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Preliminary Report on Some Volcanic Disasters in Indonesia

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I Introduction

Volcanic activity in Japan is frequently followed by volcanic landslides or mudflows, for example, the eruption of Bandai-san in the Meiji era (Sekiya and Kikuchi 1890; Mizuno 1958; Furuya 1965; Wako 1971), the Tokachi-dake mudflow in 1926 (Tada and Tsuya 1928), and the Mayu-yama disaster in the Shimabara peninsula (Ota 1969; Furuya 1974; Katayama 1974). The latter caused the most casualties, fifteen thousand people.

Indonesia also has many volcanoes and frequent volcanic disasters. In the eruption of Kelut volcano in Java in 1919 lahar flows claimed about five thousand lives. In 1963, about two thousand people were killed by lahar flows from Mt. Agung. Indonesia and Japan both suffer from disasters brought by volcanoes.

The author surveyed some volcanic districts in Indonesia in September 1975 for about one month. Field surveys were carried out on lahar deposits at the skirts of Mt. Galunggung, Mt. Merapi, Mt. Raung, and Mt. Kelut in Java, and Mt. Agung in Bali, which were found to be composed of andesitic or basaltic lava, pyroclastics and etc.

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II Geomorphological and Geological Outlines

(1) Galunggung

This conical volcano is located between Garut and Tasikmalaja in Java. In 1822 a lahar flow which accompanied volcanic activity led to the loss of 114 villages and 4011 lives

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(Cotton 1944).

The volcano has large steep cliffs at the summit in a cirque or a horse-shoe formation. The steep cliffs are part of an old crater wall which was broken by an explosion or land-slide. Below this is a skirt stretching to Tasikmalaja, which consists of a great many hillocks (Fig. 2). This landscape closely resembles the landform of Mt. Bandai and Mt. Mayu-yama in Japan (Sekiya and Kikuchi 1890; Mizuno 1958; Maruta 1968; Wako 1971; Furuya 1965, 1974; Ota 1969; Katayama 1974).

The hillocks are composed of andesite blocks, volcanic sand and from what I could observe at outcrops (Fig. 3), and the deposits overlying this pyroclastic layer seem to be lahar deposits from 1822. But some layer structures of flows could be recognized along the road from Tasikmalaja to Cibatu (Fig. 4), which do not fit into the pluverization flow hypothesis of S. Aramaki (1968), which reported the geomorphological process of hillocks.

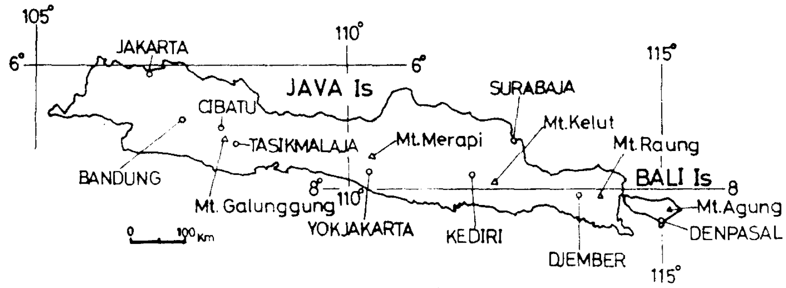

Fig. 1 Index map

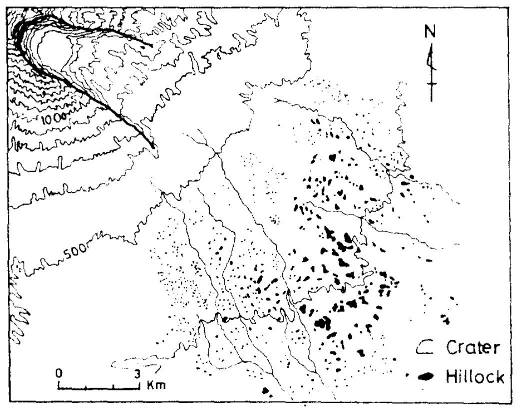

Fig. 2 The summit of Galunggung volcano and the many hillocks of Tasikmalaja. (after Cotton, 1944, partly redrawn).

Fig. 3 Schematic profile of the relationship between the hot lahar flow of 1822 and the many hillocks on the southeastern skirts of Mt. Galunggung.

