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A primordial, solar-like He and Ne signature in Michigan Basin brines - basic two-layered mantle convection model assumptions revisited

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Noble gases have historically been used as a cornerstone of the two-layered mantle convection model with a lower, primordial, largely undegassed reservoir from which ocean island basalts (OIBs) originate via deep mantle plumes, and a degassed upper mantle of which mid-ocean ridge basalts (MORBs) are representative. Among these core arguments was the so-called “mantle He-heat imbalance” or “He-heat paradox” with low He/heat flux ratios in the proximity of mid-ocean ridges which required a lower, undegassed mantle from which He removal would be impeded. Such low flux ratios were thought to result from a He deficit in the original upper mantle reservoir based on the assumption that both He and heat are in steady-state and have similar transport properties in the crust. The legitimacy of these earlier assumptions was recently assessed and proven unsound, leading to the invalidation of one of the oldest cornerstone assumptions of the two-layered mantle convection model (Castro et al., 2005). Central to this mantle convection view has also been the reported primordial He and Ne signatures in OIBs that have been systematically associated with the occurrence of deep mantle plumes and thus, the existence of a lower, undegassed mantle reservoir. Primordial He and Ne signatures became the “mantle plume fingerprint”.

Here, I report new He and Ne data from deep brines in the Michigan Basin that clearly reveal the presence of a primordial, solar-like component. While the existence of this component is unequivocal, its connection to a lower, largely undegassed reservoir in this stable continental region via a mantle plume is highly unlikely. Indeed, no hotspot

tracks are known in the region and significant mantle activity was last recorded at $\sim$1.1Ga during the emplacement of the Mid-Continent Rift (MCR) system. I argue that such primordial signature can be accounted by a shallow noble gas reservoir in the subcontinental lithospheric mantle (SCLM) beneath the Michigan Basin, possibly created by a mechanism similar to that proposed by Anderson (1998) for oceanic regions. The Michigan Basin, which is located within the ancient North American craton ($\sim$1.1 - $>$2.5 Ga), lies on a very thick, U-Th-K depleted SCLM, which is refractory and buoyant relative to the asthenosphere, thus, possibly allowing preservation of a primordial, residual, depleted mantle reservoir at shallow depths, just beneath the continental crust. Alternatively, diffusion of solar-like He and Ne isotopes from primitive material into a residual refractory reservoir such as dunites during the Earth's early history as recently proposed by Albarede (in press) might have occurred.

Overall, the primordial solar-like He and Ne signatures present in the Michigan Basin brines strongly suggest that a deep primordial mantle reservoir is not required to explain the presence of such components, an observation that disrupts yet another core argument of the two-layered mantle convection model. The notion that primordial He and Ne are fingerprints of mantle plumes should be revised, as these new data clearly suggests this is not necessarily the case. The SCLM underneath ancient cratons is a great candidate for hosting primitive ancient mantle noble gas reservoirs. This study provides a strong observational case for long-term primordial lithospheric storage of noble gases.

References

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