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Comment on "A relative geomagnetic paleointensity stack from Ontong-Java plateau sediments for the Matuyama" by Yvo S. Kok and Lisa Tauxe

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Kok and Tauxe [1999] recently presented a record of paleointensity covering a period of 2 Myr from four ocean drilling cores from the Ontong-Java plateau (OJP). They emphasize the interest of thermal treatment for paleointensity experiments in order to remove overprints caused by viscous remanent magnetization. Kok and Tauxe (hereinafter referred to as KT) stress that saw-toothed variations of field intensity [*Valet and Meynadier*, 1993; *Meynadier et al.*, 1994, 1995] are not present in the OJP record because they are caused by cumulative viscous overprint (CVR) and were removed by thermal treatment [*Kok and Tauxe*, 1996a, 1996b]. *Meynadier et al.* [1998] questioned the CVR model and argued that it is not compatible with the magnetization characteristics of the sediments. *Meynadier and Valet* [2000] showed that the only contamination present in the magnetization of sediments which display a saw-toothed pattern [*Valet and Meynadier*, 1993] was a drilling overprint that was more efficiently removed by low alternating fields (AF) than by thermal demagnetization. Since most deep-sea sediments (particularly those from Ocean Drilling Program (ODP) legs) are affected by a drilling overprint, it is not a priori evident that thermal demagnetization would be more appropriate than AF cleaning. Thermal techniques for paleointensity studies in sediments are delicate and can generate complications. In the present case, alteration of the high-temperature component occurred above 350°C so that the most stable part of the signal could not be used for paleointensity determination. Unfortunately, KT do not compare the signals obtained with AF and thermal techniques and thus do not demonstrate that the thermal approach was more appropriate.

Gallet et al. [1993] conducted a previous analysis on the sediments drilled at Sites 803, 805, and 806 during ODP Leg 130 in the Ontong-Java plateau. They noted that the viscous overprint was effectively removed in a 30-35 mT peak alternating field. However, the characteristic component with reversed polarity could not be properly AF demagnetized within specific zones of weak magnetization intensity in which thermal demagnetization was more efficient. *Gallet et al.* [1993, p.55] indicated that problems using AF demagnetization in these zones were caused by production of spurious anhysteretic remanence and that the contribution of viscous remanent magnetization (VRM) acquisition remains constant in the entire section with no special behavior within the low-intensity zones. Indeed, the demagnetization diagrams shown by *Gallet et al.* [1993, Figure 9, p.557] suggest that the VRM has been removed but that the high-coercivity primary component could not be AF demagnetized. In fact, the magnetization intensity at some steps above 25-30 mT could probably be used for paleointensity without introducing large uncertainties.

From these results, KT [1999] considered that thermal treatment would be more appropriate than AF for paleointensity experiments. Despite large experimental difficulties this may be justified provided that the mineralogy is suitable and that there is no change during heating. However, only ~8% of the samples were subjected to complete Thellier-Thellier experiments. Two examples are shown in Figures 2 and 3 of KT [1999]. The first sample from 17.17 m below seafloor (mbsf) is characterized by a low unblocking temperature (T_{ub}) component between 25°C and 325°C with a mean inclination that is larger than the 5° inclination of the axial dipole at Site 803. The demagnetization diagram indicates that a high-temperature component (HT) was isolated beyond 425°C with an inclination in agreement with the site latitude. If this component represents the actual field direction, it is thus not incorporated in the segment (250-375°C) used to calculate the slope of the natural remanent magnetization / partial thermal remanent magnetization (NRM-pTRM) plot. Alternatively, the HT component can result from chemical remagnetization during heating in presence of field, but in this case, there is no indication that the selected segment truly represents the characteristic component. This segment represents only one fourth of the total magnetization, and half of the initial NRM intensity remains in the sample after 375°C. The second sample from 18.78 mbsf has similar characteristics, but the HT component appears to be isolated at 300°C. The NRM demagnetization curve is characterized by a " plateau " between 225°C and 300°C which reflects the superposition of the low- and high-temperature components. Thus the segment (250-375°C) used to calculate the paleointensity incorporates the low and the high temperature components. KT (p. 25,403) note that the sediment is appropriate for paleointensity since "all specimens provided straight segments in the Arai plots". We rather consider that these diagrams hardly meet standard criteria of acceptance for Thellier experiments [*Coe*, 1967; *Coe et al.*, 1978]. Also there is no direct evidence that the characteristic component was completely isolated at 250°C, which is critical with regard to the choice of this step.

