

Supporting Information for ”A synoptic view of mantle plume shapes enabled by virtual reality”

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Introduction In Text S1, we describe how we construct the reference $d \ln V_S/dT$ profile along depth in more details. In Text S2, we provides more examples of how to trace conduit of plumes that have multiple possible candidate conduits or the traced conduits do not strictly follow our criteria. We also provide more cross sections of plumes that we traced in this study (Figure S2-6) and a table of the locations, buoyancy flux, and information about whether the traced conduits agree with the modeled conduits of all traced plumes.

Text S1. $d \ln V_S/dT$ profile

The $d \ln V_S/dT$ profile (Figure S1) beneath 800 km is calculated in Burnman (Cottaar et al., 2014; Myhill et al., 2021) assuming the phases at these depths are 82% perovskite $[(Mg_{0.9}Fe_{0.1})SiO_3]$ and 18% ferropericlase $[(Mg_{0.8}Fe_{0.2})O]$. The profile above 800 km

depth is adapted from Cammarano, Goes, Vacher, and Giardini (2003). Although the mantle composition used in Burnman are not in mass conversation with the mantle composition used in Cammarano et al. (2003), it is a reasonable composition of a pyrolitic lower mantle. We believe that the $d \ln V_S/dT$ profile we calculate is accurate enough for our purpose of use.

Text S2. Procedures to trace plume conduits with ambiguity.

Here, we provide some examples of how we decide the traced conduit of a plume over multiple candidate traced conduits of a plume. For example, the traced conduits of Galapagos from SEMUCB-WM1 and GLAD-M25 almost do not have any overlaps but we find that CCs resolved in the two models have overlaps (Figure S4a-b). We traced the most straightforward conduit path below 660 km for Galapagos that connects the CC resolved above 660 km depth in SEMUCB-WM1 (box in Figure S4a) to the CC right beneath this anomaly. If we decide that the upper-mantle CC is connected to the lower-mantle CC resolved in both tomographic models, the conduit traced from SEMUCB-WM1 will have much more overlaps with the conduit traced from GLAD-M25. Similarly for Easter, strongly sheared CC is observed between 660 and ~ 2000 km depth (Figure 9d). The CC resolved in GLAD-M25 below ~ 2000 km favors a conduit sheared towards the northeast, while the CC resolved in SEMUCB-WM1 could be interpreted as either vertical or sheared conduit.

The Tristan plume is thought to form the Tristan-Gough hotspot track and the Parana-Etendeka flood basalts (Richards et al., 1989). The isotopic observations of basalt from the Tristan-Gough hotspot track suggest that they are EM1 and HIMU types, which

usually indicates a mantle plume origin. Because of these observations, we include the conduit of Tristan, although a continuous conduit is only clearly resolved in SEMUCB-WM1 but not in GLAD-M25 (Figure S6). The conduit of Tristan is resolved only below 660 km depth in GLAD-M25. For plume Azores, the CC with large-amplitude negative δV_S between 660 and 1250 km depth in SEMUCB-WM1 makes us decide the conduit to pass through this region while this CSS is not significant in GLAD-M25 (Figure S3c).

References

- Cammarano, F., Goes, S., Vacher, P., & Giardini, D. (2003, August). Inferring upper-mantle temperatures from seismic velocities. *Physics of the Earth and Planetary Interiors*, *138*(3), 197–222. doi: 10.1016/S0031-9201(03)00156-0
- Cottaar, S., Heister, T., Rose, I., & Unterborn, C. (2014). BurnMan: A lower mantle mineral physics toolkit. *Geochemistry, Geophysics, Geosystems*, *15*(4), 1164–1179. doi: 10.1002/2013GC005122
- Myhill, R., Cottaar, S., Heister, T., Rose, I., & Unterborn, C. (2021, October). *BurnMan v1.0.1*. Zenodo. doi: 10.5281/zenodo.5552756
- Richards, M. A., Duncan, R. A., & Courtillot, V. E. (1989, October). Flood Basalts and Hot-Spot Tracks: Plume Heads and Tails. *Science*, *246*(4926), 103–107. doi: 10.1126/science.246.4926.103

