SCIENTIFIC PROGRAMME

Second meeting for the Irosin Drilling Project

Date: 13:00-17:00, 22nd May, 2010,
Venue: Research Center for the Pacific Island (RCPI), Kagoshima University

1. Welcome address by head of the Research Center for the Pacific Island (Prof. Shinichi Noda)
(13:00-13:10)

2. Acknowledgement remarks by head of the PHIVOLCS (Dr. Renato U. Solidum)
(13:10-13:20)

3. The purpose and perspective of the Irosin Drilling Project (Dr. Mitsuru Okuno)
(13:20-40)

4. Borehole drilling project progress report (Dr. Ma. Hannah Mirabueno)

(13:40-14:10)

5. Occurrence of the intra-plinian flow deposit from Irosin caldera (Prof. Tetsuo Kobayashi)
(14:10-14:30)

Coffee brake (14:30-14:50)

6. Petrograhic characteristics of Irosin Ignimbrite and co-ignimbrite ash falls, South Luzon, Philippine (Dr. Tohru Danhara)
(14:50-15:10)

7. Thermoluminescence (TL) Age of the Irosin Ignimbrites, Southeastern Luzon, Philippines (Dr. Isao Takashima)
(15:10-15:30)

8. Bulusan Volcano: Geologic and hazards studies (Ms. Mariton Bornas)
(15:30-16:00)

9. The seismicity of 2006-2007 Bulusan Volcano activity (Mr. Eduardo Laguerta)
(16:00-16:20)

10. Discussions of future plans
(16:20-17:00)

(Presented at Fukuoka University on May 18, 2010)
Preliminary report on chemical characteristics of hot spring from Bulusan Volcanic Complex, Philippines (Dr. Sachihiro Taguchi)

Abstracts

The purpose and perspective of the Irosin Drilling Project

Mitsuru OKUNO
Fukuoka University

The purpose of the project is to reveal the geological development and characteristics of the Irosin caldera, Luzon, Philippines. In particular, focus will be made on caldera forming and post-caldera volcanism including geothermal activity. Ms. Bornas shall present an overview of geological survey on the caldera. Prof. Kobayashi (Kagoshima Univ.) shall report the preliminary results of geological survey of the Irosin Ignimbrite. Dr. Mirabueno (PHIVOLCS) presented correlation of the ignimbrite and co-ignimbrite ash-fall on Inascan Scoria Cone at the INTAV-J, Active Tephra 2010. Dr. Torii has already reported the result of chemical analysis of glass shards from both ashfall deposits at the first meeting in March 2010. In the same meeting, Dr. Danhara presented the petrography of this ignimbrite.

There are several post-caldera volcanoes including Bulusan Volcano. The drilling cores can provide evidence of the activity. Dr. Mirabueno and Ms. Delos Reyes (PHIVOLCS) shall present description of core sediment collected from the caldera. It may indicate post-caldera volcanism. Dr. Fujiki (International Research Center for Japanese Studies) may also perform pollen analysis on the core. He will reveal paleo-environmental changes during post-caldera volcanism.

Prof. Taguchi reported preliminary results on hot springs and river water. It is important to estimate water circulation under the volcano. Mr. Laguerta (PHIVOLCS) shall report observation system at Bulusan Volcano. Prof. Kawai (Kagoshima Univ.) provides other proxy around caldera.

For 2010, various reports shall be published in one volume from Kagoshima University. International scientific collaboration is very important. This project is conducted with collaboration among various organizations in Japan and the Philippines under the JSPS foundation. To establish collaborative study, a Memorandum of Agreement (MOU) is very important. Thus, we will discuss about MOU during the meeting.

Borehole drilling project progress report

MIRABUENO, MA. HANNAH, DELOS REYES, PERLA,
and LAGUERTA, EDUARDO
Philippine Institute of Volcanology and Seismology (PHIVOLCS)
Department of Science and Technology (DOST)

Drilling was conducted in two borehole sites located in a rice field in Brgy. Taboc, Juban, Sorsogon, and inside the Irosin Techonological Institute, Brgy. San Pedro, Irosin, Sorsogon from 28 February to 30 March 2010.

