MARILLA PERLITE - VOLCANIC GLASS OCCURRENCE, BRITISH COLUMBIA, CANADA

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ABSTRACT

Perlite is a natural hydrated volcanic glass that displays concentric 'onion-skin-like' fractures in hand sample or in thin section. It can occur as silicic lava domes, lava flows, welded ash-flow tuffs, glassy plugs, laccoliths and dikes. There are two main processes that cause hydration of perlite. Primary hydration occurs during formation of the rock before it has cooled; secondary hydration occurs after the rock has cooled and is the more important of the two processes. Perlite has a number of industrial and agricultural applications. There are at least 23 known occurrences in British Columbia, which are listed in MINFILE (a British Columbia computer-based mineral inventory system). There are currently no producing perlite mines in Canada.

The Marilla perlite occurrence is located approximately 170 kilometres west of Prince George, directly south of Cheslatta Lake, and outcrops for 65 metres along the eastern side of Marilla Road. It consists mainly of aphyric or porphyritic biotite-plagioclase-bearing rhyolite typical of the Ootsa Lake Group, which outcrops sporadically throughout the area. Geochemical analysis confirms that the six identified lithological units are rhyolite or rhyodacite in composition. Expansion tests, using a propane torch, showed at least some degree of expansion in each sample, with a boulder found near the occurrence expanding readily. This study confirms the exploration potential in the Prince George area for expanding perlite deposits, however the distance to the market should be taken into consideration during a conceptual study.

BACKGROUND INFORMATION

Definition

Petrographically, perlite is defined as a hydrated natural rhyolite glass with perlitic texture (Bates and Jackson, 1987). It consists of 2 to 5% total water held within the glass structure, which is considerably higher than average obsidian water content. Industry defines perlite as any hydrated felsic rock which through rapid thermal expansion increases in volume to form a white porous lightweight cellular aggregate (McPhie *et al.*, 1993; Breese and Barker, 1994; Simandl *et al.*, 1996).

Expanded perlite is made by heating crushed perlite rock to the softening temperature of glass in a furnace. At temperatures ranging from 870 to 1100ºC, the glass becomes soft enough for the water it contains to expand into steam resulting in a cellular structure and an increase in volume of up to 20 times. The result is a frothy particle with extremely low density, high surface area and light or white colour (Breese and Barker, 1994).

Origin of Perlite

The water content of obsidian is typically less than 1 weight percent and is considered to represent "primary" magmatic water. The water content of perlite ranges up to about 5%, which is attributed to the addition of "secondary" water from external sources, such as ground water or surface water (Ross and Smith, 1955; Friedman *et al.*, 1966; Lofgren, 1971). Primary hydration occurs during the formation of a volcanic rock or glass (Nasedkin, 1988). Secondary hydration occurs after emplacement and late in the cooling history of the glass, probably under zeolite facies conditions, or after complete cooling to surface temperatures (Nasedkin, 1988). Zeolite facies metamorphism and rock weathering typically occur below 2.5 kilbars and 300ºC.

Perlite Applications / Uses

In the building and construction industry, expanded perlite is mixed in mortar, concrete and plaster to utilize its thermal, acoustic, lightweight and fire resistant properties. Its thermal insulation properties and low density make it highly effective in roof insulation board, pipe insulation, and refrigerator insulation. Its sonic insulation properties make it an ideal material for acoustical ceiling tile (Breese and Barker, 1994).

The ability of expanded perlite to retain water in its cellular structure makes it desirable in horticultural applications, and it is therefore used to condition soil. Expanded perlite adds loft, reduces compaction, and facilitates water drainage and moisture retention in soils (Simandl *et al.*, 1996). It is commonly used as a propagating medium for seedlings and for the packaging and storage of bulbs and plants (Breese and Barker, 1994). Expanded perlite can also be used as a substrate in hydroponic farming, and as a fertilizer-carrying matrix (Lin, 1989).

The internal cellular structure of expanded perlite makes it useful as a filtration aid and oil absorbent. Expanded perlite offers high porosity and does not interfere chemically with the liquid filtered (Shackley and Allen, 1992).

Expanded perlite is used extensively in livestock applications for the absorption of nutrients, liquid chemicals such as pesticides, fertilizers, oils, and pharmaceuticals. It is used as an additive in animal feed mixtures to aid in digestion and for growth promotion (Lin, 1989), and also can be used as an absorbent in litter padding for chicken coops (Lin, 1989). Unexpanded perlite can be used in ceramics, glass, explosives and several other applications (Lin, 1998).

GENERALIZED CHARACTERISTICS OF PERLITE DEPOSITS

Perlite can occur in silicic lava domes and lava flows, welded ash-flow tuffs, glassy plugs, laccoliths, and dikes (Breese and Barker, 1994). Most commercial production comes from flows associated with thick accumulations of tuffs and lava flows, and from lava domes (Chesterman, 1966).

A single perlite flow can range in thickness from less than a metre to several metres and may be traced along strike for more than a kilometer. Silicic lava flows commonly display internal textures and structures such as flow banding, aligned elongate phenocrysts, and stretched vesicles (McPhie *et al.*, 1993). Perlite domes can range from 100 metres to 2 kilometres in diameter, and can extend vertically more than 100 m from their base (Chesterman, 1966). Rhyolite domes are usually flat or gently sloping on the upper surfaces, with steep sides and flow fronts (Figure 1). Upper parts of the dome may exhibit steep flow foliations and ramp structures with ridges on the surface (McPhie *et al.*, 1993). These silicic lava flows and domes (Figure 1) typically consist of a texturally zoned exterior glass unit enclosing a partially devitrified and crystallized inner glass unit. This zonation is produced by rapid quenching of exterior surfaces and crystallization of the interior (Breese and Barker, 1994).

