National Aeronautics and Space Administration
Goddard Space Flight Center
Contract No.NAS-5-12487

ST-ES-GM-10868

CAUSES OF MOTION OF GEOGRAPHIC POLES AND NATURE OF WORLD GEOPHYSICAL FIELDS

by

A.V. Dolitskiy
(USSR)

16 SEPTEMBER 1969

CAUSES OF MOTION OF GEOGRAPHIC POLES AND NATURE OF WORLD GEOPHYSICAL FIELDS

Doklady Akademii Nauk SSSR
Vol ~~Tom~~ 187, No.3, pp 32-635,
~~Izd-vo "Nauka~~, 1969.

by

A.V. Dolitskiy

SUMMARY

This paper discusses the causes of motion of geograpic poles invoking various data concerning the planes along which the displacements of the interface "core-mantle" take place. The relative shifts of separate parts of the Earth's crust layer are examined in the light of the "Guttenberg" waveguide theory. The trajectories of motion of the North geographic and magnetic poles are shown in a chart in the form of spiral-shaped curves. Describing some of the singularities of the Earth's magnetic field, the author found a way to reconstruct it through various geological epochs. Finally, the motions of the Earth's crust and the shape of the geoid are defined, invoking the Pavoni chart.

*

* *

Causes of Motion of Geographic Poles. Considering the motion trajectories of geographic poles, it is necessary to take into account that they represent a trace of a stationary rotation axis of the crust layer or mantle, moving relative to much deeper parts of the Earth. The boundaries of the interface (core-shell) at the depths of 2900 km and 150 km (the Guttenberg waveguide is the layer of decreased viscosity) are well known. According to the most general energetic considerations, the displacement of the entire mantle relative to the core must induce retardation and halt of Earth's rotation, but this conclusion cannot be considered as indisputable for it needs a more detailed investigation such as, the data on the Earth's magnetic field generated at the "core-mantle" interface which are evidence of the fact that displacements take place precisely along this interface.

The layer of decreased viscosity (10^{19} poises against 10^{21} in the layers located lower and higher) found at a depth of 120-150 km [5,6], could also prove to be the surface of horizontal mass displacements of the Earth's crust. Displacement over it of the spherical crustal layer or of its separate parts relative to much deeper horizons of the Earth-is possible. Inasmuch as the waveguide is not traced over the entire Earth, it does not constitute a continuous spherical layer, but is propagated locally. Therefore, the relative displacement of separate parts of the crust's layer above the zones of the waveguide, appears to be more probable. Previously, it was noted [3] that in the folding epochs, great structures of V-shape were formed in the plan, consisting of platforms and mountain ranges framing them from the side of the protruding angle facing the equator. Such a shape and orientation of these structures, forming in these epochs of vast seats of plastic flow directed toward the equator. Verification reveals signs of coincidence of such seats (V-shaped structures of contemporary folding epoch) with the regions where the layer with decreased viscosity is found. The V-shaped structures have mosaic block formation, which means that plastic flow of rock masses and their block displacements represent different aspects of a single process of lateral displacement of parts of layer crust.

The trajectory of the northern geographic pole (Fig.1) may be represented as a sequence of curves:

$L_1A_1{}^1M_1$, $M_1M_1{}^1N_1{}^1N_1{}^2P_1{}^1$, $P_1{}^1C_1N_1{}^2N_1{}^3P_1{}^2$, $P_1{}^2D_1N_1{}^3N_1{}^4P_1{}^3$,

$P_1{}^3E_1N_1{}^4N_1{}^1P_1{}^4$, $P_1{}^4B_1N_1{}^1N_1{}^2P_1{}^1$, etc., each of which having a spiral shape. The curves begin at the points $P_1{}^1, P_1{}^2, P_1{}^3, P_1{}^4$, near the emergence of axes B,C,D,E and are coiled around these points, changing the curvature radius from 0 up to dimensions of the Earth's radius. The angular distances between the origin and the end points of spirals constitute 90°. Analysis of the curves shows that they could be the result of crust layer's rotation around the axis P, which responds to the origin of each curve, and simultaneous departure of this axis from the axis of Earth's rotation. The total turn may be considered as the sum of aggregate rotations around the axes X, Y and Z, or dividing them into components as a result of aggregate rotations around the axis S.

