

**Geological Survey of Canada
Open File Report 2685**

19 August, 1993

**Prairie Kimberlite Study -
Soil and Till Geochemistry and Mineralogy,
Low Density Orientation Survey Traverses,
Winnipeg - Calgary - Edmonton - Winnipeg
1991**

**Robert G. Garrett, Mineral Resources Division, GSC Ottawa
and
Harvey Thorleifson, Terrain Sciences Division, GSC Ottawa**

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Canada-Saskatchewan Partnership Agreement on Mineral Development
(1990-1995)
a subsidiary agreement under the Canada-Saskatchewan
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**Manitoba Department of Energy and Mines
Geological Services Branch**

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Introduction

The chemical and mineralogical results for two ultra-low density orientation survey soil (1 site per linear east-west 40 km interval) and till (1 site per 50 km of highway) traverses completed across the southern Canadian prairies in August 1991 are released.

These data relate to a project whose objective is to provide geochemical and mineralogical data on the regional variability of soils and glacial drift in order to assist in the exploration for kimberlites/lamproites and gold paleo-placers in the southern Prairies. Specifically by:

1. Providing geochemical, mineralogical and pebble lithology information that will permit the provenance of the till units occurring at the surface to be determined, and preparing maps indicating the boundaries of distinctive till units, in order to better understand their sources of origin and transport,
2. Providing baseline information on the above compositions in order to assist the minerals industry in establishing expected background ranges in areas where they are exploring,
3. Determining the down-ice extent of kimberlitic or lamproitic indicator mineral dispersion trains in tills from pipe/dyke swarms (N.B., not individual kimberlites or lamproites),

4. Determining the pattern of gold distribution in the tills and C horizon soils and correlating them with known placer gold occurrences,
5. Interpreting the till and C horizon soil trace element data to determine if there indications of undiscovered base-metal (Pb-Zn) and other (Ba-Sr-F) mineral resources,
6. Comparing geochemical data for soils and tills in order to assess their relative merits as an exploration sampling medium (soils being cheaper to collect than tills); and comparing geochemical and mineralogical data for till heavy mineral concentrates in order to assess their relative merits in till provenance studies (geochemical data being cheaper to acquire than mineralogical data), and
7. Providing data on the background (baseline) levels and spatial variability of a wide range major, minor and trace elements in A20 and C horizon soils that would be of interest to those concerned with epidemiology and the agricultural sciences.

The 1991 orientation survey traverses were undertaken to meet several objectives in the southern Prairies, i.e. to determine:

1. The background levels of a variety of major, minor and elements in soils and tills across the region using different analytical procedures on different size fractions,
2. The gross abundance of heavy minerals in the tills,
3. If significant patterns of regional variation occurred in the above data,
4. The patterns of element distribution associated with the weathering profile and proximity to a major highway, and
5. The range of composition for any kimberlitic indicator minerals recovered, together with compositional ranges for non-kimberlitic minerals.

The project is being supported in part as a contributions to the Canada-Saskatchewan Partnership Agreement on Mineral Development (1990-1995), a subsidiary agreement under the Canada-Saskatchewan Economic and Regional Development Agreement, and to the Canada-Alberta Agreement on Mineral Development (1992-1995), a subsidiary agreement under the Canada-Alberta Economic and Regional Development Agreement. The Manitoba Department of Energy and Mines, Geological Services Branch, has supported the project, in particular by participating in the soil and till sampling programme undertaken in 1992. In addition, the work is being funded from Mineral Resource and Terrain Sciences Divisions project funds.

Location of Traverses

The southern traverse commenced near Piney, Manitoba, 120 km southeast of Winnipeg and followed the line of Manitoba Highways 12, 205, 59 and 23 to the Red-Coat Highway (2). The Red-Coat Highway was followed through Saskatchewan (Hwy. 13) to Highway 37 north of Shaunavon. A new gravel road was continued on west into the Cypress Hills to Highway 614, and thence to Maple Creek

(via Hwy. 724). At Maple Creek the Trans-Canada Highway was joined and followed to Calgary. The soil traverse was continued west of Calgary to Exshaw. Only tills were collected between Calgary and Edmonton along the line of Highway 2.