PERLITE MARKETS

There are no producing perlite mines in Canada, so sized and expanded perlite is imported mostly from the United States and Greece. Greece is by far the largest exporter of perlite, from its deposits on the island of Milos in the Aegean Sea (White, 2002). The United States exports about 10% of its production, mainly to Canada. Crushing and sizing is generally done at facilities located close to the pits. To reduce transportation costs, the unexpanded perlite is shipped directly from the pits to local markets where it is expanded and processed for distribution to end users (Breese and Barker, 1994).

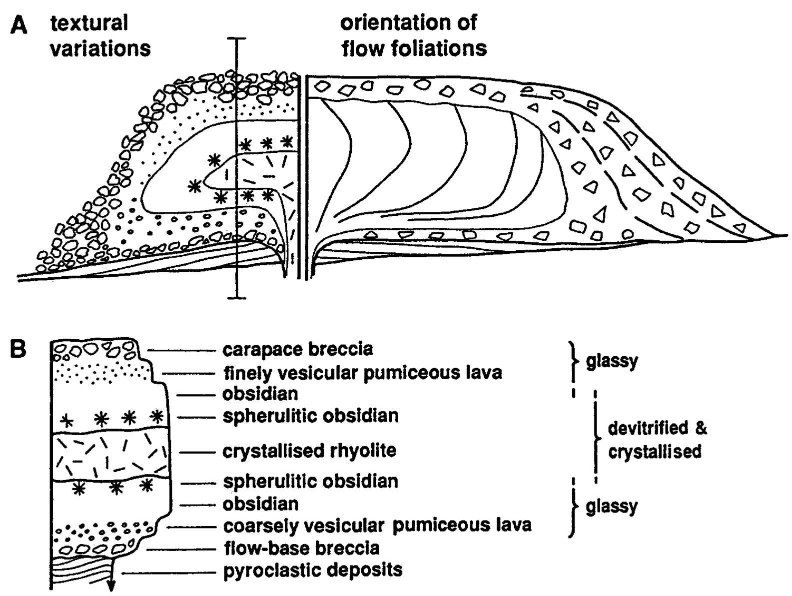

Figure 1. (A) Schematic cross-section through a subaerial silicic lava flow. The left side shows the internal textural variation arising from vesiculation, devitrification and flow fragmentation. The right side shows the orientations of internal flow foliations, and crude layering in flow margin talus breccia (B) Vertical section through the flow at the position indicated in (A), showing the major textural zones. Modified by McPhie *et al.*, (1993) from Fink and Manley (1987) and Duffield and Dalrymple (1990).

The total world production of perlite is over two million tonnes per year (Coope, 1999). The market value for high-quality raw perlite in British Columbia, Alberta, Washington, and northwest Oregon in 1994 was estimated at $2.9 million Canadian dollars, and the total market for perlite in the same region in 1994 at 42 000 tonnes (Gunning and McNeil, 1994). Of this amount, 35 000 tonnes were sized ore and 7000 tonnes were expanded perlite. Coated perlite microspheres represented 2700 tonnes and $2.5 million Canadian dollars (Gunning and McNeil, 1994).

PERLITE IN BRITISH COLUMBIA

There are 23 perlite occurrences in British Columbia described in MINFILE (a computer-based inventory system). The inventory can be accessed at: <www.em.gov.bc.ca/Mining/Geolsurv/Minfile/search/>. Several of these occurrences are within the Ootsa Lake Group in the Prince George area, including the Marilla perlite occurrence (Figure 2). Other reports on perlite resources in British Columbia were prepared by White (1990), Morin and Lamothe (1991), Hora and Hancock (1995), Simandl *et al.* (1996) and White (2002). The Francois and Frenier deposits are two past producing perlite mines in British Columbia. From 1949-1953, Western Gypsum Products Ltd. mined 1589 tonnes from the Francois deposit. The Frenier deposit yielded 6000 tonnes of crude perlite from 1983 through 1985. The Frenier mine has been inactive since 1986, in part due to a low-capacity bridge across the Fraser River.

MARILLA PERLITE SHOWING

The Marilla perlite showing is located approximately 170 kilometres west of Prince George, directly south of Cheslatta Lake at N53º 42.588’ and W125º 19.371’ (Figures 2 and 3). It outcrops along the eastern side of Marilla Road for 65 metres. The showing was mapped and sampled in 2000 by the British Columbia Geological Survey. The deposit consists mainly of an aphyric or porphyritic biotite-plagioclase-bearing rhyolite. The unit is part of the Ootsa Lake Group as described by Duffell (1959), Tipper (1963), Diakow *et al.* (1997), and Grainger and Anderson (1999).

