Generation of thermogenic methane in the Central Alps (Switzerland) during Mid Miocene metamorphism – New insights from paired clumped isotopologues ($^{13}CH_3D$ and $^{12}CH_2D_2$)

MANGENOT,X[1,3]. TARANTOLA, A.[2], GIRARD, J.P.[3], LE V.H.[2], MULLIS, J.[4], EILER, J.M.[1]

[1]Caltech, Geological and Planetary Sciences (USA)
*xmang@caltech.edu.
[2] Université de Lorraine, CNRS, GeoResssources (France)
[3]Total (France)
[4]Institute of Mineralogy and Petrography (Switzerland)

This paper reports analyses of ancient methane sealed in fluid inclusions of tectonic veins to document a widespread methanogenesis process during the Middle Miocene Alpine compression. The investigated fluid inclusions are dominated by co-genetic H_2O- and CH_4-inclusions. Molecular and isotopic analyses of the CH_4-bearing fluid inclusions ($\delta^{13}C$, δD, $\Delta^{12}CH_2D_2$ and $\Delta^{13}CH_3D$) indicate than entrapped methane is a dry thermogenic gas [C1/(C2+C3) > 95%] generated at very high maturity ($\delta^{13}C$ = –26/–30‰ and δD = –126/–137‰). This methane preserves internal isotopic equilibrium in $\Delta^{13}CH_3D/\Delta^{12}CH_2D_2$ space, that translate into temperatures of 243±18°C ($\Delta^{13}CH_3D$; n=10) and 216±14°C ($\Delta^{12}CH_2D_2$; n=10). These "clumping" temperatures agree with the mineral precipitation temperatures derived from FI microthermometry (Th = 227/260°C). Our findings reveal that a significant methanogenesis process occurred during peak metamorphic temperatures (c. 25 to 15Ma) from the catagenesis of the surrounding organic-rich flysch (Ro>4-5%). Then, in a subsequent event during the Miocene (c. 17 to 10Ma), the nappe structure started to updome and fracture, a process that may have favored significant emission of methane into the atmosphere in a time span overlapping the mid-Miocene climatic optimum event, i.e. a relatively warm period.