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Paleointensity Determination and Rock-magnetic Characters of Miyakejima 1983 Lava, Japan

Naoko UENO*, Zhong ZHENG**

Abstract

Paleointensity determination was carried on Miyakejima 1983 lava by using Zheng's method. From 4 thermal stable specimens, a good result was obtained to be 41.3±1.5μT. For reference, a differentiated Thelliers' method yielded 32.3±6.7μT, and the local field is calculated to 45.3μT based on IGRF 1985 model.

Key words: Miyakejima lava, Paleointensity, Differentiated Thellier method, Zheng method

1. Introduction

The new method developed by Zheng (Zheng et al., 2005: Ueno et al., 2008: Ueno and Zheng, 2010) was applied for paleointensity determination on Miyakejima 1983 lava, and the result yielded by a traditional differentiated Thellier method was also discussed for comparison.

Total 4 block samples were collected from the basaltic lava flows erupted in 1983, at Miyakejima Island, Izu-Bonin Arc, Japan. The local geomagnetic intensity based on the IGRF 1985 model at the sampling site (0.25km height, 34.35N,139.31E) is calculated to 45.3μT.

2. Samples and rock magnetic characters

Sampling was carried out in 1984 during the field workshop promoted by the Volcanological Society of Japan. The detailed sites are shown in Fig. 1-1 and Fig. 1-2. All of the 4 block samples were basaltic rocks.

MY83-A was massive basalt collected in the town part of Ako area; MY83-B was a volcanic bomb near the Village Farm; MY83-C was porous rock which was collected 1km apart from

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*) 上野直子：東洋大学自然科学研究室　〒 112-8606　東京都文京区白山 5-28-20
Natural Science Laboratory, Toyo University, 5-28-20, Hakusan, Bunkyouku, Tokyo, 112-8606 JAPAN
E-mail: ueno@toyo.jp
**) 鄭　重：綜合開発株式会社地球科学事業部　〒 133-0057　東京都江戸川区西小岩 1-30-16　三幸ビル 2 号館
Sogo Kaihatu Co., Sanko Buil., 1-30-16, Nishikoiwa, Edogawaku, Tokyo, 133-0057 JAPAN
E-mail: tei-cho@sogo-geo.co.jp

Fig. 1 Sampling site

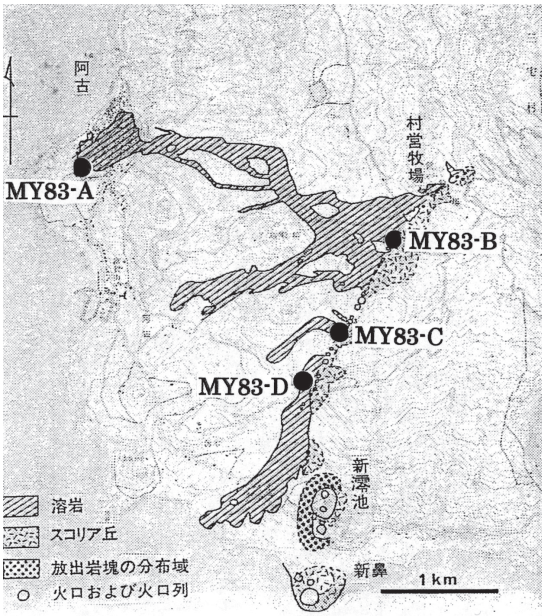


Fig. 1-1 Area map of 1983 eruption (Original map ; Soya et.al. 1983)

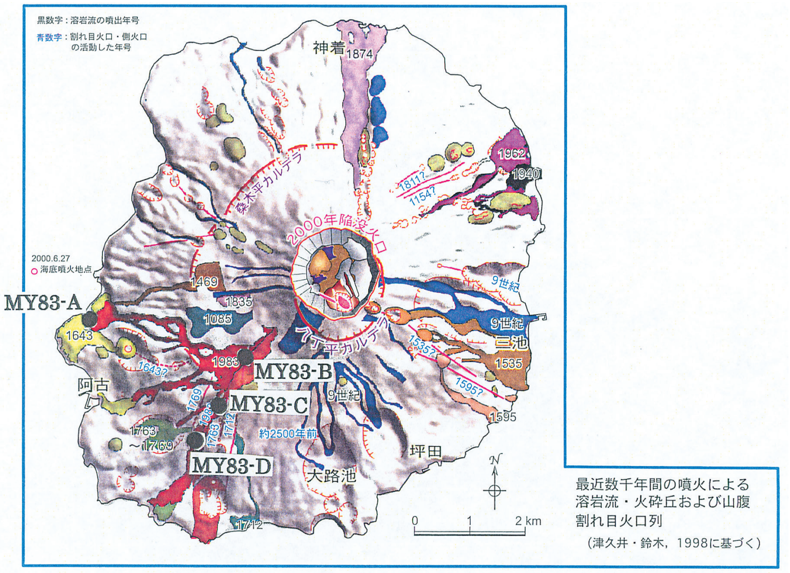


Fig. 1-2 Geological map of Miyakejima (Original map ;Tukui and Suzuki 1998, appeared in the "Urgent report of the 2000 eruption of Miyakejima" published by the Geological Survey of Japan)

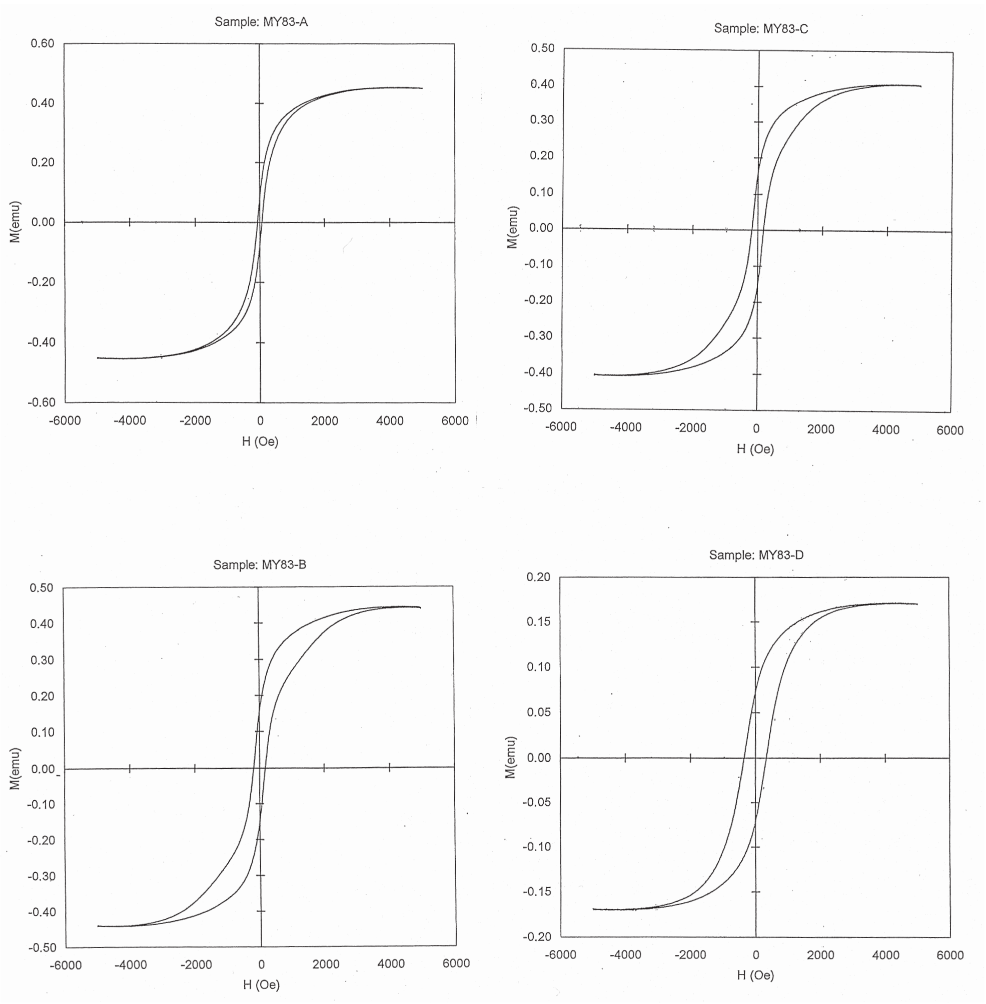


Fig. 2 Hysteresis Curves of MY83

the MY83-B; and MY83-D was also porous rock locating about 300m distant from MY83-C to the south, near the bus stop.