The Ootsa Lake Group consists of rhyolitic flows and domes, crystal and lithic-crystal tuffs, pyroclastic and autoclastic breccias, and minor dacite and andesite flows (Grainger and Anderson, 1999). The predominant rock type is a flow-laminated rhyolite that generally occurs as flows and less commonly as domes. Colour usually varies from red to white to grey, but is locally purple or green. Textures within the Ootsa Lake group can change within metres. Monolithic breccias containing flow-laminated clasts are found associated with rhyolite flows and domes. The rhyolites are aphyric or sparsely plagioclase-phyric. Biotite, alkali feldspar, quartz, and/or rare hornblende are minor phenocryst phases. Of interest here, the bases of several exposures of buff, flow-laminated rocks are black,

Figure 2. Location of perlite occurrences in BC listed in MINFILE, showing the area of Prince George deposits in Figure 3. 1-Prospect Creek; 2-Empire Valley; 3-Moore Lake; 4-Frenier; 5-French Bar Creek; 6-Terrace Mountain; 7-Anahim Peak; 8-Nazko; 9-Tasalit Mountain; 10-Denny Island; 11-Lagoon Bay; 12-Ironside Mountain; 13-Coates Creek; 14-Skelu Bay; 15-Blackwater Creek; 16-Canoe Creek; 17-Ship Keita Island; 18-Juskatla Inlet; 19-Florence Creek; 20-Cheslatta Lake; 21-Henson Hills; 22-Uncha Lake; 23-Francois; 24-Marilla. Modified from White (2002).

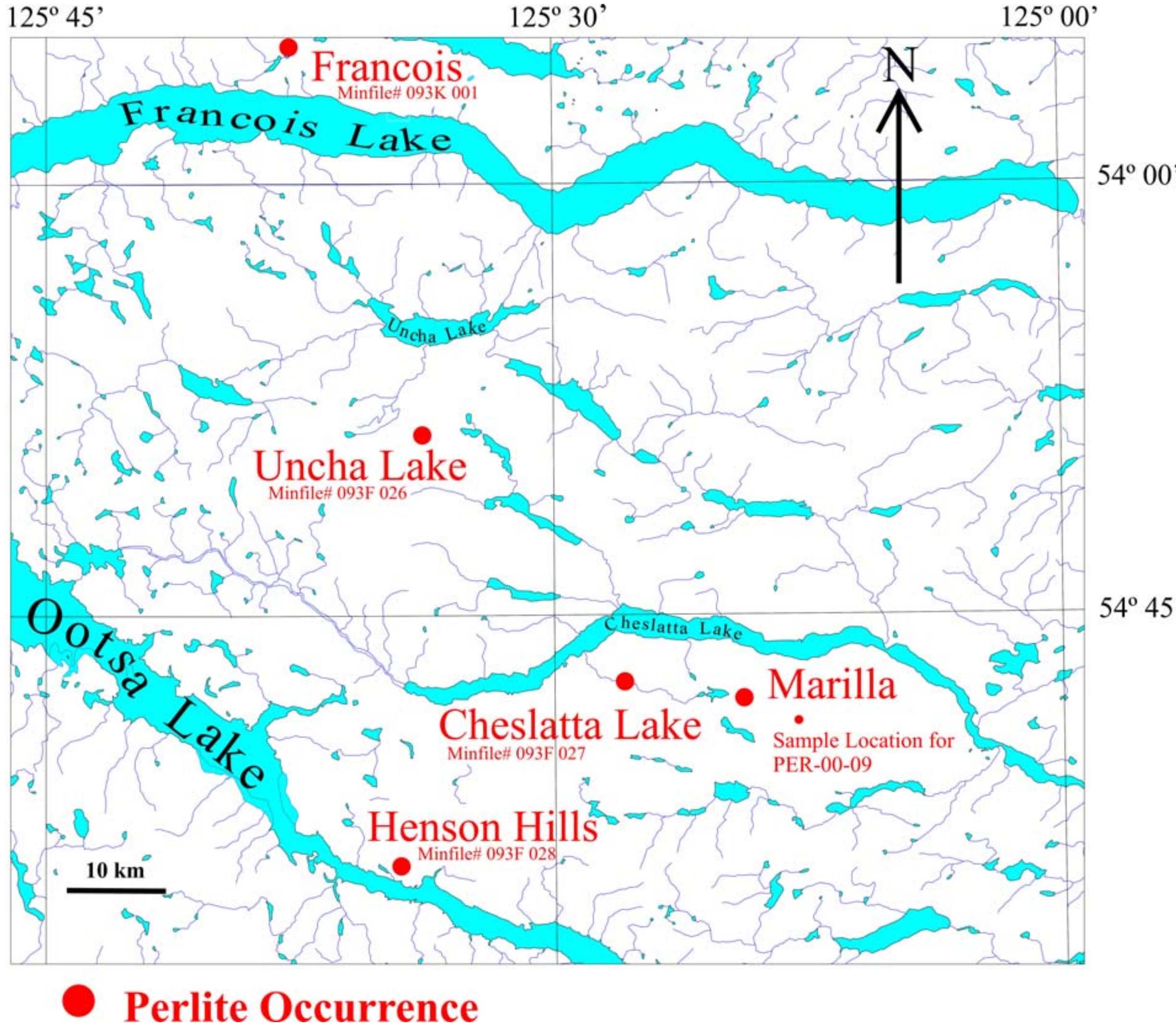

Figure 3. Perlite occurrences in the Prince George area. Ootsa Lake Group with location of the newly discovered Marilla perlite occurrence. See Figure 2 for location of map within BC.

glassy, and perlitic (Grainger and Anderson, 1999). As well as the Marilla occurrence, the Ootsa Lake Group hosts the Cheslatta Lake, Henson Hills, Uncha Lake and Francois occurrences (Figure 3).

