COBALT, NICKEL, AND VANADIUM CONTENTS OF PYRITE CONCENTRATES FROM THE MICHIGAMME FORMATION, NORTHERN MICHIGAN

by

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ABSTRACT

This open file report is an extension of the work of Trow (1979, DNR Open-File Report) and specifically deals with pyrites in the approximately 2 b. y. old Michigamme Formation in northern Michigan. The Michigamme Formation is composed of mostly slate and argillite with lesser amounts of intercalated graywacke, iron formation, ashbed (volcanogenic) and quartzite. These rocks generally contain between 0.2 and 4.0 weight percent carbon and typically, calculated pyrite content is less than 2 weight percent. There are at least four textural types of pyrite in the Michigamme rocks. Co, Ni and V content were determined for 80 pyrite concentrates of core samples from six diamond drill holes. The pyrite data can be divided into four groups: a) low Ni and Co; b) low Ni and variable Co; c) low Co and variable Ni; and d) variable Co and Ni. The Co/Ni ratios of pyrite are not simply interpretable but most can be explained by a combination of sedimentary and metamorphic processes. A few can be less certainly related to volcanic-exhalative processes. This study leaves open the question of economic potential for massive sulfide deposits in the Michigamme Formation.

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INTRODUCTION

Carbon-rich, pyritic sedimentary and metasedimentary rocks, including Precambrian black shales, are known to be host rocks for base metal sulfide mineralization. Often, these are stratiform massive pyrite and/or pyrrhotite with associated base metal sulfides. Examples of such deposits includes

1. Outokumpu, Finland, where stratiform massive sulfides containing Ni and Co are hosted by Middle Precambrian organic- and pyrite-rich metapelites (Peltola, 1978).
2. MacArthur River, Mt. Isa, and Broken Hill, Australia, where stratiform Pb-Zn sulfides are hosted by Precambrian sediments and spatially associated with iron formation (Williams, 1980f Stanton and Vaughn, 1979).
3. Kupfershiefer, Germany, where base metal sulfides are hosted by Permian shale and sandstone (Jung and Knitzschke, 1976) .
4. Ducktown, Tennessee, where massive sulfides are hosted by Precambrian metamorphosed sediments (Magee, 1968).

The Michigamme Formation of the Upper Peninsula of Michigan consists of carbon-rich slates and argillites, turbiditic graywackes, intercalated volcanics and minor iron formation that have been weakly metamorphosed to lower greenschist facies except in the vicinities of metamorphic nodes.

The Michigamme Formation (2 ± 0.2 b.y.) (Cannon and Gair, 1970) bears some resemblance in lithology of many of the host rocks cited above, particularly to the Outokumpu rocks which are of similar age. At Outokumpu, Co and Ni are found as substitutions for Fe in the pyrite structure. An average of 0.6% Co is found in the early pyrite, but as much as 3% is found in pyrite porphyroblasts in massive pyrrhotite ore. Co is enriched relative to Ni in pyrite, yielding large Co/Ni ratios (Peltola, 1978).

The trace element geochemistry of pyrite, particularly Co and Ni, have been used by numerous workers in an attempt to distinguish biogenic from volcanogenic or hydrothermal origin (Pandalai et al., 1983; Duchesne et al. , 1983? Bralia et al. , 1979; Price, 1972; Loftus-Hills and Solomon, 1967; Hegeman, 1943 and references therein). Where pyrite has not been subjected to metamorphism a Co/Ni ratio of greater than one and Co content greater than 100 ppm indicates volcanic-exhalative origin. The objective of this study is to report cobalt, nickel, and vanadium content and to discuss the mode of origin of pyrites in the Michigamme Formation.

SAMPLING AND ANALYTICAL METHODS

Core from six different diamond drill holes were examined. These cores were studied by Trow (1979a and b) who reports lithologic logs and whole-rock chemical composition for a variety of major and trace elements. The holes were drilled as part of the U. 8, Department of Energy's evaluation of uranium resources. About 2500m of Michigamme Formation were intersected by the drill holes (Fig. 1). The Michigamme Formation is composed of mostly slate and argillite with lesser amounts of graywacke, iron formation and volcanogenic deposits. The samples of Michigamme Formation used in this study are from these drill holes. Sampling of the core was based on a statistically unbiased method for each 1.5m segment. A total of 140 samples were processed but only 80 yielded enough pyrite for chemical analysis.

