This disk(s) contains sample and assay data for the Minnesota Department of Natural Resources Minerals Division Project 262: Glacial Drift Geochemistry for Strategic Minerals; Duluth Complex, Lake County, Minnesota. The data is designed to be used as a supplement to the printed copy of the report; if you do not have a printed copy and would like one, please contact Rick Ruhanen at the MN DNR Minerals Division, P.O. Box 567, Hibbing MN, 55746 or call (218) 262-6767.

Report 262 Abstract

A multi-media, regional, reconnaissance geochemical survey was conducted over a four-hundred square mile area of Lake County, Minnesota. The pilot study was funded by the Legislative Commission on Minnesota Resources for the 1987 - 1989 biennium, with the Minnesota Department of Natural Resources, Division of Minerals as operator. Objective of the project was to determine, through the use of new or improved techniques of geochemistry and analytical processes, whether anomalous values of strategic metals were present in an area underlain by mafic igneous rocks of the Duluth Complex and North Shore Volcanic Group. In addition to the detection of platinum, palladium, chrome, cobalt, vanadium, titanium and associated or pathfinder elements, a second important goal was to learn whether the varied and complex glacial overburden would mask or distort the bedrock mineral content and geochemical signatures. The ultimate interpretation of data obtained would provide a basis for determining whether the applied techniques may be used for mineral resource evaluations elsewhere in Minnesota.

Taking 195 man-days or 78 calendar days from April 25 to October 14, 1988, overburden, A and B-soils and humus samples were collected at 1,162 sample sites at quarter-mile intervals along existing roads and trails. During the two weeks in October, 715 vegetation samples were collected from 327 of those sites; three species per site when available, including black spruce, white spruce, jack pine, balsam fir and alder.

Multi-element geochemical analyses were obtained on 566 partial heavy mineral concentrates, 567 clay/silt samples, 312 humus samples and 715 vegetation samples. Initial standard assay packages for the eight sampled media were all for 19 elements. Common elements were reported when possible, including Pt, Pd, Cr, Co, Ni, Zn, As, Ag, Au, Sb and Se. Heavy minerals and silt/clays also included V, TiO_2, Cu, Pb, MgO, Fe_2O_3, Bi and Te. For humus and vegetation, the additional elements were Ba, Br, Ir, Mo, Ta, Th, U and W. Later analyses, arriving too late for evaluation, were SiO_2, Al_2O_3, CaO, MnO, Na_2O, K_2O, Ba, Sc, Sr and Zr for heavy minerals and silt/clays, P_2O_5 and Y for heavy minerals only, and Fe and Hg for humus and vegetation.

Visual interpretations of selected elements have been illustrated by 62 computer generated geochemical contour maps for the eight sample media, with Pt, Pd, Cr, Co, Ni, Zn and As common to all of them. The results suggest that three anomalous localities exist across the project area, with internal sub-areas of interest. It is also concluded that the geochemical survey does reflect bedrock lithologies, despite variable thicknesses of glacial overburden of several deposit types and complex depositional history. The western anomalous locality is expressed best in heavy minerals, silt/clays and humus with a diagnostic element assemblage of Cr, Pt, Pd, Co, Ni and MgO. The central locality responds best with Co, V, TiO_2, Fe_2O_3 and Zn in the heavies; As, Sb and Br in humus and/or vegetation. The eastern locality is best expressed in silt/clays by Pt and TiO_2; in humus by Cr, Pt, Ir and Zn; and by Cr, Pd and sometimes Ni, Zn, Br and Ba in vegetation.

The multi-media approach was appropriate for the scope of the project, was very effective in areas with 50 feet of overburden, and useful, with caution, in the 50 - 125 foot overburden range. Further investigation of strategic mineral potential is suggested in the western area (T.59-61N., R.10-11W.); and the eastern locality, east of Isabella (T.59-60N., R.7-8W.).

FILE AND ABBREVIATED EXPLANATION:

- THERE ARE 10 FILES ON THIS DISK(S)
- ALL FILES ARE RELATED BY THE ITEM S.N. (SAMPLE NUMBER)

MASFINAL.ASC
MASTER SAMPLE LIST WHICH LISTS ALL SAMPLE NUMBERS, THEIR LOCATIONS, DATE SAMPLED, SAMPLE TYPE, AND TYPE OF MEDIA SAMPLED.