Six lithologies that comprise the Marilla perlite showing were distinguished in the field (Figure 4). These are: Banded Spherulitic Rhyolite Breccia, Flow-Banded Perlite, Rhyolite with Biotite Phenocrysts, Spherulitic Amygdaloidal Perlite, Spherulitic Rhyolite, and a Grey Perlite Breccia. Sample MAR-00-09, was collected from a loose angular boulder of flow banded perlitic obsidian about one meter in diameter. This boulder was found on the roadside 200 metres west of the showing. Sample PER-00-01, from the Perlite with Amoeba-like Spherulite unit, was taken from a small flat outcrop in the ditch approximately 4 kilometres east of the Marilla perlite showing. The coordinates for this unit are N53º 42.211' and W125º 16.42'.

PERLITE ROCK UNITS

Banded Spherulitic Rhyolite Breccia (MAR-00-01)

This rock is layered grey and cream with maroon spherulites on a fresh surface. Altered surfaces are grey with 2 to 3 millimetre thick beige bleached zones. Common opal fills open spaces in the rock, with some opal forming veinlet swarms. Phenocrysts are subhedral partially dissolved plagioclase grains (5 to 10%) averaging 1 millimetre in diameter and biotite (2%), averaging 0.8 millimetres in longest dimension. Spherulites consisting of plagioclase microlites make up 40 to 45% of the rock and are up to 1 centimetre in diameter (Figure 5).The spherulite's brown colour is due to the presence of palagonite, which is a low temperature hydration and alteration mineral of sideromelane. Some spherulites are nucleated on plagioclase phenocrysts. Minor constituents are epidote (less than 1%, 0.25 millimetres in diameter) and iron oxides (2%). There are

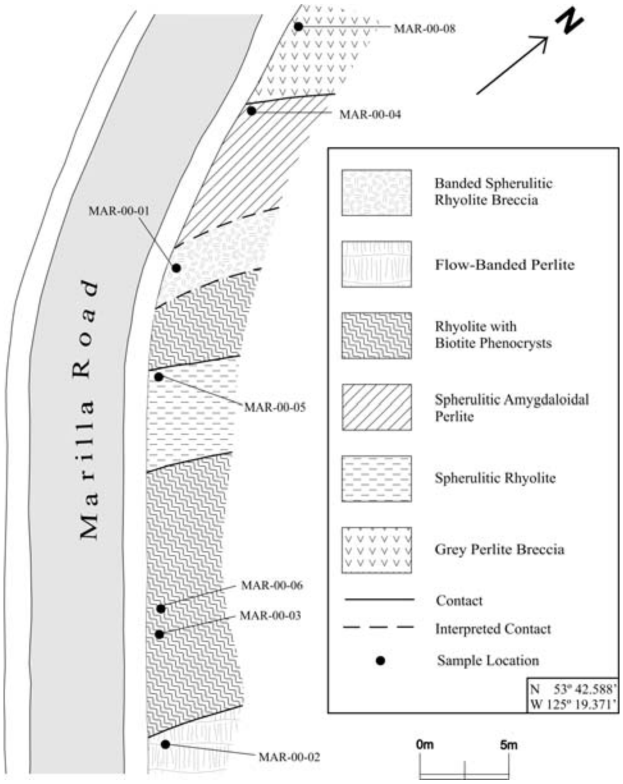

Figure 4. Outcrop at the Marilla perlite occurrence seen in plan view. It shows the six major lithological units.

Figure 5. Spherulite of sample MAR-00-01 (Banded Spherulitic Rhyolite Breccia) in plane-polarized light. The width of the field of view is 1.2 millimetres.

relatively few plagioclase microlites in the glass matrix but perlitic texture is common throughout the glass matrix. The rock expands by less than 30% when heated with a propane torch.

Flow-Banded Perlite (MAR-00-02)

This unit consists of dark grey and orange/red layers with maroon spherulites. Layers are up to 3 centimetres thick, with flow banding and spherulites following the flow banding. There is a pearly luster on the hackley glass fractured surface. The major constituents are spherulites (40%) that are up to 1 centimetre in diameter. Also present are subhedral, partially dissolved plagioclase grains (5 to 10%) averaging 0.7 millimetres in diameter and biotite phenocrysts (2%) that average 0.3 millimetres in longest dimension but may reach up to 0.9 millimetres. Minor constituents are opaques (less than 1%) averaging 0.08 millimetres in diameter, epidote (less than 1%) averaging 0.1 millimetre in diameter, and amygdules of silica, agate and common opal (1 to 2%) that average 6 millimetres in longest dimension. Large areas of alteration displaying remnant perlitic texture are common. The rock made some popping noises when heated with a propane torch, but expansion was minimal at less than 5%.