Hysteresis parameters: Hysteresis curves of the samples are illustrated in Fig. 2. The hardest coercivity was observed in sample MY83-D, while the softest one was observed in sample MY83-A.

Hysteresis parameters are summarized in Table 1. All the samples are plotted in the pseudo-single-domain (PSD) area of Day diagram (Fig. 3). Between the 4 samples, MY83-A is the closest to the multi-domain (MD) area; and MY83-D is the closest to the single-domain (SD) area.

Thermal analysis of initial susceptibility: Thermal analysis of the initial susceptibility

Table 1 Hysteresis parameters of Miyakejima 1983 basalt

Hysterisis測定結果一覧表

順番	試料名	Hc(Oe)	Hcr	Msr(emu/g)	Ms(emu/g)	Hcr/Hc	Mrs/Ms
1	MY83-A	68.05	176.00	0.2650	1.5070	2.5863	0.1758
2	MY83-B	180.60	410.30	0.5100	1.4713	2.2719	0.3466
3	MY83-C	179.60	342.90	0.5193	1.3507	1.9092	0.3845
4	MY83-D	341.60	604.20	0.2406	0.5657	1.7687	0.4254

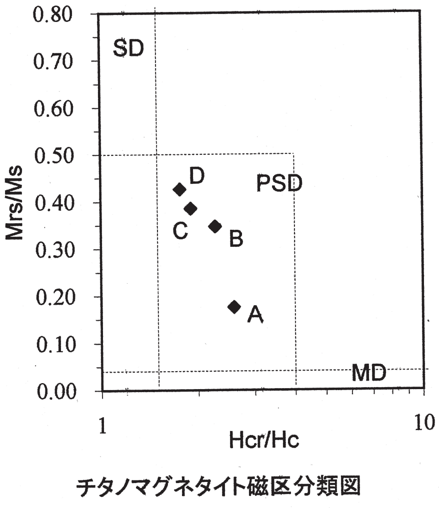


Fig. 3 Linear plots of hysteresis parameters
Single domain (SD), pseudo-SD (PSD) and mutidomain (MD) files of titano- magnetites by Day et al. (1977) are also shown.

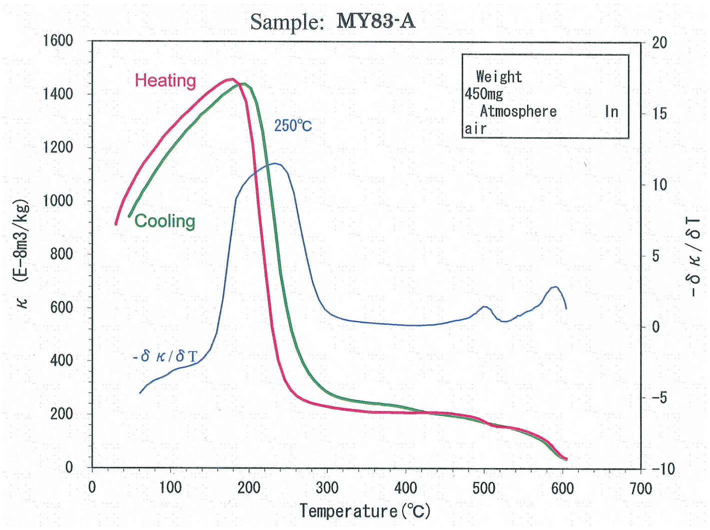


Fig. 4-1 Thermal analysis of initial susceptibility on MY83-A

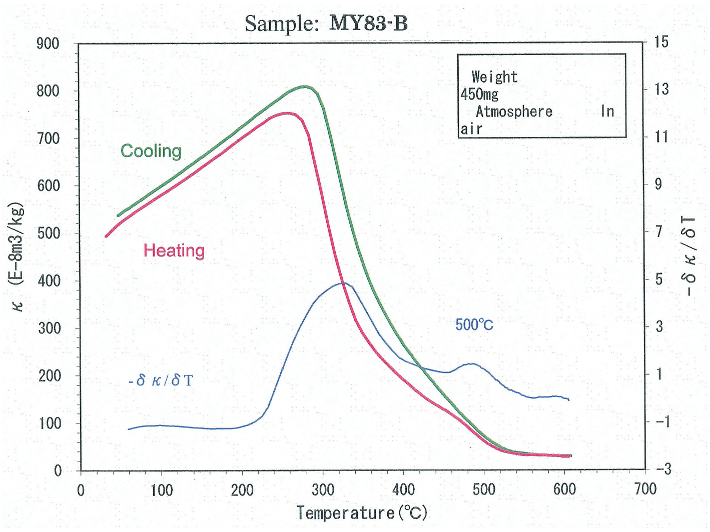


Fig. 4-2 Thermal analysis of initial susceptibility on MY83-B

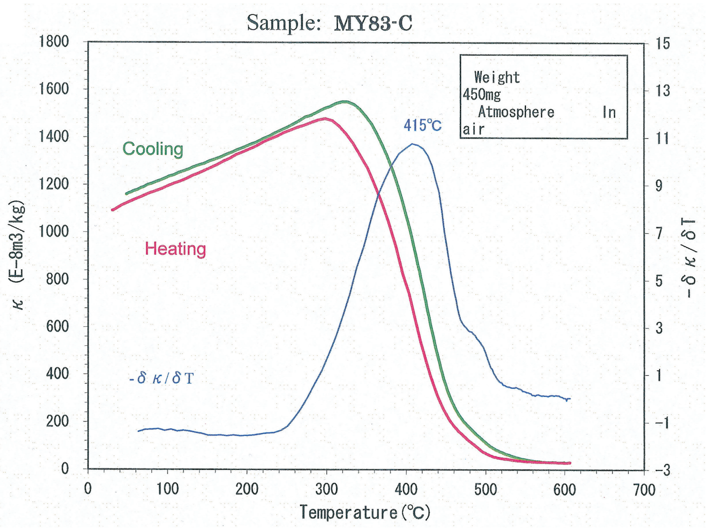


Fig. 4-3 Thermal analysis of initial susceptibility on MY83-C

(κ) was conducted with Kappabridge susceptibility meter KLY-3S in air atmosphere to find out the magnetic phase change during laboratory heating. The results are summarized in Fig. 4-1~4-4.

Sample MY83-A shows significant phase change near 250℃ , and slight one between 500℃ and 600℃ (Fig. 4-1); the significant phase change of sample MY83-B is near 300℃ (Fig. 4-2); While samples MY83-C and MY83-D are 415℃ and 470℃ respectively (Fig. 4-3 and Fig. 4-4). A reversible thermal analysis curve of sample MY83-D suggests the excellent thermal stable

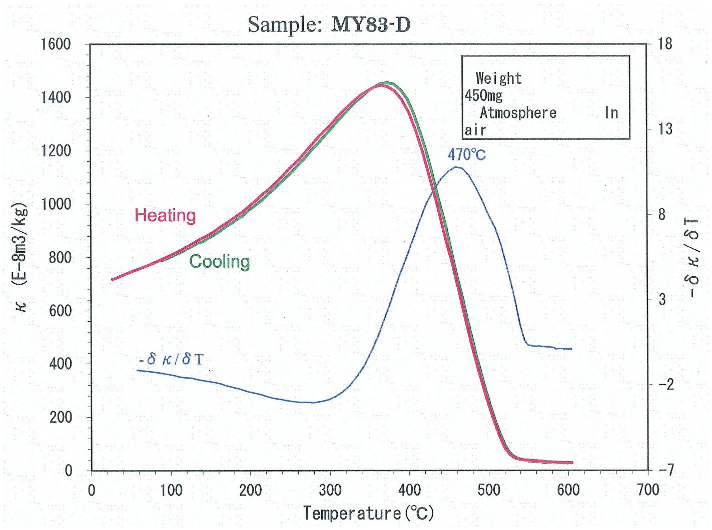


Fig. 4-4 Thermal analysis of initial susceptibility on MY83-D

property. The successive appearence of the phase change might reflect the stages of the eruption similar to the case of Unzen 1991-1995 lavas (Ueno and Nakada, 2005).

