Late Neogene porphyry Cu-Mo(±Au-Ag) mineralization in British Columbia: the Klaskish Plutonic Suite, northern Vancouver Island

Graham T. Nixon[1, a], Richard M. Friedman[2], and Robert A. Creaser[3]

[1] British Columbia Geological Survey, Ministry of Energy, Mines and Petroleum Resources, Victoria, BC, V8W 9N3
[2] Pacific Centre for Geochemical and Isotopic Research, Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, BC, V6T 1Z4
[3] Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB, T6G 2E3
[a] corresponding author: Graham.Nixon@gov.bc.ca

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Abstract

Late Neogene porphyry Cu-Mo mineralization hosted by the Klaskish Plutonic Suite (new formal name) in northern Vancouver Island occupies a unique position in the forearc of the Cascadia subduction zone. The Klaskish granitoid plutons and Alert Bay volcanic rocks comprise the Brooks magmatic suite, which forms a northeast-oriented zone, the Brooks-Haddington tract, extending for 65 km across the island from the Pacific coast to Queen Charlotte Strait in the east. The southern part of the Brooks-Haddington tract is marked by a narrow (10 km) structural corridor, the Brooks Peninsula fault zone, which hosts the mineralized Klaskish intrusions. The northern part of the tract is occupied by eroded edifices of the Alert Bay volcanic suite. High-precision U-Pb zircon and Re-Os molybdenite dates for mineralized stocks of the Klaskish Plutonic Suite (ca. 7-4.6 Ma) confirm that their emplacement was coeval with older phases of Alert Bay volcanism (8-2.5 Ma), and that porphyry Cu-Mo magmatic-hydrothermal systems are genetically linked to pluton emplacement and crystallization. Neogene plutons associated with porphyry Mo/Cu-Mo mineralization elsewhere in British Columbia are restricted to the Pemberton arc in the southeastern Coast Mountains, where pluton ages diminish progressively northwards. The late Neogene porphyry Cu-Mo mineralizing systems in the Pemberton arc and forearc environment of northern Vancouver Island are linked to the plate tectonic evolution of the northern Cascadia subduction zone, notably plate-edge effects generated by subduction of the Juan de Fuca plate and newly redefined Nootka fault zone in the oceanic crust. The young Cu-Mo porphyry mineralization in northern Vancouver Island forms a well-defined metallotect that is underexplored and rich in opportunities for discovering economic porphyry deposits.

Keywords: Porphyry Cu-Mo, Klaskish Plutonic Suite, northern Vancouver Island, geochronology, regional geology, Alert Bay volcanic rocks, Brooks magmatic suite, Brooks-Haddington tract, Wrangellia, Pemberton arc, Neogene magmatism, Juan de Fuca plate, Explorer plate, Nootka fault zone, Cascadia subduction zone

1. Introduction

British Columbia is the leading producer of copper and only producer of molybdenum in Canada thanks to its rich endowment of porphyry copper deposits in the accreted magmatic arc terranes of the Cordillera. Of eleven operating metal mines in the province in 2018, copper production at seven bulk tonnage operations amounted to $2.46 billion (Natural Resources Canada, 2019) and accounted for 70% of the value of all metal mine production excluding the principal by-product commodities of Au, Ag, and Mo (Clarke et al., 2019). The most prodigious epoch for the formation of porphyry copper deposits in British Columbia is a 15 million-year time interval (ca. 210-195 Ma) straddling the Triassic-Jurassic boundary. Porphyry production was particularly prolific within a 6 million-year window centred on ca. 205 Ma (latest Triassic) when more than 90% of the known copper endowment was acquired in the accreted magmatic arc terranes of Quesnellia and Stikinia (Logan and Mihalynuk, 2014).

The largest bulk tonnage operation on Vancouver Island was the former Island Copper mine (1971-1995), which produced 1.2 billion kg Cu, 32 million kg Mo, 294,106 kg Ag, 35,268 kg Au, and 236 kg Re from 367 Mt of ore (MINFILE 092L 158). The flooded open pit lies on Rupert Inlet adjacent to the Holberg fault near the eastern extremity of a belt of Middle Jurassic volcanic rocks of the Bonanza Group and well-mineralized, coeval intrusions of the Island Plutonic Suite that include the porphyry Cu-Mo-Au deposits of Hushamu (MINFILE 092L 240) and Red Dog (MINFILE 092L 200; Nixon et al., 2011a; Fig. 1). Estimates for drill-indicated and inferred resources at Hushamu total 532.5 Mt at a grade of 0.22% Cu, 0.0076% Mo, 0.265 g/t Au and 0.47 ppm Re; and for Red Dog are 38.3 Mt at 0.267% Cu, 0.0048% Mo and 0.376 g/t Au (Northisle Copper and Gold Inc., 2019).

The late Neogene Klaskish Plutonic Suite in northern Vancouver Island comprises some of the youngest granitoid intrusions in the Cordillera. As shown below, these intrusions

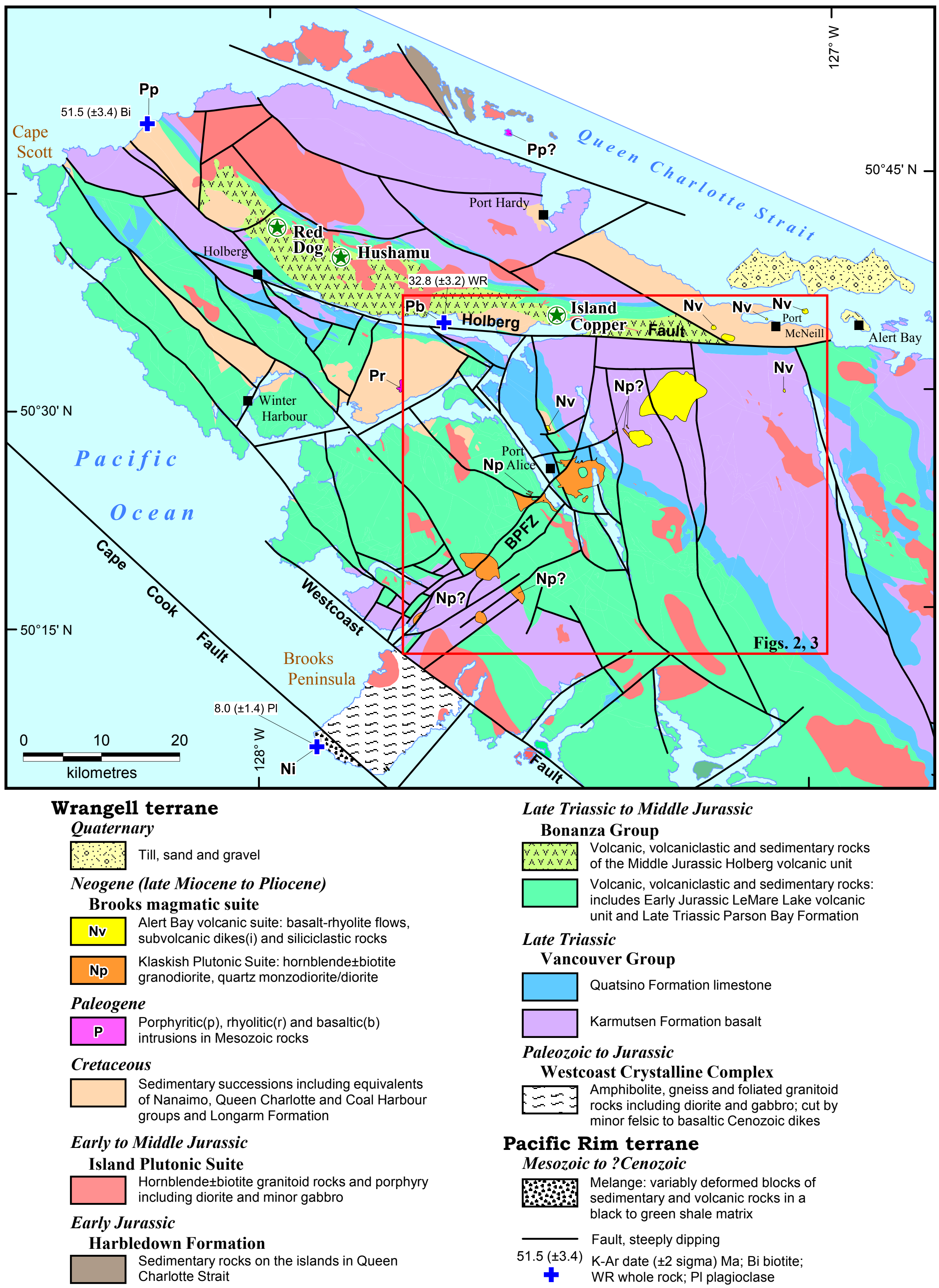

Fig. 1. Generalized geology of northern Vancouver Island showing the principal Mesozoic-Cenozoic stratigraphic and intrusive units (after Muller et al., 1974 and Nixon et al., 2011a-e with minor modifications). K-Ar dates are given for Paleogene and late Neogene localities situated outside Figs. 2 and 3 (red inset box). Geochronological data are from Muller et al. (1974) and Armstrong et al. (1985) corrected for modern decay constants where necessary (Steiger and Jäger, 1977; Breitsprecher and Mortensen, 2004). Middle Jurassic Cu-Mo-Au porphyry deposits (green stars) at the former Island Copper mine (1971-1995), Red Dog and Hushamu are shown for reference. BPFZ, Brooks Peninsula fault zone.

are spatially associated with various mineral occurrences, including genetically related and potentially economic porphyry Cu-Mo(±Au±Ag) mineralization. The Klaskish intrusions mineralogically resemble members of the Early to Middle Jurassic Island Plutonic Suite and have been mapped as such in the past. Confident discrimination between the two intrusive suites is best achieved using U-Pb dating techniques. The diverse mineral occurrences previously documented in this intrusive belt are re-evaluated herein for their porphyry copper potential. The results are encouraging and extend the prospective ground for targeting exploration throughout this young metallogenic tract.

