

Weighted Sums Modelling

The application of Weighted Sums Modelling (WSM) to exploration geochemistry was described by Garrett and Grunsky (2001) as a means to model multi-element data using a priori knowledge of the mineralogy and element composition of the sought after mineral deposit (Kane, 1977; Garrett et al., 1980). In this procedure weights or relative importances are assigned to each variable, or a subset of variables, according to some geochemical or mineralogical model of the target mineral deposit type or geological process. Weighted sums (WS) are new variables calculated from the multi-element geochemical results. Like Principal Components Analysis (PCA) or Factor Analysis scores, WS scores have the form of normal or standardized scores with a mean of zero and a standard deviation of one. The main difference between WSM and traditional multivariate statistical methods is that the user assigns the variable weightings rather than determining them with a covariance/correlation matrix for the dataset, as is done in PCA. Furthermore WSM is a robust statistical technique that is not influenced by the presence of outliers (Beckman & Cook, 1983).

The reader is referred to Garrett and Grunsky (2001) for a description of the WS calculation. In summary, relative importance is assigned for each variable. A weighting of 3, for example, means that that particular element is three times more important than an element with a weighting of one. Weighting can be positive or negative. Positive weightings mean that the target model is associated with elevated concentrations of an element. Negative weightings indicate that low concentrations or depletions of an element are important.

Individual relative importance is converted into weights that sum to one by dividing each importance by the sum of the absolute values of importance (i.e., ignoring the negative signs). A requirement of the method is that the sums of the squares of the final weights also equal one. This is achieved by dividing each weight by the square root of the sum of the squares of the weights.

The next step involves calculation of the normal scores for the variables included in the model for each individual sample. To do this, robust estimates of the mean and standard deviation are used. The median (or 50th percentile) is used as a robust estimate of the mean and the inter-quartile range (IQR) multiplied by 0.7413 is used as a robust estimate of the standard deviation. IQR is the difference between the 75th and 25th percentiles of the data distribution and therefore covers a band of data 25% wide (or 0.67449 standard deviation units) on either side of the mean. The constant 0.7413 is used to convert the IQR, which covers a range of 1.3490 standard deviation units to an equivalent standard deviation¹. Weighted sums are then calculated by multiplying the normal scores for each element by the element's corresponding weight and summing for each sample. The high resistance of the median and IQR to outliers mean that it is not usually necessary to trim outlier and far outliers from the dataset before calculation.

¹ For a normal distribution the standard deviation is equal to 0.7413*IQR, where 0.7413 is the reciprocal of 1.349.

Models and Weightings

Six mineral deposit types (SEDEX, Porphyry Cu, W-Skarn, ICG, Polymetallic veins and Carlin) that are either known or believed to occur in the map sheet areas and one geochemical process (hydromorphic dispersion) are modeled using the WS method. Included elements and their relative importance are presented in Table 1.

Data Presentation

Results of each WS model are attached to the corresponding catchment basin polygons using a spatial join in ArcGIS. This process allows for the entire polygon to be assigned a colour based on its WS score. Colours are assigned on the basis of the following percentile breaks:

0-50%	Dark blue
50-75%	Pale blue
75-90%	Pale green
90-95%	Yellow
95-98%	Orange
98-100%	Red

With this scheme, catchment basins with the hotter colours represent samples with geochemical characteristics consistent with the mineralization style being modelled.

Table 1: Table of Relative Importances used to calculate weighted sums models

Deposit Type	Ag	Au	As	Ba	Bi	Cd	Co	Cu	Cs	Fe	Hg	K	Mn	Mo	Ni	Pb	S	Sb	Tl	W	Zn
Polymetallic Veins	4	4	3	3	4	1	2	1	1	1	1	1	1	1	5	3	3	5			
W-Skarn																					
Porphyry Cu	2	2			1			5	3						3		2				
Intrusive Related Cu-Au	1	2	5		5		2	1	5		1	2	1		1		1		2		
SEDEX						5	3									1	5		1	5	5
Carlin	2	1	5	2																	
Hydromorphic Dispersion	2	1			4	5	2	5		4			5	2	4	2	1		1		3

