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PALEOMAGNETISM OF SOME PALEOGENE GRANITE [I]

by

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Abstract

Granitic rocks dated at 36 to 64 million years were collected from eight localities in San-in district, and the magnetic polality versus their ages was determined by paleomagnetic methods. Samples dated at 57±3 and 63 million years have shown the normal polarity after stability tests and those dated at 46 and 50±6 million years the reversed polarity. The direction of the natural remanent magnetization of samples taken from Ningyō-tōge, Sangenya and Ōtani deviated slightly from the present geomagnetic field direction. It is likely to be due to change in direction of the geomagnetic field such as a field reversal or secular variation.

(1) Introduction

It now is established that the geomagnetic field has frequently changed its polarity during Tertiary and Quaternary. A reversal pattern of the geomagnetic field during the last several million years has been made as the result of combined paleomagnetic measurements and potassium-argon dating of igneous rocks (Cox et al, 1964). On the other hand, extention of the reversal time scale has been done back to 80 million years by extrapolation based on sea floor spreading patterns (Heirtzler et al, 1968). This data should be needed an additional data on age versus magnetic polarity from the continents, in order to know the complete history of the geomagnetic field reversal in all.

Many dated granitic rocks belonging to the early Tertiary and Cretaceous periods are widely exposed in the San-in district. It is reported that some of them have stable permanent magnetization (Kawai et al, 1962 ; Sasajima et al, 1968). Granitic rocks acquire a permanent magnetization depend on the orientation and strength of the geomagnetic field at that time, when they cool through the Curie point in a magnetic field. The granitic magma laid down next to the preexisting rock is chilled by contact with the colder preexisting rock, and a thermal gradient is established in the granitic rock mass. This shows that an initially uniform magma body is chilled more near its contact than in its center, and that rock samples in the body will have different magnetic age between the contacts and the inner part. Such a slow cooling of granitic rocks becomes unfavorable for stability of the natural remanent magnetization (NRM) and is favorable for tracing continuous change in direction of the geomagnetic field. From these points of view mentioned above, we collected samples of dated granitic rocks and measured the NRM. In this paper results of preliminary paleomagnetic studies will be described.

(2) Sampling and measurements

The granitic rocks exposed in San-in granitic belt have been dated by some investigators (Nozawa, 1970). The results of these age determinations indicate that the granitic rocks in this region is the late Cretaceous and Paleogene periods. Especially, dated paleogene granitic rocks are exposed in Ningyō-tōge and its vicinity, Tottori and Okayama prefecture, and Yokota-cho and its vicinity, Shimane prefecture. The granitic rocks exposed in the vicinity of Yokota-cho are noted as the host rock of "Tatara" iron manufacture. Toyota (1962) reported that TiO_2 content of magnetite including in the host rock is characteristic of being rare. Such host rocks are likely to be mainly biotite granite. The rock masses in the vicinity of Ningyō-tōge are mostly granodiorite or diorite and the dating gives results of 36 to 64 million years (Kawano and Ueda, 1966 ; Shibata et al, 1968).

Oriented hand samples were taken from each dated rock body near Ningyō-tōge, and in Yokota-cho and its vicinity. The samples were collected from two or more sites at the same localities where dated samples might be taken. Hand samples are about 200 gr in weight and laboratory specimens cut from them in cubic. The ages and sampling sites are shown in Fig. 1.

