

CONTINENTAL DRIFT, SEAFLOOR SPREADING AND PLATE TECTONICS

M.V. Ramana

National Institute of Oceanography, Dona Paula, Goa

CONTINENTAL DRIFT

The Planet earth came into existence through a cosmic event about 4500 million year ago. By the late Precambrian 1000 million years ago or less all the available continental material had aggregated into two ovoid super continents called Gandwanaland and Laurasia, situated in the southern and northern hemisphere.

The seeds of continental drift were planted hundreds of years ago. As long as as 1620, Francis Bacon was impressed by parallelism of the shores of Atlantic and discussed the possibility of the drifting of two opposite continental masses. Several other workers suggested similar phenomena in 1800 and late 18 century. At the turn of 19th century, one of the most favourable theories of the earth's genesis was that of the Austrian synthesizer Edward Suess - the global contraction hypothesis. Suess proposed all the continents had been at one time joined in a single immense land mass called Gondwanaland. Alfred Wegener, a German meteorologist who collected the first evidence data in support of continental drift. An American, Frank B. Taylor (1910) independently suggested a mechanism that could account for large lateral displacement of earth's crust.

Arthur Holmes, of the University of Edinburg reactivated the convection theory as the primary mechanism for earth's dynamic processes. He was the first man to suggest that the basaltic layer acts as a conveyor belt on top of which a continent is transported to the location of the downward sinking of the convection cell. New oceanic crust is generated by the intrusion of basaltic magma with the oceanic crust. Vening Meinesz added that ocean trenches were formed by the downdragging by this same type of convection mantle flow. These large down warps, or tectogenes, came close to plate tectonic theory but subduction was not invoked. The Holmes theory of mantle convection was replaced by Careys expanding earth hypothesis of contraction and compressional features. Later paleo-magnetic studies proposed by Wegener played a major role in reconstruction of continents (Polar Wandering). E. Irving calculated the pole-paths for north America and Europe and concluded that during the Mesozoic and Paleozoic, North America lay closer to Europe and that India, Australia, North America and Europe had all drifted.

Two different reconstructions have been proposed for the original configuration of the groups of continents in the Northern and Southern hemisphere. Wegener believed that all the continents were assembled as a single mass (Pangaea) at the beginning of Mesozoic.

Du Toit (1937) suggested the existence of two large land masses: Godawanaland and Laurasia in southern and northern hemispheres. These two enormous land masses were separated by a large body of water between Africa and Eurasia called the Tethye sea, which was located north of Arabia and extended from the former location of the Atlas Mountains to the east of the Himalayas. Great thickness of sediments were deposited in the Tethys sea over the past

200 m.y. When Gondwanaland broke up and moved northward against Eurasia, the motion closed the Tethys sea and buckled these thick accumulations of sediments creating the mountain chain that extends from the western Atlas range through the Mediterranean, the western Alps the Caucasus and the Himalayas. The most spectacular tectonism occurred in the Himalayas as India rammed into Asia.

Some of the features of continental drift theory are:

- a. General similarity of coast lines
- b. Fracturing pattern as fault-line scarps and monoclines
- c. Abruptly terminated plateaux or elevated erosional plains with disturbed or reversed drainages
- d. Submarine features such as the mid-Atlantic and Mid-Indian ocean ridges.
- e. Equivalent formations on opposite coasts with due regard to their mode of origin and subsequent history
- f. Similar variation in formations when traced along opposite shores
- g. Contrast in faunal variation when traced away from opposed shores
- h. Unconformities on comparable horizons
- i. Comparable geosynclinal troughs in each mass having more or less similar trends and histories
- j. Comparable fold systems passing out to sea at opposed shores
- k. Crossing of fold or fault systems of specific ages.
- l. Synchronous intrusion of batholiths in equivalent fold systems
- m. Plateau basalts and associated dike swarms
- n. Petrographic provinces with similar eruptive studies belonging to several different ages
- o. Comparable zones and periods of ore-genesis especially such as may contain rare or distinctive minerals
- p. Strata denoting a special environment particularly extreme climate conditions such as tillite, varved shale, laterite evaporites, aeolian sand stone, coaled coral lime stone.
- q. Terrestrial faunal and floral paleontological provinces with identical or allied species.

