

## **Diffuse CO<sub>2</sub> fluxes from Santiago and Congro volcanic lakes (São Miguel, Azores archipelago)**

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Diffuse CO<sub>2</sub> degassing occurring in Santiago and Congro lakes, both located in depressions associated to maars from São Miguel Island (Azores, Portugal), was studied through detailed flux measurements. Four sampling campaigns were developed between 2013 and 2016 in each water body, split by the cold and wet seasons. São Miguel has an area of 744.6 km<sup>2</sup>, being the largest island of the archipelago. The geology of the island is dominated by three quiescent central volcanoes (Sete Cidades, Fogo and Furnas), linked by volcanic fissural zones (Picos and Congro Fissural Volcanic systems). The oldest volcanic systems of the island are located in its eastern part (Povoação-Nordeste).

Santiago lake, with a surface area of 0.26 km<sup>2</sup> and a depth of 30.5 m, is located inside a maar crater in the Sete Cidades volcano at an altitude of 355 m. The watershed of the lake has an area of 0.97 km<sup>2</sup> and a surface flow estimated as 1.54x10<sup>3</sup> m<sup>3</sup>/a.

A total of 1612 CO<sub>2</sub> flux measurements using the accumulation chamber method were made at Santiago lake, 253 in the first campaign (November 2013), and 462, 475 and 422 in the three other campaigns, respectively, in April 2014, September 2016 and December 2016. The total CO<sub>2</sub> flux estimated for this lake varies between 0.4 t d<sup>-1</sup> and 0.59 t d<sup>-1</sup>, for the surveys performed, respectively, in November 2013 and September 2016; higher CO<sub>2</sub> outputs of 1.57 and 5.87 t d<sup>-1</sup> were calculated for the surveys carried out in April 2014 and December 2016. These higher CO<sub>2</sub> emissions were associated with a period without water column stratification.

Similarly to Santiago lake, Congro lake is located inside a maar, in the Congro Fissural Volcanic system, and has a surface area of 0.04 km<sup>2</sup> with 18.5 m depth and a storage of about 2.4x10<sup>5</sup> m<sup>3</sup>/a. The lake, located at an altitude of 420 m, is fed by a watershed with an area of 0.33 km<sup>2</sup> and a runoff estimated as about 8x10<sup>4</sup> m<sup>3</sup>/a.

In Congro lake a total of 713 CO<sub>2</sub> flux measurements were performed during four surveys from November 2013 to February 2016. The CO<sub>2</sub> flux output was estimated as ranging between 0.06 t d<sup>-1</sup> and 0.31 t d<sup>-1</sup>; the lower CO<sub>2</sub> emission occurred in July 2015 and should reflect the stratification of the water column that prevents the CO<sub>2</sub> flux release at the lake surface.

Considering both volcanic lakes, the mean CO<sub>2</sub> emissions, standardized per area, in the cold season were ~14.9 t km<sup>-2</sup> d<sup>-1</sup> and ~7.1 t km<sup>-2</sup> d<sup>-1</sup>, respectively, for Santiago and Congro lakes. During summer period, CO<sub>2</sub> emissions were lower in both lakes (~1.9 t km<sup>-2</sup> d<sup>-1</sup> and ~4.1 t km<sup>-2</sup> d<sup>-1</sup> for Santiago and Congro, correspondingly), what is explained by the lake stratification. Due to the organic processes that occur in the lakes, the CO<sub>2</sub> emission is mostly associated to a biogenic origin, but a volcanic influence cannot be excluded and further research using carbon isotopic data is crucial to discriminate the CO<sub>2</sub> sources.

**Key words:** volcanic lakes, CO<sub>2</sub> flux, maars, São Miguel Island