Lexington Porphyry Revisited (NTS 082E/02), Southern British Columbia

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KEYWORDS: economic geology, porphyry, Lexington, Jurassic, volcanic, geochemistry, Elise Formation

INTRODUCTION

The Lexington mining camp is located 10 km to the south-southeast of Greenwood (Fig 1). It comprises up to 11 copper-gold-porphyry and vein deposits in BC and Washington, hosted by the Lexington porphyry within the No 7 fault zone. The mineralization stretches in a linear belt from the No 7 mine in the northwest to the Lone Star mine, in Washington, in the southeast. In Washington, the No 7 fault is offset northward to the Danville area where it hosts the Morning Star deposit. Exploration and development in the Lexington camp first started in 1890 and continues to this day. Important reviews of mineralization and historical development are provided by Church (1970, 1986) and Seraphim *et al.* (1995).

The No 7 fault is marked by a thick serpentinite sheet along its length from McCarren Creek to the international border. Along Goosmus Creek, the serpentinite is apparently split in two by the intrusion of a quartz porphyry body known as the Lexington porphyry (Church, 1992). High-grade copper-gold sulphide mineralization forms a series of stacked lenses in the porphyry just above the footwall serpentinite (Merit Mining Corp., 2006). The Gidon Creek porphyry, a quartz-feldspar porphyry body found in the footwall of the No 7 fault to the west of the Lexington camp (Fig 1), has been correlated with the Lexington quartz porphyry. This quartz-feldspar porphyry is, however, marked by large pink K-feldspar phenocrysts that are absent from the type Lexington porphyry, which raises doubts about their correlation.

Several authors have mapped areas of andesitic to dacitic volcaniclastic rocks around some of the mines within the Lexington camp (*e.g.*, Fig 9 in Church, 1986) and equivalents in Washington (*e.g.,* Morning Star deposit; Caron, pers comm, 2005; Cheney, 2004). Dacitic volcaniclastic rocks that host mineralization are also reported by company geologists in drillcore from the area (Butler, 1997; Cowley, 2004). Seraphim *et al.* (1995), however, assert that these units at Lexington are not original volcanic rocks but the result of cataclasis of the porphyry within the fault zone, though they do allow for "the presence of xenoliths and screens of old volcanic rocks in the intrusion."

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During the summer of 2005, a series of samples were collected from outcrops and selected drillcore from both the massive dacitic porphyry and possible volcaniclastic rocks within the Lexington porphyry of Merit Mining Corporation's Grenoble property. This paper reports petrological and petrochemical studies on these samples.

LEXINGTON PORPHYRY

The Lexington porphyry was observed in outcrops along the Gidon Creek – City of Paris Road on the northwest side of Goosmus Creek as well as drillcore samples from the Grenoble property. A range of rock types is present, suggesting that several different porphyry bodies may be present in the sequence, though these have never been mapped out. Typically, the porphyry is light to medium grey in colour, though can be apple green with increased propylitic alteration. It is massive to weakly foliated, foliation being defined by aligned sericite in the groundmass. Phenocrysts are predominantly white to grey feldspar, euhedral to subhedral lath shapes and usually 2 to 4 mm in diameter, occasionally up to 6 mm (Fig 2). Alteration of the phenocrysts to sericite±calcite is common and may be complete in the most severely altered samples. Quartz is present in most, though not all, outcrops. When present, the quartz eyes may be more apparent on weathered surfaces than the less distinct feldspars even though they are much less abundant. They are commonly 1 to 2 mm in diameter, ranging up to 6 to 8 mm. Mafic phenocrysts are absent from the typical feldspar porphyry, but more quartz dioritic samples have tabular to elongate hornblende, which may vary up to 6 mm and up to 20% of the phenocrysts (Fig 3). They are altered to chlorite with lesser sulphide. Groundmass comprises finer-grained feldspar, quartz and occasional mafic minerals but is usually altered to sericite-chlorite-quartz±calcite..

Volcaniclastic fabrics have been observed in some outcrops and in drillcore. Mineralogically, most tuff is similar to the massive porphyry, comprising feldspar and quartz crystals in a finer groundmass. However, there is often a pronounced alignment of feldspar crystals and any mafic minerals present. Some samples also show dark, wispy to elongate, lithic clasts (Fig 4, 5), which vary from a few millimetres up to several centimetres in size. Darker grey to reddish fine-grained units are also seen bedded with the lighter-coloured crystal tuff (Fig 6). Most tuff shows a weak to good schistosity; however, there is no evidence of comminution of crystals and no mylonitization was observed.

