# GEOGRAPHY

# By

# Neetu Singh

## 2014

Geomorphology

# Part 1

## UPSC Optional

# Geography

## By Neetu Singh

## Vol-2

## 2014

1. Geomorphology
2. climatology
3. Oceanography

Date
17/02/2014

Sustainability : Conservation not preservation

NCERT → Class Notes → Model Answers

"Physical Vs Human" Part

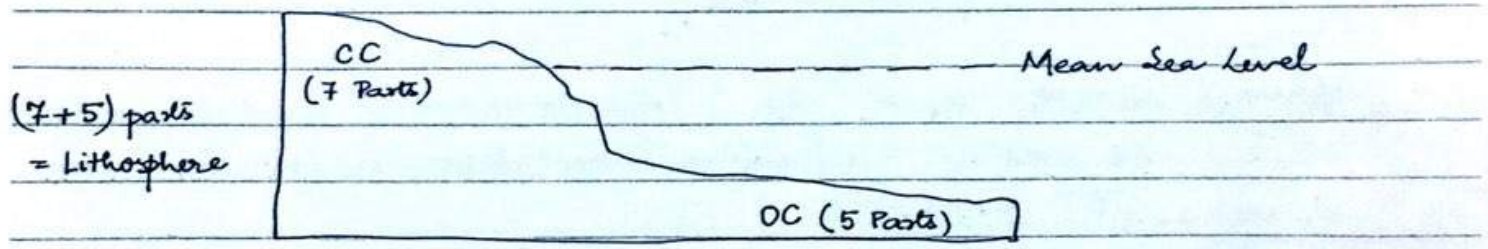
GREAT INDIAN DESERT is also a PLAIN.

↳ Environment : Lithosphere*, atmosphere*, hydrosphere, biosphere

↳ Pillars of Syllabus : (Total 5 in Block 1) → Geomorphology, Climatology ← Oceanography, Bio & Environment Geography

MACROSCALE RELIEF:

1st Order Relief : Land/Continental Crust & Oceanic Crust




Lithos = Brittle

In geomorphology, we study 7 continents (i.e. CC)

↳ Features of CC

↳ Study of 1st realm of environment

Lithosphere, the outermost layer of the Earth

Causes of features : Endogenic & Exogenic forces

Aravalis are OLD FOLD mountains.

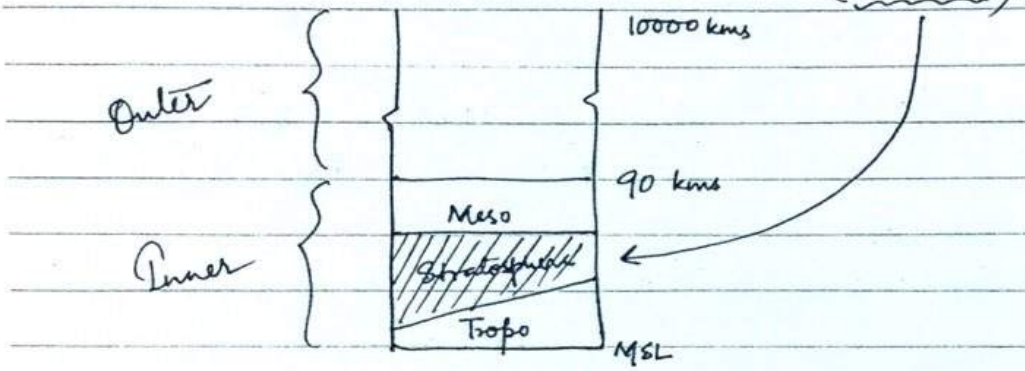
Himalayas → NEW → →

JAM

Processes
⇓

variability developers → Endo
wellers → Exo
} Reason for dynamism for CC.

matology : 2nd Realm : Atmosphere
: NCCA
National Carbonaceous Aerosol Programs: Indian Middle Atm. Program (I-MAP)




posphere : Densest ; Maxm. atm. ; Comprises components responsible for CLIMATE
All weather mechanisms takes place here (WEATHER LAYER)
JET STREAMS

opical Monsoonal Climate : INDIA

Under Climatology

RUSSIAN CLIMATE : Only 2 types — TAIGA, TUNDRA → Russian name for forest; ↳ Largest biome

Climatology → Weather Mechanisms
→ Climatic Prospects

Study oceans and their marginal extensions (in Oceanography)
Caspian Sea = Inland
Mediterrean Sea = Marginal

Marginal extensions have connectivity to oceans.

Ocean Water properties → SALINITY → These are Applications of climatology
→ TEMP. →

Photoatrophs & Decomposers ⇒ Both are important

Paper II Physical Geography :

# Physical Setting + Resource
# Indian Geological Structure
} of India

LOCK (1)

Paper 1 : Geomorphology
Climatology
Oceanography
Biogeography + Envt. Geo.

+

Paper 2:- Physical Setting & Resource
- Indian Geology

×

HUMAN GEOGRAPHY

# Demography
→ Population
[ Trends & Patterns } P1
Migration with theories
In Indian Context } P2 ]

# Settlement
→ Temporary
→ Permanent
→ Urban Vs Rural

Economic
Extractive
Manufacturing
Facilitative
Reproductive (Agriculture)

Other

Today's Social Forestary = "Economic + Green"

NCR & NCT
↳ Political

AREAS outside the political boundaries as well.

Economic Geography : ① Agriculture
② Industry
③ Trade, Transport, Comm.

Kishan Vision Project
CONCOR

thers :
egional
litical – Space Politics
eographical Thought

isa-On-Arrival" → Boost Tourism

nventional Map Marking

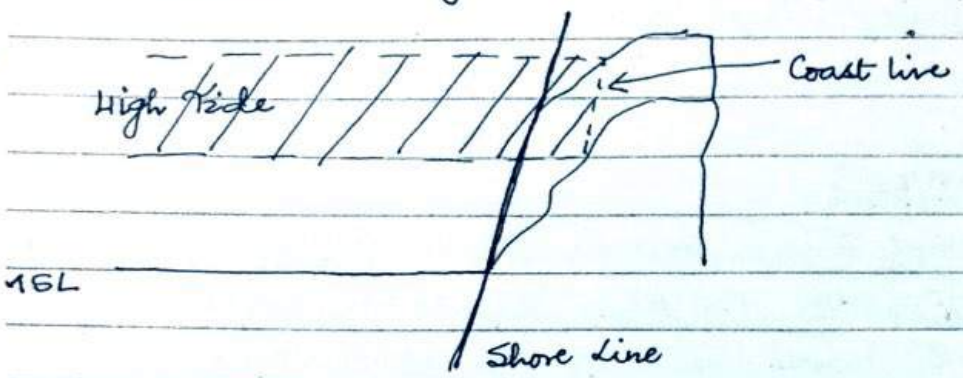
rient Black Swan → 6th Edition.

# Geography

date
18/02/2014

**Relief :**

1st Order : Macro-divide of Earth (CC & OC)
2nd Order : Mountains (CC) ; Mid-Oceanic Ridges (OC)
3rd Order : Valleys, Deltas (CC) ; Generally missing (in OC)




Endogenetic Forces : Variability generators ⇒ 2nd Order Relief Feature
Exogenetic Forces : Levellers

- Cutting Down (Erosional) — Eg. Valleys
- Depositional — Eg. Delta

## RELIEF FEATURES :

Fundamental principles of physical geography takes into account the study of relief features. Technically relief features are distinguished into 3 prominent categories :

1) Ist Order Relief Features.
2) 2nd Order " "
3) 3rd Order " "

**The first Order Relief Features :**

Represents macro-scale divide of lithospheric features including the CC & the OC. In the content of present map of world,

st order Relief is depicted as 7 continents & 5 ocean floors. he 1st order relief features largely represent their ORIGIN o be related to cooling & solidification of the Earth's Crust, ome 4000 million years ago. They, however, also represent subsequent modification regulated by drift of the continent nd the ocean floor.

## 2ND ORDER R.FEATURES :

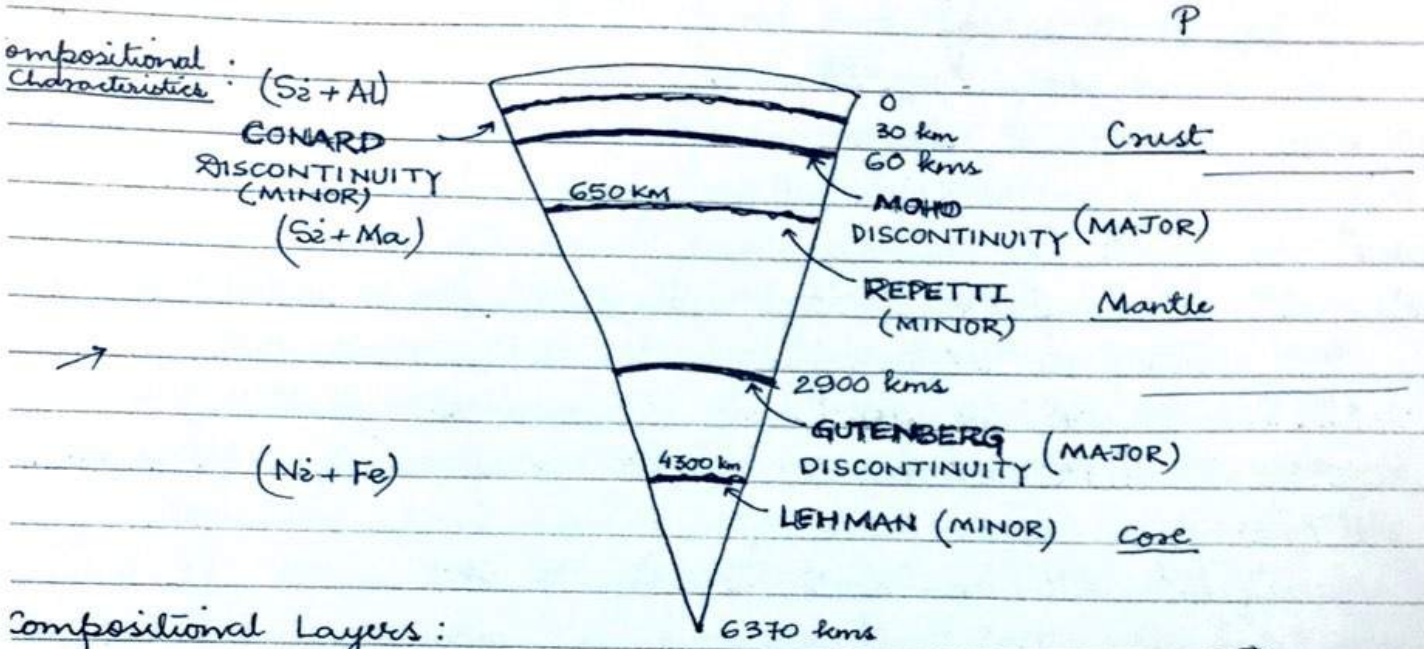
These features in comparision marks their development due to he effectivities of ENDOGENEC FORCES. These forces originate INSIDE the Earth's crust and result into development of VARIATIONS on the earth's surface. The endogenic forces, therefore, are recognised as variability developers. These includes mountain building & vulcanism as important processes. These generate features like mountains & plateaus on the CC, sub-marine ridges & trenches in the OC.

## 3RD ORDER R.FEATURES

These include the effectivities of exogenic forces. These forces are defined to be originating on the surface of the earth & work as LEVELLERS. For exogenic forces, 3 fold task therefore is commonly applied. That are: eroding, transporting & depositing. n the effectivities of these activities, carried on by exogenic orces, they developed. 3rd O.R.F includes erosional features like alleys & depositional features like deltas. The exogenic forces ncludes rivers, wind, glaciers, sea waves and underground water. s all these levellers are effective only on the CC, there is eneral absence of 3rd ORF in oceanic crust.

*Continental Shelf

General absence of 3rd O.R.F. in the oceanic crust is attributed to the fact that MEAN SEA LEVEL FORMS BASE LEVEL OF EROSION. It is however that the change of climate results in fluctuations in the base level of erosion generating the possibilities of development of 3rd order relief features along CONTINENT MARGINS. (meaning continent shelfs).

