



Newsletter 7, December 2009

North American Soil Geochemical Landscapes Project — Canadian Update



Briefly.....

In this issue we report on the successful 2009 field season. A big thank-you to scientists from the GSC, provincial surveys, AAFC and other agencies for their efforts. Sampling in southern Ontario was completed and also in Newfoundland, except for a few sites. Regional and urban in-fill work was carried out in Saskatchewan and Alberta. For Canada, there is now continuous sample coverage over all of the Maritime Provinces, including Newfoundland. The collection of soil gas radon and radiometric data at Tri-national sites started in 2007 continued in 2009. This important value-added activity is a cooperative endeavour between Health Canada - Radiation Protection Bureau and the Geological Survey of Canada. Sampling was undertaken for another study by Environment Canada where invertebrates are used for assessing soil toxicity.

A significant part of this Newsletter is devoted to listing recent publications and venues where NASGLP results were presented. Peter Friske (GSC) has nearly completed compilation of the 2007 Maritime data and Eric Grunsky and Bob Garrett (GSC) are statistically analyzing and exploring these data. In this issue, Eric shows some results based on the 2004 transect data. Work on developing and documenting field and laboratory protocols is ongoing.

In 2009 sampling was completed in another 9 states of the United States, meaning that more than half of conterminous US is covered. Great strides have also been made in Mexico where over half the country will be sampled by the end of 2010.

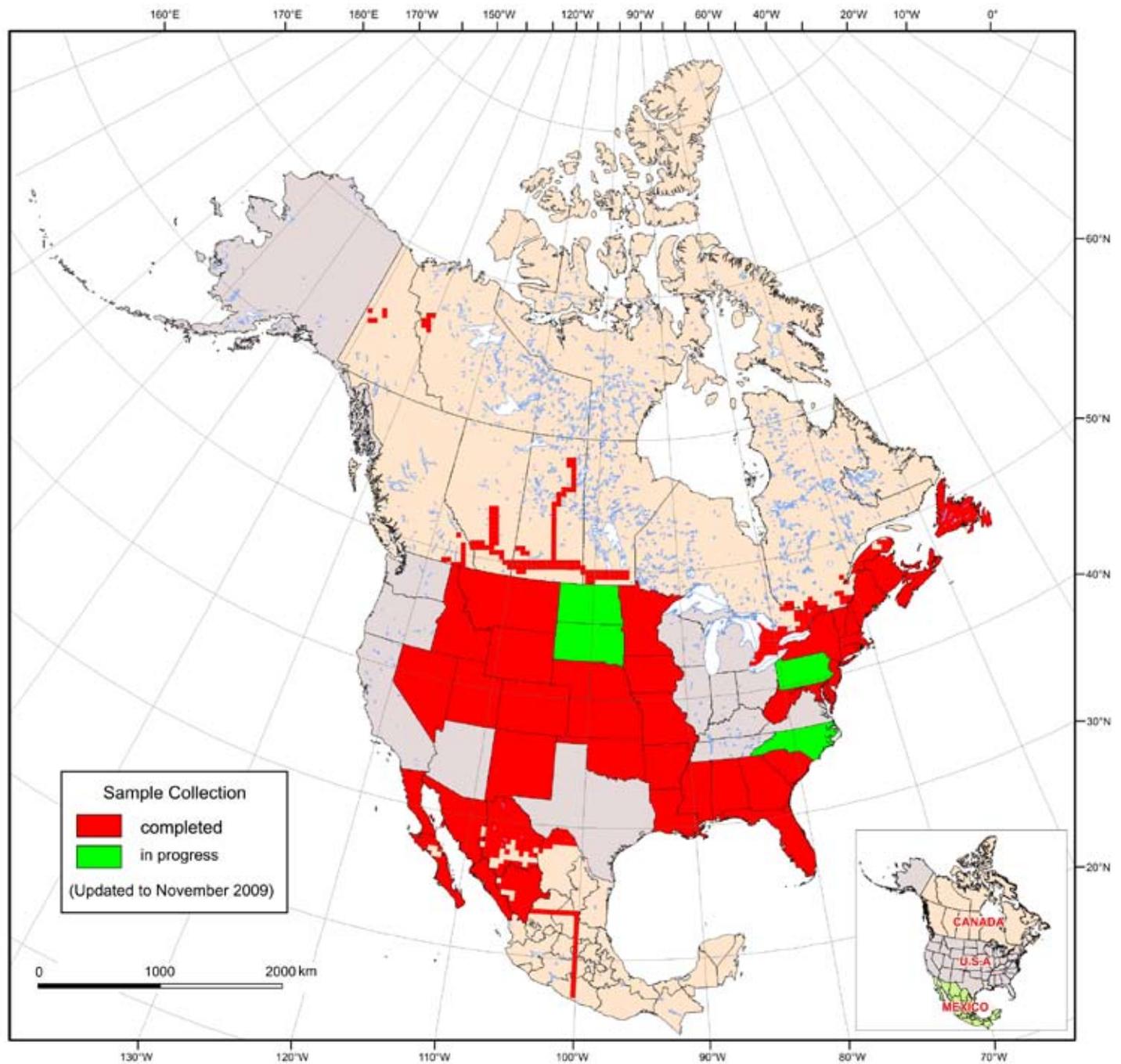
The 3-year Environment and Health Program, that included the NASGLP activities, ended in 2009. The new Environmental Geosciences Program (2009-2014) will support activities related to soil geochemical characterization. However, systematic sampling across Canada will no longer be the objective of work in the new program. Geochemical sampling will be confined to areas prospective for mineral resource development and will be undertaken to improve the understanding and assessment of ecosystem risks from this activity. There will be an extension of NASGLP sample coverage in the new areas where regional-scale soil geochemical data are needed to provide a regional context for data generated at more local scales. Planned activities include building on field and laboratory protocols for soils and developing best practice documents in support of government recommendations for regulatory and technical improvement.

