105. *Isotopic Ages of the Cretaceous Tuff from the Manji Area, Hokkaido*

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For the establishment of a reliable geochronological time-scale, it is especially important to determine radiometric ages on rocks whose biostratigraphic positions are well defined by sufficient fossil evidence. In this respect, the post-Aptian marine Cretaceous strata in Hokkaido is suitable for geochronologic research, because the adequate schemes of horizon and international correlation have been established by recent mega- and microbiostratigraphic works (e.g. Matsumoto, 1977; Maiya and Takayanagi, 1977), and because they comprise some intercalations of acid to intermediate tuff and tuffaceous rocks at various horizons. Radiometric dating on tuffaceous rocks from the Cretaceous of Hokkaido has not yet been successfully achieved, apart from the work of Shibata and Miyata (1978) on the Turonian tuff in the Obira area, northwestern Hokkaido. The reason for this is due to the difficulty to obtain fresh material without contamination.

This paper represents the biotite-whole rock isochron ages by Rb-Sr method on the three tuff samples from the Santonian sequence in the Manji area, central Hokkaido.

In the Manji area marine Cretaceous strata crop out, forming a dome-like structure termed the Manji Dome. Obata and Futakami (1975) divided the Cretaceous sequence of this area into the three stratigraphic units, *i.e.* (1) main part of the Middle Yezo Group (Upper Albian to Lower Cenomanian), (2) Mikasa Formation of the Middle Yezo (Upper Cenomanian to Upper Turonian), and (3) Upper Yezo Group (Upper Turonian to Santonian) in ascending order.

Recently we have investigated the Upper Turonian to Santonian sequences of this area and newly found predominant tuff beds at three horizons in the Upper Yezo Group. As shown in the geologic sketch map (Fig. 1), the tuff-bearing Cretaceous strata are well exposed across the southern tributaries of the Horomui River. We, therefore, collected tuff and fossils along the streams of Sannosawa and Ponnebetsu. Fig. 2 is the columnar sections along the two routes, showing the stratigraphic positions of the tuff beds and fossil localities.

The upper part of the Mikasa Formation (Mk3 in Fig. 1) is

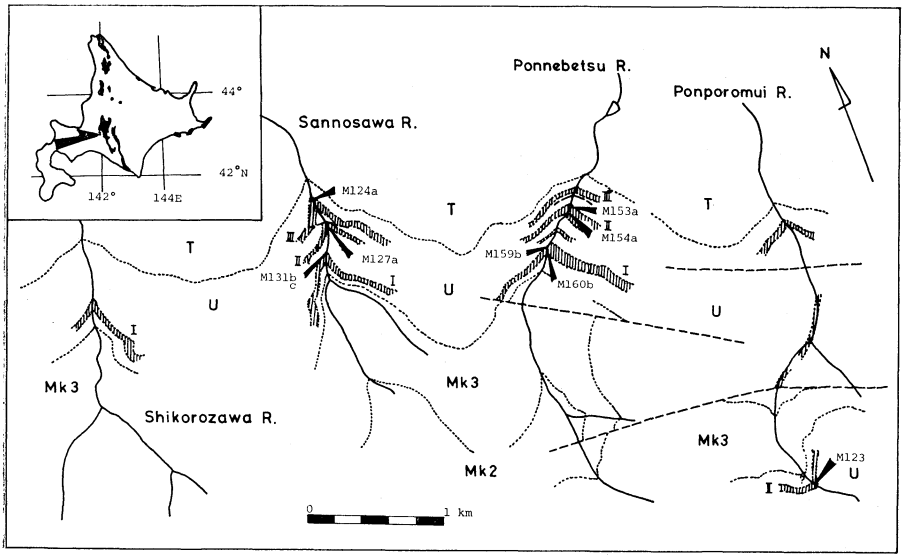

Fig. 1. Geologic sketch map in the northern part of the Manji area, central Hokkaido, showing the horizons and sampling localities of the Cretaceous tuff beds studied. Mk2 and Mk3: Middle and upper parts of the Mikasa Formation. U: Upper Yezo Group. T: Coal-bearing Paleogene. The map is partly adapted from Obata and Futakami (1975, 1977).

