Hydrogeochemical fluctuations related to Popocatepetl activity during the last decade: relevance of spring water monitoring to hazard assessment

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Most of the geochemical monitoring of active volcanoes is based on the measurement of gaseous emissions from the crater vent or fumaroles. However, at Popocatepetl volcano, Mexico, where sampling crater fumaroles is unviable because of the unpredictable dome destruction explosions, regular analyses of spring waters provides a valuable alternative to the sampling of the plume gas. Important variations of magma-derived gases dissolved in water have been observed preceding or concomitant to increasing activity. Such results have been informed to civil protection authorities and used for hazard assessment since the beginning of the current volcanic eruption in 1994. Integration of the information provided by diverse observation methods to achieve an accurate evaluation of volcanic hazard is particularly relevant since Popocatepetl poses a risk to a large population. About half a million may be exposed to primary volcanic manifestations, and nearly 20 million may be affected by ashfall. Hydrogeochemical analyses in a laboratory located in Mexico City have included main ions, boron, sulfide and fluoride, in addition to basic parameters such as pH and temperature, measured in the field. Dissolved CO2 was calculated with the PHREEQC geochemical program. Results of the last ten years of monitoring showed that boron, sulfate, chloride and dissolved CO2 are the main chemical species that may be considered as precursors to volcanic activity. However, each spring had a particular behavior, i.e. while SO4/Cl ratio steadily increased years before the appearance of a new lava dome in one site; it maintained constant values in another spring. Concentration of CO2 had an important increase in two spring water samples during 2010 and 2011 previous to the appearance of a new dome in October 2011, which was also preceded by seismic unrest. Such signals prompted an aerial reconnaissance that confirmed its presence. After almost a year of boron-deleted samples, it reappeared in one of the springs before the explosion of January 25, 2012, that destroyed a dome emplaced in December, 2011. These results confirmed the need of frequent sampling and analyses of spring waters. A regular hydrogeochemical monitoring in close communication with decision makers must be maintained to provide additional factors for decision-making directed to protect endangered population.