The principal objectives of this contribution are to 1) document the spatiotemporal distribution of late Neogene plutonic and volcanic suites on northern Vancouver Island using previously published and unpublished isotopic age determinations; 2) demonstrate the intimate timing and de facto genetic relationship between pluton crystallization and porphyry mineralization using high-precision U-Pb and Re-Os geochronology; and 3) underscore the fundamental influence that plate tectonic events at the northern margin of the Cascadia subduction zone have played in the late Neogene magmatism and mineralization.

2. Previous work

The first comprehensive regional map (1:250,000 scale) and descriptions of the geology of northern Vancouver Island (NTS 102I/92L) were published by Muller and coworkers, who also summarized earlier work in the area (Muller et al., 1974; Muller and Roddick, 1983). Subsequent regional mapping (1:50,000 scale) by Nixon et al. (2011a-e) resulted in revisions to the Mesozoic stratigraphy (Nixon and Orr, 2007) and revealed the presence of late Neogene granitoid intrusions, the Klaskish Plutonic Suite, which are coeval with previously documented Alert Bay volcanic rocks (Muller et al., 1974; Armstrong et al., 1985). The Mesozoic-early Cenozoic bedrock units of northern Vancouver Island are described briefly below before focusing on the late Neogene magmatic suite and associated mineralization.

3. Geological setting

Northern Vancouver Island is predominantly underlain by a faulted, westerly to southerly dipping, homoclinal stratigraphic succession of early Mesozoic strata intruded by granitoid plutons and unconformably overlain by the eroded remnants of Cretaceous stratigraphy (Fig. 1). The oldest exposed rocks on northern Vancouver Island are the Late Triassic Karmutsen Formation and overlying Quatsino limestone of the Vancouver Group, which form part of an accreted oceanic plateau unique to the Wrangell terrane (Greene et al., 2010; Fig. 1). Older rocks underlying the Karmutsen basalts, the Middle to Upper Triassic ‘sediment-sill’ unit and Paleozoic Sicker Group are exposed 35 km east of the map area near Schoen Lake (Muller et al., 1974), and are considered to form the substrate of northern Vancouver Island. The Vancouver Group is overlain by arc-related volcanic and sedimentary strata of the Bonanza Group including, from base to top, the Late Triassic Parson Bay Formation and overlying Early to Middle Jurassic LeMare Lake and Holberg volcanic units together with coeval intrusions of the Island Plutonic Suite (Fig. 1; Nixon and Orr, 2007). Exposures of marine tuffaceous argillites of the Early Jurassic Harbledown Formation, correlative in part with the Bonanza Group, are restricted to islands in Queen Charlotte Strait. Cretaceous sedimentary sequences deposited in fault-disrupted marine basins rest unconformably on these deformed, uplifted and eroded older rocks. Isolated occurrences of Paleogene rhyolitic to basaltic dikes (ca. 51-33 Ma; Eocene-Oligocene) cut Cretaceous and older units (Fig. 1).

The Triassic-Jurassic stratigraphy of northern Vancouver Island is separated from the uplifted block of Brooks Peninsula by the Westcoast fault (Fig. 1). The Westcoast Crystalline complex underlies most of the peninsula and comprises meta-igneous and metasedimentary rocks including amphibolite, gneiss, migmatite, agmatite and gabbroic to granodioritic plutons distinguished from the Island Plutonic Suite by the presence of a penetrative fabric. These deformed and metamorphosed rocks are considered to represent the lower crustal equivalents of Triassic-Jurassic stratigraphic units and plutons exposed to the east (Muller et al., 1974; DeBari et al., 1999). At the tip of the Brooks Peninsula, the Westcoast complex lies in fault contact with a fault sliver of the Pacific Rim terrane, an olistostromal mélange containing blocks of chert, conglomerate, greywacke and basalt set in a black shale matrix (Smyth, 1985). The Brooks Peninsula is likely bounded by northeasterly-trending, steeply dipping faults as reflected by the orientation of undeformed Cenozoic dikes mapped by Smyth (1985) along the north and south shores of the peninsula. One such basaltic dike cutting the mélange at the southwestern tip of the peninsula has yielded a late Neogene K-Ar age (ca. 8 Ma; Armstrong et al., 1985) and belongs to the Alert Bay volcanic suite (Fig. 1). The significance of the Brooks Peninsula fault zone (Fig. 1; Muller et al., 1974) with respect to late Neogene magmatism is explored below.

4. Late Neogene Brooks magmatic suite

Late Neogene volcanic rocks of the Alert Bay suite (Muller et al., 1974; Armstrong et al., 1985) and more recently identified, partly coeval granitoid intrusions of the Klaskish Plutonic Suite (Nixon et al., 2011c-d) are collectively termed the Brooks magmatic suite in this study. The volcanic and intrusive rocks are exposed discontinuously along a northeast-oriented tract, herein named the Brooks-Haddington tract, that extends 65 km across northern Vancouver Island from the Pacific coast near the Brooks Peninsula to Haddington Island east of Port McNeill (Fig. 1). The southern part of this tract hosts the Klaskish Plutonic Suite and is marked by closely spaced, steeply dipping faults, collectively known as the Brooks Peninsula fault zone (Fig. 1; Muller et al., 1974). Minor subvolcanic dikes of Alert Bay affinity continue this intrusive-structural trend for another 20 km southwest, to the tip of the Brooks Peninsula. Erosional remnants of dikes, sills, lavas and volcaniclastic rocks of the Alert Bay volcanic suite predominate in the northern part of the Brooks-Haddington tract. An island of volcanic rocks 10 km north of Port Hardy in Queen Charlotte Strait was assigned to the Alert Bay map unit by Muller et al. (1974) but they provided no description of the rocks. We have tentatively reassigned this undated unit to the Paleogene (Fig. 1). Geochronological results for the Brooks magmatic suite are summarized in Figure 2 and discussed below.

4.1. Alert Bay volcanic rocks

Isolated outcrops of Alert Bay volcanic rocks define the northeastern part of the Brooks-Haddington tract which extends for 27 km beyond the termination of the Brooks Peninsula fault zone and attains a width approaching 15 km. K-Ar whole rock ages for Alert Bay volcanic rocks in this part of the Brooks-Haddington tract include rhyolite on Haddington Island (ca. 3.7 Ma) and Cluxewe Mountain (ca. 2.5 Ma); dacite due north of Port Alice (ca. 3 Ma); and basalt, andesite and rhyodacite lavas at the voluminous Twin Peaks volcanic edifice (ca. 3-4.7 Ma; Armstrong et al., 1985; Fig. 2). According to the time-scale of Cohen et al. (2013), these ages are Pliocene except for the youngest K-Ar determination at Cluxewe Mountain that statistically falls on the Pliocene-Pleistocene boundary. Clasts of plagioclase-phyric basalt in conglomerate northwest of Cluxewe Mountain yield a highly imprecise K-Ar age due to very high atmospheric argon inherent to this sample (Armstrong et al., 1985; Fig. 2).

