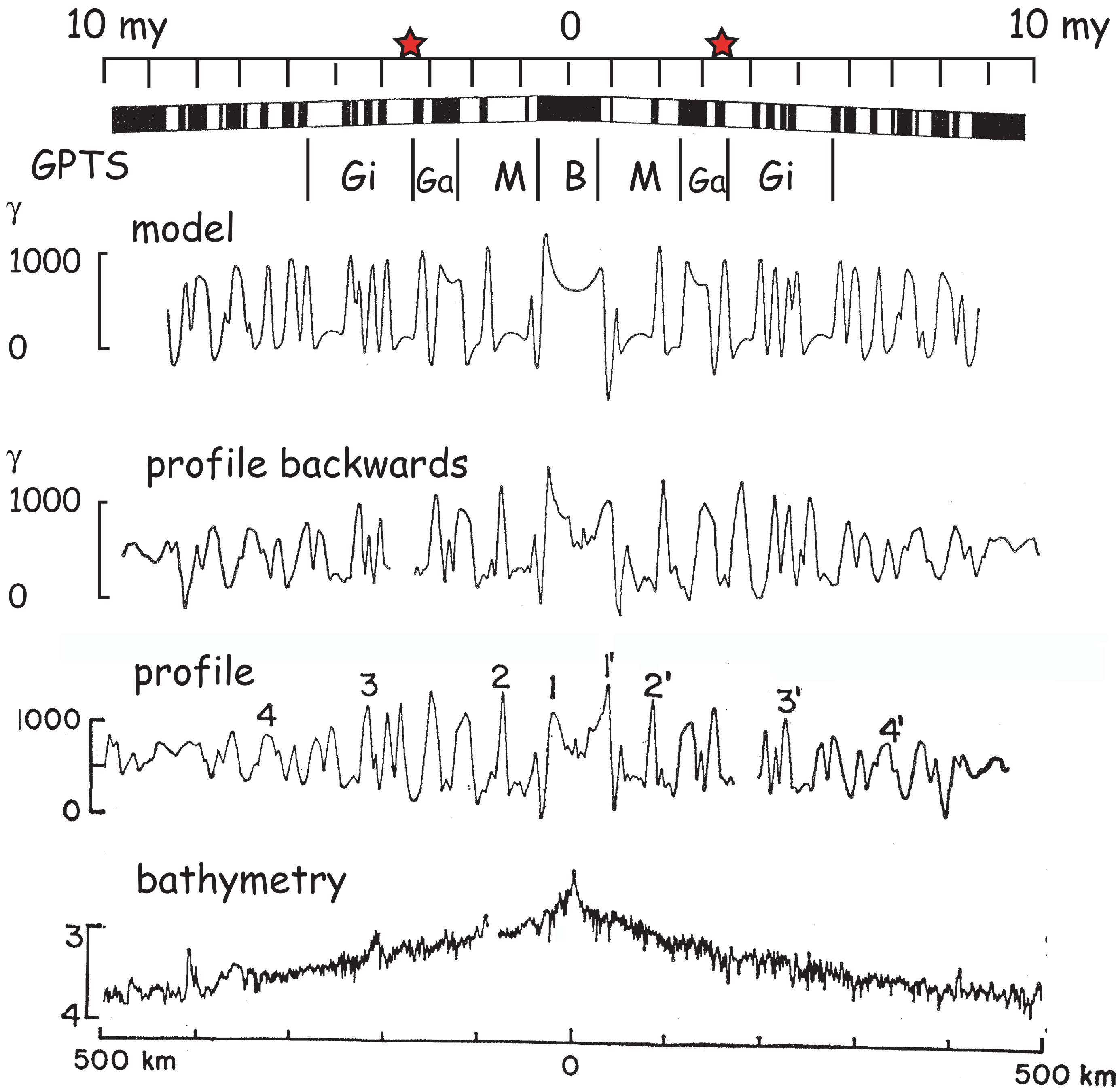


note archaic use of terms “Epoch” and “event”

