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Collaborative Research: Integrated Geophysical and Hydrogeologic Study of a Large Maine Peatland

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Principal Investigator: Reeve, Andrew S.
Organization: University of Maine
Title:
Collaborative Research: Integrated Geophysical and Hydrogeologic Study of a Large Maine Peatland

Project Participants

Senior Personnel

Name: Reeve, Andrew
Worked for more than 160 Hours: Yes
Contribution to Project:
Andrew Reeve is the principle investigator for this project.

Name: Slater, Lee
Worked for more than 160 Hours: Yes
Contribution to Project:
Lee worked with me planning this project, coordinating students and assisted with water sampling. Lee has made several trips to Maine and we have worked together collecting geophysical and hydrogeologic data. Lee's group has collected a large amount of resistivity and geophysical data that will be used in ground-water flow simultaions by an incoming graduate student.

Post-doc

Graduate Student

Name: Good, Heather
Worked for more than 160 Hours: Yes
Contribution to Project:
Heather collected water-level data, assisted with ground-water sampling, performed slug tests, and surveyed in (with GPS) monitoring wells.

Name: Comas, Xavier
Worked for more than 160 Hours: No
Contribution to Project:
Xavier assisted with the collection of peat cores.

Name: Stevens, Nathan
Worked for more than 160 Hours: Yes
Contribution to Project:
Nathan Stevens is compelting a Master's Degree at the Univeristy of Maine. His thesis research involves laboratory experiments designed to evaluate mass transport processes with peat columns. He has been supported by a research assistantship funded by this project.

Undergraduate Student

Name: Ware, Kristen
Worked for more than 160 Hours: Yes
Contribution to Project:
Kristen collected water-level data, assisted with ground-water sampling, performed slug tests, constructed a rack of peat core analysis, and surveyed in (with GPS) monitoring wells.

Name: Morton, Benjamin
Worked for more than 160 Hours: Yes
Contribution to Project:

Ben ollected water-level data, assisted with ground-water sampling, performed slug tests, constructed a rack for peat core analysis, assisted with peat coring, and surveyed in (with GPS) monitoring wells.

Ben has submitted an abstract to the annual meeting for the Geological Society of Ammerica to present the results of his water-level monitoring efforts.

Technician, Programmer

Other Participant

Name: Davis, Ronald

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Davis assisted with vegetation description. Before this project began, Dr. Davis assisted with the installation of monitoring wells used in this project.

Research Experience for Undergraduates

Organizational Partners

Rutgers University Newark

Lee is a collaborative PI on this project and is responsible for geophysical data collection and interpretation.

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities:

A tracer test was initiated in a large peatland in central Maine. The saline plume has been monitored through geophysical measurements and ground-water sampling. Water level data from monitoring wells surrounding the tracer test have been collected and all wells have been surveyed in using global positioning systems. Peat cores were collected for subsequent hydrogeologic analysis. A variety of equipment (rain gage, data loggers, etc.) has been ordered and will be installed to automate and enhance monitoring activities in the peatland.

In the Fall of 2002, data loggers were installed in the peatland. Two data loggers failed to operate properly through the winter of 2002 and these data loggers were reprogrammed or replaced in the spring 2003.
An additional monitoring well cluster was installed and surveyed in the summer of 2003. This well was installed to better define the impact of a boardwalk constructed in our study area.

Solute transport modeling was initiated to evaluate tracer migration through the peat. A finite difference model was developed using the python programing language that incorporated advection, dispersion, and matrix diffusion. These computer simulation efforts are ongoing.

A MS. student has collected peat cores within Caribou Bog, sealed these cores in paraffin wax, and used them in laboratory tracer experiments. In these experiments, a constant hydrualic gradiant was established across the cores and cores were flushed with clean water to remove any gas. A NaCl solution was injected into the core as a pulse and monitored by measuring voltage potentials between pairs of copper wires (1 cm apart) placed at 10 cm increments along the core.

Findings:

The saline plume is migrating from the tracer well at a very slow rate. Darcian ground-water flow calculations and the point dilution method indicate that ground-water is migrating at rates of 3.1 and 18 m/yr, respectively. The plume, however, is migrating at less than 1 m/yr, supporting our hypothesis that matrix diffusion is an important process in peatlands.

Geophysical measurements have provided information on peat thickness, geologic materials, and topography of the underlying mineral soil layer, and suggest that vertical ground-water flow patterns are influenced by this topography. These variations in peat thickness and geologic materials appear to correlate with vegetation patterns.

Measured tracer migration was best simulated when significant matrix diffusion was incorporated into numerical models. Matrix diffusion had two notable effects: 1) it slowed the migration of the tracer (expected result), and 2) it resulted in an inflection in plots of time against concentration in the injection well. This infection was also noted in the data collected and suggests that estimates of ground-water velocity based on the point dilution method will be inaccurate when completed in peat and similar dual domain media.