Rhyolite with Biotite Phenocrysts (MAR-00-03)

This rhyolite is beige/pink/grey with black biotite phenocrysts of 2 millimetres in diameter that have a copper coloured reflection on a fresh surface. The altered surfaces appear lighter coloured than the fresh surfaces. Main phaneritic constituents are plagioclase and orthoclase phenocrysts (5%) averaging 0.5 millimetres in diameter with some up to 2 millimetres, and bright orange/red coloured biotite (2%) averaging 0.25 millimetres in longest dimension. Carbonate amygdules (2%) display fan textures are present and average 1.3 millimetres in longest dimension. Embayed feldspar grains are cemented with a glassy matrix, and fiamme texture is evident throughout the rock. No expansion was observed when heated with a propane torch.

Spherulitic Amygdaloidal Perlite (MAR-00-04)

This rock is dark grey/green with maroon spherulites averaging 0.5 centimetres in diameter on a fresh surface. Weathered surfaces are light brown and green with maroon spherulites. Spherulites (85%) are the major constituents, and are up to 0.75 centimetres in diameter. Partially dissolved embayed plagioclase phenocrysts (8%) are an average of 0.6 millimetres in diameter, and biotite (1%) averages 0.2 millimetres in longest dimension. Minor constituents are epidote (less than 1%) averaging 0.5 millimetres in diameter, opaques (less than 1%) averaging 0.1 millimetres in diameter, amygdules (1%) averaging 2 millimetres in diameter, and swallow-tails of plagioclase (less than 1%). Most of the perlitic textured glass is altered and has been overprinted by spherulitic texture. Most spherulites are round but some are fan or plumose shaped. The lighter coloured portion of the rock popped, but no obvious expansion occurred when heated with a propane torch.

Spherulitic Rhyolite (MAR-00-05)

This rock is light grey with abundant maroon spherulites on a fresh surface. It breaks apart easily on altered surfaces due to fracture networking marked by beige bleaching and swarms of veinlets. No layering or banding is evident. The main constituents are spherulites (55%) up to 2.5 centimetres in diameter, partially dissolved plagioclase phenocrysts (7%) averaging 0.75 millimetres in diameter and biotite (2%) averaging 0.5 millimetres in longest dimension. Opaques (possibly hematite, magnetite or ilmenite) constitute 1% of the rock and are 0.1 millimetres in diameter. The spherulites are nucleated mainly on plagioclase or biotite phenocrysts, and some have reaction rims between them and the glass. The glass matrix displays perlitic texture in which microlites have grown in the perlitic fractures (Figure 6). The rock expanded by 35% when heated with a propane torch.

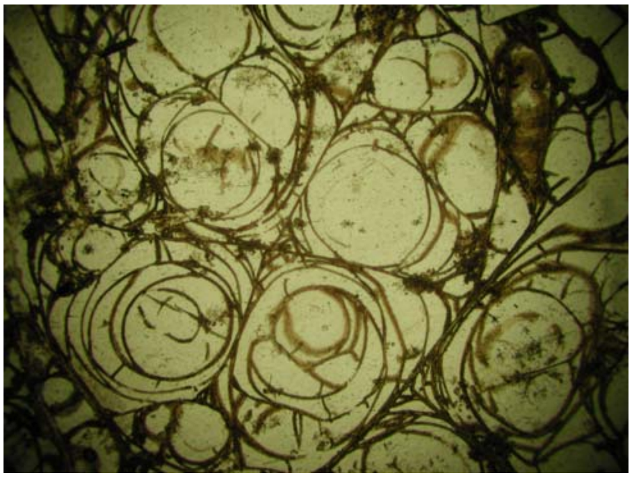

Figure 6. Perlitic fractures of sample MAR-00-05 (Spherulitic Rhyolite unit) in plane polarized light. The width of the field of view is 1.8 millimetres.

Rhyolite with Biotite Phenocrysts (MAR-00-06)

This sample was taken from the same lithological unit as sample MAR-00-03, the *Rhyolite with Biotite Phenocrysts* unit, and is similar in hand sample and thin section. The thin section has a slightly darker appearance in cross-polarized light than Mar-00-03, which may be the result of slightly more alteration, denser compaction, or a slightly thicker slide. Swallow-tails of plagioclase occur, and zoned feldspars are common. The rock expands by less than 3% when heated with a propane torch.

Grey Perlite Breccia (MAR-00-08)

On a fresh surface this rock has dark grey fragments averaging 2 centimetres in diameter, surrounded by cream coloured matrix and smaller brecciated pieces of light grey rock. The altered surface is beige/cream and light grey. Biotite phenocrysts, up to 1.5 millimetres in diameter, are present. The phenocrysts are partially dissolved plagioclase (3%) averaging 0.4 millimetres in diameter, and biotite (1%) averaging 0.5 millimetres in longest dimension. Minor constituents are epidote (less than 1%) averaging 0.2 millimetres in diameter, and a feathery high birefringence fracture-filling mineral (possibly a chlorite/sericite mix). Brecciated unaltered glass constitutes 30% of the rock, clasts average 1.0 centimetre in diameter. They are enclosed by altered lighter-coloured glass. Perlitic texture is evident throughout the glass, but more alteration occurs in the darker-coloured areas. The rock expands by 40% when heated with a propane torch.

