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## A PRELIMINARY REPORT ON A PALAEOMAGNETIC STRATIGRAPHY IN CENTRAL HOKKAIDO, N.E. JAPAN

*by*

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(with 9 figures and 1 table)

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### Introduction

The palaeomagnetic method applied to stratigraphic correlation is called magneto-stratigraphy or palaeomagnetic stratigraphy. The concept of magneto-stratigraphy or palaeomagnetic stratigraphy has already been described by many authors Cox et. al. (1963, 1964, 1967), Sasajima (1969), Darymple et. al. (1967), Doell et. al. (1966), Glass et. al. (1967) and McDougall et. al. (1966). Recent palaeomagnetic and K-A age determinations of Plio-Pleistocene volcanic rocks have led to the development of a time scale of reversals of the geomagnetic field for the past 4 m.y. The recent progress of palaeomagnetic studies of deep-sea sediment cores has also supported the applicability of the geomagnetic polarity time scale to geochronology (Heirtzler et. al., 1968). Cox and Darymple (1967) have recently summarized studies of the history of the geomagnetic field polarity changes during the past 4 m.y. on the basis of combined K-A age determination and palaeomagnetic studies of igneous rocks. The geomagnetic polarity time scale suggested by them is shown in Fig. 9. Intervals, during which the geomagnetic field has predominantly or entirely one polarity, have been termed epochs which have durations of the order of  $10^6$  y. Events, are about an order of magnitude shorter and occur within epochs. This geomagnetic polarity time scale consists of a series of four epochs, which are periods of time during which the magnetic field was predominantly or entirely of one polarity, and three events which are an order of magnitude shorter in duration. The geomagnetic polarity changes may be regarded as world-wide incidents. Therefore, the polarity time scale provides a distinctive and world-wide sequence of sharply defined time horizons that can be used as an aid to correlation and age assignments in stratigraphy.

In Central Hokkaido, many sequences of volcanic rocks ranging from Miocene to Pleistocene are widely distributed. In order to get more correct information on the ages and stratigraphy of volcanic sequences, we have

studied palaeomagnetic properties of the volcanic rocks in Central Hokkaido during the past few years. In this report, the results of palaeomagnetic measurements and discussions on the age and stratigraphy on the basis of geomagnetic polarity changes will be briefly given.

### 1) Geology and Sampling

Thick pyroclastic flows and volcanic rocks are widely developed in the eastern part of Central Hokkaido. These volcanic products comprise welded tuffs which may roughly be divided into 3 groups in terms of intercalations of sediments and dacitic to rhyolitic volcanics occurring as lava flows or dykes. These welded tuffs are named for convenience the Kuttari welded tuff, Pankenikoro welded tuff and Tokachi welded tuff in ascending order. The Kuttari welded tuff is a rhyolitic salmon-pink colored pyroclastic deposit which locally is overlain by secondary aeolian or otherwise reworked deposits. Pyroclastic flows which cover the Kuttari welded tuff unconformably, are hornblende dacitic welded tuff which typically crop out along the upper course of the Pankenikoro River. These pyroclastic flows are called the Pankenikoro welded tuffs. As will be described in later, the Pankenikoro welded tuff can probably be sub-divided into two flow units on the basis of the Palaeomagnetic results.

The uppermost member which unconformably covers the Kuttari and Pankenikoro welded tuffs is a rhyolitic pyroclastic flow called the Tokachi welded tuff. This tuff has a wide distribution in this area and also covers almost the whole of the central part of Hokkaido and has been thought to be a product of uniform eruption. However, the present study reveals at least that two different products may be included in the Tokachi welded tuff from the view point of palaeomagnetism.

The age of these welded tuffs is uncertain. The only evidence is that the uppermost member of the Tokachi welded tuff is covered by a gravel formation which is believed to be Middle Pleistocene in age and covers altered volcanic rocks of Miocene age. Therefore, these volcanic products can only be estimated to range in age from lower Pleistocene to Upper Pliocene.

The direction of magnetization of the lower half of the Pankenikoro welded tuff shows normal polarity while the direction of magnetization of the upper half member shows reverse polarity as shown in Fig. 9.