GIDON CREEK PORPHYRY

The Gidon Creek porphyry is well exposed in roadcuts in the Norwegian Creek and Gidon Creek areas. It is a leucocratic quartz-feldspar porphyry (Fig 7). Pink K-feld-

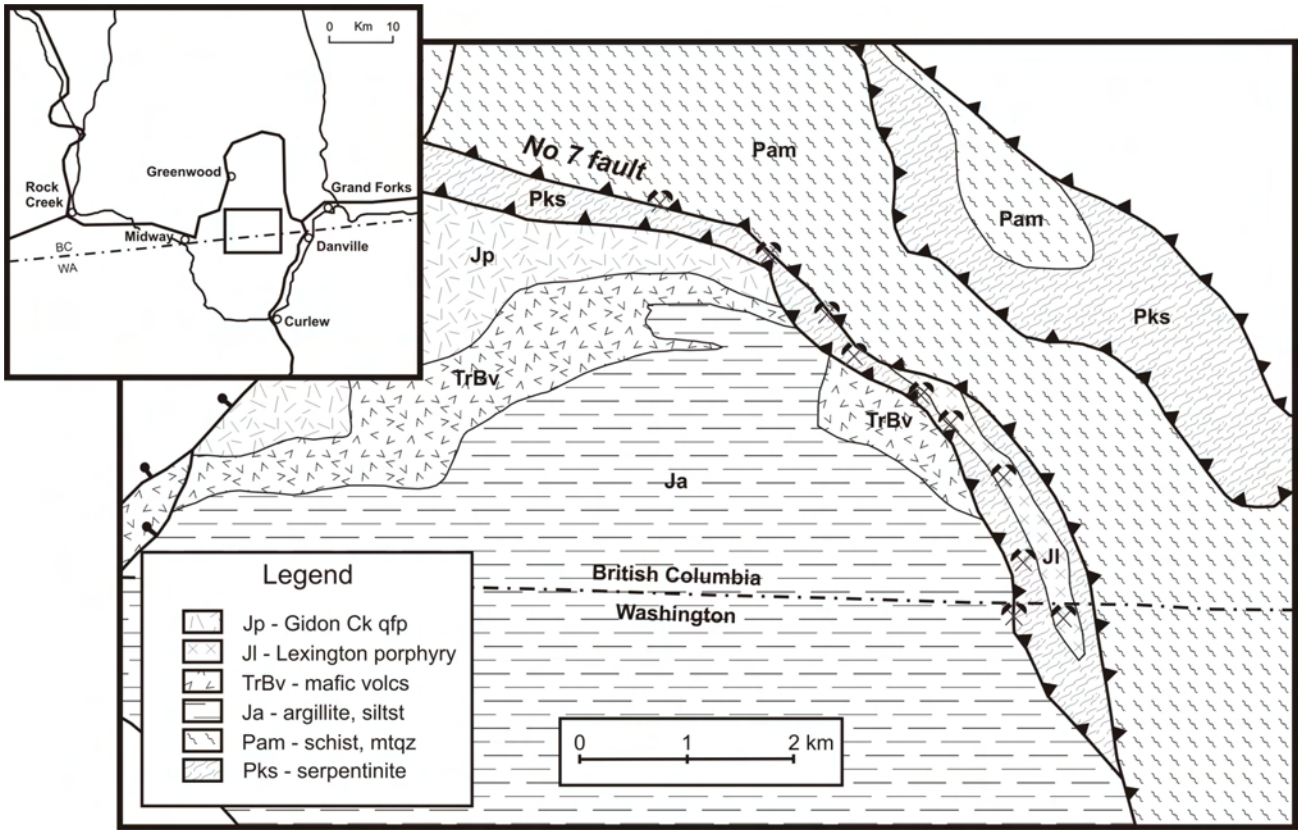

Figure 1. Simplified geological map of the Lexington Camp; individual occurrences indicated by crossed hammer symbol. Inset shows the location of the map to the south-southeast of Greenwood (abbreviations: qfp, quartz-feldspar porphyry; volcs, volcanic rocks; siltst, siltstone; mtqz, metaquartzite).

spar megacrysts are subhedral to subrounded, about 1 cm in diameter, though ranging up to 2 cm. They are perthitic and show simple twinning in thin sections. Plagioclase phenocrysts are also observed, though smaller than the K-feldspar, showing albitic and cross-twinning in thin section. Quartz eyes are rounded, commonly 3 to 5 mm in size but ranging up to 10 mm. The groundmass is a white to pale pink, finer-grained mosaic of quartz, K-feldspar and plagioclase crystals. Mafic minerals are sparse, with colour index (CI) often <5%, and mostly consists of biotite replaced by chlorite. Epidote is seen in the groundmass in thin section along with minor sphene, opaque minerals and secondary sericite.

The porphyry is seen to intrude Triassic Brooklyn Formation metavolcanic rocks in the Norwegian Creek area. The margins of the porphyry are sheared; foliation varying from trachytic to mylonitic in appearance (Fig 8). Where they are still preserved, phenocrysts are either broken and form augen or are strung out along the foliation. Quartz shows strained extinction in thin sections. Feldspar grains are completely altered to sericite, epidote and chlorite.

Figure 2. Typical Lexington feldspar porphyry (05NMA25-09, UTM zone 11, 5429300N, 382397E NAD 83).

