

Metamorphic Decarbonation and CO₂ Release in Subduction Zones: Implications to Fluid Fluxes and Volatile Recycling

D. M. Kerrick (kerrick@geosc.psu.edu)¹ & J. A. D. Connolly (jamie@erdw.ethz.ch)²

¹ Penn State University, Geosciences Dept., 243 Deike, University Park, PA 16802, USA

² Institut für Mineralogie und Petrographie, Eidgenössische Technische Hochschule (ETH Zentrum), CH-8092, Zürich, Switzerland

"One of the biggest unknowns is probably the survival of carbonates in the descending slab" (Staudigel and King, 1992) In spite of the importance for recycling of volatiles and the global carbon cycle there has been very little quantification of metamorphic decarbonation in subduction zones. Our compilation suggests that less than half of the amount of subducted CO₂ (as a component in carbonates) is returned to the atmosphere by arc volcanism. This imbalance implies that significant quantities of CO₂ are released under forearcs and/or are subducted to depths beyond subarcs. Volatile components are introduced into subduction zones by three contrasting lithologies: marine sediments, and hydrothermally altered mantle ultramafic rocks and oceanic basalts. Our approach is to quantify high-pressure phase equilibria relevant to metamorphic devolatilization of these lithologies, with particular emphasis on CO₂ release by decomposition of carbonates. Using free energy minimization (Perplex programs - web address: erdw.ethz.ch/~jamie/perplex.html), closed system pseudosection P-T phase equilibria computed to 6 GPa (~160 km) quantify the evolution of CO₂ and H₂O by prograde metamorphism of subducted ophicarbonates (carbonate-bearing serpentinites) and carbonate-bearing marine sediments. Peacock and Wang's (1999) respective geotherms for NW and SE Japan were adopted as thermal extremes along the top of subducted slabs. We computed phase equilibria with two fully hydrated harzburgite model protoliths: antigorite + brucite + calcite and antigorite + talc + calcite. Phase equilibria for these protoliths suggest little CO₂ loss to depths of 160 km; thus, ophicarbonates are a carrier of CO₂ to the mantle below subarcs. For high-temperature geotherms, complete dehydration of ophicarbonates will occur under forearcs, whereas for low-temperature geotherms major dehydration will occur under subarcs. Using Plank and Langmuir's (1998) data base, phase equilibria were computed for an average marine sediment bulk composition ["GLOSS"] and for selected bulk compositions of

siliceous limestones and marls, the two main carbonate-bearing pelagic sediments in ocean trenches. For subducted marine sediments our analysis predicts that: (a) siliceous limestones undergo negligible devolatilization, (b) along high temperature geotherms clay-rich marls completely devolatilize under forearcs and undergo virtually no devolatilization along low temperature geotherms, and (c) at 80-160 km, little devolatilization occurs for all carbonate-bearing marine sediments. With marked tectonic imbrication of subducted sediments, as evidenced by melange in accretionary prisms and blueschist-facies metasediments, the GLOSS bulk composition would be relevant. Along high-temperature geotherms, a melange of GLOSS bulk composition could provide a fertile volatile source for carbonating and hydrating peridotites of the forearc mantle wedge above the décollement. The resulting mantle wedge serpentinite and ophicarbonate would be dragged downward by corner flow and thus provide a source for volatiles through metamorphic devolatilization at greater depths. Without infiltration of H₂O-rich fluids, carbonate-bearing marine sediments will not undergo extensive devolatilization in subarcs. We conclude that marine sediments and ophicarbonates may contribute to the apparent deficiency in CO₂ fluxes from arc volcanism compared to the amounts of these volatiles contained in subducted lithologies. Carbonates in metabasic rocks of the oceanic crust could be a major CO₂ source for arc magmas. Accordingly, we are computing high pressure phase equilibria for carbonate-bearing metabasic rocks.

Staudigel, H, and King, S, *Earth Planet. Sci. Lett.*, **109**, 517-530, (1992).

Peacock, SM and Wang, K, *Science*, **286**, 937-939, (1999).

Plank, T, and Langmuir, CH, *Chem. Geol.*, **145**, 325-394, (1998).