Calcrete on Everglades tree islands: human occupation or tree growth?

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New geochemical and petrographic analyses shed light on the origin of the "enigmatic" carbonate layer perched within the soil of some Everglades tree islands. For some time, archaeologists [1, 2] have noticed the presence a 45-70 cm thick calcareous layer in the islands of terrestrial vegetation perched just a meter above the flooded wetlands of the Everglades. This layer, impenetrable without heavy equipment, had been interpreted as a topographic high in the underlying karst platform. Schwadron's archeological excavations of selected islands revealed soil and artifacts below the carbonate layer and a midden just above the karst platform [3]. As Schwadron had not observed artifacts in the layer, she interpreted it as a hiatus in midden/peat deposition. The cultural age of artifacts above and below the layer suggested that it formed ~3800-2700 cal yr BP, a period corresponding to a broad scale climate change recognized in the southeast U.S. and associated with cultural changes from the Late Archaic (Archaic = 9k to 3.5k BP) to Early Woodland culture [4].

Another model [5] proposed for the development of the calcrete layer required no major climate perturbation, only the occurrence of distinct wet and dry seasons where evapotranspiration from vegetation might result in the reprecipitation of calcium carbonate around roots within the soil profile.

Our most recent investigations indicate that a major component of the hardened layer is detrital rather than pedogenic. Most calcareous fragments show textures of an oolitic limestone with isopachous meteoric cements. Their oomoldic porosity is typical of the local underlying Pleistocene bedrock (Miami Limestone). Pedogenic features (needle-fiber calcite, root casts) in the surrounding soil indicate that the limestone fragments have been dissolving in the peaty soil profile. Phreatic acicular calcite cements fill pores in phosphatic bone fragments throughout the layer, enhancing their preservation and fixing phosphorus within the tree island soil.

This provides evidence for layer development that requires neither abandonment nor climate change. The question remains as to whether these limestone fragments were pulled up from a karstic, rubble-covered bedrock by fallen trees or if they were left by human occupants. If vegetation simply enhanced the pedogenic cementation into cohesive calcrete layers of limestone fragments left by early human occupants, these layers might have value as stratigraphic markers.

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How large is the subducted water flux? New constraints on mantle regassing rates

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Constraints on the long-term cycling of water between the mantle and exosphere (i.e., the atmosphere, oceans and crust) are critical to our understanding of mantle rheology, the structure and style of mantle convection [1], and the volatile budget of our planet. Volcanic water output from the mantle is offset by input at subduction zones in the form of chemically-bound water in subducting slabs. Water released from subducting slabs at high pressures and temperatures is outgassed to the exosphere by arc and back-arc volcanism. Any water entrained in the mantle wedge or retained in the slab beyond depths of magma generation constitutes a return flux of water to the interior, often referred to as the post-arc subducted water flux. Estimates of the magnitude of the total input flux of water at subduction zones and the magnitude of the return flux beyond arcs into the deep mantle have been used to discuss long-term regassing of the mantle [2-5]. However, these estimates vary widely, and some are large enough to have reduced the volume of water in the global ocean by a factor of two over the Phanerozoic.

In light of uncertainties in the initial hydration state of subducting slabs, magma production rates and mantle source water contents, we use a Monte Carlo simulation of the deep Earth water cycle to set limits on long-term mantle regassing. The simulation is constrained by reconstructions of Phanerozoic sea level change, which suggest that ocean volume is near steady-state, though a sea level decrease of up to 360 m may be supported [6-8]. We find that previous estimates of both the input flux of water into subduction zones and the return flux beyond depths of magma generation are frequently too large to reflect long-term water cycling. Our results [9] suggest a limited extent of serpentinization in subducting lithospheric mantle. For a near steady-state exosphere (0-100 m sea level decrease), we find an average return flux of 1.4–2.0 x 10^{13} moles/yr, corresponding to 2-3% serpentinization in 10 km of lithospheric mantle. For a maximum sea level decrease of 360 m, the average return flux is 3.5 x 10^{13} moles/yr, corresponding to 5% serpentinization in 10 km of lithospheric mantle. Our estimates of the return flux of water past arcs are up to 7 times lower than previously suggested [2-5; 9]. The net imbalance between our estimates of the return flux and the mantle-derived output flux gives an upper limit bulk mantle regassing rate of 24 ppm/Ga. Furthermore, our results indicate that while water in the mid-ocean ridge basalt source may be accounted for by recycling of water carried in subducted slabs, recycled slab water contents may not be high enough to account for the water contents of the ocean island basalt (OIB) source, such that some fraction of OIB source water appears to be juvenile.

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