Earth Science

for CSIR NET

(Career Evenues)

TO CROSS DILDI'S DEN.

	T	C	R	O	S	S	D
Si	-1	1	1	1	2	2	4
O	2	3	3	4	5	7	11
	TECTO	SINGLE/INO	RING/CYCLO	ORTHO/NESO	SHEET/PHYLLO	SORO	DOUBLE/INO

Allochem - 0.5 m.m upwards in size
Ooids, peloids, oncolites, pellets, fossil or pre-existing carbonate fragments.
Typically embedded in a matrix of micrite (lime mud) or sparry calcite.

Void ratio $e = 25\% = \frac{25}{100} = 0.25$

porosity $\phi = \frac{e}{1+e} = \frac{0.25}{1+0.25} = \frac{0.25}{1.25} = \frac{25}{125} = 0.2$

$\phi (\%) = 0.2 \times 100 = 20\%$

Stoke's Theorem - states that the surface intergal of the curl of a function over any surface bounded by a closed path is equal to the line intergal of a particular vector function round the path.

$$\int_S \vec{\nabla} \times \vec{F} \, ds = \oint_C \vec{F} \cdot \vec{dr}$$

Where, F = Vector function
ds = small surface area
dr = small line path

Engineering Properties of Rocks and Soil

Soils

→ It is the ultimate product of weathering.

Soil horizons

→ O horizon : Thin (few cm) organic matter, lower part decay to humus

A horizon : Groundwater percolates downward and remove solubles, contains more organic matter than B and C.
Dark humus layer at the top

E horizon : Transition between A and B.
O + A = Top soil
O + A + E = Zone of leaching

B horizon : Sub soil, zone of accumulation of material leach down from A.
Red, brown or grey in colour.
Very little organic material

C horizon : Mixture of soil and bedrock.

Factors controlling soil formation

1. Organic activity
2. Topography
3. Climate
4. Drainage
5. Parent material
6. Latitude

Time: 2.5 cm thick to) 1000 yrs (2.5 cm / 1000 yrs)

Engineering properties of Soil

→ Soil, water and air - Three phase
(Solid)

Total volume, $V_T = V_s + V_{air}$

Total weight, $W_T = W_s + W_w$

Weight of Solid $W_s = V_s \times \gamma \times g$

Unit weight $\gamma = \rho \times g$

Weight of Solid $\boxed{\gamma_s = G_s \times \gamma_w}$

$\boxed{V_s \times G_s = \gamma_w}$

G_s = Specific gravity of the solid

γ_w = Unit weight of water

$V_s \times g \times \gamma_w$

$V_s \times G_s \times \gamma_w$

$\boxed{g\rho = \frac{m g}{V g}}$

Weight of water $W_w = V_w \times G_w \cdot \gamma_w$

Unit wet weight of Soil $\gamma_{wet} = \frac{W_T}{V_T}$

Unit dry weight of Soil $\gamma_{dry} = \frac{W_s}{V_T}$

Void ratio (e) $= \frac{V_{void}}{V_{solid}}$

$$\boxed{e = \frac{V_{void}}{V_{solid}}}$$

Porosity $(n) = \left(\frac{V_{void}}{V_T}\right) \times 100$

Water content of soil $= \frac{W_{water}}{W_{solid}} \times 100$

$$\gamma_{dry} = \frac{W_s}{V_T}$$

$$= \frac{W_s}{V_s + V_v}$$

$$= \frac{W_s}{(1+e)\, V_s}$$

$$= \frac{G_s \gamma_w}{1+e}$$

$$\gamma_{wet} = \frac{(1+w)}{(1+e)} G_s \gamma_w$$

$$\gamma_{wet} = (1+w)\, \gamma_{dry}$$

Index properties of soil

→ Coarse grained (cohesionless) - Particle size distribution
Shape of Particles
Clay content
In-place density
Relative density

Fine grained (cohesive) - Consistency
Water content
Atterberg limits
Type and amount of clay
Sensitivity

I. Particle size distribution

→ Well graded - Soil that contains particles of various sizes (similar to poorly sorted)

Poorly graded - Similar size particles (well sorted)

II. Particle shape

→ This property of particles is dependend of sphericity, roundness and angularity.

III. In place density

→ It is measure by weighing an oven dried sample of a known volume.

IV. Relative density

$$D_R = \frac{(e_{max} - e_o)}{e_{max} - e_{min}} \times 100$$

→ Ratio of actual density to max. density.

e_{max} = Void ratio in losses condition

e_{min} = Void ratio in denses condition.

e_o = Void ratio natural state.

Index ratio of cohesive soil

I. Consistency

→ Strength and resistance to penetration of the soil in its place condition.

It is determine by the nature of fabric (arrangement)

Focculated - If there is end to end contact between soil grains the consistency is higher.

Convergent Boundaries

5/10/17 (1)

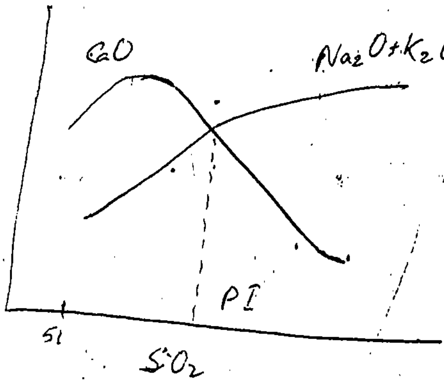
→ Porphyritic texture → Glomeroporphyritic ~~texture~~ clusters of phenocrysts
↓
Malanjkhand
Porphy Cu deposit

Petrology of Igneous rocks in the boundary

→ Basalt - have phenocryst of olivine, Augite, plagioclase
Andesites - Augite, plagioclase, Hypersthene, Hornblende.
Osillatory Zoning, Reverse zoning
Andesites in convergent boundaries show a pre dominant calcic plagioclase phenocryst. They depict oscillatory zoning.
Rhyolite - Obsidian / Pyroclasts

