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The Centrifugal Force behind the Movement of Continents, Change in the Axis of the Rotating Earth

Yeshayahu Greitzer
(18 Zeitlin St. Tel Aviv 64955, Israel)
Corresponding Author: shaya-1@zahav.net.il

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Abstract:
The movement of continents was first discerned by A. Wagener, who in his studies established the basis for the theory of plate tectonics. There are many theories explaining the forces causing the movement of continents based on internal processes in the earth. Proposed here and explained is that the main force is the centrifugal force of the rotational movement of the earth following the change in location of the axis of the earth's rotation relative to the mantle of the earth and, in accordance, a change in the location of the equator.

Keywords*: plate tectonics; centrifugal force; change in the location of the equator; movement of continents*

I. The Theory On Which The Movement Of Continents Is Based

The assumption is that over an extended geological period, the axis of the earth's rotation in a pseudo-circular orbit changes its location. In this article a model is presented in which explanations are given for the possibility of a change in the axis of the earth's rotation in a peripheral manner by about 90^0 and, in accordance, about a 90^0 change in the equator's location. The actual movement of the continents depends also on many other geological factors.

The movement of continents was first discerned by Wagener (1922; 1966) who in his studies established the basis for the theory of plate tectonics.

In the present work we assume the location of the axis of the earth's rotation in circles of large circumferences changes its position on the globe significantly relative to the mantle of the earth -- because of cosmic forces (Greitzer, 1979; 1982) and changes in the mantle composition by slab pull, ridge push, hot spots, convection currents, or other forms (Greff-Lefftz and Besse, 2014; Zhang et al., 2010), and changes of the Earth's geoid (Steinberger ad O'Connell, 2002; Steinberger and Torsvik, 2010), etc., and in accordance, the location of the equator changes.

The speed of rotation of the mantle crust of the earth is highest at the equator and gradually decreases towards the north and south poles. Hence the change in location of the equator will cause a significant change in the forces of movement – speed of the rotation – centrifugal force, that act on the continents and will move them. The movements of the continents will be, in accordance, related to the intensity and directions of the new centrifugal forces.

We assume that since the creation of earth and its beginning rotations, in the course of the geological eras the change in location of the axis of the earth's rotation had a trend and direction. In the present work we reconstruct the possibility of a change of location of the axis of the Earth's rotation, and in accordance, of the change in the location of the equator that relates to the last geological era, approximately the Mesozoic to Recent (around 200 - 250 m.y.). Likewise, we assume that in earlier periods, the earth's rotational axis changed its location by a scope of several rotations on the globe. This was not necessarily done in full circumference circles, but in large circles. We explain the activity of the centrifugal forces acting on the continents whereby the axis of the earth's rotation and the equator changed their locations on the surface of the earth by about 90^0.

The movement of every continent actually is determined according to its location relative to the equator, to the speed of its previous movement, to the size of its mass and to its lithologic composition, and also to some parts of other

neighboring continents. The size of a continent's mass affects the degree of its acceleration. The degree to which a continent is split depends mainly on its position relative to the equator and to the relations between the speed of the continent's movement and the speed of the movement of the change in location of the equator. In the course of its movement the continent meets other continents moving at slower speeds or in different directions, and at the point of contact tectonic folds, such as the Alpine fold, may be created, or subduction of the frontal part of one continent, slab pull, or mid-ocean ridge, ridge push (gravitational slide) can occur, or other tectonic forms may be created, in accordance with the pressure created between the two colliding continents (Seyfert and Sirkin, 1979; Derry, 1980).

II. Material And Methods Location Of The North Pole And The Earth's Rotation Axis

In the article by Bernhard and Richard (2002, par. 1.2), a review is given of the historical research of 'Change of Earth's Rotation Axis – Dynamic Modelling. They stated "The subject of long-term changes in the Earth's rotation axis and its relation to mass redistributions inside the Earth has a rather long history. The idea that the rotation axis might significantly change relative to some reference frame tied to the solid Earth, and that, for example, poles might move to where the equator used to be, and vice versa, was proposed much earlier than plate tectonics".

According to Besse, and Courtillot (Besse and Courtillit, 2002), "TPW (True Polar Wander) is defined as the motion of the mantle with respect to the rotation axis. The latter is defined by hot spots, which are assumed to form an array of fixed points that provide the mantle reference frame. A number of the assumptions made to determine the TPW may of course be found erroneous, such as the assumption of a hot spot fixity. This is a long debated subject" which is discussed by many authors. In practice, we use APW (Apparent Polar Wander) and HS (Hot Spot) to deduce TPW. A total TPW of some **30º** change is suggested for the last 200 Myr". Accordingly there was a change in the location of the equator.

