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The Place of Bend-Fault Carbonation in Earth's Longterm Global Carbon Cycle

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It is well known that mid-ocean ridges are a key site for chemical interactions between oceanic crust and the hydrosphere, and that these interactions modulate the chemistry of the oceans. This field is relatively mature. However, it is becoming increasingly evident that the oceanic lithosphere may also strongly interact with the hydrosphere during plate subduction, as it bends — by bend-faulting (cf. Ranero et al., 2003) — when it enters a trench. I review recent seismic evidence that suggests that bend-faulting is associated with $\sim$10% serpentinization in a layer extending at least 10km below the Moho, and potentially more for old subducting lithosphere. The age-depth-dependence of the width of the double-Wadati-Benioff-zone implies that significant serpentinization occurs at lithospheric temperatures of $\sim$300C where net reaction rates are likely to be highest. If this serpentine forms with a 1% carbonate fraction, then bend-fault serpentinization will consume an atmosphere's worth of CO_2 every 40,000 years (e.g. of order $\sim$1-2 Tmol/year), and it seems likely that the carbonate storage in serpentinized subducting lithosphere exceeds that in overlying oceanic crust and sediments. (Note that at least 1% carbonation occurs during mid-ocean-ridge serpentinization processes, but the actual fraction of bend-fault carbonation is currently unconstrained by in-situ measurements within partially serpentinized bend-fault mantle.)
The rate of mantle ingassing associated with this poorly-understood geological process appears to be similar in magnitude to the rate of carbon outgassing from the mantle at mid-ocean ridges. The implications for Earth's long-term carbon cycle are potentially significant. For example, the initiation of new subduction may be associated with the creation of a significant carbonate sink — a feedback not included within Geologic models for Phanerozoic carbon+climate evolution. It also suggests there may be a direct link between the concentration of CO_2 in seawater and the efficiency of global carbonate recycling — and that perhaps bend-fault carbonation played a key role in the regulation of carbon dioxide in Earth's early atmosphere.