

2020-2021 Birdsall-Dreiss Distinguished Lecturer



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[Jonathan B. Martin](#) is Professor of Geological Sciences at the University of Florida, where he has worked since 1994. He received a BA in Environmental Science at Wesleyan University in 1980, an MS in Geology from Duke University in 1987, and a PhD in Earth Sciences from UC San Diego, Scripps Institution of Oceanography in 1993. His research evaluates water chemistry in a range of environments to understand interactions between flow and biogeochemical and inorganic reactions. His dissertation research focused on discharge and chemical processes at cold methane-rich seeps on the seafloor at convergent margins. Following his move to Florida, his research expanded to include studies of chemical reactions in carbonate aquifers based on variations in spring water compositions. He also developed an interest in nearshore marine settings where he assesses impacts of sea level rise on freshwater-saltwater mixing in coastal aquifers and the chemistry of submarine groundwater discharge. His interests in flow through karstic systems and effects of sea level rise led to studies of glacial hydrology. This research examines how chemical and isotopic compositions of streams draining the Greenland Ice Sheet differ from those draining watersheds exposed during ice sheet retreat. Martin was selected as a GSA Fellow in 2006. He is an emeritus member of the Karst Waters Institute Board of Directors, has been associate editor of *Groundwater* since 2005, and was a visiting professor at the University of Montpellier, France (2007), and University of Bristol, UK (2017).

Institutions can schedule a visit by completing the request form at this [link](#). Martin will present one lecture on one of the topics described below.

1. High Latitude Hydrology: Water in a Changing World

Since the Last Glacial Maximum, continental ice sheets have retreated from approximately 15% of the terrestrial earth surface. This retreat exposed watersheds underlain by fine-grained sediments that originate from glacial physical weathering and are susceptible to chemical weathering. The exposed landscapes are comprised of either proglacial watersheds that drain the ice sheet or “deglaciated” watersheds that are separated from ice sheet by hydrologic divides, from which “non-glacial” streams drain. In western Greenland, non-glacial and proglacial streams have similar specific discharge (discharge normalized to watershed area) even though individual proglacial streams can have large annual discharges. The similarity in specific discharge suggests that water composition, rather than water volume, is the primary control of gas, solute, and isotopic fluxes to the ocean and atmosphere from the two types of streams. Stream compositions vary as weathering reactions in deglaciated watersheds shift towards completion with increasing exposure age and precipitation, which has been linked to variations in Pb isotopes preserved in deep-sea sediments. However, processes driving these changes have

rarely been evaluated in the foreland of an actively retreating continental ice sheet. To evaluate these processes, we have analyzed chemical and isotopic compositions of gas, water, and sediments from deglaciated watersheds extending from recently exposed arid watersheds at the ice edge to humid watersheds with longer exposure ages at the coast in western and southern Greenland. These samples show that dissolved $^{87}\text{Sr}/^{86}\text{Sr}$ ratios are > 0.003 greater than bedload values in recently exposed ice-proximal proglacial watersheds and the difference decreases to near zero in coastal watersheds. Mass balance models of major element concentrations indicate weathering reactions shift from predominately carbonic acid weathering of carbonate minerals in ice-proximal watersheds to predominately sulfuric acid weathering of silicate minerals in coastal watersheds. These different weathering reactions contribute to distinct CO_2 fluxes from the landscape. Measured gas concentrations at subglacial outflows suggest CO_2 and CH_4 sources depend on both the amount of organic matter sequestered beneath the ice sheet and the extent of mineral weathering in subglacial environments. Proglacial stream compositions are affected by extensive hyporheic exchange in sandurs, while ecosystem development decreases P and Fe fluxes as Fe-oxides precipitate in non-glacial streams. Differences in gas, solute, and isotopic compositions indicate that ice sheet retreat during glacial terminations changes riverine oceanic and atmospheric fluxes; understanding these differences could provide predictive capability for continued changes in fluxes as ice sheets retreat in a future warmer world.

2. Reversing Springs: Impacts on Carbonate Aquifers

Deconvolution of discharge and chemical time series in spring water, exemplified by the elegant quantitative models published by Shirley Dreiss in the early 1970's, has long been used to evaluate recharge, flow properties, and chemical reactions in carbonate karst aquifers. Although these signals provide valuable information, they may be disrupted as springs reverse flow direction when head gradients switch orientations and allow water to flow into, rather than from, the springs. Because surface water compositions differ from discharging groundwater, mixing during spring reversals alters groundwater compositions and water-rock reactions in the aquifers. Example of such reversals occur in springs discharging to the Suwannee River in north Florida as water drains from confining units in the uplands and raise river levels faster than groundwater levels. Other examples occur during high tide and storm setup at springs along the east coast of the Yucatan Peninsula. At flood stage, Suwannee River water is highly undersaturated with respect to calcite ($\text{SI}_{\text{calc}} < -5$) and thus reversals initiate dissolution at the spring vent, causing cave formation to proceed from the downstream end of conduits, in contrast with classic karst dissolution models. Calcite dissolution also occurs in the Yucatan coastal springs as reflected in Ca concentrations that are elevated over conservative mixing between saline and brackish water end-members. In this case, dissolution results from remineralization of a labile, protein-like fraction of dissolved organic matter derived from lagoon primary production, which also causes the intruding lagoon water to be supersaturated with dissolved oxygen. Although fresh marine organic matter remineralization would be expected to produce N/P ratios similar to the Redfield ratio, measured N/P ratios are elevated by 10 to 100 times over the Redfield ratio, implying either a source of N, which is unlikely because of the lack of N-fixing organisms, or a sink for P. The most likely P sink is sequestration during reactions with calcite even though calcite dissolution would be expected to provide a source of P. Suwannee River flood water also contains elevated dissolved organic carbon and oxygen, as well as metal concentrations. Variations in redox conditions during reversals produce nitrous oxide, an important greenhouse

gas, during denitrification and/or ammonium oxidation. Shifting redox conditions also drive alternating precipitation and dissolution of metal oxides. Fe-Mn oxide coatings contain Pb and Sr isotope ratios that suggest net precipitation occurs during spring reversal events. Although the standard model of spring discharge assumes alteration of spring water chemistry along a flow path from recharge to discharge points, spring reversals are likely the primary control of water-rock reactions and groundwater compositions where hydrologic characteristics allow reversals.