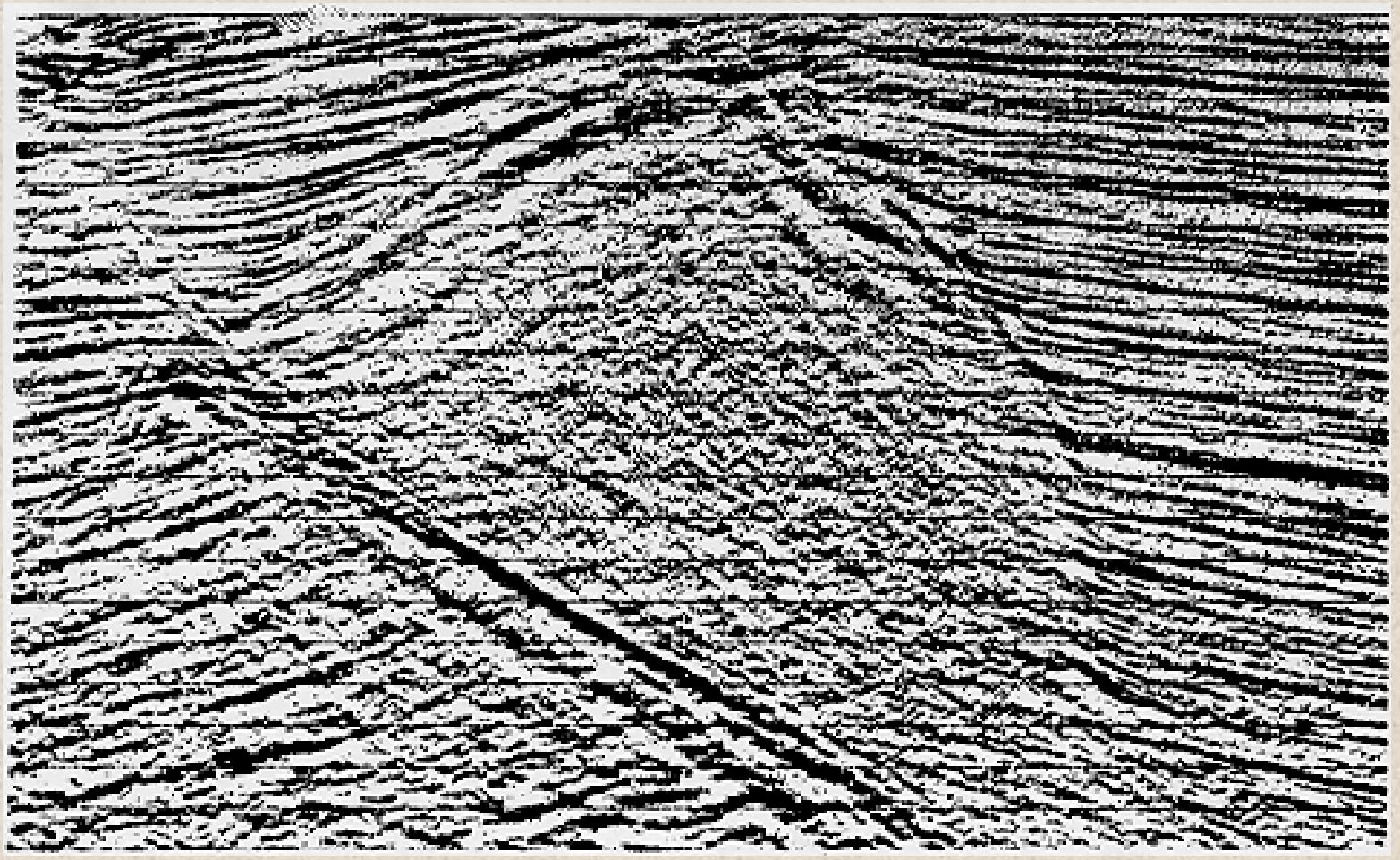
Seismische, Sequenz und Magnetostratigraphie



Seismische Stratigraphie: seismische Daten -> Informagtionen zur Stratigraphie

Sequenz Stratigraphie: abrupte Änderungen der sedimentären Fazies oder markante Schichtflächen, die jeweils Umschwünge in der Sedimentationsdynamik innerhalb der verglichenen Sedimentabfolgen widerspiegeln

Sequenze: Ablagerungszyklus, der von nichtmarinere Erosion begrenzt wird

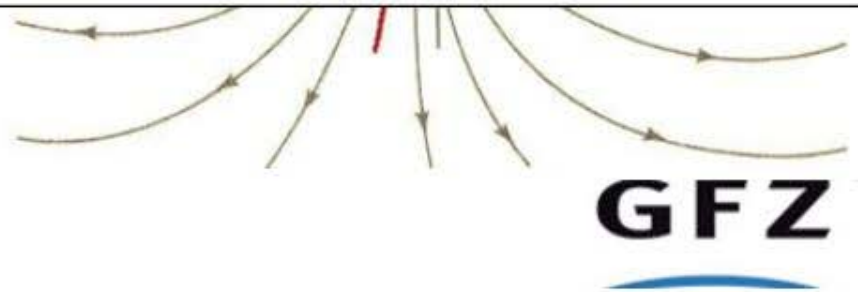
Magnetostratigraphie: Aufzeichnung des Verhaltens des Erdmagnetfelds in Sedimenten. Daierung und Korrelation.

