

Low He content of high $^3\text{He}/^4\text{He}$ Afar mantle plume

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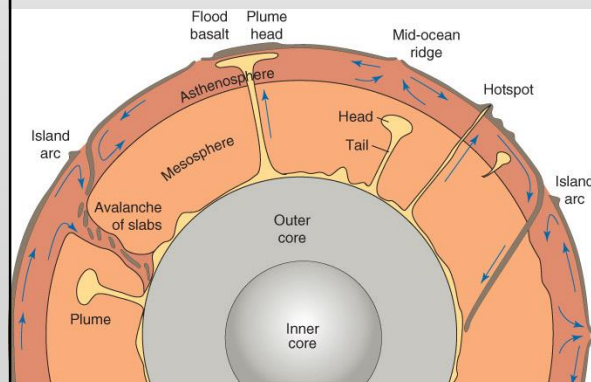
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Prevailing paradigm: deep mantle is enriched in primordial noble gases (^3He , ^{20}Ne) relative to degassed, convecting upper mantle.

Most models of geochemical evolution require high $^3\text{He}/^4\text{He}$ coupled to high He concentrations in deep Earth

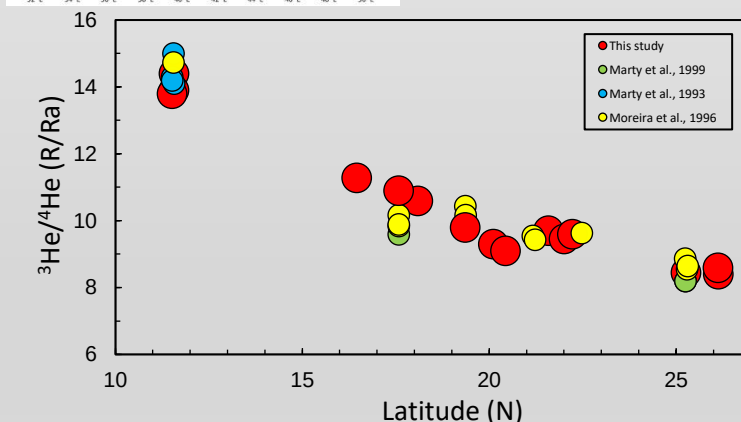
Helium concentrations in plumes have been inferred but rarely measured.



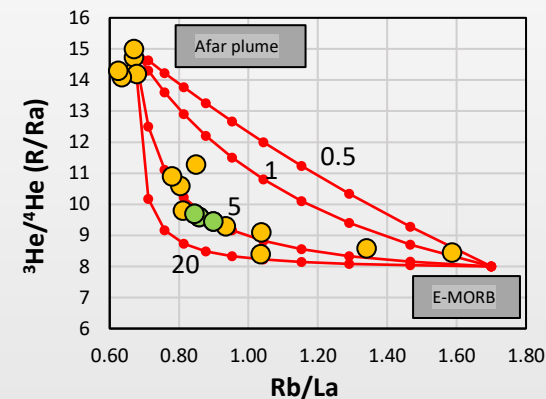
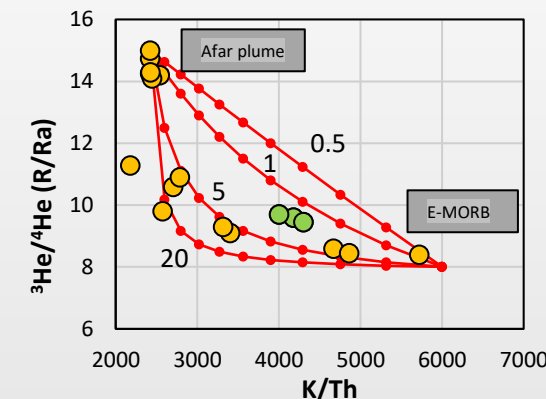
$^3\text{He}/^4\text{He}$ variation along Red Sea ridge



Basalts show systematic $^3\text{He}/^4\text{He}$ increase from north Red Sea ($8 R_a$) and to Gulf of Tadjoura ($16 R_a$)



Low-He concentration in Afar mantle plume, despite high $^3\text{He}/^4\text{He}$



- Coherent $^3\text{He}/^4\text{He}$ -trace element variation describes mixing between upwelling Afar plume (Tadjoura Gulf) and E-MORB (north Red Sea).
- High $^3\text{He}/^4\text{He}$ Tadjoura Gulf basalts have HIMU composition, Sr-Nd-Pb isotopes and trace elements
- The Afar mantle plume has 3-5x lower He concentration than degassed upper mantle, and 5-10 x lower than deep (high $^3\text{He}/^4\text{He}$) mantle.

Implications

1. Low-He high- $^3\text{He}/^4\text{He}$ mantle upwelling beneath the Afar triple junction appears to contravene the prevailing paradigm that deep Earth is enriched in primordial volatiles.
2. Afar mantle plume can most easily be generated by mixing 10-20% primordial He-rich (deep) mantle with 80-90% He-poor mantle.
3. This requires the preservation of He-poor mantle domains in deep Earth; recently subducted oceanic crust or sub-continental lithosphere.
4. This implies that OIBs with similar $^3\text{He}/^4\text{He}$ ($10-20 R_a$), e.g. Reunion, should not be used to track the composition of deep Earth.