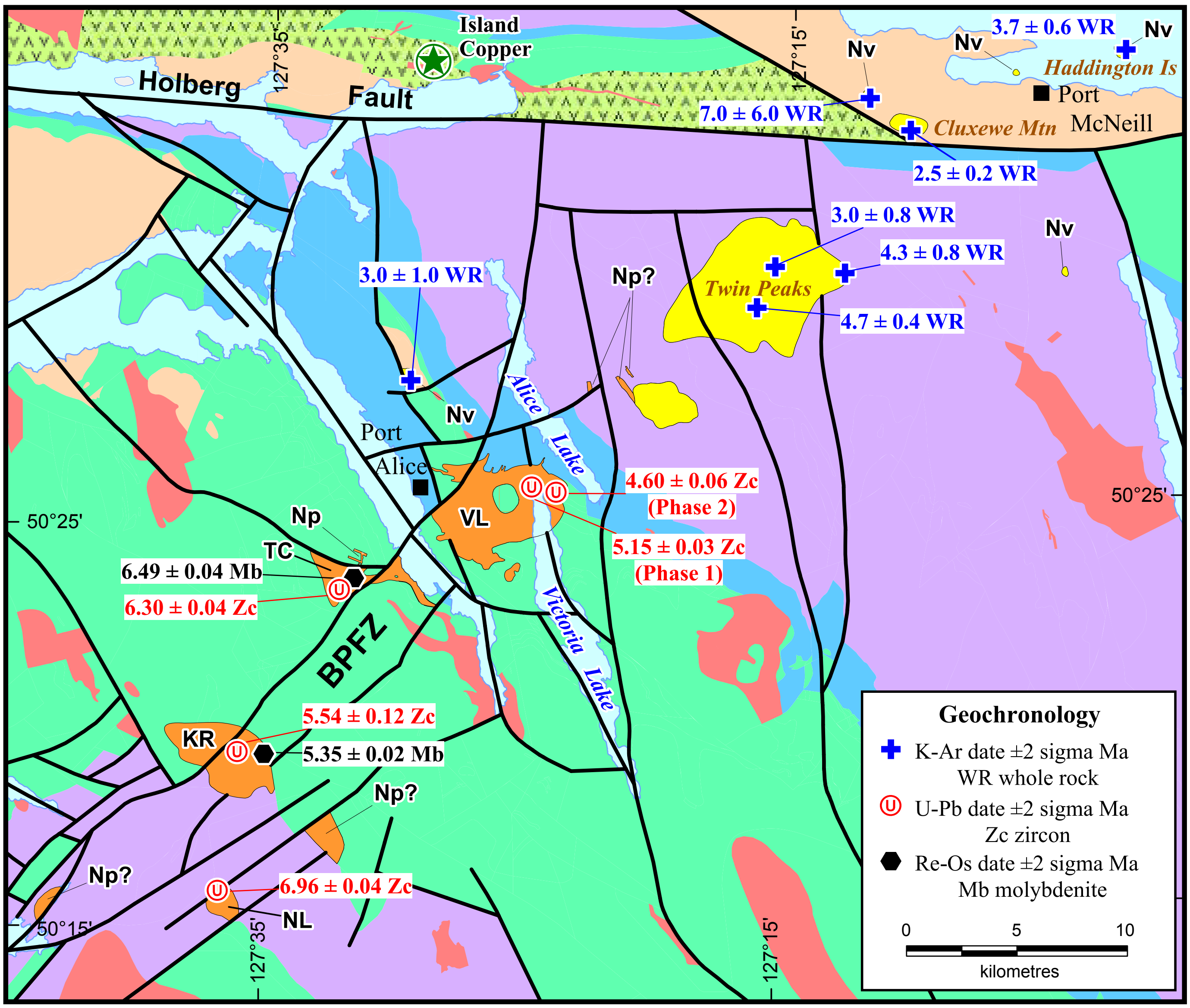

Fig. 2. Summary of currently available geochronological results for the late Neogene (latest Miocene-Pliocene) Brooks magmatic suite. K-Ar dates are from Armstrong et al. (1985); U-Pb and Re-Os dates from Nixon et al. (2011c-d and G.T. Nixon, unpublished data). Labels for Klaskish Plutonic Suite: NL, Nasparti Lake pluton; KR, Klaskish River pluton; TC, Teeta Creek pluton; VL, Victoria Lake pluton. Geological units and other symbols as in Fig. 1.

4.2. Klaskish Plutonic Suite (new formal name)

The late Neogene Klaskish Plutonic Suite was first introduced by Nixon et al. (2011c-d) as an informal map unit and is formally designated herein as a distinct lithodemic unit in accordance with the North American Stratigraphic Code (2005). The suite is named after the Klaskish River pluton approximately 20 km southwest of Port Alice (Nixon et al., 2011c), and comprises three other named lithodemes, the Nasparti Lake, Teeta Creek and Victoria Lake plutons, and some unnamed affiliated(?) intrusions (Fig. 2). The suite is constrained geographically within the Brooks Peninsula fault zone in the southern part of the Brooks-Haddington tract. The Klaskish River pluton is composed mainly of equigranular hornblende±biotite granodiorite and is genetically associated with Cu-Mo porphyry and Cu-Fe skarn mineralization. Other members of the Klaskish Plutonic Suite are also mineralized, and range in composition from biotite-hornblende granodiorite through monzodiorite to quartz diorite/diorite with ancillary feldspar±quartz porphyry and granitic phases (Nixon et al., 2011c-d).

The Klaskish Plutonic Suite occupies a narrow (10 km wide), northeast-trending structural corridor defined by the Brooks Peninsula fault zone (Fig. 1; Muller et al., 1974). The plutonic rocks follow this structural zone from the Pacific coast for at least 38 km to terminate east of Alice Lake at a group of minor intrusions near the first extensive exposures of Alert Bay lavas. Here, northeast-oriented faults give way to north-trending structures that appear to terminate near the Holberg fault.

4.2.1. U-Pb geochronology

U-Pb age determinations for intrusions of the Klaskish Plutonic Suite are taken from Nixon et al. (2011c-d and G.T. Nixon, unpublished data) and were done at the Pacific Centre for Isotopic and Geochemical Research, Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia. The results represent concordant weighted-average $^{206}Pb/^{238}U$ dates on air-abraded (Krogh, 1982) or chemically abraded zircon (Mattinson, 2005; as modified by Scoates and Friedman, 2008).

High-precision $^{206}Pb/^{238}U$ dates on zircon, interpreted as crystallization ages, have been determined for four intrusions of the Klaskish Plutonic Suite: the Klaskish River, Nasparti Lake, Teeta Creek and Victoria Lake plutons (Fig. 2). The Nasparti Lake granodiorite in the south yielded the oldest crystallization age (ca. 7.0 Ma), followed by the Teeta Creek quartz diorite (ca. 6.3 Ma) and Klaskish River granodiorite (ca. 5.5 Ma) plutons. Two intrusive phases separated by about half a million years are recognized in the Victoria Lake pluton: an early Phase 1 granodiorite (ca. 5.15 Ma) and later Phase 2 quartz monzodiorite (ca. 4.60 Ma). The pluton crystallization ages span latest Miocene to early Pliocene (Cohen et al., 2013). The youngest intrusive phase of the Victoria Lake pluton (Phase 2, ~4.6 Ma), near the northern end of the Klaskish plutonic zone, is statistically coeval with the oldest K-Ar dated lava at Twin Peaks (~4.7 Ma; Fig. 2). Armstrong et al. (1985) noted that the youngest eruptive products of the Alert Bay volcanic suite occur at the northern end of the Brooks-Haddington tract relative to a K-Ar date (ca. 8 Ma) on a basaltic dike at the tip of the Brooks Peninsula (Fig. 1). Our U-Pb dates for the Klaskish Plutonic Suite show a similar younging trend from south to north along the southern part of this tract (Brooks Peninsula fault zone), although this trend is not smoothly progressive (cf., Teeta Creek; Fig. 2). The combined K-Ar and U-Pb dating results, therefore, appear to indicate a general age progression in which the rocks get younger from southwest to northeast within the Brooks magmatic suite.

5. Mineralization in the Brooks-Haddington tract

Mineral occurrences compiled from the MINFILE database that are spatially associated with the late Neogene Brooks-Haddington tract are listed in Table 1 and shown in Figure 3. The deposit types include porphyry Cu±Mo±Au±Ag (7), base- and precious-metal stockwork/vein systems (11), skarns/igneous contact mineralization (10), volcanic redbed Cu (2), industrial minerals (2) and some unspecified (6) deposit types. We have inferred an alternative deposit type based on the MINFILE descriptions for a number of these mineral occurrences (Table 1). Descriptions of the various deposit types given below focus on the spatial relationship between the plutons and mineralization; assay results from grab samples, trenching and drill intersections are provided in the specific MINFILE summaries (Table 1) and ARIS reports listed therein. As discussed below, the age of the mineralization has been established by Re-Os dating of molybdenite for only two porphyry occurrences. However, practically all these mineral occurrences are spatially related to structures in the Brooks-Haddington tract and/or intrusions of the Klaskish Plutonic Suite, and therefore mineralization may be late Neogene rather than Jurassic as has been traditionally assumed.

