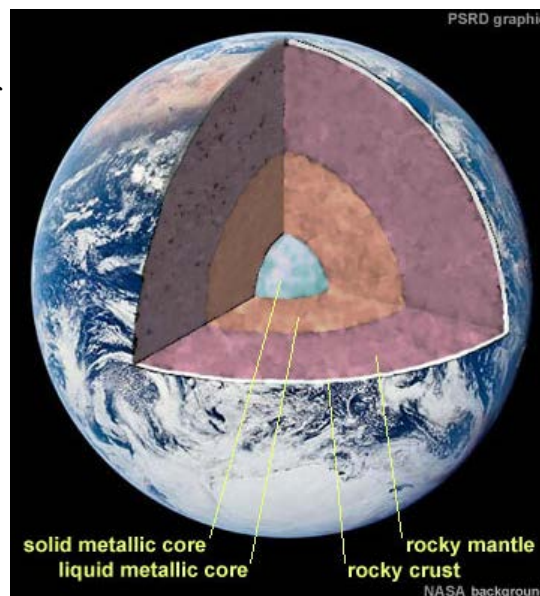


## Earth's Heat

The heat escaping Earth's interior is estimated at  $46 \pm 3$  terrawatts based on heat-flow measurements collected from twenty thousand boreholes distributed worldwide. The source of Earth's internal heat is attributed mainly to (a) residual heat from gravitational energy left over from planetary **accretion**, **differentiation**, and formation of the core, and (b) the decay of radiogenic isotopes, specifically,  $^{238}\text{U}$ ,  $^{232}\text{Th}$ ,  $^{40}\text{K}$ , and lesser contributors. Exactly how much of the planet's total internal heat comes from primordial heat or from continuous radiogenic decay is not well constrained, yet it is fundamental to our understanding of how the interior of Earth works. The internal-heat budget drives such planetary processes as mantle **convection**, **plate tectonics**, and the magnetic field. The more we know about Earth's composition, distribution of radiogenic isotopes, and heat production, the better we understand our own planet's evolution, and planetary formation and evolution in general.



Measuring the radiogenic heat production  
inside the third planet from the Sun.

Now we are closer to an answer to Earth's supply of radiogenic heat and it comes from particle-physics experiments. Seated one kilometer underground, in an unused zinc mine west of Tokyo, the KamLAND detector is measuring Earth's radiogenic heat flux one geoneutrino at a time. A geoneutrino is the antineutrino produced by the natural decay of radioactive  $^{238}\text{U}$ ,  $^{232}\text{Th}$ , and  $^{40}\text{K}$  inside Earth's crust and mantle. These electrically neutral particles, no matter how deep their source, pass through the Earth virtually unaffected. The KamLAND collaboration, an international team of scientists from Japan, the U. S., and Europe, reported the first detection of geoneutrinos in 2005 and additional measurements with geophysical results in September, 2011. The team used a bulk-silicate-Earth model that assumes uniform distribution of Th and U in the mantle, and a Th/U ratio fixed at 3.9 based on measured elemental abundances in **chondritic** meteorites and mantle **peridotites**. By combining their data with those from the Borexino detector at the Gran Sasso National Lab in Italy they report a global heat flux of  $20.0 \pm 8.7$  terrawatts from  $^{238}\text{U}$  and  $^{232}\text{Th}$ . Geoneutrinos emitted from the decay of  $^{235}\text{U}$  and  $^{40}\text{K}$  are below the detection limits of the two detectors, but are estimated to be about 4 terrawatts.

The radiogenic heat estimation from the geoneutrinos research is 24 terrawatts. That's about half of Earth's total heat flux, with the remainder assumed to be residual heat from the planet's formation, accretion, and differentiation. This is not a total surprise based on models already formulated for the Earth's interior, but from a geochemistry perspective, it will be intriguing to follow the development of geoneutrino research for its potential to constrain the amounts and distribution of the planet's radiogenic elements in the crust and mantle. More geoneutrino data collected at higher precision and measured by detectors in different locations (continental vs. oceanic crust) around the globe may allow independent tests of geochemical models of Earth's Th, U, and K content.

See:

KamLAND Collaboration (2011) Partial Radiogenic Heat Model for Earth Revealed by Geoneutrino Measurements. *Nature*

*Geoscience*, v. 4, p. 647-651, doi: 10.1038/ngeo1205. [ [Abstract](#) ].

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