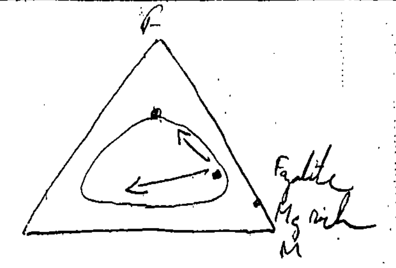
Peacock's Index
(Alkali Lime Index)

P.I SiO_2	Nature of Ig Suite
<51	Alkali
51-56	Alkali - Calcic
56-61	Calc - Alkalic
>61	Calcic



Most subduction related igneous rocks fall into Calc Alkalic group.
Based on the AFM diagram the ratio of MgO remains constant.

$$\frac{MgO}{FeO+Fe_2O_3} = Mg\# = \frac{MgO}{FeO^*}$$



Q. The chemical analysis depicts that basalt contain much more Al. (Al_2O_3 ~15%) in comparison to Peridotites (Al_2O_3 ~4%). This is because basalt contains a) very little olivine

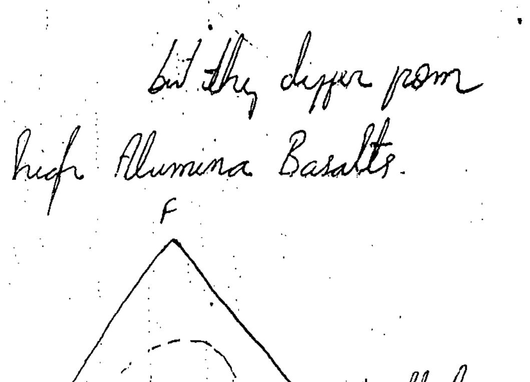
b) Feldspar as a dominant mineral

c) high proportion of pyroxene

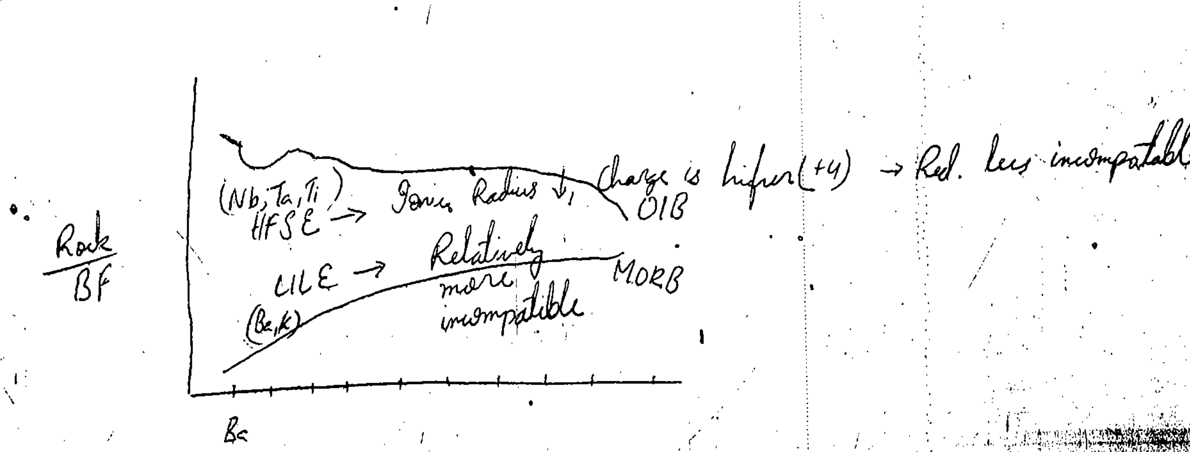
d) No quartz

- Calc-alkali basalt are sub-alkaline but they differ from
Calc-alkaline basalts 17-20% are know as high Alumina Basalts.

- Calc-alkaline trend can be explain by early removal of mineral assemblages with high Fe Mg ratio



- Another difference bet^n pdfrides and calc alkaline rocks is the presence of hydrous minerals like hornblende

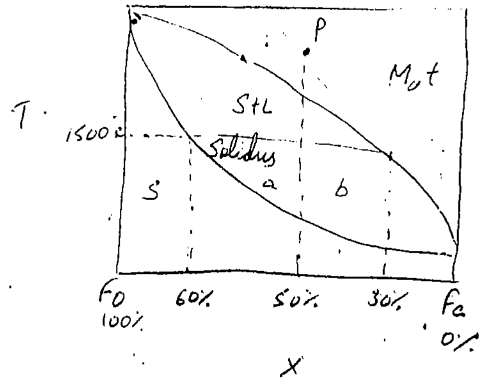


The trace elements patterns for subduction related volcanic rocks show a deviation from the partially melted subducted oceanic crust. The irregular pattern has peaks and valleys. The peaks are form due to the presence of large ion lithophyl elements. Valleys are form due to the ~~absence~~ presence of HFSE. (2)

Igneous rocks of continental crust

8. The given TX diagram shows phase relation in olivine solid solution at large P. If ~~Pes~~ P is the initial position of melt. The portion of melt at 1500°C is.

$$\frac{a}{a+b} \times 100\%$$



Igneous Rocks of Continental Crust

Granitic / Granitoid

Chemical Classification / Tectonic

S -
I - } Orogeny
A - Anorogenic
M -

S-type Granites

	Protolith	Al_2O_3	Minerals assemblage
S-Type	Meta Sedimentary or Sedimentary rocks	Peraluminous	Musconite (Al rich)
I-Type	Igneous Protolith	Meta-aluminous	Na rich pyx, hornblende (Jadeite / Aegerine (Al poor) Ribeckite)
A-Type		Peralkaline	Fe-rich (Olivine)
M-Type	Mantle rocks /		Plg rich, Flourite

Depth of Pluton emplacement
- Catazonal — > 11 km deep (less viscosity)
- Mesozonal — 8-11
- Epizonal — < 8 km depth

migmatites

Concordant → Discordant

Granite Controversy
- Granitization
- Magmatisms (mostly)

Formation mechanisms of Granites
(i) Anatexis of metasedimentary or sedimentary rocks S type
(ii) " " young crustal igneous rocks I-Type
(iii) Melting / Assimilation of mantle derives magmas.
(iv) Crystal fractionation of basaltic or magmatic magma.
(v) Granitization ultra metamorphism boardering on melting metamorphic rocks thereby changing their texture and mineralogy.

