

A novel machine-learning method to isolate volcanic signatures from sedimentary Hg records

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A key driver of Earth system perturbations is the emplacement of large igneous provinces (LIPs) and their associated volatile emissions. To diagnose how the Earth system reacts to volatile degassing, it is necessary to quantify degassing at the same (or higher) temporal resolution as environmental indicators. A common approach is to use mercury (Hg) concentration in sediments to indicate volcanic degassing because degassing is a dominant source of Hg to the environment. However, recent work has shown that various other environmental and post-depositional factors influence Hg concentration, blurring the volcanic signature.

We present a new machine learning-based approach for isolating volcanic signatures in stratigraphic Hg records. Our model uses a random-forest classification with 20 trees and no depth constraint. The model aims to predict Hg concentration, given information about the depositional environment, via geochemical data, including total organic carbon, redox-sensitive trace metals and detrital elements. The training is tailored to predict Hg variation throughout a subset of a record with no expected degassing to accurately characterise Hg behaviour in an unperturbed system. The model is then applied to the total record to quantify any unpredictable (volcanic) Hg variation.

We used our model on data from a core of Early Jurassic age from the Cheshire Basin, UK, which has a high temporal resolution (ca. 5 ka) and spans the Hettangian to Pliensbachian (ca. 13 Ma). The dataset contains 1418 unique samples. We trained the model on 98% of the dataset, excluding 2% as outliers. We evaluated our model's effectiveness at isolating regional/global increases in available Hg via four independent means: 1. Compared high-resolution coeval records from multiple localities, including sections from the Wessex Basin, UK and a section from Levanto, Peru. 2. Assessed similarity with previous methods of isolating volcanic signals in Hg. 3. Utilised Hg thermal desorption profiles to assess how Hg host variation affects the model's prediction. 4. Compared to the $\delta^{13}\text{C}_{\text{org}}$ record as an indicator of carbon cycle changes. Our results indicate a large cluster of volcanic degassing events during the Sinemurian-Pleinsbachian Boundary Event. This is a globally recognised, but less understood, carbon isotope excursion.