(a) Identify the limestone feature shown in Fig. 1. [1]

(Collapse) Sinkhole *or* (Collapse) Doline

(b) With reference to Figs 1A and 1B and your own knowledge, explain the factors contributing to the development of the limestone feature you have identified in (a). [5]

- **Mineral Composition**

Presence of calcite would facilitate carbonation and solution

- **Lines of Weaknesses**

Provide sub-surface area for acidulated water to penetrate and attack the rocks chemically. Joints and bedding planes permit sub-surface weathering that would widen caverns and voids within a limestone bed. With continued weathering, the overlying roof will be unable to support itself and collapse, forming a surface depression known as the sinkhole/doline.

- **Climate**

Precipitation would provide the agent for chemical weathering processes to operate effectively.

Vegetation would produce organic acids, that would serve as a catalyst in chemical reactions. The decomposition of plant matter and respiration process also produce carbon dioxide that would dissolve in water to form carbonic acid – carbonic acid is a key agent in the carbonation and breakdown of limestone to form the sinkhole/doline.

(c) Describe how the form and nature of a tower karst landscape differs from a limestone pavement. [6]

	Tower karst landscape	Limestone pavement
Form : Height	Made up of distinct karsitic features (aka mogotes) which extend to heights of more than 300m in height	less distinct karsitic feature, relatively flat/low feature
Form : Shape	made up of tall isolated masses of limestone separated by flat ground, relatively irregular in profile	small individual masses of limestone (clints) separated by shallow grooves (grykes)
Nature : Other associated features	Covered by dense vegetation, fluted surfaces, caves Found in tropical regions	Hardly any presence of vegetation, surfaces relatively even although there might be some solutional features such as runnels, pits and pans. Found in temperate regions

(a) Suggest the role of ocean currents in the global energy budget. [2]

- Carry warm water polewards and cold water equatorwards, [1] and thus generate a net poleward transfer of heat energy [1]
- Responsible for 20% of all heat transfers on earth [1]

(b) Describe and explain the pattern of ocean currents shown on Fig. 2. [5]

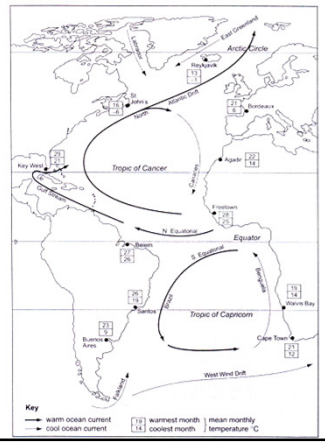
Describe pattern	Explain pattern
Moves in a circular pattern (ie: moves as gyres) • In both hemispheres, warm currents moving to the poles while cold currents move towards the equator • But orientation of gyres differ ➢ In the NH, ocean currents move in a clockwise fashion ➢ In the SH, ocean currents move in an anti-clockwise fashion	Surface winds will push surface currents via frictional drag. Their direction (influenced by PGF and Coriolis) will shape the direction of surface currents. Elaborate on the role of trade winds in driving surface currents. Bring in coriolis effect.

(c) Using examples from Fig.2, explain how warm and cool ocean currents can affect temperatures and precipitation in coastal locations. [5].

- **<u>Influence of currents on temp</u>**

➢**Warm currents will increase coastal temperatures while cool currents will reduce coastal temperatures**

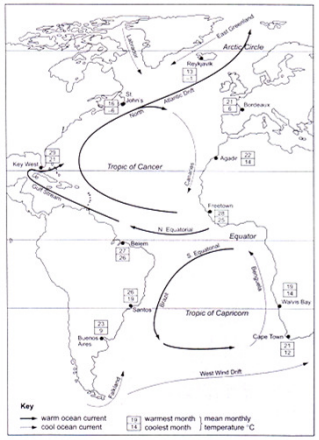
Eg: Key West and Agadir share the same latitudinal location, but Key West (which is flanked by warmer currents) has higher max and min temps than Agadir (which is flanked by cool currents)

