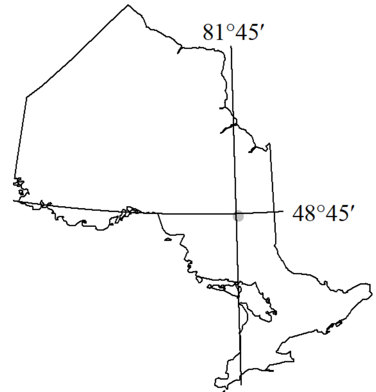
ISSN 1916-6117 (online)
ISBN 978-1-4868-6589-5 (PDF)
(for entire OFR 6390)

ISSN 0826-9580 (print)
ISBN 978-1-4868-6588-8 (print)
(for entire OFR 6390)

It is recommended that reference to the Content be made in the following form:

van Hees, E.H., Clarke, S.A., Crabtree, D.C., Péloquin, A.S. and Azadbakht, Z. 2022. Geology, geochemistry and mineralogy of the Enid Creek cobalt-copper-nickel-palladium-platinum prospect, Loveland Township, northwest of Timmins, Ontario; *in* Summary of Field Work and Other Activities, 2022, Ontario Geological Survey, Open File Report 6390, p.33-1 to 33-7.

33. Geology, Geochemistry and Mineralogy of the Enid Creek Cobalt-Copper-Nickel-Palladium-Platinum Prospect, Loveland Township, Northwest of Timmins, Ontario



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INTRODUCTION

A massive sulphide sample, collected at 320 feet (97.5 m) in Hollinger Consolidated Gold Mines Ltd. exploration drill-hole EC-16, was 1 of 10 samples selected by the staff of the Timmins Resident Geologist's office for chemical analysis because there were no geochemical data publicly available.

Hollinger Consolidated Gold Mines Ltd. drilled exploration drill-hole EC-16 in Loveland Township in 1968 (collared at Universal Transverse Mercator (UTM) 454130E 5389330N, North American Datum 1983 (NAD83), Zone 17) (MacKenzie 1968). The core was donated to the Resident Geologist Program and has been stored in the Timmins Drill Core Library.

Analysis of this sample indicated it contained 1.77 ppm Bi, 1480 ppm Co, 1926 ppm Cu, 21 290 ppm Ni, 2.06 ppm Pd, 0.32 ppm Pt, 33.4 ppm Se and 7.33 ppm Te (van Hees 2019). That resulted in additional analysis, by the Ontario Geological Survey Geoscience Laboratories, of nearby samples collected from telescoped drill core (2 inches every 5 feet (5 cm every 1.52 m)) containing disseminated sulphides from 200 to 350 feet (~61 to 106.7 m). Those analyses produced anomalous arsenic, bismuth, cobalt, copper, nickel, palladium, platinum, selenium and tellurium values over 95 feet (29 m) of core (van Hees 2019) and warranted research to identify what minerals host these elements.

GEOCHEMICAL AND MINERALOGICAL ANALYSIS

This study was conducted to establish 1) if cobaltite or pentlandite is present; 2) what mineral(s) host cobalt and nickel if there is no cobaltite or pentlandite present; 3) what minerals contain palladium and platinum; 4) what minerals host the palladium and platinum minerals; and 5) what copper phases are present.

The wall-rock geochemistry was characterized using X-ray fluorescence (XRF) and loss-on-ignition analysis (Geoscience Laboratories test methods XRF-M01, XRF-T05 and LOI-4ST) on 30 core samples between 200 and 350 feet (61 m and 106.7 m; sample 320 feet (97.5 m) was analyzed using test method IAT-100 because of the high sulphide content). These samples were also analyzed using X-ray diffraction to determine the wall-rock mineralogy. Core samples were relogged and polished thin sections examined to determine grain size of the wall rocks.

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Optical and electron microscopy studies of 8 polished thin sections cut from samples at 245 feet (74.6 m), 255 feet (77.7 m), 285 feet (86.9 m), 315 feet (96.0 m), 320 feet (97.5 m), 321 feet (97.8 m) and 325 feet (99.1 m) were completed to identify the minerals that contain the arsenic, bismuth, cobalt, copper, nickel, palladium, platinum, selenium and tellurium values reported by van Hees (2019).

