Jour. Fac. Sci., Hokkaido Univ., Ser. IV,
vol. 19, nos. 1-2, March, 1979, pp. 189-198.

PALEOMAGNETIC STRATIGRAPHY OF VOLCANIC PRODUCTS IN SOUTHWESTERN HOKKAIDO, JAPAN

– Paleomagnetic studies of the Pliocene and Pleistocene volcanic products in Hokkaido, 2nd report –

by

Yoshiki Fujiwara and Shomei Okada*

(with 5 text-figures and 1 table)

(Contribution from the Department of Geology and Mineralogy,
Faculty of Science, Hokkaido University, No. 1634)

Abstract

A paleomagnetic study was made on 149 specimens from 31 sites on Pleistocene volcanic products developing in southwestern Hokkaido. Of them, two pyroclastic flows and one lava flow are reversely magnetized. The boundary between the Brunhes normal and the Matuyama reversed epochs probably took place sometime during the eruption of volcanic products developing around the Toya and also Shikotsu Caldera in southwestern Hokkaido, North Japan.

Introduction

The concept that the earth's magnetic field may not always had the same polarity as it has today had already apprehended early this century (Brunhes 1906, Matuyama 1929). The recent progress of paleomagnetic studies and also K-Ar age determinations have led the applicability of the geomagnetic polarity time scale to geochronology especially for the past 4 m.y. Paleomagnetic method applied to stratigraphic correlation is called paleomagnetic stratigraphy. Intervals, during which the geomagnetic field had predominantly one polarity have been termed epochs. They generally have durations of the order of 10^6 years. Events which have an order of magnitude shorter occur within epochs. The result of the interpretation of the ages of the magnetic stratigraphy followed by the time scale on the basis of K-Ar age determinations is shown in Fig. 5. The stratigraphic nomenclature used for this figure is based on that of Cox and Darlymple (1967).

Various types of pyroclastic deposits including pumice flow and fall deposits ranging from the Lower Pleistocene to Holocene are widely develop in Hokkaido. We have long collaborated with Prof. Minato in field to settle the stratigraphic sequences of these pyroclastic deposits and tried to correlate them to the present international standard stratigraphy (Minato et al 1970, 1972a, 1972b). In addition to these stratigraphic investigations we have tried to applicate paleomagnetic methods on these pyroclastic sequence to settle more exact stratigraphic position. Some results of magneto-stratigraphic analysis of volcanic products in southwestern and also central Hokkaido were already reported (Hashimoto et al 1968, Fujiwara 1972 and Fujiwara et al 1975).

In this paper, further results of paleomagnetic analysis on pyroclastic deposits developed in southwestern Hokkaido and discussions on their stratigraphic positions corellate to the international standard paleomagnetic polarity time scale are briefly given.

* Present address: Department of Earth Science, Faculty of Education, Tottori University, Tottori 680

