ON THE POSSIBILITY OF VERY RAPID SHIFTS OF THE POLES

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Summary : - Evidence exists that the poles have changed position during the past ages. This possibility, however, so far has been disregarded on the basis that such a phenomenon is thought to be physically impossible. The following article shows the possibility of very rapid shifts of the poles due to the impact of astronomical objects as small as a half-kilometer diameter asteroid.

Introduction

In his book "The Path of the Pole" (Chilton Book, Philadelphia, 1970) Charles Hapgood expresses the hypothesis that the poles have changed their position three times during the recent past. From the Greenland Sea, where it shifted about seventy thousand years ago, the north pole moved to Hudson Bay fifty thousand years ago, and finally to its presents position 11.600 years ago, at the end of Pleistocene.

To support his hypothesis, Hapgood presents an impressive quantity of evidence which can be summarised as follows:

a) the presence of ice caps in North America and Northern Europe, highly eccentrical compared to the present north pole.
b) The contemporaneous absence of ice caps from Siberia which was actually populated to its northernmost regions by an impressive zoological community.
c) The arctic Sea was warmer than it is today, and there were human beings living in the New Siberia Islands.
d) Antarctica was partially free of ice.
e) The general climatic situation of the Earth was coherent with a different position of the poles.

The hypothesis that the inclination of the terrestrial axis in relation to the ecliptic and that the position of the poles might change has been taken into consideration since last century. Some of the greatest geologists of the time, including J.C.Maxwell and Sir George Darwin (son of the famous

Charles Darwin), considered this problem and decided that the stabilising effect of the equatorial bulge was so great that no conceivable force originating within the Earth could make it shifting on its axis, except for the collision with another planet. They therefore dismissed the idea of any shift of the poles as impossible and, in fact, not worth discussing. Their influence has been so highly felt that to this day no one has seriously considered such an hypothesis.

Hapgood too accepts un-critically the assumption that only a "planetary collision" is capable of displacing the axis of rotation. Therefore he proposes a theory that explains the shift of the poles as the result of the shift of the whole Earth's crust. Based on the research of the Russian scientist V.V. Beloussov, he assumes that at a depth of approximately hundred miles in the upper mantle there is a layer of liquid rock which behaves as a bearing allowing the whole crust to "shift" when subjected to a displacing force. In Hapgood's opinion this force is provided by the centrifugal momentum of ice caps eccentrical to the poles. In this way the Earth would keep its axis of rotation unchanged, but the poles and the whole Earth's surface would shift and change latitude.

The evidence proving that the poles where in different positions during the Pleistocene era is quite impressive, and this explains why Hapgood's theory was approved by scientists such as Einstein and K.F. Mather. But it meets with so many difficulties that it appears highly controversial. Above all, it is not compatible with other geological theories which are widely accepted today, such as the drift of the continents and related theories.

Furthermore the theory does not explain some of the most significant peculiarities of Pleistocene's climate changes, first of all the speed with which these changes appear to have taken place. According to Hapgood it took the north pole at least two thousand years to move from its previous position to the present. The evidence we have, however, are in favour of a definitely much faster climatic change. It was Hapgood himself who underlined the enormous amount of evidence proving the high speed at which the shift of the poles appears to have happened; speed which the mechanism he proposes is unable to explain.

The only way to completely and coherently explain what took place at the end of Pleistocene appears to be that of admitting the possibility of a shift of the poles of the same magnitude Hapgood hypothesizes, but in a much shorter time: not more than a few days. This possibility is openly refused, only because no convincing explanation has been forwarded so far.

The following work analyses the behaviour of a gyroscope subjected to a disturbing force, and shows that the torque generated by the impact of a relatively small asteroid is capable of causing almost instantaneous changes of the axis of rotation and therefore instantaneous shifts of the poles in any direction and of any amplitude.

Rotational components in a disturbed gyroscope

The rotational components in a disturbed gyroscope are connected to each other by the following equation, due to Laplace, which expresses the principle of conservation of energy:

1) $\boldsymbol{J_o\, \Omega^2 = J_o\, \omega^2 + J_p\, \omega_p^{\,2} = J_i\, \omega_i^{\,2}}$

where:

$\boldsymbol{\Omega}$ = speed of rotation of the undisturbed gyroscope
$\boldsymbol{\omega}$ = speed of rotation of the gyroscope around its main axis
$\boldsymbol{\omega_p}$ = speed of precession
$\boldsymbol{\omega_i}$ = speed of instantaneous rotation
$\boldsymbol{J_o}$ = main momentum of inertia
$\boldsymbol{J_p}$ = momentum of inertia related to the precession axis
$\boldsymbol{J_i}$ = momentum of inertia related to the axis of instantaneous rotation

The value of the torque developed by a disturbing force F_p, applied to the main axis of the gyroscope with an angle β, is evidently given by:

2) $C_p = R\ F_p\ \mathrm{sen}\beta$

where R is the arm of the force, that is the distance of his point of application from the centre of the gyroscope.