Magnetostratigraphy
Possibilities, pitfalls and applications

Newsletter on Stratigraphy
Vol. **43/3:** 207–233, April 2010

Magnetostratigraphy – concepts, definitions, and applications

Cor G. Langereis, Wout Krijgsman, Giovanni Muttoni, and Manfred Menning



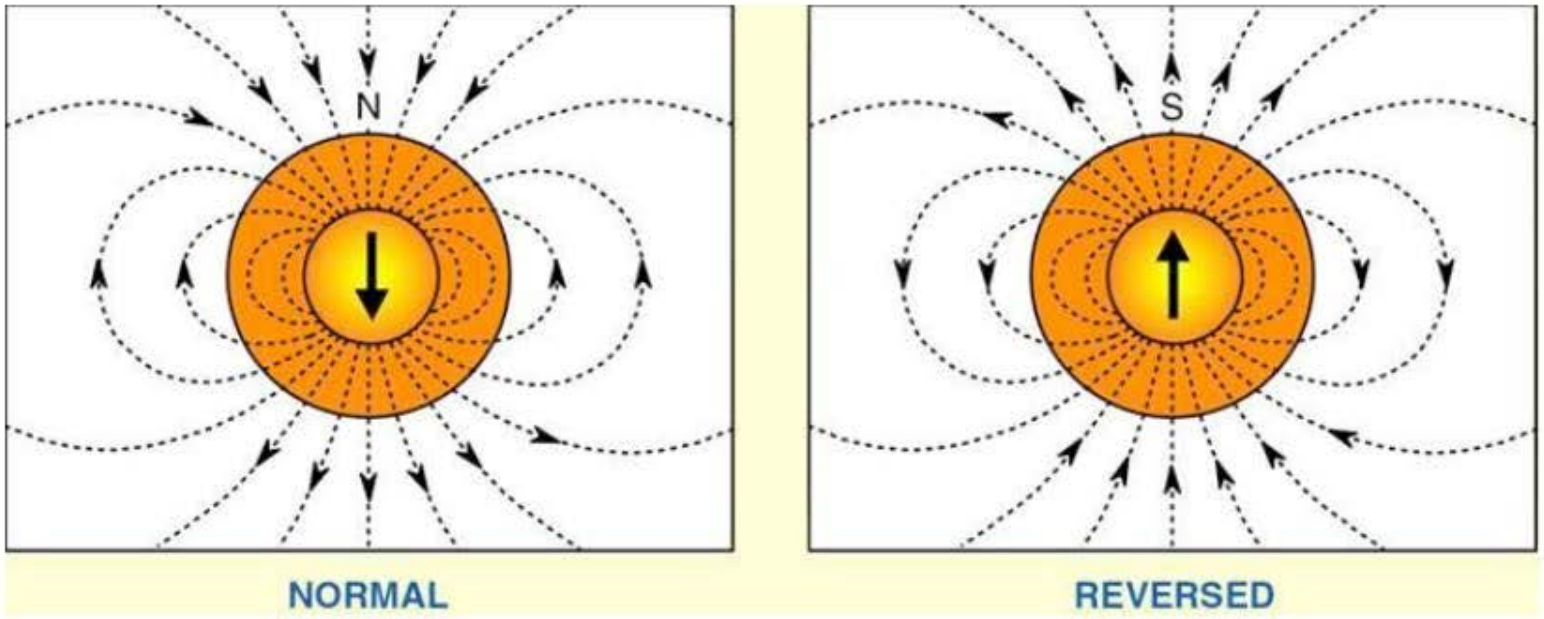
GFZ

UNIVERSITÀ DEGLI STUDI DI MILANO

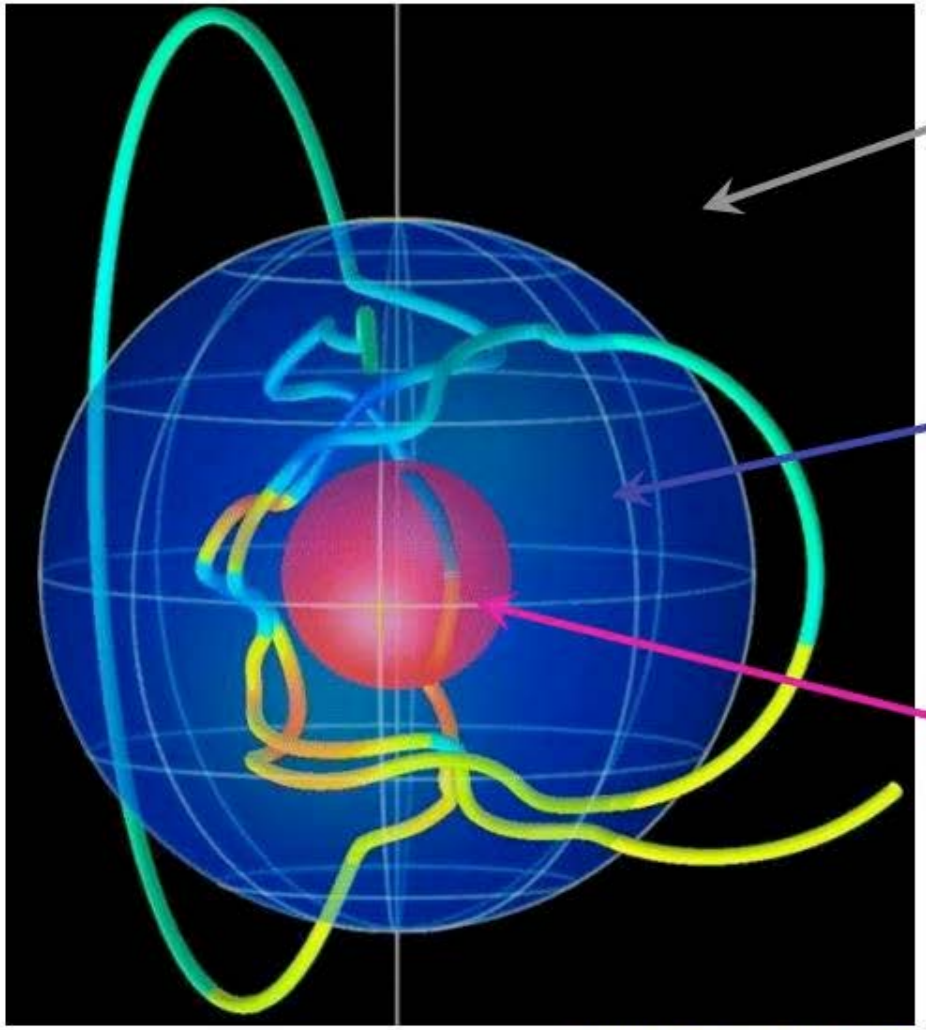
Universiteit Utrecht

Magnetostratigraphy

a dipole reversing at irregular times



Origin of reversals



Kuang & Bloxham, 1997

Mantle

Convection time scale ~100 Myr

Reversal frequency, superchrons

Liquid outer core

Convection time scale 300-500 yr

***Geodynamo action**: Secular variation, excursions, reversals*

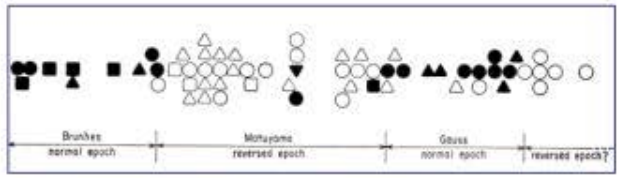
Solid inner core

Diffusion time scale 3-5 kyr

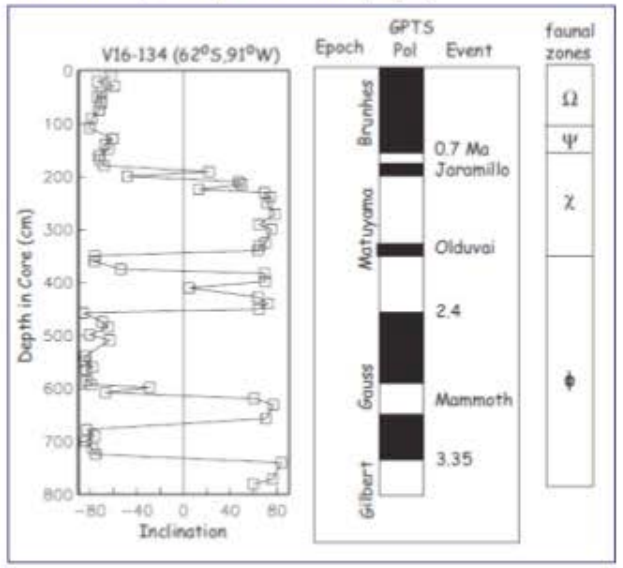
Stabilises geodynamo process

GPTS: Geomagnetic Polarity Time Scale

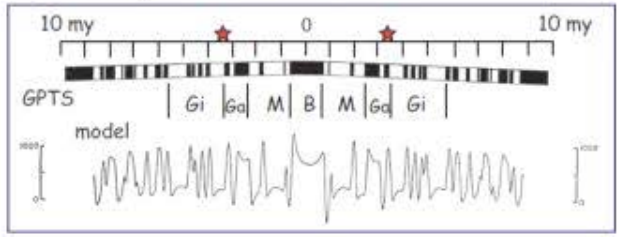
Lavas & K/Ar dating

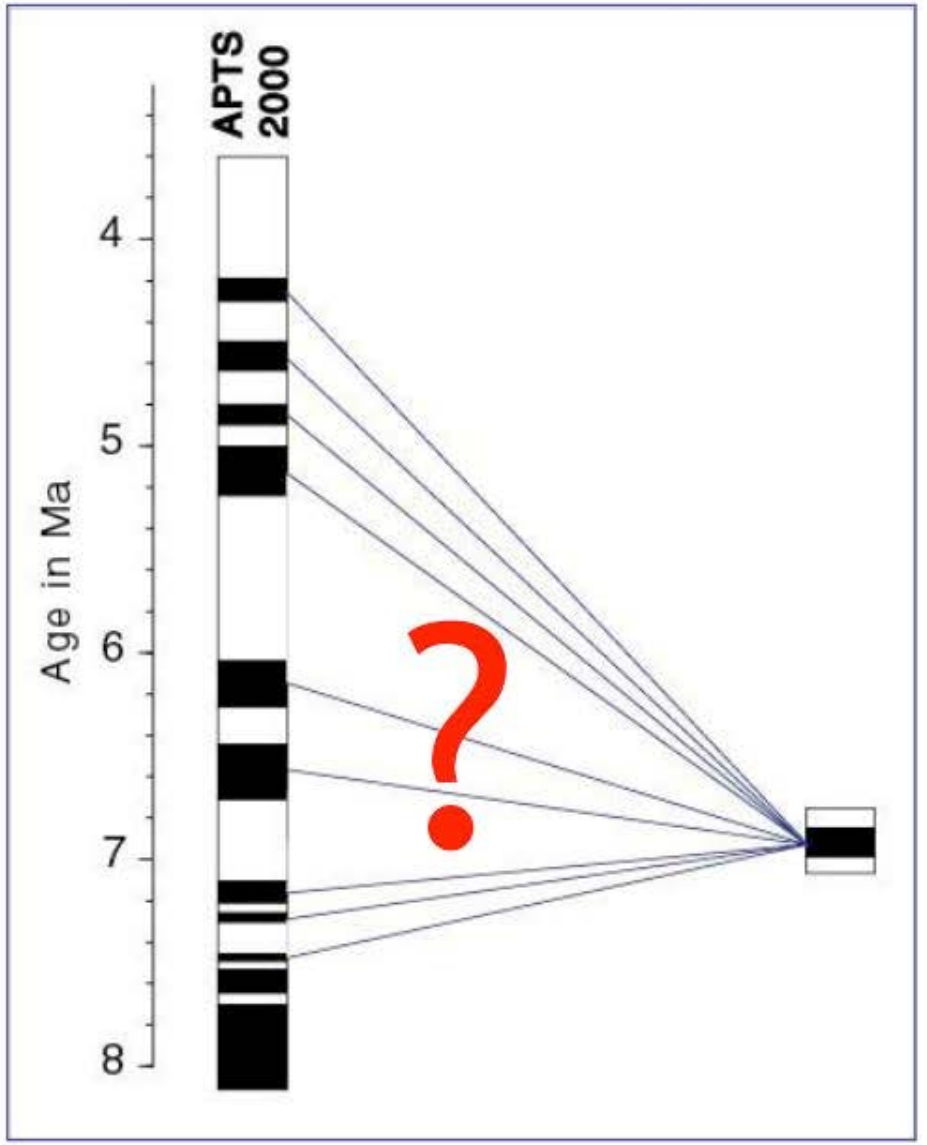


Sediments (DSDP) & biostratigraphy



Marine magnetic anomalies





Magnetostratigraphy
≡ part of integrated stratigraphy

Biostratigraphy: first-order chronology

- taxonomy, reworking, diachrony, ages

Magnetostratigraphy: globally synchonous barcode

- depends on good paleomagnetic signal & recording

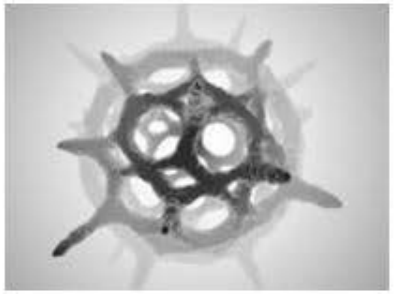
Cyclostratigraphy: astronomical dating, fine-tuning

- astronomical solutions (> 20 Ma)

- interpretation of phase relations

Integrated stratigraphy

Biostratigraphy

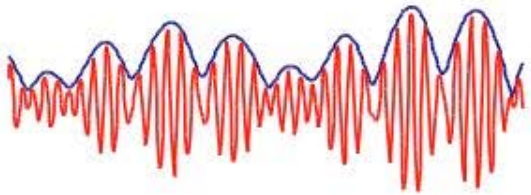


- first-order chronology

Magnetostratigraphy

- globally synchonous barcode

Cyclostratigraphy

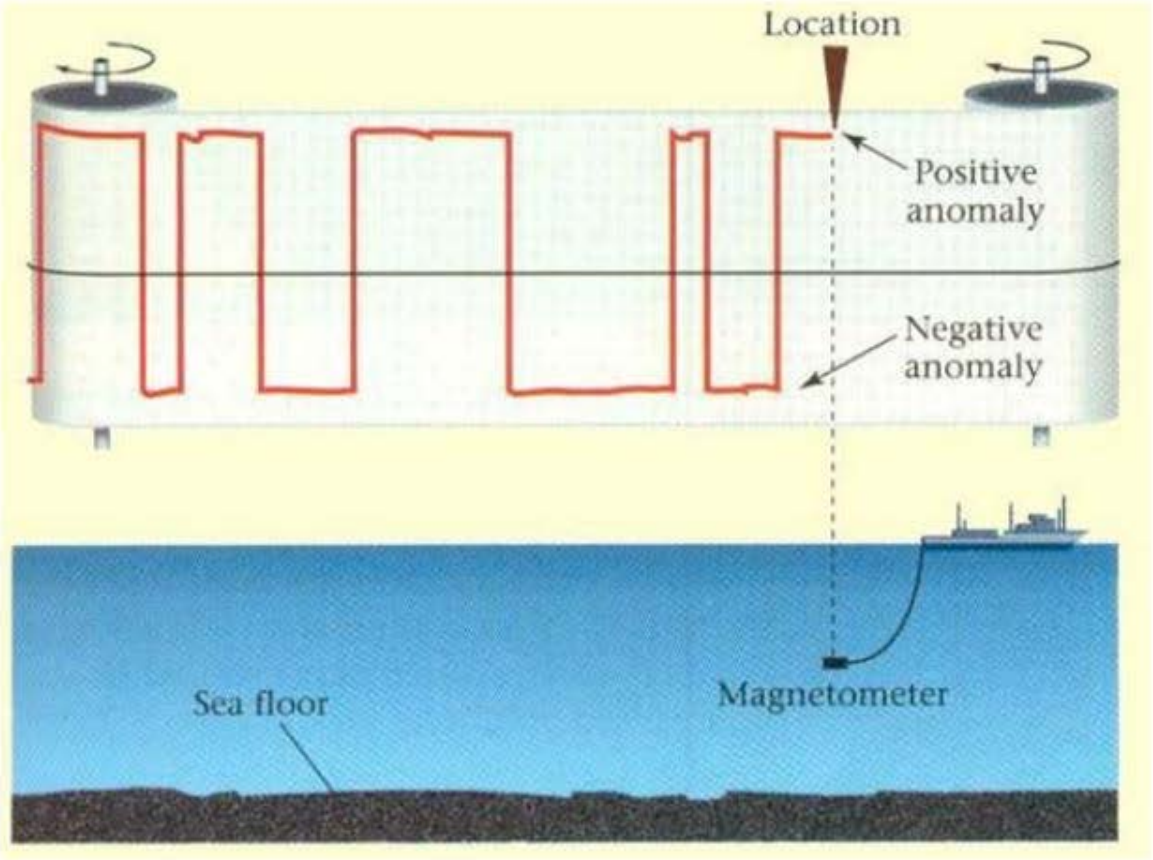


- fine-tuning & astronomical dating

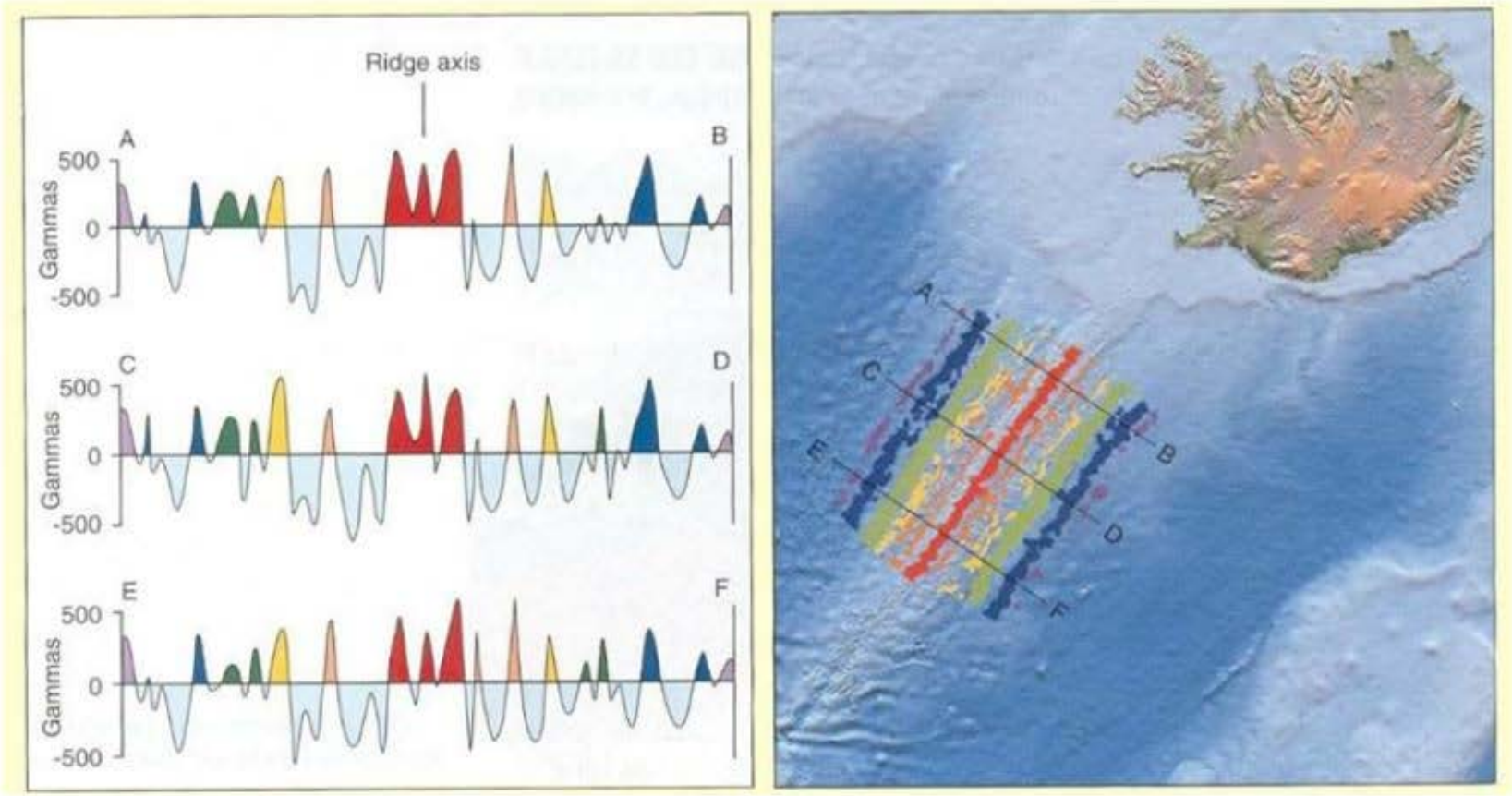
Geomagnetic time scales

Geomagnetic behavior	
Pulsations or short term fluctuations	minutes
Daily magnetic variations	hours
magnetic storms	hours to days
Secular variation	10^2 - 10^3 yr
Magnetic excursions	10^3 - 10^4 yr
Reversal transitions	10^3 - 10^4 yr
Subchrons	10^5 - 10^6 yr
Chrons	10^6 - 10^7 yr
Superchrons	10^7 - 10^8 yr

