Investigation of Polished Sections and Analysis of Digital Elevation Model (DEM) Data from Rare Element Pegmatites at Lower Caledonia (NTS 11E/08) and Seffernsville (NTS 21A/09), Nova Scotia

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Introduction

Recent recognition of potentially ore-grade beryllium, and evaluation of further occurrences of important elements such as Ta, Nb, Cs and Rb at Lower Caledonia, Guysborough County, have renewed interest in pegmatite occurrences in Nova Scotia. Pegmatite occurrences at Lower Caledonia and Seffernsville, Lunenburg County (Fig. 1), were recently the subjects of Prospector Assistance projects. The Prospector Assistance Program (1998 to 2000) provided seed funding to Nova Scotia prospectors as part of a federal - provincial cooperation agreement that required input from local prospectors as well. These and other exploration targets are receiving new, due consideration for the presence of elements that are in great demand today owing to the development of new technologies. Beryllium is used in the manufacture of ultra light and strong alloys, such as those used for fighter jet airframes, tantallum in computer chip materials and high temperature ceramics, cesium in the manufacture of new chemicals and rubidium in medical research. The market prices for these elements, while volatile, make them valuable commodities in relation to other metals.

Lower Caledonia Pegmatite

The pegmatite that hosts the Lower Caledonia beryllium occurrence was documented, and even diamond drilled, by more than one investigator (Armstrong, 1969; McMullin, 1976) as part of the evaluation of an adjacent gold - base metals exploration target. A shaft was also sunk within 50 m of one of the key outcrops described in the beryllium discovery (Goudge, 1937; Fig. 2). None of these workers recognized the presence of beryl, presumably because to beryl is easily mistaken for feldspar.

During the 1999 field season the site was visited by Nova Scotia Department of Natural Resources geologist G. A. O'Reilly, who was checking the gold - base metals prospect known as the McLaren workings. He recognized beryl in the pegmatite and presented the information to the public and industry at the Nova Scotia Department of Natural Resources Open House and Review of Activities in 1999. As a result, the prospect was staked.

History

The following history is summarized from O'Reilly, 1999. The first well documented report of work in the Lower Caledonia area was done by Goudge (1937), who described the 5 m deep shaft, trenches and related work done on the quartz veins of the McLaren workings. One of these veins returned levels in excess of 3/4 oz. Au per ton. Also noted with the free gold were pyrite, chalcopyrite, galena and sphalerite. This subsequently led to the prospect receiving attention as a base metals target as well as a gold prospect, and the site was drilled in the 1960s by two companies (Meagher, 1966; Armstrong, 1969), as well as a third in the 1970s (McMullin, 1976). The pegmatite, in which beryl was subsequently recognized, was intersected by this drilling, according to drill core records. The drillholes also encountered anomalous Zn (up to 0.33%), Pb (up to 0.15%) and Ba (0.07%). Tellurium was reported as well, but has never been confirmed at the occurrence.