3. Paleointensity experiment

The new method of paleointensity determination developed by Zheng was documented applicable by using recent Unzen volcanic rocks (Ueno et al., 2008). The experiment procedure is introduced in detail in Ueno and Zheng (2010). Sample MY83-A and MY83-D were used in the present experiment. Fig. 5-1-1 shows a diagram of unblocking temperature spectra of NRM & pTRM of specimen MY83D-1 for the 1st run to pick-up apparent paleointensity data, and Fig. 5-1-2 the 2nd run for the correction of static-magnetic interaction between magnetic mineral grains. The results from specimen MY83D-2~D-4 are shown in Fig. 5-2-1~ Fig. 5-4-2.

Figure 6-2 shows histogram of paleointensity plateau data obtained from the 37 temperature intervals of 4 specimens from the most magnetic thermal stable lava MY83-D. The upper panel diagram shows results of the differentiated Thelliers' method by using the data from NRM & pTRM spectra. The lower panel diagram represents the results of the new method of Zheng after using the spectra of TRM and pTRM for correction. The mean of 37 plateau data is calculated to 41.4±4.5μT for Zheng's method and 32.6±8.8μT for Thelliers' method; and mean of 4 specimens is 41.3±1.5μT and 32.3±6.7μT for Zheng's and Thelleirs' respectively. The Zheng's data set is much more symmetrical in distribution and much smaller in dispersion.

For comparison, histogram of the ruined MY83-A is illustrated in Fig.6-1.