According to Courtillot et al. (Courtillot et al., 2002) the origin of mental hotspots is a controversial topic. The Hawaii and Reunion hotspots can be taken as the best documented representatives from each hemisphere. However sparse, the data are compatible with the same simple two-phase history, in which there was little latitudinal motion in the last 45 Ma, but significant equatorward motion prior to this, at about 60 mm/a for Hawaii and 30 mm/a for Reunion.

The location of the TPW which is based on the mental hot spot is not precise, and could not be correct. As presented in many articles, that to a large extent the TPW represents the Earth's rotation axis, and, accordingly, a change in the location of the Earth's rotation axis and a change in the location of the equator (perpendicular to the Earth's rotation axis).

Mitchell et al. (2010) suggest that the rates of Gondwana's motion exceed those of "normal" plate tectonics as derived from records of the past few hundred million years. They state that probably "true polar wander", in which the Earth's solid land mass (down to the liquid outer core almost 3,000 km deep) rotates together with respect to the planet's rotation axis, changes the location of the geographic poles. In addition, Mitchell and Korenaga (2014) stated, "We demonstrate that maximum rates of true polar wander – wholesale rotation of mantle and crust around the core – have drastically decreased over the past one billion years. As true polar wander is a rate - limited by the viscosity structure of the mantle, we interpret that the observed decay reflects the secular cooling of Earth". Based on the above paragraph, that there was a change in the location of the equator on the surface of the globe.

According to Steinberger and Torsvik, "The location of the Earth's spin axis is apparently controlled by a combination of mass anomalies related to hot spots and subduction slabs". If the mantle moved relative to the location of the Earth's spin axis, then the equator moved together with the mantle and it is perpendicular to the location of the Earth's spin axis. This situation changes the speed of movement of the plates, and the change of speed is relatively higher near the equator.

The commonly current scenarios for driving plate tectonics are slab pull, ridge push and mantle flow (Convection current) (Hunen van and Allen (2011). Summeren, J., Conrad, C. P., Lithgow-Bertelloni, C. (2012), Crameri, F., Lithgow-Bertelloni, C. (2017). According to the result of the present work, those driving forces are secondary forces. They are created mainly as a result of the main driving forces movement due to the centrifugally forces of the globe and due to the changing the location of the Earth's rotation axis (Changing the TPW) and accordingly a change in the location of the equator.

According to Riguzzi, et al (2009), in his calculations of the force balance on plates related to variable buoyancy compared to those for rotational (centrifugally) force balance demonstrate the predominance of the former.

In his force balance on plates, he did not take in account the change in the location of the equator which is the main factor strength for enable the centrifugally forces to move the plates.

III. The Basis And Data Of The Radical Interpretation Of The Mechanism Of Lithospheric Plate Movement

The question is what research data led to the assumption that the Earth's rotation axis changed so significantly relative to the Earth's mantle. According to the paleomagnetic measurements, as presented in the previous chapter, different researchers reached the conclusions that the "TPW (True Polar Wander) can be defined as the motion of the rotation axis with respect to the mantle.

The degree of change of the Earth's rotation axis relative to the mantle is different, in accord with the different researchers, but according to Besse and Courtillit (2002), a total TPW of some 30 degree change is suggested for the last 200 Myr. They also stated that a number of the assumptions made to determine the TPW may of course be found erroneous.

The direct measurement of the change of the Earth's rotation axis relative to the mantle by instruments located mainly outside the Earth, would be difficult, and actually impossible, at least regarding small movement and in the course of a short period.

It should be noted that the difficulty in direct measurement is even intensified when it is known that Earth's obliquity (axial tilt of the pole) oscillates between 22.1 and 24.5 degrees on a 41,000- year cycle.

Thus if it is possible to find the degree of change of the Earth's rotation axis relative to the mantle by means of the tectonic structure and the movement of the Earth's continents in the course of millions of years, the result could be most reasonable.

In the present work, an experiment is presented (to a certain extent by means of "trial and error") to determine a rule (law), in the form of a model, that reconstructs the structure and directions of the movement of continents over around 200-250 million years. In accord with the results of the model, the result of the extent of change of the Earth's rotation axis relative to the mantle was also obtained.

