



# VERMICULITE RESOURCES OF BRITISH COLUMBIA, CANADA

## GEOLOGY, MARKET REVIEW AND ECONOMIC POTENTIAL

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#### **Executive Summary**

panded vermiculite is used as a lightweight aggregate in concrete, an additive in a variety of acoustic, ermal and fire insulation products, in soil conditioning, as a fertilizer or insecticide carrier, and in absorbent packing, paints and sealants. It is also used in refractory gunning and castable mixes, in rermiculite dispersions and in replacing asbestos in brake linings, primarily for the automotive market. There is currently no vermiculite produced within the province of British Columbia. Only four

localities in the BC MINFILE list vermiculite as a commodit

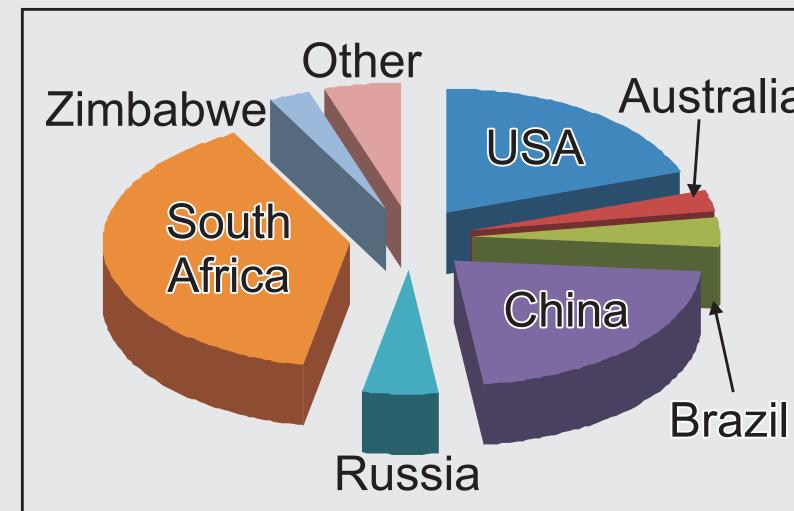
High concentrations of vermiculite were encountered adjacent to the Hodgie Rare Earth Zone previously discovered by Commerce Resources Inc. in the Blue River area. This occurrence has aboveeverage vermiculite and higher grade than other known vermiculite occurrences in the province. Reconnaissance-level field observations, in-house particle-size analyses and rudimentary laboratoryscale exfoliation tests are encouraging. They indicate that detailed chemical and mineralogical studies are the next logical step in the assessment of this and other vermiculite occurrences in the Blue River area. Chemical analyses are required to establish the trace-element levels in the vermiculite-bearing material, to ensure that it does not contain elevated levels of environmentally sensitive substances. Mineralogical follow-up should establish the absence or presence of asbestiform particles. The presence of such particles would negatively impact the development of this vermiculite resource.

If the outcomes of the above-recommended tests justify more rigorous laboratory and field investigations, then these occurrences of the Blue River area have the potential to become significant commercial sources of vermiculite.

Vermiculite [Mg<sub>1.8</sub>Fe<sup>2+</sup><sub>0.9</sub>Al<sub>4.3</sub>SiO<sub>10</sub>(OH)<sub>2</sub>4(H<sub>2</sub>O)] is a sheet silicate. It is commonly bronze coloured, but it can be grey-white, greenish, brown or colourless. Vermiculite is characterized by a scaly appearance, low density (2.3–2.7 g/cm³), a micaceous habit and perfect basal cleavage. Individual flakes split with ease, are soft (1.5 to 2 on the Mohs scale). It has a high total water content that can reach up to 20%, but commercial products contain from 6 to 17 wt. % H<sub>2</sub>O. When heated to temperatures not exceeding 500°C, the water can be driven out from the vermiculite, but the mineral rehydrates readily on exposure to humidity in the air. When heated quickly to temperatures in the 870–1100°C range, vermiculite particles exfoliate by expanding at right angles their basal cleavage. The increase in volume expected from commercial products is 8 to 12 times the original volume. Expanded vermiculite is a pale-coloured, low-density, porous material that is chemically-inert.