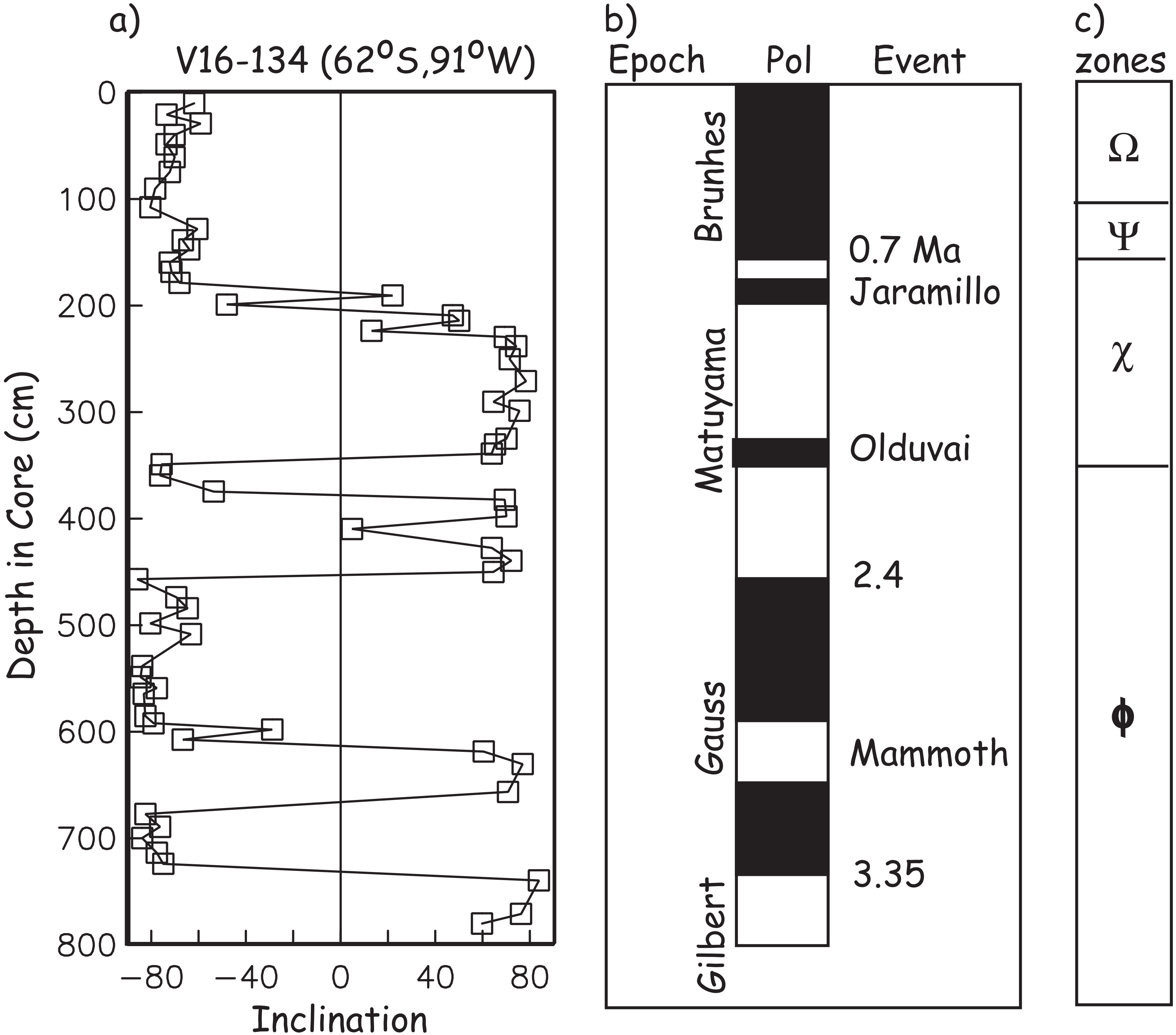
A note on terminology

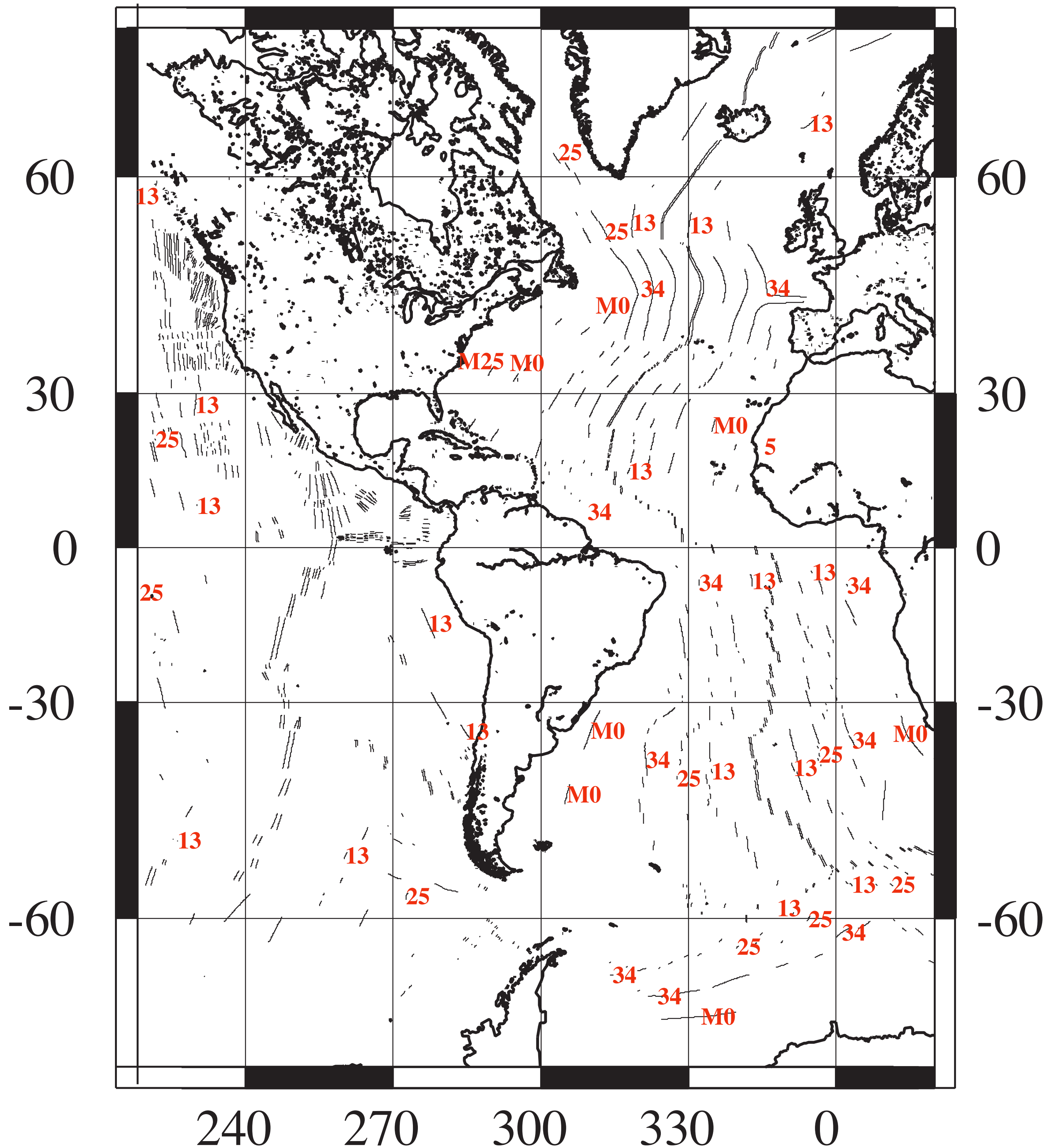
- epoch/event changed to chron/sub-chron in 1979
- superchrons and cryptochrons
- aligning anomaly terminology with stratigraphic. Anomalies won. So now the ‘Olduvai’ is Chron C2n