The northern soil traverse re-commenced east of Edson, Alberta, and followed the Yellowhead Highway to Edmonton, where till sampling re-commenced. Both media were sampled along the Yellowhead Highway (16) through Alberta to Yorkton, Saskatchewan. From Yorkton Saskatchewan Highway 10 was followed to Roblin, Manitoba. Sampling continued along Manitoba Highway 5 to Ste. Rose du Lac, thence Highway 68 was followed to Highway 6 at Mulvihill. The traverse continued south and east on Highway 6 to the junction with Highway 67, thence east along Highways 67 and 44 to River Hills, Manitoba.

Sample Collection

Till samples (25 and 2 kg) were collected from road cuts, spoil pits, etc. at approximately 1-2 m below surface in order to minimize the effects of weathering on carbonate content and heavy mineral preservation. Soil samples (2 kg) were collected from the A₂₀ and C horizons, approximately 0-20 cm and 30-50 cm respectively, by spade and Dutch auger in fields adjacent to the highways. The A₂₀ designation is used in order to specifically describe the material sampled, i.e., material from the top 20 cm of the soil profile (pedon). The term A_p is often used to describe a similar material from the "ploughed" horizon. However, as the depth of ploughing varies from region to region the interpretation of A_p varies, often being taken as 15 cm. The A₂₀ designation also more truly reflects the situation in unploughed pasture and range areas where a 20 cm channel sample was collected and homogenized.

A suite of 88 A₂₀ and C horizon soils and 50 till samples were collected along the above described route between August 7 and August 17, 1991. A stratified random sampling design was employed. Each 160 km east-west section of traverse was divided into 4 adjacent 40 km sections. One of these was sampled in duplicate, and the duplicate field sample was split at the sample preparation stage (<2 mm) and then ball-milled and analyzed in duplicate.

In addition three vertical soil profiles were collected along the southern traverse at Grunthal (black ortho-chnozem), Manitoba; Arcola (black chernozem), Saskatchewan; and Verwood (solonetzic brown chernozem), Saskatchewan. A horizontal A₂₀ soil sample traverse (4 km NW of Saskatoon city limits) was collected systematically from the northwest-southeast Yellowhead Highway to a point 400 m to the northeast. The soils, dark brown chernozems, developed on glacio-lacustrine sediments and the purpose of the traverse was to determine the effect of highway contamination on the A₂₀ soil chemistry. A series of 10 cm till samples were collected in profile to a depth of 1.5 m at till site 3037 (3 km NW of Saskatoon city limits) to determine the extent of carbonate leaching in calcareous tills close to the surface.

Field data, including UTM coordinates, were recorded at each site. Soil sampling notes followed the recommendations made in Garrett, 1974; till sampling notes followed Terrain Sciences Division field procedures. Note that Munsell colours were recorded for moist material. The soil files contain the soil classifications for the sample sites on the basis of Agriculture Canada's 1:1 million scale Soil Landscape maps of Manitoba, Saskatchewan and Alberta. In the digital files a set of Lambert

Conformal coordinates are also recorded, these permit the plotting of the data so that it overlays the Geological Survey of Canada's 1:5 million map series.

Sample Preparation and Analysis

The soils were air dried at the GSC, then screened using a stainless steel sieve, and the <2 mm fraction retained. The C horizon <63 µm fraction was prepared by dry sieving a split of the <2 mm material using a stainless steel 230 mesh sieve. For both the A and C horizon samples, 50 g of the <2 mm material was ball-milled by Bondar-Clegg & Co., Gloucester, to approximately <100 µm in preparation for analysis.

The 3 kg till samples were prepared for geochemical analysis at the GSC. A 500 g split was air dried and screened and the <2 mm fraction retained. Sealed canisters containing 300 g of air dried <2 mm till were permitted to equilibrate for two weeks prior to gamma ray spectrometric analysis. The <63 µm fraction was prepared by dry sieving a split of the <2 mm material using a stainless steel 230 mesh sieve. A 75 g split of the <2 mm fraction was pulverized to approximately <100 µm in preparation for other geochemical analyses. Prior to being pulverized, the >2 mm <63 µm fraction was repeatedly washed and dried to prepare a sand fraction free of silt/clay particles. The <2 µm fraction was prepared by centrifugation. Following a low RPM spin designed to remove the >2 µm fraction, a high RPM spin was used to remove the <2 µm fraction from suspension.

