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A PROBABILISTIC APPROACH TO THE RANKING OF TERRANES HOSTING VMS DEPOSITS IN THE WESTERN CORDILLERA

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INTRODUCTION

A typical exploration programme evolves from the stage where strategists within a company decide that a specific commodity is to be exploited in the future. This directive leads to the generative stage whereby exploration geologists and property acquisition personnel evaluate terranes for potential to host specific types of deposits. Invariably the geological reconnaissance programmes that follow are carried out solely on the basis of qualitative research and non-systematic analyses. This approach can and does lead to discoveries; however, this does not mean that exploration funds are expended in the terranes which will provide for the highest probability of a profitable venture. By carrying out exploration in the less prospective terranes exploration funds are not used in the optimum manner.

The probabilistic approach presented here is intended to systematize the discussions that are involved in the choosing of terranes for future exploration of volcanogenic massive sulphide (VMS) deposits. The tableau provided in the accompanying spreadsheets will enable discussions to revolve around economics rather than "gut feelings".

THEORY

The expected value (EV) of a terrane hosting VMS occurrences is the sum of the products of the gross in-situ metal values (GIMV) and the probabilities of each of the estimated tonnage and grade occurrences occupying the terrane. Note that the EV of a terrane will nearly always be less than the GIMV of one of the larger deposits within the terrane because of the incorporation of probabilities into the calculation.

The subjective probabilities relating to the presence of a specific tonnage and grade VMS occurrence within a terrane must be estimated. These probabilities are subsequently applied against the GIMVs of the occurrences. The sum of the probabilities is the EV of the terrane. This EV is further modified by the probability that a deposit will occur within the terrane and then also by the probability that the deposit will be discovered using standard exploration techniques.

In order to more closely approximate the expected payback of a terrane, the costs of the various stages of exploration and ultimately delineation and development must be incorporated into the EV calculations.

METHODOLOGY

Gross in-situ metal values of specific deposits were determined on the basis of average 1989 London Metal Exchange prices (Table 1) and from tonnage and grade data obtained from

the Western Cordilleran Massive Sulphide Compilation file on the Placer Dome Inc. SUN computer (Table 2). These deposits are used as proxies for the terranes in which they are hosted. In some cases more than one deposit is calculated for one terrane, for example, Kutcho Creek and Tulsequah Chief in the Stikinia Terrane and Hidden Creek and Windy Craggy in the Alexander Terrane.

The subjective probabilities associated with the occurrence of specific tonnage occurrences and the total expected GIMVs are found in Table 3. A summary of the EVs associated with proxied terranes is given in Table 4. Figure 1, (Decision Tree), and Table 5, (Prior Probabilities Associated with a Discovery), illustrate and list the exploration options and associated probabilities with the discovery of an occurrence.

The decision tree is only developed for the branch in which there is a probability of success in detecting an occurrence. To be more correct, the EV of a terrane is the sum of the EVs of the branch in which there is a probability of success of detecting an occurrence and the EVs of the branch in which there is a probability of not detecting an occurrence. These latter probabilities are extremely difficult to determine, given that it is not normal practice to carry out exploration in terranes in which a deposit type is not expected to occur.

The expected probabilities of the existence of additional occurrences within a specific terrane (proxied by known occurrences) are given in Table 7. Table 9 (below) gives the ranked potentials of the selected terranes.

TABLE 9

RANKED POTENTIALS OF TERRANES
(Proxied by known occurrences, past and present producers)

Windy Craggy	1
HW	2
Granduc	3
Goldstream	4
Tulsequah Chief	5
Kutcho Creek	6
Ecstall	7
No. 8 (Britannia)	8
Lara	9
Hidden Creek	10
Eskay Creek	11
Chu Chua	12
Seneca	13

USE OF THE LOTUS 1-2-3 SPREADSHEET

The spreadsheet is titled GIMVDISC.WK1. All tables address each other so that any change in metal value, tonnage, grade or subjective probability will result in a new EV and a new ranking for the proxied terrane.

Several tables will most likely have their inputs changed for discussion purposes. The following is a list of these tables and the effects that these changes will have on other tables.

