# He, Ne and Ar snapshot of the subcontinental lithospheric mantle from $CO_2$ well gases

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The subcontinental lithospheric mantle (SCLM) constitutes a significant portion of the upper mantle sourcing magmatic volatiles to the continents above, yet its geochemical signature and evolution remain poorly constrained [1].

Here we present new interpretation of noble gas datasets from two magmatic $CO_2$ fields in the SW US, Bravo Dome and Sheep Mountain, which provide a unique insight into the volatile character of the SCLM sourcing the Cenozoic volcanism in the region. We identify that reduction of $^3He/^4He_{mantle}$ ratio within the Sheep Mountain $CO_2$ field can be attributed to radiogenic production within the SCLM. Using a $\chi^2$ minimisation on the variation of derived $^4He/^{21}Ne_{crust}$ ratios within samples from the Sheep Mountain field, combined with a radiogenically raised $^{21}Ne/^{22}Ne_{mantle}$ end member, we resolve $^3He/^4He_{mantle}$ ratios of 2.59 ± 0.15 to 3.00 ± 0.18 $R_a$. These values correspond with a $^{21}Ne/^{22}Ne_{mantle}$ value of 0.136.

Using these $^3He/^4He_{mantle}$ end member values with $^{21}Ne_{mantle}$ resolved from Ne three component analysis, we derive the elemental $^3He/^{22}Ne_{mantle}$ of 2.80 ± 0.16 and radiogenic $^4He/^{21}Ne^*_{mantle}$ range of 1.11 ± 0.11 to 1.30 ± 0.14. A second $\chi^2$ minimisation performed on the variation of $^{21}Ne/^{40}Ar_{crust}$ ratios has allowed us to also determine both the $^4He/^{40}Ar_{mantle}$ range of 0.78 to 1.21 and $^{21}Ne/^{40}Ar_{mantle}$ of 7.66 ± 1.62 to 7.70 ± 1.54 within the field. Combining these ratios with the known mantle production ranges allows resolution of the radiogenic He/Ne and He/Ar ratios corresponding to the radiogenically lowered $^3He/^4He_{mantle}$ ratios.

Comparing these values with those resolved from the Bravo Dome field [2] allows identification of a clear and coherent depletion of He to Ne and He to Ar in both datasets. This depletion can only be explained by partial degassing of small melt fractions of asthenospheric melts which have been emplaced into the SCLM. This is the first time that it has been possible to resolve and account for both the mantle He/Ne and He/Ar ratios within a SCLM source. The data additionally rule out the involvement of a plume component in the mantle source of the two gas fields.

[1]Gautheron et al., 2005, Chemical Geology 217, 97-112
[2]Ballentine et al., 2005, Nature 433, 33-38.