Actually, the heading of the present study could be: "According results of the geological model, presented basing on the directions of the movement of the continents, show that the Earth's rotation axis changed its location relative to the mantle of the Earth in large circles in the course of millions of years"

But the aim of the present study was to clarify what the main force is driving the movement of the continents. And in accord with the model constructed, it is proposed that the centrifugal force of the rotation of the Earth is the main force driving the movement of the continents. The model proposes a change of 90 degrees in the rotation axis, and, accordingly, in the movement of the continents, which is reasonable. The explanation of the change in location of the equator in accord with the change in location of the rotation axis of the Earth and, following, that the centrifugal force causes the movement of continents, in principle suits also every significant move of the equator in relation to the mantle of the Earth, and all reasonable changes of extent, also regarding a change in the rotation axis of the Earth (TPW) by 30 degrees, as suggested (Besse and Courtillit, 2002) in accord with paleomagnetic measurements.

IV. Forces of Movement Acting on Continents Following About A 900 Change In Location of The Equator

4.1 Main Elements Presented in the Sketches (Figs. 1-6)

In order to explain the forces acting on continents following a change in location of the equator in the past, the possibility is presented of a change in the location of the equator by 90^0 to its present position through six sketches of maps (Figs. 1-6). These maps illustrate a view of the earth from different directions, whereby four of the sketches focus on the equator (Figs. 1-4) and two on the polar regions, one on the North Pole (Fig. 5) and the other on the South Pole (Fig. 6).

It should be noted that these are estimated locations, and the constant movement of continents with the change in location of the equator, there is no possibility of reconstructing the exact previous places of the equator on the present globe of the earth. There can be a shift of $10\text{-}40^0$ from the true location, but still the article is aimed to show the principles of the main forces behind the movement of continents.

As an explanation of the model presented, eight main points are marked on the globe which represent the following elements on the sketches (Figs. 1-6):

C-C' is the axis of the earth's rotation 90^0 before its present position where C' was the northern axis and C, the southern one.

A-A' is the present axis of the earth's rotation, where A is the present northern pole and A' is the present southern one.

The state of the former location of the equator 90^0 before its present position is represented by points A-D–A'–E, and its present location of the equator is represented by points C'-E-C-D.

Following the change in the axis of the earth's rotation by 90^0, the previous north pole, C', moved and reached the present north pole, A; accordingly, also the former A-D-A'-E equator moved to past the present C'-E-C-D equator. Marked also in the course of the move is the intermediate station of the equator of 45^0, which is represented by points E-B-D-B'.

The points E and D represent the regions in whose realm the equator turned while changing its location by 90^0; and this phenomenon is assumed to be an ongoing process. It is suggested naming each one of these two regions **"the region of axis of rotation that changes the location of the equator."**

The change in location of the equator according to this assumption should cause the creation of two such regions on both sides of the earth whereby one is more or less opposite the other and they represent the two ends of "the region of axis of rotation that changes the location of the equator." These two areas (regions) are marked by points E and D. All this assumes that the axis of the earth's rotation changed its location on the crust of the earth on a scope that comes close to the maximum circular circumference of the earth.

The arrows numbered 1, 2 and 3 (Figs. 1-6) indicate the direction of the forces of movement acting also on the movement of continents, and the thickness of the arrows represent, to a certain degree, the intensity of the accumulating forces of movement. Components of the forces of movement that are marked by arrows that are found on the side to which the equator advances (when looking in the direction of the earth's rotation) are termed – **"the chief driving force component,"**

The surface of the earth is divided into four equal quarters and then into eight equal parts, marked by numbers prefaced by S (Figs. 1-6), S-1, S-1a, S-2, S-2a, S-3, S-3a, S-4, and S-4a.

4.2 Further Explanations of the Main Elements Presented in the Sketches (Figs. 1-6)

The explanations concentrate on the about 90^0 change in location of the equator, but in principle suit states of equator changes in large circles on the earth's surface, under the condition that every one of **"the regions of axis of rotation that change the location of the equator"** (points D and E) has a relatively small regional circle.

The explanations are based on detailed descriptions of Figures 1-6.

We begin by tracing the action of the forces of movement from the 90^0 position the equator was in before its present location, which is represented by points A-D-A'-E (the axis of the earth's rotation was at point C-C' and was moved to point A-A,' which is the present axis of the earth). Following the change in location of the equator, forces of movement were created on the new location of the equator in a general direction in accord with the direction of the earth's rotation, marked by arrows numbered 1, 2 and 3, whereby the main driving force, termed "the chief driving force component," is marked by the thicker arrow found on the side to which the equator is advancing (Fig. 1).

