

Paper:

Credibility of Volcanic Ash Thicknesses Reported by the Media and Local Residents Following the 2014 Eruption of Kelud Volcano, Indonesia

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Ash thicknesses reported by the media and witnessed by local residents may be exaggerated. A good example of such exaggeration is ash thicknesses reported following the Plinian eruption on February 13, 2014 at Kelud volcano, East Java, Indonesia. Volcanic ash thicknesses reported by the media and local residents were generally by 2–7 times larger than the actual values measured by volcanologists. Sensational news reports and strong fresh impressions may cause such exaggeration, or these exaggerated values may simply represent abnormal concentrations of volcanic ash. It is important to pay careful attention to the parameters that are being documented by the media and by people who do not have scientific backgrounds when utilizing such reports in scientific analyses.

Keywords: Kelud volcano, media exaggeration, Plinian ash fall, volcanic ash thickness

1. Introduction

An estimation of the volume of volcanic ash released by an eruption is important information for evaluating the magnitude of an explosive event or a series of these events and for scaling disaster countermeasures [1, 2]. Field measurements of volcanic ash deposits are key data for estimating the volume of the ash. Satellite images may provide important information on the location of an ash cloud and the aerial distribution of volcanic ash. In addition, aerial surveying, satellite images, synthetic aperture radar (SAR), and laser imaging may yield information that can be used for volume estimation. However, these techniques can only be used when the thickness of the deposit is much larger than the uncertainty of the technique (typically requiring a thickness of tens of centimeters to several meters) [3–5]. In the case of small eruptions and at the distal part of any ash deposit distributions, ground-based field surveying is the only technique that provides detailed thickness information. However, field survey-

ing has certain disadvantages such that volcanic ash is eroded or accumulated by frequent heavy rains and strong winds after eruption before field survey can be carried out. Consequently, information from multiple sources such as news media outlets (television, newspapers), internet sites such as personal blogs, Facebook messages, and Twitter tweets, and the accounts of local residents who experienced ash deposition may be useful for estimating the volume of volcanic ash. However, the accuracy of such information should be checked before it is accepted. In this study, we investigate the difference between the thickness of volcanic ash of the Kelud eruption of 2014 reported by such ways and the actual thickness value.

2. Eruption at Kelud Volcano in 2014

Kelud volcano is located in East Java, Indonesia (Fig. 1). The volcano has erupted more than 30 times since A.D. 1000, according to the Smithsonian Institution's Global Volcanic Program (GVP) database [6, 7], and these eruptions include very large eruptions of VEI 5. Since A.D. 1900, large eruptions of VEI 4 have recurred every 20–30 years, e.g., in 1901, 1919, 1951, 1966, 1990, and 2014. In the 1919 eruption, about 5,000 people died due to lahars. In contrast, an unusually low explosivity eruption, with extrusion of a lava dome but without precursory explosive events, took place during 2007–2008 [8, 9].

A brief chronology of the February 13, 2014 eruption is available in the GVP bulletin [7]. The volcanic alert level, which ranges from levels 1 (normal) to level 4 (highest) in order of emergency, was elevated to level 2 (Alert, or “Waspada” in the Indonesian language) by the Center for Volcanology and Geological Hazard Mitigation (CVGHM) on February 2, based on increasing number and magnitude of volcanic earthquakes. On February 10, the alert level was raised to level 3 (Watch, or “Siaga” in Indonesian) due to further increases in seismicity. Seismicity continued to increase till February 13,



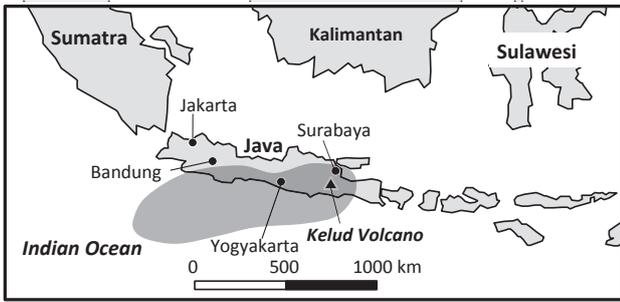


Fig. 1. Index map of the Indonesian islands. Gray area represents the area covered by the umbrella ash cloud 3 h after the onset of the eruption based on a thermal image by MTSAT-1R².