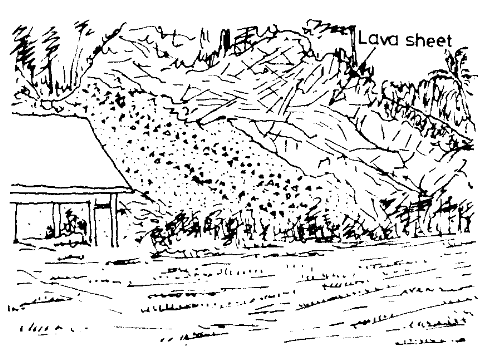

Fig. 4 An example of an outcrop among the many hillocks.

From studies of Mt. Bandai and Mt. Mayu-yama in Japan it appears that many hillocks were formed by landslides at the time of the volcanic explosion and that lowland between the hillocks was filled with hot lahar flow deposits in 1822 (Fig. 3). It seems that the lahar deposits were derived from the crater lake which was in the present.

(2) Merapi

The active volcano Merapi (2911 meters above sea level) is located to the north of Yokjarta and is conical. Large hot lahar flows occurred in 1969 and 1973, and cold lahar flows followed, flowing onto the skirt. Recently there have been frequent lahar flows on the south-facing slope of the volcano, where Yokjakarta lies. Therefore, a disaster prevention plan for this volcano is very important.

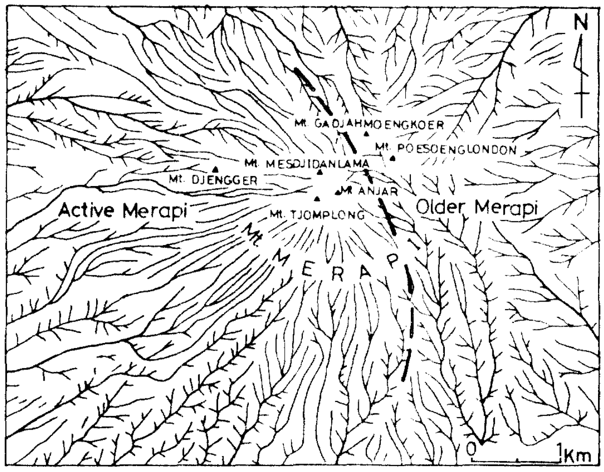

Fig. 5 The drainage pattern of the summit area of Mt. Merapi. The boundary between the active Merapi and the older Merapi can be seen from the stream pattern.

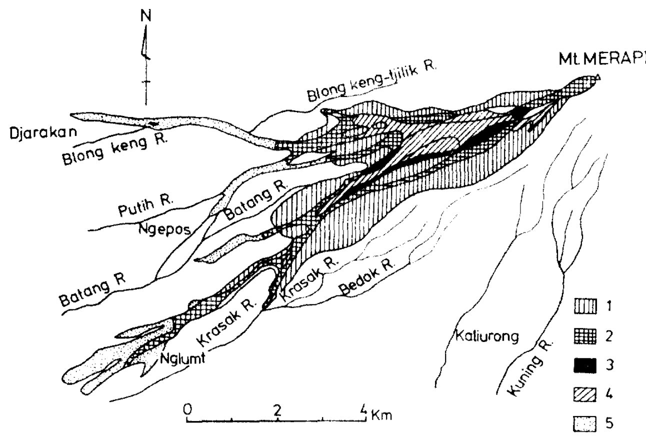

Fig. 6 Map of the distribution of lahar deposits. (after Sub-project Mt. Merapi, D. P. U. T. L., 1975). 1 ; A burnt-out area resulting from *nuée ardente*. 2 ; Deposits of *nuée ardente* in 1969. 3 ; Deposits of *nuée ardente* in 1973. 4 ; Deposits of *nuée ardente* on September 22, 1973. 5 ; Lahar deposits.

It was surveyed by R. W. Van Bemmelen, a Dutch geologist (1954). He thought that a large landslide had occurred between Mt. Batulawang at the top of Mt. Merapi and the Gendol Hills at its skirt, and that the Gendol Hills were mounds deposited at the tip of the land-slide.

