AMS Radiocarbon Dates for Pyroclastic Flow Deposits from Parker Volcano, South Cotabato, Philippines: A Preliminary Report

Marie Thess D. Quilalang[1]*, Mitsuru Okuno[2], Cathy D. Pogay[1], Ma. Mylene M. Villegas[1], Raymond Patrick R. Maximo[1], Arturo S. Daag[1], Toshio Nakamura[3], Keiji Yamasaki[4], Ericson B. Bariso[1], Danikko John V. Rivera[1], Renato U. Solidum, Jr. [1]

[1]Philippine Institute of Volcanology and Seismology – Department of Science and Technology (PHIVOLCS-DOST), C.P. Garcia Ave., University of the Philippines Campus, Diliman, Quezon City 1101, Philippines.

[2]AIG Collaborative Research Institute for International Study on Eruptive History and Informatics (ACRIFIS-EHAI), Also: Department of Earth System Science, Faculty of Science, Fukuoka University, Jonan, Fukuoka 814-0180, Japan.

[3]Institute for Space-Earth Environmental Research, Nagoya University, Chikusa, Nagoya 464-8601, Japan.

[4]Graduate School of Science, Fukuoka University, Jonan, Fukuoka 814-0180, Japan.

**Correspondence author. E-mail: thessa.quilalang@gmail.com*

Abstract

Parker Volcano is classified as one of the active volcanoes in the Philippines and is located in the province of South Cotabato in southern Mindanao. The results of AMS radiocarbon (^{14}C) dating for pyroclastic flow deposits of Parker Volcano are presented in this paper. A total of fourteen dates were obtained and are divided into five groups (*i.e.*, 4 to 3.9 kBP, 1.9 kBP, 0.5 kBP, 0.4 to 0.3 kBP and 0.2 kBP), which are almost consistent with previous reported dates. To reveal its eruptive history in detail and with high precision, evaluation of these dates with geological and geomorphological framework is necessary. Moreover, results of this study can provide useful information for disaster risk reduction efforts.

Keywords: Parker Volcano; Mindanao Island; Radiocarbon dating; Pyroclastic flow deposit; Eruptive history

1. Introduction

Parker Volcano (124.072°E, 6.360°N, 1784 m a.s.l.) is located in the province of South Cotabato in southern Mindanao, Philippines. Its summit is occupied by Lake Maughan *(locally known as Lake Holon)*, a caldera lake with a diameter of *ca*. 3 km (Fig. 1). Previous works were mainly concerned on either defining the mineralization zones of South Cotabato or evaluation of the geothermal potential of the volcano (*e.g.*, Bayon and Salonga, 1992; Delfin *et al.*, 1997). An initial effort to conduct a geologic survey was spearheaded by PHIVOLCS and Philippine National Oil Company (PNOC) in 1994. The reported radiocarbon (^{14}C) dates by Delfin *et al.* (1997) can be grouped into at least 4 major explosive eruptions: 27 to

23 kBP, 3.8 kBP, 0.6 kBP and 0.3 kBP. The latter ^{14}C age corresponds with the last eruption that occurred in AD 1641 (Delfin *et al.*, 1997) as reported in historical Spanish era documents. However, the volcano-geologic character and eruptive history of Parker are still not clear. To establish its detailed eruptive history, geologic mapping of volcanic strata at Parker Volcano was conducted in August and September 2015 (Quilalang *et al.,* 2015). This paper presents the results of AMS ^{14}C dating on charred woods obtained from pyroclastic flow deposits around this volcano.