Instant by instant the gyroscope precedes around an equatorial axis, but the resulting motion of he main axis describes a cone, with the axis parallel to the force, an opening angle of 2 β and its vertex at the centre of the gyroscope. The main axis, therefore, appears to rotate with angular speed ω_{pa} around an axis parallel to the disturbing force (see fig. 1).

The value of ω_{pa} is given by the following equation:

3) $$\omega_{pa} = \frac{\omega_p}{sen\beta}$$

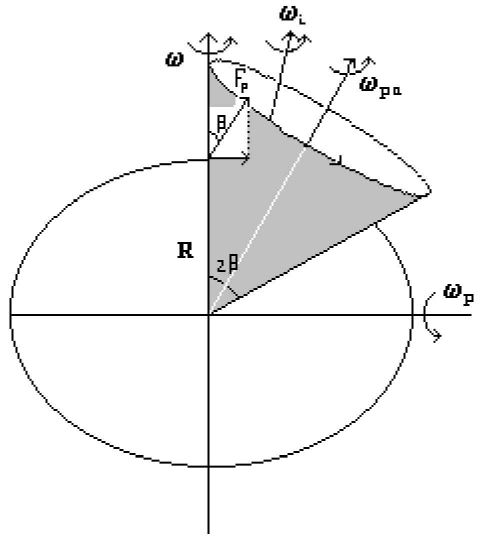

fig.1

Equations 1), 2) and 3) allow us to study exhaustively the behaviour of a disturbed gyroscope, by means of an essentially graphic method.

Given a gyroscope let's draw, on the basis of its inertia ellipse, another ellipse whose semi-axis are respectively:

$$a = \sqrt{\frac{J_o}{J_p}} \; ; \qquad\qquad b = \sqrt{\frac{J_o}{J_o}} = 1$$

Every radius of the ellipse, $r(\theta)$, where: $\theta = 0 \div 2\pi$, would obviously have the value:

$$r_\theta = \sqrt{J_o / J_\theta}$$

where J_θ is the momentum of inertia of an axis forming an angle θ with the main axis.

If we put $\Omega^2 = 1$, for equation 1) every radius $r(\theta)$ is proportional to the speed of rotation that the gyroscope has to have around axis θ to keep its initial energy unchanged.

The end of the arrows representing Ω and ω_i, therefore, always fall on the ellipse, while all the other rotational components have to be found inside the ellipse. This ellipse allows us to analyse exhaustively the behaviour of all the rotational components of the gyroscope, bound as they are by equation 1) (see fig.2).

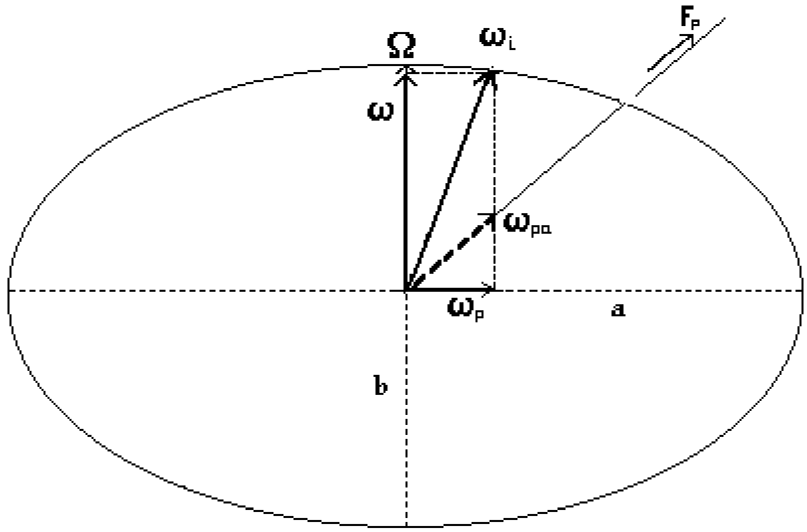

fig.2

The meaning of the rotational components shown in fig. 2 is easily understood. A gyroscope subjected to a disturbing torque reacts generating an exactly equal and opposed torque. This is achieved by means of a precession movement, ω_p, around an equatorial axis, which makes the gyroscope rotate "unbalanced", that is rotate instant by instant around an axis, which forms with the main axis an angle β proportional to the disturbing torque. The instantaneous rotation, ω_i, is given by the sum of the rotation around the main axis, ω, plus the rotation of precession, ω_p. In every moment we have:

$$\omega_i^2 = \omega^2 + \omega_p^2.$$

When a gyroscope is subjected to a disturbing force F_p, of increasing value, ω_p grows and as a consequence ω_i moves towards ω_{pa}.

When F_p reaches a certain value F_{pa} (see calculations further on), we will have:

$$\omega_i = \omega_{pa}$$

At that precise moment the axis of instantaneous rotation coincides with the axis of apparent precession, and becomes fixed with respect to both, the space and the gyroscope. This is a very special condition in which the system composed by the gyroscope and the disturbing torque behaves like a non-disturbed gyroscope, with only a single rotational component, Ω'. This axis, therefore, becomes the new axis of rotation of the system.