The drilling at first site in Brgy. Taboc, Juban was up to ten (10) meters, with systemic logging and documentation per half a meter. At this site, the core samples consisted of silty clay to sand up to 6m depth, then drilling started to encounter hard rock, possibly boulder fragments of lava flow deposits. Difficulty in drilling resulted in delay which forced the team to terminate drilling and move to the second drilling site.

Drilling in Brgy. San. Pedro reached up to 50 meters depth. The core samples consisted of alternating coarse- to fine-grained sand, consisting of free crystals, lithic fragments and pumice. Fallout deposits were encountered in various depths. Andesitic fallout layers were encountered within the first 10 meters while rhyolitic fallout occurred at depth range of 20 to 35 meters. Peaty layers occurred within the depth range of 8 to 10 meters.

Occurrence of the intra-plinian flow deposit from Irosin caldera

Tetsuo KOBAYASHI
Kagoshima University

Previously, two types of Irosin ignimbrite were presented: a lower fine and the upper coarse ignimbrite. These lithofacies are quite similar to the Tsumaya and the Ito ignimbrite from Aira caldera in Japan. However, we had no data about the plinian deposit around the Irosin caldera.

During the field survey in March 2010, stratified surge-like deposits were found that are directly overlain by the upper coarse Irosin ignimbrite. However, the surge-like deposits are actually stratified thin pyroclastic flow deposits which are intercalated with plinian pumice layers. Hence, the deposits are recognized as the intra-plinian flow deposits. Similar examples are found from Aira caldera in Japan: the Tarumizu ignimbrite associated with the Osumi plinian pumice. We need further field survey to draw the distribution of the plinian pumice deposit around the Irosin caldera.

Petrographic characteristics of Irosin Ignimbrite and Co-ignimbrite Ash Falls, South Luzon, Philippines

Tohru DANHARA[1], Mitsuru OKUNO[2], Maria Hannah T. MIRABUENO[3], Tohru YAMASHITA[1] and Tetsuo KOBAYASHI[4]

1 Kyoto Fission-Track Co. Ltd., Kyoto 603-8832, Japan
2 Department of Earth System Science, Faculty of Science, Fukuoka University, Fukuoka 814-0180, Japan
3 Geology and Geophysics Research and Development Division, Philippine Institute of Volcanology and Seismology, C.P. Garcia Ave., UP Diliman, Quezon City, Philippines
4 Department of Earth and Environmental Science, Faculty of Science, Kagoshima

University, Kagoshima 890-0065, Japan

1. Introduction

The large explosive volcanic events produced voluminous silicate pyroclastic flow deposits and co-ignimbrite ash deposits. Irosin caldera was formed by the eruption that elutriated the Irosin ignimbrite (Delfin *et al*., 1993: McDermott *et al*., 2005). During explosive ignimbrite-forming eruptions, much of the pyroclastic materials may fail to be included in the resulting ignimbrite for total eruption volumes. In particular, fine-grained ash materials can be elutriated from the eruption column, dispersed mainly by high-altitude wind, and deposited as a co-ignimbrite ash in distal areas away from source caldera (*e.g*., Sparks and Walker, 1997). In 2007, PHIVOLCS and Japan scientific co-workers found a 1.3 m thick fine white ash layer near Mayon Volcano, and it is speculated to be a co-ignimbrite ash from Irosin caldera. In this paper, we have identified the petrographic characteristics of the pyroclastic flow deposits and co-ignimbrite ash. This is the first study on the possible widespread tephra around the Philippines.

2. Samples

Three samples were obtained from two areas. Sites 1 and 2 are around Irosin caldera in the Bicol Peninsular and Site 3 is near Mayon Volcano. SP1 is the lower fine-grained part of the Irosin ignimbrite along Magallanes Road. SP2 is the upper coarse part of the Irosin ignimbrite along Matnog Road, and SP3 is 1.3 m thick fine white ash on the Inascan scoria cone near Mayon.

3. Experimental procedure

Tephra samples were collected and analyzed in order to identify and correlate each tephra layer. Part of each sample was washed on a 63-μm sieve, and residual grains were observed under a binocular microscope to determine the concentration of volcanic glass shards and their morphology. Quantitative analysis was conducted as follows: 1) each tephra sample was washed on 63-, 125- and 250-μm mesh sieves, and residual grains from between the 63- and 125-μm meshes were mounted on glass slides: 2) the bulk grain composition, heavy mineral composition, and morpho-type of volcanic glass shards were examined under the microscope: 3) the refractive index of each volcanic glass shard was measured using a RIMS analyzer, an improved refractive index measuring system using thermal immersion method (Danhara *et al*. 1992).