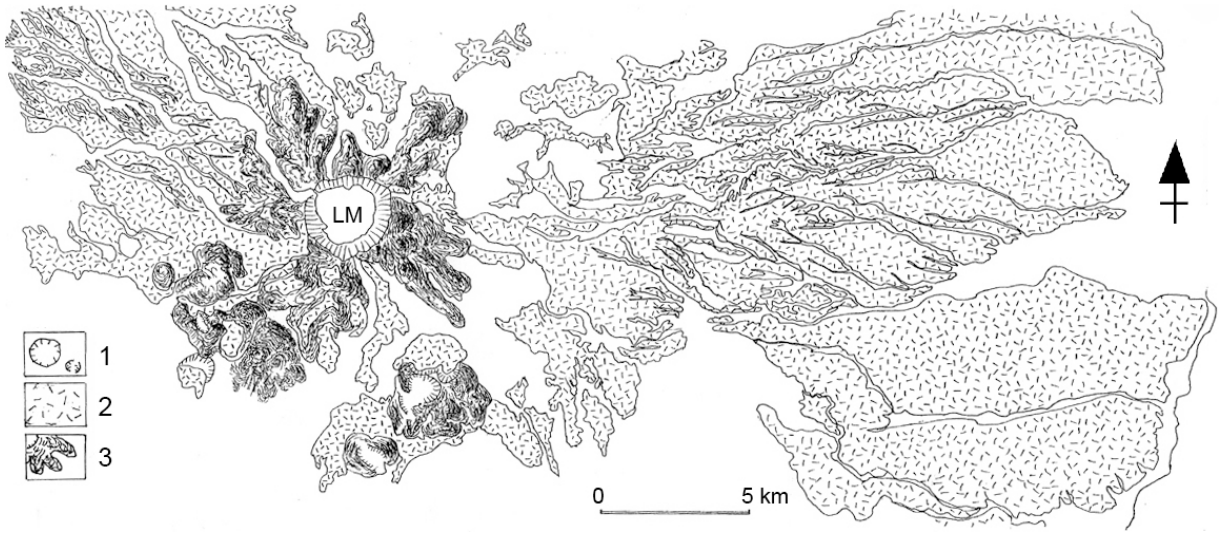

Fig. 1. Geomorphological map of Parker Volcano (after Moriya, 2014).
1: crater and caldera wall, 2: pyroclastic-flow surface, 3: slope of a stratovolcano, LM: Lake Maughan.

2. Geological Outline and Previous Works on Parker Volcano

The geology of Parker Volcano was first described in the study conducted by Bayon and Salonga (1992). Volcanic activity in Parker Volcano began during the Late Pliocene, which deposited the Old Parker Volcanics. The second episode ensued during the Early Pleistocene, which involved at least four eruptive events and comprises the Young Parker Volcanics. At least four explosive dacitic-eruptions resulted in the extensive radial deposition of pumice flow deposits owing to the creation of the 2 km wide caldera Maughan Lake. On the other hand, lava flows on the slope of stratovolcano consist of hornblende-andesite (Delfin *et al*., 1997). The Salmongan dome, south of the summit lake, is a product of last event of Parker Volcano.

The initial result by Quilalang *et al.* (2015) shows that Parker Volcano has five major types of volcanic deposits namely pyroclastic flow, pyroclastic fall, pyroclastic surge, lahar deposits, and old lava flows/domes (Fig. 2). Pyroclastic flow deposits extensively cover the eastern and western portion in the vicinity of T'Boli and General Santos City. Lava domes were recognized particularly in Mt. Salmotan and Mt. Salmongan, T'Boli while preserved tephra fall outcrops are distributed at the northern part mainly in Brgy. Simbo, T'Boli. As disclosed by extensive young pyroclastic flow deposits from the volcano, the dacitic and explosive nature of eruptions are similar to that of Pinatubo Volcano (Newhall *et al*., 1996).