The 25 kg (5 gallon) till samples were submitted to the Saskatchewan Research Council, Saskatoon, for preliminary processing. Each sample was disaggregated in a cement mixer with the aid of sodium metaphosphate (calgon). In a few cases, repeated washings were required to prevent flocculation of sulphate and carbonate rich samples. The disaggregated till was screened at 10 mesh to remove the >2 mm fraction which was washed, dried and screened prior to lithological analysis. Following experiments using shaker tables as a heavy mineral pre-concentration method, the entire <2 mm fraction, washed of its clay and fine silt fraction, was submitted to CF Mineral Research, Kelowna, for indicator mineral analysis.

CF Mineral Research used the following procedures. The sand/coarse silt fraction of the till samples was separated at 2.96 SG using tetrabromoethane. The >2.96 SG fraction was subsequently separated at 3.2 SG using methylene iodide (MI) diluted with acetone. The MI concentrate was screened at 250 µm (60 mesh) and 63 µm (230 mesh). Ferromagnetic minerals, i.e., magnetite, were removed using a Carpcop top feed roll separator. The almandine and ferro-ilmenite rich paramagnetic fraction was removed using a Carpcop bottom-feed separator, followed by Frantz isodynamic separation at low amperage. A higher amperage Frantz pass was then used to remove the non-magnetic fraction from the weakly paramagnetic fraction, which was subsequently visually examined for potential kimberlitic indicator minerals. An average of 70 mineral grains from the 0.25-2.0 mm fraction of each sample were mounted and polished. 75% of these mounted grains were regarded as potential eclogitic garnets. Black opaque grains considered possible picro-ilmenites and chromites, as well as potential lamproitic tourmalines, each make up about 10%. The remaining grains are green clinopyroxenes to be tested for chrome diopsides, and a total of 6 purple grains considered likely to be peridotitic garnets. The grains were analyzed using a multi-element EDS scan followed by quantitative EDS analysis of selected grains. All grains were later re-analyzed by electron microprobe in Electron Probe Laboratory (G.J. Pringle, J. Stirling, Mineralogy Section, Mineralogy and Chemistry Subdivision, Mineral Resources

Division) of the GSC in order to test analytical procedures being developed for this application. In addition to grains selected as potential indicator minerals, a selection of background grains were analyzed to obtain a reference set of data for non-kimberlitic minerals in the area. Peridotitic garnets subsequently were analyzed for Ni and several other elements by proton microprobe at the University of Guelph. Mineral identification for the purpose of characterizing the bulk mineralogy of the concentrates, as well as pebble lithology, were completed by Consorminex of Gatineau, Quebec.

Following preparation into different size fractions, the sample suite for geochemical analysis was augmented with control and duplicate samples and submission to the laboratory.

The geochemical analyses of soils and tills, with the exception of the carbonate (Chittick) determinations for the <63 µm fraction of the tills and the gamma-ray spectrometric K, Th, U determinations for the <2 mm tills, both undertaken at the GSC, Ottawa, were completed under contract by Activation Laboratories Ltd. The wet chemical procedures were carried out for Activation Laboratories by Acme Analytical Laboratories Ltd. The procedures were as follows:

1.	INAA, approximately 20 g sample Au, Ag, As, Ba, Br, Ca, Co, Cr, Cs, Fe, Hf, Hg, Ir, Mo, Na, Ni, Rb, Sb, Sc, Se, Sn, Sr, Ta, Th, U, W, Zn, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu
2.	ICPES, near-total HF-HCl-HNO ₃ -HClO ₄ attack, 0.5 g sample Mo, Cu, Pb, Zn, Ag, Ni, Co, Mn, Fe, As, U, Th, Sr, Cd, Sb, Bi, V, Ca, P, La, Cr, Mg, Ba, Ti, Al, Na, K, W, Zr, Sn, Y, Nb, Be, Hg
3.	ICPES, partial 3 ml 3-1-2 HCl-HNO ₃ -H ₂ O attack on 0.5 g sample at 90° C for 1 hr., diluted to 10 ml Mo, Cu, Pb, Zn, Ag, Ni, Co, Mn, Fe, As, U, Th, Sr, Cd, Sb, Bi, V, Ca, P, La, Cr, Mg, Ba, Ti, B, Al, Na, K, W
4.	ICPES, hydride procedure on partial leach solution from procedure 3 above As, Sb, Bi, Ge, Se, Te

It should be noted that for several elements all, or a large part, of the data are reported as < values. These data are reported as they provide information as to detection limits that would have to be improved if quantitative data were required for those elements.