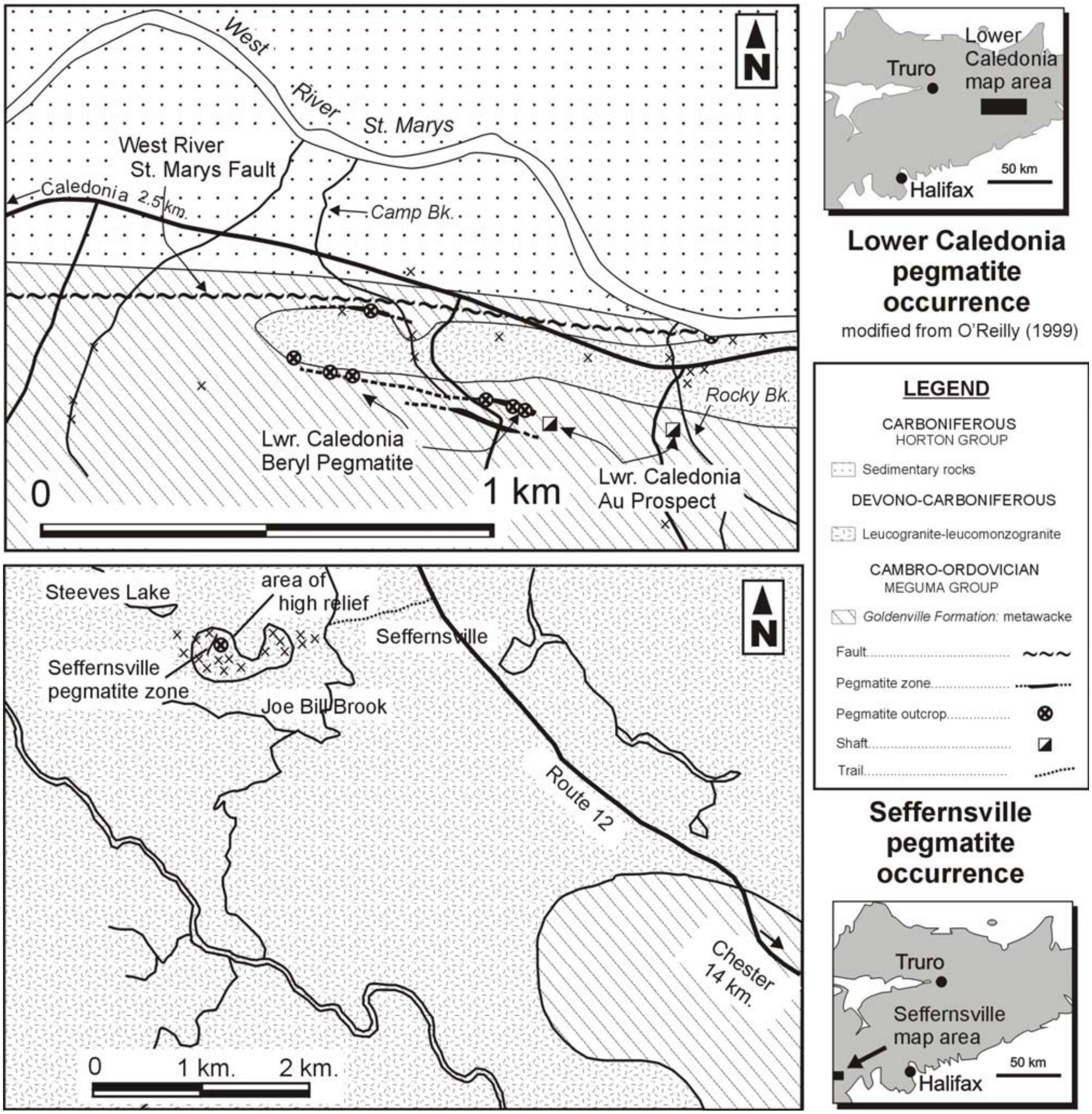

Figure 1. Geological maps of the Lower Caledonia and Seffernsville areas, showing locations of the pegmatite occurrences.

Description of Outcrops

Outcrops were examined in the 2000 and 2001 field seasons and occur west of the bush road running south and uphill from the Caledonia - Lower Caledonia highway, and approximately 300 to 400 m west of the outcrops described by O'Reilly (1999). Overburden cover in the area is extensive and the actual width of the pegmatites is not known. It is also not known if these outcrops represent a single pegmatite, or are separate parts of a pegmatitic swarm underlying that area. The pegmatites are roughly on strike with those described by O'Reilly (1999). The first (eastern-most) and second (middle) outcrops are very close

