Weathering of marine sediments in a natural high-CO_2 environment: A geochemical investigation of the hydrothermal seeps of Yonaguni Knoll, Okinawa Trough

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Carbon dioxide capture and storage (CCS) has been recognized as one practical option for mitigating anthropogenic CO_2 emissions and several demonstration projects aim at storage units below the seafloor. However, the likelihood for potential CO_2 leakage and its impacts on the marine environment are still unclear and have to be assessed.

One approach is the study of natural analogues, i.e. natural CO_2 seeps, mainly of volcanogenic origin. Here, we present geochemical data from the sediment-covered hydrothermal seeps of Yonaguni Knoll in the southern Okinawa Trough, NE off Taiwan.

Two seep sites were investigated in detail: (a) Abyss Vent, where hot, supercritical CO_2 is percolating through the sediment, and (b) Swallow Chimney, where liquid CO_2 and CO_2 hydrate form in the surface sediments. Geochemical and isotopic analyses of the porewater and solid phase indicate intense weathering of the sediments: carbonates are completely dissolved in the surface sediments, but also reactive silicate minerals, such as K-feldspars, plagioclases and pyroxenes, are leached by the low-pH fluids. Consequently, the CO_2-saturated porewaters are relatively enriched in K, Ca, Mg, and also contain high alkalinity values of 30-60 meq/l typically buffering the pH at 4.6-4.8.

While at Abyss Vent CO_2 and fluids are emitted into the water column at high advection velocities, in contrast, at Swallow Chimney the condensed liquid CO_2 and/or gas hydrates seem to have reduced the permeability trapping the CO_2 effectively below the seafloor in a depth of 30-100 cm. Here, intensive reactions with the sediments are observed. Applying a transport-reaction model to both data sets, natural weathering rates for high CO_2 conditions are determined. Strontium isotopic composition of the porewater, bulk sediment, chimney and volcanogenic material helps to constrain the mass balance of the weathered compounds.

Exploring the effects of bedrock nutrient density on life and topography in the Sierra Nevada Batholith, California

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As primary producers, plants form the basis of ecosystems. Plants themselves, however, depend on underlying substrates for mineral nutrients, which are ultimately derived from weathering of local bedrock and influxes of allocthonous dust [1]. Substrates that lack essential nutrients may preclude colonization of plant life. Where plants are absent, soil production and retention are hindered, leading to exposure of bedrock, which in turn inhibits erosion relative to surrounding soil-mantled, vegetated terrain [2]. This raises the possibility of a feedback wherein exposed bedrock hillslopes emerge in relief as stable features due to low intrinsic nutrient density. We explore the potential for such a feedback in the Sierra Nevada Batholith, California, which provides a natural laboratory for studying how gradients in intrinsic nutrient density correspond with gradients in vegetation. We restrict our analysis of controls on vegetation to minimally disturbed, unglaciated terrain, thus eliminating potentially confounding effects of intensive land use and glacial scour. We measured bedrock bulk geochemistry for slopes spanning a wide range in above-ground biomass, thus quantifying variations in intrinsic nutrient density. We leverage these point measurements of geochemistry with existing geochemical databases and geologic maps. Using spatial analysis we compare our geochemical data with measurements of above-ground biomass, net primary productivity, and remotely sensed vegetation density. Across our study area, nutrient density, as revealed by concentrations of phosphorus and magnesium in bedrock, varies by more than an order of magnitude. Biomass likewise varies widely, ranging in extremes from densely vegetated giant sequoia (*Sequoiadendron giganteum*) groves to sparsely distributed stands of stunted conifers within otherwise bare-bedrock landscapes. We find that bedrock with low intrinsic nutrient density is often associated with low biomass per unit area at sites where local climate is similar to that of forests with high biomass and productivity. This implies that bedrock nutrient density may serve as a first-order control on vegetation distributions across some portions of our study area. Our measurements of cosmogenic nuclides from exposed bedrock surfaces indicate that they are eroding slower than surrounding soil-mantled terrain, confirming that linkages between intrinsic nutrient density and vegetation could regulate relief at hillslope to mountain scales.

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[2] Portenga and Bierman (2011) *GSA Today* **21**, 4-10.