5.1. Porphyry Cu-Mo mineralization

Porphyry Cu-Mo(±Au±Ag) mineralization is hosted by the Nasparti Lake, Klaskish River and Teeta Creek plutons and is particularly widespread in the southern part of the Brooks Peninsula fault zone (Fig. 3). The principal sulphide minerals are typically chalcopyrite and pyrite±molybdenite, accompanied locally by bornite, sphalerite, arsenopyrite, trace galena and rare native gold. Chalcopyrite and pyrite are generally disseminated or contained in fractures and quartz vein stockworks along with molybdenite where present. The mineralogy of the silver minerals is currently unknown.

The mineralized Nasparti Lake (or 'Lois') granodiorite-quartz diorite is cut by rhyolitic breccias in the core and near the periphery of the stock (Stevenson, 1992; 4-5, Fig. 3; Table 1). Chalcopyrite and molybdenite are associated with pervasive potassic (biotite) alteration in the diorite; arsenopyrite and minor sphalerite are found in the rhyolitic breccias. The stock is cut by fine-grained rhyolitic dikes that are weakly mineralized and a post-mineral, partly devitrified obsidian dike, a subvolcanic member of the Alert Bay suite. Porphyry Cu-Mo

Table 1. Late Neogene mineral occurrences in the Brooks-Haddington tract and Coast Belt and selected Middle Jurassic porphyry deposits.

ID[1]	MINFILE	Name	Commodities[2]	MINFILE Deposit Type	Alternate Deposit Type[3]	Status	UTM X[4]	UTM Y[4]
	Late Neogene (late Miocene-Pliocene) - Brooks Peninsula Fault Zone (Fig. 3)							
1	092L 251	BROOKS	Cu, Pb, Zn	Cu skarn		Showing	591084	5566868
2	092L 334	NASPARTI LAKE	Cu	Cu±Ag quartz veins/ volcanic redbed Cu	Cu-Ag veins	Showing	599632	5567393
3	092L 258	PABLO 24-2	Cu, Ag	Porphyry Cu±Mo±Au	Porphyry Cu-Ag	Showing	589772	5568298
4	092L 330	LOIS	Cu, Mo, Zn, Pb, Au, Ag, Co	Porphyry Cu±Mo±Au		Prospect	598624	5568331
5	092L 447	NIC MSV	Ag, Cu, Zn	Vein/stockwork Cu-Ag-Au	Porphyry Cu-related	Showing	598297	5568912
6	092L 331	LONDON 1	ma, Fe, Cu, Zn	Unknown	Cu-Zn veins	Showing	602128	5569479
7	092L 228	IRON COP	Cu, Co, Ag, Au, Fe	Porphyry Cu±Mo±Au	Porphyry Cu-Ag-Au	Prospect	599848	5569590
8	092L 446	BERKINSHIRE	Au, Ag, Cu	Vein/stockwork Cu-Ag-Au	Porphyry Cu-Ag-Au	Prospect	599091	5569823
9	092L 001	HEART	Cu, Fe	Porphyry Cu±Mo±Au		Showing	604988	5570060
10	092L 449	KLASKINO 2	Cu, Ag	Vein/stockwork Cu-Ag)	Porphyry Cu-Ag	Showing	591555	5571665
11	092L 182	RH 1-24	Cu, Mo	Porphyry Cu±Mo±Au		Showing	605050	5571915
12	092L 265	FANG	Cu	Unknown	Porphyry Cu-related?	Prospect	600945	5572299
13	092L 237	RUF 41	Cu, Mo, Ag	Skarn	Porphyry Cu-Mo-Ag±Au	Showing	590582	5573039
14	092L 448	NIC EAST	Ag, Cu	Vein/stockwork Cu-Ag-Au	Porphyry Cu-related	Showing	601386	5573049
15	092L 191	JARR	Cu	Skarn	Cu skarn	Showing	592841	5574004
16	092L 144	SINKER	Cu, Ni, Co, Mo	Unknown	Cu skarn/porphyry Cu-related?	Showing	588777	5574491
17	092L 445	NIC NORTH SKARN	Cu, Au, Ag, Fe	Cu skarn		Showing	600538	5575010
18	092L 266	TENT	Cu, Mo, Au, Ag	Porphyry Cu±Mo±Au		Showing	599745	5575057
19	092L 176	BRAD	Cu	skarn	Cu skarn	Showing	594991	5575433
20	092L 259	MAHATTA	Au, Ag, Cu	Ag-Pb-Zn±Au veins		Showing	592744	5576134
21	092L 054	QUATSINO KING (L.676)	Cu, Au, Ag, Zn	Cu±Ag quartz veins	Cu-Ag-Au veins	Showing	606221	5582598
22	092L 235	STAR 24	Cu, Mo	Porphyry Cu±Mo±Au	Porphyry Cu-Mo-Ag±Au	Showing	605288	5582826
23	092L 453	STAR 22	Au, Ag	Vein/stockwork Cu-Ag-Au	Porphyry Cu-Ag-Au	Showing	605773	5583269
24	092L 454	JRB NO.1	Au	Unknown	Porphyry Cu-Mo-Au	Showing	604722	5583464
25	092L 455	JR 2	Au, Zn	Vein/stockwork Zn-Au	Porphyry Cu-related?	Showing	606636	5583564
26	092L 053	PAYSTREAK	Cu, Zn, Au, Ag	Cu±Ag quartz veins	Cu-Ag-Au veins	Showing	606294	5583897
27	092L 466	PANDORA	Ag, Pb, Zn	Pb-Zn-Ag veins		Showing	611618	5587066
28	092L 057	PILGRIM (L.2035)	Zn, Ag, Au, Pb, Cd	Pb-Zn skarn	Zn-Pb-Ag-Au skarn	Developed Prospect	613914	5587702
29	092L 056	JUNE (L.180)	Fe, Cu, Au, Ag, S, Zn, Pb, ma	Skarn/porphyry	Fe-Cu-Ag skarn	Prospect	612817	5588234
30	092L 314	BIG ZINC	Zn	Pb-Zn Skarn		Showing	611172	5588570
31	092L 112	MINERVA FR. (L.171,183)	Zn, Cu, Fe, ma	Skarn	Zn-Cu skarn	Prospect	612316	5588595
32	092L 055	ALICE LAKE	Au, Ag, Pb, Zn	Manto Ag-Pb-Zn	Ag-Pb-Zn-Au manto	Prospect	611912	5589049
33	092L 234	ECILA	Cu, ma, Fe	Industrial mineral	Porphyry Cu-related?	Showing	616366	5592854
34	092L 232	BLUE	Cu	Unknown	Porphyry Cu-related?	Showing	617222	5594263
35	092L 233	BLUE 44	Cu	Unknown	Porphyry Cu-related?	Showing	615366	5595304
36	092L 321	KEOGH	Cu, Mo, Ni	Igneous contact	Porphyry Cu-Mo-related?	Showing	629076	5597260
37	092L 141	WALT	Cu	Volcanic redbed Cu	Porphyry Cu-related?	Showing	626252	5599973
38	092L 146	HADDINGTON ISLAND	Building stone	Building stone		Past Producer	640181	5607187
	Middle Jurassic - northern Vancouver Island (Fig. 1)							
	092L 158	ISLAND COPPER	Cu Mo, Ag, Au, Zn, Pb, Re	Porphyry Cu±Mo±Au		Past Producer	607924	5606424
	092L 240	HUSHAMU	Cu, Au, Mo	Porphyry Cu±Mo±Au		Developed Prospect	580687	5614338
	092L 200	RED DOG	Cu, Au, Mo, Ag	Porphyry Cu±Mo±Au		Developed Prospect	572566	5618142
	Late Neogene (Miocene) - Coast Crystalline Complex (Fig. 4)						**UTM X[5]**	**UTM Y[5]**
39	092N 029	HOODOO NORTH	Mo, Ag, Zn, Pb, wo	Porphyry Mo		Prospect	319015	5692727
40	092N 028	HANNAH 8,10,11	Au, Ag, Cu, Mo	Porphyry Cu±Mo±Au		Prospect	332349	5684913
41	092JW 005	SALAL CREEK	Mo, Cu, Zn, Pb	Porphyry Mo		Prospect	471141	5622907
42	092JW 015	FALL	Mo	Porphyry Mo		Showing	465288	5612194
43	092JSE034	ROGERS CREEK	Cu, Ag, Mo, Au	Unknown	Porphyry Cu-Mo±Au±Ag	Showing	539513	5544583
44	092HSW037	MARY JANE	Mo, Au, Ag, Cu	Porphyry Mo		Showing	595706	5455678
45	092HSW065	MOUNT CHEAM 2	Cu, Zn	Skarn	Cu skarn	Showing	594700	5450688
46	092HSW007	LUCKY FOUR (L.989)	Cu, Mo, Ag, Au	Cu skarn		Developed Prospect	603402	5446427

[1] Label shown on Figs. 3 and 4; [2] wo, wollastonite, ma, magnetite; [3] Deposit Type inferred in this study; [4] UTM Zone 9 NAD 1983; [5] UTM Zone 10 NAD 1983

