Organic diagenesis: a potential provider of substrates for deep microbial ecosystems

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Bacterial gas is now known from isotopic and chemical considerations to occur at great depth, though the actual process of bacterial gas formation under these conditions is barely understood. How methanogenic bacteria can live under such hostile conditions where substrates and nutrients are sparse is an open question. An important clue is that carbon dioxide, acetate and methanol are generated during the diagenesis (Ro < 0.5%) of organic matter, especially terrigenous organic matter which is richest in oxygen functionalities on a per carbon basis. Additionally, ensuing aromatisation reactions may provide molecular hydrogen. Interestingly, it is these same compounds, albeit provided via different mechanisms in shallow sediments, which are known to be important substrates for methanogenesis via carbon dioxide reduction and acetate fermentation. Therefore the question arises as to whether substrate generation from kinetically driven abiotic reactions accompanying organic diagenesis is coupled with the deep biosphere where bacterial methane can be formed. The mechanisms of these biosphere-geosphere interactions, and the resulting implications for the process of bacterial gas formation, including timing and rate-limiting steps, will be discussed in the light of results from laboratory heating experiments and literature review.

K-Ar dating of Alpine fault gouges

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This study is the first in the Alps to attempt to directly date young fault movement on the basis of neo-crystallization of clay minerals, a technique recently applied to several other orogens. All the samples are potentially related to movement on the Periadriatic fault system, the most important late tectonic fault system in the Alps. K-Ar dates of illite separates from 14 different fault rock samples, tectonic units and grain sizes (from < 0.1 to 6-10 micron) yield values ranging from 228.8 +/- 4.5 to 3.31 +/- 0.3 Ma (n = 33). All dated sample fractions were extensively characterized by XRD, SEM and TEM.

Foliated fault gouge from the low-angle detachment of the Simplon normal fault gave an age of between 5.0 +/- 0.1 Ma (< 0.4 micron) and 7.2 +/- 0.2 Ma (< 2 micron). Samples from EW-striking steep faults in the Varzo hydroelectric tunnel to the south range between 3.3 Ma and 6.7 Ma, whereas those from the continuation of the EW-striking Centovalli brittle fault zone in the area of Trontano are in the range 8.3-11.7 Ma. Fault gouge from an EW-striking fault 50m south of the Periadriatic Fault gave an age of 23.5 +/- 5 Ma, consistent with early cooling through the brittle-ductile transition of the Southern Alps during Alpine orogenesis. One of the brittle Riedel faults to the late dextral Periadriatic fault movement, which offsets the master fault, was sampled near Passo San Jorio. The age of 19.0 +/- 0.5 Ma implies that the main component of dextral faulting on the Periadriatic master fault ceased prior to 19 Ma.

The internal consistency of the age results from K-Ar dating of fault gouges from both surface and subsurface, as well as their consistency with constraints from field relationships and existing geochronological data demonstrate the potential of this method for providing absolute time constraint on the youngest, Neotectonic part of the Alpine orogeny.