Cosmic rays reveal event in Earth's magnetic field history

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41 000 years ago, the Earth's magnetic field faded and practically disappeared, leaving our planet unprotected from the bombardment of cosmic rays. Evidence for this event has been found in ocean sediment cores by a team from the Centre de Recherche et d'Enseignement de Géosciences de l'Environnement (CEREGE, CNRS/Aix-Marseille Université/IRD/Collège de France). In the cores, the researchers measured variations in concentrations of beryllium-10, a radioactive isotope produced by the action of cosmic rays on oxygen and nitrogen atoms in the atmosphere. The work, published in the *Journal of Geophysical Research*, is an important step towards developing a new method for studying the history of Earth's magnetic field, which should shed light on why its strength has been declining over the past three thousand years.

The Earth's magnetic field forms an efficient shield that deflects charged particles of cosmic origin headed for Earth. Far from being constant, the magnetic field has undergone many reversals, with the North magnetic pole shifting to the South geographic pole. Such reversals are always accompanied by a disappearance of the magnetic field. The last such reversal took place 780 000 years ago. The magnetic field can also undergo excursions, periods when the field suddenly drops as if it was going to reverse, before recovering its normal polarity. The most recent event of this kind, known as the Laschamp excursion, took place 41 000 years ago.

Evidence for the event was uncovered by the researchers in sediment cores collected off the coasts of Portugal and Papua New Guinea. In the samples, they found an excess of beryllium-10, an isotope produced solely by collisions between particles of cosmic origin and atoms of nitrogen and oxygen. The beryllium-10 (^{10}Be) produced in the atmosphere then falls to the Earth's surface where it is incorporated into ice and sediments. In sedimentary beds dating from the age of the Laschamp excursion, the researchers found up to twice as much ^{10}Be as normal, evidence of the intense cosmic ray bombardment that the Earth underwent for several thousand years.

Traditionally, the presence of various iron oxides, especially magnetite, in volcanic lavas, sediments and ancient pottery provides information on the history of the magnetic field by indicating its direction and strength at the time when these materials solidified. This so-called paleomagnetic approach does not always allow global variations in the magnetic field to be quantified accurately. The researchers combined this method with the measurement of beryllium-10 concentrations in the same sedimentary records. This enabled them to demonstrate that peak concentrations of this isotope are synchronous and have the same dynamics and amplitude in Atlantic and Pacific sediments as in the previously analyzed Greenland ice cores. The method based on beryllium-10, which has been developed over the past 10 years at CEREGE, therefore makes it possible to obtain a continuous reconstruction of variations in the strength of the Earth's global magnetic field.

It is also known that over the past 3000 years the magnetic field has lost 30% of its strength. This trend suggests that in the coming centuries, the Earth might undergo an excursion similar to the one that took place 41 000 years ago. Since high energy cosmic rays can cause mutations and cell damage, such an event would have a significant impact on biodiversity, and in particular on humans. This is why the researchers are seeking to find out the precise rates of the magnetic field's reversal and excursion sequences, in order to identify potential regularities in its behavior and thus shed light on the cause of these phenomena, which originate in the Earth's core. This is the objective of the MAGORB project, launched in 2009, funded by the French National Research Agency ANR and run by CEREGE, the Institut de Physique du Globe de Paris (IPGP) and the Laboratoire des Sciences du Climat et de l'Environnement (LSCE, CNRS/CEA/UVSQ).

More information: L. Ménabréaz, D. L. Bourlès, N. Thouveny, in press. Amplitude and timing of the Laschamp geomagnetic dipole low from the global atmospheric 10Be overproduction: contribution of authigenic 10Be/9Be ratios in West Equatorial Pacific sediments. *Journal of Geophysical Research*. 8 November 2012.

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