Occurrence

Fold mts (Himalayas)

Deep Seated Igneous plutons

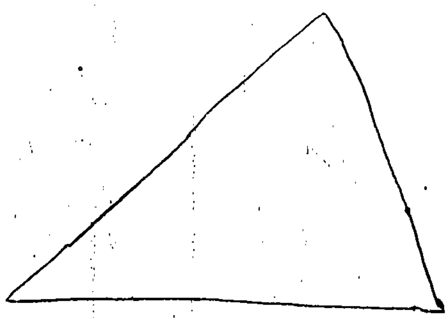
Rift valleys

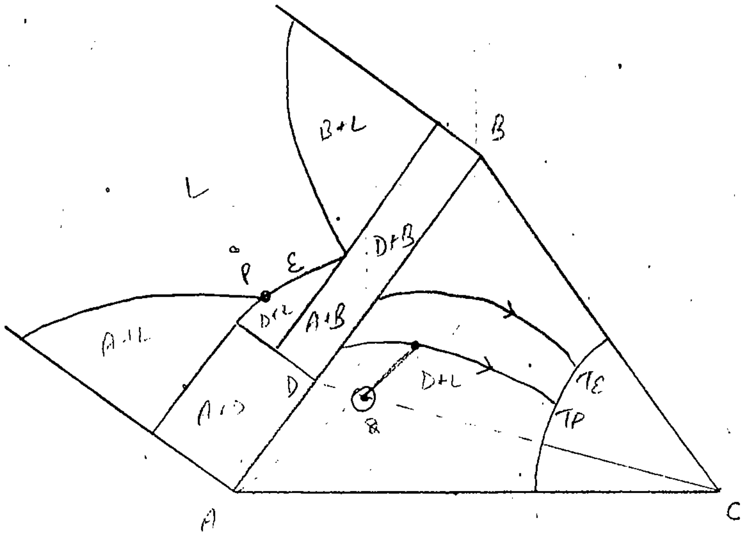
Subduction zones

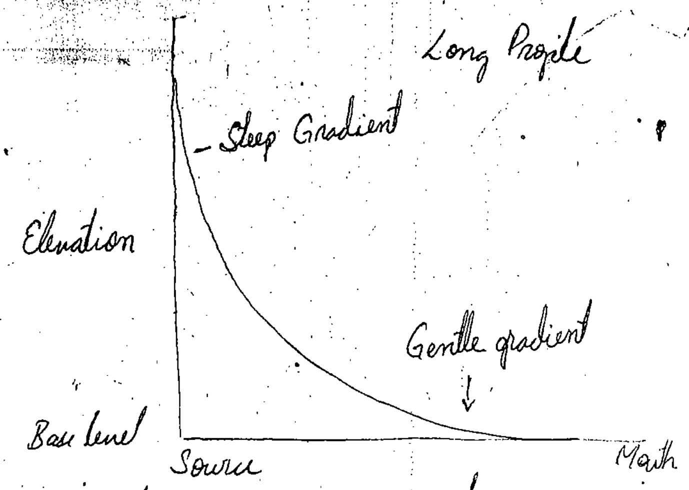
Pegmatites

- Very coarse grains, felsic rocks form from the residual
- They occur as dikes or pod-like segregation within
- They are form during the late stages of crystallization and have high water rich fluids which easily dissolve silica and alkalis.
- Other rare chemical constituents get conc. in the residual liquid forming enriched pegmatites.

Tourmaline - Li
Beryl - Be
Lepidolite - Li
Spodumene : Li




B+L
B
L
P
E
D+B
D+L
A+B
A+L
A+D
D
D+L
TE
TP
A
C

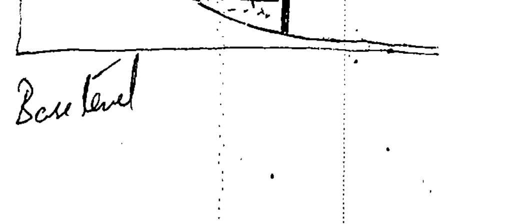


Three Stages of running water

① Youthful stage - This stage is marked by V-shape valley, no flood plains or narrow flood plains.
Water falls and rapids may exist.

② Mature stage - Streams are plenty, V-shaped valley but deep, flat and broad inter-stream areas.

③ Old stage - Smaller streams, gentle gradient and freely meandering rivers or vast flood plains, natural levees, point bars and ox bow lakes.



Base level - Level below which stream and river does not erode.
Local base level - When stream meet a resistance body, artificial dams or rocks that stop further erosion.

Load

Rock particles and dissolved ions constitute a load. Amount of load depend on topography, lithology & slope, climate, vegetation.

Suspended - Load which is carried along the stream, size depends on density and velocity of the stream.

Bed load - Coarser and denser particles that are on the bed of the river

Dissolved ions - Chemically dissolve salts present in the stream in the form of ions.

Changes downstream

-> As one moves along the long profile and comes down stream the discharge increases, width, depth and average densities inc., the gradient dec., size of the particle dec. because of abrasion, attrition

Composition might change if diff. bedrocks are encounter.