The movements of the continents located on the crust of the earth along the equator are the fastest, or in other words, their centrifugal energy is the highest. When the balance changes in the region of the equator following its move, the continents close to it will tend to move to a state of lower energy, which is found further away from the equator in the direction of the poles, and in continuation, in the direction of the movement of the earth's rotation, as marked by arrows no. 1, 2, and 3. (According to Greff – Lefftz and Bess, 16 continents leave their "stable" positions and drift more or less toward a N and S hemisphere). The true direction of the movement of continents depends also on the speed of their former movement, which was different from the present new speed in the region of the equator. Assuming the equator changes its location through relatively constant slow motion (at an average rate of about 0.4 cm/yr during about 200-250 million years at a total distance of 90^0 of the surface of the globe, from the Mesozoic to the Present), then the continents in the new region of the equator would have previously always had a different movement speed, which has to be considered in determining the balance of power that determines the actual movement of each continent.

When the equator was at its previous location, 90^0 before its present, as marked by points A-D-A'-E (Figs. 1, 2), and the forces acted in the direction of the no.1 arrows, this location in general caused the separation of the European and African continents from the North and South American continents and created the Atlantic Ocean (Fig. 1). When in the course of its movement the equator moved 45^0 from point A to point B (Fig. 1), or in other words, to its new location, to points B-D-B'-E (Figs. 1, 2), the directions of the operating centrifugal forces changed and they are marked by the no. 2 arrows. Understandably, that same movement of the equator also caused a change in the forces of movement of the continents (still marked by no. 2 arrows) in different directions in the different parts of the earth. Afterwards, in continuation of the process of the equator's move to its present location, to points C-D-C'-E, the move again caused a change in the forces of movement, as marked by the no. 3 arrows.

In the two opposite quarters that intersect, the S-1 S1a, and the S-3 S-3a quarters (Figs. 1-4) in which the equator passes, the activity of the forces of movement is the strongest, and we term them 'active quarters,' (relative to the change in the equator by 90^0 only).

V. Examples of Tectonic Phenomena

5.1 Creation of the Atlantic Ocean and the Separation of the North and South American Continent from Europe and Africa

When the equator was at its former location, 90^0 before its present location, as marked by points A –D-A'-E, and the forces operated in the direction of arrows no. 1, its location in general caused the separation of the European and African continents from the North and South American continents and the creation of the Atlantic Ocean (Fig. 1). From point A to point D the movement of forces, according to arrows no. 1, activate the move of North America away from Europe (eighth of the earth, S-1), contemporaneously with the activation of the move of Africa from point D to point A' (eighth of the earth, S-3).

For example, looking at Figure 1, on the eighth of the earth marked S-3 new forces of movement can be discerned that were created by a change in the equator, which moved from point A to B and its continuation to point C (the equator today); arrows no. 2 continue the direction of movement of arrows no. 1, and arrows no. 3 also continue the same trend of the equator's move and cause the continued distancing of Africa from South America in a counter-clockwise movement (Fig. 3).

The formation of the Atlantic Ocean began with the Mid-ocean (Spreading) Ridge, which may have been started (one of the possibilities) by a mantle diapir after which the forces of movement, as explained above, operated on widening the ridge, ridge push, and creating the Atlantic Ocean.

5.2 The Distancing of Australia from the African Continent

In Figures 3 and 6 the directions of the forces of movement in the eighth of the earth, S-3, marked by arrow nos. 1, 2 and 3, also caused a rotational movement of the African continent counter-clockwise, and also operated on the continued distancing movement of Australia from Africa; continuation of the movement in the eighth of the earth, S-3a, can be seen after this.

5.3 Formation of the Archipelago in Southeast Asia, and the Formation of the Archipelago between North America and South America

Points D and E (Figs. 1-6) represent the areas in the realms in which the equator turned in changing its location by 90^0, **"the regions of axis of rotation that change the location of the equator"** extending at least from the Mesozoic era until today, an estimated period of ~200-250 m.y.

The movement changes radically on the continents found in these two areas. Likewise the forces operate in a rotational direction in a relatively small radius. These phenomena and the closeness of the continents to the equator over a long period cause significant intense tectonic phenomena. Such tectonic phenomena are found west of the two points, D and E, at a distance of about ~ 20^0-30^0, one west of point D in the area of the Caribbean plate, between North and South America (including Cuba, Haiti, Jamaica, and the countries of Central America) and the other west of point E, in the area of the Philippine plate, between Indonesia and northern Australia. The move of 20^0-30^0 from points D and E could be explained as a result of drafting needed for the explanation, and/or the lack of the possibility of reconstructing exactly the true phenomena that operated over time on the present globe following the actual movement of the continents.