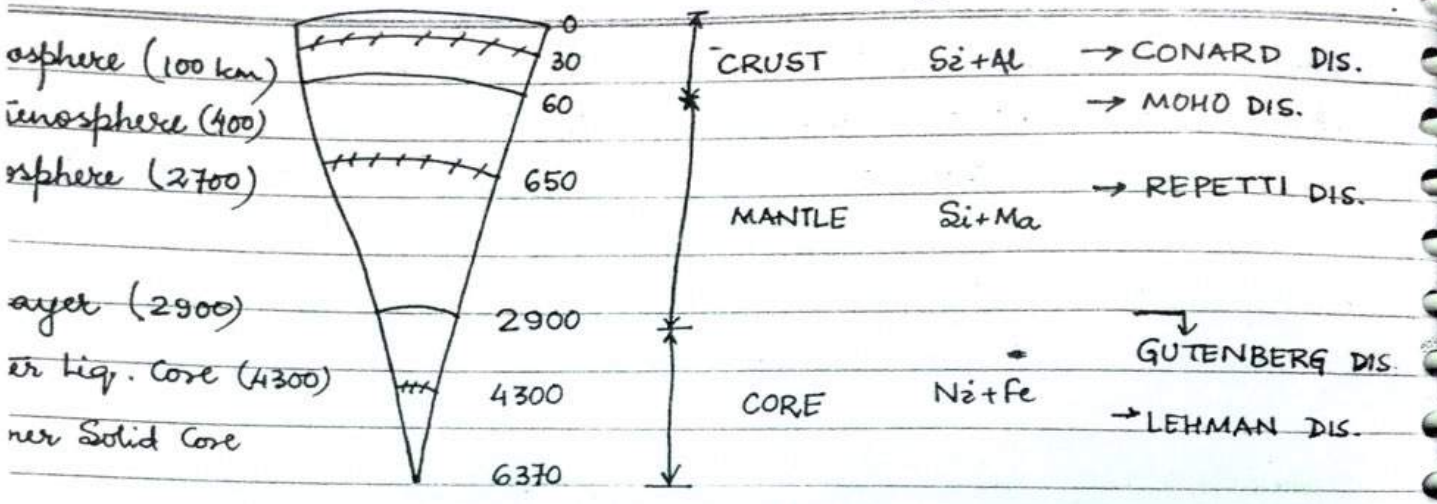



Compositional Layers:
↳ Crust, Mantle, Core

Mechanical Layers:
↳ Lithosphere (brittle): 100 km ✓
* ↳ Asthenosphere (Semi-Liquid Plastic): Upto 400 km Much molten than Mesosphere
↳ Mesosphere (Brittle): 2700 km
* ↳ D' Layer (Plastic): 2900 km
↳ Outer Liquid Core: 4300 km (Lehman Discontinuity)
↳ Inner Solid Core:

rth's Interior

① Lighter
② Plastic →




lastic

RTH'S INTERIOR:

. terrestrial planet Earth in its genesis process experience idual cooling, solidification which was combined with FASSING & SORTING effects. In the combination of these processes, ucture of Earth's interior involved the development of 3 CONCENTRIC pers:

THE CRUST, THE MANTLE & THE CORE.

THE CRUST is the outermost layer of Earth's interior that extends upto the depth of 60 kms. At this depth, compositional discontinuity alled MOHO Discontinuity is identified. It is in accordance that the utermost layer of the Earth is compositionally lightest density material ade SiAl (Silica and alumina). Within SiAl at approximate depth f 30 kms, CONARD DISCONTINUITY is demarcated distinguishing outer, lighter SiAl from denser inner SiAl. Mechanically, entire crust forms part of lithosphere that is outer brittle layer of the Earth.

(Lithosphere = Crust + 40 kms of Upper Mantle)

2) THE MANTLE: It is the second layer of the earth's interior which accounts for approx. 80% of the Earth's volume extensive from MOHO discontinuity (60 kms) to Gutenberg Discontinuity (2900 kms) Mantle represents transitional compositional layer called SiMa (Silica + Magnesium). Compositionally, this layer is divided into 2 unequal parts as outer lighter SiMa & inner denser SiMa demarcated at a depth of approx 650 kms called REPETTI Discontinuity. Mechanically, mantle involves 4 out of 6 layers of the Earth's interior: the brittle lithosphere accounts for upper 40 kms of mantle largely comprising oceanic crusts. In between 100 kms to 400 kms of depth, partially molten SUBSTRATUM asthenosphere is demarcated. This mechanical layer represents its development due to temperature increase caused by frictional drag of lithosphere floating over asthenosphere. It is this floatage that forms the cause of genesis of endogenic forces. Beneath asthenosphere, the mechanical layer called mesosphere extends upto the depths of 2700 kms. Mesosphere forms mechanically brittle layer representing the effect of termination of frictional drag and increased pressure of overlaying layers. The lower 200 km (2700 - 2900 kms) forms the 5th mechanical layer in mantle called D' layer. In the effect of radioactive core, substansive rise of temperature makes this layer partially molten.

THE CORE: It is the innermost layer of the Earth that compositionally forms the densest layer, comprised of Nickel & iron thus called, NiFe. Mechanically, this innermost layer representing the effect of radioactive disintegration and thus actual temperature increase involves the only liquid layer of Earth's interior called outer core i.e. lighter NiFe also. It is this layer that forms the cause of earth's magnetic properties called GEOMAGNETISM. at approx. depth of 4300 kms i.e. Lehman's Discontinuity. Outer liquid core

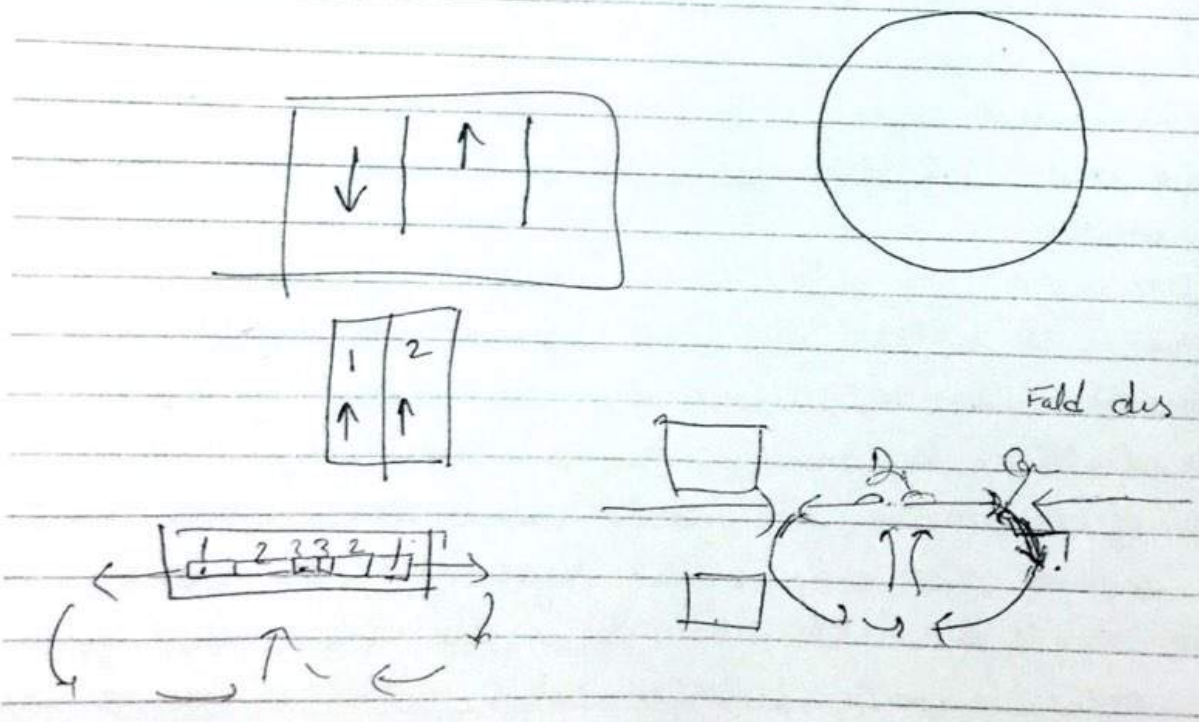
ves way to inner solid core which acts as SOLID layer
e to the pressure of over lying layers. The centre of the earth
demarcated at the depth of 6370 kms.

The interior structure of the earth is proves, consistent increase in density with increase in
pth. However, the temperature increase reveals variation,
cifically the rate of increase of temperature decreases with
creasing depth though the temperature increases thro'out
the earth's interior.

## EARTHQUAKES*

udden, endogenic force that do not generate 2nd order
lief feature but avails the windows to the study of earth's
terior.

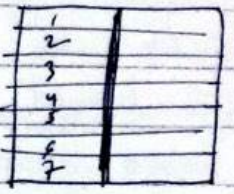
NCERT 11th Standard : Read Earthquakes



Date
3/02/2014

→ Endogenic forces are 3 but 2nd order relief features developers are two.

- Levellers → exogenic forces → generated on earth's surface → cause erosion, transfation, depo
- Sub-stratum – asthenosphere
- Plastic – 2
- Solid layer – 3
- Liquid layer – 1

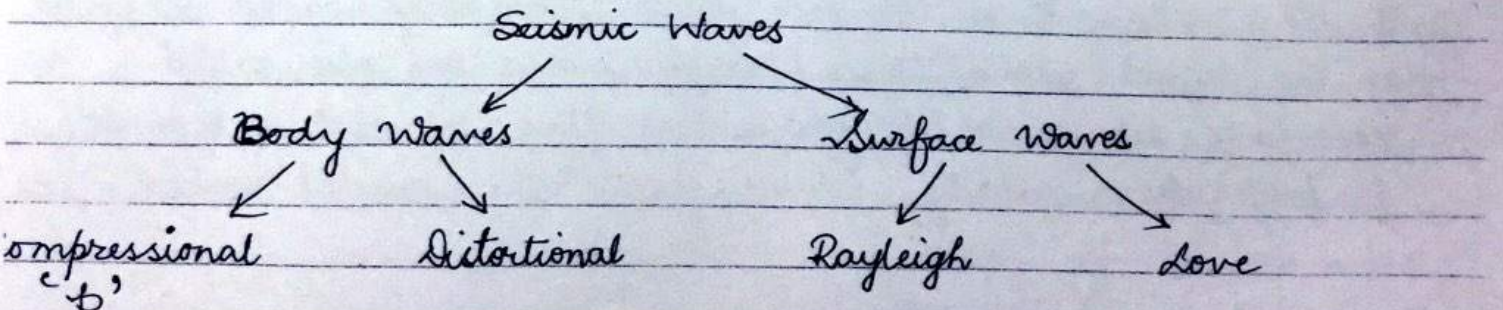



Sudden endogenic forces
Plutonic → Somewhere inside the Earth

Earthquake is defined to be the sudden tremors experienced on the surface of the Earth due to the release of accumulated energy in the deformed rocks. These tremors correlates to the focus and the epicentre. The focus is defined to be that plutonic spot where the energy gets released propagating via the adjacent rocks. These energy waves called seismic waves generate epicentre vertically over the focus on the surface of the earth where maximum impact is felt. The earthquake study involves the analysis of characteristics of seismic waves. It is this analysis that helps in outline :

) Study of earth's interior
) Earthquake as geomorphic agent.

Based on the propagation, location and behaviour, Seismic waves are classified into 2 categories :



eomorphic agent → Write only about surface waves.

ODY WAVES

hese represent those energy waves which propagates via rth's interior to be recorded on the seismograph in diff rts of the world. These energy waves are classified in bsolute accordance to their nature of propagation. The marcated categories of body waves includes: compressional aves and distortional waves.

The compressional waves form those body aves which propagates via the earths interior by compressing e media. In the propagation of these waves rocks gets ompressed only to expand beyond their original volume as he energy waves travels via it. In this sequence, propagation f these energy waves generates alternating sequence of ompression & expansion influencing the volume of the medium hese energy waves are also called primary or 'p' waves s they are the fastest moving seismic waves moving at a elocity of 7 kmps via the crustal rocks and therefore are first be recorded on the seismograph.

In comparision, the distortional waves form he body waves which propagates by inducing shearing stress. t is because these waves propagate by pulling rock particles p & down ⊥r to the direction of wave propagation. In this ffect, it generates distortional effects i.e. influencing Shape f the rocks. It is therefore that these body waves disappears n the liquid media. These energy waves are also called secondary waves or 'S' waves as they represent 3.5 kmps f propagation velocity, travelling via the crustal rocks.

