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THE ^{10}BE RECORD AS A PROXY OF PALEOMAGNETIC REVERSALS AND EXCURSIONS: A MEDITERRANEAN PERSPECTIVE

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ABSTRACT: The $^{10}Be/^{9}Be$ ratio is acknowledged as an effective tool for establishing the stratigraphic position of paleomagnetic excursions. Still, our data suggest that, in particular depositional settings, the interplay between climate, sedimentation and oceanography may jeopardize a realistic depiction of the natural $^{10}Be/^{9}Be$ record.

KEYWORDS: Lower/middle Pleistocene, central Mediterranean, stratigraphy, paleomagnetism, $^{10}Be/^{9}Be$

1. INTRODUCTION

The concentration of ^{10}Be atoms adsorbed on sediment particles is measured for tracking major geomagnetic reversals and events, whenever magnetic properties are poor and/or conventional palaeomagnetic analyses yield ambiguous results. This approach relies on both the assumptions that 1) the production rate of ^{10}Be in the atmosphere mainly depends on the strength of the Earth's magnetic field, and 2) the ^{10}Be generated in the atmosphere is rapidly conveyed to the Earth's surface and locked into sediments. However, the study of marine successions demonstrates that ^{10}Be record and palaeomagnetic events are mostly asynchronous (Valet et al., 2014). In addition, the period of low intensity of the Earth magnetic field associated to geomagnetic reversals, during which an overproduction of cosmogenic ^{10}Be is believed to occur, lasts significantly longer than the polarity switch itself (Raisbeck et al., 2006). Accordingly, there is no independent verification that a given ^{10}Be peak marks the exact stratigraphic position of the associated polarity switch, as it may have been generated at any time during the period of intensity low. To our knowledge, the only record reporting on a perfect synchronicity between the ^{10}Be and palaeomagnetic signals at the M–B reversal is that of Valet et al. (2014), reconstructed in the Equatorial Indian Ocean from a deep–sea sediment core virtually void of terrigenous influxes. In contrast, stratigraphic successions affected by a significant terrigenous input show that the ^{10}Be peak lags significantly behind the M–B boundary (e.g., Suganuma et al., 2010). According to the interpretation given by Suganuma et al. (2010), the ^{10}Be peak would point to the correct stratigraphic position (and age) of the reversal, while the geomagnetic signal would be "frozen" at a lower stratigraphic position, well below the sediment surface, in response to lock–in processes.

Mechanisms that control the flow of cosmogenic ^{10}Be particles to the Earth surface and, more significantly, their transfer to the seafloor are still ambiguous. We may reasonably assume that the deposition of cosmogenic ^{10}Be in ice caps and loess deposits results from the instantaneous "freezing" of the atmospheric signal, although ^{10}Be deposition is known to respond to numerous environmental and climatic factors, such as the regional precipitation rates and regimes (e.g., McHargue & Damon, 1991; Raisbeck et al., 2006). When dealing with marine terrigenous successions, further levels of uncertainty should be added in order to account for the much more complex arrangement of the marine sedimentary system (e.g., Brown et al., 1987, 1988; Yiou et al., 1988; Simon et al., 2017).

2. MATERIAL AND METHODS

We reconstructed a continuous $^{10}Be/^{9}Be$ record straddling the M-B reversal for the Valle di Manche (VdM) section (Calabria, Southern Italy) via the analysis of 68 sedimentary samples collected with an average resolution of ca. 9 cm, which results in a ca. 0.35 kyr resolution according to our age model (Capraro et al., 2017). Samples were prepared at the University of Xi'an, China, according to the procedures reported by Zhou et al. (2007), with minor modifications accounting for the difference between loess and marine sediments. BeO measurements were performed using the 3-MV accelerator mass spectrometer (AMS) at the Xi'an AMS Center, IEECAS. Test chemistry blank ratios are very small, in the order of 1 ×10-14.

3. RESULTS

Our results compare very well with the high–resolution record of ^{10}Be and ^{9}Be reconstructed for the coeval Montalbano Jonico (MJ) section (Basilicata, Southern Italy; Simon et al., 2016), where a conventional palaeomagnetic record of the M-B reversal cannot be achieved (Sagnotti et al., 2010). The ^{9}Be and ^{10}Be concentrations measured at VdM are ca. four times those found at MJ. The excess of ^{9}Be probably depends on the different primary sources of the terrigenous fraction, these being crystalline rocks from the Sila massif at VdM and young sediments from the uplifting Apennines at MJ. In addition, the estimated sediment accumulation rates are significantly higher at MJ, suggesting that, at VdM, the influx of ^{9}Be-free material was smaller. Probably, the lower sedimentation rates at VdM also account for the higher background concentrations of ^{10}Be.

At VdM, a prominent ^{9}Be spike is centered in correspondence to the "Pitagora ash" (Capraro et al., 2017), similarly to what documented at MJ for the V3 and V4 tephra (Simon et al., 2016). Most likely, emplacement of the "Pitagora ash" provided a massive injection into the water column of highly soluble ^{9}Be, which is very abundant in mantle sources (e.g., Baroni et al., 2011).