#### World Market

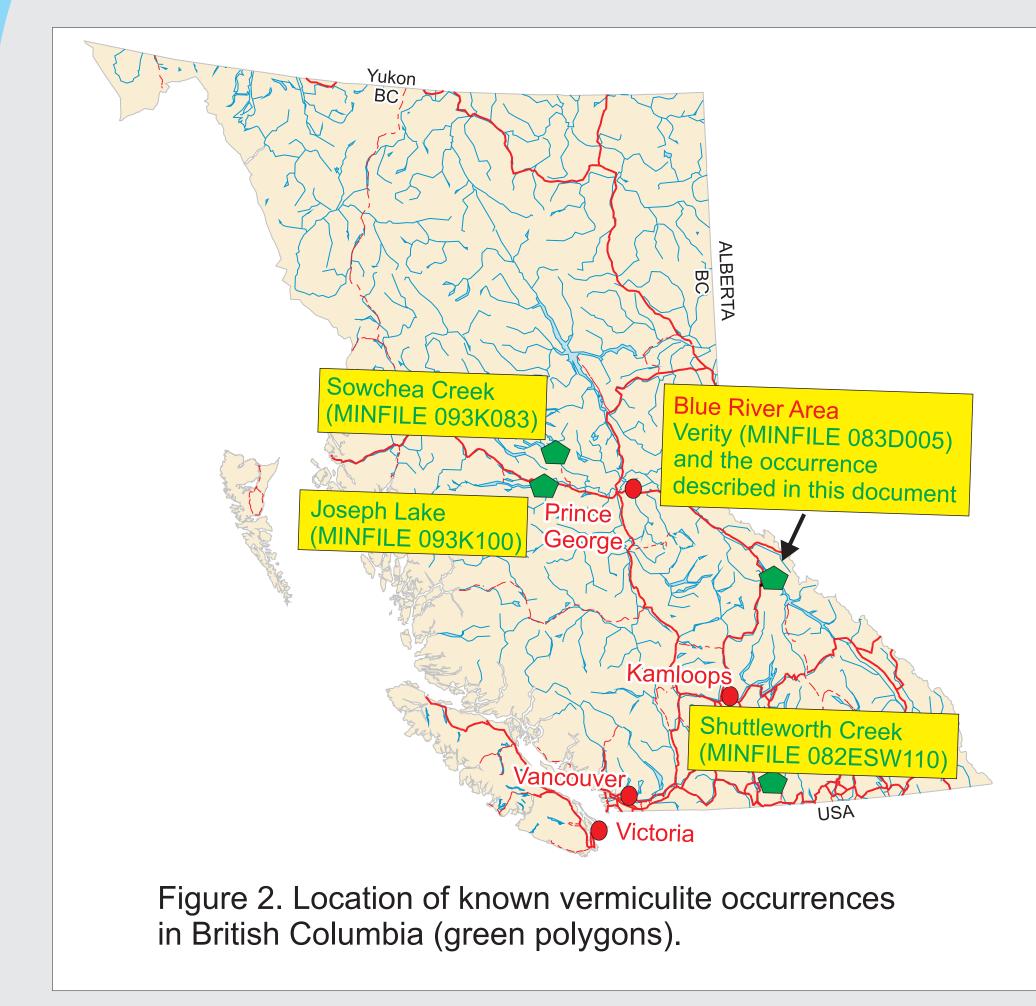
World vermiculite annual production (Figure 1) is approximately 500 000 tonnes (Simandl et al., 1999; Potter, 2009). In 2008, the main vermiculite-producing countries were South Africa, China, the United States, Russia, Brazil, Australia and Zimbabwe. American imports, excluding any material from Canada and Mexico, were about 54 000 tonnes for the first 8 months of 2008. China and South Africa provided 70% and 25% of these imports, respectively (Potter, 2009). Vermiculite concentrate (before exfoliation) is a moderately priced product that is shipped close to the market before being expanded. During 2008, depending on specifications, prices for American vermiculite concentrate (cost not including transportation and insurance; in bulk) ranged from US\$95 to US\$180 per tonne (Moeller, 2008). The average unit value of exfoliated vermiculite in the United States for 2008 was estimated at US\$430 per tonne (Potter, 2009).



