*International Research Journal of Earth Sciences*_____ ISSN 2321–2527
Vol. **2(8),** 10-14, September **(2014)** *Int. Res.J. Earth Sci.*

The Dynamics of Changing Earth: An Evolution from the beginning to the Present Scenario

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Available online at: www.isca.in, www.isca.me
Received 17th August 2014, revised 2nd September 2014, accepted 23rd September 2014

Abstract

From the creation of our mother planet, Earth about 4.5 billion years ago, the planet has undergone a number of simple and complex processes to attain the present day scenario. Though it looks like a simple process and a suitable and stable place for life to live with, many more continuous and complex processes are taking place, making it a more active and dynamic planet in our Solar system. Since the beginning of the planet from a super collision effect, it has restlessly evolved in its internal and external characteristics through various active processes. Tracking the history, we can get a glimpse of its dynamical changes on the basis of many central hypotheses, which were observed, proved and analytically described. As many of them can be attributed towards its dynamic changes, the basic and major ones which really explain the processes are Continental Drift hypothesis, sea floor spreading, Paleomagnetism and Polar Wandering Path; and collectively above all others. Though these theories explain the same consequences and results, they have undergone different evidences and experiments to reach in the last consequences. As an active planet, the continuous dynamical changes of Earth can be traced on the basis of vivid and conceptual analysis of the above hypotheses.

Keywords: Dynamic planet, continental drift, sea floor spreading, polar wandering path.

Introduction

The spatiotemporal variations in the internal and external properties of earth can be best described with the three most popular, fundamental and basic aspects such as Paleomagnetism, Polar Wandering and Paleoclimatology. These hypotheses can make the track of the geodynamic evolution of Earth from its beginning.

The Paleomagnetic theory is based upon the acquired magnetism of the rocks of different eras. Whenever a rock is formed, its minerals acquire a magnetic dipole and the net magnetic moment similar to the dipole moment of the magnetic axis of earth at that time of formation. Hence, with time, the different formations of the rock show different magnetic dipole directions suggesting the variations in the magnetic field as well as the magnetic axis. By tracing the paths of magnetic moments of the rocks of the same continent over a longer era of time, one can calculate a curved path of the magnetic direction, called Apparent Polar Wandering Curves. Again, the similarity in the nature of polar wandering curves between two different continents suggests their togetherness in the past. This draws the explanation about the movement of plates with respect to each other. Hence, this hypothesis serves as one of the most important tool to track the dynamic changes in the active processes in Earth.

Similarly, a important hypothesis termed as 'Continental drift hypothesis' serves as a major key to estimate the dynamical changes of Earth. Proposed by Wagener, it states that the plates on Earth move continuously with respect to each other. A continuous tracking of the movement of plates and their future movement simulation can be attributed towards the dynamics of Earth. A good estimation of the movement of plates and the simulation of their movements can make us know about the present happenings as well as the future set up of continents, which clearly states the dynamical changes in our planet.

Another important aspect termed as paleoclimatology can make a good estimation of the evolution and continuous changes in the Earth. By the test of stable oxygen isotopic ratio, we can simply know the past as well as present climates and the processes of their evolution to the present extent. Also we can model the future prediction on the basis of the present observations. This suggests a very important tool for estimation of the dynamical changes in the climate of Earth system.

Methodology and aspects of geodynamical reconstruction

Polar Wandering Paths and Paleomagnetism: Apparent Polar Wandering (APW) paths and their analysis can be treated as a successful tracer as well as an important tool to reconstruct the paleogeography and continuous geodynamical variations of Earth by study of the processes of paleomagnetism. The reconstruction is based upon the geomagnetic polarity record using different paleomagnetic data.

