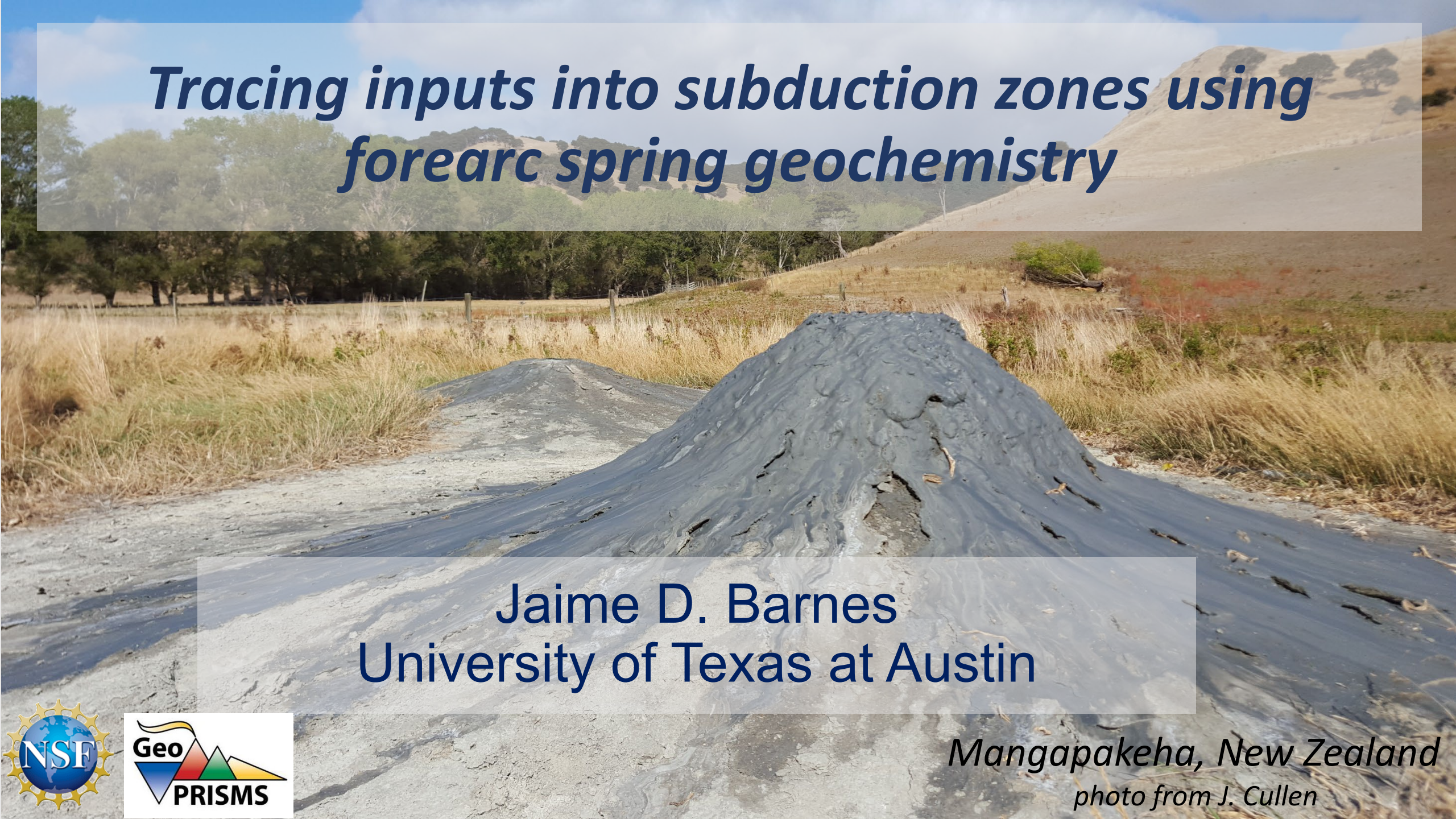
Tracing inputs into subduction zones using forearc spring geochemistry



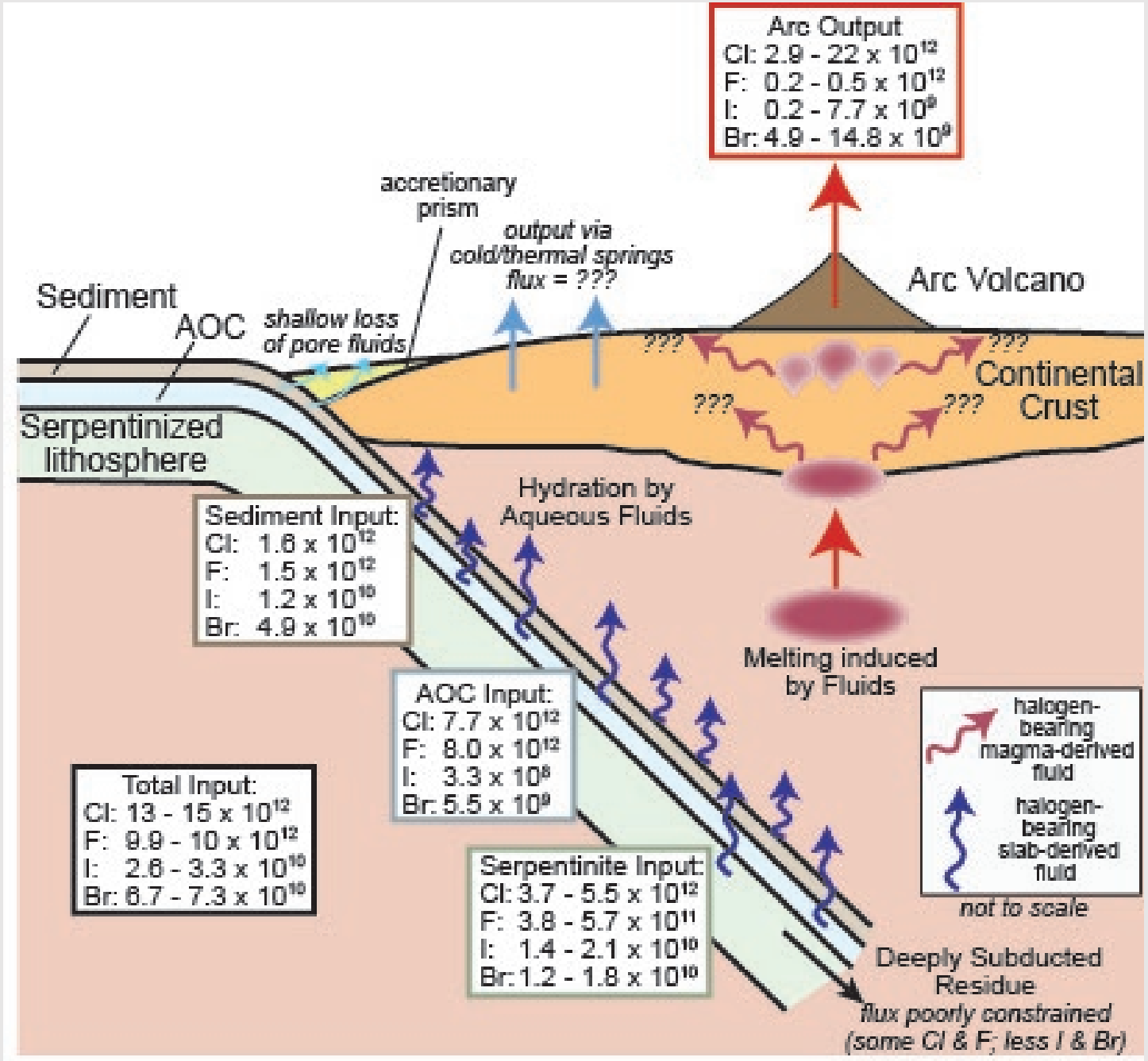
Jaime D. Barnes
University of Texas at Austin

Mangapakeha, New Zealand
photo from J. Cullen

Jacob Helper
J. Maarten de Moor
Alejandro Rodríguez
Pete Barry
Samuele Agostini
John Lassiter
Evan Ramos
María Marta Chavarría

A very special thanks to Area Conservación Guanacaste and numerous landowners for permission to sample on their property

