Non-Henrian partitioning of nitrogen in slab environments

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Nitrogen is transported into subduction zones in sediments and the uppermost oceanic crust. Because NH_4^+ is compatible in slab minerals, while NH_3 and N_2 are less so, the ability of N to be retained in the slab during dehydration and melting depends on the relative stability of N species as a function of P, T, fO_2, and pH. These dependencies make N an information-rich tracer of slab conditions, but the relative stability of N species is also predicted to be a function the total N concentration, given the stoichiometry of converting NH_4^+ or NH_3 to N_2. Nitrogen partitioning in slab environments may therefore be non-Henrian.

Confirming the prediction of non-Henrian behavior is crucial because 1) experiments documenting the reactivity of N in slab settings are uniformly run at high concentrations and 2) the natural concentration of N in slab settings is likely highly variable, but generally much lower.

We have conducted N partitioning experiments under slab conditions to test for non-Henrian behavior. We completed a series of fixed pressure (1.75 GPa) and temperature (800 °C) piston cylinder experiments (Tulane University) using a double-capsule approach to buffer fO_2 (NNO). Within the series, we reacted rhyolitic melt, biotite, and a hydrous fluid with various concentrations of N (0.4-0.25 mole fraction N). Experiments were analyzed by an electron microprobe (Smithsonian Institution).

Our results reveal that N partitioning between melt and fluid systematically decreases with increasing N concentration. This result is consistent with the non-Henrian behavior predicted by conversion between NH_4^+ or NH_3 to N_2. Application of our results to nature implies an expanded stability of NH_4^+ or NH_3 relative to N_2. To maintain the strong enrichment of N at Earth's surface, despite its continuous subduction, we suggest that oxidizing, and potentially high pH conditions, have prevailed during dehydration of the uppermost sections of slabs through time.