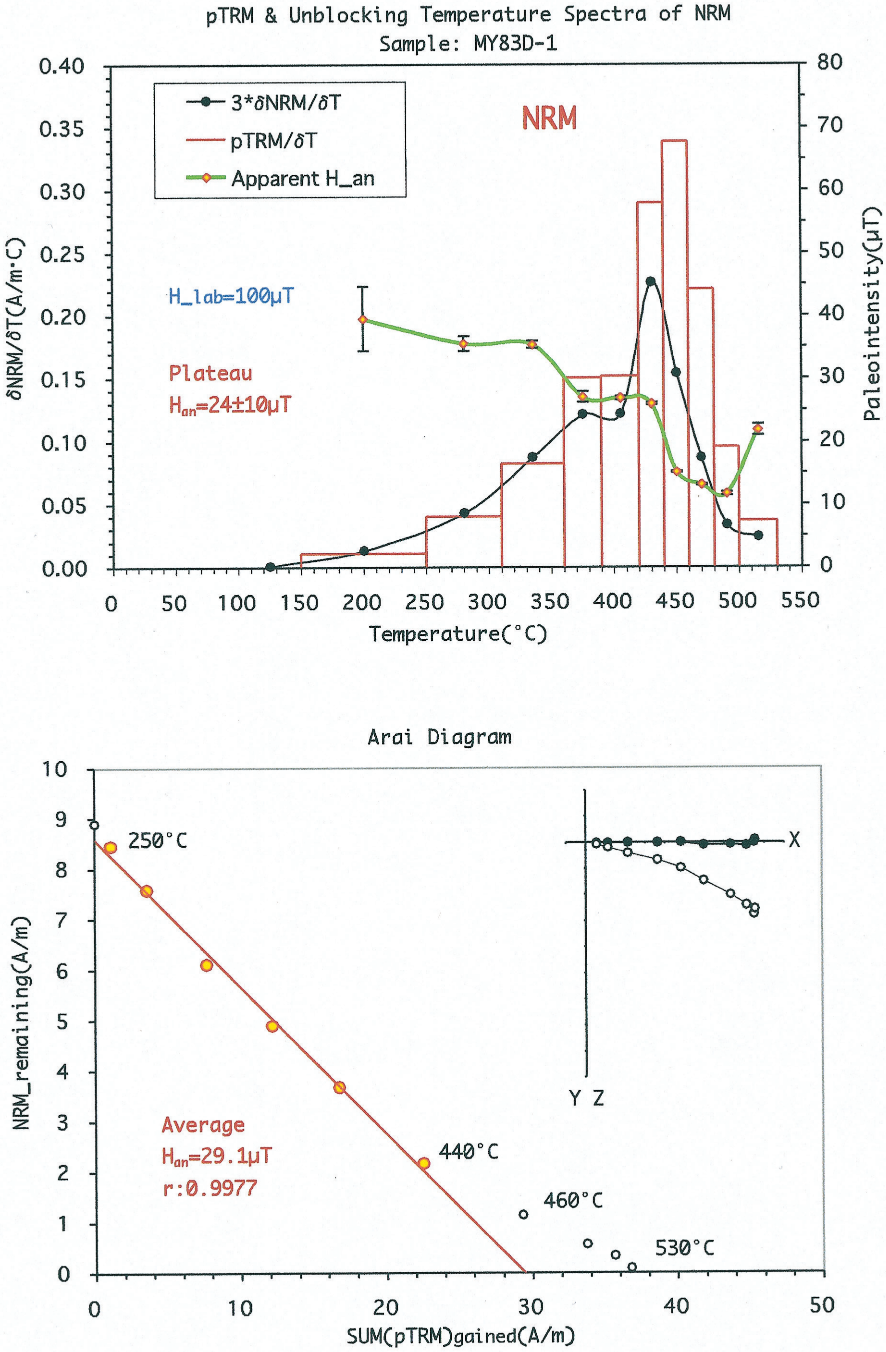


Fig. 5-1-1 Unblocking temperature spectra of NRM & pTRM on MY83D-1

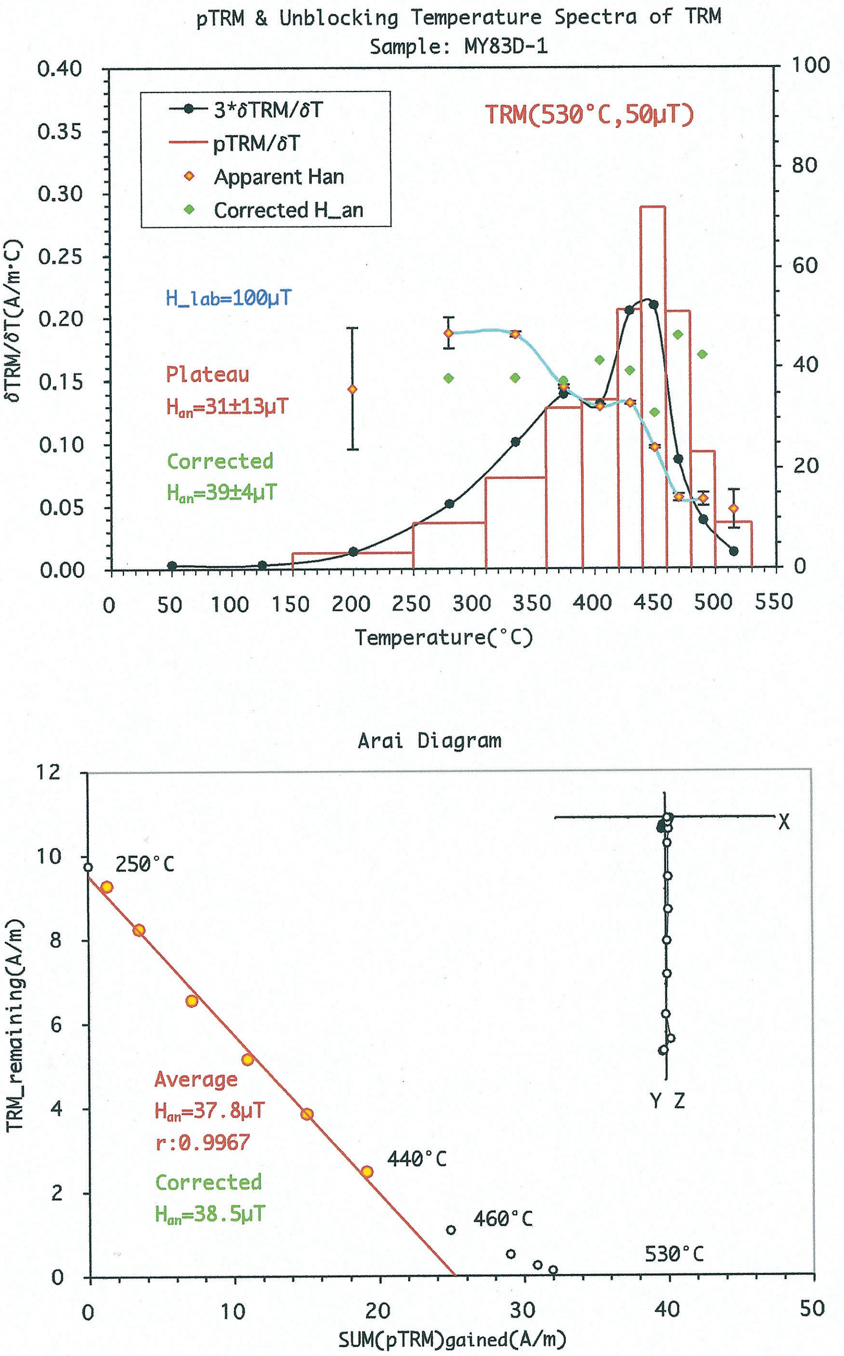


Fig. 5-1-2 Unblocking temperature spectra of TRM & pTRM on MY83D-1

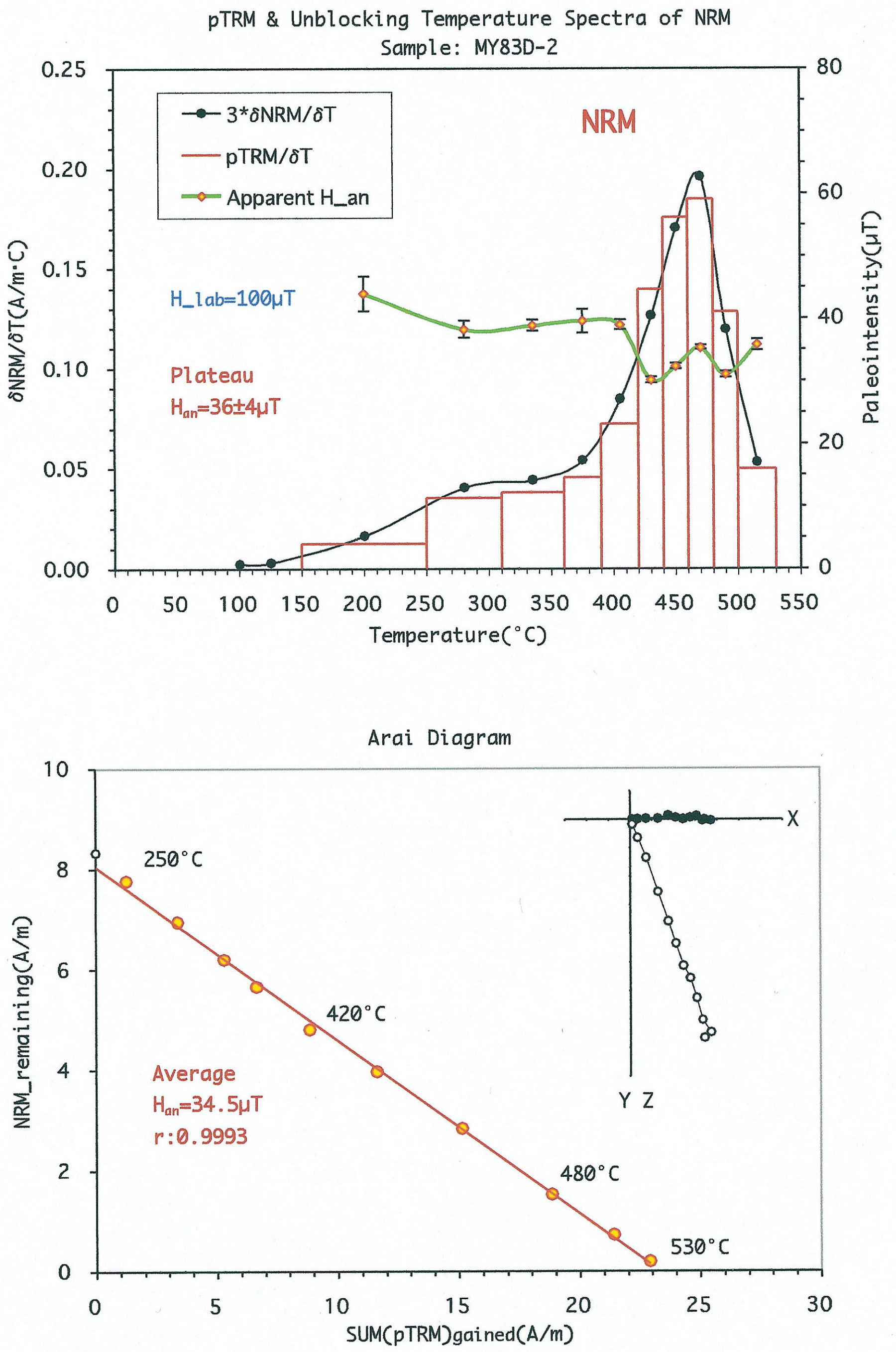