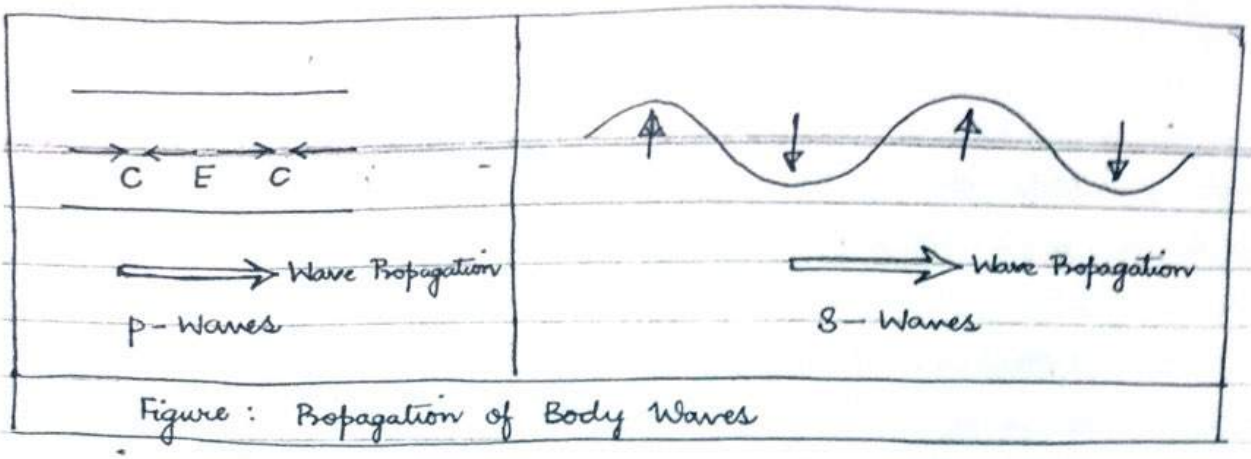



Figure : Propagation of Body Waves

## BEHAVIOUR OF BODY WAVES & EARTH'S INTERIOR

The primary waves in its compressional propagation is capable of propagating via all the likely mediums in the earth's interior. However, in the change of the medium it marks the modification in its velocity as well as in the direction of its flow. As the inelasticity of the liquid makes p-waves significantly reduce its velocity, this medium justifies disappearance of secondary waves as liquid cannot bear shearing stress. In the beginning of 20th century, analysis of seismographic records make the scholars conclude shadow zone which are defined to be that opposite part of the earth's surface in context of earthquakes focus where no energy wave is recorded on the seismograph. Enlargement of the study of shadow zones proved that shadow zone for S-waves run half the circumference of the earth on the opposite side of the focus. as these energy waves do not propagate beyond Gutenberg Discontinuity (2900 kms) proving outer core to be liquid. In comparision, refracted course of the primary waves causes the development of divided shadow zones along either side of the focus b/w 103° and 143°, that is not more than quarter of the circumference of the Earth. It is in regards to the analysis of seismic wave behaviour that both the plastic medium (asthenosphere & D' layer) are referred to be LOW VELOCITY ZONES. Similarly, Gutenberg Discontinuity & Lehman Discontinuity are highlighted to be regulators of seismic wave behaviour. It is in accordance to the minute analysis of the

smograph records that the detailed analysis of the Earth's interior
ucture have been facilitated.

unamis of marginal water bodies

EARTHQUAKE AS GEOMORPHIC AGENT / SURFACE WAVES

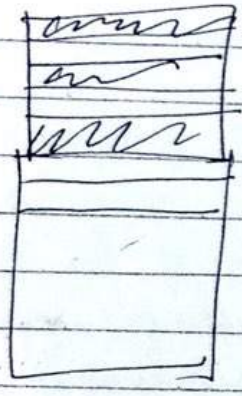
he energy waves released at the focus when readily escapes
the surface generating epicentre, there is the development of
<u>rface seismic waves</u> which propagates only on the earth's
rface It is these surface waves that forms the cause of
mors experienced making earthquake a natural hazard.
mmonly the surface wave are the slowest moving energy
aves with velocity not more than 2·5 kmps. These energy
aves generates tremors are capable of inducing secondary
zards as landslides, avalanches or liquefaction. primarily,
wever, they represent the possibilities of ground shift as the
ost recognised geomorphic effect. The possible nature of ground
ift includes horizontal ground shifts & vertical ground shift.
he <u>horizontal ground</u> shift is caused by love waves that
olves propagation called <u>weeping motion</u>. In comparision,
rtical ground shift is caused by Rayleigh waves that registers
easwell motion. These primary effectivities on the continental
rust represent restricted geomorphic influence compared to
<u>e oceanic crust</u>. High intensity submarine quake when results
nto development of Rayleigh waves, there is the genesis of
evastating secondary hazards called tsunamis or SEICHES.

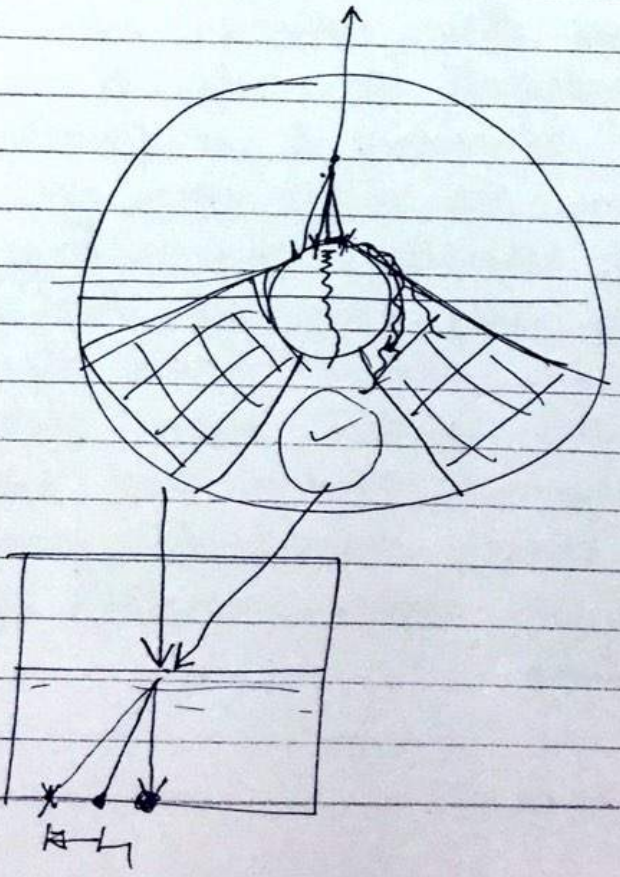
<u>Tsunamis</u> are defined to be seismic sea
aves which unlike ordinary seawaves involve the movement of
ntire water mass. These sea waves in the <u>open water</u> involves
ypical characteristics of being long waves ( wavelengths in the

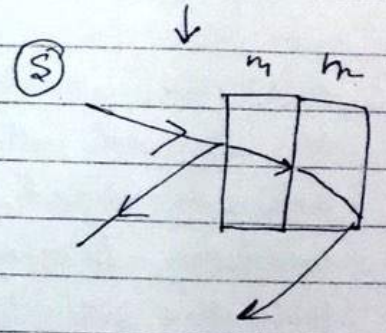
range of 150-160 km), short heighted (wave ht. not more than 3 m) and fast moving waves with velocities upto 800 kmph. Toward the shore line, however, these waves completely transform into slow moving gigantic waves with wave hts. upto 30 m. It is these gigantic waves that poses as secondary hazards caused by earthquakes. In accordance to its surfing effect as well as delayed backwash, tsunamis in marginal water bodies are called seiches which are more specific in creating secondary hazards as have proximate shoreline.

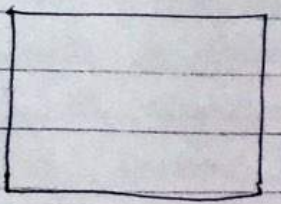
1935 → Richter Scale

Ahaggar Mts. → Ancient / Part (conical mountains) on shields } in ALGERIA in AFRICA
→ Special categories of mountains
→ Conical shield







02/2014

Lappland → European Shield
Central Russian Upland : Ancient plateau
Ural Mountains — Old fold mountains (due to compressional stress)
Alps → Young fold mountains
Pamir Plateau :
(Roof of world

CHRONOLOGICAL DEVELOPMENT OF RELIEF :

Movement of lithosphere over asthenosphere in the entire history of the planet earth have been because of development of different types of relief features. The analysis of these relief features in the chronological sequence is attempted as:

Ancient relief
Old "
Young "
Youngest "

first three categories represent 2nd ORF and ancient relief represents the shields of the world which re formed due to the cooling & solidification of the Earths ust. Developed some 4000 million years ago, shields represent mation process of lithosphere. However, being subjected to fectivities of levellers, they have lost their original size & ht. bresenting part of the continent rather than complete nlevents, mostly shields represent ancient plateaus as Canadian ields & Brazilian Highlands. However some parts of the shields ntinues to project conical characteristics forming the examples ancient mountains as Agghar Mountains of Algeria & tamersley of Australia.

The old relief dating back to 600 million years ago, represents 2 endogenic effectivities with old fold mountains & old block mountains distinguished compressional stress resulting in the formation of old fold mountains includes Appalachians, Urals and Great Dividing Range (of Australia) as excellent examples of. In the effect of tensional stress, the old block mountains involves the examples of Mantequiera (Brazil), Drakensberg (S. Africa). In the old relief, formation of table land is also specifically highlighted as lava plateau (plateau of Borborema in Brazil, Piedmont plateau, Patagonia in Argentina and Intermontane Plateau as Tarim basin in China).

The young relief represents active boundaries & it is therefore that maxm. of the focus of geographical studies remains confined to young relief. It is the most well deciphered development mechanism of these relief features that is applied to interpret the formation of older counterparts. Among the young fold mountains Himalayan Ranges of Asia and Western Mountains of North America forms significant examples with range of Intermontane plateaus as Tibetan plateau, Iranian plateau, Columbia plateau & Colorado plateau. The young block mountains largely relates to the east African Rift Valley which also corresponds to young lava plateaus as Ethiopian Highlands & Kordofan Upland (Sudan).

The youngest relief depicting the 3rd OR are largely lowlands developed by running water (rivers). Among the important examples: Central Lowlands in N. America, Amazon basin in S. America, North European Plains in Europe are included.

Human Geo.

LTURAL REGIONS

ndamental of human geography correlates to the cultural ntities of the population. These identities involves all the pects of human living including the religious beliefs, the nguage spoken, fundamentalist or cosmopolitan ideologies, ture of economic activities, food & clothing culture as ell as demographic attributes. To analyse these diverse d dynamic elements of culture, it is the classification opounded by historians Boak & Webb that is taken into nsideration. These historians have classified global cultural gions on the basis of all the cultural parameters rring the exception of language. In accordance to ir classification, the world is divided into 7 cultural gions:

Boak & Webb

Majors

i) Christianity
ii) Islamic
iii) Indic
iv) Semitic (SEIMITIC)

Minor

(i) Oceanian
(ii) Meso African
(iii) SE Asian

Oceanian → Australia & New Zealand

→ Melanesia
Micronesia
Polynesia

## CHRISTIANITY REALM:

This realm as the major cultural realm is identified with largest geographical extension incorporating entire Europe, and NEW WORLD. This cultural region is analysed geographically in the content of religious sects that includes protestant Christianity, Roman Catholic and Eastern Orthodox Christianity. The Protestant Christianity correlates to cosmopolitan cultural identities where religion has significant restricted role in dictating day-to-day living. It is western Europe that forms the SOURCE region & anglo-America along with Australia, New Zealand forming the DESTINATION. The source region with small geographic size, larger population load depicts the example of INTENSIVE CULTURE. Demographically the source regions is experiencing the threat of DE-POPULATION as maxm. population of these countries is confined in old age COHORT group. Compared to it, the destination with larger geographic size & smaller population forms the example of EXTENSIVE CULTURE. Moreover, demographically this represents progressive to stable population profile with vast resource base and sound commercial potentiality. The destination like source regions represent the similarities in the Caucasoid Race (White People). The Roman Catholic Christianity Regions confined in Southern Europe as its source area forms fundamentalist christianity regions. Vatican City makes the node of this cultural identity with religion dictating day-to-day activities., commercial & economic growth is significantly restricted with South European countries representing the examples of economies in transition.

mographically, however, southern European countries represent
milar characteristics to that of Western European Countries that
the threat of depopulation. It is the colonial legacy
at makes Roman Catholic Christianity develop its destination
. Latin America. This destination with moderate population
ad involves extensive culture with developing economic
itus combined with NEGROIDS i.e. black race. The Eastern
thodox Christianity like roman Catholics correlates to the
ndamentalist religious ideologies. Geographically it includes
ll the European break-away countries of former USSR
nd countries of Balkan Peninsula.

ortugal, Spain, Italy, Vatican city: Roman Catholics Source
Estonia, Latvia
Russia, Belarus, Ukraine, Moldova
Balkan Peninsula + Break away countries of USSR } — Eastern Orthodox

Scandenivia
Low Countries
British Isles
France, Germany, Poland, Finland, + Alpine Countries
} Protestant (Source) -

) Peninsula b/w Black Sea & Adriatic Sea

Lecture # 5

Date : 21|02|2014

Islamic Cultural Realm : This major cultural realm is extensive in tropical western margins of the continents forming the example of desert or dry cultural region. It involves mere continuous geographical expanse from Northern Africa to South West Asia. Moreover, the disintegrated Central Asia, breakaway countries of former USSR also represents this cultural realm. Overall the complete region represent the example of fundamentalist religious ideologies and dominated caucasoid race. They mark distinction from each other in terms of nature of economic activities.

