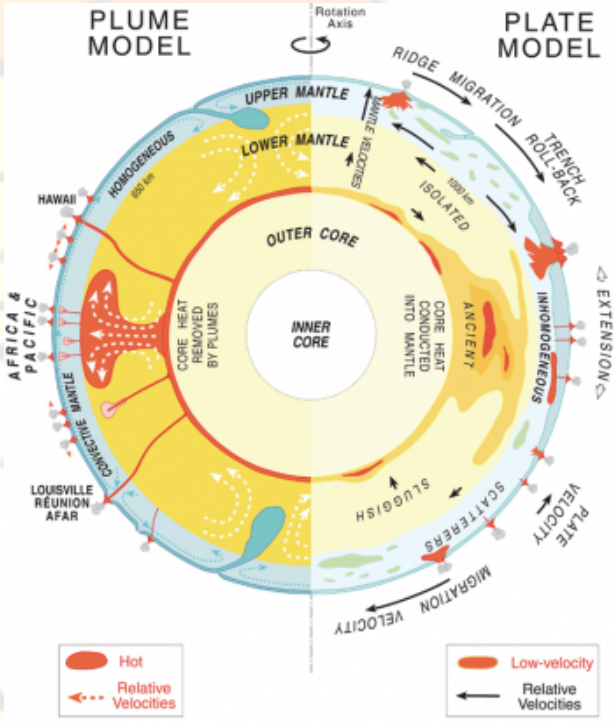
1. What are mantle plumes? How do mantle plumes give rise to various geographical features? Illustrate.

Introduction

A mantle plume is an upwelling of abnormally hot rock within the Earth's mantle. It is a buoyant mass of material in the mantle that, because of its buoyancy, rises. The existence of mantle plumes in the Earth was first suggested by Wilson(1963) as an explanation of oceanic-island chains, such as the Hawaiian-Emperor chain, which change progressively in age along the chain.

Body



1. Hot mantle rock that rises toward the earth's surface in a narrow column is called a mantle plume**.** Plumes can be located beneath continental or oceanic crust or along plate boundaries.
2. Wilson proposed that as a lithospheric plate moves across a fixed hotspot (the mantle plume), volcanism is recorded as a linear array of volcanic seamounts and islands parallel to the direction the plate is moving.
3. However, it is known today that plumes can also move, so this simplified model does not hold for all hotspot tracks. There are even a few investigators who question whether mantle plumes exist.
4. The three-dimensional tomographic model of Earth’s interior, similar to a medical CT scan, revealed large swells of what is likely hot mantle material with diameters roughly 1,000 kilometers wide. The structures, dubbed plumes by the researchers, rise from areas at the core-mantle boundary with strongly reduced seismic velocities.
5. Further, Plumes are a secondary way that Earth loses heat, much less important in this regard than is heat loss at plate margins. Some scientists think that plate tectonics cools the mantle, and mantle plumes cool the core. Two of the most well-known locations that fit the mantle plume theory are Hawaii and Iceland as both have volcanic activity.

Mantle Plumes has considered as the reason for giving rise to following geographical features:

- Plumes are thought to spread out laterally at the base of a continent, creating increased pressure that stretches the crust and results in uplift, fracturing, rifting, or flood basalts.
- Mantle plumes emanating from the upper mantle may gush up through the lithosphere as hot spots.
- Mantle plumes are thought to be strong enough to induce rifting and the formation of plates. The pressure creates a domed region that eventually splits in a three-pronged pattern (triple junction or triple point). The best example of a triple junction in the world is provided by the three faults marked by the Red Sea, the Gulf of Aden, and the inactive African Rift Valley.
- The high ratios in Hawaiian basalts were interpreted as evidence that plumes are fed by primordial material from deep in the mantle, while mid-ocean ridge systems tap recycled upper mantle material depleted in helium-3.
- As a mantle plume reaches the upper mantle, it melts into a diapir. This molten material heats the asthenosphere and lithosphere, triggering volcanic eruptions. These volcanic eruptions make a minor contribution to heat loss from Earth's interior, although tectonic activity at plate boundaries is the leading cause of such heat loss.
- The potential of mantle plumes may go well beyond volcanism within plates. For example, the mantle plume that may lie under Réunion Island in the Indian Ocean has apparently burned a track of volcanic activity that reaches about 3,400 miles (5,500 km) northward to the Deccan Plateau region of what is now India.

