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Author(s)	Fujiwara, Yoshiki
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CHANGING OF THE PALAEOLATITUDE IN THE JAPANESE ISLANDS THROUGH THE PALAEOZOIC AND MESOZOIC

by

Yoshiki FUJIWARA

(with 4 Text-figures)

(Contributions from the Department of Geology and Mineralogy, Faculty of Science, Hokkaido University, No. 1088)

Introduction

Much has been done in Japan in various fields of palaeomagnetism since the earlier works of the Late Prof. MATSUYAMA (1929). The palaeomagnetic studies in Japan were, however, almost exclusively made only on the Cenozoic rocks until some ten years ago. Under such circumstance, Prof. Minato proposed the author to set to a palaeomagnetic study on the Japanese Palaeozoic and Mesozoic rocks. It was spring field season of 1962, when he was first guided by Prof. MINATO and his co-workers in the Kitakami mountains, N. E. Honshu for sampling of rock specimens for the palaeomagnetic study where the Palaeozoic formation are most well developed in Japan.

The results of measurement on magnetic properties of the important Palaeozoic sequence in that area have been reported in a series of papers (MINATO and FUJIWARA, 1963, 1965). After then, the author tried to sample the Palaeozoic rocks in the Kwanto mountains, Central Honshu, and at a few localities of the Western Honshu, with desiring to collect suitable material for measurement. The result of magnetic investigation on these rocks was also given in his previous paper (FUJIWARA, 1967). He further extend the sampling practice on the Mesozoic rocks; he visited a few localities in Kyushu to collect the Triassic basic volcanics; in Central Hokkaido, the Jurassic basic rocks; in the Kitakami mountains and Hokkaido, the lower to Uppermost Cretaceuos basic volcanics. The results on palaeomagnetic measurements on those specimens have also been published thereafter (FUJIWARA, 1966, FUJIWARA and NAGASE, 1965).

While the author's investigation, palaeomagnetic data on some Japanese Mesozoic rocks have been given, thanks to the efforts of specialists as SASAJIMA and SHIMADA (1966) and UENO (1967), being followed by the elaborate work made by NAGATA et al. (1959). Thus, it may become possible to challenge to synthese the palaeomagnetic data on the Japanese Palaeozoic and Mesozoic rocks. No need to state, however, that much should be done in future to finally elucidate any geological meaning from them.

At the present moment, palaeolatitude of the Japanese islands seems to have been smoothly changed from north to south through Devonian to Triassic age. It had also been gradually shifted northward from the Triassic to the end of the Cretaceous, so far as the available data on palaeomagnetic studies are concerned. The changing of latitude through geological ages seems to be well harmonized with the climatic change of the Japanese islands postualated from the palaeoclimatic data, as is previously reported by MINATO and FUJIWARA (1964).

When the palaeomagnetic data are examined more carefully, the northern and southern half of the Japanese islands have been possibly shifted in different direction respectively, since the early Cretaceous, viz, the rate of changing of palaeolatitude seems to have been different between northern and southern half from the Late Mesozoic. Similarly, the different tectonic movement between northern and southern half of the Japanese islands in respect to the major direction of crustal folding since the Late Mesozoic or in early Tertiary has been also previously inferred by KAWAI et al. (1961) through their palaeomagnetic study.

1. *Palaeomagnetic properties of the measured rock specimens of Japanese Palaeozoic and Mesozoic formations*

The volcanics or pyroclastic rocks in the most of stratigraphic units developed in the Devonian, Carboniferous and Permian formations in the Kitakami mountains (MINATO, 1941, 1960, 1961, 1962, MINATO et al., 1959a, 1959b).

Nearly all of the sampled volcanics for magnetic measurement at laboratory were placed. Because of weak remanent magnetism and limitted efficiency of the available astatic magnetometer, palaeomagnetic properties were, however, only measurable on the rocks with more typical basaltic properties, and limitted to the rest.

The horizon, locality and petrographic nature of those rocks, whose palaeomagnetic properties were measured is presented in the Table 1.

A Lower Pennsylvanian reddish coloured shale collected at Ohkubo, Province of Nagato, S. W. Honshu, which is a stratigraphic unit below the *Nagatophyllum* zone, examined as is also given in the Table 1. In addition to the Palaeozoic rocks, the results of measurements for the Mesozoic rocks, also already given in various periodicals, are listed in the same table.

The direction and intensities of N. R. M. were measured by an astatic magnetometer at the palaeomagnetic laboratory of the Department of Geology and Mineralogy, Hokkaido University.