5.4 The Alpine Fold of Southern Europe and Southern Asia

In Figures 1 and 3 one can see that following the direction of the main forces activity in accord with the direction of the equator's change in the eighths of the earth S-3 and S-3a, movement on the African continent was created in a direction counter-clockwise towards Europe and Asia. The pressure between these continents created the Alpine fold, including the mountain ranges: the Pyrenees, the Alps, the Taurus and the Elbruz. In a similar manner the Himalaya Mountains, etc. were formed by a similar continuation of movement of the Indian continent.

VI. Theoretical Proofs

The theoretical proofs and convincing observation evidence of the article conclusions, are as follow.

The speed of the Earth rotation at the equator is 1670 km/hr., at latitude 45-degree 1180 km/hr. and at the earth pole of rotation the speed is zero.

It's clear that if a continent or part of a continent changes its latitude location to a different latitude, then its speed changes. The speed of the continent is highest at the equator.

When a part of a continent moves over the earth's mantle either north or south of the equator, in the beginning its speed is lower and, therefore, it gets a component of movement in a direction towards either a northern or southern pole axis, relating the movement of the continent to the north or south direction of the equator.

However, if the equator changes its position on the mantle, then it increases its speed – acceleration in the direction of the earth's rotation to the new position that the equator reaches. Since the equator moves on the mantle in a continuous manner, the continent also moves in the new direction according to the location of the equator in a continuous manner. Actually, a continuous driving force (like an engine) is produced that moves the continent by merging the power of the earth's rotation and the change in location of the equator. The direction of the continent's movement, in effect, is in the changed direction of the equator on the earth's mantle.

According to this principle, a model was prepared showing systematically the direction of the continents' movements over the surface of the entire mantle of the earth in the course of the Mesozoic period up to today, in the course of about 250 million years. The model was calibrated by trial and error, and, accordingly, the equator was found to have moved 90 degrees on the mantle in the course of those 250 million years, which is in accord with the 90 degree change of the axis of the earth's rotation. That means that the equator moved on the mantle in a continuous manner at a speed of about 0.4cm/year. According to this model, a reliable picture emerged of the subdivision of the Pangaea continent that existed about 250 million years ago and of the direction of the continents' movements and locations up to their current location.

The results obtained using the above model fits in practice the geological understanding of what is known about the subdivision of the Pangaea continent and the current positions of the various continents over the earth's mantle.

In accord with the model, six diagrams of six directions of the earth were prepared showing the direction of the movements of the continents in the course of about 250 million years, by the change in the axis of the earth's rotation by 90 degrees and a change in the location of the equator by 90 degrees (Figs. 1-6).

VII. Conclusion

The conclusion from everything discussed above is that the main force behind the movement of continents is the centrifugal force of the rotational movement of the earth following the change in location of the axis of the earth's rotation relative to the mantle of the earth and, in accordance, a change in the location of the equator. The actual movement of the continents depends also on many other geological factors.