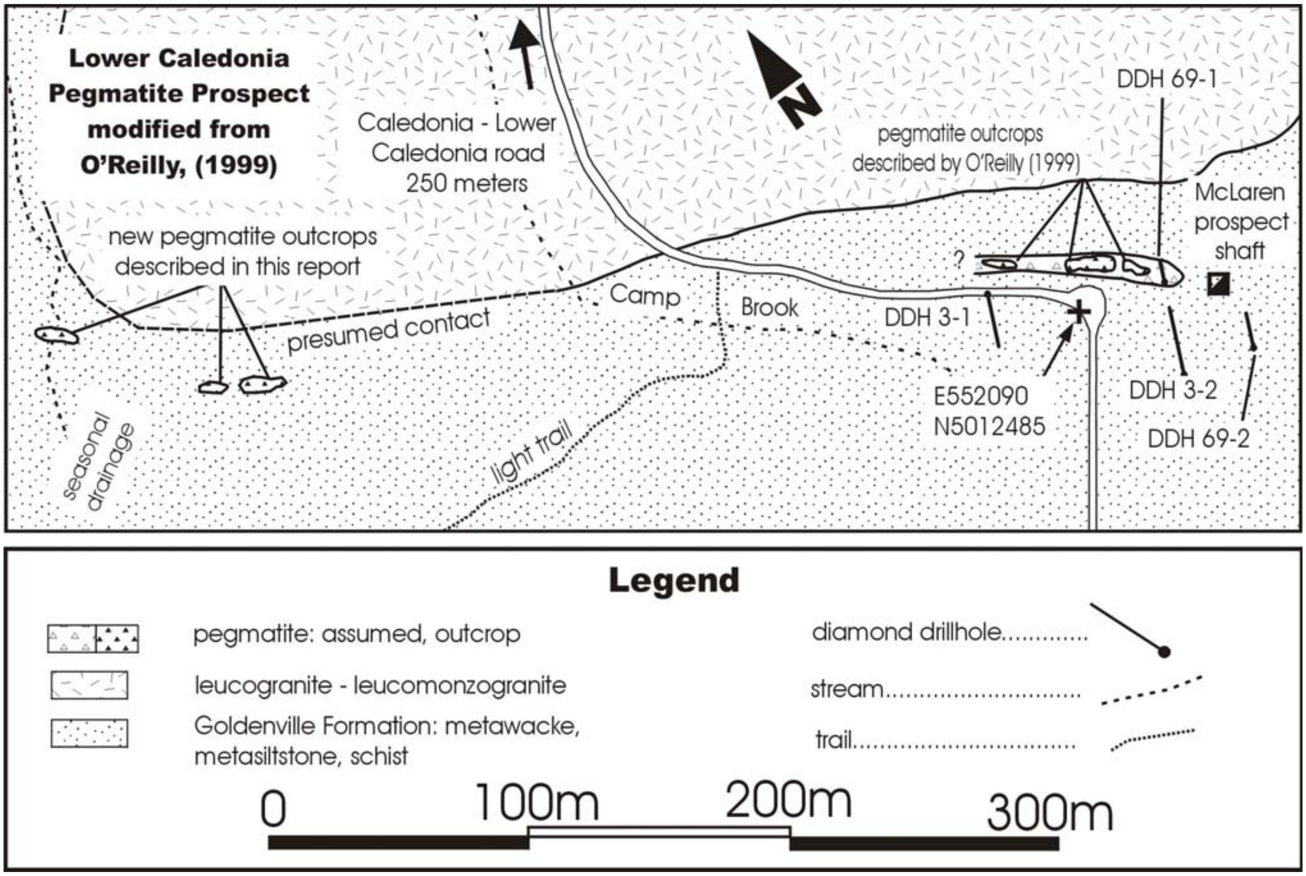

Figure 2. Geological map of the Lower Caledonia pegmatite occurrence.

to one another and are probably connected; however, the third (westernmost) outcrop is not on the same strike as the first two. This may represent a separate pegmatite from the first two outcrops, or the same pegmatite curved toward the north, around, and close to the edge of a small leucogranitic body (Fig. 2).

Comparing these three outcrops with those described by O'Reilly (1999), it is notable that the groundmass of the new outcrops seems to be marginally to significantly more coarse than the exposure to the east described by O'Reilly (1999).

The First (Easternmost) Outcrop

The first outcrop was found along a bush road approximately 275 m west to the west of O'Reilly's (1999) outcrop. To reach this outcrop, follow the trail southwest for 60 m, then west for approximately 75 m before turning due north off the trail and walking for about 50 m. The exposure measures approximately 3 m long (east to west) and 1.5 to 2 m wide and was found at (NAD 20) UTM coordinates E551764, N5012621. The outcrop consists of large blocks (0.2 m to 0.75 m) of pegmatitic colluvium that are broken and misplaced slightly but, basically *in situ*. The outcrop is partially obscured by moss and other vegetation. It is hard to comment on many of the features of the pegmatite at this location, such as zoning, due to the poor nature of the outcrop. However, some general observations reveal that these blocks are noticeably more megacrystic than the outcrops described by O'Reilly, approximately 275 m to the east. The colluvium displays much of the mineralization noted by O'Reilly in the outcrops proximal to the McLaren prospect. Minerals include abundant megacrystic potassium feldspar, tourmaline, and beryl, which was noted in at least one large angular block from this location. Large 3-4 cm crystals of a buff, unidentified (possibly feldspar) mineral are also present.

The Second (Middle) Outcrop

The second outcrop measures approximately 6 m long (east to west) and 2.5 m wide, and was found at UTM coordinates E551744, N5012633, which is approximately 20 m farther west along strike of the pegmatitic body. This outcrop consists of large blocks of pegmatitic colluvium from 0.2 m to 0.75 m in size lying around and over pegmatitic outcrop. Partially obscured by vegetation, the exposure is somewhat poor, but zoning is notable in this outcrop. Quartz is displayed as well as abundant tourmaline in close association to thin (2-6 cm) bands of schistose country rock. The texture is as coarse as the first (easternmost) outcrop, but displays a planar fabric parallel to the strike of the dyke (approximately 325°). The outcrop consists of massive megacrystic plagioclaise feldspar, quartz, and a few large (1.5-3.0 cm) crystals of beryl.

The Third (Westernmost) Outcrop

Approximately 65 m west of the second outcrop is a small, seasonal stream. Follow this north (down-stream), for approximately 40-60 m to a pegmatitic exposure below a small waterfall in a stream cut. The pegmatite measures approximately 5 m long (east to west) and 2.5 to 3 m wide, and is exposed on both sides of the stream. The dyke appears to continue at both ends where it is obscured.

There is less quartz at this location, but both tourmaline and beryl are more abundant than in the previously described outcrops. There are other black opaque minerals present that may or may not be tourmaline. Small-scale zoning can be seen in the outcrop, but an overall fabric is not apparent. Beryl crystals are relatively large, up to 2.5 cm. Several quartz veins and stringers cut the exposure.

The outcrop lies on the eastern side of a pronounced, 40 m wide ridge that runs north-south. Tourmaline-rich pegmatite can be seen on the western side of the ridge as well, due west of the third outcrop, in angular pegmatitic colluvium. At this time it is unknown whether the ridge itself represents a pegmatitic body oriented north - south, or if the pegmatite in the stream is oriented east-west.

