Nd, Sr and stable isotope signatures of ancient methane-seep carbonates (Eocene, Washington, USA) as a record of incipient subduction at the Cascadia convergent margin

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Stratigraphic and structural context of the early evolution of the Cascadia convergent margin, following major subduction reconfiguration associated with accretion of the igneous Siletzia terrane at 50−45 Ma, remains insufficiently understood. Here, we have applied a novel approach that uses combined Nd, Sr and stable isotope analyses of ancient methane-seep carbonates to constrain the early hydrogeological regime of the Cascadia margin. Analyses included the oldest-known seep deposits of Cascadia, formed during mid-Eocene time (42.5−40.5 Ma). A combination of exceptionally high $\varepsilon^{143}$Nd and low $^{87}$Sr/$^{86}$Sr signatures observed in these carbonates consistently point to former interactions between the seeping fluids and mafic, igneous constituents of the forearc basement. Moderately negative $\delta^{13}$C$_{carbonate}$ values imply thermogenic origin of hydrocarbons at three out of four studied seeps, with likely contribution of biogenic methane at a single, landward-most site. When combined with structural constraints, the recorded signals point to former interactions between the seeping fluids and mafic, igneous constituents of the forearc basement. Moderately negative $\delta^{13}$C$_{carbonate}$ values imply thermogenic origin of hydrocarbons at three out of four studied seeps, with likely contribution of biogenic methane at a single, landward-most site. When combined with structural constraints, the recorded signals point to former interactions between the seeping fluids and mafic, igneous constituents of the forearc basement.