total production for 2008 is approximately 510 000

#### Vermiculite in British Columbia

There is currently no vermiculite produced within the province and there are only four occurrences (Figure 2) listed with vermiculite as a commodity in the BC MINFILE database (BC Geological Survey, 2010 MINFILE). Two of these occurrences were described by White (1990) and tested by Morin and Lamothe (1991). The Joseph Lake occurrence (MINFILE 093K 077) has a very low vermiculite content (5.6%) and is of no economic interest (Morin and Lamothe, 1991). The Sowchea Creek showing (MINFILE 093K 083) has a slightly higher vermiculite content; however, it does not exfoliate enough to be of economic interest (Morin and Lamothe, 1991). At the Shuttleworth Creek occurrence (MINFILE 082ESW110), vermiculite is reported to be associated with asbestiform anthophyllite. Based on this association, it is unlikely that this occurrence would be considered for follow-up work as a source of vermiculite in the foreseeable future. The Verity occurrence, in the Blue River area (MINFILE 083D 005) is believed to be carbonatite related. There is no detailed location of the vermiculite mineralization in MINFILE, but brief descriptions of vermiculite-bearing outcrops were provided by McCammon (1950). One of these outcrops could correspond to the coarse mineralization (vermiculite flakes reaching more than 15 cm across) associated with the Upper Fir carbonatite, as described by Simandl et al. (2007). The occurrence described in this document (Figures 4, 5, 6, 7, 8 and 9) may be new.