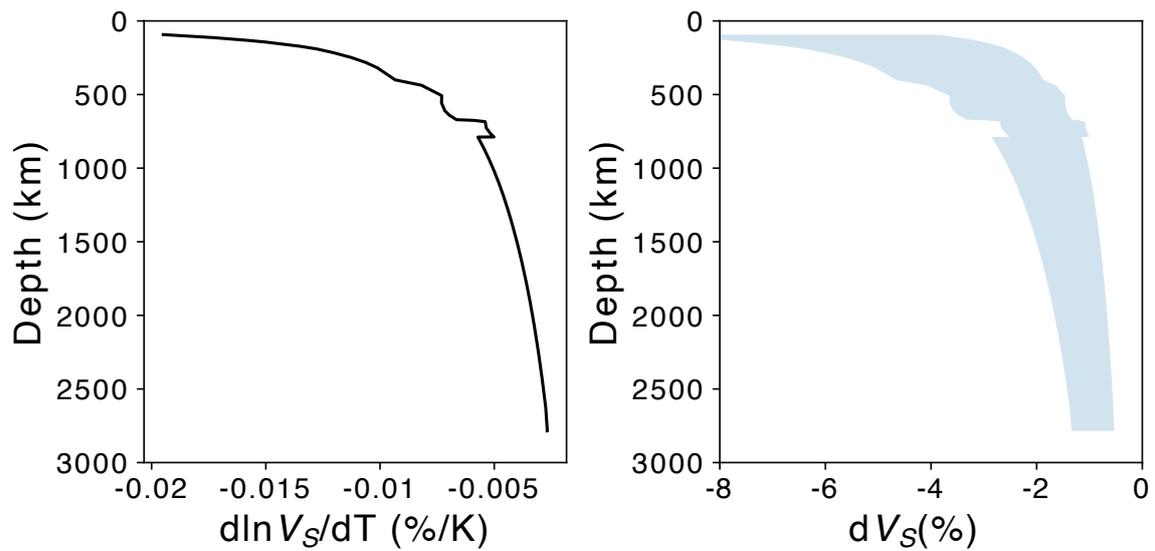


Figure S1. Sensitivity of shear velocity anomaly (left) and the reference δV_S (right) with a bulk composition of pyrolite. The reference δV_S profile (the blue shaded region) is calculated from the $\delta \ln V_S / dT$ profile assuming a purely thermal plume with excessive temperatures between 200 and 500 K along depths.