With such a geometrical interpretation of the curves, they acquire the following physical sense. The tidal forces lead to deceleration of planet's rotation, whereupon the upper crust layer and the mantle undergo a maximum deceleration. Under the action of these forces, a certain mantle rotation takes place on the surface of the core toward the side opposite to Earth's rotation. The rotation of this sphere leads to heating and upheaval of its lower boundary. In other words, the mantle thins out as a result of its own rotation. Inasmuch as the maximum heating falls on the equatorial belt, where linear velocities are higher, the result appears to be the redistri ution of the masses inside the mantle. A mass defect arises in the equatorial belt, and in the polar regions - its excess. Under the action of centrifugal forces (or, to be more precise of the Etvisch forces) the excessive masses, whose centers of gravity are above the level surface, are shifted to the equator together with the entire mantle and remain there for some time. After a period of time the excessive masses emerge in new polar regions, which leads to a new mantle rotation. However, the zone of excess masses of the preceding stage are still retained for a prolonged time, owing to which a new rotation is possible only around the axis passing through these masses. Preliminary computations by O.G. Friedland confirm the reality of such a mechanism.

Certain Singularities of the Earth's Magnetic Field. Recent data leave no doubt that the nature of the Earth's magnetic field is due to the dynamoeffect, which is evidence of a complex motion of the conducting matter at the core and mantle interface. This motion characterizes also in a certain way, the axes of rotation of the mantle found by us. Assuming that the terms of Gaussian expansion, also reflect this motion if only indirectly,one may compare the position of the axes of rotation and that of the magnetic fields' axes, responding to the terms of Gaussian expansion.

It is found that to the axis P of mantle rotation responds the geomagnetic axis, that is, the axis of the field corresponding to the first term of the expansion. To axis X, responds the dipole situated at the equatorial plane and described by the second and third terms of the expansion. The field corresponding to all subsequent terms of expansion, excluding the first three, describes the pattern of world's (continental) anomalies and is called the Bauer's field. If, one reduces this field to the 10.000 km level above the Earth's surface [4], it is possible to obtain a field, described by the fourth and other nearest terms of the expansion. With such a representation of the field, four world anomalies stand out: two positive and two negative. Each of the anomalies occupies one fourth of the sphere's surface and is separated from the neighboring, having the opposite sign, by a zero line. In the first approximation these lines represent the traces of sphere's cross-section by two mutually perpendicular planes, of which one is equatorial and the other meridional. Their cross-section line responds to the axis Q which is the equatorial axis of the mantle rotation. In relation to this axis, the position of anomalies appears to be as though they were the sites of emergence to the surface of the annular (toroidal) magnetic field, whose magnetic lines of force are oriented in the direction of crust layer's rotation i.e. clockwise, if it is observed from the side of the pole Q_1. The centers are located in the cross-section plane, perpendicular to axis Q. This effect is evidence of lesser core contraction than that of the entire Earth, which is found to be in agreement with the theory of the shape of the Earth.

Prior to their reduction to the altitude of 10.000 km, the map of world anomalies, i.e. anomalies comprising the fourth and all the subsequent expansion terms, retains certain traits, analogous to the map of geoid excess above the Earth ellipsoid (Fig.2). From this it may be concluded that higher expansion terms reflect the peculiarities of the magnetic field, connected with the inhomogeneity of the structure of the Earth's crust and mantle.

Thus, comparison of the position of mantle rotation axes with the position of axes responding to the fields described by the Gaussian expansion terms, demonstrate the following. The homogeneous magnetization may be explained by the rotation around the axis P and the orientation of ring currents in conformity with this rotation; the field of the second and third expansion terms is induced by axis P rotation around axis Y, and by the ensuing increase of the equatorial component of the field of homogeneous magnetization; the field of the fourth and other nearest terms of expansion is due to the weak rotation around the axis Q and the formation of an annular magnetic field around it. The total rotation is the sum of rotations around these axes; it may be formally expressed as the rotation around the axis S. The magnetic field may also be considered as the sum of fields induced by the rotation around the indicated axes representing in the first approximation a dipole with axis S.

The deflection of the real magnetic poles from the poles of axis S may be explained in the following manner. Rotation around the axis P passing through the excessive masses takes place continuously. Under the influence of Etvish forces they are displaced toward the equator, i.e. axis P takes a turn around axis Y, and axis P approaches the axis X, which leads to the emergence of a dipole along the latter. The rotation around axes Y and X (equatorial component of the rotation around axis P) add up and result in in the rotation around axis Q. This is why it may be considered that, following the emergence of a dipole field along the axis X, an annular field around the axis Q sets in. These events follow one another in specific time interval, necessary for the setting of the flow in viscous medium of the core and mantle interface, where a relative displacement takes place. In connection with the inhomogeneous viscosity of the boundary medium, these processes may take place at various rates in different hemispheres, and in the total magnetic field, the influence of the field connected with the rotation around either axis will prevail . It is, apparently, possible to explain by this the absence of total coincidence of magnetic poles with the poles of the axis S of instantaneous rotation. It is not excluded that a certain influence on the character of the magnetic field and the position of the poles may also be exerted by the shape of the geoid (Fig.2).