Results

The orientation survey results were required in order to determine if it was appropriate to continue the work in 1992 with a grid survey covering the southern Prairies. In particular, if the originally (1990) proposed grid design should be modified on the basis of the 1991 findings, and what mineralogical and geochemical analytical procedures should be used in the full 1992 survey.

Indicator Minerals in Till Samples

The results from the 1991 orientation survey traverse samples indicate that kimberlitic indicator minerals can be recovered from the heavy mineral fraction of 30 kg till samples, and that these occurred in identifiable geographic clusters.

From an immediate mineral exploration viewpoint the summary of indicator mineral frequency table is of the greatest interest (T_HM_PIK.DAT). The table indicates that an average of 2 0.25-2.0 mm indicator minerals were recovered per sample, including 13 peridotitic garnets (high Mg and Cr), 17 eclogitic garnets (high Ca, Mg, and Ti), 62 chrome diopsides (high Cr and Ca, low Na and Fe), and 4 picro-ilmenites (high Mg). The UTM coordinates, and township, quarter section and range, for the sample sites are recorded in the digital file.

>3.2 SG, 0.25-2.0 mm, Indicator Mineral Frequency Table

Sample number	Site name	P-Gar count	E-Gar count	Cr-Dip count	Mg-Ilm count	Total count
3001	Piney	1	0	0	1	2
3002	Grunthal	0	0	1	0	1
3003	St. Leon	0	0	1	0	1
3004	Baldur	2	0	0	0	2
3005	Elgin	1	1	0	0	2
3006	Reston	1	0	0	0	1
3007	Redvers	0	0	0	0	0
3008	Stoughton	0	1	1	0	2
3009	Weyburn	0	1	0	0	1
3010	Khedive	1	2	3	0	6
3011	Ogema	0	1	3	0	4
3012	Assiniboia	0	0	2	0	2
3013	Lafleche	0	1	1	0	2
3014	Aneroid	0	0	0	0	0
3015	Admiral	0	0	0	1	1
3016	Gull Lake	0	0	1	0	1
3017	Piapot	0	0	0	0	0
3018	Maple Crk.	0	0	0	0	0
3019	Medicine Hat	0	0	1	0	1

3020	Suffield	0	1	0	0	1
3021	Brooks	0	0	0	0	0
3022	Gleichen	1	1	1	0	3
3023	Calgary	0	0	1	0	1
3024	Airdrie	0	0	0	0	0
3025	Olds	0	0	0	0	0
3026	Red Deer	1	0	0	0	1
3027	Ponoka	0	1	1	0	2
3028	Leduc	0	0	0	0	0
3029	Edmonton	0	0	1	0	1
3030	Vegreville	0	1	0	1	2
3031	Mannville	1	0	1	0	2
3032	Kitscoty	0	0	0	0	0
3033	Marshall	1	0	2	0	3
3034	Maidstone	1	0	0	0	1
3035	North Battleford	1	0	0	0	1
3036	Ruddell	1	1	0	0	2
3037	Saskatoon	0	0	2	0	2
3038	St. Denis	0	0	1	0	1
3039	Viscount	0	0	1	0	1
3040	Lanigan	0	2	2	0	4
3041	Wynyard	0	1	1	0	2
3042	Foam Lake	0	0	2	0	2
3043	Theodore	0	0	4	0	4
3044	Yorkton	0	1	8	0	9
3045	Roblin	0	0	13	0	13
3046	Dauphin	0	0	0	0	0
3047	Ste. Rose du lac	0	1	1	0	2
3048	Eriksdale	0	0	0	0	0
3049	Woodlands	0	0	1	0	1
3050	River Hills	0	0	5	1	6

Sites south of Brandon and Winnipeg yielded 5 peridotitic garnets, including a G10 near the town of Reston, Manitoba. The highest chrome diopside concentration was found in the Yorkton-Roblin area. Between Weyburn and Assiniboia, chrome diopsides, eclogitic garnets, and 1 peridotitic garnet were recovered. In the Calgary area, results from Gleichen northwards to Ponoka include 2 peridotitic garnets, 2 eclogitic garnets, and 2 chrome diopsides. Between Edmonton and Saskatoon, 5 peridotitic garnets and other minerals may represent long distance glacial dispersal from the Fort à la Corne camp.