Conclusion

Although many details of plumes and their effects are still controversial and debated, the basic theory of mantle plumes is well established and there is considerable observational evidence to support the plume concept. Recently, as the resolution of seismic tomography improved sufficiently, it has led to at least some plumes in the upper mantle being detected seismically.

2. Why do some places on earth experience heavier air pollution than others? What role does climate play in this? Examine.

Introduction

Air pollution may be defined as the presence of any solid, liquid or gaseous substance including noise and radioactive radiation in the atmosphere in such concentration that may be directly and/or indirectly injurious to humans or other living organisms, property or interferes with the normal environmental processes.

Body

Air pollution is the mixing of unwanted and harmful substances such as chemicals, dust, auto emissions, suspended particles, gases among others in our atmosphere. It can be of two types; indoor and outdoor air pollution. It is a serious threat to the health of living beings and the different ecosystems found in our environment. According to WHO, it was the cause of death of approximately 7 million people around the world in 2014.

If we take the scenario of India,

- High dependence on coal for power: share of coal in power generation in India continue to be around 80%. Power plants with poor technology and efficiency continue to be the major source of pollutants like CO and oxides of nitrogen and sulfur.
- High levels of poverty
    - Dependence on fuelwood and kerosene for the purpose of lighting and cooking leads to high level of pollutants being released in rural and urban periphery
    - Over exploitation of commons like forests, grazing lands and mindless deforestation reduces the natural capacity to absorb pollutants
- Poor governance: the issue of environment and pollution is still to get the policy priority it deserves. While agencies liked CPCB and SPCBs continue to be under-resourced and under-staffed, multiplicity of the state authorities at the ground level leads to poor coordination, lax enforcement of rules and lack of accountability as seen in Delhi. Absence of environmental governance continues to be a major challenge
- Access to technology: India's industrial landscape continues to be dominated by MSMEs which lack access to cleaner technologies. Agricultural waste burning is also the result of poor access to farm technologies
- Unplanned urbanization: haphazard growth of urban areas has led to proliferation of slums and poor public transport has increased the burden of personal vehicles on the road. Landfills used for waste management also releases pollutants in the air. The rapid urbanization of the recent years if left unmanaged will further exacerbate the problem
- Continentality: problem of pollution in the landlocked northern states gets exacerbated due to unfavourable winds and phenomenon of temperature inversion during winters

Most of the pollution of the air is caused because of the ignorance and negligence of humans but it is also true that some time the air can be polluted by natural causes.

The natural factors causing air pollution are:

1. Forest fires
2. Wind erosion
3. Radioactivity released from decay of rocks
4. Volcanic eruptions.

Forest fires produce giant masses of smoke which tend to drift over nearby villages and cities.

Occasional eruptions of volcanoes can eject huge amount of volcanic ash and lava onto the earth surface which introduces dust and smoke into the atmosphere thereby polluting the air.
Natural air pollution can also be caused when rocks decay over time and release gas such as radon which has adverse effects on our health.

Once pollutants are emitted into the air, the weather largely determines how well they disperse. Turbulence mixes pollutants into the surrounding air. For example, during a hot summer day, the air near the surface can be much warmer than the air above. Sometimes large volumes of this warm air will rise to great heights. This results in vigorous mixing.
Wind speed also contributes to how quickly pollutants are carried away from their original source. However, strong winds don't always disperse the pollutants. They can transport pollutants to a larger area, such as the smoke from open burning or forest fires.

Sometimes the condition of the atmosphere is very still (stable) and there is very little mixing. This occurs when the air near the surface of the earth is cooler than the air above (a temperature inversion). This cooler air is heavier and will not want to move up to mix with the warmer air above. Any pollutants released near the surface will get trapped and build up in the cooler layer of air near the surface. Temperature inversions are very common in B.C., especially in mountain valleys, often forming during calm clear nights with light winds. They can even persist throughout the day during the winter.