Seffernsville Pegmatite

The Seffernsville pegmatite is located in an outcrop on a very high granite knob at UTM coordinates E387089, N4945375, approximately 3.5 km west of the village of Seffernsville, Lunenburg County (Fig. 3). The exposure is difficult to find by Nova Scotian standards. It is accessed via a bush road running west from Seffernsville off Route 12, to the junction with Joe Bill Brook. At this point, one must walk to the site following a foot path until the trail becomes obscured with overgrowth, then shooting a line with an orienteering compass on an azimuth of roughly 225° (south-southwest). The surrounding area is covered with thick boreal forest. A G.P.S. is recommended to help find the site. The hill hosting the site rises far over the surrounding terrain. Once close to the locality one can find the occurrence by locating and climbing the highest local hill.

Leading up to the site, west of Joe Bill Brook, there are exposures of unmapped Goldenville Formation rocks west of the stream. The granitic knob that hosts the pegmatite consists of coarse-grained, two-mica monzogranite and rises at least 15 m over all surrounding terrain. The site is marked by two trenches dug under the auspices of Faribault (1924), on the north side of the hill, approximately 100 m from the crest.

History

The Seffernsville pegmatite occurrence was first located and trenched by Faribault (1924). Ellsworth (1932) describes the site as having, "...the finest examples of smokey quartz crystals so far found in Canada, both in regard to perfection of form and depth of coloration...". Lepidolite is also reported to have been identified at the site by Ellsworth. No exploration of any significance has been done at the occurrence since Faribault's pits were excavated, though rocks in the area were explored on a more regional level in the 1970s and 1980s for granophile elements such as Sn, W, Mo, radio-active elements, and gold in the surrounding Meguma Group as part of a regional exploration program.

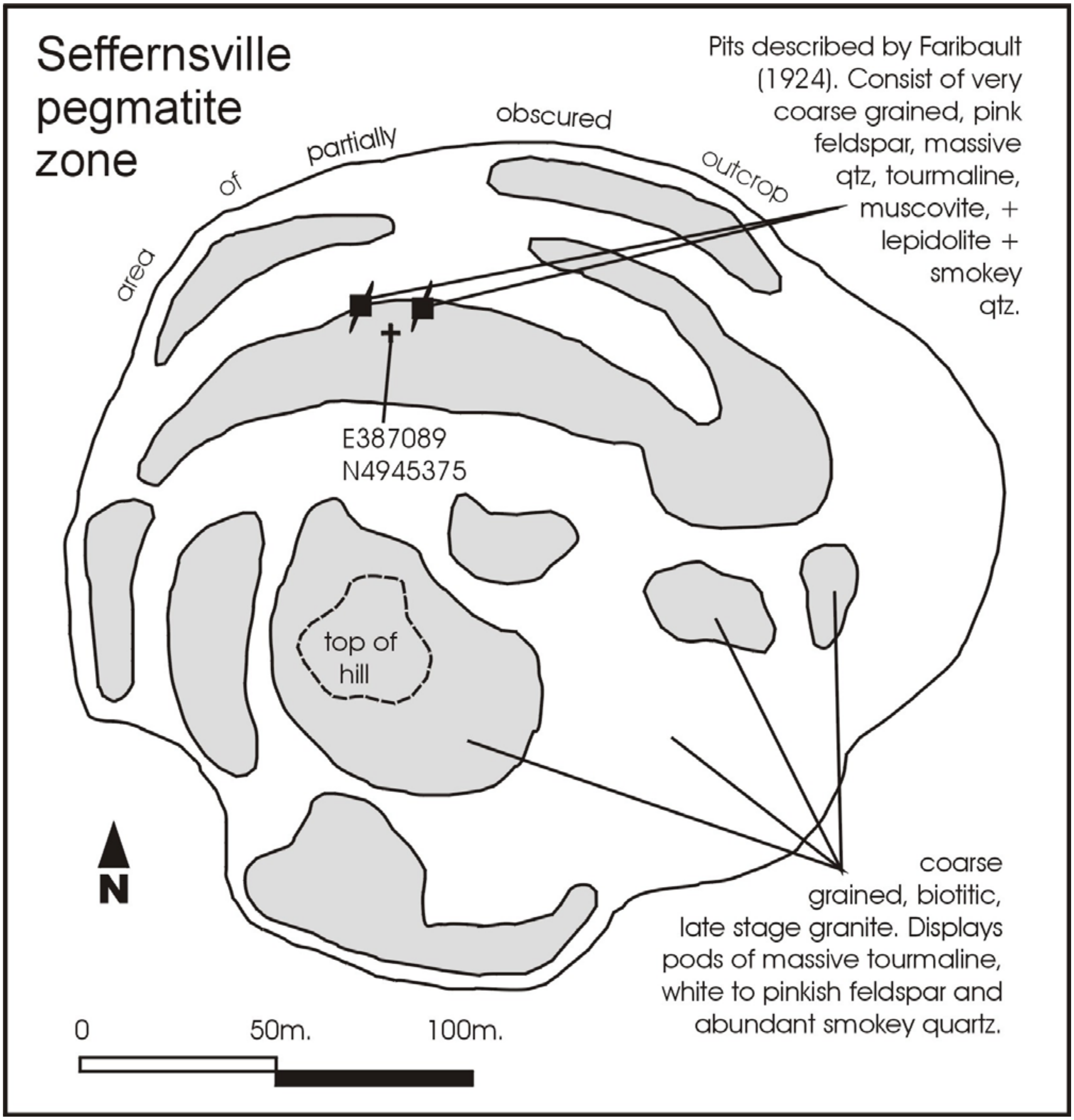

Figure 3. Sketch of the Seffernsville pegmatite zone.