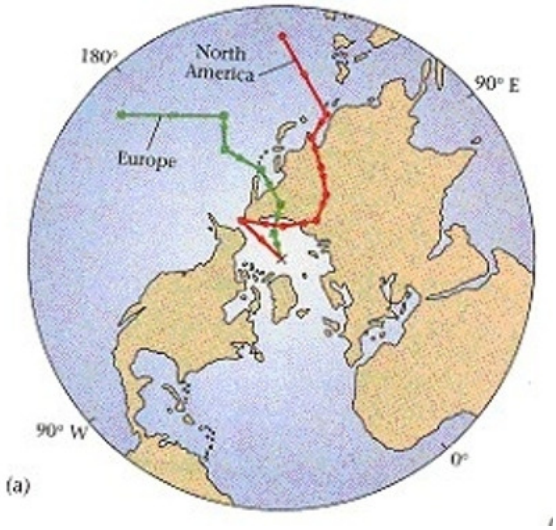

Figure-1
Representation of Apparent polar wandering paths of North America (red line) and Europe (green line)

The paleomagnetic poles obtained from the examination of rocks of Pleistocene and Pliocene ages suggest a close approximation of the positions of the Paleomagnetic pole and the geographic pole, which is in agreement with the axial geocentric dipole hypothesis. In contrast to this, the positional records of the paleomagnetic poles collected from the older rocks of the same continents, clearly describes the significant variations in the positions of these poles from the geographic pole. This illustration is best described from the stable European carton. When Pleistocene and Pliocene records show group with the geographic pole, the Permian poles show a clear 45^0 variation from the geographic pole. Considering the validity of the axial dipole hypothesis, the Permian pole distribution suggests that the geographic pole was far away from its present position in the Permian period (about 250-300 Ma ago). An alternative interpretation can be attributed by imaging that the geographical pole has not changed but the European craton has moved relative to the pole, suggesting the present position of the cluster of Permian poles was previously on the rotation axis in the Permian period. It suggests that the European continent has moved all the way to the present day position with respect to the rotation axis. This motion of the paleomagnetic pole is called as the "Apparent Polar Wander" and the path travelled by it is called as the "Apparent Polar Wandering Path"[1]. If the Apparent polar magnetic path of a particular continent is traced with records from the old rocks, the path will show an irregular, curved trend.

The APW paths of North America and Europe show clear curves since Late Paleozoic with each APW lying on the opposite side of the Geographic pole. Considering the axial geocentric dipole hypothesis, it seems difficult to imagine that the paleomagnetic pole) which is the Earth's rotational axis) has moved along two different APW paths (figure-1). These two APW paths representing the separate motions of Europe and North America, suggests the evidence of Continental drift as well as the changing dynamics of Earth. These paleomagnetic data really serves as an analytical tool for the changing dynamics interpretation. Moreover, if two continents belong to the same plate, they must possess the same trend of APW paths for that time only. Matching the same APW paths of the continents for the time they were on the same plate should give the relative positions of the continents and their movement from each other through the process of continental drift and plate tectonics. So the process of Apparent Polar Wandering Path calculation can trace out the continuous changes in geodynamics by study of the paleo-magnetism.

Continental Drift: In 1620, Sir Francis Bacon, English philosopher, mentioned in his book *Novum Organum* that the coasts on either side of the Atlantic Ocean appeared to parallel one another. He may not have been the first to make this observation, for it was readily perceptible even on the basic maps of that day. During the end of the 19th century, Eduard Suess, Austrian geologist (1914) mentioned many geologic similarities between Africa, South America, and India and proposed the division of a supercontinent, but envisioned that the oceans had created by the foundering of blocks of crust between the present landmasses. Although continental drift was first suggested in the17th century, it did not receive serious scientific investigation until the beginning of the 20th century. Alfred Wegener (1912), a German meteorologist, stated that the continents are not stationary, but actually moving or drifting away from each other. He suggested that during the Mesozoic Era approximately 200 Million years ago, all the continents of the earth were united together and form a single supercontinent named "Pangaea" and surrounded by spacious ocean, named "Panthalassa"[2]. This supercontinent began to break into smaller continents at beginning of Mesozoic Era which then drifted to their present position as like pieces of wood floating on water. That time continents were suffered by differential gravitational forces which responsible for movement of continents towards westward and equatorword. These drifted continents were divided in two spacious landmasses, which have been called "Gondwana land", associated as Africa, South America, Ausraliya, Antarctica and India, and "Laurasia", associated with North America, Greenland and Eurasia[3].

