GEOCHEMISTRY OF NOBLE GASES AND CO_2 IN MANTLE XENOLITHS AND ARC LAVAS FROM CENTRAL MEXICO

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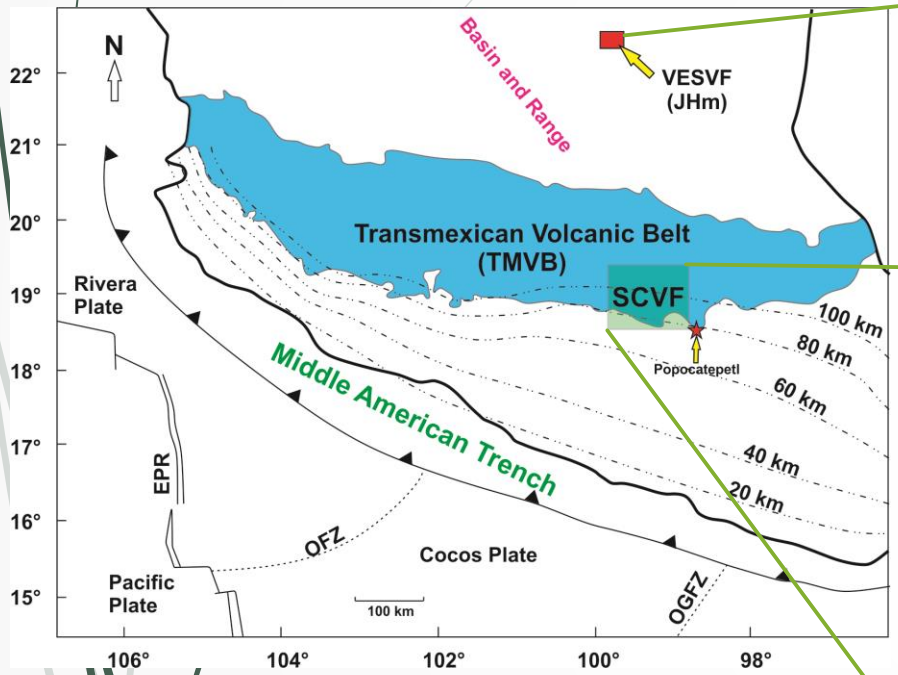
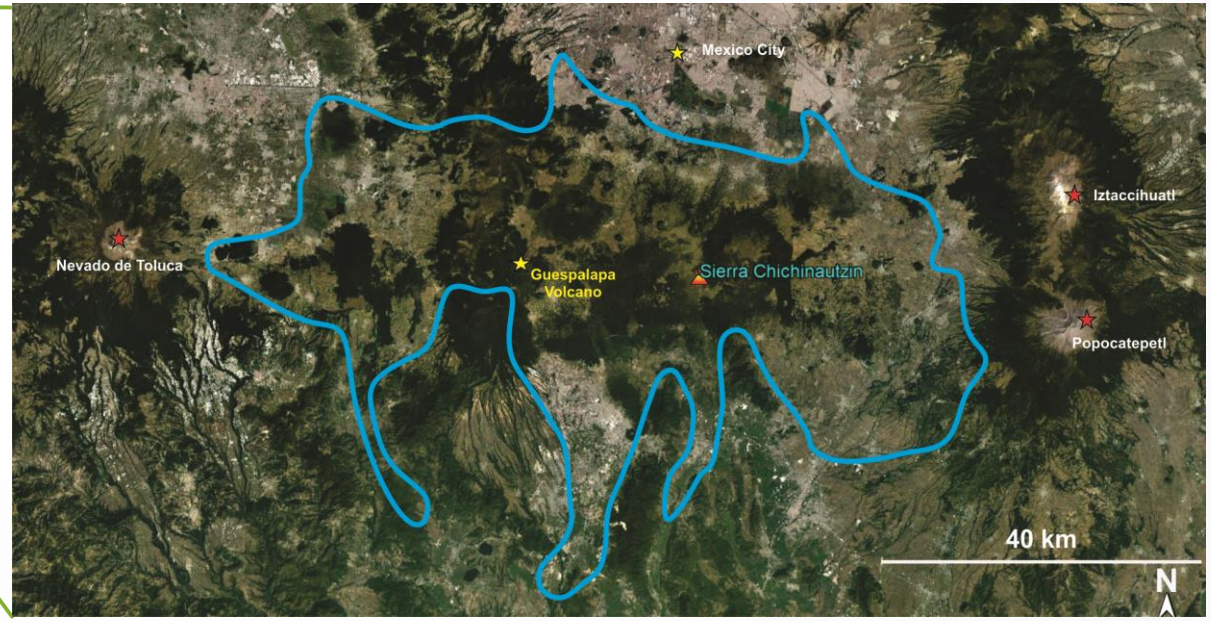
LOCATION AND GEODYNAMICS OF THE AREA: Joya Honda maar (JHm) and Sierra Chichinautzin Volcanic Field (SCVF)