Flow Banded Perlitic Obsidian (MAR-00-09)

This sample is from a boulder found on the roadside 200 metres west of the Marilla perlite showing. In hand sample, it is dark grey/green with black flow banding up to 3 millimetres in width. It has a pearly hackley/conchoidal fracture on a fresh surface and beige/brown coatings on altered surfaces. Constituents are partially dissolved feldspar phenocrysts (5%) averaging 1.0 millimetre in diameter, biotite (2%) averaging 0.1 millimetres in longest dimension, and amphibole (less than 1%), which is likely tremolite, averaging 0.1 millimetres in diameter. Minor constituents are opaques (less than 1%) averaging 0.2 millimetres in diameter, and veins of a yellow alteration material (possibly clays, zeolites, or a mineral of the silica group). The flow banding, which appears to be speckled in thin section with remnant perlitic texture, flows around plagioclase and other grains (Figure 7). The glass is relatively unaltered with abundant perlitic texture and makes up the majority of the rock (up to 90%). There are plagioclase hopper structures and swallow-tails, and some biotite hopper structures in the perlitic glass matrix. Small spherulites, in their first stages of growth, occur in 1% of the rock and average 0.4 millimetres in diameter. They radiate from plagioclase phenocrysts in fan and plumose structures. The rock expands several times its original volume when heated with a propane torch.

Perlite with Amoeba-like Spherulites (PER-00-01)

This sample was taken from a small flat outcrop in the ditch approximately 4 kilometres east on Marilla Road. Its fresh surface is black/grey with purple amoeba-like spherulites up to 0.5 centimetres in diameter. The altered surface has a peach, green or yellow coating. Spherulites occur in 60% of the rock and have amoeba-like branches that radiate from a central point (Figure 8). Some spherulites are nucleated on plagioclase grains. Relatively few phenocrysts occur in the surrounding altered glass, which displays some perlitic texture. Phenocrysts include 3% plagioclase up to 2 millimetres in diameter, 1% biotite and less than 1% epidote. Vesicles in the glass are common. The rock expands by less than 3% when heated with a propane torch.

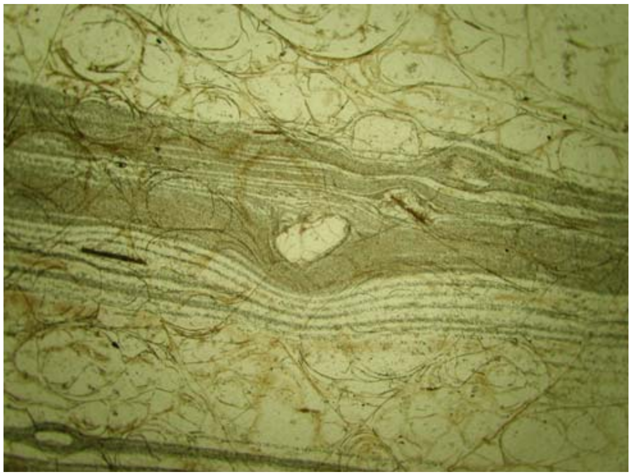

Figure 7. Flow banding in sample MAR-00-09 (Flow Banded Perlitic Obsidian unit) in plane polarized light. The width of the field of view is 4.0 millimetres.

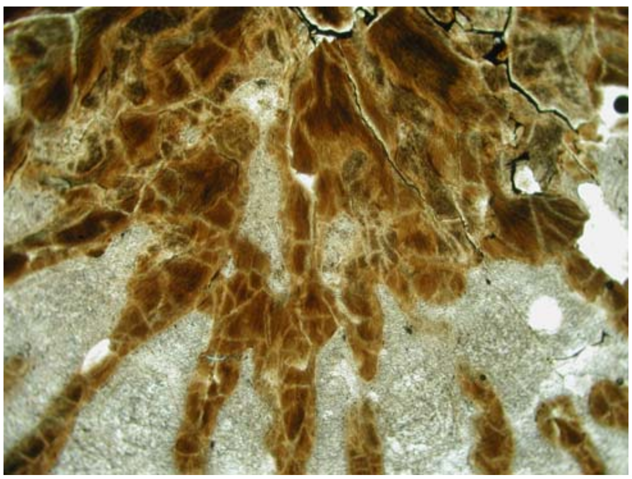

Figure 8. Spherulite in sample PER-00-01 .Perlite with amoeba-like spherulites unit, in plane polarized light. The width of the field of view is 1.2 millimetres.

GEOCHEMISTRY OF THE MARILLA PERLITE SHOWING

All units of the Marilla perlite showing were identified as rhyolites in the field based on textures and structures. The major and minor element geochemistry of representative samples was analyzed using x-ray fluorescence and results are given in Table 1. The SiO_2 content varies from 62.86% to 73.26% and the TiO_2 values are relatively low at 0.18% to 0.23%, which is normal for rhyolite. The LOI (lost on ignition) values range from 3.2% to 4.15%. The *Rhyolite with Biotite Phenocrysts* sample (MAR-00-03) has a high LOI (15.53%) and a high CaO content (2.21%), reflecting carbonate in the amygdules. LOI of the *Grey Perlite Breccia* sample (MAR-00-08) is 6.69%. It is assumed that a large portion of the LOI value represents water incorporated into the glass structure, although it was not analyzed for.

Typical chemical compositions of perlite ores around the world and the average compositions of perlite and rhyolite are given for comparison to the Marilla perlite values (Table 1). This data shows that the TiO_2 and Fe_2O_3 content of the Marilla perlite, averaging 0.23% and 1.2% respectively, are higher than other perlite ores around the world that average 0.07% and 0.8% respectively (Breese and Barker, 1994).