Excluded from the list of indicator minerals are those recovered from the 63-250 µm fraction, which were only examined for 5 sites. Included, however, are indicator minerals recognized among grains picked as background. This includes 6 chrome diopsides, 1 from site 3040 and 5 from 3050, and two Mg-ilmenites, one from 3030 and one from 3050.

All peridotitic garnets (including megacrysts) which were identified during the first phase of analyses were analyzed by proton microprobe at the University of Guelph, primarily to determine their Ni contents, and thus infer their temperatures of formation (T_HM_TNI.DAT). Two grains out of seven produced nickel temperatures in the range of diamond stability proposed by Griffin et al. (1993). An evaluation of regional thermal gradients, as well as other assumptions, will be required, however, for a confident application of the model to the Canadian prairie region. Two grains, including the single G10, produced higher temperatures, three lower.

Four files of GSC electron microprobe mineral analyses are included in order to assist interested users in establishing the expected ranges of mineral chemistry in material recovered from prairie tills.

T_HM_PRB.DAT contains analyses of 3457 grains which were picked as potential indicator minerals. About 70% of the grains are from the 0.25-2.0 mm fraction, the remainder were recovered from the 63-250 µm fraction of five samples in order to test the viability of using this fraction. The grains were mounted in four 25 mm epoxy cylindrical mounts. Coordinates of points to be analyzed were entered using an optical microscope. One point per grain was analyzed, with care to avoid inclusions or fractures. A second point was analyzed for one grain in every 20, in order to assess analytical variability, considered primarily a function of grain heterogeneity (T_HM_DUP.DAT). Occasional apparent gross errors between duplicates are attributed to inclusions. Procedures to minimize such events have since been implemented by the use of SEM backscatter images during the entry of analysis points. Tests indicated that the somewhat unusual operating conditions used for these analyses (200 nA, 20 kv) was acceptable. Background counts were included in the routine for each element, twice for sodium. Detection limits were about 0.01 wt. % for SiO₂, Al₂O₃, CaO, FeO, MgO, Cr₂O₃, TiO₂, Na₂O, and K₂O, 0.02 wt. % for MnO, NiO, ZnO and CoO, 0.04 wt. % for Nb₂O₅, and 0.05 wt. % for V₂O₃. Tentative mineral identifications are based on sorting of weight % oxides. A more rigorous mineralogical analysis has not been completed. It is not, however, anticipated that significant changes in identification will result.

Electron microprobe analysis of background grains, using the same methods as described for picked potential indicator minerals, are contained in T_HM_BKG.DAT. A total of 1378 grains, in two 25 mm araldite cylindrical mounts, were selected on the basis of the following preliminary visual identifications: 160 pink garnets, 160 orange garnets, 160 clinopyroxenes, 80 hornblendes, 80 orthopyroxenes, 50 epidotes, 10 barites, 20 rutiles, 160 black opaques, 80 grey

ilmenites, 80 magnetites, 40 hematites, 10 goethites, 10 tourmalines, 10 apatites and gahnites, 10 leucoxenes, 40 staurolites, 40 sphenes, 30 weakly paramagnetic garnets, 30 weakly paramagnetic clinopyroxenes, 28 weakly paramagnetic black opaques, 30 paramagnetic garnets, 30 paramagnetic clinopyroxenes, and 30 paramagnetic black opaques.