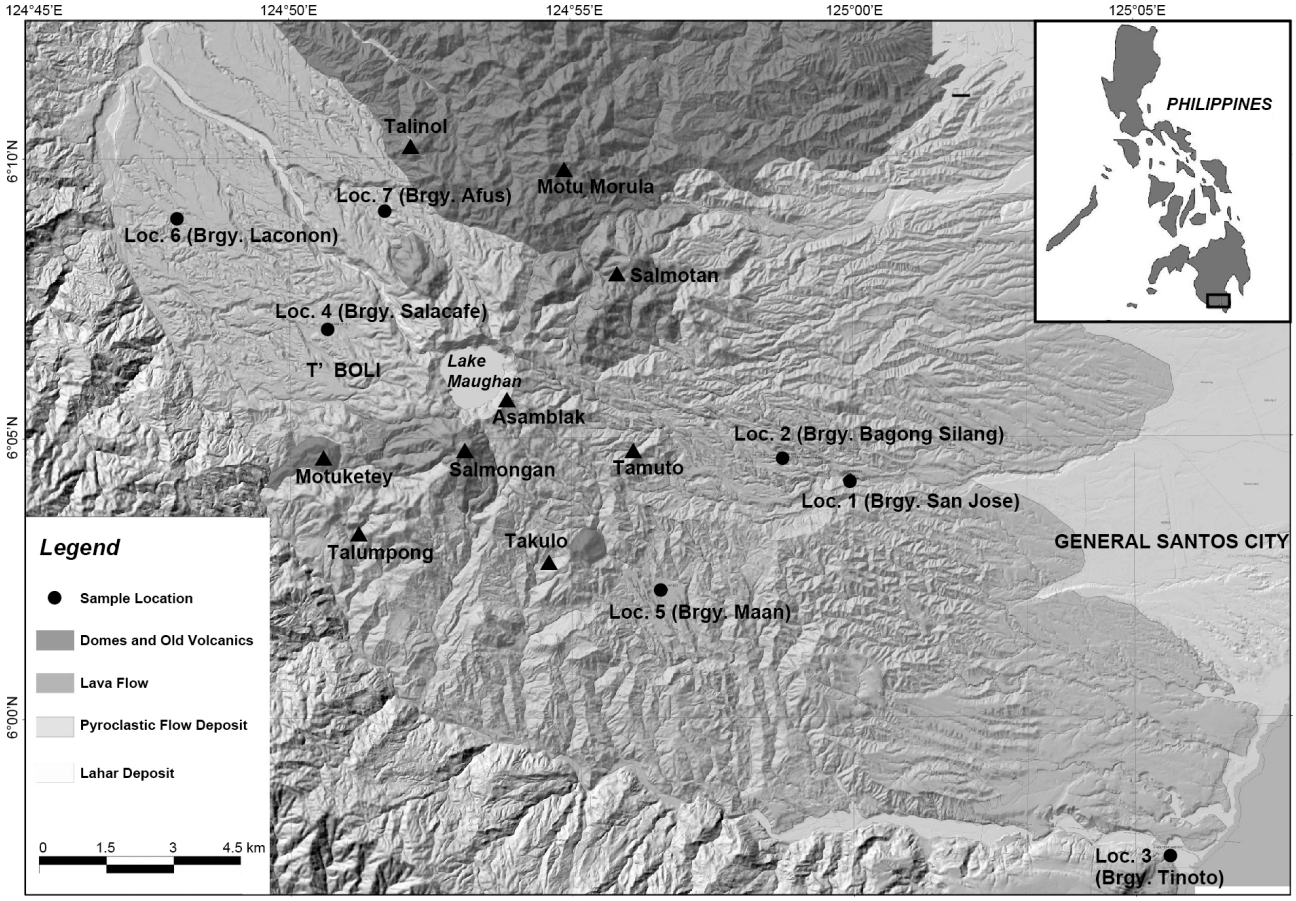

Fig. 2. Geological map of Parker Volcano (modified from Quilalang *et al.*, 2015).
Closed triangles with names show mountain. See Table 1 for sampling location.

3. AMS Radiocarbon Dating

A total of fourteen ^{14}C dates of charred woods collected from pyroclastic flow deposits of Parker Volcano were obtained in this study. Charcoal fragments were purified by a routine acid-alkali-acid (AAA) treatment, and oxidized by heating together with CuO. The produced gas was purified cryogenically to CO_2 gas using vacuum line, and then reduced catalytically to graphite on Fe powder with H_2 gas (Kitagawa *et al.*, 1993) at Fukuoka University. Radiocarbon measurement with NIST oxalic acid standard (HOxII) was carried out using the AMS system (model 4130-AMS, HVEE) at Nagoya University (Nakamura *et al.*, 2000). The ^{14}C dates are calibrated to calendar range using *IntCal13* (Reimer *et al.*, 2013) data set with a computer program *Calib 7.1* (Stuiver and Reimer, 1993).

