Quiz Four (9:30-9:35 AM)
GY 112: Earth History

Fossils Part 1:
Telling Time

Instructor: Dr. Douglas W. Haywick
Last Time

A) Stable isotopes of use to geology (fractionation)
   B) Delta values and isotopic standards
   C) Delta Oxygen applications (sea level change)

Web notes: 8a
Isotopes

Elements with the same number of protons, but different numbers of neutrons

\[ ^{12}\text{C}, \quad ^{13}\text{C}, \quad ^{14}\text{C} \]
Stable Isotope Geochemistry

**Fractionation**: The ratio of stable isotopes in a substance before and after the process.

The amount of fractionation nation is expressed via the fractionation factor ($\alpha$):

$$\alpha = \frac{H^2/H^1 \text{ (cloud)}}{H^2/H^1 \text{ (water)}}$$
There is a minor problem with this type of analysis. The abundance of $^{18}$O to $^{16}$O is very low, and the amount of fractionation is minute (but still measurable).....

... but the resulting data are really, really, really small numbers (and this is annoying!)
Stable Isotope Geochemistry

Isotopic data are usually presented using the delta value ($\delta$)

$$\delta^{18}O = \left( \frac{O^{18}/O^{16} \text{ (sample)}}{O^{18}/O^{16} \text{ (standard)}} \right) \times 1000$$

and are reported in parts per thousand (ppt or ‰)
Stable Isotope Geochemistry

Isotopic fraction of oxygen in the hydrologic cycle

http://serc.carleton.edu/images/microbelife/research_methods/environ_sampling/isotope_fractionation.jpg
Eustatic Sea level Rise

Stable isotopes provide information about world wide (eustatic) sea level change

http://portale.ingv.it/research-areas/climate-oceans-environments/reconstruction-of-paleoclimatic-variations
Today’s Agenda

1. Chronostratigraphy versus biostratigraphy
2. Paleontological correlations
3. Index fossils

Web notes: 9
Fossils & Time

Types of Stratigraphy
Fossils & Time

Types of Stratigraphy

Lithostratigraphy: using rocks to correlate
Fossils & Time

Types of Stratigraphy

Lithostratigraphy: using rocks to correlate

Chronostratigraphy: actual dates to correlate (absolute dating)
Fossils & Time

Types of Stratigraphy

**Lithostratigraphy**: using rocks to correlate

**Chronostratigraphy**: actual dates to correlate (absolute dating)

**Biostratigraphy**: using fossils to establish dates and correlate (relative dating)
Lithostratigraphy

Mountain 1

Mountain 2
Lithostratigraphy
Lithostratigraphy

Mountain 1

Mountain 2
Lithostratigraphy only works if you have sufficiently different rock types or distinctive fossil content
Biostratigraphy
Biostratigraphy
Biostratigraphy

Note pinch outs and facies changes
There are a lot of fossils in the rock record, but not all are useful for biostratigraphy.
Biostratigraphy

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Some are too restricted (they only occur in one particular place or environment (Endemic Species)).
Biostratigraphy

There are a lot of fossils in the rock record, but not all are useful for biostratigraphy.

Some are too restricted (they only occur in one particular place or environment (Endemic Species).

The best fossils for biostratigraphy are Cosmopolitan species (wide ranging)
Cosmopolitan species that occur over a very narrow time range (e.g., less than 1 million years) can be used to tell time.

They are called Index Fossils
### Biostratigraphy

Examples of Index Fossils from the USGS website

<table>
<thead>
<tr>
<th>Era</th>
<th>Period</th>
<th>Fossil Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precambrian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cambrian</td>
<td></td>
<td>Paradoxides pinus</td>
</tr>
<tr>
<td>Ordovician</td>
<td></td>
<td>Bathurus extans</td>
</tr>
<tr>
<td>Silurian</td>
<td></td>
<td>Cystiphyllum niagarensis</td>
</tr>
<tr>
<td>Devonian</td>
<td></td>
<td>Microspirifer mucronatus</td>
</tr>
<tr>
<td>Mississippian</td>
<td></td>
<td>Cactocrinus multibrachiatus</td>
</tr>
<tr>
<td>Pennsylvanian</td>
<td></td>
<td>Dictyoclostus americanus</td>
</tr>
<tr>
<td>Permian</td>
<td></td>
<td>Leptodus americanus</td>
</tr>
<tr>
<td>Triassic</td>
<td></td>
<td>Trophites subbullatus</td>
</tr>
<tr>
<td>Jurassic</td>
<td></td>
<td>Perisphinctes tiziani</td>
</tr>
<tr>
<td>Cretaceous</td>
<td></td>
<td>Scaphites hippocrepis</td>
</tr>
<tr>
<td>Tertiary</td>
<td></td>
<td>Calyptraphorus velatus</td>
</tr>
<tr>
<td>Quaternary</td>
<td></td>
<td>Pecten gibbus</td>
</tr>
</tbody>
</table>

| Cenozoic Era (Age of Recent Life) | | |
| Quaternary Period | | Neptuna tabulata |
| Tertiary Period | | Venericardia planicosta |
| Cretaceous Period | | Inoceramus labiatus |
| Jurassic Period | | Nerinea trinodosa |
| Triassic Period | | Monotis subcircularis |
| Permian Period | | Parafusulina bostei |
| Pennsylvanian Period | | Lophophyllidium proliferum |
| Mississippian Period | | Prolecanites gurleyi |
| Devonian Period | | Palmatolepus unicornis |
| Silurian Period | | Hexamoceras hertzi |
| Ordovician Period | | Tetragraptus fructicosus |
| Cambrian Period | | Billingsella corrugata |
How to use fossils to tell time

Consider trilobites, which lived during the Paleozoic era

Source: http://www.ideofact.com/archives/trilobite.jpg
How to use fossils to tell time

Species A (Late Ordovician to Earliest Silurian)

Source: http://www.ideofact.com/archives/trilobite.jpg
How to use fossils to tell time

Species B (Early Silurian to Middle Silurian)

Source: http://www.ideofact.com/archives/trilobite.jpg
How to use fossils to tell time

Species B (Early Silurian to Middle Silurian; a good index fossil if it’s cosmopolitan)

Source: http://www.ideofact.com/archives/trilobite.jpg
How to use fossils to tell time

Species C (Early Silurian to Late Silurian)

Source: http://www.ideofact.com/archives/trilobite.jpg
The age of the interval shown in blue can be relatively well constrained. It is the only time all 3 beasties were alive at the same time – sometime during the Early Silurian.
How to use fossils to tell time

The age of the interval shown in yellow can be relatively well constrained. It is the only time all 3 beasties were alive at the same time – sometime during the Early Silurian.

This is called an assemblage zone and it is how most biostratigraphery is done.
Today’s Homework

1) Study! Lecture test is coming up!

Next Time

Tuesday: Lectures 9/10: More fossils!
GY 112: Earth History

Lecture 9: Fossils: Time & Environment

Instructor: Dr. Doug Haywick
dhaywick@southalabama.edu

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