The entire range of Gulf countries depicts the examples of "Rich countries" which represent crude oil as the cause of their economic status as well as their opening to the global community. Distinguished from them are the entire range of Northern African countries, Central Asian countries, as well as caucasus states which represents developing economic states involving the combination of agricultural as well as manufacturing industries. The extreme range of cultural and economic characteristics of this region is depicted in the reference to Turkey, the only secular state of the region, proving to be culturally most advanced along with Afghanistan and Yemen, which represents poorest demographic and cultural identities with backward economic status. This entire cultural region incorporates the similarity of involving strong dictate of religion in the day-to-day living.

## THE INDIC CULTURAL REGION :

s region represents S. Asia which involves multilingual, ulti-racial, multi-religious cultural identities. The only mmon element identified with this cultural region is 'RAL AGRARIAN economic setup. Starting from its genesis its present profile, S. Asian culture represents to be docentric. For the countries with approximately 70% of the al population living in rural areas, agricultural economic ip is justified.

On the religious front, India, the secular te depicts distinction from the Islamic states of istan, Bangladesh and Maldives; Hindu state Nepal, tribal ligion Bhutan and Buddhist dominated Sri Lanka. In the nilar category all the constituents of Indic Cultural gion represents ORIENTAL CULTURAL IDENTITIES. These entities depicts joint family norms, population as cial capital, societal and religious values with minating community living.

## EIMITIC CULTURAL REGION :

e oriental culture overlaps with this region. Geographically, his cultural region belongs to East Asia where the ominating similarity is only Mongoloid race, i.e. yellow ople. In this cultural region, religious and economic liversity is of prominence where Japan represents SHINTOISM, hina - Confucianism; North Korea, South Korea and Taiwan - uddhism and Mangolia - Animism. Economically, the leveloped economy Japan and Mini Japan Taiwan depicts listinction from developing China and South Korea; whereas . Korea and Mongolia continues to dominate agrarian nd less developed profile.

It is with Japan, the oriental-most country where the unique combination of RICE-FISH CULTURE in the OCCIDENTAL traits are identified. This developed country represents urban industrial characteristics combined with cultural societal bondage.

7) SOUTH EAST ASIAN REALM: This part of Asia is geographically divided into mainland and islands which forms the cause of general absence in the development of coherent cultural characteristics for the mainland of SE Asia. Buddhist religious ideologies dominates. However, Malaysia - Islamic, Laos - Animism and Singapore - Cosmopolitan depicts the diversities. Fragmented islands also further adds to the cultural diversity with Phillipines forming the example of orthodox Christianity and Indonesia as Islamic. The entire cultural region involves dominating Mongoloid race. However, in the island region, there is substantive share of Negroid population. It is the lack of coherent characteristics that justifies SE Asia to be a minor cultural realm.

MESO AFRICAN REALM: This minor realm represents 4th world communities. It is called meso-African as maximum of African countries involves such primitive population where every tribal community has its own strong cultural bondage but with complete absence of cultural links with other tribal community.

Within Africa, Bedowins - the Camel Herders of Sahara Deserts, Masais - the Cattle Herders of Savannah, Pygmies - the hunting-gathering population of Congo Basin, San Bushmen of Kalahari Desert - very well depicts this cultural realm.

* Lapland – Only plateau that extends in 4 countries
* S. Africa - Burundi - Global Hunger Index

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Side Africa, Meso-African realm correlated ~~to~~ with — kimos of Canada, Aboriginies of Australia, Monavis of w Zealand, Mongols of Mongolia, Lapps of Finland, noyeds of Russia — as all these represents primitive bal cultural identities.

THE OCEANIAN REALM :

re Oceanian realm excluding Australia and New Zealand left out with fragmented smaller islands that are argely uninhabited. It is in accordance that they represent inor, Melanasian, Micronesian and Polynesian cultural egions.

EOGRAPHY OF LANGUAGE

ultural identities involves language as important element nd thus is analysed geographically.
- incorporates demarcation of isoglosses that are imaginary es within which same language is spoken.
ith more than 5000 spoken languages in world, isoglosses re demarcated on the basis of linguistic families.
n the reference of linguistic families, demarcated cultural egions includes :

Indo-European – This linguistic family includes English, erman, French, Spanish, Portuguese, Slavick, Russian, Celtic nd Indo-iranian languages (Pakhtu, Iranian or Persian, indi)

Ural – Altaic : Includes Finnic, Kazak, Uzbek languages.

Sino – Tibetan : includes Mandarin, Chinese, Tibetan, Thai

Japanese - Korean : includes Japanese, Korean

Austro – Asiatic : includes Khmer, Laotion, Burmese, Vietnamese

Malaya - Polynesian : includes Dayak, Phillipino

(g) Dravidian :- includes Tamil, Telegu ( S. India and Sri Lanka)
(h) Afro - Asiatic :- includes Arabic

| |
|---|
| Saharan |
| Sudanic |
| Niger - Congo |
| Khoisan |

In Africa

# "GEOMORPHOLOGY"

1) Geological time scale : Relative & Absolute time
2) Forces affecting surface of Earth : Endogenic , exogenic
3) Endogenic theories :
   - Continent Drift Theory
   - Sea floor Spreading
   - Geomagnetism*
   - Plate Tectonic Theory
4) Mountain building , Vulcanism
5) Exogenic forces
6) Geomorphic Cycles - Davisian
7) Isostasy

Strata : Rock layers

EOLOGICAL TIME SCALE : → Rel. → Abs.

eomorphological studies incorporates chronological account as important requirement. It is because each leveloped landform feature depicts its characteristics in ccordance to the time of its formation. The chronological tudies are divided into two well defined categories. alled : Relative Time and Absolute Time.

he Relative Time : Forms the older approach of hronological studies which involves the attempts of dentifying the age of the rocks in relation to the adjacent rock stratas. This chronological approach is credited to NICHOLAS, who identified relative time to be referred to as chronology of succession. He based the relative time into 4 well-defined principles including:

) Principle of superimposition (Lithostratigraphy)
) " " Faunal succession (Biostratigraphy)
) " " Cross-bedding relation.
) " " Fragmental inclusion.

The principle of superimposition states "that the low ying stratas are always older than the overlying stratas representing earlier episode of deposition". This rinciple is further ~~facilitated~~ facilitated by the principle of Faunal succession which identifies that low lying older stratas ill always involve fossil remains of primitive organisms compared to the overlying stratas. The principle of cross bedding ~~Strata~~ relation depicts relative time in content of magma intrusions. It states that "intruded and solidified magma within the existing lithospheric stratas will always be

younger than the host rocks." This principle is prominently applied in the study of INTRUSIVE VULCANISM. The principle of fragmental inclusion recognizing the effectivity of exogenic forces states that "rock fragments will always be of older rock strata as such rock stratas have been subjected to erosional effectivities after their formation."

All these principles of relative time continues to be applicable in the geomorphic studies However, with the practical ~~implication~~ implementation of these principles in the land-form studies, prominent limitations called UNCONFORMITIES were realised. Unconformities are defined to be gaps existing between the stratas as they are subjected to dynamic equilibrium of endogenic and exogenic forces. In order to minimise the generalised studies, the requirement of absolute time scale was felt.

(1.2) The Absolute Time Scale :

By mid 19th Century, well defined Absolute Time Scales were developed by different geographic schools from among which, the EUROPEAN GEOLOGICAL TIME SCALE is primarily utilised in geomorphology.

Supereons → Eons → Eras → Periods → Epoch → Age
(4 in total) (10 in total)

)PEREON = PRECAMBRIAN " 4.6 by to 600 my

NS :

ISCOAN

CHAEAN — Pre Cambrian

)TEROZOIC

1. EO ARCHAEN
2. PALEOARCH
3. MESOARCH
4. NEOARCH

Eras of Archaen Eon

5. PALEO PROTEROZOIC
6. MESO -
7. NEO

Eras of Proterozoic Eon

NEROZOIC

8. PALEOZOIC ERA

Cambrian
Ordovician
Silurian
Devonian
Carboniferous
Permian

Fish Periods

APMCN

4.6my - 600my ① Azoic
600 my - 225my ② Paleozoic
225 my - 70my ③ Mesozoic
70my - 1my ④ Cenozoic
1my - present ⑤ Neogoic

9. MESOZOIC ERA

Triassic
Jurassic
Cretaceous

Periods

10. CENOZOIC ERA

ALEOGENE PERIOD

Paleocene
Eocene
Oligocene

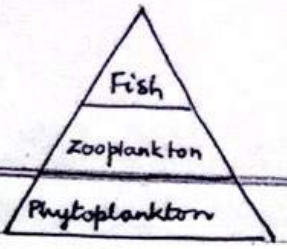
Epoch

NEOGENE

→ Miocene
→ Pliocene

QUATERNARY

→ Pleistocene
→ Holocene




Azoic → No visible life , 4600 my – 600 my

Paleozoic → 600 my – 225 my , old life , aquatic life (Primary Period)

Mesozoic → Mid-life , 225 – 70 my ; aquatic , terrestrial , aerial developm
Secondary Period

Epochs → Triassic , Jurassic , Cretaceous .

) Cenozoic → 70 my to 1 my ago , New Life , tertiary period

Epochs : Paleocene, Eocene , Oligocene , Miocene , Pliocene

Neozoic (Quaternary Period) → 1 my – till date , recent life ,

Epochs → Pleistocene (1 my – 10,000 yrs)
Holocene (10000 yrs – till date)

1) Azoic Era :

The oldest geological era that is extensive between 4000 M years to 600 M years ago. It incorporates only one epoch called pre-cambrian developed due to original cooling and solidification of the Earth's crust. Azoic constructs called shields or cratons have lost their original extension as well as height. It is, however, that they represent fundamental complex or basement rock around which subsequent developments of landform features have been registered as relief feature. Completely all shields qualify to be plateaus as Canadian Shield. However, some of the resistant parts of shield continues to project as ancient mountains as Ahaggar Mountains Economically, Azoic constructs corresponds to METALIPHOROUS MINERAL RESOURCES as in the effectivity of degassing, swift cooling, restricted sorting effect, solidifying even heavy metals in the developed shield. Richest iron ore reserves of PILBARA ( Hamersley, Australia) and CORAJAS ( Brazilian Highlands) forms excellent examples.

