The Mount Hickman ultramafic complex, northwestern British Columbia: an Fe-rich Alaskan-type intrusion

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Objective:
This study examines the petrography and geochemistry of the Mount Hickman ultramafic complex and the nearby Middle Scud ultramafic body, two poorly studied Alaskan-type intrusions of Middle-Late Triassic age in the Stikine terrane of northwestern British Columbia. The relation between the ultramafic plutons and the spatially and temporally-associated Stuhini Group (volcanic) and Stikine suite (plutonic) is unknown, as is the Ni-Cu-PGE potential of the ultramafic plutons.

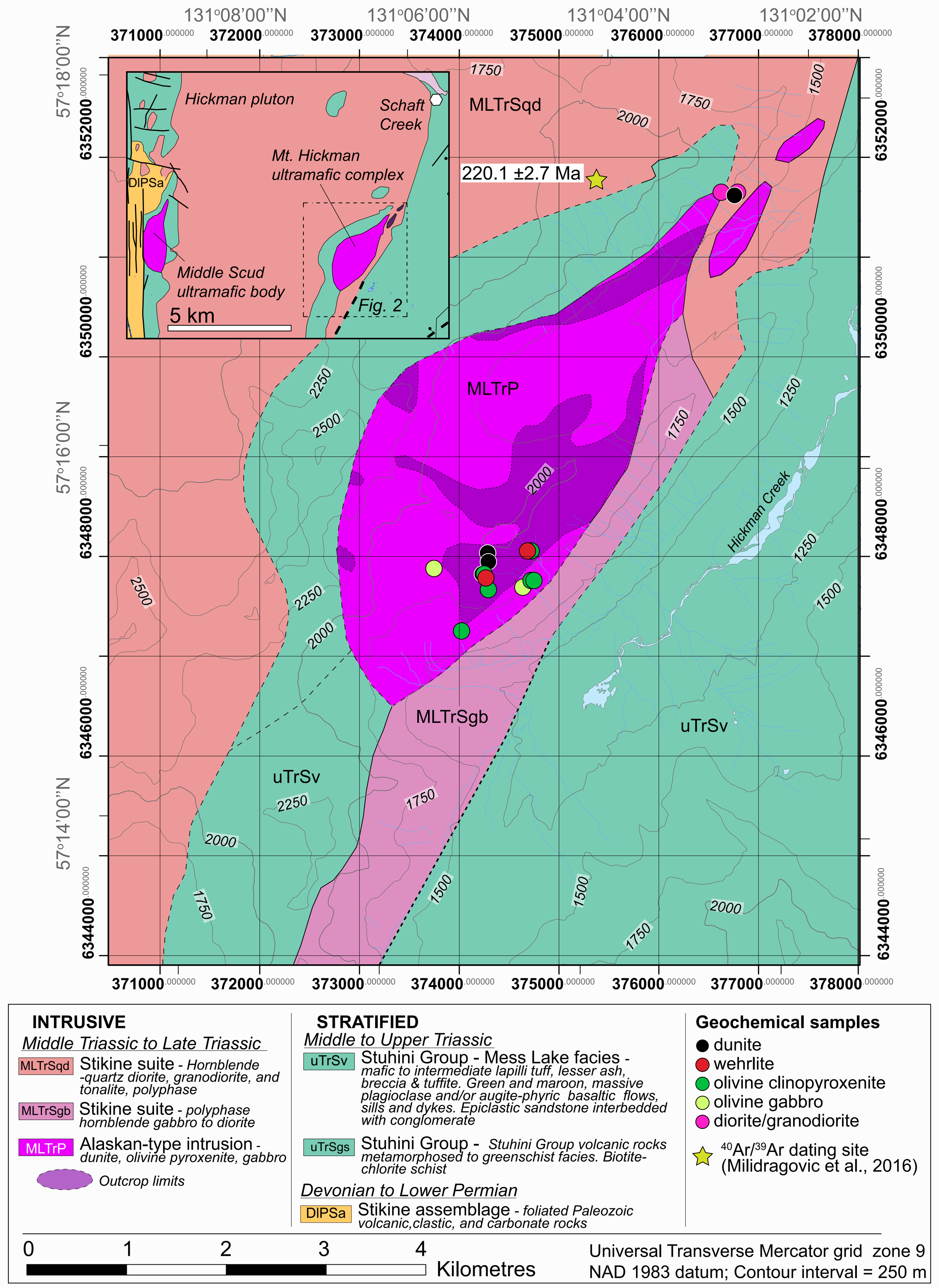
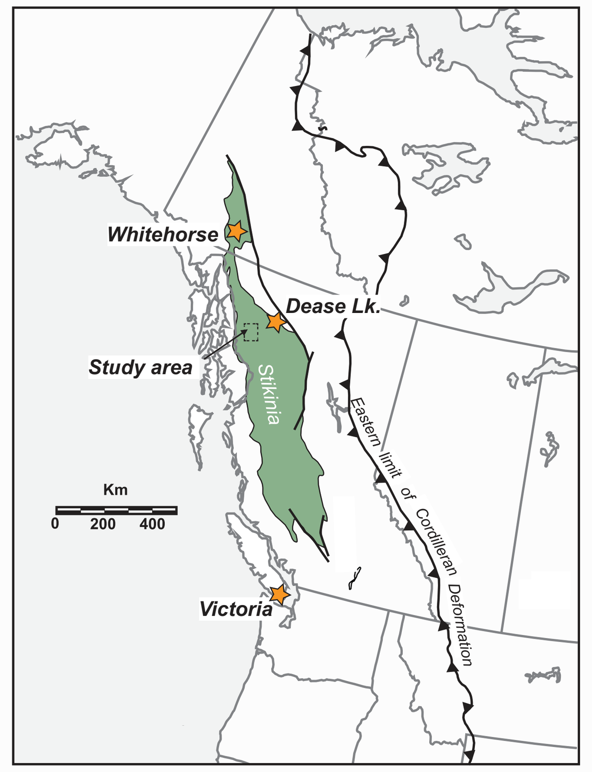