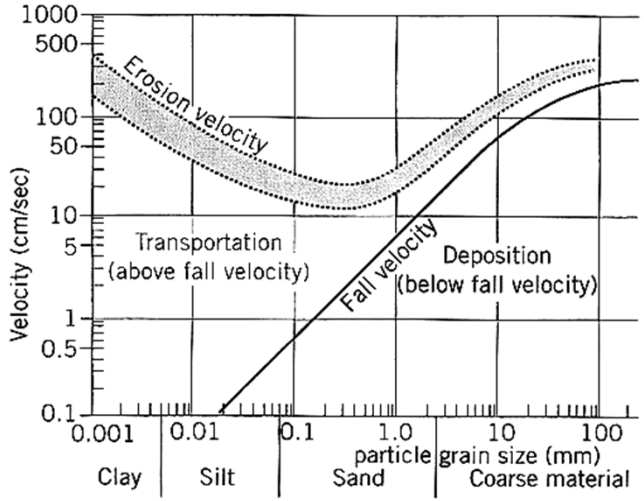


- **<u>Influence of currents on ppt</u>**

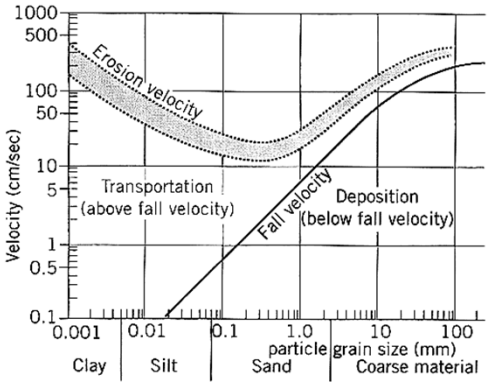
➢**Warm currents will increase coastal ppt : Higher air temp → greater uplift of warm air parcels → condensation of moist air masses → clouds → rainfall**

➢**Cool currents will reduce coastal ppt : Lower air temp → cooling and subsidence of air masses → impede cloud formation → no rainfall**



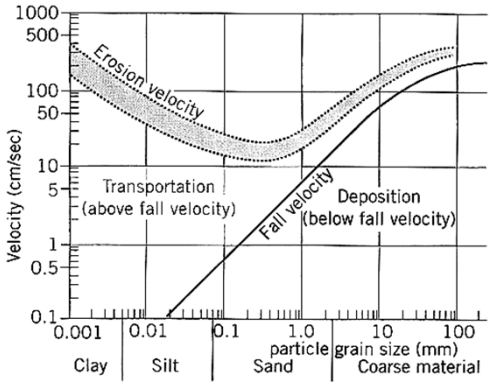


(a) With reference to Fig. 3 :
(i) Identify the largest size of material that can be eroded at the velocity of 100cm/s. [1]



(a) With reference to Fig. 3 :
(i) Identify the largest size of material that can be eroded at the velocity of 100cm/s. [1]

10 mm

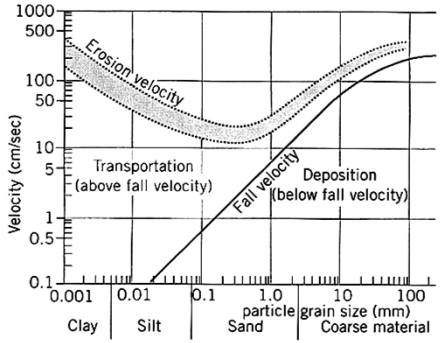


(a) With reference to Fig. 3 :
(ii) Describe what would happen to the material you have identified in (a) (i), when the velocity drops from 100cm/s to 10cm/s. [3]

- As velocity drops from 100cm/s to about 60cm/s, particle will remain in transport (likely saltation or suspension)
- Once velocity drops below 50cm/s, particle will be deposited and remain and rest

2m : Reference to transportation and deposition

1m : Data citation



(b) Suggest <u>one</u> reason why critical erosion velocity is represented by a band rather than a single line. [2]

- <u>Other factors</u> within the river influencing critical erosion velocity beyond sediment size, thus a range of values are provided.
- For instance, the turbulence of the water can reduce critical erosion velocity at a given velocity. Highly turbulent water is more erosive and can pick up a particle at a relatively lower velocity. The shape of the particle can affect critical erosion velocity as well. Irregular-shaped particles pose greater frictional drag which allows them to be picked up at relatively lower velocities.