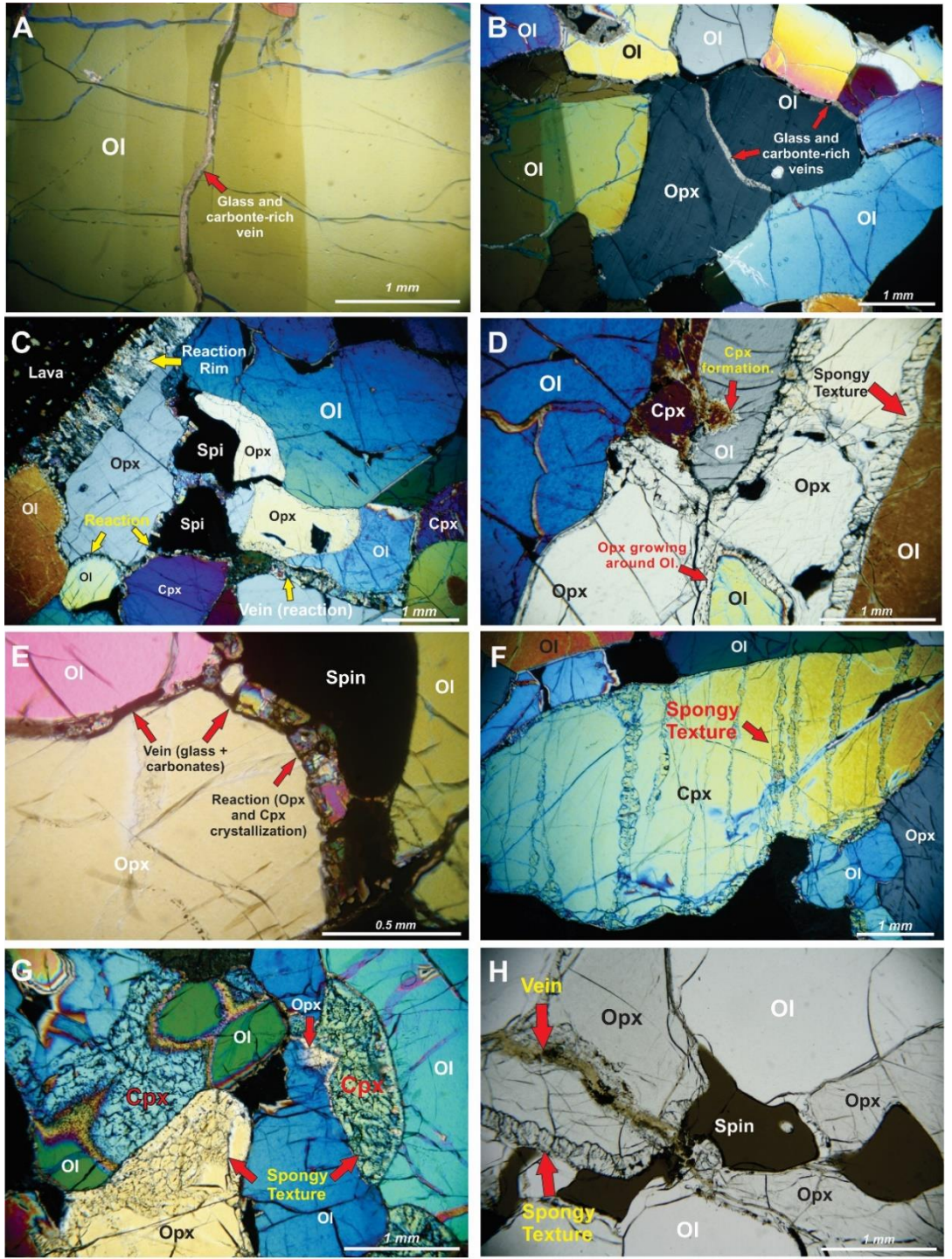
Left: Location of Joya Honda maar (JHm) and Sierra Chichinautzin (SCVF). Doted lines (and numbers in km) represent the depth of the subducted slab. Adapted from Pardo and Suárez (1995) and Schaff et al. (2005). Samples from SCVF were taken from Guespalapa Volcano.