when it culminated with over-scale continuous volcanic tremor at the near-crater seismic station. At 21:11 on February 13, about 90 min before the explosive eruption began, a level 4 (Warning, or “Awat” in Indonesian) alert level notice was issued. Due to good preparedness and knowledge of the hazard, approximately 100,000 people living near the volcano auto-evacuated in advance of the eruption [7]. At 22:46, the seismic signal was cut off abruptly due to the onset of violent explosion and resulting damage to the seismic station. Observers in the Kelud Volcano Observatory reported that at this time a real-time camera on the crater rim showed airborne ballistics as its final image. This explosion developed into the Plinian eruption.

The satellite image of this eruption¹ showed a volcanic ash umbrella more than 200 km wide and more than 20 km above the volcano at 23:06, about 20 min after the onset of eruption. According to a thermal image by MTSAT-1R², the eruption cloud continued to grow for about 2.5–3 h. The umbrella ash cloud expanded horizontally to more than 300 km across, migrated to the west from Kelud, and expanded above Yogyakarta to the Indian Ocean south of Bandung (Fig. 1). The umbrella ash cloud reached Surabaya within about 1 h after the eruption began. Wide areas surrounding Kelud and more distant areas to the west such as Yogyakarta experienced ash fall [10]. Internet and print media reported on ash fall in reports that were distributed worldwide.

3. Methodology

Field surveys were carried out at Yogyakarta and at Kediri near the eruption site soon after the eruption, and around Kelud volcano during the periods of March 1–3 and March 15–19, 2014. Measurement of volcanic ash deposits was carried out in flat open spaces, e.g., house gardens surrounded by walls, vegetated fields, wide parking spaces, and within empty plant containers in a school ground and a house garden (Fig. 2). The deposits in vegetated fields, house gardens surrounded by walls, and wide

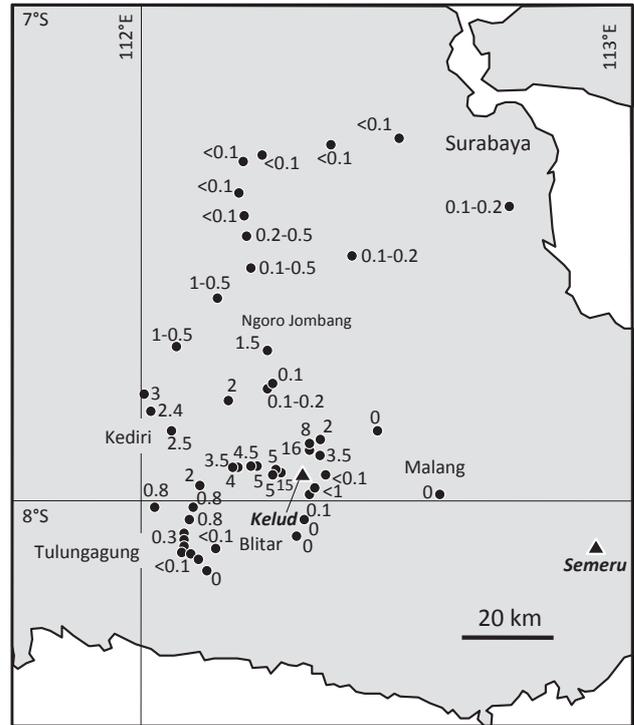


Fig. 2. Map showing the localities where the thickness of volcanic ash from the February 13, 2014 eruption of Kelud volcano was measured. Thicknesses are in centimeters.

parking spaces were believed to have had preserved their original thicknesses because ash removal by rain from the samples in plant containers and flat open spaces was minimal during the few weeks between the eruption and measurement. Ash compaction by rainfall was also believed to be minimal because of enrichment of coarse particles in ash deposits near the volcano, which had settled to produce the closest packing grain distributions (Fig. 3). Reports on the thickness of ash deposits were compiled from various media sources for comparison with our field measurements [11–15]. Interviews with local people concerning their impressions about the thicknesses of volcanic ash deposits also were carried out during March 1–3 and 15–19, 2014 (Table 1).

