No Quiz today...Assignment 1
GY 111: Physical Geology

Lecture 12: Weathering, Erosion and Soil

Instructor: Dr. Douglas W. Haywick
Today’s Agenda

1) Mineral Stability
2) Types of weathering (Physical, Chemical, Biological)
3) Chemical weathering reactions
4) Soils

Web notes 12a (weathering)
Web notes 12b (soils)
Mineral Stability
Mineral Stability

Bowen's Reaction Series

<table>
<thead>
<tr>
<th>COMPOSITION</th>
<th>1800 °C</th>
<th>1100 °C</th>
<th>900 °C</th>
<th>600 °C</th>
<th>250 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultramafic</td>
<td>Olivine</td>
<td>Pyroxene</td>
<td>Ca Plagioclase</td>
<td>Na Plagioclase</td>
<td>Orthoclase</td>
</tr>
<tr>
<td>Mafic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Muscovite</td>
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<tr>
<td>Intermediate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Quartz</td>
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<tr>
<td>Felsic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>All Solid</td>
</tr>
</tbody>
</table>

Bowen’s Reaction Series
Bowen's Reaction Series

Mineral Stability

First to form (most stable at high temperature)
Mineral Stability

Bowen’s Reaction Series

First to form (most stable at high temperature)

Last to form (most stable at low temperature)
Bowen's Reaction Series

Mineral Stability

Bowen’s Reaction Series

First to form (most stable at high temperature)

Consider what happens when these minerals are exposed at the surface of the Earth (low temp, low pressure, rain fall)

Last to form (most stable at low temperature)
Mineral Stability

Bowen's Reaction Series

**Least stable at the surface**

- All Liquid
- 1800 °C: Olivine
- 1100 °C: Pyroxene
- 900 °C: Amphibole
- 600 °C: Biotite
- 250 °C: All Solid

**Most stable at the surface**

- Ca Plagioclase
- Na Plagioclase
- Orthoclase
- Muscovite
- Quartz
Mineral Stability

Bowen's Reaction Series

**Least stable at the surface**

- 1800 °C: Olivine
- 1100 °C: Pyroxene
- 900 °C: Amphibole
- 600 °C: Biotite
- 500 °C: Orthoclase
- 250 °C: All Solid

**Most stable at the surface**

- Fe & Al-oxides (hematite, limonite, bauxite)

- Kaolinite (clay)

Bowen’s Reaction Series
Weathering: the breakdown of rocks at the surface of the Earth. There are 3 types of weathering:

1) Physical Weathering

2) Chemical Weathering

3) Biological Weathering (Chemical + Physical)

- Roots
- Bacteria
- Fungi
- Lichen, etc.
Weathering: the breakdown of rocks at the surface of the Earth. There are 3 types of weathering:

1) Physical – mechanical reduction in the size of rock components.

2) Chemical weathering:

3) Biological weathering

(Chemical + Physical) → roots, burrow, bacteria, fungi, Lichen, etc.
Weathering: the breakdown of rocks at the surface of the Earth. There are 3 types of weathering:

1) **Physical** – mechanical reduction in the size of rock components.

2) **Chemical** – chemically-induced changes in the composition of rock.

3) **Biological Weathering**

   - (Chemical + Physical) → roots burrow, baste
   - → fungi
   - → Lichen, etc.
Weathering: the breakdown of rocks at the surface of the Earth. There are 3 types of weathering:

1) Physical – mechanical reduction in the size of rock components.

2) Chemical – chemically-induced changes in the composition of rock.

3) Biological – a bit of both
Exfoliation – sheet weathering of granite by heating/cooling cycles
Physical Weathering

Exfoliation – sheet weathering of granite by heating/cooling cycles (also known as spherical weathering)
Frost heaving – weathering by alternating freeze-thaw cycles
Frost heaving – weathering by alternating freeze-thaw cycles
Physical weathering increases the surface area of rocks which in turn speeds up chemical weathering.
Chemical Weathering

Chemical weathering is responsible for the deterioration of natural materials (some of which are used as building materials)

http://boldt.us/4704-2/weathered-old-tombstone
Chemical Weathering

Water dissolves some of the solid leaving behind an altered material, ...