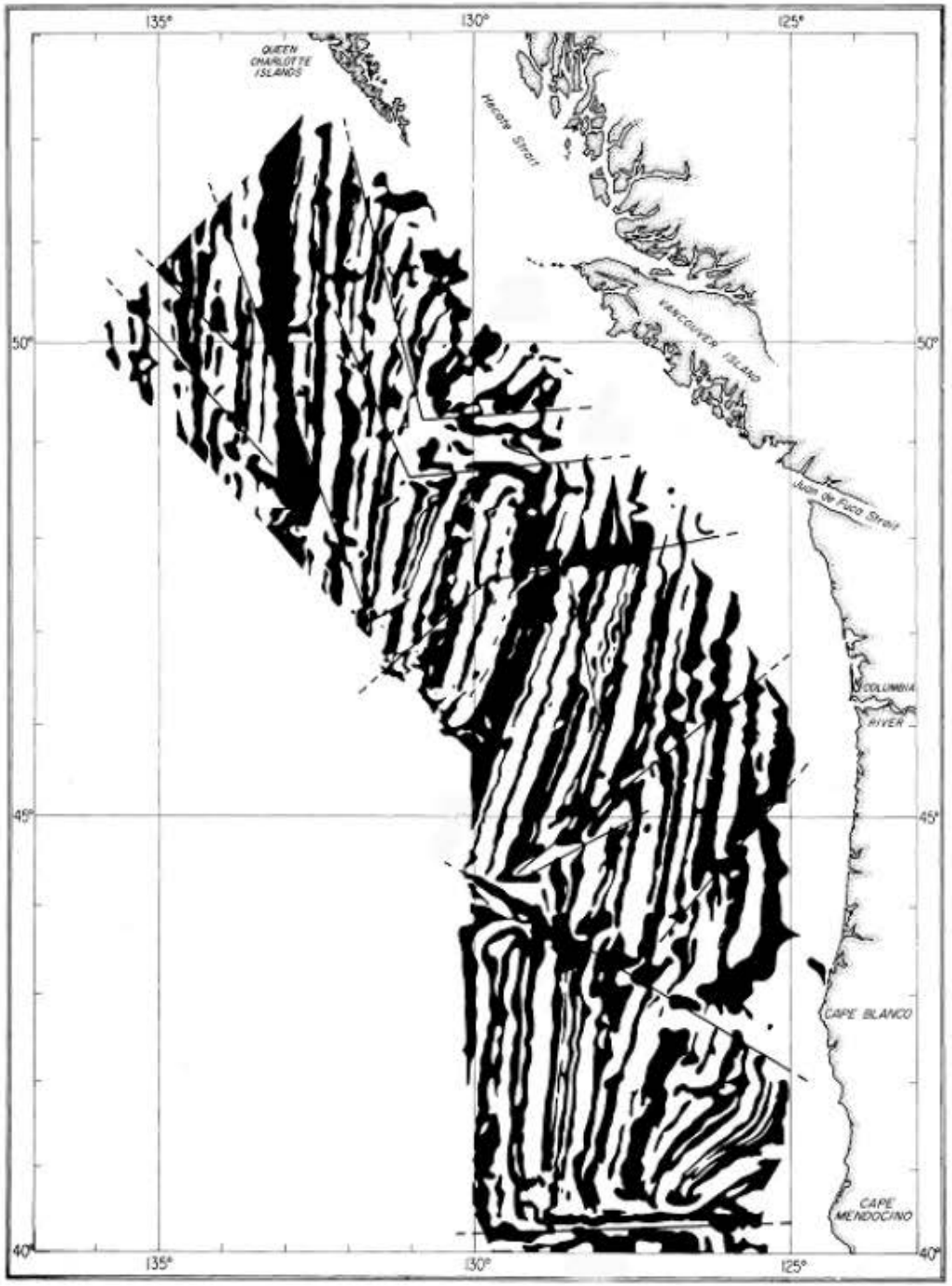
Marine magnetic anomalies

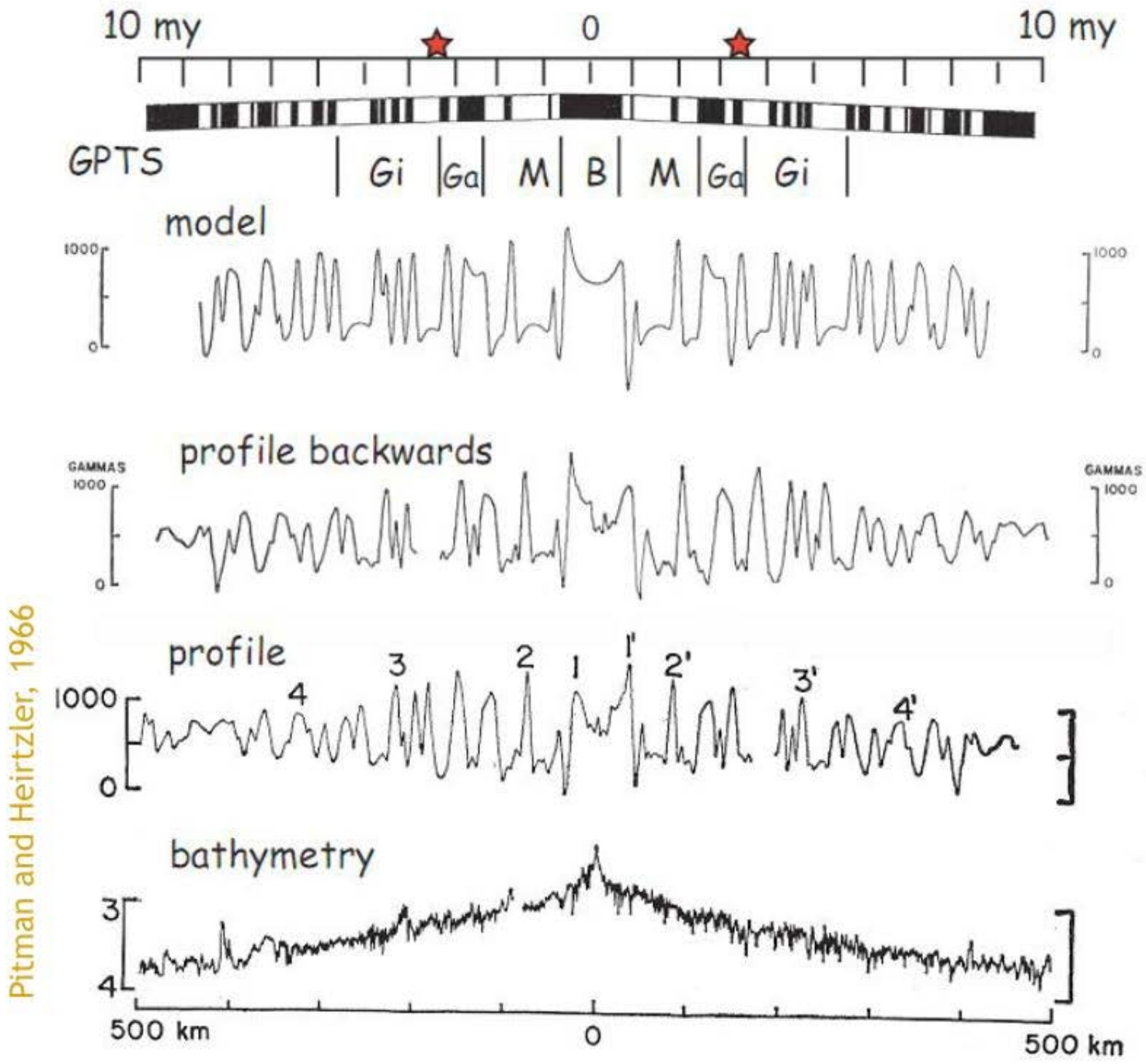


Marine magnetic anomalies



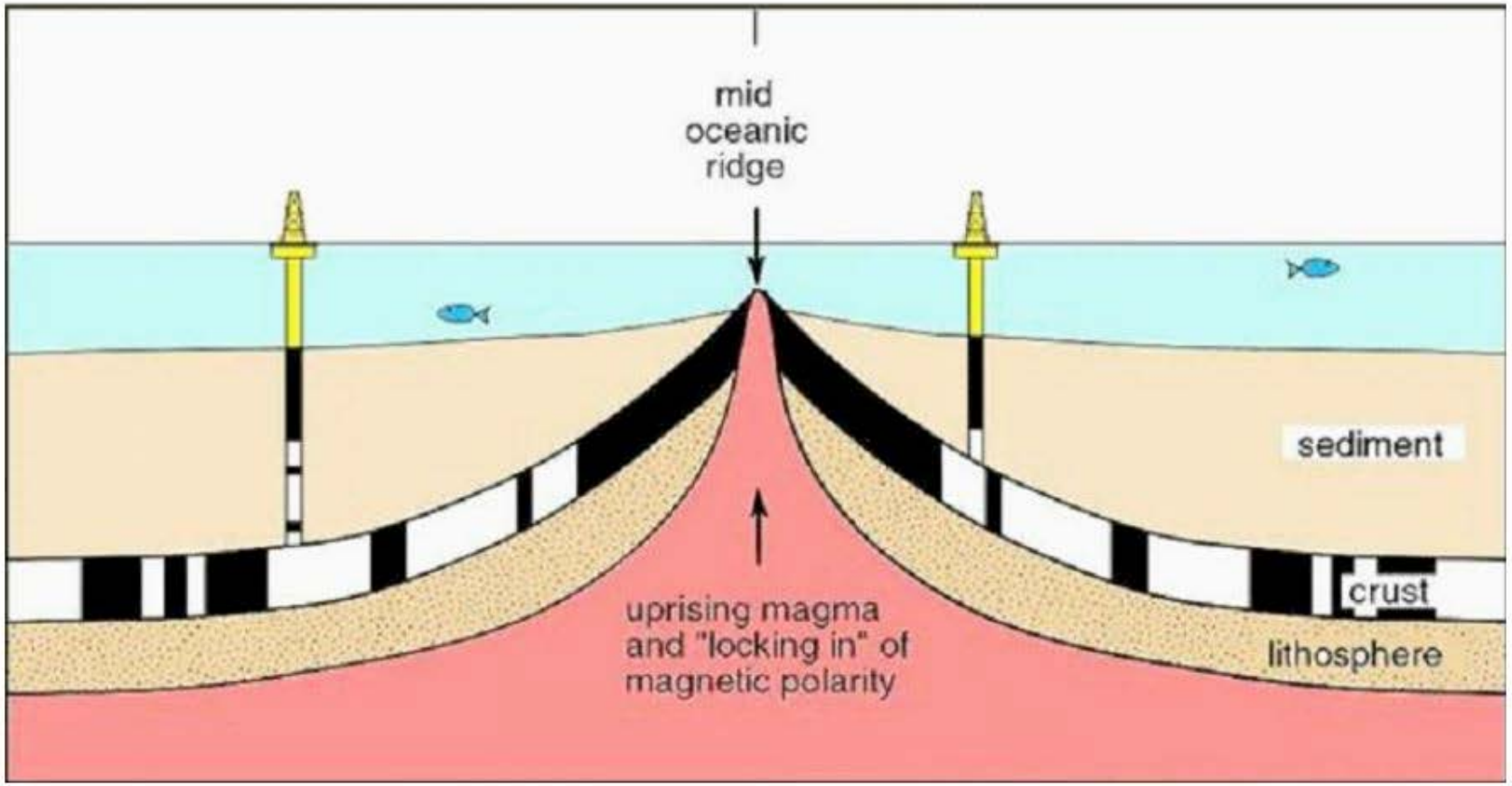
Marine magnetic anomalies





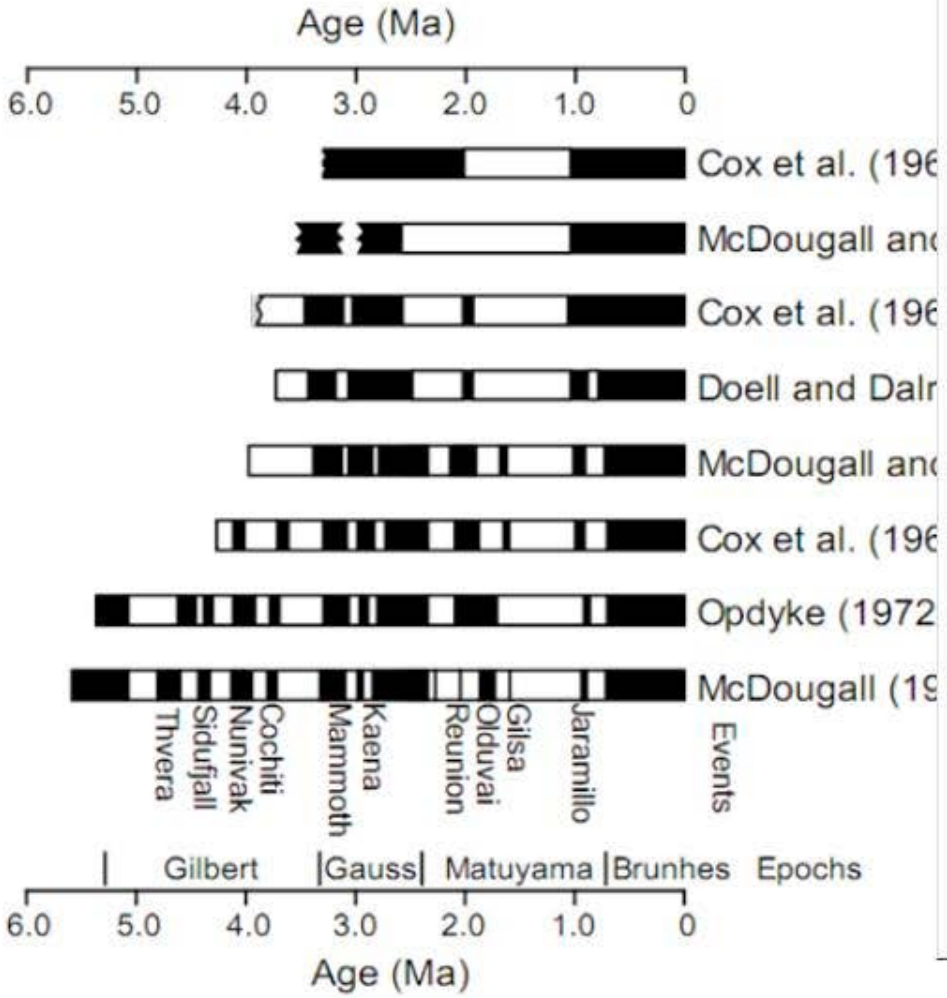
Pitman and Heirtzler, 1966

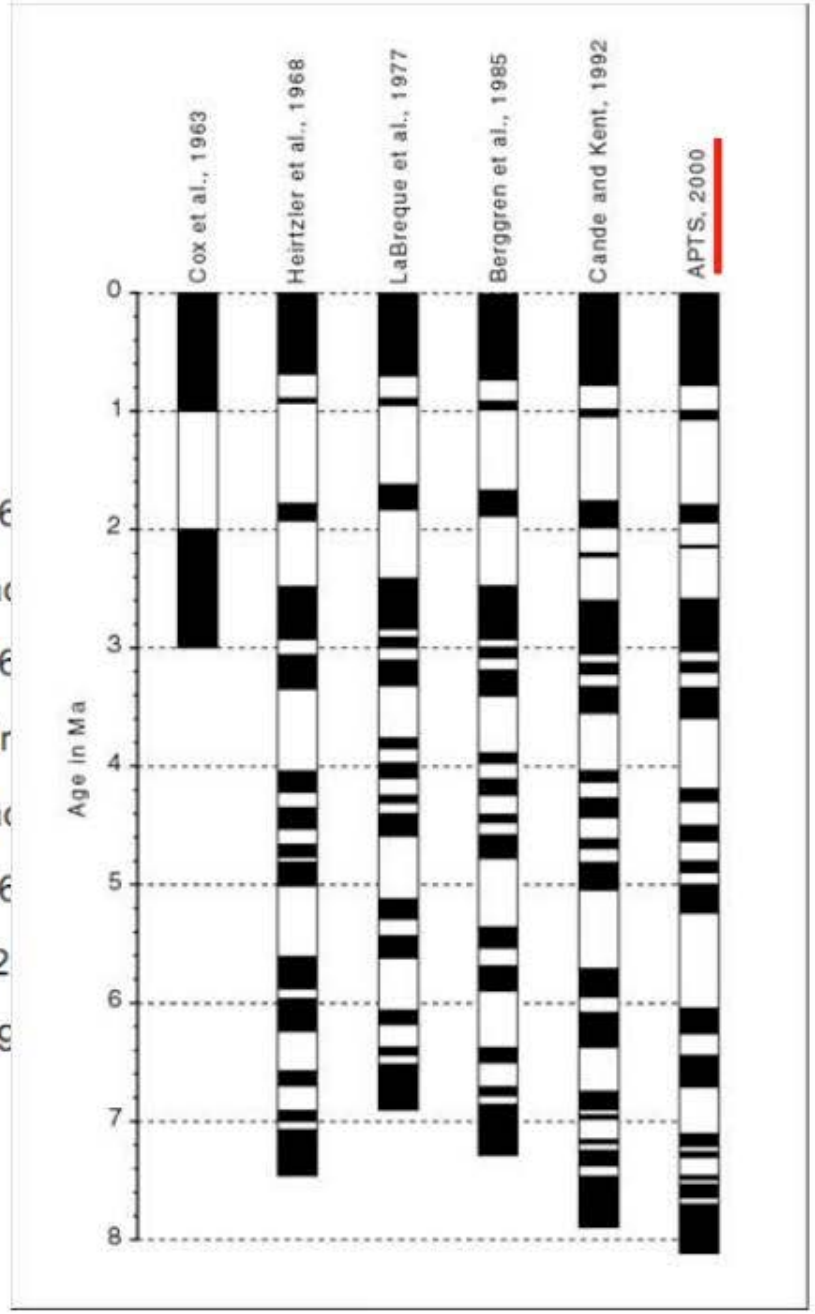
Marine Magnetic Anomalies *vs.* **Deep Sea Cores**



