Nova Scotia's Involvement in the North American Soil Geochemical Landscape Project

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Introduction

The objective of the North American Soil Geochemical Landscape Project (NASGLP) is to establish a comprehensive continental-scale framework of inorganic, organic and microbiological soil geochemical data and to ensure the data are available to a wide range of applications, issues and disciplines. The project is a cooperative tri-national initiative shared by the federal, provincial and state geological surveys of Canada, the United States and Mexico, and will produce the first-ever continental-scale map of the soil geochemistry of North America based on 13 215 sample sites yielding an overall sample density of 1 sample per 1600 km^2 (based on 40 km by 40 km grid cells).

All sampling and analytical protocols, including: (1) the identification of the various soil horizons to be sampled; (2) the type, number and size of samples to be collected; (3) the type and proper use of accepted sampling equipment; (4) laboratory preparation; and (5) analytical procedures, were designed by the Geological Survey of Canada in conjunction with numerous partners including the National Forestry Service, Agriculture and Agri-food Canada, Environment Canada and Health Canada.

Prior to the commencement of the 2007 field season, two planning meetings involving all potential partners including the Nova Scotia Department of Natural Resources were held. The first was held in Ottawa in October 2006, and involved discussions regarding the project objectives, especially establishing field sampling protocols. A February 2007 planning meeting was held in conjunction with the 2007 Atlantic Geoscience Society (AGS) Colloquium in Moncton in order to review project objectives and finalize sampling protocols. The two meetings were followed by a one week field orientation program held in the Amherst area in early June 2007. The orientation sampling program introduced the Nova Scotia sampling team to the field equipment, the sample data sheets, sampling protocols and the identification of various soil horizons to be sampled.

The Nova Scotia component of the project initially involved a total of 38 sample sites, but 57 sites (including three field duplicates) were ultimately sampled. Analytical results are pending, with the first results expected in the spring of 2008. Funding for the project was provided by: Natural Resources Canada and Health Canada.

Regional Geology

Bedrock Geology

The Atlantic Provinces are part of the Canadian Appalachian orogen which extends from Newfoundland, Nova Scotia, Prince Edward Island, and New Brunswick into Quebec. From west to east these terranes include the Humber, Dunnage, Gander, Avalon, and Meguma zones. The Canadian Appalachian orogen consists of early Paleozoic as well as older terranes that were accreted to Laurentia during the middle Paleozoic.

In Nova Scotia, rocks representing the late Neoproterozoic to Ordovician Humber Zone are located along the northern edge of western Cape Breton Island. The Dunnage Zone (subdivided into the Notre Dame and Exploits subzones) contains remnants of numerous Cambrian-Ordovician arc systems that existed within the Iapetus Ocean. Rock units likely equivalent to the Exploits Subzone have recently been recognized in the Faribault Brook area and include the Jumping Brook Suite on Cape Breton Island (Tucker et al., 2007). The Gander Zone occupies most of eastern Cape Breton as a distinct package of Lower Cambrian to Lower Ordovician sedimentary rocks

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likely formed on the edge of a passive continental margin. The Avalon Zone is a belt of distinctive Neoproterozoic, arc-related, volcanic and sedimentary sequences and related plutonic rocks. These rocks are overlain by Cambrian to Ordovician sedimentary rocks that are located in northern mainland Nova Scotia and eastern Cape Breton Island (Barr *et al.,* 1998). The outermost terrane in the Canadian Appalachian orogen is the Meguma Zone, a thick succession of dominantly Cambrian siliciclastics that are in turn disconformably overlain by the Upper Ordovician-Lower Devonian White Rock, Kentville and Torbrook formations (White *et al.,* 1999). Within the Meguma Zone is the Meguma Supergroup, host to the vast majority of the province's past-producing gold districts.

Surficial Geology

Most of the surficial glacial deposits and associated landforms throughout Nova Scotia were formed during the Wisconsinan glaciation in the last 70 000 years (Lewis *et al.,* 1998). Superimposed till sheets and various multiple-flow directional indicators, the result of shifting ice centres, have been mapped and indicate that Nova Scotia has had a relatively complex ice-flow history that includes palimpsest landforms such as lobate drumlins (Stea *et al.,* 1992; Stea and Finck, 2001; Stea, 2004).

