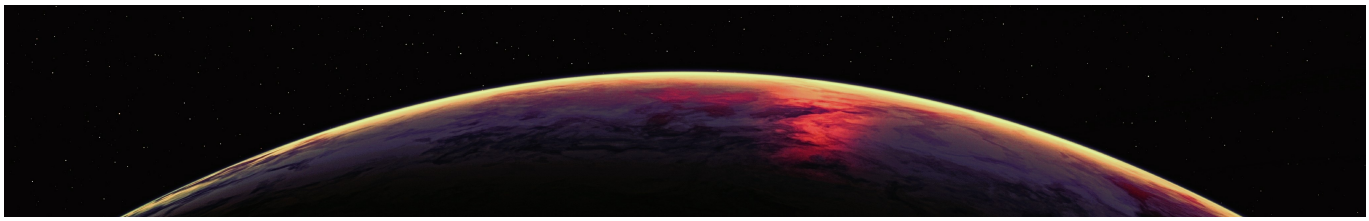
Summary Notes on

ES 1201

Planetary Sciences



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ES1201 NUMERICALS

1. INTRO to Structure and Composition of Earth.

1.1 Hypsometric Plot

It Plots the relative area % against the relative topographic height (0 at Median) to show the land area that exists at diff. points of elevation on planet.

For Earth → Plot is BIMODAL (2 peaks)

1.2 Seismic Wave speeds.

→ Longitudinal wave

Body waves $\begin{cases} v_p = \sqrt{\frac{\frac{4\eta}{3} + K}{\rho}} \\ v_s = \sqrt{\frac{\eta}{\rho}} \end{cases}$ → Transverse wave.

η = Shear Modulus ($=0$, for liquids)

K = Bulk Modulus.

Surface waves – Love, Rayleigh wave → originate after 20–30 s.
↓
snake like.

1.2.1 Refraction

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2}$$

when $i = c$, wave gets reflected.

$r = 90°$

$$\sin c = \frac{n_R}{n_D}$$

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1.2.2 Shadow Zones.

	Epicentral Angle (Δ)
P wave -	$105° - 142°$
S-wave.	$> 105°$

1.2.3 Density Determination.

Using eq^{n}s for v_s & v_p,

$$\eta = \rho v_s^2 = \frac{3}{4}\left(\rho v_p^2 - K\right)$$

$$\left[\frac{K}{\rho} = v_p^2 - \frac{4}{3} v_s^2\right]$$

Variation of density with depth. (as a result of self compression) is given by eq^{n} →

$$\frac{\Delta \rho}{\Delta r} = \frac{\rho G m}{r^2\left(v_p^2 - \frac{4}{3} v_s^2\right)}$$

m = total mass at distance r from Earth's center.

1.3 Distribution Coefficients.

The way in which elements distribute themselves between solid and molten states is known as element partitioning. Expressed as → (K, K_d, K_D, D) Partition/Distr. Coeff.

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$$D = \frac{C_a^i}{C_b^i} = \frac{[liq]}{[sol]}$$

C_a^i = concentration of element i in phase a, liquid.

C_b^i = —"— phase b, solid

For Lithophile $D < 1$ (Incompatible)

Siderophile $D \geq 1$ (Compatible)

Related

[liq] ~ molten metallic iron

[solid] ~ solid silicate minerals.

1.3.1 Electronegativities (0 ↦ 4.0)

- E < 1.6 Lithophiles (cation)
- 1.6 < E < 2.0 Chalcophile (covalent with S)
- 2.0 < E < 2.4 Siderophile (Metallic Bonds)
- E > 2.4 (Forms bond with Lithophile).

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2. The Early Earth.

2.1 Accretional Heating

The rise in temp, ΔT of Earth if a planetisimal of mass 'm' strikes with velocity of impact 'v'

$$\frac{1}{2}mv^2 = (m+M_\oplus) S_\oplus \Delta T$$

$$\Delta T = \frac{mv^2}{2(m+M_\oplus) S_\oplus}$$

For Earth

$S_\oplus = 750 \text{ J/kg-K}$

$M = 6 \times 10^{24} \text{ kg}$

2.2 Tidal Heating

Rate of Heating by tidal distortion $= E$ (J/yr)

Mass of Earth $= M$ kg

Rate of Tidal Heating $= W/kg = r = ?$

$$E \frac{J}{yr} = E \frac{J}{365 \text{ days}} = E \frac{(J/s)}{365 \times 86400} = E' W$$

$$\therefore r = \frac{E' (J/s)}{M \text{ kg}}$$

2.3 Radiogenic Heating

Radiogenic Daughter Atom = $D^* = n_0 - n$.