The old Merapi volcano is situated to the east of Mt. Anjar, and its location is clearly shown by the pattern of ridges and valleys (Fig. 5). The Gendol Hills protrude through the volcanic fan on the south-west by west skirt of Mt. Merapi and they are in topographical unconformity against the Merapi skirt. The Gendol Hills are therefore not the elevated tip of a landslide, but can be thought to be part of an old mountain (maybe of Tertiary formation). The unconformity of the top of Mt. Merapi is the result of the destruction of the crater of the old volcano, and volcanic activity revived in this area the present Merapi came into existence as a composite volcano. The other areas which have experienced recent lahar flows are not in the old volcanic area, but are on the south-west slope of Mt. Merapi. The flows contain many unconsolidated volcanics. The hot lahars of 1969 and 1973 are deposited over areas more than 500 meters above sea level, and from that elevation downward there are many cold lahar flows. Mt. Merapi erupted lava and volcanic ash which was a secondary source of cold lahar flows. The relationship of the areas of hot lahar and cold lahar deposits it shown in Fig. 6.

Erosion of the hot lahar deposits produced much debris, which flowed down as cold lahar and developed into a volcanic fan. This process can be divided into three stages—supply, transportation, and deposition of debris. The sand dams and sand pockets constructed to contain lahar flows on the skirts of Mt. Merapi are regarded as emergency measures. For example, debris is not deposited downstream of the sand pocked on the Woro River, but the embankment has already been partly destroyed. The Simpin River, the downstream continuation of the Woro, has a raised river bed, which suggests a large quantity of debris is being carried from upstream. A study of the quantity and location of debris deposition is necessary if future disasters are to be avoided.

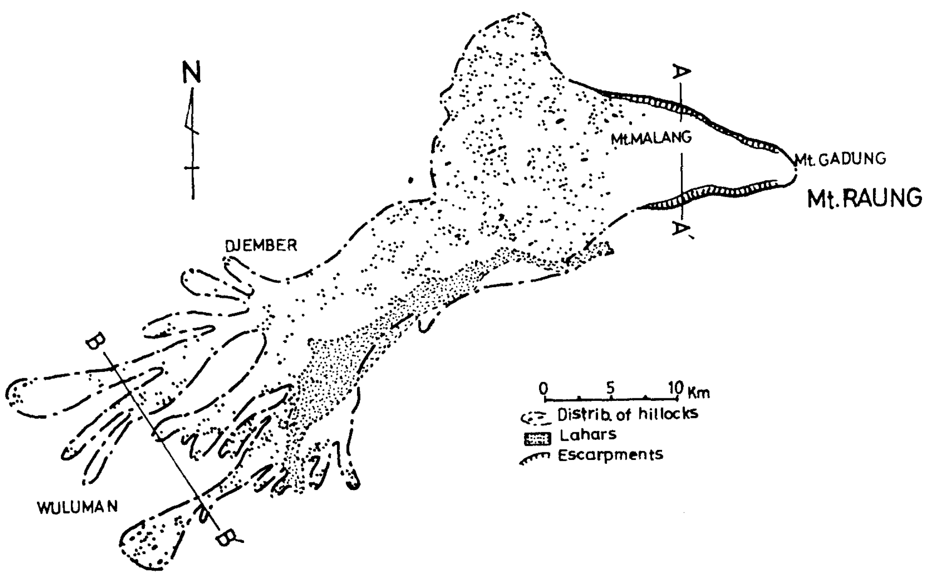

Fig. 7 A major slide on the western flank of Mt. Raung (from a figure by Van Bemmelen).

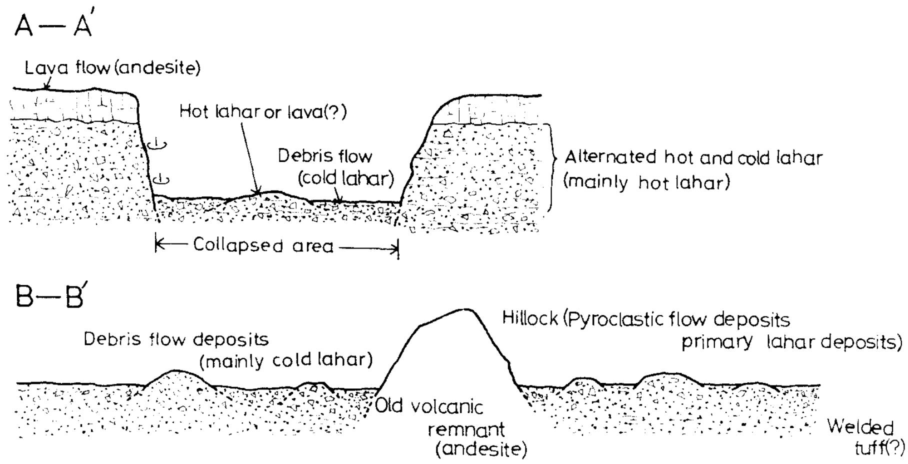

Fig. 8 Schematic profile. A—A', B—B' are shown in Fig. 7.

