Crater lakes and the transfer of mantle-derived volatiles to the human environment

(Work presented at the International Seminar AASPP-Misasa Magmatic gases, their trip from the mantle to the surface of the Earth, 27 February 2006, Misasa, Japan)

Manfred J. van Bergen
Department of Earth Sciences, Utrecht University, Utrecht, the Netherlands (vbergen@geo.uu.nl)

Sri Sumarti
Directorate of Volcanology and Geological Hazard Mitigation, Yogyakarta, Indonesia (martisumarti@yahoo.com)

María Martínez
Volcanological and Seismological Observatory of Costa Rica, Universidad Nacional, Heredia, Costa Rica (martinez@geo.uu.nl; mmartine@una.ac.cr)

Potentially harmful effects of subaerial volcanic emissions to human health and environment are relatively well known, both in the case of passive venting and after explosive eruptions. The role of crater lakes in controlling the dispersal of volcanogenic chemicals and possible adverse consequences has received less attention so far. Here we highlight some key aspects on how crater lakes may regulate element transfer routes, using the hyper-acid lakes of Kawah Ijen (Indonesia) and Poás (Costa Rica) as typical but contrasting examples.

In the Ijen region dental fluorosis is endemic among residents of a coastal irrigation area that receives high input of fluorine from a river carrying up to a few percent of acid lake seepage. Estimates of the total daily intake suggest that there is also a high risk of skeletal fluorosis. Chemical fingerprints of well waters that are the principal sources of drinking water identify the Ijen lake as the ultimate source of the fluorine, situated at some 40 km distance from the impacted area. The geographic correspondence between the irrigation network and fluoride-rich water wells is strong evidence for contamination of groundwater reservoirs through long-term irrigation practices, although a contribution from directly infiltrated river water cannot be excluded. From long-term monitoring it appears that variations in the quality of irrigation water should be ascribed to hydrological conditions rather than to significant changes in activity of the volcano.

Although the lake-hosting summit area of Poás also produces acid stream water, health complaints and extensive crop damage that have received attention over the years are attributable to air pollutants and acid rain from SO_2 and HCl bearing gas emissions that occasionally affect villages and plantations on the flank of the volcano. Temporal fluctuations in the impact correspond to the extent to which gas emissions in the crater area are intercepted and scrubbed by the water body. Observed shifts in the locus of fumarolic vents or drying out of the lake in response to increased volcanic activity explain this variability, which is clearly reflected by changes in lake chemistry over the last decades.

Chemical characteristics of the Ijen and Poás lakes are overall comparable, but time series trends of volatiles for Poás show significant variations as well as subtle differences with Ijen and other highly active acid lakes, as do other major and trace solutes. Since element fluxes into both lakes result from magma degassing and fluid-rock interaction in predominantly igneous arc-crust environments, much of their chemical fingerprints must be derived from properties of local mantle domains. Some of the complexities in tracing volcanogenic pollutants back to the sub-arc mantle and evidence for such a provenance will be discussed.