Sabana Grande



Inputs into subduction zones

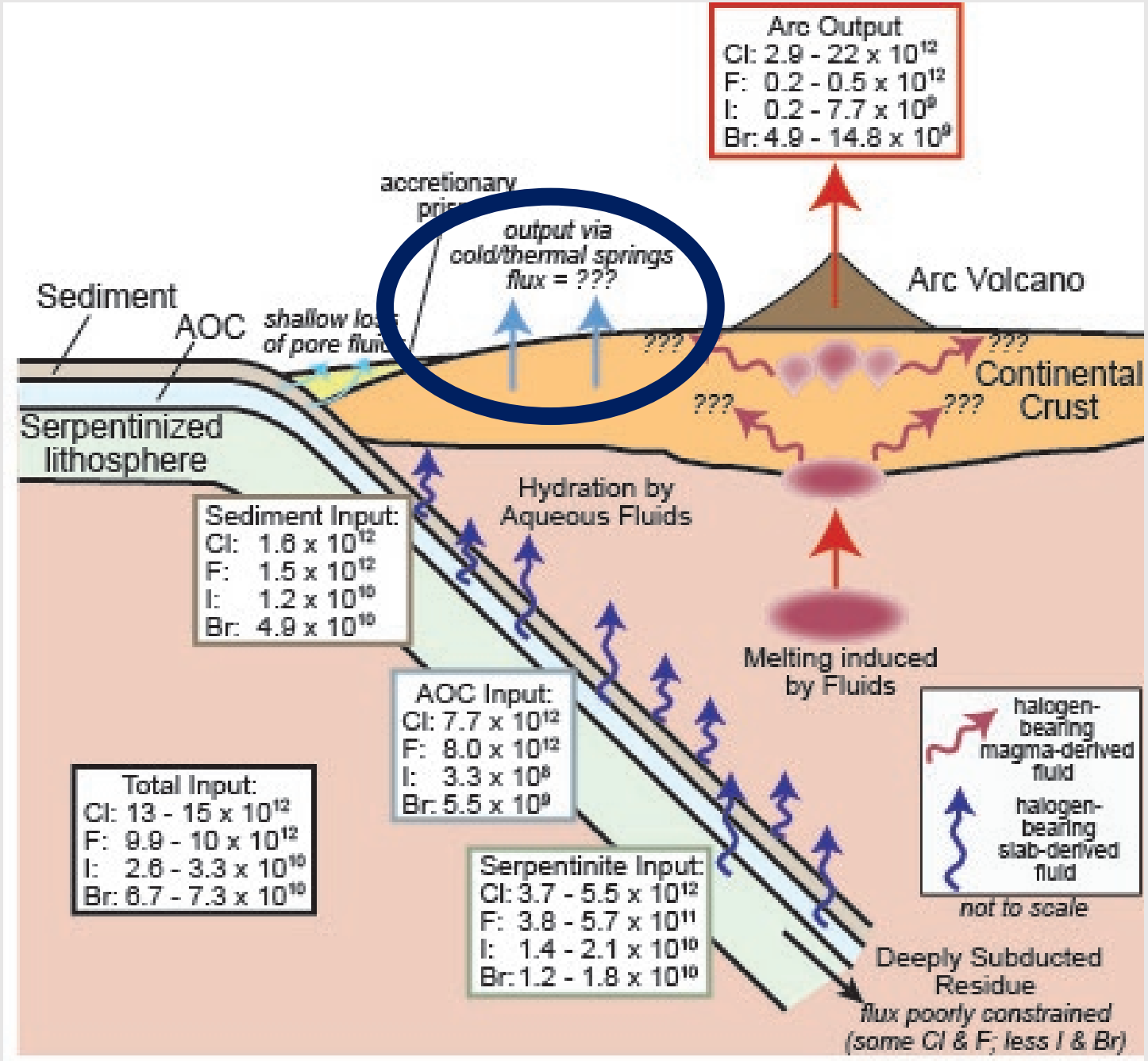
→ sedimentary pore fluids

→ sediments

→ altered oceanic crust

→ serpentinites

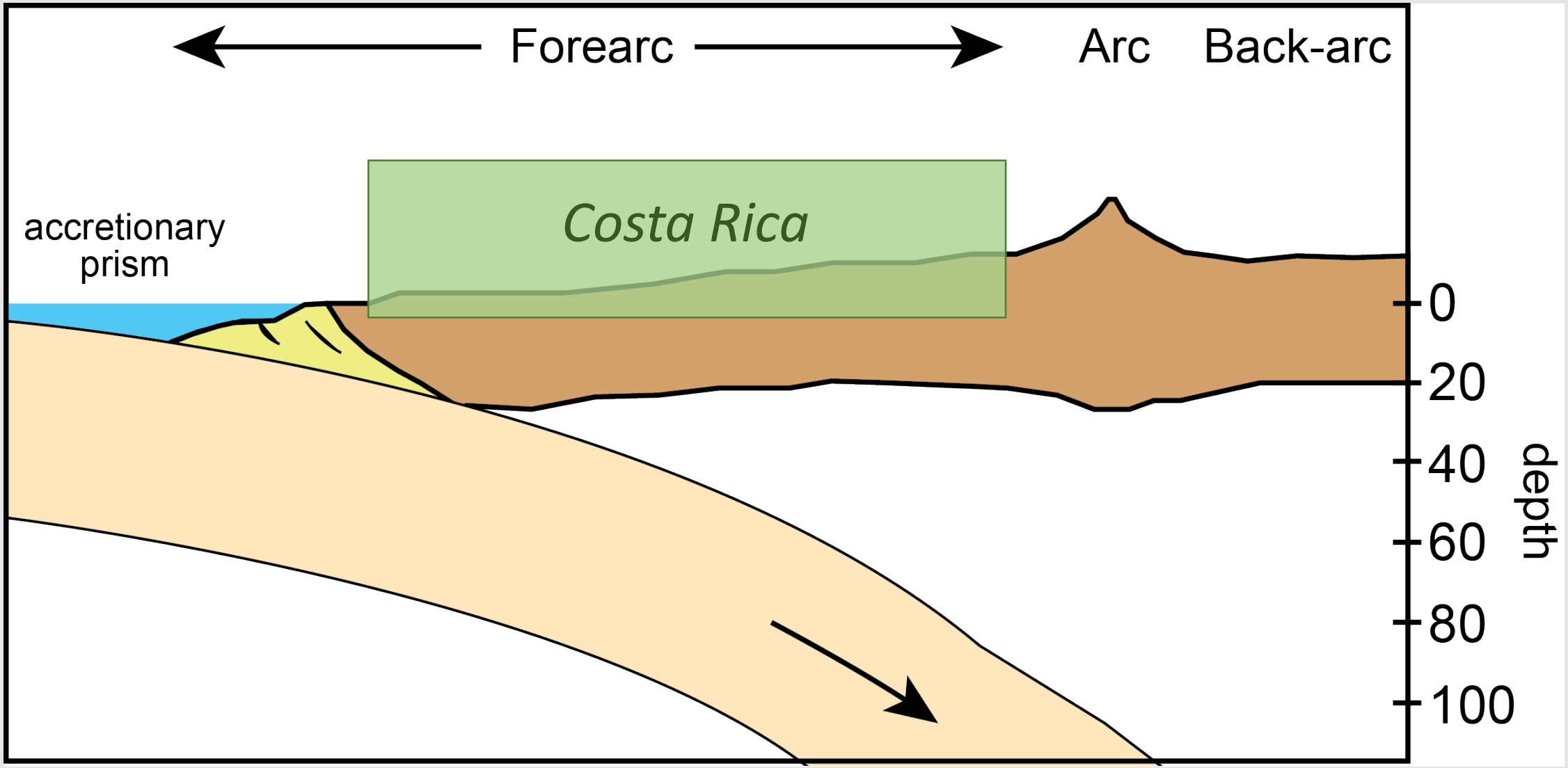
Barnes et al. (2018)

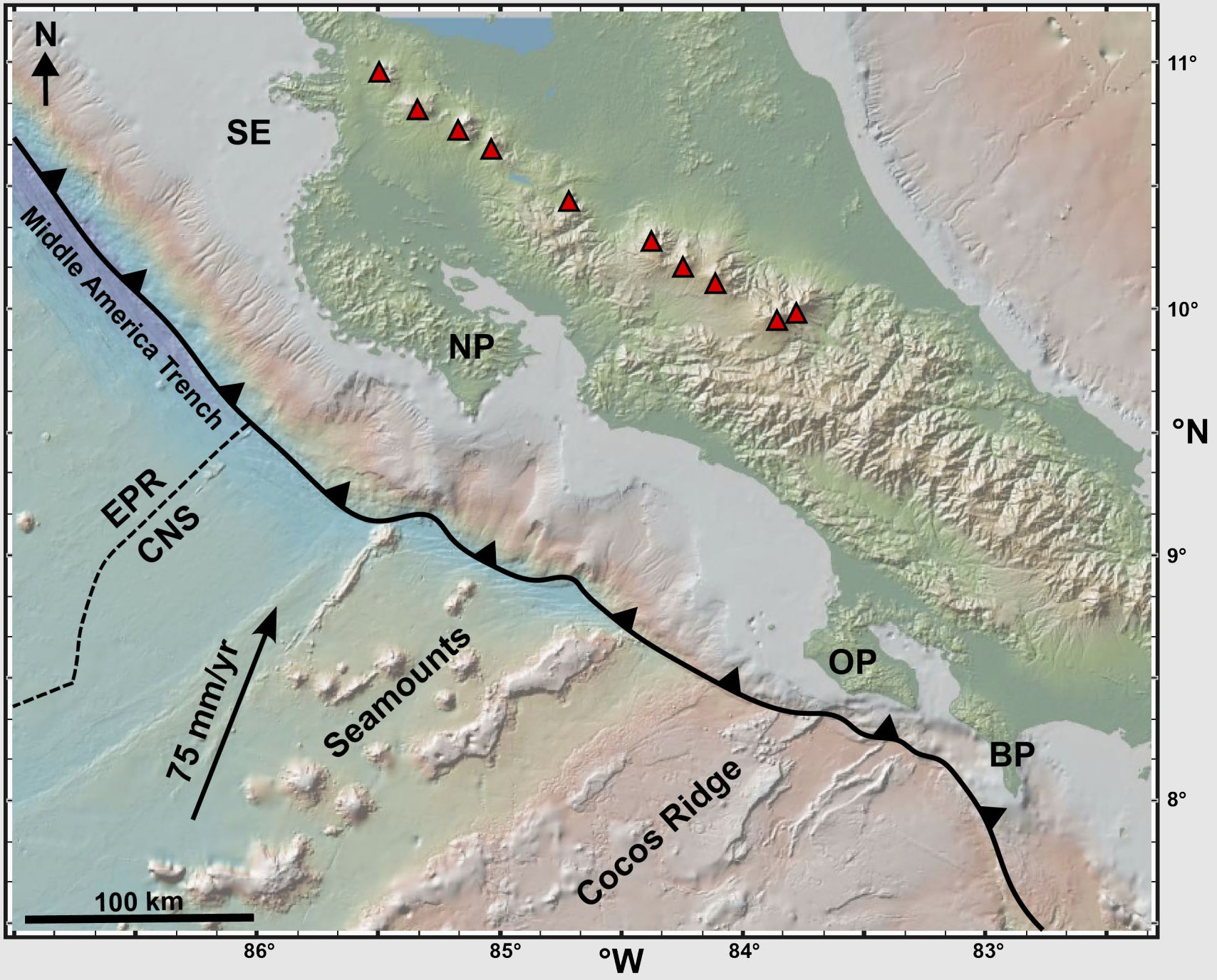


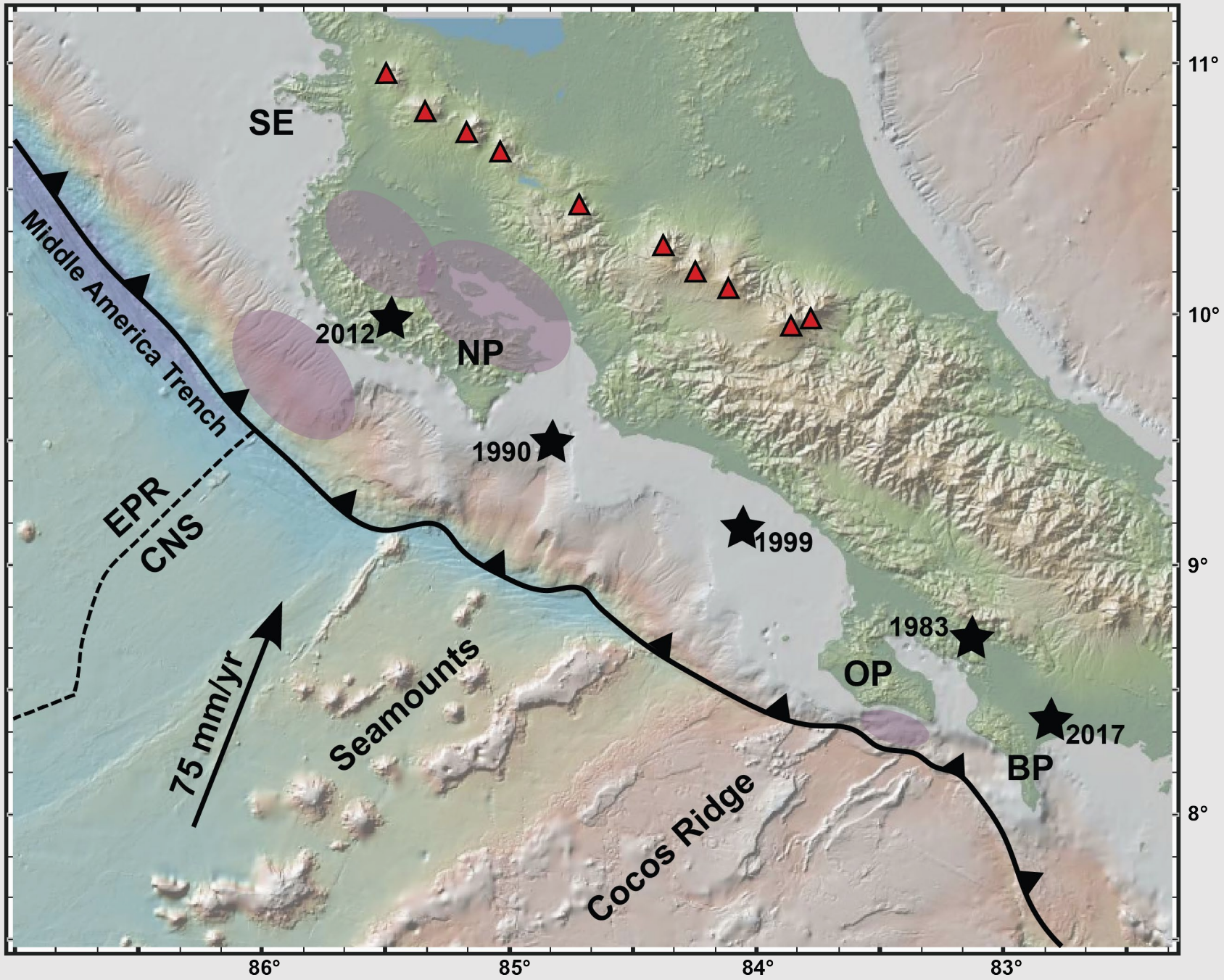
Forearc Springs → window into the subducting slab?

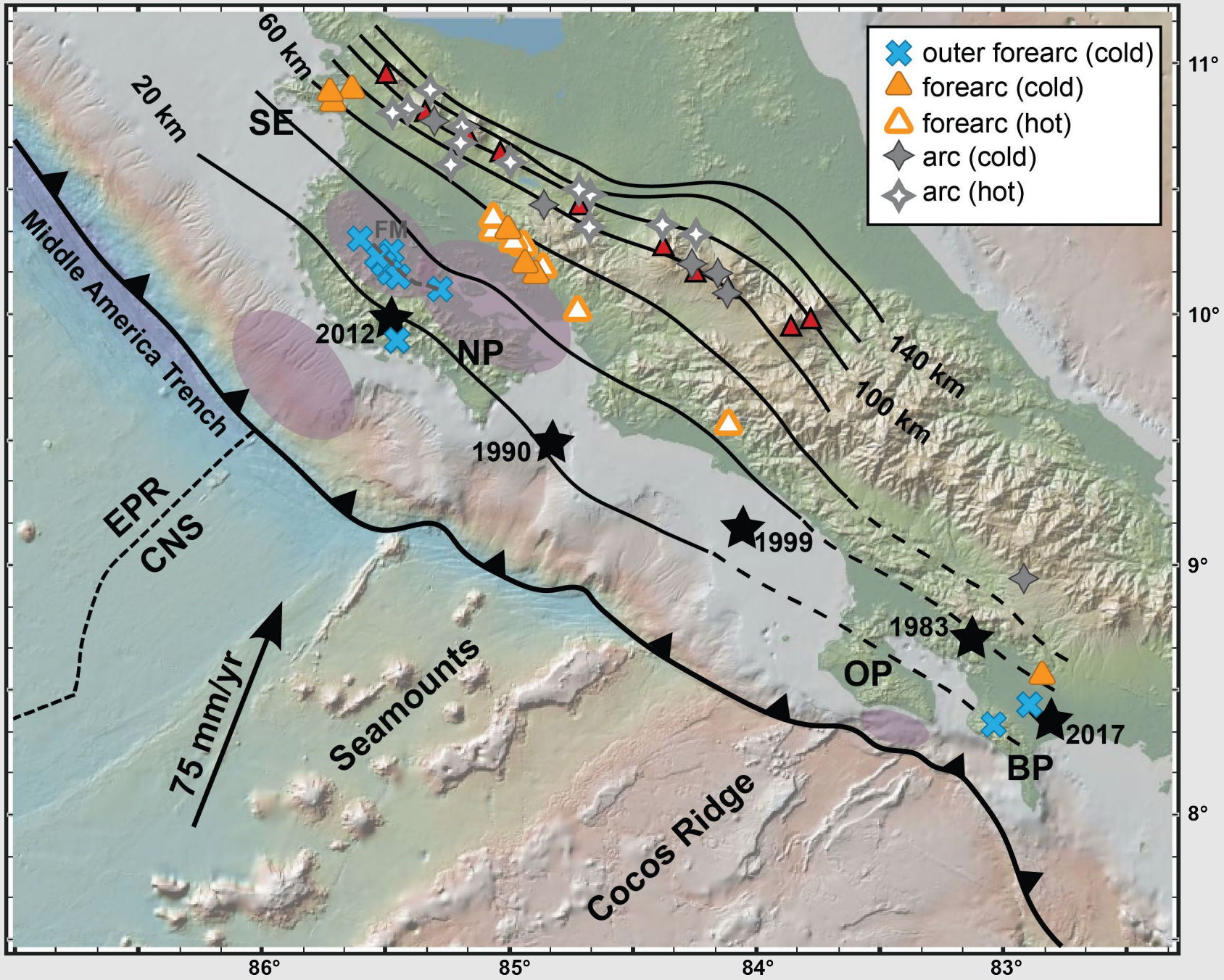
Are volatiles in forearc springs telling us about ***source*** or ***secondary modification (W/R interaction)***?

