Evaluating magmatic volatile input in Taal volcano´s Main Crater Lake and Lake Taal, using combined geochemical and hydro-acoustic techniques

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Taal Volcano is a complex volcano 60km south of Manila, capital of the Philippines. The volcano has developed at the centre of a large caldera, filled with Lake Taal (15x22km). It contains a 1.5x1km lake in its largest crater, called the Main Crater Lake (MCL). The MCL is warm (T = 30°C), acidic (pH = 2.7-3) and has a Cl-SO4-Na composition. Gas bubbles are visible at the lake surface. Lake Taal is slightly colder (T = 27°C), alkaline (pH = 8.0) and composed mainly of Cl, HCO3 and Na. It suffers from episodic fish kills for which the cause is currently unknown. Both lakes incorporate seawater from a marine source.

Three field campaigns have been set up in January 2011, September 2012 and January 2013. The chemical composition of the MCL is relatively stable in time, showing variations of less than 10% for most major elements since the early nineties. Its large volume makes the MCL relatively inert to changes in fluid input compared to smaller crater lakes. Temperature, conductivity and pH do not vary with depth, excluding stratification of the MCL.

The concentration of dissolved CO2 in the MCL was measured using three different methods. In situ measurements were performed using a miniature IR sensor, headspace samples were analysed in the lab with an IRMS and a headspace variant has been developed for use in the field with gas detector tubes. Preliminary results show a decrease in dissolved CO2 from 428mg/l in 2011 to 181mg/l in 2012 and 181mg/l in 2013. All concentrations are in strong disequilibrium with the atmosphere. Therefore, residence times are short and the dissolved CO2 concentration can vary quickly in response to changes in in- and output.

The episode of elevated dissolved CO2 in 2011 coincides with a period of elevated seismic activity and high CO2 flux from June 2010 to July 2011, when PHIVOLCS raised the alert status for Taal Volcano twice from 1 to 2 (scale is 0-5). In January 2011, the CO2 flux emitted by the lake surface, measured by a floating accumulation chamber, was 2903T/day, whereas the 672T/day measured in 2012 falls in the range of background values from 500 to 800T/day.

The MCL was surveyed with a single-beam sonar to produce images of sublacustrine fumarolic activity, which were analysed for their volumetric concentration in gas bubbles on the lake floor. Individual profiles were interpolated over the entire lake using kriging to evaluate the spatial distribution of fumaroles. Areas with very low fumarole density can clearly be distinguished from more active zones for both 2011 and 2012. Many fumaroles that were active in 2011 show a decrease in activity or have gone extinct in 2012.

A surface profile of Lake Taal parallel to the shores of the volcanic island points out several areas of decreased pH and elevated temperature and conductivity. These observations demonstrate the input of subaerial or sublacustrine hot springs modifying the chemistry of Lake Taal, on at least a local scale.