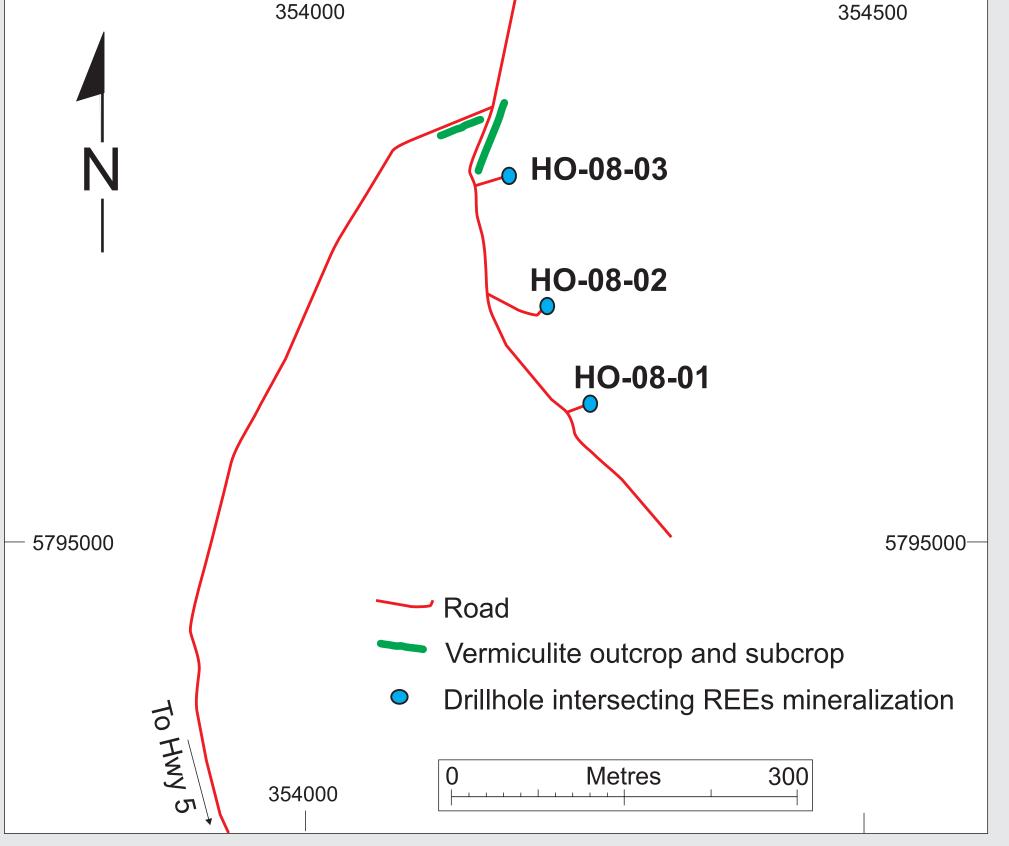


Figure 4. Sketch showing the position of the vermiculite occurrence relative to diamond-drill holes HO-08-01, HO-08-02 and HO-08-03, which intersect the Hodgie rare earth zone, Blue River area.



Figure 6. Semi-consolidated nature of the vermiculite-bearing zone, Blue River area; for location see Figure 5; folding shovel for scale.