Role of climate

Climate change can impact air quality and, conversely, air quality can impact climate change.
Changes in climate can result in impacts to local air quality. Atmospheric warming associated with climate change has the potential to increase ground-level ozone in many regions, which may present challenges for compliance with the ozone standards in the future. The impact of climate change on other air pollutants, such as particulate matter, is less certain, but research is underway to address these uncertainties.

Conclusion

Given air pollution issues in the country, Government has launched National Clean Air Programme (NCAP) A time bound national level strategy for pan India implementation to tackle the increasing air pollution problem across the country in a comprehensive manner.

3. What is an air mass? How does it get formed? In what ways does it affect the local climate conditions? Discuss.

Introduction

An air mass is a large volume of air in the atmosphere that is mostly uniform in temperature and moisture.

Body

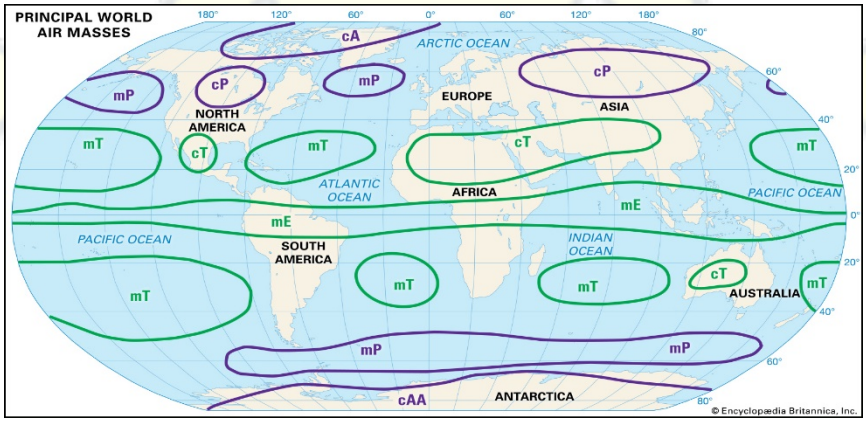
Formation of air masses:

When the air remains over a homogenous area for a sufficiently longer time, it acquires the characteristics of the area. The homogenous regions can be the vast ocean surface or vast plains. The homogenous surfaces, over which air masses form, are called the source regions. An air mass acquires these attributes through heat and moisture exchanges with the surface.

Further, Low wind speeds let air remain stationary long enough to take on the features of the source region, such as heat or cold. When winds move air masses, they carry their weather conditions (heat or cold, dry or moist) from the source region to a new region.

Furthermore, Uneven warming and cooling of the earth's surface by the Sun gives rise to air masses. Air Masses are most common in the tropics, subtropics and high latitudes. The zones from which air masses grow are called "source regions" which are the large surfaces with uniform temperatures and humidity. These are generally tracts of ocean, desert or snow-covered plains. For instance,

- The warm air masses form over the equator or desert areas where the solar radiation is maximum. In clear, almost cloudless days, the heat is reflected back to the atmosphere. The air becomes light and spreads.
- Cold air masses form near the poles where solar radiation is at a minimum. On cloudless days, the snow cover near the Poles, reflect sunlight away, preventing the earth to warm up. When this persists for a long period of time, cold air masses form over a large area.



(Use a simple diagram depicting airmass in the exam)

Air masses affecting local weather conditions:

In a particular area, the occurrence of particular air masses helps to ascertain the climate of that region. This in turn decides the type of flora and fauna as well as the type of crops that can be grown. For instance,

- Precipitation: E.g. the maritime-tropical air over Atlantic Ocean, Caribbean Sea is a major reason for precipitation east of Rocky Mountains. It is also the cause of persistent humidity in the summer season.
- Temperature: Maritime polar air affects the coastal temperature in subtropical and arctic regions.
- Cyclones and anti-cyclones: Stormy cyclones form near the air-mass fronts. The mixing of air masses will result in rising air feeding the cyclone formations in the subtropical cyclone. Similarly, the warm maritime tropical air mass will provide the energy for tropical cyclones.
- Drought: they are the result of hot, dry air mass. This can destroy natural vegetation and kill trees. These regions have the increase risk of devastating wildfires. E.g. California wild fires.
- At the boundaries between air masses, the clash of masses of air with different characteristics can lead to dynamic weather like hail, tornadoes, high winds or ice storms. E.g. tropical cyclones formed in east china sea.