Floods

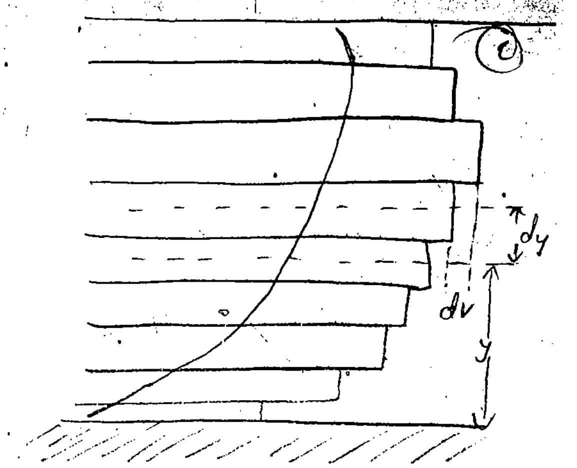
-> When discharge becomes too high to make accomodiated in the original stream. The area that becomes flooded is called flood plain.

Dam failure, glacier outcast, heavy rainfall

Hydrograph

->

Hydraulic Shear



→ Hydraulic shearing stress at any point y
Above the channel floor = $\mu \, dv/dy$

Geological activity of River

→ ① Erosion
② Transportation
③ Deposition

Erosion – Break down of rock by dynamic action of any geomorphic agent like running water

① Hydraulic action : Mechanical loosening or removal of the material by action of the water along.

② Abrasion : Grinding of rock fragments carried by river against the bed and the ~~sides~~ bank
This action both widens and deepens the channel.

④ Attrition : Knocking of rock fragments with one another in the water leading to smaller and smoother surface particles.

⑤ Corrosion : Process by which the river water reacts chemically with soluble minerals in the rock and dissolve it.

Important Erosional Features

→ ① Pot Holes : Circular depression on the river bed.
Formed by corrosion or abrasion
Most effective in flood plains.

~~Waterfall~~

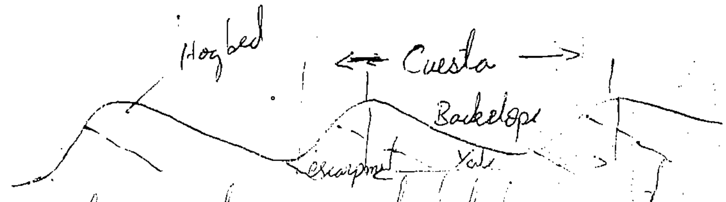
② Waterfalls : Vertical flow of fast moving water flowing from great height.
Formed by two ways :

due to unequal resistance of rock flowing.

Rapids - a series of short and fast falls.

③ Gorges and Canyons : Deep cut narrow valley with steep or almost vertical walls.

④ Escarpments : Deep cut and narrow valley common in region of alternating beds with hard and soft rocks. Soft rock erodes faster there by creating a steep scarp on one side and gentle slope on one side.



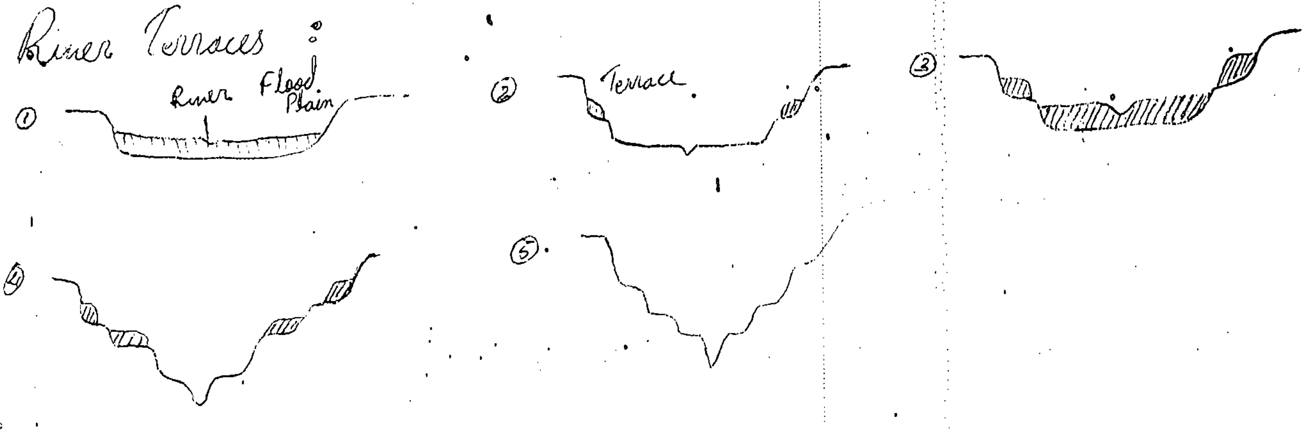
Hog Beds - when rocks are uplifted by mountain building process erosion of the softer, less resistant rocks, leaving a ridge of more resistant rock.

Cuesta - an upline belt with a short steep slope (descent) or escarpment on one side.

⑤ Mesa : It is an elevated area of land with a flat top and sides are un-usually steep.

⑥ Butte : French term meaning "small hill". It is an isolated hill with steep, often vertical sides and a small relatively flat topped.