evidently correlated to the Upper Turonian, because *Reesidites minimus, Sciponoceras intermedium* and *Inoceramus teshoensis* occur abundantly at various localities (e.g. M135, 136, 163a–d). *S. intermedium* and *Mesopuzosia* cf. *pacifica* were also obtained from the uppermost horizon of the formation in the Sannosawa section at M134. We collected some megafossils such as ammonoids and inocerami from the Upper Yezo Group in the Sannosawa section. They are as follows: *Damesites ainuanus* and *I. tenuistriatus* from the basal part of the group at SN2001; *I. naumanni* and *Damesites damesi intermedius* from the horizon immediately below the lowest tuff bed (Tuff I) at M133; *I. naumanni, I.* cf. *amakusensis, Anapachydiscus* (?) sp. young, *Baculites* sp. and *Polyptychoceras* sp. from the horizon immediately below the middle tuff (Tuff II) at M129. These lines of fossil evidence indicate that the basal part of the Upper Yezo is included in the Upper Turonian. The fossils from M129 apparently suggest Lower Santonian, while those from M133 are long-ranging species from Upper Coniacian to Santonian. Thus, the zone of *I. uwajimensis,* which represents the main part of the Coniacian, is lacking in the Sannosawa section. Obata and Futakami (1975), however, reported *I.* cf. *mihoensis* from river gravels, which may have been derived from the lower part of the Upper Yezo Group in the Ponporomui River. This

