

# **Appendix B.13**

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## **Asbestiform Mineral Quantification Procedure**

# Asbestiform mineral quantification procedure- Crawford Project

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Referenced document: Royal Nickel Corporation. "Rapport de Quantification du Chrysotile". 2013.

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## Summary:

Crawford Project, owned by Canada Nickel Corp (CNC), is a Nickel-PGE deposit that is hosted in an Ultramafic body that is known to have a "minor" amount of asbestiform minerals. Asbestiform minerals are classified as a dangerous substance and regulated under the Ontario Health and Safety Act due to its long-term toxicity if inhaled. As such, this document was created to measure the quantitative value of "minor" amount of asbestiform minerals through logging, which will aid in assessing the overall health risk related to operations.

Chrysotile, along with antigorite and lizardite, is one of the three most important polymorphs of the serpentine mineral group. It's often-fibrous habit is the result of its growth in expansion fractures during the serpentinization of ultramafic rocks under specific conditions. Given the similar compositions and structures of polymorphs and other existing serpentine phases, chrysotile identification and quantification are complex.

Royal Nickel Corporation (RNC) spent a considerable amount of time to find a method of quantification of asbestiform minerals for their Dumont Project, which is like the Crawford Project. For this reason, CNC is using the document created by RNC as a reference guide.

RNC tried 5 methods that were determined not suitable due to lack of representation/repeatability or cost/time constraints:

- Fiber counting
- X-ray Diffraction
- Thermal differentiation analysis
- Photonic knowledge
- Measurement of fibers per volume

RNC determined that the best quantification method was to visually inspect the core through logging a representative drill hole in each metallurgical domain and assigning quantifiable % presence over length of core.

## Introduction:

The term "asbestos fiber" refers to six silicate mineral fibers that are distinguished by their so-called "asbestiform" shape. These six asbestos fibers are divided into two families as identified in Table 1.

Table 1: Asbestiform minerals

Asbestiform Mineral	Non-asbestiform equivalent	Composition	Presence
<b>Serpentine Family</b>			
Chrysotile	Lizardite, Antigorite	$Mg_3(Si_2O_5)(OH)_4$	Yes
<b>Amphibole Family</b>			
Crocidolite	Riebeckite	$Na_2Fe_3^{2+}Fe_2^{3+}(Si_8O_{22})(OH)_2$	?
Amosite	Grunerite	$(Fe^{2+}, Mg)_7(Si_8O_{22})(OH)_2$	?
Anthophyllite- Fibrous	Anthophyllite	$(Mg, Fe^{2+})_7(Si_8O_{22})(OH)_2$	?
Actinolite- Fibrous	Actinolite	$Ca_2(Fe^{2+}, Mg)_5(Si_8O_{22})(OH)_2$	?
Tremolite- Fibrous	Tremolite	$Ca_2Mg_5(Si_8O_{22})(OH)_2$	?

Analytical methods for the determination of asbestos fibers do not always differentiate an asbestiform mineral fiber from its non-asbestiform counterpart. The methods used to measure chrysotile content in the chrysotile industry focus on the concentration of commercially valuable fibers and do not provide a good representation of the total chrysotile concentration in the rock.

At Crawford, chrysotile can be found in the Dunite and Peridotite units of the Ultramafic body. In isolated parts within the Dunite and Peridotite, there is talc alteration, which together with magnesite, is an alteration product of chrysotile. Talc in the presence of quartz can produce tremolite. At Crawford, tremolite has not been identified to date. Quartz is not typically found in the serpentine level of metamorphism- which is the case at Crawford. Quartz can be found with higher levels of metamorphism in the amphibolite phase.

Talc samples at Crawford have not been assessed for asbestiform minerals to date.

It should be noted that another fibrous mineral can be present at Crawford- brucite. Brucite is a magnesium hydroxide mineral, and so it is not classified as a dangerous substance because it is not a silicate.

## Method:

Chrysotile can form in these styles: as interstitial/network alteration (around/in between grains), coating on fracture surfaces/foliation or as thicker stringers and veins. For the purposes of being consistent with logging practices, each of these styles were assessed, and determined to have the following ranges, which were then assigned a value- found in Table 2.