The 3rd Workshop related to soil geochemistry is to be held in Ottawa on February 24-25, 2010. Details will be e-mailed out at a later date.

More Details.....

Sample collection over North America

The map below shows the progress to date on the NASGLP sampling.



Activity in Ontario and Alberta - Report from Brad Harvey (GSC)

Soil, soil gas radon and radiometric sampling was completed in southern Ontario and parts of eastern Quebec through the efforts of a team from GSC - Ken Ford, Brad Harvey, Marty McCurdy, Rick McNeil, - with the help of students Chris Stieber, Sean Murphy, Melissa Fafard and Liam Hartree. Airborne geophysical surveys were contracted out to complete southern Ontario, Manitoba, Saskatchewan and selected areas of eastern Quebec. The airborne data will be released in the spring of 2010.

In Alberta, samples were collected at 17 regional sites by Jill Weiss (Alberta Geological Survey) and Chris Stieber. Urban sampling was also undertaken at 18 sites in Calgary and Edmonton by Brad and Chris.

Ken, Brad, Marty, and Rick, helped by students - Liam Hartree and Jessica Rueger, continued urban sampling in the National Capital Region and in Chelsea, Quebec.

Sample collection in Newfoundland - Report from Steve Amor (Geological Survey of Newfoundland and Labrador)

Soil sampling of the island of Newfoundland began during the period of June and July, 2009. Thanks to the early completion of another project, it was possible to resume sampling in mid-August and by Labour Day, coverage was essentially complete, with gaps in the coverage being caused by lack of road access, impenetrable soil and in one case, simply bad timing. We encountered almost continuous fine weather with only two days completely lost to rain.

The sampling crew (Steve Amor of the Geological Survey of Newfoundland and Labrador, and Steven Fraser of Memorial University) was fortunate to have the services of Ken Ford and Martin McCurdy for four days in June, to get us started and instruct us in the finer points of spectrometer and soil-gas radon measurements, and soil sampling, respectively. Furthermore, they provided telephone support “on demand” throughout the work period. We also received invaluable assistance from Agrifoods Newfoundland, in the form of a day spent in the field with soil scientist Rick St. Croix of that organization, while their Corner Brook office acted as a receiving centre for additional supplies that were shipped from Ottawa while we were working in the western part of the island.

