Massive production of abiotic methane during subduction evidenced in metamorphosed ophicarbonates from the Italian Alps

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Alteration of ultramafic rocks plays a major role in the production of hydrocarbons and organic compounds via abiotic processes on Earth and beyond. This process contributes to the redistribution of C between solid and fluid reservoirs over geological cycles. Abiotic methanogenesis has been widely documented at shallow crustal levels, whereas little natural evidence exists at greater depths. We provide proof of intense deep abiotic methanogenesis during high-pressure alteration of ophicarbonates in the Italian Alps. Protracted (≥0.5-1Ma) production of CH_4 occurred from at least ~ 40 km depth, and then even increased during decompression up to ~15-20km depth. Textural, mineralogical and petrological evidence, including abundant CH_4-H_2 fluid inclusions, shows that saturation of CH_4 triggered precipitation of graphite and replacement of the precursor serpentinite. Although previous studies proposed that ophicarbonates contribute little to the deep C cycle at forearc depths, this study provides a clear natural evidence of massive abiotic methanogenesis from these rocks, with strong implications for deep C mobility. Moreover, as shown for other fluid-precipitated graphite, the massive graphite precipitation exerts a negative feedback on C fluxes from the deep Earth to shallower reservoirs, and a strong redox potential in mantle rocks. This study also provides new views on the genesis of extra-terrestrial methane and condensed organic C compounds in ultramafic rocks.