In the eastern part of Central Hokkaido, Plio-Pleistocene volcanic rocks and pyroclastic flows also occur extensively. According to Takahashi and Mitani (1970), these Plio-Pleistocene volcanic products, which cover unconformably altered volcanic rocks and pyroclastic deposits of probable Miocene age, may

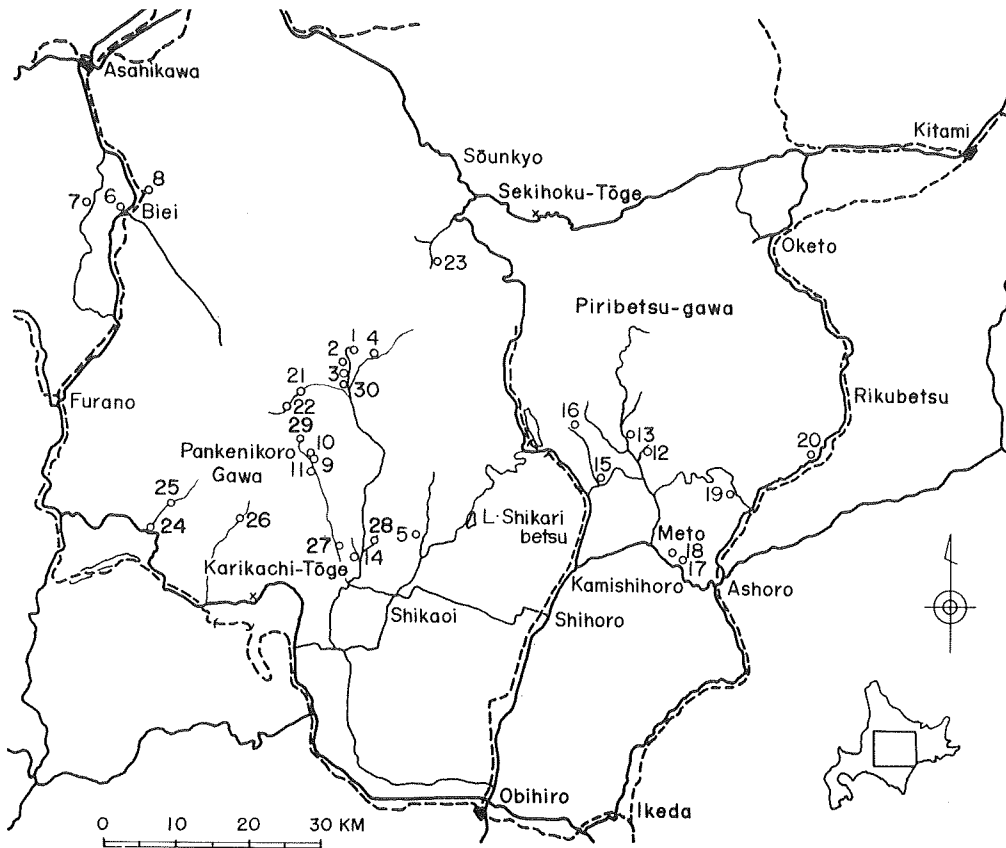


Fig. 1 Locality map showing the sampling sites.

be roughly sub-divided into three lava flows and two pyroclastic flows with intercalations of agglomerate, sandstone and gravel formations. The gravel formation which is sometimes associated with tuffs and peat layers is called the Ikeda Formation and forms a good stratigraphic marker in Central Hokkaido.

The schematic stratigraphic sequences in the eastern part of Central Hokkaido are as follows (Takahashi and Mitani 1970);

Holocene	{	Alluvial deposits	
		Talus deposits	
Pleistocene	{	Terrace deposits	
		Uesakayama gravel bed	
		Kamiasahigaoka gravel bed	
		Meto tuff	
		Kitoushi lava*	
		974.7m yama lava*	
Pliocene	{	Ikedo Formation*	
		Ashoro Formation*	{
			Dacitic welded tuff member*
			(Shimoaikappu welded tuff)
			Pumiceous tuff member
			Agglomerate and sandstone member
			Andesite lava member*
			Sandstone and mudstone member