HMCFINAL.ASC
ASSAY ANALYSIS RESULTS FOR HEAVY MINERAL CONCENTRATES

BSFINAL.ASC
ASSAY ANALYSIS RESULTS FOR BLACK SPRUCE TWIG SAMPLES

ALDFINAL.ASC
ASSAY ANALYSIS RESULTS FOR ALDER TWIG SAMPLES

JPFINAL.ASC
ASSAY ANALYSIS RESULTS FOR JACK PINE TWIG SAMPLES

WSFINAL.ASC
ASSAY ANALYSIS RESULTS FOR WHITE SPRUCE TWIG SAMPLES

BALFINAL.ASC
ASSAY ANALYSIS RESULTS FOR BALSAM FIR TWIG SAMPLES

HUMFINAL.ASC
ASSAY ANALYSIS RESULTS FOR HUMUS SAMPLES

CLYFINAL.ASC
ASSAY RESULTS FOR SILT AND CLAY SAMPLES

262WTS.ASC
HEAVY MINERAL PROCESSING DATA INCLUDING TABLE FEED WEIGHTS AND PERCENTAGES, HEAVY MINERAL CONCENTRATE WEIGHTS, LIGHT MINERAL FRACTION WEIGHTS AND PERCENTAGES, WEIGHT LOST AND PERCENTAGES, CONCENTRATION RATIO (TABLE FEED/HMC WEIGHT)

ALL ANALYSES PERFORMED BY TECHNICAL SERVICES LABORATORIES, MISSISSAUGA, ONTARIO

ORDER OF ITEMS AND ELEMENTS IN FILES:

SEE NEXT PAGE FOR DEFINITION OF TERMS

MASFINAL.ASC

S.N., SEC, TWP, RNG, FORTY, DATE, GEOMORPH, GLACIAL, BEDROCK, HMC, SILT/CLAY, BLACK SPRUCE, WHITE SPRUCE, JACK PINE, BALSAM FIR, ALDER, HUMUS

HMCFINAL.ASC

S.N., Pt, Pd, Cr, Au, Ag, Co, V, TiO2, Cu, Ni, Pb, Zn, Bi, Sb, Se, Te, As, MgO, Fe2O3, SiO2, Al2O3, CaO, MnO, Na2O, K2O, P2O5, Ba, Sr, Zr, Sc

BSFINAL.ASC

S.N., Au, Sb, As, Ba, Br, Cr, Co, Ir, Mo, Ni, Se, Ag, Ta, Th, W, U, Zn, Pt, Pd, Fe, Hg

ALDFINAL.ASC

S.N., Au, Sb, As, Ba, Br, Cr, Co, Ir, Mo, Ni, Se, Ag, Ta, Th, W, U, Zn, Pt, Pd, Fe, Hg

JPFINAL.ASC

S.N., Au, Sb, As, Ba, Br, Cr, Co, Ir, Mo, Ni, Se, Ag, Ta, Th, W, U, Zn, Pt, Pd, Fe, Hg

WSFINAL.ASC

S.N., Au, Sb, As, Ba, Br, Cr, Co, Ir, Mo, Ni, Se, Ag, Ta, Th, W, U, Zn, Pt, Pd, Fe, Hg

BALFINAL.ASC

S.N., Au, Sb, As, Ba, Br, Cr, Co, Ir, Mo, Ni, Se, Ag, Ta, Th, W, U, Zn, Pt, Pd, Fe, Hg

HUMFINAL.ASC

S.N., Au, Sb, As, Ba, Br, Cr, Co, Ir, Mo, Ni, Se, Ag, Ta, Th, W, U, Zn, Pt, Pd, Fe, Hg

CLYFINAL.ASC

S.N., Pt, Pd, Cr, Au, Ag, Co, V, TiO2, Cu, Ni, Pb, Zn, Bi, Sb, Se, Te, As, MgO, Fe2O3, SiO2, Al2O3, CaO, Na2O, K2O, MnO, Ba, Sr, Zr, Sc