Conclusion

Air masses spread across massive region up to 1600 km or more. They exercise a considerable influence on the climatic conditions of the region over which they lodge and carry with them distinctive climatic features of their source region.

Additional information (Per se not required in the answer as per the demand of the question):

The air masses are classified according to the source regions. There are five major source regions:

- Warm tropical and subtropical oceans.
- The subtropical hot deserts
- The relatively cold high latitude oceans
- The very cold snow-covered continents in high latitudes
- Permanently ice-covered continents in the Arctic and Antarctica

Accordingly, the following air masses are formed.

- Maritime tropical (mT): Maritime Tropical air mass results from the warm waters of the Gulf of Mexico and Gulf Stream. This air mass is characterized by hot, humid conditions.
- Continental tropical (cT): These are the hot, dry air masses which originate over regions like northern Mexico and the southwestern United States.

- Maritime polar (mP): Maritime Polar air masses have their source region over cold ocean currents or high latitude ocean waters. This air mass can produce widespread rain or snow, fog, drizzle, cloudy weather and long lasting light to moderate rain.
- Continental polar (cP): Continental Polar air masses are cold to cool and dry. Continental Polar air masses form over Canada and Siberia. These air masses bring cold air during the winter and cool, relatively clear, rather pleasant weather in the summer.
- Continental arctic (cA): This air mass is considered very cold. Their source of origin is Arctic Ocean, Siberia, Northern Canada, Southern Ocean.

4. Illustrate the role of the Tibetan plateau in the Indian Monsoon.

Introduction

Indian monsoon is a complex system characterized by seasonal reversal in wind direction in south and South East Asia. Monsoon system is modified trade winds guided by various landforms such as Himalayas and water systems such as Pacific. Tibetan plateau especially has very major role to play in genesis of monsoon.

Body

Landforms play a major role in deciding the path of propagation as well as intensity of rainfall, as most of the rainfall in India is orographic in nature. The Himalayas plays a major role in genesis of monsoon as well as monsoon breaks. Tibet Plateau is an enormous block of a high ground act as a formidable barrier as well as a heat source.

Role of the Tibetan plateau in the Indian Monsoon

- Tibetan Heating creates a low pressure in summer which gets coupled with Massacarene High pressure area and thus helps in initiation of Monsoon.
- The vast mountain range also acted as a tall barrier, preventing cold, dry air in the northern latitudes from entering the subcontinent and subduing the warm, moisture-laden winds from the oceans that drive the monsoon.
- During southwest monsoon, a thermal anticyclone appears over Tibet, which the resultant formation of dynamic anti-cyclogenesis. On the south side of the anticyclone, the tropical jet stream is from. The plateau accents the northward displacement of the jet stream in the middle of the October. The withdrawal sub-tropical westerly jet stream to the north Himalayas marks the onset of monsoon season in India.
- With the Tibetan heating and ENSO acting independently of each other, the two factors taken together could have predictive value for rainfall in the monsoon's early and late phases.

- The tropical easterly jet stream is formed at an eastern longitude of India then moves towards westwards across India and the Arabian Sea to eastern Africa. This upper-level easterly jet stream creates a flow of air on the south side of Tibetan Plateau that reaches down to low levels over northernmost India. During summer, the insolation heating of air above Tibet Plateau weakens the western subtropical jet stream south of the Himalayas with the resultant reversal of pressure gradient and wind flow over northern India.

Conclusion

Thus the presence of Tibet Highland is very important, even if there is no significant barrier effect on the flow of air.