WHOLE-ROCK GEOCHEMICAL RESULTS AND INTERPRETATION

Major element composition of the 30 wall-rock samples indicate that they are calc-alkaline and plot between andesite and komatiitic basalt on the Jensen cation diagram (Figure 33.1):

- 200 to 255 feet (61–77.7 m):
  examination of archived drill-hole EC-16 core samples indicates they are a coarse-grained diorite (possibly porphyritic basalt) or coarse-grained gabbro as logged by MacKenzie (1968).
  - ♦ 200 to 230 feet (61–70.1 m): samples plot in the calc-alkaline, high-magnesium and komatiitic basalt fields (Figures 33.1 and 33.2).
  - ♦ 235 to 255 feet (71.6–77.7 m): samples plot in the andesite and basalt fields (*see* Figures 33.1 and 33.2).
  - ♦ Their trace element compositions straddle the basalt and andesite field boundaries (*see* Figure 33.2).

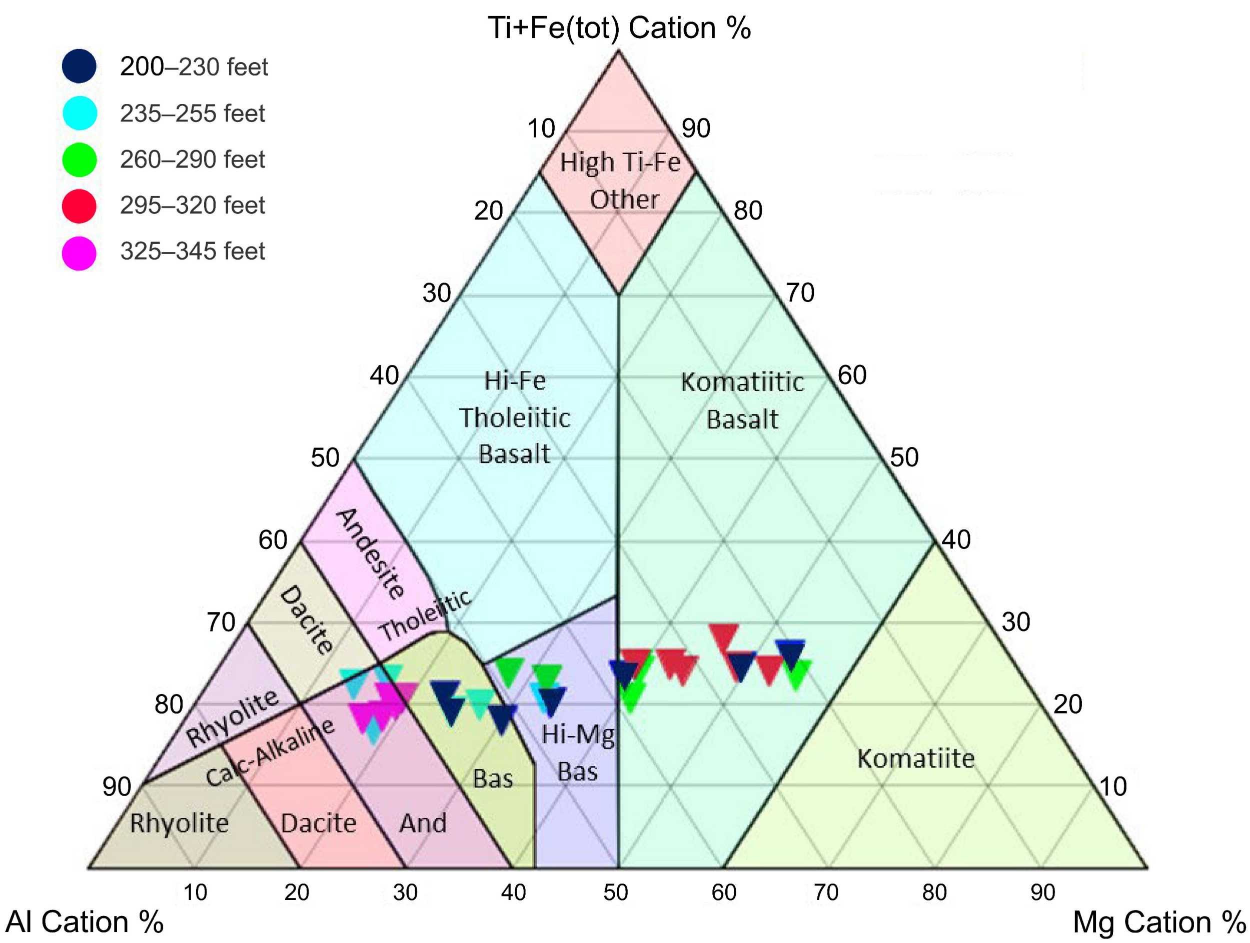

Figure 33.1. Jensen cation plot (Jensen 1976) for archived Hollinger Consolidated drill-hole EC-16 core samples that were collected at intervals of 5 feet (1.52 m) starting at 200 to 345 feet (61 to 105.2 m). Abbreviations: And = andesite; Bas = basalt.