Continental drift

Developing the GPTS



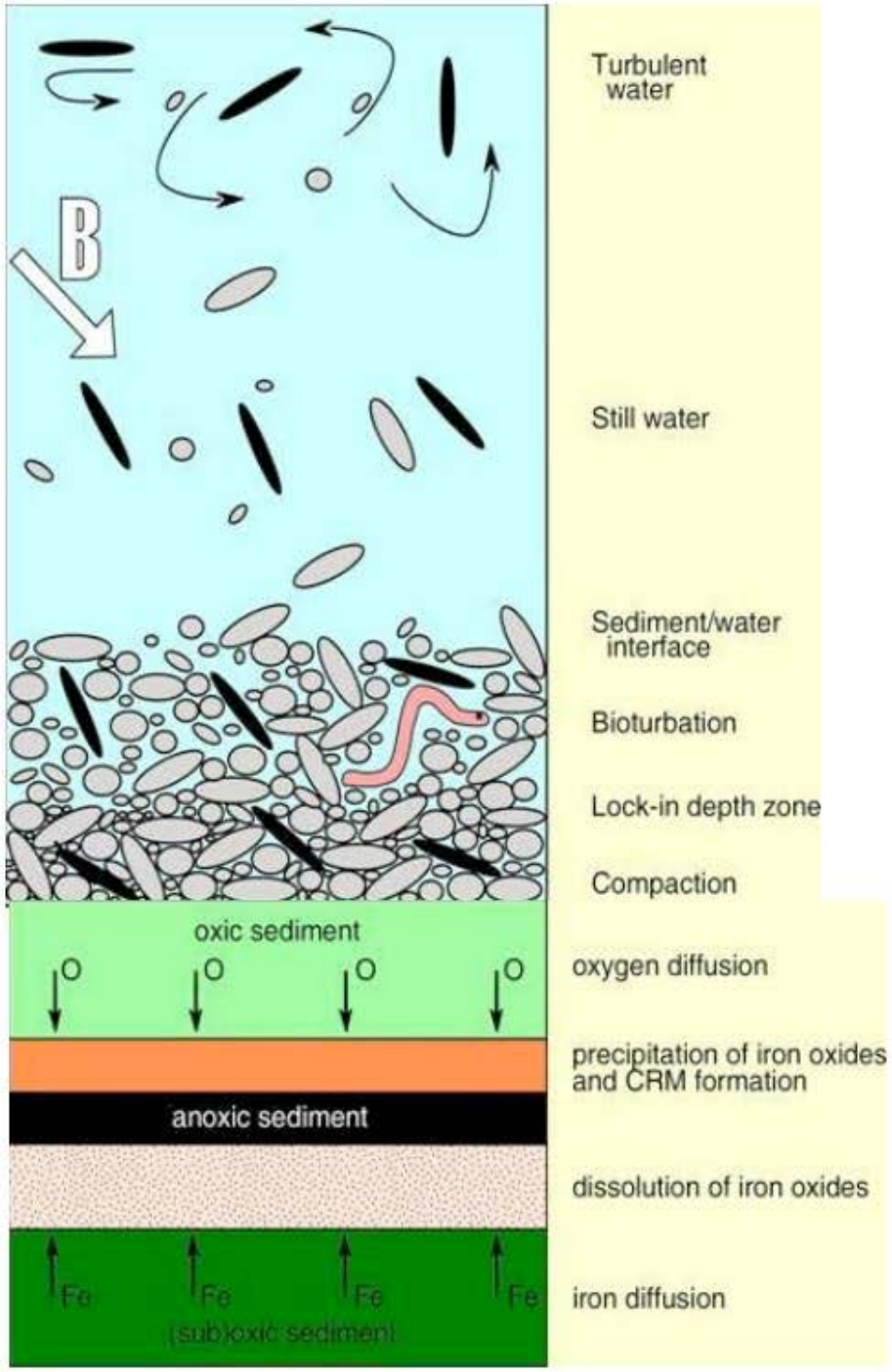


Paleomagnetism

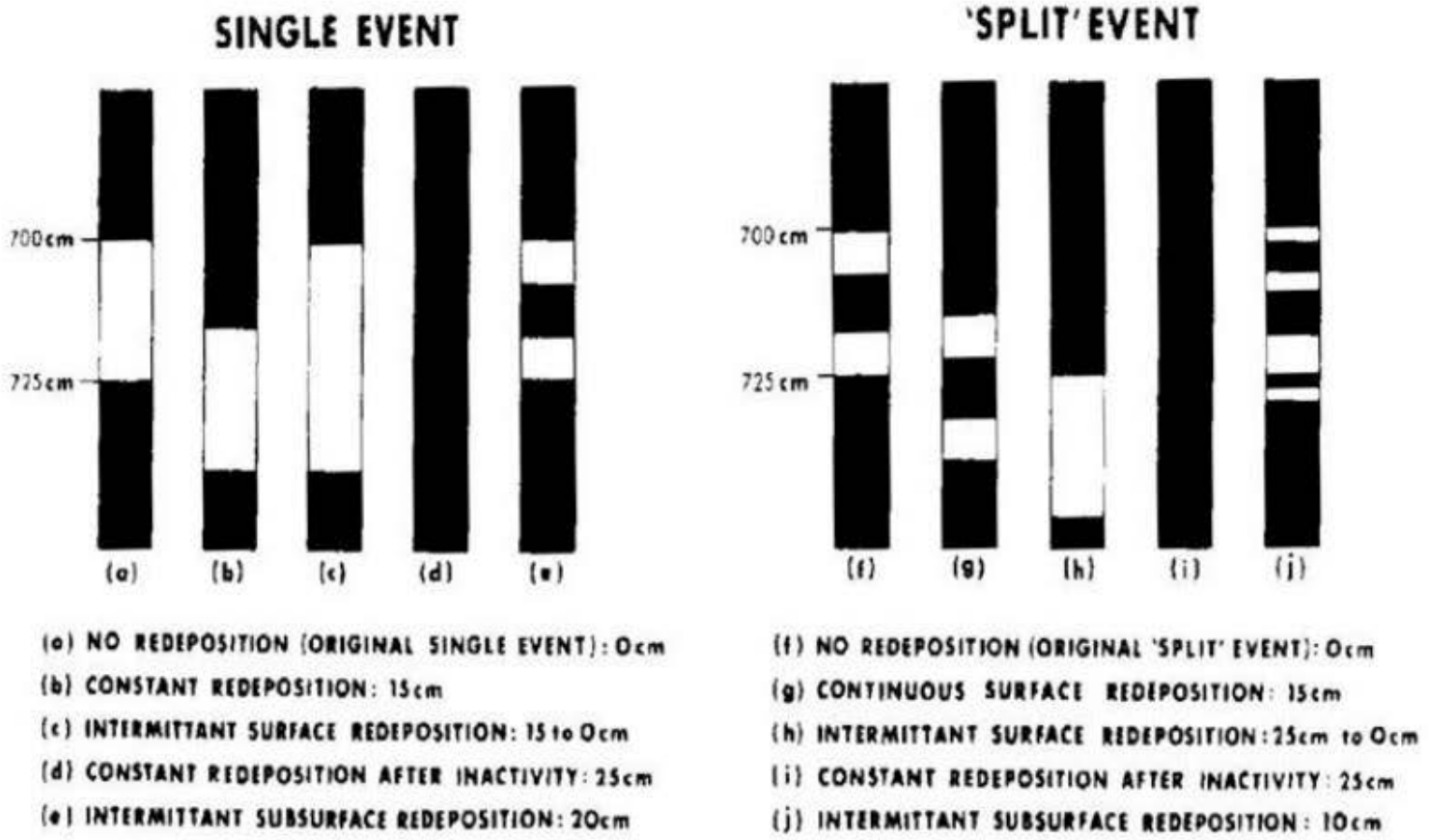
DRM *vs.* CRM:

- *inclination error*

- *delayed NRM acquisition*



Accuracy of recording reversals



Watkins, 1968

Polarity zones (subchrons) or excursions (cryptochrons) ?

Geomagnetic Polarity Time Scale (GPTS)

or …

Geomagnetic Instability Time Scale (GITS)

'reversal excursions'

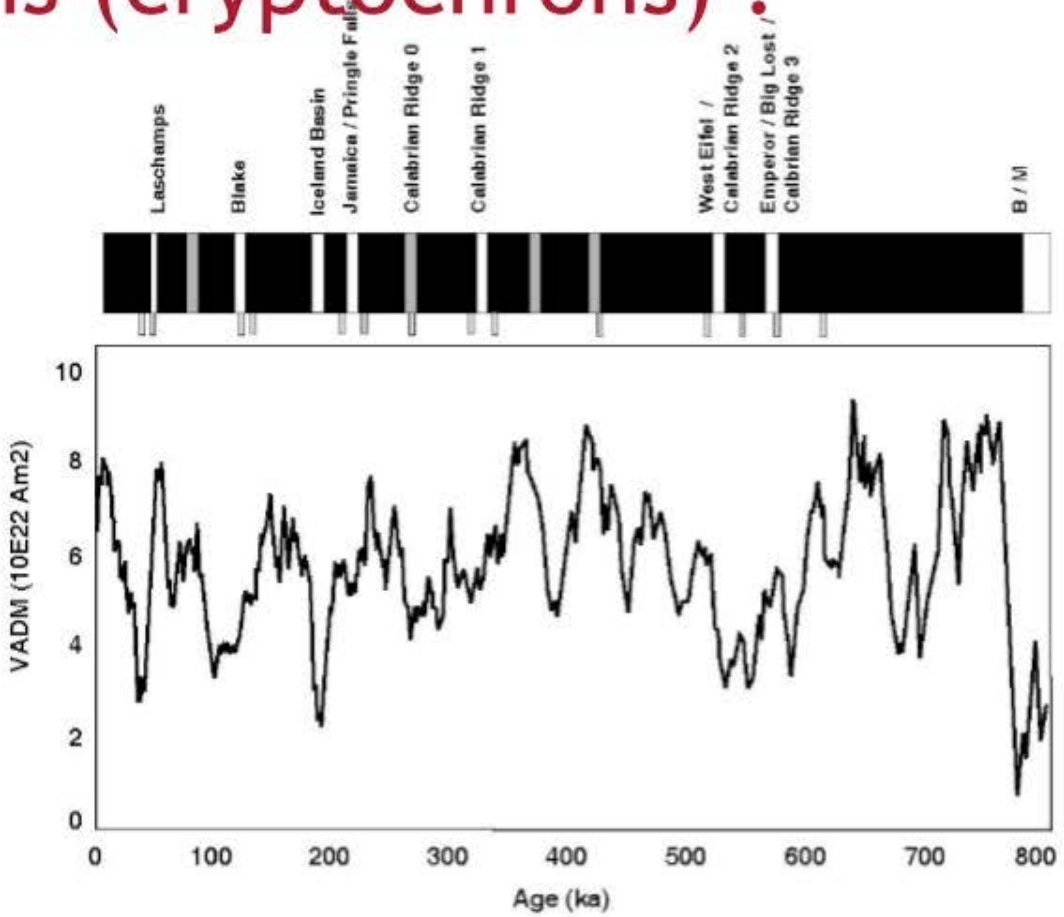


Figure 5: Virtual Axial Dipole Moment (VADM) of the field for the past 800 kyr (Guyodo & Valet, 1999). Low intensities are typically correlated with the occurrence of reversal excursions, short periods where the virtual geomagnetic pole deviates more than 90° from the north geographic pole (white intervals are well confirmed reversal excursions, grey intervals require confirmation ; Langereis et al., 1997). Small grey bars outside the column are excursions from ODP cores found by Lund et al. (1998). B/M is Brunhes/Matuyama boundary, showing very low intensities - down to 10% of the stable polarity field - during the reversal.