Description of the Seffernsville Outcrops

The high knob-like granitic host for the occurrence consists of coarse-grained, two-mica monzogranite, cut by stockworks of quartz and smaller pegmatitic dykes. Under stereoscopic analysis, air photos reveal the high knob is surrounded by a series of partially circular ridges that are interpreted to represent some phase of convection or a separate magma pulse within the local intrusion. The pegmatite strikes approximately 010° at the occurrence and has been trenched by two pits approximately 20 m apart. The easternmost pit is marked on the east side by approximately 0.5 m of massive, coarse, megacrystic potassic feldspar, exhibiting tourmaline, large muscovite crystals and abundant smokey quartz. The west side of the pit displays massive white quartz up to 2.5 m wide. West of this pit the exposure is partially obscured with lichen and moss, but the massive nature of the quartz and coarse pegmatite is evident in the outcrop between the pits. The westernmost pit is also marked by abundant quartz development and massive, coarse potassium feldspar. Minor lepidolite was noted in dump samples from this pit. Lepidolite crystals were surrounded by a zone of feldspar in one instance. Minor iron sulphides, abundant muscovite, and tourmaline were also noted. There are several other unidentified dark, opaque minerals present in minor or trace amounts. Fluorite is also reported to have been recovered from the site (B. Paul, personal communication).

Analytical Methodology

Hand specimens were collected and inspected visually with a binocular microscope. Polished sections were made from samples recovered from the newly described Lower Caledonia pegmatite outcrops and the Seffernsville pegmatite occurrence. The sections were investigated by electron microprobe at Dalhousie University, Halifax, Nova Scotia. Backscatter images were also recorded (Fig. 4).

As part of the spatial analysis to the parental intrusives, three-dimensional wireframe images (maps) and shaded relief images (maps) were produced using recently released digital elevation model (DEM) data from the Geological Survey of Canada (1999; Fig. 5).

Results

Hand Specimens

At Lower Caledonia, beryl was identified in the field, as well as galena. Lepidolite was positively identified in the field at Seffernsville. Trace sphalerite was also noted at Seffernsville.

Polished Sections, Lower Caledonia

The slides revealed an overall groundmass in the Lower Caledonia pegmatite that was very different from the Seffernsville samples. (Fig. 4). The groundmass of the Lower Caledonia pegmatite exhibits three distinct phases of feldspar development. These phases are relatively uniform in nature, and produce a massive, amorphous groundmass that appeared to cool uniformly. Anomalous levels of Zr (42.9%), Nb (5.7%), Cs (0.091%) and Ba (0.97%) were noted. The unidentified buff mineral seen in the field at Lower Caledonia contains SiO_2 (67-68%) and Al_2O_3 (19-20%), with approximately 80% of the probe beam returned. Unfortunately, microprobe analysis is not sufficient for analysis of several of the lighter elements under investigation at the Lower Caledonia site, such as Be. A lack of suitable analytical standards gave inconclusive analyses for Ta and Cs.

Polished Sections, Seffernsville

Samples produced from Seffernsville revealed a groundmass of different appearance from that recorded at Lower Caledonia. The crystal texture shows a brecciated (cataclastic) fabric in the groundmass of the pegmatite. There is a mineral phase present that fills the interstitial space and cuts across other crystals (albite, quartz) in the groundmass. Microprobe analysis is not sufficient for analysis of the same elements under investigation at the Seffernsville occurrence site, such as Be and Li, and produced inconclusive results.

Digital Elevation Model (DEM) Analyses

Data reduction of the Caledonia area DEM reveals ridges representing the small parental intrusive, as well as several other local ridges that may represent further pegmatites in the area. Approximately 750 m west-northwest, a similar topographic feature to the parental granitic body is clearly exposed in the DEM wireframe diagram (Fig. 5a.).

