ASTR 390 Astrobiology

Clays, Minerals and the Origin of Life

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Food for thought...

"It was a dark and stormy night. In the shallow tide pool, a nucleic acid base collided with a sugar molecule. An amino acid sank beneath the murky depths.”

- Eric Chaisson and Steve McMillan, 1992

What I’m Going to Talk About

- What preceded nucleic acids?
- Clay polymers
  - Polycationic polymers
  - Polyanionic polymers
- Time to form “polymer” clays
- Clays and the need for inheritance
- Other minerals and their possible affect on the development of life

Review of Timeline

What preceded nucleic acid?

- Inorganic polymers
  - simpler, more accessible
- Examples of inorganic polymers
  - clays and non-clay minerals
- Clays might have a role in life evolving
- Clays and combinations of clays might have evolved into living system prior to nucleic acid lifeforms
**From Gravel to Clay**

<table>
<thead>
<tr>
<th>#10 Sieve 2 mm</th>
<th>#200 Sieve 0.075 mm</th>
<th>0.002 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>Sand</td>
<td>Silt</td>
</tr>
</tbody>
</table>

Coarse Fraction
Visible to Naked Eye

Fine Fraction
Microscopic

**Faujasite Structure**

**Rocks and Soil Cycle**

ROCK → WEATHERING → RESIDUAL SOIL → TRANSPORTING AGENT → TRANSPORTED SOIL

**Clay Polymers**

- Clays are linked with covalent bonds
  - composed of cationic and anionic polymers
- Polycationic polymers
  - metallic cations pickup hydrogen in water
  - hydrated cations can act as Lewis acids
  - as pH increases, so does tendency to polymerize
  - examples
    - brucite (magnesium type polymer)
    - gibbsite (aluminum type polymer)

**Polyanionic polymers**
- tendency to form when pH is lower
- silicon is central semi-metal

**Metallic polymers form clays**
- most minerals are silicates
- 1:1 clay
- 2:1 clay (see Figure 4 in Chapter 20)

**A Clay - Kaolinite**
Kaolinite and Talc

Montmorillonite

Time to form Clay Polymers
- Covalent bonds are made and broken
- Molecules must be eliminated in process
- Clay polymer growth can be blocked
- Clay polymers more likely to form in higher concentrations of precursors
- Rock weathering adds precursors
- Got to remember that things take time

Clays and inheritance
- Can clays reproduce?
- Can clays transfer information forward?
- Clays do not produce and separate
- Clay minerals possess disorderly arrangements
- Few reactions have been noticed on clays

Other Minerals effects on the Evolution of Life
- Pyrite (iron sulfide) has been known to act as a surface for reactions
- Calcite has been shown to preferentially bond left and right organic molecules
- Clays may act as “catalysts” by holding molecules in place and allow time for chemical bonding of more complex molecules

Pyrite and Calcite
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References (Books)