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
Addition of biostratigraphy

<table>
<thead>
<tr>
<th>Age (Ma)</th>
<th>Epoch</th>
<th>Stage</th>
<th>Polarity</th>
<th>Chron</th>
<th>Planktonic Foraminifers</th>
<th>Nannofossils</th>
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<td>N22</td>
<td>Pt1</td>
<td>NN21/20 NN19</td>
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<td>Gelasian</td>
<td>C2</td>
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<td>Piacenzian</td>
<td>C2A</td>
<td>N20/N21 PL5</td>
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<td>C5</td>
<td>N14</td>
<td>M10</td>
<td>NN5</td>
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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

<table>
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<tr>
<th>Gauss</th>
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<th>sapropels</th>
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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)
similarity to Indus/Soan River system today
And the Indus is still doing it...

August, 2009

August, 2010