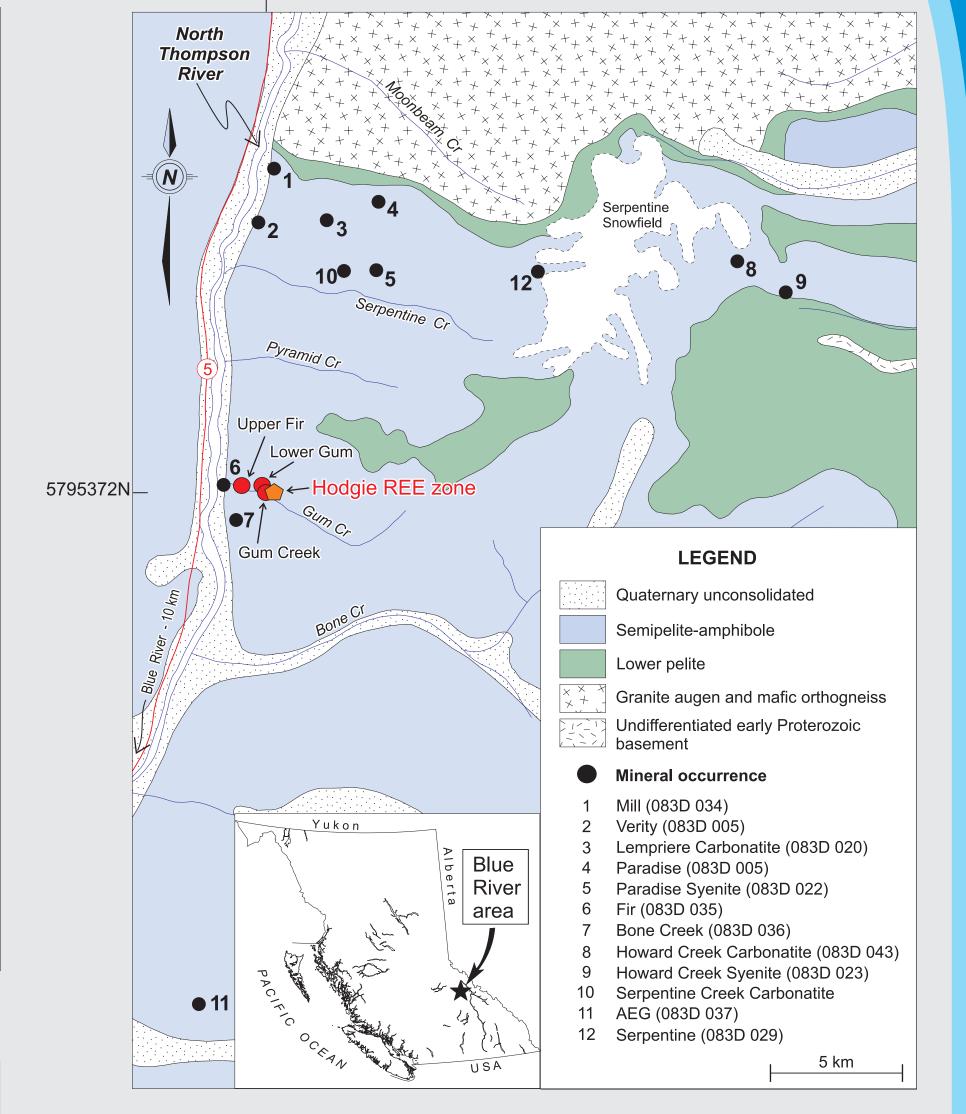
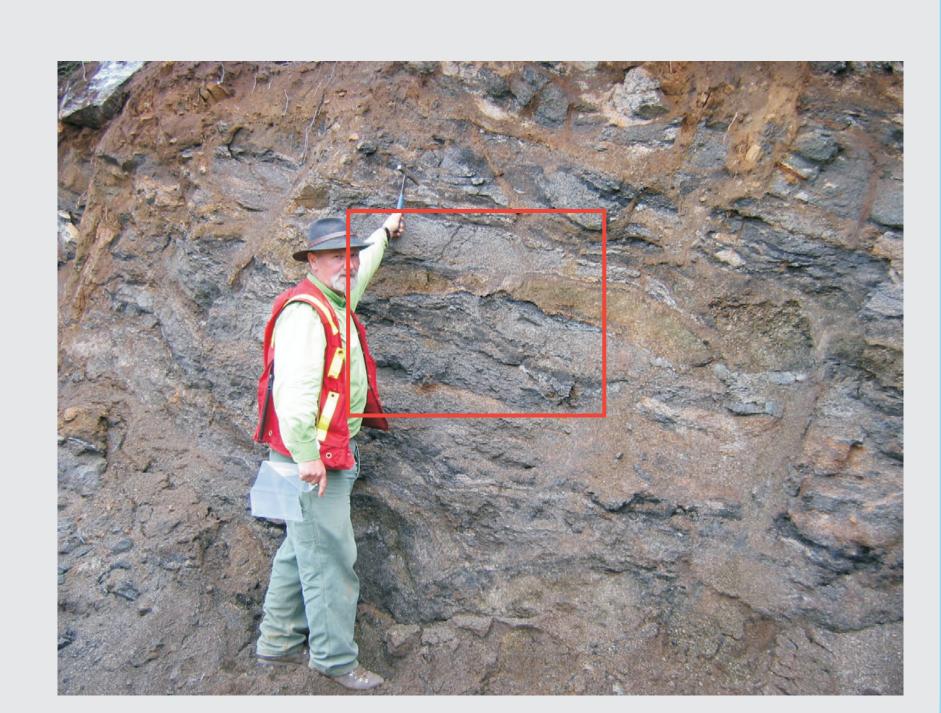


Figure 3. Location of vermiculite and carbonatite occurrences in the Blue River area (modified from Simandl et al., 2002).



