# A Subduction Zone Barrier for Sediment-Derived Nitrogen

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The distinct isotopic compositions of the noble gases in various terrestrial reservoirs makes them ideal for exploring deep Earth processes. Helium in particular is a powerful tracer of mantle versus crustal contributions to volatile degassing at the surface. Here we use He in combination with N-isotope systematics to trace the sources of nitrogen in subduction zones, and to address the mass balance between the input of nitrogen into the subduction zone and the output via arc volcanism. We show that nitrogen stored in sediments of the oceanic crust is efficiently recycled back to the atmosphere and is not transported into the deeper mantle. To subduct nitrogen past the zone of arc magma generation transport of nitrogen in the oceanic basement is necessary.

Investigation of the He-$N_2$ systematics of volcanic and geothermal gases discharging from the Costa Rican and Guatemalan segments of the Central American arc shows that 1) The majority of samples have $^3He/^4He$ ratios in the range 5-8 $R_A$ indicating that both arc segments sample He primarily of mantle wedge origin; 2) nitrogen isotope systematics (and $N_2$/He ratios) vary considerably between Guatemala and Costa Rica. Guatemala volatiles have $\delta^{15}N$ values in the range –0.5 to 6.3 ‰ and $N_2$/He ratios fall between 1,400 and 25,000 (typical range of other arc-volcanoes). Volatiles from Costa Rica, have significantly lower $N_2$/He values (73- 333) and mostly negative $\delta^{15}N$ (-3.0 to 1.7 ‰). With the effects of air contamination removed, the data is interpreted as a binary mixing between mantle-derived nitrogen ($^3He/^4He$ = 8 Ra, $\delta^{15}N$ = -5‰) and subducted sedimentary nitrogen ($^3He/^4He$ = 0.05 Ra and $\delta^{15}N$ = +7 ‰). Volatiles from Costa Rica are characterised by mantle-derived nitrogen, whereas in Guatemala the subducted sedimentary contribution dominates.

To evaluate nitrogen mass balance, we determine the volatile input flux via the Central American trench by combining estimates of the volatile characteristics of localized sediments and oceanic basement with extrinsic properties such as subduction rate, arc length, sediment thickness and porosity. The flux of sediment-hosted N is 2.3 x $10^8$ mol N/yr for the Central American margin. The output is determined by combining the chemistry of the gas emissions ($CO_2$, $SO_2$, $N_2$) with the time-averaged $SO_2$ flux from the arc. This approach yields a non-air $N_2$ flux of 2.9 x $10^8$ mol/yr, which balances almost exactly the input flux of nitrogen via the trench. This implies that nitrogen is efficiently released from the slab and transported through the mantle wedge to the atmosphere via arc volcanism. We argue that this observation holds for arcs globally suggesting that subduction zones act as a barrier to the deeper mantle for sedimentary nitrogen.

# Constraining landscape evolution of the West Antarctic rift flank of southern Victoria Land

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The Transantarctic Mountains (TAM) define the western flank of the intracontinental West Antarctic rift system (WARS). Cretaceous extension is distributed across the WARS, whereas extension since the early Cenozoic was concentrated along the western side of the WARS adjacent to the front of the TAM. Cenozoic geomorphic evolution of the TAM in this area has previously been summarised as escarpment retreat, formation of planation surfaces and down-cutting by fluvial processes until about the mid-Miocene. Subsequent modification of the landscape by glacial processes has been minor due to the hyper-arid polar climate. Erosion rates since rift flank formation are constrained using apatite fission track thermochronology (AFTT), (U-Th)/He dating of apatite, information from offshore drill-holes, preservation of volcanic ash, and cosmogenic surface exposure age dating. In general, AFTT constrained denudation rates in the Late Cretaceous are low but reach ~65 m/my on the inland flank of the Kukri Hills. Near the coast at Mt Barnes AFTT data indicate the onset of Cenozoic denudation at 55 Ma. Average denudation since then is ~85 m/my but at a rate of 115 m/my from 55-40 Ma. At Peak 1880 20 km inland, AFTT data suggest denudation started later at ~40 Ma, with a similar average rate. (U-Th)/He data from Peak 1880, while exhibiting considerable scatter in single grain ages due to the effects of slow cooling on zoned apatites, also suggest the onset of more rapid cooling at ~40 Ma. This younging-inland trend for the onset of early Cenozoic denudation is interpreted as escarpment retreat at a rate of ~1.5 km/my. Existing information from nearby offshore drill-holes in the WARS agree well with estimates on the amount and timing of denudation and continued slow erosion from the end of the Eocene through the Oligocene. Previously reported exposure age data indicate Miocene to present erosion rates of 0.1-1 m/my. Thus, a combination of different techniques document the history of this rift flank, its initial formation, the style and rate of geomorphic development, the overall slow and decreasing erosion rates, deposition of eroded sediment offshore, and preservation of the landscape since the mid-Miocene.