Table #	Title	Variable to be changed.	Effect of Change
1	Average 1989 LME prices	Metal prices for Cu, Pb, Zn, Ag, Au	Varies GIMV in Table 2
2	Summary tonnages and grades of selected VMS deposits in the ..	Tonnage and grade	Varies GIMV in Table 2
3	Arbitrary probability distributions of potential future...	Subjective probabilities, and tonnage ranges	Varies expected GIMVs in Table 4, and Ranking of terranes in Table 9
5	Prior probabilities associated with a discovery	Prior probabilities	Ranking of terranes in Table 9
7	Expected probabilities of the existence of an occurrence within...	Expected probabilities	Ranking of terranes in Table 9

In order to commence a re-calculation of rank press Alt-C. If any value is changed after the initial recalculation it will be necessary to save the file, exit and re-enter LOTUS 1-2-3. During the file retrieve process, the computer memory will be cleared and the Macros used in the calculations will operate correctly.

APPENDIX A

Selected Tables used in the calculation
of Terrane Rankings

(as proxied by occurrences, past and present producers)

TABLE 1

AVERAGE 1989 LONDON METAL EXCHANGE PRICES

(US $)

	ELEMENT				
	Cu ($/lb)	Pb ($/lb)	Zn ($/lb)	Ag ($/g)	Au ($/g)
Price	1.29	0.306	0.777	0.176831	12.24962

TABLE 2

SUMMARY TONNAGES AND GRADES OF SELECTED VMS DEPOSITS IN THE WESTERN CORDILLERA

Deposit Name	Tonnage (millions mt)	Grade Cu (%)	Pb (%)	Zn (%)	Ag (g/tonne)	Au (g/tonne)	Gross in-situ Metal Value (millions US $)
Tulsequah Chief	5.79	1.60	1.33	7.00	103.51	2.85	$1,316.88
HW	12.86	2.57	0.35	5.22	38.06	2.40	$2,585.00
Eskay Creek	8.74				468.00	15.22	$2,353.08
Hidden Creek	39.23	1.05			10.30	0.17	$1,325.33
Granduc	44.11	1.66			7.05	0.11	$2,196.85
Ecstall	6.90	0.63		2.55	18.81	0.50	$490.24
Ecstall*	33.46	8.00		0.40	44.00		$8,101.36
Goldstream	3.18	4.49		3.12	20.00		$586.35
Kutcho Creek	28.50	1.49		2.09	30.91		$2,383.81
Lara	0.91	0.61	0.81	3.59	89.49	3.26	$127.18
Twin J	0.30	3.30		7.50	94.29	4.46	$88.11
Seneca	1.50	0.63	0.15	3.57	45.00	0.90	$148.60
Windy Craggy	111.50	1.70			3.60	0.20	$5,734.88
No. 8 (Britannia)	10.82	2.06	0.06	1.00	10.00	1.97	$1,104.05
Chu Chua	2.50	2.00		0.50	9.00	0.50	$182.90

Ecstall* Neves-Corvo deposit in Spain acting as a proxy for a potential deposit in the Ecstall River Valley

TABLE 3

ARBITRARY PROBABILITY DISTRIBUTIONS OF POTENTIAL FUTURE OCCURRENCES IN SELECTED TERRANES

Tulsequah Chief

Subjective Probability Range	Tonnage Range Minimum (mt)	Tonnage Range Maximum (mt)	Mid-Point (mt)	Expected GIMV (Thous. US$)
0.40	0	200,000	100,000	$9,104
0.30	200,001	400,000	300,001	$20,484
0.20	400,001	1,000,000	700,001	$31,864
0.07	1,000,001	2,000,000	1,500,001	$23,898
0.02	2,000,001	5,000,000	3,500,001	$15,932
0.01	5,000,001	7,000,000	6,000,001	$13,656
		Total expected GIMV		$114,938