LEGEND

- Regional Geochemistry Sample (RGS) location

National Topographic System grid (1:250 000 scale)

National Topographic System grid (1:50 000 scale)

Yukon-Northwest Territories border

highway, paved

highway, unpaved

local road, unpaved

watercourse

waterbody

wetland

Carlin-type Deposits

WSM Percentiles: WSM Score, Number of RGS Samples

0 - 50%: -6.760 - 0.142, 483 samples
50 - 75%: 0.143 - 1.403, 225 samples
75 - 90%: 1.404 - 2.789, 137 samples
90 - 95%: 2.790 - 3.737, 47 samples
95 - 98%: 3.738 - 4.754, 28 samples
98 - 100%: 4.755 - 7.311, 18 samples

QUATERNARY

Q QUATERNARY: unconsolidated glacial, glaciofluvial and glaciolacustrine deposits; fluvialite silt, sand, and gravel, and local volcanic ash, in part with cover of soil and organic deposits

MID-CRETACEOUS

mKS SELWYN SUITE: plutonic suite of intermediate (g) to more felsic composition (q); equivalent felsic dikes

mKgS

mKgS SELWYN SUITE: resistant, blocky, fine to coarse grained equigranular to porphyritic (K-feldspar) biotite quartz monzonite and granodiorite and minor quartz diorite; minor leuco-quartz monzonite and syenite

mKgS SELWYN SUITE: equigranular to porphyritic (K-feldspar) biotite hornblende muscovite granite, quartz monzonite and granodiorite; porphyritic biotite hornblende granite with large smoky grey quartz phenocrysts and locally K-feldspar phenocrysts

MIDDLE TO UPPER TRIASSIC

TJd JONES LAKE: brown to buff weathering, calcareous fine-grained sandstone, argillite, and shale; extensive ripple cross-lamination and bioturbation; massive/light grey weathering, fine crystalline, dark grey limestone; minor orange weathering platy limestone

CARBONIFEROUS TO PERMIAN

CPMC MOUNT CHRISTIE: burrowed, interbedded greenish grey cherty shale and green shale; thin to medium bedded, light grey-green to black chert; black siliceous shale and siltstone; minor quartzite, limestone and dolostone; locally abundant, large grey barite nodules

CPT

CPT TSICHU: thin to medium-bedded siliceous calcarenite, dolostone, sandy dolostone and minor grey quartzite; buff and grey weathering, thick bedded, dark grey bioclastic limestone; black to silvery shale; minor chert, and chert pebble conglomerate

MISSISSIPPIAN

MK KENO HILL: massive to thick-bedded quartz arenite; thin to medium-bedded quartz arenite interstratified with black shale or carbonaceous phyllite; local scour surfaces and shale intracasts; locally foliated and lineated

DEVONIAN AND MISSISSIPPIAN

DME EARN: complex assemblage of submarine fan and channel deposits (1) or within black siliceous shale and chert (2); barite common, and many occurrences of stromatolite Pb-Zn

DME1

DME1 EARN: thin bedded, laminated shale with thin to thickly interbedded fine to medium-grained chert-quartz arenite and wacke; thick members of chert pebble conglomerate, black siliceous siltstone; nodular and bedded barite; rare limestone

DME2

DME2 EARN: silvery blue weathering black shale, argillite, cherty argillite and thin bedded chert; nodular and bedded barite; rare limestone

ORDOVICIAN TO LOWER DEVONIAN

ODR ROAD RIVER - SELWYN: black shale and chert (1) overlain by orange siltstone (2) or buff platy limestone (3); locally contains beds as old as Middle Cambrian (4); correlations with basal strata in Richardson Mountains include: ODR1 with ODR2 (upper part) and ODR2 with ODR4

ODR1

ODR1 ROAD RIVER - SELWYN: black, gun-blue, or silvery white weathering black graphitic shale and black chert; resistant grey weathering, thin to medium bedded, light grey to black, greenish grey or turquoise chert; minor argillaceous limestone