262WTS.ASC

S.N., TABLE FEED(g), HMC(g), LMF(g), WEIGHT LOST(g), HMC(%), LMF(%), WEIGHT LOST(%), CON RATIO

SHORT DEFINITION OF TERMS USED:

S.N. ------ SAMPLE NUMBER
SEC ------- SECTION
TWP ------- TOWNSHIP
RNG ------- RANGE
FORTY ------ FORTY ACRE PARCEL
DATE ------ DATE SAMPLED
GEOMORPH -- GEOMORPHOLOGY

1	(1A)BEDROCK-DOMINATED, ICE-MOLDED
2	(1B)DRUMLINS, ICE-MOLDED
3	(1C)ROGEN MORAINE, ICE-MOLDED
4	(1D)OTHER-BASAL TILL, ICE-MOLDED
5	(2A)OUTWASH, SUPER & EXTRA GLACIAL
6	(2B)END MORAINES, SUPER & EXTRA GLACIAL
7	(2C)OTHER-TILL &DRIFT, SUPER & EXTRA GLACIAL

GLACIAL ---- GLACIAL DEPOSITS

1	(rt) RAINY, TILL
2	(ra) RAINY, REWORKED TILL
3	(ri) RAINY, ICE-CONTACT DEPOSITS
4	(ro) RAINY, OUTWASH
5	(rtd)RAINY, DRUMLINIZED TILL
6	(st) SUPERIOR, TILL
7	(rst)SUPERIOR & RAINY, TILL
8	(sa) SUPERIOR, REWORKED TILL
9	(rsa)SUPERIOR & RAINY, REWORKED TILL
10	(si) SUPERIOR, ICE-CONTACT DEPOSITS
11	(rsi) SUPERIOR & RAINY, ICE-CONTACT DEPOSITS
12	(so) SUPERIOR, OUTWASH
13	(uo)UNDIVIDED, OUTWASH
14	(ul) UNDIVIDED, LAG DEPOSITS

BEDROCK --- BEDROCK UNITS

1	(Ku)KEWEENAWAN UNDIVIDED, EXTRUSIVE VOLCANICS
2	(Df) DULUTH COMPLEX RED, GRANOPHYRE & ADAMELLITE
3	(Di) DULUTH COMPLEX INTERMEDIATE INTRUSIVES
4	(Da)DULUTH COMPLEX ANORTHOSITIC GABBRO, ANORTHOSITE
5	(Dto)DULUTH COMPLEX CUMULATE TROCTOLITE, LAYERED
6	(Dt) DULUTH COMPLEX TROCTOLITE, ANORTHOSITIC TROCTOLITE, LAYERED
7	(Dg)DULUTH COMPLEX GABBRO & FE GABBRO
8	(Du)DULUTH COMPLEX INTRUSIVE ROCKS, UNDIVIDED
9	(Hm)MIDDLE PROTEROZOIC CONTACT-METAMORPHIC, MAFIC VOLCANICS
10	(Nsu)NORTH SHORE VOLCANICS, UNDIVIDED

TABLE FEED(g) - TABLE FEED WEIGHT IN GRAMS
HMC(g) ---- HEAVY MINERAL CONCENTRATE WEIGHT IN GRAMS
LMF(g) ----- LIGHT MINERAL FRACTION WEIGHT IN GRAMS
WEIGHT LOST(g) TABLE FEED - (HMC + LMF) IN GRAMS
HMC(%) ---- HEAVY MINERAL CONCENTRATE WEIGHT PERCENT
LMF(%) ---- LIGHT MINERAL FRACTION WEIGHT PERCENT
WEIGHT LOST(%) PERCENTAGE OF WEIGHT LOST
CON RATIO -- CONCENTRATION RATIO = TABLE FEED/HMC WEIGHT

Table 5 White Spruce Twigs, Basic Statistics and Determination of Threshold Values for Selected Elements.