Indeed, "since the Thellier-Thellier technique is very time consuming," *Kok and Tauxe* [1999, p. 25,403] preferred to use "a faster procedure". Because "all Arai plots of the Thellier-Thellier experiments indicate straight segments between 250°C and 375°C" (p. 25,403), it is concluded that "the ratio of NRM and pTRM at 250°C is by approximation proportional to the

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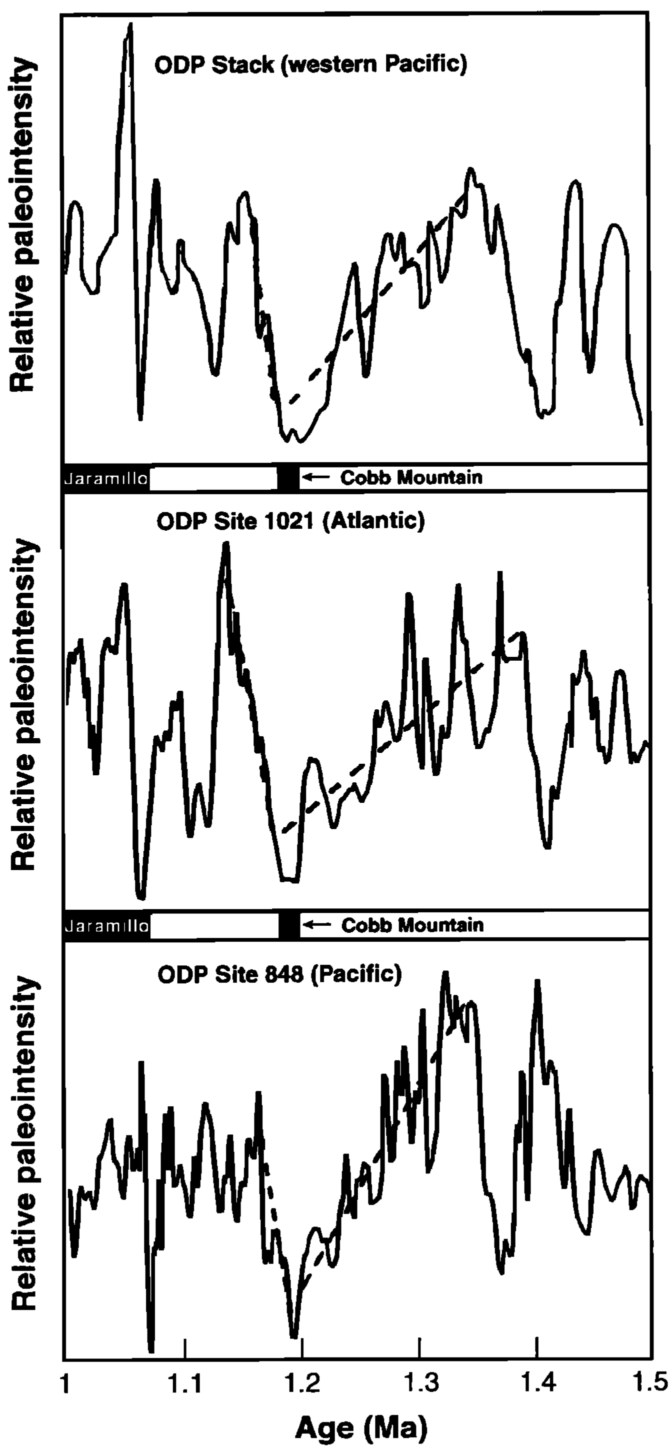
slope of the best fitting line in this interval" (p. 25,403). Thus KT normalized the NRM left in the interval 250-575°C by the pTRM acquired in the interval 25°-250°C. There is no reason a priori why downcore variations in concentration of magnetic grains with T_{ub} between 250°C and 575°C would be reflected by similar changes in concentation of grains with T_{ub} between room temperature and 250°C, even with homogeneous mineralogy as this is defended by KT. This requires one to check that the $pTRM_{20°C-250°C}/pTRM_{250°C-Tc}$ ratio is constant over the entire sedimentary column. KT consider that the results derived from the 250°C-375°C segments of the Arai plots do not differ significantly from those obtained from $NRM_{250°C-Tc}/pTRM_{20°C-250°C}$. However, there are differences which add uncertainties to the paleointensity record [*Kok and Tauxe*, 1999, Figure 4]. We wonder also why this comparison was restrained to the depth interval from 17 to 21 m, which represents only ~25% of the total record. The pTRM variations shown in KT's Figure 5 vary by more than a factor of 30. Such changes in concentration exceed the usual recommendations [*King et al.*, 1983; *Tauxe*, 1993] and could be accompanied by variations in grain size and/or magnetic mineralogy. It would have been appropriate and not much more time consuming to perform at least two demagnetization steps.