(3) Raung

This volcano is located at the east end of Java. The west slope of Mt. Raung is a field of mounds which spreads out as a skirt from Mt. Gadung to Wuluman (Fig. 7). Van Bemmelen (1954) attributed these mounds to a great landslide.

Both in the great horse-shoe-shaped cliffs and in the many hillocks on the skirt Mt. Raung resembles Mt. Galunggung, and the skirt with many hillocks is thought to be formed from lahar from the explosion which occurred at Mt. Gadung on the west slope of the Raung volcano. The relationship between landform and geology at Mt. Malang and at Wuluman is schematized in Fig. 8. The remnants of an old volcano would be found as part of the many hillocks at Raung volcano.

(4) Kelut

Mt. Kelut, a typical active volcano in east Java, is a conical volcano, the slope of which is dissected by deep ravines. The ridges and summits of this volcano at about 1400 meters above sea level are arranged in a circle about 4 kilometers in diameter, at the center of which is the recent crater, 1.5 kilometers in diameter. This volcano is perhaps a double volcano. My field survey was carried out mainly at the crater lake and near the Bladak River. The eruptions of Kelut volcano are listed in Table 1, prepared by the observatory of the volcano.

The lahar flows were caused by an abnormal rise in the level of the crater lake through

Table 1 (Sub-project Mt. Kelut, D. P. U. T. L., 1975)

Eruption year	Amount of casualty	Damage
1000		
1311		
1334		
1376		
1385		
1395		
1411		
1451		
1462		
1481		
1586	10000 ?	
1826		65 Villages
1835		
1848	21 ?	11 Villages
1864	Many	100 Houses
1875	30	
1901	Many	
1919	5110	104 Villages, 9000 Houses
1951	7	
1966	281	

volcanic activity and the sudden escape of this water, and are crater lake is about 400 meters in diameter and about 40 meters deep and has a capacity of about 2×10^5 cubic meters. I found the water temperature to be 40°C at nine o'clock on September 17, 1975, and conditions were normal. To prevent lahar flows a drainage tunnel was built after the disaster of 1919, and since then lahar flows have not been as destructive. It is necessary to restore the drainage tunnel after every eruption. Gold lahar flows (secondary flows) of a small scale are frequent on the skirts at the present time.

The Bladak River area suffered from a hot lahar flow in 1966. The lahar flowed down the trunk stream as far as Blitar, and killed about sixty people. The lahar Blitar River is one of the radial streams flowing off Mt. Kelut and the Badak River joins it near Tjandisewoe. A Sabo (sediment control) dam was constructed on the Badang just upstream of the junction to keep hot lahar flows and debris out of the Bladak River area. However this was not sufficient to control the flow, and the construction of tunnels is thought the best method of preventing the crater lake lahar disasters of Kelut.

(5) Agung

Agung volcano, 3,142 meters above sea level, the highest peak on Bali Island, is situated to the south-east of Batoer caldera in the east of the Island. It is conical and has a vast volcanic skirt, scattered with the ruins of Hindu temples and buildings of old dynasties. The skirts of Mt. Agung stretch to the rim of Batoer caldera to the southeast.

In the great eruption of 1963 about 100 people on the southern and about 2000 on the northern slope were killed by hot lahar flows. Volcanic ash reached the stratosphere, and caused the temperature in the Southern hemisphere to fall. But the problem of disaster prevention has not been treated seriously and it is necessary to plan countermeasures to predicted eruptions.

Recenty, cold lahar flows, which are frequent on the skirts of Agung, washed the sediment of the hot lahar flows of 1963 to the lower part of the skirts. For example, at Kalanganjar, debris from the Sabta and the Pendnggungan rivers reached the road from Dempasal to Singaradja on the north coast of the island. This road, constructed on the river floor, functioned as a Sabo dam, and lahar was deposited upstream of it. The road was useful as a Sabo dam, but the water from the rivers eroded land downstream from the road. The road was composed of gabion and unconsolidated lahar deposits, and as these erode easily it was gradually destroyed. Furthermore, because the road was built like a dam on the wide riverbed, ordinary stream water flowed through the limited central bridge space, where the road had been destroyed by the concentrated stream water.