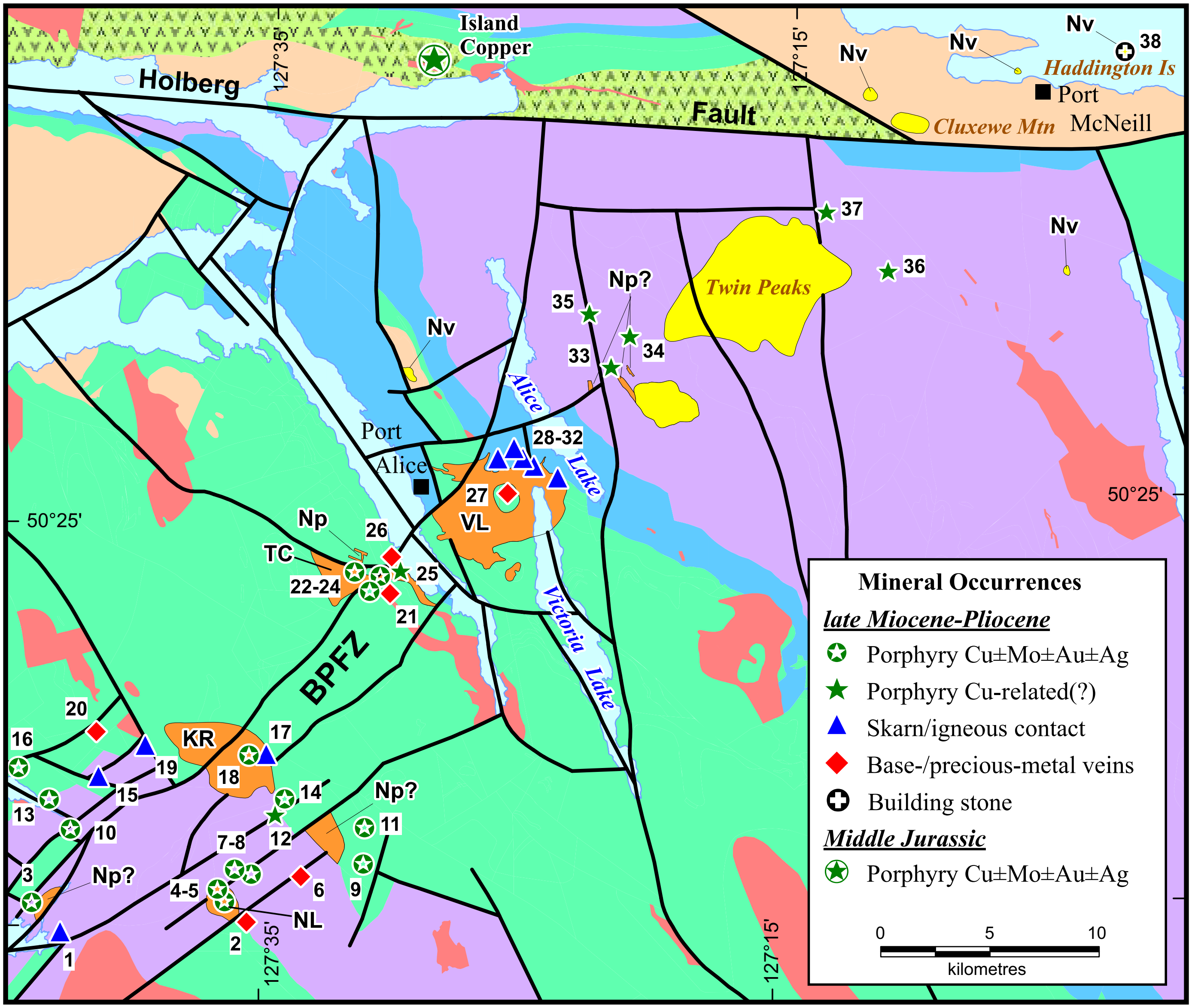

Fig. 3. Porphyry copper, skarn and vein mineral occurrences spatially associated with the Brooks magmatic suite. Mineral occurrences are taken from the MINFILE database and numbered according to Table 1. Age of the mineralization is based on direct dating results (Fig. 2) or the spatial association with inferred late Neogene intrusions. Geological units and other symbols as in Figs. 1 and 2.

mineralization also occurs 2 km to the north along northeast-trending structures and proximal to a small dioritic stock (7-8, Fig. 3; Table 1). Quartz-vein stockworks and shears hosted by Karmutsen Formation basalts carry chalcopyrite and pyrite. A Jurassic(?) pluton farther north along the same structure may also belong to the Klaskish Plutonic Suite and extend to the east in the subsurface where porphyry Cu-Mo mineralization is spatially associated with small bodies of granodiorite-diorite (9, 11, Fig. 3; Table 1).

Mineralization hosted by granodiorite and quartz diorite in the Klaskish River pluton locally contains chalcopyrite, pyrite and molybdenite in disseminations, fractures and locally well-developed quartz vein stockworks that have anomalous abundances of Au and Ag (18, Fig. 3; Table 1). Secondary biotite and kaolinite are reported to be associated with the Cu-sulphide mineralization, and sodic metasomatism of the granodiorite is locally pronounced (Nixon et al., 2011c). Petrographic examination of the latter rocks confirms the presence of secondary 'chequerboard' albite thereby distinguishing these metasomatized rocks from igneous tonalite. The most recent work on Cu-Mo mineralization in the Klaskish River pluton and surrounding area is summarized by Houle (2012).

Cu-Mo±Au±Ag mineralization in the Teeta Creek quartz diorite-granodiorite-porphyry intrusive complex occurs in disseminations, shears and quartz vein stockworks containing chalcopyrite, molybdenite, pyrite and pyrrhotite, and rare narrow massive sulphide veins (22-25, Fig. 3; Table 1). A rhyolite porphyry dike complex cuts Bonanza volcanic stratigraphy at the northern margin of the pluton, and hydrothermal breccia pipes are exposed in road cuts on the northern slopes of Teeta Creek. In addition to the porphyry Cu-Mo mineralization, prospecting on the south side of Teeta Creek identified a zone of anomalous gold values in quartz veins trending subparallel to the Teeta Creek fault in the valley bottom. The gold is accompanied locally by anomalous Cu, Pb and Zn abundances and the mineralization has been interpreted as part of an epithermal system above a Cu-Mo porphyry at depth. Pyritic volcanic host rocks exposed in new logging roads south of Teeta Creek may represent an outer sulphidic halo related to the Cu-Mo-Au mineralization. Previous exploration work in the Teeta Creek area is summarized by Sookochoff (2013) and includes historical drill results from holes collared in the Teeta Creek valley bottom where an intersection of 146 m at 0.256% Cu was reported. Due to the presence of porphyry-style mineralization on both sides of Teeta Creek, we infer that the Teeta Creek pluton extends south and east towards Neroutsos Inlet where it may be genetically linked to a telescoped or peripheral precious-metal epithermal system.

A number of porphyry Cu-Mo occurrences are found in the Brooks Peninsula fault zone southwest of the Klaskish River pluton. One occurrence (3, Fig. 3; Table 1) is related to a small late Neogene(?) dioritic intrusion where chalcopyrite and bornite are hosted by a breccia zone at the margin of the body. Other occurrences (10, 13, 16, Fig. 3; Table 1) contain quartz-molybdenite stockworks or chalcopyrite and pyrrhotite stringers hosted by Late Triassic volcanic and sedimentary rocks and invite further investigation.

In the northern part of the Brooks-Haddington tract southwest of Twin Peaks, several mineral showings occur near north-trending faults and dike-like dioritic to feldspar porphyry intrusions hosted by Karmutsen Formation basalts (33-35, Fig. 3; Table 1). These intrusions were originally mapped as Jurassic except for one composite diorite-rhyolite dike where the rhyolite was assigned to the Alert Bay volcanic suite (Nixon et al., 2011d). We now speculate that these granitoid intrusions belong to the Klaskish Plutonic Suite and may well be genetically related to mineral occurrences in the surrounding area. The mineralization is described as disseminated chalcopyrite and bornite within the basalts, and locally silicified breccia contains chalcopyrite and magnetite accompanied by pyrrhotite and pyrite in fracture fillings. Similar Cu-Fe sulphide mineralization is also found northeast of Twin Peaks where molybdenite is reported in quartz vein stockworks and shears along with chalcopyrite, pyrite and pyrrhotite (36-37, Fig. 3; Table 1). Small dioritic intrusions occur in this area and a larger Jurassic(?) body is shown on maps by Muller et al. (1974) and Muller and Roddick (1983). We suspect that these mineral occurrences are vestiges of late Neogene porphyry Cu-Mo systems.