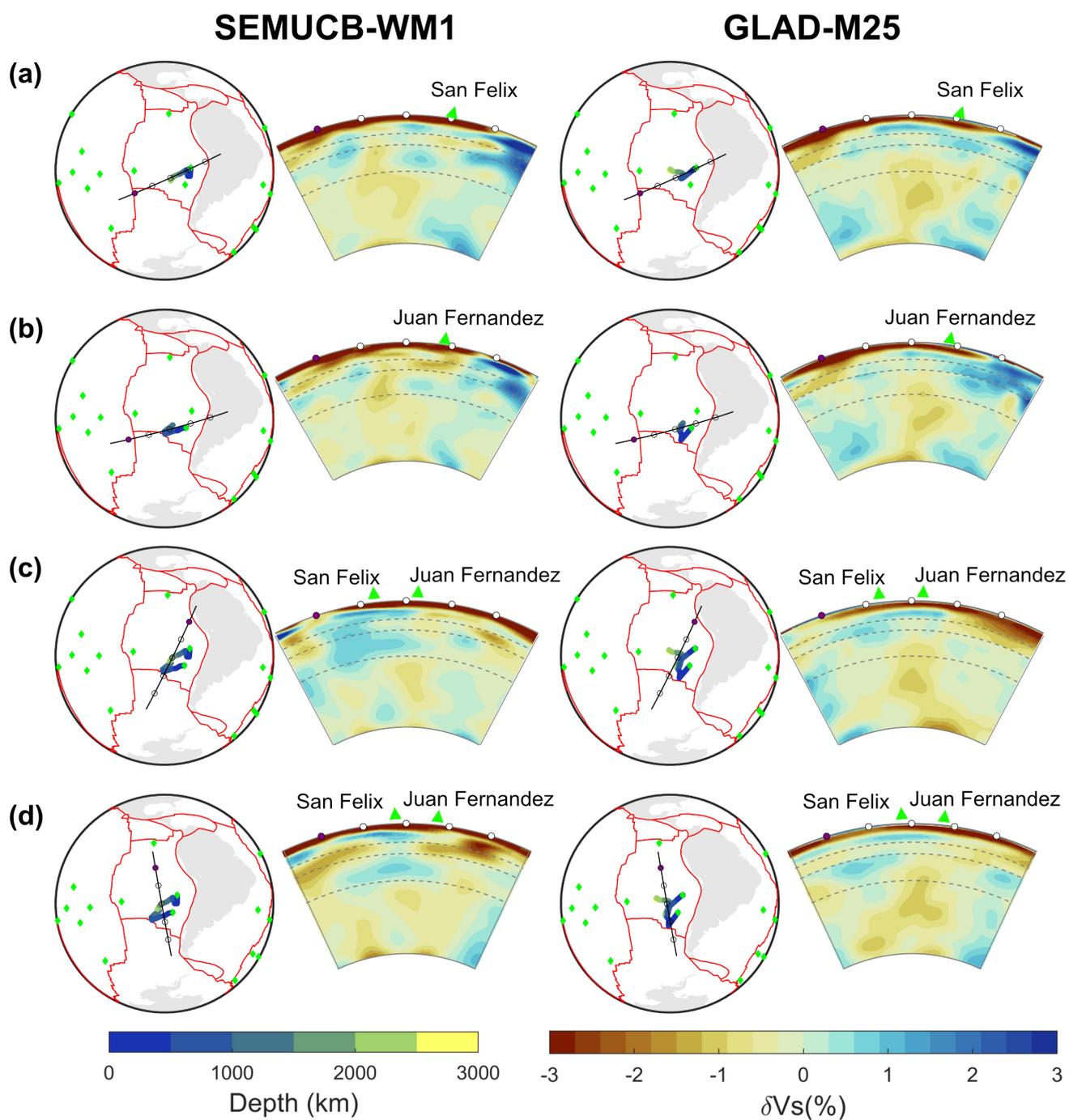


Figure S2. Cross section and map view of the traced conduits of San Felix and Juan Fernandez similar to Figure 8.