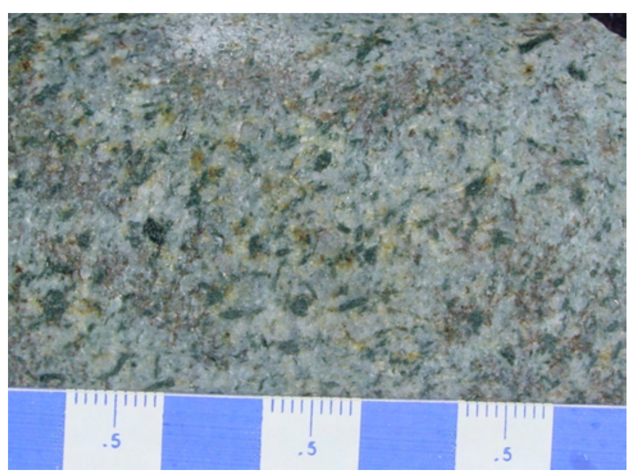

Figure 3. Hornblende phenocrysts in the quartz dioritic phase of porphyry (DHL-05-44-75, Grenoble Property)

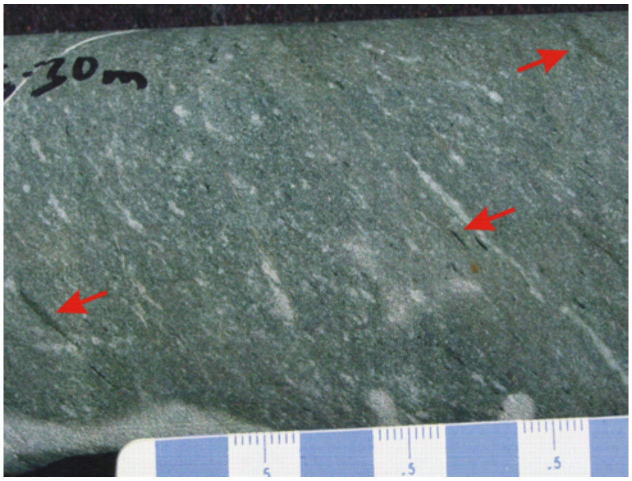

Figure 4. Feldspar-quartz crystal tuff with dark, wispy to elongate, lithic clasts (DHL05-48-195, Grenoble property).

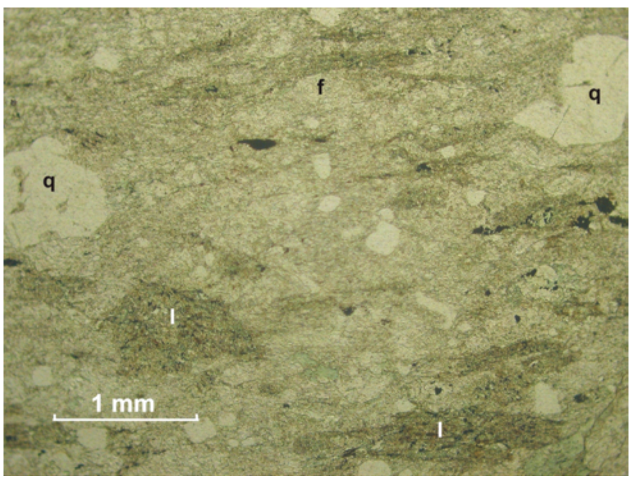

Figure 5. Photomicrograph (plane-polarized light) of feldspar-quartz crystal lithic tuff. Note the weakly foliated texture with the alignment of elongate lithic fragments (l) and feldspar phenocrysts (f). Also note embayments in rounded, clear quartz (q) (DHL 04-08-91, Grenoble property).

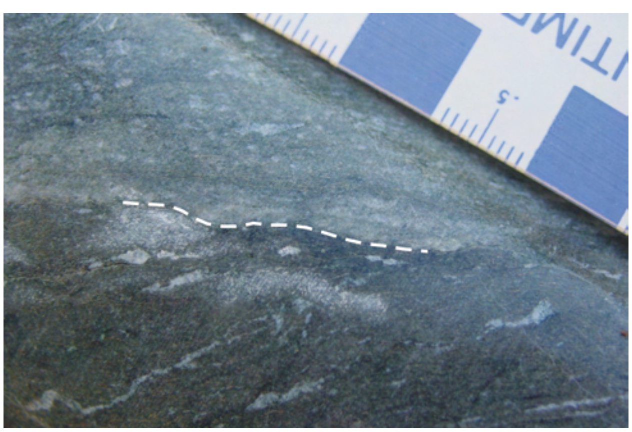

Figure 6. Bedding between light grey crystal tuff and dark grey fine-grained tuff (DHL 05 48-195, Grenoble property).

Figure 7. Typical Gidon Creek quartz-feldspar porphyry (05NMA25-03, UTM zone 11, 5431227N, 377351E NAD 83).

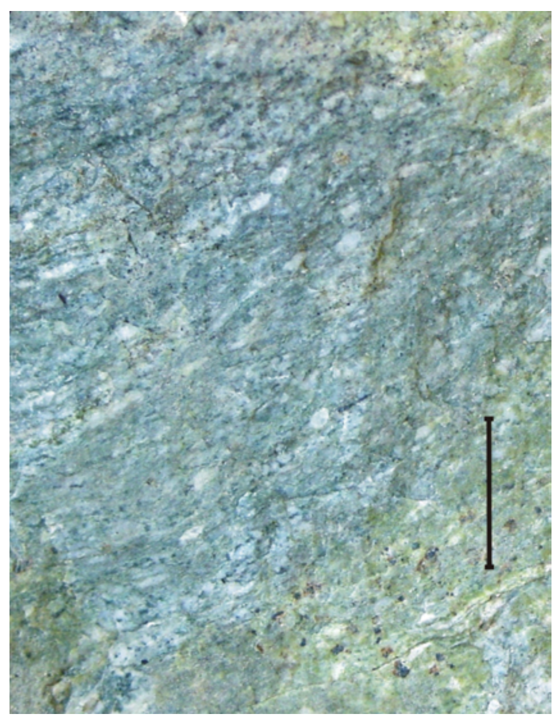

Figure 8. Sheared margin of Gidon Creek quartz-feldspar porphyry. Scale approximately 1 cm (05NMA25-01, UTM zone 11, 5429810N, 376039E NAD 83).

