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Submission date: 28-Jun-2023 10:23AM (UTC+0700)
Submission ID: 2123764366
File name: 4_Kirana_et_al_2018_A_high-resolution.pdf (2.18M)
Word count: 6538
Character count: 34929

Physics of the Earth and Planetary Interiors 275 (2018) 9–18

Contents lists available at ScienceDirect

Physics of the Earth and Planetary Interiors

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

A high-resolution, 60 kyr record of the relative geomagnetic field intensity from Lake Towuti, Indonesia

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ARTICLE INFO

Keywords:
Lake Towuti
Relative paleointensity record
Ophiolite belt
Laschamp excursion

ABSTRACT

Past changes in the Earth's magnetic field can be highlighted through reconstructions of magnetic paleointensity. Many magnetic field variation features are global, and can be used for the detailed correlation and dating of sedimentary records. On the other hand, sedimentary magnetic records also exhibit features on a regional, rather than a global scale. Therefore, the development of regional scale magnetic field reconstructions is necessary to optimize magnetic paleointensity dating. In this paper, a 60 thousand year (kyr) paleointensity record is presented, using the core TOW10-9B of Lake Towuti, located in the island of Sulawesi, Indonesia, as a part of the ongoing research towards understanding the Indonesian environmental history, and reconstructing a high-resolution regional magnetic record from dating the sediments. Located in the East Sulawesi Ophiolite Belt, the bedrock surrounding Lake Towuti consists of ultramafic rocks that render the lake sediments magnetically strong, creating challenges in the reconstruction of the paleointensity record. These sediment samples were subject to a series of magnetic measurements, followed by testing the obtained paleointensity records resulting from normalizing natural remanent magnetization (NRM) against different normalizing parameters. These paleointensity records were then compared to other regional, as well as global, records of magnetic paleointensity. The results show that for the magnetically strong Lake Towuti sediments, an anhysteretic remanent magnetization (ARM) is the best normalizer. A series of magnetic paleointensity excursions are observed during the last 60 kyr, including the Laschamp excursion at 40 kyr BP, that provide new information about the magnetic history and stratigraphy of the western tropical Pacific region. We conclude that the paleointensity record of Lake Towuti is reliable and in accordance with the high-quality regional and global trends.

1. Introduction

The reconstruction of past variations in the geomagnetic field is important towards understanding the driving mechanisms which generate the field itself (Yamazaki, 2013). One of the most frequently studied behavior in the geomagnetic field, is change in the field intensity over time, a.k.a. the magnetic paleointensity, which is an important factor for understanding fluctuations in the geodynamo (Guyodo and Valet, 1999). Many magnetic paleointensity studies have been carried out using igneous rocks (Perrin et al., 2009), marine sediments (Nowaczyk et al., 2013), lacustrine sediments (Gogorza et al., 2006; Irurzun et al., 2009; Levi and Banerjee, 1976) and even archeological objects (Gallet et al., 2015; Manoharan et al., 2008). These studies have shown that magnetic paleointensity records contain evidence of many global phenomenon, but also show differences that result from a more localized variety of processes including variation in the fidelity of the materials recording the paleointensity changes, regional geomagnetic events, and/or different regional signatures of global changes in the magnetic field. For instance, Valet and Meynadier (1998) compared paleointensity records from the Pacific and Indian Oceans, which showed an overall similarity but also some discrepancies between parallel records due to sedimentological factors controlling the process of magnetization. Stoner et al. (2002) showed that paleointensity records from sediments in the North Atlantic Ocean are similar to those from the South Pacific Ocean, but differ due to imprecision in temporal correlation, local geomagnetic field effect, or

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https://doi.org/10.1016/j.pepi.2017.12.007
Received 20 April 2017; Received in revised form 14 December 2017; Accepted 20 December 2017
Available online 21 December 2017

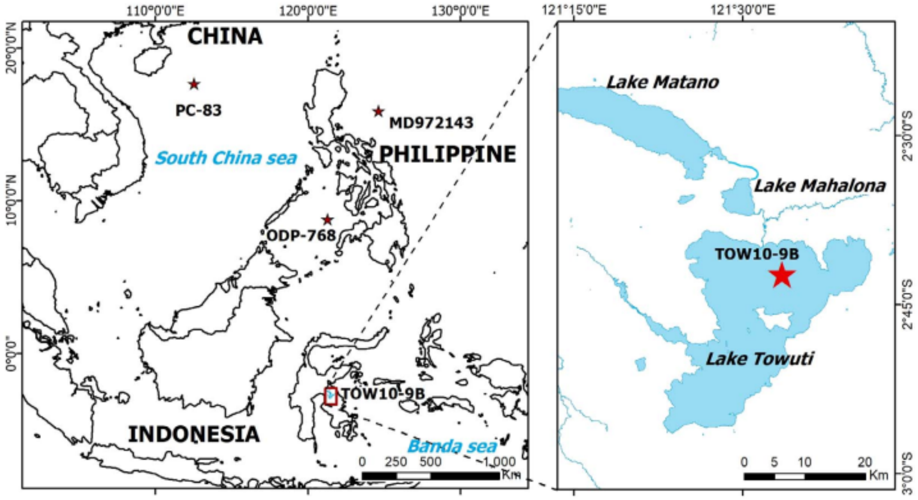

Fig. 1. Map of Lake Towuti. The red star inside the enlarged section box indicates the site of sediment core TOW10-9B, while the other stars show locations of sediment cores from the western tropical Pacific region near Lake Towuti.

uncorrected environmental factors. Thus, understanding global changes in the geomagnetic field intensity, their manifestations at a regional level as magnetic features, requires a global network of regional records.