4. Results

The eruption was Plinian, and the volcanic ash was composed of coarse- to medium-grained crystal-rich (dense) scoria and pumice of basaltic andesite composition. The bulk density of the ash deposit measured in the field ranged from 1.2 to 1.5 g/cm³. This variation may have resulted from the different moistness of the samples and from errors in the volume estimates. Stratigraphic variation of the density was not determined. Fine particles were rare at locations near the volcano, so ash particles tend to remain on flat surfaces, without rapid removal by rains.

A comparison of the measured thicknesses of volcanic ash with the reported thicknesses is shown in Fig. 4. It is

1. Earth Observatory: Image of the day from NASA, <http://earthobservatory.nasa.gov/IOTD/view.php?id=83144>
 2. <http://cimss.ssec.wisc.edu/goes/blog/archives/14910>

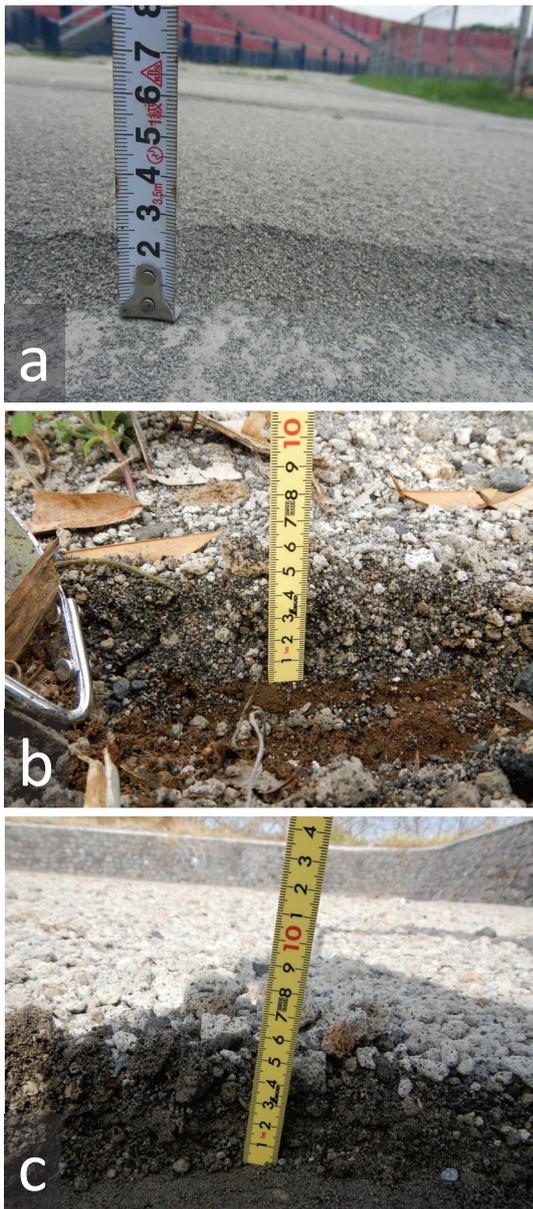


Fig. 3. Photographs of volcanic ash deposits from the February 13, 2014 eruption at Kelud volcano: (a) Brawijaya football stadium, Kediri, February 21, 2014 (courtesy of Raditya Putra). (b) Ash deposit in a pineapple field near the Kelud Volcano Observatory (photo by SN taken on March 1, 2014). (c) Ash deposit in parking space about 2 km west of the crater of Kelud Volcano. White grains at the surface are due to drying from the top (photo by SN taken on March 1, 2014).

clear that the reported values are larger than the measured values by factors of 1–10. This likely indicates that most of the reported values do not represent the actual thicknesses and that they are exaggerated. However, the possibility that some of the deposited ash was washed away before the field survey remains because the area around Kelud received heavy rain each afternoon.

Yogyakarta: The city of Yogyakarta is located about 230 km west of Kelud volcano. Solopos.com [15] reported ash thickness of about 5 cm thick at both the Yo-

gakarta Palace and airport in the central part of the city, where a total of 110 flights were canceled on February 14. Geologists of the Gadjah Mada University reported ash thicknesses on the day following the eruption of 5 mm in the northern part of the city and 2 cm in the southern part. No rains events were reported at these sites after the eruption. In addition, images from the Internet of roofs covered by the volcanic ash did not show thickness as large as 5 cm, because the boundaries of roof tiles were still visible. This result supports our view that news reports tend to exaggerate the thickness of ash deposits, in this case by a factor of more than 2.

