STRUCTURE OF EARTH

Earthquake Focus

P waves = Primary waves = Pressure waves
S waves = Secondary waves = Shear waves (Don't penetrate liquids)

CRUST < 50-70 km thick
MANTLE = 2900 km thick
INNER CORE (Liquid) = 3200 km thick
INNER CORE (Solid) = 1300 km radius.
CRUST:
Conrad discontinuity = upper / lower crust boundary
Mohorovicic discontinuity = base of Continental Crust
(35-50 km continents; 6-8 km oceans)

MANTLE:
Lithosphere = Rigid Mantle < 100 km depth
Asthenosphere = Plastic Mantle > 150 km depth
Low Velocity Zone = Partially Melted, 100-150 km depth

Upper Mantle = < 410 km
Transition Zone = 400-600 km --> Velocity increases rapidly
Lower Mantle = 600 - 2900 km
Outer Core (Liquid) = 2900-5100 km
Inner Core (Solid) = 5100-6400 km
Center = 6400 km
A. Composition of Earth

Density of the **Bulk Earth** (Uncompressed) = **5.45 gm/cm³**

Densities of Common Rocks:

- Granite = 2.55 gm/cm³
- Peridotite, Eclogite = 3.2 to 3.4 gm/cm³
- Basalt = 2.85 gm/cm³

Density of the **CORE** (estimated) = **7.2 gm/cm³**  
Fe-metal = 8.0 gm/cm³, Ni-metal = 8.5 gm/cm³

**EARTH must contain a mix of Rock and Metal.**

Stony meteorites  Remains of broken planets  Planetary Interior  
Rock=Stony Meteorites “Chondrites” = Olivine, Pyroxene, Metal (Fe-Ni)

Metal = Fe-Ni Meteorites

Core density = 7.2 gm/cm³ -- Too Light for Pure Fe-Ni  
Light elements = O₂ (FeO) or S (FeS)

B. How do we know constitution of upper mantle ??

1. Seismic constraints: **Mantle P wave velocity = 8.0 km/sec**

   >> Corresponds to **Density** of about 3.2 g/cm³  
   >> Peridotite, Eclogite only common rocks w/density 3.2 g/cm³

2. Stony meteorites same mineralogy as Peridotites:  

   **Olivine (65%), Opx (22%), Cpx (10%)**
C. Where do we see Peridotite ?

**Xenoliths** in basalts, kimberlites >> Magmas of Deep origin
**Alpine** Peridotites >> Tectonic slices of upper mantle in mountain belts.

D. Peridotite Facies in the Mantle

Some Solid State Reactions:

\[
\text{CaAl}_2\text{Si}_2\text{O}_8 \ (\text{An}) + 2 \times \text{Mg}_2\text{Si}_2\text{O}_4 \ (\text{Fo}) \leftrightarrow \text{CaMgSi}_2\text{O}_6 \ (\text{Di}) + \text{MgAl}_2\text{O}_4 \ (\text{Sp}) + \text{MgSiO}_3 \ (\text{En}) \\
\text{Plagioclase Peridotite} \leftrightarrow \text{Spinel Peridotite} \quad \{8-9 \text{ kb} = 25-30 \text{ km}\}
\]

\[
4 \times \text{MgSiO}_3 \ (\text{En}) + \text{MgAl}_2\text{O}_4 \ (\text{Sp}) \leftrightarrow \text{Mg}_3\text{Al}_2\text{Si}_3\text{O}_12 \ (\text{Gt}) + \text{Mg}_2\text{Si}_2\text{O}_4 \ (\text{Fo}) \\
\text{Spinel Peridotite} \leftrightarrow \text{Garnet Peridotite} \quad \{20-25 \text{ kb} = 65-80 \text{ km}\}
\]

No Plagioclase Peridotite Under Continental Crust -- Too Deep

![Diagram showing the transition of peridotite facies with depth and temperature](image)

- **Plagioclase Peridotite**
- **Spinel Peridotite**
- **Garnet Peridotite**

**Adiabatic Gradient**
PHASE RELATIONS

MELTING IN THE MANTLE

• One way that mantle peridotites may melt is by plastic flow of large regions toward the surface (i.e., lower pressures).

• These regions form “blobs” called “DIAPIRS”.

• Diapirs rise with nearly constant heat content --> follow ADIABAT.

• Diapirs rise above the regional Geothermal Gradient and perturb the local geotherm.

• Because the Adiabatic gradient (1°C/kbar) is much steeper than the slope of the Solidus (10°C/kbar), the Diapir will eventually intersect the solidus and begin to melt.

WHAT CAUSES DEEPER MANTLE TO RISE UPWARD ??

• Radioactive heat production in deep mantle (U, Th, K): Heating “expands” manlte --> less dense --> rises.

• Movement of dense, depleted mantle and/or ocean crust (eclogite) into deep mantle: Deeper mantle must rise to compensate.