

SUBMARINE GEOLOGICAL FEATURES AND THEIR EVOLUTION.

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INTRODUCTION:

Oceans form a dominant and conspicuous part of our globe covering about 72% of the global area. The distribution of oceans is very uneven. Around 80% of the southern hemisphere is covered with oceans against only 60% of the northern hemispheric area. The world oceans contain nearly 1350 million cubic km of water (Menard and Smith, 1966). Marine geology is a very important part of the oceanography. The study of oceanic evolution, tectonic setting, geographical distribution etc form a foundation to understand the various aspects of the oceans. Without the marine geology the science of earth is incomplete. herefore, Kuenen wayback in 1958 rightly published a paper with title "No geology without marine geology". The geological features which are encountered while opening the remote doors of oceans tell the story of the evolution of our planet earth. Most of the marine geological features are dynamic about which the earth science comunity knew very little till recently. Much of our present day knowledge regarding the geology of the ocean basins is the outcome of Challenger expeditions (1872-1876), DSDP endeavours which started during 1968 and the scientific publications of the last 50 years.

In this lecture we discuss the major submarine geological features and in brief their evolution. The ocean floor can be subdivided into three major topographic provinces viz., Continental margins, Ocean basins and Oceanic idge systems.

I. CONTINENTAL MARGINS:

Continental margins lie between the continents and the ocean basins (Figure 1). These margins underlie approximately 20% of the total oceanic area, i.e., around 70 mil. sq.km. Continental margins are classified in to two major forms;

a) Atlantic type margins: which consists of three components viz., continental shelf, continetal slope and continental rise with increasing depth (Figure 1).

b) Pacific type margins: which grade from shelf to slope to deep trench and is widespred around the Pacific.

The Atlantic type margins are passive or aseismic margins while Pacific types are active or seismic margins. Figure 2 gives the distribution of the two type of margins. Continental margins mark the transition between thin dense oceanic crust and thick light continental crust. These margins are the main repositories of the sediment flux to oceans and comprise more than half the total sediment volume of the oceans (Heezen and Tharp, 1965).

Passive type of continental margins demarcate the ocean, continental transition within a plate. Therefore they are not the plate boundaries. They develop due to the rifting of the continents to open new oceans. Thus the

continent and the adjacent oceanic region forms a part of a same plate.

e.g., Continental margins of India lies within the Indian plate which comprises both continent and part of the Indian ocean. Initially passive margins form at the divergent plate boundaries by rifting of the continental crust. As the time lapsed, the rifted continental crust move away from these boundaries and eventually these boundaries become the sites of massive subsidence and thick accumulation of sediments.

i.e., Breaking down of super continents Gondwana land and Laurasia during Mesozoic (~200 ma) and Tertiary (~50 ma) produced the divergent or passive margins (Figure 3).

Active continental margins evolve as a result of two converges plates resulting in destruction of the crust often by underthrust of oceanic crust below the continental crust. Thus, these margins comprise the part of two different plate. The continental crust and the adjacent oceanic crust belong to two different plates. Therefore, such margins are usually associated with deep trenches, earthquake activitie (Figure 3).

e.g., West coast of South America.

i. Continental shelf: A shallow platform or terrace which surrounds the continent is termed as shelf. It forms the seaward extension of the adjacent continent from the shoreline to a line called the shelf break or shelf edge. The crust beneath the shelf is continental in nature but thinner than the adjacent continental crust. The average depth at the shelf break is nearly uniform (~130 m) over the world oceans. The slope gradient of the shelf is very gentle ($< 1:1000$) and has no conspicuous relief features. The width of the shelf ranges between a few km and 400 km. The average width is around 80 km. The continental shelf is the cumulative effect of erosion and sedimentation of the continental material and the large scale sealevel oscillations in the past 1 million years.

ii. Continental slope: At the edge of the continental shelf the depth increases rapidly from 200-300 m to 1500-3500 m. The slope starts from shelf break which is believed to be formed around 18000 y BP when paleo-sea level stood at that level. The regional slope is steep of the order of 1:40 i.e.,

$\sim 4^\circ$. The extension of the slope is very narrow of the order of only 200 km as compared to its gradient. The slopes basically may be divided into escarpments due to series of faults which have been filled with sediments in later course to give rise to smooth reliefless topography. In case of convergent margins, continental slopes extend down into deep trenches. Ex: Peru-Chile trench.

iii. Continental rise: The topographic province between the slope and ocean basin is termed as continental rise. It is a zone approximately ranging between 100-1000 km wide with gentle seaward gradient (1:100 to 1:700) without any conspicuous relief features. The continental rise is formed due to the sediment accumulation at the base of the slope to the extent of several km thick. These sediments are the products of the continental weathering processes. The continental rise often cut across by several submarine canyons and channels which act as conduits for the seaward transport of the sediments. Every submarine canyon has a fan like structure at its mouth similar to those of land drainage systems. Continental rise is a depositional feature and hence invariably associated with deep sea fans.