4. Results and Discussion

Results of AMS ^{14}C dating for Parker Volcano are shown in Table 1. The calibrated year ranges are also shown in Fig. 3. The obtained ^{14}C dates can be divided into five groups, approximately 4 to 3.9 kBP, 1.9 kBP, 0.5 kBP, 0.4 to 0.3 kBP and 0.2 kBP, respectively. Especially during the last 500 years, chronological evaluation comparing with geological and geomorphological framework is necessary to reveal its eruptive

history in detail and with high precision. The obtained ^{14}C dates are almost consistent with a part of previous published ones (*i.e.*, 3.8 kBP, 0.6 kBP and 0.3 kBP). These dates will be crucial for evaluating explosive eruption history, hazards and potential risk of the volcano. Therefore, the results in this study will provide useful information for local governments in their decision-making and disaster risk reduction efforts.

Table 1. Results of AMS ^{14}C dating.

Location no. *1	Latitude	Longitude	^{14}C age (BP)	$\delta^{13}C_{PDB}$ (‰)	Lab code (NUTA2-)	Calibrated year range *2 (cal BP, 2σ, probability %)	Remarks
7	6.332520°N	125.031432°E	190±35	-32.2	23796	0 - 33 (17.4) 74 - 100 (2.9) 105 - 114 (1.1) 136 - 225 (54.9) 254 - 303 (23.7)	WP 225
1	6.071637°N	124.999059°E	310±30	-21.3	23712	301 - 342 (24.3) 346 - 463 (75.7)	WP 001
1	6.071683°N	124.998944°E	325±30	-25.5	23709	306 - 469 (100)	15091201 S-1
3	5.959558°N	125.093316°E	330±30	-25.3	23710	308 - 472 (100)	15091203 S-1
1	6.071717°N	124.999237°E	335±35	-26.1	23795	308 - 481 (100)	WP 172
1	6.070533°N	124.997616°E	375±35	-26.8	23790	316 - 399 (41.6) 403 - 406 (0.4) 422 - 506 (58.1)	WP 002
3	5.959583°N	125.093389°E	400±45	-20.6	23792	316 - 399 (33.4) 403 - 406 (0.3) 422 - 520 (66.3)	WP 005 (blue)
3	5.959583°N	125.093389°E	510±35	-22.6	23715	503 - 557 (90.6) 604 - 627 (9.4)	WP 005 (black)
5	6.037962°N	124.944356°E	530±50	-25.9	23793	502 - 568 (62.8) 584 - 648 (37.2)	WP 076
4	6.115944°N	124.845083°E	1910±35	-28.5	23711	1737 - 1764 (4.4) 1771 - 1931 (95.6)	15091401 S-1
6	6.148998°N	124.800243°E	1955±40	-32.9	23794	1824 - 1989 (100)	WP 093
2	6.076927°N	124.979387°E	3895±35	-29.3	23713	4184 - 4196 (0.8) 4234 - 4422 (99.2)	WP 004
2	6.076666°N	124.979509°E	3970±40	-29.6	23800	4295 - 4335 (8.1) 4340 - 4527 (91.9)	WP 421 #2
2	6.076666°N	124.979509°E	4010±40	-31.7	23798	4410 - 4580 (99.1) 4770 - 4780 (0.9)	WP 421 #1

*1 see Fig. 2, *2 using *IntCal13* (Reimer *et al*., 2013) and *Calib 7.1* (Stuiver and Reimer, 1993).