With the position of mantle rotation, an explanation is also found for the secular variations of the magnetic field. Currently rotation around the axis Y takes place and will continue with increasing velocity through the moment of time when the angle between axes P and Z reaches 45°, after which velocity decrease will begin. The increase of the rotation velocity around the axis Y induces that around the axis Q and its displacement toward the side of axis Y, i.e. toward the West. Precisely this is expressed by the rise of world Bauer anomalies and their westerly drift.

Judging by the paleomagnetic data of the last $3 \cdot 10^8$ years, obtained on the basis of analysis of rocks of Europe and North America (Fig.1), the vector of remanent magnetization was directed to the side of Northern magnetic pole, but subsequently it underwent rotation toward the side of its displacement. The sharp deflection of paleomagnetic poles for the epochs from Permian to Cretaceous (300-150 million years) is demonstrated by the rocks of India and Australia. Attracting attention is the fact that India and Australia are situated near the centers of world anomalies of the corresponding epochs which are the anomalies, symmetrical to axis Q. It is toward the side of these anomalies that the vectors of remanent magnetization of these territories' rocks, deviates. Knowledge of the trajectories of the geographic pole allows us to find not only the trajectory of the magnetic pole, but also to restore the state and intensity of world anomalies of different geological epochs. By the same token a possibility is found to reconstruct the magnetic fields.

Motions of the Earth's Crust and the Shape of the Geoid. The Investigation of spatial regularities in the shape of the geoid (Fig.2) reveals four equipotential surface excesses, located in equatorial belt of axis E at the distance of 90° from each other. These are the South American, North American, Indonesian and South African maxima. It is found that between these protrusions of the geoid, a continuous belt of subsidences passes through.. It frames, from the Southern hemisphere side of axis E, the Indonesian and South American maxia, situated predominantly in the Northern hemisphere, and from the side of Northern hemisphere, the North Atlantic and South African maxima, situated predominantly in the Southern hemisphere. The pattern may be explained as the result of mass displacement of Earth's crust, toward the side of the equator and the formation them of largest V-shaped structures facing it with their acute angles. It is ahead of this front of mass displacement that the warping belt is located in the equatorial zone of the axis E. With it the geographic axis combined with the Baikal one (600 million years) and Karelian (1800 million years) epochs. To one of these borders (apparently the earlier) one should therefore attribute the formation of the indicated structures, which later could undergo only insignificant displacements.

Similar displacements of crushed masses toward the equator and the formation by them of V-shaped structures, surrounded at the displacement front by zone of compression and folding, take place in every epoch of folding. The condition of dispacement is found to be the crushing of crust over large areas, where the direction of breaks and acting strains coincide, and this is possible with the combination of axes of rotation and symmetry. The upheaved V-shaped structures, framed at the front by folded mountain chains, and further by throughs, are typical peculiarities of structure and