Figure 2. Geological map of the Mount Hickman ultramafic complex (modified after Brown et al., 1996, Mihalynuk et al., 1996, and Milidragovic et al., 2016), showing the locations of samples analyzed for geochemistry. Inset: regional geology map, showing the location of the Mount Hickman ultramafic complex the Middle Scud ultramafic body, and the Schaft Creek exploration camp.

Figure 1. Location of the study area



1. Introduction:

The Stikine terrane of the Canadian Cordillera (Fig. 1) experienced a period of arc building and extensive mineralization during the Middle to Late Triassic. Alaskan-type mafic-ultramafic intrusions, defined by the association of olivine, clinopyroxene, and hornblende, and lack of orthopyroxene (Taylor, 1967; Nixon et al, 2015) represent a volumetrically minor magmatic component of this period. The petrogenetic significance and relationship of Alaskan-type intrusions to coeval igneous rocks of Stikine terrane (Stuhini Group and Stikine suite) are poorly understood.

The Mount Hickman ultramafic complex is an Alaskan-type intrusion exposed on the southeastern margin of the Hickman pluton (Fig. 2; ~220-222 Ma; Holbek 1988; Nixon et al., 1989; Milidragovic et al., 2016). The mineralogy, location, and approximate age of the Middle Scud ultramafic body on the west side of the Hickman pluton (Fig. 2 inset) suggests a possible genetic link to the Mount Hickman complex.

Fig. 3. a) Irregularly-shaped serpentinized dunite pod in olivine clinopyroxenite. Remnants of a magnetite vein are visible on the surface. b) Brown to rust-stained rubbly outcrop of olivine clinopyroxenite. c) Weathered surface of an extreme-end member of orthocumulate magnetite olivine clinopyroxenite. Cumulus clinopyroxene and olivine (not discernible) are hosted in intercumulus magnetite; see also Fig. 4c). d) Recessive, sheared serpentinized dunite between hornblende diorite.