Pyrite was separated using standard heavy liquid and magnetic susceptiblity methods. Purity of the pyrite separate was checked and if necessary impurities were removed by hand-sorting. Co, Ni and V contents were determined by graphite furnace atomic absorption spectrometry. The pyrite was dissolved by aqua regia acid digestion. Detection limits were estimated to be about 2 ppm for each element. Precision of the data is better than plus or minus 15 percent of the amount determined. A total of 80 pyrite separates were analyzed (Appendix I). Whole-rock total sulfur was determined for the same 80 samples by a combustion and titration method (Appendix II).

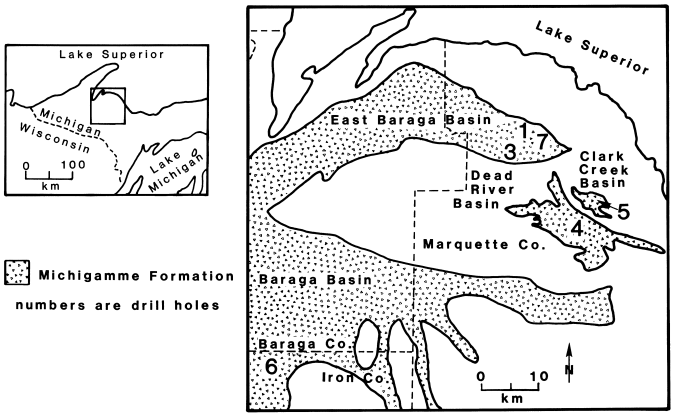

Figure 1: Distribution of the Michigamme Formation and location of drill holes, west-central northern Michigan.

Whole-rock chemical data (N=270) reported by Trow (1979b) were integrated into this study. Trow (1979b) reported Co, Ni and V contents analyzed by radio frequency argon plasma emission spectrometry. Carbon was determined by colorimetry.

RESULTS

Pyrite is common throughout the Michigamme Formation. In the polished sections which were examined pyrrhotite is very rare. Chalcopyrite and sphalerite are present in trace amounts and almost exclusively in veinlets. Whole-rock Zn and Cu contents reported by Trow (1979b) were used to calculate the percent of sphalerite and chalcopyrite assuming that all Zn and Cu are tied up in stoichmetric minerals. Calculated weight percent chalcopyrite and sphalerite is generally between 0.01 to 0.02 but there are a few values as much as about 0.1% (excluding one very anomalous value). After partitioning whole-rock total sulfur to sphalerite and chalcopyrite the remaining sulfur was assumed to be stoichmetric pyrite. Calculated pyrite content ranges up to 6.8 weight percent (Fig. 2). The linear correlation coefficient is 0.35 (N = 80, 0.22 significant at 95% confidence level) between carbon and calculated pyrite, both tend to be more abundant in slaty rocks and iron formation (Table 1).

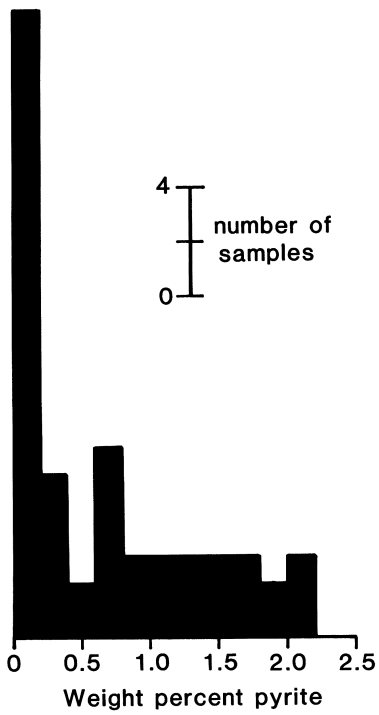

Figure 2: Histogram of calculated weight percent pyrite in representative samples of the Michigamme Formation. Two values of 4.3 and 6.8 are excluded from this figure.