Core was laid out and visually inspected for which style was present. The length of core which the style occurred was measured against the total length of core present. This interval would be assigned the % value based on the information in Table 2.

Table 2: Assigned values to chrysotile styles

Style	Intensity Category	Assigned value %
Interstitial chrysotile/network	Intense = 5-8%	6
	Strong = 3-5%	3.5
	Moderate = 1-3%	1.75
	Weak = 0.1-1%	0.75
	Trace = 0-0.1%	0
Chrysotile fracture coating/foliation	Intense = 50%	50
	Strong = 25-40%	33
	Moderate = 10-25%	15
	Weak = 1-10%	5
Chrysotile stringers and veins	70-100%	100%

A chrysotile tab was created in the logging software. It contained columns for: Hole number, From, To, Length, Chrysotile%, Dominant Style, Second Style if necessary and Comments - similar to screen shot below:

From	To	Length	Chrysotile % *	Dominant Style *	Second Style	Comments	Additional Files (Phot
33	36	3	0.5	FV			
36	38.5	2.5	0	Null			
38.5	48	9.5	0.5	FV			
48	58	10	0.1	FV			
58	66	8	0.5	FV			
66	69.5	3.5	0.1	FV			
69.5	118	48.5	0	Null			

Canada Nickel has been capturing chrysotile visual estimation starting 2022. Crawford deposit was summarized in Feb. 2023 (Table 4) for the length weighted avg % like Dumont's method- as shown below- which was done after export of the data:

Longueur de la carotte	Réseaux de chrysotile					Chrysotile dans les zones hautement fragmentées				Chrysotile dans les veines /fractures	Calculs		
	Aucun	Faible	Modérée	Élevée	Intense	Faible	Modérée	Élevée	Intense		% Chrysotile	Total Length	Chrysotile Length
2.969	1.084	0.266	0.21	0.09	0	0.872	0.377	0	0.07	0	4.380	2.969	0.1300

Chrysotile length is an automatic calculation as follows:

$$\text{Chrysotile length} = (\text{Total length}) * (\% \text{ Chrysotile})/100$$

Dumont subsequently calculated the average chrysotile % for each lithology in each hole by dividing the sum of all the data in “Chrysotile length” column by the sum of all the data in the “Total length” column, then multiplied by 100. This rendered a value that would act as the expected value for a similar hole in the same domain.

Then the weighted average for the entire project is calculated based on the averages of the above data divided by total core length and multiplied by 100.

For the Dumont Project, the results are summarized in Table 3:

Table 3: Statistical results of chrysotile content in examined core at Dumont:

Lithologies	Moyenne Pondérée	Écart-Type	Nombre de valeurs	95e Percentile	Intervalle de Confiance 95%	Limite de tolérance 95% sur la moyenne	
						Inférieure	Supérieure
Péridotite Supérieure	1.7	1.1	294	3.8	3.5	1.6	1.8
Dunite	1.8	2.0	917	4.9	5.1	1.6	1.9
Péridotite Inférieure	1.1	1.5	166	3.3	3.5	0.9	1.4
Ensemble des roches ultramafiques du projet Dumont	1.7	1.8	1 377	4.4	4.6	1.6	1.8

## Conclusion:

Of all the possible options for quantifying chrysotile, only the quantitative visual estimate could be applied to the ultramafic rocks of the Dumont Project. A detailed method and procedure were put in place for RNC geologists to follow and maintain a level of consistency in their descriptions. This method was therefore considered good for use and adopted for ongoing Canada Nickel logging.

Table 4 summarizes the weighted average for rocks found at the Crawford Deposit, Feb 2023.

<b>Litho</b>	<b>Weighted Avg- ChrysotileLength%</b>	<b>Standard Deviation- ChrysotileLength%</b>	<b>Count</b>
Dunite	1.670	0.156	3,622
Peridotite	0.921	0.078	2,965
Pyroxenite	0.215	0.005	468
Gabbro	0.024	0.007	249
Metavolcanic	0	0	31