\* sampled sequence

## 2) Measurements

About 200 oriented block samples were collected from 30 sites. Localities of each site are shown in Fig. 1. Two to five cubic specimens were cut from each individual block sample resulting in a total of 650 specimens. Two pilot specimens from each site were stepwise demagnetized using alternating fields up to 400 oe peak intensity and thermally demagnetized in one hundred degree steps up to 600°C in order to test the stability of natural remanent magnetization (NRM). Furthermore, the same treatments mentioned as above were used for specimens which has acquired artificial thermo remanent magnetization (TRM) in the present geomagnetic field of the laboratory (0.5 oe). Specimens for which the demagnetization curves of NRM and TRM do not coincide are omitted from the final statistics. The measurements of intensity and direction of magnetization have been made using an astatic magnetometer. The mean direction and statistical parameters have been obtained using the method of Fisher (1953).

Thermomagnetic analysis has been carried out to investigate the change of saturation magnetization with temperature and Curie temperature of magnetic minerals for at least one specimen from each site using a thermomagnetic balance.

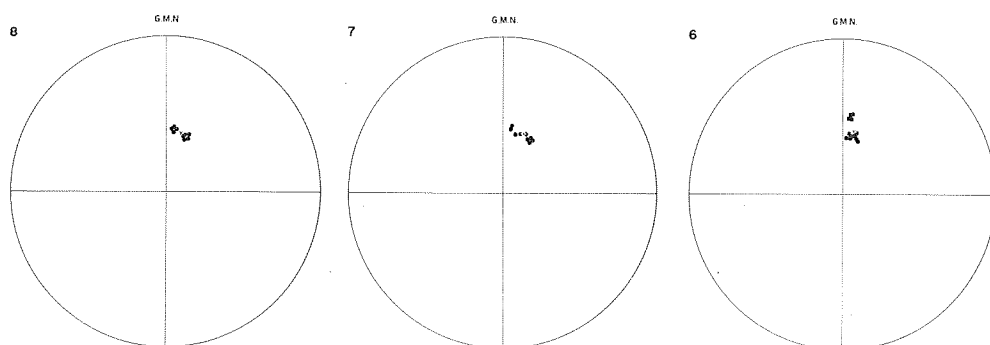


Fig. 2 Directions of magnetization of the Tokachi welded tuff I. (Schmidt net projection)  
Cross indicates the mean direction, site 8 (left), site 7 (middle), site 6 (right).

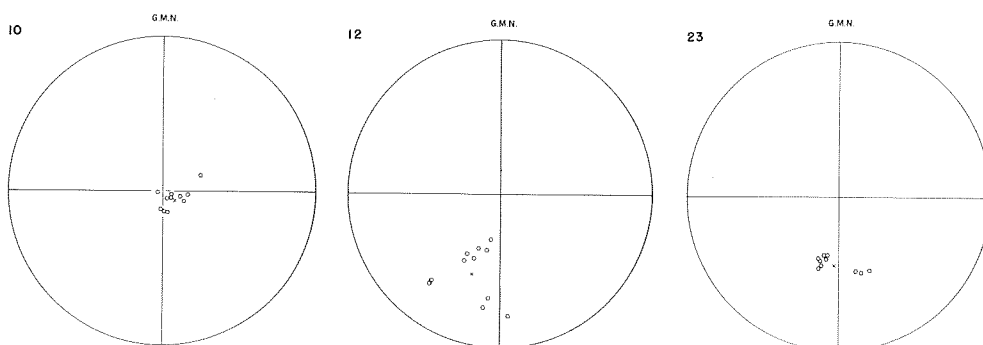


Fig. 3 Directions of magnetization of reversely magnetized welded tuffs and lava flow. left: Pankenikoro welded tuff (site 10), middle: Kitoushi lava (site 12), right: Dacitic welded tuff (site 23).