Pyrite occurs as disseminated grains and rarely in veinlets. Generally, the disseminated grains are subhedral to anhedral in form. The maximum equivalent diameter of individual grains range from 0.1 mm to more than 2 mm. Ten samples were etched and no visible zoning or framboidal textures were observed. There are at least four textural types of pyrite: 1) finely disseminated pyrite in a fine-grained chlorite and carbon matrix which follows bedding; 2) fine-grained pyrite concentrated in crudely spherical shaped masses surrounded by disseminated pyrite in the matrix; 3) pyrite porphyroblasts with a recrystallized boxwork texture surrounded by matrix that is virtually devoid of pyrite; and 4) rarely euhedral pyrite is found filling veinlets which in some cases are surrounded by and partially replaced by later chalcopyrite and sphalerite. We interpret the first type of pyrite to be of syngenetic origin, the second and third types to be diagenetic (third possibly metamorphic?) and the fourth type to be epigenetic. Based on textural interpretation only a few samples contain more than a trace amount of epigenetic pyrite. In most cases pyrite is syngenetic with or without diagenetic/metamorphic remobilization.

The pyrites contain up to 7 90 ppm Co, up to 770 ppm Ni, and up to 400 ppm V (Fig. 3). The trace element data for Michigamme pyrites approach a log-normal distribution when values below the detection limit are considered. Pyrite from iron formation tends to have relatively high Ni contents and tends to have Co below the detection limit; pyrite from units defined by Trow (1979a) as interbedded ashbed and argillite often to have both Ni and Co contents below the detection limit or either one or the other with greater than 500 ppm (the high values raise the log-normalized means reported in Table 1).

Table 1: Log-normalized mean whole-rock and pyrite composition of various rock types in the Michigamme Formation. Rock types are based on drill core logs of Trow (1979a,b). For pyrite the detection limit value of 2 ppm for each element was used in calculating log-normalized means. Data are given in Appendix I and II.

	WHOLE-ROCKS						WHOLE-ROCK		PYRITE			
Rock Type	N	ppm Co	ppm Ni	ppmV	Co/Ni	Wt.%Carbon	N	Calculated Wt.%Pyrite	Co	Ni	V	Co/Ni
Slate (Gray-Black)	70	29	86	180	0.34	1.79	29	0.6	28	24	46	1.2
Slate + Argillite (Gray-Black)	42	32	99	173	0.32	1.59	15	1.2	27	11	14	2.5
Argillite (Gray-Black)	105	35	67	136	0.52	0.69	20	0.3	8	32	38	0.25
Argillite + Graywacke (Gray)	17	28	49	92	0.57	0.72	6	0.1	11	91	15	0.1
Ashbed _ Graywacke (Gray)	20	30	62	119	0.48	0.54	7	0.2	7	24	22	0.3
Iron Formation	9	44	37	80	1.19	0.87	3	1.7	<2	188	42	<0.1
Quartzite	7	19	14	25	1.36	0.36			NO DATA			

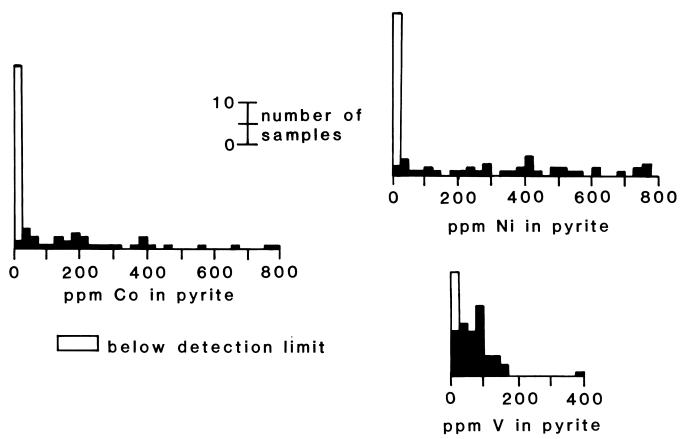

Figure 3: Histograms of Co, Ni and V contents in pyrite from the Michigamme Formation.

The Co/Ni ratios of pyrites from the Michigamme Formation are generally less than 1.0 (Fig. 4). The Co/Ni ratios of pyrite with Co and/or Ni below the detection limit are difficult to evaluate. We arbitarily assummed the detection limit value for calculation of the ratios. Lithologically, slates tend to have the highest ratios (Table 1).