HW

0.50	0	500,000	250,000	$25,125
0.20	500,001	1,000,000	750,001	$30,150
0.15	1,000,001	2,500,000	1,750,001	$52,762
0.10	2,500,001	5,000,000	3,750,001	$75,374
0.05	5,000,001	10,000,000	7,500,001	$75,374
		Total expected GIMV		$258,783

Eskay Creek

0.75	0	200,000	100,000	$20,192
0.10	200,001	500,000	350,001	$9,423
0.07	500,001	1,000,000	750,001	$14,135
0.05	1,000,001	2,000,000	1,500,001	$20,192
0.02	2,000,001	5,000,000	3,500,001	$18,846
0.01	5,000,001	8,000,000	6,500,001	$17,500
		Total expected GIMV		$100,289

Hidden Creek

0.50	0	200,000	100,000	$1,689
0.30	200,001	500,000	350,001	$3,547
0.20	500,001	750,000	625,001	$4,223
0.05	750,001	1,000,000	875,001	$1,478
0.03	1,000,001	2,000,000	1,500,001	$1,520
0.02	5,000,001	10,000,000	7,500,001	$5,067
0.01	10,000,001	15,000,000	12,500,001	$4,223
		Total expected GIMV		$21,747

TABLE 3 (Cont'd)

Granduc

Subjective Probability Range	Tonnage Range Minimum (mt)	Maximum (mt)	Mid-Point (mt)	Expected GIMV (Thous. US$)
0.50	0	500,000	250,000	$6,225
0.25	200,001	1,500,000	850,001	$10,583
0.15	400,001	2,000,000	1,200,001	$8,965
0.10	1,000,001	5,000,000	3,000,001	$14,941
0.07	2,000,001	10,000,000	6,000,001	$20,918
0.03	5,000,001	20,000,000	12,500,001	$18,676
		Total expected GIMV		$80,309

Ecstall

0.70	0	100,000	50,000	$2,487
0.20	100,001	500,000	300,001	$4,263
0.10	500,001	1,000,000	750,001	$5,329
0.07	1,000,001	2,500,000	1,750,001	$8,704
0.02	2,500,001	5,000,000	3,750,001	$5,329
0.01	5,000,001	10,000,000	7,500,001	$5,329
		Total expected GIMV		$31,439

Goldstream

0.50	0	200,000	100,000	$9,234
0.30	200,001	400,000	300,001	$16,621
0.10	400,001	1,000,000	700,001	$12,927
0.05	1,000,001	3,000,000	2,000,001	$18,468
0.03	3,000,001	5,000,000	4,000,001	$22,161
0.02	5,000,001	7,000,000	6,000,001	$22,161
		Total expected GIMV		$101,572

Kutcho Creek

0.40	0	1,000,000	500,000	$16,728
0.30	1,000,001	2,000,000	1,500,001	$37,639
0.20	2,000,001	5,000,000	3,500,001	$58,550
0.05	5,000,001	7,000,000	6,000,001	$25,093
0.03	7,000,001	10,000,000	8,500,001	$21,329
0.02	10,000,001	15,000,000	12,500,001	$20,911
		Total expected GIMV		$180,250

TABLE 3 (Cont'd)

Lara

Subjective Probability Range	Tonnage Range Minimum (mt)	Maximum (mt)	Mid-Point (mt)	Expected GIMV (Thous. US$)
0.75	0	100,000	50,000	$5,251
0.10	100,001	250,000	175,001	$2,451
0.05	250,001	500,000	375,001	$2,626
0.05	500,001	1,000,000	750,001	$5,251
0.04	1,000,001	2,500,000	1,750,001	$9,802
0.01	2,500,001	5,000,000	3,750,001	$5,251
		Total expected GIMV		$30,632

Seneca

0.50	0	50,000	25,000	$1,238
0.30	50,001	100,000	75,001	$2,229
0.10	100,001	200,000	150,001	$1,486
0.07	200,001	500,000	350,001	$2,427
0.03	500,001	1,000,000	750,001	$2,229
		Total expected GIMV		$9,609