⑦ River Terraces :



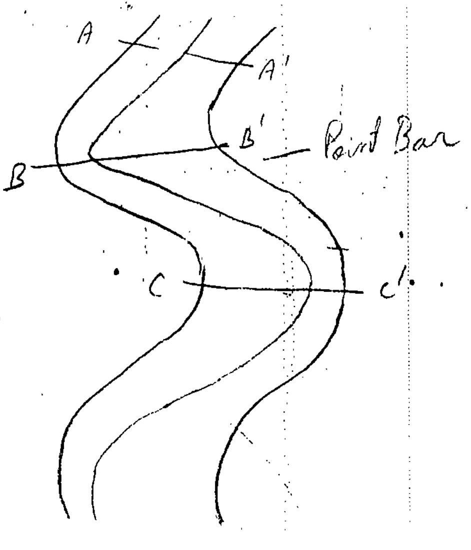
This are areas of flat land which are raised above the flood plain. River terraces use to be flood plains but the river has cut down and form a new flood plain at a lower level.

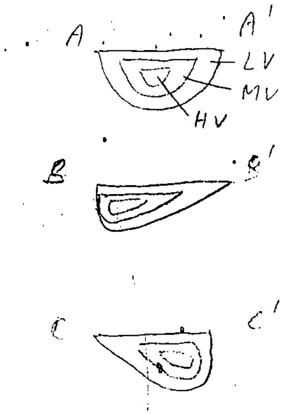
~~Transportation~~

→

Meandering Channels

→ Meanders occurs most commonly in channels that lie in fine grain streams sediments and have gentle gradients.
Velocity is lowest along the bed and the walls of the channel.





Levees - Vertical
Point bars - Lateral ~~Horizo~~

Grain Size
Coarse
Medium
Fine
Very fine

Depositional features

→ ① Alluvial fans / Cones - forms when streams reach the fine valley and enters the depositing the coarser material at the head and finer material down the slope.

If slope is ~~less than 10°~~ betⁿ 10-15° - alluvial cone

less than 10° - alluvial fan

Series of adjacent fans comes together to form an extensive alluvial plain (Pedmont) is called Bajada.

② Flood plains - areas that are periodically ~~elongated~~ inundated by lateral overflow of rivers or lakes or by direct ppt is called flood plains.

a) Aggradation : It occurs when deposition is slightly greater than erosion.

b) Incision : when erosion is greater than deposition.

Floodplains can form either by deposition of suspended sediment or by deposition of bed loads as the channel migrates.

④ Natural levees - The boundary between flood plain and channel may be the site of natural levee.

Levees form when debri-laden flood water ~~bed~~ flows water ~~over~~

Levees have coarser deposits.

⑤ Point bars - depositional feature of a stream.

abundantly found in meandering rivers or mature rivers.

Crescent shape and located on the inside of the stream bend.

Reservoir Properties of Rocks

Porosity

→ Porosity

- Morphological Classification
  - Effective Porosity
    - Catenary Porosity
    - Cul-de-sac / Dead end porosity
  - Ineffective Porosity
    - → Closed porosity
- According to time of formation

Type	Origin	Time of Formation
- Intergranular - Intragranular	Sedimentation	Primary
- Intercrystalline - Fenestral	→ Cementation (Limestone) (Dolomite)	Secondary
- Vuggy (open space) - Moldic	Solution	
- Fracture	Dehydration / Tectonic	

Porosity $\phi = \frac{\text{Vol. of Voids}}{\text{Total vol. of rock}} \times 100$

Intergranular porosity - Present in all sediments. Porosity resulting within crystal grains or within particles.

Intragranular porosity - Porosity within individual grains.

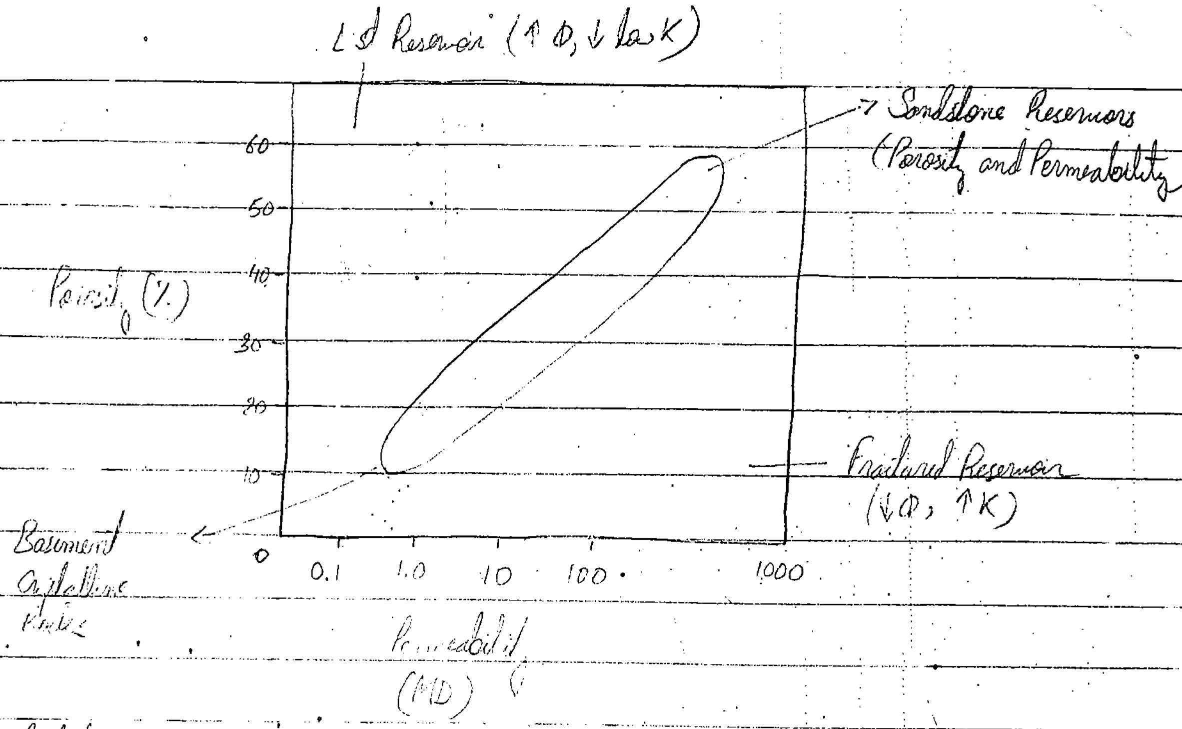
Intercrystalline - Pores occurring in between crystal faces of crystalline rocks. Generally result the replacement or cementation process.