The primary sources of evidence associated as glacial till deposits of carboniferous age, similarities in shape of coastlines of continents and the apparent shifting of climatic belts over time[4]. The most evident and compelling evidence for continental drift compose of the shapes of the continents. Wegener (1912) noticed that the continents seemed to fit of some continents, for example, South America and Africa match at the edges of their continental shelves is readily visible on casual observation of a world map, but it is even more remarkable when they are juxtaposed[2]. The fit was optimized by computer in the early of 20th century and turned out to be better than even the proponents of continental drift had predictable figure-2. Wagner (1912) was noticed similarities in lithology,

structural trend, stable plate form and ages of different stratigraphic sections of different continents and found existence of same lithology, orogenic belt and structural trend as other continents, for an example, in Ghana near Accra (West Africa) there is clear boundary million year old rocks and much younger (about 400 million year ago) rocks[2]. This boundary runs into the Atlantic Ocean in the southwest direction. Same boundary occurs in Brazil at Sao Luis and the late Precambrian – Paleozoic terranes define a continuous belt from eastern Australia through Antarctica into southern Africa and Argentina when the continents in the southern hemisphere are considered in their pre-drift positions. The fit of South America to Africa was suggested by matching of crustal provinces and structural trend. Remains of the glossopteris flora, dinosaurs, and trilobites occur in South America, South Africa, India, Australia and Antarctica of same age. The nature of their species distribution can only be explained if all the southern continents were joined together[3].

Figure-2
Computerized least square fit at 500 fathoms of the continents around the Atlantic Ocean[5]

Several researchers have been worked on continental drift and noticed the Atlantic Ocean is still emergent at the moment due to passage of time (in term of geological time scale) it will start to shrink again, develop its own 'ring of fire', as the old tired ocean floor starts to obtain pushed under the continental crust. Between 195 million years to present, have been observed a period of clearly frenetic continental collision and mountain-building process, for example, India hit Asia, Spain hit France, Italy hit France and Switzerland, Greece and Turkey hit the Balkan region, Arabia hit Iran and Australia hit Indonesia. Researchers suggested that this process will further occur and finally united as once again huge masses which will floats on spacious ocean as shown in figure-4a-d.

Sea floor Spreading: In the early 1960, the Princeton geologist, Harry H. Hess, proposed the hypothesis of seafloor spreading and postulated two fundamental fact that lead to sea floor spreading such as: the mid oceanic ridges occur in all major basin and next one is mid oceanic crust has a thickness of 6-7 km wherever the typical thickness of continental crust is 30-40 km. He postulated that ocean floor is progressively widen and continuously new oceanic crust is created along the crest of mid ocean ridges and estimated that South America and Africa had both moves from the mid Atlantic ridge during an interval 2500 million years ago at rate of 10 mm per year[6]. Till 1962, this theory had not fairly accepted but in 1963, Fred Vine and Drummond Matthews, British geologists, observed that ocean crust surrounding the mid ocean ridges are showing alternate bands and each band magnetized with a polarity opposite the surrounding bands i.e. positive and negative magnetic strip. Vine and Mathews suggested that, on the basis of their observations, Hess's sea floor spreading combined with a reversing magnetic field would act as gigantic tape recorder which might provide compelling and detailed evidence for sea floor. Till 1966, Mathews and vine finding become quite clear rather than three year back because that time earth scientists were identified the Jaramillo event which confirmed the theory of earth magnetic field.

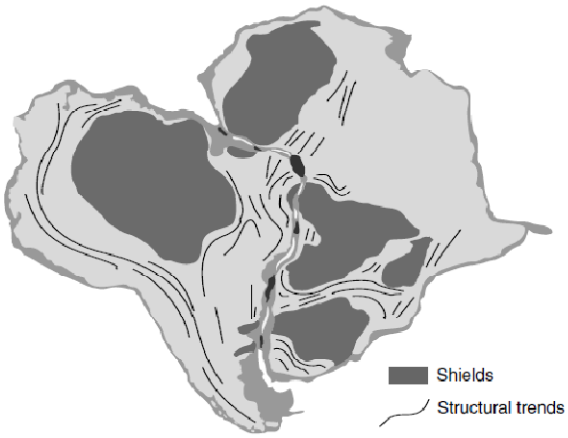

Figure-3
Computerized geometric fit of South America and Africa[7]