...and produces a solution containing substances drawn from the original solid

Liquid coffee containing caffeine and other substances

Kaolinite clay and other substances

http://www.gly.fsu.edu/~salters/GLY1000/10Weathering_Erosion/10Weathering%20and.htm
Chemical Weathering

Chemical weathering occurs in three different ways:

1) **Dissolution** (solution)
2) **Oxidation**
3) **Hydrolysis**
Chemical Weathering

1) Dissolution/Solution

\[ \text{Na} (l) \xrightarrow{H_2O} \text{Na}^+ + (l^-) \]

\[ \text{Ca}(O_3) \xrightarrow{H_2O} \text{Ca}^{2+} + HCO_3^- \]
Chemical Weathering

1) Dissolution/Solution

\[ \text{Na}(l) \xrightarrow{\text{H}_2\text{O}} \text{Na}^+ + (l^-) \]

\[ \text{Ca} \text{(O}_3 \text{)} \xrightarrow{\text{H}_2\text{O}} \text{Ca}^{2+} + \text{HCO}_3^- \]

2) Oxidation (reaction with oxygen)

\[ \text{FeS}_2 \xrightarrow{\text{O}_2} \text{Fe}_2\text{O}_3 + \text{SO}_2 \]
Chemical Weathering

1) Dissolution/Solution

\[ \text{Na}(l) \xrightarrow{\text{H}_2\text{O}} \text{Na}^+ + (l^-) \]
\[ \text{Ca}(\text{O}_3) \xrightarrow{\text{H}_2\text{O}} \text{Ca}^{2+} + \text{HCO}_3^- \]

2) Oxidation (reaction with oxygen)

\[ \text{FeS}_2 \xrightarrow{\text{O}_2} \text{Fe}_2\text{O}_3 + \text{SO}_2 \]

3) Hydrolysis (reaction with water)

\[ \text{FeS}_2 + \text{H}_2\text{O} + \text{O}_2 \rightarrow \text{FeOOH} + 2\text{H}_2\text{SO}_4 \]
\[ \text{KAlS}_3\text{O}_8 + \text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 \]
Chemical Weathering

Weathering reactions

Silicates

\[ CaSiO_3 + 2CO_2 + 3H_2O \rightarrow Ca^{2+} + 2HCO_3^- + Si(OH)_4 \]

Weathering of feldspar (or other silicates):
K-feldspar + acidic water = K\(^+\) + kaolinite
(a clay mineral)

\[ 2KAlSi_3O_8 + H_2CO_3 + 12H_2O \rightarrow 2K^+ + 2HCO_3^- + 5H_4SiO_4 + Al_2SiO_5(OH)_4 \]
K-feldspar kaolinite

\[ 3KAlSi_3O_8 + 2H_2CO_3 + 12H_2O \rightarrow 2K^+ + 2HCO_3^- + 6H_4SiO_4 + KAl_3Si_3O_10(OH)_2 \]
K-feldspar mica

Weathering of silicates uses carbonic acid which reduces the carbon dioxide level in the atmosphere
Soil

**soil** - (i) The unconsolidated mineral or organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants. (ii) The unconsolidated mineral or organic matter on the surface of the earth that has been subjected to and shows effects of genetic and environmental factors of: climate (including water and temperature effects), and macro- and microorganisms, conditioned by relief, acting on parent material over a period of time. A product-soil differs from the material from which it is derived in many physical, chemical, biological, and morphological properties and characteristics.
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Soil

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Regolith is broken up bits of rock and chemically altered rock (no organic stuff). Soil also contains organic material (including bacteria). We will regard it as being an in situ deposit.
Soil Profiles

soil profile: A vertical section through a soil that shows its horizontal structure (e.g., Soil horizons)
Soil Profiles

soil profile: A vertical section through a soil that shows its horizontal structure (e.g., Soil horizons; A, B, C)

A- Zone of Leaching
B- Zone of Accumulation
C- Zone of Altered Bedrock
O- Topsoil or humus (subdivision of A-Horizon)
Soil Profiles

- Topsoil (rich in organic matter)
  - Soil leached of soluble minerals; rich in clay and insoluble minerals

- B-horizon
  - Little organic matter; dissolved minerals from A-horizon precipitated
  - Bedrock cracked and weathered

- C-horizon
Types of Soils

Soils come in many different flavors, but Geology students in GY 111 only have to worry about 3 types.
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PEDALFER
Humus and leached soil (quartz and clay minerals present)
Some iron and aluminum oxides precipitated; all soluble materials, such as carbonates, leached away
Granite bedrock

alfe = aluminum and iron (e.g. iron oxides)
Soils come in many different flavors, but Geology students in GY 111 only have to worry about about 3 types.

cal = calcium carbonate (e.g. calcite)
Soils come in many different flavors, but Geology students in GY 111 only have to worry about about 3 types.
Types of Soils

![Diagram showing types of soils based on climate dependence: Pedalifer, Laterite, and Pedocal. The diagram includes a map of the United States highlighting Pedocal and Pedalifer soils with a line indicating 30 inches of rain per year.]
Today’s Homework

1. Download and read web lectures 12a,b
2. Assignment 1: due Oct 4
3. Why wait; start studying now for the next exam

Next Time

1. Lecture: Sediment Classification
2. Exams returned
• Assignment 1 is contouring
• It is available for download on the class website
• Due Date: Tuesday Oct 4\textsuperscript{th}
• In-class instruction will be given if required
GY 111: Physical Geology

Lecture 12: Weathering and Soils

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