Bonaparte gold: another 195 Ma porphyry Au-Cu deposit in southern British Columbia?

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Abstract

An erosional window in the Miocene Chilcotin Group basalt blanket exposes deformed Early Jurassic (?) porphyritic quartz diorite and monzodiorite on the Bonaparte Plateau, 38 km north of Kamloops. These plutonic rocks host Au-Cu quartz veins and reported W-Mo quartz stockworks at the Bonaparte mine. Intrusion and mineralization appear to have coincided temporally and spatially with motion along a greenschist-grade, north-trending reverse (east-side-up) shear zone. Shear strain, characterized by mylonitic fabrics, a prominent down-dip lineation, and local kinematic indicators (sigma and delta porphyroclasts, displaced broken grains) culminated with a later phase of extensive hydrothermal quartz and quartz-carbonate veins, and stockworks. Auriferous veins form at least eight separate, metre to cm-wide, north-trending zones. Two bulk samples (3700 tonnes in 1994 and 364 tonnes in 2009) of mineralized quartz veins from the Bonaparte have produced ~103 kg of gold or 25.58 g/t Au from the total 4064 tonnes shipped. Biotite, sericite- and carbonate-alteration of the intrusions adjacent to the vein structures is accompanied by disseminated pyrite, chalcopyrite and arsenopyrite ± molybdenite, and gold mineralization. Historically, exploration at Bonaparte has focussed on quartz vein networks. Yet the Bonaparte intrusions align with a north-trending belt of Early Jurassic porphyry deposits in the Takomane-Wildhorse magmatic belt, some of which have similar metal and alteration assemblages. We speculate that the Bonaparte deposit represents an upper level of a buried porphyry system.

Keywords: Calcalkaline diorite porphyries, gold quartz veins, chalcopyrite, quartz stockwork, potassic, synkinematic alteration and mineralization

1. Introduction

The eastward migration of Mesozoic arc magmatism in southern Quesnellia (Fig. 1) led to the growth of three temporally distinct, north-trending, plutonic belts (from west to east): Late Triassic; Late Triassic-Early Jurassic; and Early Jurassic (Fig. 2). Three porphyry copper mineralization events are directly linked to each of these calcalkaline-alkaline magmatic episodes. The youngest, easternmost train of granodiorite plutons (Wildhorse-Takomkane suite) defines a 375 km long arcuate belt that is prospective for Cu-Mo±Au mineralization (Logan et al., 2011) and hosts porphyry copper-molybdenum-gold deposits such as the past producing Brenda mine (Cu-Mo) and the recently discovered Woodjam prospect (Cu-Mo, Au). In the central part of this belt, ~38 km northeast of Kamloops and between the Brenda and Woodjam deposits (Fig. 2), is the Bonaparte Au property of WestKam Resources (Fig. 3; MINFILE 092P 050).

Reported mineralization at Bonaparte includes intrusion-hosted Au-Cu quartz veins and W-Mo quartz stockworks. This mineralization is in a dioritic intrusive complex near contacts with hornfelsed and skarned sedimentary rocks of the Paleozoic Harper Ranch Group (Peatfield, 1986; Durfeld, 1980). Although the age of plutonism is unknown, the Bonaparte intrusive complex is assumed to be Early Jurassic, based on its position in the

Fig. 1. Location of the Bonaparte gold property (red), shown straddling the NTS boundary between 92I and 92P map sheets (black), near the eastern edge of Quesnel terrane shown as a transparent green overlay on the coloured topographic map of British Columbia.