Fenestral porosity - It occurs where there is a primary gap in a rock framework i.e larger than the grain supported inter-spaces.

Vuggy porosity - Large void spaces occurring due to solution activity.

Moldic porosity - Porosity resulting due to selective replacement of grains of matrix.

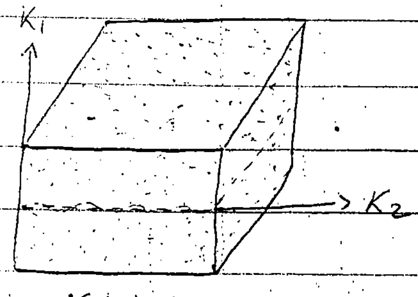
Fracture porosity - Resulting due to fractures because of overburden pressure or tectonic activity or dehydration. This type of porosity increases the storage capacity and permeability.



Permeability

$$\Rightarrow \quad Q = \frac{K(P_1 - P_2)A}{\mu L}$$

Permeability is not same in all rock, generally permeability along the bedding plane is greater than the permeability



$K >> K_1$

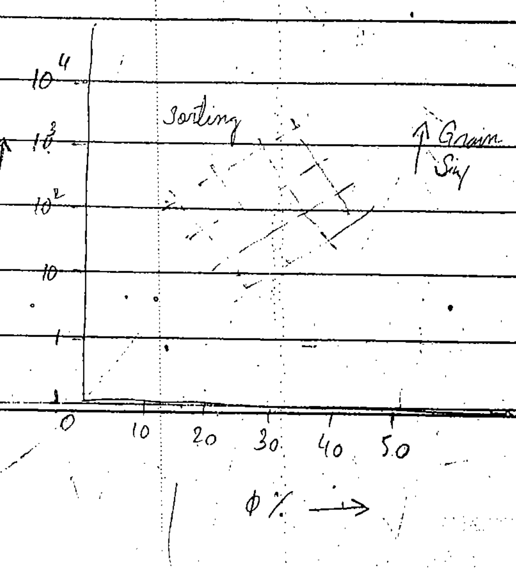
Effective permeability is the ability of a rock to conduct a fluid in presence of other fluid.

Relative permeability Effective p. of a given fluid at partial saturation divided by p at 100% saturation

Porosity, K and Sorting

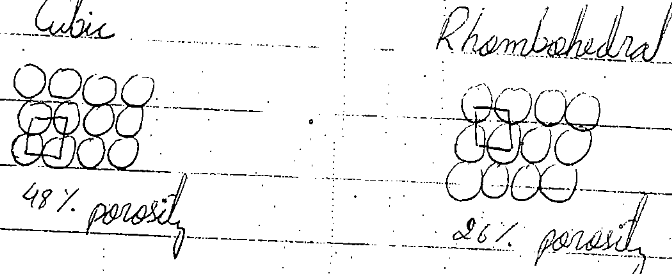
Grain Size - Roundness and Sphericity
Greater the roundness greater the porosity.
Sphericity is the degree to which a particle

Since spherical grains are more tightly pack in comparision to subspherical grains



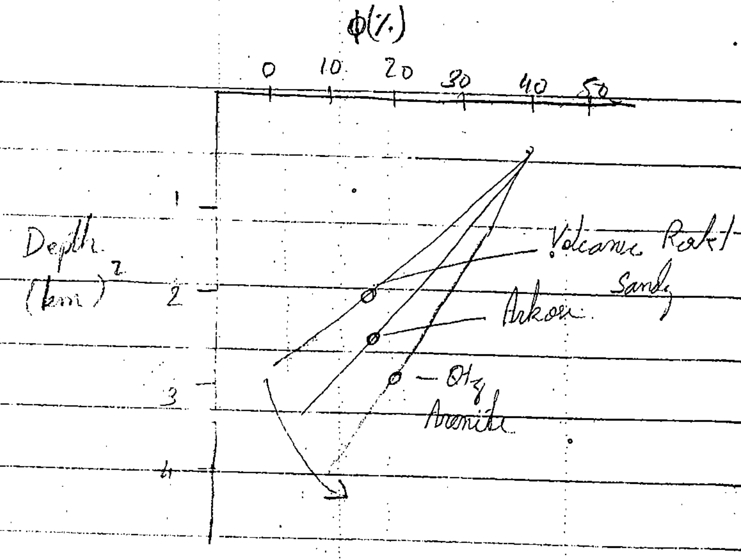
Sorting
Greater the Sorting ↑ porosity ↑ permeability

Depositional features
Point bar > Beaches > Dunes Sorting
Permeability
Point bars - 45%
Beaches - 45-48%
Dunes - 48%



Grains are because of stratification the por and perm are affected i.e. vertical perm will be much lesser than horizontal permeability since in horizontal direction there will least resistant to fluid movement.

Effect on Depth
→ $\phi^D = \phi' - GD$
ϕ^D = Porosity at a depth.
ϕ' = Primary porosity at surface.
G = Porosity gradient, controlled by — Mineralogy Maturity; Texture & Sediment
D = Burial depth.