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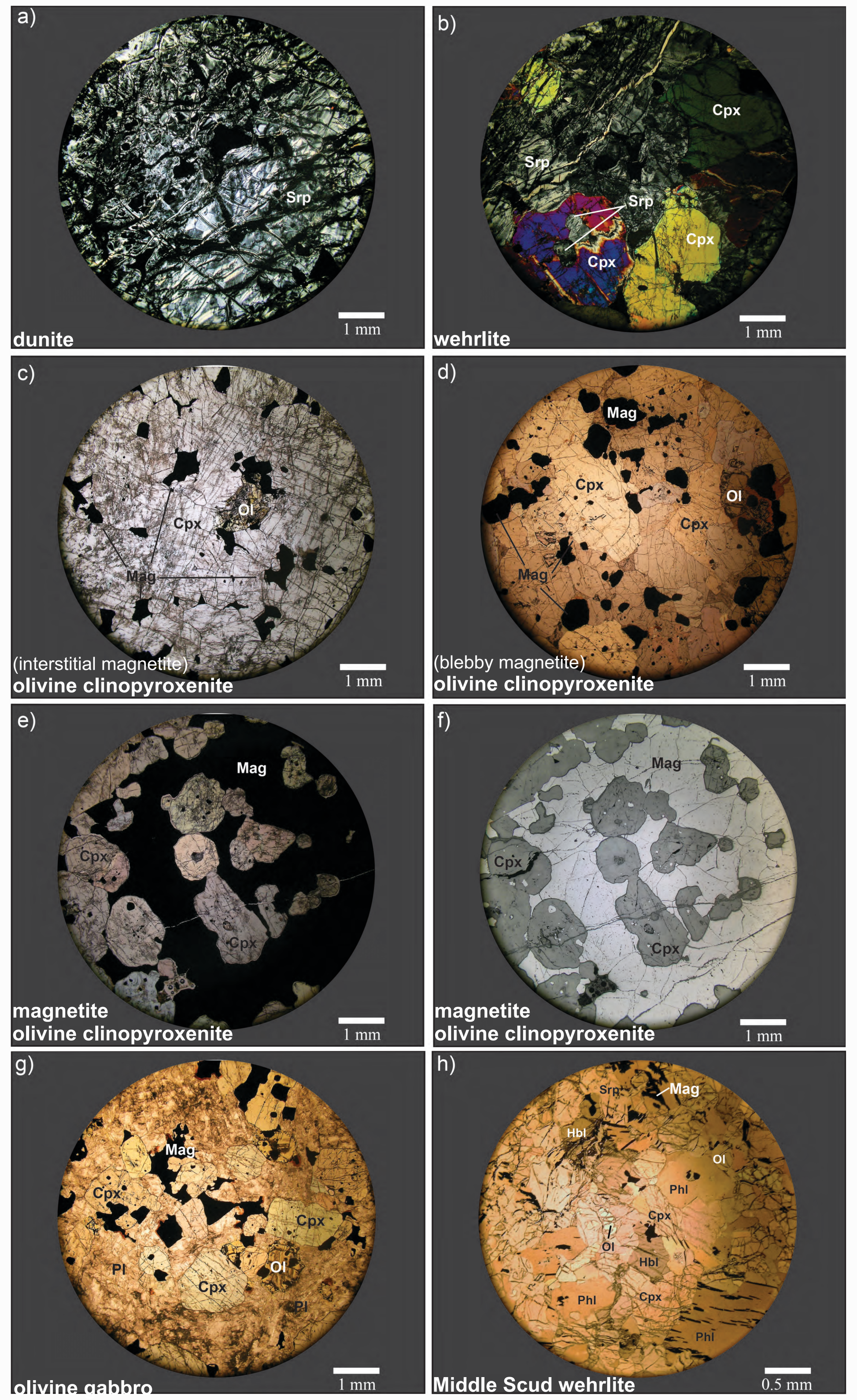


2. Key lithologies

Dunite: Volumetrically minor, serpentinized dunite forms light brown to beige weathering, strongly magnetic, irregularly shaped pods in wehrlite or olivine clinopyroxenite. Pods are elongate irregular bodies, metres to 10s of metres long, that pinch out in surrounding pyroxenite (Fig. 3a). Dunite flowed plastically through the more competent wehrlite and olivine clinopyroxenite.
Dunite is completely replaced by serpentine. All samples are cut by a pervasive network of magnetite veins and microveins (Fig. 4a). Minor phlogopite, and strongly-altered clinopyroxene (<15 % modal) occur as irregularly shaped interstitial crystals.