Windy Craggy

0.18	0	500,000	250,000	$2,315
0.30	500,001	1,000,000	750,001	$11,573
0.25	1,000,001	2,500,000	1,750,001	$22,502
0.15	2,500,001	5,000,000	3,750,001	$28,932
0.05	5,000,001	10,000,000	7,500,001	$19,288
0.05	10,000,001	30,000,000	20,000,001	$51,434
0.02	30,000,001	50,000,000	40,000,001	$41,147
		Total expected GIMV		$177,190

Britannia

0.40	0	100,000	50,000	$2,040
0.27	100,001	250,000	175,001	$4,820
0.15	250,001	500,000	375,001	$5,738
0.10	500,001	1,000,000	750,001	$7,650
0.05	1,000,001	2,000,000	1,500,001	$7,650
0.02	2,000,001	2,500,000	2,250,001	$4,590
0.01	2,500,001	4,000,000	3,250,001	$3,315
		Total expected GIMV		$35,802

TABLE 3 (Cont'd)

Chu Chua

Subjective Probability Range	Tonnage Range Minimum (mt)	Tonnage Range Maximum (mt)	Mid-Point (mt)	Expected GIMV (Thous. US$)
0.60	0	100,000	50,000	$2,195
0.20	100,001	250,000	175,001	$2,561
0.10	250,001	500,000	375,001	$2,744
0.07	500,001	1,000,000	750,001	$3,841
0.02	1,000,001	2,000,000	1,500,001	$2,195
0.01	2,000,001	3,000,000	2,500,001	$1,829
		Total expected GIMV		$15,364

TABLE 4

SUMMARY TABLE OF EXPECTED GROSS IN-SITU METAL VALUES WITHIN VARIOUS TERRANES
(using occurrences, and past and present producers as proxies)

	(millions US$)
Tulsequah Chief	$114.938
HW	$258.783
Eskay Creek	$100.289
Hidden Creek	$21.747
Granduc	$80.309
Ecstall	$31.439
Goldstream	$101.572
Kutcho Creek	$180.250
Lara	$30.632
Seneca	$9.609
Windy Craggy	$177.190
No. 8 (Britannia)	$35.802
Chu Chua	$15.364

FIGURE 1

DECISION TREE

WHICH TERRANE IS MOST PROSPECTIVE FOR PRODUCING
THE HIGEST GROSS IN- SITU METAL VALUE DEPOSITS?