Hydrocarbon Traps

→ Factors that control migrat^n of Oil

① Capillary Pressure

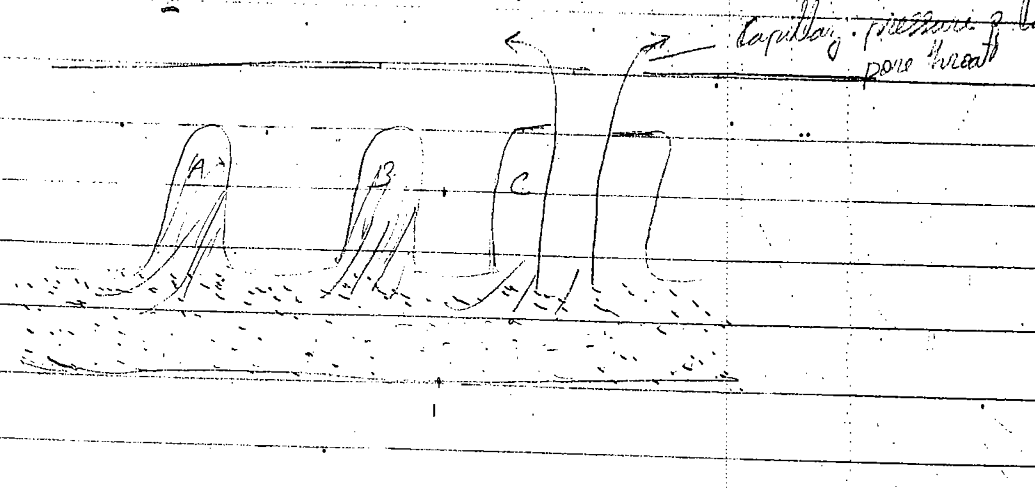
② Buoyancy

C.P > B

C.P < B

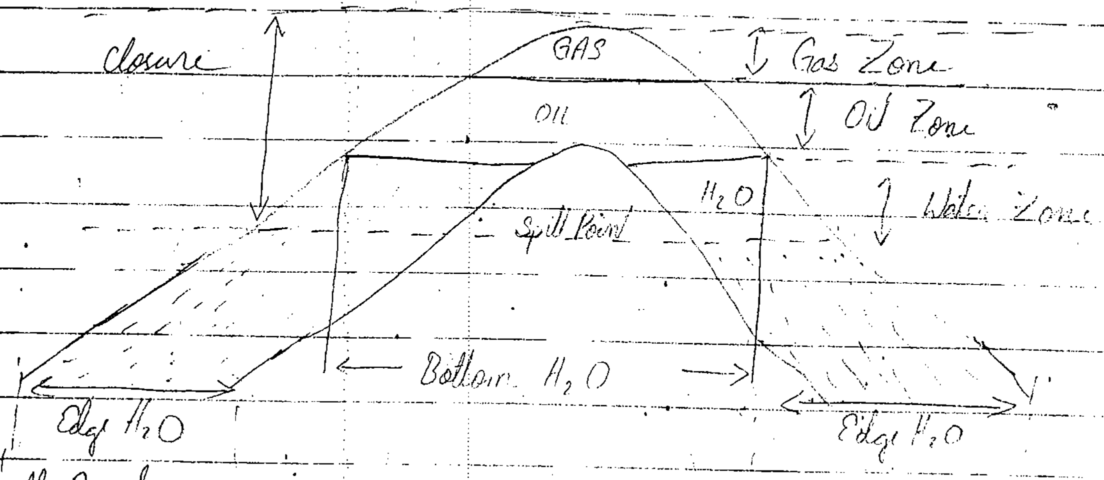
- Buoyancy is the main driving force helps in the upward movement of a fluid.
- Capillary pressure is the main restricting force to the movement of a fluid.

A rock is seal and underline petroleum accumulation if capillary or displacement pressure of its largest pore throat is greater than the upward buoyancy force of petroleum column.



Terminology of hydrocarbon trap

3



Spill Point
→ Lowest point at which hydrocarbon may be present or content.
Closure
→ Vertical distance from crest to spill point.
Bottom water
→ Zone immediately below petroleum
Edge water
→ Zone laterally adjacent to the trap.
Pay zone
→ Productive reservoir within a trap.
Gross pay
→ Vertical distance from top of the reservoir to oil water contact zone.
Net pay
→ Cumulative vertical thickness of a reservoir from which petroleum can be extracted.

Trap Classification

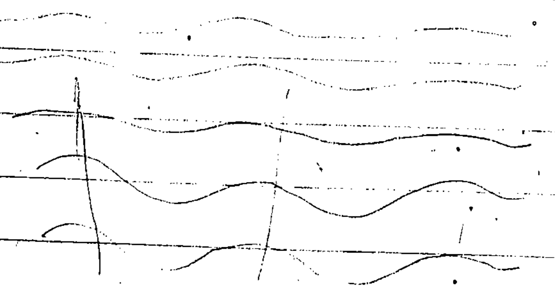
① Structural Traps
- → Fold Traps < Compressional / Compactional
- → Fault Traps

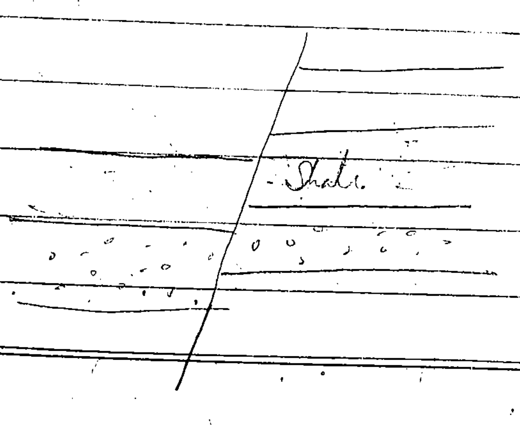
② Diapiric Traps → Salt Diapirs
- → Mud Diapirs

③ Stratigraphic Traps
- → Un-Associated with Unconformity → Pinch-outs channels, Bars, Reefs
- → Associated with Unconformity → Onlap, Strike Valley, Channels, Truncations

④ Hydraulic Traps

⑤ Combination Traps.





