A preliminary study of vegetation and climate changes during the last geomagnetic reversal

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1. Introduction

The correlation between galactic cosmic ray intensity and global cloud cover suggests a possibility that the cosmic ray flux affects the global environment and climate. The geomagnetic field governs the cosmic ray flux through an effect of shielding. It is known that the geomagnetic field intensity declines to 10-20 % of its normal value during a reversal. Therefore during a geomagnetic reversal the decline of shielding effect causes an increase of cosmic ray flux, which raises the cloud cover. This study revealed vegetation and climate changes focusing on marine oxygen isotope stage (MIS) 19 across the Matuyama-Brunhes (M-B) magnetic polarity boundary to examine a link between the geomagnetic field, climate, and vegetation.

2. Materials and methods

A total of 26 clay samples were collected at about 1 m depth intervals ranging from a sequence from 409.13 m to 384.83 m in depth from a 1700-m Osaka Bay core. For the sequence, a detailed record of the M-B polarity transition has been examined.

Extracted pollen grains and spores were identified under an optical microscope at the magnification of X 400. At least 500 arboreal pollen (AP) grains were counted over the entire coverslip for each sample.

3. Results

The late MIS 20 is characterized by the boreal climate with a coniferous forest. In MIS 19, the cool-temperate climate lasted, and the forest was dominated by cool-temperate deciduous broad-leaved tree taxa such as *Fagus* and *Quercus* (*Lepidobalanus*) throughout. At the beginning of MIS 18, the vegetation shows a slight decline in temperature, and yet other climatic conditions are similar to those of MIS 19.

Excluding the upper and lower parts affected by coastal vegetation, the vegetation of MIS 19 is divided into three stages. The early stage is characterized by the highest occurrence of Fagus, while the late stage by the highest occurrence of *Cryptomeria* in the analyzed sequence. These stages are connected by the middle stage of a short-term thermal maximum characterized by a highest rate of *Quercus* (*Cyclobalanopsis*).

4. Discussion

The climate of the early stage of MIS 19 is characterized by relatively cool temperature and high seasonality precipitation. The short-term warmest middle stage is characterized by a small annual variation in temperature with warm winter and cool summer. The late stage shows a long-term warm cool-temperate climate with very high precipitation throughout the year.

The thermal maximum occurred several kyr after the sea-level highstand correlated with isotopic event 19.3 which is the highest during MIS 19. In addition, the sea-level was lower in the late stage than in the early stage, whereas the temperature was warmer in the late stage. Thus, the climate estimated from vegetation contradicts that suggested by sea-level changes based on ice-volume.

In comparison with the detailed relative paleointensity record during transition, the cool early stage coincides with the period of very low geomagnetic intensity just before the main polarity reversal. Within the warmest short-term middle stage, the main polarity reversal and a short reversal episode occurred. During the warmer late stage, the geomagnetic field kept strong intensity after the full recovery from the low field intensity lasted for several kyr. These results show that the vegetation changes correlate with the geomagnetic intensity variations throughout MIS 19. The geomagnetic field may link to the climate and then to the vegetation.

Recently, the geomagnetic field intensity has been decreasing at a rate of about 6 % per century. This suggests a global cooling in the future.