So far, there is only one published paleointensity record from the Indonesian archipelago: an 800 kyr record derived from a 39.9 m MD012380 core in the Banda Sea (Huang et al., 2009). When compared to an 800 kyr composite record from a stack of 33 paleointensity records (SINT-800, Guyodo and Valet, 1999), the Banda Sea record (Huang et al., 2009) shows a good correlation for segments that are 100 kyr or older, but a poor agreement with the younger sediments. Other records from Southeast Asia (e.g., Schneider and Mello, 1996; Yang et al., 2009) show substantial differences that cannot be easily evaluated with such a paucity of records from the region. Although existing records from Southeast Asia are largely derived from marine sediments, previous studies have shown that lacustrine sediments also provide high-resolution magnetic paleointensity records due to their continuous sedimentation with low rates of bioturbation, high temporal resolution, and global availability (Gogorza et al., 2006; Levi and Banerjee, 1976; Tauxe, 1993). Merrill et al. (1996) found that many lake sediments contain stable remanent magnetization which could provide high-resolution geomagnetic records. Currently, there are many ongoing studies on the Indonesian marine and lacustrine sediments. The absence of a high-resolution paleointensity record, particularly for the last 100 kyr, and the availability of high quality lake sediments from Lake Towuti, led us to carry out a paleointensity study to evaluate whether the regional magnetic field history tracks global variations over the past 60 kyr.

Lake Towuti is located in the Eastern Sulawesi Ophiolite (ESO) belt, which consists predominantly of ultramafic rocks that supply strongly magnetic particles to the lake sediments (Tamuntuan et al., 2015). In contrast, many lakes whose sediments have been studied for paleointensity are surrounded by a volcanic or igneous bedrock (see for instance Gogorza et al., 2004, 2006; Haltia-Hovi et al., 2011; Irurzun et al., 2009). Using a variety of rock- and environmental magnetic analyses, Tamuntuan et al. (2015) showed that magnetic particles in sediments of Lake Towuti were not solely derived from detrital influx, but also from magnetite produced during a shallow diagenesis. This result, combined with the evidence of episodic magnetite dissolution, indicates that sediments of Lake Towuti contain a complex mixture of magnetic particles which requires a careful investigation for determining the fidelity of this magnetic paleointensity record with respect to global magnetic field variations. In this study, we have generated new paleointensity records from the Lake Towuti sediments. Different procedures for reconstructing magnetic paleointensity in the magnetically susceptible sediments were evaluated and assesses to determine the reliability of Towuti's relative paleointensity variation in relation to global records. Our study highlights the potential for paleointensity reconstructions using magnetically strong lake sediments in ophiolite belts.

2. Site description and materials

Lake Towuti (Fig. 1) is the largest tectonic lake in Indonesia with a total surface area of ~561 km^2 (Lehmusluoto and Machbub, 1997). It is located at the downstream end of the Malili Lake System, a chain of five large lakes located in the ESO belt, the third largest ophiolite belt in the world (Kadarusman et al., 2004). The sediments analyzed in this study come from the core TOW10-9B obtained during the 2010 Indonesia Deep Lake Expedition. The chronology, or age model, for core TOW10-9B was derived using an accelerator mass spectrometry (AMS) ^{14}C dating of 23 samples, including 20 samples of bulk organic carbon and 3 samples of terrestrial macrofossils used to correct for the ^{14}C-reservoir effects. The age model was developed using a mixed-effect regression method (Heegaard et al., 2005) that incorporates the uncertainty of both the calibrated ^{14}C ages and age model when calculating the sediment age. The age-depth model from the present to ~42,500 years BP has an average uncertainty of ~480 years over the ^{14}C-dated interval. Sediments below this depth were not dated directly, rather, ages were estimated by extrapolating of the mean sedimentation rates in the ^{14}C-dated interval. Although this approach results in a higher uncertainty, sedimentation rates in the ^{14}C dated interval show little variability, and the reconstructed climate changes near the base of the core are consistent with well-known climate events such as Heinrich Event 6 (Russell et al., 2014). This age model indicates that the 11.5 m core contains a record of 60 kyr (Russell et al., 2014). Geochemical studies by Costa et al. (2015) reveal that the sediments of TOW10-9B have a high Fe content, averaging ~14% Fe by weight. Furthermore, rock magnetic study by Tamuntuan et al. (2015) indicated that the concentration of magnetic minerals in the sediments is strongly influenced