Magnetostratigraphic resolution

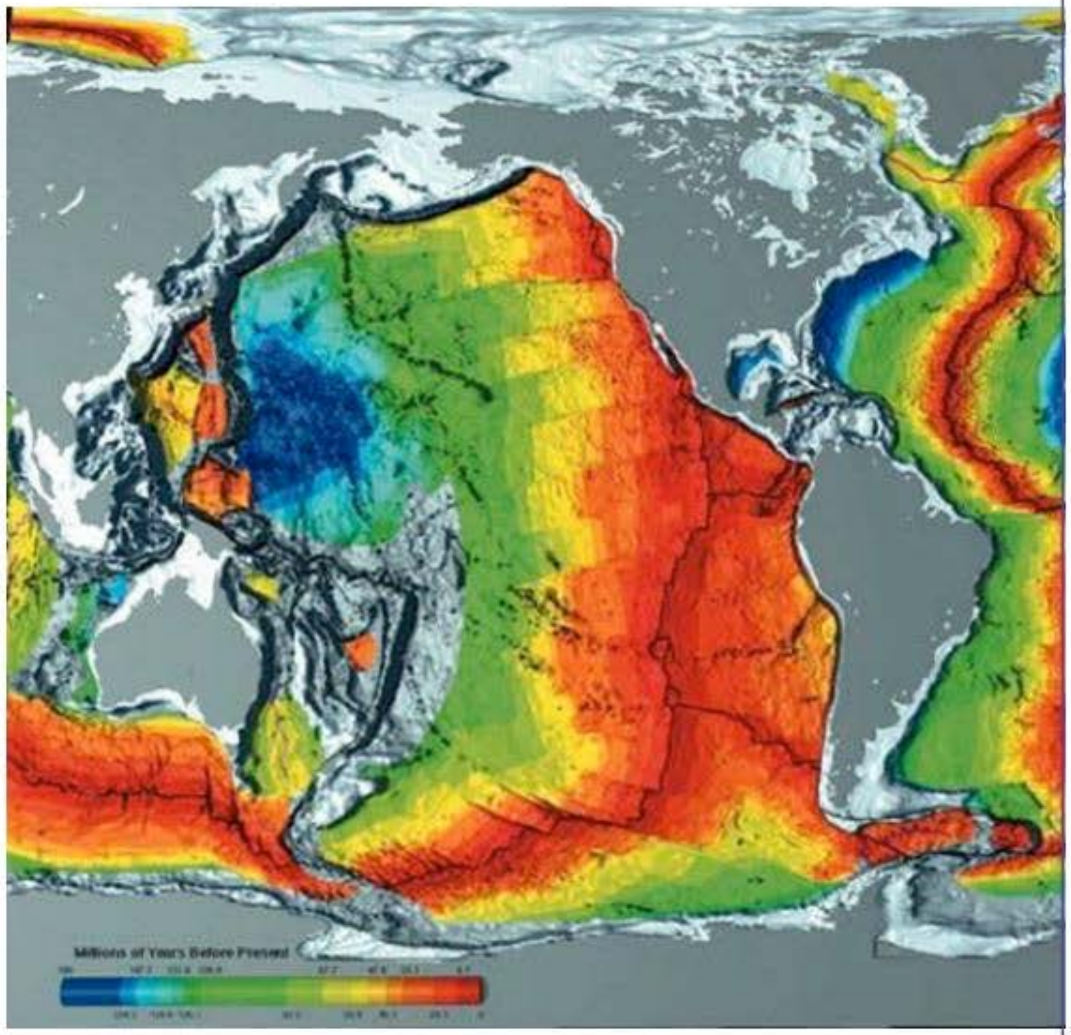
Table 1 Nomenclature for polarity intervals and excursions

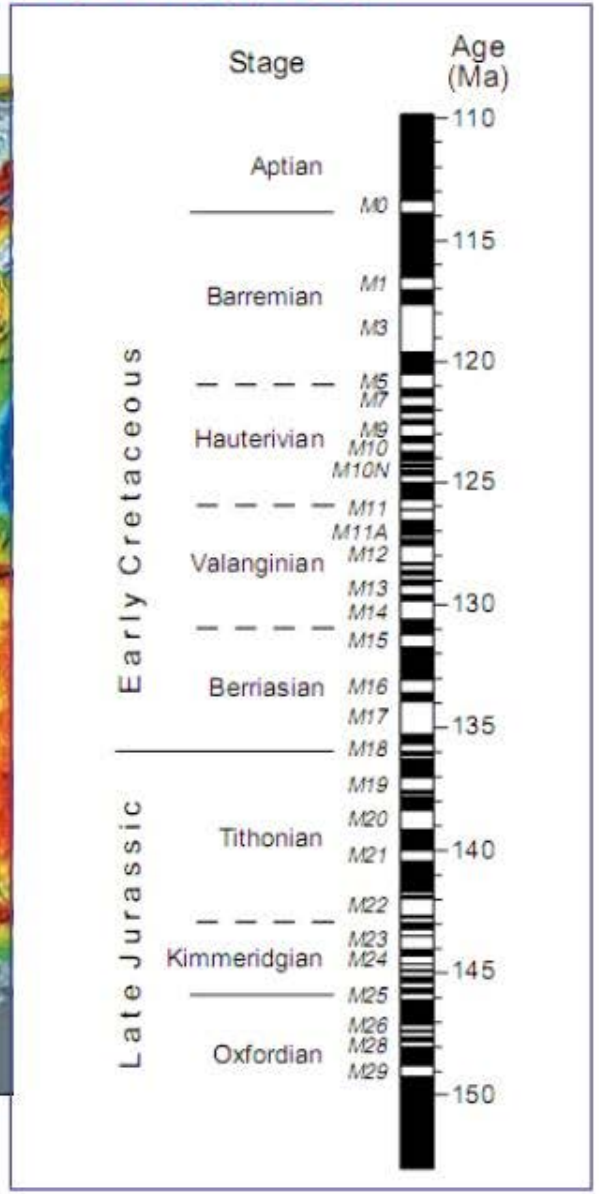
Magneto-stratigraphic polarity zone	Geochronologic (time) equivalent	Chronostratigraphic equivalent	Duration (yr)
Polarity megazone	Megachron	Megachronozone	10^8–10^9
Polarity superzone	Superchron	Superchronozone	10^7–10^8
Polarity zone	Chron	Chronozone	10^6–10^7
Polarity subzone	Subchron	Subchronozone	10^5–10^6
~~Polarity microzone~~	~~Microchron~~	~~Microchronozone~~	~~$<10^5$~~
~~Excursion zone~~	~~Excursion~~		~~Brief departure from normal secular variation~~
~~Polarity cryptochron~~	~~Cryptochron~~	~~Cryptochronozone~~	~~Uncertain existance~~

Nomenclature OK …

but for practical (integrated) stratigraphy and constraints on chronostratigraphy ?

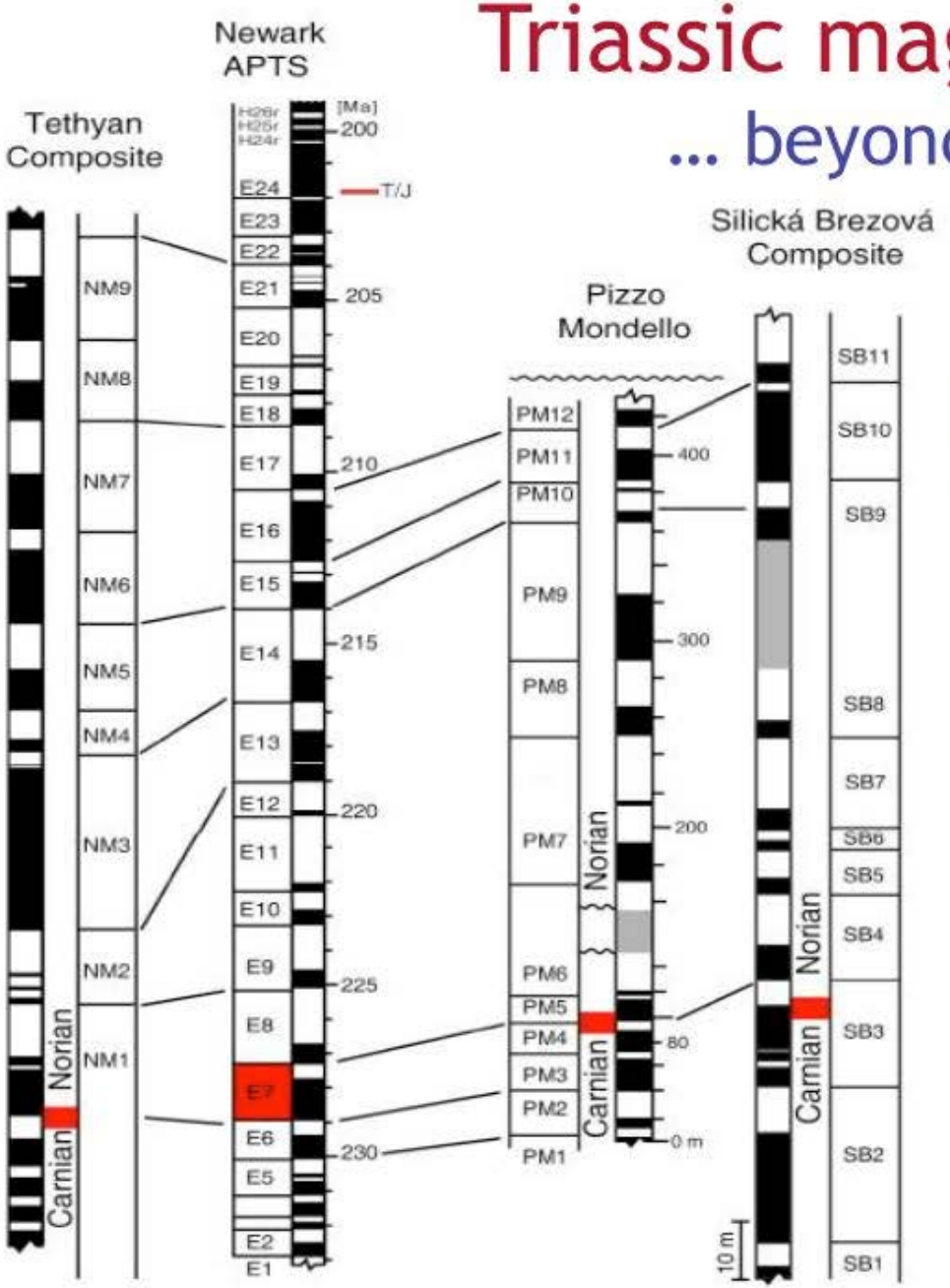
Marine magnetic anomalies

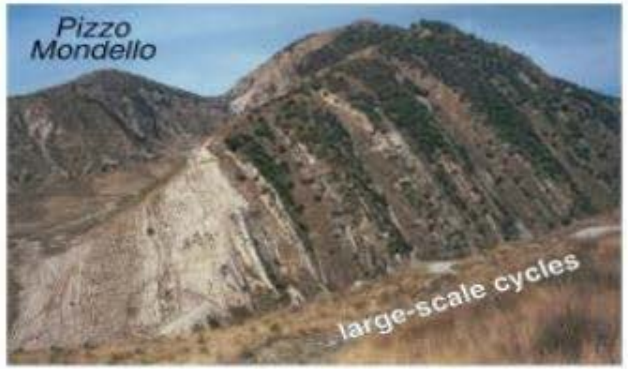


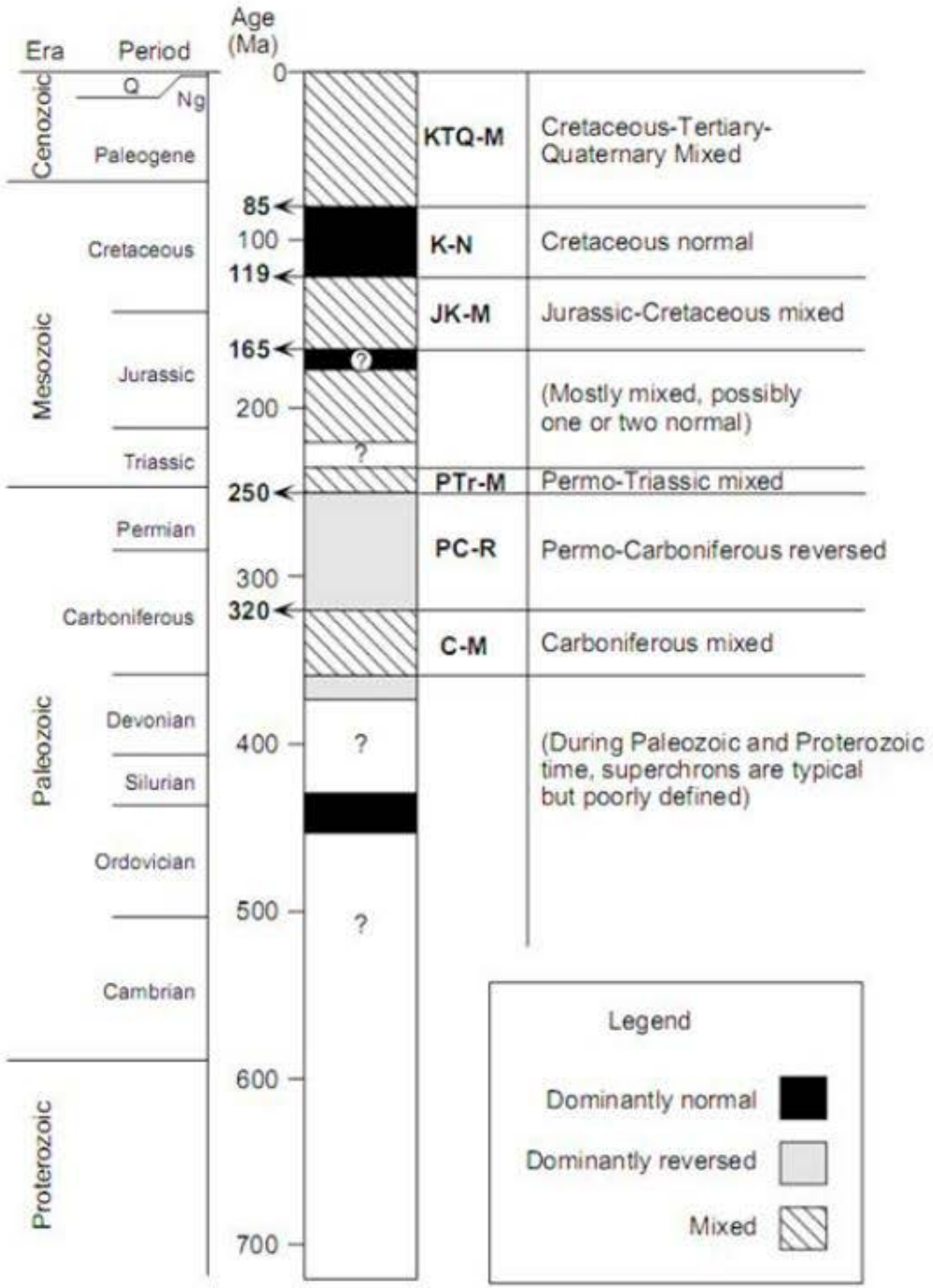


Triassic magnetostratigraph

… beyond the sea floor record







Even older:

magneto-stratigraphy ?