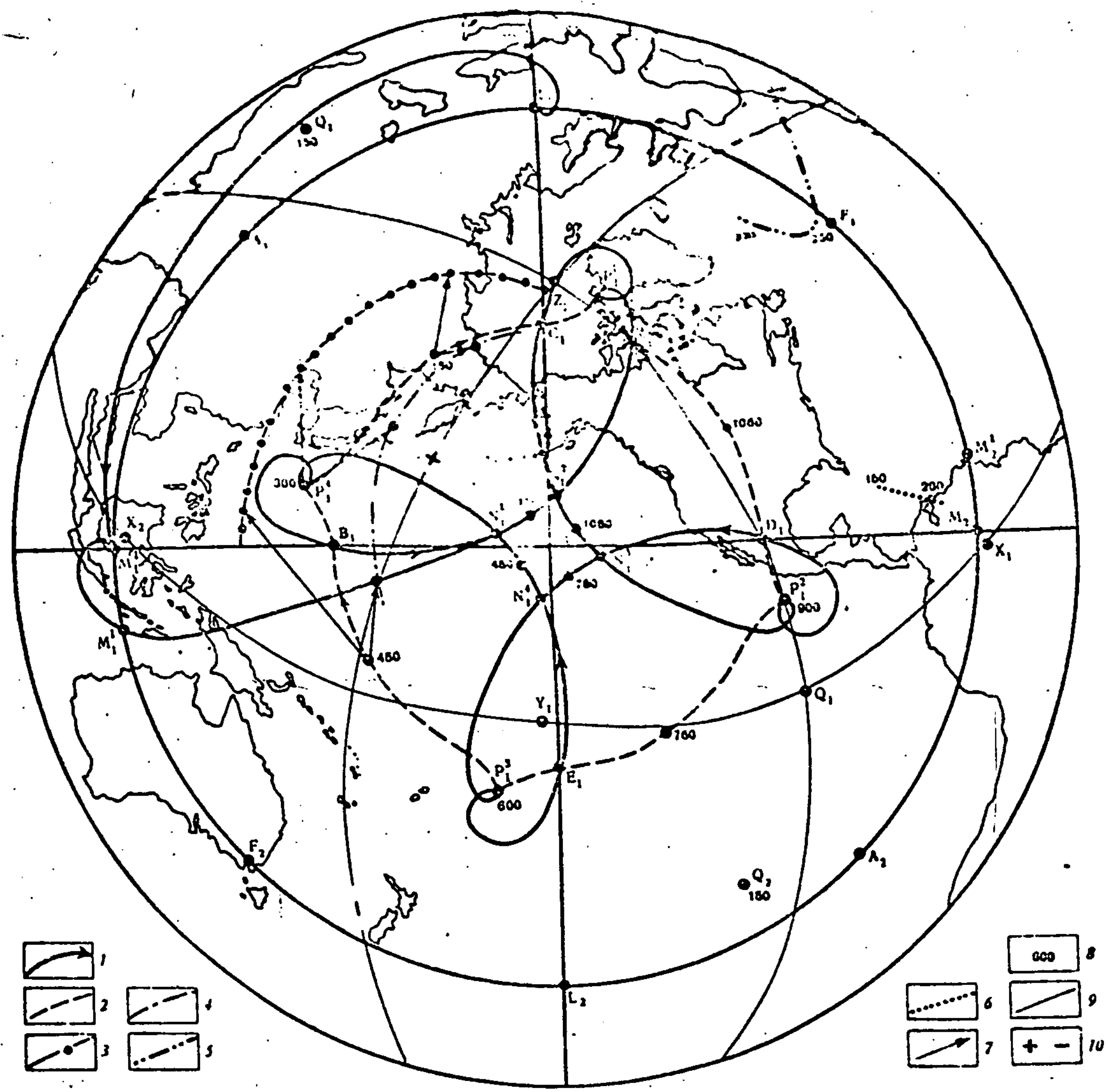

Fig.1

Motion trajectories of the North geographic and North magnetic poles of the Earth. 1) Motion trajectory of the North geographic pole; 2) motion trajectory of the North magnetic pole (of instantaneous rotation); 3) same according to North American paleomagnetic data; 4) same according to European paleomagnetic data; 5) same according to Australian paleomagnetic data; 6) same according to Indian paleomagnetic data. 7) rotation direction of the remanent magnetization vector; 8) absolute age in million years; 9) lines dividing the contemporary Bauer anomalies or passing through them; 10) centers of contemporary positive and negative Bauer magnetic anomalies