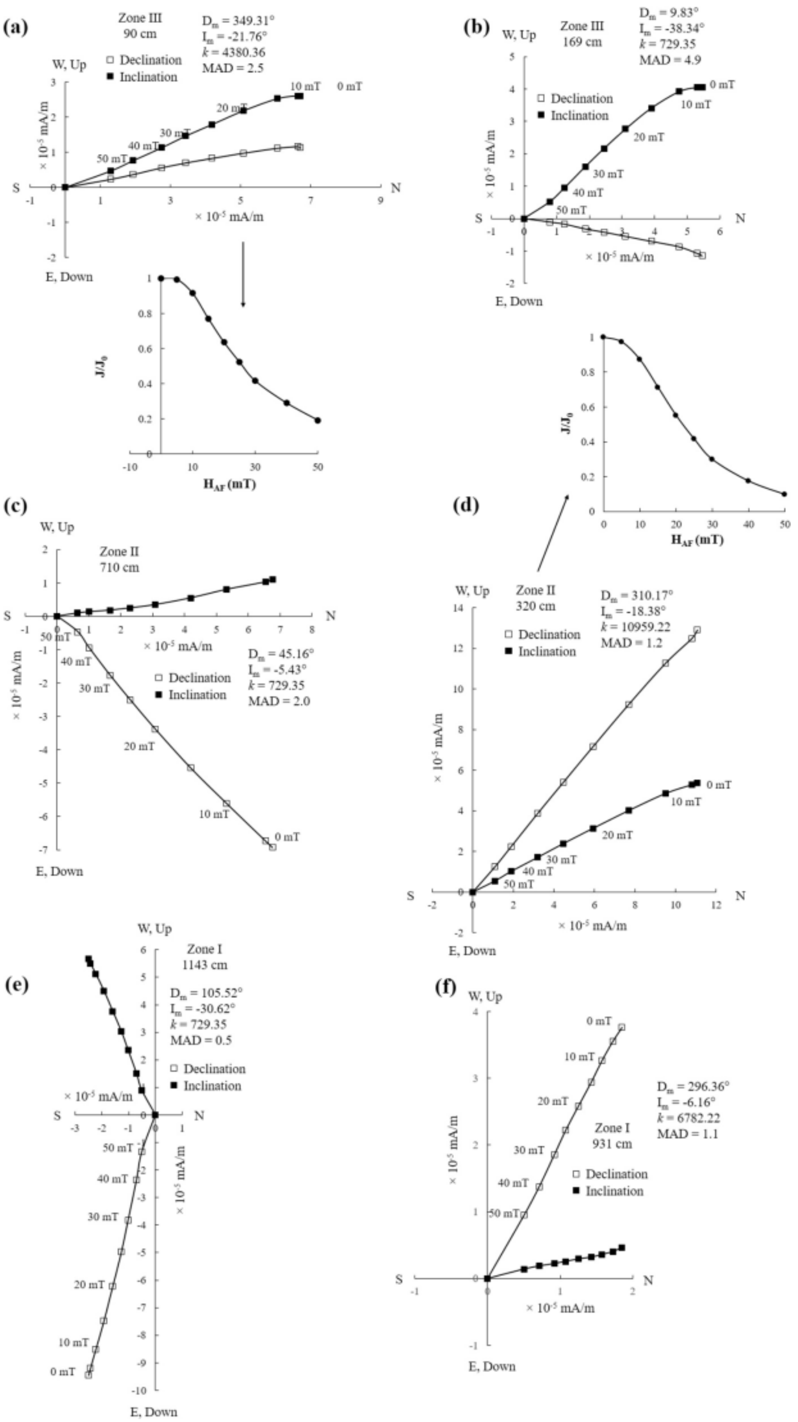

Fig. 2. Zijderveld diagrams with decay curves of NRM demagnetization (at 90 cm and 320 cm, another decay curve of NRM is on Fig. 6), and statistical analysis of samples from Zone III at 90 cm and 169 cm (a, b), Zone II at 320 cm and 710 cm (c, d), and Zone I at 931 cm and 1143 cm (e, f).

by both the detrital influx of magnetite from erosion in the lake catchment region, as well as reduction of iron oxides in the lake and its sediments thereby inducing magnetite precipitation. These processes produce a combination of larger detrital multidomain (MD) and pseudosingle domain (PSD) magnetite grains in the Towuti sediments.

3. Methods

Measurements of volume-based magnetic susceptibility (κ), anhysteretic remanent magnetization (ARM), and saturation isothermal remanent magnetization (SIRM) on core TOW10-9B were previously

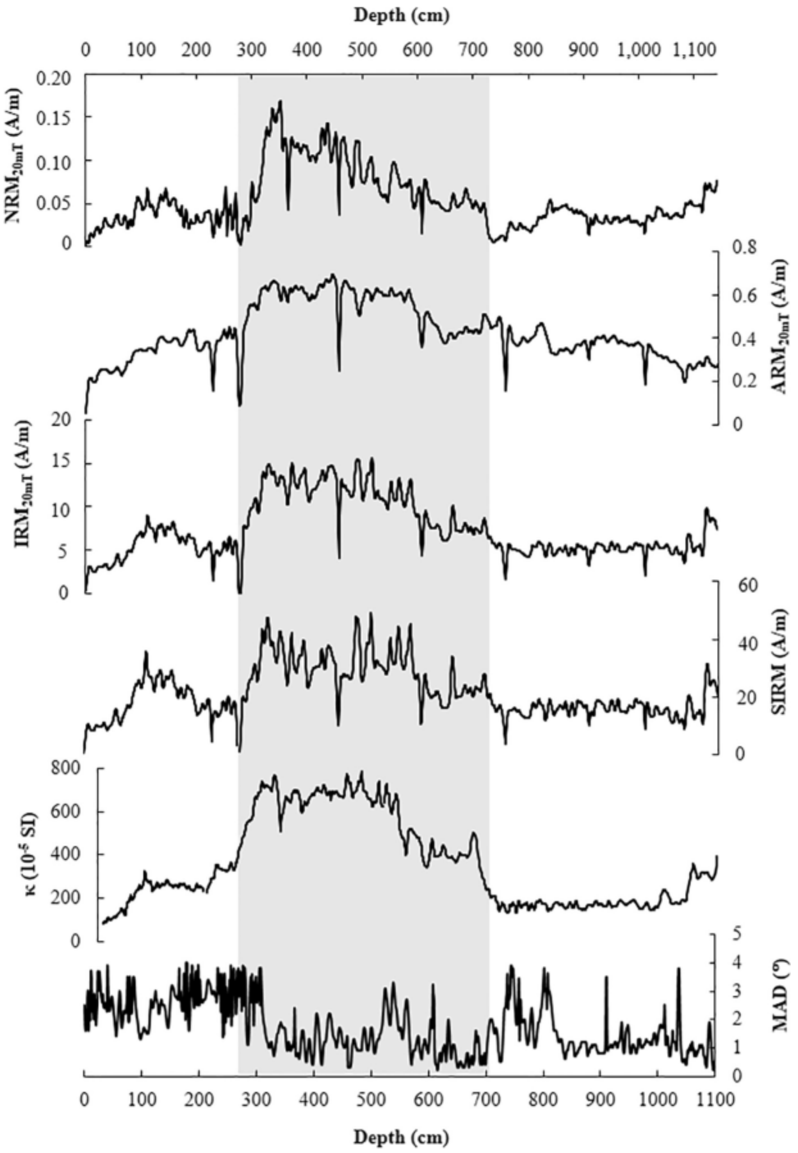

Fig. 3. Variations of NRM$_{20mT}$, ARM$_{20mT}$, IRM$_{20mT}$, SIRM, κ, and MAD versus depth and age of core TOW10-9B. Based on Tamuntuan et al. (2015), the magnetic records are categorized into three zones: Zone I (1143-726 cm), Zone II marked by grey shade (725-281 cm), and Zone III (280-0 cm).

conducted and described in detail by Tamuntuan et al. (2015). The core TOW10-9B was also subjected to measurements of natural remanent magnetization (NRM) as well as NRM$_{20mT}$, which is the NRM after alternating field (AF) demagnetization to a peak field of 20 mT. The AF demagnetization is very effective in isolating the secondary NRM carried by MD grains, which have a coercivity ≤20 mT (Butler, 1998; Gogorza et al., 2006). The core was also subjected to measurements of ARM$_{20mT}$ and IRM$_{20mT}$, which are the intensities of ARM and SIRM after an AF demagnetization to a peak field of 20 mT, respectively. The ARM susceptibility, denoted by κ_{ARM}, was calculated by dividing the measured ARM with the value of a superimposed steady magnetic field of 0.05 mT (Tamuntuan et al., 2015). The measurements of NRM$_{20mT}$, ARM$_{20mT}$ and IRM$_{20mT}$ were carried out in the Paleomagnetic Laboratory of the University of Rhode Island using a 2G-Enterprises cryogenic magnetometer with a measurement interval of 1 cm. The positions of all data within the core were then converted to the corresponding ages using the age model of Russell et al. (2014), described above. For a statistical assessment, we have determined the D_m (mean declination), I_m (mean inclination) from the cores by substituting the data of inclination and declination into the formulas. We have also calculated the maximum angular deviation (MAD) values using methods prescribed by Mazaud (2005).