If at this point force F_p diminishes again, the system behaves like a gyroscope to which is applied a torque of value:

$$C'_p = C_{pa} - C_p$$

Therefore the new axis of rotation begins to precede around the main axis, moving on the surface of a cone as shown in fig. 3.

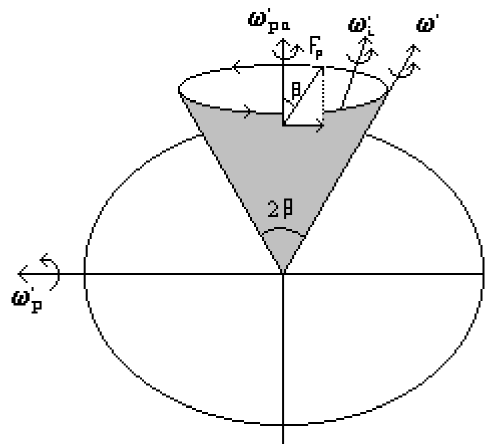

fig. 3

As a consequence ω_i' moves back towards the main axis, following the same path it has run along in the previous journey. Value and direction of the gyroscope's rotational components in this case are represented in fig.4

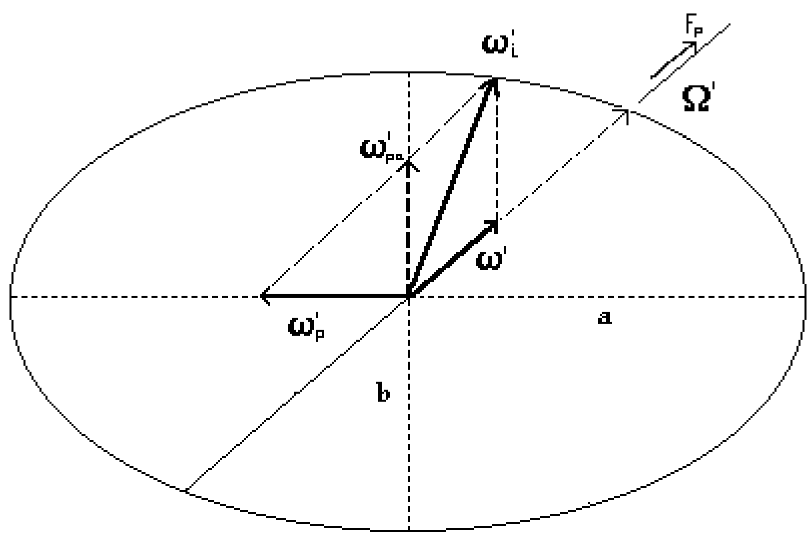

fig.4

Due to the principle of conservation of energy we will evidently have:

$$J_{pa}\,\Omega'^2 = J_o\,\omega'^2 + J'_p\omega_p'^2 = J_i\,\omega_i'^2 = J_o\,\Omega^2$$

For each value of the disturbing force, F_p, the speed of the instantaneous rotation is exactly the same both ways, there and back, that is $\omega_i' = \omega_i$. The other rotational components, instead, change considerably and ω'_p has direction opposite to that of ω_p . This is justified by the fact that while F_p is growing, the main axis rotates around axis $\omega_{pa.}$ In the "return journey " the contrary happens: it is the axis of ω' (now fixed in respect to the body of the gyroscope) that rotates around the main axis.

The most important fact is that along the ω' axis we have a rotational component which is fixed in respect to the gyroscope. This means that the gyroscope keeps "memory" of the position of the new axis of rotation. That rotational component, therefore the "memory", is cancelled only if and when F_p is completely zeroed. If F_p should not be zeroed , the gyroscope would keep this rotational component, and therefore the "memory", indefinitely.

Behaviour of a semifluid gyroscope like the Earth

The behaviour of the Earth when subjected to a disturbing torque is exactly the same as that of a gyroscope, with a fundamental difference due to the fact that the planet is not a homogenous and rigid solid, made up, as it is, of liquid parts inside and outside an intermediate plastic shell. Every rotational component of the planet exercises on its parts a centrifugal force, which causes deformations and/or displacements of them.

If we force a gyroscope to rotate around an axis different from the main, it develops a reaction torque constant in time . The Earth too, forced to rotate around an axis different from the main, would at first develop a reaction torque. The same centrifugal force responsible for this torque, however, would act on solid and liquid masses causing deformations and /or displacements tending to restore the equatorial bulge around the new axis of rotation. As a consequence the reaction torque would decrease, until completely spent after a while.

We do not know forces capable of making the Earth rotate around an axis different from the main, for a time long enough to complete such a process. But we do know that the planet is periodically hit by large celestial bodies at high speed, which develop an impulsive torque, that can have a very high peak value, as high as the highest reaction torque possibly developed by Earth (see following paragraph and relative calculus).

Graphics of fig.2 and fig.4, can help us to understand what happens in this case.

As soon as the torque developed by the impact starts growing, the ω_i moves in the direction of ω_{pa}, parallel to the direction of impact. If the impact develops a torque of sufficient value, ω_i will coincides with ω_{pa}. On that instant the axis of ω_{pa} becomes axis of permanent rotation. As soon as the torque value decreases, the axis of ω_i returns quickly towards the main axis, but following a different path as shown in fig. 4. As soon as the shock ceases, an instant later, the Earth should again return to rotate around its natural axis, without any further repercussion. But it is not necessarily so.