Barnes et al. (2018)


Forearc
Arc
Back-arc
Costa Rica
accretionary
prism
0
20
40
60
80
100
depth


N
SE
NP
OP
BP
Middle America Trench
EPR
CNS
75 mm/yr
Seamounts
Cocos Ridge
100 km
11°
10°
9°
8°
°N
86°
85°
84°
83°
°W


SE
Middle America Trench
2012
NP
1990
1999
1983
OP
2017
BP
EPR
CNS
75 mm/yr
Seamounts
Cocos Ridge
11°
10°
9°
8°
86°
85°
84°
83°


outer forearc (cold)
forearc (cold)
forearc (hot)
arc (cold)
arc (hot)
60 km
20 km
SE
FM
2012
NP
1990
1999
1983
OP
2017
BP
140 km
100 km
Middle America Trench
EPR
CNS
75 mm/yr
Seamounts
Cocos Ridge
11°
10°
9°
8°
86°
85°
84°
83°


El Sitio

44 different spring sites

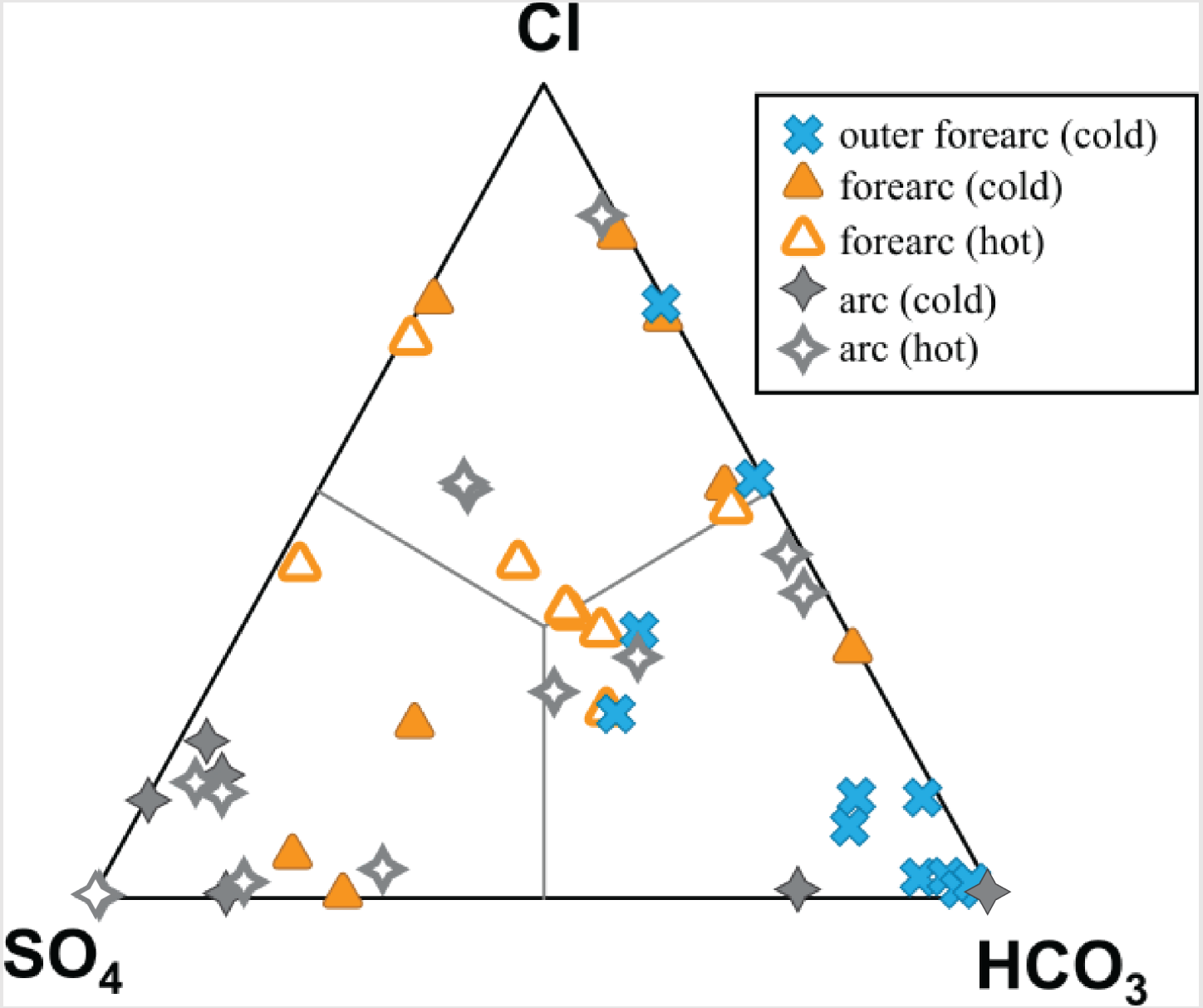
-> total of 56 samples

-Targeting cold springs

-Major element concentrations

-Trace element concentrations (Cl, Br, I, Li, and B)

-Isotopes (O, H, Cl, B, Li, and He)



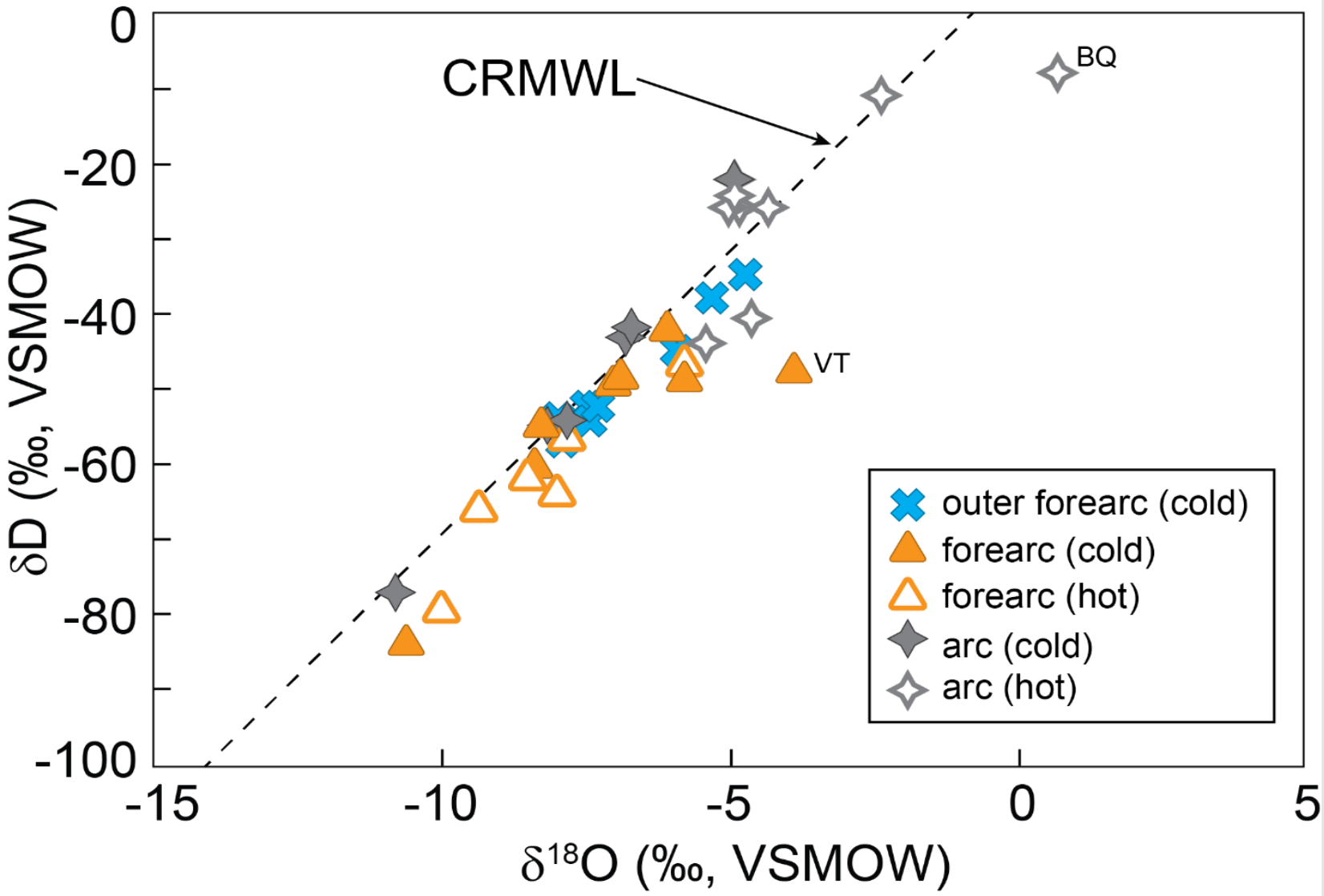
T range 20.6 °C to 98.4°C
pH range 1.7 to 11.3

Cation & anion concentrations vary over 2 to 5 orders of magnitude

$\delta^{37}Cl$ = -1.7 to +1.0‰
$\delta^{11}B$ = -12.0 to +30.9‰
$\delta^{7}Li$ = -2.4 to +27.5‰

$$\delta^7\text{Li} = \left(\frac{^7Li/6Li_{sam}}{^7Li/6Li_{std}} - 1\right) x\ 1000$$

Source or Secondary Modification?

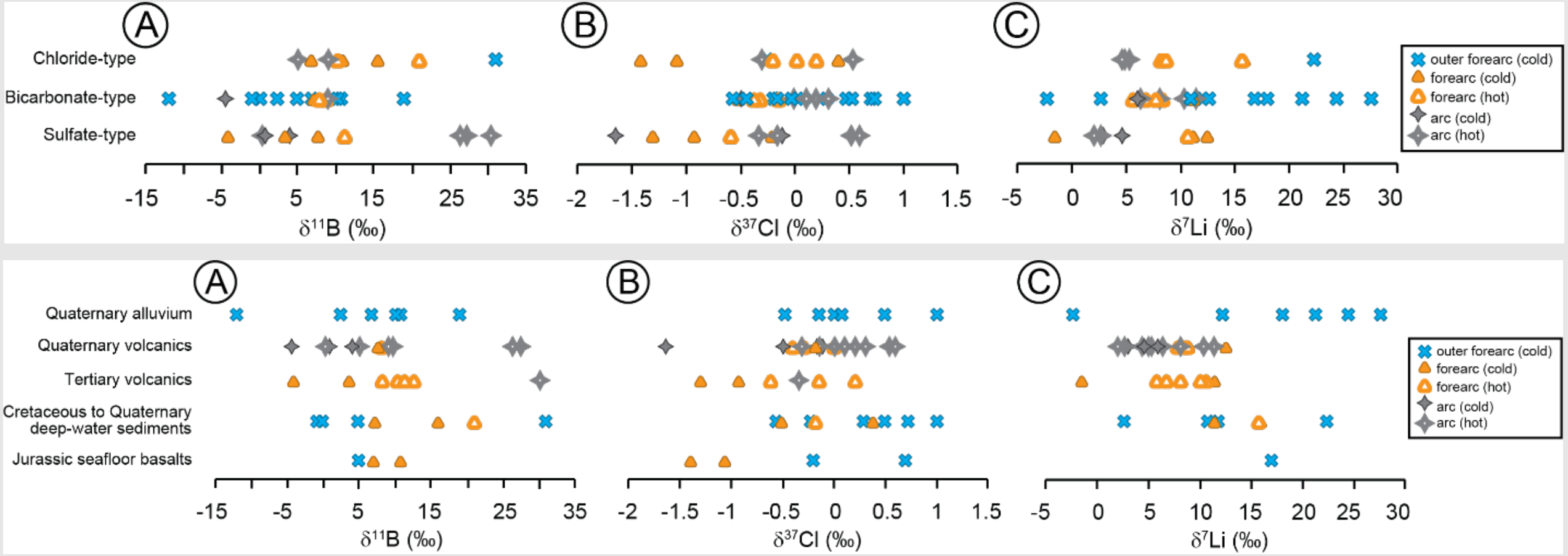


Local meteoric water

Limited modification by fluid-rock interaction

Helper et al. (2024, GCA)