Biostratigraphy vs. Magnetostratigraphy

Problems:

- Taxonomy
- Diachrony
- Reworking
- Ages

Problems:

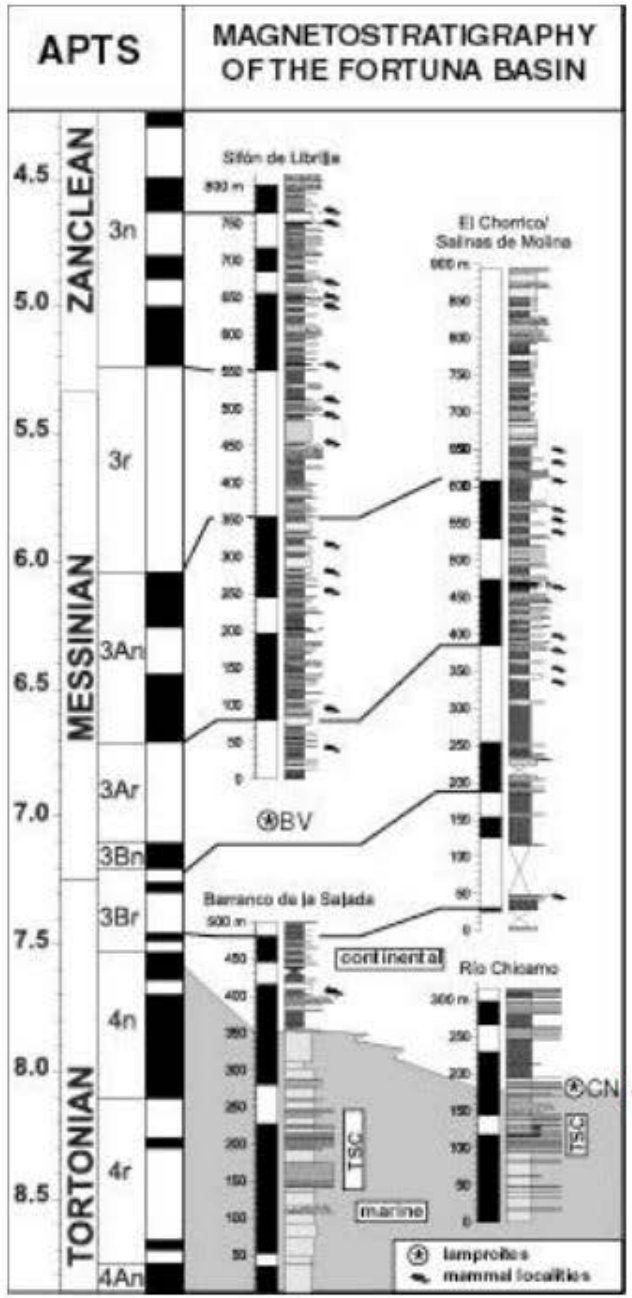
- Correlation
- Primary signal
  vs. overprint
- Ages

Correlation

Requires

unique pattern fit

Magneto age
7.6 ± 0.1

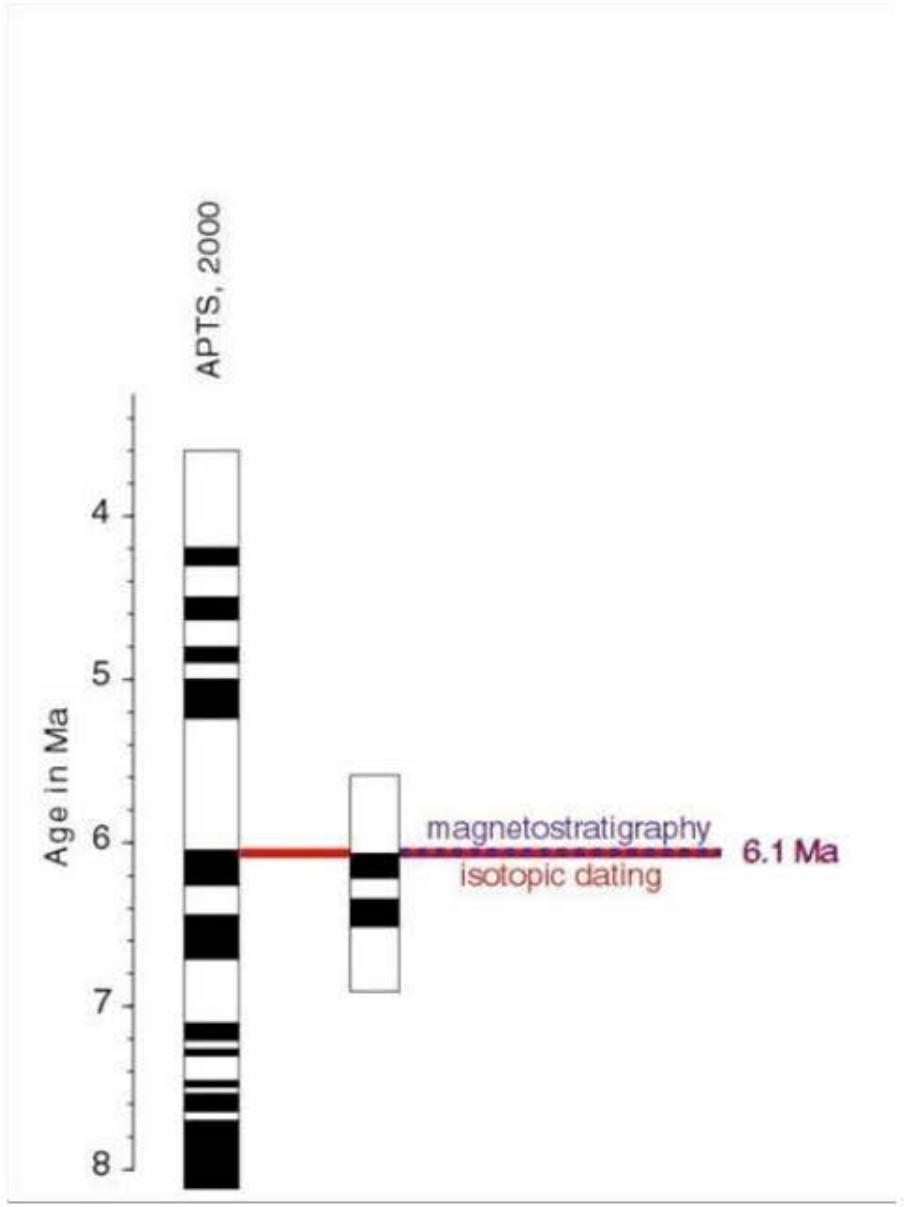


K/Ar age
6.16 ± 0.30

Garces et al., 2001

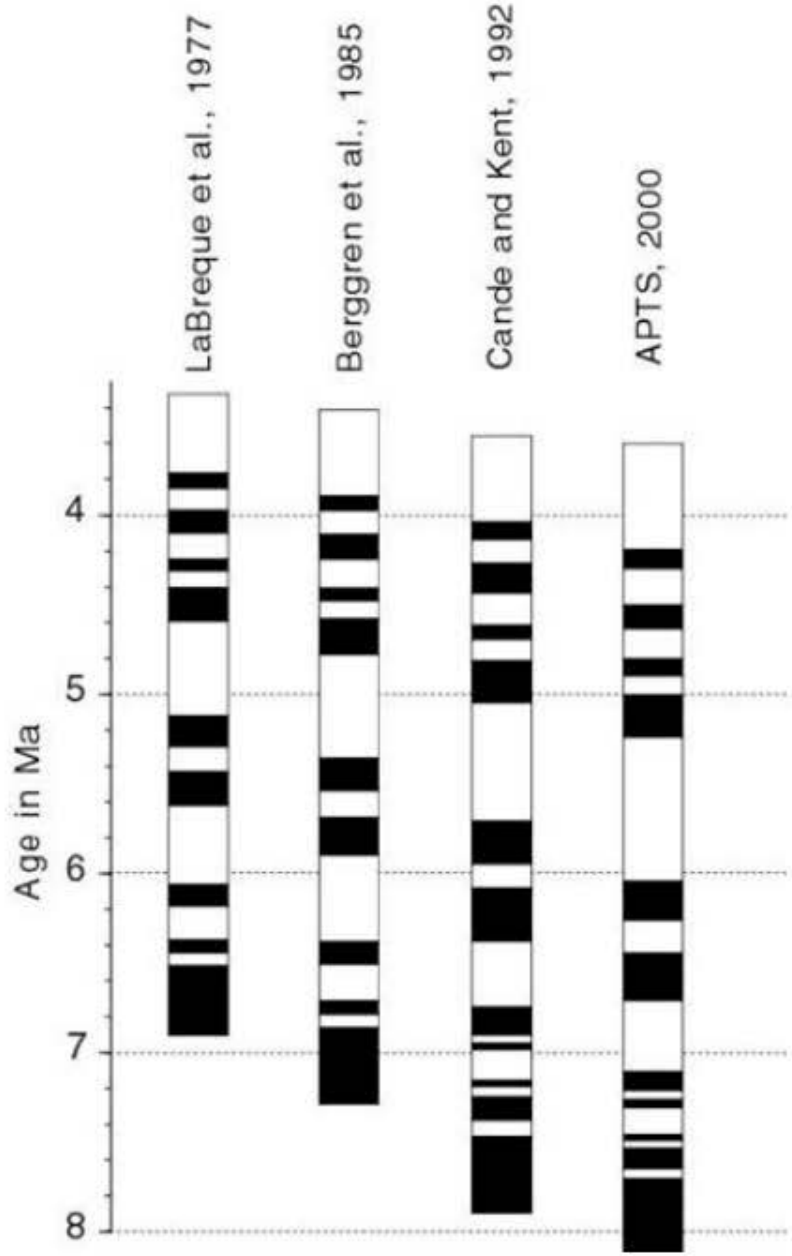
Ages

GPTS not independent of other dating techniques

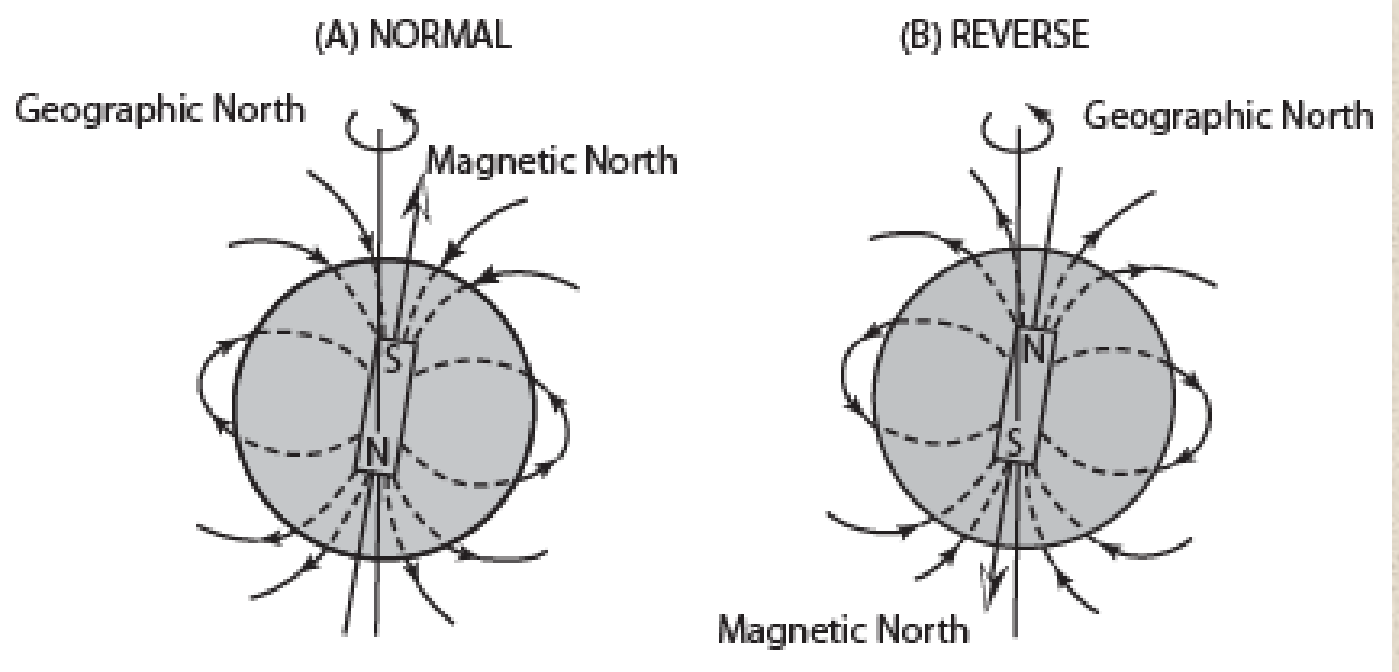


The times they are a-changing’

Ages change with time …



<u>Magnetostratigraphy:</u> uses records of changes in polarity of the geomagnetic field preserved in sedimentary sequences to correlate between wells and to date the sediment.