In sediments with high concentrations of MD grains, such as those from Lake Towuti, the paleointensity values would be typically calculated by normalizing the NRM$_{20mT}$ values with respect to other magnetic parameters in order to isolate the effects of the geomagnetic field. To evaluate which of the magnetic parameters are the best suited normalizers for such magnetically strong sediments, the NRM$_{20mT}$ values were plotted against the potential normalizers (ARM$_{20mT}$, IRM$_{20mT}$, SIRM, and κ) to identify the normalizer stability (Levi and Banerjee, 1976; Matsuoka, 2013; Tauxe and Wu, 1990). Several other tests, including the analysis of the magnitude squared coherence (MSC) (Tauxe and Wu, 1990), were also carried out to evaluate whether the normalized paleointensity records were free of any environmental effects

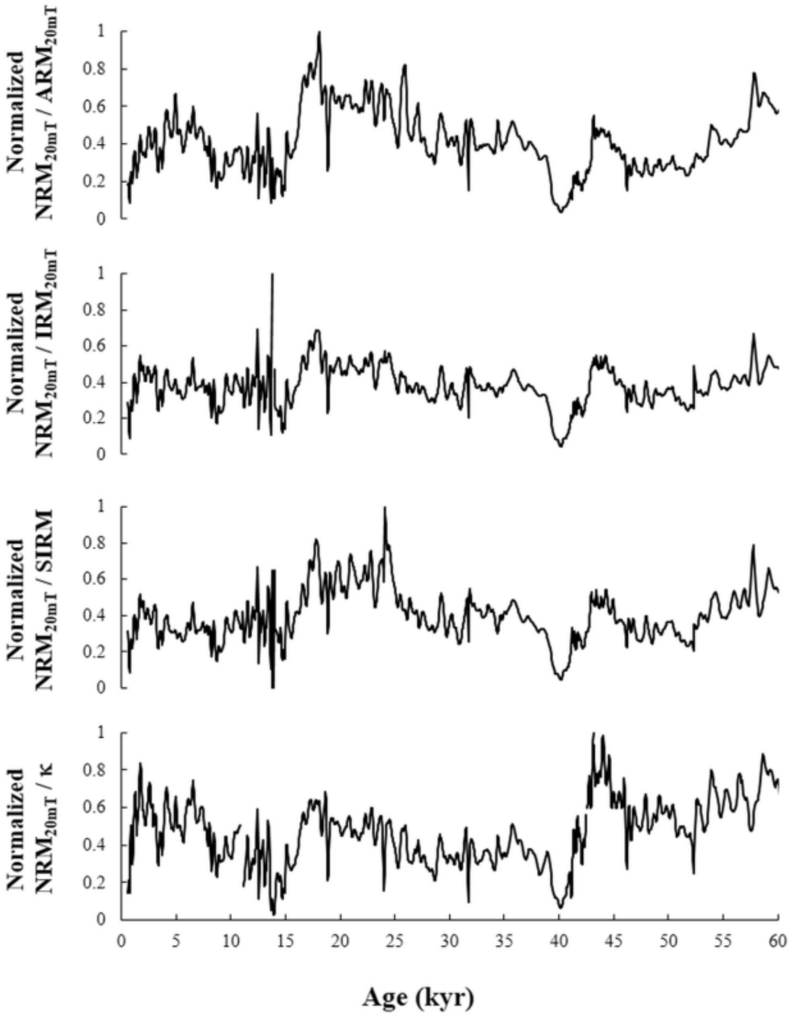

Fig. 4. Variations in the normalized NRM$_{20mT}$/ARM$_{20mT}$, NRM$_{20mT}$/IRM$_{20mT}$, NRM$_{20mT}$/SIRM, and NRM$_{20mT}$/κ as function of depth.

(lithology). This process also helps evaluate the best normalizer. Furthermore, we evaluated the correlation between various ratios, including NRM$_{20mT}$/ARM$_{20mT}$ versus NRM$_{20mT}$, and NRM$_{20mT}$/ARM$_{20mT}$ versus ARM$_{20mT}$, to test for any reflections the geomagnetic field strength in the normalized remanent record (Vigliotti et al., 2014). Lastly, we analyzed the correlation between the NRM$_{20mT}$/ARM$_{20mT}$ and κ$_{ARM}$/κ to assess the magnetic grain size distribution (Channell et al., 2016).

Our new paleointensity (RPI) record from Lake Towuti was then compared to multiple magnetic paleointensity records of marine sediment cores from the southeast Asia region, including (Fig. 1) PC-83 from the South China Sea PC-83 (Yang et al., 2009), ODP-768 from the Sulu Sea (Schneider and Mello, 1996), and MD972143 from the west Philippine Sea (Horng et al., 2003). We evaluated the concurrence between the records by picking correlative peaks and troughs, accounting for potential errors in the age model of each record. Similarly, we evaluated the temporal occurrence of features from the Towuti paleointensity record relative to globally distributed datasets, including data of core 21-PC02 from the South Atlantic Ocean (Channell et al., 2000), the synthetic composite paleointensity record of the past 200,000 years (SINT-200; Guyodo and Valet, 1996), as well as a global paleointensity stack for the past 75 kyr (GLOPIS-75; Laj et al., 2004).

