# AMS Radiocarbon Dating of Paleosols Intercalated with Tephra Layers from Mayon Volcano, Southern Luzon, Philippines : A Preliminary Report

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**Abstract**

This paper presents the AMS $^{14}C$ dates of paleosols intercalated with tephra layers in the vicinity of Mayon Volcano, southern Luzon, Philippines. The obtained $^{14}C$ dates are almost consistent with the stratigraphy of the Mayon tephra group. On the basis of calibrated $^{14}C$ age of soil layer directly overlying the lowest ash layer, the oldest eruptive event must have taken place shortly before 20 cal kyr BP. This age is younger than the previous estimates for Mayon.

Key words : Mayon Volcano, tephra layer, AMS $^{14}C$ dates, Philippines

## Introduction

Mayon Volcano (13°15.4' N, 123°41.1' E), the most active volcano in the Philippines, is an andesitic stratovolcano located in the province of Albay, southern Luzon. It is one of the volcanic centers comprising the northwest-trending dominantly basaltic andes ite- andesite Bicol Volcanic Chain in the Bicol Peninsula (Fig. 1).

Mayon's age has not been precisely dated because most of the earliest deposits have been buried beneath recent volcanic deposits (Ramos-Villarta *et al.*, 1985). The oldest radiocarbon ($^{14}C$) age known is 5050±250 BP (Meyer, unpublished data). To obtain much older ages of Mayon, we studied tephra outcrops which are located outside of the slope of the volcano (Fig. 2). The tephra sequences at Ligao City and Oas, Albay were previously noted but remained undated due to lack of datable materials such as charred wood, which is essential for conventional $^{14}C$ dating method. However, Okuno *et al.* (1997) and Okuno and Nakamura (2003) showed that determining the age of soil associated with tephra fall deposits through the accelerator mass spectrometry (AMS) method is very convenient

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to use because soil samples are much easier to collect systematically than charcoal or wood, and the AMS method requires very small amount of carbon, i.e., about 1 mg of carbon.

To determine the age of tephra, we measured the $^{14}C$ dates of soil layers that directly underlie distinct layers of fall deposits at three outcrops. This paper, thus, presents and discusses the results of $^{14}C$ dating of soil samples in conjunction with stratigraphy of the tephra layers in the vicinity of Mayon Volcano, which we collectively named as the Mayon tephra group (My).

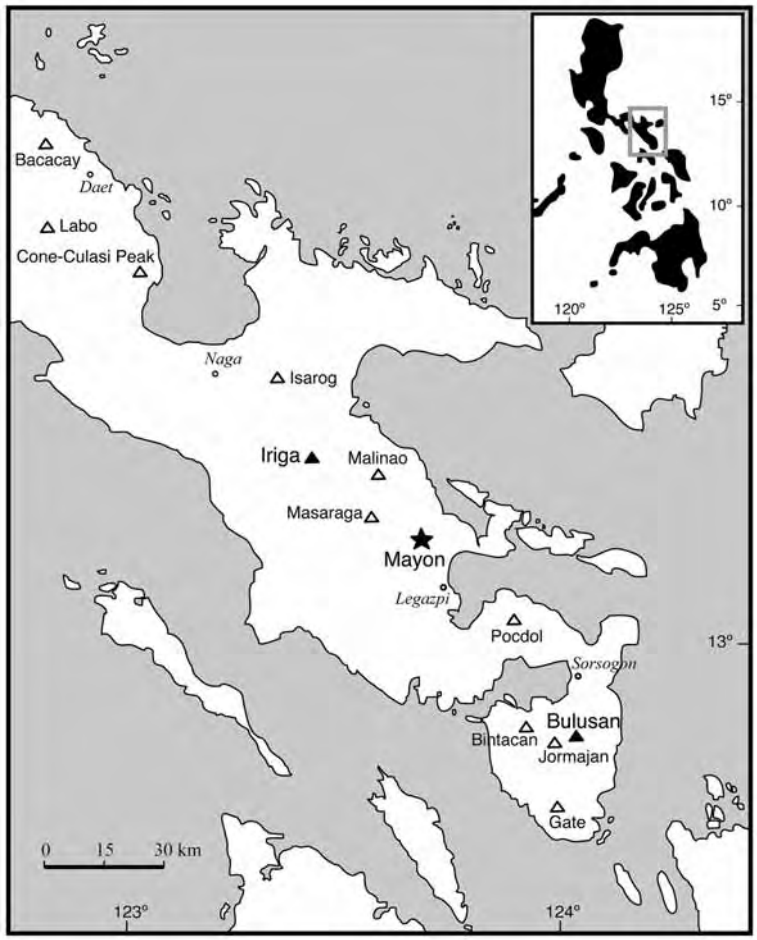


**Fig. 1.** Map showing the volcanoes of the Bicol Volcanic Chain (modified from PHIVOLCS, 2002). Star represents Mayon Volcano. Solid triangles represent active volcanoes while open triangles denote inactive and potentially active volcanoes. Inset shows map of the Philippines; box in the inset map shows location of the Bicol Peninsula.