Measurement of refractive index of volcanic glass and minerals has been an orthodox method for tephra characterization (Wilcox, 1965). Particularly in Japan, refractive index is widely used to identify tephras (e.g., ATLAS OF TEPHRA IN AND AROUND JAPAN: Machida and Arai, 1992, 2003). The reason that measurement of refractive index has been done can be made easily and instantly. However, recent development of the electron probe micro-analysis (e.g. Smith and Westgate, 1969) and laser abration inductively coupled plasma mass spectrometry (LA-ICP-MS) technique (e.g. Pearce *et al*., 1999) appeared to have diminished the significance of refractive index measurement because EPMA or LA-ICP-MS techniques enable us to obtain chemical composition of an individual grain. Single-grain analysis is highly informative when we deal with tephra, in which mixture of detritus grains is occasional. But RIMS system with which the refractive index of each single grain can be determined with a high precision. This progress stimulates reassessment of refractive index measurement because the system is useful not only for tephra identification but also for recognition of various types of heterogeneity in glass or mineral. Heterogeneity can affect various analyses. It is therefore important to recognize what sort of heterogeneity is present in a sample.

4. Results and Discussion

Table 1 and Fig.1 show the result of petrographic analysis.

We found similarities of the petrographic characteristics among the three samples as follows;

(1) SP1: lower fine-grained Irosin gnimbrite

Glass is very abundant and light minerals, plagioclase and quartz are rare. Glass particles consist of pumice-type shards with refractive index of 1.4975-1.4984 and the mode is 1.498. Plagioclase crystals are commonly euhedral and tabular with main refractive index of 1.541-1.553 (andesine), and the mode is 1.549. Heavy minerals are found in rare: they are cummingtonite, biotite, opaque minerals and zircon. Cummingtonite crystals are euhedral with index of 1.657-1.662, and the mode is 1.659.

(2) SP2: upper coarse-grained Irosin ignimbrite

In general, glass is very abundant, and light minerals consist of plagioclase and rare quartz are rare. Lithic fragments are found in trace amounts. Glass particles consist of pumice-type shards with refractive index of 1.4978-1.4987 and the mode is 1.498. Plagioclase crystals are commonly euhedral with main refractive index of 1.546-1.555(andesine), and the mode is 1.549. Heavy minerals are found as green-hornblende and zircon. Cummingtonite crystals are euhedral with index of 1.657-1.662 the mode is 1.659.

(3) SP3: INASCAN cone lowermost WT

In the sample, glass is very abundant, light minerals consist of plagioclase and rare quartz rare. Lithic fragments are found in trace amounts. Glass particles consist of pumice-type and bubble-wall-type with index of 1.4966-1.4998 mainly, and the mode is 1.498. Plagioclase crystals are euhedral with index of 1.543-1.555 (andsine) and 1.557-1.559 (labradorite), and the mode is 1.549. However, the presence of green hornblende is not consistent with the two Irosin ignimbrite samples. We infer from the analytical results that the three samples are in good agreement, and therefore, SP3 is the co-ignimbrite ash from the Irosin ignimbrite. The green hornblendes of SP3 are supposed accidental crystals.

Irosin ignimbrite has a unique petrographic characteristic. We know only one Quaternary widespread tephra that has the same petrographic similarity to the Irosin ignimbrite in Japan. As inferred from the tephrochronological study on Quaternary tephras in Japan, these petrological characteristics of Irosin ignimbrite is quite unique. Further, our data and AMS ^{14}C age control (Mirabueno *et al*., 2007) can be a first step to establish the tephrochronological framework in Philippine.

Reference

Danhara, T.,Yamashita, T., Iwano, H. and Kasuya, M. (1992) An improved system for measure refractive index using the thermal immersion method. *Quat. Int.* 13/14, 89-91.