The Seffernsville DEM displays the high topographical feature that hosts the known pegmatite in the area, as well as the outline of the leucocratic intrusive parent. There are many small ridges around the site that could represent pegmatites; an

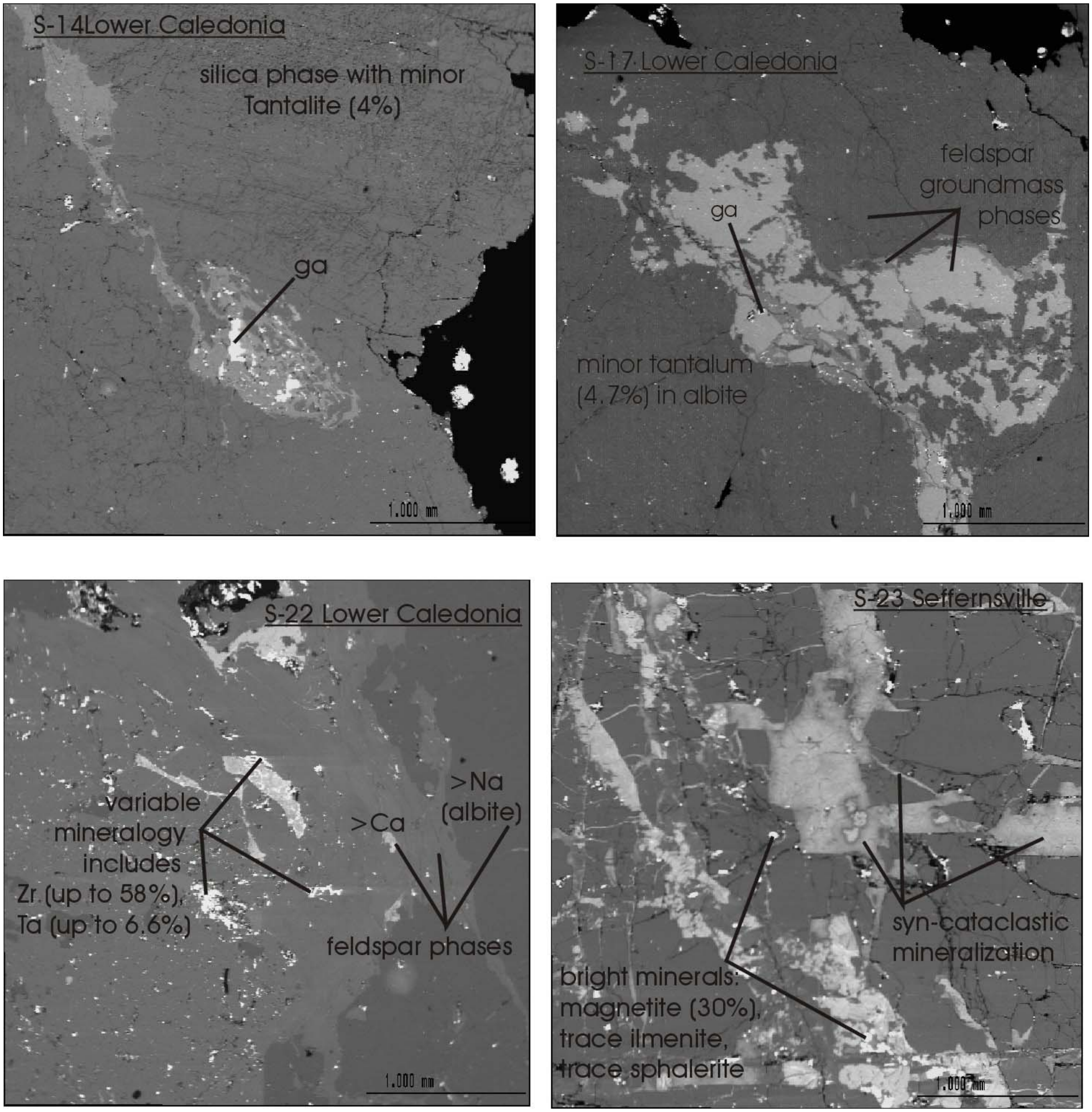

Figure 4. Scanning electron backscatter images from Lower Caledonia (both upper images and lower left) and Seffernsville (lower right). Phased groundmass mineralization at Lower Caledonia appears syngenetic and presumably relates to primary cooling. Groundmass mineralization at Seffernsville follows a cataclastic fabric. This phase is believed to represent genetic alteration or partial anatexis of an existing fabric.