Such marginal shearing is typical of synkinematic intrusions of the Rossland area (Dunne and Höy, 1992).

GEOCHEMISTRY

Geochemical analyses were performed on 15 samples from Lexington porphyry and volcaniclastic rocks and two samples of Gidon Creek porphyry. Major, minor and trace element data are reported in Table 1.

All Lexington samples are typical calcalkaline rocks of generally dacite to rhyolite composition (Fig 9, 10) and of typical volcanic arc affinity (Fig 11). Crystal tuff and massive dacite porphyry are similar in chemistry and appear to be comagmatic. Mafic tuff, however, differs significantly from its felsic cohort in high field-strength elements (HFSE) and rare earth elements (REE; Fig 12) and, despite being coeval, must be derived from a different magmatic source.

The Gidon Creek porphyry is also calcalkaline and of volcanic arc affinity (Fig 9, 10, 11) but differs from the Lexington dacite rocks in being more enriched in Ta, Nb (Fig 11b, d) and light rare earth elements (LREE; Fig 12). Along with lithological differences, this suggests that the Gidon Creek porphyry is not directly correlatable with the Lexington porphyry.

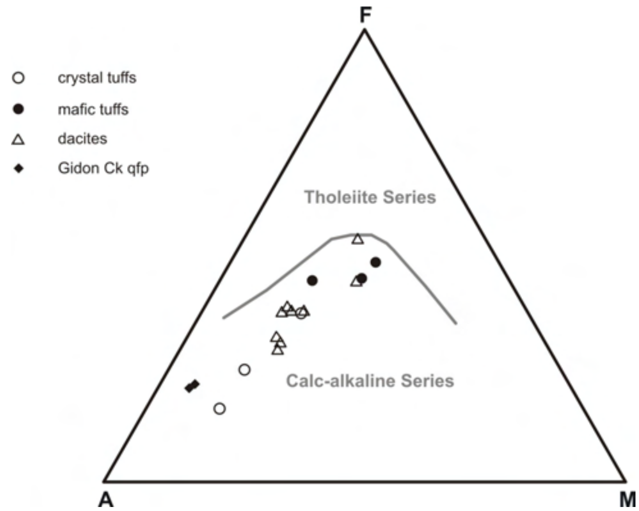

Figure 9. AFM diagram for Lexington and Gidon Creek samples; abbreviations: A, Na_2O + K_2O; M, MgO; F, FeO(t) + MnO: qfp, quartz-feldspar porphyry. Tholeiite-calcalkaline discriminant line after Irvine and Baragar (1971).

GEOCHRONOLOGY

The Lexington porphyry was previously ascribed a Cretaceous or Tertiary age (Little, 1983). Church (1992) and Dostal *et al.* (2001) have reported U-Pb zircon data for a quartz porphyry sample collected from the City of Paris mine area. This sample yielded zircons with variable inheritance from a Proterozoic source (2445 Ma old), though one concordant fraction suggested an age of 199.4 ±1.4 Ma. Ages of the volcaniclastic rocks have not been determined, though geochemical data would suggest that the crystal tuff is comagmatic and coeval.

A sample of Gidon Creek porphyry collected in 2005 from the Norwegian Creek area has also yielded zircons with considerable Proterozoic inheritance. A preliminary interpretation of the data by Mortensen (pers comm, 2006) suggests a date of 175 to180 Ma, which is younger than the Lexington porphyry.

TABLE 1. MAJOR, MINOR AND TRACE ELEMENT ANALYSES FOR SAMPLES FROM THE GIDON CREEK AND LEXINGTON PORPHYRY DEPOSITS. ABBREVIATIONS: FSP, FELDSPAR; HB, HORNBLENDE; MEGAXST, MEGACRYST; QZ, QUARTZ; XST, CRYSTAL.

