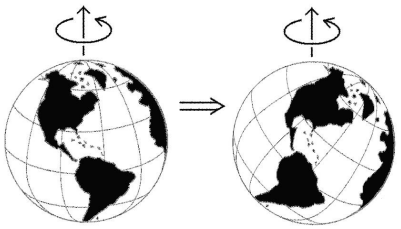
True polar wander

True polar wander is a solid-body rotation of a planet or moon with respect to its spin axis, causing the geographic locations of the North and South Poles to change, or "wander". In a stable state, the largest moments of inertia axis is aligned with the spin axis, with the smaller two moment of inertia axes lying in the plane of the equator. When this is not the case, true polar wander will occur: the planet or moon will rotate as a rigid body to realign the largest moment of inertia axis with the spin axis.



This diagram of true polar wander shows the present-day Earth rotating with respect to its rotational axis

Description in the context of Earth

The Earth is not a true sphere, and therefore has three orthogonal axes of inertia. The axis around which the moment of inertia is greatest is closely aligned with the rotation axis (the axis going through the Geographic North and South Poles). The other two axes are near the equator. This is similar to a brick rotating around an axis going through its shortest dimension (a vertical axis when the brick is lying flat). But if the moment of inertia around one of the two axes close to the equator becomes nearly equal to that around the polar axis, then the constraint on the orientation of the object (the Earth) is relaxed.

This situation is like a Rugby football or an American football spinning around an axis running through its "equator". (Note that the "equator" of the ball does not correspond to the equator of the Earth.) Small perturbations can move the football so that it spins around another axis through this same "equator". In the same way, when the conditions are right, the Earth (both the crust and the mantle) can slowly reorient so that a new geographic point moves to the North Pole, while keeping the axis of low moment of inertia quite near the equator.

Such a reorientation changes the latitudes of most points on the Earth by amounts that depend on how far they are from the axis near the equator that does not move.

Examples

Cases of true polar wander have occurred several times in the course of the Earth's history.[1] The speed of rotation (around the axis of lowest inertia) is limited to about 1° per million years. Mars, Europa, and Enceladus are also believed to have undergone true pole wander, in the case of Europa by 80°, flipping over almost completely.[2]

Uranus' extreme inclination with respect to the ecliptic is not an instance of true polar wander (a shift of the body relative to its rotational axis), but instead a large shift of the rotational axis itself. This axis shift is believed to be the result of a catastrophic series of impacts that occurred billions of years ago.[3]

Distinctions and delimitations

Polar wander should not be confused with precession or nutation, which is where the axis of rotation moves, in other words the North Pole points toward a different star. These are caused by the gravitational attraction of the Moon and Sun, and occurs all the time and at a much faster rate than polar wander. It does not result in changes of latitude.

True polar wander has to be distinguished from continental drift, which is where different parts of the Earth's crust move in different directions because of circulation in the mantle.

The effect should further not be confused with the effect known as geomagnetic reversal that describes the repeated proven reversal of the magnetic field of the Earth.

Tectonic plate reconstructions

Paleomagnetism is used to create tectonic plate reconstructions by finding the paleolatitude of a particular site. This paleolatitude is affected both by true polar wander and by plate tectonics. To reconstruct plate tectonic histories, geologists must obtain a number of dated paleomagnetic samples. Because true polar wander is a global phenomenon but tectonic motions are specific to each plate, multiple dates allow them to separate the tectonic and true polar wander signals.

References

Article Sources and Contributors

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