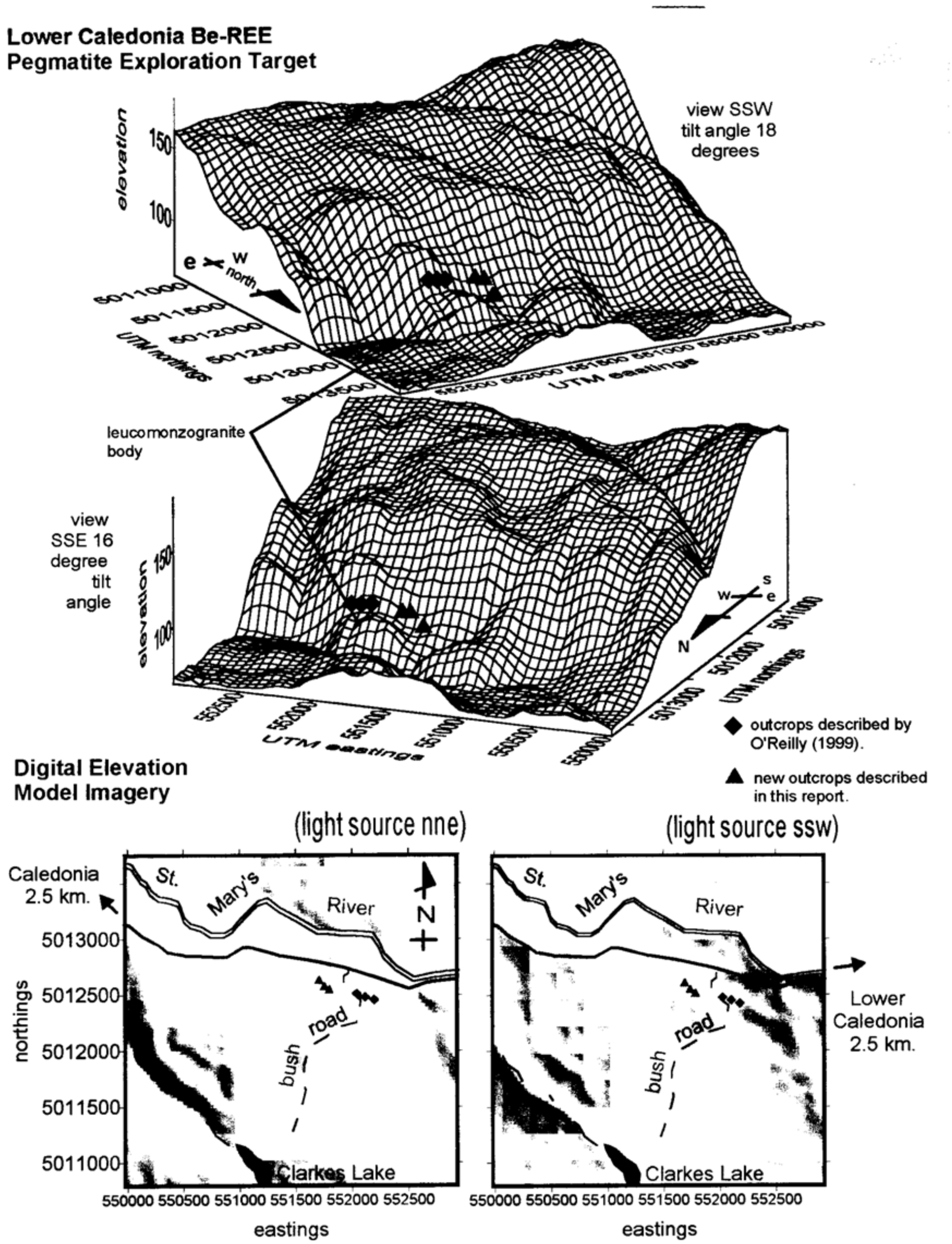

Figure 5a. Three-dimensional wire frame images and shaded relief images of the Lower Caledonia pegmatite occurrence, based on digital elevation model data (Geological Survey of Canada, 1999).