Element	Max.	Min.	Detection Level	Average	Standard Deviation	Threshold
Pt	40	0	10	0.4	3.7	7.8
Pd	25	0	1	2.6	4.5	11.6
Cr	30	1.2	.3	4.8	4.6	14.0
Co	1.1	0	.3	0.3	0.2	0.7
Ni	11	0	2	1.1	2.3	5.7
Zn	65	26	2	41.5	9.3	60.1
As	2	.02	0.01	0.10	0.18	0.46
Ir	0	0	5	-	-	-
Sb	0.04	0	0.01	0.00	0.01	0.02
Mo	0.39	0	0.05	0.03	0.06	0.15
Br	3.8	0.98	0.01	2.00	0.53	3.06
Ba	120	25	20	66.8	19.2	105.2

Note: Results in ppm; Pt, Pd, Ir in ppb
Note: Threshold = 2 x Standard Deviation + Average

Table 6 Jack Pine Twigs, Basic Statistics and Determination of Threshold Values for Selected Elements.

Element	Max.	Min.	Detection Level	Average	Standard Deviation	Threshold
Pt	30	0	10	0.9	4.8	10.5
Pd	17	0	1	3.3	4.5	12.3
Cr	25	0.5	.3	3.2	4.3	11.8
Co	0.5	0	.3	0.2	0.1	0.4
Ni	8	0	2	0.6	1.7	4.0
Zn	42	13	2	24.4	5.3	35.0
As	2.9	0	0.01	0.09	0.32	0.73
Ir	.1	0	5	0.0	0.01	0.02
Sb	12	0	0.01	0.14	1.25	2.64
Mo	.21	0	0.05	0.02	0.04	0.10
Br	1.9	0.6	0.01	1.1	0.23	1.56
Ba	88	0	20	3.4	10.4	24.2

Note: Results in ppm; Pt, Pd, Ir in ppb
Note: Threshold = 2 x Standard Deviation + Average

Table 7 Balsam Fir Twigs, Basic Statistics and Determination of Threshold Values for Selected Elements.

Element	Max.	Min.	Detection Level	Average	Standard Deviation	Threshold
Pt	20	0	10	0.2	1.7	3.6
Pd	52	0	1	1.1	4.2	9.5
Cr	9.4	0.7	.3	2.2	1.4	5.0
Co	0.5	0	.3	0.2	0.1	0.4
Ni	4	0	2	0.1	0.4	0.9
Zn	110	17	2	30.8	9.6	50.0
As	.12	0	0.01	0.03	0.02	0.07
Ir	0	0	5	-	-	-
Sb	.07	0	0.01	0.0	0.01	0.02
Mo	.17	0	0.05	0.01	0.03	0.07
Br	2.4	.5	0.01	0.8	0.2	1.2
Ba	210	6	20	66.3	22.7	111.7

Note: Results in ppm; Pt, Pd, Ir in ppb
Note: Threshold = 2 x Standard Deviation + Average

Table 8 Alder Twigs, Basic Statistics and Determination of Threshold Values for Selected Elements.

Element	Max.	Min.	Detection Level	Average	Standard Deviation	Threshold
Pt	20	0	10	0.4	2.3	5.0
Pd	16	0	1	1.1	3.1	7.3
Cr	1.6	0	.3	0.2	0.3	0.8
Co	.7	0	.3	0.1	0.1	0.3
Ni	4	0	2	0.0	0.4	0.8
Zn	220	0	2	14.4	19.8	54.0
As	1.9	0	0.01	0.0	0.18	0.36
Ir	0	0	5	-	-	-
Sb	2.5	0	0.01	0.0	0.27	0.54
Mo	1	0	0.05	0.04	0.1	0.06
Br	1.8	.28	0.01	1.05	0.36	1.77
Ba	69	0	20	8.4	8.53	25.46

Note: Results in ppm; Pt, Pd, Ir in ppb
Note: Threshold = 2 x Standard Deviation + Average

MISCELLANEOUS INFORMATION:

ALL FILES ARE IN A COMMA-SEPARATED VARIABLE (ASCII) FORMAT, 1 SAMPLE PER LINE.

ALL UNITS ARE ppm WITH THE EXCEPTION OF:

Au	ppb
Pt	ppb
Pd	ppb
MgO	%
Fe2O3	%
SiO2	%
Al2O3	%
CaO	%
MnO	%
Na2O	%
K2O	%
P2O5	%

On the following pages Tables 1-8 show, from the analysis results, the averages, standard deviations and threshold values for thirteen elements within each of the eight media.