To cancel the "memory" of the new axis of rotation, and have the gyroscope rotating again around the main axis, it is necessary that the torque be completely spent. Unfortunately, there are good probabilities that this may not happen. We know that the Earth is permanently subjected to a torque generated by the gravitational forces of the sun and the moon on the equatorial bulge. This torque is millions of times smaller than the one developed by the impact, but its role is fundamental.

If at that moment it has a different direction than the one developed by the impact itself, as soon as the shock is exhausted, the Earth instantly recovers its previous axis of rotation and all ends there. The only consequences would be the destruction resulting from the impact.

If, however, the torque due to the Sun-Moon attraction has the same direction of the torque caused by the celestial body, it is added to this, and contributes in its small way to the instantaneous change of the position of the poles. A few instants later the shock exhausts itself while the Sun-Moon gravitational attraction continues, and however small, it nonetheless develops a torque higher than zero. Therefore the "memory" of the axis around which the Earth has rotated during the impact, even for a very short moment, cannot be cancelled.

In this case the Earth actually behaves like a gyroscope whose main axis coincides with the one adopted during the impact, subjected to a disturbing torque equal but opposite to the torque generated by the impact. The overall motion is apparently exactly the same, but in reality there are fundamental differences, as illustrated in fig.5 .

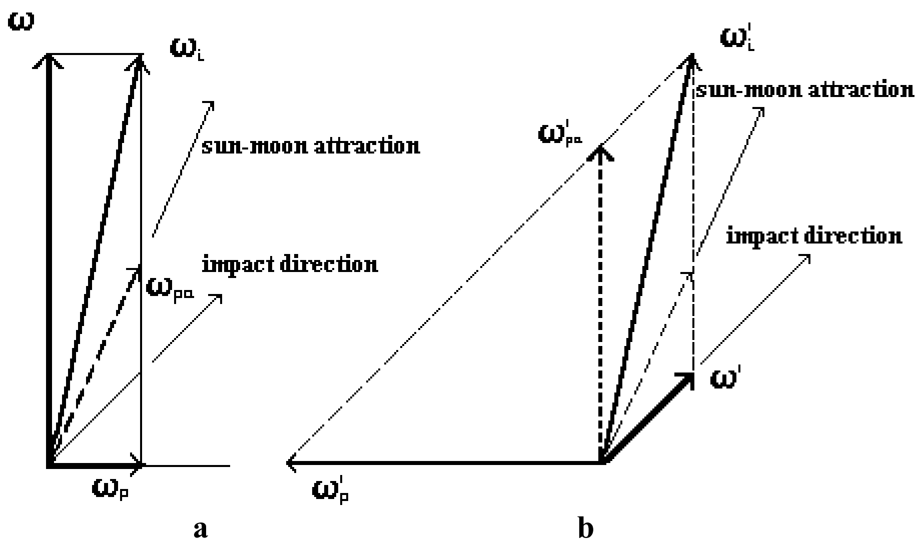

fig.5

Graphics n. 5.a and 5.b represent the situation of Earth's rotational components immediately before (5.a) and after (5.b) the impact, in the case in which the Sun-Moon disturbing force has the same direction of the force developed by the impact. (To make it easier to represent them, the precession rotational components in the illustration are greatly exaggerated; in reality they are more than one million times smaller than the main rotation. The rationale however does not change).

Apparently the situation has not changed, because ω_i is exactly equal to $\omega'_{i,}$ and ω' has the same magnitude as the previous precession speed $\omega_{pa.}$ There is however a crucial difference: at this point ω' is the only rotational component "fixed" with respect to the Earth's body. Thus, the axis of ω' has become axis of permanent rotation. The rotation around it is extremely small (as much as millions times smaller than the main rotation), but it develops in any case a centrifugal force strong enough to form an equatorial bulge (of a few meters) around the new axis of rotation.

If the Earth was a solid gyroscope, this situation would last indefinitely unchanged. The planet, however, is covered by a thin layer of water, which reacts immediately to any change of motion.

Sea water begins to move towards the new equator, and as this happens, the value of ω' increases again, therefore increasing the force which makes the water move towards the new equator. This process gradually accelerates, until the centrifugal force developed by ω' grows strong enough to induce deformations of the Earth's mantle.

From here on the equatorial bulge is quickly reformed around the new axis of rotation and Earth will soon be stable again, with a different axis of rotation and different poles.

This mechanism shows that the Earth's poles, contrary to what has always been postulated, can "jump" almost instantaneously from a location to another thousands kilometres away, due to the combined effects of forces at first sight irrelevant, such as the impact of a medium size asteroid and the Sun-Moon gravitational attraction on the equatorial bulge.

Let's now evaluate the probability of such an event. According to Hapgood, in the short lapse of time represented by the last 100.000 years, no less than three "jumps" happened. This means that the probability of such an event should be extremely high.