(c) Explain the importance of critical erosion velocity in the transportation of the load within a river channel. [6]

(c) Explain the importance of critical erosion velocity in the transportation of the load within a river channel. [6]

- **<u>Overview statement :</u>** Critical erosion velocity (CEV) is the minimum velocity at which a particle can be picked up and it thus determines the velocity at which a particle can be subsequently transported since transportation can only occur after erosion.
- Medium sized particles

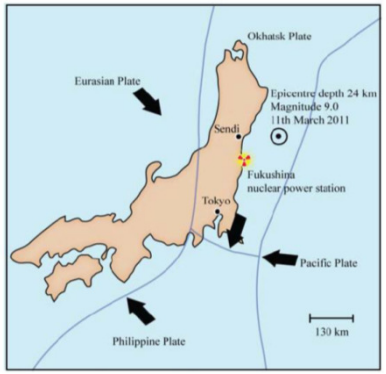
➢Lowest CEV, easily transported

- Fine and Coarse particles

➢Highest CEV, harder to transport

➢Fine particles stay in transport after being eroded, despite high CEV, due to light weight

(a) Using Fig. 4A, comment on the nature of the plate boundary and plate movement leading to the 2011 Tohoku earthquake. [2]



- Convergent plate boundary [1] involving convergence of the oceanic crust of the Okhotsk Plate and Pacific Plate [2]

(b) With reference to Fig. 4B, describe and explain the effects of the tsunami on the morphology of the Kitakami river. [3]

Tsunami would have caused an intrusion of sea-water into the river , leading to heightened discharge levels. This will lead to greater erosive power of the river, leading to :

- Slight widening of the channel mouth
- Removal of depositional features at the mouth of the river
- Shrinking/reshaping of depositional features within the river

(c) Suggest the effects of earthquakes on channel flow and morphology. [4]

- Earthquakes can trigger landslides, which when displaced into rivers, will affect flow and channel morphology
- Identify 3 ways in which EQ affect channel flow and morphology

5E (a) Describe the role of plate tectonics in the rock cycle. [9]

- Key Idea: plate tectonic processes (such as subduction and partial melting, uplift and mountain building) drives some of the geological processes in the rock cycle [1]

Body

- Para 1: Formation and extrusion of magma
- Para 2 : Uplift
- Para 3 : Heat and pressure

(b) Compare the volcanic hazards at convergent and divergent plate boundaries. Discuss the challenges associated with managing these hazards at the different plate boundaries. [16]

Introduction

- **Define :** Volcanic hazards
- **Argument :** Both convergent and divergent plate boundaries produce volcanic hazards, however the hazards may differ based on type, composition and explosivity. In response to these volcanic hazards, many strategies have been put in place to reduce casualties and property damages. However the successful management of these hazards has been hindered by various physical and human challenges.

Body

P1: Compare the volcanic hazards at convergent and divergent plate boundaries

P2: Common challenges in managing volcanic hazards at both plate boundaries

P3: Convergent plate boundaries can be more challenging to manage than divergent plate boundaries

P4: However, at selected divergent plate boundaries, there may still be difficulties in management

(b) "A knowledge of deep weathered profiles enables us to understand the form and formation of granitic landforms." Discuss. [16]

Introduction

- **Define :** Deep weathered profiles
- **Argument :** A knowledge of deep weathered profiles enables us to understand the processes contributing to the form and development of granitic landforms such as tors and inselbergs.
- **Balance argument :** However, to fully appreciate the form and formation of granitic landforms, an understanding of other processes are required.

Body

P1: Description of deep weathered profile (Ruxton and Berry model)

P2: Deep weathered profiles enable to understand the process of deep weathering, which is relevant to understanding the form and formation of tors

P3: Deep weathered profiles enable to understand the process of deep weathering, which is relevant to understanding the form and formation of inselbergs

P4: However, a knowledge of deep weathered profiles is insufficient

6E(a) With the use of diagram(s), how and where can El Nino influence the development of droughts? [9]

- Key Idea: El Nino can induce high pressure conditions that lead to development of droughts in locations in the Western Pacific

- Body

diagram [max 3m]

- Para 1: Normal Walker circulation [max of 2]
- Para 2 : Devt of El Nino circulation [max of 3]
- Para 3 : Link between El Nino and droughts [max of 3]

(b) "Hazards arising from tropical cyclones are immediate, whereas those arising from droughts are longer term." Discuss the validity of the statement. [16]

Introduction

- **Define :**tropical cyclone, droughts, hazard
- **Argument :** Hazards arising from tropical cyclone are deemed to be more immediate than droughts due to the way the two systems develop, the time frames that the meteorological phenomena last for and the spatial extent of their impacts.
- **Balance argument :** However, human factors such as economic devt and nature of governance can prolong the impacts of a tropical cyclone.

