ES1201 Assignment - 2.

Name : Priyanshu Mahato
Roll No. : pm21ms002

Q1. What is upwelling and where does it occur? Does Ekman transport play a role in upwelling and downwelling? Please explain.

ans. Upwelling is a process in which currents bring deep, cold water to the surface of the ocean. When net water column transport is away from land, subsurface water flows upward to replace the water that is moving away. This process is known as upwelling. Upwelling is most common along the west coast of continents (Eastern sides of Ocean basins). In the Northern Hemisphere, upwelling occurs along West coasts when winds blow from the North causing Ekman Transport of surface water away from the shore. Upwelling also occurs along west coasts in the Southern Hemisphere when the wind direction is from the South because the net transport of surface water is Westward away from the shoreline.

Ekman transport is the net movement of the water column at 90° to the wind dirn. This occurs due to the formation of the 'Ekman Spiral' where each successive layer of water is deflected more than its predecessor due to the Coriolis force.

Ekman transport affects both upwelling and downwelling eg. if we take a counterclockwise gyre in the Southern Hemisphere, Ekman transport will push water to the centre (convergence).

The water flows at 90° to the winds that are driving the gyre and hence cause convergence or downwelling.

Near coastal regions, Ekman transport can also cause water column to move away from or towards the landmass causing upwelling or downwelling respectively.

Q2. Explain the physics of geostrophic current.

Ans. Areas of convergence and divergence produce slight variations in sea-surface elevation across the ocean basins, so the sea surface actually slopes from one point to another. This difference in elevation is very slight - on the order of a few metres over 10^2 to 10^5 km. Yet these slight elevation gradients are sufficient to cause a downslope force on the water due to gravity. If we consider the subtropical ocean in the Northern Hemisphere, for example, we have already seen that the North East trade winds produce a Westward-flowing ocean current near the equator, whereas the prevailing Westerly winds in the mid-latitudes result in an Eastward-flowing current. The circulation is completed by the deflection of water along the coastlines at the ocean margins. Ekman Transport in the surface layers causes convergence and the pile-up of water in the middle of the ocean.

The sea surface is only about 50 cm higher in the centre of the gyre than at the edges, but gravity acting on this pile of water results in a force that pushes outward down the gradient from the center. As the water flows, however, it is deflected by the Coriolis effect until that effect balances the pressure gradient force acting down the slope. The result of the two forces acting in opposition is to cause a flow of water off to the side – to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. Thus, we end up with a circular flow of water around the gyre that is approximately parallel to the ocean slope. The resulting current is called a geostrophic current.

Q3. Explain the bottom-water formation and its importance for driving deep ocean circulation.

Ans. Near the poles, the surface waters are cooled below the normal freezing point by coming in contact with the cold overlying atmosphere. The freezing point is lower than that of pure water due to the presence of salt. When that water freezes, it forms a layer of sea ice several metres thick that floats on the surface of the polar oceans. When the ocean surface freezes, most of the sea salt is excluded, because the salt does not fit into the crystal structure of ice. As a result, the water just beneath the sea ice becomes saltier, and an underlayer of very cold, highly saline water forms. The combination of low temperatures and high salinity results in very dense water that sinks and flows down the slope of the basin and spreads towards the equator as the bottom layer of water in the deep ocean

basins. This is how bottom water is formed. Deep ocean circulation is driven by differences in water density. This difference in density is caused by bottom water which has the highest density due to low temp. and high salinity while other regions have less dense water. Hence, bottom water is important for driving deep ocean circulation because of its high density.

Q4. Explain briefly why the source of major fraction of Earth waters seems to be from meteorites but not from comets.

Ans. D/H ratio is the ratio of Deuterium to Hydrogen. The D/H ratio for bulk earth is estimated to be around $(149 \pm 3) \times 10^{-6}$. The D/H ratio for comets is $(310 \pm 40) \times 10^{-6}$ while the D/H ratio for carbonaceous meteorites is about (160×10^{-6}). From this data, it seems that a major fraction of Earth waters must have been contributed by meteorite impacts.

(5) Briefly explain the role of greenhouse gases in early Earth atmosphere when the luminosity of Sun was 30% less ~~that~~ ~~that~~ than that of today. (Faint Young Sun).

→ As we know that greenhouse gases absorbs some of the radiation which are radiated by sun. This is called greenhouse effect. So when; there was Faint Young sun era; 30% fainter than today; green house gases had a great effect on keeping Earth's atmosphere at suitable temperature. There are some some evidences ~~Ede~~ of liquid water indicating normal temperature at that time instead of ice-ball Earth condition