T_HM_KIM.DAT contains electron microprobe data for 0.25-2.0 mm grains classified as kimberlite indicator minerals. Thirteen grains, 7 orange, 6 purple, and 1 red, were classified as peridotitic garnet (including megacrysts) on the basis of anomalous levels of both Mg and Cr. Using a simplified classification procedure based on Dawson and Stephens (1975) and Fipke (1989), these grains classified as 1 G10, 1 G11, 6 G9, 4 G2 and 1 G1. Seventeen grains, all orange, were classified as eclogitic garnet on the basis of anomalous levels of Mg, Ti and Ca. These grains were classified as 2 G6 and 15 G3. A total of 62 chrome diopsides, defined as pyroxenes with >7.5% CaO, <2.7% Na₂O, <6.0% FeO, and >0.5% Cr₂O₃, are present. Four occurrences of magnesian ilmenite exceed 6% MgO. No analyzed chromites exceed Cr₂O₃ values typical of diamond inclusion chromites (e.g.>62.5%, Gurney and Moore, 1993). Two chromites, however, from sites 3001 and 3010, exceed 60% Cr₂O₃. Users accustomed to the alternate classifications for indicator minerals are encouraged to reclassify the analyzed grains according to procedures with which they are accustomed.

Gross Textural and Mineralogical Properties of Till Samples

In addition to the indicator mineral frequency and chemistry data mappable gross mineralogical (63µm-250µm, >3.2 s.g., non-ferromagnetic fraction) variations were also detected using the ultra-low density sampling procedures which could assist in till provenance studies (T_HM_GRN.DAT and T_HM_PPM.DAT).

The total >3.2 SG heavy mineral productivity of the <2 mm fraction, expressed as the weight of ferromagnetic minerals, and the coarse (0.25-2.0 mm), medium (63-250 µm), and fine (<63 µm) fractions of the non-ferromagnetic minerals is recorded in T_HM_WTS.DAT.

The mineralogy of the >3.2 SG, 63-250 µm, non-ferromagnetic fraction as visually determined under a stereoscopic microscope in araldite mounts, expressed as number of grains in a 300 grain count is recorded in T_HM_GRN.DAT. Many grains were tested for birefringence in order to confirm an identification. The recorded mineral classes are hornblende, garnet, epidote, ilmenite, goethite, hematite, orthopyroxene, clinopyroxene, leucoxene, unknown, barite, rutile, zircon, staurolite, sulphide, sphene, kyanite, and monazite.

T_HM_PPM.dat contains the same information as file T_HM_GRN.DAT, i.e., >3.2 SG, 63-250 µm, non-ferromagnetic fraction, re-expressed as concentration (yield) in ppm of the air-dry <2 mm fraction, without allowance for variation in specific gravity between the several mineral classes present.

The total moist weight of the 5 gallon sample (.30 kg), dry weight inferred from air dry weight loss of a 500 g split, weight of the gravel fraction (>16 mm, 5.6-16 mm, 2-5.6 mm), inferred weight of the sand/silt/clay (<2 mm) fraction are recorded in T_SZANL.DAT.

Textural data for the <2 mm fraction, based on the analysis of a 50 g split at the GSC, derived by dry sieving (sand or >63 µm fraction) and pipette analysis (silt and clay or <63 µm fraction)

are recorded in T_PHYSCL.DAT. Data are reported first as wt. % sand, silt and clay, and then as wt. % retained at 16 phi values.

The lithology of the entire 5.6-16 mm fraction of the till samples, expressed as total weight in each of the following classes based on the work of Shetsen (1984), are recorded in T_PEBBLE.DAT. The classes are: brown carbonate mostly derived from southern Manitoba, Precambrian shield rocks, quartzite mainly derived from Tertiary gravel deposits within the region, quartz sandstone derived from the Athabasca sandstone and the Cordillera, grey carbonate and related rocks derived from the Cordillera, unmetamorphosed volcanic rocks, immature poorly cemented sandstones derived from Cretaceous and Tertiary sediments within the region, and locally derived shale, ironstone, and coal.

Geochemical Analyses of Till Samples

The geochemical data for the various fractions of the tills reveal changes in level that are largely predictable on the basis of grain size, i.e., finer grained fractions generally exhibit higher levels than coarser grained fractions. Within the fine sand and silt sized fractions differences in geochemistry due to till provenance may be observed. In some instances, e.g., Ba, barite data in the mineralogical analyses of the till were clearly reflected in the Ba geochemical results.

The till profile northwest of Saskatoon, T_PROF.DAT, indicates that at that location carbonate weathering and leaching are restricted to the upper 55 to 75 cm of the profile. On the basis of this it was concluded that samples collected at depths of greater than 1 m would be adequate, however the target depth would continue to be 2 m.