Basic insight that proved plate tectonics



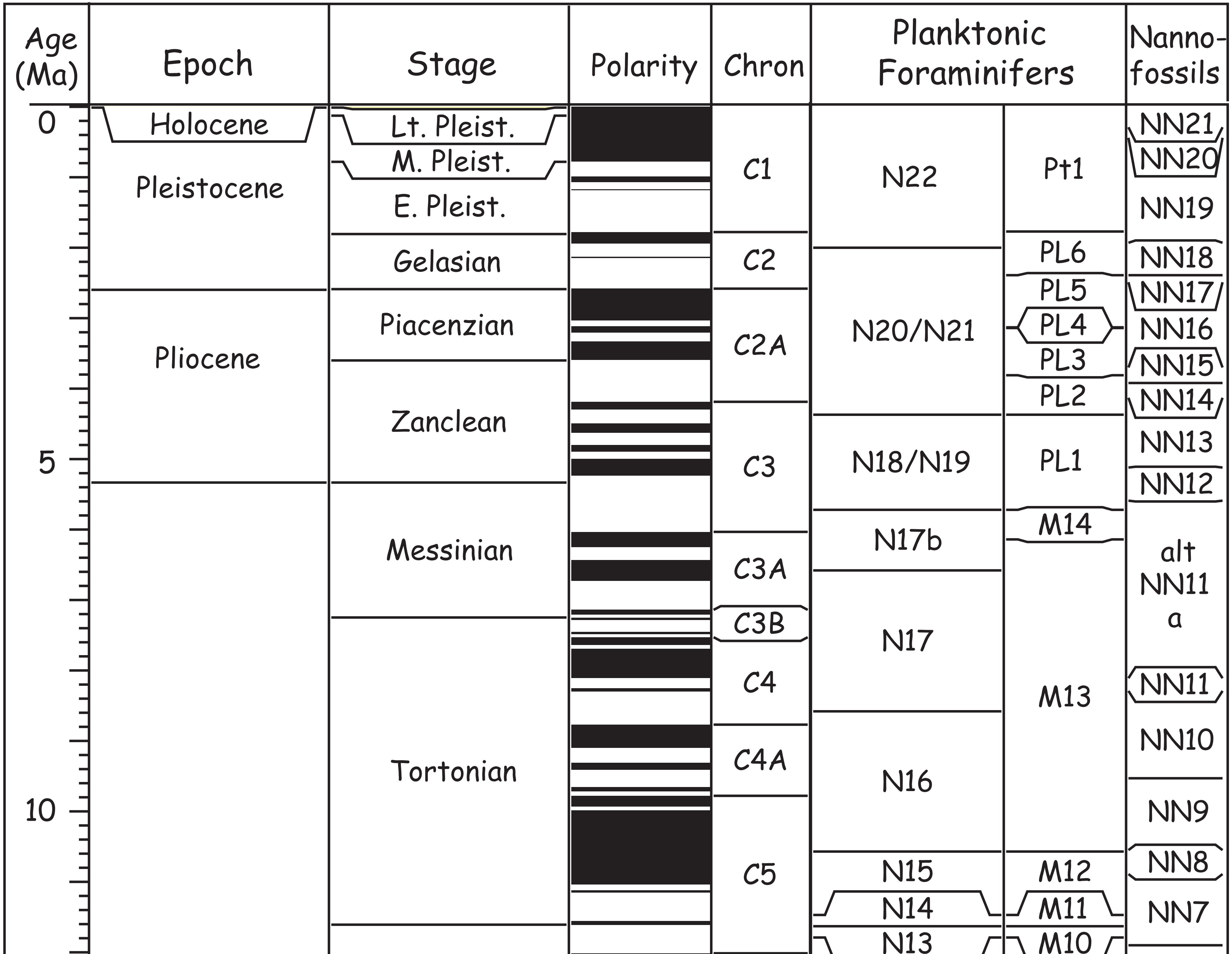
Pitman, 1966


a)
V16-134 (62°S,91°W)
Depth in Core (cm)
0
100
200
300
400
500
600
700
800
−80
−40
0
40
80
Inclination
b)
Epoch
Pol
Event
Brunhes
Matuyama
Gauss
Gilbert
0.7 Ma
Jaramillo
Olduvai
2.4
Mammoth
3.35
c)
zones
Ω
Ψ
χ
φ



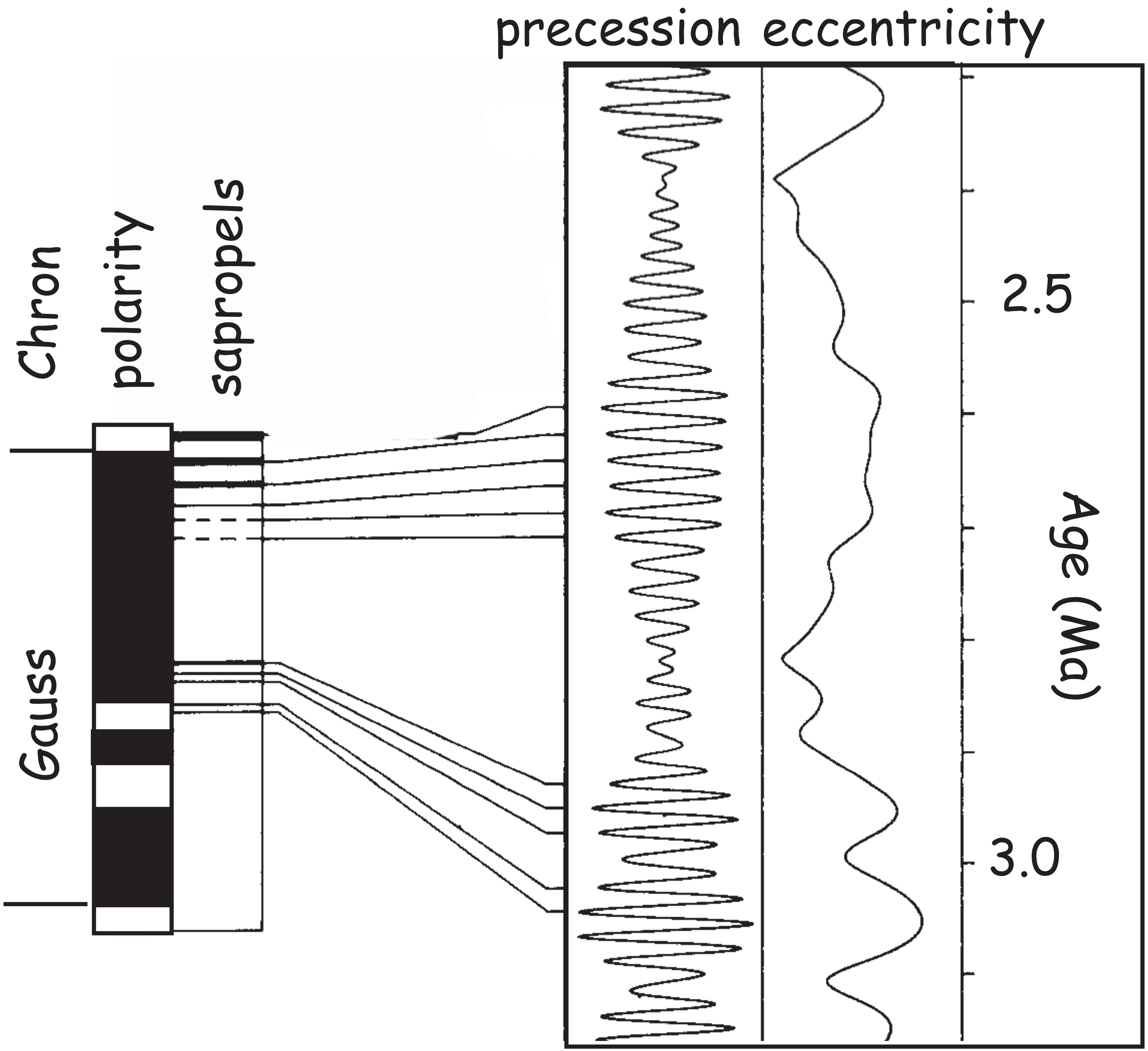
60
30
0
-30
-60
240
270
300
330
0
13
25
M0
M25
34
5

