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A PRELIMINARY STUDY OF SECONDARY MAGNETIZATION DURING SUCCESSIVE HEATING OF ROCKS FROM THE NAPIER COMPLEX

Naoko UENO[1], Tomoko OGISHIMA[2], Naoto ISHIKAWA[3]
and Minoru FUNAKI[4]

[1] *Natural Science Laboratory, Toyo University, Oka 2-chome, Asaka 351-8510*
[2] *Mejiro Gakuen High School, Nakaochiai 4-chome, Shinjuku-ku, Tokyo 161-0032*
[3] *School of Earth Sciences, IHS, Kyoto University, Sakyo-ku, Kyoto 606-8501*
[4] *National Institute of Polar Research, Kaga 1-chome, Itabashi-ku, Tokyo 173-8515*

Abstract: Secondary magnetization produced during a thermal experiment in Thelliers' method was studied on 12 samples from the Mt. Riiser-Larsen area for that paleomagnetic data already been reported (N. ISHIKAWA and M. FUNAKI: Proc. NIPR Symp. Antarct. Geosci., **10**, 79, 1997), and considered suitable for paleomagnetic study from the rock magnetic characteristics of samples. A remeasurement test of NRM on the same temperature step (NRM-check) as well as PTRM (PTRM-check) in air and in vacuum revealed secondary magnetization concerned with NRM and TRM which appeared at the same temperature, around 350°C, that would be explained by the oxidation of sulfide observed under a microscope. Secondary magnetization around 550°C which appeared in air might also be caused by magneto-mineralogical change. These results are supported by the large variation of initial susceptibility around 300°C and 550°C. Both the secondary magnetization of NRM and that of PTRM produced in vacuum were comparable to in air.

key words: paleointensity, Thelliers' method, secondary magnetization, the Napier Complex

1. Introduction

In a preliminary paleomagnetic intensity study of igneous and metamorphic rocks from the Napier Complex, inconsistent paleointensity was found in the same sample from the low temperature part of the Arai diagram (UENO and FUNAKI, 1991), and very low paleointensity from the high temperature part (UENO, 1995). To discuss the results, investigation of the secondary magnetization produced during the experiment is needed. Secondary magnetization might effect both the demagnetization of the natural remanent magnetization (NRM) and the acquisition of the thermoremanent magnetization (TRM), and induce incorrect paleointensity. Samples for paleomagnetic studies that had already reported ancient VGP (ISHIKAWA and FUNAKI, 1997) were used.

2. Samples

Samples were collected during the 35th Japanese Antarctic Research Expedition (JARE-35, 1993-1995). The localities of samples are shown in Fig. 1. Granulitefacies metamorphic rocks from sites 1 and 2, and a dolerite dike from site 5, were used for analysis. Paleomagnetic and rockmagnetic experiments on the same samples were performed by ISHIKAWA and FUNAKI (1997, 1998). Their work included progressive demagnetization experiments, thermometer analysis, isothermal remanence acquisition experiments and hysteresis measurements. Those results indicate that a principal magnetic carrier is magnetite of pseudo single domain size, which probably occupies a large portion of NRMs. Figure 2 shows progressive thermal demagnetization experiments carried out by ISHIKAWA and FUNAKI (1997). Deviation of the susceptibility from the original is about 10%. The susceptibility change shows a broad peak around

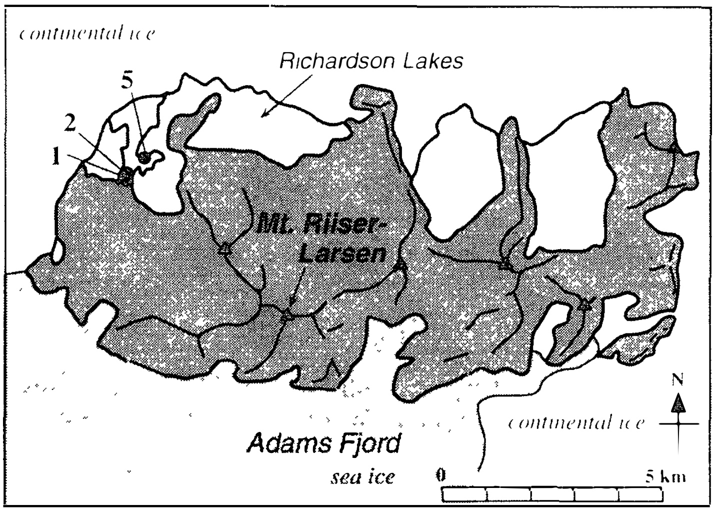

Fig. 1. Sampling sites (modified after ISHIKAWA and FUNAKI, 1997).