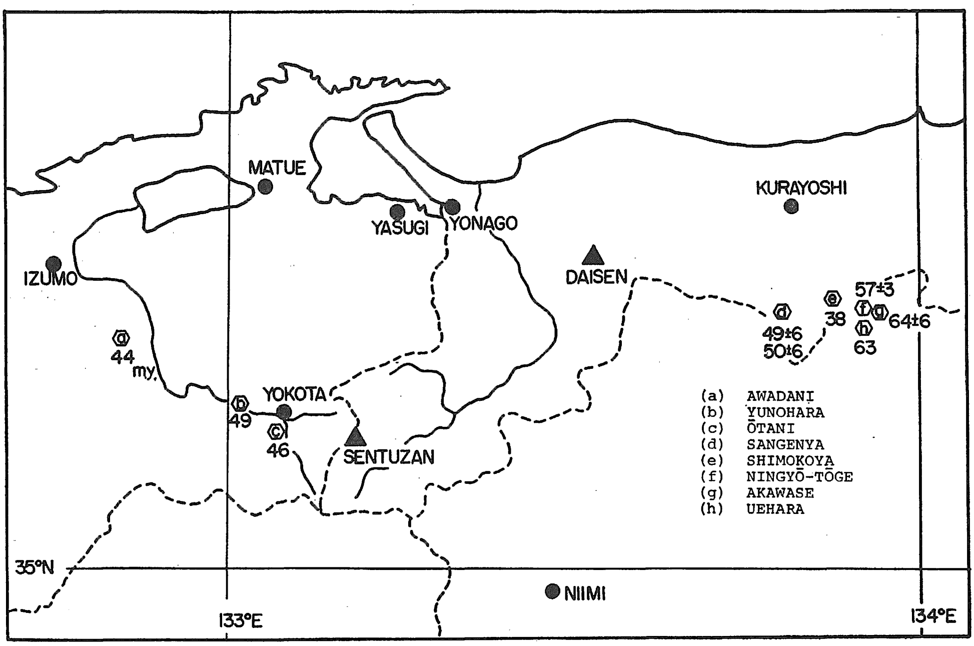

Fig. 1. Map of sampling area.

All samples were measured by an astatic magnetometer and some of them were demagnetized in the A. C. field up to 200 or 500 oe. A few examples of the A. C. demagnetization of 100 oe are shown in Fig. 2. Samples taken from Ōtani and Sangenya