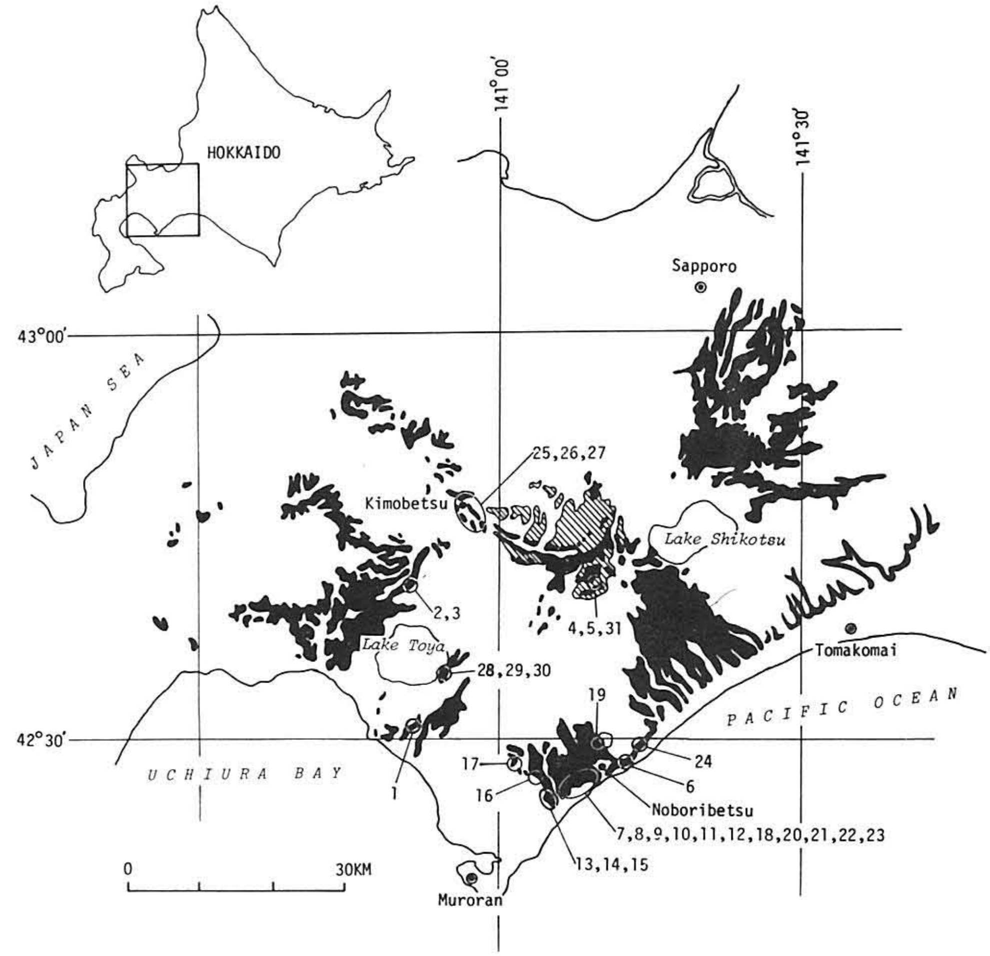

Fig. 1 Distribution of the Quaternary pyroclastic deposits and the volcanic product developed in the Shikotsu – Toya districts.
Black: Pyroclastic deposits. Hatched: the Sokeishu lava. Numerals correspond with the numbers of the sampling sites shown in the Table 1.

Sampling and lithologic characteristics of sampled rocks

The Pleistocene volcanic products developed in southwestern Hokkaido are mainly composed of ash and pumice flows, either welded or non welded, ash and pumice falls, and pumiceous gravel. Of these ash or pumice falls generally occupy the lower horizon of any given volcanic sequence such as the Ranpoge, Noboribetsu, Shadai, Ponayoro, Morino and Shikotsu volcanic Formation (Minato et al, 1972). The samples for the present study were collected on 31 sites from eight pyroclastic deposits and one lava flow as shown in Fig. 1. The stratigraphic position and it's lithologic characteristics of each sampled pyroclastic unit are briefly given as follows:

The Sobetsu pumice flow: The Sobetsu pumice flow locally distributes along at southeastern margin of the Toya Caldera. This pumice flow shows dacitic lithologic nature and is mainly composed of volcanic ash dark gray in color, containing pumice and lithic fragment of andesite. Some part shows eutaxitic texture. This pyroclastic flow unit occupy the most lowest stratigraphic position in the present study.

The Takinoue welded tuff: This welded tuff is also recognized at along the southeast of the Toya Caldera covering unconformably above mentioned the Sobetsu pumice flow. This is well consolidated andesitic welded tuff consisting from mainly dark gray colored volcanic glass and pumice. Eutaxitic textures are common.

The Sokeishu lava flow: The Sokeishu lava flow distributes widely in western flat topped mountaineous region of the Shikotsu Caldera. This lava flow is covered by the Shikotsu welded tuff and covers pumiceous gravel formation probably lower Pleistocene in age (Fujiwara 1955). This lava is quartz bearing hypersthene andesite characterized by black extremely elongated volcanic glass with well recognized flow texture.

The Kimobetsu welded tuff: This welded tuff is typically developed at around the township of Kimobetsu. This welded tuff is highly consolidated grayish white rhyolitic pyroclastic deposit characterized by large quartz phenocryst. The age of this welded tuff have generally considered to be the lower Pleistocene on the basis of the field evidences that this welded tuff is covered by terrace deposit and also the Shikotsu welded tuff which is described in later chapter (Fujiwara 1955).