Body

P1: Hazards arising from TC are more immediate than droughts due to shorter time frame that they last for

P2: Hazards from TC last for a shorter period of time than droughts as the spatial extent of their impacts tend to be smaller.

P3: In addition, hazards from TC may last for or a shorter time, since they are easier to predict (and subsequently manage) than droughts

P4: However, human factors such as economic devt and nature of governance can prolong the impacts of a tropical cyclone.

6Or (a) Compare the features of the day-time and night-time energy budget. [9]

- Key Idea: Day time and night time energy budget differs in terms of type and direction of pathways. Overall there is a surplus in the daytime budget while a deficit exists in the nighttime budget. [1]

- Body
- diagram [max 3m]
- Para 1: Difference in insolation and reflection [1m]
- Para 2 : Difference in latent heat transfer processes [max of 2m]
- Para 3 : Difference in energy absorbed and released [max of 2m]

6Or (b) Assess the role of anthropogenic factors in influencing the earth's energy budget. [16]

Introduction

- Define : energy budget, anthropogenic factors
- Context : Trend of rising temps that has sparked "global warming" fears. Much evidence suggests that global warming is due to human activities as there is a sharp correlation between the increase in carbon emissions and rising temps since industrialisation. Climatic models have taken into account natural factors like solar maximum, but these have failed to account for current trends in rising temps. Beyond the global scale, human influence on climate on a local scale is also evident via the "heat island effect". Heat island effect becoming more apparent due to rising levels of urbanisation.
- Argument : Human activities are playing an increasing role in influencing the earth's energy budget because of the increase in intensity of activities that influence energy pathways on a global and local scale.
- Balance argument : However, it must be emphasised that while human activities are playing an increasing role, other factors are critical in influencing the energy budget.

Body

P1:Human activities influence energy budget on a local scale (urban heat island)

P2: Human activities influencing energy budget on a global scale by increasing emissions of greenhouse gases (global warming effect)

P3: Human activities influencing energy budget on a global scale by reducing carbon sinks (global warming effect)

P4: Other factors influencing energy budget

7E (a) Explain the meaning of the terms: hydraulic radius, channel discharge and channel competence in relation to a river channel. [9]

Key Idea : Channel discharge influences hydraulic radius and shapes channel competency

Body

P1: Explain hydraulic radius, discharge

P2: Link between hydraulic radius, discharge and channel competence

P3: Link between discharge and river channel

7E (b) Assess the extent to which an understanding of hydraulic radius leads to successful flood management strategies. [16]

Intro:

- **Define** hydraulic radius
- **Argument :** An understanding of hydraulic radius leads to flood management strategies that can successfully reduce death toll and property damage.
- **Balance argument** : However, an understanding of hydraulic radius is not useful in all contexts in devising successful flood management strategies.

Body:

P1: An understanding of HR helps in the formulation of successful flood management strategies

P2: An understanding of HR is not sufficient in formulating successful flood management strategies

P3: Beyond HR, need to understand other factors contributing to flood hazards and thus devise other flood management strategies

7Or (a) With the aid of a diagram, describe and explain how sub-surface flows and stores may contribute to surface flows and stores. [9]

Define: [2m]

- Surface flows and storages
- Sub-surface flows and storages

Body:

- P1: Soil moisture storage and through-flow can contribute to surface storages and flows [3m]
- P2: Groundwater storage can contribute to river channel flow [1m]
- P3 : Factors encouraging the contribution of sub-surface storages/flows to surface storages/flows [3m]

7Or (b) With reference to one or more examples, discuss how humans influence storages within the drainage basin. [16]

Intro:
- Define storages (surface and sub-surface storages)
- Argument : Humans influence storages within the basin by affecting their quantity, quality and location. While most of these actions affect storages adversely, there have been recent efforts to improve water quantity and quality.

Body:
P1 : Human activities can deplete storages within the basin
P2 : Human activities can adversely affect water quality
P3: Human activities can redirect the volume of water from one storage to another, thus affecting the location of dominant storages within a basin
P3 : In response to the mismanagement of storages and their associated problems, humans have tried to recharge storages and restore water quality