Fig. 5-2-1 Unblocking temperature spectra of NRM & pTRM on MY83D-2

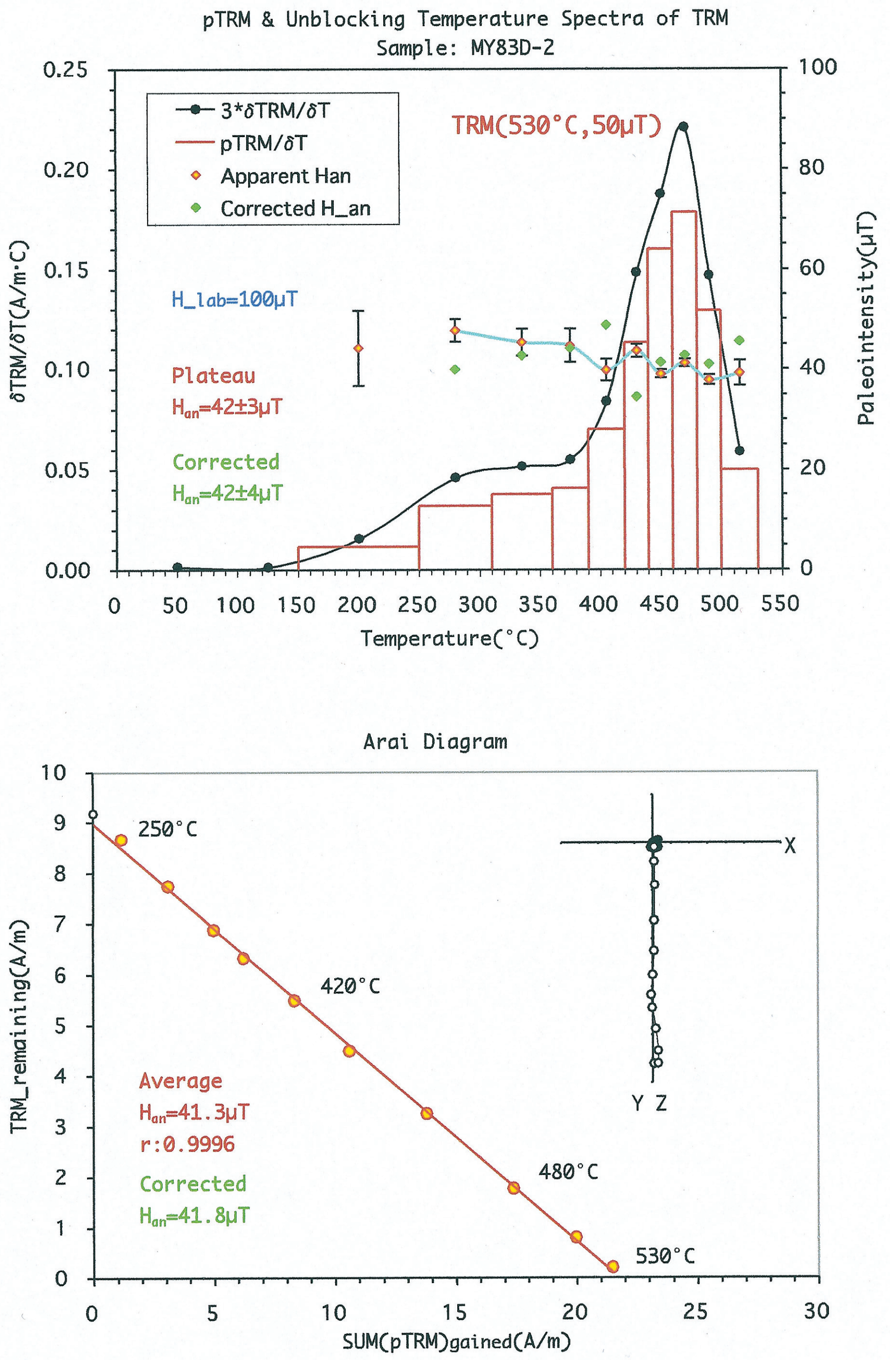


Fig. 5-2-2 Unblocking temperature spectra of TRM & pTRM on MY83D-2

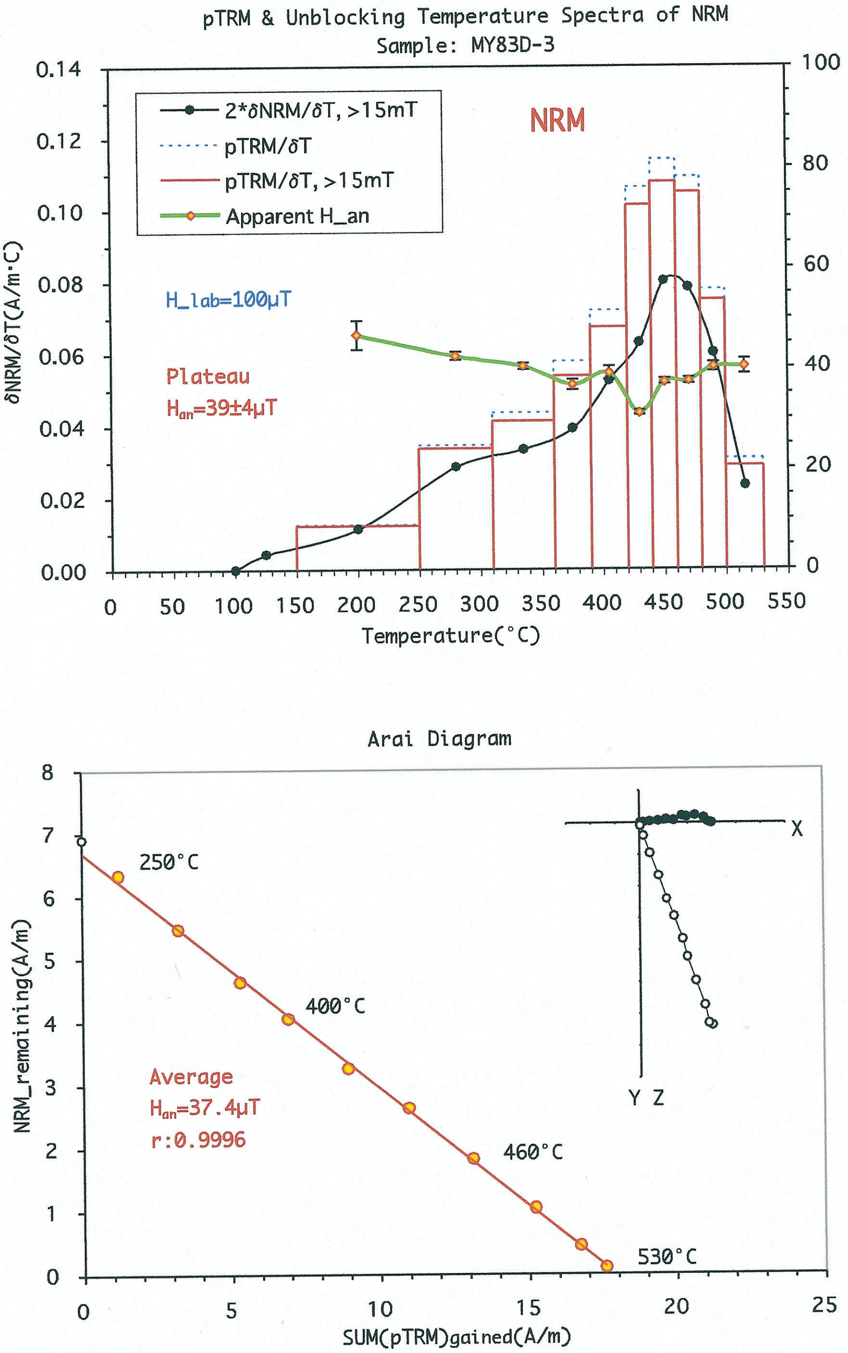


Fig. 5-3-1 Unblocking temperature spectra of NRM & pTRM on MY83D-3