Total daughter atom $D = D_0 + D^*$

↳ At $t=0$:

$n = n_0 e^{-\lambda t}$ → $n_0 = n e^{\lambda t}$

$\therefore D = D_0 + n(e^{\lambda t} - 1)$

↓ present.

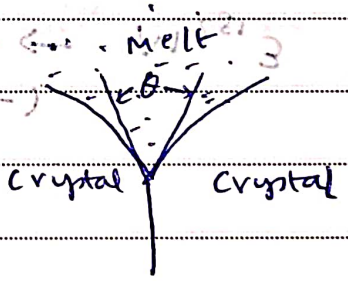
Total Amt of Radiogenic Heating by π half $t_{1/2}$ = $\left(2^{\frac{-\pi}{t_{1/2}}} \times\right)$ (original Heating)

↓ ×100

↳ %

2.4 Crystal Formation in Melt.

Metal melts and forms interconnected network.



θ : Dihedral Angle

$\theta < 60°$ → Metal will fill channels b/w solid grain

$\theta > 60°$ → Melt is confined to pockets. (until $\Phi > 10\%$)

$$v = \frac{K}{\eta} \Delta\rho g \quad ; \quad K = \frac{a^2 \Phi}{24\pi}$$

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v = velocity of melt relative to solid Matrix
= migration velocity

η = viscosity (Pa-s)

Φ = fraction of volume melt.

$\Delta\rho$ = Density diff. b/w melt and solid.

K = Permeability.

a = Mean grain radius.

2.5) Tungsten Isotope Ratio, notation.

$$\varepsilon^{182}W = \left[\frac{\left(\frac{^{182}W}{^{184}W}\right)_{sample}}{\left(\frac{^{182}W}{^{184}W}\right)_{BSE}} - 1 \right] \times 10^4$$

$\varepsilon^{182}W \rightarrow$ -ve (-2) $\Rightarrow$ chondrite (sample) has lower amt of ^{182}W by @ 2 parts in 10^4

3. GEOMORPHOLOGY

3.1 Fluvial Processes

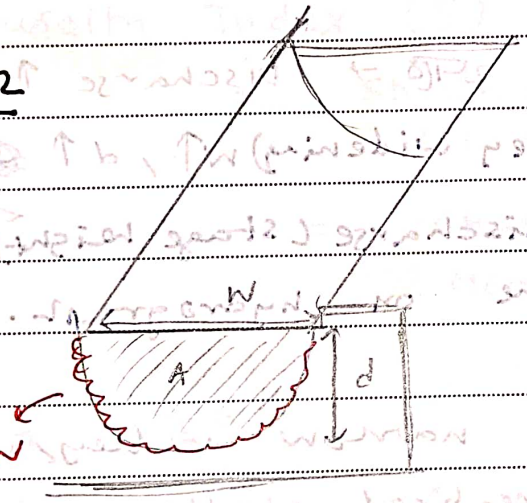
3.1.1

$\frac{dV}{dt}$ Discharge (m^3/s) = (Cross sectional Area (m^2)) x (Velocity m/s)

$$Q = \frac{dV}{dt} = A \cdot v$$

A ↑ as river goes downstream, due to increase in discharge.