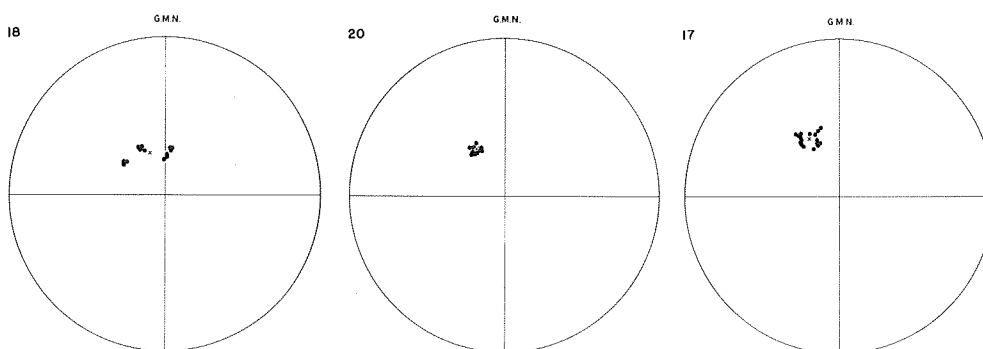


Fig. 4 Directions of magnetization of the Shimoaikappu welded tuff. site 18 (left), site 20 (middle) site 17 (right).

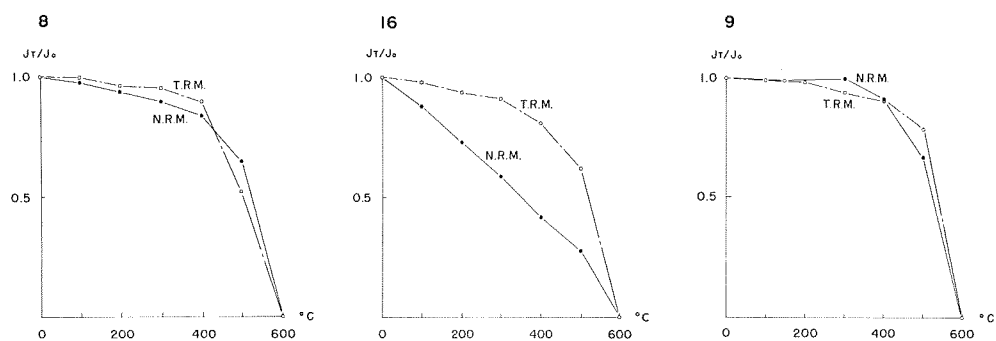


Fig. 5 Thermal demagnetization curves of the Tokachi welded tuff (left), Shimoaikappu welded tuff (middle) and the Pankenikoro welded tuff (right).

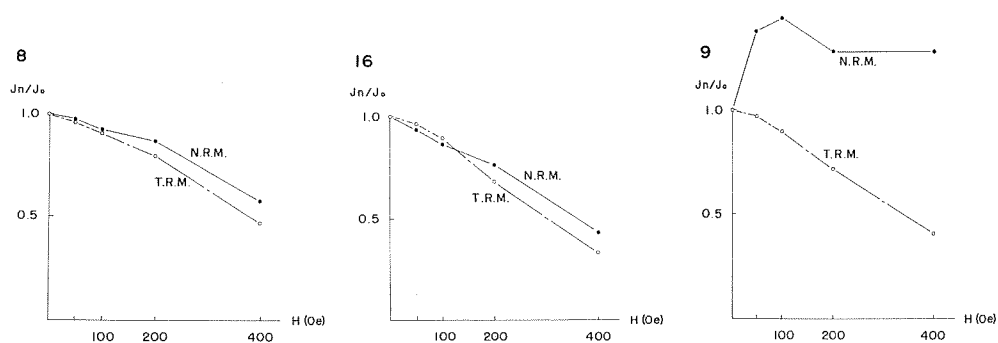


Fig. 6 Alternating field demagnetization curves of the Tokachi welded tuff (left), Shimoaikappu welded tuff (middle) and the Pankenikoro welded tuff (right).

