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Q6

Define mantle plume and explain its role in plate tectonics.

UPSC Civil Services Mains 2018 · GS I · 10 marks · World's Physical Geography

Salient features of world's physical geography.

Core demand of the question

- Define **mantle plume** and explain its role in plate tectonics
- Link plumes to hotspots, flood basalts, and how plates move and break
- Keep the explanation within a 10-mark length

Revision summary

A **mantle plume** is a hot column rising through the mantle toward the lithosphere.

Its head can make a **large igneous province**; its tail can feed a long hotspot.

Hawaii shows an oceanic track; Deccan-Reunion shows a continental flood then a track.

Plumes can dome and rift plates and add melt at ridges such as Iceland.

They supplement, and do not replace, ridge-push and slab-pull.

Introduction

A **mantle plume** is a narrow, hot upwelling of rock from deep in the mantle toward the base of the lithosphere. It is not a plate boundary by itself, but it can burn through a plate, feed volcanoes, and help a continent split.

Body**Definition**

- In the plume model, a thermal anomaly rises from the core-mantle boundary or from the mid-mantle as a mushroom-shaped head and a thinner tail.
- When the head reaches the base of the crust it melts, producing a **large igneous province**; the tail may keep a long-lived hotspot as the plate drifts above it.
- **The Hawaiian-Emperor chain is the classic ocean example:** a fixed melt source and a moving Pacific plate leave a line of islands and seamounts.
- **The Reunion hotspot and the Deccan Traps show the same idea on a continent:** a flood-basalt burst, then a hotspot track toward the Indian Ocean.

Role in plate tectonics

- Plumes add heat and magma that thin and dome the lithosphere, so rifts can open; the Afar region and the Ethiopian traps sit where a plume and three rifts meet.
- Flood basalts such as the Deccan, Siberian, and Columbia River provinces show that a plume head can cover huge areas in a short geologic time and may stress climate and life.
- Hotspot tracks give a reference for plate motion, because the volcano age increases away from the active island, as in Hawaii.

- Plumes interact with mid-ocean ridges, as near Iceland, where extra melt builds a high plateau on a spreading centre.
- They do not replace slab-pull and ridge-push as the main motors of plates, but they are a vertical heat engine that can start breakup and decorate plates with chains of volcanoes.

Way forward for the answer

- Define the plume as deep hot upwelling, then show hotspot tracks and flood basalts as its surface role.
- Keep plate tectonics as the horizontal machine and the plume as a deep extra.

Flow diagram

Deep mantle heat -> Mantle plume
Mantle plume -> Hotspot volcano chain
Mantle plume -> Flood basalt LIP
Flood basalt LIP -> Rift and breakup
Hotspot volcano chain -> Plate motion track

Conclusion

A **mantle plume** is a deep thermal upwelling that melts the lithosphere from below. In plate tectonics it explains hotspots, flood basalts, and some rifts, while the plates still move mainly by their own ridges and slabs.

Facts & figures

Mantle plume

Proposed narrow upwelling of hot mantle, often from near the core-mantle boundary.

Hawaiian-Emperor chain

Age-progressive volcanic line used as a type hotspot track on the Pacific plate.

Deccan Traps

Late Cretaceous-Palaeogene flood basalts of western India, linked to the Reunion hotspot.

Large igneous province

Huge, short-lived basalt outpouring often tied to a plume head.

Afar / Ethiopia

Region where plume-related volcanism meets the East African and Red Sea rifts.