Mud eruption in Java Island: SAR interferometric analysis of PALSAR data and boundary element modeling

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On 29 May 2006, a mixture of mud, steam, gas and water started to erupt at a gas exploration site in eastern Java. More than 0.012 cubic kilometers of mud had been erupted as of November 2006, and the activity is still ongoing. There have been 13 fatalities and more than 11,000 people are being evacuated. It therefore has a social importance to understand the current state of the activity and to forecast the future development of the eruption.

A synthetic aperture radar (SAR) PALSAR equipped on the Japanese ALOS satellite launched in January 2006 has captured several images at the eruption site. This study preliminarily analyzes these radar data by 1) measuring the ground subsidence associated with the eruption by SAR interferometry, and 2) modeling the measured data by using a method that consists of a boundary element method and a Monte-Carlo inversion algorithm.

From the pair of the SAR images acquired on 19 May 2006 and 4 October 2006, we obtained ellipsoidal fringes roughly in a zone NS 4 km x EW 3 km centered at the eruptive vent (Figure, left. A color cycle of red-blue-yellow corresponds to an increase in the distance between the satellite and the ground. The arrow indicates the horizontal projection of the radar look direction. The incidence angle is approximately 41.5 degrees). Around a roughly circular zone of diameter 1.5 km covered by mud, we observe 7 cycles of color change, indicating that at least 80 cm of displacements away from the satellite have occurred in the four and a half months of observation period.

In the modeling, we first assumed a horizontal planar ellipsoidal crack whose longer axis lies in the NS direction. Inverting for the location, lengths of the longer and shorter axes, and overpressure of the source found a model having its center at close to the vent, its longer and shorter axes 2.5 km and 1.5 km, respectively, and its depth at 0.36 km (Figure, middle. The black break curve denotes the source geometry). The sum of the squared residuals was 7 percent of that of the observed data. Next, we assumed a spheroid having its thickness in the vertical direction. This assumption predicted a model having its smallest depth about 0.1 km and greatest depth 1 km. The sum of the squared residuals was 5 percent of that of the observed data.

Considering that the eruption started when the drilling reached close to 3 km beneath the ground, materials that triggered the eruption probably come from this depth. On the other hand, our analysis indicates that the deformation source lies at several hundred meters beneath the ground. Our results are consistent with Davies et al. (2007, GSA Today, 17, 4-9) who conclude from their consideration based on geologic data that fluid coming from depth entrains mud at a shallower depth. We plan to employ more detailed SAR interferometric analysis and to consider more realistic model of the ground subsidence mechanisms, in order to forecast the future activity of the eruption and hazard risks.