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MEETING

Multidisciplinary Monitoring Experiments at Kawah Ijen Volcano

Cities on Volcanoes "Wet Volcanoes" Workshop; Yogyakarta, Indonesia, 14–21 September 2014

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"Wet volcanoes" with crater lakes and extensive hydrothermal systems pose challenges for monitoring and forecasting eruptions. That's because their lakes and hydrothermal systems serve as reservoirs for magmatic heat and fluid emissions, filtering and delaying the surface expressions of magmatic unrest.

One such volcano, Kawah Ijen, which hosts the world's largest natural acid crater lake (30 million cubic meters, pH <1), expelled large volumes of acidic lake water during its last major eruption in 1817, creating lahars that inundated areas that are now densely populated. Today, even small eruptions from Ijen pose a hazard and put the local population, including sulfur miners, and tourists, at risk.

During 2011 and 2012, swarms of locally felt volcano-tectonic earthquakes, low-frequency earthquakes, intense tremor, and a 12°C increase in lake temperature raised concerns within Indonesia's Center for Volcanology and Geologic Hazard Mitigation (CVGHM). The center determined that efforts are needed to better monitor and understand Kawah Ijen and other wet volcanoes. The center asked the U.S. Geological Survey's Volcano Disaster Assistance Program (VDAP) to convene a workshop to develop recommendations on how to improve monitoring and forecasting at wet volcanoes.

As a result, VDAP scientists teamed with colleagues from CVGHM, the Royal Observatory of Belgium, the Earth Observatory of Singapore, GNS Science of New Zealand, and McGill University of Canada to organize an international workshop in mid-September 2014 at Kawah Ijen. The participants—25 scientists from 10 countries—conducted measurements using broadband seismic and infrasound arrays, thermal infrared imaging of surface temperatures, differential optical absorption spectroscopy for sulfur dioxide (SO_2) emission rates, an ultraviolet SO_2 camera, multi-gas detectors for real-time measurement of multiple volcanic gas species, newly developed diode laser spectroscopy for atmospheric carbon dioxide (CO_2) measurement, and samples of fumarole gases, acid waters, and gypsum deposits.

The workshop participants discussed analog volcanoes and monitoring methods, as well as interpretations of the magmatic and hydrothermal processes that are important when forecasting eruptions. One particularly useful outcome was the identification of the Ruapehu volcano in New Zealand as a "sister volcano" of Kawah Ijen, with remarkably similar and well-studied geologic structures and geochemical/geophysical processes. In the absence of modern monitored eruptions, information from analog volcanoes like Ruapehu aid in the interpretation and identification of precursory signals leading up to eruptive events at other wet volcanoes.

Recommendations include establishing a "best practice" suite of techniques and appropriate instrumentation for routine monitoring of wet volcanoes, taking into account the unique situation of each volcano (e.g., the extreme acid environment at Kawah Ijen). The international team recommended real-time (telemetered) monitoring of gases (especially CO_2, which can provide early warnings of unrest owing to its nonreactivity in acid environments), coupled with traditional real-time seismic and geodetic monitoring, as well as frequent sampling of acid seepage springs that have direct links to active hydrothermal systems below the volcanic edifice.

A detailed account of the results of the experiments and recommendations for monitoring wet volcanoes is being prepared for an upcoming publication on volcanic crater lakes by the Geological Society of London.

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