VIII. Acknowledgement

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Figures

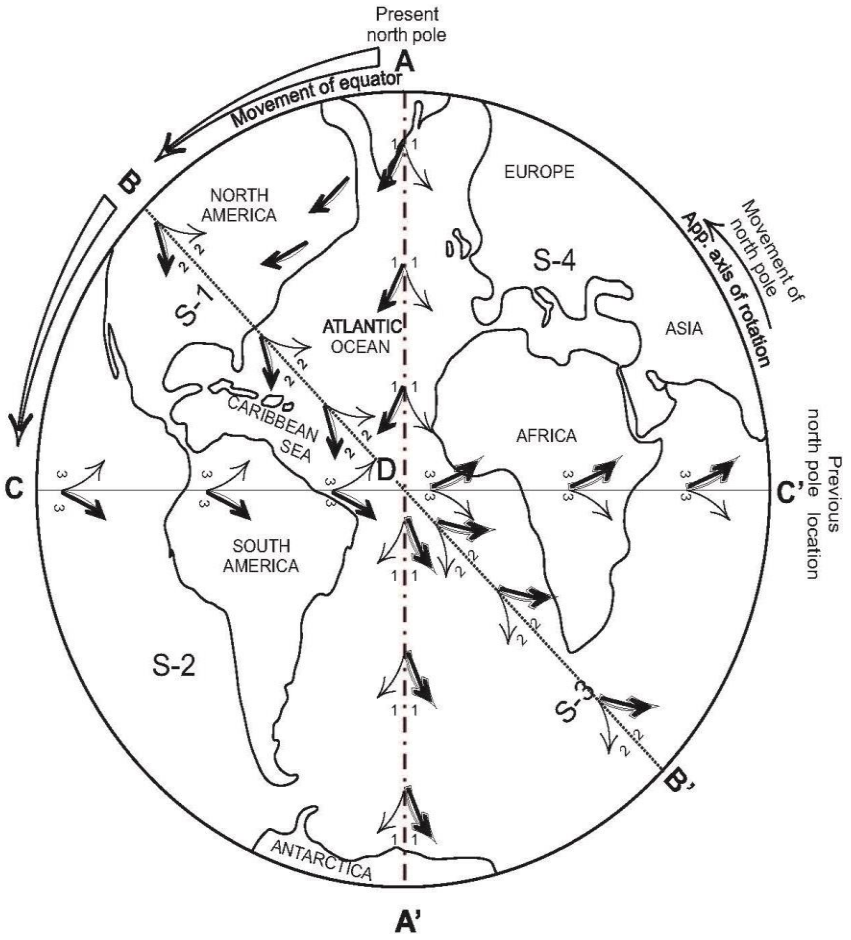

Figure 1. Movement of equator 90^0 from point A to C (movement of pole also 90^0 from point C' to A). View from Atlantic Ocean – Caribbean Sea. By Y. Greitzer

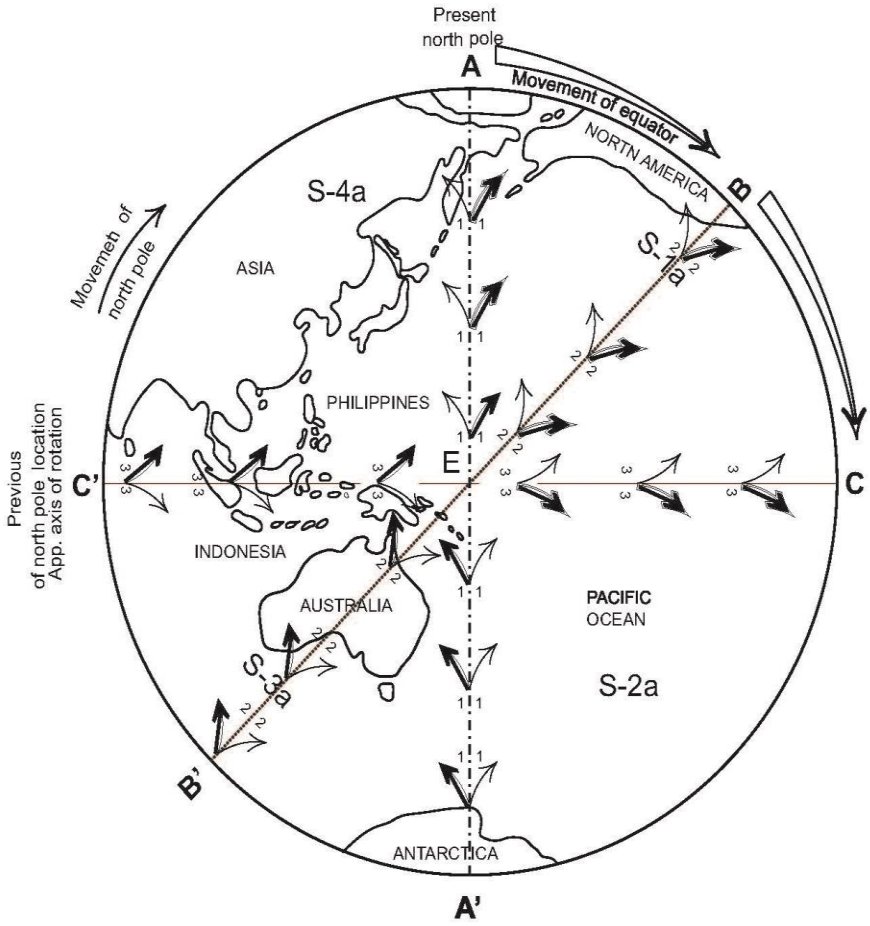

Figure 2. Movement of equator 90^0 from point A to C (movement of pole also 90^0 from point C' to A). View from Pacific Ocean, Philippines – Caribbean Sea. By Y. Greitzer