Sixty-four sites were sampled and total travelling distance was more than 15,000 km. In terms of distance, most of this was on Newfoundland’s excellent system of paved highways, but what seems like a disproportionate (read: infinite) time was spent inching along steadily-deteriorating forestry and cottage-access roads, before giving up on the GRTS-prescribed site and settling for being “somewhere within the cell”. We only needed to get a landowner’s (freely-given) access permission at one site.

Steve Amor of the Geological Survey of Newfoundland and Labrador collecting NASGLP samples. Photo by Stephen Fraser.



We also found time to collect bulk and “live” soil samples for the Biological Methods Section of Environment Canada, at a site near Clarenville that is both typical of much of the island in terms of surficial and vegetation cover, and easy of access both from the highway and from St. John’s itself.

If I could do it over again, I’d definitely add a machete to the tool kit, and give some thought to designing a different device for more effective bulk-density sampling of A-horizon and Public Health soils that are choked with roots.



More photos from Newfoundland. Above left - Steve Amor (GSNL) and Marty McCurdy (GSC) looking into the problem . Photo by Steven Fraser. Above right - Steven Fraser (Memorial University Newfoundland) cleaning ionization chambers (immediately) before turning in for the night. Photo by Steve Amor.

Saskatchewan Sampling - Report from Janet Campbell (formerly of Saskatchewan Geological Survey)

This past summer the Saskatchewan Geological Survey (SGS), Saskatchewan Ministry of Energy and Resources conducted more focused activities as part the Tri-national Project. The Saskatchewan team consisted of Janet Campbell (project leader), and summer assistants Luc Chabanole and Donovan Shire.

In June we joined forces with Steve Webster of the Ministry of Labour, and Brad Harvey and Chris Stieber of GSC to investigate the relationships between radon levels with soil gas radon. Two areas were selected for sampling. Eastend, in southwest Saskatchewan, is known for radon in both soil and groundwater originating from underlying bedrock sources, and Eston, where past sampling in public buildings and private homes had identified anomalous levels of indoor radon gas. In both areas, four regional Tri-national sites were selected, based on double density grid sampling, and also four green space sites in the hamlets. At the regional sites, soil horizon samples were collected according to protocol as well as the “public health”, national forest inventory and anthrax samples and soil gas radon and radiometric data. Work at the urban sites followed protocols for the ongoing national urban sub-activity (GSC), including collection of soil radon gas and ground gamma-ray spectrometry data and the “public health” soil sample. In conjunction with this work, Steve Webster installed both long term and short term monitors in homes near the regional sites and within the hamlets to determine indoor radon gas levels.

While up north as part of an SGS surficial mapping project, Janet and Luc collected samples from a Tri-national site on Robins Lake (74P/14). Core soil horizon samples as well as “public health” and National Forest Inventory samples were collected. Ground gamma-ray spectrometry measurements were made but unfortunately equipment was not available for measuring the on-site soil gas radon. It is hoped that, in future, geochemical samples from accessible Tri-national sites will be collected as part of ongoing SGS mapping programs within Saskatchewan.

The Robins Lake site was also selected for collection of soil arthropods and a Taiga Shield forest soil section to assist Juliska Princz (Environment Canada) with her biomethods development and research into the health of forest soils. Two bags were collected of the forest litter and surface soil for soil invertebrates study as well as 2 buckets of each soil horizon for reconstruction of the soil profile in the laboratory.



Above - Brad Harvey and Chris Stieber from GSC and Donovan Shire (in white) and Luc Chabanole (in yellow) collect samples west of Eastend in the Frenchman Valley, Saskatchewan. Photo by Janet Campbell.



Above - At the Robins Lake site, Luc Chabanole and Jory Stricker are collecting from the organic layer as part of an effort to recreate the soil profile for the soil arthropods study. The 2 bags at the right are samples collected for the above study. Photo by Janet Campbell.



Soil sampling according to urban protocols at an urban site in Eston, Saskatchewan, Steve Webster (Occupational Health and Safety Division, Saskatchewan Ministry of Labour), Brad Harvey (GSC), Chris Stieber (GSC) and Donovan Shire (far right) collected soil samples and soil gas radon and radiometric measurements. Photo by Janet Campbell.

