Integrated Monitoring Enables Good Early Warning: The 2007 Kelud Volcano Crisis in Indonesia

Indonesia

The Kelud volcano is one of the most active volcanoes in Indonesia. Parts of the volcano lie within the two regencies of Blitar and Kediri in East Java. The summit elevation of this stratovolcano is 1731 m and a large lake occupies the summit crater. Historical eruptions of the Kelud volcano during the twentieth century were recorded in 1901, 1919, 1951, 1966 and 1990. Those eruptions were characterized by initial phreatomagmatic eruptions followed by Plinian eruptions which produced pyroclastic flows, ash-fall and lapilli. Furthermore, the eruptions of the Kelud volcano usually take place within a short time.

The Center for Volcanology and Geological Hazard Mitigation (CVGHM) monitors the Kelud volcano using 5 seismometers (L4-C, 1 Hz). Four of the seismometers are installed close to the crater and another about 5 km from it. Two tiltmeter stations have been set up on the west and SW flanks. A temperature sensor was installed in the crater lake to monitor the lake temperature on the surface, at 10 m and 15 m of depth.

CVGHM has classified the volcano activity into 4 alert levels, as shown in Table 1.

Table 1. Alert level, indication and action as determined by CVGHM

Level	Indication	Action
I	The activity of the volcano is in a normal state. There is no indication of increasing activity, though poisonous gases could threaten the area close to the crater.	
II	The activity tends to be increasing, as deduced from visual and seismic data, though at some volcanoes, eruptions may have occurred but threaten only the area around the crater.	Issue an early warning and technical recommendation to the local government
III	If the trend of increasing unrest continues, an eruption may have occurred. At some volcanoes, eruptions have occurred but without threat to the inhabited area.	Issue an early warning and technical recommendation to the local government
IV	The initial eruption begins to occur with the emission of ash/vapor and potentially leads to the main eruption, and threatens people living nearby.	Issue a technical recommendation to the local government: EVACUATION

– Level I

During the normal state of activity (Level I), the seismicity of the Kelud volcano is dominated by tectonic earthquakes. The number of VT earthquakes is usually less than 5 events/month; B-type and other types of volcanic earthquakes are very rarely recorded. In addition, the usual color of the lake is green.
In August 2007 the activity increased as the water color of the lake changed from its typical green to yellow. This change was accompanied by the increase of CO_2 concentration and lake temperature.

– Level II (September 10 – 29)

On September 11, 2007 the state of activity was raised to Level II, when the number of VT earthquakes reached 13 events within 5 hours. However, an intense degassing of the lake floor was been observed in early July 2007. It caused the color of the lake waters to change rapidly in August and September from the typical green to yellow and bluish.

– Level III (September 29 – October 15)

On September 29, the alert level was upgraded to Level III since from September 26 to 29, VT earthquakes reached a remarkable number of 61 events. The lake temperature measurements continued to increase gradually.

– Level IV (October 16 – November 8)

The occurrence of VT earthquakes still continued. On October 16, a swarm of 306 B-type events occurred within 7 hours causing a rise in the alert level from Level III to the highest one, Level IV (Fig. 1). However, this phenomenon was not followed by an eruption.

Another swarm of VT earthquakes occurred on October 31, November 1 and 2. On November 3, the lake temperature and tangential tiltmeter sharply increased and were then followed by a saturation of seismic events. The following day, on November 4, 2007, a lava dome emerged in the middle of the Kelud crater lake.

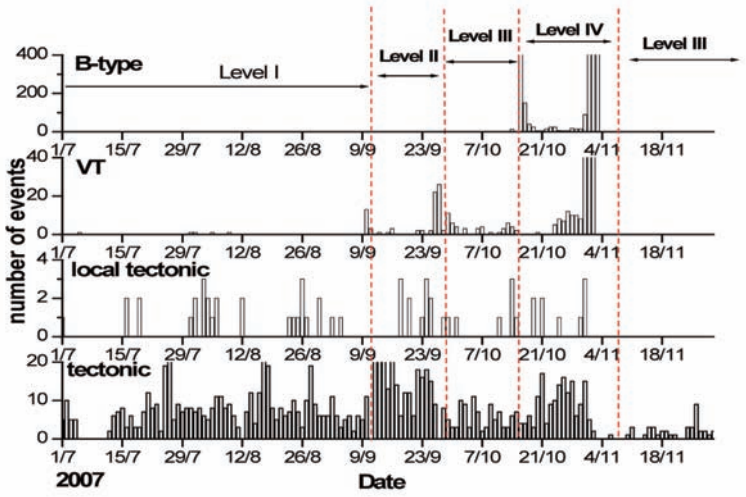

Figure 1. The daily number of earthquakes recorded at the Kelud volcano during July – November 2007. The vertical lines and horizontal arrows represent the change in the level of activity.

– Background

CVGHM has classified the volcano activity into four alert levels: Level I, II, III and IV. The increase in the levels is based on visual, seismic and other data such as geochemistry and deformation.

– Objective

In order to minimize the loss of life and property caused by volcanic eruptions, it is necessary to issue an alert through the early warning system to the local government and people.

– Term/Time frame

Depends on when the activity of volcanoes starts to increase.

– Contact details

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