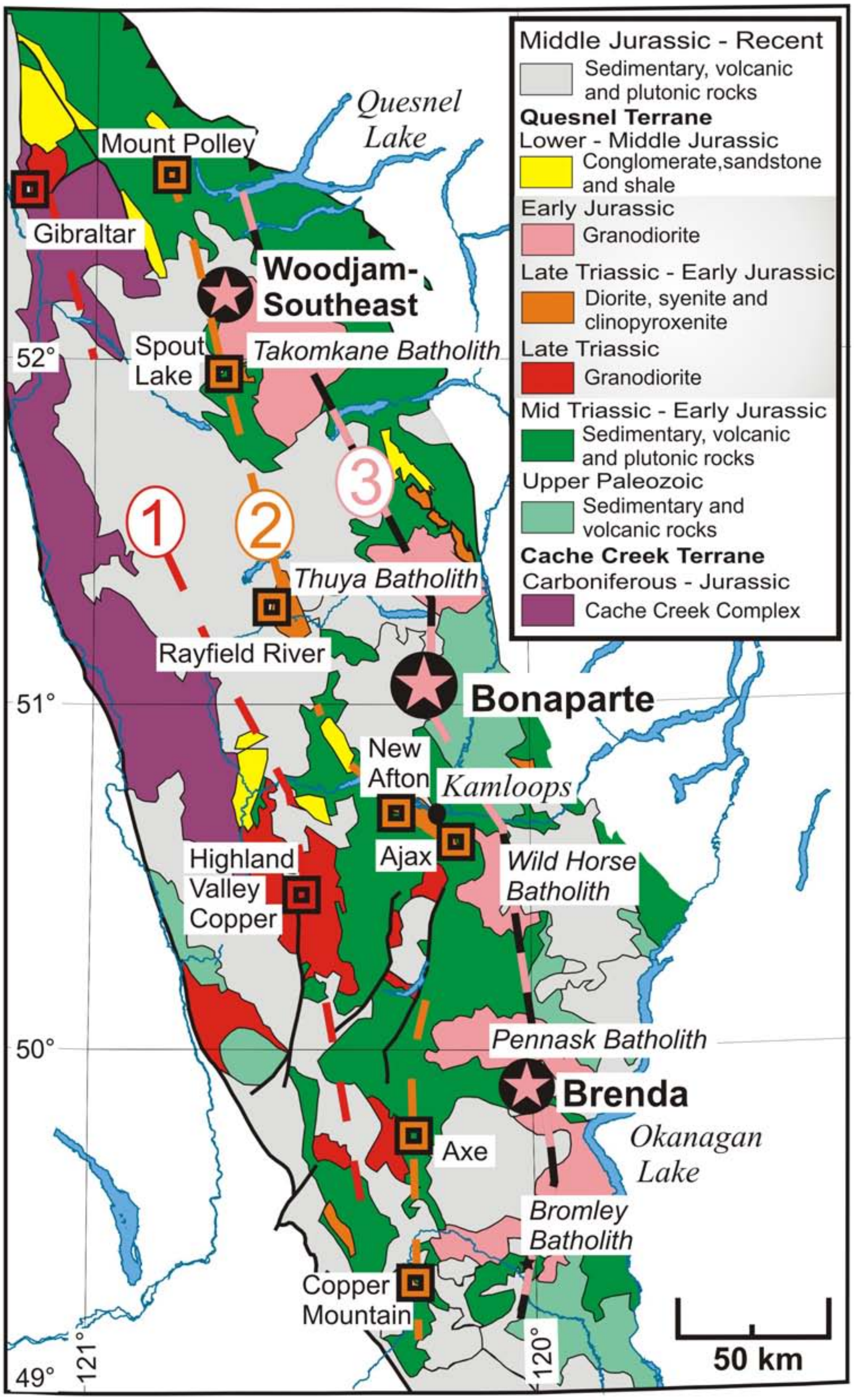

Fig. 2. Generalized geology of southern Quesnellia and Cu-Mo±Au deposits. Mesozoic arc plutons align along the length of southern Quesnellia to define three, north-trending, temporally distinct belts that get younger to the east: 1) Late Triassic; 2) Late Triassic – Early Jurassic; and 3) Early Jurassic. Discrete porphyry copper mineralizing events are directly linked to each of these magmatic episodes. The Bonaparte deposit lies in the tract of Early Jurassic plutons **(**Wildhorse-Takomkane plutonic suite), midway between the Brenda and Woodjam-Southeast deposits (modified after Massey et al., 2005).