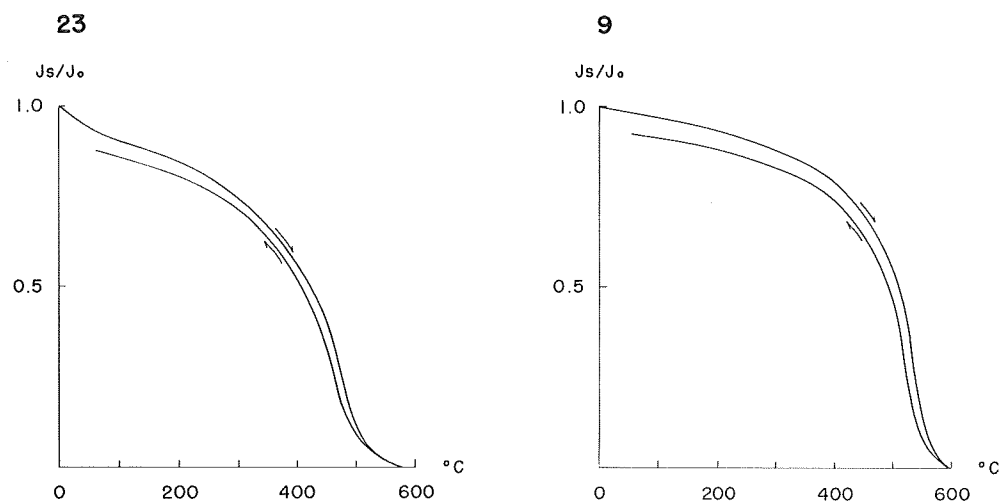


Fig. 7 Thermo-magnetic curves of the reversely magnetized welded tuffs. Above curves show heating process and below curves show cooling process. left: dacitic welded tuff, right: Pankenikoro welded tuff.

Table 1

Site No.	D°	I°	$\alpha_{95}^\circ$	N	M ( $\times 10^{-4}$ e.m.u./gr)	NRM/TRM
Tokachi welded tuff (I)						
1	339	52	7	12	0.5	
2	358	48	2	18	3.0	0.3
3	354	49	3	12	3.0	
4	006	55	2	6	6.0	
5	314	52	6	6	2.5	0.2
6	002	56	2	18	7.0	0.9
7	011	56	6	18	8.0	0.3
8	007	68	3	12	7.0	0.7
Pankenikoro welded tuff (Upper)						
9	037	-78	8	12	1.5	0.1
10	121	-82	5	24	1.5	0.1
Pankenikoro welded tuff (Lower)						
11	013	57	3		2.0	0.2
Kitoushi lava						
12	191	-44	8	24	1.5	0.2
974.7m yama lava						
13	194	-50	3	24	1.0	0.2
Kuttari welded tuff						
14	328	55	4	9	2.0	0.4
Shimoaikappu welded tuff						
15	349	61	2	24	4.0	0.2
16	336	56	2	18	3.5	0.4
17	324	55	2	30	5.0	
18	331	60	5	24	2.5	
19	313	58	2	12	2.5	
20	319	61	4	24	1.5	
Dacitic welded tuff						
21	232	-64	13	18	0.5	
22	191	-67	13	30	1.0	
23	175	-50	13	18	14.0	0.6
Tokachi welded tuff (II)						
24	} No polarity					
25						
26						
27						
28						
29						
30						



Directions and intensities of magnetization of the sites which are considered to be stable enough for reliable palaeomagnetic data on account of the stability tests are listed in Table 1. The results of statistics and thermomagnetic properties are also given in the same table.

### 3) Discussion

At least 13 geomagnetic polarity changes during the past 4 m.y. have been determined on the basis of palaeomagnetic and K-A age determinations. This geomagnetic polarity time scale consists of a series of four epochs. Each epoch includes two or three events except the Brunhes normal epoch which have ages ranging from 0.00 to 0.69 m.y. Correlation and age assignment of the present palaeomagnetic results are based on the polarity time scale proposed by Cox and Darymple (1967).

The Tokachi welded tuff, which is covered by the Ikeda gravel Formation is probably Upper-Middle Pleistocene in age and has a natural remanent magnetization (NRM) with normal polarity. Therefore, this welded tuff may have formed near the base of the Brunhes normal epoch. Rhyolitic welded tuff in the west to southwest of the Tokachi welded tuff shows no magnetic polarity, but the properties of the magnetic minerals in this welded tuff are proved to be stable. The Tokachi welded tuff is therefore, divided into two units: I a Lower member with normal polarity, II an Upper member with no polarity. Detailed studies need to clarify this division.