Surabaya: The city of Surabaya is about 80 km north-east of Kelud volcano. Solopos.com [15] reported ash deposition of 2 cm at the Surabaya airport, where about 300 flights were canceled. In addition, BeritaSatu.com [11] reported that the thickness reached 5 cm, and a taxi driver based at the Surabaya airport reported 1–2 cm of ash thickness in reply to our interview. A geologist (a friend of the authors) reported a thickness of 1 mm to less than 1 mm in Surabaya on the day following the eruption. Workers in the office of the mud volcano area, south of the city center, did not notice ash deposition on the day after the eruption. During our fieldwork in early March, we did not find any ash remaining at parking spaces at the airport or along roads to the airport, even in small holes in rough cement surfaces. However, we did observe thin patches of sand along the margins of the main roads from the airport, but it was not possible to confirm that this sand was a product of the Kelud eruption.

Ngoron Jombang: This city is located about 30 km north of the crater of Kelud volcano. Gardeners who work at an elementary school in Jombang reported to us that the volcanic ash thickness at the playground of the school was about 5 cm. However, a teacher at the same school reported that the ash deposits were only 1–2 cm thick. By the time of our observations at the school, no ash remained on the ground surface, but we measured 1.5-cm-thick ash deposits in planters on the playground.

Kediri: This city is located about 35 km west of Kelud volcano. Solopos.com [14] reported 5 cm of accumulation in the city 3 h after the eruption, and MetroTVnews.com [13] reported about 10 cm of accumulation near the city center and about 15 cm in the eastern Kediri area nearer the volcano on the day following the eruption. However, the thickness observed by a geologist of CVGHM on the playing field at Kediri Stadium in the city center on February 21 was 2.5 cm (**Fig. 3a**).

Kelud Volcano Observatory (POS): This POS station is about 5 km west of the crater. After the eruption, on February 15, a thickness of volcanic ash of about 10 cm was reported by observers at the POS station. However, the volcanic ash deposited in a pineapple field near the observatory was 4.5 cm on March 1, two weeks after the eruption (**Fig. 3b**). Ash is not easily removed from the vegetated field by rain because masses of ash trapped among the stems of pineapple are not easily entrained by rainwater, whereas ash on the hard surfaces at the observatory is easily swept away by rain.

Table 1. Volcanic ash thicknesses measured by our field study and thicknesses reported by the media and local residents.

Location	Measured thickness (in cm)	Reported thickness	Reporter
City center of Kediri	2.0–3.0	10	webnews
E of Kediri	2.5–3.5	15	webnews
Kelud hotel near volcano	3.5	5	owner and staff
Gandusari, Malang	1.0–2.0	4	webnews
Ngantang, NW of Malang	10–20	50	resident
Surabaya Airport	<0.1–0.2	5	webnews
S of Surabaya	<0.1–0.2	1–2	taxi driver
City of Yogyakarta	1.0–2.0	5	webnews
Ngelgok, Blitar	0.5–1.5	4	resident
Restaurant at Mojokert	<0.1–0.2	0.5–1	costumer & owner
Ngorojobang, Jombang	1.0–2.0	1–5	gardeners & teacher
Kelud Volcano Observatory	4.5	10	observers
NW of Malang, near Batu	0.1	0.2–0.5	shop owner
W of Blitar	0.8	1–2	resident
NW of Blitar	0.8	2	resident
NW of Kediri	1.0–2.0	3–5	resident
W of Jonbang	0.1–1.0	1	workers & teachers
N of Jonbang	<0.1–0.2	0.1–0.6	resident
S of Lamongan	<0.1–0.2	0.5	resident

Parking space at Kelud volcano: This location is about 2 km west of the crater. On March 1, 2014, this site was opened to the public, and a road sweeper was working in the parking space to remove the volcanic ash deposited there. The space is a flat wide square (about 40 × 20 m), three sides of which are blocked by walls and a bank. The deep area of the parking space is considered to have maintained the original thickness of the ash, even 2 weeks after the eruption. There was no thickness reported by the media. The thickness of volcanic ash at this location was 5 cm (Fig. 3c).

