CLOSE TO 'SUPERDENSE' CO_2 FLUID INCLUSIONS IN MANTLE XENOLITHS FROM SCOTTISH PERMO-CARBONIFEROUS

NIKOGOSIAN, I.[1, 2], DAVIES, G.[2], KIRSTEIN, L.[3]
[1] Utrecht University, Faculty of Earth Sciences, PO Box 80.000, 3508 TA Utrecht, The Netherlands.
[2] Vrij Universiteit, Faculty of Earth & Life Science, De Boelelaan 1085, 1081 HV, Amsterdam, The Netherlands.
[3] School of GeoSciences, University of Edinburgh, EH9 3JW, Scotland.
E-mail: niki@geo.vu.nl

Fluid inclusions in mantle xenoliths are generally dominated by CO_2 (Andersen, Neumann, 2001) and are characterized by wide range of densities, from less than the critical density (0.47 g/cm^3) to the triple point density (1.18 g/cm^3). As summarized in Andersen and Neumann, 2001, carbon dioxide fluid inclusions with triple point density (1.18 g/cm^3, Th = -56.6°C) or even 'superdense' fluid inclusions (>1.18 g/cm^3, Thm < -56.6°C) are not common and have only been reported in xenoliths from two locations: (i) a plume-derived setting (Hawaii, Oahu) and (ii) a continental setting (SE Australia). Here we report new high-density CO_2 fluid inclusions in mantle xenoliths from two localities in Scotland. The xenoliths were brought to the surface in alkaline dykes and sills associated with the Scottish Permo-Carboniferous magmatic province. The studied xenoliths are spinel lherzolites from Fidra (FID) in the Midland Valley Terrane and from Streap Com'laidh (STP) in the Northern Highlands Terrane. Low temperature microthermometry on fluid inclusions was performed at the Vrije University Amsterdam on a Linkam TP/91-THMS 600 stage, cooled by liquid nitrogen N_2.

Petrography of fluid inclusions

All the samples that were studies contain a number of fluid inclusions, which commonly occur as single-phase (liquid-rich) inclusions at room temperature, but show a liquid/vapor transition upon cooling in the temperature range of –10 – 45°C. Bi-phase (liquid/vapor) and single-phase (gas-rich) fluid inclusions are less common at room temperature. The shapes of the fluid inclusions are sub-spherical or approaching negative crystals with quite variable size. Size varies from < 2 to 15 microns for high-density inclusions and up to 50 microns for gas-rich, low-density inclusions. Most fluids are preserved as trails with tens of inclusions along the border of crystals (1). However sometimes groups of separate inclusions are present far away from the margins (2). Spinel crystals are characterized either by this separate fluid inclusions group (2) or by mixed inclusions, containing crystal/melt + fluid. No obvious difference in the range of fluid inclusion density was observed in different minerals, with the exception of ultra-pressure fluids that have been found only in olivine crystals from STP sample.

Microthermometry of fluid inclusions

Most of the identified types of fluid inclusions were measured by microthermometry. From observations of the freezing (solid/vapor) temperature (– 63°C to – 98°C) and solid phase melting temperature (–56.7 +/-0.5°C, rarely till - 58°C), the fluid inclusions are primarily pure CO_2, but in rare cases, they contain minor amounts of other gases. Homogenization temperatures Th (to liquid) range from – 2.5 °C to –35°C for high-density inclusions, and from +9 °C to +30.2 °C for low-density inclusions. These Th correspond to a range of CO_2 densities from 0.34 to 1.1 g/cm^3. In addition to low and high dense inclusions *ultra-pressure, close to super-dense* fluid inclusions have been found. These inclusions was observed following phase transitions: fluid heterogenization (gas bubble origin) at temperature from – 71 to – 78 °C; freezing (solid/liquid) at temperature from – 81 to – 99 °C; solid phase melting (with visual again gas bubble origin) at temperature from – 58 to –56.6 °C and rapid homogenization to liquid at temperature from –56.6 to –54.2 °C. This type of inclusions is characterized by a range in density of 1.17 to 1.18 g/cm^3.

Estimated densities and entrapment pressures of studied fluid inclusions have been calculated based on the equation of state following Holloway, 1981 and an assumed average equilibrium temperature of 1150 °C. The calculated pressures (1.5 – 15.5 kbar) imply minimum entrapment depths between 4 and 50 km. These pressure estimates are therefore considered very conservative, because most inclusions could be partially decrepitated during transport to the surface resulting in re-equilibration at lower pressures (see review by Andersen and Neumann, 2001), as a result it can be assumed that the fluids were derived from greater depth.

Evidence of the microthermometry experiments were recorded on videotape and are available on request.

References

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