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Interpreting Earth's geoneutrino flux

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The surface heat flux of the Earth is 46 $\pm$ 3 TW (terawatts, 10^{12} watts) or on average about 90 mW/m^2 and is the sum of contributions from primordial and radiogenic sources. Often geologists predict Earth's radiogenic power at 20 $\pm$ 10 TW, which comes from heat-producing elements (K, Th \& U). However, the full range of published estimates spans from 10 to 30 TW, documenting a factor of 3 variation in Earth's predicted heat production. The continental crust is uniformly estimated to have $7.1^{+2.1}_{-1.6}$ TW radiogenic power. Consequently, the convecting mantle is estimated to have the remaining radiogenic power at between 1 and 26 TW, which is more than an order of magnitude of uncertainty. The contribution of radiogenic heat from K decay is 20\% of the total signal and K geoneutrinos cannot be detected with current technologies. Time-integrated ^{208}Pb/^{206}Pb isotope data for 10^3 rocks document the Earth's Th/U molar ratio being identical to that of the solar system, that is 3.90.

Recent particle physics findings challenge this dominant geological paradigm with experimental results reporting the measured geoneutrino flux from Th and U. Taking the experimentally measured flux in TNU (terrestrial neutrino units) and converting to Earth's power gives $15.4^{+8.3}_{-7.9}$ TW for KamLAND (Japan), $31.3^{+13.6}_{-12.7}$ TW for Borexino (Italy) and 63^{+62}_{-56} TW for SNO+ (Canada) (Abe et al., 2022; Abreu et al., 2025; Agostini et al., 2020). Although uncertainties allow these model predictions to overlap with geological models, Borexino's predicted high central value for mantle power is due to an inaccurate estimate of near-field (local) geoneutrino flux (Sammon and McDonough, 2022), and that for SNO+ is simply well above Earth's measured heat flux.

We welcome this opportunity to highlight the fundamentally important resource offered by the physics community and call attention to the shortcomings associated with the characterization of the geology of the Earth. We review the findings from continent-based physics experiments, the predictions from geology, and assess the degree of mismatch between the physics measurements and predicted models of the continental lithosphere, the conductive lid, which is the product of continent formation and is not involved in mantle convection.

The large uncertainties associated with the recently reported geoneutrino flux measurement at SNO+ limit its usefulness. We anticipate that a year of JUNO data will provide a significant advance towards constraining the mantle geoneutrino flux. Data from the developing Jinping experiment, located in an extra-thick crust ($\sim$55 km thick vs. normally 36 km), will provide additional insights when used with the data from nearby experiments of JUNO and KamLAND, with the latter being approximately one mantle depth east of the Jinping experiment.

Detection of a geoneutrino signal in the ocean, far from the influence of continents, offers the potential to resolve this tension. Neutrino geoscience is a powerful new tool for interrogating the composition of the continental crust and mantle and its structures.

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Collaboration you are representing

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