3.1.2



P_W = Wetted perimeter

= effective perimeter of the channel in contact with water.

$$Q = W d v$$

Relationship

$a Q^x = W$

$b Q^y = d$

$c Q^z = v$

$a b c = 1$

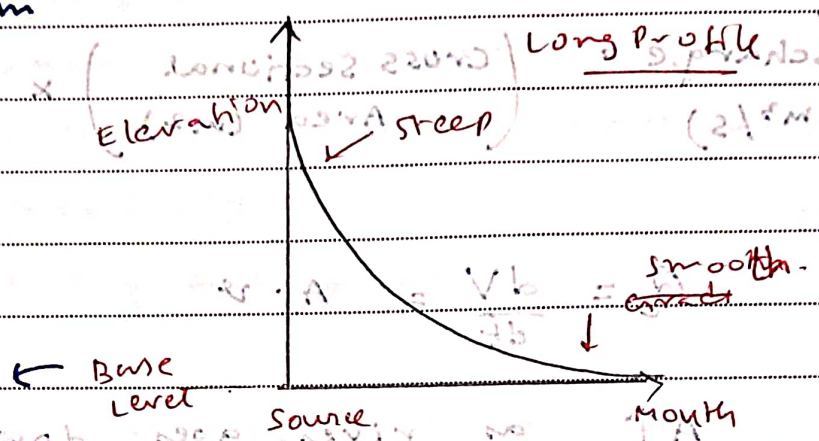
$x + y + z = 1$

- For silty / clayey sand → y ↑, x ↓
- Loose sand → y ↓ x ↑

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3.1.3

Gradient of a stream decreases downstream

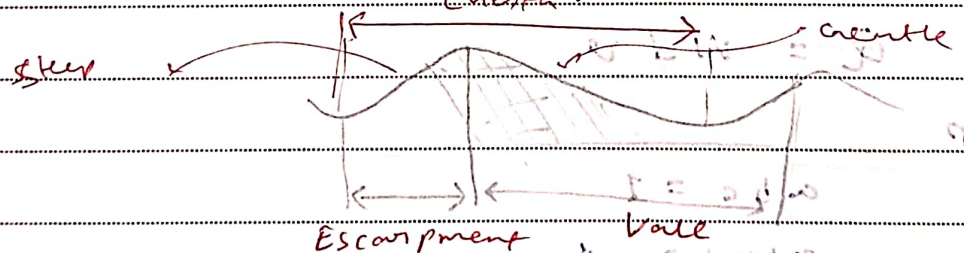


level below which streams cannot erode.

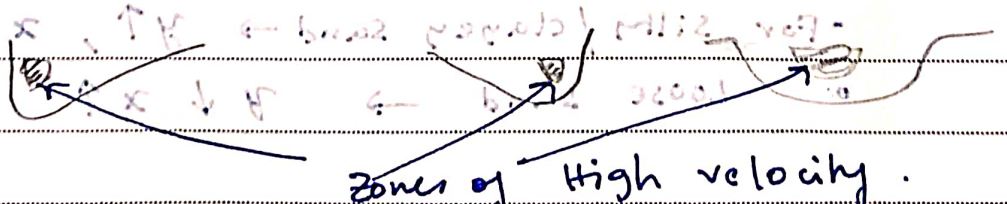
Downstream → Discharge ↑ (valley widening) W↑, d↑

* Fluctuation in stream discharge (stage height) can be plotted against time on hydrograph.

- Escarpments – Deep cut narrow valleys with steep / vertical walls.



3.1.4 Meandering Channels.



Zones of High velocity.

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~~High sed~~

High sediment Load,
Easily Erodible banks. } ⇒ Braided channel form
Q → Highly Variable

- Slope < 10° → Alluvial Fan
- Slope 10 - 50° → Alluvial cone } coalesce to form a Bajada (piedmont alluvial plane)

3.1.5 Meander Dynamics

Sinuosity Index (S)

$$= \frac{\text{Stream Length}}{\text{Valley length}} = \frac{\text{Thalweg Length}}{\text{Valley length}}$$

$$= \frac{\text{Channel Length}}{\text{Meander Wavelength } (\lambda)}$$

$\lambda = K Q^{\alpha}$ $\quad Q \uparrow \ \lambda \uparrow$

K, α - constants

Q = Mean Annual discharge.

3.1.5.1 $\lambda = 106\, Q^{0.46}$

$$\lambda = \frac{1890\, Q^{0.34}}{M^{0.74}}$$ ✓

M = % of silt/clay in channel perimeter.

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Erosion > Deposition → Incision

Deposition > Erosion → Aggradation

3.2 Glaciers

Types:-

- Alpine/Mountain
  - Cirque
  - Valley
  - Fjord
  - Piedmont
- Ice sheet/ Ice cap
- Ice shelves.