SAMPLES AND METHODS

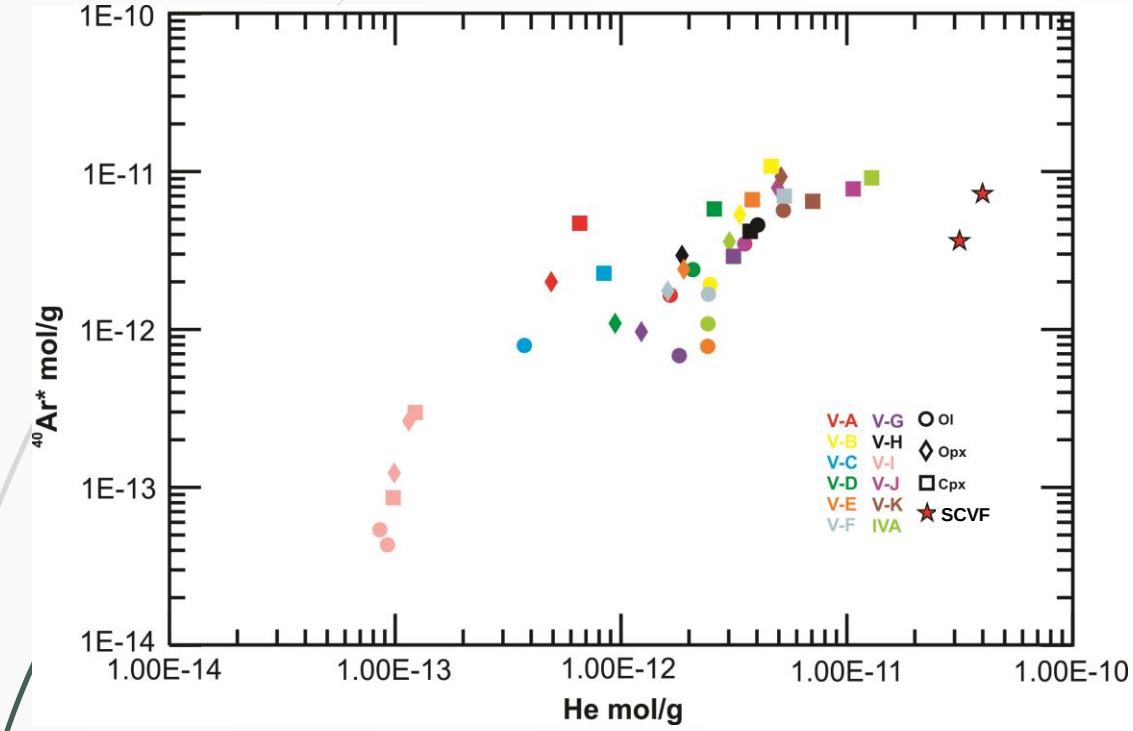
- **JHm:** Thirteen fresh nodules (with diameters between 5 and 10 cm) were selected from the eastern part of the JHm; generally, these are dispersed in pyroclastic fall and flow deposits or hosted in basanitic lavas. Eight nodules were selected for petrographic analysis on thin and polished thin sections. Noble gas and CO_2 isotopic analysis in fluid inclusions were performed in olivine, orthopyroxene and clinopyroxenes in all samples.
- **SCVF:** Two lava samples from the Guastapalapa Complex (located in the central part of the SCVF) were analyzed. Samples were crushed with the aim of hand-picking olivine crystals with diameters >0.25 mm. These lavas were previously classified as calc-alkaline basaltic andesites.
- Petrographic analysis was performed at University of Milano-Bicocca based on the textural classification proposed by Mercier and Nicolas (1975); the modal composition was carried out by point counting (from 4000 to 7000 points per section). Noble gas and CO_2 isotopic determinations were performed at Palermo INGV laboratories (Italy) following the preparation methods and analytical procedures described in Gennaro et al. (2017), Rizzo et al. (2018), Faccini et al. (2020).