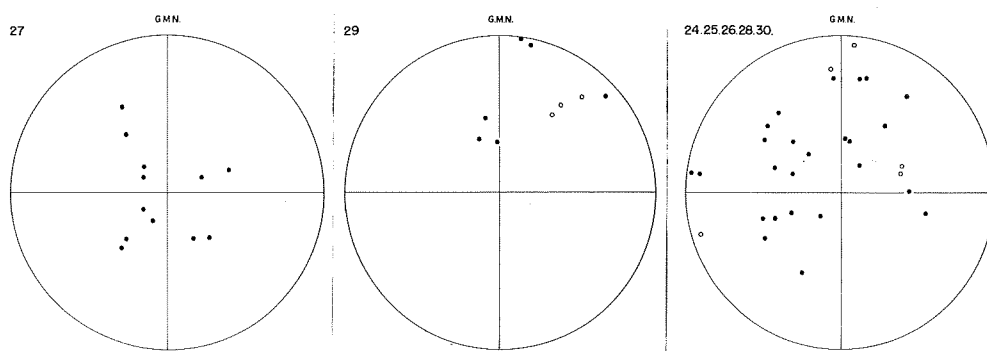


Fig. 8 Diagrams show that direction of magnetization dispersed in each locality. In composite diagram, note no concentration of direction. left: Tokachi welded tuff II. (site 27). middle: Tokachi welded tuff II. (site 29) right: Composite diagram.

The upper part of the Pankenikoro welded tuff, which is covered by the Tokachi welded tuff, is reversely magnetized. This suggests that the reversal of the Pankenikoro welded tuff may be correlated with the uppermost portion of the Matuyama reversed epoch. The boundary between the Brunhes and

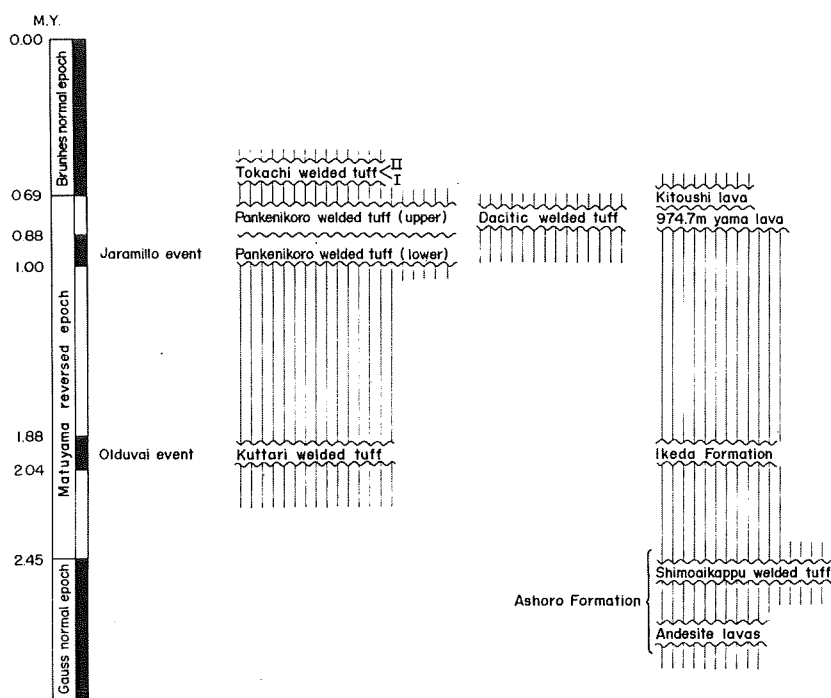


Fig. 9 Correlation diagram of volcanic products in Central Hokkaido.

Matuyama probably took place sometime between the eruption and deposition of the Tokachi and Pankenikoro welded tuffs. Two dacitic welded tuffs which were collected from the northern part of Central Hokkaido show reversed polarity. They may also correlate with the top of the Matuyama reversed epoch. Evidence of the Jaramillo event may be represented in the bottom part of Pankenikoro welded tuffs which is normally magnetized. In the eastern part of Central Hokkaido, the two normally magnetized lava flows, Kitoushi and 974.7m yama lava, most likely represent an early stage of the Matuyama reversed epoch. The Olduvai normal event may be represented by the Ikeda Formation because of the occurrence of a normally magnetized ash member in the lower sequence of this formation.

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