Observation of saw-toothed variations can differ between records of relative paleointensity. Indeed, the same geomagnetic features are frequently recorded with different amplitudes in parallel records and thus yield different long-term trends. This is mostly a consequence of changes in the physical properties of the sediment which induce subtle changes in the alignment of the magnetic grains [*Valet and Meynadier*, 1998]. An interesting example is given by the paleointensity variations across the Cobb event. In Figure 1 we show the present KT record along with the records from ODP Site 1021 in the Atlantic Ocean [*Guyodo et al.*, 1999] and from ODP Sites 848-851 in the Pacific Ocean. In the last two cases we calculated a linear fit for the period preceding the Cobb event (unfortunately the KT data set is not available to make the same calculation). In all three cases, there is a long-term decrease of the field prior to the event which contrast with a rapid recovery during restoration of the initial polarity. Note that the calculation of the fit removed most subjectivity to the interpretation. A similar description can be done for the Réunion event [*Kok and Tauxe*, 1999, Figure 9]. Short events were not included in the initial description of saw-toothed records [*Meynadier et al.*, 1994]. They cannot be caused by post-depositional realignment [*Meynadier and Valet*, 1995; *Mazaud*, 1996; *Meynadier and Valet*, 1996] since the period of reverse polarity does not exceed a few thousand years. Alternatively, despite the same overall trend is common to all

Figure 1. Field intensity variations within the interval surrounding the Cobb event as recorded from the Ontong-Java plateau (OJP) in western equatorial Pacific Ocean [*Kok and Tauxe*, 1999], at ODP Sites 848 and 851 in eastern equatorial Pacific [*Valet and Meynadier*, 1993; *Meynadier et al.*, 1995] and at Site 1021 [*Guyodo et al.*, 1999] in northern Atlantic. The OJP stack has been obtained after thermal demagnetization of the NRM at 250°C. This portion of the 848-851 splice record has been obtained after stepwise alternating field demagnetization of Uchannels. The paleointensity record from Site 1021 was obtained after stepwise AF demagnetization and constructed from a composite splice section of Holes 1021B and 1021C. Time control for the OJP stack was given by the reversal boudaries. Time control for the 848-851 splice has been obtained by orbitally tuning the density variations with a resolution of 21 kyr [*Meynadier et al.*, 1995]. Chronology of Site 1021 was established by correlation of the magnetic susceptibility to the insolation curve. The linear fit of the variations preceding the Cobb Mountain event (1.1 Ma) indicates a long-term decrease of the field with a slope of 0.32 (correlation coefficient R= 0.91) for 848-851 and 0.45 (R = 0.8) for 1021 and a much faster recovery (slopes of 0.9 for 848-851 and 2.5 for 1021). Asynchronism between identical features is most likely caused by variations in deposition rates and the use of different timescales.

records there are significant discrepancies between the amplitudes of the variations. This points out that conclusions regarding long-term trends must be drawn from several distinct records.

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