The Ranpoge pumice flow: This flow unit is typically developed at the Cape Ranpoge and also lower course of the Noboribetsu River; white to gray in color, composed of ash and a less amount of pumice and lithic fragment. Phenocrysts of feldspar and quartz are common. A little amount of hornblende, hypersthene, augite and opaque minerals are observable. Presence of hornblende becomes a good key to distinguish this unit. This pumice flow may lithologically call hornblende bearing augite-hypersthene dacite.

The Noboribetsu welded tuff: The type locality of this unit was designated at the hill behind the Noboribetsu railway station (Minato et al, 1972). This unit is characteristic in well welding throughout its extensive exposures. Platy joint is observed both at the basal part and also the upper part of this unit. Mineral assemblage shows that this welded tuff belongs to augite-hypersthene andesite.

The Ponayoro pumice flow: This flow unit shows most widespread distribution in the Noboribetsu area. This pumice flow is dacite in lithology, characterized by large quartz phenocryst. Generally, it increases its thickness toward northwest. In most areas along the beach, this unit is unconsolidated and composed of white pumice, ash, felsic and mafic minerals and relatively few lithic fragments. This flow unit is observed to be gradually consolidated or weakly welded towards the north, where this unit makes cliffs at the boundary between non-welded and welded part.

The Toya pumice flow: The Toya pumice flow occupies a very wide area around the calderal lake Toya. This pumice flow is mainly comprise from volcanic ash, pumice and lithic fragments of andesite, rhyolite, rhyolitic breccia, green tuff and a little amount of plutonic rock. Minato (1966) reported that the Toya pumice flow should be devided into at least two flow units, Toya I and II, on the basis of existence of unconformity between them and their

Table 1.

Horizon	Loc. No.	N	Site Mean Direction			Jn	Pole Position	
			Decli.	Incli.	α_{95}	$x10^{-4}$ emu/gr	Lat.	Long.
Toya	1	3	341	58	5	1.5		
	2	3	354	60	2	5.0		
	3	3	358	61	4	2.5		
	Mean	9	351	60	5		83°N	37°E
Shikotsu	4	8	13	59	2	25		
	5	7	356	59	2	30		
	6	2	31	64	4	5.5		
	7	3	357	63	3	10		
	Mean	20	9	62	7		83°N	124°W
Ponayoro	8	3	342	50	1	20		
	9	7	348	49	2	15		
	10	5	341	49	3	6.5		
	11	6	348	47	3	15		
	12	3	352	50	1	15		
	13	3	352	49	1	25		
	14	4	352	51	2	20		
	15	6	336	51	2	15		
	16	6	344	48	2	10		
	17	4	353	53	2	14		
	Mean	47	347	50	2		74°N	6°E
Noboribetsu	18	7	342	64	2	15		
	19	6	348	69	3	15		
	Mean	13	345	67	5		78°N	13°E
Ranpoge	20	4	1	58	4	15		
	21	3	359	65	3	10		
	22	3	6	62	1	15		
	23	3	359	63	3	15		
	24	5	0	56	11	10		
	Mean	18	2	61	3		88°N	97°W
Kimobetsu	25	5	3	61	6	5.5		
	26	3	346	63	3	15		
	27	3	350	70	4	10		
	Mean	11	353	65	6		84°N	10°E
Takinoue	28	6	178	−50	5	0.5	80°S	149°E
Sobetsu	29	9	215	−48	6	6.0		
	30	3	205	−65	1	30		
	Mean	12	211	−57	15		66°S	53°E
Sokeishu	31	13	194	−61	4	9.0	80°S	52°E

