Quaternary Science Reviews 131 (2016) 1–19

Contents lists available at ScienceDirect

Quaternary Science Reviews

journal homepage: www.elsevier.com/locate/quascirev

Invited review

Relative paleointensity (RPI) and oxygen isotope stratigraphy at IODP Site U1308: North Atlantic RPI stack for 1.2–2.2 Ma (NARPI-2200) and age of the Olduvai Subchron

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ARTICLE INFO

Article history:
Received 17 April 2015
Received in revised form
17 September 2015
Accepted 1 October 2015
Available online 2 November 2015

Keywords:
Quaternary
Late Pliocene
North Atlantic
Stable isotopes
Relative paleointensity
Age of Olduvai Subchron

ABSTRACT

Integrated Ocean Drilling Program (IODP) Site U1308 (49°53′N, 24°14′W; water depth 3871 m) provides a record of relative paleointensity (RPI) and benthic stable isotope stratigraphy back to 3.2 Ma. The record since 1.5 Ma was published previously, and here we present the interval from 1.5 Ma to 3.2 Ma (Early Pleistocene-Late Pliocene). The benthic oxygen isotope record in this interval is correlated to Marine Isotope Stage (MIS) 51 to KM2, with an apparent hiatus that removed part of the interval spanning MIS 104-G2 (2.6–2.65 Ma), at the Gauss-Matuyama boundary. The mean sedimentation rate for the 1.5–3.2 Ma period is 8.5 cm/kyr. The age model was built by correlation of the benthic oxygen isotope record to a global stack (LR04). Apart from the expected polarity reversals, three magnetic excursions are recorded: Punaruu in MIS 31/32 at 1092 ka, Gilsa in MIS 54/55 at 1584 ka, and a newly recognized excursion labeled Porcupine (after the nearby Porcupine Abyssal Plain) in MIS G6/G7 at 2737 ka. The ages of polarity reversals at Site U1308, on the LR04 time scale, are consistent with the current geomagnetic polarity timescale (GPTS) with the exception of the base of the Olduvai Subchron that occurred in MIS 73, corresponding to 1925 ka on the LR04 time scale, 25 kyr younger than in the current GPTS. The RPI record at Site U1308 is calibrated using the oxygen isotope age model, and combined with four other North Atlantic records to obtain a North Atlantic RPI stack for 1.2–2.2 Ma (NARPI-2200) that is compared with published RPI stacks: Epapis, Sint-2000 and PADM2M. For 2.2–3.2 Ma, the Site U1308 RPI record is compared with a RPI record from North Atlantic IODP Site U1314, and with the Pacific Epapis stack. The mean sedimentation rates of the North Atlantic sites in NARPI-2200 are greater (by about an order of magnitude) than most of the records incorporated in other stacks. The comparison of Epapis and NARPI-2200 yields an apparent lag for NARPI-2200 relative to Epapis, attributed the Epapis age model constructed by correlation of magnetic concentration parameters (a proxy for carbonate percentage) to a calibrated oxygen isotope record. The long RPI record from Site U1308 yields a very similar mean value for the Brunhes and Matuyama virtual axial dipole moments (7.05×10^{22} Am^2), implying no polarity bias in the strength of the main geomagnetic dipole, in contrast to interpretations from Sint-2000 and PADM2M. The results strengthen the case that RPI can be used to improve global stratigraphic correlation for sites with mean sedimentation rates up to several decimeters/kyr.

1. Introduction

Integrated Ocean Drilling Program (IODP) Site U1308 (49°53′ N, 24°14′W) was drilled in 2004 in a water depth of 3871 m (Fig. 1). It is a reoccupation of Deep Sea Drilling Project (DSDP) Site 609, drilled in 1983. Construction of a complete composite section at DSDP Site 609 was compromised by intervals of poor recovery (Ruddiman et al., 1987). Six holes were drilled at Site U1308 and a composite splice was constructed shipboard to 248 m composite depth (mcd) (Expedition 303 Scientists, 2006). The composite splice was then modified from its shipboard version in the upper 103 mcd (Hodell et al., 2008) and, for this paper, we use a mcd-scale amended to follow the modified version. Shipboard paleomagnetic measurements (Expedition 303 Scientists, 2006) demonstrated

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http://dx.doi.org/10.1016/j.quascirev.2015.10.011
0277-3791/

that the recovered section at Site U1308 reaches to just below the base of the Mammoth Subchronozone at ~264 m composite depth (mcd), although the composite splice ends at 248 mcd, just below the base of the Kaena Subchronozone. Post-cruise magnetic measurements using u-channel samples, continuous $2 \times 2 \times 150$ cm^3 samples encased in plastic, collected from each core section within the composite splice, extend to just below the Kaena Subchronozone to 248 mcd, equivalent to 3.15 Ma. Below this depth, the sediments were too indurated for efficient u-channel sampling.

