CO$_2$-RICH FLUIDS IN THE MANTLE: A COMPARATIVE FLUID INCLUSION STUDY

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Introduction

- Transport of fluids through the convecting mantle are the least understood and state-of-the-art problems.

- The composition and behavior at upper mantle depths of the supercritical aqueous fluids have been intensively studied (Keppler, 1996; Newton and Manning, 2000; Scambellurri and Philpot, 2001; Kessel et al., 2005; Hermann et al., 2006; Spandler et al., 2007).

- However, less information is available on CO₂-rich supercritical mantle fluids and their interactions with peridotitic mantle wall rocks.

- As study on fluid inclusion is the most suitable method to obtain information and evidences on upper mantle fluid systems (Roedder, 1984; Szabó and Bodnar, 1996; Andersen and Neumann, 2001), we intend to carry out a complex study on a representative series of such fluid inclusions.
Sampling – 5 continents, spinel peridotite xenoliths

Spinel lherzolites – from the subcontinental lithospheric mantle
The fluid inclusions-photomicrographs

- Hosted mainly by silicates (e.g. Opx-orthopyroxene)
- At room temperature, commonly one visible liquid ± solid phase(s) within the inclusions
- Occur along healed fractures or in clusters
- Their size ranges between 2-90 microns
FLUID PHASES-Raman spectroscopy

$\text{H}_2\text{S} \rightarrow$ Hungary, Cameroon

![Graph of Raman spectroscopy for H$_2$S]
SO₂ → S-Korea, USA

**FLUID PHASES-Raman spectroscopy**
Detection of N\textsubscript{2} within the fluid inclusions became easy by using the LabRAM HR!
Orthopyroxene – hosted fluid inclusion:

- Magnesite
- α-Quartz

\[ \text{MgSiO}_3 \text{(enstatite)} + \text{CO}_2 = \text{MgCO}_3 \text{(magnesite)} + \text{SiO}_2 \text{(quartz)} \]
SOLID PHASES-Raman spectroscopy

Clinopyroxene – hosted fluid inclusion:

- Dolomite

\[
\text{CaMgSi}_2\text{O}_6 \text{ (diopside)} + 2\text{CO}_2 = \text{CaMg(CO}_3)_2 \text{ (dolomite)} + 2\text{SiO}_2 \text{ (quartz)}
\]

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Why FIB-SEM?

- Calculation of the volume proportions
- Morphology
- Identification at submicron scale

Arbitrary size can be cut from the surface exposed by the ion beam and then see the exposed part of the inclusion by SEM and analyze with EDX.

The actual progress of the inclusion exposing process is monitored acquiring secondary electron (SE) images of the sample.

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The “response” of Raman spectroscopy: FIB-SEM exposure technique

Sample from Pannonian Basin (Hungary)

Opx – orthopyroxene, Mgs – magnesite, Qtz – quartz
GCM – Gallium contaminated material

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The “response” of Raman spectroscopy: 
FIB-SEM exposure technique

Opx – orthopyroxene, Mgs – magnesite, Qtz – quartz
GCM – Gallium contaminated material

Sample from Mt. Quincan
(Australia)

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Sample from Mt. Quincan, Australia

H₂O in CO₂

OH-bearing silicate

Pargasite and phlogopite
SOLID PHASES-Raman spectroscopy and Infrared spectroscopy (mapping)

Sample from Mt. Quincan, Australia
SOLID PHASES-Raman spectroscopy and Infrared spectroscopy (mapping)

Sample from Mt. Quincan, Australia

Pargasite and phlogopite
SOLID PHASES-Raman spectroscopy and Infrared spectroscopy (mapping) and FIB-SEM

Sample from Mt. Quincan, Australia
Silicate components dissolved in a supercritical, CO$_2$-rich fluid is the most likely explanation of the ability of mantle fluids to transport trace elements and produce cryptic metasomatism.

*Berkesi et al. 2012 EPSL*
Concluding remarks

1) The fluid inclusions from mantle peridotites represent CO$_2$-rich, S-, N$_2$- and H$_2$O-bearing fluid systems as proved by Raman microspectrography at ambient and elevated temperatures.

2) Daughter (step-daughter) phases including their volume proportions can be efficiently studied by the combined use of Raman spectroscopy and FIB-SEM technique on mantle fluid inclusions.

3) We can conclude that similarly to the rocks, building up the subcontinental lithospheric mantle, the co-existing fluid can also be heterogeneous in the mantle although the dominant component in each case is the common CO$_2$.

4) The combination of heating freezing experiments and high resolution Raman microspectroscopy together with FIB-SEM technique allow us to determine or at least approximate the bulk composition of the fluid, which is in turn one of the main aims of the fluid inclusion studies.
Thank You for your attention!

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