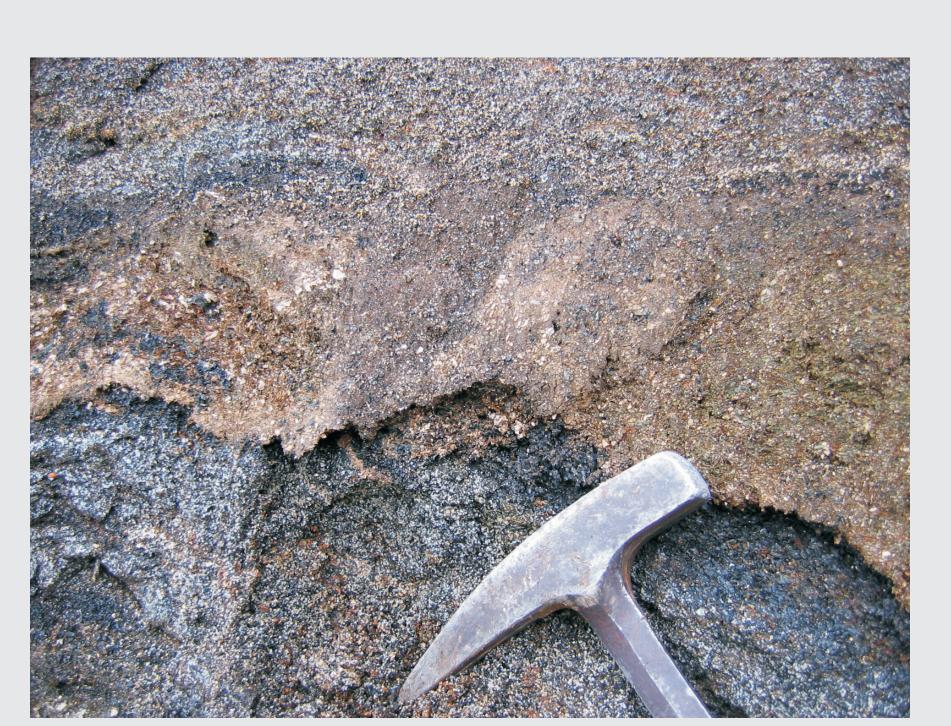
Figure 5. An 80 m long vermiculite-bearing outcrop, adjacent to the Hodgie rare earth zone, Blue River area (looking southwest). Red rectangle locates Figure 7.



dominated by vermiculite are greenish and pale brown. Red rectangle locates Figure 8.



Figure 8. Vermiculite zone (detail of figure 7) showing layering inherited from the protolith. Layers dominated by amphibol are dark grey and those dominated by vermiculite are greenish and pale brown. Red rectangle locates Figure 9.



(dark grey) and vermiculite-dominated (beige to pale brown) semi-consolidated layers; vermiculite zone. For location see

### Summary of laboratory findings

No attempt was made to upgrade the unconsolidated to weakly consolidated vermiculite-bearing samples (Figures 8 and 9) prior to testing (besides sieving). The results shown in Tables 1 and 2 are useful for preliminary assessments of the occurrence, in relation to other BC occurrences. Propane torch was used to exfoliate vermiculite (Figure 10).

- 1) Vermiculite is present within the three samples that we studied.
- 2) Most of the particles composing the three samples are smaller than 2 mm in size (Table 1).
- 3) Vermiculite grades are higher than grades reported elsewhere in the province and could locally exceed
- 4) Vermiculite content varies from sample to sample.
- 5) Vermiculite is most abundant in the coarse fraction of sample 09-SP-305 and least abundant in the finest fraction. The opposite is true for samples 09-SP-306 and 09-SP-307, which have higher amphibole content than sample 09-SP-305. This variation reflects the mineral composition of the protolith.
- 6) Raw samples of vermiculite-bearing rock from the Blue River area exfoliate to a significant extent (Figure 11 a, b); however, it is unlikely that optimal operating conditions for vermiculite exfoliation were achieved during our experiments (using the propane torch). Better results are expected if the tests are performed to the standards of the Vermiculite Institute. Figure 12 shows the result of a successful separation of expanded vermiculite from gangue minerals by flotation. Dominant morphology of amphibole particles is shown on Figure 13. Characteristic appearance of expanded vermiculite particles is shown on Figures 14 and 15.

Table 1. Description and grain-size fractions of vermiculite-bearing samples from outcrop adjacent to the Hodgie rare earth zone, Blue River area.