The mean direction of sampled rocks for each locality and the value of radius of the circle of confidence (α_{95}) were calculated based on FISHER's statistic method

Table 1

Geological age	Sampling Locality	D	I	Pole Position	λp	Rock	Reference
Uppermost Creta. (Senonian)	Nemuro Peninsula	314	83	52N, 128E	67	Porphyritic basalt	Fujiwara & Nagase (1965)
"	"	4	77	68N, 150E	56	"	"
Uppermost Creta. (Seno.-Danian)	"	69	−72	25N, 112E	57	Pyroxine-monzonite	"
Uppermost Creta. (Touro.-Coni.)	Kisa, Yamaguchi pref.	80	53	35N, 146W	34	Andesite	Sasajima & Shimada (1966)
Low Creta. (Albian-Aptian)	Hikojima, Yamaguchi pref.	45	50	47N, 143W	32	Andesite	"
Low Creta. (Aptian)	Kamaishi, Iwate pref.	327	50	62N, 45E	29	Granodiorite	Ueno (1967)
"	"	299	35	38N, 57E	26	Qz-diorite	"
Low Creta. (Neocomian)	Kitakami district	34	−23	30S, 101E	10	Basaltic tuff	Fujiwara (1966)
Mid-Low Cretaceous	Yamaguchi pref.	58	50	42N, 153W	32	Red shale	Nagata et al. (1959)
Up. Jurassic	Kitakami district	327	41	57S, 147W	21	Shale	Nagata et al. (1960)
"	"	334	34	59S, 155W	16	Standstone, Shale	"
Up. Triassic	Kumamoto pref.	350	3	58N, 30W	5	Basaltic andesite	Fujiwara (1968)
Low Permian	Kitakami district	12	31	65N, 67W	10	Magnetite sandstone	Minato & Fujiwara (1965)
Up. Carb. (L. Pennsylvanian)	Akiyoshi province	245	27	7S, 67E	17	Red shale	Fujiwara (1967)
Low Carb. (Mississippian)	Kitakami district	8	39	71N, 63W	20	Basaltic tuff	Minato & Fujiwara (1965)
Mid. Dev.	"	71	64	39N, 166W	43	"	"

(FISHER, 1955). The stability of measured N. R. M. of rocks of each locality and horizon was carefully examined by various methods such as alternative magnetic field demagnetization, thermo-demagnetization, thermomagnetic analysis and X-ray analysis. A storage test was also adopted on the samples of reddish coloured shale from the Akiyoshi Province, Lower Pennsylvanian in age.

The data from the specimens with more reliable remanent magnetism are only adopted for geologic consideration. The samples with unstable palaeomagnetic properties are placed out of consideration from the present study.

2. Result of measurement for the palaeomagnetic properties of the Triassic basic volcanics in the Kōnose district, Kyushu

Triassic formations have long been believed lacking volcanics in every horizons of almost everywhere throughout Japan. Single exception for this was relatively thin tuff included in the Lower part of the Scythian formations developed in the northern end of the Kitakami mountains (ONUKI, 1956). The rock is the andesitic tuff or sandstone with volcanic glass (MINATO, 1968, oral information). Such being the case, new find of thick basic pyroclastic rock series in the Late Triassic formation by KANMERA and FURUKAWA (1964) from the central part of Kyushu is remarkable contribution for the Japanese geology.

The rock samples of basic lava were collected from the Kōnose district where the limestone and basic lava is developed in alternation. According to KANMERA (1964), the age of these sampled rocks is ranging from the Carnic to Noric.

The results of measurements of these basic rocks are given in the Table 1. The stability of the magnetic properties for these rocks have been also throughly tested and obained statisfactory result as shown in Fig. 1, 2.

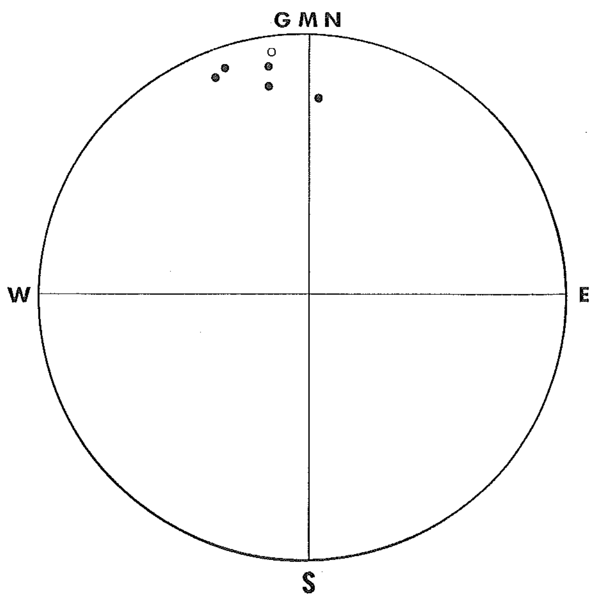

Fig. 1
The directions of magnetization of Triassic basic volcanics collected from Kōnose district, Kyushu.