Addition of biostratigraphy



Calibration

- The polarity sequence is based on marine magnetic anomalies for the last ~200 Myr
- Prior to that, have to use terrestrial sequences, piecemeal
- Dates attached by
  - direct or indirect radioisotopic dating
  - "astrochronology"

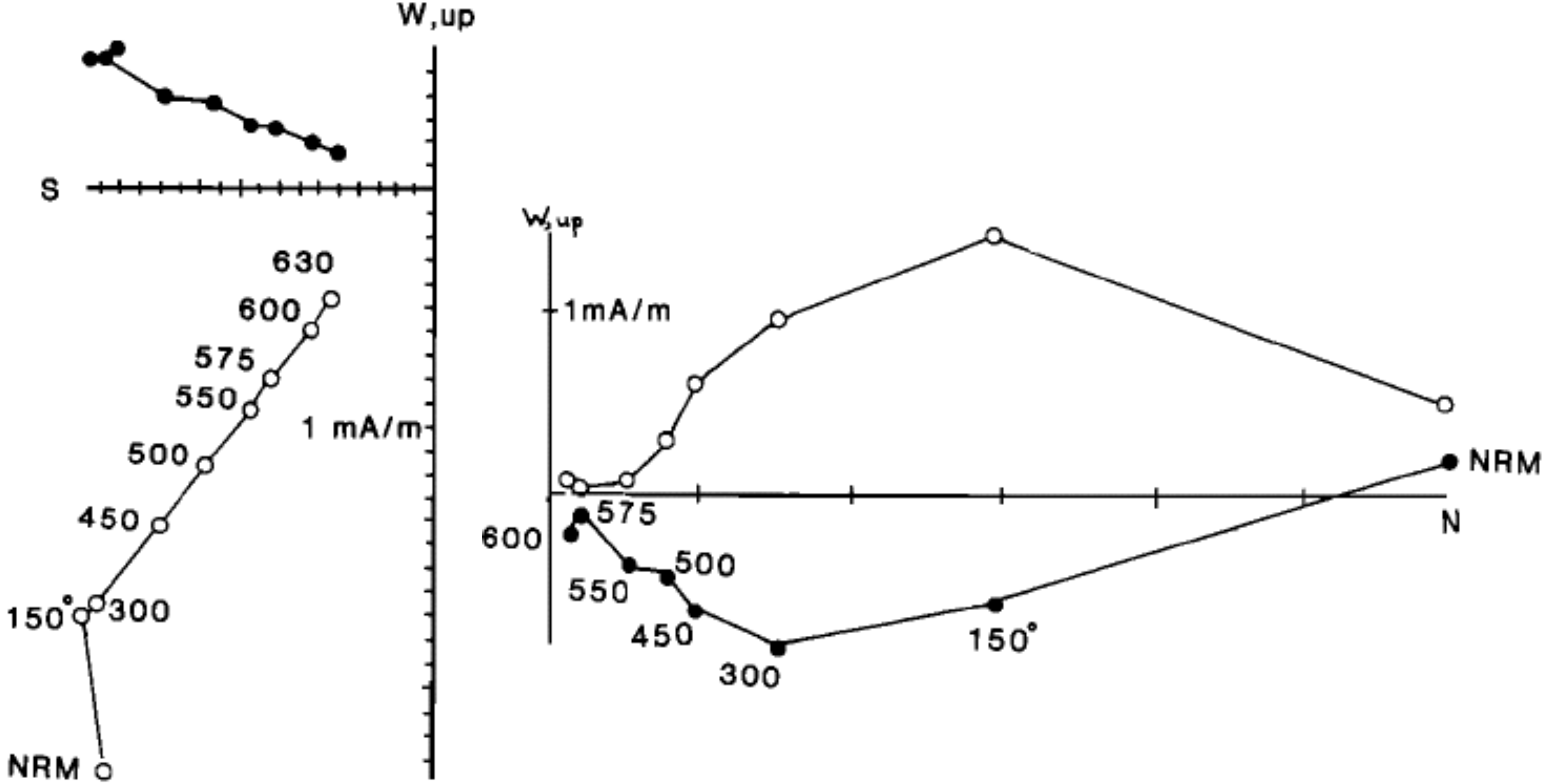

precession eccentricity
Chron
polarity
sapropels
Gauss
2.5
3.0
Age (Ma)

How to do magstrat

- Need to establish that magnetic record is of polarity history and not some overprint
- Need to sample sufficiently long and densely to recover a unique period of geomagnetic polarity history (avoiding gaps and changes in sed rate)
- Need some idea of age
- Need to correlate to time scale