4. Results and discussion

Tamuntuan et al. (2015) divided the core TOW10-9B into three magnetic zones based on magnetic susceptibility, ARM, SIRM, and a variety of other magnetic properties. Zone I is marked by low κ values prior to the ~40 kyr BP mark, likely due to dissolution of magnetite. Zone II shows high κ values between 40 and 15 kyr BP due to high detrital magnetite flux and magnetite precipitation. Zone III, from ~15 kyr BP to the present, has low to moderate κ values with less intense magnetite dissolution than in Zone I. These changes correspond to large changes in the sediment lithology and geochemistry, commonly associated with glacial-interglacial scale climate changes in the region (Costa et al., 2015; Russell et al., 2014). Tamuntuan et al. (2015) reported that the predominant magnetic mineral throughout the core is a PSD (pseudo-single domain) type magnetite with a grain size range of 0.06–10 mm, as evidenced by relatively high ARM/SIRM values, especially in Zone II. The dominance of PSD grains, together with a high κ value suggests the potential of these sediments to provide reliable paleointensity records, as proposed by earlier studies (King et al., 1983; Levi and Banerjee, 1976; Stoner et al., 1995; Tauxe, 1993).

We evaluated Zijderveld diagrams using D_m, I_m, and MAD values. The NRM demagnetization decay curves for samples (90 cm, 169 cm,

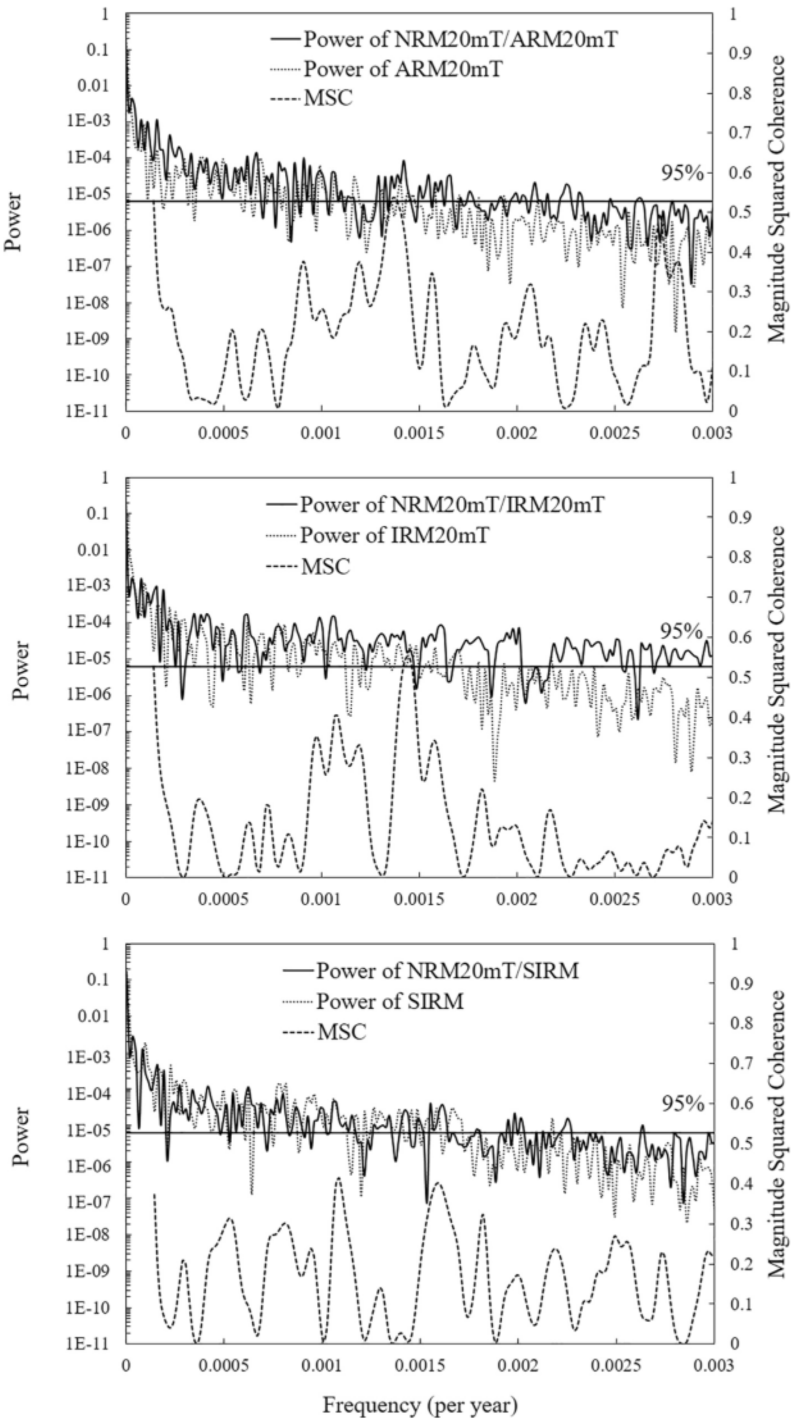

Fig. 5. Spectral analysis of the ARM_{20mT}, IRM_{20mT}, and SIRM, as well as the spectral analysis of NRM_{20mT}/ARM_{20mT}, NRM_{20mT}/IRM_{20mT}, NRM_{20mT}/SIRM, and NRM_{20mT}/κ. Magnitude squared coherence tests are shown by dashed lines, while the 95% confidence level is shown by a horizontal line.

320 cm, 710 cm, 931 cm, and 1143 cm) representing the three different magnetic zones of the core were also analyzed to ensure comparability between the NRM characteristics (ChRM) of the zones (Fig. 2). These analyses confirm the stability of the magnetic remanence recorded by the sediments. In each Zijderveld diagram, there is a weak secondary remanent magnetization that can be removed using 20 mT of demagnetization. The SD or PSD retains the ChRM, while the secondary remanent magnetization is dominantly carried through MD grains with low coercivity (≤20 mT). Moreover, since there is a consistency between the declination and inclination beyond 20 mT, any