SEAFLOOR SPREADING

Until the 1960s most geologists believed in the permanence of continents and ocean basins. A new detailed model that provided a tenable alternative to Wegener's ideas was provided in the classic paper, "History of the ocean basins", by H.H. Hess (1962) of Princeton University, in which he incorporated some of the concepts of Arthur Holmes. Hess suggested the lateral movement of the crust from the source of a convection current to its sink. New oceanic crust is generated at the mid oceanic ridges, where hot mantle material rises the topographic elevation of the ridges due to lower density of hotter rocks. At the ridges, the surface rocks are broken by tension and pulled apart, and the rift is filled by new volcanic material from the mantle. The ocean floor thus spreads laterally as if on a conveyor belt where the convection cells converge, the ocean crust is dragged downward to form trenches. These

descending currents are the sites of compression, marked by mountain ranges and volcanic arcs associated with the trenches. The continents, having been built up by the accumulation of higher silica rich rocks are not dragged downward at the trenches but accumulate or are thrust upward as mountains. It is R. Dietz who termed the seafloor spreading to describe a theory primarily concerned with the process by which the ocean floor is created and destroyed. The beauty of this theory is that it satisfied most of the results available from the fields of marine geology and geophysics.

Since, the theory of seafloor spreading was formulated in detail by Hess and Dietz, it has created a profound understanding of the ocean basins and their margins, and the new data are nearly always compatible with this unifying concept. In effect, the formulation of these new theories created the well known revolution in the earth science, the Wegenerian Revolution (Wilson, 1973).

The seafloor spreading was based upon the following :

- The paleo reconstruction fits of the continents and other evidence for continental drift.
- The height and topography of ocean ridges.
- Systematic thickening of sediments away from ridges.
- Volcanism on ridge axes
- Seismic zones, island arcs, and Volcanism at or near certain oceanic margins.

J.T. Wilson (1963) of the University of Toronto observed a systematic increase in the age of islands in the Atlantic with increase in distance from the mid-ocean ridge. The bathymetric surveys by Heezen and others of Lamont Geological Observatory have revealed the basic symmetry of the flanks of mid ocean ridge. Further the seismic reflection data showed large thick sediments on the either flanks of the mid oceanic ridges and sediment free zone on the crest of the ridge.

Although various lines of evidence pointed towards the concept of seafloor spreading, the most crucial evidence was provided by magnetometer surveys of large segments of ocean floor. The pattern of linear magnetic anomalies have been discovered in North West Pacific by Vacquier and others (1961) and Mason and Raff (1961). They proposed that the linear magnetic anomalies resulted from an alternation of lava flows and sediments forming a sequence of troughs. Further significance offsets were noticed in the anomaly distribution. Positive magnetic anomaly associated with the median rift valley of mid Atlantic ridge.

During the early 1960s the polarity time scale was being developed independently and Vine and Mathew (1963) offered a simple explanation to account for the enigmatic central magnetic anomaly observed over ridge crest and linear magnetic anomalies. They combined Hess's seafloor spreading theory

with the new data on the history of reversals of the earth's magnetic field and suggested that as new seafloor forms at the mid ocean ridges through extrusion of submarine lava, it becomes magnetized in the earth's magnetic field prevailing at the time it cooled. When the newly formed material was subsequently pushed laterally from the ridge axis by the new seafloor material, it would form strips of alternating normal and reversed magnetization. The magnetic surveys over these alternate strips give rise to positive and negative magnetic anomalies.

PLATE TECTONICS

The essential idea of plate tectonics is that the entire surface of the earth is composed of a series of internally rigid, undeformable, but relatively thin (100 - 150 km) plates. The earth's surface is covered by mostly seven plates. The plates which are essentially aseismic, are bounded by active ridges, trenches, rifts, and great fractures or megashears associated with extensive seismic activity.

The major plates are) North American plate, i) South American plate
iii) African plate iv) Arabian plate v) Antarctica plate vi) Eurasian plate
and vii) Indian plate.

REFERENCE

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