Delfin, F.G., Panem, C.C. and Defaut, M.J. (1993) Eruptive history and petrochemistry of the Bulusan volcanic complex: implication for the hydrothermal system and volcanic hazards of Mt. Bulusan, Philippines. *Geothermics*, 22**,** 417-434.

Machida, H. and Aral, F. (1992) The Atlas of volcanic Ash. Univ., Tokyo press, Tokyo, 277pp.

Machida, H. and Arai. F. (2003) Atlas of Tephra in and around Japan [revised edition] Univ. Tokyo Press, Tokyo, 336pp.

McDermott ,F., Delfin, F. G., Defant, M.J., Turner, S. and Maury, R. (2005) The petrogenesis of volcanics from Mt. Bulusan and Mt. Mayon in the Bicol arc, the Philippines. *Contribution to Mineralogy Petrology*, 150, 652-670.

Mirabueno, M.H.T., Okuno, M., Nakamura, T., Laguerta, E.P., Newhall, C.G. and Kobayashi, T. (2007) AMS radiocarbon dating of a charcoal fragment from the Irosin Ignimbrite, Sorsogon Province, Southern Luzon, Philippines. *Bull. Volcanol. Soc. Japan*, 52, 241-244.

Sparks, R.S.J. and Walker, G.P.L. (1977) The significance of vitric-enriched air-fall ashes associated with crystal-enriched ignimbrites. *Jour. Volcanol. Geotherm. Res.*, 2:329-341.

Wilcox, R.E. (1965) Volcanic-ash geochronology. In : Wright, H.E. Jr and D.G. (eds.), The Quaternary of the United States, pp.807-816. Princeton University Press.

Thermoluminescence (TL) Age of the Irosin Ignimbrites, Southeastern Luzon, Philippines

Isao TAKASHIMA
Mining Museum, Faculty of Engineering and Resource Science
Akita University

Thermoluminescence (TL) dating is applied to 4 samples of the Irosin ignimbrites. Three of them are collected from Irosin Caldera area (Sp7, Sp8 and Sp8b) and one from Inascan Scoria Cone, foot of Mayon volcano (Sp9). Obtained ages are 37±8ka (Sp7), 39±10ka (Sp8), 32±8ka (Sp8b) and 47±10ka (Sp9) (Table 1). Samples Sp7 and Sp8 are matrix part of ignimbrite which show almost similar to ^{14}C age (Mirabueno et al., 2007). However, Samples Sp8b and Sp9 show different from such ^{14}C age.

Sample Sp8b is the lithic fragment of about 10cm size. Its TL signal is very clear and gives good data. One reason for show young TL age is fading of TL signal. Sample

Sp9 is a distal ash fall deposit far away and consists of very fine grain size. Possivble reasons for the old TL age are grain size and/or water contents. Further experiments are needed for getting precise TL ages for the above samples.

Table 1 TL ages of the Irosin Ignimbrite

Sample	Rock type	U (ppm)	Th (ppm)	K_2O (%)	Water (%)	Quartz size (mm)	Annual Dose (mGy/a)	Paleodose (Gy)	TL age (ka)
Sp7	Matrix part of IG	2.45	5.30	2.62	18.4	0.25	2.44	90	37±8
Sp8	Matrix part of IG	2.14	5.39	2.65	6.1	0.25	2.84	110	39±10
Sp8b	Lithic fragment	2.84	7.23	3.45	0	2.0	2.47	80	32±8
Sp9	Ash fall deposit	2.44	5.72	3.01	22.5	0.10	2.58	120	47±10

Reference

Mirabueno, M.H.T., Okuno, M., Nakamura, T., Laguerta, E.P., Newhall C.G. and Kobayashi, T., 2007, AMS Radiocarbon dating of charcoal fragment from the Irosin Ignimbrite, Sorsogon Province, Southeastern Luzon, Philippines. *Bulletin of the Volcanological Society of Japan*, **52**, 241-244.

Bulusan Volcano: Geologic and hazards studies

Ma. Antonia V. Bornas
Philippine Institute of Volcanology & Seismology
Earth Observatory of Singapore

Geologic studies in the past have produced various datasets that were utilized for understanding hazards from the active Bulusan Volcano edifice. GIS databases vis-a-vis RS data were used in geomorphologic and/or field mapping of eruptive deposits, including those of pyroclastic flows and surges from both dome and explosive eruptions over the last 5,000 years, and a buried summit caldera which may be associated with possible Plinian deposits. More voluminous lava flows are geochemically indiscriminate from pyroclastics, both falling within the narrow range of 57-62%. The potential scope of eruption hazards has been modelled in the GIS platform to match the mapped distribution of deposits, and are anticipated to be improved soon with more quantitative geologic data and new, publicly available geophysical numerical programs.