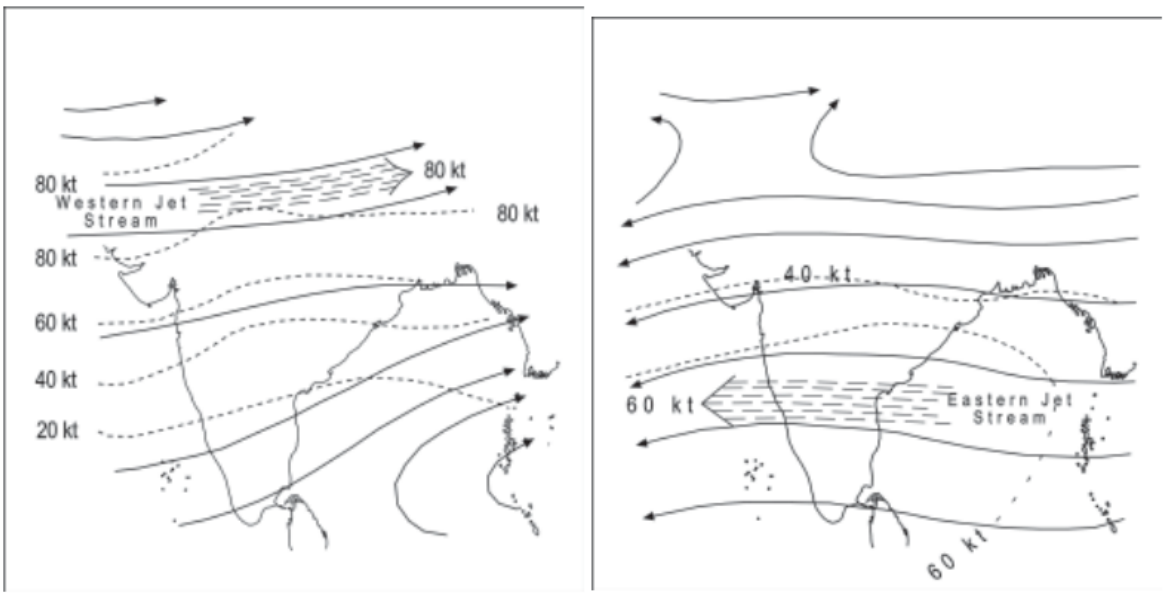
5. How do jet streams get formed? How do jet streams affect India? Examine.

Introduction

Jet streams are relatively narrow bands of strong wind in the upper levels of the atmosphere. The winds blow from west to east in jet streams but the flow often shifts to the north and south. Jet streams are like rivers of wind high above in the atmosphere. These slim strips of strong winds have a huge influence on climate, as they can push air masses around and affect weather patterns.
The jet streams on Earth typically run from west to east, and their width is relatively narrow compared to their length. Jet streams are typically active at 20,000 feet to 50,000 feet, above the surface and travel in what is known as the troposphere of Earth's multi-layered atmosphere.

Body

Effect of Jet Stream on India

- 

d that the southern branch of the jet stream in northern hemisphere exercises an important influence on the winter weather in India.

- The western cyclonic disturbances which enter the Indian subcontinent from the west and the northwest during the winter months, originate over the Mediterranean Sea and are brought into India by the westerly jet stream.
- The Sub-Tropical Jet stream plays a significant role in both hindering the monsoon winds as well as in quick onset of Indian monsoons.
- The burst of monsoons depends upon the upper air circulation which is dominated by Sub Tropical Jet Streams (STJ).
- During summer, there is a presence of easterly jet streams. An easterly jet stream flows over the southern part of the Peninsula in June and has a maximum speed of 90 km per. In August, it is confined to 15°N latitude, and in September up to 22° N latitudes. The easterlies normally do not extend to the north of 30° N latitude in the upper atmosphere.
- The easterly jet stream steers the tropical depressions into India. These depressions play a significant role in the distribution of monsoon rainfall over the Indian subcontinent. The tracks of these depressions are the areas of highest rainfall in India. The frequency at which these depressions visit India, their direction and intensity, all go a long way in determining the rainfall pattern during the southwest monsoon period.
- At times, Jet Streams bring about some moisture to the stratosphere, leading to the formation of Noctilucent clouds (tenuous cloudlike phenomena in the upper atmosphere which are made of ice crystals visible in a deep twilight)
- Known to have brought some ozone depleting substances to stratosphere which result in ozone layer depletion.

Conclusion

Jet stream has wide ranging effect on India. The theories explaining and predicting the effects are still evolving.