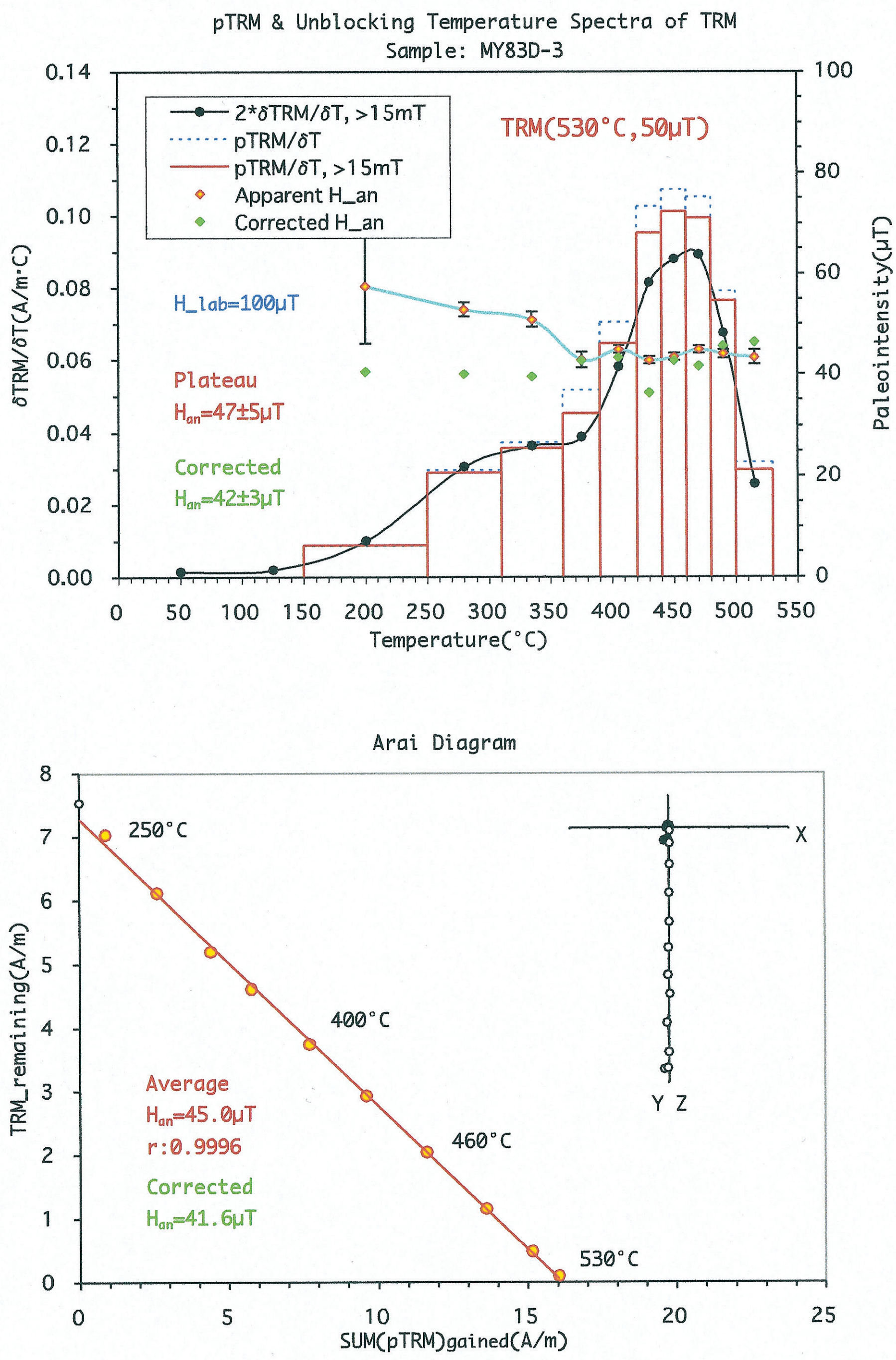


Fig. 5-3-2 Unblocking temperature spectra of TRM & pTRM on MY83D-3

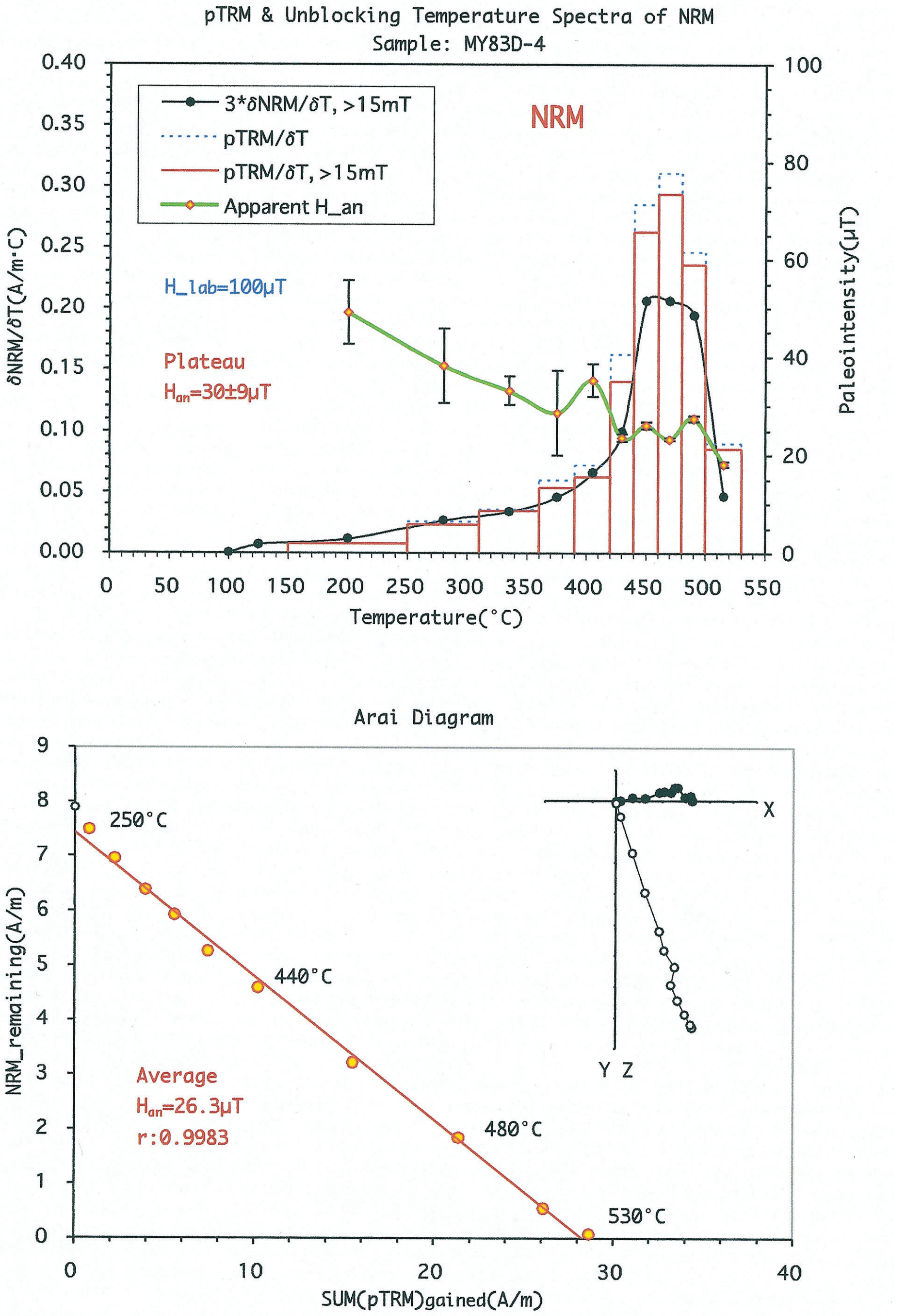


Fig. 5-4-1 Unblocking temperature spectra of NRM & pTRM on MY83D-4

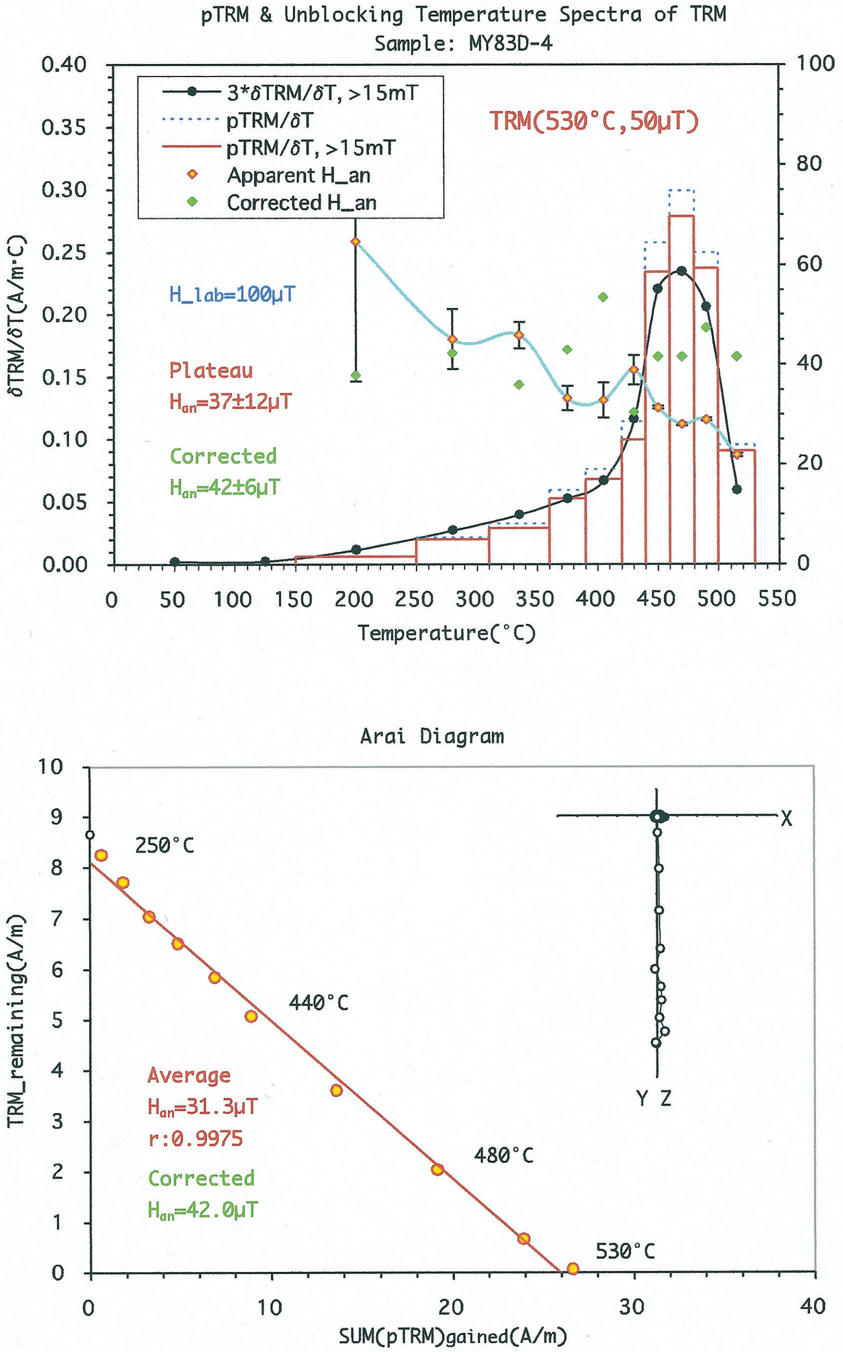