For whole-rock chemical data of the Michigamme Formation reported by Trow(1979b) we calculated the following linear correlation coefficients (N=270; 0.11 significant at the 95% confidence level): nickel versus vanadium, +0.71; vanadium versus organic carbon, +0.62; nickel versus organic carbon, +0.44; nickel versus cobalt, +0.19; cobalt versus organic carbon, +0.10; and cobalt versus vanadium, +0.09. The partitioning of Co, Ni, and V between the whole rock and pyrite was evaluated by using the calculated percent pyrite in combination with the pyrite and whole rock trace element data. For the majority of samples, less than 1.0% of the Co, Ni, and V in the whole rock is contained in the pyrite. For 30 percent of the samples, pyrite contained 1 to 20% of the total Ni in the whole rock and 1 to 30% of the total Co in the whole rock, and for 13 percent of the samples, pyrite contained 1 to 4% of the total V in the whole rock.

The distribution of cobalt-nickel ratios in pyrite separates from Michigamme rocks is illustrated in Figure 5. There are four obvious populations:

A. Ni and Co are below detection limits,

B. Ni is below detection limit and Co ranges up to 790 ppm.

C. Co is below detection limit and Ni ranges up to 770 ppm.

D. variable Co and Ni contents.

There is no clear correlation between the textural types of pyrite and cobalt-nickel ratios.

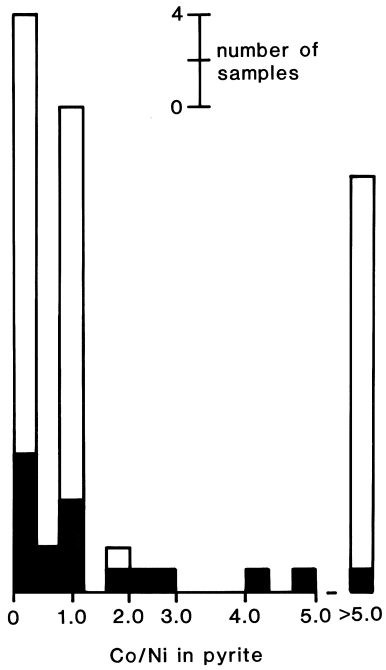

Figure 4: Histogram of Co/Ni ratio in pyrites from the Michigamme Formation. Open bars represent either Co and/or Ni below the detection limit and 2 ppm (detection limit) was used to calculate the Co/Ni ratio.

DISCUSSION

The whole rock trace element geochemistry of the Michigamme Formation reported by Trow (1979b) is not diagnostic of any particular shale environment. Trace element concentrations are of the same order of magnitude as average shales. The Michigamme rocks are enriched in carbon (typically 0.2 to 4 wt. %, two reported values are between 4 and 6 wt. % and 13 are below 0.2 out of 270) but contain less than “typical” black shales. High vanadium contents in the sedimentary environment usually are associated with the transport of V as vanadate ions and precipitation as sulfide. In the Michigamme Formation V is correlated with carbon content. The low V contents in the pyrite probably reflects low V content of the source rocks. Sediments typically have whole-rock Co/Ni ratios less than 1.0; however, Co is relatively enriched in oxidate minerals (e.g. Fe and Mn hydroxides). Thus, higher Co contents may be indicative of higher Fe or Mn hydroxides in the original sediments. In the sedimentary environments Ni is typically enriched in hydrolzates (e.g. clays), since Ni readily enters the octahedral unit in layered silicates. The lower whole-rock Co/Ni values in slates and argillites are probably indicative of larger proportions of layered silicates. Rocks containing mostly quartz, with only a minor clay component (quartzite) and iron rich rocks (iron formation) are relatively enriched in Co, resulting in Co/Ni ratios greater than 1.0 and probably reflect a high proportion of Fe hydroxides.

Pyrites of sedimentary origin might be expected to have Co/Ni ratios of less than 1.0 whereas those of volcanogenic origin (exhalative) are characterized by Co/Ni ratios of greater than 5, but more often greater than 10. The interpretation of the four obvious populations of Co/Ni ratios of pyrites from the Michigamme Formation (Fig. 5) is complicated by the fact that the Michigamme Formation has been subjected to variable degrees of folding and greenschist facies metamorphism. Duchesne et al. (1983) suggest that metamorphism can result in an enrichment of Co relative to Ni, an increase in the Co/Ni ratio. Thus, metamorphism could be invoked to explain Michigamme Formation pyrites of Groups B and possibly D. Some of the Co/Ni ratios of Group D pyrites fall within the field of magmatic origin and thus suggest the possibility, if one excludes Co enrichment by metamorphism, that a few samples could have been strongly influenced by volcanic-exhalative processes. These were from the East Baraga Basin (Fig. 1). Rocks with comparable whole-rock chemical composition but not enough extractable pyrite are present in the Dead River and Clark Creek Basins suggesting that this pyrite compositional type may exist beyond the East Baraga Basin. Loftus-Hills and Solomon (1967) reported pyrite related to granitic intrusions with both low cobalt and nickel contents and Co/Ni ratios of less than 1. Thus, Michigamme Formation Group A pyrites might have a volcanic-exhalative origin. This conclusion is supported by the fact that pyrites from interbedded ashbed