ODR2

ODR2 ROAD RIVER - SELWYN: rusty dark green to orange buff weathering, pyritic, burrowed, thin to thick bedded, argillite and dolomitic siltstone with members or partings of black shale and chert; minor bright orange dolostone

ODR3

ODR3 ROAD RIVER - SELWYN: blue-grey weathering, black limestone; tan, buff, or dark grey weathering platy, silty limestone

ODR4

ODR4 ROAD RIVER - SELWYN: black shale; limestone, limestone conglomerate, and interstratified argillite and pale yellow limestone

CAMBRIAN TO SILURIAN

CSM MARMOT: lower Paleozoic mostly mafic volcanics, in locally thick accumulations (1) - (6) but also of common occurrence as undifferentiated thin scattered members within other units

CSM1

CSM1 MARMOT: resistant, dark grey weathering, massive, locally pillowed, dark grey-green basalt, tuff and breccia

CSM5

CSM5 MARMOT: massive brown to green, basic lapilli tuff, breccias, flows, sills, and dikes; intracast breccia and conglomerate; brown weathering, green to grey, medium to very thick-bedded volcanoclastic sandstone

UPPER CAMBRIAN AND ORDOVICIAN

COR1 RABBITKETTLE: thin bedded, wavy banded, silty limestone and grey lustrous calcareous phyllite; limestone intracast breccia and conglomerate; massive to laminated, grey quartzose siltstone and chert and rare black slate; local mafic flows, breccia, and tuff

COR2

COR2 RABBITKETTLE: as in COR1, but may include Middle Cambrian and Middle Ordovician beds undivided

LOWER CAMBRIAN

ICG1 GULL LAKE: shale, siltstone, and mudstone, locally bioturbated, with minor quartz sandstone; rare green-grey chert; local basal limestone and limestone conglomerate; phyllite to quartz-muscovite-biotite schist (garnet, sillimanite, staurolite, andalusite)

ICG2

ICG2 GULL LAKE: dark green massive to fragmental mafic metavolcanic and volcanoclastic rocks; siltstone and argillite

UPPER PROTEROZOIC TO LOWER CAMBRIAN

PCH HYLAND: consists upwards of coarse turbiditic clastics (1), limestone (2), and fine clastics typified by maroon and green shale (3); includes scattered mafic volcanic rocks (5)

PCH1

PCH1 HYLAND: thin to thick-bedded, brown to pale green shale, fine to coarse-grained quartz-rich sandstone, grit, and quartz pebble conglomerate; minor argillaceous limestone, phyllite, quartzofeldspathic, and micaceous psammite, and minor marble

PCH2

PCH2 HYLAND: grey weathering, dark grey to grey white, thin to thick bedded, very fine crystalline limestone, locally sandy; calc-silicate and marble; may locally include carbonate members within (1) or (4)

PCH3

PCH3 HYLAND: distinctive, recessive, maroon weathering, interbedded maroon and apple-green slate; "Olichania" trace fossils; rare grey chert; locally basal member and interbeds of quartz siltstone, sandstone and quartz-pebble conglomerate

PCH5

PCH5 HYLAND: dark brown and green to light grey weathering, dark green volcanic rocks, commonly with calcite filled vesicles, breccia, tuff, and agglomerate; minor interbedded shale, chert, siltstone, and limestone

MIDDLE DEVONIAN

DH1 HUME: buff-brown weathering argillaceous to silty, dark grey, fine-grained limestone, platy to thin bedded; minor intercalated irregularly banded orange weathering dolostone and thin beds of resistant, orange-brown weathering limestone; richly fossiliferous

DH2

DH2 HUME: massive, thick-bedded, fine to medium-grained, light grey weathering limestone

DH4

DH4 HUME: buff-orange weathering, thin to medium-bedded silty limestone

DL

DL LANDRY: thin to very thick bedded, resistant, light grey weathering, medium to light grey and brownish crypto-grained limestone; massive and thick-bedded bioclastic, locally reefoid limestone; black, platy limestone