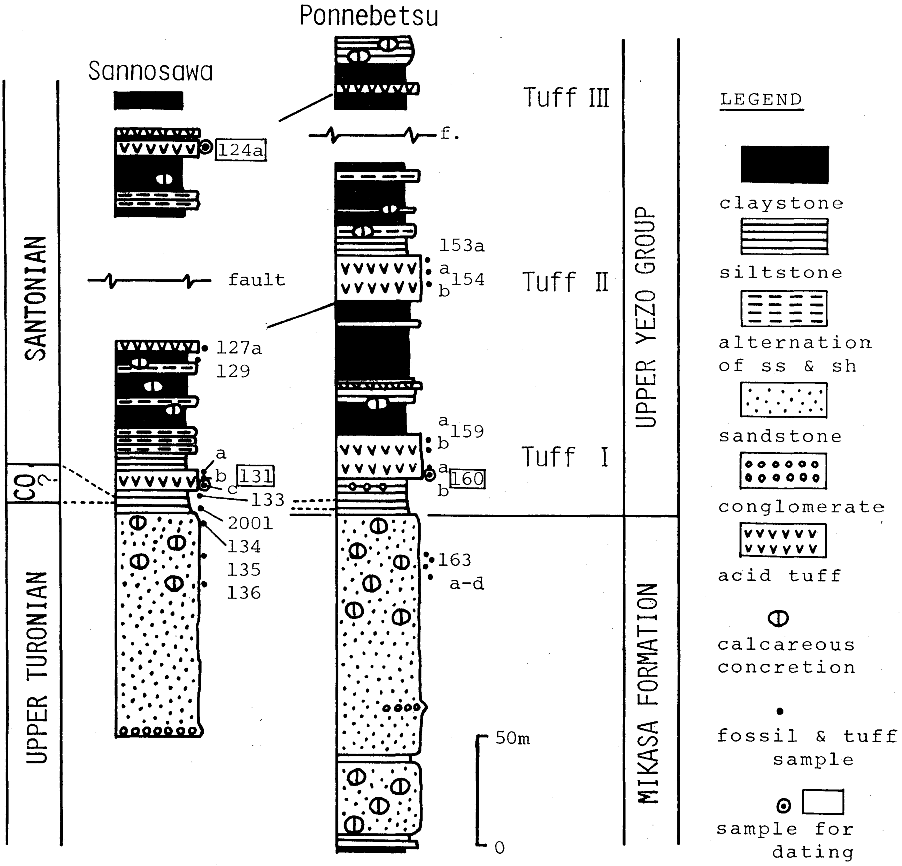

Fig. 2. Columnar sections of the Upper Turonian to Santonian strata along the Sannosawa and Ponnebetsu Rivers, showing the stratigraphic positions of tuff and fossil samples.

suggests the Upper Coniacian. From the work of Obata and Futakami (1975, 1977), Tanabe *et al.* (1978) and our own data, it is strongly suggested that the Coniacian may be very thin and/or partly absent in the Manji area. In the Upper Cretaceous of Hokkaido the occurrence of *I. naumanni* is less common in the Coniacian than in the Santonian (T. Matsumoto's personal communication). Therefore, the Coniacian-Santonian boundary probably exists immediately below M133, and furthermore, Tuff I and II are assigned to the Lower Santonian. The uppermost tuff bed (Tuff III) may be included in the Santonian, although we have collected no index fossil from the strata above Tuff II.

Tuff I to III are light-colored, acid to intermediate rocks with biotite flakes. As summarized in Table I, the mineral assemblages and

Table I. Mineral compositions of the Cretaceous tuff beds of the Manji area

	Loc.	Quartz	K-feld.	Plagio.	Glass	Rock-f.	Calc.	Glauco.	Matrix	Biot.	mm
III	M124a	14.9	14.1	36.9	11.2	11.7	2.3	0.60	6.7	2.10	0.4
	M153a	1.8	2.0	35.0	53.1	5.8	-	-	0.9	1.40	0.3
	M154a	5.1	0.40	23.2	60.9	6.4	-	hornb. 0.30	2.2	1.59	0.2
II	M127a	3.3	0.79	47.5	-*	21.9	24.5	1.58	-*	0.49	0.5
	M123	3.5	0.10	53.7	27.0	8.9	5.0	-	0.5	1.30	0.4
	M131c	23.3	15.2	21.2	11.1	14.4	7.1	0.69	4.6	2.37	0.6
I	M159b	12.3	9.4	26.5	30.2	15.1	0.01	1.58	2.7	2.08	0.3
	M160b	10.6	8.5	16.7	45.3	10.5	-	0.90	5.1	2.50	0.3

Analysed by Miyata. * Replaced by calcite. mm: Average grain size in mm.

mode of Tuff I and III somewhat differ from those of Tuff II. Tuff II is rich in volcanic glass and zoned plagioclase, but poor in quartz, K-feldspar and biotite, hence inadequate for dating. Although a few glauconite grains are occasionally found in the tuff and some other clastic rocks of the Upper Yezo Group, it is very difficult to separate a pure sample for dating.

Radiometric analysis was made for the three samples (M124a, M131c and M160b) which were collected from Tuff I and III in the Sannosawa and from Tuff I in the Ponnebetsu (see Fig. 2). A few fragments of shale and chert occur in every sample. Both feldspar and biotite in M124a and M131c are fresh, though biotite in M160b is partly weathered. These samples, about 1 to 3 kg in weight, with fresh surface were first crushed into powder. A part of the powder samples (about 100 to 150 g) is selected for the whole rock analysis, and biotite minerals were separated from the residual powder samples with an aid of Frantz isodynamic separator. Although the biotite separated includes a small quantity of apatite, we did not dare to eliminate it (Yanagi, 1980). About 0.1 g of the whole rock sample and about 0.2 g of the biotite one were analysed. The analytical techniques are based on the method described by Yamaguchi *et al.* (1969). Rubidium and strontium concentrations were measured by means of the Hitachi RMU-5G mass-spectrometer, and 600 to 800 sets of $^{87}Rb/^{86}Sr$ were measured with unspiked samples using the JEOL-05RB mass-spectrometer. All of the $^{87}Sr/^{86}Sr$ ratios were normalized to $^{86}Sr/^{88}Sr$ ratios equal to 0.1194. The average $^{87}Sr/^{86}Sr$ ratio of the Eimer and Amend standard replicate measure is $0.70795 \pm 0.00044(\sigma)$. The errors in rubidium and strontium concentrations are estimated to be within $\pm 3\%$ and within $\pm 1\%$ respectively. The decay constant used in this study is $^{87}Rb = 1.42 \times 10^{-11}/y$ (Steiger and Jager, 1978). The experimental results and calculated ages of the tuff samples are summarized in Table II.