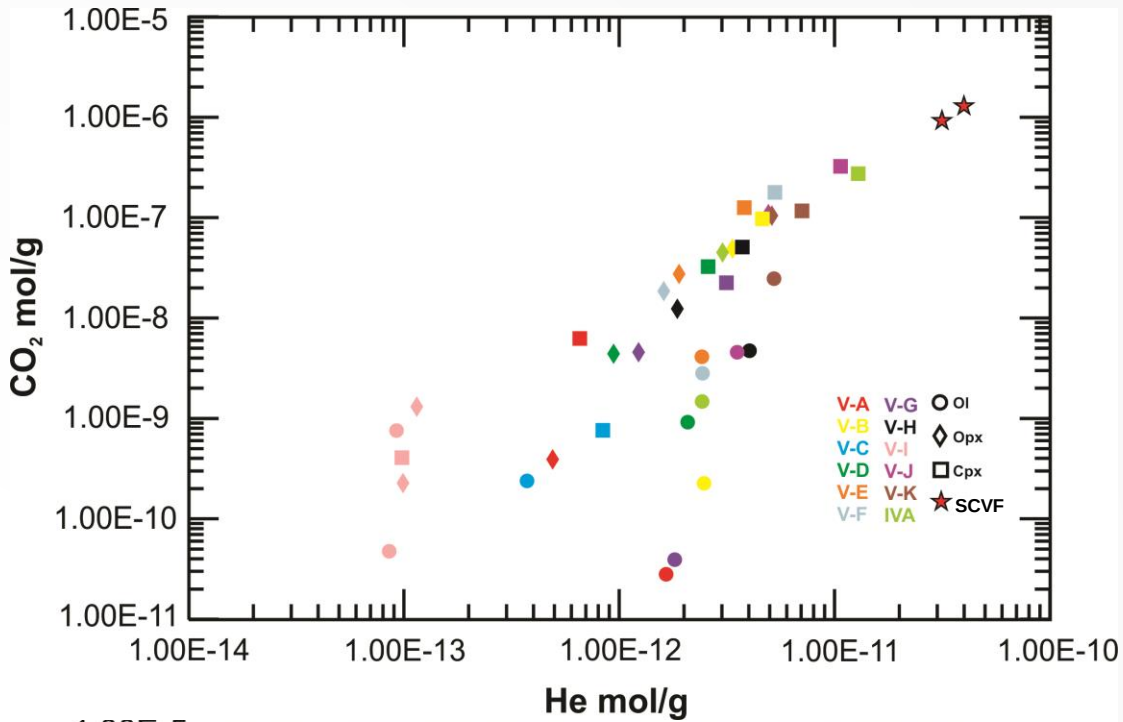
PETROGRAPHIC ANALYSIS

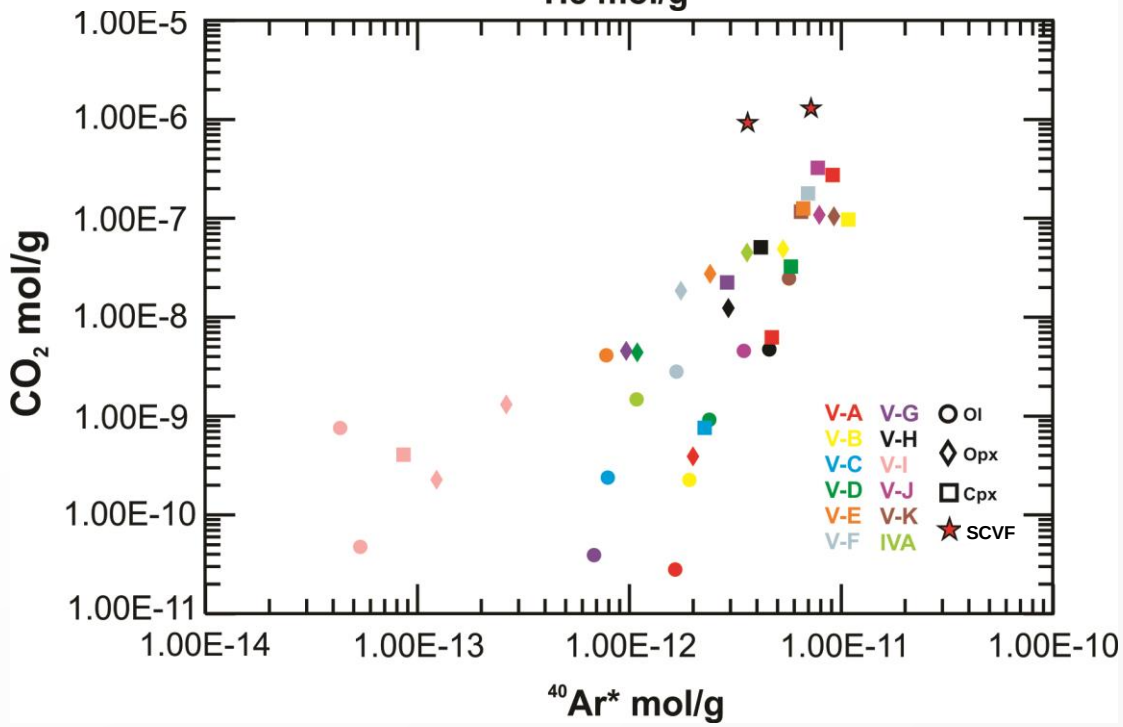
- Paragenesis: Olivine> Opx> Cpx >> Spinel.
- Samples are classified as Spinel-Lherzolites and Harzburgites.
- All samples are plagioclase-free.
- Protogranular to porphyroclastic texture in which two generations of olivine (Ol) and orthopyroxene (Opx) are observed.
- Spongy Texture in Opx and Cpx. Partial melting?
- Xenoliths are affected by veins composed of glass and small crystals of high birefringence (possible carbonates). Metasomatism?