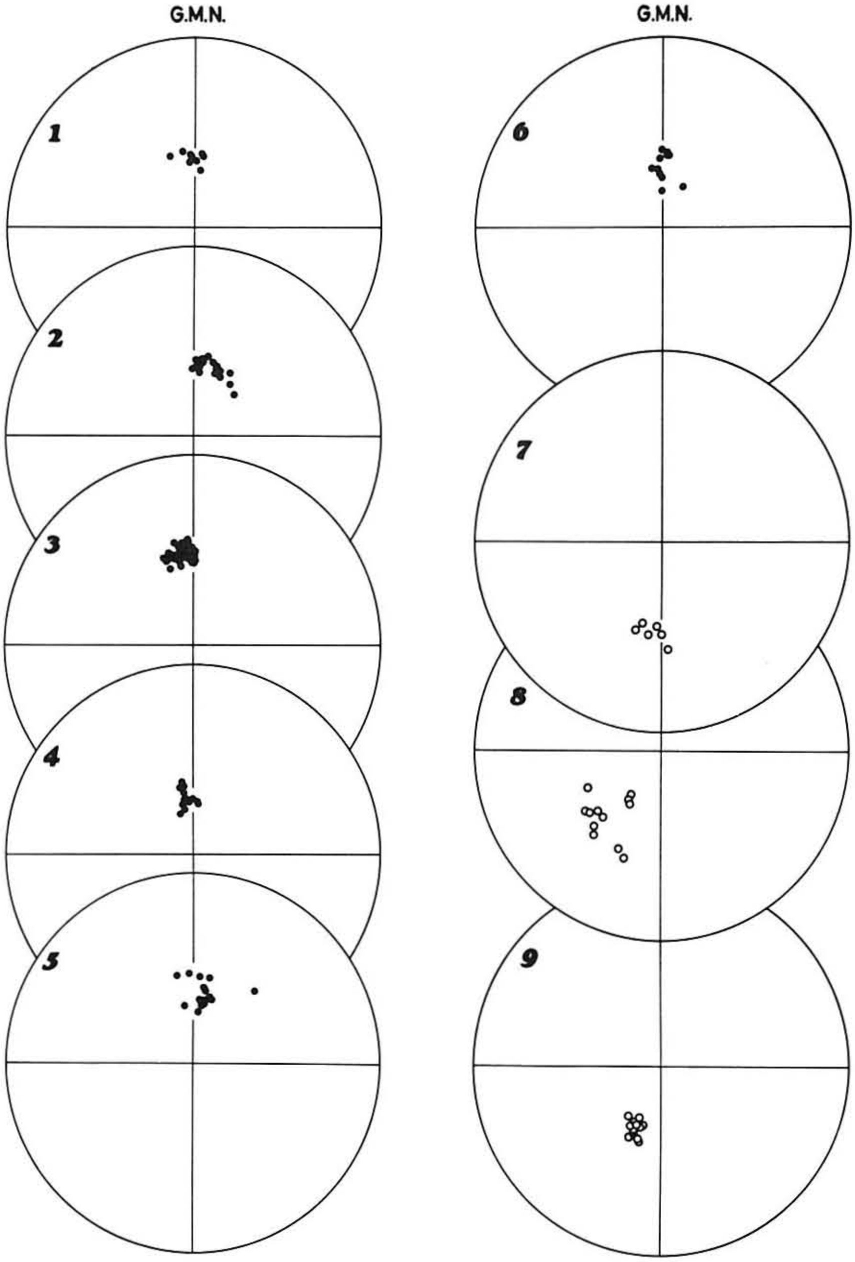

Fig. 2 Directions of natural remanent magnetization for the pyroclastic deposits distinguished. Solid circles represent lower hemisphere prjections and open circles represent upper hemisphere on Schmidt's net. G.M.N.: Geomagnetic north

1: Toya pumice flow. 2: Shikotsu welded tuff. 3: Ponayoro pumice flow. 4: Noboribetsu welded tuff. 5: Ranpoge pumice flow. 6: Kimobetsu welded tuff. 7: Takinoue welded tuff. 8: Sobetsu pumice flow 9: Sokeishu lava flow.

C^{14} ages were 25,000 B.P. and 13,900 B.P. respectively. Suzuki et al (1970) also reported the pyroclastic deposits derived from the Toya Caldera could be divided into five flow and fall units based on their stratigraphic relations and lithologic characteristics. Both Toya I and II were collected for the present study.