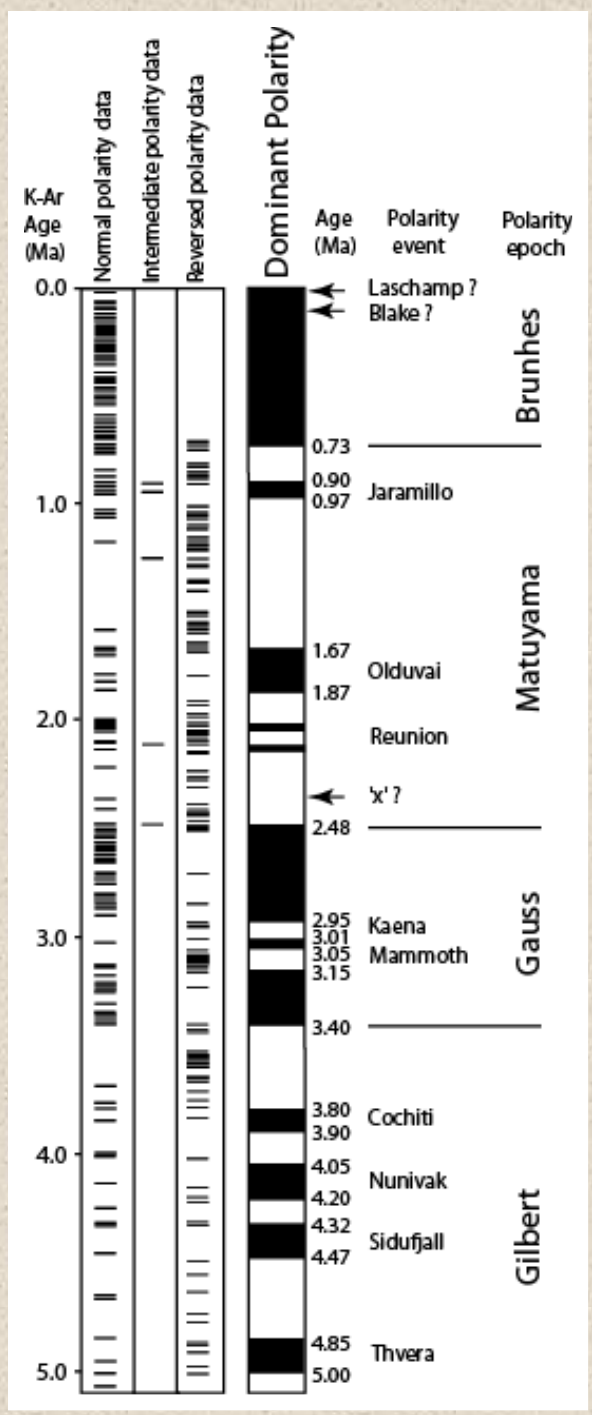
Curie point: the critical temperature of about 500° C - 600° C (for magnetite) where iron-bearing minerals become magnetized in alignment with the Earth's magnetic field. When cooled further, the magnetite molecules with retain this orientation unless subsequently heated past Curie point. This semipermanent alignment is referred to as **thermal remanent magnetism**.

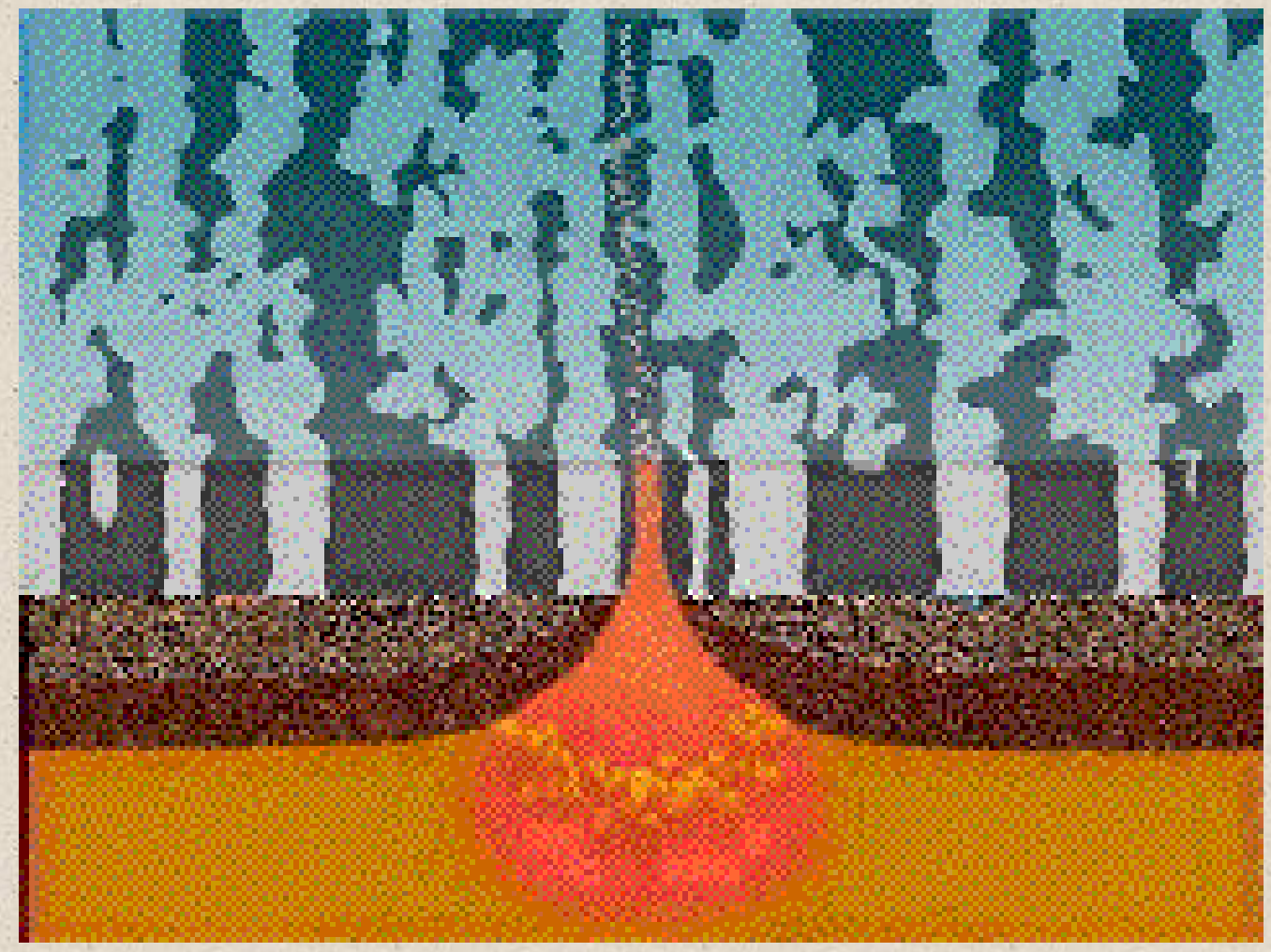
Detrital remanent magnetism: When the preferred orientation of magnetic minerals in sedimentary rocks imparts bulk magnetic properties to the rocks.

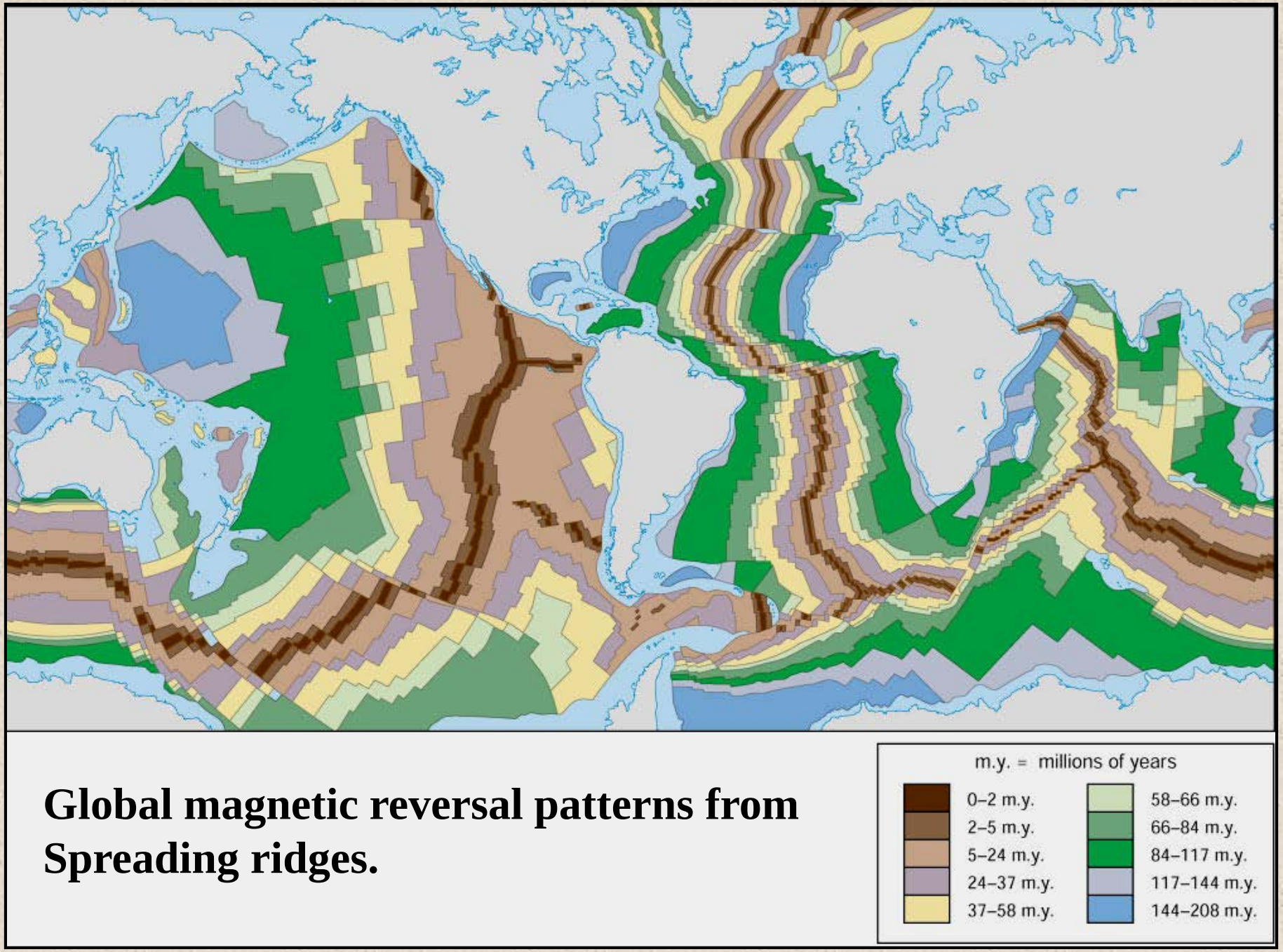
How?

During deposition of sediments, small magnetic mineral grains are able to rotate in the loose unconsolidated sediment of the depositional surface and thus align themselves mechanically with Earth's magnetic field.

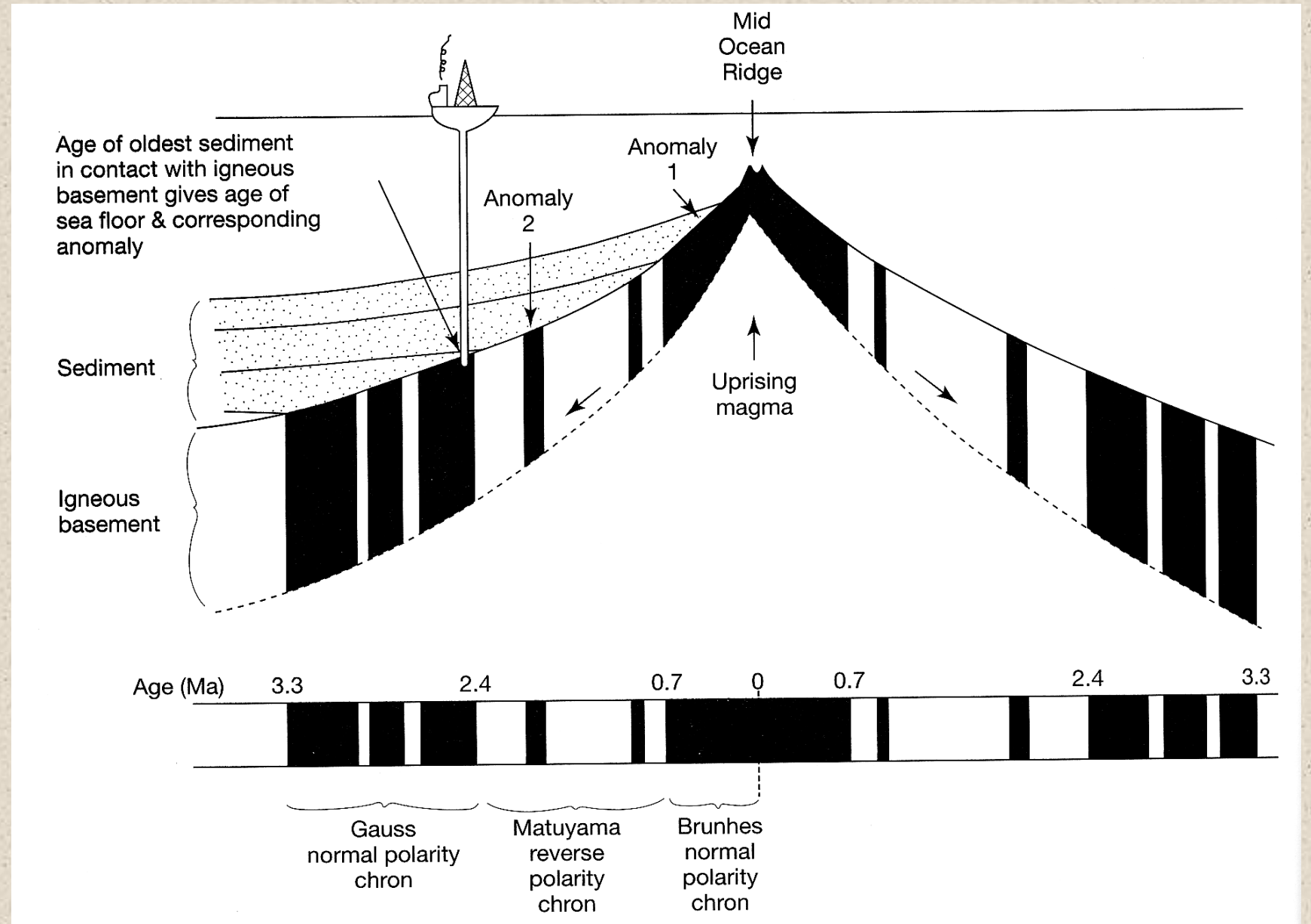
Geomagnetic polarity time scale for last 5 million years.



