In search of recycled continental crust in the Mantle Transition Zone using geoneutrino measurements

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Plate tectonics provides the framework for understanding the modern evolution of the crust and mantle system, with subduction zones linking these two major domains of the silicate Earth. Sediment recycling into the mantle at subduction zones is well established, although unknowns (e.g., past and present-day rates, amounts, depth of recycling, etc) remain significant. The present day subduction zone settings include ocean-ocean, ocean-continent, and continent-continent collisions and each of these likely have differing degrees of efficiencies of sediment recycling, as evidence by distinct differences in the remnants of meta-sediments exposed in fossil forearc regions of different collision zones. The retrieved metamorphic record of ocean-ocean and ocean-continent collision zones documents meta-sediments experiencing high-grade (granulite to eclogite facies) metamorphism. In contrast, continent-continent collisions return meta-sediments having experienced ultrahigh-grade (up to diamond facies) metamorphism. What is not known is the effectiveness of deep sediment recycling, past the magmatic zone, in each of these three different convergent margins.

Models that envisage successful subduction channel transport of upper crustal materials below 300 km depth, past a critical phase transition in buoyant crustal lithologies, are capable of accumulating and assembling these materials into so-called “second continents" that are gravitationally stabilized at the base of the Transition Zone, at some 600 to 700 km depth [Kawai et al., 2013]. Global scale, Pacific-type subduction (ocean-ocean and ocean-continent convergence), which lead to super continent assembly, were hypothesized to produce second continents that scale to about the size of Australia, with a maximum potential of continental upper crustal concentration levels of radiogenic power. Seismological techniques are incapable of imaging these second continents because of their negligible difference in seismic wave velocities with the surrounding mantle. We can image the geoneutrino flux linked to the radioactive decays in such hypothesized continental lithologies with land and/or ocean-based detectors. We present predictions of the geoneutrino signal for these continental lithologies, assuming different scaled models and show that the combination of the KamLAND-JUNO-Jinping neutrino experiments are strategically positioned to discover or constrain a predicted second continent beneath eastern China. The power emissions from such second continents were proposed to be drivers of super continental cycles. Thus, testing models for the existence of continental lithologies in the Mantle Transition Zone will place constraints on mantle and plate dynamics when using land and ocean-based geoneutrino detectors deployed at strategic locations.

Keywords: mantle transition zone, geoneutrino, second continent, heat producing elements, sediment subduction