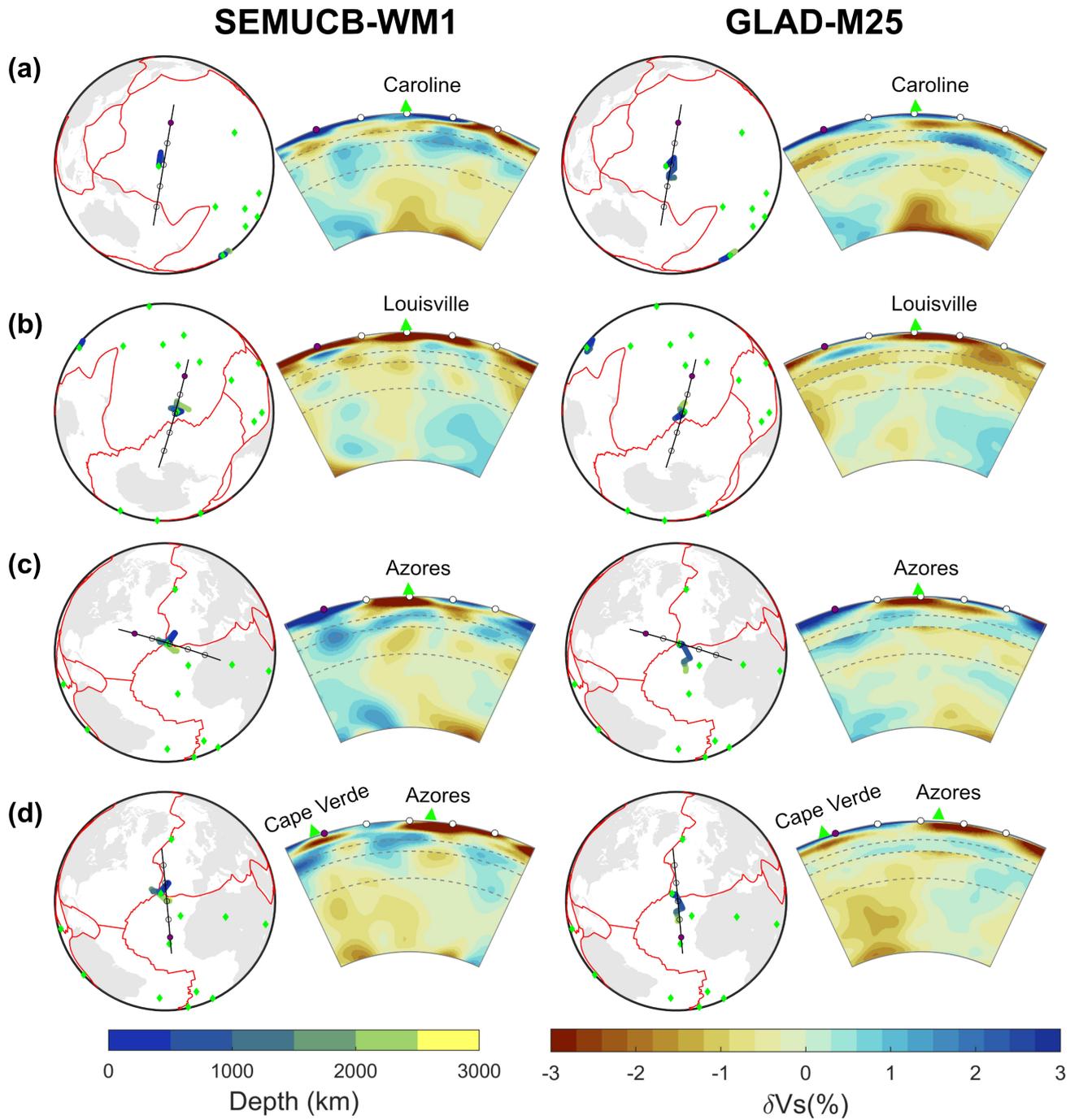


Figure S3. Cross section and map view of the traced conduits of a) Caroline, b) Louisville, and c,d) Azores similar to Figure 8.