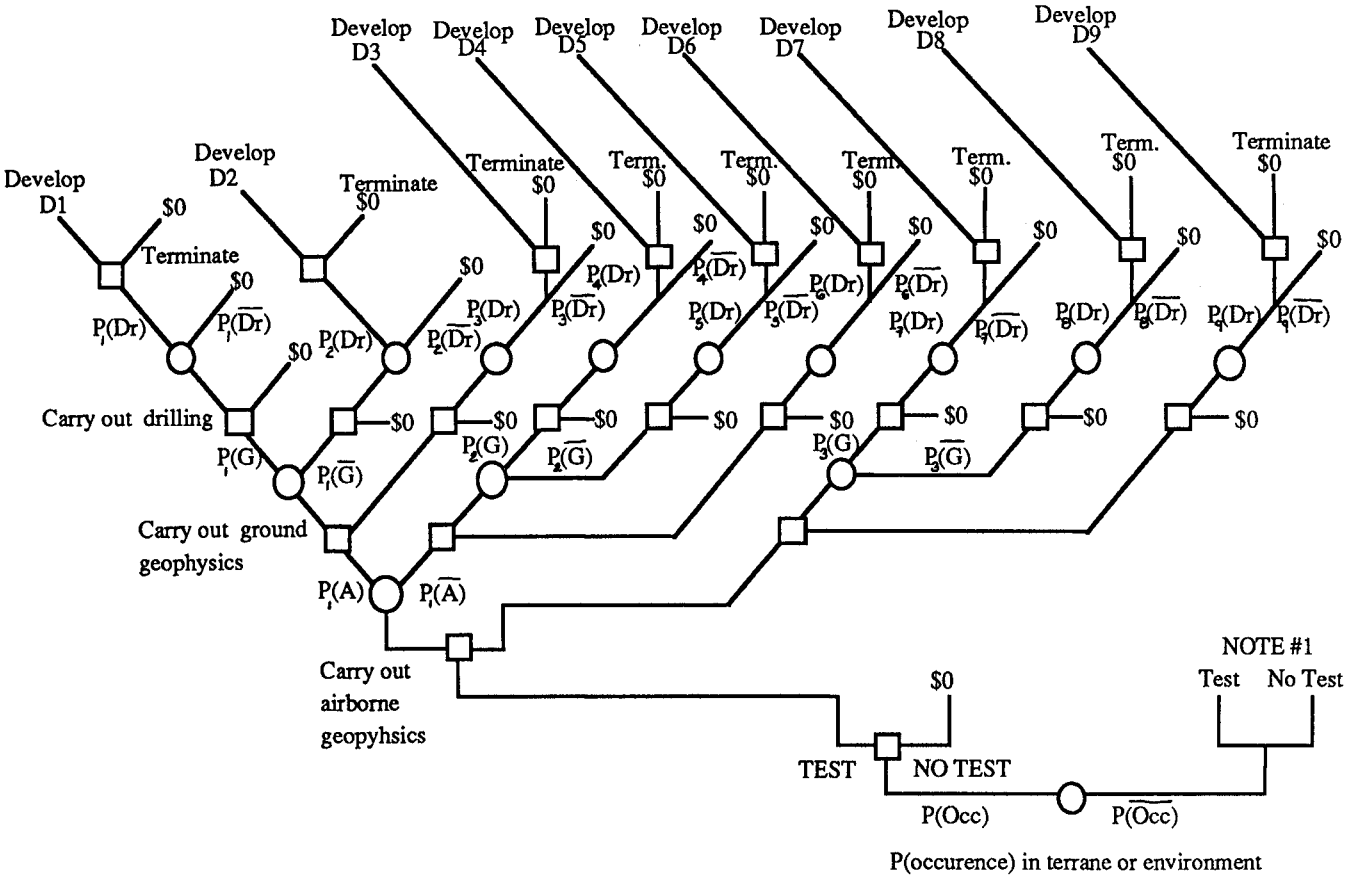

TABLE 5

PRIOR PROBABILITIES ASSOCIATED WITH A DISCOVERY

P1(A)	0.3000	P1(a)	0.7000
P1(G)	0.7000	P1(g)	0.3000
P1(DR)	0.0180	P1(dr)	0.9820
P2(DR)	0.0045	P2(dr)	0.9955
P3(DR)	0.0022	P3(dr)	0.9978
P2(G)	0.3500	P2(g)	0.6500
P4(DR)	0.0100	P4(dr)	0.9900
P5(DR)	0.0020	P5(dr)	0.9980
P6(DR)	0.0010	P6(dr)	0.9990
P3(G)	0.3000	P3(g)	0.7000
P7(DR)	0.0100	P7(dr)	0.9900
P8(DR)	0.0020	P8(dr)	0.9980
P9(DR)	0.0001	P9(dr)	1.0000

TABLE 7

SUMMARY TABLE OF EXPECTED PROBABILITIES OF THE EXISTENCE OF AN OCCURRENCE WITHIN THE SAME TERRANE AS....
(using occurrences, and past and present producers as proxies)

	Prior Probabilities
Tulsequah Chief	0.40
HW	0.50
Eskay Creek	0.20
Hidden Creek	0.95
Granduc	0.70
Ecstall	0.95
Goldstream	0.50
Kutcho Creek	0.20
Lara	0.80
Seneca	0.25
Windy Craggy	0.80
No. 8 (Britannia)	0.70
Chu Chua	0.75

TABLE 9

RANKED POTENTIALS OF TERRANES
(Proxied by known occurrences, past and present producers)

Windy Craggy	1
HW	2
Granduc	3
Goldstream	4
Tulsequah Chief	5
Kutcho Creek	6
Ecstall	7
No. 8 (Britannia)	8
Lara	9
Hidden Creek	10
Eskay Creek	11
Chu Chua	12
Seneca	13