In order to be able to estimate it, we must first determine the value of the reaction torque developed by Earth. This value will allow us to determine the dimensions and speed a celestial body must possess in order to be able to overcome such a torque.

Value of the reaction torque developed by Earth

The value of the reaction torque developed by a gyroscope, when rotating around an axis different from the main, can be calculated (see fig, 6) reckoning the torque developed by the element of mass, dm, rotating around the axis of ω_i:

$$C_i = F_i\, b$$

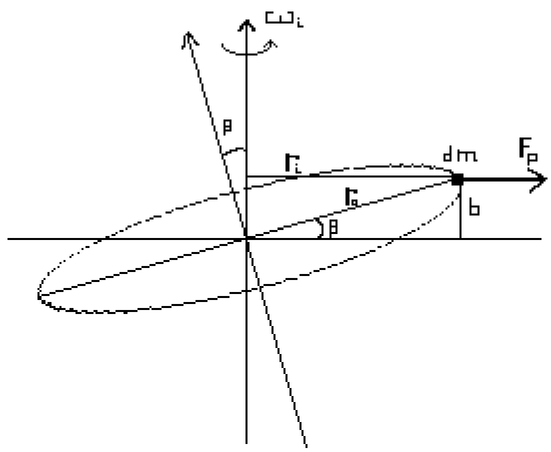

fig. 6

where:

$F_i = dm\, \omega_i^2\, r_i = dm\, \omega_i^2\, r_o \cos\beta$ is the centrifugal force;

$b = r_o\, sen\beta$ is the arm of the torque.

We have therefore:

$C_i = dm\ r_o^2\ \omega_i^2\ sen\beta\ cos\beta = dJ_o\ \omega_i^2\ sen\beta\ cos\beta = ½\ dJ_o\ \omega_i^2\ sen2\beta$

where $dJ_o = dm\ r_o^2$ is the momentum of inertia of mass dm with respect to the main axis.

For a ellipsoid of revolution we will have therefore (see fig. 7):

4) $\boldsymbol{C = (J_o - J_p)\ \omega_i^2\ sen\beta cos\beta = ½\ \ J_r\ \omega_i^2\ sen2\beta}$

where $J_r = (J_o - J_p)$ is the momentum of inertia of the bulge.

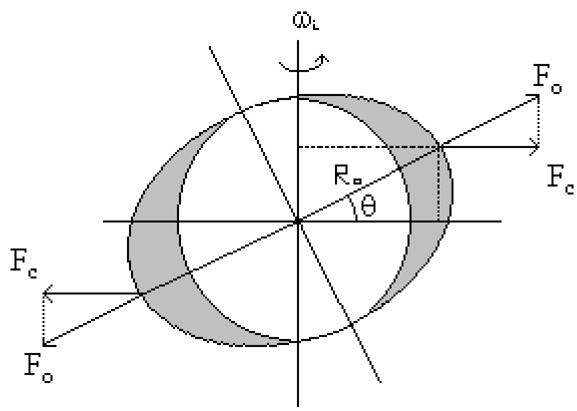

fig7

Equation 4) shows that a gyroscope may develop a reaction torque only if $J_o \neq J_p$. In the case of it being perfectly spherical, it would rotate indifferently around whatever axis and it wouldn't have any stability.

This is due to the fact that in a rotating homogenous sphere, all centrifugal forces balance each other and there is no reaction torque, no matter what the axis of rotation is. Only the equatorial bulge can develop a reaction torque

Value of the stabilising torque developed by the equatorial bulge

From equation 4) we see that the maximum reaction torque possibly developed by a gyroscope is reached when $\beta = 45^o$:

$C_m = ½\ J_r\ \ \omega_i^2$

For Earth the value of ω_i is almost equal to that of the main rotation, so we can assume that:

$\omega_i^2 \approx (2\pi / 8{,}64)^2\ 10^{-10} = 5{,}28\ .\ 10^{-9}\ \ \text{sec.}^{-2}$

The calculation of J_r can be made by using the value of the centrifugal force, F_o, developed by the equatorial bulge due to Earth's rotation, as calculated by Gallen and Deininger for Hapgood (see insert at the end):

F_o = 4,1192. 10^{19} kg.

For an approximate calculation we can put:
$J_r \cong M_r R_o^2$
$F_o \cong M_r\ \omega_i^2 R_o = J_r\, \omega_i^2 / R_o$
where M_r is the mass of the bulge and R_o the radius of the Earth.
We have then:
$J_r \cong F_o R_o / \omega_i^2 \cong 5\ 10^{34}$ kgmt^2

And finally, thanks to equation 4) we have:

4') $\mathbf{C = \tfrac{1}{2}\ J_r\, \omega_i^2\ sen2\beta = 1{,}38\ \ 10^{26}\ sen2\beta}$ kgmt

For $\beta = 45^o$ we have :

$C \cong 1{,}38\ \ 10^{26}$ kgmt

which is the maximum reaction torque possibly developed by Earth.

Calculation of the size an asteroid should have to cause the shifting of the poles

According to equation 4) to displace the axis of rotation of for instance 20^o, an asteroid hitting the Earth must develop an impulsive torque of the following value:

$C_{20°} = 8{,}87\ .\ 10^{25}$ Kgmt.

