Efficiency of Deep Carbon Subduction: Input, Metamorphic Records, and Bearing on Estimated Sources of Arc Volcanic Gases

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Circum-Pacific and Italian Alps high- and ultrahigh-pressure metasedimentary rocks record the subduction of organic (reduced) and carbonate (oxidized) C through forearcs (10-70 km) to depths approaching those beneath volcanic fronts. Still uncertain are the efficiency of delivery of such sections to subarc depths, as related to varying degrees of accretion and underplating, the mobilization of C during prograde metamorphism and fluid-rock interactions, and the fractions of C recycled in arcs, stored in forearc reservoirs (e.g., the mantle wedge), or added to the deeper mantle.

Franciscan Complex (FC) blueschist-facies rocks, and lower-grade units (lawsonite-albite and lawsonite-blueschist) of the carbonate-poor Catalina Schist (CS), preserve reduced C (RC) concentrations and $\delta^{13}C$, and C:N, similar to those of sediment protoliths, as does the lowest-grade unit of the Schistes Lustres (SL) exposed in the Alps (regardless of carbonate content). In CS units that experienced warmer prograde *P-T* paths (epidote-blueschist grade and higher), RC is shifted in $\delta^{13}C_{VPDB}$ from -25 per mil to as high as -19 per mil, seemingly related to minor loss of C as CH_4 during prograde devolatilization. The higher-grade units of the SL extend, to depths of ~70km, the extremely low-*P/T* trajectory represented by the FC and low-grade CS. Across this range of grade, RC shows little evidence of loss but considerable increase in $\delta^{13}C$ toward mantle values (-5 to -6 per mil) related to isotopic exchange with coexisting carbonate. In SL metashales, RC preserves protolith $\delta^{13}C$ of -24 to -21 per mil independent of grade and degrees of devolatilization. Reduced C occurs as amorphous carbonaceous matter at low grades, and its transformation to graphite at higher grades presumably enhances isotopic exchange with carbonate. This work implies that much of the RC reservoir is retained to depths beneath volcanic fronts and could be available for transfer into the sub-arc mantle wedge, likely via partial melting (K. Kraft, Lehigh Univ. M.S. thesis, 2018).

The blueschist to eclogite facies SL contains carbonate-rich flysch formed prior to and during Eocene subduction of the Piemonte-Liguria Ocean and underplated at 40-70 km depths. We analyzed $\delta^{13}C$ and $\delta^{18}O$ of carbonate in this unit, over a regional scale, and made field and petrographic observations bearing on mechanisms of C mobilization. A study of decarbonation history by Cook-Kollars et al. (2014) for the same suite demonstrated that, depending on extents of open-system infiltration by H_2O-rich fluid, large fractions of initially subducted carbonate could be retained in such rocks to at least 70 km depths. Assessing the magnitude of removal of carbonate via dissolution, at the whole-unit scale, has proven difficult. Isotopic exchange between the reduced and oxidized C reservoirs, and any fractionation during sub-arc mobilization and delivery into the mantle wedge, would have implications for the approach of Sano and Marty (1995) used to estimate proportions of gas from mantle and disparate sediment sources.

Study of along-margin C input flux at the Sunda margin (House et al., 2016; Fall AGU) emphasizes the role of sediment composition, source, and degree of accretion on the nature and size of the deeply subducted C reservoir. Ongoing NSF-funded work on the Hikurangi margin, New Zealand (collaborative with Bruce Christenson-GNS-NZ, Hirochika Sumino-Univ. Tokyo, and Ikuko Wada-Univ. Minnesota), is aimed at resolving C inputs vs. outputs in arc volcanoes and associated hydrothermal systems, in part considering the makeup of the incoming sediment section (based on drilling by IODP Exp. 375), extents of accretion,

along-margin thermal structure, and calculated extents of devolatilization. Studies of the Schistes Lustrés and other HP and UHP suites provide insight regarding the structural and geochemical evolution of sediments similar in composition to those subducting at modern margins (e.g., Sunda).

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