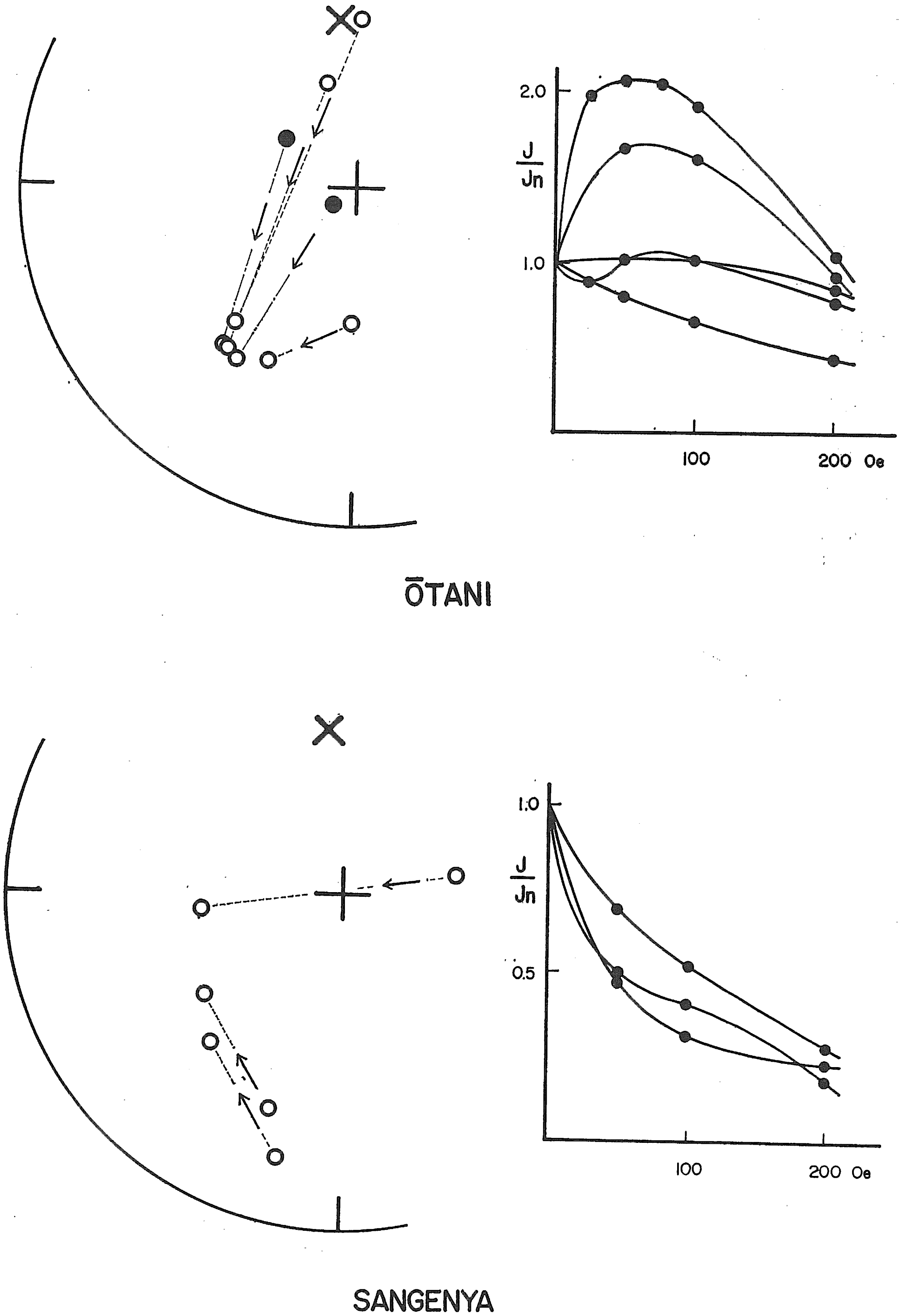

Fig. 2. Examples of NRM directions after A. C. treatment of 100 oe and demagnetization curves for samples with stable reversed magnetization.
×: Direction of the present geomagnetic field.

are reversely magnetized after the A. C. demagnetization of 100 oe, and samples from Uehara and Ningyō-tōge are normally magnetized after storage treatment. Rocks sampled in the other localities changed its NRM direction at random during demagnetization

Table (1)

Locality	Age	Rock kind	Stability	Intensity	D	I	K
Akawase	64±6 m. y.	granodiorite	unstable	3.5×10^{-5} emu/gr			
Uehara	63	granodiorite	stable	0.61	354°21′	+47°55′	32
Ningyō-tōge	57±3	granodiorite	stable	2.6	320°06′	+42°26′	13
Sangenya	50±6 49±6	granodiorite	stable	2.8	207°42′	−48°17′	25
Yunohara	49	granodiorite	unstable	2.5			
Ōtani	46	granodiorite	stable	7.4	210°10′	−41°01′	242
Awadani	43	granodiorite	unstable	0.9			
Shimokoya	38	granite	unstable	1.9			

D, I : Declination and Inclination of stable NRM
K : Precision

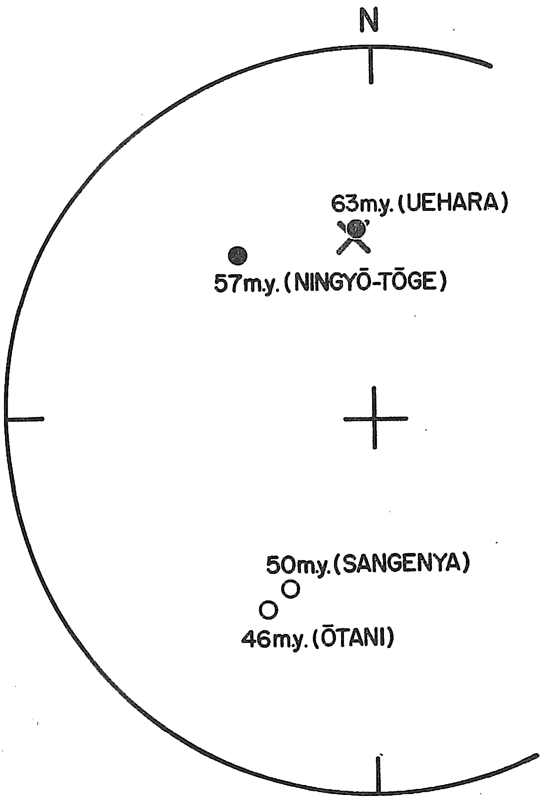

Fig. 3. Mean NRM directions and ages of samples with stable magnetization
× : Direction of the present geomagnetic field.

or storage treatment. However, their intensity of the NRM was the order of 10^{-5} emu/gr and the same order with that of the samples with the stable NRM.