LEOZOIC ERA :

presenting old life, paleozoic era or primary period arked its extension between 600 – 225 M years ago. This eological era is well demarcated in the identified pochs. The lower paleozoic epochs sustained the development of aquatic life forms paving way to DEVONIAN EPOCH i.e. the fish epoch. In this epoch, well developed aquatic ecosystem is traced back. to Following Devonian epoch, prominent changes in the climate and resultant destruction of the habitat resulted in mass death and burial of aquatic organisms including carbon secreting organisms. Economically, therefore, paleozoic era is known for CARBON i.e. coal bearing stratas which belongs to CARBONIFEROUS and PERMIAN EPOCHS. The geological constructs of paleozoic era includes broken rock materials of Azoic Era as well. It is, therefore, that metallic mineral resources are also associated with this era. Geomorphologically, this era depicts its importance in the formation of OLD MOUNTAINS ( fold as well as block). Among the prominent examples are the Appalachians (USA), which correlates to world's richest anthracite coal seams (layers)

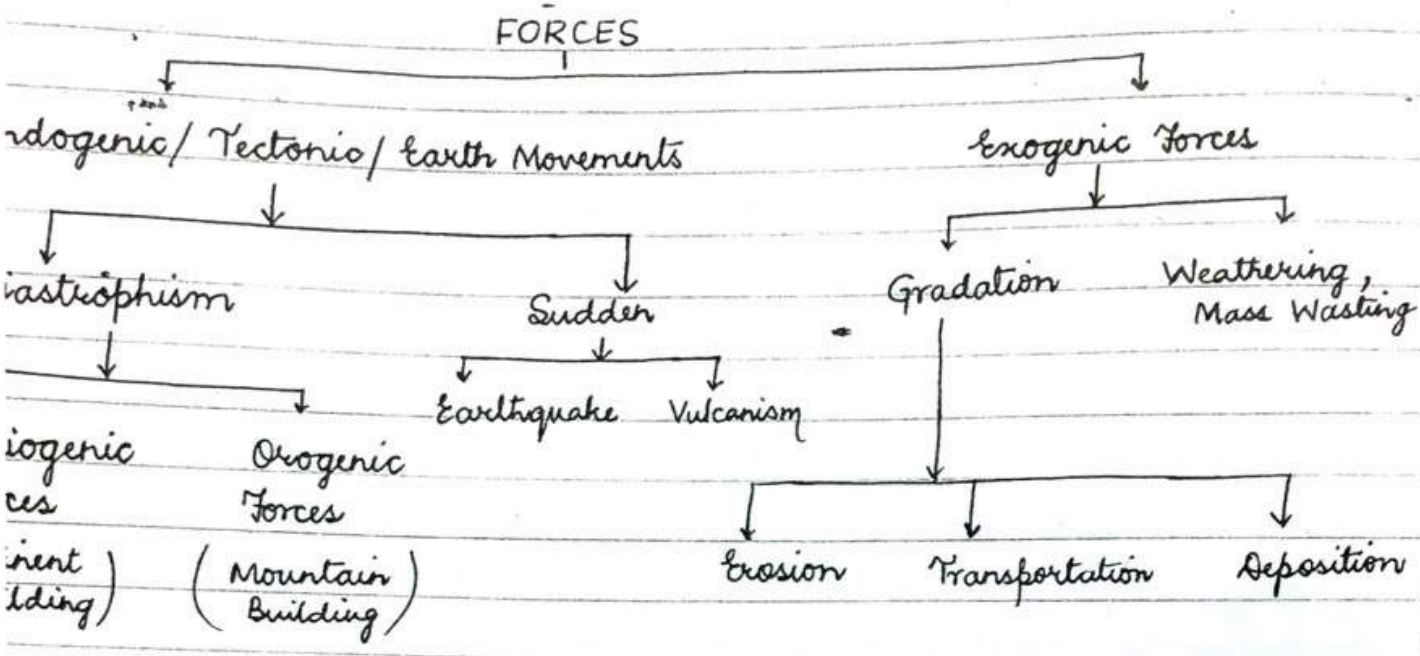
MESOZOIC ERA : MID LIFE

It is recognised to be extensive between 225 M years – 70 M years ago, called secondary period. It qualifies to be the QUIET TECTONIC ERA as it depicted TRANSITIONAL DRIFT OF LITHOSPHERIC PARTS IN ISOLATION. This era is primarily known for well developed life forms in all the habitats: aquatic, terrestrial and aerial. These fully developed life-forms are traced to CRETACEOUS EPOCHS.

## CENOZOIC ERA — NEW LIFE :

It is tertiary period extensive between 70 M years — 1 M years ago. This era corresponds to all the young relief. It is par excellent active tectonic era and is also known for evolution of new life. All the tertiary reliefs are as young fold mountains or young block mountains dominates physiographic map of world because of their elaborate heights. It is cenozoic relief that are directly deciphered in geomorphological studies. These reliefs largely depicts to be deprived of resources primarily because difficult physiography restricts the fundamental exploration of the resource relief. Cenozoic era with its well defined 5 epochs paved way to the present NEOZOIC ERA, denoting recent life and quaternary period. Neozoic era began 1 million years ago and is extensive till date. Tectonically it correlates to continuation of Cenozoic mountain building. However, have active earthquakes and vulcanism. This era is divided into Pleistocene and Holocene epochs with each of the epoch denoting the example of important developments. The Pleistocene epoch forms important present day map of the world evolved. Moreover, it represents formation of all the youngest reliefs i.e. river plains of the continents. In terms of resource, the Pleistocene epoch correlates to the crude oil and natural gas related sedimentary stratas. The present epoch called Holocene that began some 10,000 years ago before present is known as for Homo Sapiens.

# 2. FACTORS, FORCES & PROCESSES THAT INFLUENCES SURFACE OF THE EARTH




Dynamic characteristics are the topographical features developed on the surface of the Earth and is primarily related to the dynamic equilibrium of endogenic and exogenic forces. The endogenic forces are also called the tectonic forces which originates inside the surface of the Earth and registers influence on the Earth's surface as the development of these forces are directly related to the movement of lithosphere over aesthenosphere. These processes are also called Earth's movement. In the context of time taken by these forces, they are categorised into :

Diastrophism

Sudden Forces

Diastrophism : It forms slow processes that take million of years to generate variations on the surface of the Earth. In accordance to their nature of effectivity, they are classified as epeiriogenic and orogenic forces. The epeiriogenic forces are continent building forces that are

vertical in nature. These forces correlates to the vertical upliftment or subsidence of large mass of land. Practically epeiogenic forces are not identified in the formation of continents as all the continents of the world have marked their genesis around the shield or craton. It is these fundamental complex that supported the subsequent developments of endogenic and exogenic processes evolving present shape and size of the continents. In these developments, attachment of "Terranes" are specified as important development. Terranes are defined to be "small fragmented shields which eventually buckles up with main shield enlarging the size of the continent. Among the prominent examples are included : CHILOE ISLAND in S. America and VANCOUVER ISLAND in North America.

Orogenic Forces :

These are the horizontal forces that results in the formation of mountains. These forces are analysed as DEFORMATION or STRAIN. In accordance to the dimensions of orogenic forces, the deformation is classified into folding and faulting.

Folding as deformation is the outcome of compressional stress with the rocks acting in ductile manner. In the effect of compressional stress, original rock strata generates out Anticline and Syncline. The Anticlines are defined to be upthrown part of the fold. Syncline is, in comparision, the down-thrown part of the fold. It is in accordance that anticlines make the mountain peaks and synclines, the valley. The geometry of the fold is applied to interpret the nature of compressional stress applied to the rocks in the

development of the fold. It includes HINGE, AXIAL PLANE, and LIMBS. The limbs are defined to be the parts of the Anticline or the syncline. The intersection point of limbs is called the HINGE and the plane developed by combining the HINGE in both horizontal and vertical direction is called AXIAL PLANE. It is on the basis of the angles that limbs make with the axial plane that the types of the fold are classified.

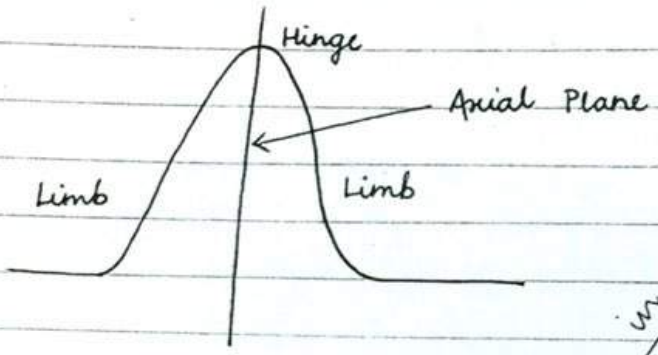



Figure: Geometry of fold.

- Fold terminology in 2-D:

HINGE & LIMB →

* The hinge point is the point of maximum radius of curvature for a fold.

* The axial surface is the surface defined by connecting all the hinge lines of stacked folding surfaces. Can be planar.

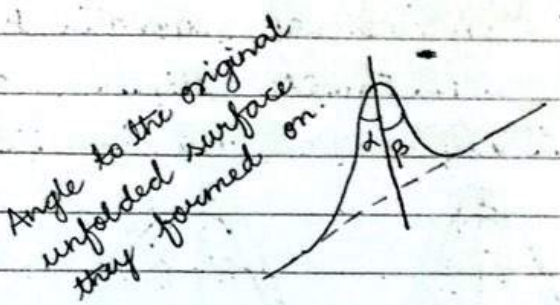
# LECTURE # 7

Date: 23/02/2014

## DIFFERENT TYPES OF FOLDS :

The nature of the compressional stress experienced by the ductile rocks is interpreted by the angle that the limbs makes with the axial plane. Primarily, therefore, folds are classified into 5 different categories:

i) Symmetrical Fold
ii) Asymmetrical Fold
iii) Isoclinal Fold
iv) Recumbent Fold
v) Nappe




### 1) Symmetrical Fold :

It is identified to be the fold type where limbs make similar angle with the axial plane. This represents similarity of compressional stress experienced from either sides. This type of folds are identified with Western Cordilleras of N.Am. and Andean Cordilleras of S.America.

### 2) Asymmetrical fold :

In this type of fold, the limbs make different angles with the axial plane. It, therefore, represents variation in the compressional stress from either sides. Both the Himalayan Cordilleras and Alpine Cordilleras are examples of asymmetrical folds.

### 3) Isoclinal fold :

It is commonly designated as special type of symmetric fold with a tilted axial plane. The Middle Himalayas throughout its expanse are of this fold type.

### i) Recumbent fold :

When the tilt of the axial plane becomes stronger making it horizontal or near horizontal, the fold developed is recumbent fold. It is also called sleeping fold and do not represent complete mountain range. However, are correlated to all the four young fold cordilleras.

Nappe or Broken fold

It is also a major fold wherein the induced compressional stress & surpasses the ductile characteristics of the rocks. This type of broken fold corresponds to either "terminus of greater Himalayas which corresponds to the SYNTAXICAL BENDS along River Indus and River Tsangpo ( Dhang in Tibet)

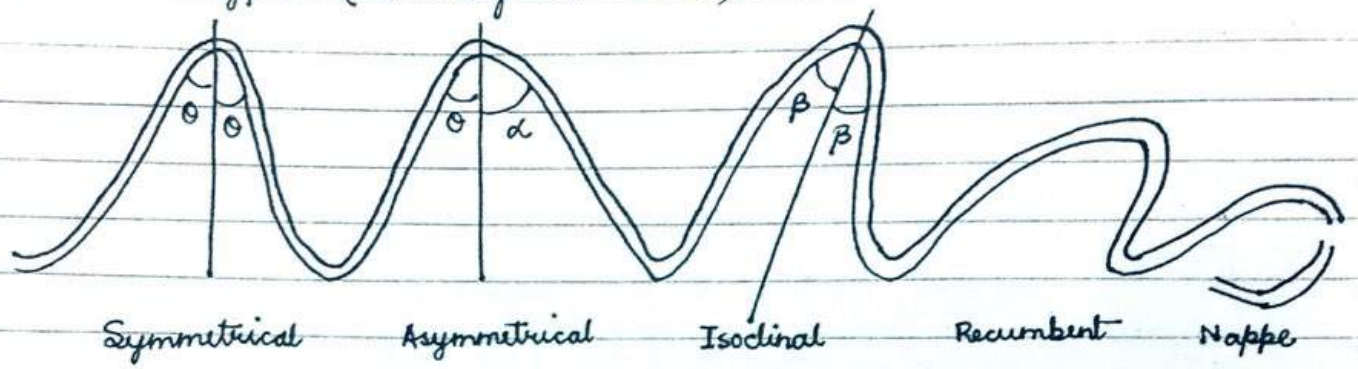



FIGURE : DIFFERENT TYPES OF FOLDS

MINOR FOLD TYPES :

These folds incorporate variable combination of geological construct and compressional stress. These are largely deprived of global representation. Prominent examples include fan fold, chevron fold & monoclinal fold.

Fan fold – Represents the category where multi-directional compressional stress have facilitated genesis of IMMATURE anticline and syncline called ANTICLINORIUMS & SYNCLINORIUMS respectively.

Chevron fold : This fold has unique structure generating geometrically correct triangular folds. It is variations in the compressional stress that open & closed folds are also categorised to be minor type of fold.

Monoclinal Fold :

It is a step-like fold in rock strata consisting of a zone of steeper dip within an otherwise horizontal or gentle-dipping sequence. It has only one limb depicting the condition where part of rock have ductile characteristic and another part brittle. If the complete rock is brittle in nature, compressional stress generates reverse faults.