The Shikotsu welded tuff: Detailed stratigraphic and also petrographic descriptions of this flow unit were already reported by Minato et al (1972). Results of some paleomagnetic measurements of the Shikotsu welded tuff were previously reported in this journal (Fujiwara 1972). The results of paleomagnetic determinations on newly collected samples are given in this paper.

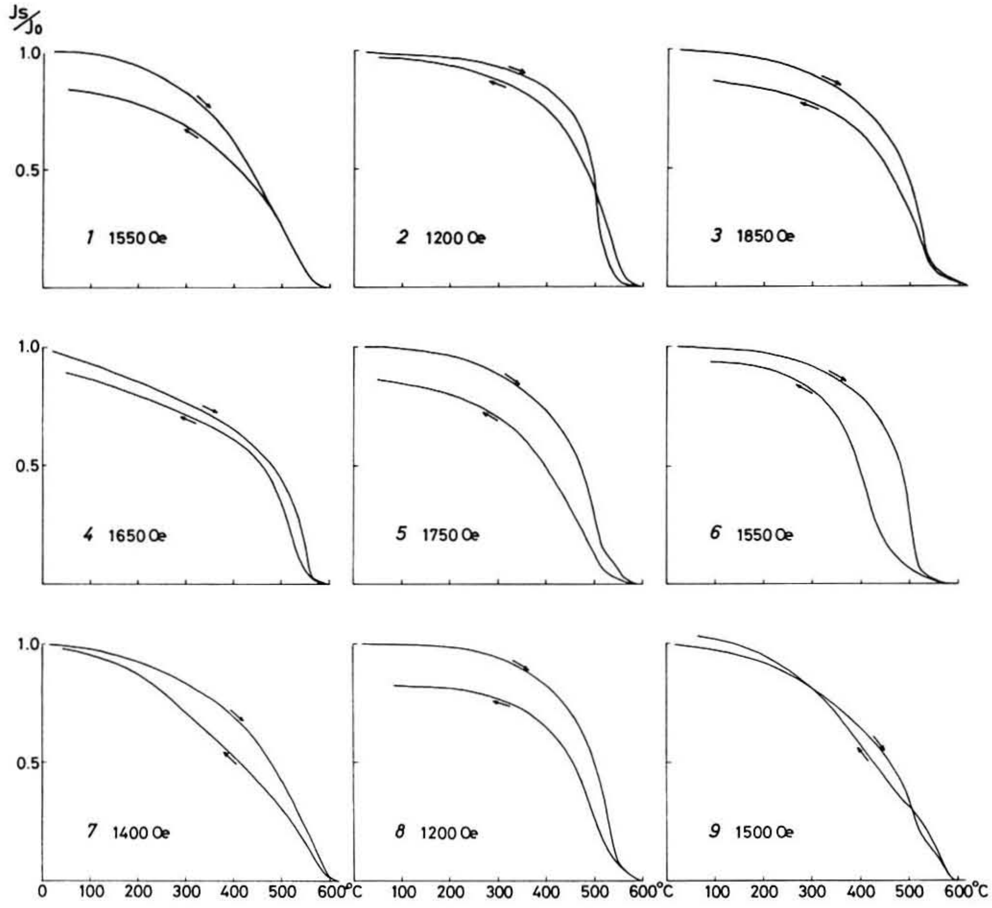

Fig. 3 Typical thermomagnetic curves for each pyroclastic deposit (1–8) and the Sokeishu lava (9). 1: Toya pumice flow. 2: Shikotsu welded tuff. 3: Ponayoro pumice flow. 4: Noboribetsu welded tuff. 5: Ranpoge pumice flow. 6: Kimobetsu welded tuff. 7: Takinoue welded tuff. 8: Sobetsu pumice flow.