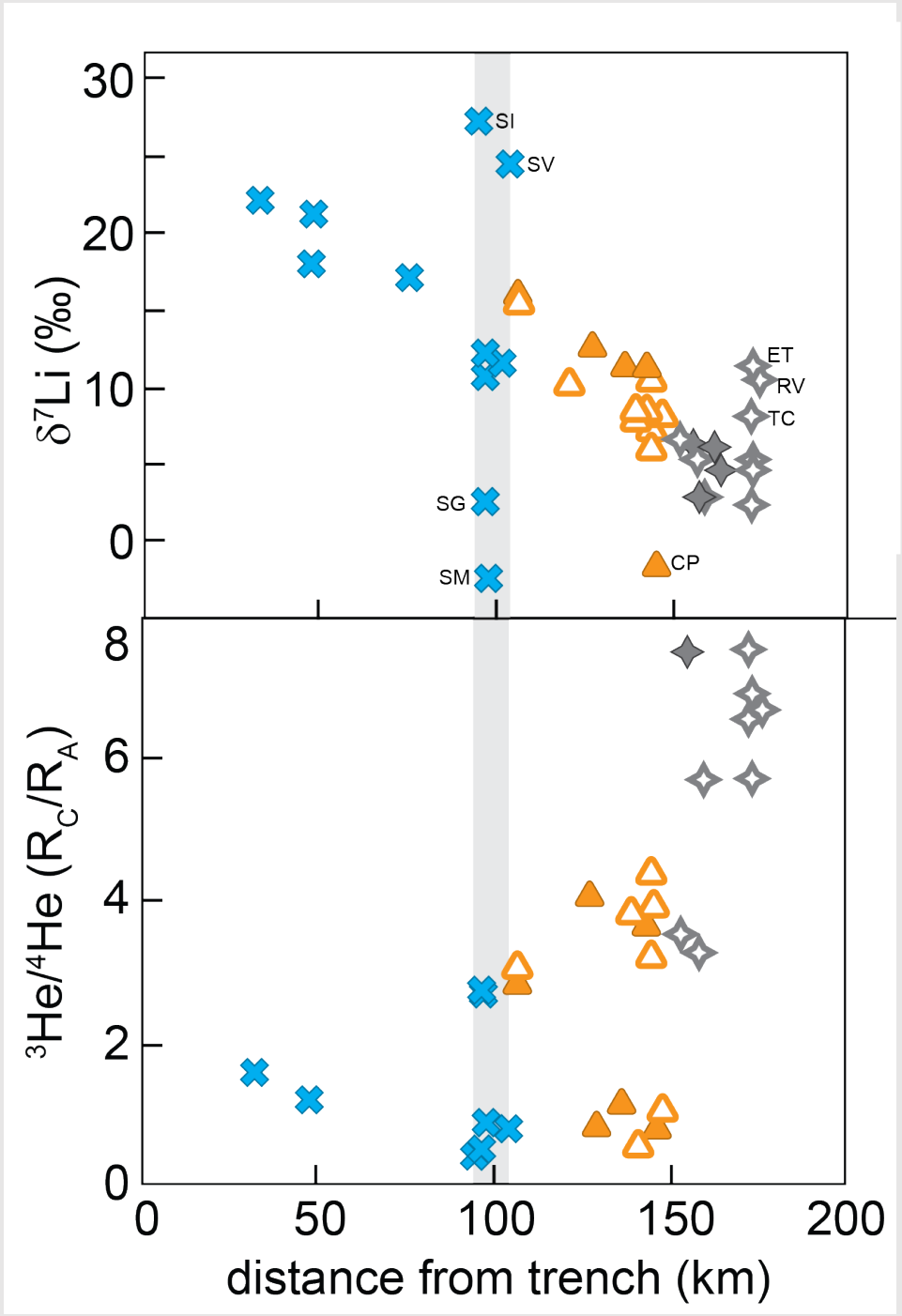
Source or Secondary Modification?



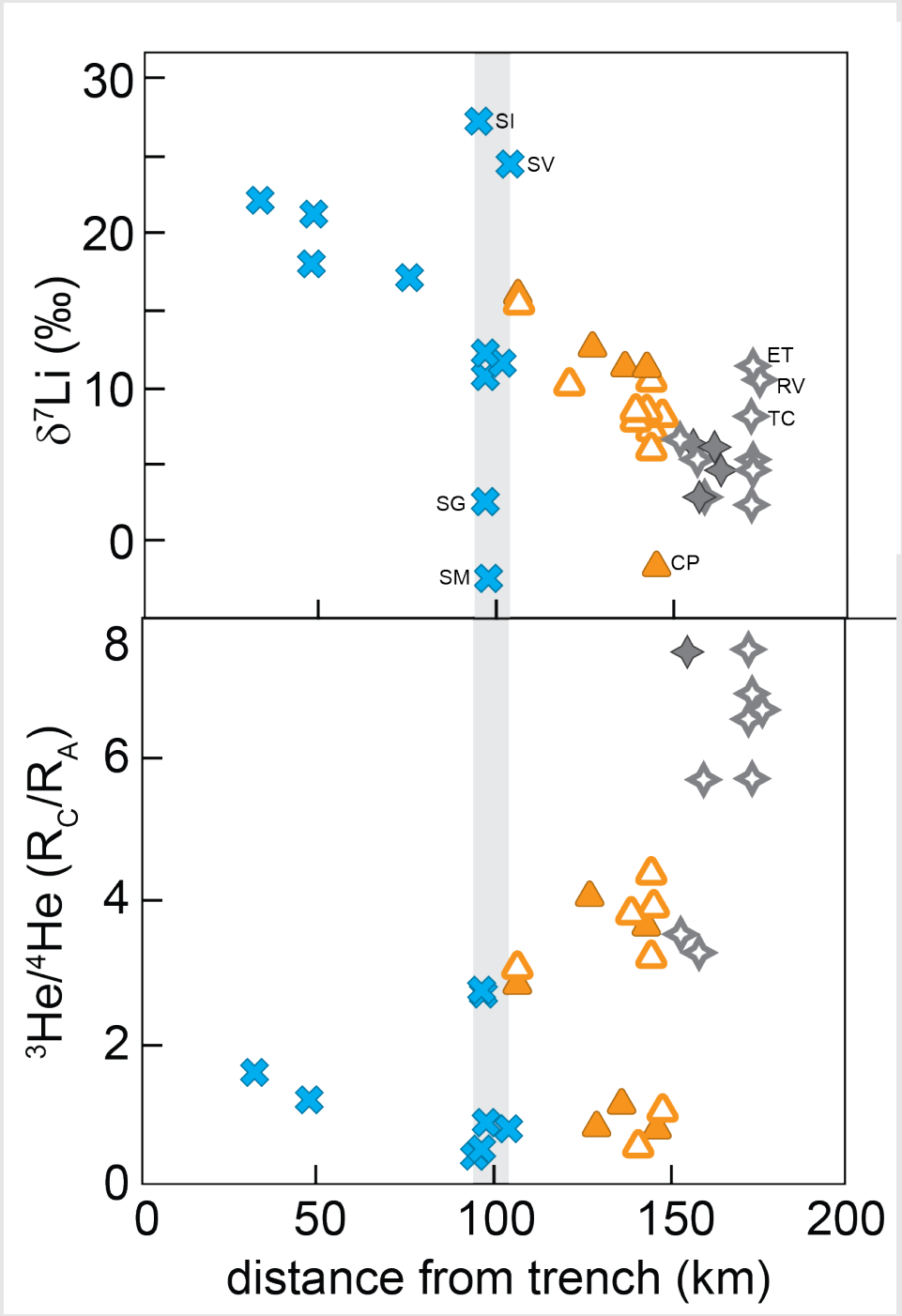
Helper et al. (2024)

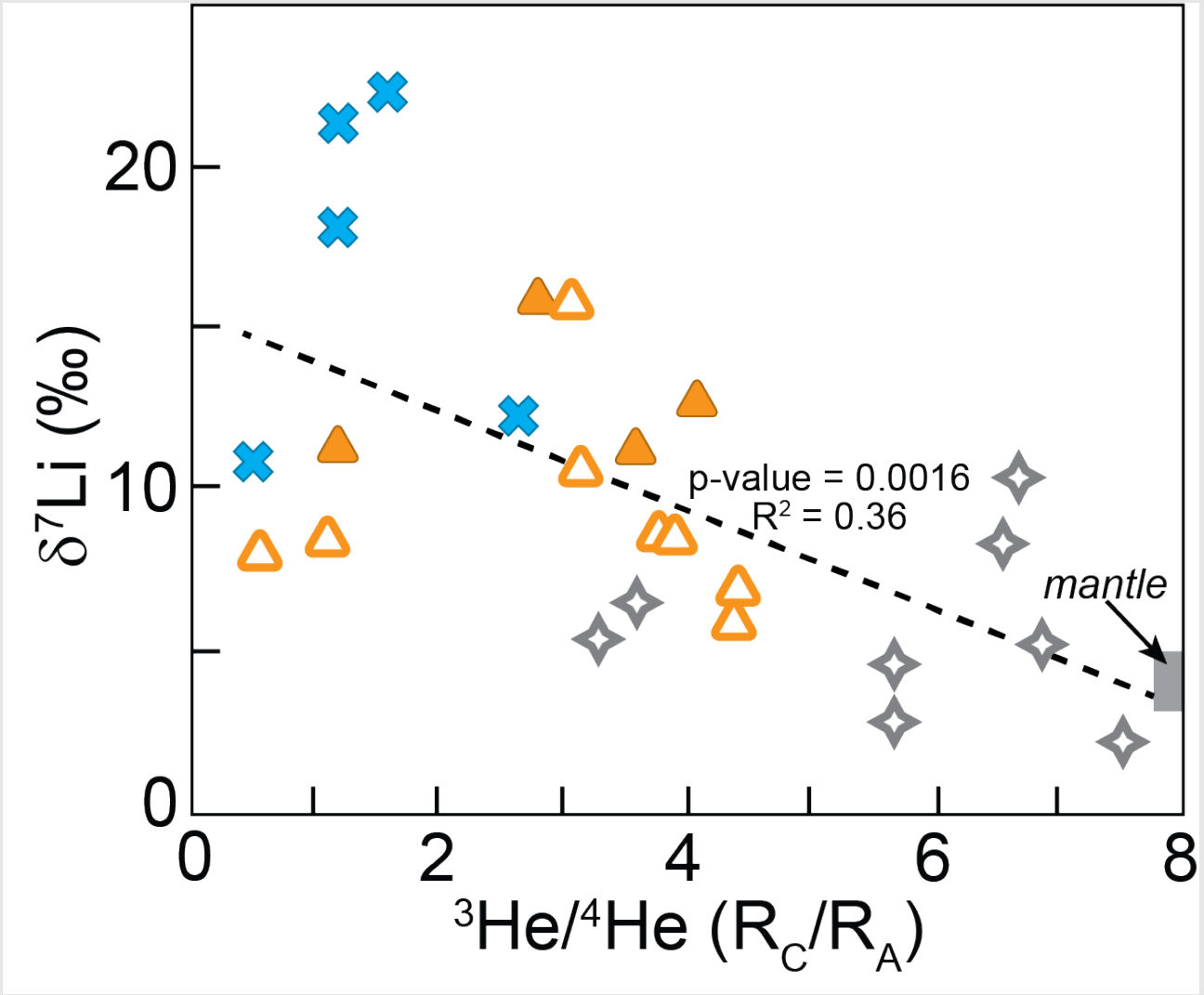
No correlation with water type, host lithology, and/or concentration

Source or Secondary Modification?



Helper et al. (2023, Geology)