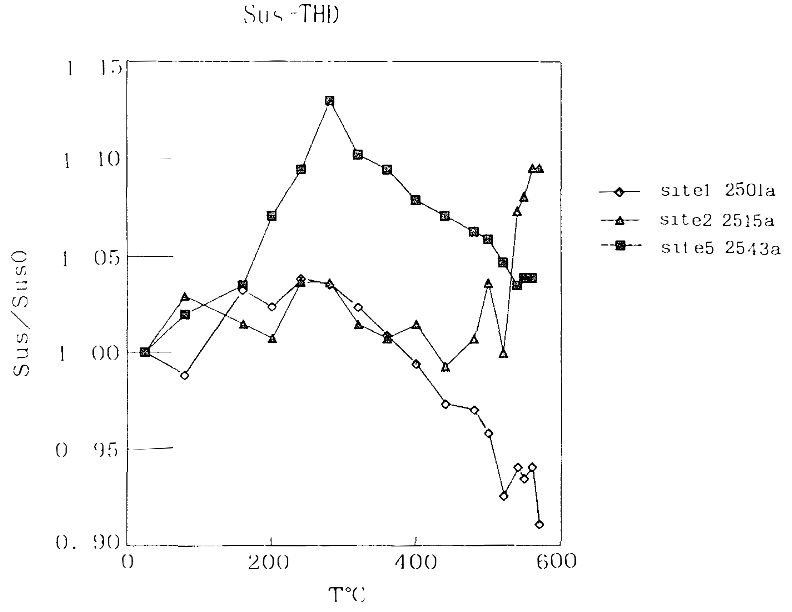

Fig. 2. Change of initial susceptibility during thermal demagnetization.

300°C and an increase above 550°C

Magnetic characteristics of the samples described above seem to be appropriate for study using Thelliers' method.

3. Experiment to Detect Secondary Magnetization

To verify primary thermoremanence or to detect magnetomineralogical changes, improved methodology for Thelliers' has been proposed (*e.g.* McClelland and Briden, 1996; Valet *et al.*, 1996). Referring to these papers, the following experiments were each performed on 6 samples (2 samples from each site) both in air and in vacuum.

Stage 1. Measurement of NRM. Specimens to be experimented in vacuum were AF demagnetized in a 5 mT field in advance.

Stage 2. Thermo-demagnetization of NRM at temperature step T_i.

Stage 3. Acquisition of PTRM by heating and cooling in a 20μT field in T_i.

Stage 4. AF demagnetization in a 5 mT field.

Stage 5. Repeated thermo-demagnetization at T_i.

Stage 6. Repeated PTRM acquisition in a 20μT field at lower temperature, one temperature step below (T_{i-1}).

Stage 7. AF demagnetization in a 5 mT field.

After Stage 7, from Stage 2 to Stage 7 were performed in one temperature step above (T_{i+1}). After the Stage 4 of the final step, TRM was thermally demagnetized progressively.

All the samples are cut to 1-inch standard size. The experiment was performed in air (specified by the name of the specimen starting with A), or in vacuum of about 1×10^{-2} Pa after replacement of air by He (specified by starting with V). The experiment in vacuum was stopped at 500°C by breakage of the instrument. All the measurements were carried out at the National Institute of Polar Research with a three-axis cryogenic magnetometer (2G Enterprises) and thermal demagnetizer made by Schonstead.

Experiments were not performed in a shielded room, but the specimens were always kept in a shielded box.

4. Results and Discussion

In Fig. 3, examples of the NRM checks calculated by subtracting the result of Stage 2 from the result of Stage 5, and normalized to the original NRM are shown. In Fig. 4, examples of the PTRM checks obtained by subtracting the result of Stage 6 at T_i from the result of Stage 3, and normalized to the TRM of the last step at 600°C are shown.