- 260 to 320 feet (79.2–97.5 m) (above massive sulphide unit):
  examination of archived drill-hole EC-16 core samples identified that they are coarse-grained gabbro as logged by MacKenzie (1968).
  - 260 to 290 feet (79.2–88.4 m): gabbro samples plot mostly as high-magnesium basalt (*see* Figures 33.1 and 33.2).
  - 295 to 320 feet (89.9–97.5 m): gabbro samples plot as komatiitic basalt (*see* Figures 33.1 and 33.2).
- 325 to 345 feet (99.1–105.1 m) (below massive sulphide unit):
  examination of archived drill-hole EC-16 core samples found aphanitic rock with major and trace element compositions that plot as andesites (*see* Figures 33.1 and 33.2).

The lithogeochemical and textural results indicate that drill-hole EC-16 encountered 3 different rock units between 200 and 345 feet (61 and 105.2 m). These units are

- diorite between 200 and 255 feet (61 to 77.7 m)
- gabbro between 260 and 320 feet (79.2 to 97.5 m)
- andesite between 325 and 345 feet (99.1 to 105.2 m).

The telescoped core (2 inches collected every 5 feet (5 cm every 1.52 m)) available for this study precludes commenting on how the rock units relate to each other, except to say that the massive sulphide unit lies on the gabbro–andesite boundary as logged for drill-hole EC-16 by MacKenzie (1968).

