The Earth Palaeoclimate Response to Cosmic Rays Exposure During Geomagnetic Field Excursions

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Abstract

The link between climate changes and excursions of the geomagnetic field during the past 400,000 years is discussed. Coincidence of the Earth surface temperature jump, the drop in stratosphere dust content and increase in 10 concentration in marine sediments is revealed. The model when during reversals and excursions the geomagnetic field loses a lot in its module value making cosmic rays penetration into the Earth atmosphere possible with resulting destruction of stratosphere aerosols which are backscattering incoming solar radiation at the time of glaciation is proposed. The following atmosphere transparency enables the Sun rays to warm the Earth surface giving rise to ice sheets wane and global climate hazards. If the excursion is starting in transparent atmosphere conditions similar to modern ones then the penetrating cosmic rays generate ionization, condensation nuclei and eventually the solar radiation shielding, i.e. cooling.

1 Introduction

Relationships between excursions and climate remain unsolved. Climate cooling synchronous to the youngest excursion Etrusca (or Sterno) dated 2.8 thousand years ago was revealed [1]. Just as climate cooling and so its warming synchronous to the excursions are discussed in [2]. During the last 420,000 years sharp decreases of dust concentration measured in Antarctica ice were dated 20, 120, 250 and 330 thousand years ago (Kyr) [3]. Fig. 1 shows that they were synchronous both to climate warming and geomagnetic field excursions [4]. High content of ^{10}Be produced by cosmic rays and air nuclei interaction inheres in marine sediments which are contemporaries of excursions when the intensity of the geomagnetic field is the low and the penetration of cosmic rays into the atmosphere is high. During Brunhes epoch most of the interglacial periods were associated with relatively low geomagnetic field intensity and high concentration of ^{10}Be [5].

2 Region study

Stratosphere aerosol particles produced by volcanoes eruptions are known to backscatter incoming solar radiation. Fig. 2 shows that reducing sunlight transmitting the eruptions with *VEI* (Volcanic Explosive Index, from 1 to 8) more than 6 generate climate cooling or volcanic winter [6,7]. Ice records synchronous to eruptions register high content of dust [3,7] produced by volcanic aerosols deposition. We propose that during excursions the decrease of stratosphere aerosols concentration results from their destruction by charged particles of cosmic rays flux which density rises sharply on 4–6 orders after geomagnetic field disappearance and radiation belts destruction [8,9,10,11].

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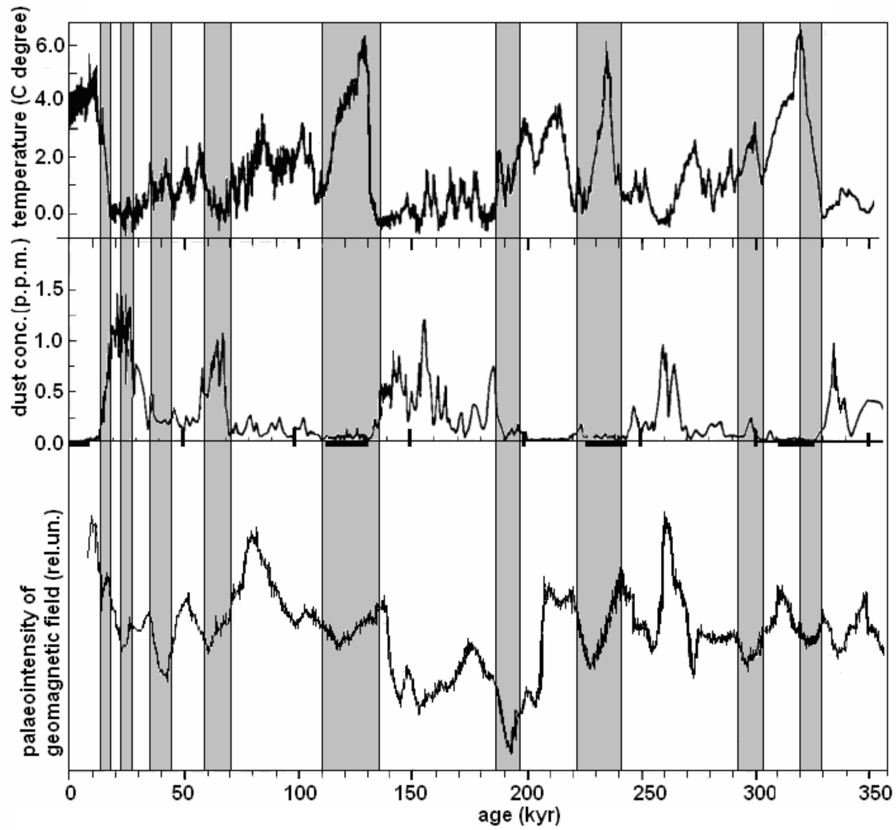

Figure 1: Time variations: bottom – palaeointensity of geomagnetic field, middle - dust concentration, recorded in ice and sediments, top – surface temperature.