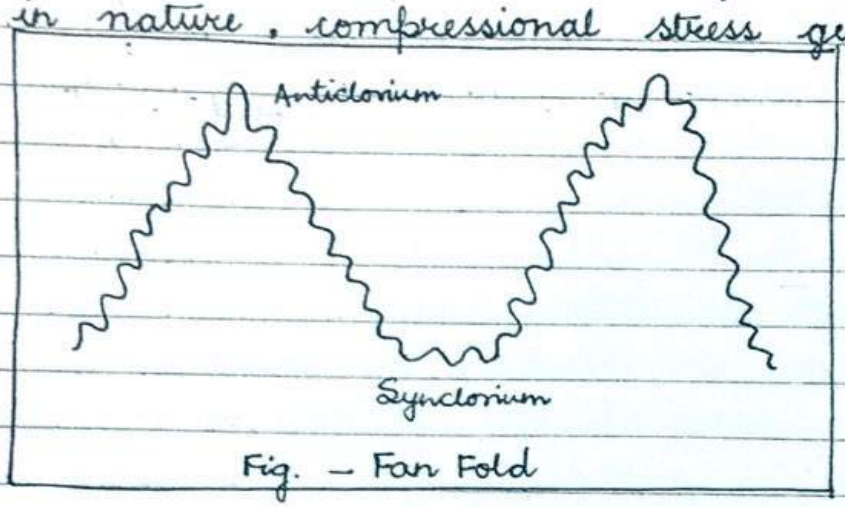



Fig. – Fan Fold

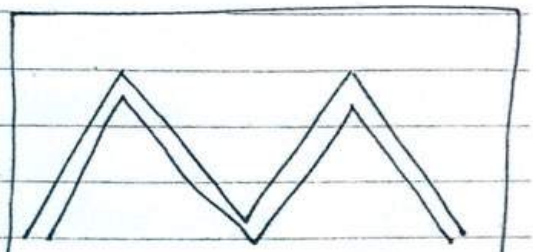
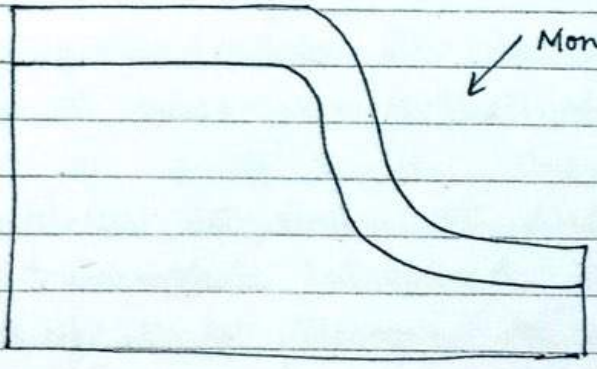
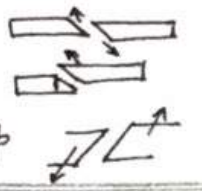


Fig. – Chevron Fold



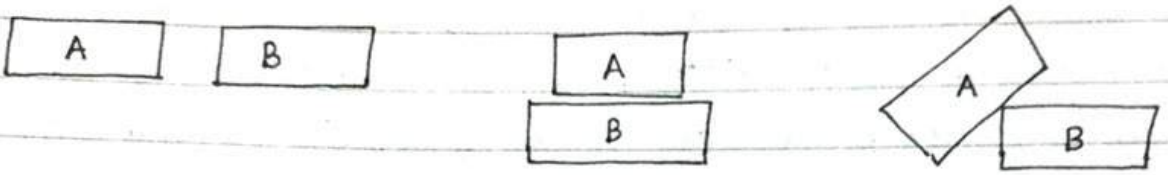

Reverse Fault : These are of 2 types namely THRUST FAULT & OVER THRUST FAULT. The overthrust fault is that type of reverse fault where there is absolute horizontal override of one slab on the other. However, elevation increase due to the ride of one slab over the other with

Fault — Normal, Reverse, Strike Slip



Hanging Wall
Footwall

re angle of 45° or more denotes the THRUST FAULT. It is this category that makes reverse fault applied to mountain building process with all the global examples confined along mightiest young fold mountains Himalayas.




Overthrust Fault — Thrust Fault

Faulting (Tensional Stress)

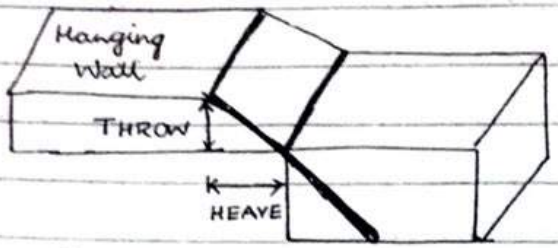
Faulting is defined to be plastic deformation leading to brittle failure or breakage. This strain or deformation is commonly correlated to the tensional stress which in turn is classified as NORMAL & OR TRANSVERSE tensional stress.

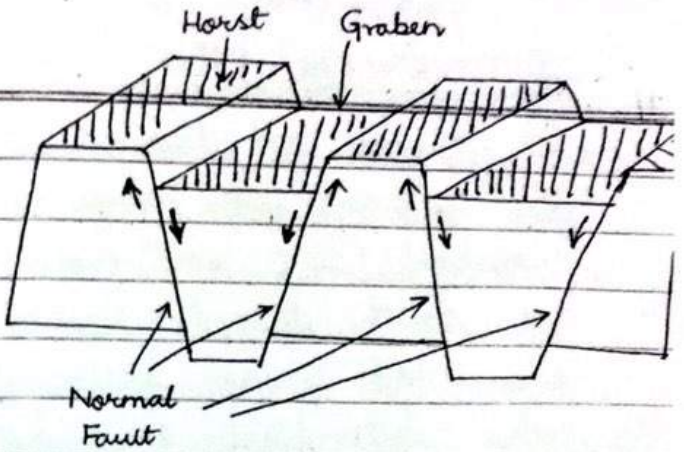
The normal tensional stress is correlated to the pulling apart effect which on brittle failure leads to the development of NORMAL FAULTS.

The transverse stress correlates to slide pasting effect, which when results in brittle failure, causes the development of transverse fault.

In both the cases, the development of fault stand synonym to horizontal displacement. This horizontal displacement in the geometry of the fault is called HEAVE. In the case of development of only heave, the developed fault is called STRIKE SLIP FAULT. For the mountain building process, simultaneous requirement of THROW i.e. vertical displacement is mandatory. The developed topography is called HORST & GRABEN topography or BLOCK MOUNTAIN WITH RIFT VALLEY, depicting DIP SLIP FAULT.

Pangea in Greek means "entire Earth"




Horst & Graben Topography

MINOR FAULTS : Transform Faults

1) These represent the development of brittle failure due to the differential rate of movement of the crustal slabs in the SAME DIRECTION.
2) These are, thus, examples of Strike Slip Faults
3) These faults ~~led~~ leads to the formation of lava plateaus on the continental crust and development of fracture zones with ancillary ridges in the submarine floor.
(4) These do not correlate to dip slip fault.

## THEORIES ON "ENDOGENIC FORCES"

Chronological development of endogenic forces with Azoic, Palezoic and Cenozoic formations are explained in the light of plate tectonic theory. This theory in turn marks its development in the gradual evolution process which involves

1) Continent Drift Theory
2) Sea-floor spreading

Humbolt (1801)
Antonio Pellegrini (1858)
F. B. Taylor (1910)

A. Wegener (1915)

# ONTINENTAL DRIFT THEORY

Its genesis is traced back to early 19th century when the pillar of modern geography, German scholar Humboll (1801) outlined striking similarity of the shoreline of South Atlantic Ocean.

His work was followed on by Antonio Pellegrini (1858) who attempted the first map of the region highlighting the similarity of shape of the shoreline.

The complete theory on the drift of the continent of the specified region was, however, attempted by F.B. Taylor (1910).

In the global perspective, the study of continent drift is credited to the German Climatologist – Alfred Wegener (1915) as the compilation of his conclusions of the analysis of PALEOCLIMATOLOGY.

In his attempt of identifying the nature of the climatic conditions experienced by different locations in different geological time, he concluded prevailing of contrasting climatic conditions compared to present latitudinal locations.

To prove these contrasts, he concluded "drifting of the continents from their "original" latitudinal locations/ positions to the present position.

In order to specify the cause of the drift he concluded " Free float of SIAL over SIMA in the effect of "Gravitational Force" & "Tidal Force"

Based on these factors, the propounded continental drift theory identifies the existence of the super-continent PANGEA to be existing till CARBONIFEROUS EPOCH surrounded by super ocean called PANTHALASA.

The beginning of disintegration of Pangea traced

| | |
|---|---|
| Angaraland<br>Gondwanaland<br>Tethys Sea | Equator-ward movement<br>– Indian, Arctic, Southern Ocean<br>West-ward movement<br>– Atlantic & Pacific |

from Carboniferous epoch, was simultaneous to the division of Panthalasa. Initially, Pangea got disintegrated into unequal parts called Angaraland and Gondwanaland.

Angaraland/Laurasia, formed the northern part of the Pangea, comprised of North America and Eurasia. The Gondwanaland, the southern part of Pangea incorporated S. America, Africa, India, Australia and Antarctica as major constituents. In between Angaraland and Gondwanaland, the intruded water of Panthalasa formed Tethys Sea. Continuation of disintegration due to gravitational force leading to equator-ward movement generated buckling up of Eurasia with Africa and India like landmasses along with the formation of Indian Ocean, Arctic Ocean and Southern Ocean. The disintegration due to the tidal force leading to the westward movement facilitated formation of Atlantic Ocean and substantive contraction of Panthalasa making the largest ocean of the world with the oldest oceanic rocks, the Pacific Ocean.

Drawbacks:

1) SiAl does not float over SiMa
2) Lunar & solar tidals cannot contribute to continent shift

ARGUMENTS IN FAVOUR OF THE CONCEPT:= Wegener's Concept includes the convincing arguments, contributed also by him, in favour of his ideology. These arguments include:

(1) Jig Saw Fit Evidences
(2) Paleoclimatic Evidences
(3) Paleomagnetic Evidences

sstatic Change = Results in alteration to the global sea levels due to hanges in either the volume of water in the oceans or net changes the volume of the ocean basins.

The JIG-SAW FIT evidence : It has 3 different dimensions :

Jig = saw fit of shape (Wegener) (Sir Edward Bullard)
" " " " process
" " " " structure

1 FIT OF SHAPE := The jigsaw fit of shape was mphasized by Wegener in highlighting near complete it of shape of the S. Atlantic shoreline. Sir Edward ullard (1960) further elaborated Wegener's conclusion hrough computer fit and concluded that the best fit is obtained if the coastlines are matched at the depth of 1000 m below current sea level, barring the exception of minor unconformities. The unconformities (gaps and overlaps) are explained by :

(a) Coastal erosion since continental separation
(b) " deposition " " "
(c) Rises in sea level (eustatic change) since sepn
(d) Changes in land level (isostatic change)

* Examples include erosion as well as deltaic deposits on either shoreline as that of River Niger and River Sao Francisco.

FIT OF PROCESS: The fit of process includes generation of normal tensional stress leading to the development of Dip-Slip fault generating Horst-Graben topography which includes Serra da Mantiqueira and Admawa highlands as the old block mountains with proto Atlantic floor proven to be the example of Rift Valley.

FIT OF STRUCTURE : The fit of structure primarily credited to Wegener involves the mention of absolute

* Wegener could not explain how the plates move.

fit of the super imposed stratas compositionally on either sides of the Atlantic Ocean, which also includes embedded fossil remains of specialised land organism as "Mesasauraus". Moreover, economically important reserves specifically of Gold have been emphasized by the scholar as the evidence of fit where "Lode-deposits (metalliferous) of Guinea Coast is projected as placers deposits (mineral) of Belem (Brazil). The combination of these evidences proves the drift of South America away from Africa, thus, Continent Drift Theory.

2) PALEOCLIMATIC EVIDENCES :

These evidences are credited to A. Wegener. Based on his analysis, Wegener concluded that Gondwanaland constituents which are lower latitudinal locations in present perspective and far off from each other experienced ice-age together. This was simultaneous to warm-tropical climate being experienced by Angaraland constituents. Wegener identified that fitting Gondwanaland towards south polar location helps in explaining glaciation experienced by these landmasses and as none of these landmasses are in combined position today nor are in colder latitude, there has been the drift of the continent. For Angaraland, flourishing tropical vegetation of the geological past due to the drift of the continents in comparative colder climate have paved way to the formation of rich coal belts availing added evidence of continent drift. The paleoclimatic evidences are recognised to be the most compelling argument in favour of continent drift

theory presented by Wegener.