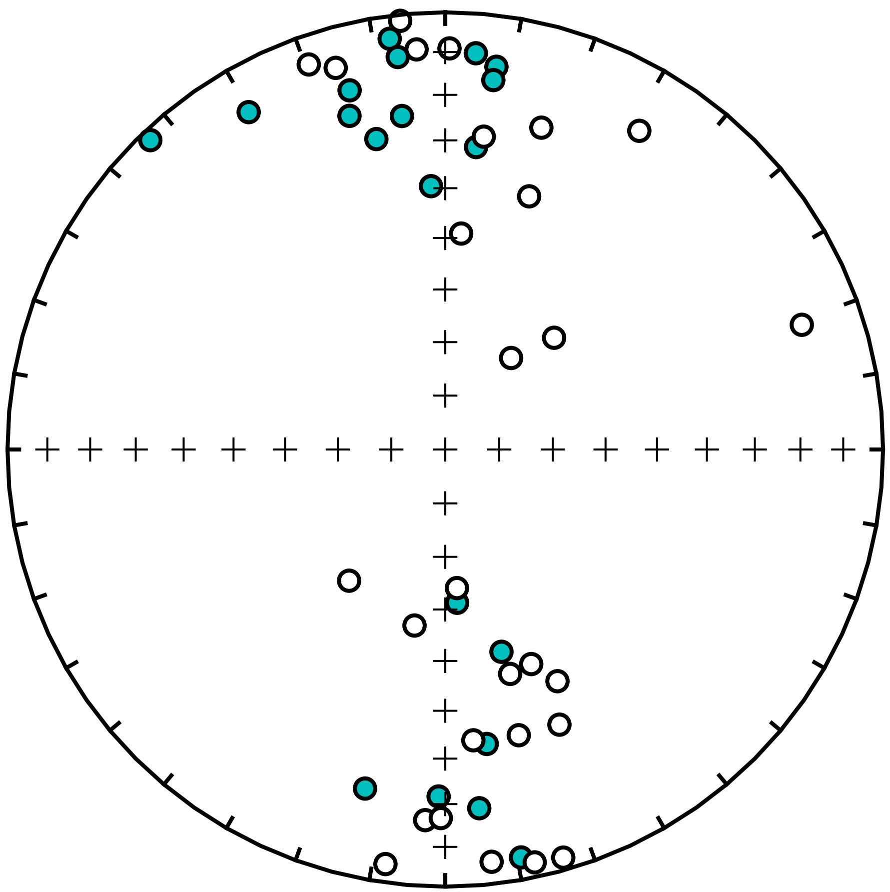
Magnetostratigraphy example in Miocene east african rift deposits Tauxe et al. (1985)