It is therefore easy to calculate the size and speed that such an asteroid must have.

The impulsive force F_i developed on impact with Earth by the asteroid is given by:

$F_i = M_a.a$

where:

$a = dv/dt$ is the acceleration the asteroid undergoes on impact

M_a is the mass of the asteroid

To calculate the acceleration, a, we can assume the asteroid has, on impact, a speed:

$v = 5 \, . \, 10^4$ mt/sec.

To calculate dt we have to rely on an estimate. In a very conservative way, considering the depth of known craters, we can presume that the depth of the crater caused by that impact to be 500 m, which means that the speed of the asteroid decreases from 5.10^4 to 0 mt/sec, in a space of 500 meters. The time in which this happens is approximately one hundredth of a second, that is:

$dt = 0{,}01$ sec.

The average acceleration of the asteroid will therefore be:

$a_m = dv/dt = 5.10^4 / 0{,}01 = 5.\,10^6 \; m/sec^2$

The acceleration peak is certainly much higher. In a conservative calculation we can assume it to be double the average value. We will have then:

$a = 5.10^4 \;/\; 0.005 = 10^7$ mt/sec^2

And therefore:

$F_i = M_a \, . \, 10^7$ kg

The torque developed by this force will obviously be:

$C_i = F_i \, . \, R_i$

where R_i is the arm of the torque.

The value of R_i can be between 0 and $R_o \cong 6{,}4 \; 10^6$ mt, that is the radius of the Earth. For statistical reasons we can put:

$R_i = ½ \; R_o = 3{,}2 \; 10^6$ mt

The mass of the asteroid will therefore be:

$$M_a = \frac{F_i}{a} = \frac{C_i}{R_i a} = \frac{8{,}87.10^{25}}{3{,}2.10^6.10^7} = 2{,}77 \; 10^{12} \text{ kg}$$

If the density of the asteroid is of 3 Kg/dm^3, we will have a volume of:

$\mathbf{V_a = 0{,}92 \; km^3}$

that is then a lithic asteroid of approximately a 1000 metres diameter. This calculation is very conservative. We can realistically suppose that an object of half that size is enough to develop a torque of sufficient value for a huge shift of the poles.

Probability of a shifting of the Poles due to an asteroid impact

Following are the essential conditions necessary to cause a shift of the poles by an asteroid falling on Earth:

1) The torque developed by the asteroid on collision must be equal to the maximum Earth reaction torque, even if for only one instant. This means that the asteroid must not only have size and speed of sufficient magnitude, but the arm of the torque, as well, has to be sufficiently long.

2) The force of the Sun-Moon gravitational attraction on the equatorial bulge must have the same direction of the force developed by the impact.

This second condition has no more than 50% probability of being verified. Therefore, the probability that an impact results in a shifting of the poles is smaller than 50%, regardless of the size of the asteroid. The size of the object has also little influence on the probability that it generates a torque of adequate value, the main influence residing with the length of the arm of the torque. If the impact is directed exactly towards the centre of the Earth, there is no torque at all, regardless of the size and/or the speed of the asteroid. On the other hand, even a very small object can develop a very high torque if it hits the Earth at an almost tangent angle to the surface. Of much importance to the peak value of the torque developed, should be the density of the object and the nature of the surface it falls on.

These variables make it impossible to calculate with precision the probability that an impact might develop a torque sufficient to cause a shifting of the poles. However, we can reasonably expect this probability to be in the range of 20 to 30% for objects of a diameter of 500 m or more; under this size the probability should fall sharply.

The Apollo objects

We can expect the chances of a celestial body as large as 500 mt colliding with Earth to be rather high, in the range of several collisions each 100.000 years period. The majority of these collisions is caused by a class of celestial bodies named by astronomers “Apollo objects”, that is a class of asteroids whose perihelion lies inside the orbit of the Earth.

The first of these objects was discovered by Reinmuth on 1932 and named Apollo, which gave the name to the class. At present, approximately one hundred Apollos of a diameter of at least one kilometre are known. The largest discovered so far, Hephaistos, has a diameter of ten kilometres. The total number of Apollo objects with a diameter of one kilometre or more is estimated to be between 1.000 and 2.000.

As the perihelion of the Apollos lies inside the orbit of the Earth, it follows that periodically they have the chance to collide with it. The probability of such an event is estimated at 5. 10^{-9} per year per single Apollo. Therefore we have a probability of at least 4 collisions each million year period with objects as large as one kilometre or more. As the size of the objects becomes smaller, this probability grows exponentially to become of one impact every few centuries for objects of 100 to 200 metres diameter.

The calculated probability of 4 collisions every one million year period is coherent with the statistic of one-kilometre-wide asteroids fallen on Earth during the last 600 millions years (see: G.W. Wetherill, "The Apollo Objects", Scientific American May 79; and Tom Gehrels, "Collision with comets and asteroids", Scientific American, March 96) . If the Earth didn't have oceans and atmosphere its surface would be marked with craters like the Moon and Mercury . On our planet, instead, erosion and sedimentary processes delete very quickly the marks of collisions by meteorites. Only where recent ice sheets have scraped the surface, thus uncovering the traces of ancient collisions as in Canada, it is possible to count the craters accurately. Based on this count G.W. Wetherill has estimated that in the last 600 million years the planet has been hit at least by 1500 objects with a diameter larger than one kilometre.