The following summary of the glacial history of Nova Scotia is taken from Stea and Finck (2001) and Stea (2004). The oldest observed ice-flow indicators in Nova Scotia are associated with the Caledonia Phase (75-40 ka), with movement toward the east and southeast. South and southwest flow of the Escuminac Phase (22-18 ka) followed. The Scotian Phase (18-15 ka) was characterized by an ice divide situated over Nova Scotia and the resulting ice flow varied from northwestward in northern Nova Scotia to south and southeast in southern Nova Scotia. The Chignecto Phase (13-12.5 ka) was characterized by shifting ice flow associated with several small ice caps, the remnants of waning stages of the Scotian Phase glacier. The Collins Pond Phase was the final phase of glacier formation in response to a short-lived period of climatic cooling during the Younger Dryas Chronozone (approximately 11 ka).

Glacial dispersal distances vary from hundreds of metres to several kilometres down-ice from source (McClenaghan *et al.,* 1992; Stea and Finck, 2001).

Methods

Introduction

A total of fifty-four sites across the province were sampled according to the NASGLP protocols (Fig. 1). Field duplicates were also collected at three sites, bringing the total to fifty-seven sample sites. Concurrent with the Nova Scotia field program, sampling of an additional one hundred and sixteen sample sites in New Brunswick was being lead by Mike Parkhill and Toon Pronk (New Brunswick Department of Natural Resources).

Field Sampling

Soil samples were collected by shovel from hand-dug pits averaging approximately 90 cm in depth. Depth-based samples were collected from the Public Health (PH) layer (0-5 cm) as well as from the 0-15 cm , 15-35 cm and the 35-55 cm depth intervals. Horizon-based samples were collected from A, B and C soil horizons. Additional soil samples were collected by staff of Environment Canada and will be analyzed for metals, polycyclic aromatic hydrocarbons (PAH), total organic carbon, pH, grain size and limited toxicological testing (Mroz *et al.,* 2008).

In addition to collecting soil samples for analysis, measurements of: (1) soil gas radon; (2) *in situ* gamma ray spectrometric readings of Total Counts, eU, eTh, and K; and (3) soil permeability were also collected at each site. Additional material was also collected for bulk density and/or moisture content.

Detailed field descriptions including sample depth, colour, redoximorphic features, texture, clast type/percentage and root size/quantity were recorded at each site. Digital photographs of the setting of each site, as well as close-ups of the soil profiles, were also taken for future reference. All sample sites were geo-referenced in Latitude/ Longitude (NAD 83) by GPS and later converted to the Universal Transverse Mercator (UTM) grid (Zone 20).