Table 1 Heavy Mineral Concentrates, Basic Statistics and Determination of Threshold Values for Selected Elements.

Element	Max.	Min.	Detection Level	Average	Standard Deviation	Threshold
Pt	75	0	10	1.4	6.5	14.4
Pd	92	0	1	8.5	12.7	33.8
Cr	7141	6	5	753.5	698.5	2150.4
Co	292	4	1	123.1	38.4	199.9
V	2197	8	1	767.4	335.9	1439.1
TiO_2	26.81	1.14	0.01	7.9	3.7	15.3
Cu	726	0	5	48.5	52.5	153.5
Ni	897	0	5	198.0	125.0	448.1
Pb	80	0	5	1.7	5.2	12.1
Zn	409	0	5	196.1	59.5	315.2
As	5	0	1	1.0	1.6	4.1
Fe_2O_3	51.74	0	0.01	26.8	8.0	42.8
MgO	23.96	0	0.01	7.2	3.0	13.3

Note: Results in ppm; Pt, Pd in ppb; Oxides in %
Note: Threshold = 2 x Standard Deviation + Average

Table 2 Silt and Clay Fraction, Basic Statistics and Determination of Threshold Values for Selected Elements.

Element	Max.	Min.	Detection Level	Average	Standard Deviation	Threshold
Pt	47	0	10	1.1	5.2	11.5
Pd	97	0	1	3.1	5.9	15.0
Cr	479	0	5	101.6	48.1	197.3
Co	190	0	1	47.9	16.9	81.6
V	891	0	1	129.7	55.1	239.9
TiO_2	1.47	0.16	0.01	0.7	0.2	1.0
Cu	2496	0	5	228.1	167.2	562.5
Ni	1237	0	5	191.7	175.5	542.8
Pb	100	0	5	20.9	12.8	46.5
Zn	365	0	5	104.4	46.3	197.0
As	100	0	1	4.1	5.0	14.1
Fe_2O_3	39.69	3.89	0.01	10.2	2.9	16.0
MgO	10.0	0.7	0.01	2.2	0.9	4.0

Note: Results in ppm; Pt, Pd in ppb; Oxides in %
Note: Threshold = 2 x Standard Deviation + Average

Table 3 Humus Samples, Basic Statistics and Determination of Threshold Values for Selected Elements.

Element	Max.	Min.	Detection Level	Average	Standard Deviation	Threshold
Pt	20	0	10	0.5	2.8	6.1
Pd	16	0	1	1.5	2.8	7.1
Cr	400	0	.3	51.2	51.5	154.2
Co	30	1	.3	7.6	4.8	17.2
Ni	130	0	2	14.8	20.2	55.2
Zn	240	0	2	74.4	37.0	148.4
As	6.1	0.43	0.01	2.4	1.2	4.8
Ir	0.7	0	5	0.0	0.03	0.06
Sb	73	0.06	0.01	0.5	3.0	6.5
Mo	2.2	0	0.05	0.07	0.28	.63
Br	14	1.9	0.01	5.4	1.9	9.2
Ba	470	53.0	20	195.3	80.8	356.9

Note: Results in ppm; Pt, Pd, Ir in ppb
Note: Threshold = 2 x Standard Deviation + Average

Table 4 Black Spruce Twigs, Basic Statistics and Determination of Threshold Values for Selected Elements.

Element	Max.	Min.	Detection Level	Average	Standard Deviation	Threshold
Pt	10	0	10	0.1	1.2	2.5
Pd	21	0	1	1.0	2.8	6.6
Cr	28	1.7	.3	6.1	4.6	15.3
Co	1.5	0.1	.3	0.4	0.2	0.8
Ni	10	0	2	1.7	2.4	6.5
Zn	54	20	2	36.2	6.6	49.4
As	0.20	0.02	0.01	0.08	0.04	0.16
Ir	0	0	5	-	-	-
Sb	0.03	0	0.01	0.01	0.01	0.13
Mo	0.45	0	0.05	0.03	0.08	0.19
Br	4.4	0.74	0.01	1.77	0.63	3.03
Ba	110	17	20	62.0	18.4	98.8

Note: Results in ppm; Pt, Pd, Ir in ppb
Note: Threshold = 2 x Standard Deviation + Average

GIS Compilation of MN DNR Project 262: Glacial Drift Geochemistry for Strategic Minerals; Duluth Complex, Lake County, Minnesota.

