# A heterogeneous recycled oceanic lithosphere in the Azores plume revealed by the Hf-Nd isotope systematics of Terceira Rift lavas

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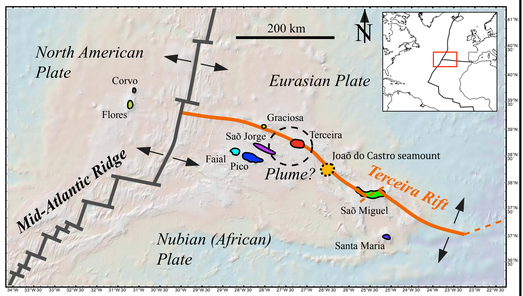
## Summary

- We present Hf-isotope data on lavas from the Azores island chain.
- The Joaõ do Castro seamount and the island of Saõ Miguel display two arrays below the mantle array in Nd-Hf space. This duplicity of steep arrays is an unprecedented feature in OIBs. Joaõ do Castro data overlaps Mangaia (HIMU) in Nd-Hf, but has unradiogenic Pb values.
- Aged pyroxenites seem a suitable lithological end-member to explain the isotopic compositions of both Saõ Miguel and Joaõ do Castro.
- Pb modeling does not exclude a unique geochemically heterogeneous source for the two end-members, but Nd-Hf data clearly shows that they do not mix together.

## Aims

- Unravel the full spectrum of isotopic heterogeneity in Azores lavas.
- Characterize the source of Saõ Miguel and Joaõ do Castro.
- Explore how isotopic end-members are spatially located and how they mix prior to eruption.

## Geological setting



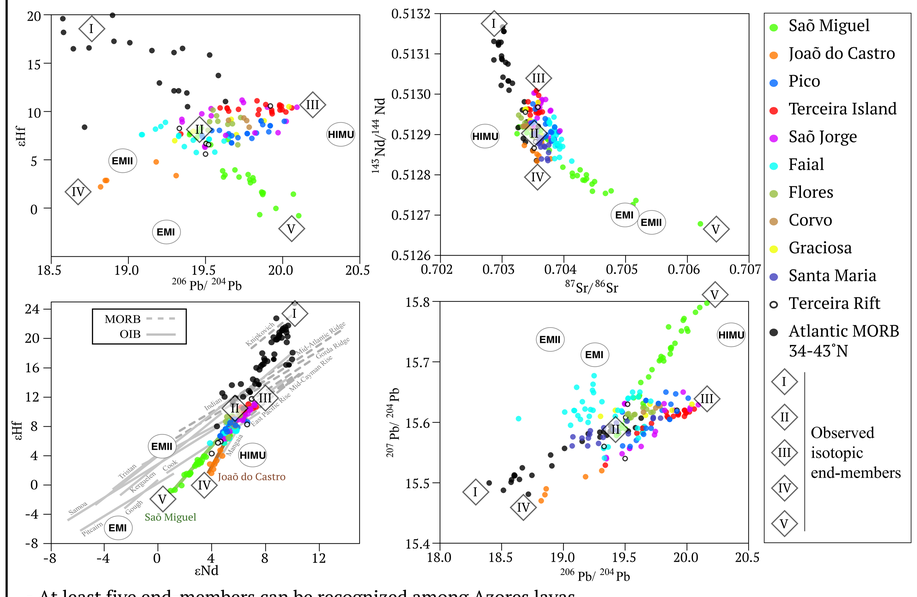

The Azores Archipelago sits on a triple rift junction with an underlying mantle plume. Islands do not display the typical age progression of oceanic island chains, and activity seems to be spatially controlled by the tectonically complex lithosphere as most islands are either located on, or aligned with the ultraslow Terceira Rift.

## Methods

Analyzed samples are basalts, trachybasalts and trachytes from the islands of Graciosa, Faial, Terceira, Pico, São Jorge, the Terceira Rift and the Joaõ do Castro seamount. Subaerial samples were obtained from the database of P. King and during the fieldwork of C. Beier. Submarine samples were obtained during two cruises with the German research vessel POSEIDON in 1997 (POS 232) and in 2002 (POS 286). Existing major, trace elements and Sr – Nd – Pb - Hf isotope data is from Beier et al. (2008 and 2012), Elliott et al. (2007) and Turner et al. (1997).

