Cosmogenic isotopes and geomagnetic signals in a Mediterranean sea sediment at 35 000 y BP

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Summary. — In this paper we present the results on the relative changes of the geomagnetic field intensity measured in the Tyrrhenian sea core CT85-5 between 23 and 51 ky BP in order to investigate the origin of the enhancement of the cosmogenic isotope ^{10}Be concentration, recently reported in the same core at 35 ky BP.

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1. – Introduction

We have reported in a recent paper [1] the evidence for an enhanced ^{10}Be deposition at about 35 ky BP in the Mediterranean sea sediment core CT85-5. The peak is similar both in age and amplitude to the increase in the ^{10}Be concentration observed in Vostok and Dome C ice cores [2]. Be and Zn profiles were also measured in the same sea core in order to enquire whether biogeochemical and sedimentological processes would produce variations similar to those observed in the ^{10}Be concentration. We obtained clear evidences in favour of the view that the global enhancement of the ^{10}Be flux is related to an increase in the production rate and not to a redistribution of the ^{10}Be fallout between different latitudes and reservoirs.

Changes of the production rate can be related to the cosmic-ray flux variations due to helio- and geomagnetic modulation effects or due to fluctuations in the primary cosmic-ray flux. In this paper we enquire the possibility that the precise cause of the observed peak could be a concomitant decrease in the Earth magnetic moment.

2. – Experimental data

The ^{10}Be concentration measurements in the CT85-5 Tyrrhenian core are given in [1]. In fig. 1a) we show the part of the profile that includes the peak. This peak has an absolute age estimated to be 34 ± 3 ky BP on the basis of its stratigraphic position

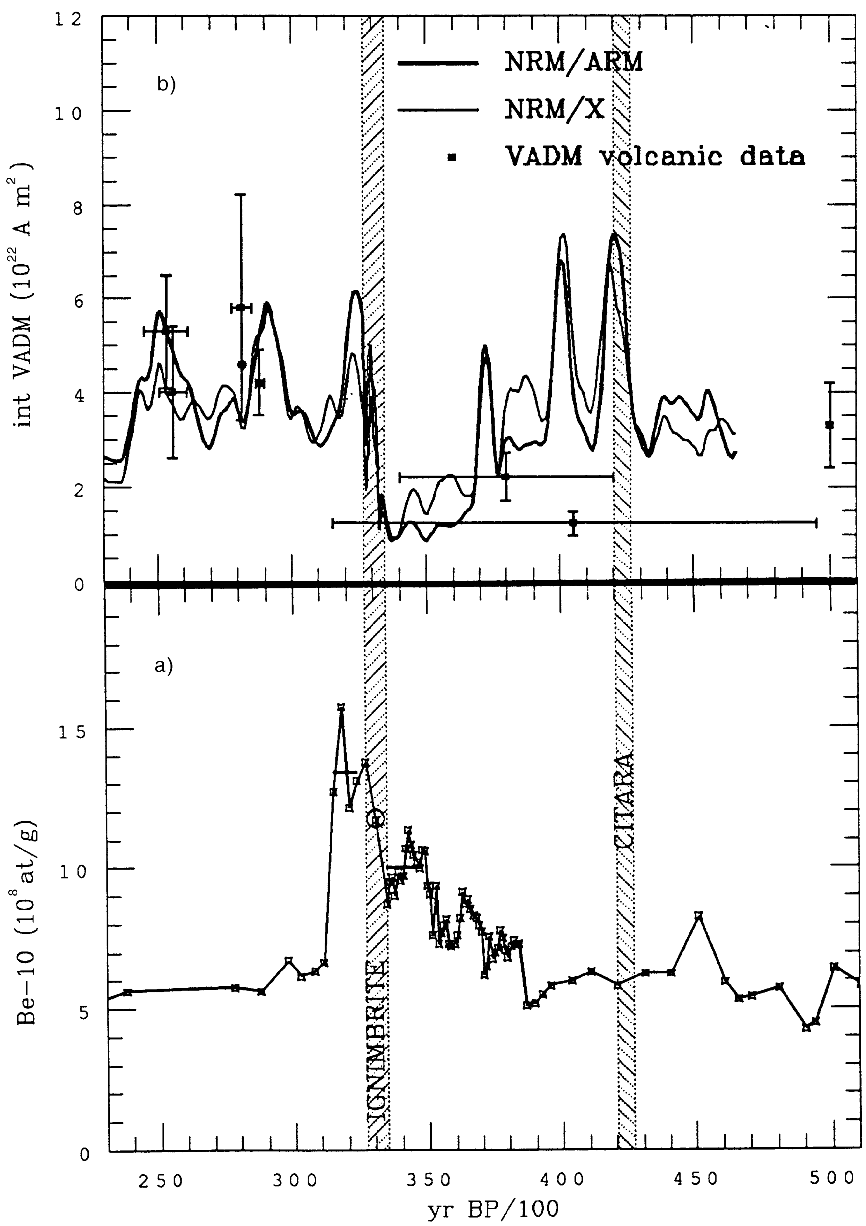

Fig. 1. – a) ^{10}Be profile from 23 to 51 ky BP. b) Curves for NRM with ARM and χ normalizations as VADM calibration using the volcanic data available.