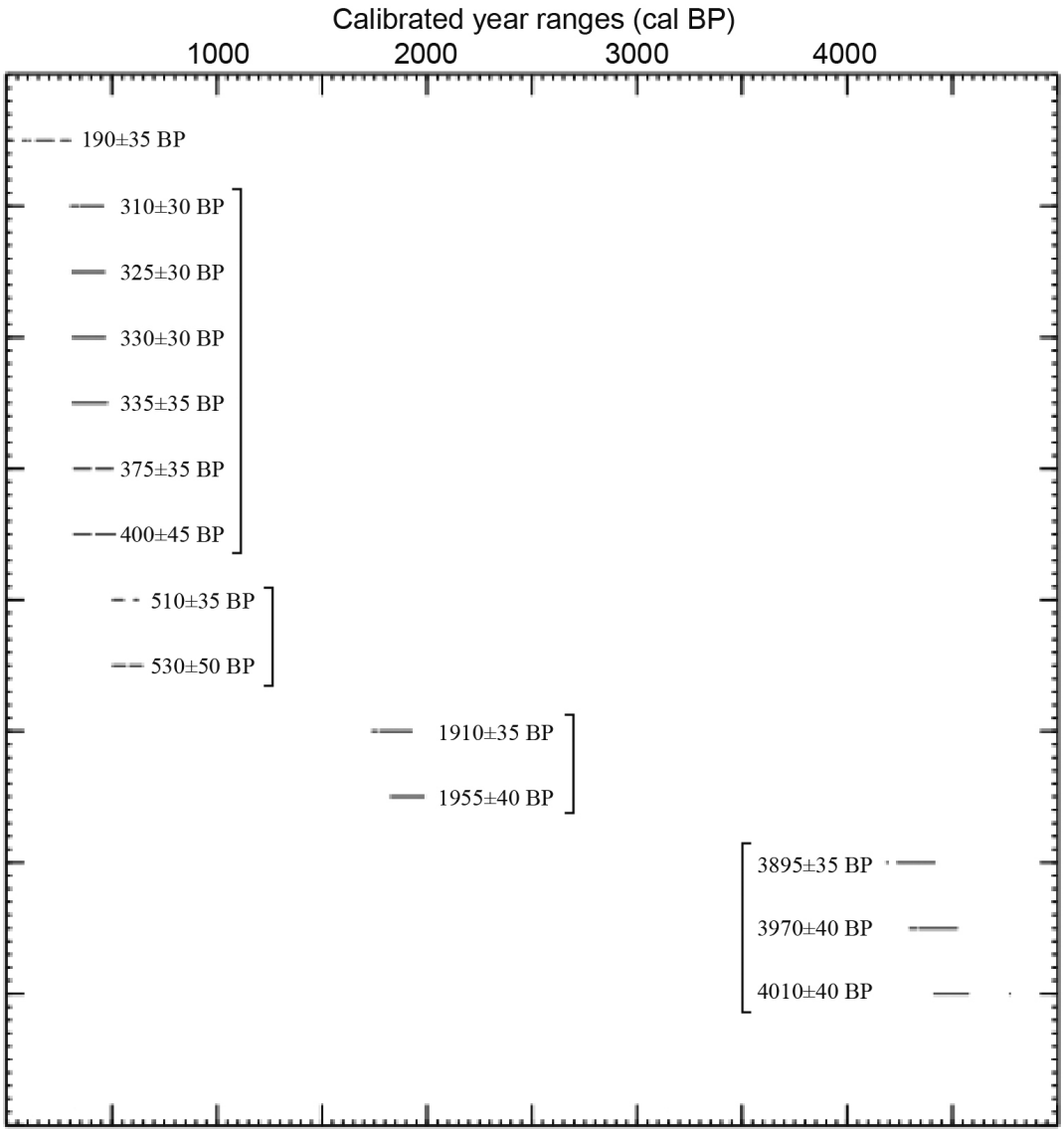

Fig. 3. Bar showing calibrated year range for Parker Volcano, using a computer program *Calib 7.1* (Stuiver and Reimer, 1993).

Acknowledgement

This study was partly supported by a Grant-in-Aid for Scientific Research "KAKENHI" (no. 24401006) from the Japan Society for the Promotion of Science (JSPS) and budget from DOST-PHIVOLCS.