For each sample, 100 mg of rock powder was dissolved in a HF-HNO3 mixture and Pb, Sr, Nd and Hf were separated using chromatographic cation columns. Isotope ratios were then measured in liquid mode using a THERMO Finnigan Neptune MC-ICP-MS at the Center for Elemental Mass Spectrometry (CEMS) of the University of South Carolina.

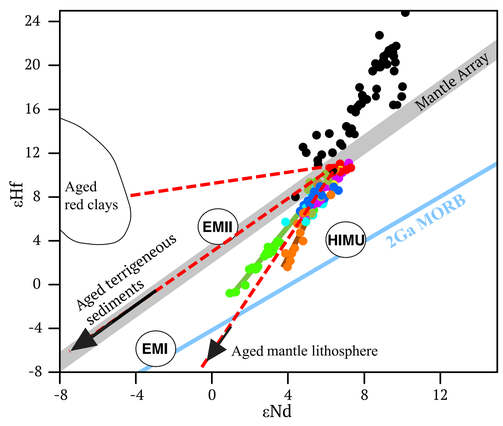
## Results



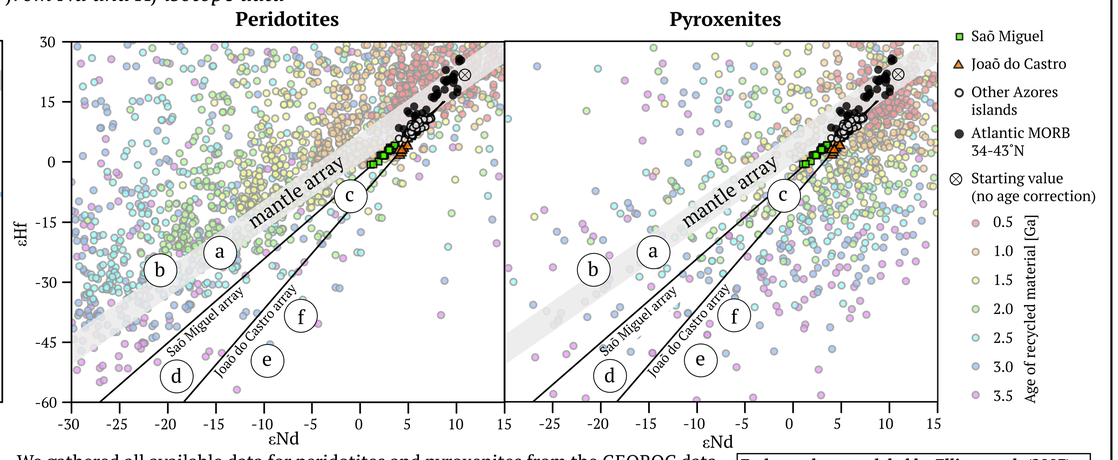

- At least five end-members can be recognized among Azores lavas.
- Saõ Miguel and Joaõ do Castro show two similar arrays towards compositions below the mantle array in Nd-Hf, but are fundamentally different in Pb-Hf and Pb-Pb. These two groups mix with end-members (IV and V) that do not overlap with traditional mantle end-members. Joaõ do Castro overlaps Mangaia (HIMU) in Nd-Hf space, but shows unradiogenic Pb values.
- End-member II mixes with III, V mixes with II, IV mixes with II and/or III, I mixes with II and/or III. I and IV do not mix, I and V do not mix, IV and V do not mix, III and V do not mix

## Discussion

### *Source modeling of Saõ Miguel and Joaõ do Castro from Nd and Hf isotope data*




- Sediments plot above and along the mantle array (Salters and White, 1998), which discard them as possible end-members for Saõ Miguel and Joaõ do Castro.
- Elliott et al. (2007) modeled the enriched end-member of Saõ Miguel as low-degree melts from a spinel and/or garnet peridotite.