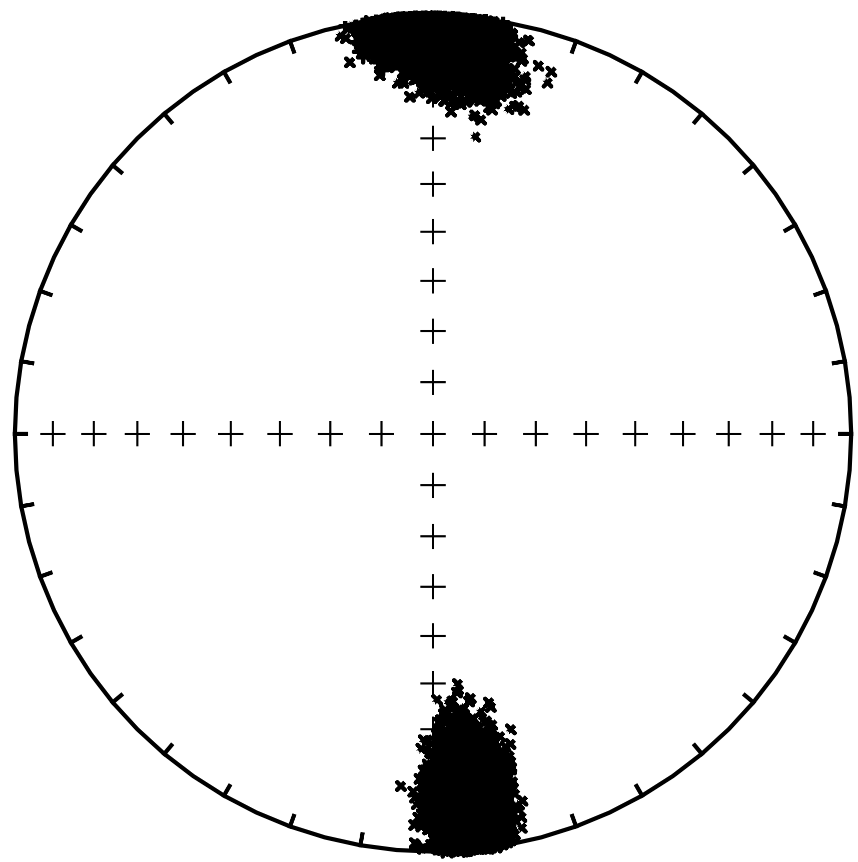
Demonstrate stability



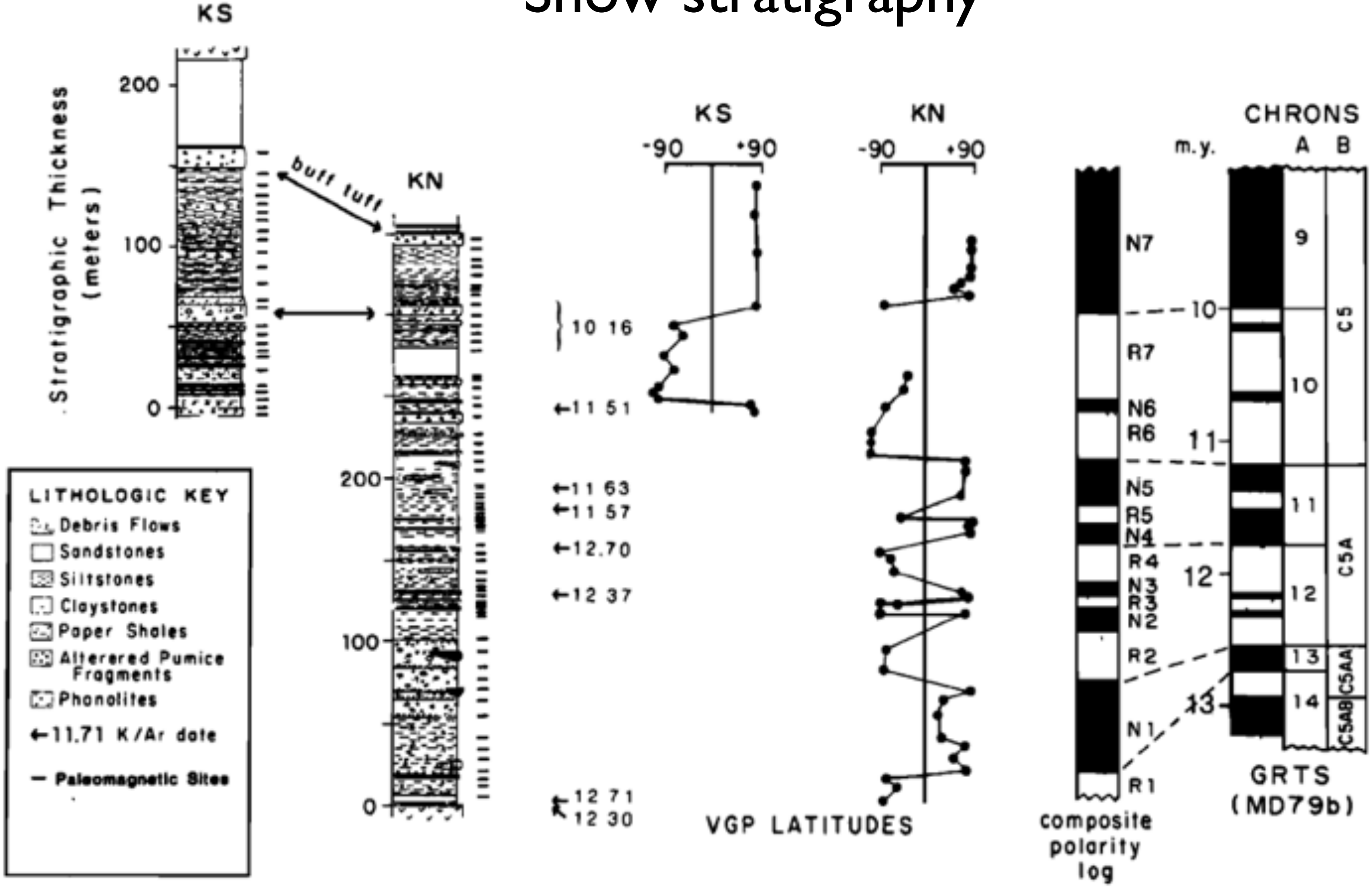
b) NA 10A

Demonstrate two polarities





Show stratigraphy



Tracing isochrons, Siwaliks of Punjab Pakistan (Behrensmeyer and Tauxe, 1982)