Figures 3 and 4 seem to have the same pattern, that is, the secondary NRM and PTRM are produced at the same temperature. They have two peaks around 350°C both in air and in vacuum, and at 550°C at which all the specimens were in air. Under microscopic observation, sulfide was identified. Sulfide might be oxidized to magnetite at around 350°C. Initial susceptibility change after thermal demagnetization at each step (Fig. 2) suggests magneto-mineralogical change at around 300°C and 550°C, especially on samples from sites 1 and 2 granulite.

After the acquisition of PTRM in Stage 3 and Stage 6, 5 mT AF demagnetization

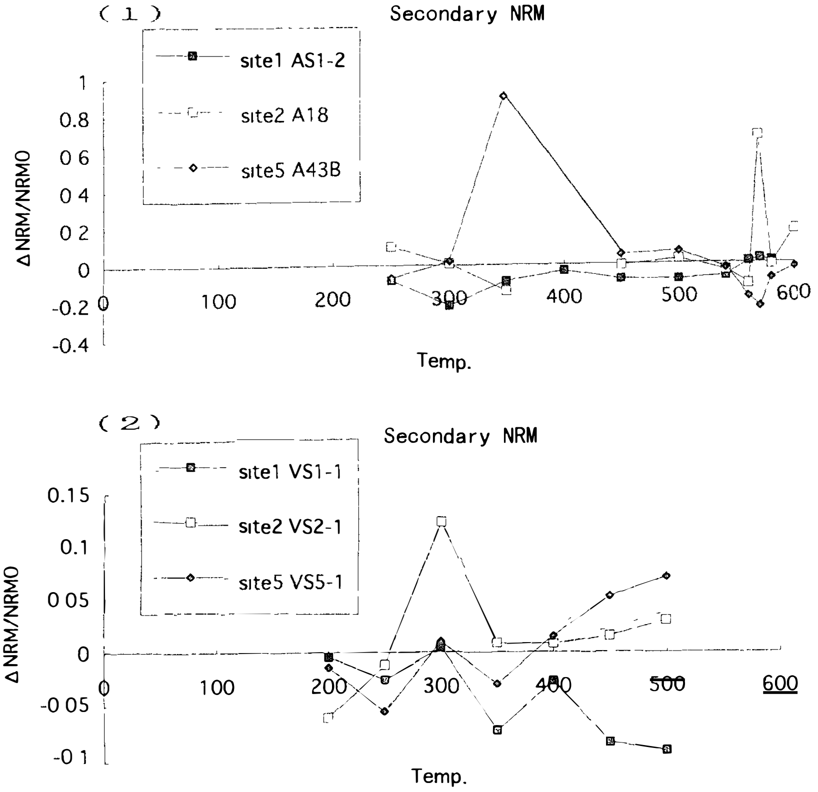

Fig. 3. Examples of NRM-check.

