Reversals and Excursions of the Earth’s magnetic field

The Earth’s magnetic field changed its polarity from the last reversed into today’s normal state approximately 780 000 years ago. The geomagnetic field before and after this so called Matuyama/Brunhes reversal was essentially an axial dipole, interrupted by frequent excursions. All these events, reversals and excursions, are marked by strong field intensity drops and directional changes. The presently observed decrease of the Earth’s magnetic dipole moment (Fig. 1), which is recorded in geomagnetic observatories around the globe, and the formation of a strong field anomaly in the South Atlantic, led to speculations about an impending field reversal. Here we investigate the yet still largely unknown transitional structure of the Earth’s magnetic field in order to potentially predict the nature of upcoming field instabilities.

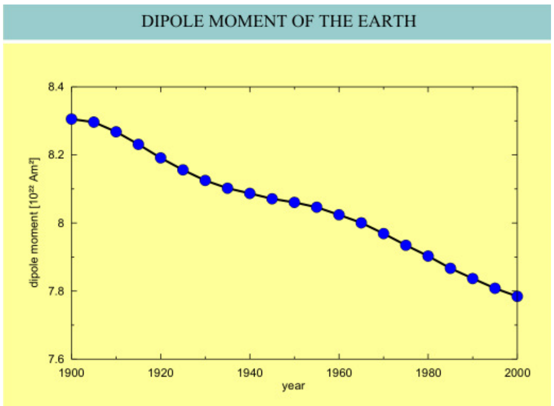

Figure 1: Decrease of the dipole moment during the last 100 years.

For the best documented field reversal, the Matuyama/Brunhes transition at 780,000 ka BP (Fig. 2) and best documented excursion, the Laschamp event at 41,000 years BP we have reconstructed the evolution of the global field morphology by using a Bayesian inversion of several high-resolution paleomagnetic records. In the excursion scenario inverse magnetic flux patches at the core-mantle boundary emerge near the equator and then move poleward.

Contrary to the situation during the last reversal, these flux patches do not cross the hydrodynamic boundary of the inner-core tangent cylinder. While the last geomagnetic reversal began with a substantial increase in the strength of the non-dipolar field components, prior to the Laschamp excursion, both dipolar and non-dipolar field decay at the same rate. Such coherent decrease of dipolar and non-dipolar components is also observed for the Iceland basin excursion. This result suggests that the nature of an upcoming geomagnetic field instability, whether it develops into a reversal or excursion, can be predicted several hundred years in advance. A clear tendency towards either type of instability, however, is not apparent in the modern data yet.

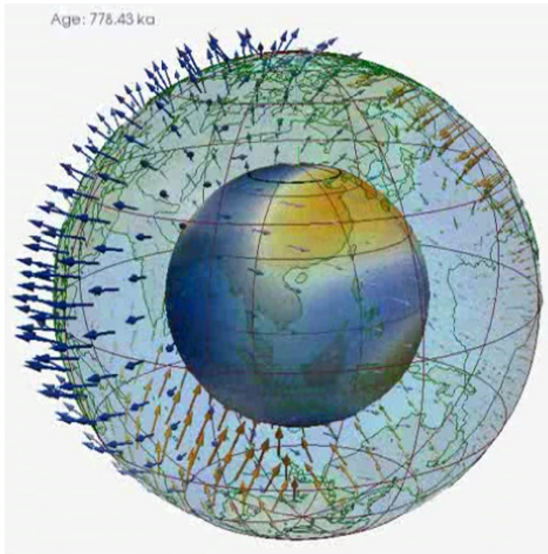

Figure 2: The geomagnetic field during the last reversal.

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