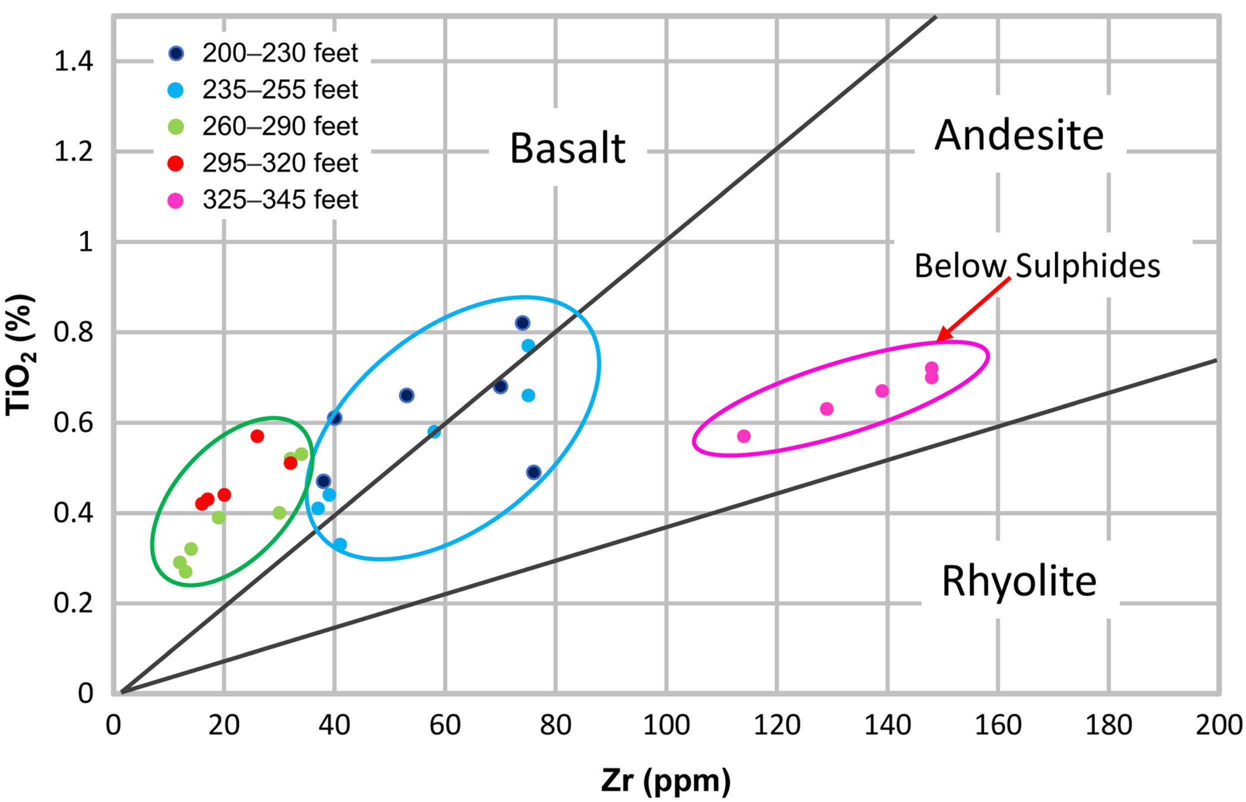

Figure 33.2. Zirconium (Zr) versus TiO_2 plot (MacLean 1990) for Hollinger Consolidated drill-hole EC-16 core samples that were collected between 200 feet (61 m) and 345 feet (105.2 m). Samples at various depths in the hole separated into 5 different groups (colours correspond to Figure 33.1). Pink dots are samples from beneath the massive sulphides, and were collected at 325 feet (99.1 m), 330 feet (100.6 m), 335 feet (102.1 m), 340 feet (103.6 m) and 345 feet (105.2 m).

MINERALOGY OF THE HOST ROCKS

Wall-rock samples from 245 feet (76.7 m), 255 feet (77.7 m), 285 feet (86.8 m), 315 feet (96.0 m), 320 feet (97.5 m), 321 feet (97.8 m) and 325 feet (99.1 m) in drill-hole EC-16 were examined using X-ray diffraction on pulp samples and optical microscopy on 8 polished thin sections. These studies found that all 7 samples consisted primarily of albite, amphibole, chlorite, epidote, mica (sericite) and carbonate. This mineral assemblage is interpreted to indicate that most primary minerals have been altered by hydrothermal fluids. Primary albite, present in all samples, appears to have been saussuritized by hydrothermal fluids. Quartz observed in narrow veinlets in the sample at 325 feet (99.1 m), and found in 6 of 8 polished thin sections, is consistent with a hydrothermal origin.

PLATINUM GROUP MINERAL ANALYSIS

Geoscience Laboratories produced high-resolution montaged backscattered electron images of 8 polished thin sections using AZtec® software on the JEOL IT-500HR FEG scanning electron microscope equipped with an Oxford Instruments® 80 mm^2 energy dispersive SDD X-ray spectrometer. Each thin section was examined using Feature® analysis to explore for a suite of minerals including platinum group minerals. Feature® analysis allows the analyst to explore for minerals by manipulating