Palaeontology

8/11/17 (1)

Proxy - Plate tectonics, Palaeogeology, Oceanography, Palaeoclimate

(Geology) (Biology)

Proxy
① Palaeogeography
② Paleoclimate
③ Oceanography
④ Plate tectonics

Proxy
① Evolution
② Ecology
③ Paleo Biology / Biogeography

Life
Domain
Kingdom
Phylum ✓
Class
Order
Family ✓
Genus ✓
Species ✓

Taphonomy (life history of fossils)

Fossilization
→ Process by which living organism become preserved as geological material.

Good fossil
→ ① Durable skeleton
② Multiple skeletal elements
③ Large geographical extent
④ Abundant
⑤ Long evolutionary duration
⑥ Living in area where sediments are depositing.

Moldes of Preservation

Molds and Casts

→ They are impression of organism's original shape left in the sediments by organisms hard parts, which were dissolved or remove from the enclosing rock.

A mold is an impression of the hollow interior or the exterior surface of an organisms. They are refer to as either internal holes or external holes.

A cast is a replica of an organisms created when a mold becomes infilled by sediments.

Recrystallisation

→ Is the process which commonly occurs as when many tiny niddle like calcite or aragonite that composed the shell material breakdown and reform in fewer larger crystals. Normally the recrystallizat^n of aragonite result in the mineralogy change to calcite.

Recryst^n may result in a more stable fossil and have no visible effect on the outer appearance of a fossil.

Permineralization

→ It is a process that involve the addition of mineral matter to originally porous material.

It is common for bones, echinoderms, wood or corals, which have numerous internal pores or cavities to be augmented by minerals such as silica or calcite that ppt from groundwater moving through the pores.

Replacement

→ It is a complex chemical process that results in gradual molecule by molecule substitution of hard tissue by minerals carrying in groundwater.

The petrificat^n of fossil wood by silica rich groundwater is a good example of this, and this also is more correctly called silicification

Calm

The calcium carbonate shells of invertebrates as well as chitinous exoskeleton of trilobite are commonly silicified as well.

Pyritization : It is similar process that occurs in marine invertebrate fossils with the replacement of original shell by pyrite.

Phosphatization and Dolomitization.

→ They are rare form of replacement

Carbonization

→ It occurs when the volatile compound in an organism body (H_2O, CO_2 and Sulphur) are removed as the enclosing sediments are heated and compress during progressive burrial.

This distillation of an organism tissue results in lost of all compounds except the stable organic carbon that is the basis of most soft tissue.

This is the same process i.e responsible for the format^n of coal.

Soft tissue preservation

→ In rare instances soft tissue of plants and animals may be preserved. The soft tissue anatomy of insects, worms, flowering plants and the internal organs and skin / feathers

Compare to the fossil record in general, such circumstances of soft tissue preservation are consider examples of exceptional preservation. The vast deposit of such preservation are sometimes called: Lagerstatten (mother-lode) Because of their great importance for understanding past life.

Chitin

→ It is a complex carbohydrate that makes up the shell or exoskeletons of many arthropods, the phylum of organisms that include insects and crustaceans.

Trace Fossil

→ The study of trace fossils is called ichnology.
Record of the activity of an organism
Useful to reconstruct behavioral patterns

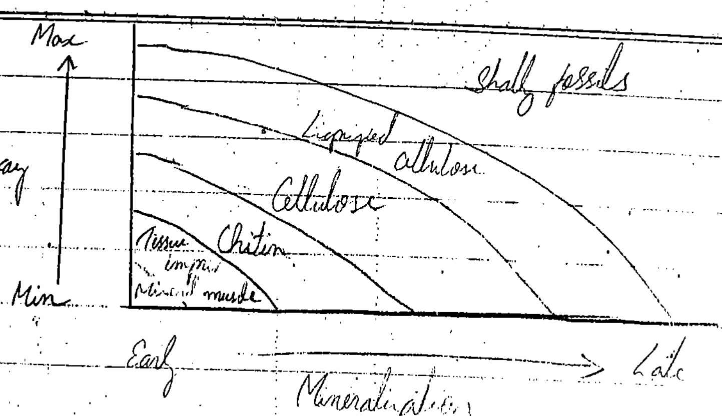
Process of fossilization

→ Living organisms
↓ Necrolysis (Removal of soft parts)
Dead Skeleton
Soft parts decay
Requires O_2
Dead skeleton
↓ Burial and Alteration
Preserved fossils

- Dead organisms are sediment
- Well preserved remains require rapid burial
- Disturbed, damaged fossils require time

Encrustation

→



Soft tissue requires immediate mineralization to be preserved as fossil

Resistance to Chemical destruction

Most resistant

- Silica - Diatoms, Radiolarians, Sponges
- High Mg calcite - Red algae, echinoderms, bryozoans
- Calcite - Foraminifera, Cocoliths; Rugose and tabulate, Corals, Brachiopods, Arthropods and some molluscs
- Apatite - Vertebrates (teeth and bones)
- Aragonite - Green calcareous algae, scleractinian corals, arthropods, most molluscs.

Least resistant

Nature of the fossil record

Is it adequate?
Is the sampling random?
Is the inference sample size?
<u>Sample size dependent!</u>

Sampling the fossils: Random
→ Sources of Biases:
① Environment
② Skeletal
③ Global distribution

II Size dependence.

How big is your sample size?

Does it affect your conclusion about the ecological diversity?

Eg:

Sample: 100, Species represented: 10

How many sp. will be there in a sample of 10 randomly selected specimen?

Why does it matter?

Sampling: Standardization

→ Interested in questions related to

- Diversity
- Extinction
- Taphonomic

Ideally standardized

Sampling: Rarefaction