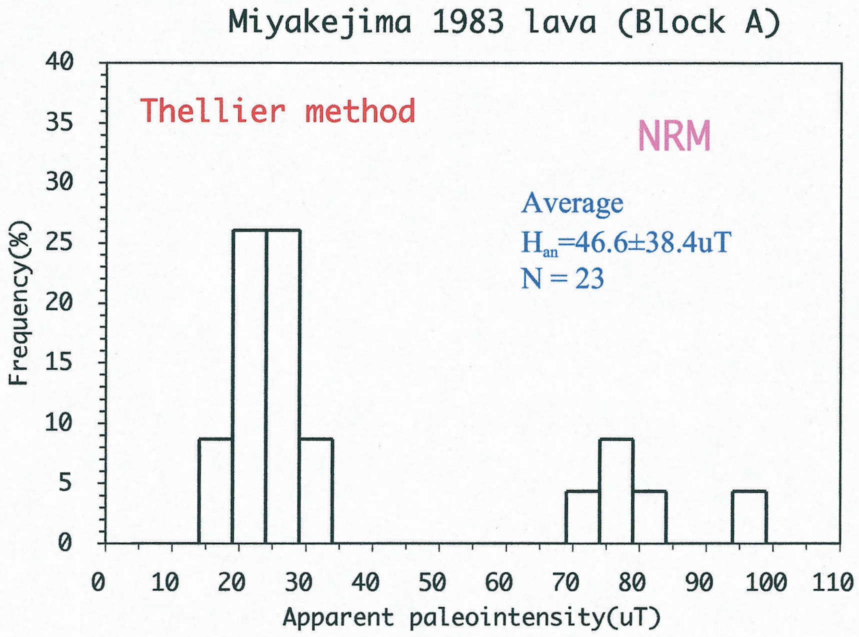


Fig. 5-4-2 Unblocking temperature spectra of TRM & pTRM on MY83D-4



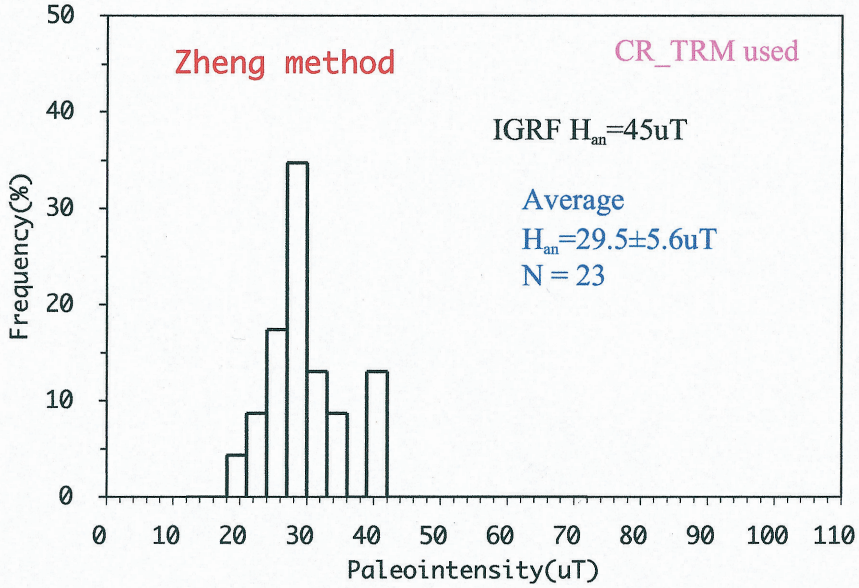
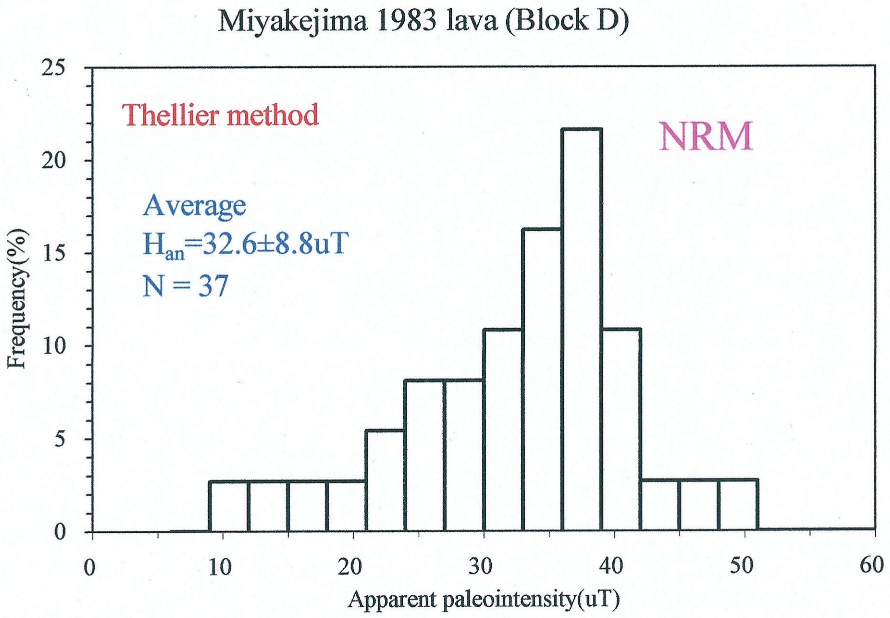


Fig. 6-1 Frequency distribution diagram paleointensity of MY83-A (ruined)



