Possible linkage between geomagnetic field and climate and/or Earth's orbit

Toshitsugu Yamazaki[1]

[1] GSJ, AIST

http://staff.aist.go.jp/toshi-yamazaki/

In this presentation, I discuss the present status of studies on possible connections between the geomagnetic field and paleoclimate or the Earth's orbit. The idea was proposed more than 30 years ago, and has been argued repeatedly since then. However, paleomagnetic data with quality good enough for such discussions were not available until late 90s.

On the time scale of 10^4 to 10^5 years, variations of orbital frequencies have recently been found in relative paleointensity and inclination records for the last few million years obtained from marine sediment cores (~40 kyr obliquity frequency: Channell et al., 1998; ~100 kyr eccentricity: Yamazaki, 1999; Yamazaki and Oda, 2002; 2005), which suggests the possibility that energy of the geodynamo is supplied from outside the core. Arguments against the orbital forcing hypothesis are mainly from the following three viewpoints. First, it was proposed that the orbital frequencies in paleointensity may be an artifact caused by paleoclimatically induced magnetic property changes of sediments (e.g. Guyodo et al., 2000). This possibility can be tested by comparing paleointensity and magnetic property records of sediments from various oceanographic regimes, because a response of sediments to climate changes varies place by place but geomagnetic variations should be globally synchronous. Based on this strategy, Yokoyama and Yamazaki (2000), Yamazaki and Kanamatsu (2007), and Yokoyama et al. (2007) showed that the ~100 kyr quasi-period is of geomagnetic origin. Second, the statistical significance of the signal was questioned (e.g. Roberts et al., 2003). The third problem is that the mechanism to power the geodynamo by orbital changes is not known, and the changes of the orbital parameters might be too small for the energy although it is merely an impression and has not yet been confirmed. The presentation of Yokoyama and others in this session will address these problems. To obtain paleointensity and directional records back to ca. 10 Ma and confirm the orbital modulation, we have proposed a coring program to IODP. A possible relationship between the Earth's orbit and the occurrence of geomagnetic reversals and excursions has also been disputed for a long time (e.g. Rampino, 1979; Worm, 1997; Kent and Carlut, 2001; Fuller, 2006). This issue is closely connected with the possibility of the orbital frequencies in paleointensity records because it has now been established that reversals and excursions occur at paleointensity lows.

On the time scale of 10^2 to 10^3 years, on the other hand, a possibility of a geomagnetic control on paleoclimate has recently been argued. A possible mechanism proposed is that an increase of cosmic ray flux penetrating into the atmosphere by a reduction of the shielding effect of the geomagnetic field could induce nucleation of cloud and then a colder climate. An archaeomagnetic study in Western Europe for the past 1300 years has suggested that periods of stronger paleointensity correspond to the periods of Alpine glacier advance (Gallet et al., 2005), which is interpreted as an increased cosmic ray flux to polar regions by a dipole tilt. To probe the possibility, it is important to understand the configuration of non-dipole components on this time scale, and hence contributions from Japan is expected.