The seismicity of 2006-2007 Bulusan Volcano Activities

Eduardo P. Laguerta, Bella S. Tubianosa
PHIVOLCS

Bulusan Volcano's long repose of 45 years lasted when it erupted on July 30, 1978. The activity was followed by phreatic eruptions spaced for months and sometimes few years until 1988. The last sequence of this type of activity prior to the current eruptions was in 1994-1995. The eruptions were mostly preceded by volcanic earthquake occurrences and sometimes swarms interspaced through time. Most notable of these seismic precursors prior to current activities of the volcano was the 2006-2007 eruptions.

About six months before the onset of the eruptions, sporadic recordings of low frequency earthquakes were noted at two remote digital seismic stations. The low frequency events quiet down after about three months and only few high frequency earthquakes were recorded. Three days prior to the onset of the 2006 eruptions, a significant increase was noted in the recorded volcanic earthquakes which might be of various processes. This might be the inflection point of the abnormal condition of the volcano in terms of seismicity which was first noted by the occurrence of low frequency earthquakes.

Preliminary report on chemical characteristics of hot spring water from Bulusan Volcanic Complex, Philippines

Sachihiro TAGUCHI

Department of Earth system Science
Fukuoka University

Five water samples are collected from Bulsan Volcanic Complex in March, 2010; two are hot springs, and the others are surface water (Table 1). Water from San Benon and Buhang hot springs are slightly acidic in near neutral region, and dominant in bicarbonate (Table 1). However, these two hot springs seems to have different origin. Anion contents suggest that San Benon hot spring water is hybrid resulting from mixing with steam-heated sulfate and bicarbonate waters while Buhang hot spring is sourced from the mixing with deep chloride water and steam-heated bicarbonate water. Further chemical data will be required to consider their origins.

Table 1. Chemistry of waters from Bulsan Volcanic area

Sp. No.	T100309-1	T100309-2	T100309-1	T100309-4	T100309-5	T100310-1	Tiwi*	Tiwi*	Tiwi*	Seawater	Kuju	Kuju	Kuju	Kuju
Location	Sanbenon H.S	Stream	Bulsan Lake	Buhang H.S.	Buhan S.W.	Inascan	(1)	(2)	(3)		Iwo-yama(4)	H-13(5)	Komatsu-jigoku(6)	Kawara-yu(7)
Temp.(℃)	47.6	31.3	30.4	45.1	6.82	27.4					89		95	68.5
pH	6.52	6.31	6.55	6.28	6.68	6.72	7.16	5.75	3.20	8.2	1.51	7.8	2.32	5.8
Na^+(mg/l)							89	2441	1672	10770	82.5	1660	11.9	19.4
K^+(mg/l)							32	582	310	380	11.6	300	9.9	12.5
Ca^{2+}(mg/l)							38	40	22	412	90.2	13.3	20.5	17.1
Mg^{2+}(mg/l)										1290	44.7	0.05	9.83	2.24
F^-(mg/l)	0.2	0.3	0.2	0.3	u.d.	0.3				1.3		5.1	0.42	
Cl^-(mg/l)	160	29.1	5.0	598	15791	5.8	25	4300	3100	19500	423	2780	0.88	11
Br^-(mg/l)	0.4	n.d.	n.d.	1.9	u.d.	n.d.				67				
NO_3^-(mg/l)	0.2	0.7	n.d.	n.d.	u.d.	7.1								
HCO_3^-(mg/l)	727	203	51.1	1061	300	142	333	7076	4650	142	–	29.9	–	114
SO_4^{2-}(mg/l)	(606)	105	16.2	22.7	u.d.	7.8	38.0	59	550	2712	3540	96	1292	3.2
FreeCO_2(mg/l)	93	40	11	175	23	9								
SiO_2(mg/l)							135	648	509		314	1010		163
$\delta^{18}O$(‰)							-4.5	-3.4	-2.8	0				
δD(‰)							-30	-33	-33	0				