However, as his approach was significantly "different" from the solid ideologies of geomorphological studies, his work was completely sidelined as the work of imagination. The arguments presented against the concept included:

Inappropriate mechanism

Treatment of oceanic crust as passive crust

Failing to explain 2nd order relief.

The primary reason to discard Continent Drift Theory was that the concept was technically wrong. SiAl cannot float over SiMa as Moho discontinuity falls well within lithosphere.

The description of equator-ward and westward drift proves to be faulty as most of the Gondwanaland constituents have actually crossed equator.

The tidal force is proven to be "too weak" to cause the drift of continents.

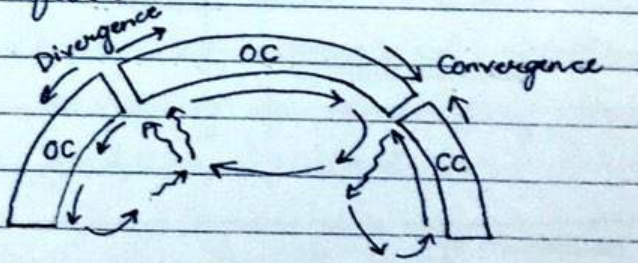
The entire concept is oriented towards the movements of continents and presumed the oceanic crust to be absolutely passive.

Only availed the description of relative positioning of the first order relief and failed to justify geomorphic requirements in analysing the formations of 2nd order relief.

## 2/ SEA-FLOOR SPREADING CONCEPT : HARRY HESS

1) Based on the study of submarine topography specially specifically the Challenger Ridge of southern Atlantic Ocean and Albatros Plateau of S.E. Pacific, American scholar Harry Hess proposed the concept of sea floor spread.
2) He based his concept on the "convective magma currents approach", propounded by Arthur Holmes in accordance to which movement of magma currents in Aesthenosphere forms the cause of movement of lithosphere, creating tectonic forces.
3) In accordance to convective magma current concept, magma cells generate converging, diverging as well as transverse movement of lithosphere over aesthenosphere.
4) Harry Hess applied diverging and converging movements to develop his sea-floor spread concept. He emphasized his concept to be recognising drift of continent as outlined by A. Wegener along with spreading of the sea-floor.

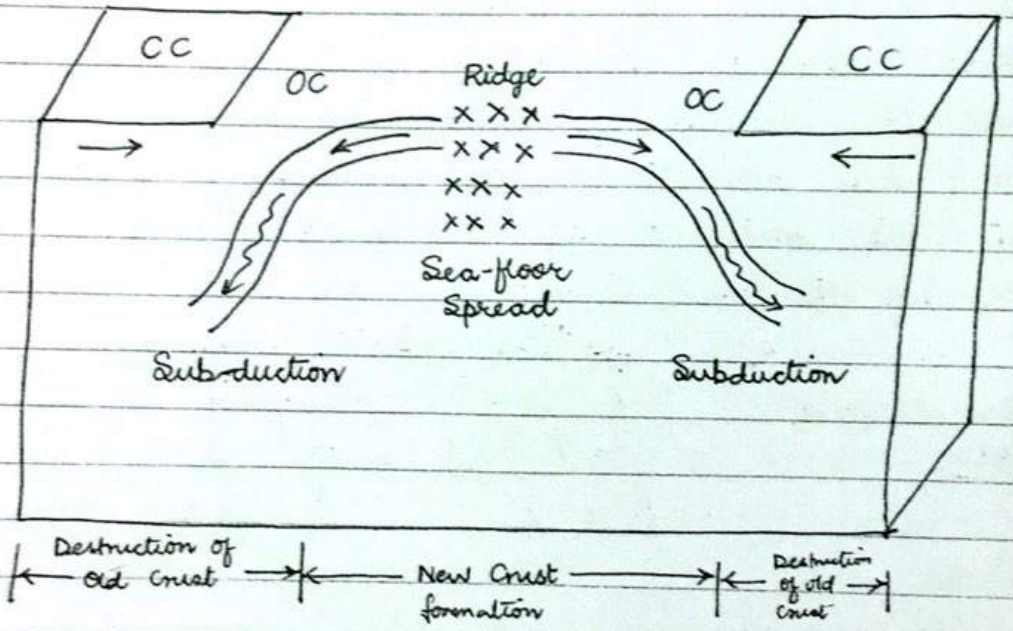
Fig. = Convective Magma Cells




5) The concept of sea floor spreading emphasizes on the construction of new oceanic crust at the spreading boundary and destruction of old crust at converging boundary. Taking empirical evidences along the spreading boundary, Harry Hess identified existence of paired rocks along either sides of the submarine ridge. He identified paired rocks to be similar in terms of their formation

is well as their composition. He concluded that with increase in the distance from the central ridge, age of paired rocks goes on increasing, justifying the seafloor spread. The destruction of the old crust at the converging boundary proves ACTIVE sea-floor and so also explains the fact that the oldest oceanic crustal rocks are not older than Paleozoic era whereas oldest continental rocks are as old as Azoic era.

The concept of sea-floor spread proves that Atlantic crust forms the example of spreading boundary whereas the Pacific crust represents destructive boundary.




## GEOMAGNETISM

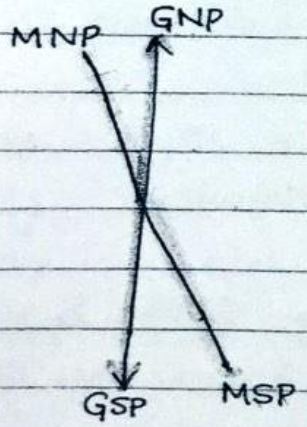
The magnetic property of planet earth generated due to iron rich interiors is called geomagnetism. This field of study in geomorphology is credited to William Gilbert, American scholar.

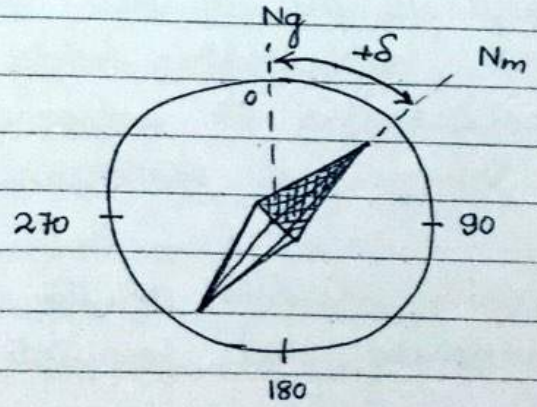
He identified that the Earth's magnetic field is like a giant bar magnet which is caused due to iron rich core. Due to prevailing temperature, molten core registers movement, creating dynamic characteristics of the magnetic field. The analysis of geomagnetism for geomorphological purposes involves 3 interrelated components :

① Magnetic Declination
② Magnetic Inclination
③ Magnetic Equator

i) Magnetic Declination :- (Also called horizontal component)

- It is the angle on the horizontal plane between magnetic north and geographic (true) north. By convention, the declination is +ve when magnetic north is east of true north, and negative when it is to the west.
- In the present perspective, magnetic declination reveals north magnetic pole to be slightly west of GNP and thus, MSP slightly east of GSP.
- The molten mobile iron-rich core, which spins like a dynamo forms the cause of gradual westward drift of geomagnetic field, resulting in changing magnetic declination in entire geological past.



Magnetic Inclination / Dip Angle / Magnetic Dip :=
This component of geomagnetism is identified to be the vertical component. It is defined to be the angular inclination between freely suspended magnetic needle & the horizontal plane of the earth's surface.

Magnetic dip results from the tendency of a magnet to align itself with lines of force. With increase in the sign of latitude, the dip angle increases, making it 90° at the magnetic poles and 0° at geographic equator.

Magnetic Equator :
The locus of the points having zero dip is called the magnetic equator (or aclinic line).

PALEOMAGNETISM :
It is the study of the record of "direction and intensity of the magnetic field", locked in rocks formed in different geological time period. These records are classified as :
Thermoremanent
Depositional remanent

These categories depict maintenance of record, not just in the igneous rocks but also in sedimentary and metamorphic rocks.
The major contributers to paleomagnetic studies include Runcorn, Fred Vine and Matthews.

Runcorn
His paleomagnetic studies in the early 1950's provided compelling evidences that facilitated "Revival of Continental Drift Theory.
He recognised that in the past 500 million years,

North magnetic pole have registered wandering from near ~~Hawiian~~ Hawaiian Islands via Eastern Siberia to its present position at Bathurst Island, Canada.

ii) In this apparent north magnetic polar wandering, he facilitated the understanding of combined existence of Eurasia and N. America.

iv) Moreover, it helped in the conclusion that the Appalachians, Kjollen, Urals, Verkhoyansk and Chukotsky forms the part of the same old fold orogenesis. It is in accordance that their present respective position readily justifies continent drift.

## Fred Vine & Matthews in Paleomagnetism

i) In 1963, Fred Vine and Matthews added to the studies of paleomagnetism by identifying Zebra Strips.

i) Analysis the magnetic records of the oceanic basins and the ridges, they concluded that older existing basins show polarity different than Earth's magnetic field, referred to as reverse (weak) polarity. On the other hand, the younger ridges represent normal polarity.

ii) This paleomagnetic conclusion is recognised to be evidence of sea-floor spreading as the older diverging basins generate condition for new ridge to get formed.

v) Moreover, with increasing distance from the central ridge, with increase in the age of the paired rocks, there is also gradual increase in magnetic anamolies.

vi) This zebra strip concept facilitated consolidation of sea-floor spreading propounded by Harvey Hess.

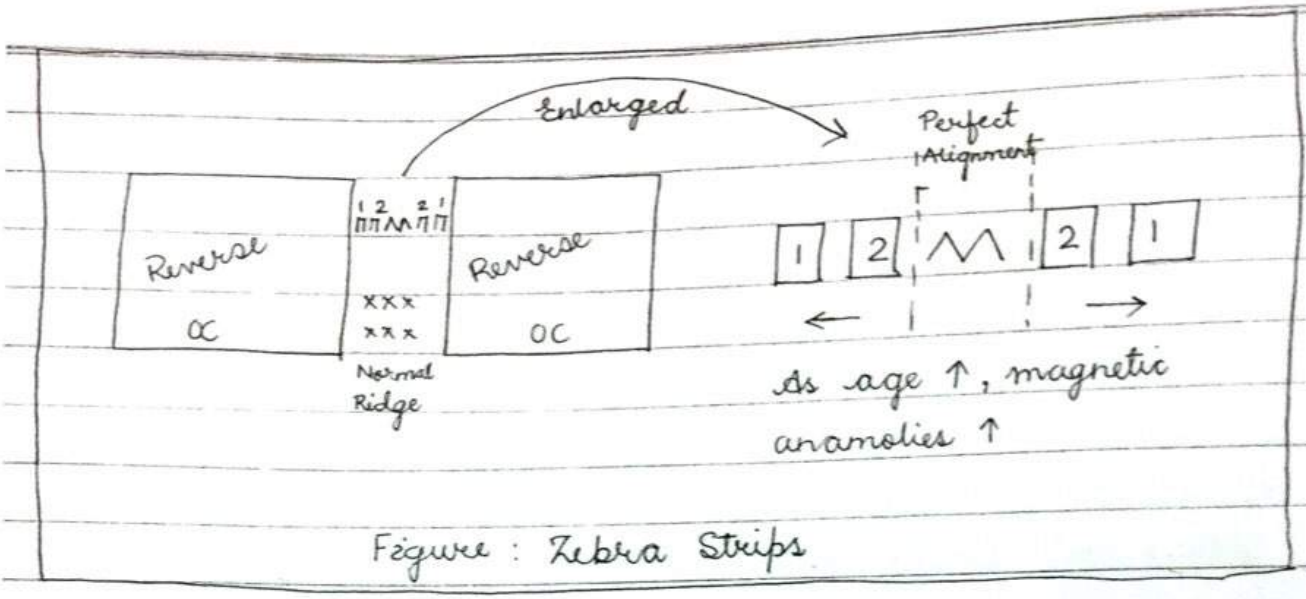



Figure : Zebra Strips

# PLATE TECTONIC THEORY

In late 1960's consolidation of different work of different geomorphologist towards analysis of locational characteristics of tectonic forces led to the plate tectonic theory. Among the major contributors – Parker, Harry Hess, Woolridge, Morgan, Tuzo Wilson® are included. The tectonic theory is based on the recognition that under the effect of convective magma currents, lithosphere floats over aesthenosphere.