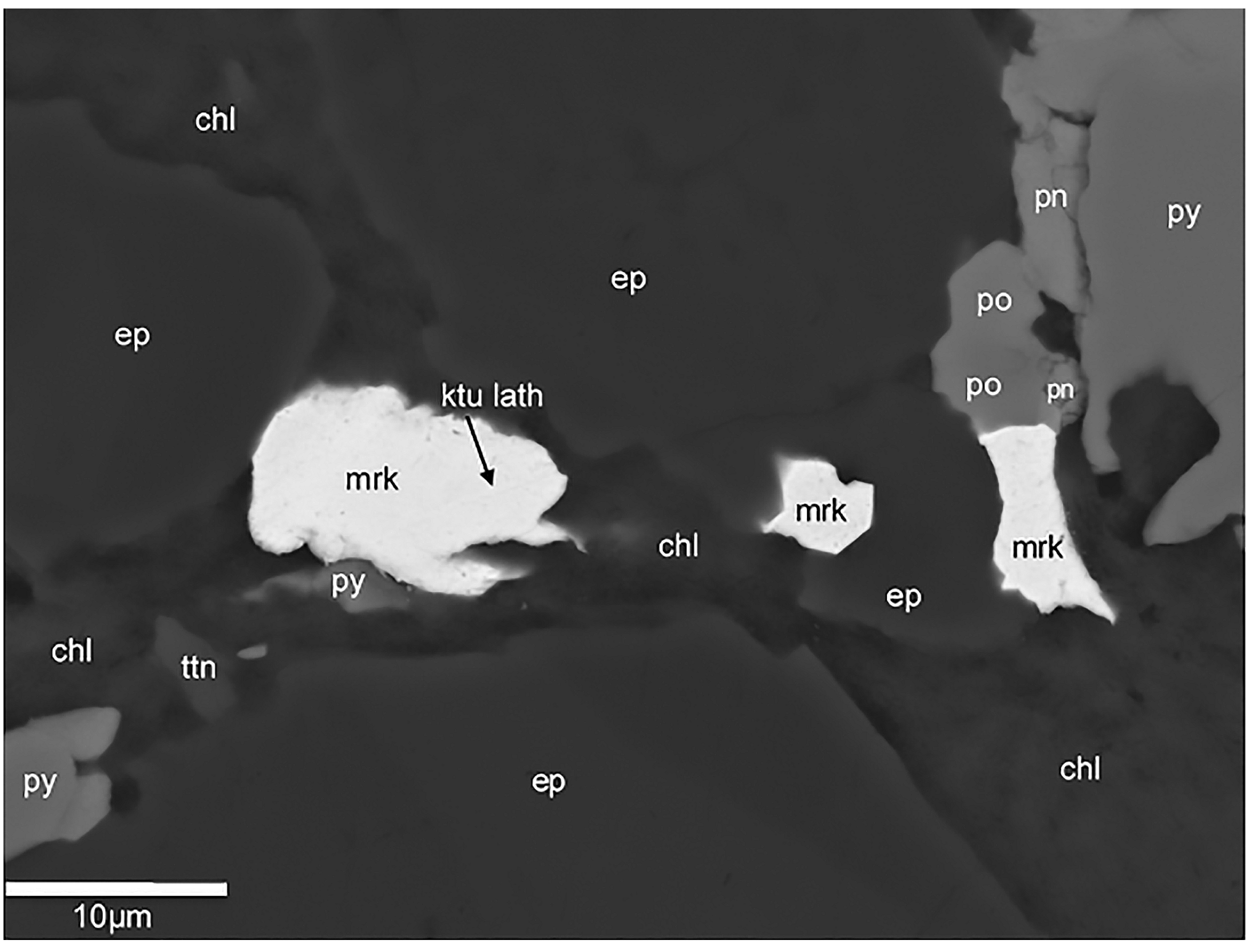

Photo 33.1. Backscattered electron image of polished thin section EC16-321S. Kotulskite (ktu) and merenskyite (mrk) are hosted in silicate minerals and attached to pentlandite (pn) and pyrrhotite (po). Other abbreviations: chl = chlorite; ep = epidote; ttn = titanite; py = pyrite.

Table 33.1. Summary of results for sulphide and platinum group minerals following analysis by scanning electron microscope.

Feet (m)	Is cobaltite[1] (CoAsS) (cob) or pentlandite (pn) present?			If no cob or pn, where is Co or Ni found?	Where are Pd and Pt found?		What copper phases are present?
	Cobaltite	Details	Pentlandite		Palladium (Pd)	Platinum (Pt)	
245 (76.7)	cob absent		pn present		mrk	spy	cp
255 (77.7)	cob present	7 grains	pn present		mrk	No Pt-bearing minerals	cp
285 (86.8)	cob absent		pn present	some Co in pn	mrk/ktu	No Pt-bearing minerals	cp
315 (96.0)	cob present	1 Rh-bearing FeAsCoNi sulphide	pn present		mrk/ktu	spy	cp
320 (97.5) [2]	cob present	8 very small grains intergrown with mrk	pn present		mrk	spy	cp
321 (97.8)	cob absent		pn present	some Co in pn	mrk	spy	cp
325 (99.1)	cob present	26 grains found during Feature® analysis	pn absent		bdl in geochem	bdl in geochem	cp

[1] *Software was set to find platinum group minerals (PGMs), so there might be more cobaltite (CoAsS) present.*
[2] *Results for 2 polished thin sections (320 and 320s) were combined in this table.*
Mineral abbreviations: *cob = cobaltite; cp = chalcopyrite; ktu = kotulskite; mrk = merenskyite; pn = pentlandite; spy = sperrylite.*
Other abbreviation: *bdl = below detection limit; geochem = geochemical data.*

Table 33.2. Platinum and palladium mineral grain abundances determined by scanning electron microscopy analyses.