Noble Gases and CO_2 Concentrations

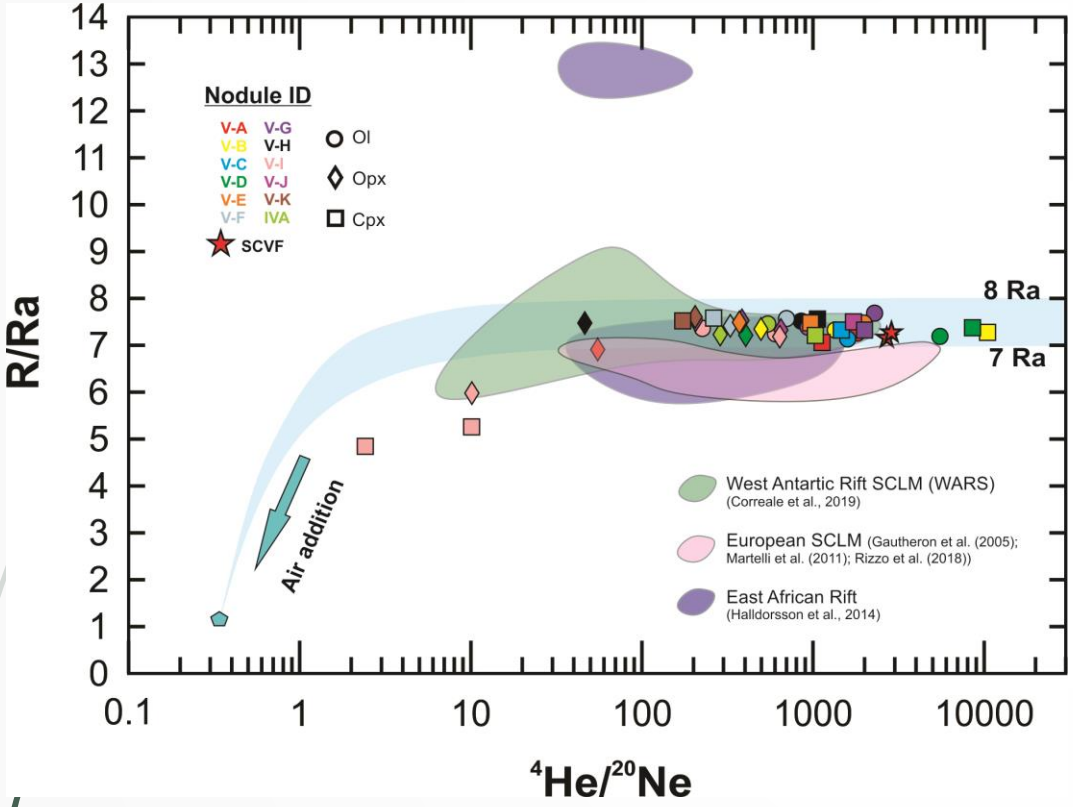


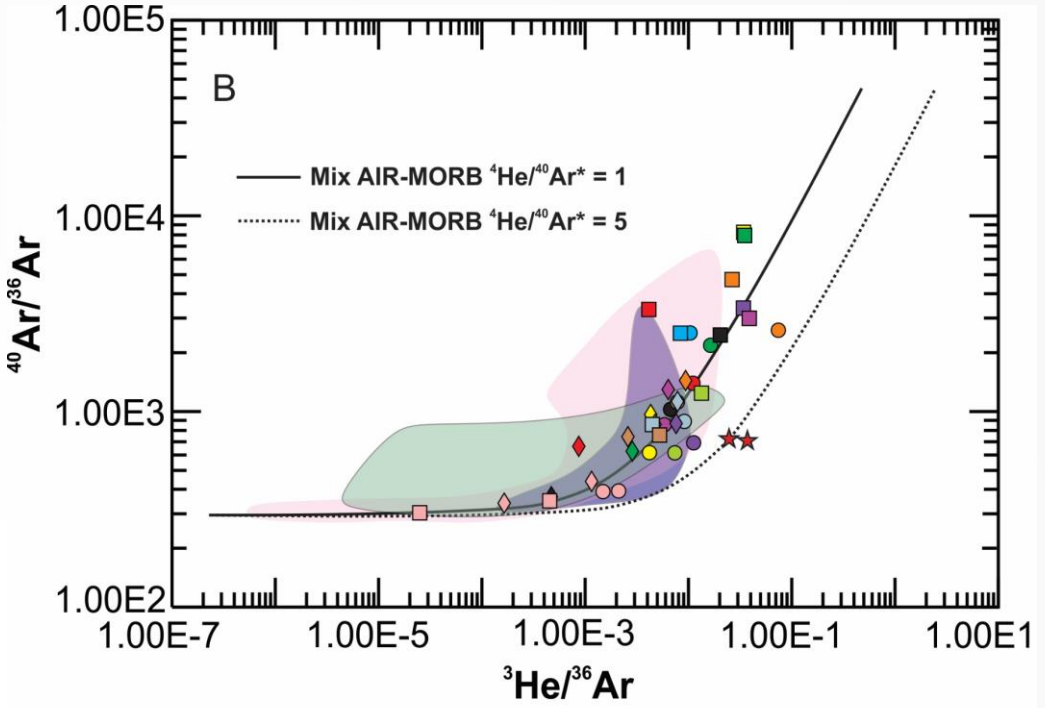


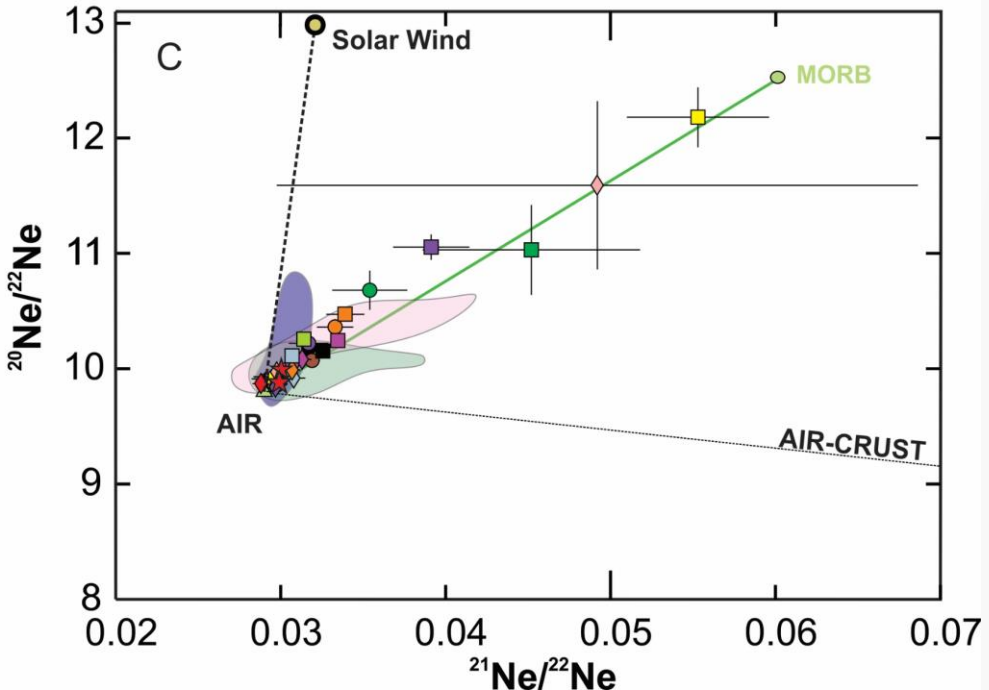


- A positive relationship between the concentration of noble gases and CO_2 was determined. Olivines from SCVF have the highest values for He and CO_2 compared to JHm xenoliths.