Sample	Lab No	Suite	Description	SiO_2 wt %	TiO_2 wt %	Al_2O_3 wt %	Fe_2O_3t wt %	MnO wt %	MgO wt %	CaO wt %	Na_2O wt %	K_2O wt %	P_2O_5 wt %	LOI wt %	Total wt %
05NMA25-01B	59134	Gidon Creek	Quartz-eye, K-feldspar megaXst porphyry	66.62	0.34	16.28	2.73	0.07	0.77	3.19	4.74	3.38	0.12	0.92	99.23
05NMA25-03A	59135	Gidon Creek	Quartz-eye, K-feldspar megaXst porphyry	66.03	0.32	16.60	2.61	0.07	0.68	3.46	4.50	3.73	0.18	1.04	99.30
05NMA25-08A	59136	Lexington	dacite	61.11	0.55	18.91	5.07	0.01	2.38	2.33	2.52	2.66	0.32	3.92	99.83
05NMA25-08B	59137	Lexington	qz-fsp xst tuff ?	68.86	0.33	17.38	1.81	0.01	1.44	0.65	5.19	1.84	0.15	1.99	99.67
05NMA25-09	59138	Lexington	qz-fsp xst tuff ?	64.36	0.36	17.54	3.10	0.01	1.67	1.92	4.19	2.66	0.14	3.49	99.49
DHL04-01-99	59139	Lexington	dacite	60.46	0.35	17.14	4.29	0.02	2.35	3.05	2.70	3.69	0.14	4.39	98.64
DHL04-08-91A	59140	Lexington	?xst tuff	46.49	0.73	16.45	9.19	0.05	4.77	7.98	2.88	1.19	0.17	9.72	99.64
DHL04-08-91B	59141	Lexington	xst tuff	61.02	0.49	17.41	5.03	0.02	2.32	2.84	2.68	2.62	0.19	4.64	99.30
DHL04-08-126	59142	Lexington	qz-fsp-?hb dacite	61.64	0.16	16.60	4.39	0.34	2.35	3.81	2.60	0.05	2.64	4.59	99.21
DHL04-39-110	59143	Lexington	tuff	51.02	0.88	15.09	7.71	0.13	2.80	7.63	4.87	1.08	0.44	7.56	99.25
DHL05-44-75	59144	Lexington	?hb-qz-fsp dacite	64.27	0.16	17.81	3.95	0.43	2.32	1.57	6.38	0.03	0.39	2.11	99.60
DHL05-44-102	59145	Lexington	qz-fsp porphyry	61.66	0.19	17.28	5.41	0.41	1.99	4.93	2.14	0.10	1.48	3.51	99.15
DHL05-45-88	59146	Lexington	fsp-?hb-qz porphyry	60.40	0.39	16.28	5.21	0.01	1.95	3.75	3.37	2.57	0.15	4.46	98.59
DHL05-45-112	59147	Lexington	qz-fsp porph dacite	61.81	0.38	16.62	4.35	0.02	2.13	3.24	4.81	1.45	0.14	4.11	99.09
DHL05-48-195	59148	Lexington	?fsp xst tuff/schist	45.13	0.94	12.44	8.61	0.21	4.63	10.91	3.80	1.01	0.42	10.92	99.11
DHL05-53-165	59149	Lexington	fsp-qz(-hb) porph dacite	55.93	0.37	14.60	4.61	0.04	1.90	7.91	2.64	2.37	0.20	6.96	97.56
DHL05-55-154	59150	Lexington	qz-fsp-?hb porph dacite	60.53	0.33	16.33	5.53	0.02	2.05	3.39	3.81	2.07	0.22	4.83	99.16
			Reported detection limit	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
			Analytical method	XRF1	XRF1	XRF1	XRF1	XRF1	XRF1	XRF1	XRF1	XRF1	XRF1	FUS	

XRF1 = Fused Disc - X-ray fluorescence

XRF2 = Pressed pellet - X-ray fluorescence

FUS = Loss on Ignition by fusion @1100 C

PIMS = Peroxide fusion-ICPMS

DISCUSSION

Petrological and lithological studies demonstrate that volcaniclastic rocks are included with massive dacite porphyry in the package known as the Lexington porphyry. Lithologically and geochemically, the intermediate to felsic crystal lithic tuff is very similar to the dacitic porphyry and is believed to be comagmatic. The massive rock types may be either shallow-level intrusions or flows. Mafic tuff interbedded in the sequence is coeval, though derived from a different magmatic source. The recognition of these units as true volcanic rocks could have significant implications not only for regional correlation and tectonic history, but also for the possible potential for VMS deposits such as the Lamefoot deposit (Cheney, 2004; Cheney *et al.*, 1994).

Similar felsic volcaniclastic rocks are not found in the immediate Lexington area and correlative equivalents are not recognized in the overall Boundary region. An age of 199 Ma would suggest a correlation of the Lexington package with the Lower Jurassic Elise Formation of the Rossland Group. Höy and Andrew (1989) report a U-Pb zircon age of 197.1 ±0.5 Ma for a feldspar crystal tuff approximately in the middle of the Elise Formation succession. Like the Lexington sample, this also has Proterozoic inheritance. Felsic volcanic rocks overlying the stratabound Lamefoot copper-gold deposit in Washington have been previously correlated with the Paleozoic Attwood Group (Cheney *et al.*, 1994). However, Rasmussen (2000) reported an Ar/Ar plateau age of 195 Ma on sericite from these volcanic rocks and suggested correlation with the Elise Formation. Similar correlations are made for felsic volcanic rocks at the Morning Star mine (Cheney, 2004; Caron, pers comm, 2005). In the Rossland area itself, however, the type Elise Formation comprises dominantly mafic

