Digital Drill Logs for the Duluth Complex

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Since 1988, the Natural Resources Research Institute (NRRI) Economic Geology Group has been logging Duluth Complex drill holes for various projects. They have logged 950 drill holes of the ~1,550 holes that still have core available (of the approximately 2,200 holes recorded as penetrating the Complex). The majority of these holes were drilled to evaluate copper-nickel sulfide or iron-titanium oxide deposits. References for most past studies are in Miller et al., 2002.

The current project involves transcribing all of the NRRI logs, plus our interpretation of available company logs for drill holes with no core remaining, into a consistent digital format. This downhole "from-to" interval format includes logged rock type, map unit (reconciled from our cross-sections and geologic maps where available), and the interval distance up from footwall. This information is being combined and consolidated with data tables from other reports and projects and will include: all drill hole specific information (location, company, year drilled, etc.); down hole survey data; all original assays (mostly copper-nickel +/- sulfur); secondary assays on selected intervals; all available PGE plus gold assays; and eventually all whole rock geochemistry and microprobe data. The format will allow this data to be sorted and filtered geographically, by intrusion, by deposit, by company, by depth or distance from footwall, and other criteria. No new data is being collected for this project.

This data format is intended primarily for use in 3-D mining software or adaptation to ArcView and is available on CD-ROM as Excel spreadsheet files, ASCII text files, and as a Gemcom for Windows (Microsoft Access) database. NRRI staff will also format this database to the users needs if practical. The database will also be posted on the NRRI Economic Geology Group website at: http://www.nrri.umn.edu/egg/.

The ultimate purpose of this work is to improve one's ability to do statistical and spatial analysis of Duluth Complex geology by rapidly combining lithological and assay data for both scientific study and ore deposit evaluation. This analysis breaks down into two broad categories: 1) simple 2-D comparisons, and 2) more complex 3-D evaluations. Examples of the 2-D comparisons include: comparisons between intrusions or deposit areas; rock type versus grade; ratio of a particular rock type, which is mineralized versus portion not mineralized; assay grades of a particular map unit; or grade as a function of distance from footwall (see Table 1 and Figure 1 for examples from Babbitt and Serpentine deposits). The 3-D analysis would include: creation of lithological and grade surfaces, solids, or block models, the evaluation of the intersection of these models; compositing grades by rock type, map unit, level, or distance from a particular point or surface; assessing linear and 3-D variography; contouring by level or distance from a point; and other manipulations of the raw data.

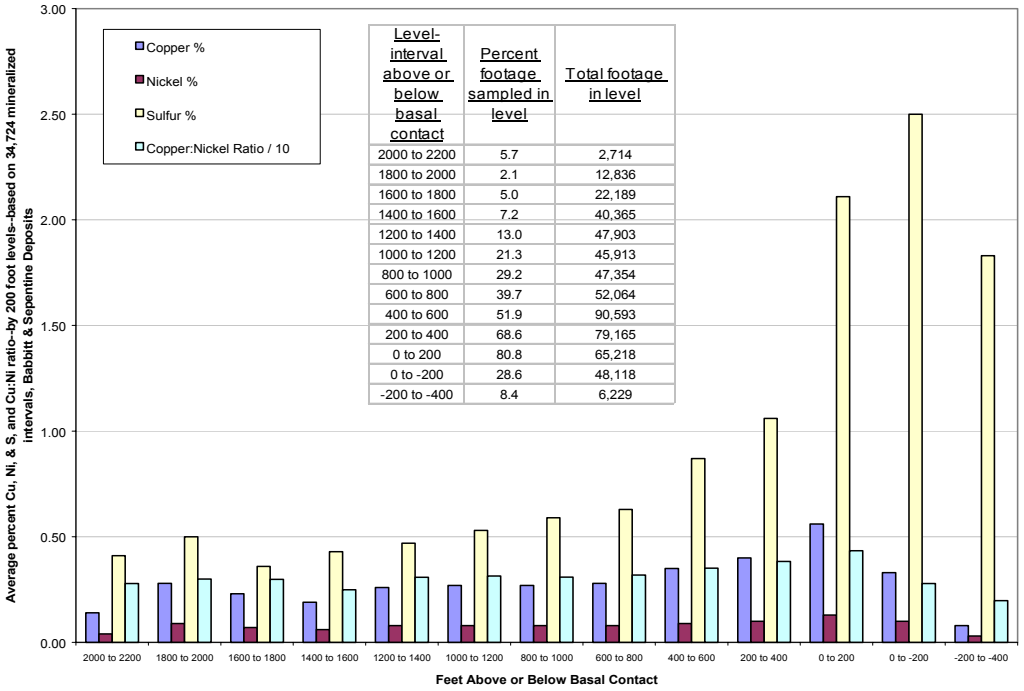
Most 3-D mining software is very flexible, and the overall data layout will allow NRRI or others to add any distance or point data (distance from collar, such as a thin section location) or from-to interval data (such as alteration, grain size, or any other assayed elements) as separate tables, which can then be compared to the existing data set.

The utility in this is the time savings in answering the numerous small questions that arise as well as easing major modeling efforts on the Duluth Complex copper-nickel and iron-titanium deposits. A few examples of these simple questions are: where is a particular rock type found; are there relations between unit thickness and grade; is grade related to rock type; does PGE grade really follow copper grade; and are there cryptic assay or rock type boundaries lateral to pinched out lithological units?

Another avenue to explore would be a full geostatistical study of some or all of the Duluth Complex deposits. Pieces of this work have been done, but the ability to efficiently combine large sets of assay, lithology, and geochemical data has been lacking.