The results of measurements are tabulated in Table 1 and NRM directions of samples with the stable component are also seen in Figs. 2 and 3. Intensity of the reversed NRM after the treatment of 100 oe is the same order with that obtained from the Laurel Hill and Tatoosh intrusions of 8 and 15 million years (Ito and Fuller, 1970). The direction of the reversed NRM deviated slightly from that of the present geomagnetic field, and also that of the normal one obtained at Ningyō-tōge represented the same tendency.

(3) Discussion

Granitic rocks have been injected into pre-existing rock being several hundred meter or more under the surface. The rocks are subjected to some physical or chemical changes since they were laid down. Unfortunately, the primary magnetization of the granitic rocks tends to be destroyed by physical changes or modifications that take place in such rocks. Of course, the rocks which the primary magnetization were completely destroyed are clearly unsuitable for paleomagmetism. On the other hand, the granitic rocks have a special feature being able to trace continuous change in direction of the geomagnetic field. Therefore, samples with the stable magnetization will give some informations about the history of the geomagnetic field. Although an opportunity to encounter the rock body having the stable NRM are not so frequent in the field, younger granitic rocks than the Cretaceous rocks often have the stable component of magnetization which it seems to be primary after stability tests of magnetization.

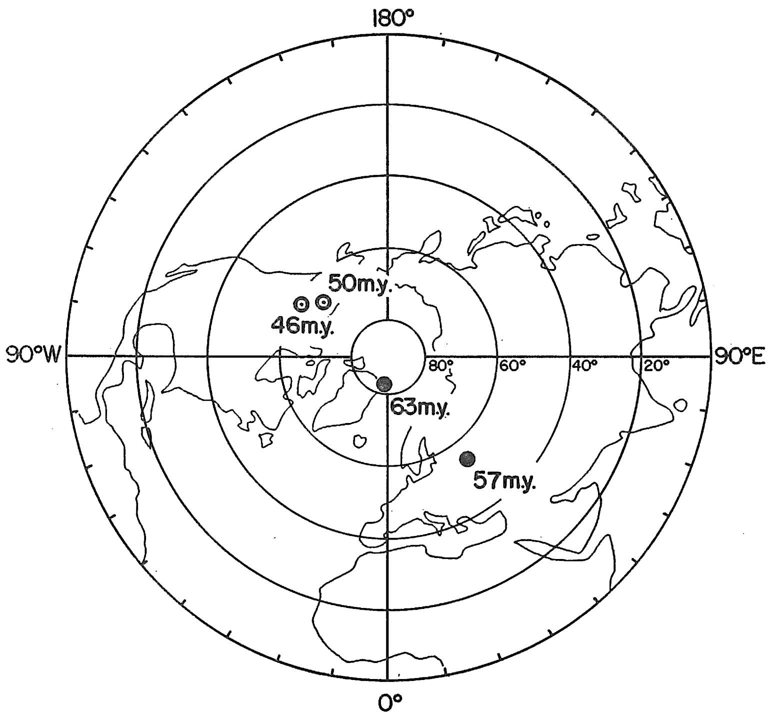

Fig. 4. Paleomagnetic pole positions for stable normal and reversed samples from Uehara (63 m. y.), Ningyō-tōge (57 m. y.), Sangenya (50 m. y.) and Ōtani (46 m. y.)
● : North seeking pole
◉ : South seeking pole

A few granitic rock bodies having the stable NRM after the A. C. demagnetization or storage treatment have been found in Yokota-cho and near Ningyō-tōge. The samples taken at Ōtani (46 m. y.) and Sangenya (46±6, 50±6 m. y.) were reversely magnetized and those at Uehara (63 m. y.) and Ningyō-tōge (57±3 m. y.) were normally magnetized. This results indicates that the geomagnetic field had reversed itself at about 46 million years ago and was normal at about 60 million years ago as seen in Fig.4. Although the direction of NRM of samples obtained from Ōtani, Sangenya and Ningyō-tōge deviated slightly from the present geomagnetic field direction, it is unlikely to be due to the geotectonic movement such as bending of Japanese Islands (Kawai et al, 1961) or due to the poler wandering. This deviation is likely to be based on short changes in the geomagnetic field such as a secular variation or field reversal.

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