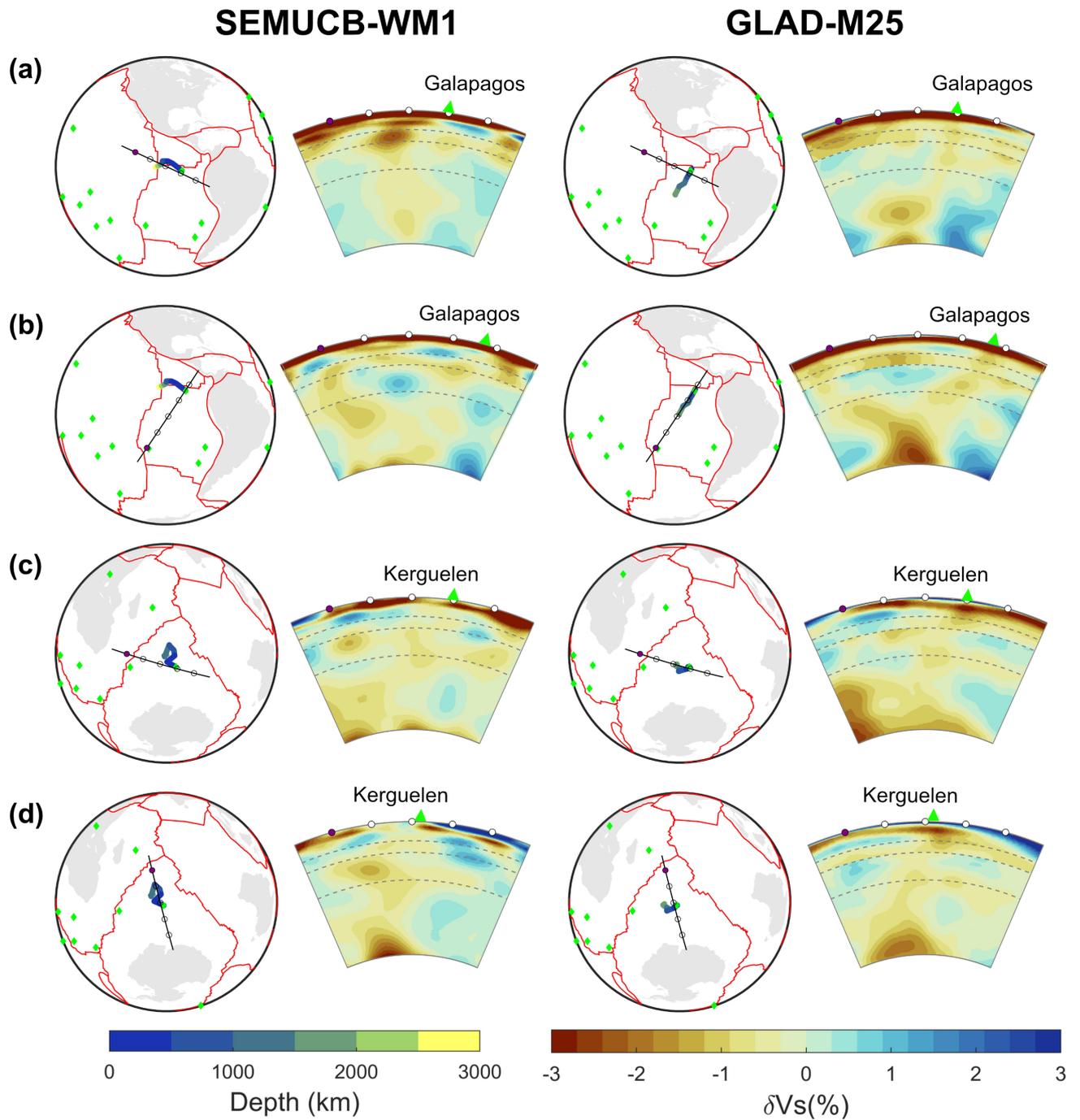


Figure S4. Cross section and map view of the traced conduits of a,b) Galapagos and c,d) Kerguelen similar to Figure 8.