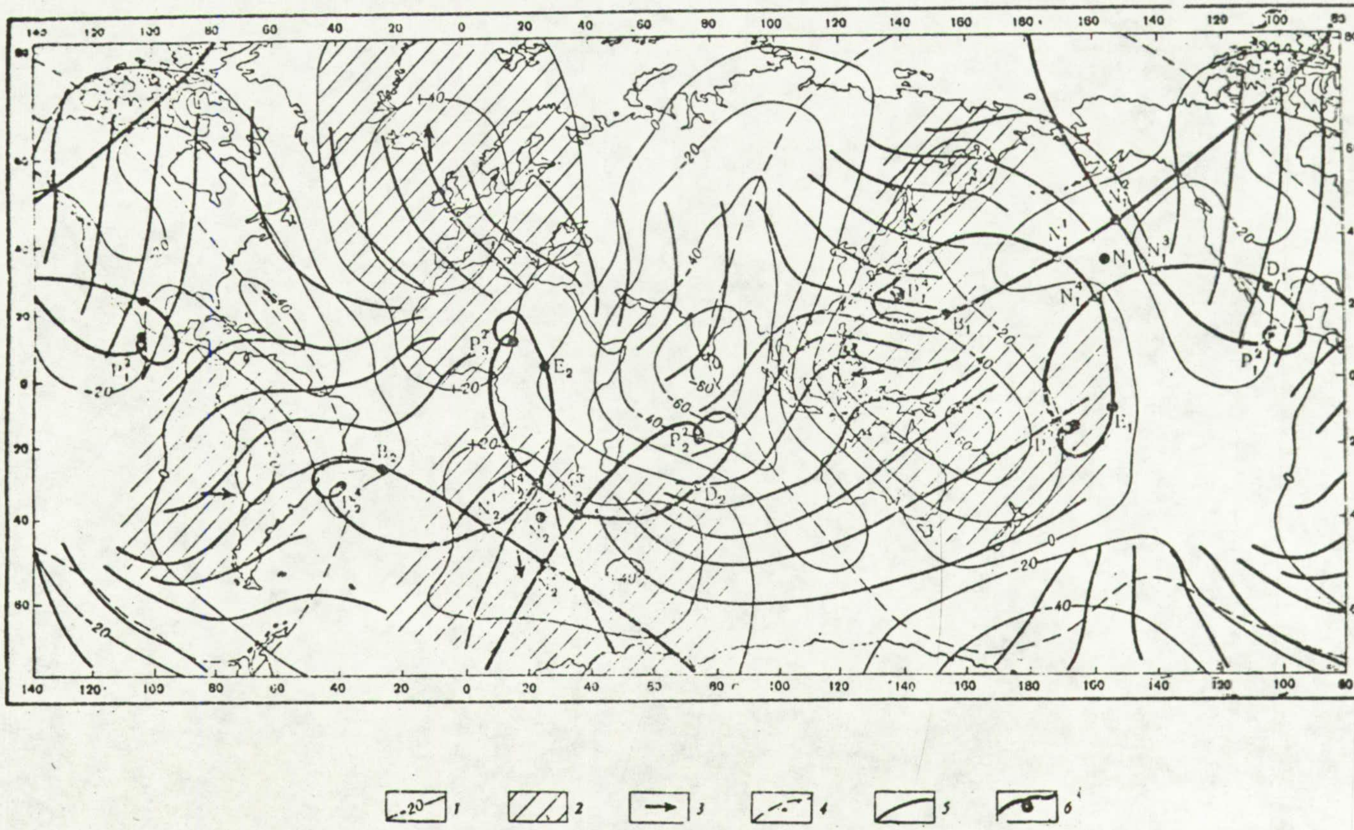

Fig.2

1) Isolines of geoid excesses over the terrestrial ellipsoid in m (after V. Köplein) 2) Regions of upheavals (excess masses) of the geoid; 3) direction of the assumed displacement of geoid's excess masses; 4) axes of geoid sagging; 5) direction of compression forces during the Cenozoic-Quaternary (cf. Pavoni); 6) motion trajectory of geographic poles

relief of the Earth's surface in the folding epoch, which may be considered as phenomena of second order, complicating the basic structure of the geoid. The fact, that the direction of horizontal mass displacement of Earth's crust in each folding epoch is directed toward the side of the equator, may be seen on the N. Pavoni plan drawn in Fig.2. On the strength of inheritance, the motion directions of the preceding nearest stages, continue also to have effect in the subsequent epochs, despite the variation in the condition of polar regions.

* * * * THE END * * * *

Geological Institute of
AN SSSR Moscow

Manuscript received on
23 December, 1968.

R E F E R E N C E S

1. A.V. DOLITSKIY, DAN, 177, No.1, 1967.
2. A.V. DOLITSKIY, Geomagnetizm i Aeronomiya, No.4, 1968.
3. A.V. DOLITSKIY, DAN, 184, No.1, 1969.
4. I.M. PUDOVKIN, Geomagnetizm i Aeronomiya, No.2-4, 1964.
5. O.A. USHAKOV, Vestnik Moskovsk. Univ., No.1, 1968.
6. B. GUTENBERG, Physics of the Earth's Interior, N.Y. - London, 1959.
7. N. PAVONI, - Recent Horizontal Movements of the Earth's Crust as Related to Cenozoic Tectonics, Helsinki, 1966.

CONTRACT No.5-12487
VOLT INFORMATION SCIENCES, INC.,
LANHAM, MD. & WASHINGTON, D.C.
Telephones: [301] 577-5200
[202] 223-6700

Translated by
Ludmilla D. Fedine
10-12 September, 1969

Revised by
Dr. Andre L. Brichant
13 September, 1969