4. DISCUSSION AND CONCLUSIONS

Our record does not provide a complete documentation across the MIS 19–MIS 18 transition, where ^{10}Be concentration attains a relevant peak that correlates almost perfectly to that recognized at MJ at ca. 775 ka, which Simon et al. (2016) interpret as the geochemical signature of the M-B reversal. This interpretation is at odds with that accomplished at VdM, where the palaeomagnetic record provides unquestionable evidence that the M-B reversal occurs in the midst of full MIS 19 (ca. 787 ka according to our age model; Macrì et al., 2018).

At VdM, ^{10}Be concentrations peak ca. 3.5 m above the M-B reversal, i.e. ca. 12 kyr later than the geomagnetic event. This delay is grossly in agreement with that calculated by for many open-ocean records straddling the M–B reversal, where the effects of lock–in processes are invoked (Suganuma et al., 2010). However, the high sediment accumulation rates at VdM made the impact of lock-in processes virtually negligible, if any. Instead, our results suggest that, in particular settings prone to clastic sedimentation, the M-B reversal may actually predate the deposition of the ^{10}Be peak by ca. 10 kyr, possibly in response to the complex dynamics of both climate, ocean circulation and sedimentary system.

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REFERENCES

Baroni M., Bard E., Petit J.R., Magnan O., Bourlès D.L. (2011) - Volcanic and solar activity, and atmospheric circulation influences on cosmogenic ^{10}Be fallout at Vostok and Concordia (Antarctica) over the last 60 years. Geochimica et Cosmochimica Acta, 75, 7132-7145.

Brown L. (1987) - ^{10}Be as a tracer of erosion and sediment transport. Chemical Geology, 65, 189-196.

Brown L., Pavich M.J., Hickman R.E., Klein J., Middleton R. (1988) - Erosion of the eastern United States observed with ^{10}Be. Earth Surface Processes and Landforms, 13, 441-457.

Capraro L., Macrì P., Scarponi D., Rio D. (2015) - The lower to Middle Pleistocene Valle di Manche section (Calabria, Southern Italy): state of the art and current advances. Quaternary International, 383, 36-46.

Capraro L., Ferretti P., Macrì P., Scarponi D., Tateo F., Fornaciari E., Bellini G., Dalan G. (2017) - The Valle di Manche section (Calabria, Southern Italy): a high resolution record of the Early-Middle Pleistocene transition (MIS 21-MIS 19) in the Central Mediterranean. Quaternary Science Reviews, 165, 31-48.

Macrì P., Capraro L., Ferretti P., Scarponi D. (2018) - A high-resolution record of the Matuyama-Brunhes transition from the Mediterranean region: The Valle di Manche section (Calabria, Southern Italy). Physics of the Earth and Planetary Interiors, 278, 1-15.

McHargue L.R., Damon P.E. (1991) - The global beryllium 10 cycle. Review of Geophysics, 29, 141-158.

Raisbeck G.M., Yiou F., Cattani O., Jouzel J. (2006) - ^{10}Be evidence for the Matuyama–Brunhes geomagnetic reversal in the EPICA Dome C ice core. Nature, 444, 82-84.

Sagnotti L., Cascella A., Ciaranfi N., Macrì P., Maiorano P., Marino M., Taddeucci J. (2010) - Rock magnetism and palaeomagnetism of the Montalbano Jonico section (Italy): Evidence for late diagenetic growth of greigite and implications for magnetostratigraphy. Geophysics Journal International, 180, 1049-1066.

Simon Q., Bourlès D.L., Bassinot F., Nomade S., Marino M., Ciaranfi N., Girone A., Maiorano P., Thouveny N., Choy S., Dewilde F., Scao V., Isguder G., Blamart D. (2016) - Authigenic $^{10}Be/^{9}Be$ ratio signature of the Matuyama-Brunhes boundary in the Montalbano Jonico marine succession. Earth and Planetary Science Letters, 460, 255-267.

Simon Q., Thouveny N., Bourlès D., Nuttin L., Hillaire-Marcel C. (2017) - Authigenic $^{10}Be/^{9}Be$ ratios and ^{10}Be-fluxes ($^{230}Th_{xs}$-normalized) in central Baffin Bay sediments during the last glacial cycle: Paleoenvironmental implications. Quaternary Science Reviews, 2016, 140, 142-162.

Suganuma Y., Yokoyama Y., Yamazaki T., Kawamura K., Chorng-Shern H., Matsuzaki H. (2010) - ^{10}Be evidence for delayed acquisition of remanent magnetization in marine sediments: implication for a new age for the Matuyama-Brunhes boundary. Earth and Planetary Science Letters, 296, 443-450.

Valet J.P., Bassinot F., Bouilloux A., Bourlès D., Nomade S., Guillou V., Lopes F., Thouveny N.,

Dewilde F. (2014) - Geomagnetic, cosmogenic and climatic changes across the last geomagnetic reversal from Equatorial Indian Ocean sediments. Earth and Planetary Science Letters, 397, 67-79.
You C.F., Lee T., Brown L., Shen J.J., Chen J.C. (1988) - ^{10}Be study of rapid erosion in Taiwan. Geochimica et Cosmochimica Acta, 52, 2687-2691.
Zhou W.J., Lu X.F., Wu Z.K., Zhao W.N., Huang C.H., Li L.L., Cheng P. (2007) - New results on Xi'an-AMS and sample preparation systems at Xi'an-AMS center. Nuclear Instruments and Methods in Physics Research B, 262, 135-42.

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