between two tephra layers originating from two volcanic eruptions (Campanian Ignimbrite and Citara) dated by K-Ar, ^{40}Ar-^{39}Ar and ^{14}C methods [3-5] (shadowed areas in fig. 1). We briefly discuss here the correction in the time scale, to be applied due to the discontinuity in the sedimentation rate introduced by the thick Campanian Ignimbrite (CI) layer. To evaluate the actual duration of the deposition of the vitric tuffs, we consider the dilution effect produced in the ^{10}Be concentration by the volcanic material. The average concentration (see fig. 1a)) over 12 cm (1200 y) before the CI is $(10 \pm 1)\cdot 10^8$ at/g and over 12 cm after the CI is $(13.5 \pm 1)\cdot 10^8$ at/g. The mean concentration value of $11.7\cdot 10^8$ at/g together with the measured average concentration of $2\cdot 10^8$ at/g may be used to evaluate the dilution factor of about 6. A sedimentation rate of $5.9\cdot 10^{-2}$ cm/y is therefore used during the CI layers instead of the average value 10^{-2} cm/y. The time scale of fig. 1 is constructed according to these results. The radiocarbon test of this time scale has been also performed [6].

In order to obtain a record of the relative changes of the geomagnetic field from the core CT85-5, we have used the ratio of the Natural Remanent Magnetization (NRM) to the Anhysteretic Remanent Magnetization (ARM) or to the low-field susceptibility (χ) which are both related to the amount of magnetite. This method is classically used for relative paleointensity studies deduced from marine sediments.

We have examined the rock-magnetic characteristics of the core to determine whether they are rock-magnetically uniform and suitable for estimating relative paleointensity. Values of NRM, ARM and χ were used with hysteresis parameters. The NRM and the ARM were measured on U-channel with a small access high-resolution 3-axes cryogenic magnetometer. In line AF demagnetization was used throughout with demagnetization steps at 5, 10, 15, 20, 25, 30, 40, 50 and 60 mT for the NRM and at 10, 20, 25, 30, 40, 50 and 60 mT for the ARM. Hysteresis parameters and derived parameters were obtained using an alternating gradient field magnetometer. For estimating relative paleointensity the core should meet three main requirements: *a*) homogeneity of the magnetic minerals; *b*) low-concentration changes; *c*) homogeneity of magnetic granulometry [7]. The results of our investigations show that the CT85-5 core is suitable for paleointensity studies (paper in preparation). The curves for NRM with ARM and χ normalizations are shown in fig. 1b) as Virtual Axial Dipole Moment (VADM) calibration using the volcanic data available [8]. We can see that there is a fairly good agreement between our curves and the volcanic data. Very pronounced minima are observed around 35 ky BP. These values can be correlated with the Laschamp event which occurred during a low-intensity period around 40 ky. This event has been observed on Massif Central (France) and Iceland lavas and has been dated by different methods at different localities between 33 and 50 ky [9, 10].

Our core meets well with all the requirements that are generally asked to make paleointensity studies and offers the advantage to record paleomagnetic intensity in the same samples in which the ^{10}Be concentration was measured. The time sequence is the same for the two records.

At this stage of the study we cannot exclude perturbations in the deposition of the magnetic grains due to short-time climatic events. However, the results seem very interesting and worthy of further investigation.

3. – Discussion of the results

The ^{10}Be profile (see fig. 1a)) shows a rise from the average concentration (6 ± 1) 10^8 at/g at cm 385 up to $(10 \pm 1)\cdot 10^8$ at/g at cm 334, where the CI ash layer starts to disturb the record, diluting ^{10}Be atoms in the volcanic tuffs. At cm 289, where the glass shards disappear, the ^{10}Be concentration rises again reaching its maximum value of $16\cdot 10^8$ at/g at cm 280. The relative paleointensity (see fig. 1b)) drops at cm 368 from the average value and stays fairly constant at this low value until the volcanic ash layer starts. Thereafter the average value is restored.

The ratio $10/6 = 1.6$ in the ^{10}Be production rate attained at cm 334 is in good agreement with the value $\sqrt{4/1.5} = 1.6$ expected from the concomitant variations of the Earth magnetic moment. However, we may notice: *a*) that the peak of the ^{10}Be concentration after the volcanic ash layer is not easily explained by this process and *b*) that the ^{10}Be increase starts about 18 cm ($\sim$ 1800 y) before the magnetic moment drops. These results cannot unambiguously lead to the conclusion that the magnetic-moment variation is the primary origin of the cosmogenic isotope event but certainly support the view that the two very exceptional behaviours partly overlap.

Further studies are in progress in this core to understand the concurrence of such interesting phenomena around 35 ky BP.

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