5.2. Skarns

A cluster of skarn deposits, some with historic reserves, occur near the contact between the Victoria Lake pluton and limestone of the Quatsino Formation (28-32, Table 1; Fig. 3). The Zn-Pb skarns generally form disseminations or massive replacements of limestone that are locally intruded by quartz diorite, aplite and porphyry dikes emanating from the pluton. The ore minerals include sphalerite, pyrrhotite, galena, bornite, pyrite and arsenopyrite; the latter two minerals were reported in assessment work to carry anomalous abundances of Au and Ag. Gangue minerals include epidote, chlorite, garnet and tremolite. One occurrence contains massive sphalerite (30, Table 1) and one developed prospect has historical resources (non-NI 43-101 compliant) of 46,266 tonnes of ore grading 8.7% Zn and 32.6 g/t Ag with anomalous Cd, in addition to a similar tonnage classed as probable reserves (28, Table 1).

The southern part of the Brooks Peninsula fault zone contains numerous isolated skarn occurrences at the margin of the Klaskish River pluton and associated with northeast- and northwest-trending faults in an area of widespread porphyry Cu-Mo mineralization (Fig. 3). Disseminated chalcopyrite, pyrite, magnetite and pyrrhotite are developed in calcareous sedimentary rocks of the Parson Bay Formation and basalts of the Karmutsen Formation. Assessment work has documented chalcopyrite and pyrite in localized quartz vein stockworks; and a thin (~20 cm) massive Fe-Cu skarn carrying chalcopyrite and magnetite near the eastern margin of the Klaskish River pluton (17, Table 1).

5.3. Base- and precious-metal stockworks and veins

Base- and precious-metal veins and stockworks commonly occur peripheral to plutons that host porphyry Cu-Mo mineralization and/or adjacent to faults (Fig. 3). Thin (2-25 cm) quartz±calcite veins are generally steeply dipping and contain chalcopyrite±pyrite (2, 20, Table 1). A magnetite-rich vein occurrence is cut by sulphide stringers carrying pyrite, chalcopyrite and sphalerite (6, Table 1). Quartz veins along easterly trending structures near the Teeta Creek pluton are reported to contain pyrrhotite, sphalerite, pyrite and chalcopyrite (26, Table 1). A vein occurrence within a roof pendant of pyrite-impregnated volcanic-sedimentary rocks enclosed by the Victoria Lake pluton was reported in assessment work to have anomalous Ag, Pb, and Zn values (27, Table 3).

5.4. Age of porphyry Cu-Mo mineralization

High-precision Re-Os age determinations on molybdenite in the Klaskish River and Teeta Creek plutons were done at the University of Alberta following analytical protocols described by Selby and Creaser (2004) and Markey et al. (1998, 2007). The results are shown in Figure 2. Molybdenite in these plutons occurs in quartz stockworks and fractures accompanied by chalcopyrite±pyrite and is associated with a broader signature of porphyry Cu-Mo±Ag±Au mineralization. The Re-Os dates for molybdenite mineralization in the Klaskish River (ca. 5.35 Ma) and Teeta Creek (ca. 6.49 Ma) plutons are within about 200,000 years of the U-Pb zircon crystallization dates (Fig. 2). These results are interpreted to indicate that porphyry Cu-Mo mineralization is genetically linked to the emplacement and crystallization of late Miocene-Pliocene intrusions of the Klaskish Plutonic Suite. These intrusions are related to the structural development of the Brooks Peninsula fault zone as discussed below.

6. Structural evolution of the Brooks-Haddington tract

The structural evolution of the Brooks-Haddington tract is constrained by the geochronological data. Northeast-oriented structural lineaments defining the Brooks Peninsula fault zone cut the Klaskish River and Teeta Creek plutons, indicating that faulting post-dated their emplacement and crystallization (i.e., younger than ca. 5.5 Ma; latest Miocene). These faults were evidently active before 5.5 Ma because the Klaskish River pluton cuts one of these structures (Fig. 2). Similar relationships are apparent farther east where northerly trending faults predate emplacement of the Victoria Lake pluton (ca. 5.15-4.6 Ma), and faulting at Twin Peaks predates and postdates extrusion of Pliocene lavas (ca. 4.7-3.0 Ma). Furthermore, undeformed Cenozoic basaltic to rhyolitic dikes intruding rocks on Brooks Peninsula, including one dated basaltic dike, are oriented parallel to the projected southern extension of the Brooks Peninsula fault zone (Smyth, 1985), and provide evidence for fault motion predating or broadly synchronous with dike emplacement and cooling at ca. 8 Ma (Fig. 1). From the geochronological constraints, therefore, the northeast-oriented structures forming the Brooks Peninsula fault zone and northerly trending faults farther east appear to have developed during an interval of at least 5 million years (ca. 8-3 Ma). Evidence from seismicity in the Brooks Peninsula fault zone and in the crust offshore of the Brooks Peninsula indicates that faulting in this zone of structural weakness continues today (Savard et al., 2019).

7. Late Neogene porphyry Cu-Mo mineralization in the Coast Belt

The major porphyry Cu deposits in British Columbia are Late Triassic to Early Jurassic in age and confined almost exclusively to the accreted magmatic arc terranes of Quesnellia and Stikinia (Logan and Mihalynuk, 2014; Fig. 4). Beyond Vancouver Island, the youngest porphyry Cu-Mo and skarn occurrences in the province are spatially associated with Miocene plutons in the Pemberton magmatic arc in the southeastern Coast Mountains (Fig. 4; Table 1). These small, high-level stocks of the Chilliwack Suite (Woodsworth et al., 1991) extend northwards from near the British Columbia-Washington border to at least 51°25' N, coincident with erosional remnants of coeval and cogenetic Mio-Pliocene volcanic rocks (Souther, 1991).

Porphyry Mo mineralization considered genetically related to the Miocene plutons occurs at the Hoodoo (39), Salal Creek (41), Fall (42) and Mary Jane (44) MINFILE occurrences; porphyry Cu-Mo occurrences are found at Hannah (40) and the Rogers Creek cluster (43, Fig. 4; Table 1). The youngest known Cu skarns in the province are peripheral to the Mount Barr batholith (ca. 18 Ma, U-Pb zircon; Mullen et al., 2018) which hosts the Mary Jane porphyry Mo showing (45-46, Fig. 4; Table 1).

Early K-Ar dating studies detected a northward decrease in the age of the Pemberton plutons (and associated volcanic rocks) from about 35 Ma in the south near the US border (late Paleogene phase of the Chilliwack batholith) to 7 Ma in the north (Franklin Glacier stock, Woodsworth et al., 1991; Breitsprecher and Mortensen, 2004; 40, Fig. 4). Recent U-Pb zircon geochronology by Mullen et al. (2018) corroborates this northward age decrease (Fig. 5a). We show below that the distribution and age of Neogene plutons and related porphyry mineralization in the Pemberton magmatic arc and their counterparts in northern Vancouver Island are manifestations of a common plate tectonic evolution. We first address the plate tectonic history pertinent to northern Cascadia and subsequently attempt to rationalize our observations and geochronological results within this tectonic framework.

8. Plate tectonic setting of northern Cascadia

Vancouver Island lies at the northern termination of the Cascadia subduction zone in a region where late Cenozoic interactions between oceanic and continental lithosphere are complex (Fig. 5). In the plate tectonic model for Cascadia presented by Madsen et al. (2006), at about 10 Ma the Pacific-Juan de Fuca-North America triple junction (Juan de Fuca ridge-trench-Queen Charlotte fault intersection) lay to the north of Vancouver Island in Queen Charlotte Sound. Vancouver Island at this time was underlain by the subducting Juan de Fuca plate whereas a slab-absent region (slab window) existed to the north of the triple junction. After plate readjustments, the triple junction and northern edge of the subducted Juan de Fuca plate migrated southwards to arrive near the Brooks Peninsula at ~8-9 Ma (Madsen et al., 2006; Fig. 5a). This interpretation differs from the plate tectonic model of Mullen et al. (2018) who reconciled the northward decrease in pluton ages in the Pemberton arc with progressive northward migration of the edge of the subducted Juan de Fuca slab during the last 35 million years.

In the simple rigid-plate geometry model proposed by Riddihough (1977) using offshore magnetic anomalies, the Juan de Fuca ridge remained in a stable position near the Brooks Peninsula from about 10 Ma to 5 Ma, and the northwestern edge of the subducted Juan de Fuca plate was inferred to have a northeast trajectory beneath the Brooks Peninsula. The residence time for the triple junction at this position is limited by the inception of the Nootka fault at ~3.5 Ma. This event spalled away a fragment of the formerly contiguous Juan de Fuca plate as ocean floor spreading opposite the Brooks Peninsula ceased and the Juan de Fuca ridge shifted northwest to complete the formation of the Explorer plate (Savard et al., 2019; Fig. 5b).