(volcanogenic) and argillite tend to be in Group A. In contrast, Price (1972) reports pyrites of sedimentary origin with 1 ppm Co and 5 to 15 ppm Ni. Michigamme Group C pyrites have no clear analog in the literature. Because of the very low Co/Ni ratios, we conclude that the Michigamme Group C pyrites are of probable sedimentary origin.

CONCLUSION

Petrographic and trace element data support a syngenetic and/or diagenetic origin for the majority of the pyrite. These data includes textural nature of the pyrite, abundance of pyrite in organic-rich rock, absence of significant amounts of sulfides other than pyrite and low partitioning of Co, Ni and V in pyrite of most samples. The Co/Ni ratios of pyrite are not interpreted to have a simple origin. Most of the data can probably be explained by a combination of sedimentary and metamorphic processes. The origin of Group A and a few of Group D might be volcanic-exhalative, although this conclusion is subject to debate. Overall, we suggest that hydrothermal or magmatic solutions were not a major contributor to sulfides in most of the Michigamme Formation sediments. This is not a surprising conclusion since such hydrothermal solutions are likely to be of relatively local extent. The location of the drill holes may have been a significant distance from such local hot spots.

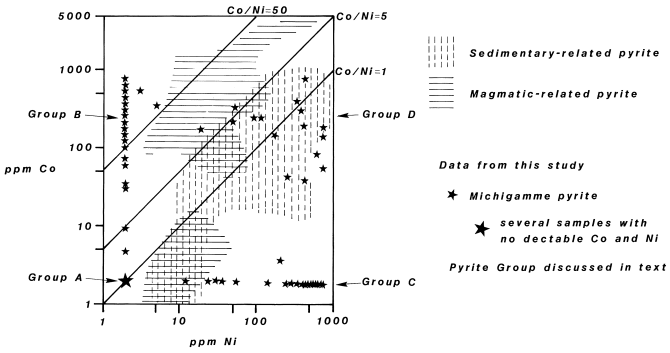

Figure 5: Variation of Co and Ni in pyrites from the Michigamme Formation. Field for the composition of sedimentary- and magmatic-related pyrites are drawn based on the data reported by Duchesne et al. (1983), Bralia et al. (1979), Price (1972) and Loftus-Hills and Solomon (1967). Groups of Michigamme Formation pyrites are discussed in the text. Data below the detection limit are plotted at the detection limit.

Clastic sedimentary rocks are known to host base metal massive sulfide deposits (Hutchinson, 1980). The lithology of the Michigamme Formation, mid-Proterozoic age, probable tectonic setting (Larue and Sloss, 1980), and the pyrite data reported in this study clearly leaves open the economic potential for massive sulfide deposits in the Michigamme Formation.

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APPENDIX I

Michigamme Formation
Pyrite Analyses

Cobalt, nickel and vanadium contents in pyrite as determined by atomic absorption analysis of separates from drill core. Details of the analytical technique can be found in Stadnik (1983). Drill hole numbers and the footage interval which was sampled correspond to Trow (1979a and b). Details about the drill core can be found in Trow (1979a and b). NE is equivalent to not enough pyrite for analysis.

Co, Ni and V Concentrations in Pyrite for Drill Hole 1.

Sampling Footage	Co (ppm)	Ni (ppm)	V (ppm)
134 - 139	145	767	34
194 - 199	<2	<2	136
284 - 289	<2	293	28
344 - 349	32	<2	81
404 - 409	35	<2	<2
464 - 469	<2	12	21
524 - 529	NE	NE	NE
584 - 589	<2	<2	<2
644 - 649	179	20	6
704 - 709	<2	<2	88
764 - 769	NE	NE	NE
824 - 829	788	445	34
884 - 889	453	<2	50
944 - 949	NE	NE	NE
1004 - 1009	NE	NE	NE
1064 - 1069	NE	NE	NE
1124 - 1129	NE	NE	NE
1184 - 1189	NE	NE	NE
1244 - 1249	368	48	27
1304 - 1309	<2	51	<2
1364 - 1369	<2	537	7
1424 - 1429	<2	<2	31
1484 - 1489	NE	NE	NE
1544 - 1549	176	748	<2
1604 - 1609	88	589	<2
1664 - 1669	205	<2	24
1724 - 1729	132	<2	85
1784 - 1789	101	<2	<2
1844 - 1849	286	<2	21
1904 - 1909	37	203	105
1964 - 1969	NE	NE	NE
2024 - 2029	NE	NE	NE
2084 - 2089	NE	NE	NE
2144 - 2149	73	<2	123