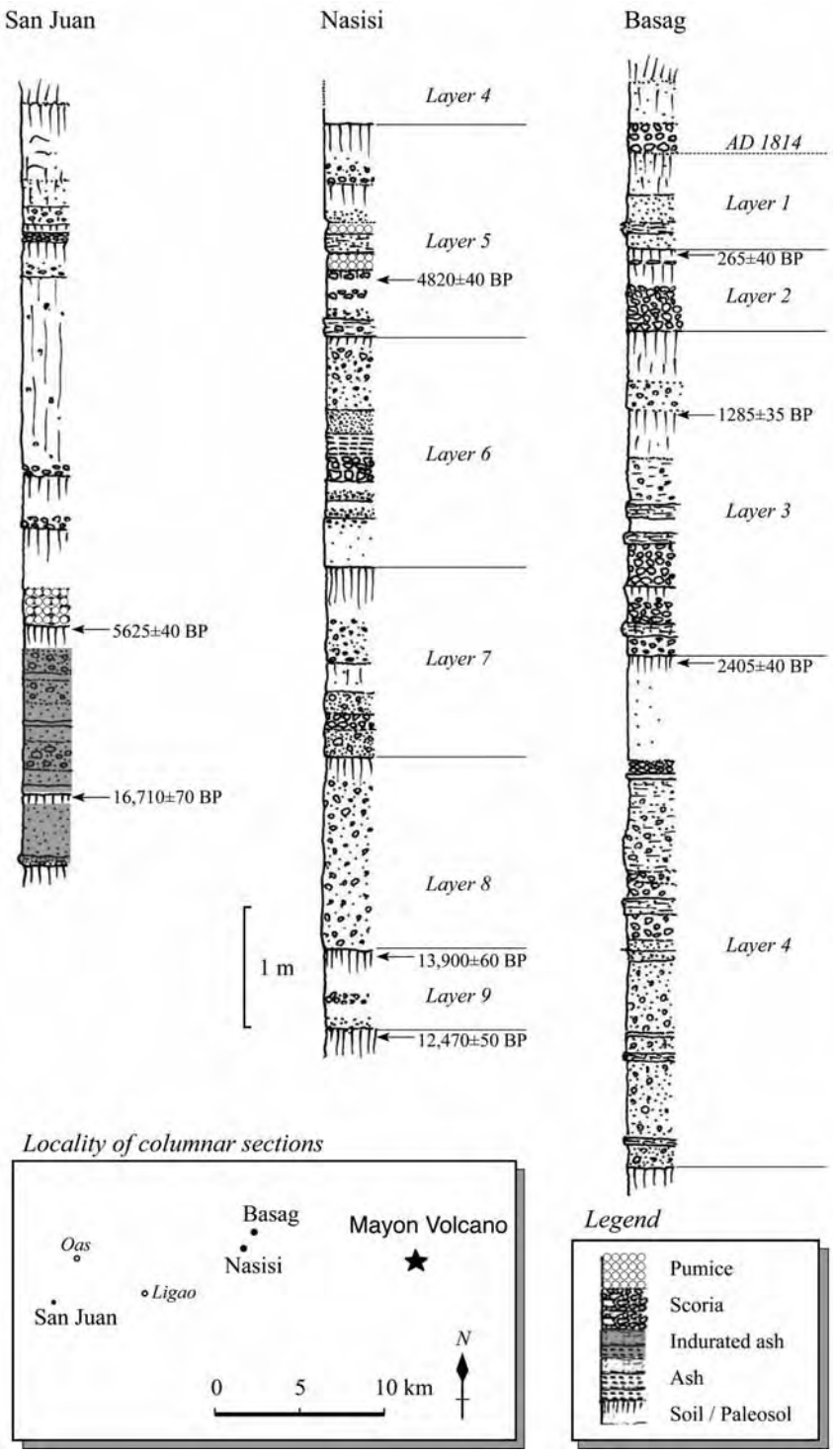


**Fig. 2.** Columnar sections showing stratigraphy of the Mayon tephra group with $^{14}C$ ages. Arrows indicate sampling horizons. Locality of columnar sections is shown in the box.

## Description of Mayon tephra group (My)

Detailed stratigraphic studies were conducted in quarries and an outcrop exposing sequences of the Mayon tephra group (My). Two adjacent quarries were studied at Nasisi (13° 15.53' N, 123° 35.30' E) and Basag (13° 15.87' N, 123° 35.74' E), Ligao City in Albay, and another tephra outcrop at San Juan (13° 14.21' N, 123° 29.23' E), Oas, Albay, 11 km and 20 km west of Mayon's crater, respectively (Fig. 2). The generalized stratigraphic sections of Nasisi and Basag outcrops at Ligao City and San Juan at Oas, Albay are shown in Fig. 2.

