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Investigating Earth's mantle with geoneutrinos

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As for us close, our planet still largely escapes our understanding. Starting from the mid-twentieth century, the electron antineutrinos originating from the radioactive β^- emitters inside our planet, geoneutrinos, were proposed as a precious tool for exploring the inner Earth. While decaying, the radioisotopes belonging to ^{238}U and ^{232}Th decay chains release geoneutrinos and energy dissipated as heat in a well-fixed ratio. The weak interaction of these particles with matter allows them to pass through most matter without interacting, bringing to surface useful information about the Earth's deep interior. A measurement of the geoneutrino flux at surface permits to estimate the uranium and thorium content of our planet's mantle and in turn to derive the radiogenic heat production of the mantle.

We present valuable insights on mantle radioactivity and on the contribution of radiogenic heat to the Earth's energy budget, inferred by combining theoretical crustal models and the latest geoneutrino flux measurements provided by KamLAND (Japan) and Borexino (Italy) experiments. The obtained results are discussed and framed in the puzzle of the diverse classes of formulated Bulk Silicate Earth (BSE) models, analyzing their implications on planetary heat budget and composition. The multi-site investigation of the geoneutrino signal permitted to disentangle the crustal contribution, estimating a mantle radiogenic power in agreement with geochemical proposed BSE models, and to derive estimates for the abundances of uranium and thorium, two refractory and lithophile elements, in the mantle.

The promising potential of geoneutrinos in investigating deep Earth radioactivity confer them a prestigious role in the comprehension of geodynamical processes of our planet and lets us glimpse a bright future for this discipline in view of next generation SNO+ (Canada) and JUNO (China) geoneutrino experiments.

Bellini, G., Inoue, K., Mantovani, F., Serafini, A., Strati, V., Watanabe, H., 2021. Geoneutrinos and geoscience: an intriguing joint-venture. Riv. Nuovo Cim. https://doi.org/10.1007/s40766-021-00026-7