Radon soil gas in the Halifax Regional Municipality: A progress report from Terry Goodwin (Nova Scotia Department of Natural Resources)

During the 2009 field season, additional radon soil gas samples were collected from within the Halifax Regional Municipality (HRM). The samples were collected as a continuation of the HRM radon soil gas study that began in 2008 and is part of the larger on-going NASGLP that was initiated during the 2007 field season.

One of the main objectives of this program is to determine radon soil gas concentrations, soil permeability and the soil radon potential (SRP) index within the HRM that encompasses an area where approximately 40% of the province's population resides. In 2008, a total of twenty radon soil gas samples were collected from various bedrock/soil types. The focus of the 2009 sampling program was to have a minimum of ten sample points in each of the six defined till units that characterize the surficial geology of the HRM. As a result, forty additional sample sites were tested in 2009.



Summer student, Kelsey O'Brien, extracts 150 ml of soil gas from the Sandy Lake sample site. Kelsey is working on the HRM radon data for a B. Sc. (Hons.) thesis at St. Francis Xavier University. Photo by Terry Goodwin.

The 2009 results closely mirror the 2008 results with the highest (mean) radon soil gas concentrations associated with locally-derived granite till sourced from the late stage, highly evolved leucomonzogranite. The distally-derived Lawrencetown Till returned the lowest radon soil gas concentration. Previous sampling of radon in soil gas indicates that radon is present everywhere across Nova Scotia and throughout the HRM.

It is anticipated that radon soil gas concentrations (as it applies to a particular bedrock or soil type unit) from this study will assist health officials and municipal planners determine if there is a correlation between homes with a high concentration of radon in indoor air with areas of naturally elevated radon in soil gas.

The radon work here in Nova Scotia has had tremendous impact and garnered abundant interest from a

number of groups. Some requests for meetings and presentations were related to education - Dr. Mark Gibson (Assistant Professor, Community Health and Epidemiology, Dalhousie University), Professor Svetlana Barkanova (Department of Physics, Acadia University), and Professor Zelda Abramson (Department of Sociology, Acadia University) for a sociology class.

Dr. Louise Parker (Research Director, Cancer Care Nova Scotia) is interested in the research results in order to determine where human exposure to (elevated) radon levels may occur. At the request of Nova Scotia Environment, there was a presentation on the radon work from across the Province and within HRM where Nova Scotia representatives from Health Canada were also in attendance. Two papers “Radon Soil Gas in Nova Scotia” and “Radon Soil Gas in the Halifax Regional Municipality: Should We Be Concerned?” in the annual NSDNR Report of Activities are requested frequently.

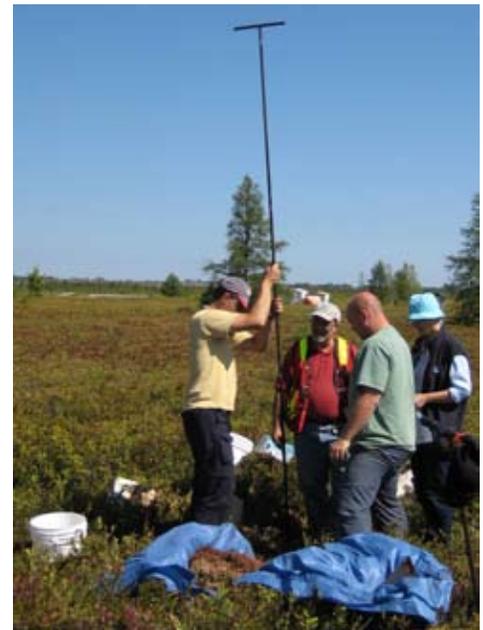
Development and Documentation of Field Sampling Protocols

A manual for sampling unfrozen mineral soils is now going through the review process at GSC. We expect that it will be released as Geological Survey of Canada Open File 6282 in early 2010.

There have been several excursions to the Mer Bleue outside Ottawa to develop protocols for sampling unfrozen organic soils. Participants from GSC included Rick McNeil, Alain Grenier, Inez Kettles, Peter Friske, Mélissa Fafard, Liam Hartree and Jessica Rueger and from Agriculture and Agri-Food Canada - Dave Kroetsch and Xiaoyuan Geng. At NASGLP sites in areas of organic soils, samples will be collected from the “public health” (0-5 cm layer) and from the following depth intervals corresponding to the 3 tiers used in the Canadian classification of organic soils - 0-40, 40-120, and 120-160 cm.



