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Volcanic aerosols captured by plants: A study of nanoparticles and their chemical composition

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Nanoparticles (NPs) exhibit high reactivity and mobility in the environment, and a significant capacity to penetrate living organisms, potentially leading to harmful effects. Volcanoes are the second major source of natural NPs emitted into the atmosphere, with an estimated flux of 342 Tg/year. Few studies have focused on their fate. Thanks to technological advances in single-particle inductively coupled plasma mass spectrometry (spICP-MS), this trend is starting to reverse. La Soufri`ere volcano in Guadeloupe, chosen as a case study, exhibits increasing hydrothermal activity since its last eruption in 1530. This study aims to characterize NPs produced during volcanic activity by analysing ancient ash deposits, as well as those formed during periods of volcanic inactivity by examining condensates near fumaroles, as ultrafine particles are primarily generated through gas condensation. In this study, plants are utilized as samplers for NPs produced by fumarole activity. The use of a ICP-MS time-of-flight in single particle mode (spICP-ToF-MS), combined with data processing techniques such as hierarchical agglomerative clustering, enables the detailed characterization of NPs by determining their multi- element composition, concentration, and mass distribution. The results demonstrate that plants can effectively serve as samplers, even under the extreme environmental conditions present at the volcano’s summit. However, differences in their efficiency at trapping particles on leaf surfaces can be attributed to varying physical char- acteristics of the plants. The spICP-ToF-MS analysis identified three types of multi-elemental NPs (NP-Al + Si, NP-Al + Fe, NP-Ti + Al) and three mono-elemental NPs (NP-Al, NP-Si, NP-Fe). Additionally, NPs containing trace elements were detected exclusively in undiluted Sphagnum pore water, where one tri-elemental NP (Sr-Ce-La), one bi-elemental NP (Ce– La), and nine mono-elemental NP families (Cr, Cu, Zn, Sr, Y, Zr, Ba, La, Ce) were identified. Elements with potential negative effects on biota such as Cu, Zn, and Cr were also highlighted.