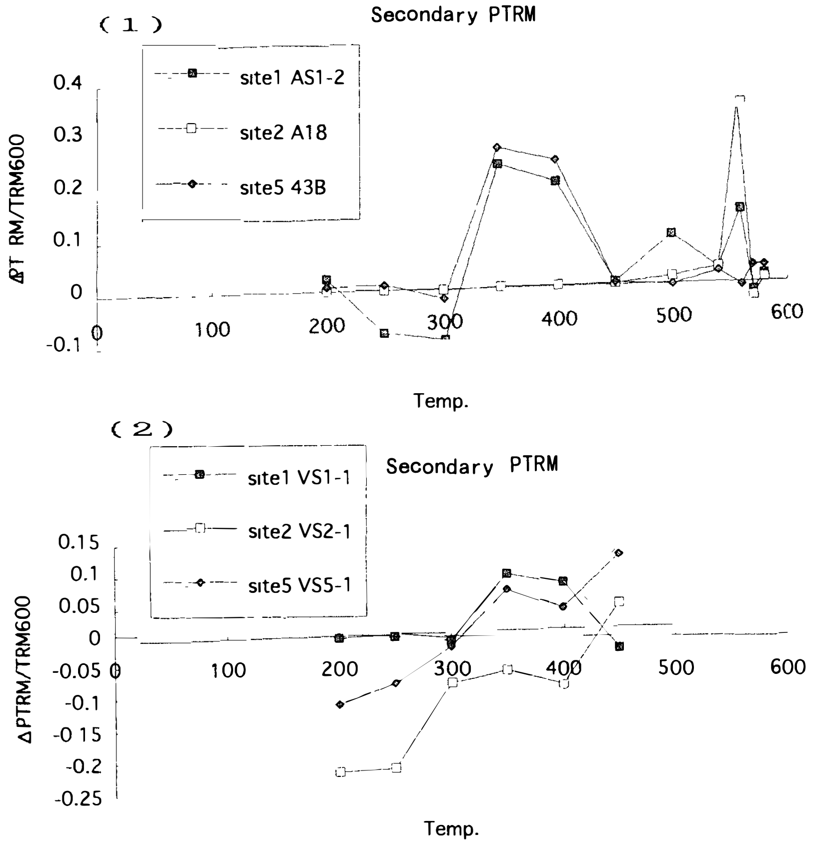

Fig. 4. Examples of PTRM-check.

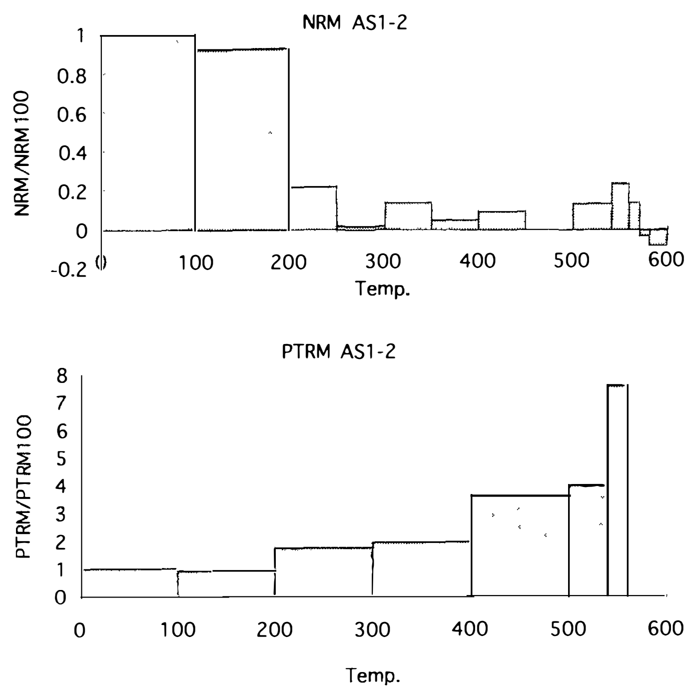

Fig. 5. Unblocking temperature spectra of NRM and blocking temperature spectra of PTRM for AS1-2 (site 1, in air).

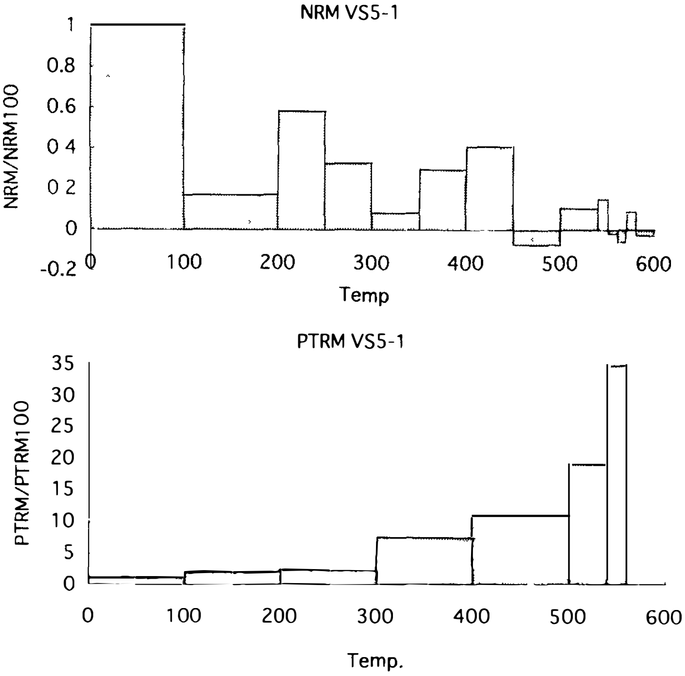

Fig. 6. Same as Fig. 5 but for VS5-1 (site 5, in vacuum).

was performed to decrease the secondary magnetization. Five mT was decided because the MDF of the total NRM of the samples was lower than 10 mT.

