

Biogenic methane leakage on the Aquitaine Shelf: fluid system characterization from source to emission

Guillaume Michel (1), Stéphanie Dupré (1), Agnès Baltzer (2), Patrice Imbert (3), Axel Ehrhold (1), Anne Battani (4), and Eric Deville (4)

(1) IFREMER – Unité Géosciences Marines, B.P. 70, 29280 Plouzané, CEDEX, France, (2) Université de Nantes – 44312 Nantes Cedex 3, France, (3) TOTAL – Centre Scientifique et Technique Jean Féger. Avenue Larribau, 64018 Pau Cedex, France, (4) IFP-EN – 1 et 4 avenue de Bois Préau - 92852 Rueil-Malmaison, France

The recent discovery of biogenic methane emissions associated with methane-derived authigenic carbonate mounds along the Aquitaine Shelf edge offshore SW France (140 to 220 m water depth) questions about the initiation and temporal evolution of this fluid system (80 km N-S and 8 km E-W). Based on a multi-data study (including multibeam echosounder, subbottom profiler, single channel sparker seismic, 80 traces air gun seismic data and well cuttings and logs), different scenarii are proposed for the organic matter source levels and migration pathways of the methane.

Several evidence of the presence of gas are observed on seismic data and interpreted to be linked to the biogenic system. Single channel sparker seismic lines exhibit an acoustic blanking (between 75-100 ms TWT below seafloor and the first multiple) below the present-day seepage area and westwards up to 8 km beyond the shelf-break. An air gun seismic line exhibits chaotic reflections along 8 km below the seepage area from the seabed down to 700 ms TWT below seafloor. Based on 1) the local geothermal gradient about 26 °C/km and 2) the window for microbial methanogenesis ranging from 4 to 56 °C, the estimation of the bottom limit for biogenic generation window is about 1.5 km below seafloor. Cuttings from 3 wells of the area within the methanogenesis window show average TOC (Total Organic Carbon) of 0.5 %; however, one well shows some coal levels with 30-35 % TOC in the Oligocene between 1490 and 1540 m below seafloor. Geochemical analysis on crushed cuttings evidenced heavy hydrocarbons up to mid-Paleogene, while shallower series did not evidence any.

In the first scenario, we propose that methane is sourced from the Neogene prograding system. The 0.5% average TOC is sufficient to generate a large volume of methane over the thickness of this interval (up to 1 km at the shelf break area). In the second scenario, methane would be sourced from the Oligocene coals; however their spatial extension with regard to available data is too limited to supply the gas system along 80 km from north to south. The third scenario corresponds to methane production in the early Paleogene and Cretaceous source levels; but evidence for heavy hydrocarbons is not consistent with the isotopic signatures of the gases seeping at the seabed. The first scenario is therefore the most coherent one even if the TOC is relatively low in the Neogene formations. Regarding the fluid system geometry and the associated source level position, migration pathways may involve 1) upslope migration from the base of the Neogene clinoforms, 2) sub-vertical migration through faults and fractures at the shelf edge, and 3) groundwater circulation from onshore forcing methane migration westward through hydrodynamism.

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