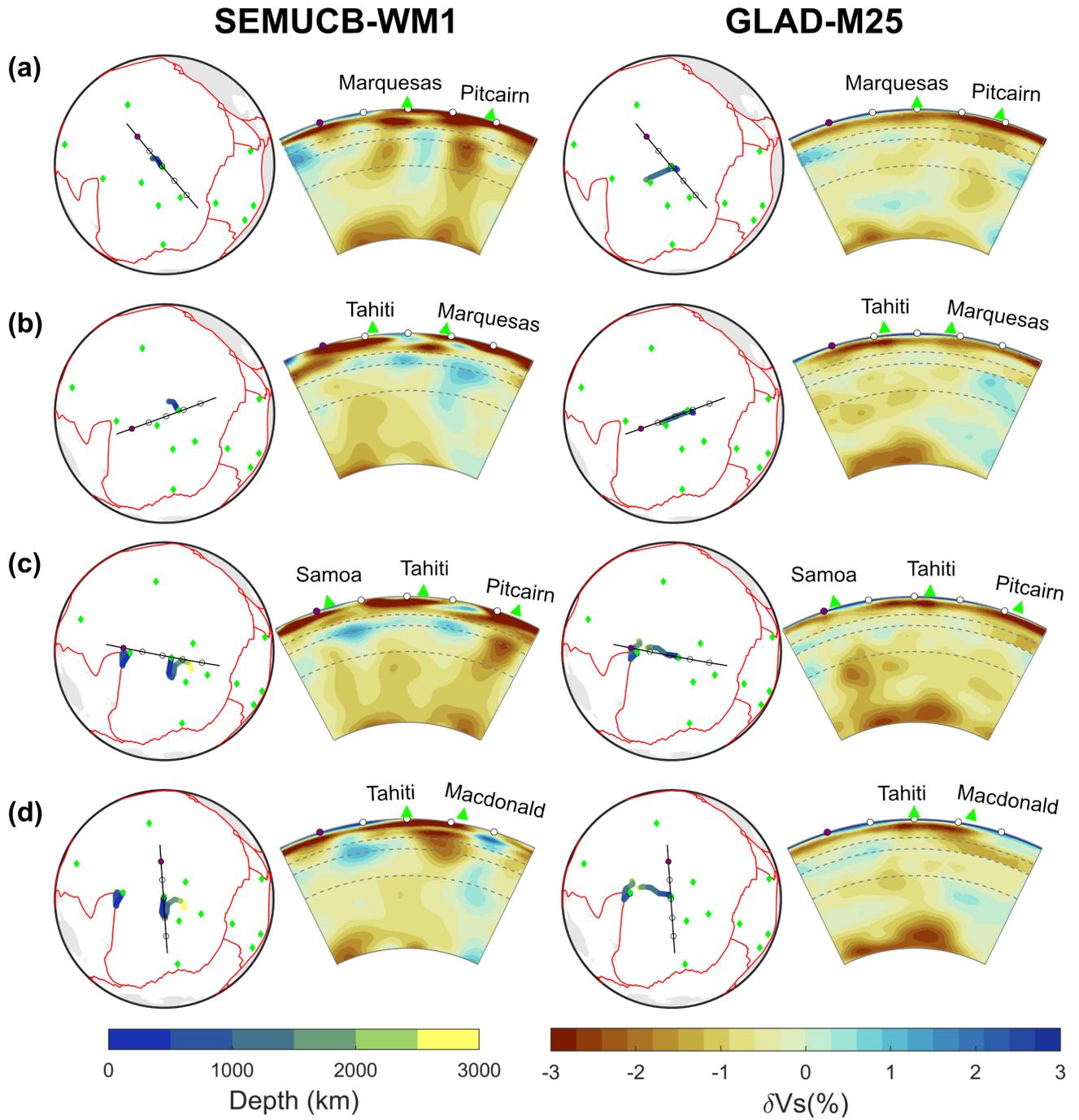


Figure S5. Cross section and map view of the traced conduits of a,b) Marquesas and c,d) Tahiti similar to Figure 8.

