Appendix

THE NOVEMBER 2002 ERUPTION AT GUNUNG PAPANDAYAN

As this thesis was being completed, Gunung Papandayan spectacularly demonstrated the importance of continuously monitoring active volcanoes.

In October 2002 seismographs operated by the VSI recorded first deep and then shallow volcanic earthquakes and tremors beneath the volcano, indicating magma migration towards the surface. The number and intensity of these earthquakes increased during the next four weeks.

Then, on November 11, 2002, a *phreatic* eruption occurred from Kawah Baru (formed in 1942), which also triggered a landslide at the west wall of the old crater complex (see Fig. A.4). A phreatic eruption is an explosive volcanic eruption caused when water and heated volcanic rocks interact to produce a violent expulsion of steam and pulverised rocks; magma is not involved (Foxworthy & Hill, 1982). The material taken along the small rivers turned into *lahars* (volcanic mudflows consisting of a mixture of water-saturated ash, mud and debris), destroying several houses in nearby villages during the next few days.

The eruption progressed into a few sporadic magmatic eruptions and continuous ash eruptions up to 1km high. On November 15, at 6.30am local time, a large eruption occurred, producing dark-thick eruption ash, which was ejected up to 6km above the crater (Fig. A.1). Smaller ash and gas explosions continued during the following days.

On November 20 a large ash eruption occurred in the Nangklak crater as a directed lateral blast towards the northeast, reaching as far as 2km, stripping all trees along the inside of the horseshoe-shaped crater and leaving a deposit of blocks and smaller fragments of altered rocks covered by a wet 4-8cm thick layer of ash. In a radius of 500m from the crater, several trees were charred by the high temperature of the gas emitted (Fig. A.2). However, this eruption was not dominated by high temperatures, but rather by high-pressure steam and gas.

Fig. A.1: Eruption on 14 November 2002 (left), and the major eruption on 15 November 2002 that produced a 6km high ash cloud (right)

Fig. A.2: Tree blowdown at a radius of 400m from the crater due to the directed blast of Kawah Nangklak (left), and charred trees located 300m from the crater (right) (VSI, 2002b)

The following days were characterised by ash explosions of up to 600m high at Nangklak crater, while six other craters emitted white plumes as high as 200-400m. A more detailed description of the events can be found on the VSI website (VSI, 2002b). At the time of writing volcanic activity remains high (Fig. A.3).

Fig. A.3: Four eruption points in the horseshoe-shaped crater of Gunung Papandayan (left), and a close-up of Kawah Baru (right) (VSI, 2002b)

The eruptive activity changed the topography inside the horseshoe-shaped crater of Gunung Papandayan. New craters were formed, emitting large amounts of steam and ash, and a lot of material was transported over long distances inside the old crater complex. Most of the trees were flattened and the whole area was covered in a thick layer of wet ash. Fortunately the population of the nearby villages had been evacuated in time, so there were no human casualties. However, several tea plantations and rice fields were damaged by ashfall. At least 20 houses were destroyed by lahars along the Cileutik, Cibeureum and Cimanuk Rivers (Fig. A.4). The heavy rainfalls expected during the rainy season will certainly cause additional landslides and collapses of the very fragile volcanic landscape, and may result in further lahars threatening the surrounding villages.

Fig. A.4: Damage caused by ashfall at a tea plantation (left) and by a lahar in a nearby village (right) (VSI, 2002b)

Although there was no GPS equipment installed on the volcano during the eruption, the three 'slave' stations were affected significantly. Nangklak, which was located on the edge of the old crater wall, was completely destroyed by the November 11 landslide (Fig. A.5). At Kawah the radio antenna pole, all fence posts and the PVC tubing were demolished. Due to its location away from the main point of volcanic activity, the GPS station Bukit Maung survived the eruption relatively well, although one solar panel disappeared while the other (as well as the solar panel frame) was badly damaged. In both cases the monuments, plastic drums and GPS antenna poles remained unharmed. Figure A.6 shows the condition of these two stations on December 4, 2002. (The EDM reflector at Kawah was used by the VSI for ground deformation monitoring.)

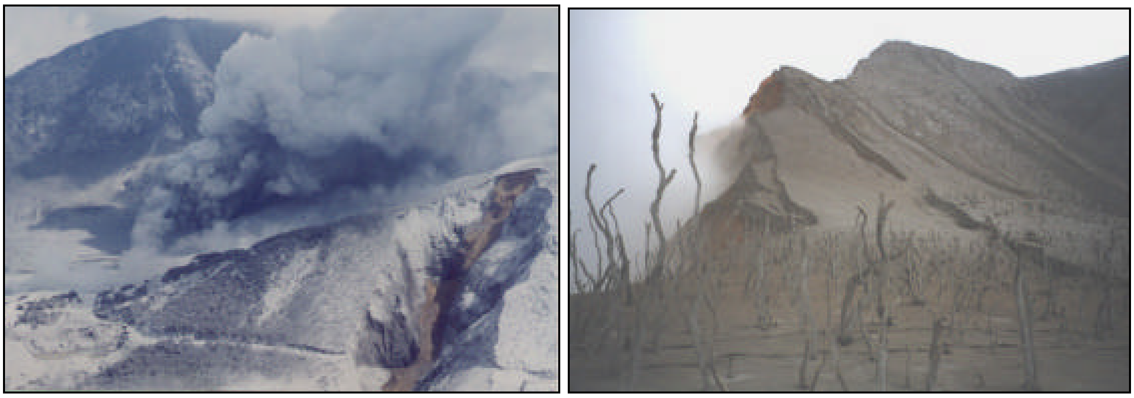

Fig. A.5: Landslide with ash emission from Kawah Baru in the background (left), and the former location of Nangklak (right)

Fig. A.6: Damage at Kawah (left) and Bukit Maung (right)

This eruption stresses the importance of monitoring active volcanoes in a continuous manner. After a very long period of silence it took Gunung Papandayan only four weeks to transform from a 'lazing beauty' into a 'raging beast'. If it had been installed on the volcano at the time, the GPS volcano deformation monitoring system described in this thesis would certainly have picked up the signs of the impending eruption. In combination with the seismic measurements routinely carried out by the VSI, this would have created a more detailed picture of the volcano's behaviour leading up to the eruption. This information would also be very useful in helping to detect and analyse future periods of heightened activity, thereby contributing to volcanic hazard mitigation.

The advantage of operating a low-cost volcano deformation monitoring system is obvious. In the case of monitoring sites getting damaged or destroyed during an eruption, the relatively low cost of the equipment permits rapid repair and replacement.