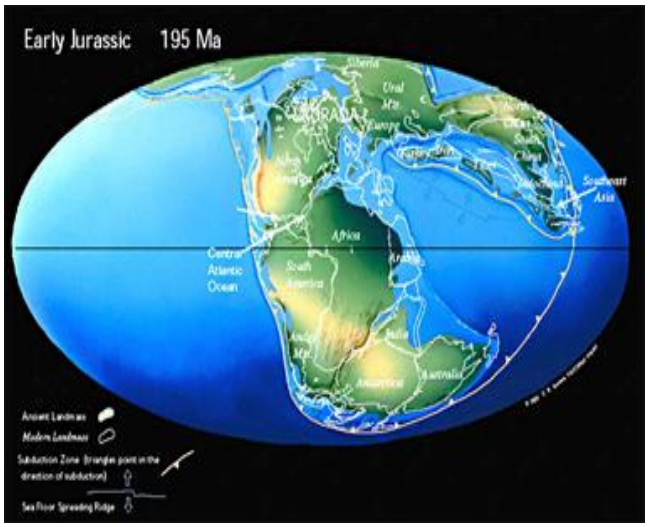

Figure-4(a)

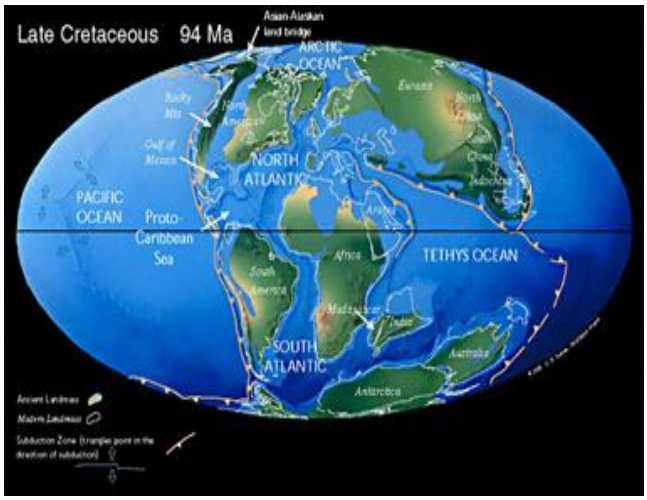

Figure-4(b)

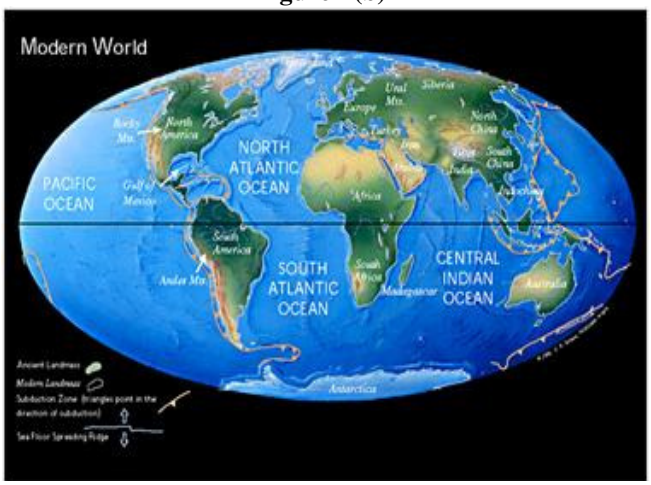

Figure-4 (c)

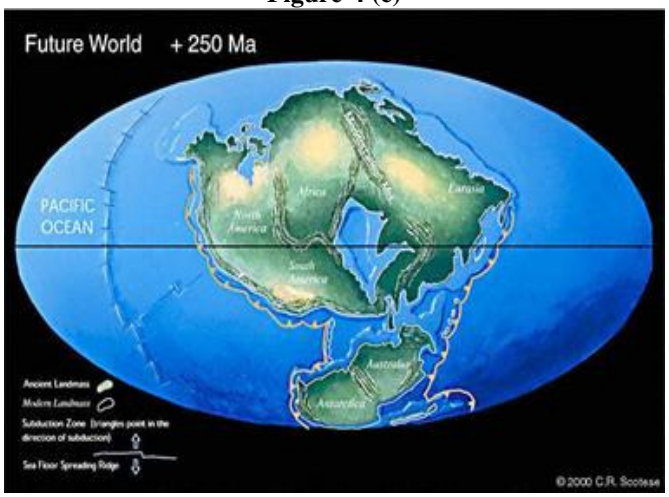

Figure-4(d)
Figure-4a-d
Past-present and future scenario of our Earth's Continents