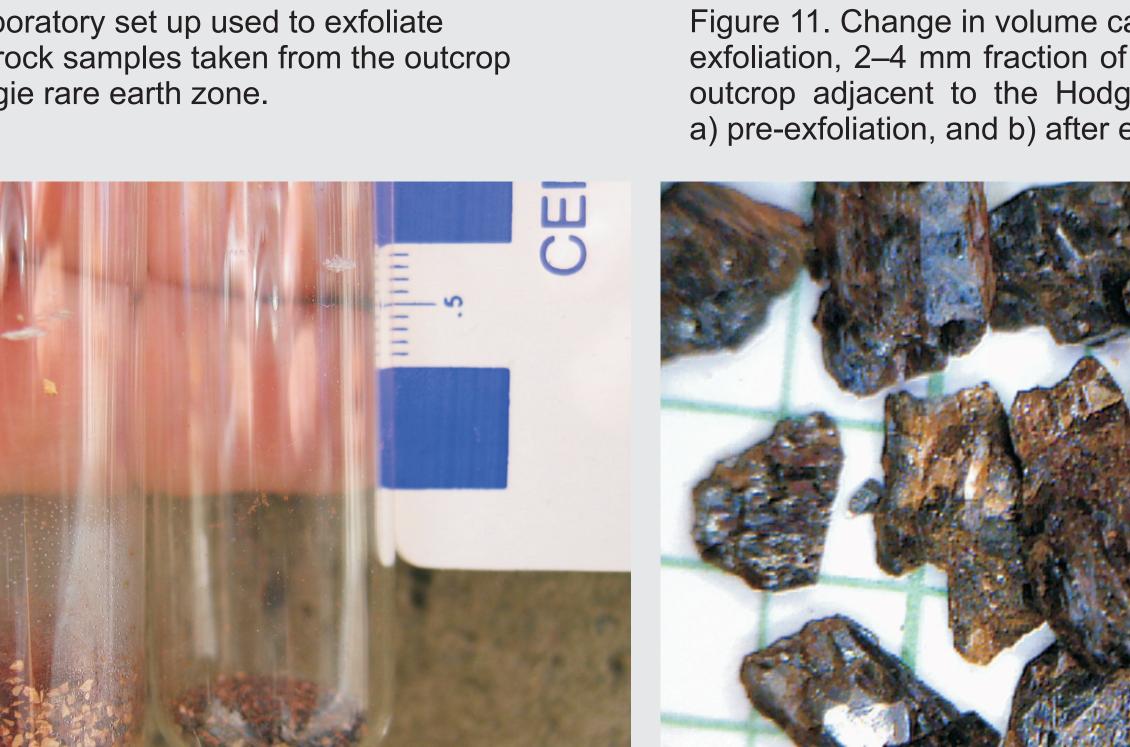
Sample number	Sample type	Sample weight (grams)	Size fraction and its weight (grams)		
09-SP-305	grab	491,7	> 4 mm	6.6	
			2-4 mm	59.3	
			1-2 mm	122.5	
			<1 mm	298.8	
09-SP-306	channel	911,8	> 4 mm	98.3	
	(2 metres)		2-4 mm	107.6	
			1-2 mm	307.4	
			<1 mm	389.6	
09-SP-307	channel	609,4	> 4 mm	3.1	
	(1.5 metre)		2-4 mm	35.6	
			1-2 mm	290.7	
			<1 mm	280.0	

Table 2. Results of the laboratory-scale exfoliation tests on raw materials (without vermiculite pre-concentration) suggest high vermiculite content.

d its	Sample #	Particle size	-	Weight pre-		Heavy	Volume	Estimate of
s)			exfoliation $(\pm 0.2 \text{ cm}^3)$		post- exfoliation	fraction post-	increase (raw)	vermiculite content (raw)
5.6			(± 0.2 cm )	( 3,328)	$(\pm 0.2 \text{ cm}^3)$	exfoliation (±0.05g)	()	(2000)
9.3		(mm)	(cm <sup>3</sup> )	(g)	(cm <sup>3</sup> )	(g)	(factor)	(wt.%)
2.5	09-SP-305	>4						
		2-4	2	2,15	7,2	0,9	3,6	58
8.8		1-2	2	2	6,3	0,95	3,2	52
		<1	2	2,2	5,7	1,25	2,9	43
3.3								
7.6	09-SP-306	>4						
		2-4	2	2,5	2,7	2,4	1,35	4
7.4		2-4 duplicate	2	2,3	2,4	2,1	1,2	9
9.6		1-2	2	2,7	3,7	2,15	1,85	20
		<1	2	2,65	4,3	1,9	2,15	28
1								
3.1	09-SP-307	>4						
5.6		2-4	2	2,8	4	2,3	2	18
0.7		1-2	2	2,7	4,3	1,7	2,15	47
0.0		<1	2	2,5	5	1,1	2,5	56