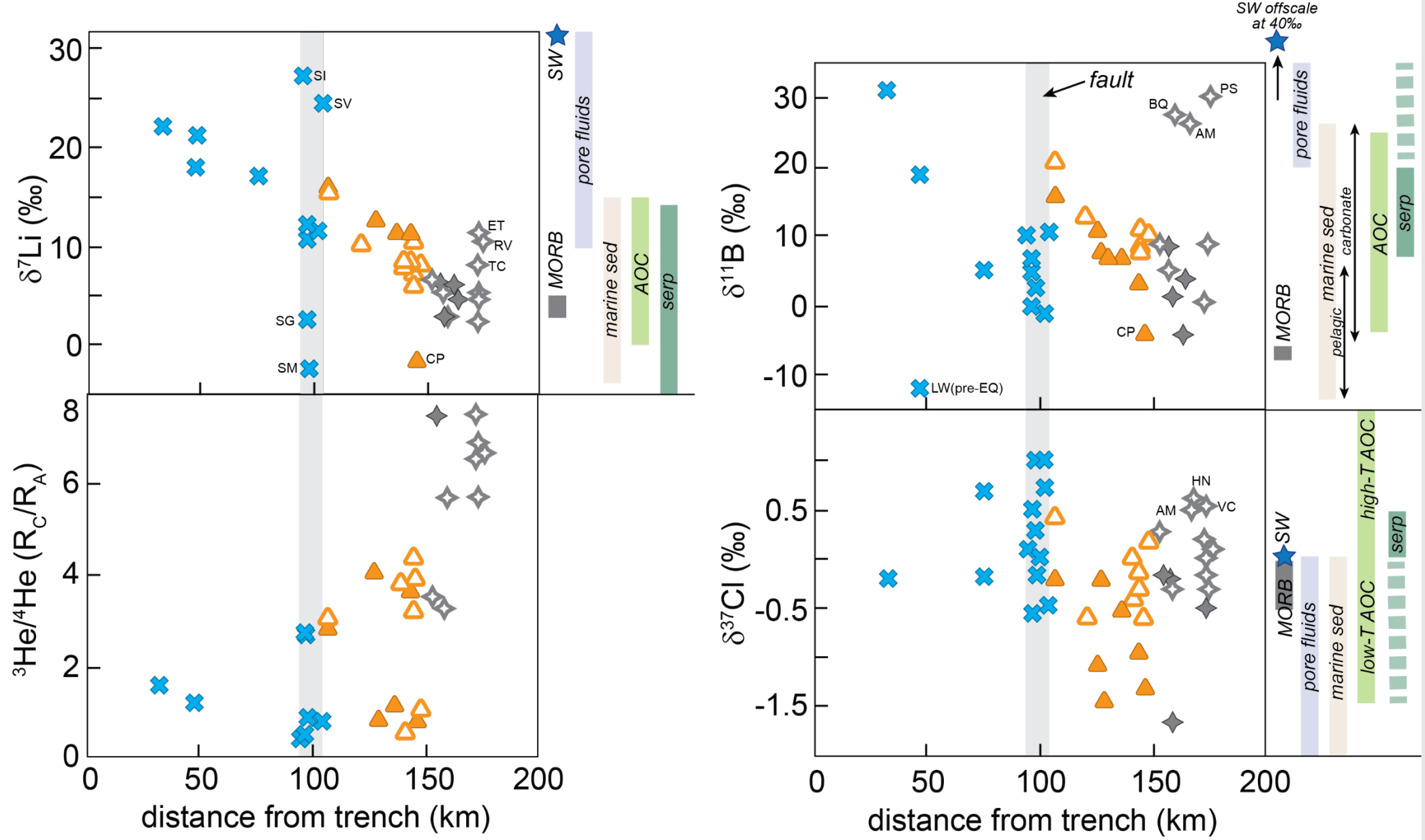




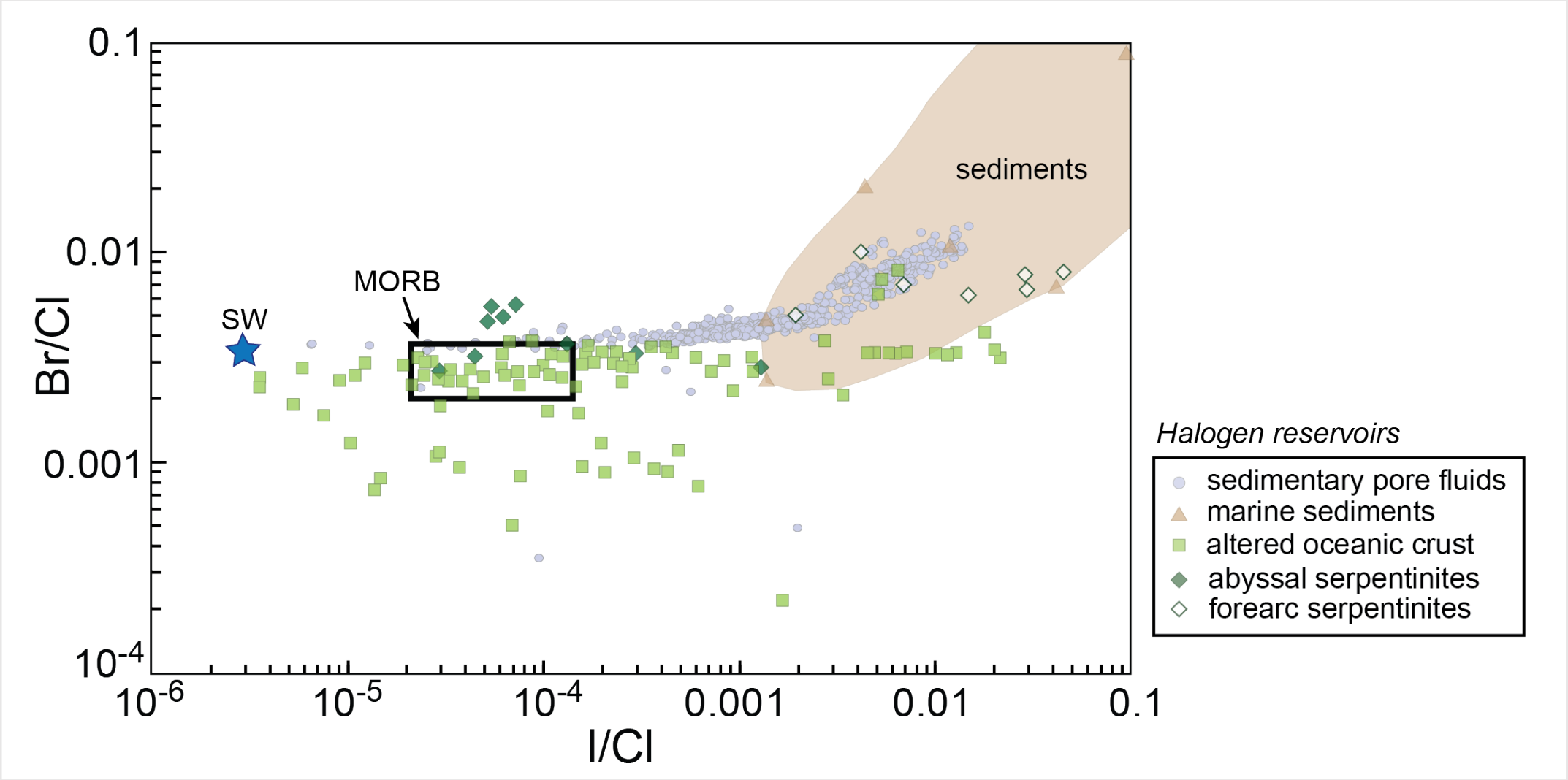
Slab derived → source!

Helper et al. (2023, Geology)

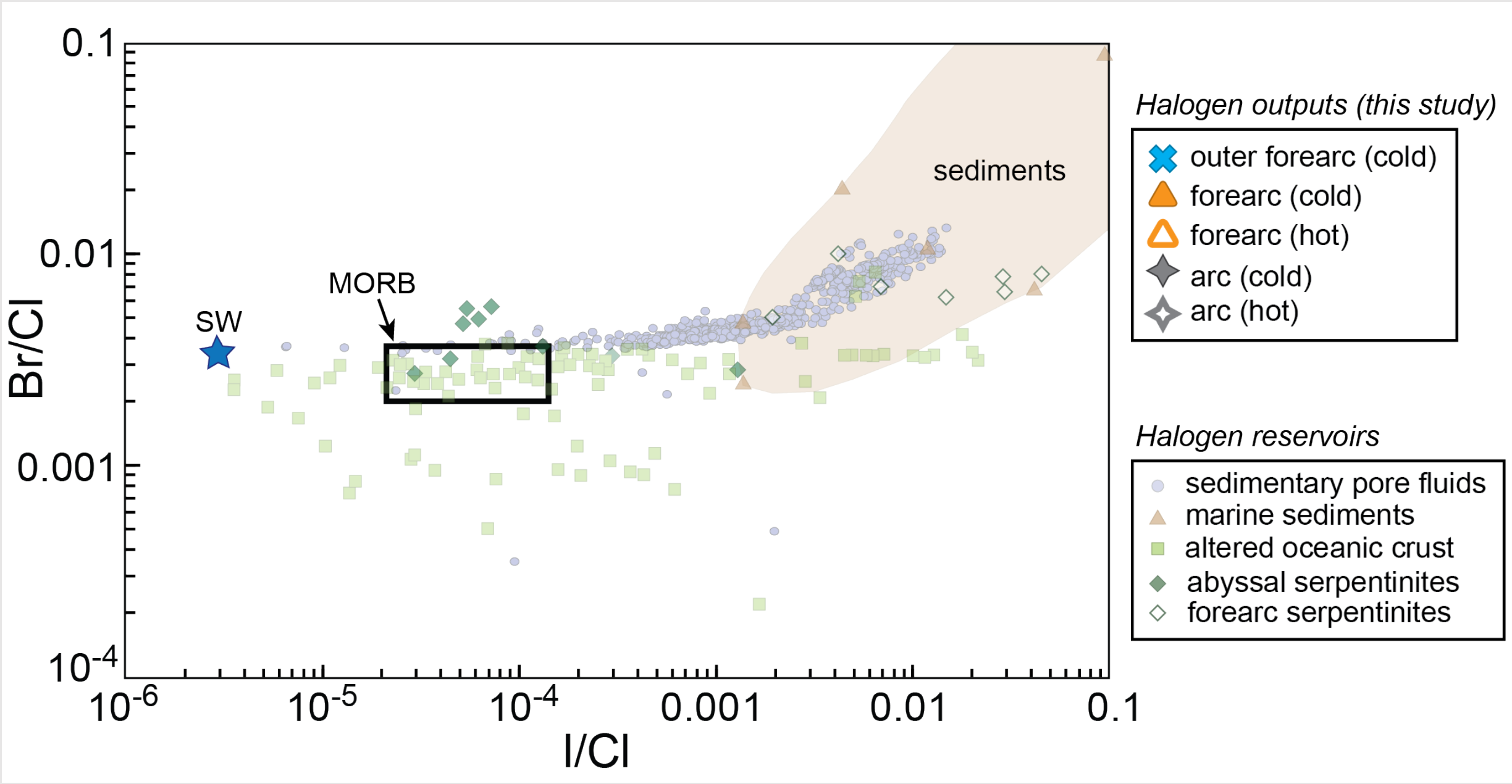
Source


δ7Li (‰)
SI
SV
ET
RV
TC
SG
SM
CP
SW
MORB
pore fluids
marine sed
AOC
serp
3He/4He (RC/RA)
distance from trench (km)
SW offscale at 40‰
fault
PS
BQ
AM
LW(pre-EQ)
δ11B (‰)
pelagic
carbonate
δ37Cl (‰)
HN
VC
high-T AOC
low-T AOC