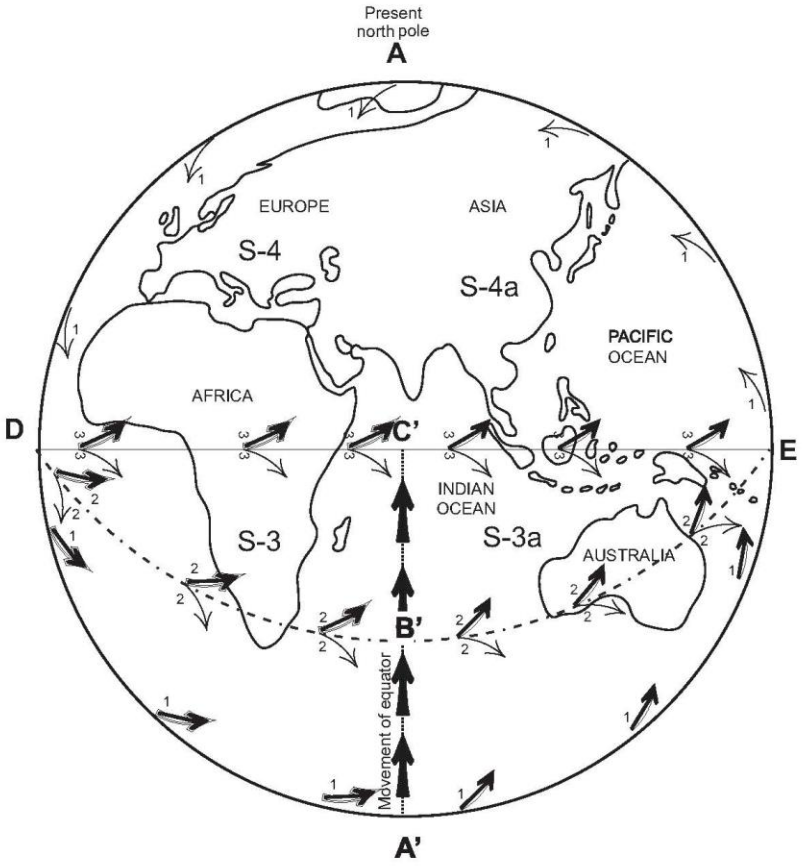

Figure 3. Movement of equator 90^0 from point A' to C' (movement of pole also 90^0 from point C' to A). View from Indian Ocean. By Y. Greitzer

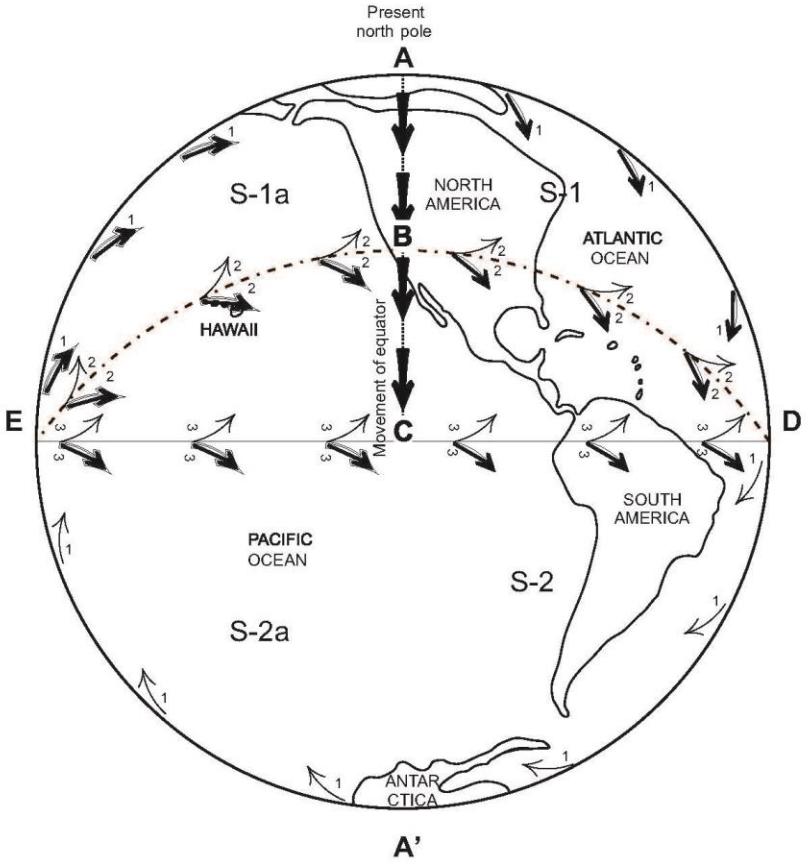

Figure 4. Movement of equator 90^0 from point A to C (movement of pole also 90^0 from point C to A'). View from Pacific Ocean. By Y. Greitzer

