Using paleowind data to reconstruct Pangean paleoclimate

Erin Eastwood
GEO 387H
December 2, 2008
Supercontinent Pangea

- Extraordinary effect on global paleoclimate
- Global red beds and evaporites
- Monsoons: seasonal reversal in surface winds
- Past climate change key to future

Chart from Dr. Yang’s lecture notes

Map by Ron Blakey
Paleomagnetism

- Earth’s magnetic field
- Iron-bearing minerals
- Determine paleo-latitude
- Requires multiple data points from each continent
- Detrital hematite in sedimentary rocks
- Igneous rocks

Dott and Prothero (2002)
Paleoclimatology

- Ancient climate change, various time-scales
- Establish range of natural climatic variability
- Type of proxy data used = function of geologic time period trying to construct
- Late Carboniferous-Jurassic:
  - atmospheric circulation = loessites & aeolian dune deposits
  - Paleo-latitude = paleomagnetism

Permian Cutler Group, SE Utah
Aeolian dunes = wind-blown sand

Aeolian loess = wind-blown dust

Photo by Lynn Soreghan
Colorado Plateau

- 2500m aeolian sandstone deposits during time of Pangea

Permian Cedar Mesa Sandstone

Paleogeographic maps by Ron Blakey
Aeolian Sediment Transport

Permian Cedar Mesa Sandstone, Utah

Modern dune

Ancient dunes

Permian Cedar Mesa Sandstone, Utah

LiDAR image of White Sands, NM
Wind Direction Controls
Dune Morphology

Barchans, Morocco

Crescentic ridges, Saudi Arabia

Linears, Mauritania

Stars, Algeria
Winds Interpreted from Aeolian Dunes

Peterson (1988)

- Each vector represents > 20 dip measurements
- Random sampling – statistical average
- Largest paleowind dataset

Modified from Rowe et al. (2007)
Paleoclimate from Loess Deposits: Early Permian Cutler Group

- U-Pb geochronology zircon crystals
- Summer=monsoonal westerly winds
- Winter=easterly winds (N or S direction not constrained)
- Loessite soils record seasonally wet conditions
- Loess lacks wind intensity information
Winds Predicted from GCMs

NH summer winds → NH winter winds

Parrish and Peterson (1988)
- Summer = subtropical H-P cell, dominate winds
- Winter = monsoon L-P cell

Patzkowsky et al. (1991)
- Summer = monsoon L-P cell
- Winter = subtropical H-P trade winds

Rowe et al. (2007), Chandler et al. (1992)
- Subtropical H-P trade winds turn to tropical westerlies

Modified from Rowe et al. (2007)
Paleoclimate Reconstructions

Looke et al. (2004)
- Paleo-latitudes using detrital hematite paleomagnetism
- Western US remains near-equatorial through Jurassic
- NE trade winds shift to tropical north-westerlies

Map by Ron Blakey
Rowe et al. (2007)

- Traditional paleomagnetism
- Western US 18N by Jurassic
- Assume paleowinds correct

One of the following must be true:

- Paleomagnetism & paleogeography incorrect
- Climate model incorrect – no shift from trades to westerlies
- Paleowind data imply circulation patterns different from today
Alternate Reconstructions

- Multiple wind directions – seasonal winds
- Seasonal signature lost in statistical averaging
- Create detailed paleowind dataset

Permian Cedar Mesa Sandstone

Dune migration to the East

Dune migration to the South
Thank you
Monsoon: Sea/Land-Related Circulation of the Atmosphere

- Monsoon (Arabic “season”)
- Monsoon is a climate feature that is characterized by the *seasonal reversal in surface winds*.
- The very different heat capacity of land and ocean surface is the key mechanism that produces monsoons.
- During summer seasons, land surface heats up faster than the ocean. Low pressure center is established over land while high pressure center is established over oceans. Winds blow from ocean to land and bring large amounts of water vapor to produce heavy precipitation over land: A rainy season.
- During winters, land surface cools down fast and sets up a high pressure center. Winds blow from land to ocean: a dry season.

(figures from *Weather & Climate*)