II. OCEANIC RIDGES:

These are the most conspicuous submarine relief features run all through the world oceans. The total length of the oceanic ridge system (termed as "mid oceanic ridges" (Figure 4)) is around 80,000 km and an average depth of their occurrence is around 2500 m. They typically run through the middle portion of the oceans except in case of Pacific where it intersect with north America. The mid oceanic ridge system is a submarine mountain chain which reaches its highest elevation at its axis and slopes away on either side of the flanks. These ridges are cross cut by numerous fracture zones developed due to transform and transverse faulting. The crest of the ridge varies between 1000-3000 m elevation above the adjacent basin floor and cover a width of approximately 1000 km. The flanks of the ridges are nearly symmetrical in their topography (Figure 5). A typical ridge system (Mid-Atlantic-Ridge) constitutes a central rift valley of 1-2 km depth and a few tens of km wide and run all along the axis of the ridge system. The recent FAMOUS (French American Mid Ocean Undersea Studies) project has revealed that, these median rift valleys contain within them a still narrower inner rift valley often marked with fissures and volcanic hills. The fresh oceanic basalts were recovered from this inner valley. Thus the rift valley act as the centres of seafloor spreading. The Iceland is the rare extension of the mid-ocean ridge system.

i. Fracture zones: The world ocean floor is cut by several fracture zones of 10-100 km width. They are nearly semiparallaly arranged and even cut across the midocean ridges offsetting its axis. Fracture zones are the extensive linear zones of irregular topography marked by troughs, escarpments large seamounts and asymmetrical ridges. They normally extend for long distances across the flanks of mid-ocean ridges and in some cases extend as surface or subsurface fractures across the basin floor extending up to the continental margins. In cases, their extension is of the order of 3500 km. These fracture zones are formed due to the movement of crustal blocks. In majority of the cases the fracture zones run almost linear but also show the changes of direction in their extension.

III. OCEAN BASIN:

The major portion of the submarine floor (~40%) is covered by the basins. The Basin is the area of the ocean floor which lie between continental margin and midocean rid es. It can be divided in to three subgroups;

i. Abyssal plain: Abyssal plain is the area of the ocean basin floor that is flat with a slope of less than 1 m per km (1:1000). Abyssal plains are the most conspicuous flattest portions on the earth. The lateral extension of the plains vary between 200-2000km from continental margins and the depths vary between 3000-6000 m. The abyssal plains are developed due to the deposition of thick sediment column of a few thousands of meters thick over the original topographic irregularities. The sediment thickness and the development of an abyssal plain is directly related to the type of continental margin. In case of convergent margins the marginal trenches act as the trap or sink for the land derived sediments and very little portion of sediment reaches the abyssal plain and hence in such case the the development of abyssal plain is rather poor as compared to the divergent margins.

The abyssal plains are wide spread in Indian and Atlantic ocean, occur in marginal seas such as Mediterranean, Gulf of Mexico and Caribbean.

ii. Abyssal hills: These are the small hills which rise from the abyssal plain no higher than 1000 m. Horizontally they cover an area of 1-10 km. The slope ranges between 1° - 15° . These hills usually occur in groups in the areas between abyssal plains and flanks of the mid ocean ridges. Abyssal hills are the integral part of the mid-ocean ridges though they occur at deeper level away from the zones of mid-ocean ridges. Their low relief is due to the burial by sediments.

iii. Seamounts: Volcanic mounts those rise more than 1000 m above the basin floor are termed as seamounts. They are distributed randomly over the ocean floor and some times occur in clusters. The slope of the seamounts range between 5° - 15° and most are conical in shape. They rise very rapidly over the abyssal plains suggesting that their major portion of the basement is buried under the sediments. Once the seamount rises above the sea level, is called as volcanic island. Subsequently these volcanic islands are subject to erosional processes making their topography flat. Later subduction of these volcanic islands yield a submarine mount with flat topography which is called as "guyot".

Apart from the above major topographic feature other spectacular submarine features are the marginal trenches which have been discussed earlier. The deepest portion of the oceans are encountered in these trenches, i.e., Mariana trench- 11 km deep. Aseismic ridges like Ninety East Ridge in Indian ocean which trends exactly NS is another spectacular submarine feature. This ridge is believed to be of volcanic origin and at present is inactive. The subsequent sedimentation has covered the irregularities of the ridge providing nearly smooth topography.

If, our imagination could pump out all the water from the world oceans the visible topography is no less complex than the continental topography. The history of development of oceanic submarine features is the history of evolution of oceans, is the history of geographical distribution of oceans and continents, is the history of complex plate tectonics; therefore the marine geology reveals the most astonishing events which have shaped the present day earth and opens the doors of evolutionary history of our planet.

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