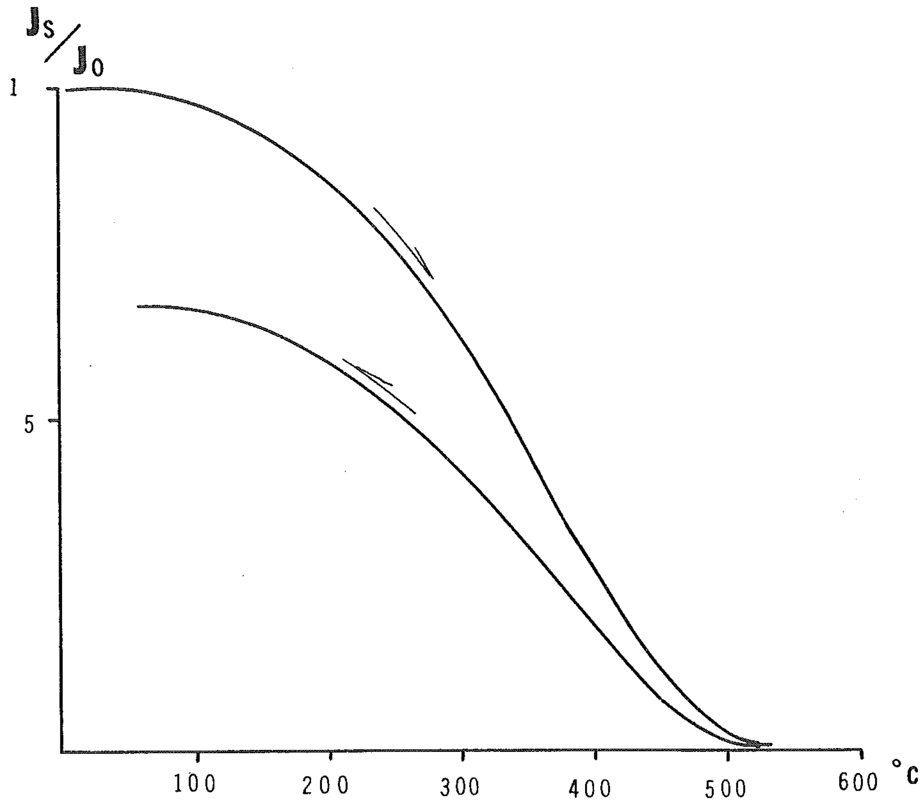

Fig. 2
Thermomagnetic curve of the Triassic basic volcanics.

3. *Pole position and palaeolatitude of the Japanese islands in the Palaeozoic and Mesozoic and its bearing on crustal movement*

The pole position of various geologic ages postulated from the result of palaeomagnetic measurements on the Japanese rocks described in the above is presented in the Table 1.

As is shown in the table and also in the Fig. 3, the virtual pole positions are widely scattered on the earth, and no regularity is perceived in their geographical distribution from the view point of geologic sequence. However, the shift of palaeolatitude of the Japanese islands through geological ages suggests that it have been occured in the past with a certain regularity.

As is shown in the Table 1, the palaeolatitude of the Japanese islands seems to have been smoothly changed. Namely, the Middle Devonian is 43°N, Lower Carboniferous Tournasian: 20°N, Namurian: 17°N, Lower Permian: 10°N and

Fig. 3
Positions of the virtual geomagnetic poles inferred from Japanese Palaeozoic and Mesozoic rocks.
1 : Middle Devonian, 2 : Tournasian, 3 : Namurian 4 : Sakmarian, 5 : Carnian-Norian, 6 : Neocomian 7,8,9 : Uppermost Cretaceous black circle : northern hemisphere, white circle southern hemisphere

Late Triassic: 5°N.

The palaeolatitude for Devonian, Lower Carboniferous and Permian are postulated from the rocks sampled in the Kitakami mountains, N. E. Honshu, while the palaeolatitude for the Namurian and Triassic are from the S. W. Japan. It should be noticed that the palaeolatitude inferred from the rocks both in northern and southern half of Japanese islands may well line up along the smooth curve from north to south. In the text-figure 2, black circle means the palaeolatitude postulated from the rocks sampled either in the northern Honshu or Hokkaido, while the white circle either from the Southwestern Honshu or Kyushu. The de-