GIS Data Completed: April 30th, 2010

Original Data (ASC files) Completed: 1989

Provided here is a general description of files that are found in the DATA folder under 'P262_DRIFTGEOCHEM'.

Folders and their contents:

ASC_FILES_ORIGINAL_SOURCE

- This is the original sourced data in ASC file format. See page 1-4 of this document for information on the specifics of this data. These files were used in combination with the Georeferenced Plate 1: Sample Location Map (Report_262_Plate1geo) to create the shapefiles seen below.

ACCESS_DB_FROM_ASCFILES

- The original ASC files were imported into Microsoft Access and given the appropriate field headings and given the appropriate data type. **Note** this database still displays records like the original that have a '<' symbol, while the GIS shapefiles and file geodatabase attribute records calculate the '<' out of the record and change them to numerical values. This conversion allows them to be best displayed and analyzed in a spatial database.
    - Example of the conversion - <1 = 0.70 or <.100 = 0.070 or <.600 = 0.40

SHAPEFILES

Viewable in most GIS software packages

- The shapefiles listed below have the same descriptions as what is seen in the metadata for the original ASC files seen on pages 1-4 of this document. The file names of the shapefiles have been kept relatively the same as the ASC files to reduce confusion.
    - p262_masfinal.shp – Master sample list which lists all sample numbers (UNQ_ID field), their locations (Township, Range, Section, 40 Description), Date Sampled, Sample Type, and Media Samples, Source of Spatial Location, Spatial Location Date. The locations were determined by creating a point file based on the initial spatial locations (Township, Range, Section, 40 Description), to the centroid of the 40 acre parcel. Then the point file was relocated based on the georeferenced Plate 1: Sample Location Map. This shapefile

was then joined to each of the nine (seen below as shapefiles) exported DBF IV files from the Microsoft Access Database seen above.

- p262_262wts.shp - *See page 2 for description*
- p262_aldfinal.shp - *See page 2 for description*
- p262_balfinal.shp - *See page 2 for description*
- p262_bsfinal.shp - *See page 2 for description*
- p262_clyfinal.shp - *See page 2 for description*
- p262_hmcfinal.shp - *See page 2 for description*
- p262_humfinal.shp - *See page 2 for description*
- p262_jpfinal.shp - *See page 2 for description*
- p262_wsfinal.shp – *See page 2 for description*

FILE _GEODATABASE

[Only viewable in ArcGIS 9.3 and above]

File name - mndnr_mpes_p262

- **Feature Dataset – Features**
  - p262_masfinal – Master sample list which lists all sample numbers (UNQ_ID field), their locations (Township, Range, Section, 40 Description), Date Sampled, Sample Type, and Media Samples, Source of Spatial Location, Spatial Location Date. The locations were determined by creating a point file based on the initial spatial locations (Township, Range, Section, 40 Description), to the centroid of the 40 acre parcel. Then the point file was relocated based on the georeferenced Plate 1: Sample Location Map. This feature class was then joined to each of the nine (seen below as shapefiles) exported DBF IV files from the Microsoft Access Database seen above.
  - p262_262wts - *See page 2 for description*
  - p262_aldfinal - *See page 2 for description*
  - p262_balfinal - *See page 2 for description*
  - p262_bsfinal - *See page 2 for description*
  - p262_clyfinal - *See page 2 for description*
  - p262_hmcfinal - *See page 2 for description*
  - p262_humfinal - *See page 2 for description*
  - p262_jpfinal*See page 2 for description*
  - p262_wsfinal– *See page 2 for description*

GEOREFERENCED_PLATES

- Plate 1: Sample Location Map. This map was used as a reference to place the sample locations in the most accurate location. The sample locations were generally located to the centroid of 40 acre parcel from a current
    - file name - Report_262_Plate1geo
- Plate 2: Bedrock Geology Map
    - file name - Report_262_Plate2geo
- Plate 3: Glacial Geology Map
    - file name - Report_262_Plate3geo

Any questions regarding the GIS compilation contact:

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