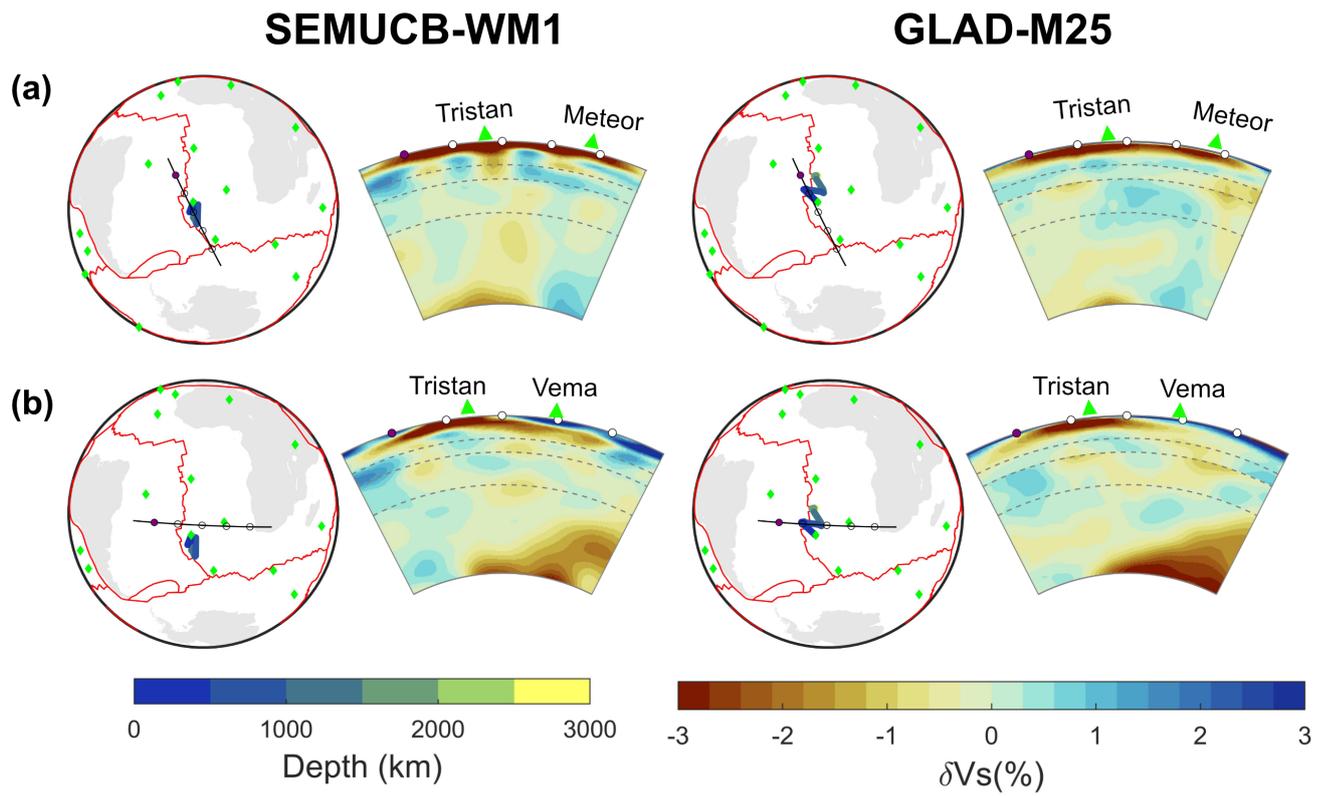


Figure S6. Cross section and map view of the traced conduits of Tristan similar to Figure 8.

Table S1. List of plumes traced in this study. The buoyancy flux is obtained from Jackson et al. (2021), the hot spot locations are obtained from Steinberger (2000), and the excess temperature is the petrological estimated excess temperature obtained from Putirka (2008).

Plume	Lat	Lon	Buoyancy Flux (10^3kg s^{-1})	$T_{ex}(K)$	Agree with MC?	
					SEMUCB	GLAD
Azores	38.5°	-28.4°	1.1	124	No	No
Canary	28.0°	-18.0°	0.8	164	Yes	Yes
Cape Verde	15.0°	-24.0°	1.1	114	Maybe	Maybe
Caroline	5.0°	164.0°	1.2	150	No	No
Easter	-27.1°	-109.3°	1.6	N/A	No	No
Galapagos	-0.4°	-91.5°	1.4	130	No	No
Hawaii	19.4°	-155.3°	6.3	290	No	Yes
Iceland	65.0°	-19.0°	5.5	186	Maybe	Maybe
Juan Fernandez	-34.0°	-82.0°	1.7	185	Yes	Yes
Kerguelen	-49.0°	69.0°	1.1	209	Maybe	Yes
Louisville	-51.0°	-138.0°	1.5	200	No	No
Macdonald	-29.0°	-140.2°	3.3	N/A	No	No
Marquesas	-11.0°	-138.0°	3.1	167	Maybe	No
Pitcairn	-25.0°	-129.0°	2.1	189	No	No
Reunion	-21.2°	55.7°	1.4	176	Yes	Yes
Samoa	-15.0°	-168.0°	1.7	223	No	No
San Felix	-26.0°	-80.0°	2.0	N/A	Yes	Yes
St Helena	-17.0°	-10.0°	0.5	164	Yes	Yes
Tahiti	-17.9°	-148.1°	3.7	185	No	No
Tristan	-38.0°	-11.0°	1.0	176	No	No