Co, Ni and V Concentrations in Pyrite for Drill Hole 3.

Sampling Footage	Co (ppm)	Ni (ppm)	V (ppm)
264 - 269	<2	<2	88
324 - 329	560	<2	67
384 - 389	257	99	70
444 - 449	9	<2	<2
504 - 509	NE	NE	NE
564 - 569	764	<2	137
624 - 629	<2	136	24
684 - 689	<2	<2	127
744 - 749	<2	434	164
804 - 809	145	178	96
864 - 869	<2	436	91
924 - 929	<2	<2	87
984 - 989		248	52
1044 - 1049	45	<2	79
1104 - 1109	<2	634	85
1164 - 1169	<2	402	105
1224 - 1229	<2	632	108
1284 - 1289	197	426	160
1344 - 1349	153	31	38
1404 - 1409	65	<2	141
1464 - 1469	187	<2	<2
1524 - 1529	378	353	82
1584 - 1589	43	248	136

Co, Ni and V Concentrations in Pyrite for Drill Hole 4.

Sampling Footage	Co (ppm)	Ni (ppm)	V (ppm)
139 - 144	<2	<2	21
199 - 204	<2	<2	5
259 - 264	NE	NE	NE
319 - 324	<2	276	<2
379 - 384	<2	<2	87
439 - 444	<2	<2	174
499 - 504	<2	439	<2
559 - 564	<2	768	84
619 - 624	NE	NE	NE
679 - 684	NE	NE	NE
739 - 744	NE	NE	NE
799 - 804	387	<2	70
859 - 864	301	<2	400
919 - 924	NE	NE	NE
979 - 984	667	<2	100
1039 - 1044	NE	NE	NE
1099 - 1104	57	736	NE
1159 - 1164	<2	754	7
1219 - 1224	<2	501	69
1279 - 1284	NE	NE	NE
1339 - 1344	<2	<2	71
1399 - 1404	<2	<2	68
1459 - 1464	<2	<2	<2
1519 - 1524	NE	NE	NE
1579 - 1584	<2	264	67
1639 - 1644	NE	NE	NE
1699 - 1704	NE	NE	NE
1759 - 1764	NE	NE	NE
1819 - 1824	236	122	89
1879 - 1884	NE	NE	NE
1939 - 1944	NE	NE	NE
1999 - 2004	NE	NE	NE
2059 - 2064	NE	NE	NE
2119 - 2124	NE	NE	NE
2179 - 2184	NE	NE	NE
2239 - 2244	NE	NE	NE
2299 - 2304	NE	NE	NE
2359 - 2364	NE	NE	NE
2419 - 2424	<2	506	19
2479 - 2484	NE	NE	NE
2539 - 2544	NE	NE	NE
2599 - 2604	NE	NE	NE
2659 - 2664	NE	NE	NE
2719 - 2724	NE	NE	NE
2779 - 2784	NE	NE	NE
2839 - 2844	<2	<2	<2
2899 - 2904	208	392	77
2959 - 2964	<2	<2	79
3019 - 3024	<2	<2	48
3079 - 3084	NE	NE	NE
3139 - 3144	NE	NE	NE

Co, Ni and V Concentrations in Pyrite for Drill Hole 5.

Sampling Footage	Co (ppm)	Ni (ppm)	V (ppm)
394 - 399	NE	NE	NE
454 - 459	<2	<2	54
514 - 519	<2	564	65
574 - 579	NE	NE	NE
634 - 639	<2	533	<2
694 - 699	NE	NE	NE
754 - 759	384	424	33
814 - 819	NE	NE	NE
874 - 879	NE	NE	NE
934 - 939	NE	NE	NE
994 - 999	NE	NE	NE
1054 - 1059	30	<2	156
1114 - 1119	57	28	100

Co, Ni and V Concentrations in Pyrite for Drill Hole 6.