Major and minor elements are plotted on three different discrimination diagrams (Figures 9, 10, and 11). The $\%SiO_2$ - ($\%Na_2O$+$\%K_2O$) diagram shows that all, but the *Rhyolite with Biotite Phenocrysts* unit (sample MAR-00-03) plot in the rhyolite field. This unit contains carbonate amygdules that make classification by this means unreliable (Figure 9). Samples from the Marilla perlite showing are relatively pristine with no visible effects of hydrothermal alteration or weathering. Consequently, the major element plot of $\%SiO_2$ - ($\%Na_2O$+$\%K_2O$) is considered to be reliable, and most units are interpreted as rhyolite.

Four of the eight samples were sent for trace element analyses (Table 1). These samples are plotted on a Zr/TiO_2 - % SiO_2 graph (Figure 10). Three of these samples plotted in the rhyodacite-dacite field with one sample falling in the trachyte field. The same four samples were also plotted on a Nb/Y - Zr/TiO_2 graph (Figure 11). Diagrams using immobile element ratios such as Nb/Y and Zr/TiO_2 are useful in determining the original composition of volcanic rocks affected by alteration. Elements such as Zr, Ti, Nb, and Y are relatively immobile and remain in the rock when alteration occurs. Figure 11 shows all the samples falling near the rhyolite, rhyodacite/dacite, and trachy-andesite boundaries.

ECONOMIC POTENTIAL

When they were subjected to a torch flame, most samples displayed at least some degree of expansion. Rigorous testing using standard laboratory equipment is needed to confirm whether the occurrence or surrounding area could provide raw material for an expanding perlite plant. The *Flow Banded Perlitic Obsidian* unit (sample MAR-00-09 from the boulder found 200 metres west of the showing), expanded several times its original volume. The source of this expanding perlite may be found in the area covered by overburden. The direction of ice flow during the last glaciation was estimated at 66º NE (Plouffe, 1999), and the angularity of this boulder suggests a nearby source for the Flow Banded Perlitic Obsidian boulder (sample MAR-00-09) that would be southwest of the Marilla perlite showing. The Ootsa Lake Group is a favourable host for expandable perlite, so testing of known volcanic glass occurrences and further exploration in Prince George area is justified. Several of the volcanic glass and perlite localities in this area have

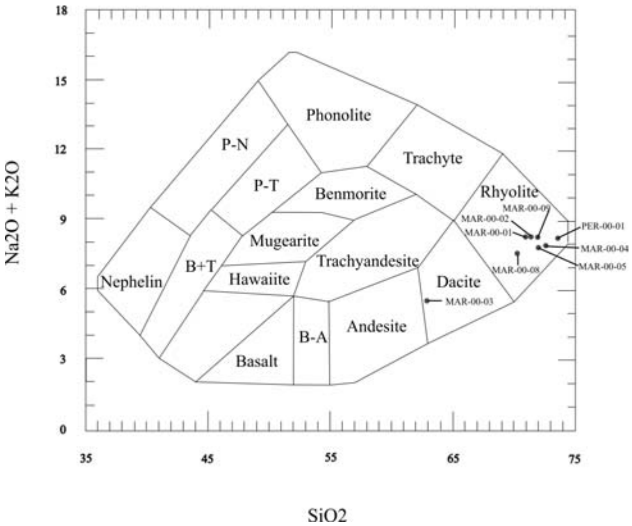

Figure 9. {%SiO_2 - (%Na_2O+%K_2O)} discrimination diagram for volcanic rocks, (Cox *et al*., 1979).

been previously described by Tipper (1963), Duffel (1959), Grangier and Anderson (1999), White (1990) and White (2002). Distance of the deposit from perlite consumers should be taken into consideration before investing heavily into exploration of this geologically favourable area, however, production from the Francois occurrence (Figure 3), where Western Gypsum Products Ltd. mined 1589 tonnes from 1949 to 1953 proved that material from this area can satisfy industry specifications.

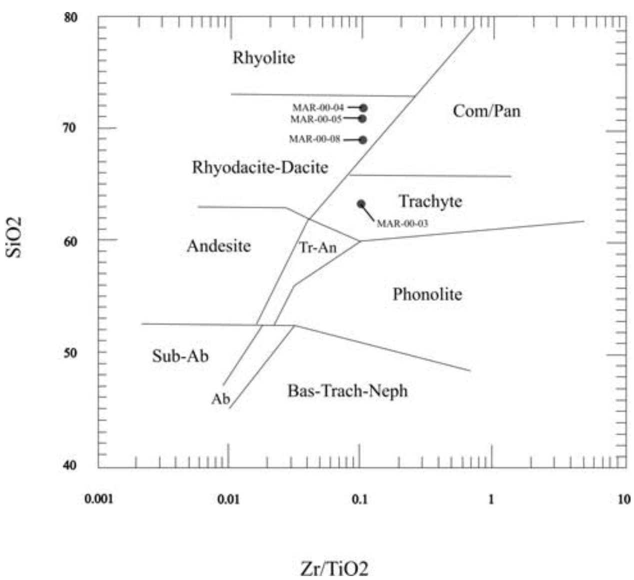

Figure 10. (Zr/TiO_2 - %SiO_2) discrimination diagram for volcanic rocks. Abbreviations: Com = comendite, Pan = pantellerite, TrAn = Trachy Andesite, Ab = andesite basalt, Bas-Trach-Neph = basalt/trachite/nephelinite (Winchester and Floyd, 1977).