( )=preliminary data, n.d.=not ditected, u.d.=under determing
*=Sugiaman et al.(2004), (1)=groundwater bellow 77m, (2)=Upflow of geothermal water at Barris area, (3)= acid fluid at the subsurface.
(4)=volcanic water from Kuju Iwo-yama (Ehara et al., 1983), (5)=deep fluid from priduction well H-13 at Hatchobaru (Shimada et al, 1985)
(6)=steam-heated acid sulphate water at Komatsu-jigoku steaming gorund in Hatchobaru (Kiyosaki et al, 2006)
(7)=steam-heated bicarbonate water at Otake to the north of Hatchobaru(Shigeno et al., 1985)

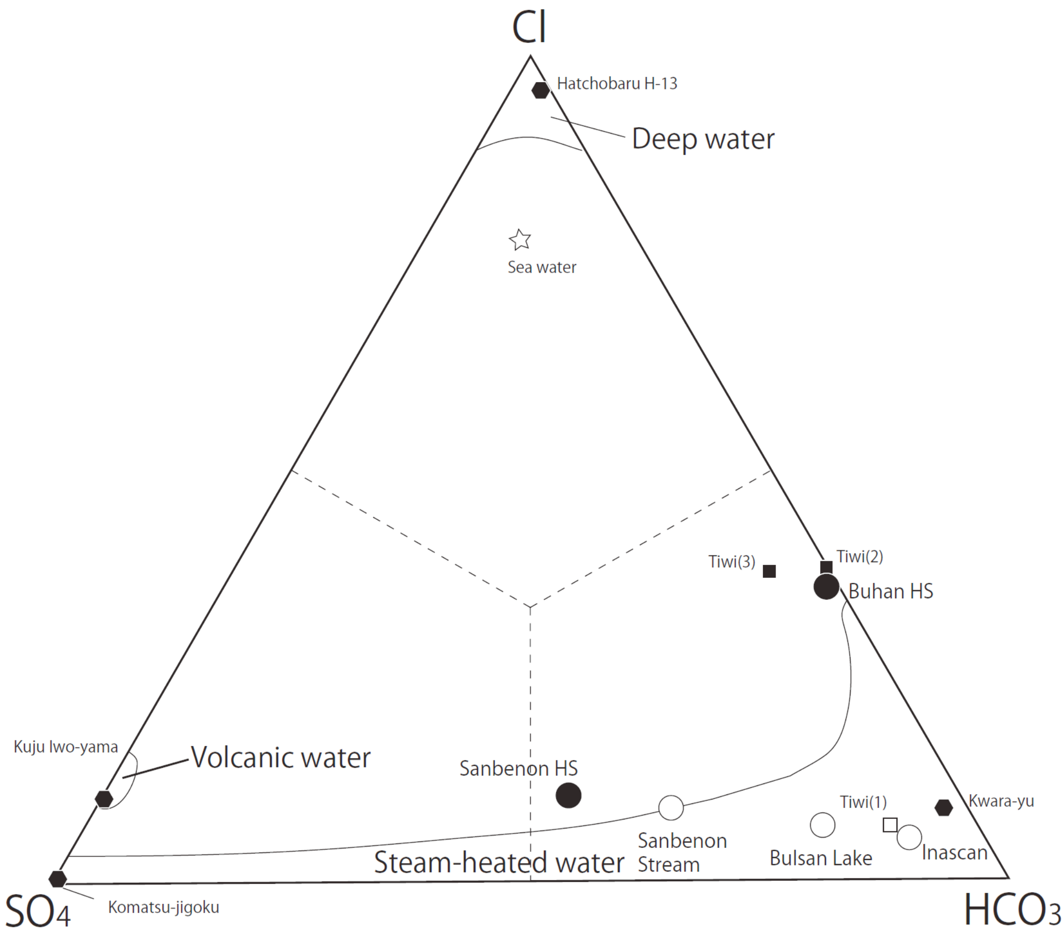

Figure 1 Cl-SO4-Hco3 diagram of water from Bulsan Volcanic area. The other geothermal and volcanic waters from Tiwi, Philippines and Kuju, Japan are also shown.