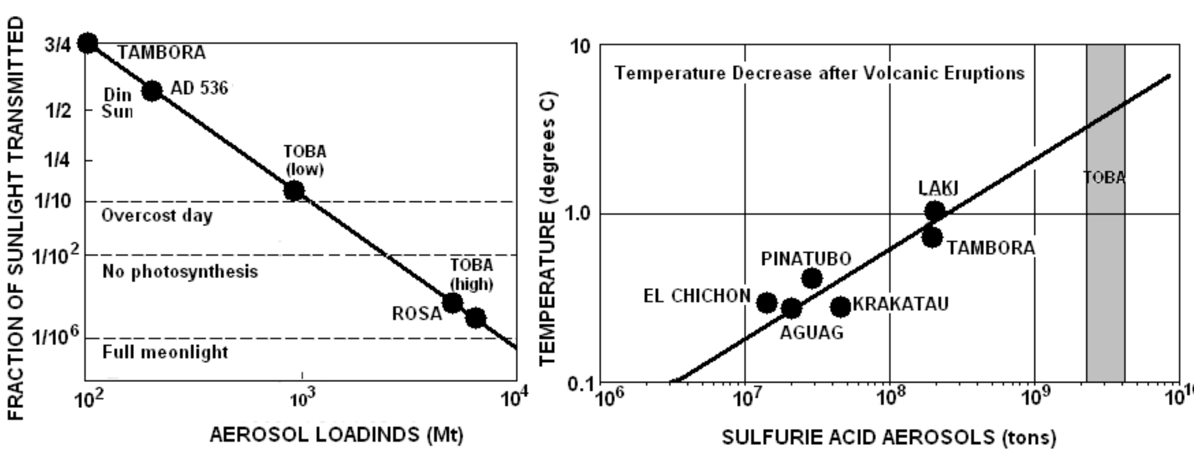

Figure 2: Effects of volcanic stratosphere aerosols on sunlight transmission and surface temperature.

3 Results

From curve slopes at Fig. 3,a the dust concentration N is evident to reduce from 1000 p.p.b to minimum in a time t of 10 thousand years and from 100 p.p.b in t of 1 thousand years consequently. On the other hand the stratosphere aerosol of Tambora eruption with N=94 p.p.b. is known to disappear in 4 years [6] that is much shorter than above mentioned value. Fig.3,b shows that the $N - t$ linear dependence slopes for individual volcanic eruptions and total atmosphere dust content

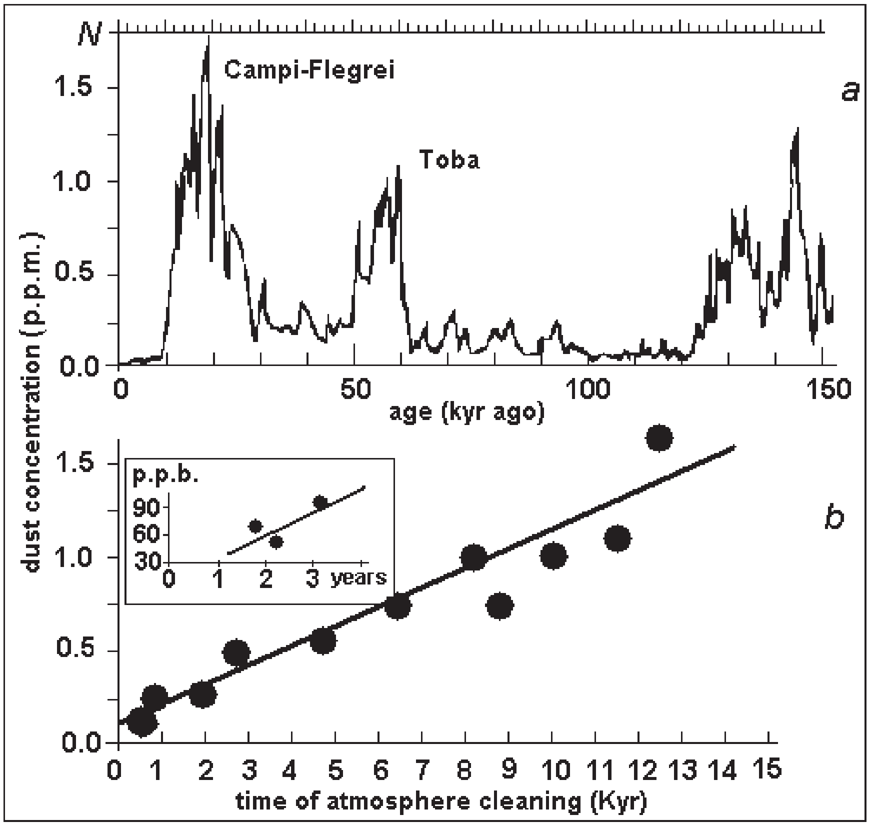

Figure 3: Decrease of atmosphere dust concentration: a – variation of dust concentration in ice related to large volcanic eruptions Toba and Campi-Flegrei; b – estimated from top curve data the time of atmosphere cleaning required by initial value of dust concentration.

were different up to 10–12 Kyr when atmosphere became clear. Differences in time of atmosphere cleaning may be accounted for aerosol composition. These are supereruptions like Toba which are known to produce a lot of fine mineral volcanic dust which time of living in atmosphere is about ten thousand years. Black strips under the curve of dust content in ice (Fig.1) mark periods preceding the dust increase which may be caused by volcanism onset. The marked periods last about 10 thousand years. As against the preceding 60 thousand years Fig.1 shows no dust in the stratosphere during the past 10 thousand years, that may be accounted to almost complete absence of eruptions with *VEI* more that 6 (a single known eruption) [12].

4 Conclusions

Following to our estimations during excursions and reversals when the geomagnetic cut-off action disappears and protons out of the destructed radiation belt add to cosmic rays flux, the flux density rises on about 4–6 orders resulting in stratosphere cleaning due to aerosol particles coagulating, enlarging and falling down. Transparent atmosphere permits solar radiation to reach the Earth surface and climate warming arises. If the excursion starts in clear atmosphere conditions as modern ones the enlarged cosmic rays flux as ionizing agent generates condensation nuclei and origin of aerosols which are backscattering solar radiation and climate cooling arises.

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