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Natural gas seeps in the French Alps: Sources and pathways

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Natural gas emanations are part of the geochemical baseline to take into account when assessing global greenhouse gas emissions and potential impacts of conventional and unconventional gas exploration and exploitation on groundwater. Examples of such natural gas macro-seeps are known in several parts of the world (Etiope *et al.*, 2009). Only a limited number of them have been characterized for their gas and isotopic compositions. Such analyses can provide essential information for baseline studies, providing insight in the sources (biogenic vs. thermogenic or modified thermogenic) and pathways of such seeps and may allow for distinction of natural seeps from stray gas leakage associated with human activities.

Here, we report gas concentrations and multi-isotope data (δ^{13}C and δ^{2}H of methane and ethane, δ^{13}C and δ^{18}O of CO_2, ^{3}He/^{4}He ratio) of two gas seeps in the French subalpine chains, both in a similar geological and structural position within Middle Jurassic claystones along the eastern border of the large synclinal structures of the Vercors and the Chartreuse massifs (Moss, 1992). The "ardent fountain" (*fontaine ardente*) of Le Gua, 30 km south of Grenoble has most likely the longest continuous written record of existence of any individual natural gas seep, mentioned explicitly as early as the first quarter of the 5th century (Augustin of Hippo (St. Augustin), approx. 426) This natural seep was described in the past as a "wet seep" associated with a spring, whereas the second investigated seep, Rochasson near Meylan north of Grenoble, is a dry seep.

Both seeps contain methane and ethane with thermogenic C and H isotope signatures, comparable with a seep in the Northern Swiss Alps at Giswil (Etiope *et al.*, 2010) but with a higher dryness (C1/(C2+C3)>1000) for the Le Gua seep, possibly due to molecular fractionation upon advective fluid+gas migration (Etiope *et al.*, 2009). Maturity (R_0) of the reservoir rocks deduced from $\delta^{13}C_{(CH4)}$, $\delta^{13}C_{(C2H6)}$ is similar to values found by Moss (1992) for West-alpine Oxfordian shales. CO_2 contents of <9% could stem from methane oxidation. He isotope ratios are radiogenic with only minor mantle contributions, as it is typical for the Western Alps (Marty *et al.*, 1992). This preliminary investigation reveals that thermogenic natural gas can migrate naturally to the surface in significant flux rates over millenaries without anthropogenic causes, in cases that appropriate leakage pathways exist. This study was co-funded by French ANR and Canadian NSERC.

ND_ABSTRACT@

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