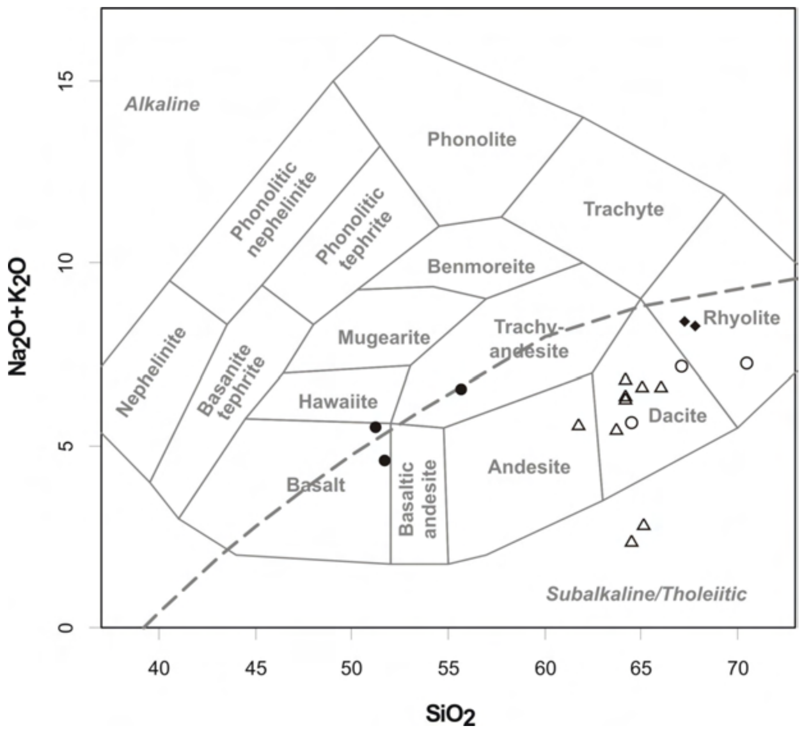

Figure 10. Total alkali-silica diagram for Lexington and Gidon Creek samples (symbols as for Fig 9). Classification *after* Cox *et al.* (1979).

TABLE 1 (CONTINUED)

Sample	Rb ppm	Sr ppm	Ba ppm	Cs ppm	V ppm	Y ppm	Zr ppm	Hf ppm	Nb ppm	Ta ppm	Th ppm	La ppm	Ce ppm	Pr ppm	Nd ppm	Sm ppm	Eu ppm	Gd ppm	Tb ppm	Dy ppm	Ho ppm	Er ppm	Tm ppm	Yb ppm	Lu ppm
05NMA25-01B	80	1062	751	-3	63	21	144	3.428	18.646	1.014	4.405	19.798	35.702	4.225	16.687	3.124	0.850	2.825	0.400	2.437	0.540	1.584	0.240	1.565	0.240
05NMA25-03A	106	1087	836	-3	61	10	146	3.068	20.360	1.142	4.701	18.209	34.140	4.037	16.161	3.043	0.818	2.716	0.398	2.362	0.524	1.514	0.232	1.558	0.232
05NMA25-08A	84	391	500	-3	131	16	84	2.274	4.228	0.240	1.319	8.229	17.498	2.412	11.624	2.745	0.925	2.954	0.435	2.703	0.599	1.734	0.255	1.706	0.247
05NMA25-08B	72	314	241	-3	71	5	73	1.473	3.518	0.209	0.865	3.629	6.554	0.986	4.540	1.113	0.309	1.222	0.195	1.216	0.277	0.847	0.131	0.912	0.134
05NMA25-09	85	226	455	5	87	5	65	1.941	2.814	0.169	1.060	5.346	10.024	1.387	6.143	1.371	0.429	1.574	0.209	1.225	0.247	0.724	0.104	0.738	0.113
DHL04-01-99	114	195	556	-3	100	12	67	1.717	3.781	0.208	1.053	6.651	12.669	1.556	6.666	1.352	0.422	1.537	0.230	1.468	0.316	0.955	0.148	1.007	0.152
DHL04-08-91A	48	302	215	-3	249	15	52	1.491	2.570	0.129	1.122	7.752	16.135	2.211	10.378	2.449	1.098	3.062	0.464	2.997	0.635	1.858	0.280	1.830	0.242
DHL04-08-91B	74	255	388	-3	132	10	74	2.275	4.614	0.243	1.352	7.694	16.081	2.141	9.188	2.056	0.672	2.276	0.330	2.078	0.435	1.312	0.196	1.355	0.202
DHL04-08-126	105	209	575	4	110	11	58	1.776	3.777	0.206	1.072	4.998	9.731	1.219	5.214	1.186	0.375	1.464	0.226	1.439	0.312	0.953	0.147	0.972	0.149
DHL04-39-110	36	419	370	-3	245	12	116	3.275	16.026	1.008	3.373	17.063	33.569	4.220	17.950	3.702	1.153	4.182	0.590	3.580	0.723	2.060	0.299	1.999	0.276
DHL05-44-75	70	180	260	-3	122	27	76	2.232	3.991	0.250	1.620	41.443	70.440	7.442	26.214	4.427	0.960	4.225	0.688	4.334	0.861	2.454	0.362	2.391	0.321
DHL05-44-102	138	136	967	5	90	12	83	1.882	4.263	0.220	1.400	8.026	16.313	2.118	9.132	2.012	0.724	2.100	0.334	2.093	0.435	1.328	0.195	1.348	0.202
DHL05-45-88	83	281	555	3	120	3	60	1.778	3.811	0.181	0.968	4.694	9.191	1.174	5.082	1.201	0.446	1.390	0.225	1.484	0.327	0.991	0.146	1.007	0.153
DHL05-45-112	53	382	346	-3	103	14	61	1.333	3.644	0.175	0.920	5.083	10.032	1.269	5.367	1.224	0.387	1.354	0.217	1.379	0.286	0.856	0.130	0.927	0.135
DHL05-48-195	36	481	961	-3	255	24	92	2.648	15.033	0.856	2.411	15.393	30.877	4.010	17.411	3.896	1.195	4.016	0.596	3.549	0.690	1.916	0.272	1.785	0.249
DHL05-53-165	74	284	278	-3	94	13	57	1.419	2.942	0.137	0.774	6.207	11.934	1.540	6.797	1.563	0.638	1.648	0.252	1.558	0.320	0.966	0.144	0.980	0.146
DHL05-55-154	79	405	459	-3	101	4	61	1.911	2.430	0.124	0.942	5.137	10.025	1.254	5.375	1.299	0.440	1.425	0.203	1.340	0.261	0.776	0.119	0.830	0.137
	3	3	3	3	3	3	3	0.011	0.004	0.010	0.005	0.004	0.003	0.002	0.027	0.010	0.004	0.013	0.003	0.009	0.001	0.005	0.001	0.007	0.003
	XRF2	XRF2	XRF2	XRF2	XRF2	XRF2	XRF2	PIMS	PIMS	PIMS	PIMS	PIMS	PIMS	PIMS	PIMS	PIMS	PIMS	PIMS	PIMS	PIMS	PIMS	PIMS	PIMS	PIMS	PIMS