Major events during a shifting of the poles

The effects of a collision with an Apollo-like object are devastating. Gehrels estimates that a one-kilometre-wide object, colliding with the Earth at a speed of 20 kilometres per second, would liberate an energy equivalent to ten billions of Hiroshima-type nuclear bombs.

These effects, however, although disastrous, are not even comparable with the destruction brought about by an instantaneous shifting of the poles. Following is a short analysis of what could happen.

Suppose the Earth has been hit by an asteroid and that the conditions for a shift of the poles have been met. On the basis of the adjustments necessary to re-shape the equatorial bulge around the new axis of rotation, and the consequent re-establishment of the isostatic equilibrium of the crust, we can predict what the phenomena would be.

Some areas of the Earth's crust would be driven to move upward, others downward. The up and down movements necessary to re-shape the bulge, would be different from site to site of the Earth . For a shift of 20^{o} the movements would be of 3 or 4 kilometres at the most. Very small, compared with the diameter of the Earth, but nonetheless of great consequence on the surface. We know that the mechanisms which maintain the isostatic equilibrium of the crust are very effective; there is no doubt that after a while the equilibrium would be re-established around the new axis of rotation, with poles and equator in different positions.

It is important to evaluate how long it would take for this to happen. We know that the layers of the crust, when subjected to a force over a certain limit, break suddenly, causing an earthquake. In the situation we have hypothesised, at the beginning only sea water would be displaced, with a very slow and gradual increase of the speed of rotation around the new axis. When the rotational speed reaches a certain critical value, sudden adjustments of the crust would begin to happen and from that moment the process would be sharply accelerated and the re-shaping of the bulge would be completed in a very short time.

How short? days or hours? Impossible to say. A simulation with a mathematical model should give reliable results. The process of re-shaping the equatorial bulge should follow a course of exponential type: after the initial sharp peak, it should decrease very quickly. Adjustment phenomena, however, are expected to continue for a long time, as the isostatic equilibrium is re-established more and more accurately.

Obviously, readjustments of that size of the equatorial bulge cannot happen without causing extensive fractures of the crust, which would provoke earthquakes of such a tremendous magnitude as to dwarf the most devastating known today. A sudden incredibly strong burst of volcanic activity in all areas subjected to strain would also be inevitable.

The beginning of adjustments of the crust would start not only earthquakes and volcanic activity, but even a dreadful hurricane all over the continents, with violent winds and torrential rains. A gigantic water avalanche would devastate the valleys and plains of the world. On the whole the oceans' water and the atmosphere follow the rotational movement of the Earth, but they are not tied to it. If the Earth should suddenly change the direction of its rotation, they would, at first, thanks to their inertia , keep up their previous motion; only after a while the attrition with the Earth's surface would force them to follow the new movement.

The continents would be swept by hurricane force winds, reaching speeds of hundreds of kilometres per hour. The water of the oceans would play a much greater destructive role.

If we abruptly change the movement of a bowl full of water, we see the level of the water rising on one side and getting lower on the opposite. Something like this would happen on Earth. We must expect wide fluctuation of sea levels in many parts of the world. Presumably an enormous tide, dozens, or even hundreds of meters high, would slowly move around the globe.

The same reasoning applies where the core of the Earth is concerned. It being liquid it would at first continue on its motion, naturally undergoing a strong attrition in the core-mantle boundary region. Obviously, after a certain time the core would adopt the same rotational motion of the mantle, but the attrition would create a turbulence which might have important effects. According to the last theories, the liquid core is the site of electrical currents, that are responsible for the magnetic field. This turbulence could influence the behaviour of the magnetic field, and it could break the balance, thus provoking perturbation on the magnetic field that might lead even to an inversion of the magnetic poles.

An important element in order to evaluate the climatic conditions following a shift of the poles, is the inclination that the new axis of rotation will assume with respect to the ecliptic. This has a tremendous effect on the climate. According to the mechanism we have spelt out so far the axis of rotation that the Earth would acquire at the moment of impact should be parallel to the direction of the hit. It is impossible to predict which would be the actual direction of the new axis once stabilised. It is certain that it would not be the same as the previous one, except for a fortuitous chance. Therefore, following a shift of the poles the course of the seasons would very likely be different .

For example, in the hypothesis that the axis of rotation is almost vertical with respect to the ecliptic, there would be an enormous growth of ice at high latitudes and altitudes, with subsequent lowering of sea level. On the other hand the climate would be much more stable then it is today, with very limited (or non-existent) seasonal climatic differences and an uninterrupted vegetation’s growth. This would bring about the disruption of today’s climatic barriers, with subsequent spreading of tropical species towards northern regions and viceversa. There would also be the maximum possible development of ecological communities.