Above- Xiaoyuan Geng, (AAFC-CanSIS) , Dave Kroetsch (AAFC) and from GSC - Mélissa Fafard and Marty McCurdy - examine bog vegetation in the Mer Bleue. Photo by Inez. Kettles



Above right- Alain Grenier (GSC) using the macaulay corer to collect peat samples, accompanied by Dave Kroetsch (AAFC), Rick McNeil (GSC) and Inez Kettles (GSC). Photo by Peter Friske.

News from our International Partners

United States - Report from Dave Smith, USGS

In the United States, we had a very productive year in continuing our sampling. The following states have been completed this year: Florida, South Carolina, Georgia, Alabama, Oklahoma, New Mexico, Montana, Idaho, and Minnesota. Added to the states completed during the previous two years, this makes for a total of 2,677 sites that we have sampled. This represents about 55% of the conterminous United States. We hope to complete the conterminous United States by the end of 2011. That leaves Alaska still to do.

We also hope to complete Iowa and North Carolina by the end of this year, if all goes well. Significant progress has been made in Pennsylvania by the Pennsylvania Geological Survey and in North Dakota and South Dakota by the Natural Resources Conservation Service. Those states may also be completed by the end of the year, but we do not know for certain.

The following states are completed: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Missouri, Arkansas, Louisiana, Mississippi, Wyoming, Colorado, Utah, Nevada, Kansas, New Jersey, Maryland, Delaware, West Virginia, Nebraska, Florida, South Carolina, Georgia, Alabama, Oklahoma, New Mexico, Montana, Idaho, and Minnesota. The following states are in progress: North Dakota, South Dakota, Pennsylvania, Iowa, North Carolina.

Our special issue of Applied Geochemistry was published in August of this year (Volume 24, Issue 8). The issue contained 21 papers dealing with results from the pilot study phase of the NASGLP. The issue represents a lot of hard work by all involved.

Also this year, I gave a briefing about the project to the U.S. National Committee for Soil Science, National Academy of Sciences. We also had a session at the 24th International Applied Geochemistry Symposium in Fredericton, New Brunswick devoted to the project. In November, we have three presentations at the National Environmental Public Health Conference in Atlanta, Georgia. Andy Rencz and I attended the Global Geochemical Mapping Symposium in Langfang, China on October 10-12 and discussed the NASGLP in our presentations. A Tri-national project meeting will be held in Reston, Virginia at the USGS Headquarters on November 17-18.

Harley King (USGS) prepared to collect soil sample in eastern Montana. (Photo by Jim Kilburn, USGS.)



Mexico - Report from Alfredo De la Calleja Moctezuma, Servicio Geologico Mexicano

During this year's field work the Mexican team was working in the Baja California, Baja California Sur, Sonora, Sinaloa, Nayarit and Durango states. The area covered was 444,800 km² and more than 278 40 x 40 km cells. On account of bad weather and road conditions, a very small area in each state is remaining to be sampled and will be completed next year.

We have continued our analytical work at the Oaxaca City laboratory facilities. The chemical mobility test has been undertaken on the samples from almost the total 244 cells sampled last year.



Above - Jessica Rivera Perez collecting a sample near the town of C. Carreras, County Tepehuanes, Durango State.



Above - Ángel Campos Jiménez and Veronica work at the summit of Sierra Madre Occidental in the Chihuahua State.



Above - Alfredo at the Sonoran Basin and Range area, near the Sierra Madre Occidental.



Left - Veronica C. Rivas Riosour is a biologist working at the Chihuahua Range. She is collecting a soil sample near the town of La Laja, County Guachochil, Chihuahua State.



Above - Alfredo De la Calleja collecting a sample at San José, County Pueblo Nuevo, Durango State.