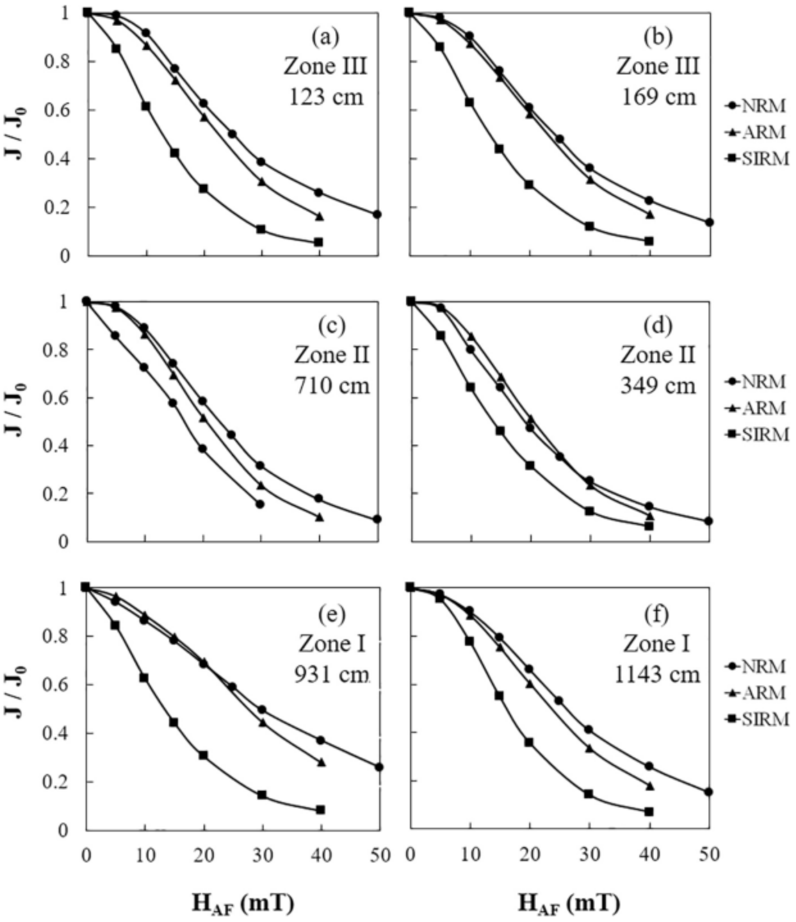

Fig. 6. The AF demagnetization curves for Zone III (a, b), Zone II (c, d), and Zone I (e, f). The dots represent the NRM, while triangle and square symbols indicate the ARM and SIRM, respectively.

demagnetization after 20 mT is used to define the remanence. A statistical assessment of the ChRM and demagnetization behavior shows very low MAD values (< 5°), with an average MAD of 1.93° for core TOW10-9B. This result indicates good regularity in magnetization (Walczak et al., 2017).

Fig. 3 shows various magnetic parameters with respect to depth (cm) and age (kyr) within core TOW10-9B. The NRM_{20mT}, ARM_{20mT}, IRM_{20mT}, SIRM, and κ range from 0.002 to 0.169 A/m, 0.051 to 694 A/m, 0 to 15.6 A/m, 0.816 to 49.3 A/m and 81 to 787 ($\times 10^{-5}$ SI), respectively (Fig. 3). Variations in these parameters with age follow similar patterns, with large shifts between ~40 and 15 kyr BP. Fig. 4 shows the NRM_{20mT} values normalized by the ARM_{20mT}, IRM_{20mT}, SIRM, and κ. All curves display similar trends suggesting that all four parameters could serve as suitable normalizers for NRM_{20mT} for the detection of magnetic paleointensity changes. Although magnetic susceptibility could be a good normalizer, the κ is dependent on grain size, which could cause errors in paleointensity estimates (Brachfeld and Banerjee, 2000). This factor is particularly important in sediments, like those from Towuti, which show a variation in magnetic grain size with depth (Tamuntuan et al., 2015). In particular, the κ is sensitive to coarse MD grains and SP magnetite, with SP grains strongly contributing to the susceptibility rather than the remanent magnetization. The ARM/SIRM in Lake Towuti indicates large fluctuations in SP and MD grains, rendering κ unsuitable as a normalizer for paleointensity in the region. Magnitude squared coherence tests (Fig. 5) show that only the ARM_{20mT} and SIRM have MSC values that meet the 95% confidence level (Tauxe and Wu, 1990). Similar results for MSC analyses are observed in the different magnetic zones (Tamuntuan et al., 2015). This result implies that the relative paleointensity estimate is not primarily controlled by lithology. The MSC values also indicate that the normalized records of the rock magnetic properties are not influenced by environmental effects, such as magnetic mineralogy or grain size variations. Therefore, the two parameters, ARM_{20mT} and SIRM, appear to be good normalizers.

To identify the best normalizer, demagnetization curves for the NRM, ARM, and SIRM were developed for six representative discrete samples (two samples each from Zones I, II, and III) using an AF field (Fig. 6). Based on these profiles, it is evident that the demagnetization curves of the ARM closely resemble those of the NRM, more so than curves from SIRM do, suggesting that the ARM is the better normalizer for the NRM than the SIRM.

Fig. 7 shows plots of NRM_{20mT}/ARM_{20mT} versus NRM_{20mT}, ARM_{20mT} and κ_{ARM}/κ (e.g., Channell et al., 2016; Vigliotti et al., 2014). The NRM_{20mT}/ARM_{20mT} and NRM_{20mT} are better correlated ($r = 0.824$, $n = 1144$, $p < .001$) than the NRM_{20mT}/ARM_{20mT} and ARM_{20mT} ($r = 0.311$, $n = 1144$, $p < .001$) and NRM_{20mT}/ARM_{20mT} and κ_{ARM}/κ ($r = -0.571$, $n = 1144$, $p < .001$). This comparison implies that normalization of the NRM using the ARM_{20mT} best reflects the strength of the geomagnetic field (Vigliotti et al., 2014). We also tested the effect of normalization parameter selection and grain size on the RPI record. Fig. 7(b) shows no statically significant correlation between the NRM_{20mT}/ARM_{20mT} and ARM_{20mT}. This comparison indicates a greater

