

EARTH STRUCTURE

Compositional Layers

- Crust – continental (felsic, granitic, low density), oceanic (mafic, basaltic, higher density)
- Mantle – ultramafic (peridotite), Fe-Mg rich
- Core – Fe-Ni metallic

Mechanical Layers

- Lithosphere – rigid (crust + uppermost mantle)
- Asthenosphere – plastic/ductile, partial melt
- Mesosphere – lower mantle
- Outer core – liquid
- Inner core – solid

Density Trends

- Density increases with depth
- Continental crust $\sim 2.7 \text{ g/cm}^3$
- Oceanic crust $\sim 3.0 \text{ g/cm}^3$
- Mantle $\sim 3.3+ \text{ g/cm}^3$
- Core $> 10 \text{ g/cm}^3$

MINERALS

Definition Naturally occurring, inorganic, solid, definite chemical composition, ordered internal structure.

Silicate Structure

- Silicon-Oxygen Tetrahedron (SiO_4^{4-})
- Polymerization increases silica content and viscosity

Common Silicates

- Olivine – mafic
- Pyroxene – mafic
- Amphibole – intermediate
- Biotite – sheet silicate
- Muscovite – felsic
- Feldspars – most abundant
- Quartz – high silica

Physical Properties

- Hardness (Mohs scale)
- Cleavage vs Fracture
- Luster
- Streak
- Density
- Crystal form

IGNEOUS PROCESSES

Magma Formation Mechanisms

- Decompression melting (divergent boundaries, hotspots)
- Flux melting (subduction zones – volatiles lower melting point)
- Heat transfer melting

Bowen's Reaction Series

- Discontinuous: Olivine \rightarrow Pyroxene \rightarrow Amphibole \rightarrow Biotite
- Continuous: Ca-rich Plagioclase \rightarrow Na-rich Plagioclase
- Final: K-Feldspar, Muscovite, Quartz

BASALTIC vs FELSIC MAGMA

Property	Basaltic (Mafic)	Felsic
Silica	Low (45–52%)	High (65–75%)
Temperature	High (1000–1200°C)	Lower (650–800°C)
Viscosity	Low	High
Gas Content	Low	High
Eruption Style	Effusive	Explosive
Rock Type	Basalt	Rhyolite/Granite
Color	Dark	Light
Density	Higher	Lower

VOLCANO TYPES

Shield Volcano

- Broad, gentle slopes
- Basaltic lava
- Effusive eruptions

Composite (Stratovolcano)

- Alternating lava + pyroclastics
- Felsic/intermediate
- Explosive

Cinder Cone

- Pyroclastic fragments
- Steep slopes
- Short-lived

PYROCLASTIC MATERIAL

- Ash ($< 2 \text{ mm}$)
- Lapilli (2–64 mm)
- Bombs/Blocks ($> 64 \text{ mm}$)
- Pyroclastic flow – hot, fast-moving gas + fragments
- Lahars – volcanic mudflows

PLATE TECTONICS

Boundary Types

- Divergent – mid-ocean ridges, rifting
- Convergent – subduction or collision
- Transform – strike-slip motion

Ocean-Continent Convergence

- Oceanic plate subducts
- Volcanic arc forms
- Deep ocean trench

Ocean-Ocean Convergence

- Island arc

Continent-Continent

- Mountain building
- No subduction (buoyant crust)

CHEMICAL vs PHYSICAL BEHAVIOR

Physical Weathering

- Frost wedging
- Exfoliation
- Abrasion

Chemical Weathering

- Hydrolysis
- Oxidation
- Dissolution
- Increases in warm, wet climates

ISCHEMATIC CONCEPTS

Isostasy

- Buoyant equilibrium of crust
- Thicker crust = deeper root

Seafloor Spreading

- Symmetrical magnetic stripes
- Youngest rock at ridge
- Age increases away from ridge

KEY EXAM DISTINCTIONS

- Mafic = Mg + Fe rich
- Felsic = Feldspar + Silica rich
- Viscosity controlled by silica + temperature + volatiles
- Density differences drive subduction
- Explosivity tied to trapped gas + viscosity