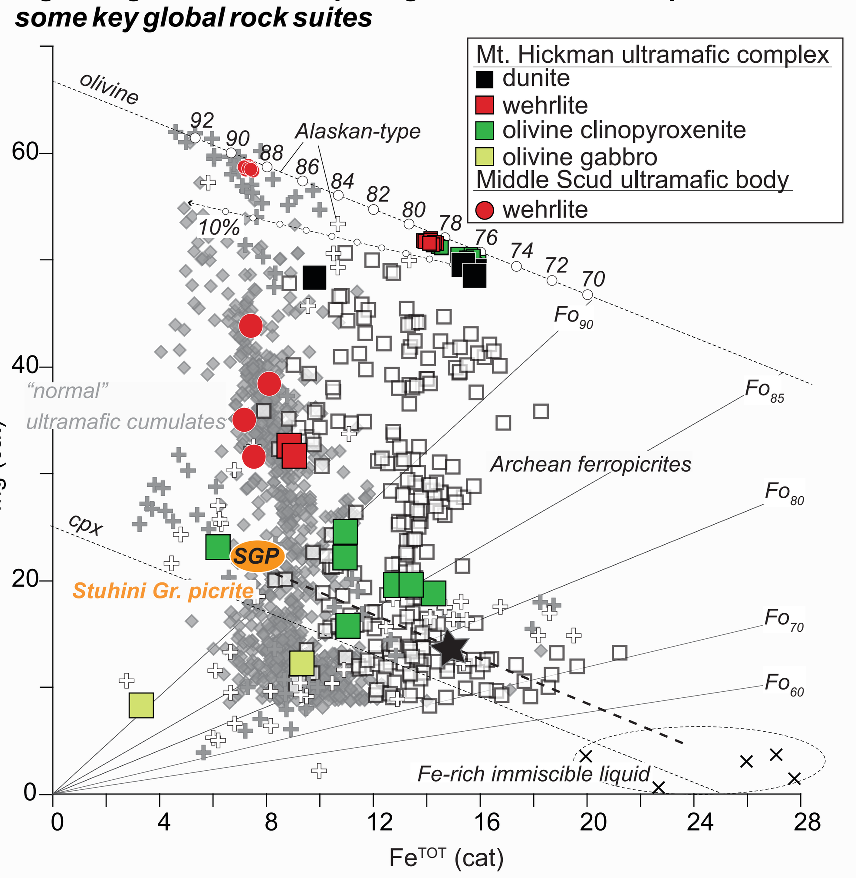
Wehrlite: Mesocumulate wehrlite weathers brown and appears massive and black on fresh surfaces. Olivine is variably serpentinized (40-90%), whereas clinopyroxene is largely fresh and unaltered.
Wehrlite is medium grained and contains highly fractured and irregular shaped olivine, and euhedral to subhedral clinopyroxene (0.5-0.8 cm across). Predominantly cotectic crystallization of the two minerals is indicated by their subequal proportions and similar crystal size, as well as the subhedral to euhedral crystal habit of clinopyroxene.

Olivine ± magnetite clinopyroxenite: Brown weathering, dark green olivine clinopyroxenite is the predominant lithology of the Mount Hickman ultramafic complex (Fig. 3b). Meso- to orthocumulate olivine clinopyroxenite is medium grained, and composed of euhedral clinopyroxene (>80 %), pseudomorphed olivine, and magnetite (2-10 %). Well saussuritized plagioclase and biotite form local intercumulus crystals.
Clinopyroxene is fresh, and contains inclusions of olivine and magnetite. Magnetite also occurs both as irregular shaped interstitial crystals and blebby cumulus grains (Figs. 4c-d). Rare, magnetite-enriched olivine clinopyroxenite contains up to 40 % interstitial, net-textured magnetite (Figs.3c and 4e-f).

