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Geochemical compositional tracking of the Hawaii-Emperor chain revealing mantle evolution over the past 100 Ma

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In the Pacific mantle domain, the Hawaii-Emperor chain is the most studied example of an age-progressive, intraplate volcanic trail resulting from the activity of the Hawaiian hotspot. This long-lived and deep-rooted hotspot is located on the northern edge of the Pacific Large Low Shear Wave Velocity Province (LLSVP), and the volcanic chain thus provides a unique window into the evolving mantle heterogeneities and related mantle dynamics over time. Studies over the past decade identified sub-parallel geochemical heterogeneities within numerous recent hotspot volcanic islands over the Pacific LLSVP, including Hawaii, Samoa, Marquesas, and Easter. However, the origin and spatiotemporal evolution of such geochemical heterogeneities are still poorly constrained due to a sparsity of data from the older sections of the relevant volcanic chains and a lack of systematic data compilation analysis.

Here we report an extensive data compilation of geochemical data from igneous samples of the Hawaii-Emperor chain, covering both online databases and published literature. Our database highlights the uneven distribution of data along the volcanic chain, with over 90% of data being sourced from the Hawaiian Islands (<6 Ma), where previous studies describe two sub-parallel geochemical heterogeneities: the Loa and Kea trends located inside and outside of the Pacific LLSVP, respectively. Although significant data gaps exist along the entire chain, the database nonetheless shows distinct geochemical variations since the late Cretaceous, such as the MORB-like depleted signature identified from the oldest seamounts of the Emperor chain, whose origin remains controversial. Taking advantage of our database, we targeted seamounts within the data gaps for a new geochemical investigation, including the most primitive and fresh samples from the International Ocean Discovery Program (IODP) and the Scripps Institution of Oceanography collections. We have carried out high-precision geochemical analyses with a focus on Os-Re isotope systematics, aiming to investigate the geochemical evolution of the mantle plume over time and the geodynamic processes that have affected this area of the Pacific LLSVP.