

## CO<sub>2</sub>-rich fluids in the mantle: a comparative fluid inclusion study

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Negative crystal shaped fluid inclusions enclosed in spinel lherzolites from five different locations all around the world were the subject of a detailed fluid inclusion study. Samples were studied from: the Central Pannonian Basin (Hungary), Cameroon Volcanic Line (Cameroon), Jeju Island (S-Korea), Rio Grande Rift (New-Mexico, USA) and from Mt. Quincan (Australia). As a result, CO<sub>2</sub>-rich fluids within the fluid inclusions could be studied and compared.

High resolution Raman spectroscopy at different temperatures revealed that fluids in inclusions are heterogeneous and contain small amounts of other species. We show that nitrogen (N<sub>2</sub>) can be present in the dense fluid and is more common than was previously thought. H<sub>2</sub>O is present in almost all of the inclusions, and was identified by the combination of stepwise heating experiments and Raman spectroscopy [1]. Our results show that, although H<sub>2</sub>O is a minor component in mantle fluids, its relative amount varies between different locations, which has not been previously recognized.

Sulfur in the fluid at room temperature can be present either as H<sub>2</sub>S or as SO<sub>2</sub>, however these species never occur together at the same location. In addition, following fluid inclusion exposure by the FIB-SEM (Focused Ion Beam-Scanning Electron Microscopy) technique, a complexity of S-bearing solid phases has also been identified: sulfides and sulfates were also found within the fluid inclusion cavity. OH-bearing solids are also found in some cases within the fluid inclusions.

Combination of Raman spectroscopy and the FIB-SEM technique proved the presence of carbonates and quartz that are interpreted to be a reaction product of the trapped CO<sub>2</sub> and the host pyroxene. In addition, a common feature found on the inclusion walls is a thin glass film at a submicron scale that documents the ability of mantle fluids to dissolve and transport trace elements and cause cryptic metasomatism as has previously been inferred [2].

We can conclude that, similar to the solid phases involved in the construction of the subcontinental lithospheric mantle, the coexisting fluid can also be heterogeneous in the mantle, although the dominant component in each case is CO<sub>2</sub>.

[1] Berkesi *et al.* (2009) *J. Raman Spectrosc.* **40**, 1461-1463.

[2] Hidas *et al.* (2010) *Chem. Geol.* **274**, 1-18.

## Investigating the role of microbial processes in the weathering of rock-derived graphitic carbons

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During erosion and chemical weathering, organic carbon contained in (meta)sedimentary rocks may be oxidized or recycled. Recent studies in the Himalaya<sup>1</sup> and Andes<sup>2</sup> orogenic systems have demonstrated that the fate of these carbonaceous phases is highly dependent on their graphitization degree: in such large-scale systems only graphite is finally preserved whereas poorly graphitic compounds are oxidized. This oxidation which happens in the bedrock or during fluvial transport is assisted, and most likely driven, by microbial processes. The present study investigates the effect of inorganic compounds commonly found in shale and coal (metals, sulphur and nitrogen compounds) on the bio-alteration of carbonaceous material by microbial populations. For that purpose, we sampled several carbon-bearing rocks which experienced varying metamorphic grades and have therefore various structural organizations for carbons (from kerogen/coal to graphite) following a strict protocol to minimize contamination. The sample set includes carboniferous coals (Graissessac and Briançon basins, France) and black shales as well as graphitic schists (Western Alps, France). The mineralogy and structure of organic carbon have been characterized by various techniques (XRD, Raman and IR, SEM). The high-grade metamorphic rocks contain highly crystalline carbonaceous phases (graphite) and a low mineral diversity (chlorite, muscovite and quartz). In addition, sulfate minerals such as jarosite and gypsum were detected in slightly less graphitized schist rock. By contrast, the coals contain turbostratic carbons and a wide variety of minerals (montmorillonite, feldspar, illite and kaolinite). Back to the lab, enrichment cultures were set up under both oxic and anoxic conditions using the rock-derived carbonaceous material as the sole carbon source. The effect of various inorganic electron donors and acceptors added in combination are tested. Microscopy and biomolecular studies show a low biomass content in microbial enrichments, but we have detected in some of them thin filamentous bacteria and short rod cells that are embedded in a biofilm deeply-incrusted inside carbonaceous particles and other minerals. The metabolic functions of enriched microbial populations are currently assessed by microscopy, hybridization techniques and spectroscopy techniques. Their possible influences on the alteration of rock-derived graphitic carbons will be discussed.

[1] Galy (2008) *Science* **322**, 943-945.

[2] Bouchez (2010) *Geology*, **38**, 255-258.