High-resolution authigenic $^{10}Be/^{9}Be$ records : A proxy indicator of the past geomagnetic field variability

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At global scale, the synchronicity of abnormal directions of the paleomagnetic field and minimum intensities supports the hypothesis of a relationship between the occurrence of excursions and/or polarity changes and the collapse of the dipolar component. Prior studies of the coincidence between low geomagnetic field intensity and high cosmogenic nuclide production rates have been limited and focussed on a restricted number of geomagnetic events. We present quantitative evaluations of relationships between ^{10}Be production rate variations and geomagnetic events using high resolution authigenic $^{10}Be/^{9}Be$ and continuous paleointensity records measured in four marine sediment cores.

^{10}Be concentrations are normalized to the concentration of the stable isotope ^{9}Be in order to account for variations in the sedimentation rate and/or in the composition of the sediments. Due to their different sources, only the soluble form of both beryllium isotopes may have be homogenized in the water column before deposition in the sediment. A selective leaching technique that selectively extracts authigenic ^{10}Be and ^{9}Be, has thus been used.

The cores used in this study (MD01-2440G, MD95-2042 and MD95-2040, eastern Atlantic, Portuguese Margin; and MD97-2140, Western Pacific, north of New Guinea) provide a broad range of temporal coverage along which the Laschamp (~40 ka), the Blake (~120 ka), the Jamaica (~180 ka), the Calabrian Ridge (~250 ka), the Levantine (~289 ka), the Jaramillo Superior and Inferior (0.99 and 1.07 Ma) and the Cobb Mountain (1.2 Ma) Events as well as the Brunhes-Matuyama Reversal (0.78 Ma) have been identified. The measured $^{10}Be/^{9}Be$ ratios increase significantly at all identified excursions and reversals, which are associated with decreased paleointensities. This is consistent with the expected relationship between magnetic moment and cosmic ray flux ($Q/Qo=(M/Mo)^{-1/2}$). We also find a evidence for number of additional excursions manifested in both the ^{10}Be and paleomagnetic records. Finally, comparison of depths of $^{10}Be/^{9}Be$ peaks and the geomagnetic signatures allows determination of the depth at which remanent magnetization is acquired in marine cores.

A quick trip from dust to planets

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Understanding the detailed chronology of early solar system events is hindered by the fact that these events occurred on such short time scales as to test the resolution of the available chronological methods. Precise U-Pb dates for Allende and Efremovka CAI inclusions (4568 ± 0.4 Ma; Amelin et al., 2002) and the angrites (4558 ± 0.5 Ma; Lugmair and Galer, 1992) indicate a 10 million year interval between the formation of individual grains and the growth of planetesimals to a size where endogenous melting and igneous differentiation could occur. Supporting this short timescale, ^{26}Al has been found in objects ranging from CAIs to chondrules to at least one eucrite implying a formation interval of less than 5.6 Myr. The lack of ^{26}Al in most chondrules and eucrites, however, suggests either that the formation of these objects, or their later metamorphism, was not completed in this narrow time window. The Pd-Ag system provides an approximately 3.5 Myr window for the crystallization times of the iron-rich meteorites; a surprisingly narrow time interval if these ages mark the cooling and crystallization of planetesimal cores. Linking the Pd-Ag timescale, and hence planetesimal core formation, to an absolute chronology is difficult. Using a value of $^{107}Pd/^{108}Pd$ measured for Allende whole rocks (Carlson and Hauri, 2001) suggests that Canyon Diablo crystallized 26 Myr after Allende, (4542 Ma if using Allende CAI age, 4534 Ma using the Allende chondrule Pb-Pb age). However, Mn-Cr ages for pallasites and the phosphates from IIIAB irons imply that these meteorites range in age from 4556 Ma to 4573 Ma when compared to the U-Pb and Mn-Cr data for angrites. The upper value of these Mn-Cr ages introduces the problem of whether these short-lived isotopes were uniformly distributed in the solar nebula; a requirement if these systems are to provide valid chronological information. Given the short processing times discussed above, the Earth-Moon system stands out for its long formation time of 50-80 Myr. This longer interval could reflect the time needed for a planet to grow to Earth size, or it could reflect a “resetting” of chronometers on a planetary scale during a major impact of the type that may have formed the Moon.

References

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