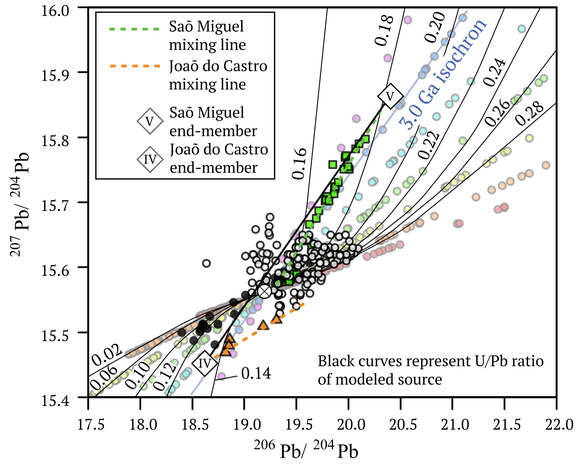


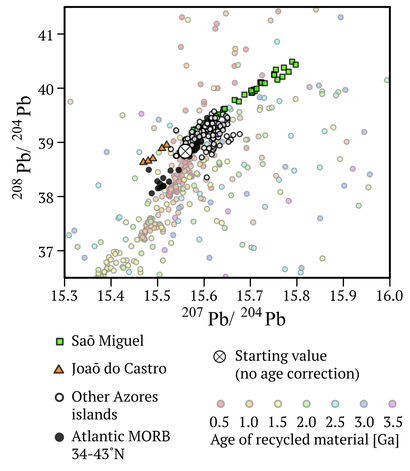

- We gathered all available data for peridotites and pyroxenites from the GEOROC database and modeled their Nd-Hf isotopic composition after 0.5 to 3.5 Ga using an age-corrected average MORB isotopic composition as a starting value for all points.
- Aged peridotites follow the mantle array, whereas the vast majority of aged pyroxenites plot below the mantle array. Pyroxenite is therefore a better lithological candidate to explain both Saõ Miguel and Joaõ do Castro arrays.

**End-members modeled by Elliott et al. (2007):**

| | | |
|---|---|---|
| a | 1% | melting of a spinel peridotite aged 3 Ga |
| b | 3% | melting of a spinel peridotite aged 3 Ga |
| c | 10% | melting of a spinel peridotite aged 3 Ga |
| d | 1% | melting of a garnet peridotite aged 3 Ga |
| e | 3% | melting of a garnet peridotite aged 3 Ga |
| f | 3% | melting of a garnet peridotite aged 2.5 Ga |

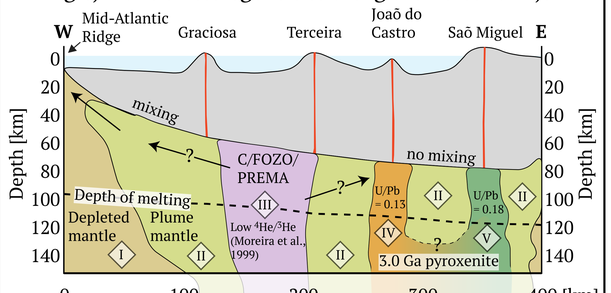
### *Source modeling of Saõ Miguel and Joaõ do Castro from Pb isotope data*




- We modeled pyroxenites from the GEOROC database using MORB as a starting isotopic composition.
- Model data is too scattered in $^{207}$Pb/$^{204}$Pb vs $^{208}$Pb/$^{204}$Pb space to narrow down source age and composition, but in $^{206}$Pb/$^{204}$Pb vs $^{207}$Pb/$^{204}$Pb space, the two extreme end-members of Joaõ do Castro and Saõ Miguel can be linked by a straight line (black line on the plot) parallel to the 3.0 Ga isochron. This raises the possibility that those two end-members are both 3.0 Ga old, but characterized by different U/Pb ratios: 0.13 for Joaõ do Castro and 0.18 for Saõ Miguel. However, a different starting isotopic composition (not on the black line) would imply two different ages.

### *Mixing of mantle heterogeneities along the Terceira Rift*




In this conceptual model, two strands of 3.0 Ga pyroxenite mix with a common plume mantle under Joaõ do Castro and Saõ Miguel, but those two strands do not mix together. A primitive component situated below Saõ Jorge, Graciosa and Terceira might contribute to Joaõ do Castro, but not to Saõ Miguel. Profile adapted from Beier et al. (2008).

## Conclusion

- Modeling shows aged pyroxenite is a good lithological candidate for both Saõ Miguel and Joaõ do Castro low εHf end-members.
- Pb modeling does not exclude a unique 3.0 Ga geochemically heterogeneous source for the two end-members, but Nd-Hf isotopic data shows that they do not mix together
- Short scale mantle heterogeneities originating in the deep mantle seem to be conserved in the uppermost asthenosphere, and little to no lateral mixing of melts occur, especially far from the Mid-Atlantic Ridge, where the melting column is shorter.

## References

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