Table 1. *Consolidated Rock type versus Copper, Nickel, Sulfur, and Copper:Nickel ratio, for Babbitt and Serpentine Deposits, St Louis County, Minnesota. Surface drill holes only. "Consolidated Rocktypes" are condensed from over 1,000 individual rock types over about 25,000 lithological intervals. "Percent Mineralized" assumes that company sampled all mineralized zones. This is essentially true at Babbitt-Serpentine, but not always true for other deposit areas. Grades are only for the mineralized portions; no unsampled footage (zero value?) was included in the* average.

"Consolidated Rocktype"	**Total footage of rock type**	**Percent of rock type in deposit**	**Total mineralized footage of rock type**	**Total unmineralized footage of rock type**	**Percent mineralized of rock type**	**Average copper grade of rock type**	**Average nickel grade of rock type**	**Average sulfur grade of rock type**	**Average Cu:Ni ratio**
Overburden (glacial drift)	10,122	1.8							
OUI (Oxide Ultramafic Intrusions)	2,824	0.5	447	2,377	16	0.31	0.10	1.92	3.29
Anorthositic rocks	63,510	11.3	18,151	45,359	29	0.31	0.09	0.66	3.32
Augite Troctolites	63,210	11.2	28,443	34,767	45	0.42	0.10	1.14	4.02
Contaminated Rocks	30,792	5.5	18,248	12,544	59	0.44	0.11	2.25	4.06
Gabbroic Rocks	3,022	0.5	1,348	1,674	45	0.33	0.08	0.85	4.32
Mixed Duluth Complex (not logged)	166,344	29.5	70,695	95,649	42	0.39	0.10	1.03	3.74
Pegmatitic Rocks	710	0.1	139	571	20	0.36	0.10	0.71	3.53
Ultramafic Rocks	24,473	4.3	7,732	16,741	32	0.36	0.11	0.74	3.17
Troctolitic Rocks	143,059	25.4	63,929	79,130	45	0.38	0.10	0.90	3.62
Dikes, Basaltic	698	0.1	181	517	26	0.08	0.02	0.35	2.58
Veins, Granitic	2,428	0.4	870	1,558	36	0.29	0.08	1.04	3.51
Massive Sulfides	415	0.1	413	2	100	2.02	0.57	12.68	3.86
Semi-Massive Sulfides	343	0.1	341	2	99	1.45	0.43	9.69	4.17
Virginia Formation	24,760	4.4	6,279	18,481	25	0.38	0.10	2.43	3.04
Bedded Pyrrhotite Unit of VF	3,834	0.7	2,928	906	76	0.13	0.04	4.25	2.50
Virginia Sill	1,686	0.3	311	1,375	18	0.09	0.05	0.35	1.58
MG portion of Virginia Sill	9,537	1.7	1,129	8,408	12	0.10	0.03	0.49	2.45
Sill in Biwabik Iron Formation	284	0.1	4	281	1	0.03	0.01	0.14	2.67
Biwabik Iron Formation	6,976	1.2	507	6,469	7	0.11	0.03	0.44	3.05
Pokegama Quartzite	20	0.0		20	0	0	0	0	0
Giants Range Granites	420	0.1	119	301	28	0.14	0.05	0.29	2.34
Basalts	2,951	0.5	547	2,404	19	0.20	0.08	0.85	2.65
Massive Chlorite	12	0.0	8	4	67	0.19	0.06	0.34	2.75
Faults	630	0.1	187	443	30	0.36	0.10	1.15	3.66
Massive Graphites	10	0.0	6	5	60	0.41	0.08	1.31	4.58
Hybrids (Hornblendite, etc.)	505	0.1	93	412	18	0.31	0.12	1.67	2.86
Orthopyroxenites	111	0.0	91	20	82	0.44	0.14	2.29	3.79
Massive Oxides (not in OIUs)	49	0.0	27	23	55	0.52	0.13	0.56	4.40
Serpentinites	76	0.0	19	57	25	0.47	0.11	1.62	4.72
deposit total:	563,811	100	223,192	330,500	40				
deposit averages:						0.39	0.10	1.29	3.66
maximums:						24.40	5.20	37.10	47.00
number of assayed intervals:						34,742	34,314	34,532	34,414
number of unassayed intervals:						25,445	25,873	25,655	25,773
total number of intervals:						60,187	60,187	60,187	60,187



Level-interval above or below basal contact	Percent footage sampled in level	Total footage in level
2000 to 2200	5.7	2,714
1800 to 2000	2.1	12,836
1600 to 1800	5.0	22,189
1400 to 1600	7.2	40,365
1200 to 1400	13.0	47,903
1000 to 1200	21.3	45,913
800 to 1000	29.2	47,354
600 to 800	39.7	52,064
400 to 600	51.9	90,593
200 to 400	68.6	79,165
0 to 200	80.8	65,218
0 to -200	28.6	48,118
-200 to -400	8.4	6,229

Figure 1. *Copper %, Nickel %, Sulfur % and Copper:Nickel ratio for 200 foot composites referenced to distance from basal contact. Data from Babbitt and Serpentine deposits; sampling represents about 40% of total drill footage. Copper:Nickel ratio divided by 10 for display purposes.*

Our reconciliation of the Babbitt and Serpentine deposits data modified parts of our interpretation of the geometry of lithological units. As we proceed with this data reconciliation, we expect to see other changes in interpretation. We hope that others will use this data to aid the development of mineral resources in northeastern Minnesota and improve the definition of possible drilling targets in the Duluth Complex.

Reference:

Miller, J.D., Jr., Green, J.C., Severson, M.J., Chandler, V.W., Hauck, S.A., Peterson, D.M., and Wahl, T.E., 2002, Geology and mineral potential of the Duluth Complex and related rocks of northeastern Minnesota: Minnesota Geological Survey Report of Investigations 58.