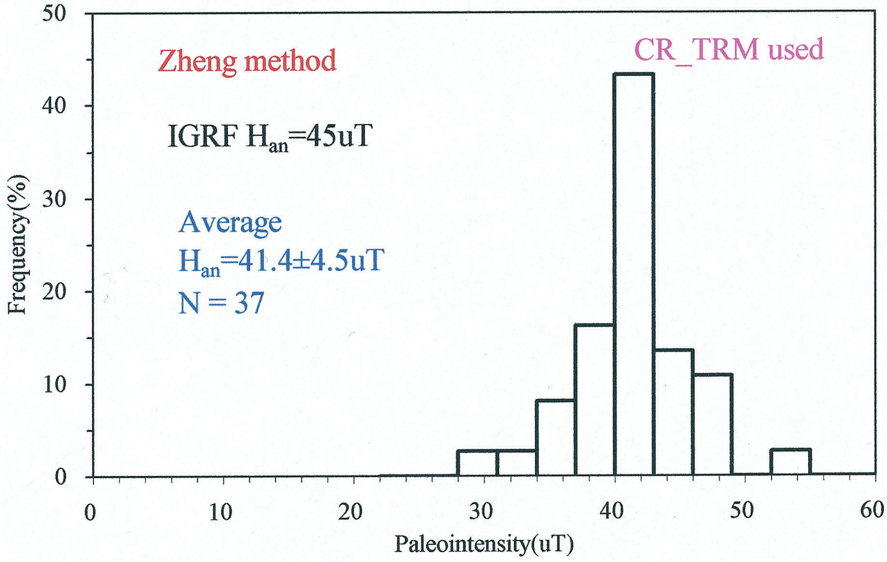


Fig. 6-2 Frequency distribution diagram paleointensity of MY83-D

Table 2 Summary of the intensity of Miyakejima 1983 basalt

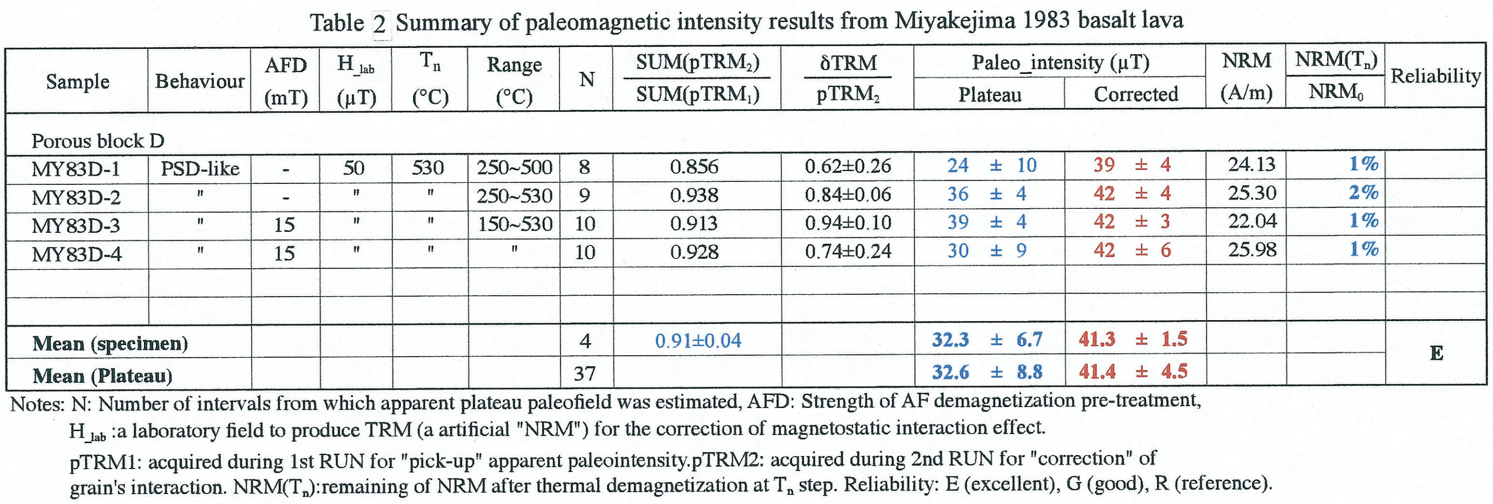


Table 2 Summary of paleomagnetic intensity results from Miyakejima 1983 basalt lava

Sample	Behaviour	AFD (mT)	$H_{\_lab}$ (μT)	T_n (°C)	Range (°C)	N	$\frac{SUM(pTRM_2)}{SUM(pTRM_1)}$	$\frac{\delta TRM}{pTRM_2}$	Paleo_intensity (μT) Plateau	Paleo_intensity (μT) Corrected	NRM (A/m)	$\frac{NRM(T_n)}{NRM_0}$	Reliability
Porous block D													
MY83D-1	PSD-like	-	50	530	250~500	8	0.856	0.62±0.26	24 ± 10	39 ± 4	24.13	1%	
MY83D-2	"	-	"	"	250~530	9	0.938	0.84±0.06	36 ± 4	42 ± 4	25.30	2%	
MY83D-3	"	15	"	"	150~530	10	0.913	0.94±0.10	39 ± 4	42 ± 3	22.04	1%	
MY83D-4	"	15	"	"	"	10	0.928	0.74±0.24	30 ± 9	42 ± 6	25.98	1%	
Mean (specimen)						4	0.91±0.04		**32.3 ± 6.7**	**41.3 ± 1.5**			**E**
Mean (Plateau)						37			**32.6 ± 8.8**	**41.4 ± 4.5**			

Notes: N: Number of intervals from which apparent plateau paleofield was estimated, AFD: Strength of AF demagnetization pre-treatment, $H_{\_lab}$:a laboratory field to produce TRM (a artificial "NRM") for the correction of magnetostatic interaction effect.

pTRM1: acquired during 1st RUN for "pick-up" apparent paleointensity.pTRM2: acquired during 2nd RUN for "correction" of grain's interaction. $NRM(T_n)$:remaining of NRM after thermal demagnetization at T_n step. Reliability: E (excellent), G (good), R (reference).

Summary of the paleomagnetic results from Miyakejima 1983 lava is compiled in Table 2.

We also tried the method of Dekkers and Bohnel (2006) in which only one thermal step of TRM was compared with NRM to estimate paleointensity. A TRM acquired by cooling from its maximum unblocking temperature 530℃ to room temperature was used. The paleointensity was estimated to 41μT, 46μT, 46μT, 49μT (mean 45.5±3.3μT) from 4 specimens respectively. Slight high value of 4μT in Dekkers's seems due to contribution of slight thermal alteration during laboratory heating.

4. Result and Discussion

From 4 thermal stable specimens of MY83-D, a good result was obtained to be 41.3±1.5μT by using Zheng's method and 32.3±6.7μT by using differentiated Thelliers' method; the method of Dekkers & Bohnel yielded 45.5±3.3μT. The paleointensity data of Thelliers' were strongly disturbed by the interaction between magnetic mineral grains, thus cannot to be treated as genuine paleointenisity but apparent one; while little high value of Dekkers & Bohnel is clearly due to slight thermal alteration during experiment. The paleointensity data estimated by Zheng's method is the genuine in situ geomagnetic field record. For reference, the local field is 45.3 μT at the MY83-D site (0.25km height, 34.35N,139.31E) based on IGRF 1985 model. (http://wdc.kugi.kyoto-u.ac.jp/igrf/point/index.html).

The difference between the geomagnetic in situ field and local field is considered due to the remanent magnetization generated by underlain lava flows.

Acknowledgements

Experiments were carried in the Natural Science Laboratory of Toyo university with VSM and Laboratory of Geological Analysis, Earth Science Division, Sogokaihatsu Co.,Ltd by using Sogo model fine-TD thermal demagnetizer, Agico JR-5A magnetometer, KLY-S Kappabridge susceptibility meter and LDA-3A AF demagnetizer.

Sampling was carried out during the field excursion promoted by the Volcanological Society of Japan in 1984..

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要 旨

三宅島 1983 年噴出溶岩の地球磁場強度と磁気特性

上野直子・鄭 重

鄭によって開発された古地球磁場強度測定法を用いて、1983 年に噴出した三宅島玄武岩について、その古地球磁場強度を測定した。岩石採取地点 4 箇所のうち最も熱安定性の高い地点の 4 試料から、41.3±1.5μT の非常に良い値が得られた。また、この 4 試料から微分テリエ法で得られた古地球磁場強度は 32.3±6.7μT であった。なお、標準地磁気モデル IGRF による 1985 年の三宅島の地球磁場強度は 45.3μT である。