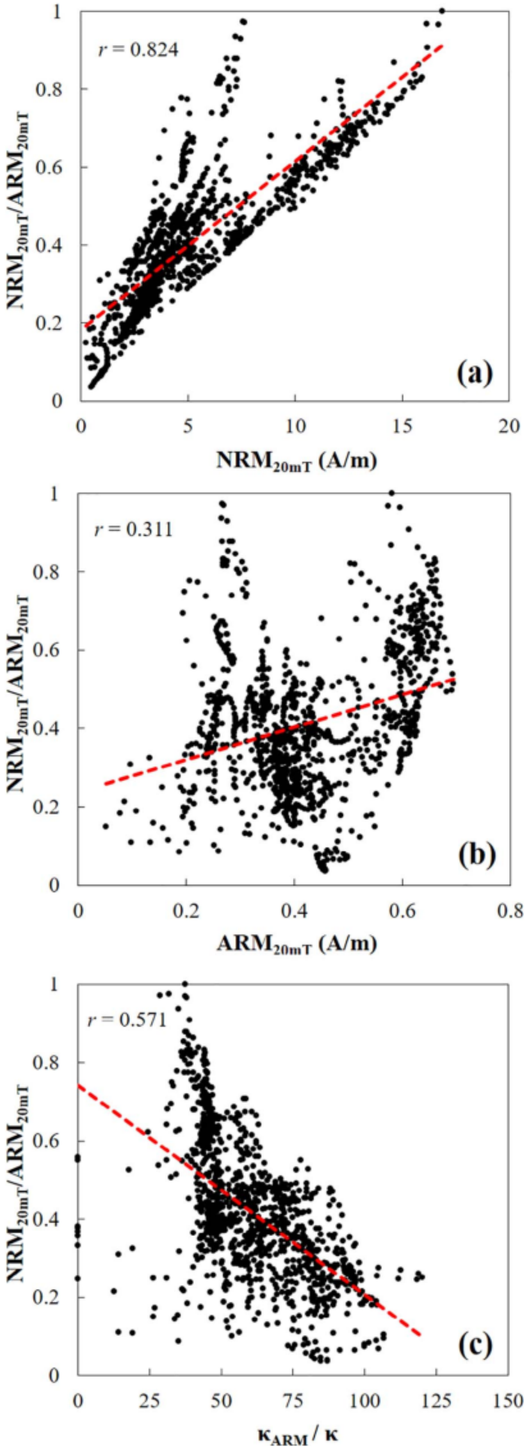

Fig. 7. Correlation between the (a) NRM_{20mT}/ARM_{20mT} and NRM_{20mT}, (b) ARM_{20mT} (b), and (c) κ_{ARM}/κ for 1144 samples. Dashed red lines represent the best fit. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

influence of the NRM on the relative paleointensity record compared to the ARM. Lastly, we observe weak correlation between the NRM_{20mT}/ARM_{20mT} and κ_{ARM}/κ (Fig. 7), indicating a weak effect of grain size on the relative paleointensity record.

Fig. 8 shows the RPI record from Lake Towuti inferred from the NRM_{20mT}/ARM_{20mT} in comparison with RPI records from GLOPIS-75 (Laj et al., 2004), the global composite record SINT-200 (Guyodo and Valet, 1996), the South Atlantic (core 21 PC-02) (Channell et al., 2000), and RPI records from the western tropical Pacific region. The RPI record from Lake Towuti resembles the South Atlantic record, wherein both show a paleointensity minimum associated with the Laschamp excursion at almost identical times (~41 kyr BP). This excursion can be identified by a globally recorded intensity minimum at ~40 kyr BP in the GLOPIS-75 and SINT-200 records. The GLOPIS-75 and Lake Towuti records also show interesting correlative features in the Holocene. Starting at 7.5 kyr in GLOPIS-75 and at 8.8 kyr in Lake Towuti, the paleointensity increases until ~3 kyr BP following a decrease until the present. Although this pattern is not perceived in all records, indications of this phenomenon do appear in other records from the western Pacific (see Richter et al., 2006).

Emphasizing on records from the western tropical Pacific region, even though differences in the trends of the RPI records are seen, the paleointensity records from Lake Towuti, South China Sea, Sulu Sea, and west Philippine Sea, all clearly show a minimum paleointensity marker associated with the Laschamp excursion. They do not, however, show much evidence for the Mono Lake excursion (32–33 kyr). While the Laschamp excursion has been corroborated by geological archives from many parts of the world (see Carvallo et al., 2003; Channell et al., 2000; Macrì et al., 2010; Meynadier et al., 1992; Nowaczyk et al., 2013), the Mono Lake excursion was mostly detected by records from the northern hemisphere. Although it was recently observed in basalts from the Auckland volcanic field in New Zealand (see Cassata et al., 2008; Cassidy and Hill, 2009), the Mono Lake excursion does not show as wide spatial record as the Laschamp excursion. This difference could be due to the relatively short duration of the Mono Lake excursion (Xiao et al., 2016).

Furthermore, there is a variance between records from 60 to 50 kyr, during which phase the intensity in the Lake Towuti record decreases, but intensity in the other records increases. During this time, the NRM values in Lake Towuti decrease whereas the ARM slightly increases, causing the RPI record to sharply decline. This difference could be due to the magnetic mineral diagenesis in Lake Towuti that can distort the NRM signal (Dekkers et al., 1994). It is possible that magnetic mineral grain dissolution reduces grain sizes and magnetic domains, leading to a higher proportion in PSD magnetite grains that cause larger NRM values. The effect of magnetite dissolution is also observed as a low magnetic susceptibility during this time (Tamuntuan et al., 2015). However, low κ values occur from ~60 to 40 kyr, and not only during the 60–50 kyr period when the records appear to disagree. The variance could also be due to the radiocarbon dating of TOW10-9B, which extends to a depth 895 cm (~45 kyr). Sediments deeper than this level were dated only by extrapolating the 0–45 kyr sedimentation rates between 896 and 1143 cm (45–60 kyr).

The new 60 kyr RPI record from TOW10-9B has features similar, but not identical, to other regional records from the South China Sea (PC-83; Fig. 8). The RPI from TOW10-9B is also similar to records from the Sulu Sea (ODP-768). In contrast, the RPI record from the Banda Sea (MD-12380) (Huang et al., 2009) bears little resemblance to the other records. The main difference between these cores is that the TOW10-9B has a shorter core and younger records than that of the Banda Sea. Moreover, we also observe a 1 kyr (~15 cm) shift between the TOW10-9B and the PC-83 from the South China Sea, and an even larger (6 kyr or ~80 cm) offset, between the TOW10-9B and the ODP-768. These differences on the RPI records may be due to the differences between lacustrine Towuti sediments and marine sediments. Marine sediments have been known to experience bioturbation, therefore the timing of