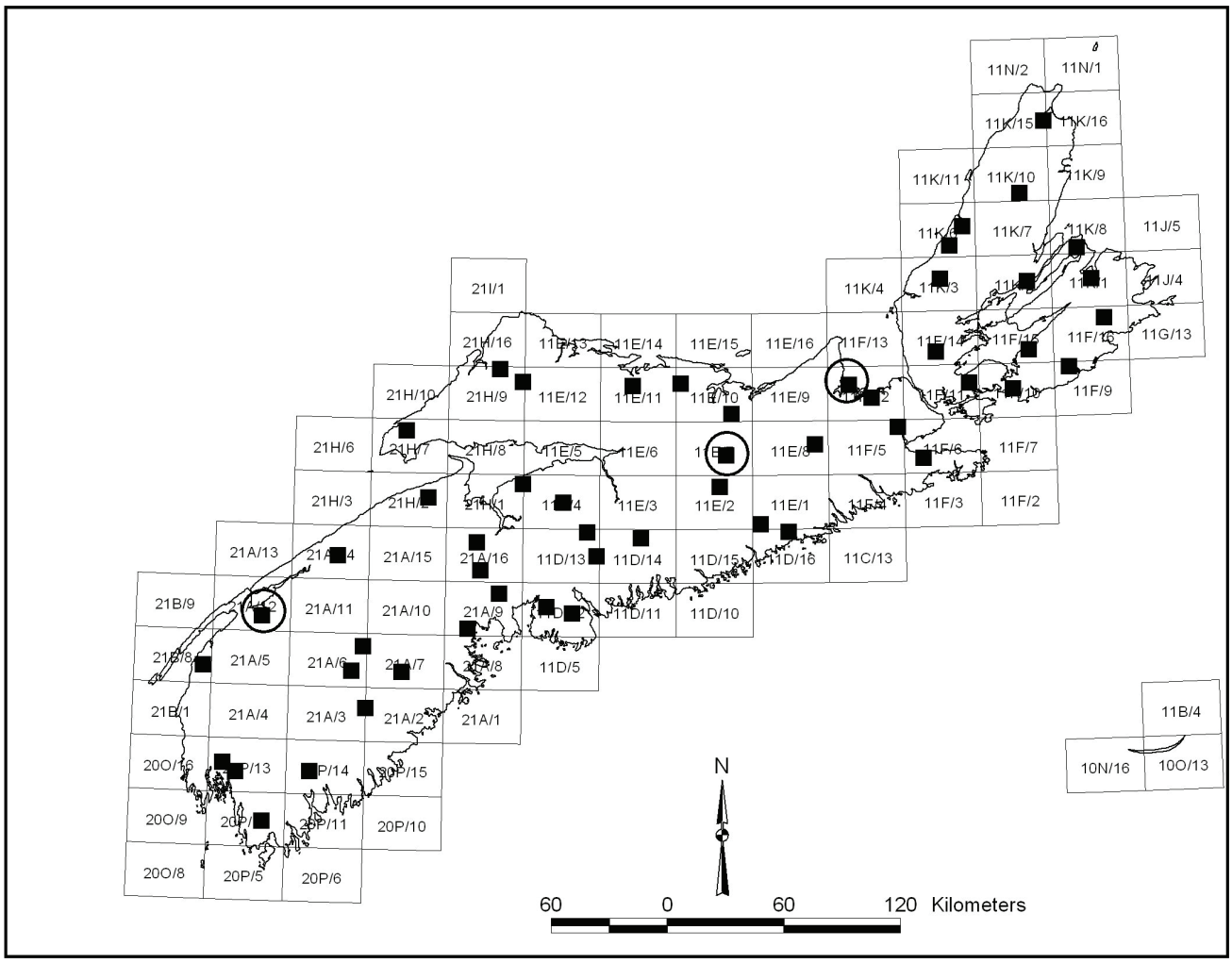

Figure 1. Sample locations (black squares) for soil samples collected during the 2007 field season on NTS grid of Nova Scotia. Circles indicate that field duplicates were also collected at the site.

Laboratory Preparation and Analytical Methods

All samples collected were sent to the Geological Survey of Canada (GSC) in Ottawa for preparation. Besides the large number of samples collected at each site, there is a wide range of preparation and analytical techniques that will be applied to the samples. The following description is not all-inclusive but gives a snapshot of the breadth of analytical techniques that will be applied.

All sample horizons (A, B and C) and depth-based samples will be sieved to obtain a <2.0 mm size fraction. The B and C horizons will also be sieved to obtain the <0.063 mm size fraction. All fractions will be analyzed by ICP/MS for multi-element geochemistry by commercial laboratories. Organic/inorganic C will be determined on the <2.0 mm size fraction only by the GSC in Ottawa.

The GSC will also be analyzing a <2.0 mm size fraction for pH and inorganics (using a weak water leach), as well as completing a size fraction analysis. Health Canada will take the lead in assessing bioaccessibility and perchlorates in the C horizon and the Public Health layer. The United States Geological Survey will complete X-Ray mineralogy studies on the <2.0 mm size fraction for the A and C horizon samples. Likewise, Agriculture Canada will analyze the <2.0 mm size fraction for all horizon- and depth-based soil samples for a number of soil variables related to soil nutrients.

The GSC will also complete bulk density and moisture content analysis for all soil horizons,

including the Public Health layer, and will determine their Munsell colour.

Results

All geochemical analytical results for the inorganic and organic chemistry are pending. It is anticipated that the first analytical results will likely be received by the spring of 2008 with the final results by the spring of 2009. Results for the other analytical techniques will likely be received sometime after the spring of 2008. The readings associated with radioactivity and radon are currently being assessed.

Conclusions

During the 2007 field season, the first soil samples of the North American Soil Geochemical Landscape Project (NASGLP) were collected in Nova Scotia and New Brunswick. The NASGLP is the first geochemical survey that is designed to provide a soil geochemical framework of inorganic, organic and microbiological soil geochemical data for all of North America using strict sample collection, preparation and analytical protocols. It is anticipated that the results will be used to determine regional background concentrations that will help provide the basic information necessary to link soil geochemistry with human and ecological health. This type of geochemical information will be useful in establishing guidelines for policy decisions regarding human and ecological health, as well as issues regarding land-use planning.

A total of 57 sample sites (including 3 field duplicates) were sampled across the province at an average sampling density of 1 sample per 1600 km^2. Concurrent sampling in New Brunswick resulted in the collection of soils samples from an additional 116 sample sites.

Analytical results are pending with the first results expected in the spring of 2008. Funding for the project was provided by the Geological Survey of Canada and Health Canada.

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