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What is powering the Earth's Engine?

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The fuel driving plate tectonics, volcanism, mantle convection, and the generation of the Earth's magnetic field comes from two sources: primordial energy from assembling the planet and nuclear energy from the heat produced during natural radioactive decay. The current surface heat flux is 46±3 TW (terrawatts, 10^{12} watts). Models vary widely as to how much primordial and nuclear fuel remains inside Earth. It is generally agreed that the continental crust has ~7±1 TW of radiogenic power. Although many assume we know the Earth's abundances and distribution of radioactive heat producing elements (i.e., HPE, U, Th, and K), current estimates for the mantle's heat production varying by an order of magnitude (2 to 20+ TW of radiogenic power). Thus, we lack sufficient constraints on the thermal evolution of the planet.

For the last two decades neutrino physicists have been detecting low energy (MeV) electron anti-neutrino being emitted from the Earth (geoneutrinos) that are produced via beta minus radioactive decay of U and Th. Collectively, the flux of geoneutrinos measured at detectors in Japan and Italy, soon a report from Canada, and in 2026 data from China reveal the radiogenic power driving the Earth's engine. Converting the measured geoneutrino flux into TW of power requires that we accurately and precisely define the local geological model of the lithosphere (crust and mechanically coupled mantle) that surround these detectors (50% contribution of the signal), as well as predict the signal contributions from the mantle (~25%) and distant lithosphere (~25%). With increasing accuracy and precision these data define the compositional model of the Earth, place tight constraints on its thermal evolution, and independently confirm the planets chondritic ratio of refractory elements. A combine data analysis using KamLAND and Borexino geoneutrino experiments affirms the Earth has 20^{+7}_{-9} TW of radiogenic power and sets the proportions of refractory lithophile elements at 2.7 times that in CI carbonaceous chondrites.