The boundary separating the Explorer and Juan de Fuca plates, the Nootka fault zone, has been depicted as a left-lateral transform fault extending northeasterly from the Juan de Fuca ridge towards Nootka Island (Hyndman et al., 1979; Fig. 5b). Recent geophysical studies summarized by Savard et al. (2019)

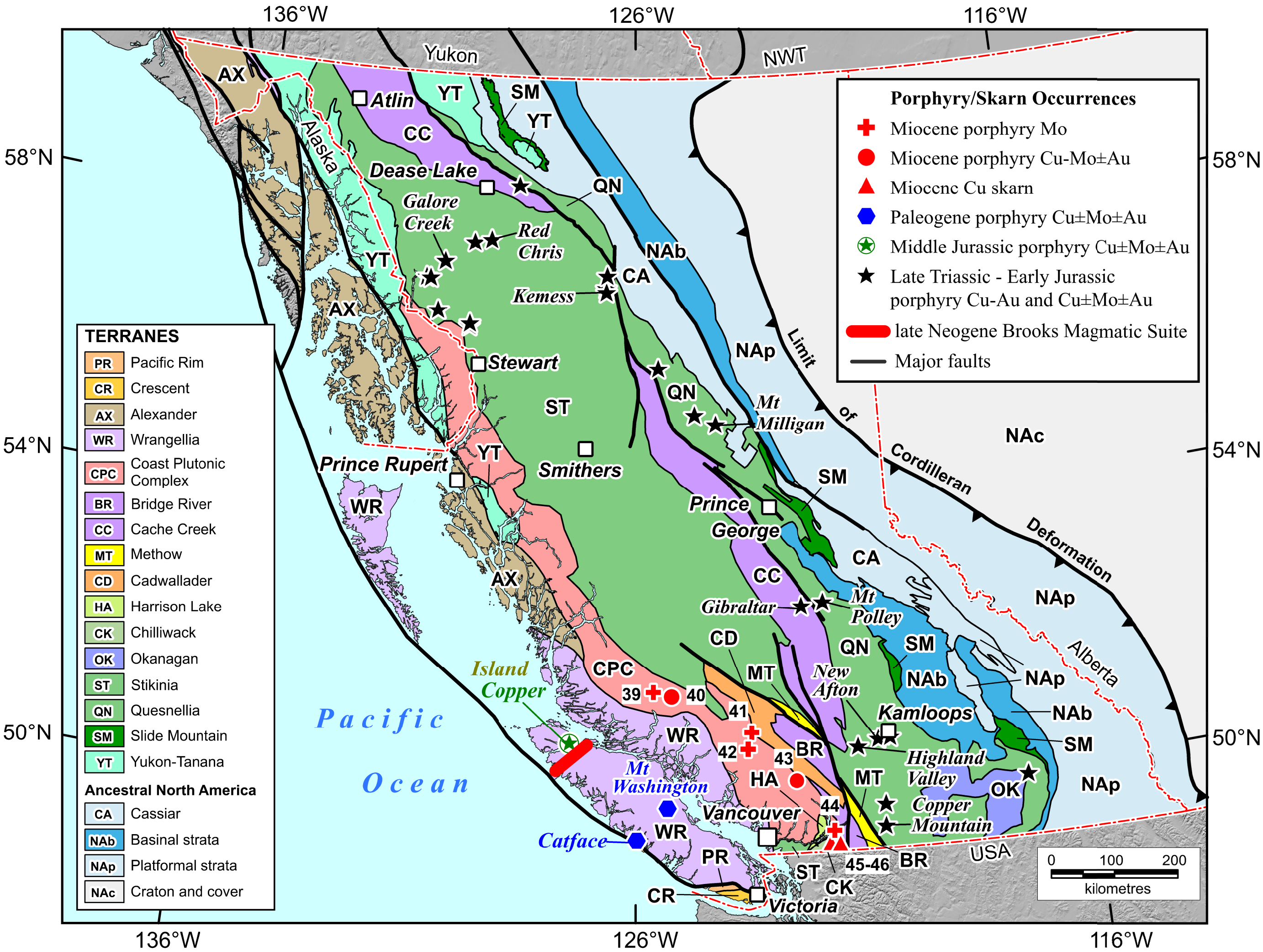

Fig. 4. Distribution of selected Mesozoic-Cenozoic porphyry copper and skarn occurrences in British Columbia and their terrane affiliation. Named Late Triassic-Early Jurassic deposits identify operating mines or deposits at an advanced stage of development in 2018 (Clarke et al., 2019). Numbered Miocene occurrences are listed in Table 1. Mesozoic porphyry copper deposits after Logan and Mihalynuk (2014); Cenozoic mineral occurrences compiled from the MINFILE database; terranes after Colpron and Nelson (2011) and Nelson et al. (2013). Note that late Neogene porphyry/skarn occurrences are confined to the southeastern part of the Coast Plutonic Complex and the forearc region of the Brooks-Haddington tract.

have demonstrated that the Nootka fault, a ~20 km-wide zone of complex faulting in the ocean floor, assumes a more north-northeast orientation than traditionally shown. These authors argue that, since the inception of the Nootka fault at ~3.5 Ma, the zone of deformation offshore has widened and the landward continuation has broadened reflecting a component of extension across the fault zone resulting from the differing subduction rates of the Explorer and Juan de Fuca plates. The eastern boundary of the Nootka fault zone defines the present-day location of the northwestern edge of the Juan de Fuca plate, which can be extrapolated in the subsurface across Vancouver Island. The leading edge of the subducted Juan de Fuca slab has advanced no farther than the northeast coast of Vancouver Island (below Haddington Island) constrained by the relative rates of convergence of the Juan de Fuca/North America plates (Fig. 5b). The western edge of the Nootka fault zone marks the margin of the Explorer plate whose leading edge presently underlies the Brooks Peninsula because it is underthrusting North America at about half the rate of the Juan de Fuca plate (Savard et al., 2019; Fig. 5b).

9. Plates, magmatism and porphyries

Armstrong et al. (1985) noted the spatiotemporal correspondence between the descending Juan de Fuca plate edge as proposed by Riddihough (1977), the Brooks Peninsula fault zone and the 8-2.5 Ma Alert Bay volcanic suite, remarked on an apparent eastward shift in the volcanic activity, and interpreted the forearc location and 'within-plate' geochemical signature of the volcanic rocks as an enigmatic product of descending plate-edge magmatism. We examine these observations below within the context of the newly advanced plate configuration described above and our geochronological