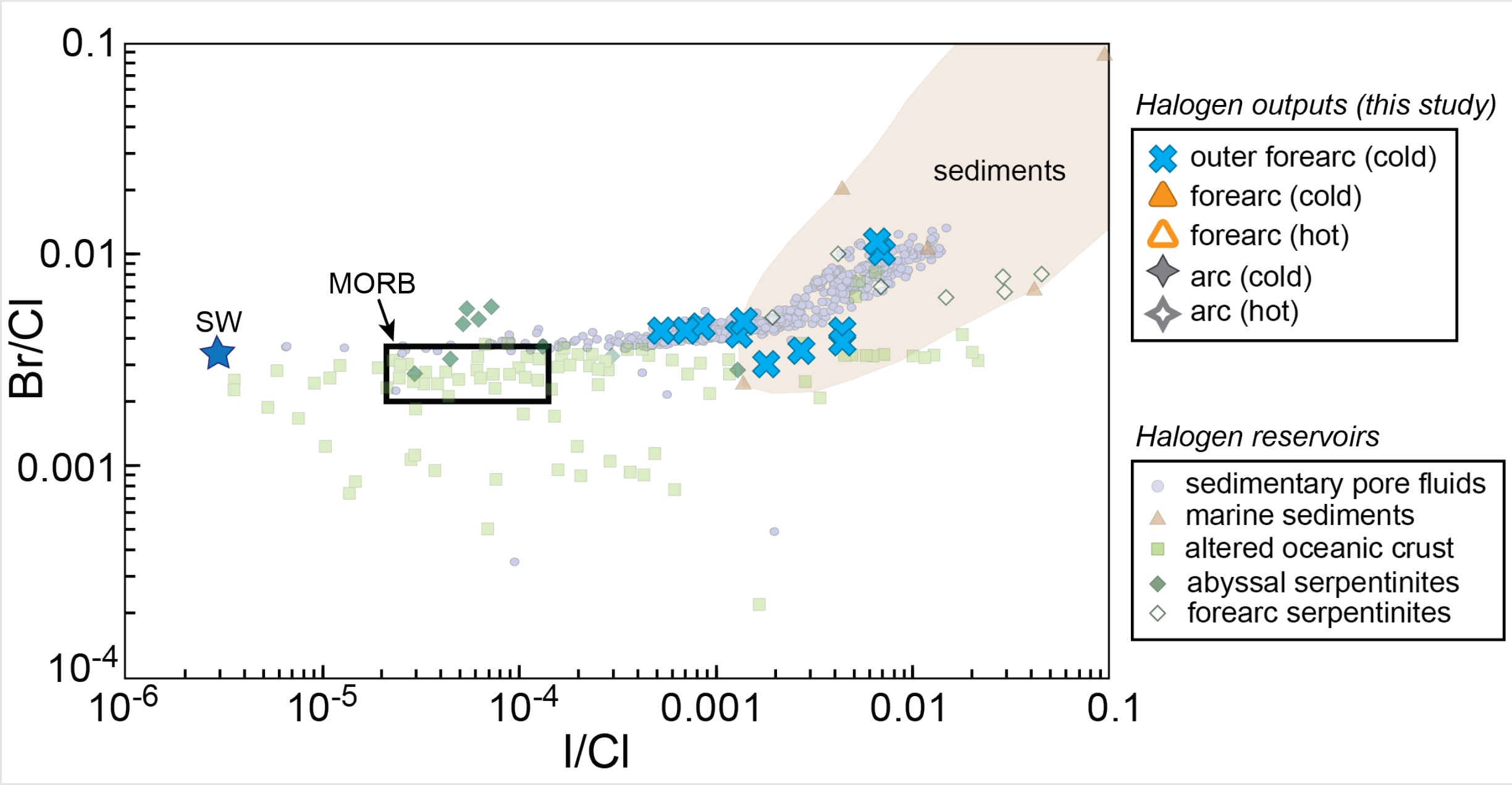
Halogen Inputs into Subduction Zones



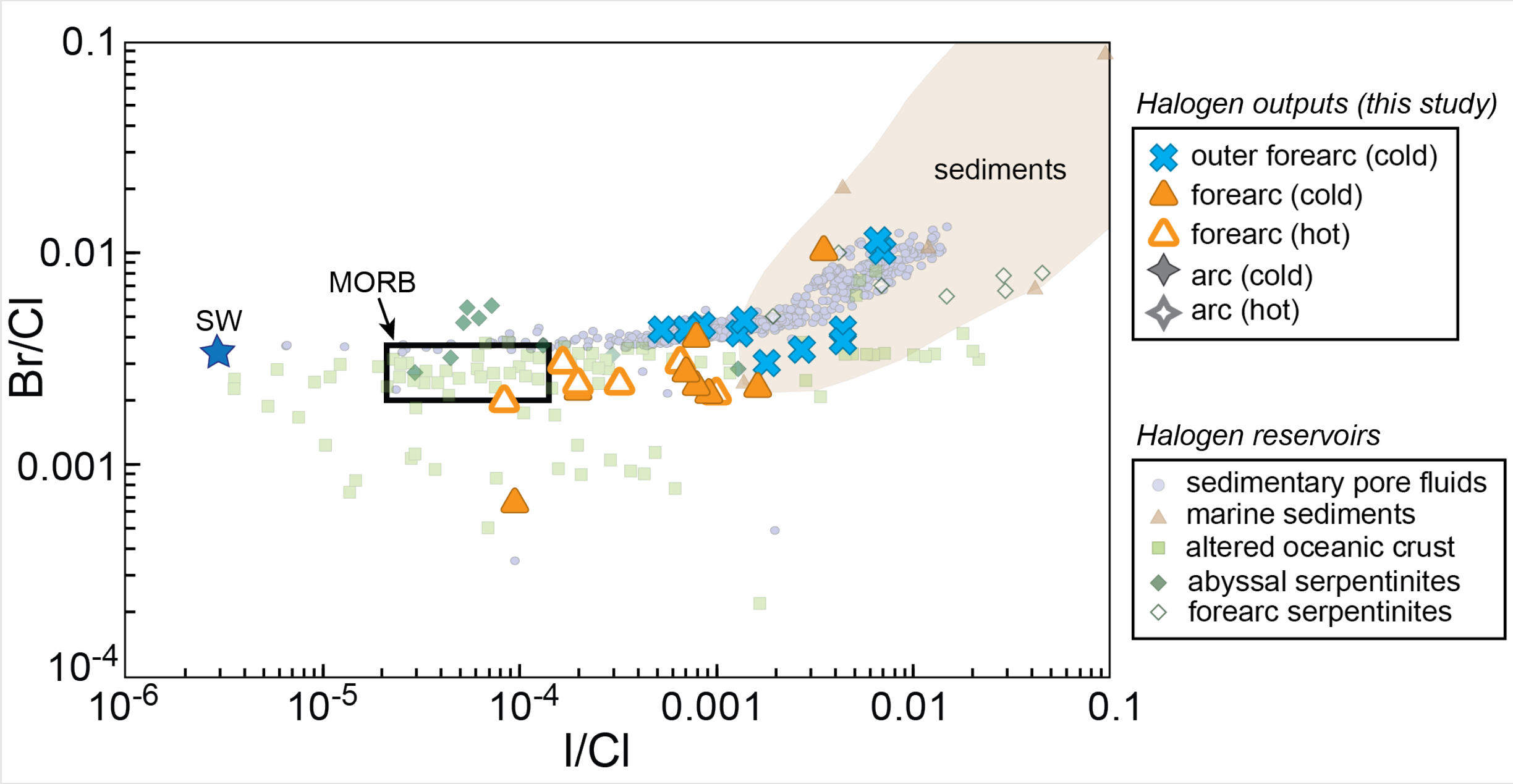
Data sources: SW (seawater; blue star) = Drever (1997); MORB (range outlined by black rectangle) = Kendrick et al. (2017); sedimentary pore fluids = Muramatsu et al. (2007), Fehn et al. (2006), Fehn et al. (2007), Gieskes et al. (2000), Mahn and Gieskes (2001); marine sediments = John et al. (2011); altered oceanic crust = Chavrit et al. (2016); Kendrick (2019b), Kendrick (2019a), Beaudoin et al. (2022); abyssal (seafloor) and forearc (mantle wedge) serpentinites = Kendrick et al. (2013).



Helper et al. (2024; GCA)



Helper et al. (2024; GCA)



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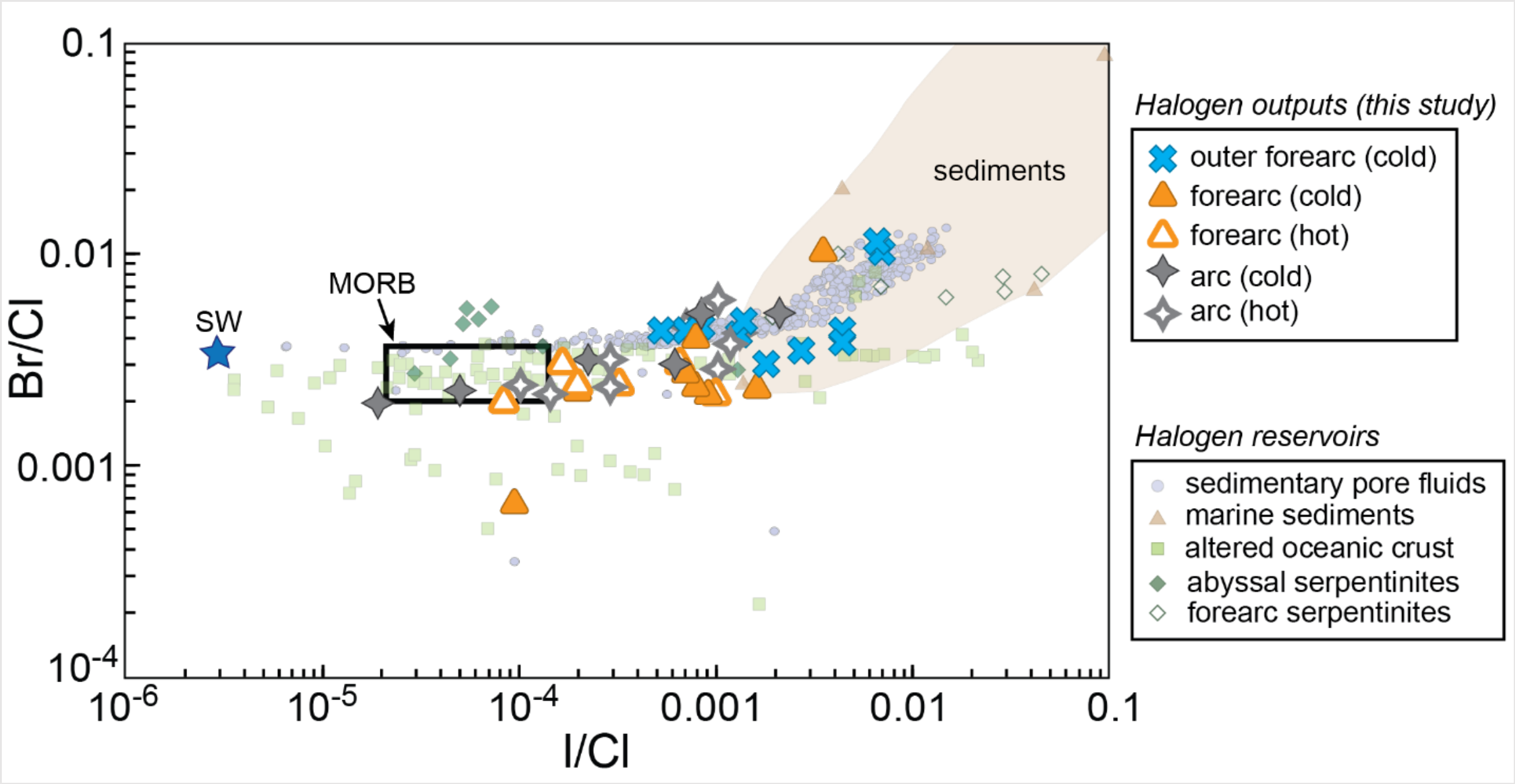
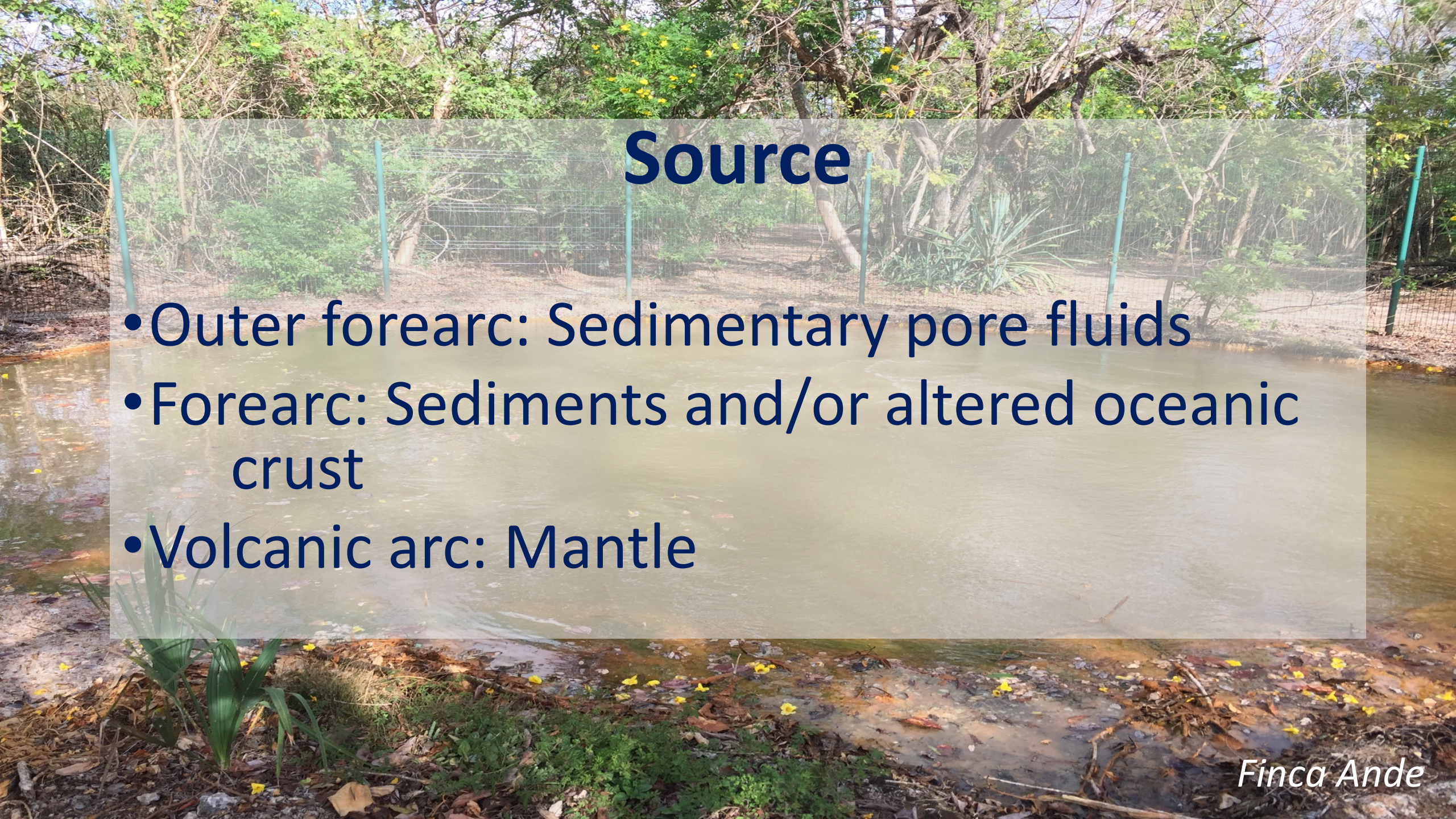


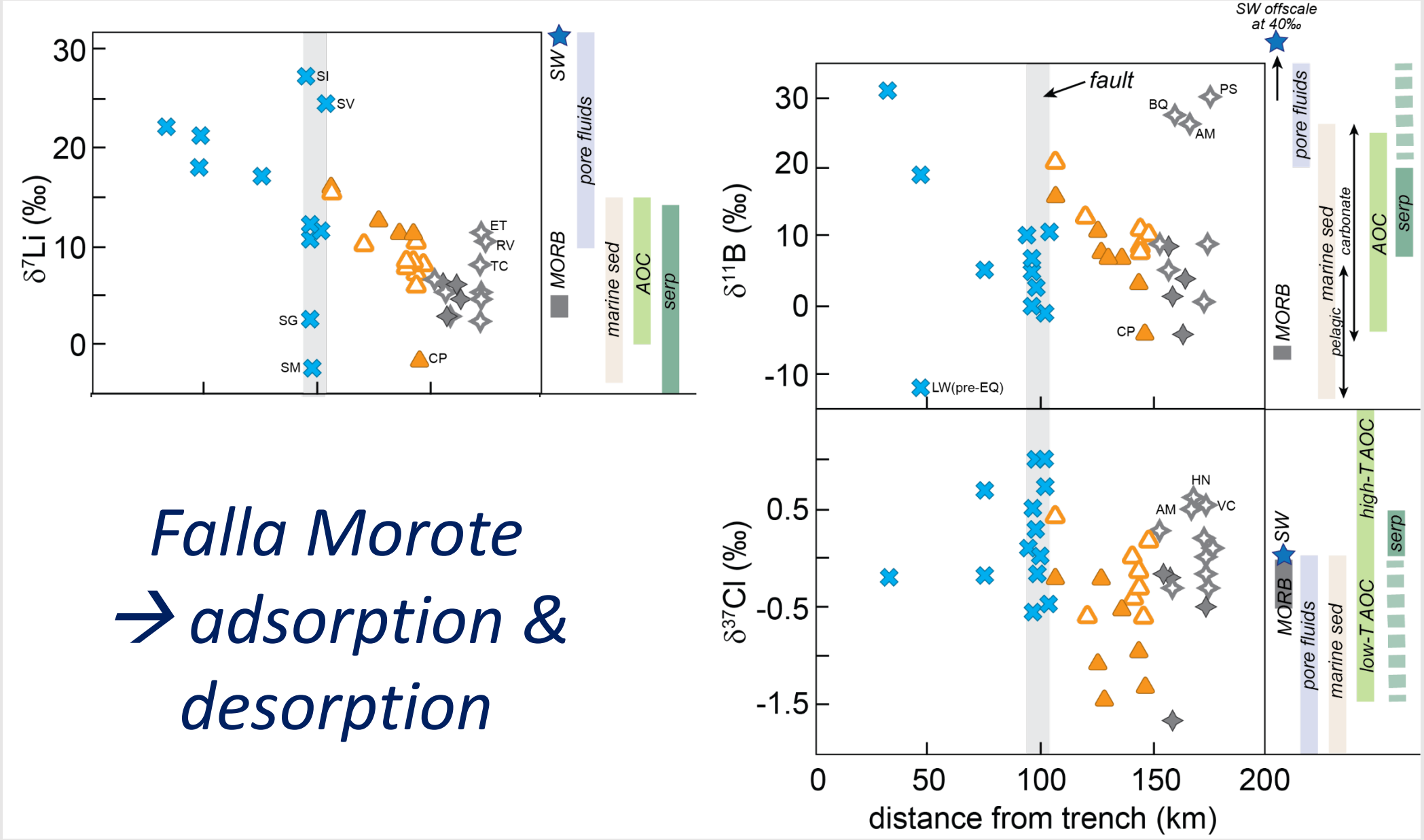
Helper et al. (2024; GCA)