Re-evaluation of the 2004 Soil Survey Transect - United States and Canada - Reported by Eric Grunsky

A re-evaluation of the soil geochemistry and mineralogy of the east-west and north-south transects has been carried out by Larry Drew (USGS), Eric Grunsky (GSC) and Laurel Woodruff (USGS). The study confirms continental trends in both the geochemistry and mineralogy. From west to east, there is a progressive amount of weathering in the soil profile, which is indicated by a relative increase in organic carbon, Hg, Se, As, Cd and Zn. As well, there is a relative increase in quartz, clays and other sheet silicates in sols in the eastern part of the transect, whereas the western part of the transect has a relative increase in carbonate, feldspar and ferromagnesian minerals. This pattern is also reflected in the multi-element geochemistry.

Results from the north-south transect show a distinct break in geochemical associations and mineralogy at the southern limit of glaciation (~43 degrees north latitude). The mineralogy and geochemistry of samples within the zone of glaciation show less overall weathering. Linear discriminant analyses of the multi-element geochemistry over both transects indicate that the compositions are distinct between ecoregions and that the ecoregion origin from any part of the soil profile can be determined from the geochemistry of the sample. This finding is consistent for both the east-west and north-south transects.

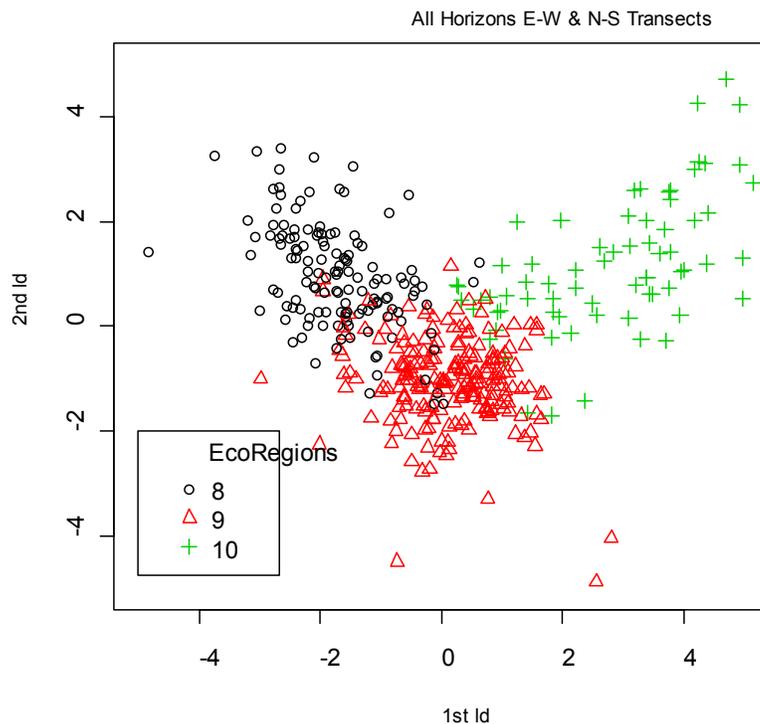


Figure shows the first two linear discriminants for the three major ecoregions intersected by the transect. There is a notable distinction between the geochemical compositions of the soils over the ecoregions - 8 - Eastern Temperate Forests; 9 - Great Plains; and 10 - North American Deserts.

PUBLICATIONS, CONFERENCES AND MEETINGS

Journal Articles

The special issue of *Applied Geochemistry* was published in August of this year (Volume 24, Issue 8). The issue contained the following 21 papers dealing with results from the pilot study phase of the NASGLP.