Atmospheric Contamination

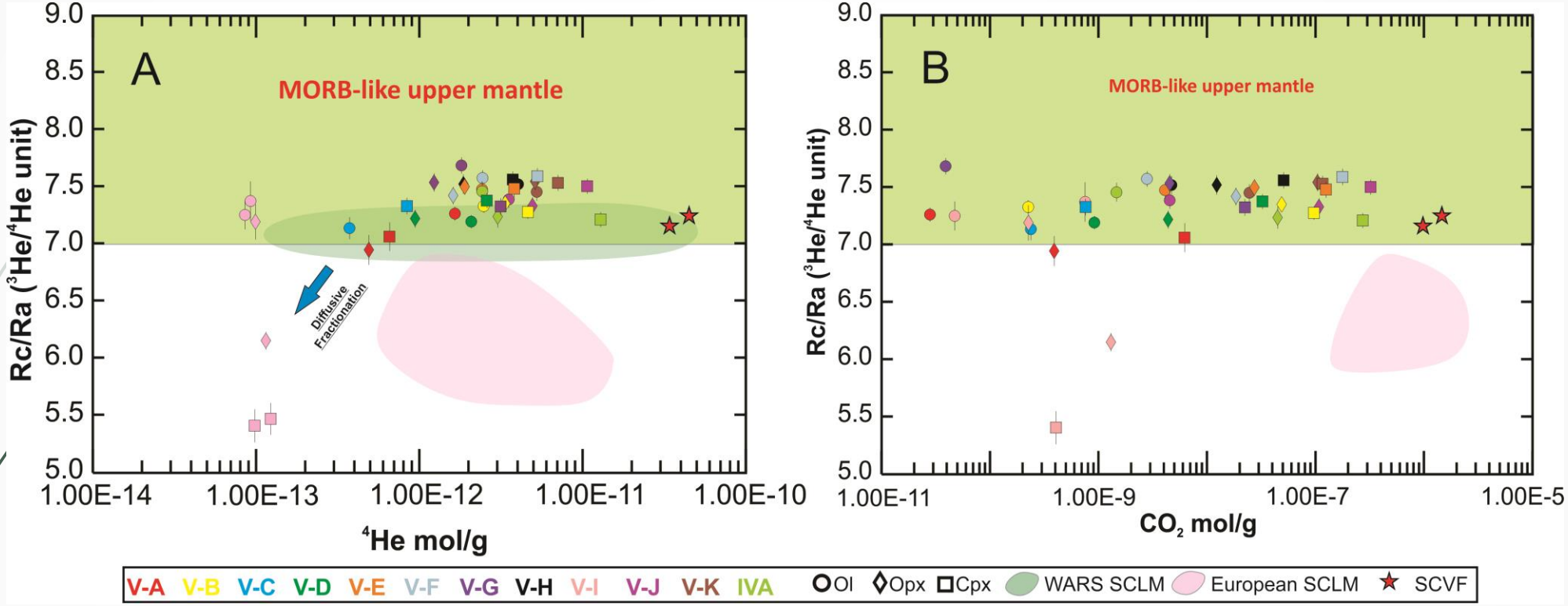




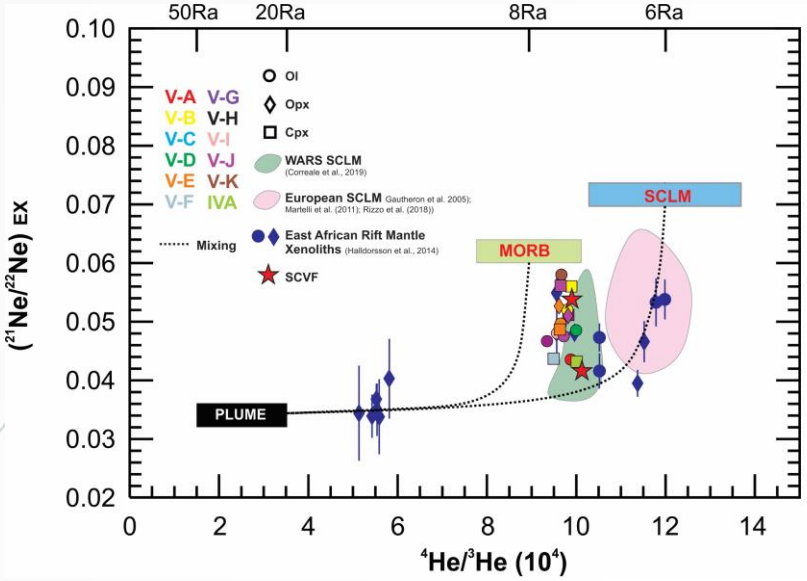


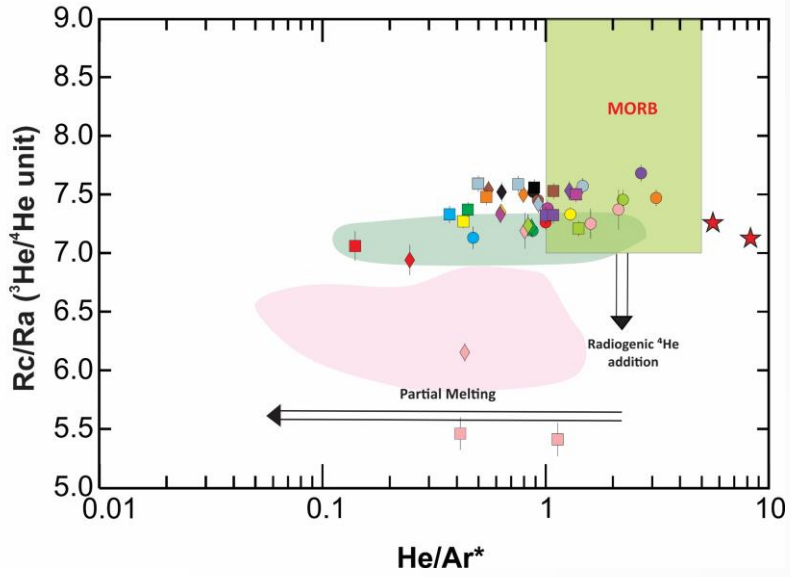
He, Ne and Ar isotopes reflect a mix between upper mantle volatiles and atmospheric gases confirming the presence of non-atmospheric noble gases in the Fluid Inclusions. The xenolith VI suffers diffusive fractionation of helium, so it cannot be considered as a representative sample of the local mantle. The presence of a Primitive mantle component is ruled out as noted by Ne isotopes.