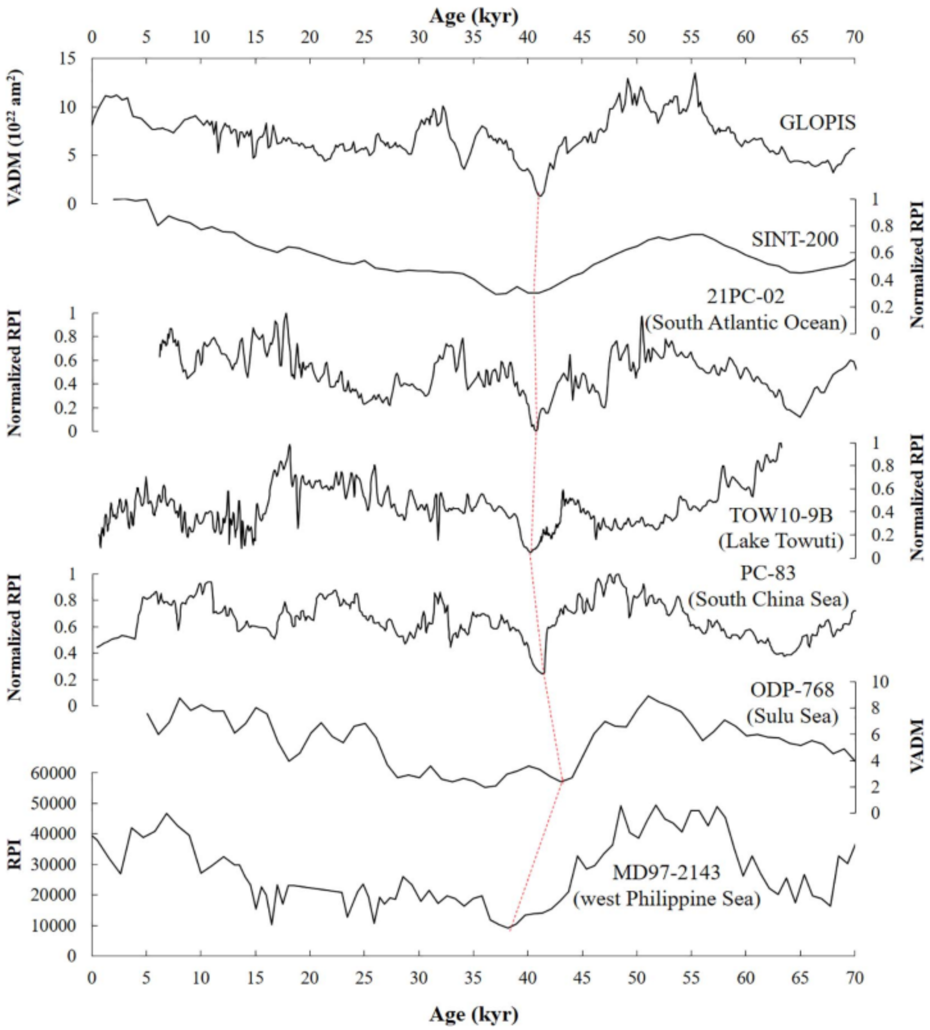

Fig. 8. Comparison of the relative paleointensity records of TOW10-9B with global records (GLOPIS-75; SINT-200; 21PC-02, South Atlantic), and records from the western tropical Pacific region (PC-83, South China Sea; ODP-768, Sulu Sea; MD972143, west Philippine Sea). The dashed red line indicates the paleointensity minima in the records associated with the Laschamp excursion.

paleointensity might differ from the actual age (Roberts and Winklhofer, 2004). Also, the age models of the TOW10-9B and PC-83 are based on ^{14}C dating, whereas the ODP-768 age model is based on the correlation of δ^{18}O measured in the foraminifera to the benthic δ^{18}O LR04 stack (Lisiecki and Raymo, 2005). The ^{14}C dating provides an independent measurement of samples as old as 45 kyr BP, (Frank et al., 1997). In general, the record from Towuti has a higher resolution than those from the South China Sea and the Sulu Sea. For instance, the TOW10-9B has 23 samples dated by ^{14}C, compared to only 5 samples from the PC-83 and ODP-768, suggesting that the latter records could have larger age errors.

In 2015, funded by the ICDP (International Continental Scientific Drilling Program) and several other agencies, the Towuti Drilling Project (TDP) successfully recovered more than 1000 m of core from 11 drilling sites in Lake Towuti (Russell et al., 2016). The maximum drilling depth was 175 m and the average recovery was 91.7% (Russell et al., 2016), providing sufficient material for extensive paleointensity measurements. The reliability of the core TOW10-9B in terms of recording paleointensity, as demonstrate here, suggests a high potential for dating these new drill cores using magnetic paleointensity, and also highlights the capacity of RPI records from similar ultramafic lakes as dating tools.

5. Conclusion

The sediments of Lake Towuti derived from an ultramafic bedrock have experienced complex diagenetic processes that have potentially affected their iron mineralogy (Tamuntuan et al., 2015; Vuillemin et al., 2016). However, our study shows that these sediments yet record changes in the geomagnetic field intensity reliably. Through a number of tests, the ARM was determined as the most appropriate normalizer for the NRM in these magnetically-strong sediments. When compared with other regional and global paleointensity records, the high-resolution relative paleointensity (RPI) record for Lake Towuti computed from the NRM_{20mT} over ARM_{20mT} shows good corroboration, particularly with a high-quality RPI record from the South China Sea (PC-83). The RPI of Lake Towuti has recorded a ~40-kyr event associated with the Laschamp excursion, however not the more recent Mono Lake excursion, confirming previous studies that the Mono Lake excursion was relatively short lived and potentially geographically limited. The reliability of the core TOW10-9B in terms of recording paleointensity, has encouraged the TDP team to measure the magnetic parameters from cores of other TDP holes, producing a more temporally extensive paleointensity record for the Indonesian region.

Acknowledgements

We thank Satrio Adi Wicaksono for field assistance and discussion. This data is partially based upon work supported by the National Science Foundation United States of America under Grant Number NSF-EAR-0902845 to JMR. Additional financial support was received from the Indonesian Ministry of Research, Technology and Higher Education of the Republic of Indonesia in the form of *Penelitian Unggulan Perguruan Tinggi* (PUPT) to SB and a sandwich research grant (PKPI 2015) to KHK.

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