This appears to be exactly the existing situation in the Pleistocene era, when formidable ice caps covered North America and North Europe, and there were enormous glaciers on all mountains. In the immediate surroundings of these masses of ice one of the most impressive zoological communities of all times thrived. Millions (more than 40 millions, according to F.C. Hibben) of mammoths roamed Siberia and Alaska, large animals the size of which can be found today only in tropical regions, or in those areas where the supply of fodder is guaranteed all the year round.

It’s against common sense that precisely during the ice age, one of the largest zoological communities since the dinosaurs existed in those very areas which are today reputed, due to their extreme climatic conditions, as the most hostile on Earth. With the mammoths there were dozens other animal species, the majority of which are extinct today. Of these species we have a great number of skeletons, several complete animals that have been perfectly preserved in the permafrost, and many wonderful paintings in Palaeolithic caves. The oldest amongst them is the “Chauvet” cave, in France, which is believed to have been painted 30.000 years ago, precisely in the middle of the ice age. They are pictures of breathtaking beauty. The unknown artists, with a few strokes, have represented to perfection animals which at the time were living in the plains of central Europe (and at the same time in Siberia and Alaska) .

But the beauty of the paintings makes the zoologist wonder in more than one way: how could such a varied assembly of animals coexist? To what a bizarre ecological environment could such a motley fauna belong? We find the rein-deer next to rhinoceros, the mammoth, with its woolly mantle, near the hippopotamus, bears with lions, the leopard and Brezalwski horses. There were also giant beavers and sloths, big horn deers, camels, sabre teeth tigers, buffaloes, aurochs bulls and many more.

It's an incredible mixture which leaves us puzzled and astonished. Arctic and tropical fauna together, on the same plain, in perfect balance with the environment! Such an extraordinarily varied and numerous animal community disagrees with whatever current opinion we might have on climatic conditions during the ice age. And definitely such a community couldn't exist anywhere on Earth today.

This community suddenly disappeared at the end of the Pleistocene era, when, according to today's theories, the climatic conditions were supposed to have become milder.

A shift of the poles occurred 11.600 years ago, with all its related destructive phenomena, could explain completely and coherently the climatic situation before that date, and the situation brought on after that date.

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Gallen's calculation of the stabilising centrifugal effect of the equatorial bulge of the Earth

Let the equations of the sphere and the ellipsoid of revolution be:

1) $x^2 + y^2 + z^2 = b^2$

2) $\dfrac{x^2}{a^2} + \dfrac{y^2}{b^2} + \dfrac{z^2}{c^2} = 1$

where the axis of y is the axis of revolution. Take as the element of mass, dM, the ring generated by revolving the rectangle dxdy about the axis of y. We have:

3) $dM = 2\pi\delta x \, dxdy$

where δ is the density. For each particle of the ring the centrifugal acceleration is the same, being equal to $\omega^2 x$, where ω is the constant angular velocity in radiants per second.

The element of centrifugal force, dF, exerted by the ring is then:

4) $dF = \omega^2 x\, dM = 2\pi\delta\omega^2 x^2\, dxdy$

Integrating equation (4) with respect to x and y, there results:

5) $$F = 2\pi\delta\omega^2 \int_{-b}^{b} \int_{\sqrt{b^2-y^2}}^{\frac{a}{b}\sqrt{b^2-y^2}} x^2 dxdy = \frac{\pi^2\delta\omega^2}{4} b\left(a^2 - b^2\right)$$

In equation (5) F is expressed in dynes when δ is given in grams per cubic centimeter, and a and b in centimeters. The quantity ω may be replaced by $2\pi n$, where n is revolutions per second. The Earth makes one complete revolution in 86,164.09 mean solar seconds.

Mrs. Deininger's computation based on Gallen's calculus

Computation of centrifugal force produced by rotation of the bulge,

A. Essential data:

1. The attached formula should apply to the bulge taken as 13.3443 miles at the equator, not the bulge as it would be if there were no flattening at the poles.
2. In making the calculation, Hapgood asked Mrs Harriet Deininger, of the Smith College faculty, to subtract three miles from the depth of the bulge, because he was concerned with a purely mechanical action of stabilisation, in which water could not have effect. (He later recognised that he subtracted about three miles too much, because he had disregarded isostasy, which in this case makes it probable that the rock under the oceans has a density higher than the density of the rock of the continents; so he should have subtracted the weight rather than the volume of the water. This however is a minor correction)
3. Mrs. Deininger actually took the depth of the bulge as nine miles, without the water.

B. Calculation:

1) $F = \frac{\pi^2 s w^2}{4} b\left(a^2 - b^2\right)$

where	s	=	density in gm/cc
	a	=	radius of Earth at bulge in cm
	b	=	radius of Earth at poles in cm
	w	=	2 - n r = rps

2) $F = \pi^4 s n^2 . b(a^3 - b^3)$

where	π	=	3,1415
	s	=	2,7 gm/cm^3
	n	=	1/86.164
	b	=	6,402 . 10^8 cm
	a	=	6,4165 . 10^8 cm (using nine miles or 1,450,000 cm as depth of bulge)

3) ***F = 4,0368 . 10^{25} dine = 4,1192. 10^{19} kg.***

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