**Archean Rocks**

Chapter 15A

**Archean Terranes**

- >2.5 Gy old
- Younger supracrustal sequences
  - Greenstone belts
  - Calc-alkaline metavolcanic rocks
- Older gneiss complexes
  - Quartzo-feldspathic rocks
  - Tonalites and migmatites intruded by granites

**West Greenland**

- Contains the oldest rocks on Earth
- Isua supracrustal sequence
- Dated at 3.71 to 3.77 Gy
- Amphibolites and pyroxenites
  - Tholeiitic to komatiitic affinities

**Southeastern Africa**

- Rhodesian Craton
- Kaapvaal Craton

**Kaapvaal Craton**

- Ancient gneiss complex
- Overlying Barberton Greenstone Belt

**Ancient Gneiss Complex**

- Alternating sequence
  - Trondjehmite-tonalite (70% $\text{SiO}_2$
  - Amphibolite (55% $\text{SiO}_2$)
- Younger tonalite gneiss
  - 3.4 Gy
- Youngest migmatites and gneisses
  - 3.2 Gy
**Barberton Greenstone Belt**

- Upper part of the Kaapvaal Craton
- Alternating meta peridotite & pillow lavas
- Overlain by thin tuffs, cherts, and shales

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**Superior Province, Canada**

- Basement of gneiss sequence
- Younger greenstone belt
- Upper clastic sequence

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**Gneiss Sequence**

- >3.0 Gy tonalitic gneisses
- 2.8 to 2.7 tonalite-granite intrusions

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**Greenstone Belt**

- 2.7 to 2.5 Gy old
- Lower part is tholeiite lava and peridotite
  - 5 to 8 km thick
- Upper part is intermediate and felsic
  - Calc-alkaline metavolcanics
  - 4 to 7 km thick
<table>
<thead>
<tr>
<th>Clastic Sequence</th>
<th>Petrology of Archean Rocks</th>
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<tbody>
<tr>
<td>• Capping units</td>
<td>• Gneiss complexes</td>
</tr>
<tr>
<td>• Quartzo-feldspathic clastics</td>
<td>• Komatiite</td>
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<tr>
<td>• 10 km thick</td>
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<thead>
<tr>
<th>Characteristics of Gneisses</th>
<th>Metamorphism in Gneisses</th>
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<tbody>
<tr>
<td>• Contain feldspar, quartz, mica, hornblende</td>
<td>• Ranges from amphibolite to granulite facies</td>
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<tr>
<td>• Early tonalitic gneisses are Na rich</td>
<td>– P = 0.7 to 1.2 GPa</td>
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<tr>
<td>– They probably originated by partial melting of tholeiitic basaltic sources</td>
<td>– T = 700° to 1200°C</td>
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<tr>
<td>• Later granitic gneisses are K rich</td>
<td>• Charnockites are common</td>
</tr>
<tr>
<td>– Their source could have been greywackes or calc-alkaline volcanics</td>
<td>• Suggests intermediate P/T facies series</td>
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<thead>
<tr>
<th>Komatiites</th>
<th>Spinafex Texture</th>
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<tr>
<td>• Composed of peridotite magma</td>
<td>• Criss-crossing blades of feathery olivine or clinopyroxene</td>
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<tr>
<td>• Occur only in Archean terrane</td>
<td>• Intergrown devitrified glass and skeletal crystals of clinopyroxene and chromite</td>
</tr>
<tr>
<td>• Emplaced as lavas</td>
<td>• This texture indicates rapid under cooling of magmas (entirely liquid at first)</td>
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<tr>
<td>– Pillows, breccias, glassy rinds</td>
<td></td>
</tr>
<tr>
<td>• Spinafex texture</td>
<td></td>
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<tr>
<td>• Very high temperature melts (&gt;1600° C)</td>
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Evolution of Archean Crust

- Different or similar to modern petrologic evolution?
- Thermal evolution
- Oldest crust?
- Plate tectonic models

Thermal Considerations

- Early Earth was much hotter
- Geothermal gradients were much higher
- More convective flow within the Earth
- Conditions (thin crust, meteorite bombardment) favored the destruction of very old crust
- Oldest crust is ~ 3.8 Gy

What Was the Oldest Crust?

- Model 1 - no early sialic crust identified
  - Gneisses were intruded into a more mafic scum at the surface
- Model 2 – sialic crust formed early
  - Mafic rocks are intrusive into this early crust
- Model 3 – modern plate tectonic processes apply
  - Small island arcs formed of sialic material

Model 1 for Oldest Crust

- No early sialic crust - West Greenland case
  - Early basaltic lavas pushed into imbricate piles over descending mantle currents
  - Deeper parts of the piles changed to amphibolites
  - Partial melting produced tonalitic magmas
  - Gneisses intrude a mafic framework

Model 2 for Oldest Crust

- Sialic crust formed early – Canada example
  - Sialic partial melts collected and froze above the protomantle
  - Thickness constrained by the 750°C isotherm
  - Early crust would have been thin and may have covered much of the globe
  - This crust would not have been easily subducted
  - Mantle-derived basaltic magmas then intruded this crust
Uniformatarian Model 3

- Small sialic arcs and microcontinents
  - Collision produced greenstone belts in marginal basins
- Barberton example supports an ocean ridge model
  - Sheeted dike complex
  - Flanking pillow lavas
  - Thick sedimentary capping
- Both of these models are on a smaller scale