Abiotic methane occurrence associated with natural H_2 generation

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Although hydrocarbons are considered mainly originating from organic sources, several examples have been documented indicating a clear inorganic origin for gas compounds, methane being the main representative. Its abiogenic origin may be attested through geological setting (continental basement without any organic source) and/or through isotopic evidence (very heavy $\delta^{13}C$ of methane up to $\delta^{13}C$ values, without any possible post-genetic fractionation). One paramount factor enabling abiotic methane generation is definitely the presence of molecular hydrogen.

It is known for a long time that one route of bacterial methanogenesis is the CO_2 reduction in the presence of H_2. In subsurface environment without any bacterial activity, deep generation may be also encountered, if: 1) natural hydrogen is present thanks to water reduction mainly (and possibly through other processes as radiolysis), 2) carbon is available, either in an oxidized form (CO_2, carbonates) or overmature kerogen, 3) high temperatures and/or the presence of catalysts allowing a kinetic efficiency.

Several examples, both in oceanic and continental (cratonic and sedimentary) contexts will be presented. The main source of water reduction is by far ferrous iron, present in olivine (in oceanic ridges, ophiolites, volcanic areas) and other easily decomposing minerals (siderite, chlorite, etc.). If the associated generation of hydrogen and methane is relatively well studied in oceanic rocks, its occurrence appeared recently larger in continental areas, and is poorly constrained so far. Associated very high concentrations of radiogenic helium (up to 3%) indicate a deep and old source as cratonic formations. This implies new considerations about the carbon cycle in the Earth, in association with the water cycle. Noble gas isotopes associated with carbon and hydrogen stable isotopes allow to investigate various processes: mantle gas contribution, generation temperatures, gas/water ratio in the kitchen of generation and formation processes (direct formation of methane from water-carbon interaction, or intermediate H_2 generation subsequently involved in abiotic methane genesis).