The different parts of lithosphere are being referred to as PLATES.

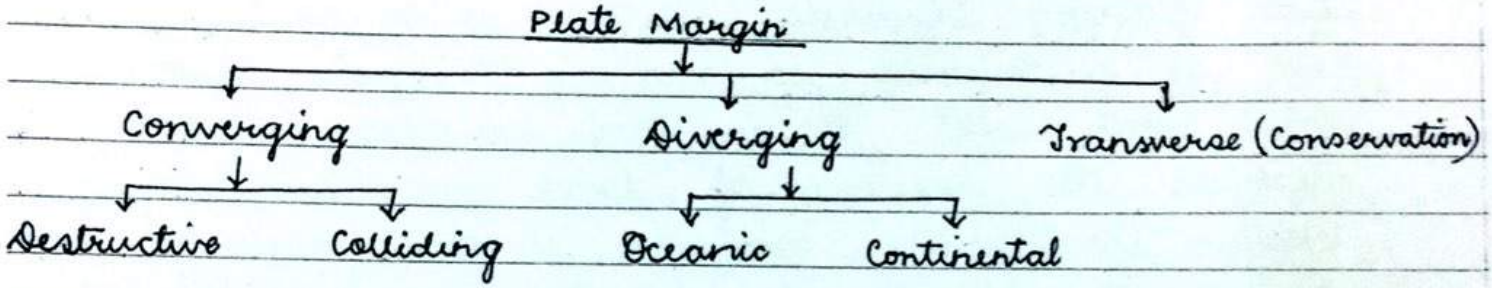
With their active tectonic characteristics, movement of these plt tectonic plates in relation to each other forms the cause of development of tectonic boundaries or plate margins.

At present there are 7 major tectonic plates namely

i) Pacific Plate
ii) N. American Plate
ii) S. American Plate
(iv) Eurasian Plate
(v) African Plate
(vi) Indo-Australian Plate
(vii) Antarctic Plate.

Each of these major plates involves different number of minor plates with their respective tectonic boundaries.

As all the endogenic forces takes place at tectonic boundaries or plate margins, the study of tectonic theory is primarily confined to the study of types of boundaries. The major categories of boundary include :




CONVERGING BOUNDARY :

The converging plate boundaries are recognised to be geomorphologically most important boundary as it correlates to the continental crust. Along this type of boundary, generated compressional stress results in fold orogenesis. Deformation of rocks causes earthquake. However for volcanic activity, destruction forms a mandatory clause. It is in accordance that converging boundary is classified into :

(a) Converging Destructive & (b) Converging Colliding.

2) Converging Destructive :

The converging destructive boundary on the map of world relates to Circum-Pacific Belt and Mid-Continental Belt. The circum-pacific belt corresponds to the entire shoreline of Pacific Ocean involving convergence of Pacific plate with the

## TRANSVERSE BOUNDARY :

This '⌇' boundary was outlined by TUZO WILSON who called this '⌇' boundary transform boundary. Along this boundary slide pasting effect of the continental crust paving way to faulting, vulcanism & earthquake – have been recognised. The only location of this plate boundary is SW N. America where California 'Minor plate' is slide pasting towards south / south-east whereas rest of N. America is moving towards ~~South~~ / ~~South~~-North/ north-west. It is this boundary that justifies the presence of block mountains in the Western Cordilleras. Moreover, it also forms the cause of absence of development of continuous "North American Trench."

## APPRAISAL OF PLATE TECTONICS :=

Since the publication of Plate Tectonic Theory in late 1960's, complete orientation of the studies of endogenic forces were channelised, as the theory not just availed the understanding of tectonic boundaries developed in TERTIARY PERIOD but also provided the recognition to the dynamic characteristics of tectonic boundaries, in reference to which, changing locations of tectonic boundaries in the geological past have been taken up to be the cause of different location of older reliefs. In accordance to the theory formation process of older mountains are explained in the light of the fact that :
Law of nature do not change with time.

(ii) Tectonic forces remain applicable only to the plate boundaries.

This full-proof theory have been eventually added with two modifications, recognised as:

(1) HOTSPOTS

(2) ACCRETION WEDGES

Hawaiian I. located in the north central part of Pacific Ocean forms the excellent example of hotspot developed due to INTRAPLATE OCEANIC DIVERGENCE, which is not given recognition in the original plate tectonic theory. The hotspots are defined to be localised spot of lithospheric opening from where there is continuous ejection of molten rock material. Long-lived hotspots are identified with the age of upto 100 M years.
In the beginning of the Cenozoic Era, converging boundary of Northern Circum-Pacific generated the hotspot where continuous ejection of magma, in accordance to the plate drift, facilitated formation of island chain called Hawaiian Islands. The oldest island of this chain is called EMPEROR SEA MOUNT and the youngest island in formation is LOHII. This active intra-divergence forms added evidence of plate movements and tectonic activities. At present, the term hotspot is only applied to almost all vulcanic islands.

The ACCRETION WEDGES or converging boundaries developed due to attachment of terrains with the mainland, have been added to the plate tectonic theory as additional example of tectonic boundaries.

# SUDDEN ENDOGENIC FORCES

## VULCANISM :

Solidified → ↑ Extrusive → Surface → Vulcanic
Solidified → ↓ Intrusive → Plutonic

**Magma Components :**

→ Silica ↑ ⇒ Mobility ↓ ⇒ Viscosity ↑
→ Iron ↑ ⇒ Density ↑.

Ejected Matter
- MAGMA
  - sic
    - 40% Si
    - xteaus
    - saltic
    - re Fe Content
    - nser
  - Acidic
    - → > 70% Si
    - → Cones
    - → Granitic
    - → Less Fe Content
    - → Viscous
- GASES
  - → $H_2O$ (g) [~70%, most prominent]
  - → $CO_2$
  - → $SiO_2$
- PYROCLASTS
  - → Solid particles ejected

The sudden endogenic force that is capable of developing 2nd order relief feature as lava plateaus and vulcanic cones is defined to be all set of processes that leads to movement of molten rock material towards the earth's surface. This molten rock material called MAGMA, in its composition and trapped gases reveals various intensities of ejection. These intensities based categories of vulcanism is best described with the reference to the plate tectonic theory. The distinguished categories in increasing order of intensity of ejection includes:

* Converging
Destructive

| | | |
|---|---|---|
| Hawaiian | ↕ | Quiet |
| Strombolian | ↕ | Transverse |
| Vesuvian | ↕ | Strong |
| Pelean | ↕ | |

i) Hawaiian Type of Activity :-
This type of vulcanic activity is the quietest which is correlated with complete absence of trapped gaseous constituents and involves quiet ejection of mobile magma in well-defined individual flow of lava streams, technically called as PELE'S HAIR. This type of activity is confined along oceanic divergence and derived its name from the "smoking mountains" of Hawaiian Is. as Mt. Mauna Loa.

ii) The Strombolian Type :
This vulcanic type represents the category which is slightly stronger than the Hawaiian type. It involves some trapped gases but is not associated with precipitation after vulcanic ejection. This type of activity attains its name from *Mt. Stromboli of Italy. is designated to be the "LIGHTHOUSE OF MEDITERRANEAN". Tectonically this type of activity is correlated to continent divergence as Mt. Kilimanjaro and Transverse boundary as Mt. Whittney, CA, USA.

ii) The Vesuvian Type :
It reveals stronger activity and is also identified to be the commest type of vulcanic activity confined along converging destructive boundaries. This activity therefore represents all circum - Pacific belt and mid-continental belt with

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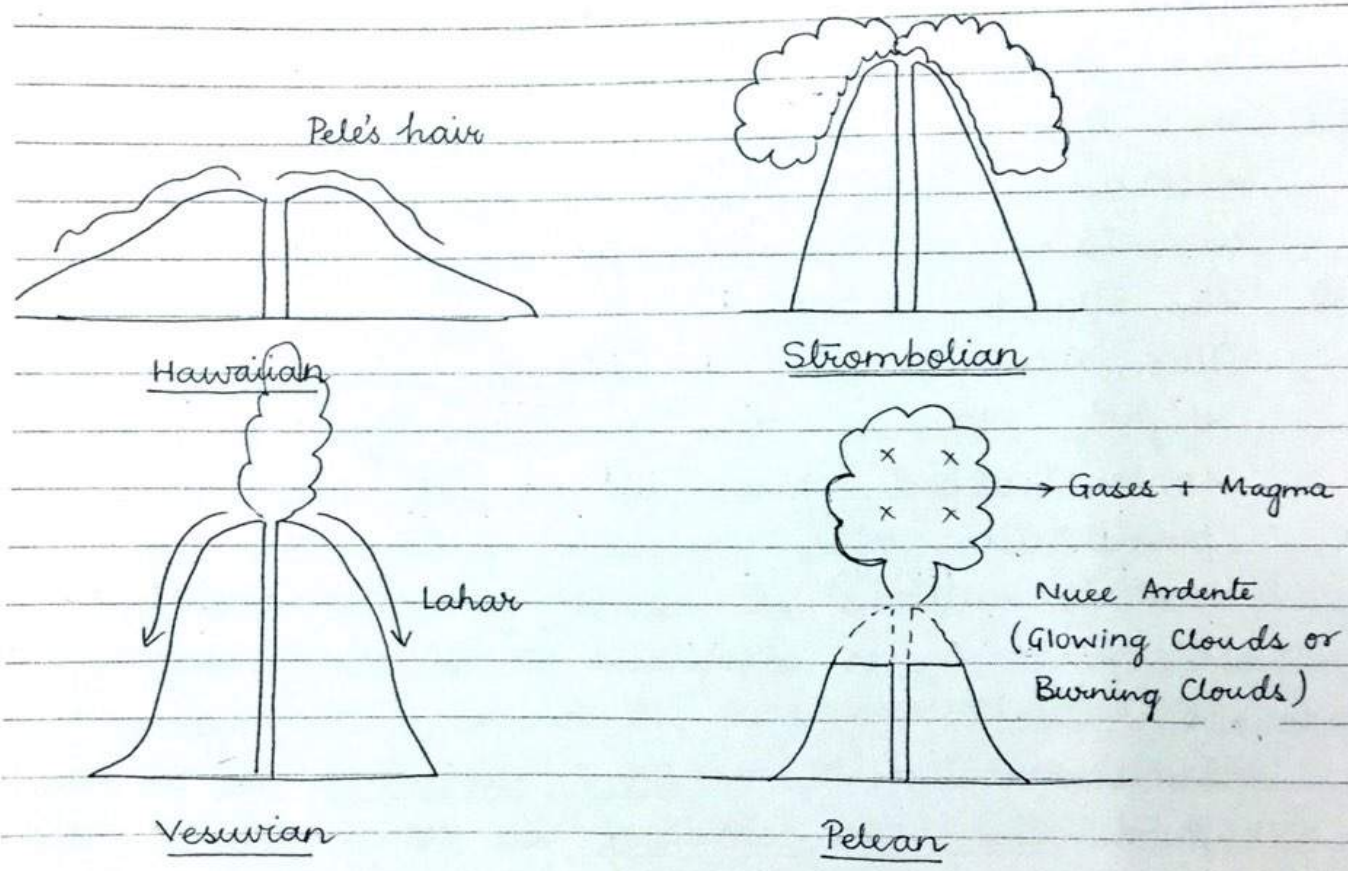
Mt. Vesuvius as the most studied vulcanic cone, providing the source of the name. The intensity of ejection in this activity is such great that trapped gases are thrown to greater heights always resulting in condensation & precipitation. This type of activity thus is also always correlated to LAHAR, i.e. down-slope movement of water saturated pyroclast generating Piedmont deposits of vulcanic soil.




Pelean Type :

When Vesuvian type of activity becomes further intensified, it is called pelean type of activity. In this activity existing cone gets blown off generating largest amount of pyroclasts. However,

with complete absence of 'Lahar'. Another characteristic is the 'Burning or Glowing Clouds' that are the thrown magma patches upto the height of the clouds. This type of activity has been experienced only in Krakatoa in Greater Sundae Is. (East Indies) and Martinique Island in Lesser Antilles (West Indies).

# Original plate tectonic drawbacks :
(i) Hotspots
(ii) Terranes

# Write note on Volcanoes ⇒ Extensive Vulcanoes, lava platea

Critically examine the continental drift theory of Alfred Wegener (250 words)