- 1.1. Smith, D.B., Woodruff, L.G., O'Leary, R.M., Cannon, W.F., Garrett, R.G., Kilburn, J.E., Goldhaber, M.B., 2009. Pilot studies for the North American Soil Geochemical Landscapes Project—Site selection, sampling protocols, analytical methods, and quality control protocols. *Applied Geochemistry* 24, 1357 – 1368.
2. Woodruff, L.G., Cannon, W.F., Eberl, D.D., Smith, D.B., Kilburn, J.E., Horton, J.D., Garrett, R.G., Klassen, R., 2009. Continental-scale patterns in soil geochemistry and mineralogy: Results from two transects across the United States and Canada. *Applied Geochemistry* 24, 1369 – 1381.
3. Klassen, R.A., 2009. Geological controls on soil parent material geochemistry along a northern Manitoba - North Dakota transect. *Applied Geochemistry* 24, 1382 – 1393.
4. Eberl, D.D., Smith, D.B., 2009. Mineralogy of soils from two continental-scale transects across the United States and Canada and its relation to soil geochemistry and climate. *Applied Geochemistry* 24, 1394 – 1404.
5. Garrett, R.G., 2009. Relative spatial soil geochemical variability along two transects across the United States and Canada. *Applied Geochemistry* 24, 1405 – 1415.
6. Chiprés, J.A., de la Calleja, A., Tellez, J.I., Jiménez, F., Cruz, C., Guerrero, E.G., Castro, J., Monroy, M.G., Salinas, J.C., 2009. Geochemistry of soils along a transect from Central Mexico to the Pacific Coast: A pilot study for continental-scale geochemical mapping. *Applied Geochemistry* 24, 1416 – 1428.
7. Bern, C.R., 2009. Soil chemistry in lithologically diverse datasets: The quartz dilution effect. *Applied Geochemistry* 24, 1429 – 1437.
8. Garrett, R.G., Hall, G.E.M., Vaive, J.E., Pelchat, P., 2009. A water leach procedure for estimating bioaccessibility of elements in soils from transects across the United States and Canada. *Applied Geochemistry* 24, 1438 – 1453.
9. Morman, S.A., Plumlee, G.S., Smith, D.B., 2009. Application of in vitro extraction studies to evaluate element bioaccessibility in soils from a transect across the United States and Canada. *Applied Geochemistry* 24, 1454 – 1463.
10. Griffin, D.W., Petrosky, T., Morman, S.A., Luna, V., 2009. A survey of the occurrence of *Bacillus anthracis* in North American soils over two long-range transects and within post-Katrina New Orleans. *Applied Geochemistry* 24, 1464 – 1471.
11. Reeves, J.B., III, Smith, D.B., 2009. The potential of mid- and near-infrared diffuse reflectance spectroscopy for determining major- and trace-element concentrations in soils from a geochemical survey of North America. *Applied Geochemistry* 24, 1472 – 1481.
12. Goldhaber, M.B., Morrison, J.M., Holloway, J.M., Wanty, R.B., Helsel, D.R., Smith, D.B., 2009. A regional soil and sediment geochemical study in northern California. *Applied Geochemistry* 24, 1482 – 1499.
13. Morrison, J.M., Goldhaber, M.B., Lee, L., Holloway, J.M., Wanty, R.B., Wolf, R.E., Ranville, J.F., 2009. A regional-scale study of chromium and nickel in soils of northern California, USA. *Applied Geochemistry* 24, 1500 – 1511.
14. Wanty, R.B., Goldhaber, M.B., Morrison, J.M., Lee, L., 2009. Regional variations in water quality and relationships to soil and bedrock weathering in the southern Sacramento Valley, California, USA. *Applied Geochemistry* 24, 1512 – 1523.

15. McCafferty, A.E., Van Gosen, B.S., 2009. Airborne gamma-ray and magnetic anomaly signatures of serpentinite in relation to soil geochemistry, northern California. *Applied Geochemistry* 24, 1524 – 1537.
16. Holloway, J.M., Goldhaber, M.B., Morrison, J.M., 2009. Geomorphic controls on mercury accumulation in soils from a historically mined watershed, Central California Coast Range, USA. *Applied Geochemistry* 24, 1538 – 1548.
17. Tuttle, M.L.W., Breit, G.N., 2009. Weathering of the New Albany Shale, Kentucky, USA: I. Weathering zones defined by mineralogy and major-element composition. *Applied Geochemistry* 24, 1549 – 1564.
18. Tuttle, M.L.W., Breit, G.N., Goldhaber, M.B., 2009. Weathering of the New Albany Shale, Kentucky: II. Redistribution of minor and trace elements. *Applied Geochemistry* 24, 1565 – 1578.
19. Chiprés, J.A., Castro-Larragoitia, J., Monroy, M.G., 2009. Exploratory and Spatial Data Analyses (EDA-SDA) for determining regional background levels and anomalies of potentially toxic elements in soils from Catorce-Matehuala, Mexico. *Applied Geochemistry* 24, 1579 – 1589.
20. Cannon, W.F, Horton, J.D., 2009. Soil geochemical signature of urbanization and industrialization—Chicago, Illinois, USA. *Applied Geochemistry* 24, 1590 – 1601.
21. Grunsky, E.C., Drew, L.J., Sutphin, D.M., 2009. Process recognition in multi-element soil and stream-sediment geochemical data. *Applied Geochemistry* 24, 1602 – 1616.