The till geochemical data are recorded in the following files:

T_PROF.DAT	Field, INAA, Partial decomposition ICP-ES, and Chittick carbonate data (<63 µm fraction)
T_-2MM_P.DAT	Field, INAA, Partial decomposition ICP-ES, and gamma ray K, Th and U data (<2 mm fraction).
T_SAND_P.DAT	Field, INAA, and Partial decomposition ICP-ES data (sand fraction).
T-63UM_P.DAT	Field, INAA, Partial decomposition ICP-ES and, Chittick carbonate data (<63 µm fraction).
T_-2UM_P.DAT	Field, INAA, and Partial decomposition ICP-ES data (<2 µm fraction).
T_-63UM.DAT	Field, and Total decomposition ICP-ES data (<63 µm fraction).

Geochemical Analyses of Soil Samples

An analysis of variance of the <2 mm ball-milled soil geochemical data revealed that there were systematic variations in the data for many of the elements determined in both the A₂₀ and C horizon soils at the 160 km block level. Thus there are large scale mappable geochemical features within the prairie region.

Again, as with the till geochemistry, some mineralogical observations, e.g., higher barite contents in the tills, were reflected in the C horizon geochemical data.

The A₂₀ horizon data are more difficult to correlate to the till data, due in part to varying contents of organic material. However, from an environmental geochemistry viewpoint the data are relevant as they reflect the composition of the material in which crops and grasslands are rooted.

To determine if proximity to a highway could influence the geochemistry of A₂₀ soil samples an extended 500 m traverse was sampled in a northeasterly direction from the Yellowhead Highway northwest of Saskatoon. The data reveal that only Ca and Pb show significant increases close to the highway, but that these have dropped to background levels in the ploughed land at a distance of 40 m (130 ft) from the centre of the westbound lane. On the basis of this, it is recommended that samples be collected at least 40 m from the centre of major highways.

Three soil profiles were sampled as the opportunities arose. All three profiles show a depletion in Ca in the upper parts, at Arcola, Saskatchewan, Sr and U levels also appear to be depleted relative to the C horizon. In contrast, As appears to be enhanced in the upper portions of all three profiles. At Grunthal, Manitoba, there appears to have been some Na and Sc concentration in the upper horizons; and in contrast to the U depletion observed at Arcola, U is enhanced in the upper parts of the strongly solonchic profile sampled at Verwood, Saskatchewan. The remaining elements determined did not reveal any major patterns of concentration or depletion.

The soil geochemical data are recorded in the following files:

A_-2MM.DAT	Field, INAA and Total digestion ICP-ES data (<2 mm fraction).
C_-2MM.DAT	Field, INAA and Total digestion ICP-ES data (<2 mm fraction).
C_-63UM.DAT	Field, INAA and Partial digestion ICP-ES data (<63 µm fraction).
S_PROFS.DAT	Field, INAA and Total digestion ICP-ES data (<2 mm fraction).

Conclusions

From the above results it was concluded that patterns of regional variation did exist for both mineralogical and geochemical variables in the prairie tills and soils sampled that would be of

relevance to kimberlite and lamproite exploration, studies of till provenance, and environmental geochemistry. Therefore the major ultra-low density sampling program of some 735,000 km² of the Canadian Prairies proposed in 1990 was undertaken in the summer of 1992.

Design Modifications and Analytical Requirements for 1992 Survey

A basic sample density of 2 regional sites per 40 x 40 km cell was selected for the 1992 survey. This was approximately twice as dense as the 50 km orientation sampling, providing better spatial resolution of the patterns expected to be found. The soil sampling followed in the foot-steps of the till sampling. The incremental analytical costs of the additional three samples per 80 x 80 km sampling cell would be offset by the improved quality of the resulting maps of prairie-wide regional geochemical variation.

The <63 µm fraction was selected for till geochemical studies in order to reduce the induced variability due to the nugget effect for Au and heavy mineral grains. The <2 mm fraction of the A₂₀ and C horizon soils was chosen for analysis. This size fraction is compatible with the large amounts existing agricultural and environmental studies data already in existence.

It was decided to use a near-total acid decomposition. It is believed that total data are superior for the till provenance studies, and that for environmental geochemical studies they provide a more desirable "first value". Also, AAS rather than ICP-ES analytical procedures were selected for those trace elements not obtainable by INAA, particularly, Cd and Se, as the detection limits for the AAS work were superior.

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