Khaur, Pakistan
© 2010 Google
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lat 33.236780° lon 72.522320° elev 388 m
Eye alt 9.46 km
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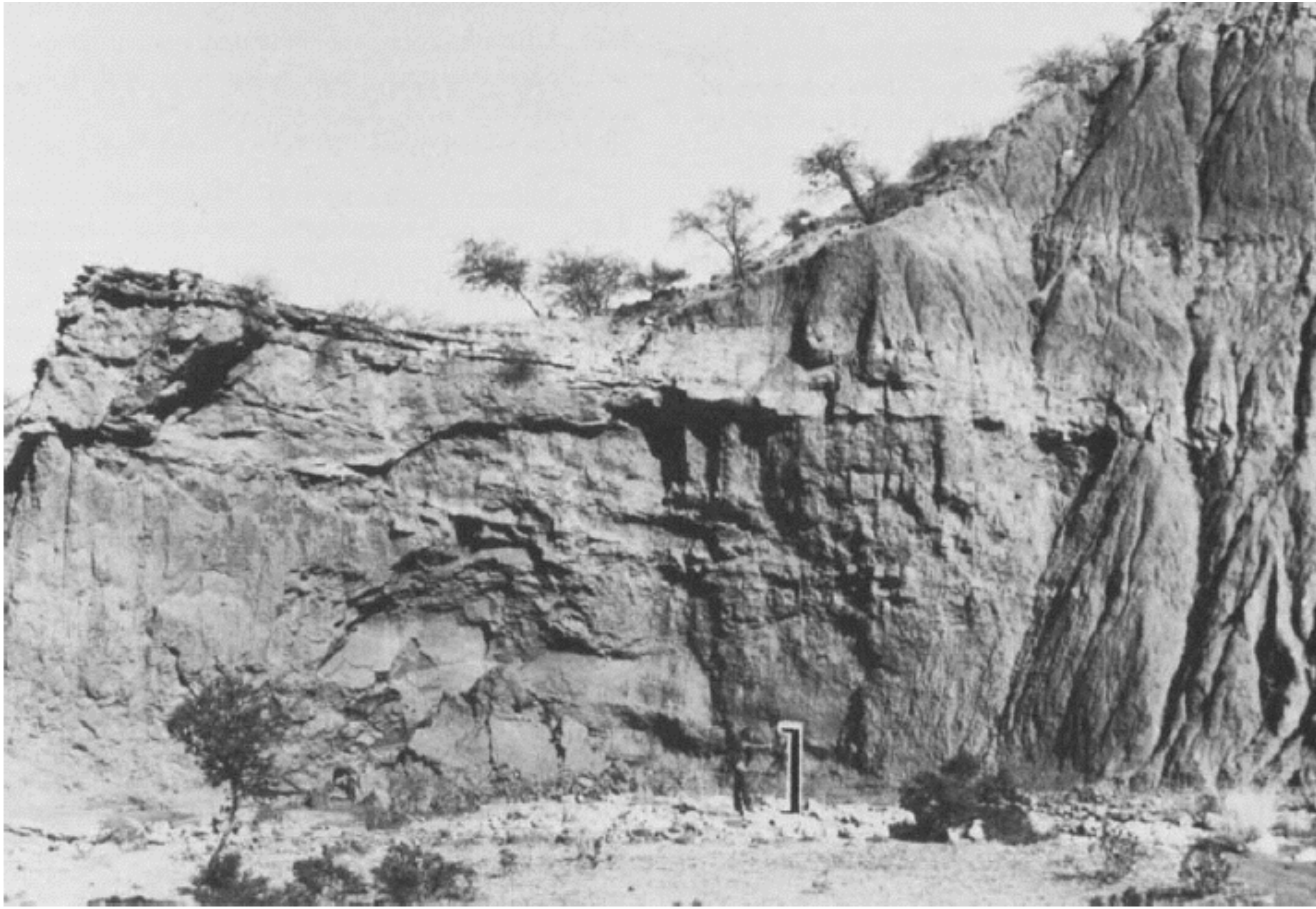
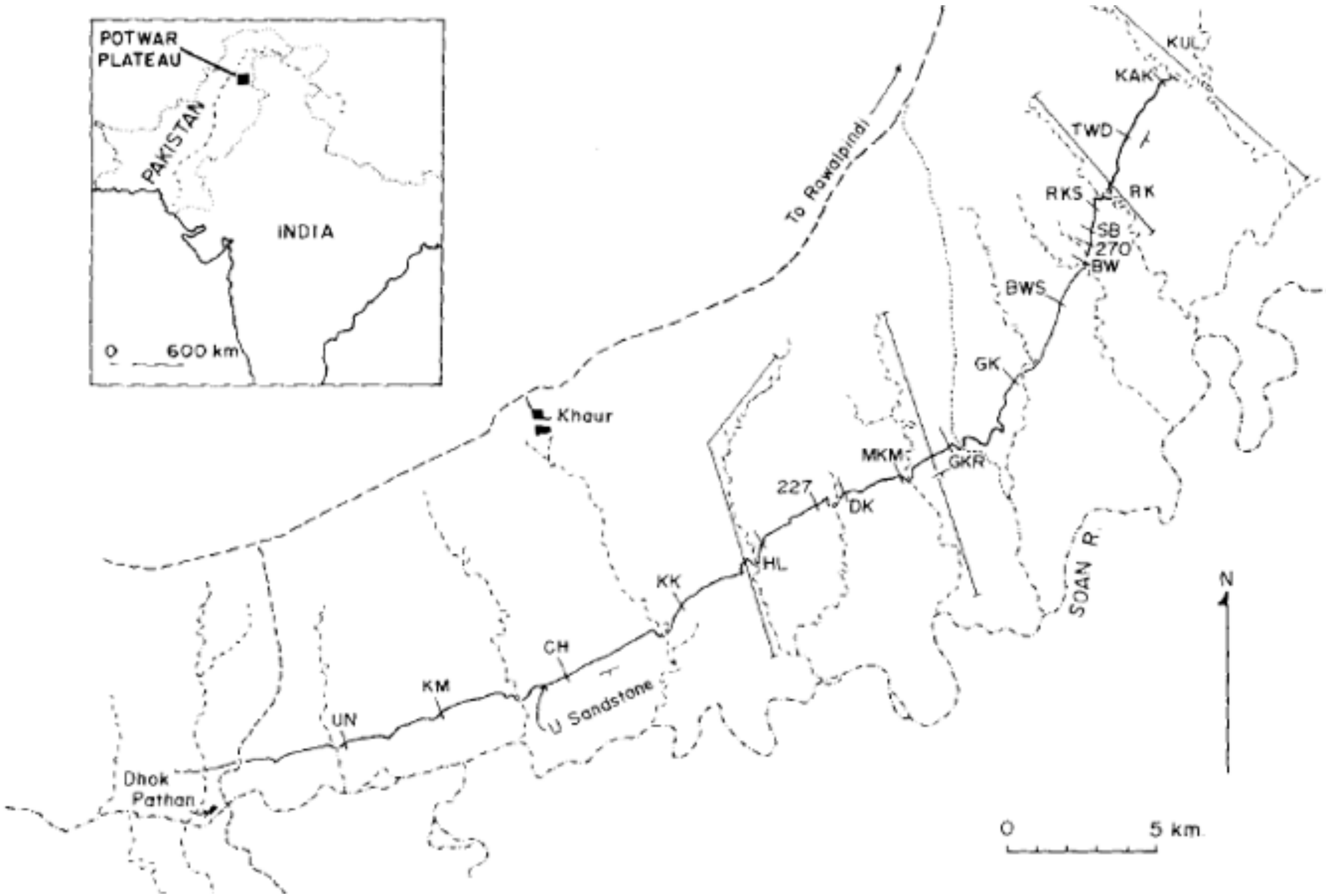
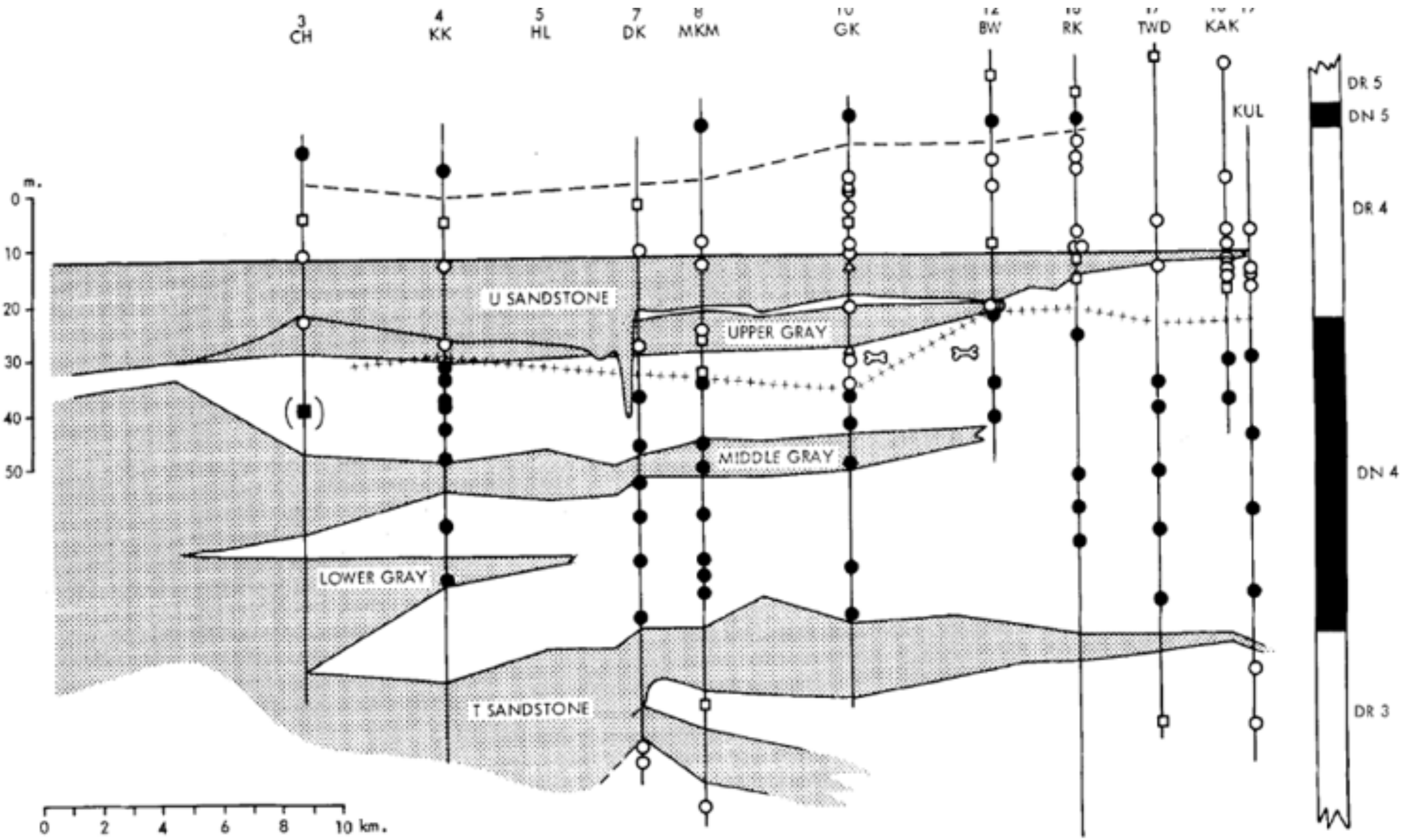
© 2010 Google
©2009 Google
lat 33.238158° lon 72.522845° elev 393 m
Eye alt 1.38 km