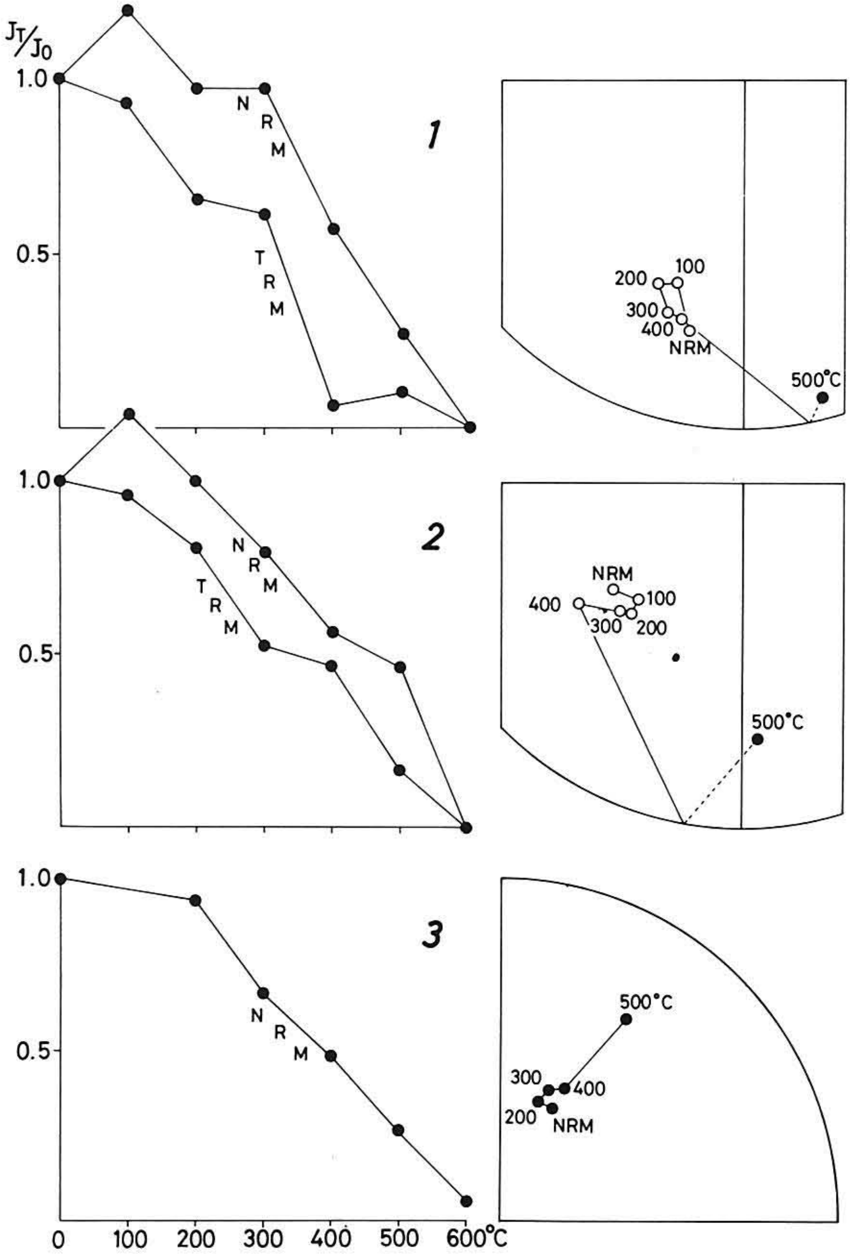

Fig. 4 Intensity decay curves for natural remanent magnetization (NRM) and also thermo remanent magnetization (TRM) and changes in the directions of NRM during demagnetization with temperature.
1, 2: Sobetsu pumice flow. 3: Shikotsu welded tuff.

Measurement

Generally about five or six oriented samples were collected at one sampling site. Sample sites are summarized in Fig. 1. Five to thirteen cylindric specimens were drilled from each individual block sample. In case of collecting unconsolidated samples such as pumice flows or ash flows, specimens about 4 cm cubic shape, were taken using a plastic frames with plaster. Measurements of intensities and directions of remanent magnetization were made by an astatic magnetometer. In order to check the stability of natural remanent magnetization (NRM), some specimens were thermally demagnetized in one hundred degree steps up to 600°C. Furthermore, the same treatment mentioned as above was used for specimens which have acquired artificial thermo remanent magnetization (TRM) in the present geomagnetic field. The mean directions and statistical parameters have been obtained using the method of Fisher (1953). Thermo magnetic analysis was carried out to analyse change of saturation magnetization with temperature and Curie temperatures of magnetic minerals for at least one specimen from each site using a thermomagnetic balance. The results of these measurements are summarized in the Table 1 and also Figs. 2, 3, 4.