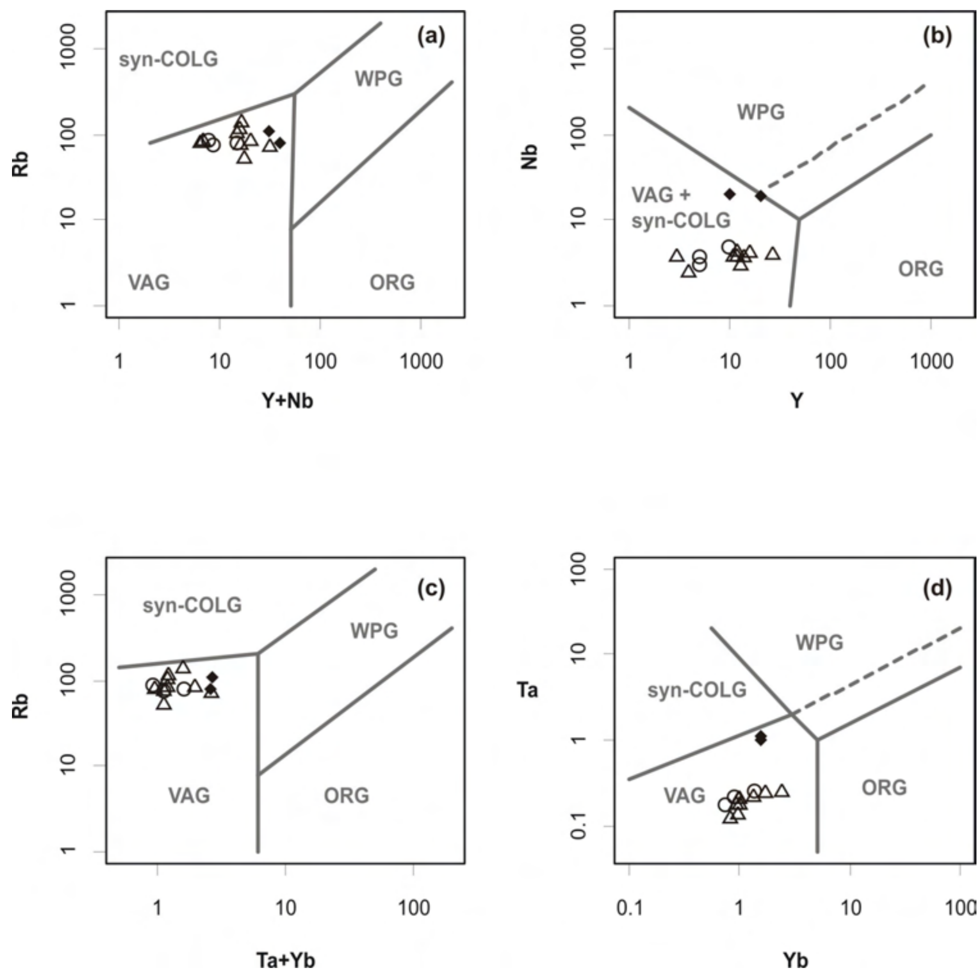

Figure 11. Tectonic discrimination diagrams for Lexington and Gidon Creek samples (symbols as for Fig 9), *after* Pearce *et al*. (1984); a) Y+Nb vs. Rb; b) Y vs. Nb; c) Ta+Yb vs. Rb; d) Yb vs. Ta. Abbreviations: ORG, ocean-ridge granite; WPG, within-plate granite; VAG, volcanic arc granite; syn-COLG, syn-collision granite.

to andesitic volcanic rocks and lacks significant felsic rocks (Höy and Andrew, 1989; Andrew *et al.*, 1990; Höy and Dunne, 1997).