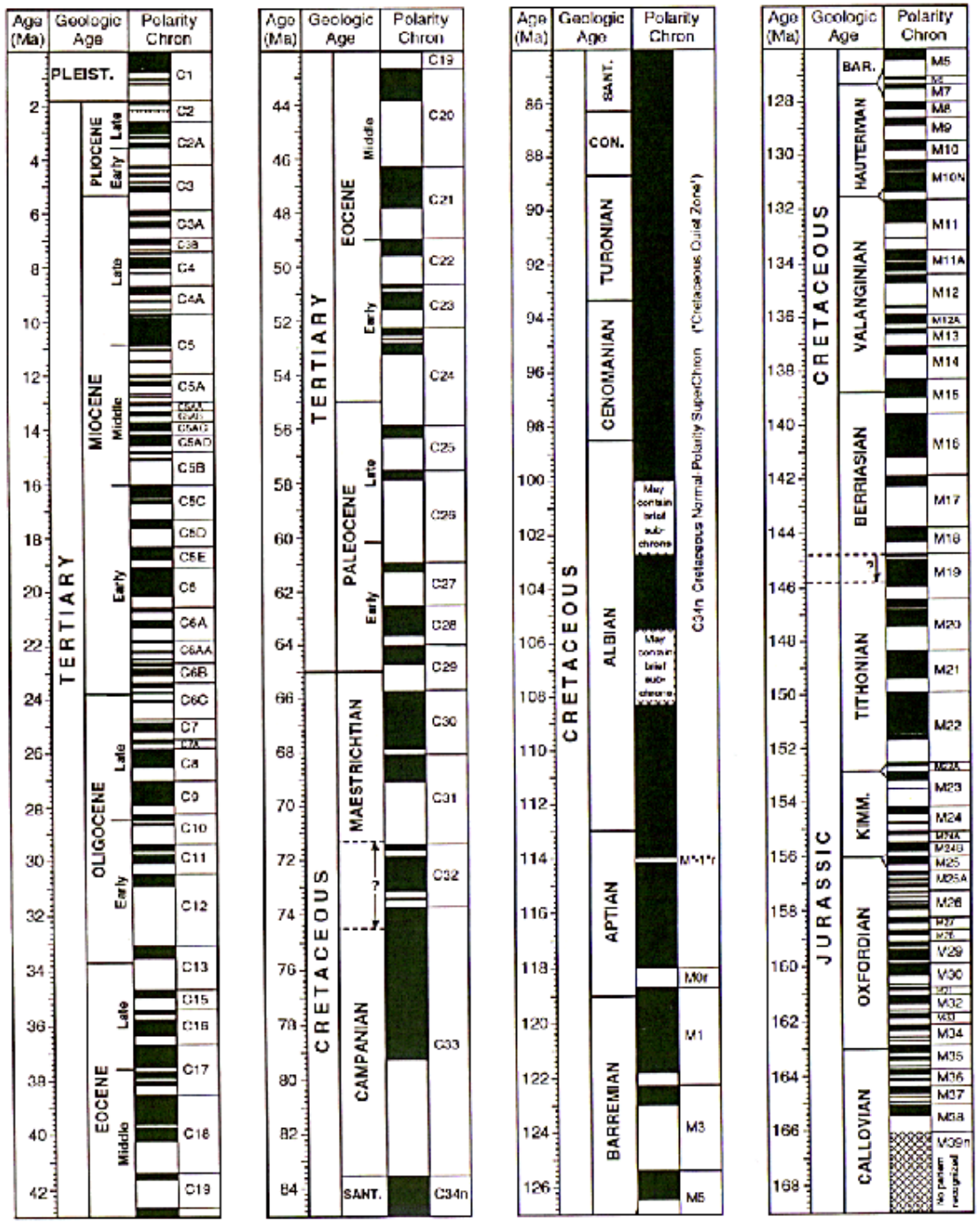




Global magnetic reversal patterns from Spreading ridges.


Mid
Ocean
Ridge
Age of oldest sediment
in contact with igneous
basement gives age of
sea floor & corresponding
anomaly
Anomaly
1
Anomaly
2
Sediment
Igneous
basement
Uprising
magma
Age (Ma)
3.3
2.4
0.7
0
0.7
2.4
3.3
Gauss
normal polarity
chron
Matuyama
reverse
polarity
chron
Brunhes
normal
polarity
chron

13.26


Age (Ma)
Geologic Age
Polarity Chron
PLEIST.
TERTIARY
PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
Early
Late
Middle
C1
C2
C2A
C3
C3A
C3B
C4
C4A
C5
C5A
C5AA
C5AB
C5AC
C5AD
C5B
C5C
C5D
C5E
C6
C6A
C6AA
C6B
C6C
C7
C7A
C8
C9
C10
C11
C12
C13
C15
C16
C17
C18
C19
CRETACEOUS
MAESTRICHTIAN
CAMPANIAN
SANT.
PALEOCENE
EOCENE
C20
C21
C22
C23
C24
C25
C26
C27
C28
C29
C30
C31
C32
C33
C34n
CRETACEOUS
BARREMIAN
APTIAN
ALBIAN
CENOMANIAN
TURONIAN
CON.
SANT.
M0r
M1
M3
M5
C34n Cretaceous Normal Polarity SuperChron ("Cretaceous Quiet Zone")
JURASSIC
CALLOVIAN
OXFORDIAN
KIMM.
TITHONIAN
BERRIASIAN
VALANGINIAN
HAUTERIVIAN
BAR.
M5
M7
M8
M9
M10
M10N
M11
M11A
M12
M12A
M13
M14
M15
M16
M17
M18
M19
M20
M21
M22
M22A
M23
M24
M24A
M24B
M25
M25A
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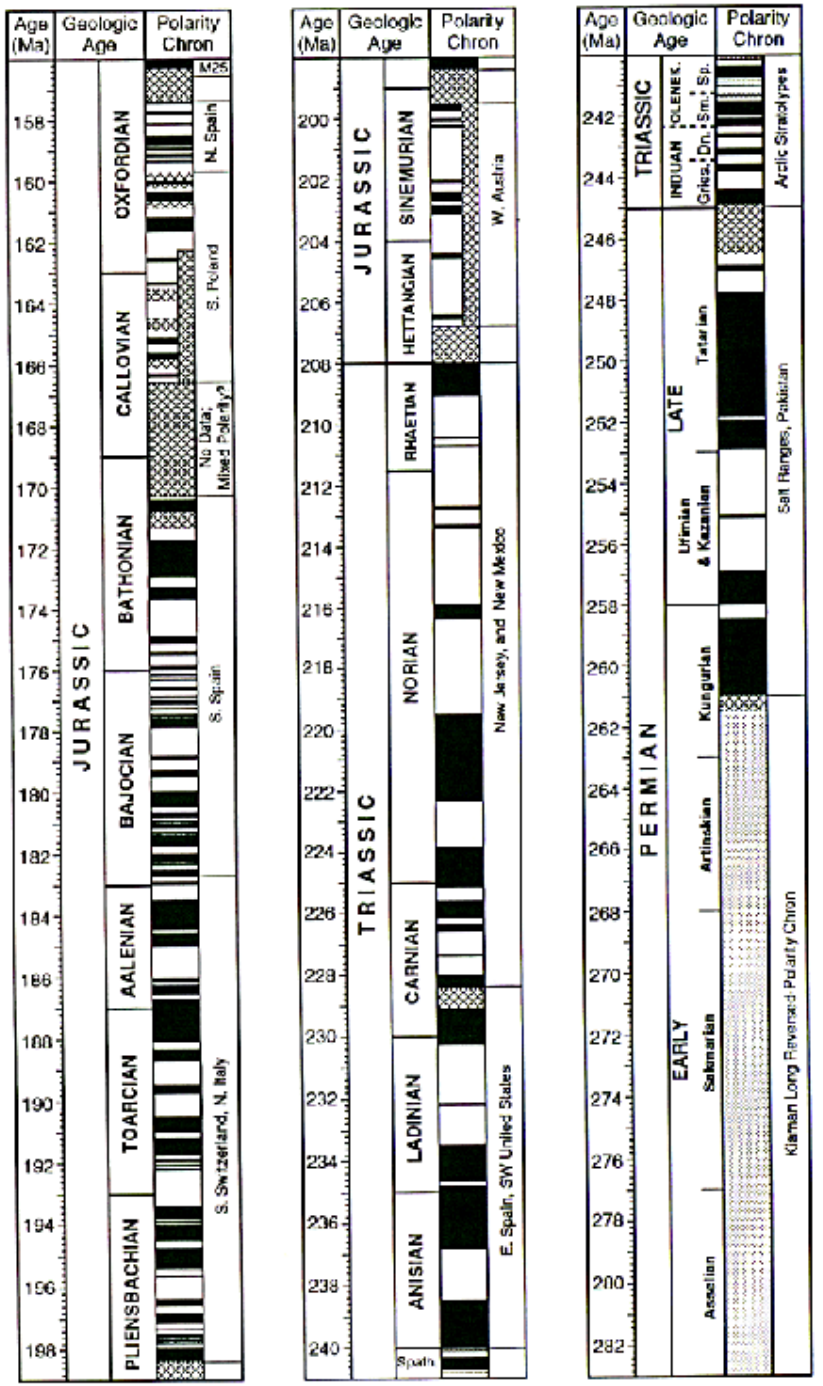
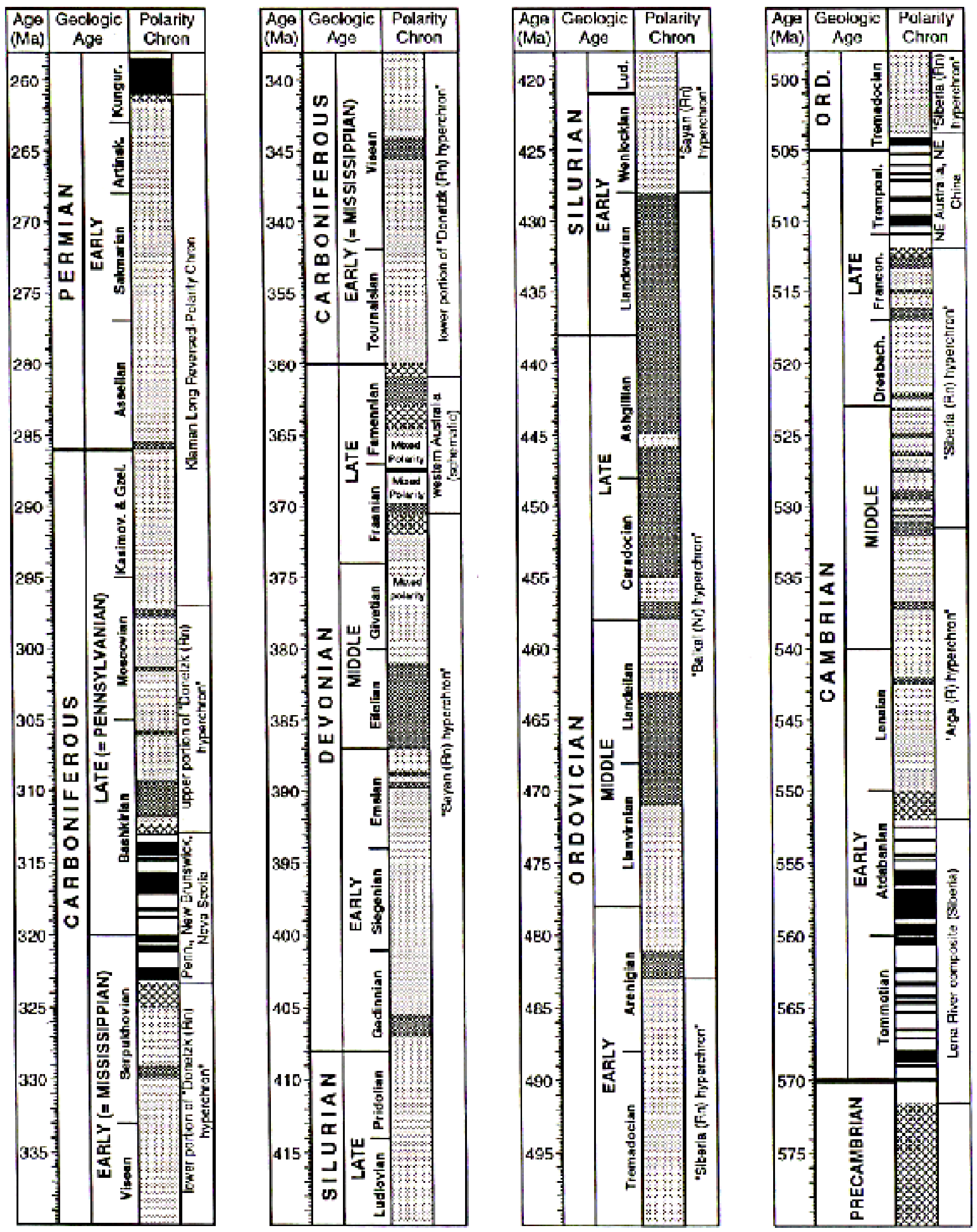
V29
V30
M32
M33
M34
M35
M36
M37
M38
M39n

13.27


Age (Ma)
Geologic Age
Polarity Chron
JURASSIC
TRIASSIC
PERMIAN
PLIENSBACHIAN
TOARCIAN
AALENIAN
BAJOCIAN
BATHONIAN
CALLOVIAN
OXFORDIAN
ANISIAN
LADINIAN
CARNIAN
NORIAN
RHAETIAN
HETTANGIAN
SINEMURIAN
EARLY
LATE
Asselian
Sakmarian
Artinskian
Kungurian
Ufimian & Kazanian
Tatarian
INDUAN
OLENEK.
Griesb.
Dn.
Sm.
Sp.
M25
N. Spain
S. Poland
No Data; Mixed Polarity?
S. Spain
S. Switzerland, N. Italy
W. Austria
New Jersey, and New Mexico
E. Spain, SW United States
Salt Ranges, Pakistan
Arctic Siraiolypes
Kiaman Long Reversed Polarity Chron

13.28



Age (Ma)
Geologic Age
Polarity Chron
PERMIAN
CARBONIFEROUS
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
PRECAMBRIAN

Paleomagnetic correlations of cores from the Arctic, Pacific, Indian, and Atlantic oceans. Cores have different lithologies and fossil assemblages.