DN

DN NATLA: dark grey weathering, platy, thin bedded, recessive sooty limestone, in part crinoidal; uncommon beds of massive crinoidal limestone

DA

DA ARNICA: thin and thick-bedded dark grey to black commonly laminated dolostone; minor light grey dolostone and light grey to medium grey weathering dark grey to black limestone; striped dolostone; local massive wuggy breccia

UPPER LOWER TO LOWER MIDDLE DEVONIAN

DB GRIZZLY BEAR: limestone, well bedded, blocky partings, massive, fine to medium crystalline; scattered corals, brachiopods, bryozoans, and twin canal echinoderm ossicles

LOWER DEVONIAN

IDS SOMBRE: light and medium grey, even bedded, fine-grained dolostone; silver-grey dolostone; locally three members of light grey dolostone (lower); dark grey dolostone, in part crinoidal (middle); alternating light and dark grey dolostone (upper)

UPPER SILURIAN TO LOWER DEVONIAN

SDD DELORME: buff to orange weathering, well bedded, buff, light grey, brownish grey and dark grey; very fine grained dolostone; platy to flaggy, wavy banded blue-grey silty limestone with rare thin beds of buff weathering dolostone

UPPER CAMBRIAN TO SILURIAN

CSH HAYWIRE: undivided medium to thick-bedded, white to dark-grey dolostone, locally cherty; rare amygdaloidal basalt and tuff; basal member of grey-white dolostone, quartz arenite, and maroon mudstone

UPPER ORDOVICIAN AND SILURIAN

OSK2 KINDLE: thick-bedded, black, coarse-grained dolostone and interbedded grey weathering laminated dolostone with nodules and bands of black chert; medium grey weathering, platy, grey argillaceous limestone with minor chert shale; massive and reefoid dolostone

OSK4

OSK4 KINDLE: thick bedded to massive light grey dolostone and limestone; dark grey, feld limestone; includes undifferentiated beds as young as Lower Devonian

MIDDLE ORDOVICIAN

OS SUNBLOOD: mainly buff, rouge and light grey weathering platy dolostone and limestone; local interbedded light and dark grey fine crystalline and white coarse crystalline dolostone at base; rare thick beds of light blue-grey limestone

UPPER CAMBRIAN AND ORDOVICIAN

COF2 FRANKLIN MOUNTAIN: well bedded, rhythmically bedded, grey and buff-orange dolostone; includes grey to black dolostone and dark grey to black limestone; local basal member of maroon dolostone and sandstone, silver-grey sandstone, and sandy dolostone

MIDDLE CAMBRIAN

mCH HESS RIVER: shale, black, pyritic, unfossiliferous; occurs as interstratified thick units of black calcareous shale and rusty black shale

mCR

mCR ROCKSLIDE: recessive, dark grey weathering, laminated, platy calcareous shale, and silty, dark grey fine to crypto-grained limestone; minor thin beds of light brown to grey weathering platy dark crypto-grained limestone and rare bands of buff dolostone

LOWER CAMBRIAN

ICS SEKIWI: limestone, locally wavy bedded and nodular; limestone conglomerate slope breccia; massive grey dolostone; medium to thick-bedded quartz sandstone; purple siltstone; bright orange weathering, fine crystalline dolostone

UPPER PROTEROZOIC TO LOWER CAMBRIAN

uPCV VAMPIRE: dark brown weathering, thin-bedded, argillaceous fine-grained sandstone and siltstone, minor interbedded medium to coarse-grained white to light grey quartzite; phyllite, slate, and argillite

PCB1

PCB1 BACKBONE: light grey, red-brown, white, and pink, thick-bedded, medium to coarse-grained orthoquartzite; minor brown or maroon phyllite, platy siltstone, silty shale, thin-bedded fine-grained quartzite, grey limestone, and sandy to pebbly limestone