The correlation of the Lexington porphyry rocks with the Elise Formation may shed some light on the age of sedimentary rocks in the footwall of the No 7 Fault. Black argillite, fine-grained dark grey siltstone or quartz wacke, with minor pebble conglomerate crop out around Mount McLaren and Rusty Mountain. This unit was assumed to be Jurassic by Little (1983) and to rest conformably on volcanic flows of the Triassic Brooklyn Formation to the north. However, the argillite was included in the Attwood Formation by Church (1986) and Fyles (1990). Similar argillite rocks, in a similar structural position in the footwall of the No 7 fault, and also associated with possible Elise Formation volcanic rocks, are found around the Morning Star deposit in Washington, where they are correlated with the Lower Jurassic Archibald Formation of the Rossland Group (Cheney, 2004; Caron, pers comm, 2005). Such a correlation can also be suggested for the Mount McLaren area.

The Gidon Creek quartz-feldspar porphyry is lithologically and chemically distinct from the Lexington porphyry. It is also younger and may correlate with the similarly aged 178 to 182 Ma Silver King intrusions of the Rossland area. These synkinematic intrusions show similar intensely sheared margins to the Gidon Creek porphyry but lack the K-feldspar megacrysts (Dunne and Höy, 1992). Significantly, the Silver King intrusions and other synorogenic intrusions such as the Aylwin Creek and Cooper Creek stocks host copper-gold-silver mineralization, though no such mineralization has yet been reported in the Gidon Creek porphyry.

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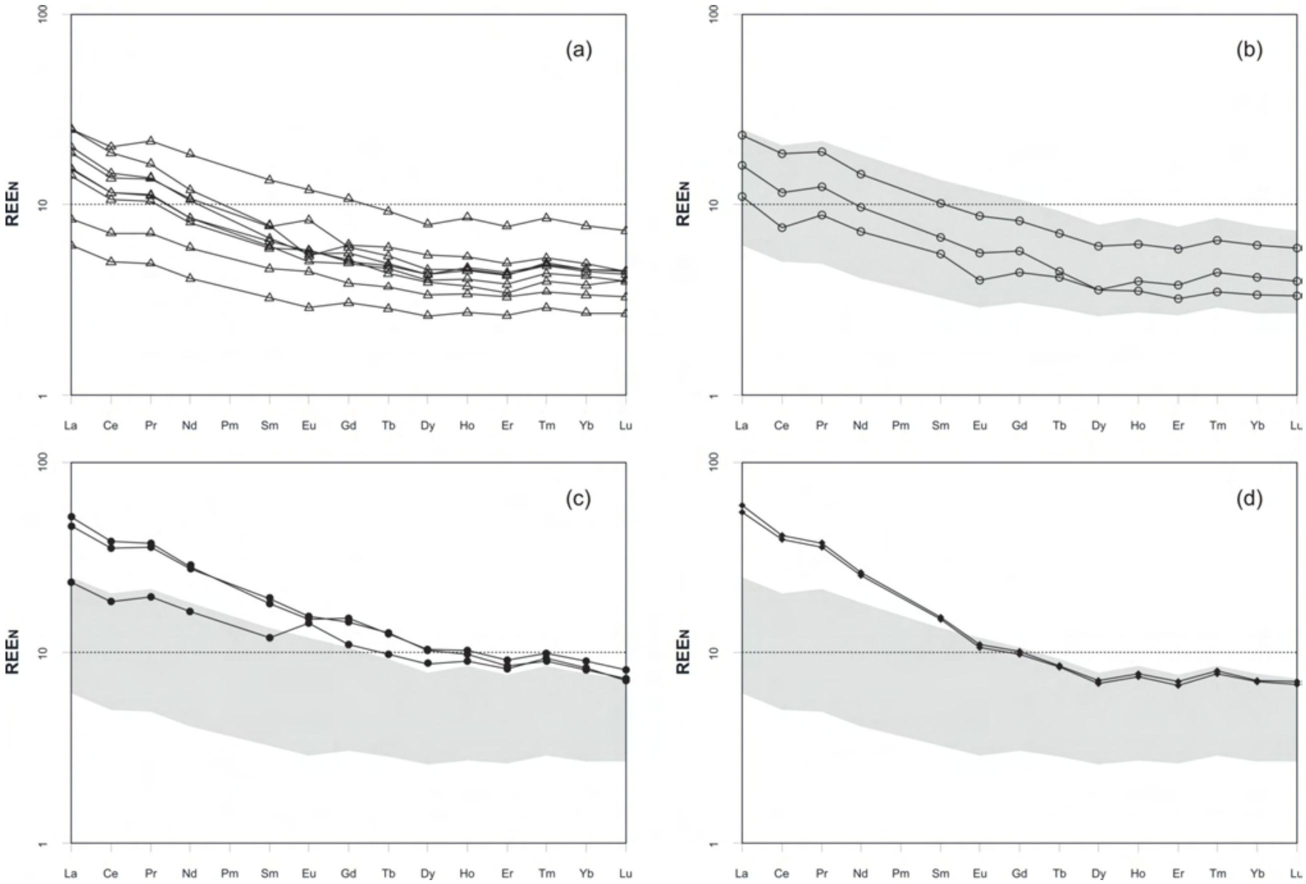

Figure 12. Chondrite-normalized rare-earth element plots for Lexington and Gidon Creek samples; a) dacite porphyry; b) crystal tuff; c) mafic tuff; and d) Gidon Creek porphyry. Shaded area in b) to d) is occupied by the dacite porphyry of Figure 12a. Normalizing values for REE (REE_N) *after* Nakamura (1974).

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