Methane in chromitites: evidence of abiotic gas source in continental serpentinization systems

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Recurring discoveries of abiotic methane (CH_4) in gas seeps and springs in ophiolites and peridotite massifs worldwide raised the question of where, in which rocks, methane was generated. Answers will impact the theories on life origin related to serpentinization of ultramafic rocks, and the origin of CH_4 on rocky planets. Recent analyses of gas liberated by rock crushing [1] revealed that among the several mafic and ultramafic rocks composing classic ophiolites in Greece, i.e., serpentinite, peridotite, chromitite, gabbro, rodingite and basalt, only chromitites, characterized by high concentrations of chromium and ruthenium, host considerable amounts of ^{13}C-enriched CH_4, hydrogen (H_2) and heavier hydrocarbons with inverse isotopic trend, which is typical of abiotic gas origin. Raman analyses showed that CH_4 is occluded not in fluid inclusions but in widespread microfractures and porous serpentine- or chlorite-filled veins. Other rocks surrounding the chromitites are methane-free, which suggests that the gas is autochthonous, formed within the chromitites. The data are compatible with the hypothesis of CH_4 generated via low temperature, gas-phase Sabatier reaction between H_2 and CO_2 (migrating from serpentinized and C bearing rocks, respectively), catalyzed by chromium and/or ruthenium [2]. Chromitites may represent source rocks of abiotic methane on Earth, documented not only in peridotite systems, but also in the world's leading chromium and ruthenium mines in Canada and South Africa. CH_4 in chromitites may act as energy source for microbes and may have played a role in the origin of life in serpentinization systems. Since chromite-rich rocks with ruthenium exist also on Mars (Chassigny meteorites, likely originated in Nili Fossae) they could be one of the sources of methane detected in the martian atmosphere.

[1] Etiope et al. (2018) *Sci.Rep.*, **8**, 8728 ; [2] Etiope and Whiticar (2019) *Appl.Geoch.*, **102**, 139-152.