Sampling Footage	Co (ppm)	Ni (ppm)	V (ppm)
308 - 313	NE	NE	NE
368 - 373	<2	<2	78
428 - 433	<2	34	27
488 - 493	NE	NE	NE
548 - 553	NE	NE	NE
608 - 613	NE	NE	NE
668 - 673	NE	NE	NE
728 - 733	NE	NE	NE
788 - 793	NE	NE	NE
848 - 853	<2	279	101
908 - 913	NE	NE	NE
968 - 973	<2	697	29
1028 - 1033	<2	465	69
1088 - 1093	154	<2	<2

Co, Ni and V Concentrations in Pyrite for Drill Hole 7.

Sampling Footage	Co (ppm)	Ni (ppm)	V (ppm)
305 - 310	418	107	32
365 - 370	NE	NE	NE
425 - 430	NE	NE	NE
485 - 490	NE	NE	NE
545 - 550	206	50	31
605 - 610	NE	NE	NE
665 - 670	<2	<2	69

APPENDIX II

Michigamme Formation Whole-Rock Sulfur Analyses and Calculated Pyrite Content

Whole-rock sulfur content was determined by a combustion and titration method on drill core described by Trow (1979a and b). The whole-rock weight percent pyrite was calculated from the sulfur data by first allocating sulfur to sphalerite, and chalcopyrite by whole-rock Zn and Cu data of Trow (1979b) and using then assuming the remaining sulfur occurs in pyrite.

Sulfur and Calculated Pyrite Content in Drill Hole 1.

Sampling Footage	Wt. % Total Sulfur	Wt. % Pyrite
134	.14	.10
194	.86	.73
284	1.00	.86
344	7.85	6.80
404	1.90	1.64
464	1.53	1.32
584	1.78	1.55
644	1.82	1.56
704	1.06	.92
824	.57	.48
884	1.01	.87
1244	.19	.16
1304	.29	.25
1364	.26	.22
1424	1.68	1.45
1544	.93	.80
1604	1.79	1.55
1664	1.86	1.61
1724	4.98	4.31
1784	.57	.47
1844	2.05	1.75
1904	1.19	1.02
2144	.57	.45

Sulfur and Calculated Pyrite Content in Drill Hole 3.

Sampling Footage	Wt. % Total Sulfur	Wt. % Pyrite
264	.99	.84
324	1.10	.92
384	.49	.41
444	1.82	1.55
564	.14	.12
624	.38	.31
684	.91	.76
744	.54	.44
804	.89	.76
864	.75	.63
924	.67	.57
984	.32	.26
1044	.84	.72
1104	.99	.83
1164	.88	.75
1224	2.52	2.17
1284	.83	.71
1344	1.53	1.32
1404	1.62	1.38
1464	2.09	1.80
1524	2.07	1.79
1584	1.70	1.45

Sulfur and Calculated Pyrite Content in Drill Hole 4.

Sampling Footage	Wt. % Total Sulfur	Wt. % Pyrite
139	.19	.15
199	.18	.15
319	.17	.14
379	.39	.32
439	.10	.08
499	2.02	1.75
559	.15	.12
799	.43	.36
859	2.40	2.07
979	.11	.09
1099	.23	.18
1159	.28	.23
1219	.19	.16
1339	.02	.01
1399	2.46	2.04
1459	1.65	1.36
1579	.12	.05
1819	.05	.04
2419	.07	.06
2839	1.82	1.54
2899	1.20	1.01
2959	2.23	1.92
3019	.10	.08

Sulfur and Calculated Pyrite Content in Drill Hole 5.

Sampling Footage	Wt. % Total Sulfur	Wt. % Pyrite
454	.19	.16
514	.21	.17
634	.16	.13
754	.11	.01
1054	1.31	1.12
1114	1.13	.97

Sulfur and Calculated Pyrite Content in Drill Hole 6.

Sampling Footage	Wt. % Total Sulfur	Wt. % Pyrite
368	.15	.09
428	3.17	1.78
848	2.15	1.08
968	1.26	.89
1028	1.03	.01
1088	.39	.33

Sulfur and Calculated Pyrite Content in Drill Hole 7.

Sampling Footage	Wt. % Total Sulfur	Wt. % Pyrite
305	.05	.03
545	.53	.04
665	.12	.01