Magnetite olivine gabbro: Gabbro is rare and exposed along the southwestern margin of the complex. It contains subequal proportions of euhedral clinopyroxene and saussuritized plagioclase (>90 %), heavily altered (iddingsite) olivine (~5 %), and interstitial magnetite (Fig. 4g).

Middle Scud wehrlite: The ultramafic rocks of the Middle Scud body are weakly to strongly foliated, brown to dark grey weathering, fine-grained meta-wehrlites. Metamorphism and recrystallization vary from recrystallized, fine-grained granoblastic amphibolite to wehrlite with well-preserved igneous cumulate textures (Fig. 4h). All samples contain magnetite and variable amounts of phlogopite (up to15 %).

Fig. 5 Mg vs. Fe^{TOT} comparing Mt. Hickman complex rocks to some key global rock suites



3. Geochemistry

The rocks of the Mount Hickman ultramafic complex are crystal cumulates; their geochemical composition is governed by the relative proportions of mafic minerals. The striking characteristic of the ultramafic rocks of the Mount Hickman ultramafic complex is the relatively high FeO^{TOT} content (Fig. 5) which, at a given MgO concentration, exceeds that of most Alaskan-type intrusions in the North American Cordillera and most terrestrial ultramafic rocks in general. Two explanations are favoured:

1) Alteration and mobility: One explanation for the high content of FeO^{TOT} in dunites from the Mount Hickman ultramafic complex is metasomatic enrichment by Fe-rich melts and fluids. Mass balance calculations indicate that the observed FeO^{TOT} concentrations of the dunite would require the addition of 6-10 mol. % FeO as magnetite to 'normal' dunite with Mg-number of 0.86-0.90 (Fig. 5). Assuming average serpentine and magnetite density of 2.55 g/cm^3 and 5.2 g/cm^3, respectively, such metasomatically Fe-enriched dunites would comprise ~10-20 vol. % magnetite; modal magnetite abundance in samples collected for geochemical analysis is significantly lower than this. Furthermore, the density of analyzed dunite samples (~2.9 g/cm^3) suggests that the maximum magnetite content is ~10 %.

2) Fe-rich parental magma formed by magma mixing: The abundant olivine and clinopyroxene cumulus crystals indicate crystallization from a silicate, mafic to ultramafic, parental liquid. The rounded and embayed clinopyroxene crystals in intercumulus magnetite (Figs. 4e-f), however, suggest that clinopyroxene was not in equilibrium with the Fe-oxide -saturated magma that occupied the interstitial space. Based on these observations, we infer the coexistence of a olivine ±clinopyroxene-saturated silicate magma and magma with high normative magnetite content. Accordingly, we attribute the Fe-rich character of the ultramafic rocks to mixing of these two different magmas at different stages of the complex's evolution.

References: *Brown, D.A., Gunning, M.H., and Greig, C.J. (1996) BCGS Bulletin 95, 175 p; Holbek, P.M. (1988) M.Sc. thesis, The University of British Columbia, 184 p.; Mihalynuk, M.G., Bellefontaine, K.A., Brown, D.A., Logan, J.M., Nelson, J.L., Legun, A.S. and Diakow, L.J. (1996) BCGS Open File 1996-11; Milidragovic, D., Joyce, N.L., Zagorevski, A., and Chapman, J.B., (2016) Geological BCGS Paper 2016-1, 95-111; Nixon, G.T., Ash, C.H., Connely, J.N., and Case, G. (1989) BCGS Paper 1989-1, 429-442; Nixon, G.T., Manor, M.J., Jackson-Brown, S., Scoates, J.S., and Ames, D.E. (2015) GSC Open File 7856, 17–34; Taylor, H.P.Jr., (1967) In:Ultramafic and Related Rocks. John Wiley and Sons Inc., New York, p. 97-121*