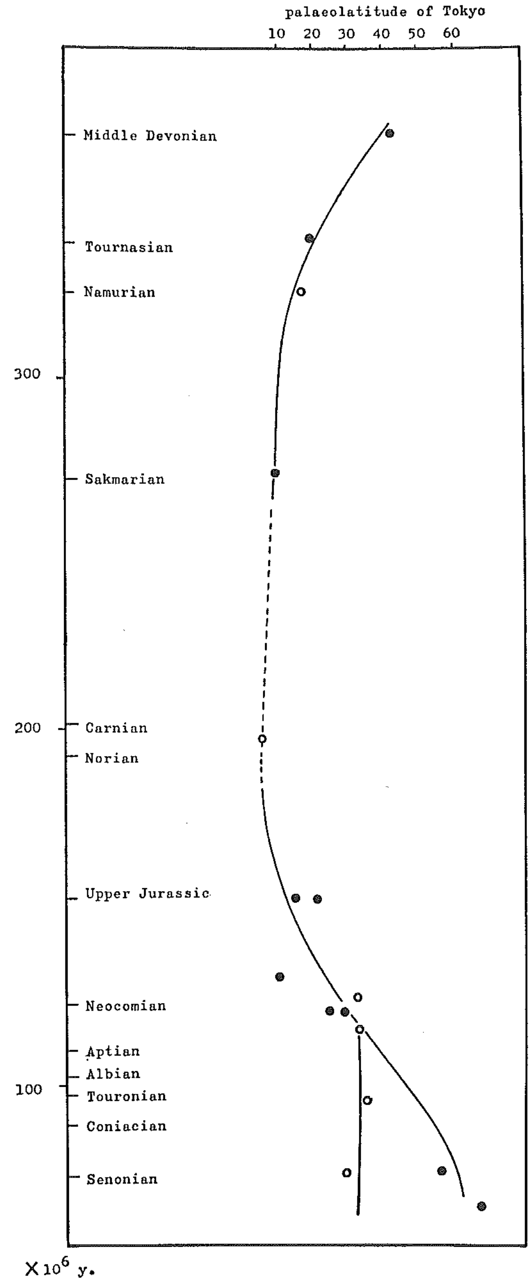

Fig. 4
Changing of the palaeolatitude of Tokyo through the Palaeozoic and Mesozoic estimated from the palaeomagnetic studies on the Japanese rocks. Time scale is based on the Holm's symposium volume (1964).

grees of latitude in this figure are shown as the latitude of Tokyo, viz. all the estimated degrees of palaeolatitude for each sampled locality are calculated as being represented by the latitude of Tokyo.

From the Late Triassic to the end of the Cretaceous, the changing of latitude seems to have been shifted from south to north in general. Namely, in the Late Triassic; 5°N, Upper Jurassic: 16°–21°N, Neocomian; 9°N, Aptian; 26°–29°N, Aptian-Albian: 32°N, Turonian-Coniacian; 35°N, Uppermost Cretaceous: 56°–67°N, respectively. The Upper Jurassic, Neocomian and Aptian, Uppermost Cretaceous are inferred from rocks sampled from Northern Japan and the Late Triassic, Albian and Turonian-Coniacian are the consequence of estimation from the rocks collected in Southern Japan.

It could be concluded that the palaeolatitude of the Japanese islands have been gradually shifted from north to south since the Late Triassic until the end of the Cretaceous.

However, the palaeolatitude postulated from the rocks sampled from the Southern Japan do not show any meaningful fluctuation for the age ranging from the Cenomanian until the Palaeogene, while the palaeolatitude shown by the rocks from the Northern Japan seems to have been ever shifted northward from the Aptian until the Palaeogene through the end of the Cretaceous. Therefore, the rate of changing of palaeolatitude may have been different between northern and southern half of Japan since the Cenomanian.

The shift of palaeolatitude and pole position inferred from the Japanese Palaeozoic and Mesozoic rocks could be interpreted in various ways. The result of palaeomagnetic studies summarized in this paper, suggests that a horizontal shifting of the Japanese islands could have occured in the geological past in addition to the shift of the pole position. Further, it is believed that the rate of horizontal shifting and its direction might become different between northern and southern part of Japan since the Middle Cretaceous.

In conclusion, the entire Japanese islands including the main four islands, may have been shifted smoothly from north to south since the Middle Devonian to the Late Triassic and also smoothly northward during the age ranging from the Late Triassic to the Early Cretaceous. This changing seems to well conform with the climatic changing inferred from the palaeoclimatic data in concern to geohistory of the Japanese islands, as is once stated by MINATO and FUJIWARA (1964). The movement may have different between northern and southern half of the Japanese islands since the Cenomanian. At least, the horizontal movement may have been more stronger in the northern half compared to the southern part during the Late Cretaceous and Palaeogene.

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