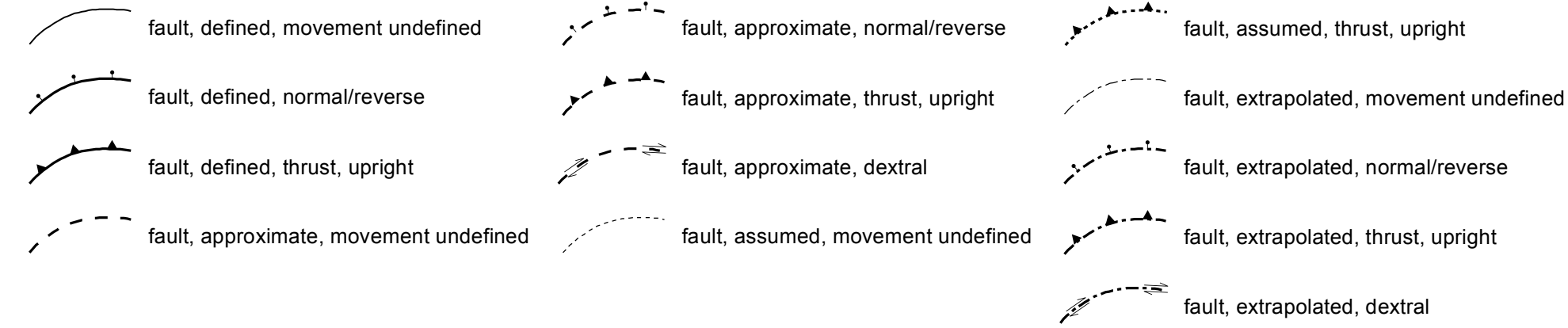


Table 2: List of Mineral Occurrences for NTS map sheets 1050 and part of 105P

OCCURRENCE #	OCCURRENCE NAME	ALIAS(ES)	DEPOSIT TYPE	STATUS	ECONOMIC COMMODITIES	OTHER COMMODITIES
1050 001	TOM		Sedimentary Exhalative Zn-Pb-Ag (Sedex)	Deposit	Pb, Ag, Zn, Ba	Sb, barite, Cu
1050 002	MACLUNG		W Skarn	Deposit	W	Cu
1050 003	JEFF		Porphyry Mo (Low F-Type)	Showing		Mo
1050 004	ALP		Au-Quartz Veins	Showing		Au, Ag
1050 005	NIDDERY		Plutonic Related Au	Prospect		barite, Cd, Cu, Au, Ni, Ag
1050 006	SCOT		Sedimentary Exhalative Zn-Pb-Ag (Sedex)	Drilled Prospect		Cu, Ni, Ag, Zn
1050 007	ART		Au-Quartz Veins	Prospect		Sb, As, Bi, Au, Pb, Ag
1050 008	KEELE		Porphyry Mo (Low F-Type)	Showing		Mo
1050 009	EMERALD		Porphyry-related Au	Showing		Bi, Cu, Au, Mo, Ag, W
1050 010	HOHN		Cu Skarn	Prospect		Cu, Au
1050 011	BEN		Sedimentary Exhalative Zn-Pb-Ag (Sedex)	Showing		Pb, Zn
1050 012	ARROWHEAD		Polymetallic Veins Ag-Pb-Zn+/Au	Showing		Cu, Pb, Zn
1050 013	RACCOT		Sediment-Hosted Barite	Deposit	barite	Zn
1050 015	INCA		Polymetallic Veins Ag-Pb-Zn+/Au	Past Producer	Ag	Pb, Zn
1050 016	STANDARD		Polymetallic Veins Ag-Pb-Zn+/Au	Showing		Pb, Ag, Zn
1050 018	ODD		Mississippi Valley-Type Pb-Zn (MVT)	Drilled Prospect		Pb, Ag, Zn
1050 019	JASON		Sedimentary Exhalative Zn-Pb-Ag (Sedex)	Deposit	Pb, Ag, Zn	barite
1050 020	SANDYBAR	TEA	Sediment-Hosted Barite	Deposit		
1050 021	WALT	BAR	Sediment-Hosted Barite	Deposit		barite, Cu, Pb, Ag, Zn
1050 022	TRYALA		Sediment-Hosted Barite	Drilled Prospect		barite, Ba, Cu, Pb, Ag, Zn
1050 023	ORZLE	RAIN	Shale-Hosted Ni-Zn-Mo-PGE (Nick)	Showing		barite, Cu, Pb, Mo, Ni, V, Zn
1050 024	NIDPO		Sedimentary Exhalative Zn-Pb-Ag (Sedex)	Drilled Prospect		barite, Ag, Zn
1050 025	BREMNER		Unknown	Drilled Prospect		Cu, Pb, Zn
1050 026	DICKIE		Sedimentary Exhalative Zn-Pb-Ag (Sedex)	Unknown		Cu, Pb, Mo, Zn