Source

- Outer forearc: Sedimentary pore fluids
- Forearc: Sediments and/or altered oceanic crust
- Volcanic arc: Mantle



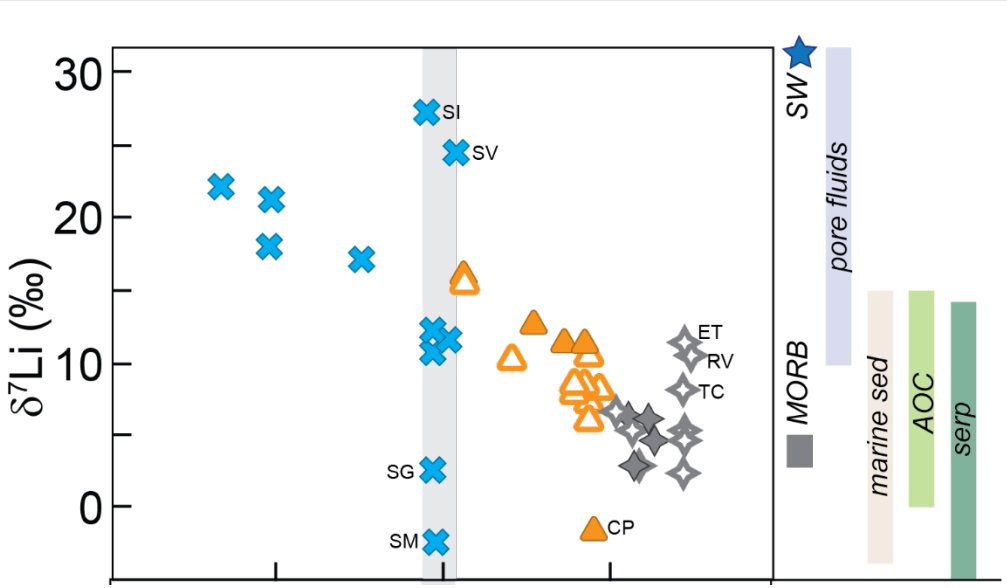
Secondary Modification



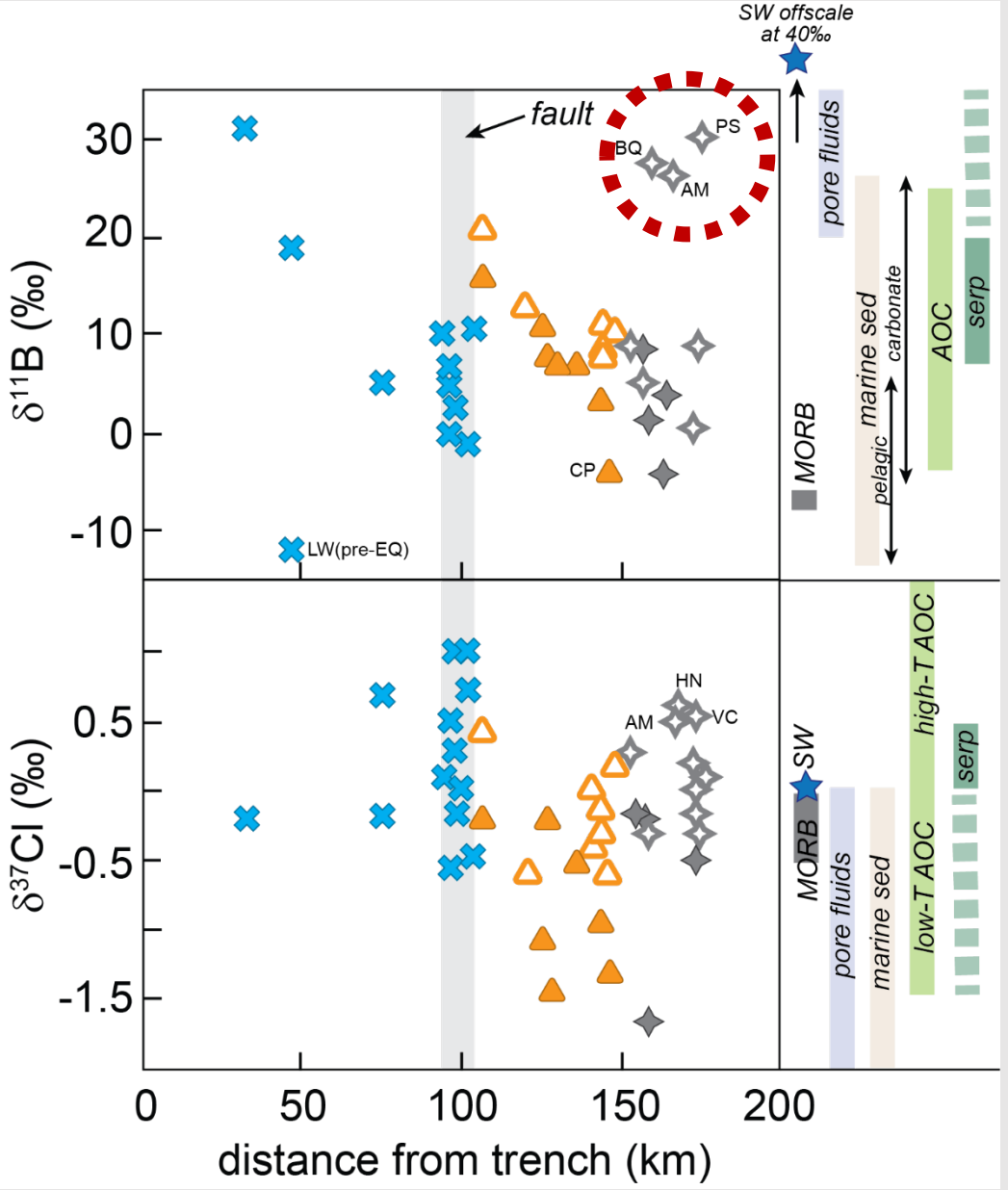
Falla Morote

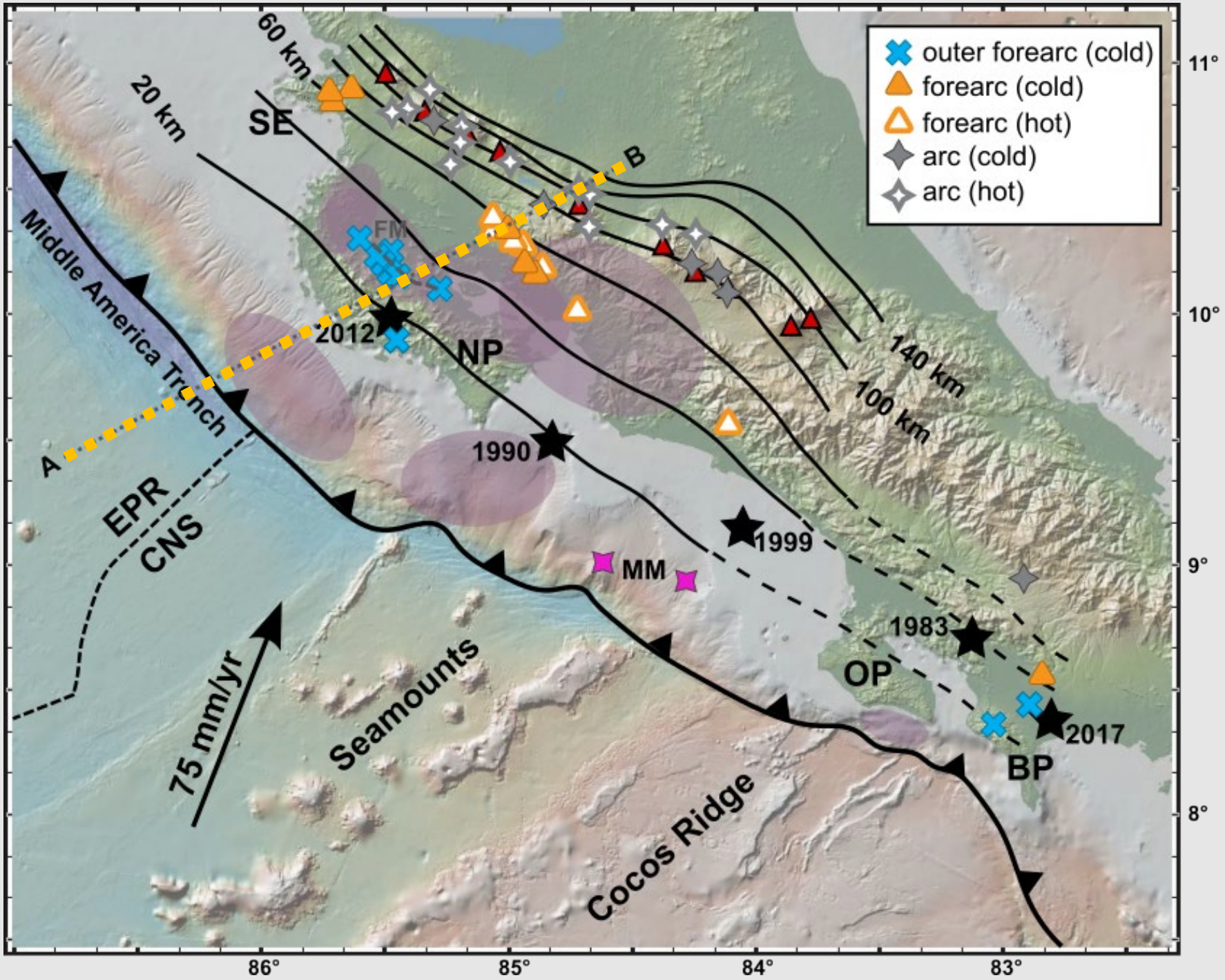
→ adsorption & desorption

Secondary Modification



Volcanic degassing → kinetic fractionation during phase separation




outer forearc (cold)
forearc (cold)
forearc (hot)
arc (cold)
arc (hot)
60 km
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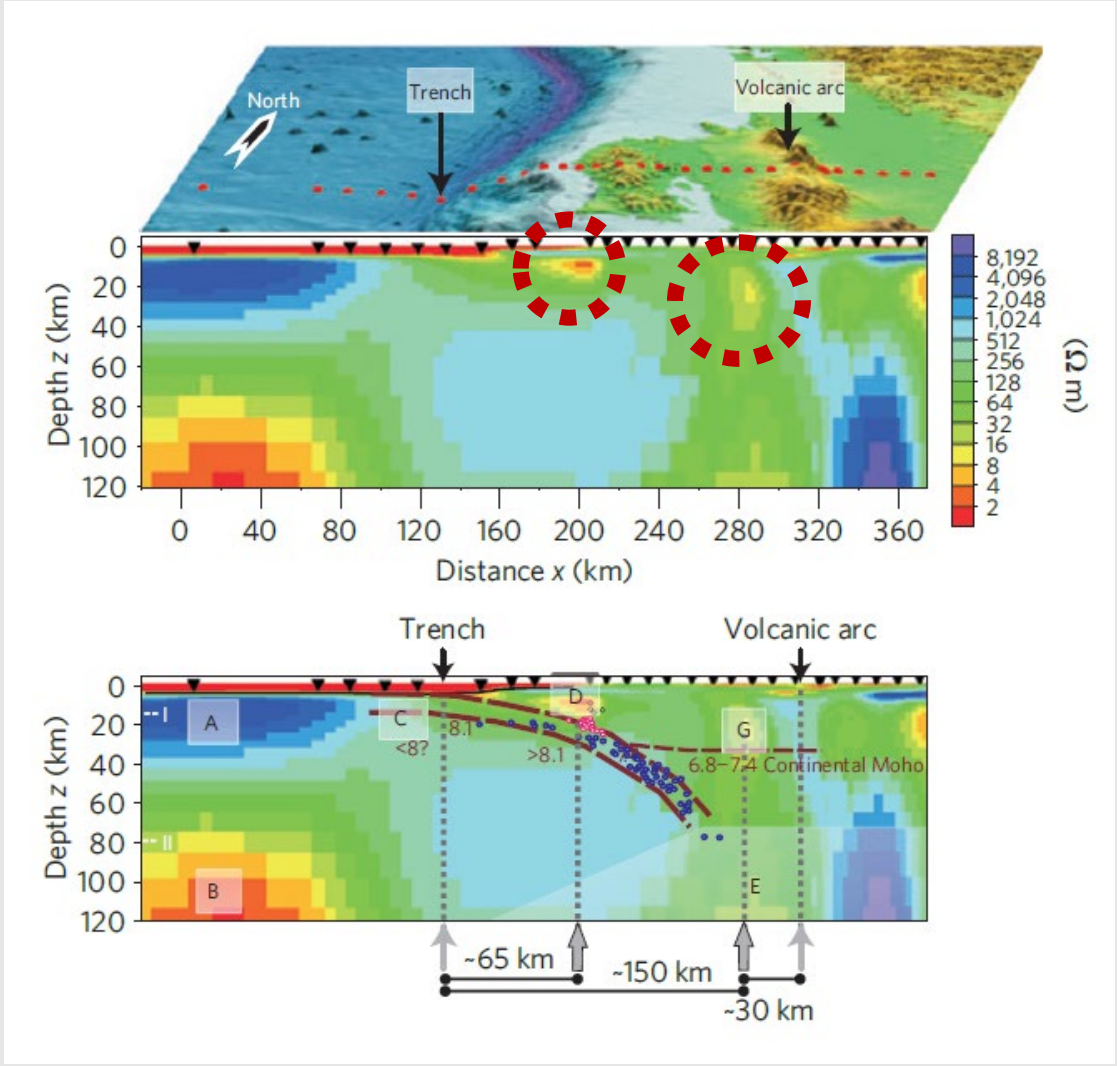
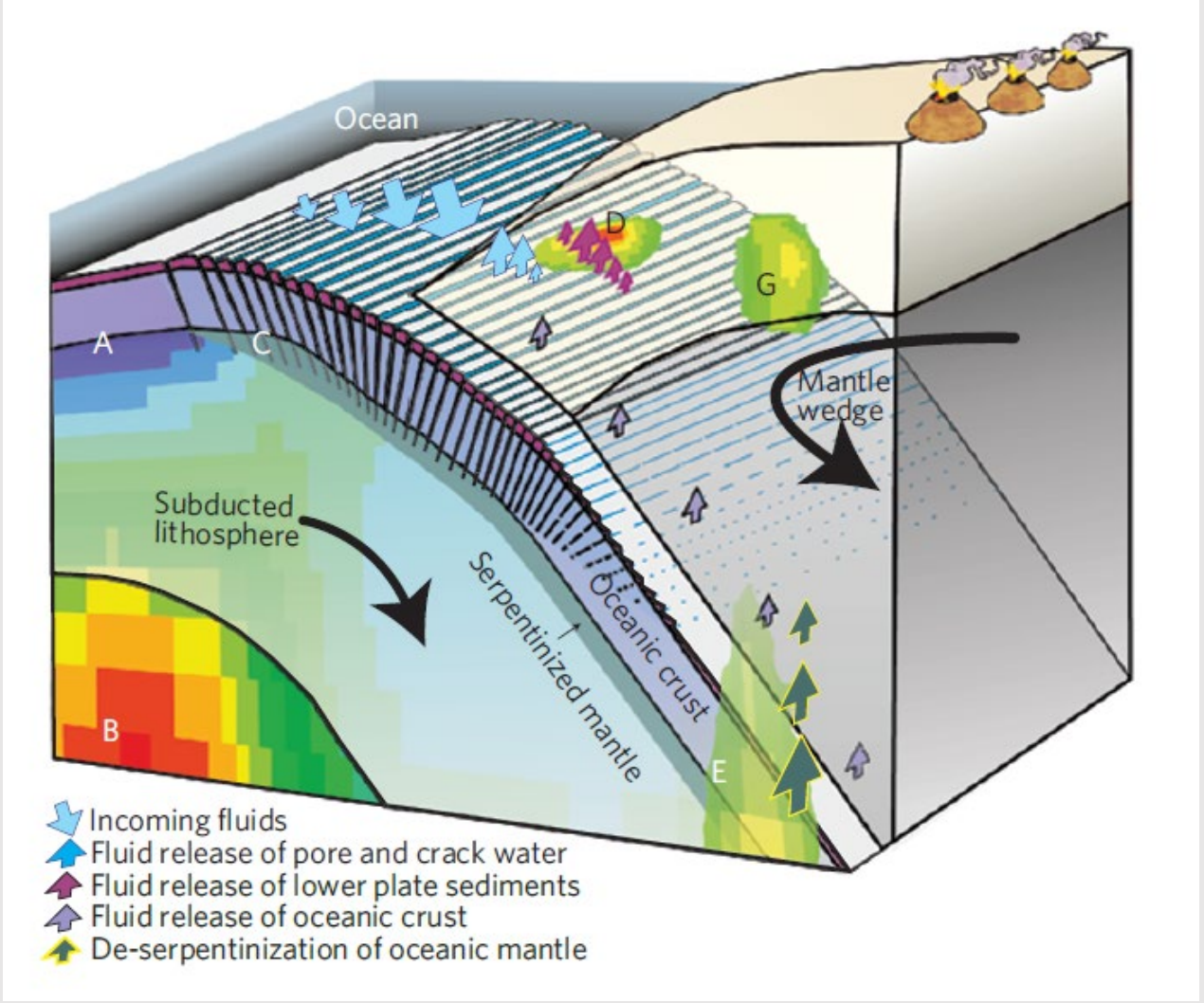