Comparison of the normalized data suggests that both the secondary NRM and PTRM are comparable in vacuum to in air.

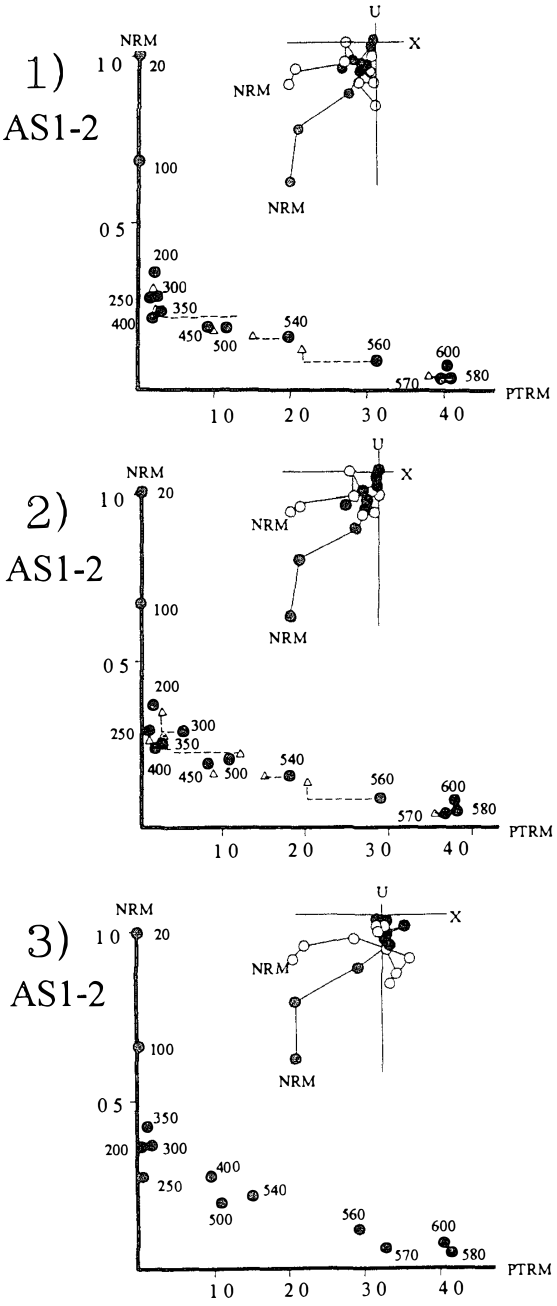

Fig. 7.