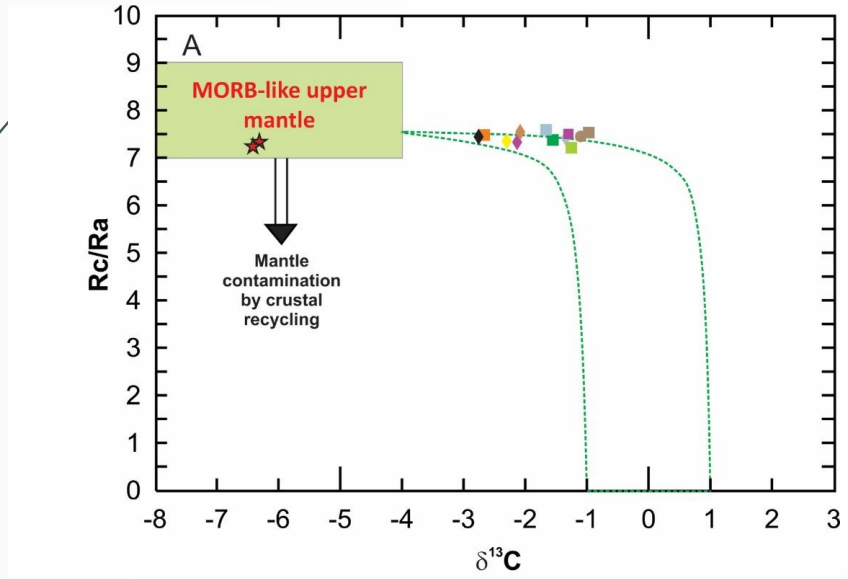
Noble Gases and $\delta^{13}C$ Analysis

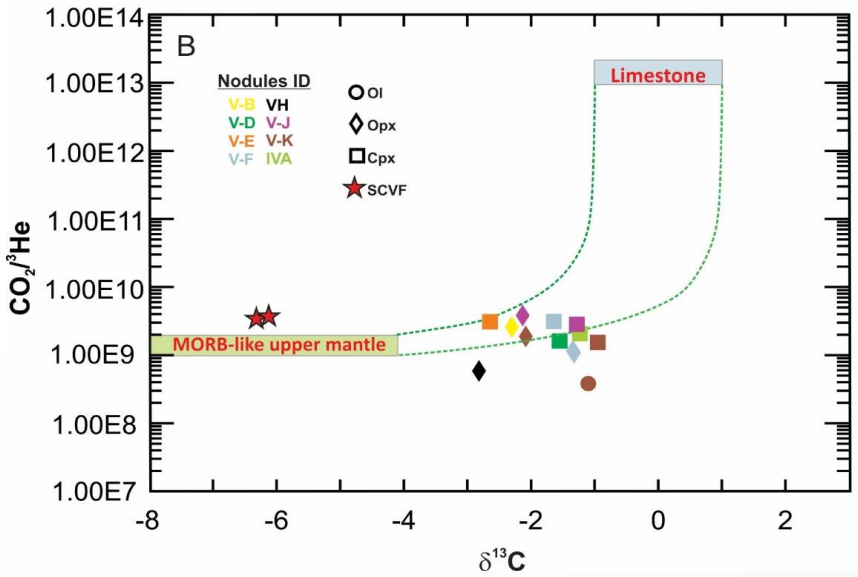


- The ^{3}He/^{4}He (Rc/Ra values): **Ol:** 7.13 - 7.68 Ra, **Opx:** 6.94 - 7.54 Ra, **Cpx:** 7.06–7.59 Ra, **SCVF:** 7.1-7.3. Xenoliths from JHm indicate a less radiogenic mantle compared to other localities.
- Values comparable to the ^{3}He/^{4}He ratio for a MORB-like mantle.
- JHm mantle xenoliths exhibit a decrease in Rc/Ra and ^{4}He values likely linked to a diffusive loss of He.









- Compared to other worldwide SCLM localities, JHm mantle xenoliths and SCVF olivines exhibit a lower extent of crustal recycling and their composition does not exhibit the influence of a mantle plume component (top left image; adapted from Halldorsson et al. (2014)). On the other hand, He/Ar* values tend to be high and vary between 0.14 and 3.11 and could reflect a partial melting process affecting Opx and Cpx crystals (top right image).
- The $d^{13}C$ in the olivine phenocrysts from SCVF is around -6.2‰ with $CO_2/^3He$ ratios of $3.3x10^9$, comparable to MORB-like range ($-8 < d^{13}C < -4$).
- JHm mantle xenoliths exhibit more positive $d^{13}C$ signatures between -1.0 and -2.7‰ $d^{13}C$, suggesting a crustal recycling in the local upper mantle as a consequence of subduction.

PRELIMINARY CONCLUSIONS

- JHm mantle xenoliths are classified as Spinel-Lherzolites and Harzburgites.
- Both the boundaries and the fractures of the crystals in the JHm nodules develop veins composed of yellowish glass and possible tiny crystals of carbonates and could be associated with deep fluid-metasomatism events.
- The presence of nodules with Opx contents greater than 25% is associated with the consumption of olivine; this could be related to different degrees of partial melting which agrees with the presence of spongy rims and the variability of He/Ar* ratios.
- JHm xenoliths and SCVF olivines present values of Rc/Ra (6.9 – 7.7Ra) comparable to the MORB-like mantle and their composition do not exhibit a plume-like component; compared to other worldwide SCLM localities, mantle xenoliths suggest a low extent of crustal recycling.
- The effect produced by carbonate recycling during the subduction process cannot be ruled out as evidenced by the $\delta^{13}C$ values in JHm nodules which vary between -1.6 and -2.3% and tend to adjust over the mixing line MORB-Limestone. Conversely, SCVF olivines exhibit a more pristine composition which suggest a less contaminated mantle under Sierra Chichinautzin, or they result from the magmatic degassing of a mantle with a signature similar to JHm nodules.
- It is necessary to perform analysis of mineral chemistry and fluid inclusions to corroborate the idea of a process of partial melting and metasomatism due to the interaction of xenoliths with fluids from the subducting slab.