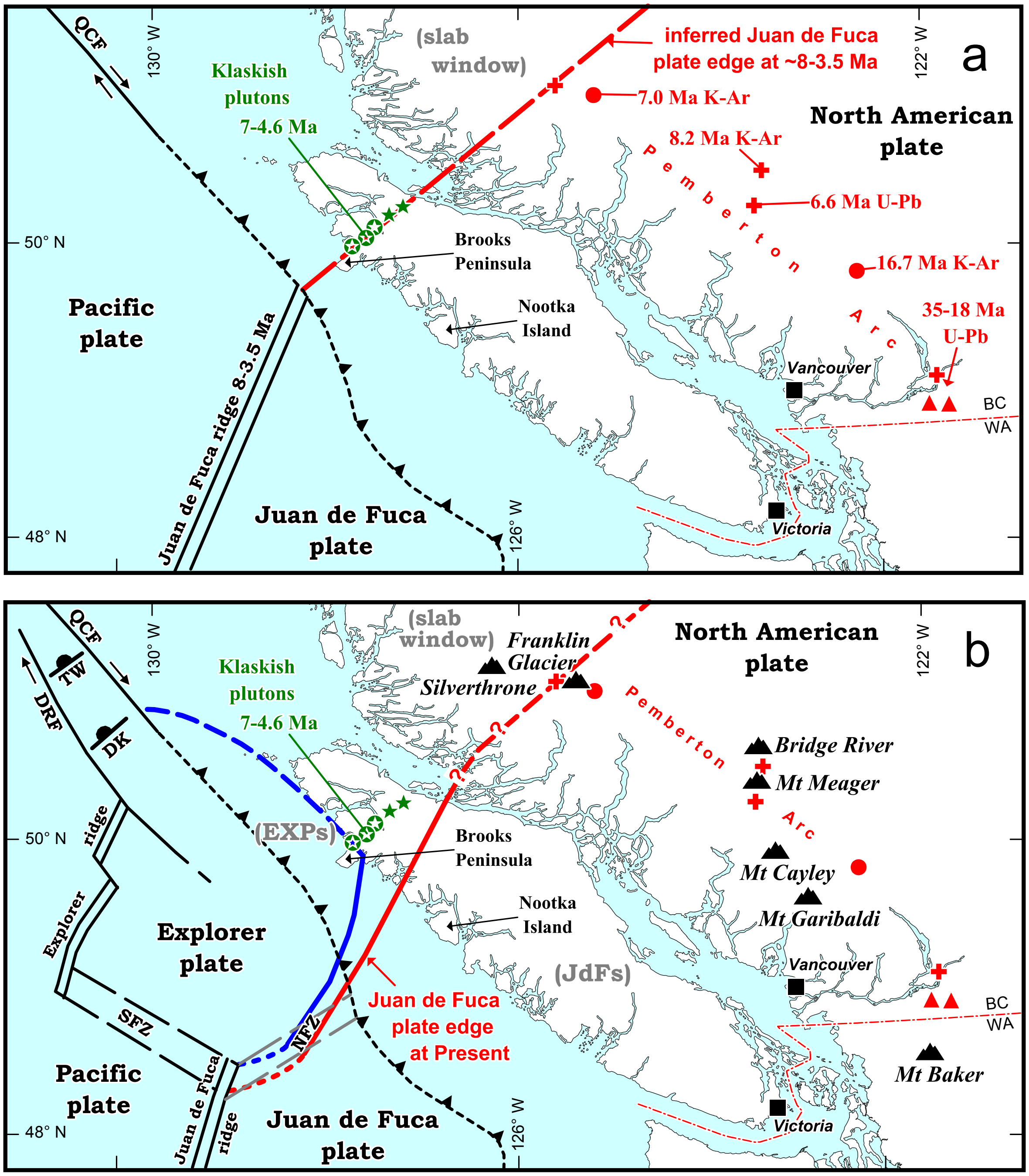

Fig. 5. Late Neogene to present plate configuration at the northern termination of the Cascadia subduction zone (after Savard et al., 2019) showing the distribution of late Neogene porphyry Cu-Mo and Mo systems in the Pemberton arc and forearc region of northern Vancouver Island. **a)** Inferred position of the Juan de Fuca ridge (Pacific-Juan de Fuca-North America triple junction) offshore of the Brooks Peninsula and subducted plate edge at 8-3.5 Ma (Riddihough, 1977; this study). Note that a slab-absent region (slab window) exists north of the subducted Juan de Fuca plate edge at this time. Isotopic age dates for mineralized plutons in the Pemberton arc are from Mullen et al. (2018, U-Pb zircon) and Wanless et al. (1978, K-Ar, corrected for the decay constants of Steiger and Jäger, 1977, by Breitsprecker and Mortensen, 2004). Age determinations for the Klaskish Plutonic Suite in the Brooks-Haddington tract on northern Vancouver Island are from this study and Nixon et al. (2011c-d). **b)** Plate configuration at present showing the redefined location of the Nootka fault zone (NFZ, solid red and blue lines; Rohr et al., 2018) extrapolated to its present position under Vancouver Island according to the relative convergence velocities of these plates with respect to North America (Savard et al., 2019). The Nootka fault zone was initiated at ~3.5 Ma and delineates the boundary between the Explorer and Juan de Fuca plates. Also shown are the inferred extension of the Nootka fault zone to the Juan de Fuca ridge (short-dash red and blue lines); the subducted leading edge of the Explorer plate (long-dash blue line; Savard et al., 2019) and inferred position of the Juan de Fuca plate edge (long-dash red line); the subducted portions of the Explorer (EXPs) and Juan de Fuca (JdFs) plates and slab window to the north; the traditionally depicted orientation of the Nootka fault zone (grey dashed lines); the limit of deformation in the Cascadia subduction zone (dashed barbed line); and modern volcanoes of the northern Cascade arc (Garibaldi belt). Symbols as in Figs. 3 and 4. Other abbreviations: QCF, Queen Charlotte fault; DRF, Dellwood-Revere fault; DK, Dellwood Knolls; TW, Tuzo Wilson seamounts; NFZ, Nootka fault zone; SFZ, Sovanco fracture zone.

data for late Neogene plutons and genetically related porphyry Cu-Mo mineralization on northern Vancouver Island and in the Coast Mountains.

The inferred northeasterly trajectory of the northwestern edge of the Juan de Fuca plate during the late Neogene (≥8 Ma to ~3.5 Ma) underlies the loci of Alert Bay volcanism, Klaskish plutonism and related porphyry Cu-Mo systems of the Brooks magmatic suite that form the Brooks-Haddington tract, and passes beneath the northernmost mineralized pluton in the Pemberton arc (39, Figs. 3, 5a). The northward age progression of granitoid intrusions in the Pemberton arc in the late Cenozoic (ca. 35-7 Ma) appears to fit the northward migrating slab model of Mullen et al. (2018). However, in their model the subducted edge of the Juan de Fuca slab does not arrive beneath the Brooks Peninsula until the present day, contrary to our interpretation (Fig. 5a). One of the youngest mineralized plutons in the Pemberton arc (Franklin Glacier stock dated at 7 Ma by K-Ar; Wanless et al., 1978; Breitsprecker and Mortensen, 2004; Fig. 5a) is similar in age to the Teeta Creek and Nasparti Lake plutons (~6.3-7 Ma, U-Pb zircon). Thus, we consider that forearc plutons and porphyry Cu-Mo systems on northern Vancouver Island and their northernmost counterparts in the Pemberton arc (39-40, Fig. 5a) formed above or close to the projected edge of the subducted Juan de Fuca plate in the late Neogene. The present location of the northwestern edge of the subducted Juan de Fuca slab is uncertain but appears to also limit the distribution of Quaternary volcanoes in the Garibaldi belt (Fig. 5b).

A minimum time of arrival for the Juan de Fuca ridge opposite Brooks Peninsula is concomitant with the early stages of development of the Brook Peninsula fault zone and late Cenozoic dike emplacement and cooling at ca. 8 Ma (Armstrong et al., 1985; Figs. 1 and 5). The Klaskish plutons and porphyry Cu-Mo systems (7-4.6 Ma) are coeval with the older rocks of the Alert Bay volcanic suite (8-4.7 Ma), and structural development of the Brooks Peninsula fault zone continued until at least 4.6 Ma. The stable position of the triple junction and northwestern edge of the subducted Juan de Fuca plate during this period resulted in focused faulting that facilitated magma transit through the crust.

The well-defined narrow structural corridor that hosts the Klaskish plutons and porphyry mineralization in the southwest is interrupted in the northeast by north-trending faults, and the plutons transition to younger Alert Bay volcanic rocks (ca. 4.3-2.5 Ma) coupled with an apparent widening of the Brooks-Haddington tract. We speculate that the eastward younging of Alert Bay volcanism noted by Armstrong et al. (1985) and northerly oriented structures reflect the eastward motion of the subducted Juan de Fuca plate edge relative to North America and evolving Nootka fault zone from ~3.5 Ma to Present.

The geochemical signature of the Alert Bay volcanic suite has been interpreted to have ambivalent within-plate or volcanic arc (Armstrong et al., 1985) or mid-ocean ridge basalt (Lewis et al., 1997) affinity, implying the involvement of sub-slab mantle source(s) in magma genesis. The widening of the Nootka fault zone during eastward migration of the Juan de Fuca slab and its subduction beneath Vancouver Island would allow the ascent of asthenospheric mantle and promote mixing of depleted and subduction-modified mantle sources. Given the global proclivity for the formation of porphyry copper deposits above subduction zones, porphyry Cu-Mo mineralization in the forearc of the Cascadia subduction zone would appear to require a component of subduction-modified mantle in the source regions of the late Neogene Klaskish Plutonic Suite. Future geochemical studies of the Brooks magmatic suite may help to resolve this intriguing issue.

10. Summary and conclusions

The foundation for this study was laid by a diverse array of previous work on northern Vancouver Island and in the offshore region that included regional mapping, paleontological, geochronological, geochemical and geophysical studies, mineral occurrence data gathered by the exploration community and made available through the MINFILE and ARIS databases, and plate tectonic reconstructions. Building on this infrastructure, our study advances the understanding of the mineral potential of northern Vancouver Island in several respects.

Late Neogene magmatism on northern Vancouver Island is restricted to the Brooks magmatic suite, which comprises volcanic (Alert Bay) and plutonic (Klaskish Plutonic Suite) components. Magmatism developed above the subducted edge of the Juan de Fuca plate and landward extension of the Nootka fault zone. The Klaskish Plutonic Suite occupies an anomalous forearc setting in the Cascadia subduction zone and hosts porphyry Cu-Mo mineralization. High-precision U-Pb and Re-Os dating of Klaskish plutons confirms that these intrusions are coeval with the older volcanic rocks of the Alert Bay suite and establishes a genetic relationship between pluton emplacement, crystallization and mineralization. The dating is crucial for distinguishing these Neogene plutons from Early to Middle Jurassic intrusions of the Island Plutonic Suite which are proven ground for major porphyry Cu-Mo-Au-Ag deposits. The underexplored late Neogene Klaskish metallogenic belt occupies a well-defined structural zone, the Brooks Peninsula fault zone, and this young metallotect offers fertile ground for future economic discoveries.

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