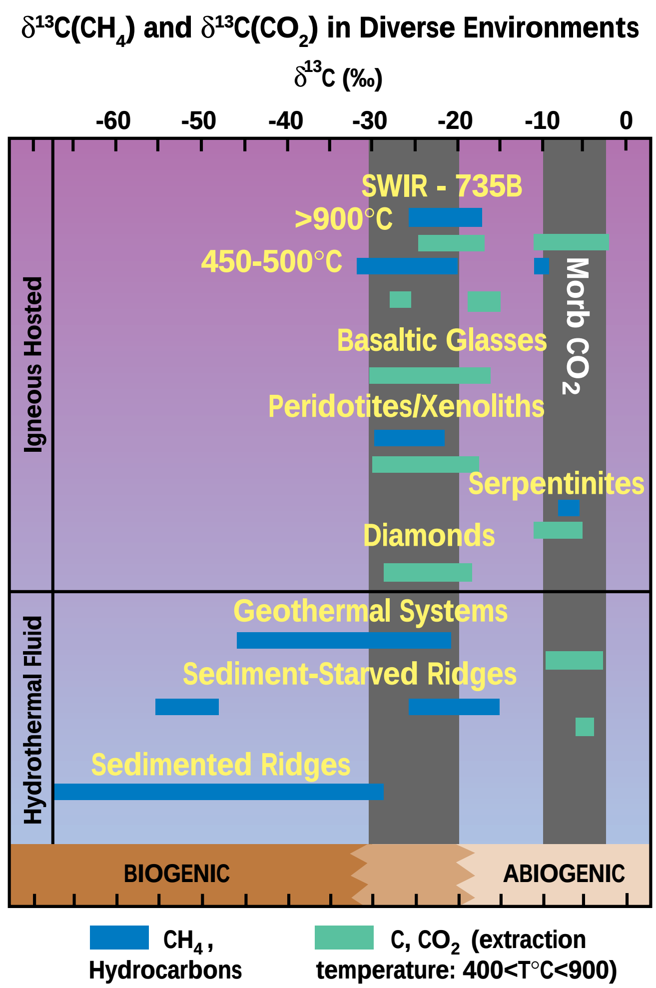
A newly discovered methane reservoir in the oceanic crust

Deborah S. Kelley, School of Oceanography, University of Washington, and
Gretchen Früh-Green, Institute for Mineralogy and Petrology, ETH-Zürich, Switzerland

Characterizing the origin and evolution of gases such as CO_2, H_2O, and CH_4 is crucial to studies of mid-ocean ridge systems as volatiles represent a common link between geological, hydrothermal, and biological processes in ridge crest environments. Volatiles govern the physical properties of melts and profoundly influence the eruptive behavior of submarine magma chambers. In turn eruptive events result in the cataclysmic release of magmatic gases hundreds of meters into the overlying deep ocean waters and more steady state degassing of CO_2, H_2, and He provides a key tracer of hydrothermal sites on the seafloor. Although many of these links have long been recognized, until recently little was known about fluids deep within the oceanic crust. Key insights into high-temperature plutonic environments have been gained through the successful recovery by ODP of *in situ* rocks from the crystallized portions of submarine magma chambers. In 1987, the Ocean Drilling Program drilled 500 m into gabbroic crustal layer 3 at Site 735 on the Southwest Indian Ridge. Analyses of fluid inclusions in gabbroic rocks from this site provide the first isotopic and compositional data on CO_2-CH_4-H_2O-H_2 volatiles in plutonic rocks from the mid-ocean ridge system. A surprising result of this study is the discovery of fluids with abiogenic methane concentrations >50 times those of volcanic gases and of vent fluids in sediment-starved environments [*Kelley*, 1996; *Kelley and Früh-Green*, 1997]. The compositions and isotopic signatures of CO_2-CH_4-H_2O and CH_4-H_2O-H_2 fluids show that methane production involved two phases of magma-hydrothermal activity spanning supersolidus to greenschist facies conditions. Although total methane concentrations per unit rock are low (0.29-0.60 μmol/gr) in the SWIR samples, on a global scale plutonic layer 3 comprises ~60% of the oceanic crust and is thus a potentially immense reservoir for abiogenic methane (~10^{19} gr CH_4) in submarine hydrothermal systems. This is particularly significant because carbon-bearing fluids may provide sustenance to subsurface and vent-associated microbial communities and therefore, represent an important link between deep-seated hydrothermal systems and more shallow crustal environments.

References:
Kelley, D.S., Methane rich fluids in the oceanic crust, *J. Geophys. Res., 101,* 2943-2962, 1996.
Kelley, D.S. and G.L. Früh-Green, Abiogenic Methane in deep-seated mid-ocean ridge environments: insights from stable isotope analyses, *Geochim. Cosmochim. Acta, in review,* 1997.



Comparison of carbon isotope values for CO_2-CH_4-H_2O (extracted at >900°C) and CH_4-H_2O (extracted at >400°C) fluids in plutonic rocks from the SWIR with other localities. The CO_2-CH_4-H_2O fluids are believed to reflect the cumulative effects of extensive fractionation during volcanic degassing and respeciation of magmatic fluids during cooling through the subsolidus regime. The CH_4-H_2O rich fluids may represent the end product of these processes or formation during serpentinization reactions.