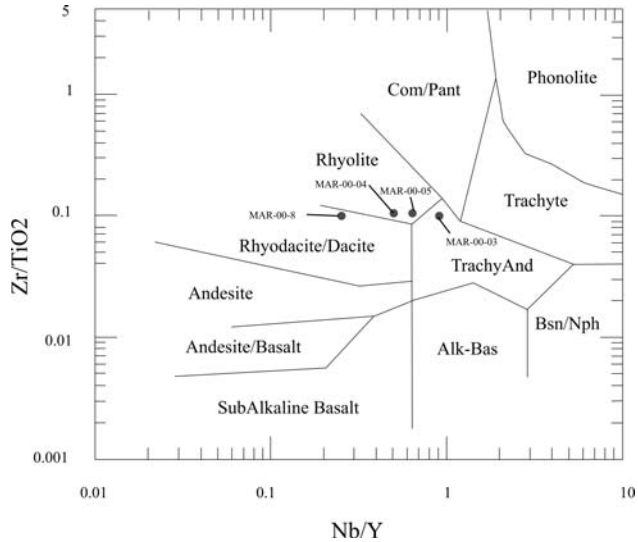

Figure 11. (Nb/Y - Zr/TiO_2) discrimination diagram for volcanic rocks. Abbreviations: Com = comendite, Pant = pantellerite, Bsn = basanite, Nph = nephelinite, Alk-Bas = alkali basalt (Winchester and Floyd, 1977).

ACKNOWLEDGEMENTS

We would like to thank Bob Lane of the Ministry for showing us the site, Amy Boulton and Dan Marshall for assisting in the fieldwork, and Mike Fournier for his help in drafting figures. Suzanne Paradis of the Geological Survey of Canada and Jennifer Beauregard of the University of Victoria reviewed an earlier version of this manuscript.

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TABLE 1. GEOCHEMISTRY OF THE MARILLA PERLITE, CHEMICAL COMPOSITIONS OF PERLITE ORES AND AVERAGE COMPOSITIONS OF PERLITE AND RHYOLITE

Marilla Perlite	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	LOI %	Y ppm	Zr ppm	Nb ppm	Th ppm	Ti ppm	V ppm	Ba ppm	Hf ppm
MAR-00-01	71.62	0.23	12.78	1.15	0.01	0.14	0.87	3.13	5.3	0.01	4.15								
MAR-00-02	72.33	0.23	13.05	1.4	0.01	0.18	0.82	3.18	5.28	0.01	3.08								
MAR-00-03	62.86	0.21	12.09	1.37	0.03	0.55	2.21	0.93	3.69	0.01	15.53	26	205	21	11	1250	10	967	4
MAR-00-04	72.23	0.23	12.86	1.38	0.02	0.18	0.93	2.9	5.3	0.01	3.2	35	214	19	31	1378	11	1051	5
MAR-00-05	71.65	0.23	13.03	1.25	0.01	0.17	0.87	3.05	5.07	0.01	4.15	31	221	20	18	1370	8	1046	5
MAR-00-08	69.83	0.21	12.6	1.15	0.02	0.25	1.1	2.47	5.13	0.01	6.69	35	207	20	19	1200	8	1050	5
MAR-00-09*	71.51	0.23	12.75	1.34	0.02	0.18	0.77	3.06	5.36	0.01	4.13								
PER-00-01**	73.26	0.18	12.35	1.02	0.03	0.12	0.69	2.98	5.34	0.01	3.48								

*boulder found 200 metres west of the Marilla perlite showing

**sample from approximately 4 kilometres east along Marilla Road from a small flat outcrop in the ditch (N53°42.211' W125°16.42') see Figure1b.

Perlite Ores	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	LOI %
No Agua, NM+	72.1	0.06	13.5	0.8		0.5	0.89	4.6	4.4		3
Superior, AZ+	73.6	0.1	12.7	0.7		0.2	0.6	3.2	5		3.8
Pioche, NV+	73.1	0.08	12.8	0.7		0.2	0.9	3	4.7		3.9
Big Pine, CA+	73.6	0.07	13.2	0.8		0.1	0.6	4.1	4.1		3.3
Milos, Greece+	74.2	0.08	12.3	0.95		0.13	0.85	4	4.4		2.8
Akita, Japan+	74.2	0.06	12.9	0.68		0.05	0.45	4.1	4		3.3
Bulgaria+	73.8	0.07	12.8	0.56		0.03	0.5	3	4.9		4
Argentina+	72.3	0.08	13.4	1		0.3	0.59	3.4	4.7		3.7
Hungary+	73.5	-	13	1.8		0.4	1.5	3.5	3.8		3
Average Chemical Composition of Perlite^	72.70	0.91	12.91	1.35	0.05	0.23	0.82	3.07	4.73	0.04	3.19
Average Chemical Composition of Rhyolite^	72.82	0.28	13.27	2.58	0.07	0.39	1.57	3.55	4.30	0.07	1.10

+Taken from Breese and Barker (1994), source Kadey Jr., (1983).

^from Shackley and Allen, (1992). Based on 50 perlite samples examined by Shackley (1989) and 60 rhyolite samples examined by Le Maitre (1976).

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