Similar results were observed in laboratory experiments, with tracer moving a factor of 10 slower than the water (based on Darcy calculations). Pulses of tracer had a 'heavy-tailed' response, indicating that the tracer diffused into the peant and then slowly diffused out when the concentration gradient between the active and inactive pore-space reversed. Curiously, tracer speed varied greatly between individual pairs of electrodes. It is unclear whether this reflected small-scale changes in peat hydraulic properties or changes in cross-sectional area (variation in how far paraffin seeped into the peat).

Training and Development:

Undergraduate students, particularly Ben Morton, were exposed to spreadsheets during manipulation of water level and slug test data. Ben, Heather, and Kristen were all trained in many basic field hydrogeologic methods (water-level measurement, core collection, water sampling, GPS surveying). Heather is applying these skills to her M.S. research.

Ben Morton worked on this project and presented results of his work at the Geological Society of America 2003 meeting.

Chris Catherman began an MS program in the fall 2002, with the intent of completing a thesis on ground-water simulation of Caribou Bog. Mr. Catherman's interests did not match well with this project and he evaluating other carrier options. Because Chris left the project, a new student was recruited. Nathan Steven began working on this project in the Fall 2003. Nathan has competed class, field and laboratory work and is currently completing his thesis.

Outreach Activities:

A annual 'nature walk' along a boardwalk (www.oronoboardwalk.org) constructed through Caribou Bog has been lead by Andrew Reeve. This seminar introduces participants to the hydrology of peatlands and the research being conducted in Caribou Bog.

Journal Publications

Lee Slater and Andrew Reeve, "Investigating peatland stratigraphy and hydrogeology using integrated electrical geophysics", GEOPHYSICS, p. 365, vol. 67, (2002). Published

Andrew S Reeve and Lee D Slater, "Initiating a solute transport experiment in a large Maine peatland", 2002 Abstracts with Programs, GSA Northeast Section Meeting, p. 1, vol. 34, (2002). Published

Andrew S. Reeve and Lee D. Slater, "Hydrology and mass transport processes in Caribou Bog, Maine", Wetland Linkages: A watershed Approach; 23rd Annual Conference, Society of Wetland Scientists, p. 146, vol. , (2002). Published

Andrew Reeve and Lee Slater, "Ground-water hydrology and solute transport in Caribou Bog, Maine
", 2003 Abstracts with Programs, GSA Northeast Section Meeting, p. 1, vol. 35, (2003). Published

Comas, X., L. Slater and A. Reeve., "Evidence for
spatial distribution and volume estimation of biogenic gas in a
peatland using ground penetrating radar (GPR)", Geophysical Research Letters, p. L08401, vol. 32, (2005). Published

Comas, X., L. Slater and A. Reeve, "Geophysical evidence
for peat basin morphology and stratigraphic controls on vegetation
observed in a northern peatland.", Journal of Hydrology, p. 173, vol. 295, (2004). Published

Morton, B. and A. Reeve, "Temporal changes in
ground-water hydrology and solute transport in Caribou Bog,
Maine.", Geological Society of America Annual Meeting, p. 253-1, vol. , (2003). Published

Reeve, A.S. and N.A. Stevens, "Hydrogeologic properties
in peat columns", Geological Society of America Annual Meeting, p. 246-5, vol. , (2004). Published

Books or Other One-time Publications

Web/Internet Site

Other Specific Products

Contributions

Contributions within Discipline:

The preliminary results of the tracer experiment suggest that matrix diffusion (or sorption) strongly retards the migration of solutes in a peatland. Geophysical data (collected by Lee Slater) suggest that ground-water flow and vegetation patterns are influenced by the geologic conditions beneath the peat deposit.

Matrix diffusion is an important control on solute transport in peatlands and cannot be ignored when considering solute transport in peatland systesm.

Contributions to Other Disciplines:

This project demonstrates the complementary nature of hydrogeologic and environmental geophysical measurements. The association between peat landform/vegetation, geologic setting, and hydrology has strong implications for peatland ecology and carbon sequestration in the pedosphere.

Contributions to Human Resource Development:

All students were exposed to basic peatland ecology, basic hydrogeologic field methods, and environmental geophysics. Students also performed data entry into spreadsheets and graphics software. This was Ben Morton's first exposure to a spreadsheet.

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

In May, 2003 I was contacted by environmental policy makers for Washington State regarding the function of peatlands. This inquiry focused on the hydrologic function of peatland systems and how this should be reflected in guidance document for local governments. My response to this inquiry was considered 'very helpful' in drafting a section on the relationship between peatlands and stream baseflow.

Categories for which nothing is reported:

Any Book

Any Web/Internet Site

Any Product

Contributions: To Any Resources for Research and Education