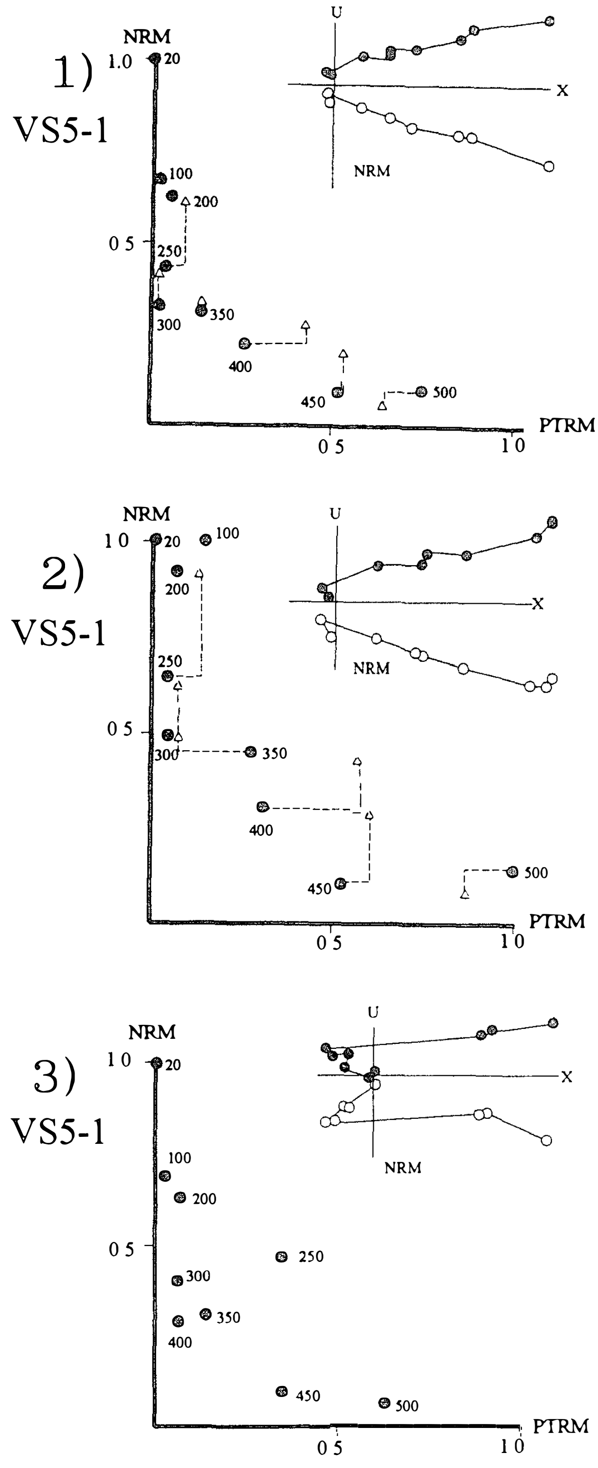

Fig. 8.

Figs. 7, 8. Arai diagrams for AS1-2 (in air) (Fig. 7) and VS5-1 (in vacuum) (Fig. 8).
1) Before AF demagnetization in each temperature step.
2) After AF demagnetization in each step.
3) After correction of secondary NRM and TRM in each step.

In Fig. 5, examples of the unblocking temperature distribution of the NRM and the blocking temperature distribution of the PTRM are shown for a sample in air (AS1-2). In Fig. 6, the same figures as in Fig. 5 are shown for a sample in vacuum. In Fig. 5 and Fig. 6 the pattern should be symmetric when the NRM are of TRM origin. Some specimens (*e.g.* AS1-2) seemed to be symmetric and some (*e.g.* VS5-1) did not.

In Fig. 7, three Arai diagrams for specimen AS1-2 in air are illustrated: 1) by data of Stage 2, Stage 3 and Stage 6; 2) by data of stages 2, 4 and 7; and 3) corrected Arai diagrams over 250°C obtained by subtracting the secondary NRM from Stage 2 for a vertical axis and subtracting the secondary PTRM from Stage 4 for a horizontal axis. In Fig. 8, the same figures as in Fig. 7 for the specimen VS5-1 in vacuum are illustrated. In both figures, the un-corrected Arai diagram seems to have the better linear line than the corrected diagram. We did not calculate the paleointensity in this study because previous works (UENO and FUNAKI, 1991; UENO, 1995) had better Arai diagrams than the best examples (AS1-2,VS5-1) in this study. Decrease of the original NRM by 5 mT AF demagnetization might be the reason for the degraded diagram. It is necessary to have a criterion to decide the AF demagnetization field in Thelliers' method. Even without the procedure for selecting suitable samples for AF demagnetization, this experiment required too many procedures and too much time. A simpler method should be developed.

5. Conclusions

On the samples from the Mt. Riiser-Larsen area collected during JARE-35 that are suitable for VGP study (ISHIKAWA and FUNAKI, 1997), secondary magnetization during successive heating in Thelliers' experiment was studied. Secondary magnetization appeared both on NRM and PTRM around 350°C and 550°C. Sulfide in the samples might be the main cause of the secondary magnetization around 350°C. For the paleointensity study, sulfide should be removed in advance. A criterion is needed to utilize the AF demagnetization in Thelliers' method.

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