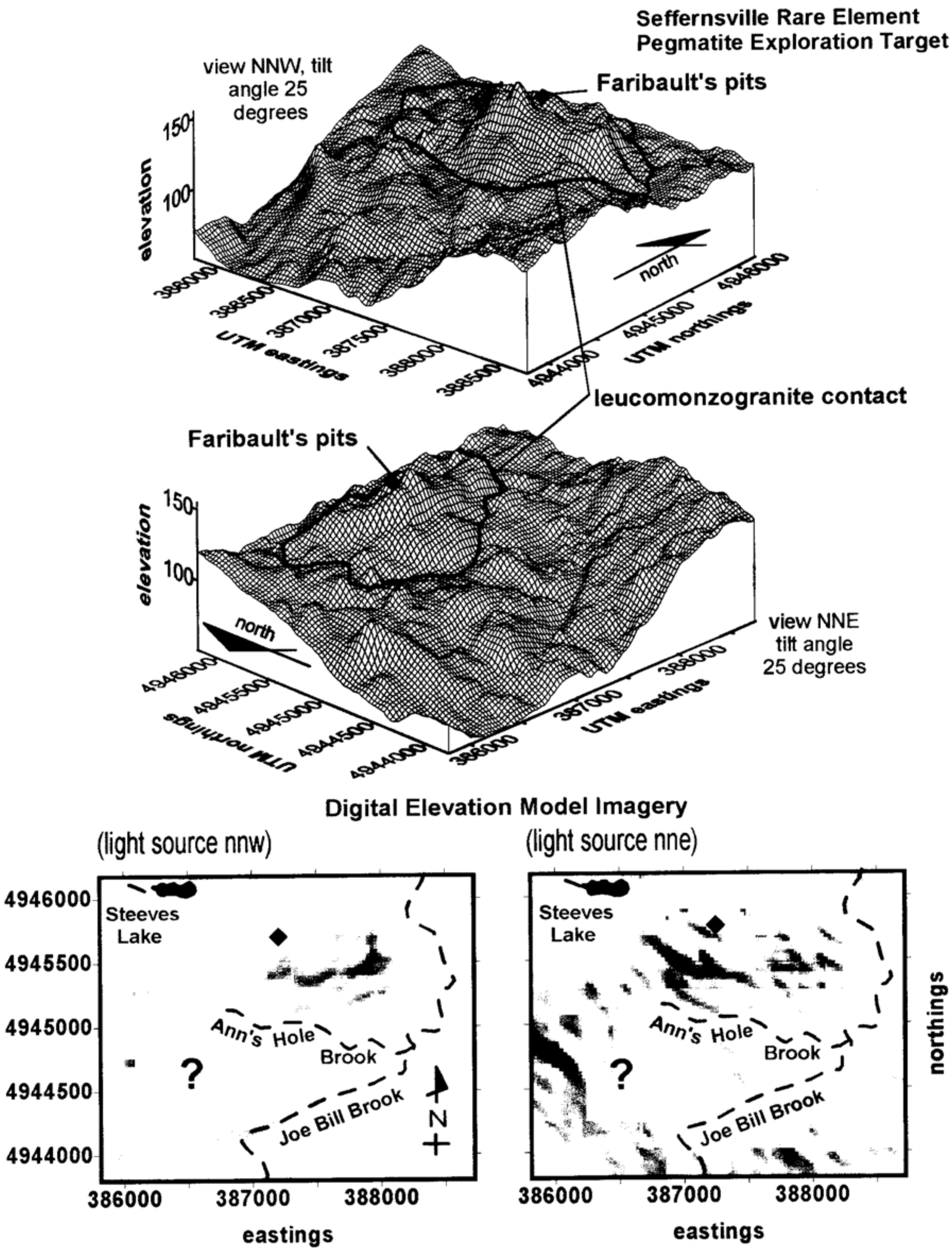

Figure 5b. Three-dimensional wire frame images and shaded relief images of the Seffernsville pegmatite occurrence, based on digital elevation model data (Geological Survey of Canada, 1999).

area 1200 m south - southwest of the occurrence is a notable example (Fig. 5b.). This area displays a strong magnetic signature similar to that for the known pegmatite (King, 1997).

Discussion

Lower Caledonia

Pegmatite outcrops were known to exist north of the small leucocratic intrusion, as well as to the south (King, 2001). It is possible that several pegmatites were intruded, roughly stratabound with east-trending Goldenville Formation rocks around the intrusive body, or that a single, or several pegmatitic dykes formed around the western terminus of the intrusive and are joined together. Information from the 2001 field season would suggest the latter (King, 2002, personal communication) The dykes north of the intrusion are also known to host beryllium (O'Reilly, 2002, personal communication).

Exposure is poor beneath the widespread overburden and vegetation in the area. The third (westernmost) outcrop and the surrounding area needs close evaluation to determine the orientation of pegmatite. An east - west orientation (such as the outcrops described by O'Reilly) would suggest the pegmatitic body is either offset around the western extremity of the parental magma, or several pegmatites inhabit the locale as a "swarm". A north - south orientation, along the steep ridge west of the seasonal stream, would suggest a pegmatitic body that envelopes the parental granitic intrusive on the western contact. Trenching in this area of the occurrence to expose the nature of pegmatite emplacement is recommended.

Ridges representing the parental granite of the pegmatitic body noted on the DEM suggest further areas ripe for investigation of more pegmatite development. One notable candidate is clearly revealed 750 m west - northwest of the current exploration target.

The increasing number of beryl-bearing float and outcrops at Lower Caledonia continues to be the main source of interest for investigators at this exploration target. The unidentified buff coloured mineral has SiO_2 and Al_2O_3 in the correct percentages for this mineral to be beryl. The remaining (missing) percentage of beam loss is attributed to the presence of Be, which is too light for probe measurement.

Seffernsville

There is obvious zoning in this pegmatite occurrence. However, the exposure is partially obscured and it is unknown whether the massive quartz veins represent more than one phase of pegmatitic zoning. The polished section data suggest that it does. The presence of rare lepidolite from pit dump material suggests evolution beyond purely a primary level. Massive quartz stockwork close to the occurrence suggests alteration, possibly due to shear deformation related to intrusive emplacement, or to regional deformation.

The host leucogranite of the Seffernsville pegmatite displays evidence of being a good parent magma for the formation of highly evolved pegmatites (Cerny, 1982). It displays structures suggesting partial local segregation and evolution of the magma within the body of the intrusive. The micro-brecciated fabric present in the polished section from Seffernsville, and seen in Figure 4, confirms the presence of a cataclastic fabric. Mineral phases seen under scanning electron microscope analyses follow this shear fabric, and mineral phases are relegated to veins and other replacement and invasion sites within a brecciated texture. Ilmenite and sphalerite have been identified under the scanning electron microscope, and may account for the unidentified dark, opaque minerals noted in hand specimens. The site continues to be of economic interest. The presence of lepidolite clearly identifies this occurrence as a highly evolved pegmatite that warrants further investigation.

There has been less field evaluation of the Seffernsville site than the Caledonia location. Further field investigation of the site as a possible beryllium - lithium and rare-earth element source at the prospecting level is warranted.

Acknowledgments

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