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Greenhouse gas estimates from fluid inclusion degassing in exposed metasediments.

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Quantifying carbon fluxes between the atmosphere and solid Earth is key to understanding the global carbon cycle. Efforts in quantifying geological fluxes of greenhouse gases (GHG) have focused on estimating carbon sources and sinks in the Earth's crust and mantle (deep carbon), and the role of surficial chemical weathering reactions by erosion. Although metamorphic production of GHGs such as CO_2 and CH_4 is already accounted for by deep C recycling models, these have large uncertainties regarding their residence time in the solid Earth and conversion upon migration. Fluid inclusions trapped in exhumed rocks testify for the storage of deep fluids in minerals over geologic timescales. However, their contribution to GHG flux residence times in the lithosphere and emissions are not quantified.

Here we present an assessment of geologic GHG fluxes derived from CO_2 and CH_4 in fluid inclusions trapped in minerals during metamorphic processes and preserved therein for millions of years after their formation. GHG emission quantities were obtained by mechanically milling rock samples (n = 70) containing fluid inclusions and measuring CO_2 and CH_4 concentration by CRDS bulk gas extraction analysis. We find that concordant quartz veins in metapelites have higher potential for fluid inclusion degassing when compared to their host rock, with CO_2 being the dominant GHG phase. Quartz vein emission estimates were up to 1.70×10^7 tons of CO_2 and 7.40×10^7 tons of CH_4 per km^3 of rock, whereas host rocks had concentrations that were three to four orders of magnitude lower. Conservative fluxes assuming low erosion rates (34 - 75 m/Myr) are estimated at 2.69 ton m^{-2} Myr^{-1} for CH_4 and 3.34 ton m^{-2} Myr^{-1} for CO_2, increasing at a higher erosion rate (100 m/Myr) to 3.42 and 9.12 ton m^{-2} Myr^{-1}, respectively.

Our preliminary dataset provides a starting point for evaluating the global contribution of fluid inclusion decrepitation to geologic GHG emissions. Future work to investigate the transport, fate, and surface release of carbon driven by exhumation and erosion processes over geologically significant time scales will further constrain GHG fluxes from fluid inclusions in metasedimentary rocks.