Thus, cold lahar flows are causing damage in areas not effected by the hot lahar in 1963. A Sabo dam constructed to protect the bridge area in the Unoa River was destroyed by cold lahar deposits of 7000 cubic meters. The dam was about 70 meters long and built with concrete, in a ratio of five sand and gravel to one cement. These cold lahar flows were all caused by concentrated heavy rainfall, but precipitation records are not kept.

III Conclusion

All the volcanic disasters described here can be attributed to lahar.

Lahar flows composed of andesitic blocks and debris are ordinarily deposited as gentle volcanic fans or skirts, but this cannot be regarded as simple sedimentation. The lahar flows can be classified into three different types.

1) Cold lahar flows, which are common to all volcanoes, and caused by tropical rainfall. They fan out at the edges of volcanic skirts.

2) Hot lahar flows, which occur in connection with volcanic activity. They are caused by *nuée ardente* (primary lahar flows) and the overflow of crater lake water (crater lake lahar flows). The lahar flows spread down the flanks of volcanoes, and in general form a hummocky, rugged surface.

3) Landslides caused by explosions, which result in horse-shoe-shaped steep cliffs with many hillocks spreading below them.This pattern is also seen in the landform of two volcanoes in Japan, Mt. Bandai after the 1888 eruption and Mt. Mayu-yama after the 1792 eruption.

4) The three types are closely related geomorphologically, and each type of lahar flow frequently brings disaster because it reaches inhabited areas. To avoid this the planning of land use on volcanic slopes should be considerred.

References

1) Sekiya, S. & Kikuchi, Y. 1890. "The eruption of Bandai-san," *Journal of the College of Science, Imperial University*, No. 3, pp. 91-172.

2) Mizuno, Y. 1958. "Flow Mounds of the Okinajima Mudflow," *Fukushima Pref. Ann. Tohoku Geogr. Assoc.*, Vol. 11, No. 1, pp. 22-24.

3) Furuya, T. 1965. "Topography of the Bandai and Nekoma Volcanoes," *Sci. Rep. Tohoku Univ.*, Seventh series (Geography), No. 14, pp. 465-469.

4) ———. 1974. "A Geomorphological Consideration of the Mayu-yama Great Landslide in 1792," *Disaster Prevention Reserch Institute Annuals, Kyoto Univ.*, No. 17 B, pp. 259-264.

5) Maruta, H. 1968. "Some Consideration about the Urabandai Mudflow," *Geographical Review of Japan*, Vol. 41, No. 7, pp. 465-469.

6) Wako, T. 1971. "Bibliographical Study on the Geomorphology as a Result of the Bandai-san Meiji Eruption," *Ann. Tohoku Geogr. Assoc.*, Vol. 23, No. 1, pp. 10-17.

7) Tada, F. & Tsuya, H. 1927. "The eruption of the Tokachi-dake Volcano, Hokkaido, on May 24, 1926," *Tokyo Univ. Earthq. Res. Inst., Bull.*, Vol. 2, pp. 49-85.

8) Ota, K. 1969. "Study on the Collapses in the Mayu-yama—1. On the Mechanism of Collapse," *Sci. Rep. Shimabara Inst. Volcanology and Balneology, Fac. Sci., Kyushu Univ.*, No. 5, pp. 6-35.

9) Katayama, N. 1974. "Old Record of Natural Phenomena Concerning the Shimabara Catastrophe," *Sci. Rep. Shimabara Inst. Volcanology and Balneology, Fac. Sci., Kyushu Univ.*, No. 9, pp. 1-45.

10) Aramaki, S. 1968. *Geology of Asama Volcano and Monograph*, No. 14, 45p, Assoc. Geol. Collabo., Japan.

11) Cotton, C. A. 1944. *Volcanoes as Landscape Forms*, Whitcombe & Tombs Ltd., Christchurch, pp. 247-252.

12) Van Bemmelen, R. W. 1954. *Mountain Bullding*, Martius Nijhoff, Hague, pp. 99-103.