83°

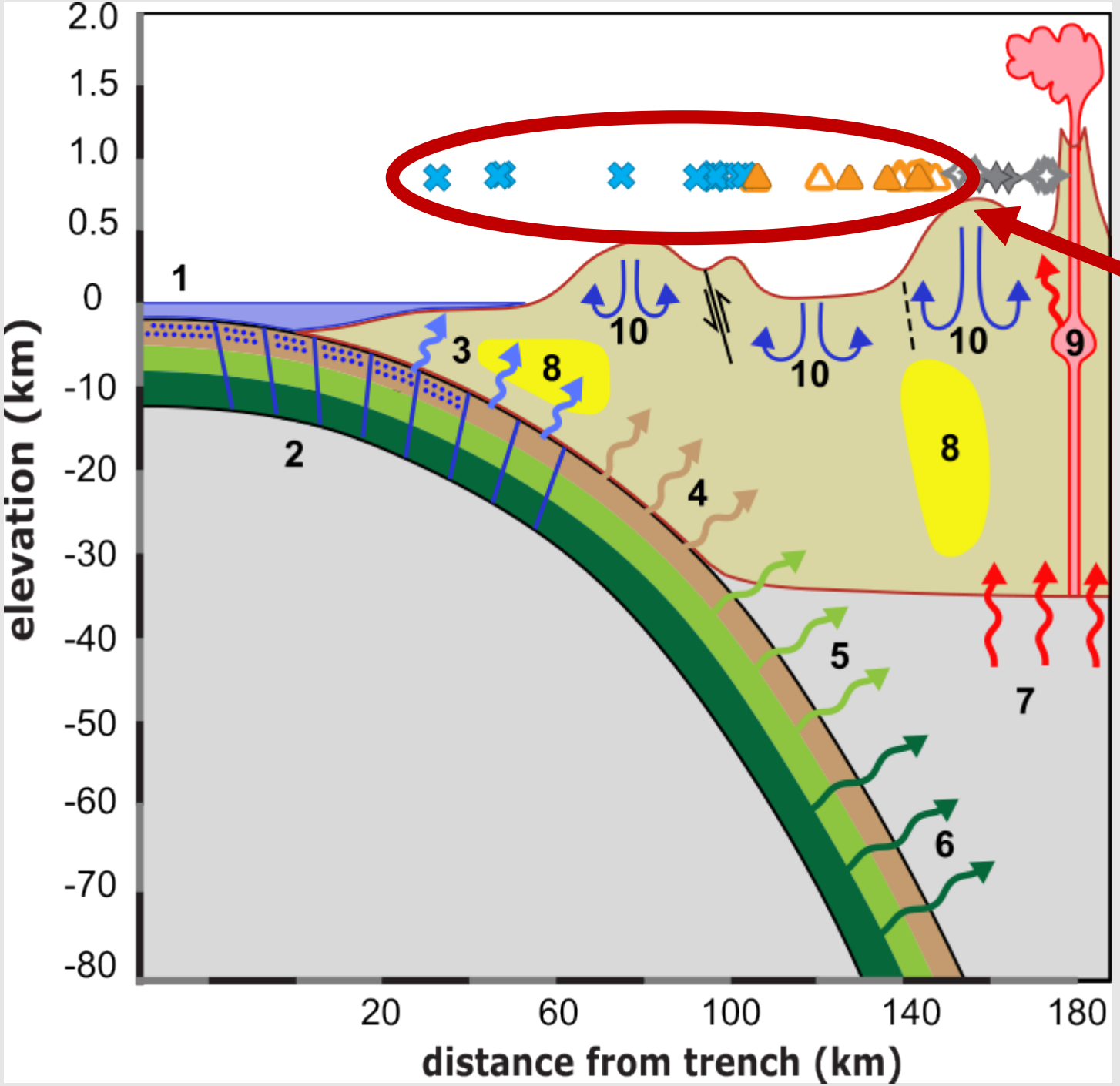
Magnetotelluric Imaging





low resistivity → high fluid content

Worzewski et al. (2011; NatGeo)

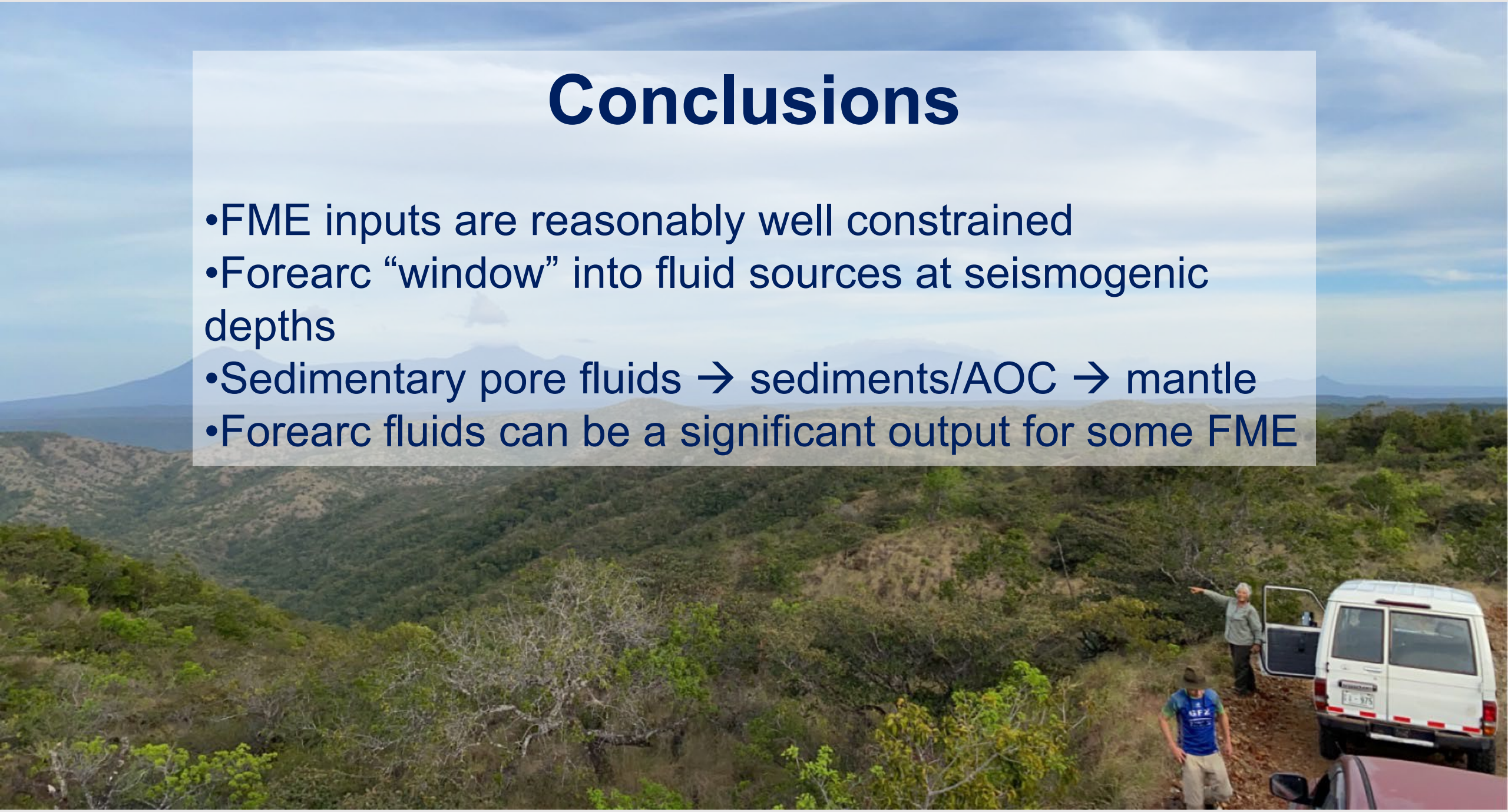


up to ~70% of Cl
~50% of Br, ~30% of B,
~15% of I
minimal Li
recycled through the
outer forearc and
forearc springs of the
Costa Rican margin

Helper et al. (2024)

Conclusions

- FME inputs are reasonably well constrained
- Forearc “window” into fluid sources at seismogenic depths
- Sedimentary pore fluids → sediments/AOC → mantle
- Forearc fluids can be a significant output for some FME



Questions?