5. Discussion

Although many may assume that media reports are truthful, our work on ash thicknesses from the eruption of Kelud shows a consistent exaggeration in media reports of ash thickness (Fig. 4). Our observations are consistent with a pattern of systematic exaggeration in order to generate high news value. We also suspect that the media tends to report abnormally large thicknesses of volcanic ash at places along the shoulders of major roads or under the eaves of buildings, where volcanic ash deposition is concentrated. Furthermore, it is likely that human memories tend to be influenced by extreme experiences. Therefore, eyewitness accounts by local people who do not have a background in geology should be checked carefully before accepting them.

A similar situation occurred in the eyewitness story of a mountain guide about the phreatic eruption of Mount Ontake in central Japan on September 27, 2014. Sixty-three

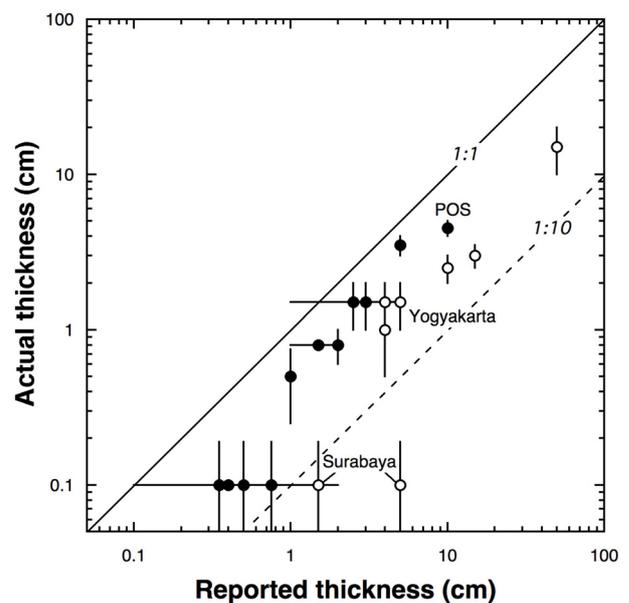


Fig. 4. Plot of volcanic ash thicknesses measured by our field study (actual thickness) and those reported by the media and local residents (reported thickness). Horizontal and vertical bars indicate the ranges of reports and measurements, respectively, and the solid and open circles show the median. Open circles are values reported by the media. POS: Kelud Volcano Observatory.

climbers died or are still missing during the eruption as a result of being stuck by volcanic blocks and lapilli. The mountain guide experienced showers of volcanic blocks near the summit, and she reported that a volcanic block

with the size of a small truck flew by in front of her [16]. However, blocks observed in areal surveys soon after the eruption and from on-site field surveys 2 and 10 months after the eruption were less all than 1 m across [17, 18]. Under the fear that she experienced, it is possible that the actual size of the block was exaggerated in her memory.

Old documentations of natural disasters are sometimes used to evaluate the scale of natural events. In most cases, such descriptions of events are not based on observations made by individuals with a scientific backgrounds, and may have been influenced by fear or other external factors. Furthermore, these old documents often are made on the basis of hearsay rather than by witness of the disaster. For example, in ancient Japan, reports of damage larger than the actual damage were sometimes made in an attempt to reduce the annual tribute paid to the feudal lord. Conversely, in order to hide the weakness of damaged land from their enemies, ancient reporters may have minimized reports of damage. Therefore, when data from old documents are used for scientific purposes, it is necessary to pay attention to the likely exaggeration or, in some cases, understatement of damage.

6. Conclusions

Prompt information about ash deposition is important for estimation of the scale of an eruption because erosion by rain and removal by people takes place quickly where ash deposits are not so sufficiently thick to make removal difficult. Thicknesses of volcanic ash reported by the media and even eyewitnesses do not usually reflect actual values and are normally exaggerated or represent local abnormal accumulations, such as drifts, or secondary accumulations along the margins of roads or below the eaves of houses. Therefore, volume estimation of eruption products based on such reports is misleading. Old non-scientific documentations of ash accumulation are subject to similar problems. However, information on the presence or absence of ash deposits may be available and tends to be more accurate. Consequently, maintaining a system in which geological surveys undertaken by specialists take place soon after ash deposition is important.

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