At least ten events of magmatic and phreatomagmatic eruptions are interpreted for the Ligao tephra deposits. The nine tephra layers are referred to as Layers 1 to 9 in descending order from the first layer below the uppermost thick scoria layer erupted in AD 1814. The Nasisi section contains all nine layers while the Basag section, which is more accessible, represents the upper horizon of the Nasisi section. Hence, we present two tephra sections at Ligao in Fig. 2; the lower half from Nasisi and the upper half from Basag. The layers are composed mostly of vesicular scoria and dense lithics of varying proportions and accumulated fine ash mixed with small proportion of lapilli. Among the nine layers, Layer 5 consisted of white pumice lapilli with hornblende phenocrysts. Six soil samples were collected from various horizons of the Ligao quarries as shown in Fig. 2.

The San Juan section is composed of an upper 4-m-thick, highly weathered soil with intercalated scoria layers and a lower 2-m-thick, highly indurated layer composed of fine gray ash with dense essential lapilli. A hornblende-bearing pumice layer occurs in the lowermost horizon of the upper soil layer. The lower unit in this section, which consists of indurated gray ash, rests upon a highly weathered basement rock. Thus, the San Juan section is interpreted as the site of the oldest eruptive deposits from Mayon. Two soil horizons were sampled in this outcrop (Fig. 2).

## Experimental procedure

To determine the eruption age of tephra layers, buried soil (2 cm in thickness) was collected from various horizons (Fig. 2). A humim fraction was separated by acid-alkali-acid (AAA) treatments (Okuno *et al.*, 2001). The organic carbon and nitrogen contents were measured for a humic fraction, using a CN coder (MT-700, Yanaco). The $CO_2$ from a humin fraction was reduced catalytically to graphite on Fe-powder with $H_2$ in a sealed Vycor® tube (Kitagawa *et al.*, 1993). We used a HVEE Tandetron AMS system at Nagoya University to make $^{14}C$ measurements of graphite targets with NIST oxalic acid (HOxII) as standards (Nakamura *et al.*, 2000). We corrected for carbon isotopic fractionation using the $^{13}C/^{12}C$ ratio ($\delta^{13}C_{PDB}$). These $^{14}C$ dates are calibrated to the calendar years by the calibration data set IntCal 04 (Reimer *et al.*, 2004) using the CALIB 5.0 program (Stuiver and Reimer, 1993).

## Results and discussion

The results of AMS $^{14}C$ dating are shown in Table 1. The C/N ratios of samples are much less than 10, which indicate that organic materials contained in these samples have been considerably decomposed. However, the results that we obtained are still reliable since the $^{14}C$ dates are quite consistent with the stratigraphy of the Mayon tephra group (Fig. 2), except for one $^{14}C$ date (i.e. 12,470 ± 50 BP, NUTA2-10806). These results also show that the hornblende-bearing pumice lapilli

**Table 1.** Result of AMS $^{14}C$ dating for the Mayon tephra group.

| Locality | Stratigraphic horizon | C (%) | N (%) | C/N | $\delta^{13}C$ (‰) | $^{14}C$ age (BP) | Lab code (NUTA2-) | Calibrated year range | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | cal BP (2σ) | Probability (%) |
| Sun Juan | Below Pumice layer | 0.17 | 0.03 | 6.4 | -22.9 | 5625±40 | 10802 | 6312-6485 | 100 |
| | In Indurated ash | 0.23 | 0.03 | 8.2 | -15.0 | 16,710±70 | 10801 | 19,579-19,693<br>19,766-20,078 | 14.0<br>86.0 |
| Nasisi | In Layer 5 | 0.06 | n.d. | — | -33.4 | 4820±40 | 10797 | 5468-5620<br>5626-5644 | 97.1<br>2.9 |
| | Below Layer 8 | 0.24 | n.d. | — | -15.8 | 13,900±60 | 10796 | 16,182-16,942 | 100 |
| | Below Layer 9 | 0.20 | n.d. | — | -15.6 | 12,470±50 | 10806 | 14,211-14,907 | 100 |
| Basag | Below Layer 1 | 0.13 | 0.04 | 3.5 | -32.6 | 265±40 | 10805 | 275-340<br>347-461 | 42.7<br>46.4 |
| | In Layer 3 | 0.38 | 0.03 | 10.8 | -21.9 | 1285±35 | 10804 | 1137-1162<br>1167-1293 | 3.8<br>94.8 |
| | Below Layer 3 | 0.07 | 0.01 | 5.1 | -29.0 | 2405±40 | 10803 | 2344-2513<br>2636-2697 | 80.4<br>14.6 |

layers from the Nasisi and San Juan sections have similar $^{14}C$ ages. Furthermore, our data suggest that there was considerable lack of tephra layers between the pumice layer and basal indurated ash at the San Juan outcrop.

On the basis of calibrated $^{14}C$ ages of intercalated paleosols and stratigraphic positions of associated tephra deposits, the oldest age is about 20 cal kyr BP (Table 1). Since this soil layer directly overlies the oldest ash layer, the oldest eruptive event must have taken place shortly before 20 cal kyr BP. Previous studies estimated the oldest eruption age as > 25,000 years old (Ramos-Villarta *et al.*, 1985), 24,000 years old (Punongbayan, 1985) and 70,000 years old (Newhall, 1977). Thus, our new data give a younger age than the previous age estimates of Mayon.

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