Benthic stable isotope data, and relative paleointensity (RPI) data, from the upper 109 mcd (last 1.5 Ma) at Site U1308 have been published (Hodell et al., 2008; Channell et al., 2008). The Site U1308 RPI/isotope records were used as the target for the generation of the PISO-1500 paleointensity stack for the last 1500 kyrs that utilized 13 records, mainly but not entirely from the North Atlantic, which have both oxygen isotope data and RPI associated with them (Channell et al., 2009). For PISO-1500, the RPI and oxygen isotope records from the 12 sites were optimally correlated *in tandem* to the RPI and oxygen isotope records of Site U1308, using the *Match* protocol (Lisiecki and Lisiecki, 2002). The PISO stack therefore utilizes the Site U1308 age model. Here, we present Site U1308 RPI/δ^{18}O records for 1.5–3.2 Ma and generate a RPI stack for 1.2–2.2 Ma (NARPI-2200) from five available North Atlantic records, which is then compared with existing RPI stacks.

DSDP Site 609 has been important for studies of benthic δ^{18}O, δ^{13}C and %$CaCO_3$ for the Pleistocene and late Pliocene and the interpretation of these records in terms of ice sheet variability and oceanic circulation, and for producing orbitally-tuned timescales integrated with magnetic polarity stratigraphy (Ruddiman et al., 1986, 1989; Raymo et al., 1989). Also at this site, early recognition of detrital (Heinrich-type) layers led to the correlation of sea surface temperature minima to cold stadials in the δ^{18}O from the Summit (Greenland) ice core record and to the grouping of Dansgaard–Oeschger (ice core) cycles into Bond cycles where each cycle is terminated by the massive iceberg discharges from Hudson Strait that constitute Heinrich events (Bond et al., 1993, 1999). The purpose of this paper is to integrate the magnetic stratigraphy and oxygen isotope stratigraphy at Site U1308 prior to 1.5 Ma, and produce a high-resolution temporally calibrated RPI record for 1.5–3.2 Ma.

2. Methods

2.1. Magnetic methods

Core sections within the composite splice at Site U1308 were sampled using u-channels to the base of the composite section at 248 mcd. For this paper, the natural remanent magnetization (NRM), of u-channel samples collected from the 110–248 mcd interval, was measured at 1-cm intervals on a u-channel cryogenic magnetometer at the University of Florida, with a 10-cm leader/trailer, as the sample was tracked through the measurement space. Each 1-cm measurement is not independent of adjacent measurements due to the ~4.5-cm width at half-height of the magnetometer response function (see Weeks et al., 1993; Guyodo et al., 2002). After initial NRM measurement, stepwise AF demagnetization was carried out at 5 mT intervals from 10 to 80 mT, and then 10 mT steps to 100 mT. Component magnetizations were determined for a uniform 20–80 mT demagnetization interval, at each 1-cm measurement step, using the standard procedure (Kirschvink, 1980) and the software of Xuan and Channell (2009). The maximum angular deviation (MAD) values provide a measure of the definition of each determination of the component magnetization direction, with values <5° indicating high quality data. After NRM

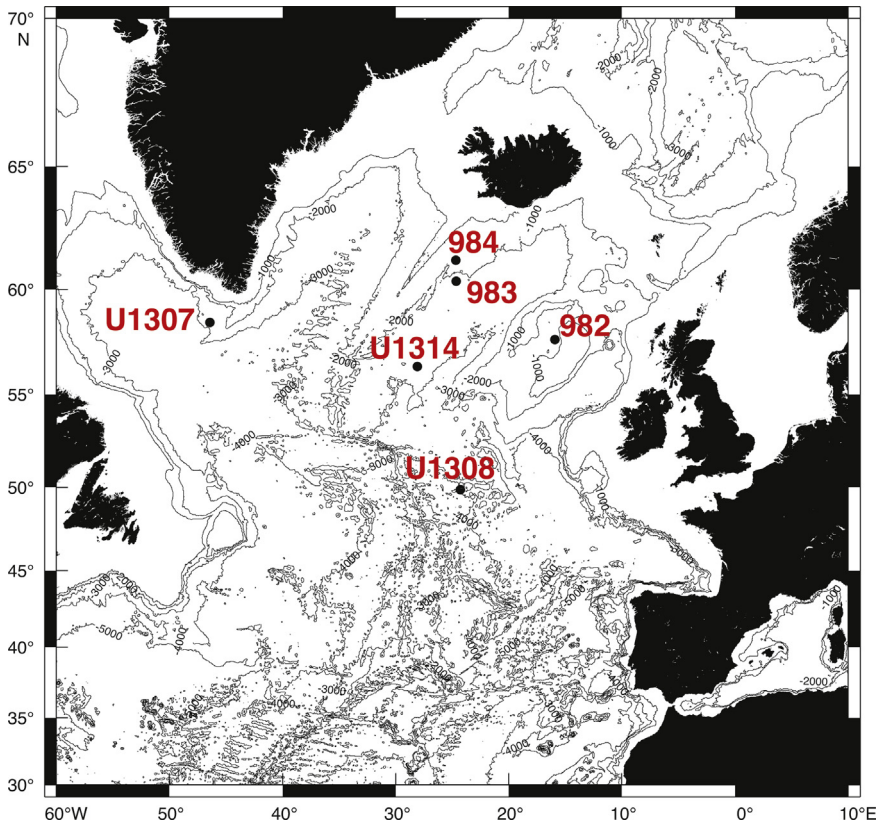

Fig. 1. Location of Sites U1308, U1307 and U1314 recovered during IODP Expedition 303/306; and Sites 982, 983 and 984 recovered during ODP Leg 162.