Feet (m)	Total PGM Grains	Palladium- (Pd-) rich tellurium (Te) (±Sb, Bi, Ni, Fe)								Sperrylite ($PtAs_2$)			
		Kotulskite (Pd,Ni,Fe)(Te,Bi,Sb)				Merenskyite $(Pd,Fe,Ni)(Te,Sb,Bi)_2$							
		Grains	Min size [1] µm	Max size [1] µm	Avg size [1] µm	Grains	Min size [1] µm	Max size [1] µm	Avg size [1] µm	Grains	Min size [1] µm	Max size [1] µm	Avg size [1] µm
245 (76.7)	20	0				18	1.65	29.31	4.44	2	1.88	5.21	3.54
255 (77.7)	3	0				3	1.68	14.53	7.07	0			
285 (86.8)	3	2	3.46	5.24	4.35	1	2.66			0			
315 (96.0)	30	2	4.24	4.86	4.55	22	1.68	10.43	3.45	6	1.33	2.06	1.75
320 (97.5) [2]	120	12	0.81	7.73	2.89	105	0.57	11.73	2.65	3	0.57	1.99	1.12
321 (97.8)	71	0				52	1.68	16.39	4.85	19	1.68	7.37	2.85
325 (99.1)	0	0				0				0			

[1] *Size is reported as a calculated circular diameter.*
[2] *Results for 2 polished thin sections (320 and 320s) were combined in this table.*
Abbreviations: *Min = minimum; Max = maximum; Avg = average; µm = microns; PGM = platinum group minerals.*

backscattered electron imaging thresholds. The imaging conditions were 60× magnification, 4096 resolution, 5 µs dwell time for image acquisition, 2 second scan of whole features (energy-dispersive X-ray spectroscopy analysis), and accelerating voltage of 20 kV and 1.25 nA beam current. The smallest mineral grain that could be resolved was ~0.60 µm in diameter. Backscattered electron Feature® analysis identified cobaltite, chalcopyrite, native gold, kotulskite ($Pd(Te,Bi)_{2-x}$), merenskyite ($PdTe_2$), pyrite, pyrrhotite, pentlandite and sperrylite (Tables 33.1 and 33.2). The greatest concentration of kotulskite, merenskyite and sperrylite grains occur in the gabbro at 315 feet (96.0 m), 320 feet (97.5 m) and 321 feet (97.8 m), just above the andesite–gabbro contact (*see* Table 33.2). The second highest concentration of merenskyite and sperrylite grains is found in the sample at 245 feet (74.7 m), which appears to be a diorite, close to the gabbro contact. Eight gold grains occur with platinum group minerals at 321 to 315 feet (97.8 to 96.0 m) and 3 gold grains at 245 feet (74.7 m). Pentlandite and pyrrhotite occur in 6 of 8 polished thin sections (*see* Table 33.1). Kotulskite, merenskyite and sperrylite are associated with these sulphides and the wall-rock silicate minerals (Photo 33.1). Cobalt, in the 0.1 to 3 weight % range, was detected in all pentlandite. Chalcopyrite occurs in all polished thin sections (*see* Table 33.1). These sulphide, telluride and arsenide minerals were likely introduced by the hydrothermal fluids that formed the suite of silicate alteration minerals (*see* Photo 33.1).

COMPARABLE DEPOSITS

The telluride, sulphide and arsenide mineral assemblage, plus average Pd/Pt ratios of 11.06 (range = 3.3 to 16.9: van Hees 2019), are comparable to those found in the Lac des Iles deposit (Watkinson and Dunning 1979; Cabri and Laflamme 1979; Barnes and Gomwe 2011). Other mineral deposits with similar mineral suites include the Marathon deposit (Good, Cabri and Ames 2017), and Boston Creek (Stone et al. 1992) and Shebandowan Mines (Watkinson et al. 1978).

ACKNOWLEDGMENTS

Aaron Bustard, the Timmins District Geologist (Acting) in early 2018, selected the massive sulphide sample from Hollinger Consolidated drill-hole EC-16 that initiated this and previous studies on the Enid Creek cobalt-copper-nickel-palladium-platinum prospect. Dawn-Ann Metsaranta facilitated obtaining additional analyses required to complete this study. This manuscript has benefitted from reviews by Sonia Préfontaine and Michael Easton (OGS Earth Resources and Geoscience Mapping Section), and editing by Monica Gaiswinkler Easton (OGS Publication Services).

POST-PUBLICATION ADDENDUM AND ERRATA

In January 2023, following publication (in December 2022) of these related analytical data, the Timmins Resident Geologist Office staff were contacted about the content of this article. After a search of the Timmins Drill Core Library, staff found there existed 2 separate boxes of donated company drill core, both labelled as "box 155406". One box contained core from drill-hole L-13 and the other box contained core from drill-hole EC-16. Further investigation revealed that the drill core studied in this project was, in fact, from drill-hole EC-16, rather than from drill-hole L-13. The analytical data reported have not been affected; however, the location of the drill hole was corrected and the descriptions of the examinations of the drill core required modifications. This version, as of February 2023, corrects the errors.

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