Evidences which favor the theory of sea floor spreading are as follows: i. Earth scientist had drilled out ocean floor to study about sediments characteristics and found that only thin layer of young sediment overlie the oceanic crust while an increase in distance from ridge, sediments generally thickens and the age of sediments also increase. ii. The occurrences of shallow focus earthquake and active volcanic island along the crest of the mid oceanic ridges provides clear ideas about sea floor spreading. iii. Distribution of positive and negative magnetic anomalies along mid oceanic ridges provides evidences of sea floor spreading. Because new sea floor record the reversal in the earth magnetic field as well as time elapsed between the reversal ranges from thousand s to hundreds of thousands of years.

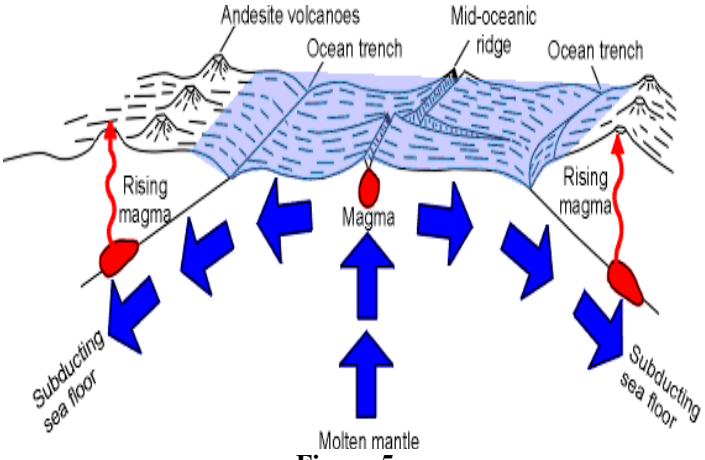

Figure-5
Schematic diagram of sea-floor spreading

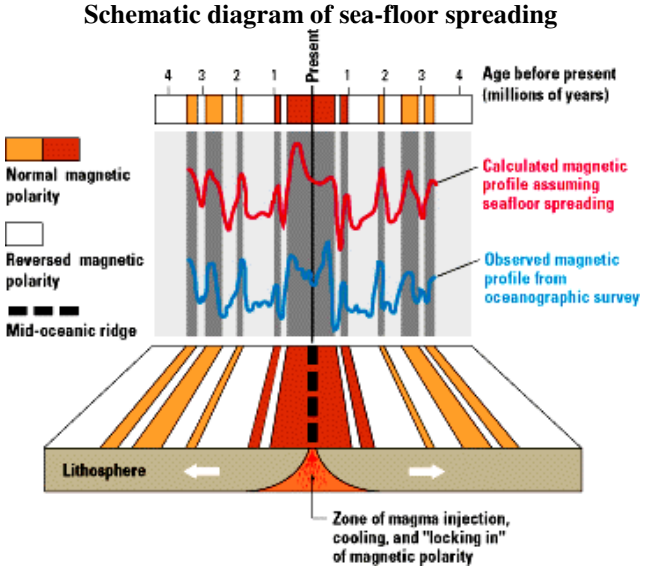

Figure-6
Schematic diagram of magnetic anomalies on the sea floor

Conclusion

The experimental and observational hypotheses reveal, that all about changes likewise sea-floor spreading, polar wandering curves, continental drift and the changing the earth through geologic history. Though these processes are very macro canonical in nature, these are well established and observed by the erath scientists up to date. The continuous changes in the

dynamical processes of the earth can be summed up as a consequence of many more small and giant processes. Observations show that, the earth which is a very active and relentless, will one day going to be in the same nature as of its beginning. This support is explained on the basis of continental drift and polar wandering theories. The separated continents as present scenario are going to be messed up into a single huge super continent in the time span of about 250 million years in the future.

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