The whole rock-biotite isochron ages dated are 81.1 ± 1.6Ma on

Table II. Rb-Sr analytical results of the Cretaceous tuff from the Manji area

Sample No.	Mineral	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$ (σ)	Age (Ma)	Initial $^{87}Sr/^{86}Sr$ (σ)
M124a	Biotite	212.7	34.39	17.94	0.72521±13	81.1±1.6	0.70453±16
	Whole rock	151.4	222.5	1.971	0.70680±13		
M131c	Biotite	208.5	36.39	16.62	0.72506±50	83.0±2.8	0.70546±27
	Whole rock	57.27	218.7	0.8632	0.70648±25		
M160b	Biotite	268.9	181.5	4.291	0.71229±34	84.4±8.3	0.70715±36
	Whole rock	45.06	1861	0.0701	0.70723±35		

Analysed by Hamamoto.

M124a, 83.0±2.8Ma on M131c and 84.4±8.3Ma on M160b. M160b sample was collected from the same horizon within Tuff I as M131c, and its error in estimated age is large because of the low Rb/Sr ratio. Therefore, the age of M160b is consistent with that of M131c. Thus 83.0±2.8Ma can be regarded as representing the age of Tuff I, whose biostratigraphic position is probably assigned to the lowest Santonian. Likewise, the age of Lower to Middle (?) Santonian Tuff III is 81.1±1.6Ma.

Some isotopic ages have been dated on such Cretaceous rocks as bentonite, glauconite and tuff (Folinsbee, 1965; Odin, 1978; Obradovich and Cobban, 1975). However, no mineral ages that bear directly on the Coniacian-Santonian boundary have been reported (Lanphere and Jones, 1978). In this respect, it is important that the sample from the lower part of the Santonian has been radiometrically dated as 83.0±2.8Ma by Rb-Sr method. This suggests the minimum age of the Coniacian-Santonian boundary.

Many detailed Cretaceous time scales have been proposed after 1964 and 1971 "PTS items", but the opinions on the ages of stage boundaries are somewhat different among authors (Armstrong, 1978; Obradovich and Cobban, 1975; Odin, 1978; Van Hinte, 1976; Lanphere and Jones, 1978). For comparison, all K-Ar ages dated there are recalculated using a decay constant and isotope abundance of ^{40}K based on Steiger and Jager, 1978. Obradovich and Cobban (1975) measured K-Ar age on biotite separated from a bentonite bed in the *Desmoscaphites bassleri* Zone as 84.5±0.8Ma, and they also suggested that the Santonian-Campanian boundary might be placed at 84Ma. Armstrong (1978) proposed a pre-Cenozoic Phanerozoic time scale based on their computer file of K-Ar, Rb-Sr and U-Pb age data. According to him the Santonian ranges from 84 to 88Ma. On the other hand, Van Hinte (1976) proposed a Cretaceous time scale which is based on the combination of presently available age data, biostratigraphic framework, and geomagnetic-reversal time scale. According to him, the Santonian ranges from 80 to 84Ma. The Rb-Sr ages of the Santonian tuff beds in the Manji area are well comparable with the estimation of Van Hinte (1976).

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