1050 027	GARY	GARGANTUA	Sediment-Hosted Barite	Deposit	barite	
1050 028	FETCH		Sediment-Hosted Barite	Drilled Prospect		barite, Zn
1050 029	GOW	TH	Sedimentary Exhalative Zn-Pb-Ag (Sedex)	Anomaly		barite
1050 030	GRIZ		Porphyry Mo (Low F-Type)	Showing	Au, Mo, Ag, W	
1050 031	ELAN ANDERSEN		Porphyry Mo (Low F-Type)	Showing		Mo
1050 032	NEVE	BIRD	Au-Quartz Veins	Drilled Prospect	Sb, Au, Ag, Zn	
1050 033	KELVIN	OROCK	Polymetallic Veins Ag-Pb-Zn+/Au	Prospect	Sb, Au, Pb, Ag	
1050 036	FAN		Unknown	Showing	barite	
1050 037	LOMER		Barite Veins	Showing		
1050 038	DUET		Unknown	Anomaly	Zn	
1050 039	OLD CABIN		Polymetallic Veins Ag-Pb-Zn+/Au	Showing	Cu, Au, Pb, Mo, Ag	
1050 040	URSA		Unknown	Anomaly	Cu	
1050 041	FANGO		Polymetallic Veins Ag-Pb-Zn+/Au	Prospect	Sb, Au, Pb, Ag, Zn	
1050 042	FAL		Unknown	Unknown		
1050 043	SIM		W Skarn	Showing	Pb, W, Zn	
1050 044	NUT		W Skarn	Showing	Cu, Pb, Ag, W, Zn	
1050 045	STROSHEN		Sediment-Hosted Barite	Showing	barite	
1050 046	MINORCO		Sediment-Hosted Barite	Showing	barite	
1050 048	NURK		Polymetallic Veins Ag-Pb-Zn+/Au	Showing	Sb, As, Bi, Cu, Au, Pb, Ag	
1050 049	FARNZ		Au-Quartz Veins	Showing	As, Au	
1050 050	NORTH MACMILLAN		Barite Veins	Showing		
1050 051	DALL	HAIRAN	Au-Quartz Veins	Prospect	Cu, Au	
1050 052	BAILES		Unknown	Unknown	Cu, Au, Pb, Ag, Zn	
1050 054	ROSCUE		Polymetallic Veins Ag-Pb-Zn+/Au	Prospect	Cu, Ag, Zn	
1050 055	CHRISTINA		Subvolcanic Cu-Au-Ag (As-Sb)	Showing	Cu, Au, Ag	
1050 056	GOLD		Porphyry Cu (Low F-Type)	Anomaly		
1050 057	STAMP	NID	Plutonic Related Au	Prospect	As, Cu, Au, Pb, Ag	
1050 058	LM		Plutonic Related Au	Drilled Prospect	Cu, Ag, Ag	
1050 059	SCRONK		Polymetallic Veins Ag-Pb-Zn+/Au	Showing	Sb, Bi, Cu, Au, Ag, Zn	
1050 060	HASTEN		Unknown	Drilled Prospect	Zn	
1050 061	LUN		Unknown	Anomaly	Pb, Zn	
1050 071	MEHTABEL		Cu Skarn	Drilled Prospect	Au	