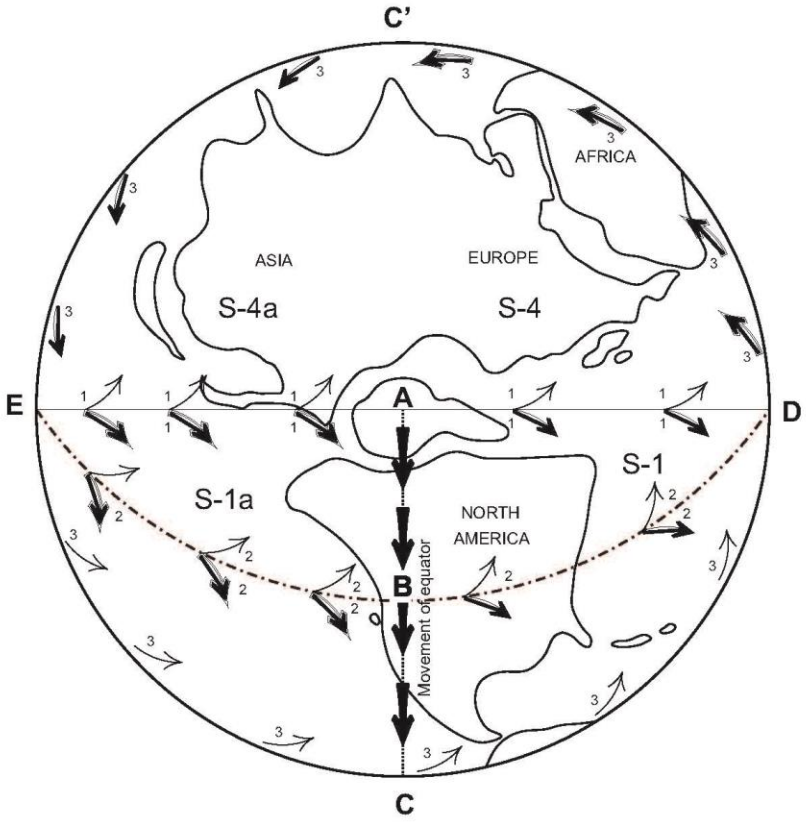

Figure 5. Movement of equator 90^0 from point A to C (movement of pole also 90^0 from point C' to A). View from the present North Pole. By Y. Greitzer

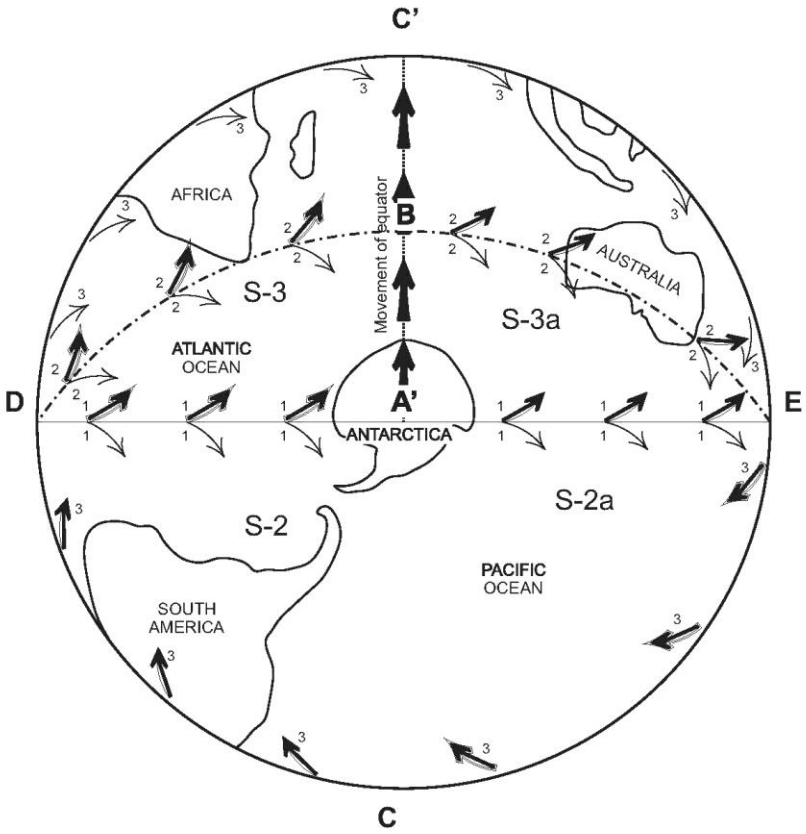

Figure 6. Movement of equator 90^0 from point A' to C' (movement of pole also 90^0 from point C to A'). View from present South Pole. By Y. Greitzer