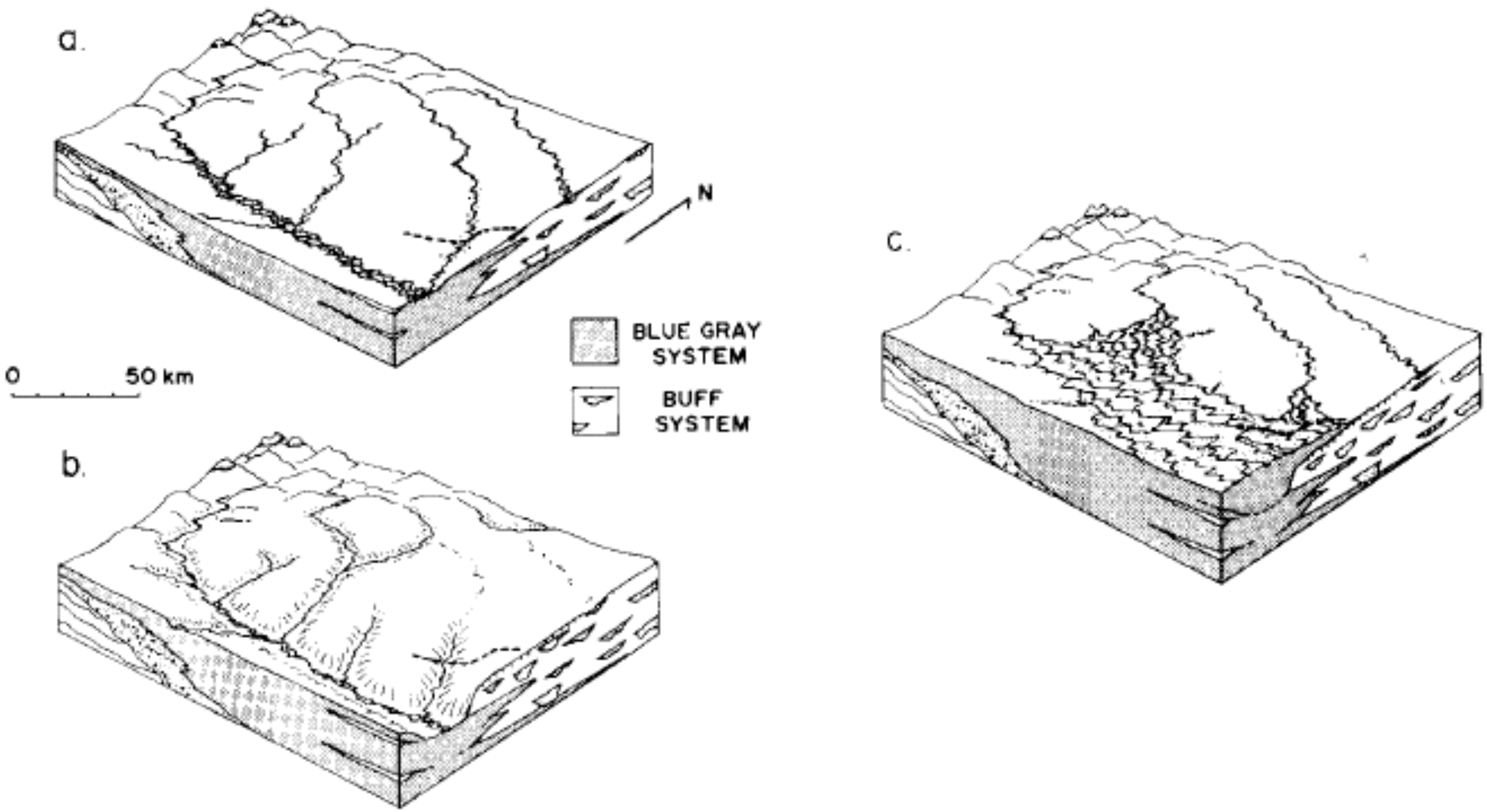




POTWAR PLATEAU
PAKISTAN
INDIA
0
600 km
To Rawalpindi
Khaur
KUL
KAK
TWD
RKS
RK
SB
270
BW
BWS
GK
MKM
GKR
227
DK
HL
KK
CH
KM
UN
U Sandstone
SOAN R.
Dhok Pathan
N
0
5 km



3
CH
4
KK
5
HL
7
DK
8
MKM
GK
BW
RK
TWD
KAK
KUL
m.
0
10
20
30
40
50
U SANDSTONE
UPPER GRAY
MIDDLE GRAY
LOWER GRAY
T SANDSTONE
0
2
4
6
8
10 km.
DR 5
DN 5
DR 4
DN 4
DR 3


a.
N
BLUE GRAY SYSTEM
BUFF SYSTEM
0
50 km
b.
c.

similarity to Indus/Soan River system today

And the Indus is still doing it…