

New insights into the evolution of boron isotope composition of seawater from evaporites

DR. HANA JURIKOVA¹, ESZTER SENDULA², ROBERT BODNAR², OSCAR BRANSON³, MATTHEW DUMONT¹, DAVID EVANS⁴, FERNANDO GÁZQUEZ⁵, YANA KIRICHENKO⁶, BOAZ LAZAR⁷, MAO-CHANG LIANG⁸, TIM K LOWENSTEIN⁹, MADELEINE E MURPHY¹⁰, NETTA SHALEV⁷, ROBERT STEELE¹, CLAUDIA VOIGT⁵, MEBRAHTU WELDEGHEBRIEL¹¹, ROSS WHITEFORD¹², CHEN XU¹ AND JAMES W. B. RAE¹

¹University of St Andrews

²Virginia Tech

³University of Cambridge

⁴University of Southampton

⁵University of Almería

⁶ETH Zürich

⁷The Hebrew University of Jerusalem

⁸Academia Sinica

⁹Binghamton University

¹⁰Lamont-Doherty Earth Observatory

¹¹State University of New York

¹²Royal Holloway University of London

The chemical history of seawater provides key insights into Earth's geological processes, ocean habitability, and is essential to robust reconstruction of past climatic conditions. Boron is an important minor dissolved element and a key component of marine carbonate chemistry. Oceanic boron isotope composition is homogeneous, but is expected to vary over multi-million year time scales, given its residence time of approximately 10 million years. The knowledge of past trends in boron isotope composition of seawater ($\delta^{11}\text{B}_{\text{sw}}$) is fundamental for robust reconstruction of CO_2 using the boron isotope proxy, and can provide crucial insights on key processes such as chemical weathering and seafloor spreading. However, to date, the secular evolution of the oceanic boron isotope budget has been difficult to constrain, posing a major challenge for reliable boron-based pH and CO_2 reconstruction from Earth's geological past and critically limiting our understanding of the global (bio)geochemical cycling of this important element through time.

Marine evaporite minerals bearing fluid inclusions—halites in particular—have provided important insights into past variations in major ion composition of seawater, and present a highly appealing archive for reconstructing $\delta^{11}\text{B}_{\text{sw}}$ given their direct origin from seawater. However, the interpretation of their signatures is not straightforward due to the possibility of fractionation during evaporation, crystallisation, and local biogeochemical interactions. Here, we present insights into boron isotope evolution during evaporite formation from laboratory experiments and natural modern evaporitic settings across the globe, accompanied by new analytical developments for high-precision individual fluid inclusion measurement using laser

ablation. These data enable us to critically evaluate the evaporite archive and place constraints on boron fractionation in ancient evaporites, offering new insights into $\delta^{11}\text{B}_{\text{sw}}$ during key periods of the Phanerozoic.