Discussions

In the Shikotsu and Noboribetsu districts, the paleomagnetic directions of all individual flow of which stratigraphic position is higher than the Ranpoge pumice flow, show normal polarity and almost coincide with the direction of the present geomagnetic field. Therefore, the age of following five pyroclatic deposits, the Ranpoge pumice flow, the Noboribetsu welded tuff, the Ponayoro pumice flow and the Shikotsu welded tuff may be considered to be volcanic products brought within the time of the Brunhes normal epoch (0.00–0.69 m.y.)

The directions of NRMs of the Toya pumice flow are also considered to be normal polarity, however, underneath two pyroclastic flows, the Takinoue and the Sobetsu pumice flow are reversely magnetized as shown in the Table 1 and Fig. 2. This suggests that the reversals of these two pyroclastic deposits may be correlated with the upper portion of the Matuyama reversed epoch (0.69–2.45 m.y.). The boundary between the Brunhes normal and Matuyama reversed epochs probably took place sometime between the eruptions of the Takinoue welded tuff and the Kimobetsu welded tuff. The present paleomagnetic investigation suggests that the age of reversely magnetized Sokeishu lava flow may also be correlate to sometime during the Matuyama reversed epoch. Both Jaramillo and Olduvai normal events may not be represented in any pyroclastic unit in the present study.

Acknowledgement

Our sincere thanks are expressed to our respect teacher, Professor Masao Minato of the Department of Geology and Mineralogy, Faculty of Science, Hokkaido University for his continuous encouragements and supervision during the course of our work.

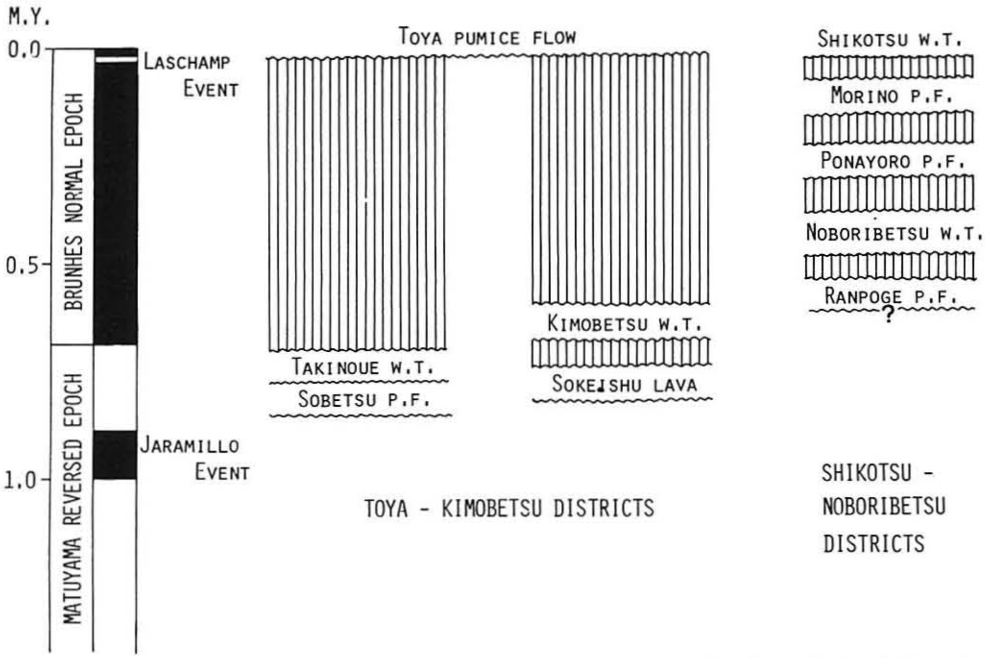

Fig. 5 Correlation diagram of pyroclastic deposits in southwestern Hokkaido as deduced from the present paleomagnetic measurements.

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(Received on Oct. 30, 1978)