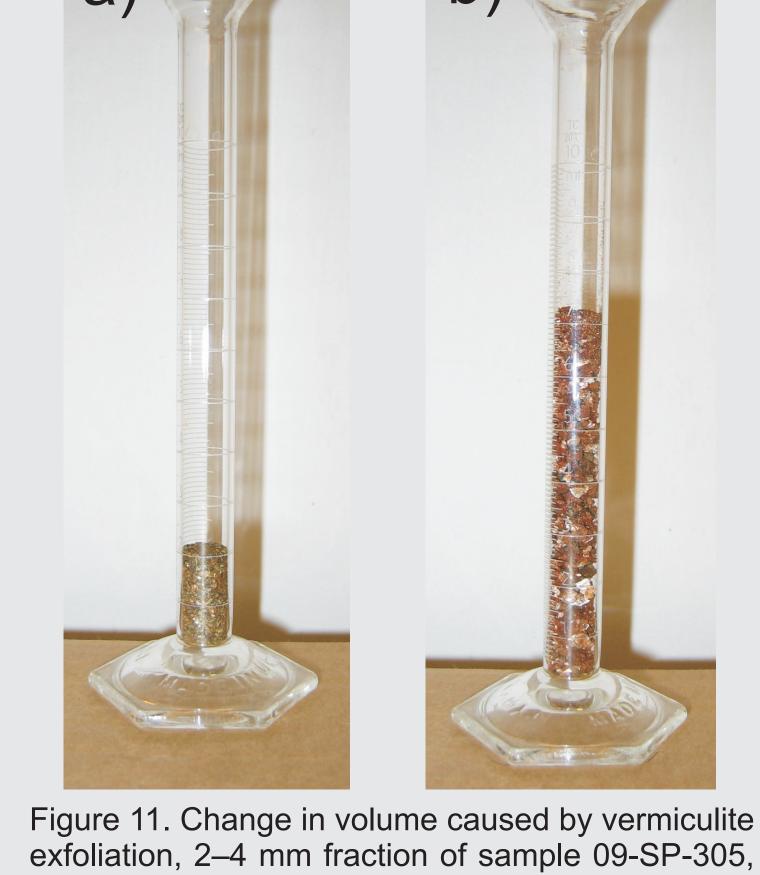
Figure 10. Crude laboratory set up used to exfoliate vermiculite-bearing rock samples taken from the outcrop adjacent to the Hodgie rare earth zone.



separated from the rest of the sample by flotation. The composite grains, where vermiculite is attached to amphibole or o



2-4 mm size fraction of sample 09-SP-305, Blue River area (2 mm grid for scale).



exfoliation, 2-4 mm fraction of sample 09-SP-305, outcrop adjacent to the Hodgie rare earth zone: a) pre-exfoliation, and b) after exfoliation.



grid for scale). Systematic studies of larger samples are needed to make sure that asbestiform particles are not present (Simandl et al., 2010).



Figure 15. Characteristic morphology of exfoliated vermiculite particle derived from the 2-4 mm size fraction of sample 09-SP-305 (2 mm grid for scale).

#### References

For complete list of references, please consult: Simandl, G.J., Paradis, S., Simandl, L. and Dahrouge, J. (2010): Vermiculite in the Blue River Area, East-Central British Columbia, Canada (NTS 083D/06); in: Geological Fieldwork 2009, BC Ministry of Energy and Mines and Petroleum Resources, Paper 2010-1, pages 83-91.