Reference

Bayon, F.E.B. and Salonga, N.D. (1992) Surface Geology and Hydrothermal Systems of Mts. Parker and Matutum Geothermal Prospects. *PNOC-EDC Internal Report*.

Delfin, Jr. F.G., Newhall, C.G., Martinez, M.L., Salonga, M.D., Bayon, F.B., Trimble, D. and Solidum, Jr. R. (1997) ^{14}C, and historical evidence for 17th century eruption of Parker Volcano, Mindanao, Philippines. *Journal of Geological Society of Philippine*, **3** (1), 25–42.

Kitagawa, H., Masuzawa, T., Nakamura, T. and Matsumoto, E. (1993) A batch reparation method for graphite targets with low-background for AMS ^{14}C measurements. *Radiocarbon*, **35**, 295-300.

Martinez, M.M.L. and Pataray. A.L. (1994) Report of Investigation: 13 May – 26 May 1994 Reconnaissance Mapping of Parker Volcano, South Cotabato. *PHIVOLCS Internal Report*.

Moriya, I. (2014) Evolution and classification of volcanic edifices on the Philippine Islands. *Journal of Geography (Chigaku Zasshi)*, **123**, 89-122. (in Japanese with English Abstract)

Nakamura T., Niu E., Oda H., Ikeda A., Minami M., Takahashi H., Adachi M., Pals L., Gottdang, A., Suya N. (2000) The HVEE Tandetron AMS system at Nagoya University. *Nuclear Instruments and Methods in Physics Research, B* 172, 52–57.

Newhall, C.G., Daag, A.S., Delfin, Jr. F.G., Hoblitt, R.P., McGeehin, J., Pallister, J.S., Regalado, M.T.M., Rubin, M., Tubianosa, B.S., Tamayo, Jr. R.A. and Umbal, J.V. (1996) Eruptive History of Mount Pinatubo. *In Newhall, C.G. and Punongbayan, R.S. (eds), Fire and Mud: Eruptions and Lahars of Mount Pinatubo, Philippines*, Philippines Philippine Institute of Volcanology and Seismology, Quezon City, and University of Washington Press, Seattle and London, 165–195.

Quilalang, M.T.D., Pogay, C.D., Maximo, R.P.R., Villegas, M.M.M., Daag, A.S., Okuno, M., Rivera, D.J.V., Bariso, E.B. and Solidum, Jr. R.U. (2015) Stratigraphy of selected eruptive deposits from Parker Volcano, South Cotabato, Philippines. *GEOCON 2015*, Poster Presentation.

Reimer, P.J., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Bronk Ramsey, C., Buck, C.E., Cheng, H., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Haflidason, H., Hajdas, I., Hatté, C., Heaton, T.J., Hoffmann, D.L., Hogg, A.G., Hughen, K.A., Kaiser, K.F., Kromer, B., Manning, S.W., Niu, M., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Staff, R.A., Turney, C.S.M. and van der Plicht, J. (2013) *IntCal13* and *Marine13* radiocarbon age calibration curves 0–50,000 years cal BP. *Radiocarbon*, **55**, 1869–1887.

Stuiver, M. and Reimer, P.J. (1993) Extended ^{14}C data base and revised *CALIB* 3.0 ^{14}C age calibration program. *Radiocarbon,* **35**, 215–230.

日本語要旨

フィリピン共和国，ミンダナオ島のパーカー火山に分布する火砕流堆積物中の炭化木片の放射性炭素（^{14}C）年代を加速器質量分析（AMS）法により測定した．得られた ^{14}C 年代は，4～3.9，1.9，0.5，0.4～0.3，0.2 kBP の５つのグループに区分される．ただし，最近 500 年間にある３つのグループは近接しているため，今後，地形や地質層序を踏まえて詳細に検討する必要がある．今後，さらに研究を進めて噴火間隔（休止期間）と噴出物の分布（噴出量）が明らかになれば，火山災害の防止・軽減にも役立つものと期待される．