The composition of noble gas and CO_2 in the European subcontinental lithospheric mantle

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The investigation of mantle-derived products coming from Sub Continental Lithospheric Mantle (SCLM) is crucial for constraining its geochemical features and evolution, the mantle-crust interaction, the volatiles recycling, and for better evaluating the information arising from the study and monitoring of volcanic gases. A significant contribution in the comprehension of the mantle features may come from the study of noble gases and CO_2 trapped as fluid inclusions (FI) hosted in ultramafic xenoliths, coupled with the petrography and chemistry of the minerals.

Here, we report a reappraisal of the knowledge recently developed on the European SCLM, based on the study of distinct suites of mantle xenoliths representative of the mantle beneath Lower Silesia (19-21 Ma; Eger Rift in SW Poland), Persani Mts. (0.6-1.2 Ma; Eastern Transylvanian Basin, Romania), Eifel (0.01-0.5 Ma) and Siebengebirge (6-30 Ma; Germany).

The chemistry of FI (He-Ne-Ar-N_2-CO_2 systematics) reveal that: i) FI are CO_2-dominated with variable amounts of N_2; ii) there seems to be a systematic different partition of volatiles between olivine and pyroxene, which probably reflect either crystallographic features or the distinct behaviour of the minerals during mantle recrystallization in sub-solidus conditions.

In detail, the mantle below Lower Silesia and Siebengebirge was depleted by variable extents of partial melting, with the overprinting in Lower Silesia of at least one metasomatic event by carbonated hydrous silicate melt related to Cenozoic volcanism. This process resulted in entrapment of CO_2-rich inclusions whose chemical and isotope composition resembles that of a metasomatizing melt with MORB-like signature. Instead, the mantle beneath Eifel reflect multiple metasomatism/refertilisation events by CO_2-rich melts that took place in the regional SCLM between ~6 and ~0.5 Ma. In Lower Silesia, however, the CO_2 isotopic composition indicates for the first time clear evidences of a recycled crustal carbon by old subducted altered oceanic crust and/or oceanic lithosphere. Finally, the mantle beneath Persani Mts. was strongly refertilized by a calc-alkaline subduction-related melt, which reflects the different geodynamics that characterizes this portion of the European mantle.

The $^3He/^4He$ ratio of the European mantle varies in the range 5.5-6.9 Ra, indicating a widespread recycling of crustal material related to fossil subduction(s) and confirms the complex geodynamics that characterized this continent. A more careful observation reveals that the $^3He/^4He$ values are the lowest in Persani Mts., where a subduction is still active, while are the highest where the SCLM was metasomatized or refertilized by astenospheric MORB-like melts.