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Revisiting the subduction zone carbon cycle: What goes down, mostly comes up

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As we reported (PNAS 2015), carbon fluxes in subduction zones can be better constrained by including new estimates of carbon concentration in subducting mantle peridotites, consideration of carbonate solubility in aqueous fluid along subduction geotherms, and diapirism of carbon-bearing metasediments. Whereas previous studies concluded that about half the subducting carbon is returned to the convecting mantle, we find it is likely that relatively little carbon is recycled. If so, input from subduction zones into the overlying plate is larger than output from arc volcanoes plus diffuse venting, and substantial quantities of carbon are stored in the mantle lithosphere and crust. Also, if the subduction zone carbon cycle is nearly closed on time scales of 5–10 Ma, then the carbon content of the mantle lithosphere + crust + ocean + atmosphere must be increasing. This is consistent with inferences from noble gas data and crustal carbon inventories (review in Hayes & Waldbauer PTRSL 2006). Carbon in diamonds, which may have been recycled into the convecting mantle, is a small fraction of the global carbon inventory. Increasing NaCl and decreasing pH and fO_2 in aqueous fluids all increase carbon solubility at HP to UHP conditions, strengthening the prediction of wt% solubility (Manning & Kelemen, Fall AGU 2015), while hydrous carbonatite formed on high T subduction geotherms (Poli, Nat Geosci 2015) has still higher concentrations. Fractures heal rapidly at UHP conditions, so fluid transport is mainly via porous flow, with increasing downstream solubility and porosity due to heating in the subducting plate and base of the mantle wedge. Depending on flow and reaction rates vs diffusivity (Damkohler number), this could yield diffuse or channelized flow. High, increasing solubilities and reaction rates, with slow diffusion, can produce diffuse, pervasive porous flow (e.g., Hoefner & Fogler, AIChEJ 1988; Spiegelman et al, JGR 2001) and efficient recycling of carbon.