Government Reports

- Garrett, R.G., Kettles, I M., 2009. North American Soil Geochemical Landscapes Project (NASGLP): Database of GRTS sample sites with notes on the sampling design and site selection procedure. Geological Survey of Canada, Open File 6300. CD-ROM.
- Rencz, A.N., Kettles, I M (eds.), 2009. North American Soil Geochemical Landscapes Project (NASGLP): Proceedings of Workshop II, Ottawa, Canada, 2008. Geological Survey of Canada, Open File 6209. CD-ROM.
- Rencz, A.N., Kettles, I M (eds.), 2009. North American Soil Geochemical Landscapes Project (NASGLP): Proceedings of Workshop III, Ottawa, Canada, 2009. Geological Survey of Canada, Open File 6210. CD-ROM.
- Klassen, R A, Douma, S L, Ford, A, Rencz, A, Grunsky, E., 2009. Geoscience modelling of relative variation in natural arsenic hazard potential in New Brunswick; Geological Survey of Canada, Current Research (Online) 2009-7, 12 p.

Professional Association Publications

- Kettles, I.M., Rencz, A.N., Friske, P.W.B.
2008: The North American Soil Geochemical Landscapes Project – a Canadian perspective; *Explore* (Association of Applied Geochemists); No. 141, December, 2008. Download from <http://www.appliedgeochemists.org/>

Conferences and Meetings

- Smith, D.B., 2009. National-scale geochemical mapping in the United States: History and progress. Abstracts, Global Geochemical Mapping Symposium, Langfang, China, October 10 - 12, 2009, p. 6 - 9.
- Rencz, Andrew, 2009. Evolution of geochemical surveys at the Geological Survey of Canada. Abstracts, Global Geochemical Mapping Symposium, Langfang, China, October 10 - 12, 2009, p. 10.
- Grunsky, E.C., Garrett, R.G., Friske, P.W.B., McCurdy, M. 2009. Testing the variants of Aqua Regia digestion using certified reference materials, in 24th International Applied Geochemistry Symposium, Lentz, D.R., Thorne, K.G., Beal, K-L. (eds.), University of New Brunswick, Fredericton, New Brunswick Canada, June 1-4, 2009, p. 705-708.

Goodwin, T.A., Friske, P.W.B., Ford, K.L., Grunsky, E.C. 2009. The North American soil geochemical landscapes project: preliminary results from Nova Scotia, in 24th International Applied Geochemistry Symposium, Lentz, D.R., Thorne, K.G., Beal, K-L. (eds.), University of New Brunswick, Fredericton, New Brunswick Canada, June 1-4, 2009, p. 701-704.

Grunsky, E.C., Smith, D.B., Friske, P.W.B., Woodruff, L.G. 2009. The North American soil geochemical landscapes project: preliminary results from the northeast United States and Maritime Provinces of Canada, in 24th International Applied Geochemistry Symposium, Lentz, D.R., Thorne, K.G., Beal, K-L. (eds.), University of New Brunswick, Fredericton, New Brunswick Canada, June 1-4, 2009, p. 709-712.

Drew, L.J., Grunsky, E.C., Sutphin, D.M., Woodruff, L.G., 2009. Compositional Data Analysis of the Mineralogy and Geochemistry of Soil and Stream Sediment Samples Along an East-West Continental-scale Transect in the United States. Proceedings, International Association for Mathematical Geology, Annual Meeting, Stanford University, California, USA, August, 2009.

Grunsky, E.C., 2009. Geochemical variability and process recognition from soils in the Maritime Provinces, Canada, American Geophysical Union, Fall Meeting, San Francisco, USA, December, 2009.

For More Information or To Make Submissions to the Next Newsletter



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