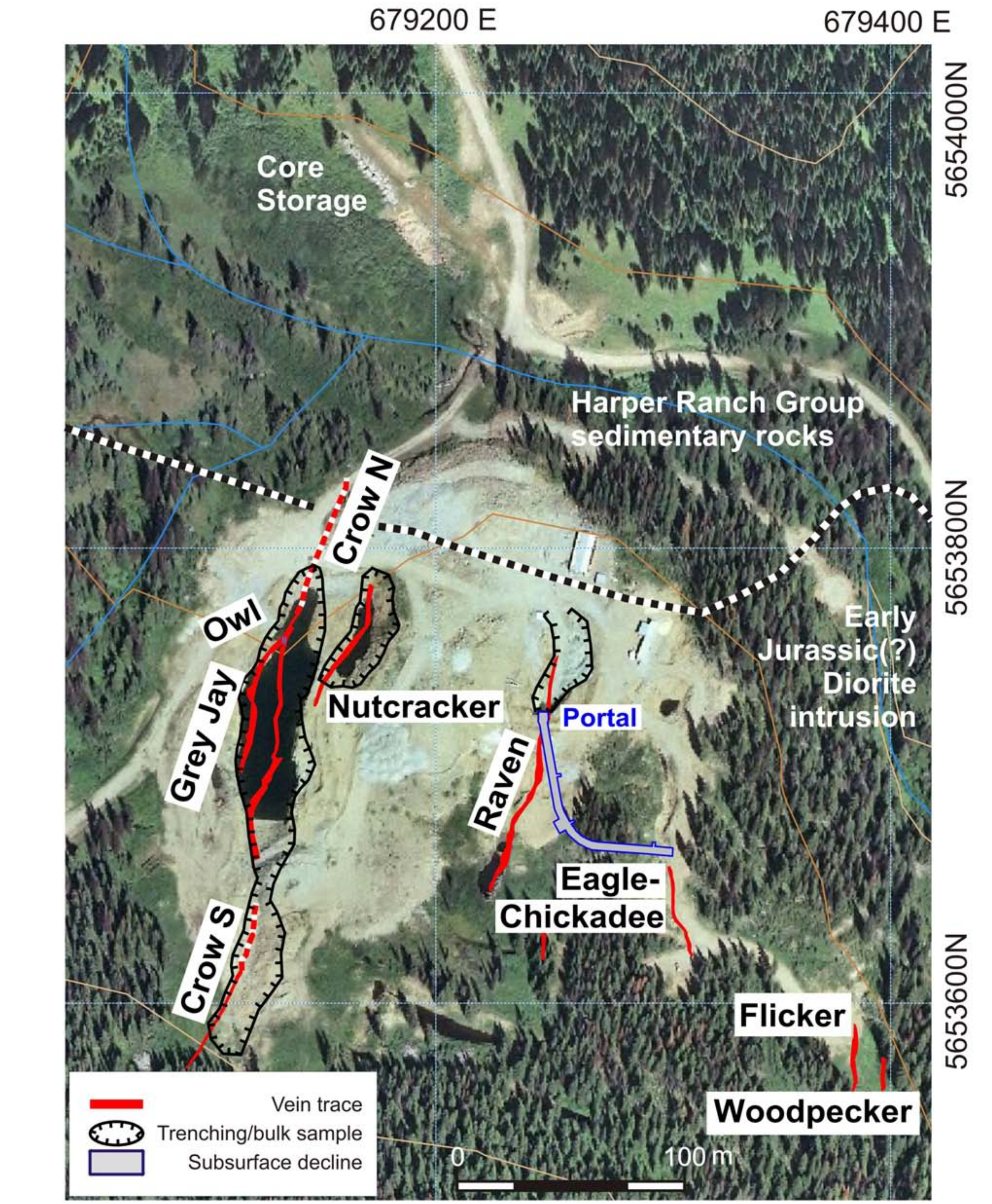

Fig. 3. Location of the main quartz veins at the "Discovery Zone" on the Bonaparte developed prospect showing surface trenches, bulk sample locations, and the surface projection of the decline (after Beaton, 2011). The dashed line indicates the approximate contact between the dioritic intrusive complex and hornfelsed sedimentary country rocks of the Harper Ranch Group.

Wildhorse-Takomkane magmatic belt (Breitsprecher et al., 2010). To test this correlation, we collected samples of quartz diorite and monzodiorite for U-Pb zircon geochronology, and a sample of sericite-altered intrusion associated with quartz-carbonate veins and gold mineralization to determine cooling ages using the Ar^{40}-Ar^{39} method. This work is ongoing; results will be presented as they come available.

Herein we present mapping, sampling, and petrographic data to establish the geological history of the Bonaparte property and the paragenesis of alteration and mineralization. Historically, exploration at Bonaparte has focussed on quartz vein networks. Based on similarities in metal and alteration assemblages and an assumed Early Jurassic age, we pose the question: "does this vein-related mineralization represent the upper level of a Brenda or Woodjam porphyry copper-gold deposit?". Samples collected for isotopic age determination will provide some of the first tentative answers.

2. Access and history of development

The Bonaparte gold mine is approximately 38 km north of Kamloops, B.C., straddling map sheets 92I/16W & 92P/1W, at about 51° 02' N and 128° 28' W (Fig. 1). Access is by way of a 24 km-long paved road north from Kamloops and then by an additional 24.7 km-long series of well-maintained gravel logging roads (Jamieson-Wentworth Creek and Bob Lake).

The first recorded mineral exploration on the Bonaparte property was by Amoco Canadian Petroleum Company Ltd., between 1969 and 1973 (Neugebauer, 1973). Their search for molybdenum culminated in the drilling of two diamond-drill holes, which met with discouraging results. In 1984, regional geochemical sampling by Minequest Exploration Associates Ltd. revealed anomalous gold and arsenic values in stream, soil, and graphitic and siliceous sedimentary rocks. Follow-up work resulted in the discovery of auriferous quartz float (Gourlay, 1985). Drilling in 1986 confirmed in-situ gold mineralized veins hosted by diorite (Peatfield, 1986).

In 1986, the Hughes-Lang Group of companies optioned the property and carried out geological mapping, stripping, trenching, and 4674 metres of diamond drilling. They succeeded in intersecting veins with gold values (multiple grams of gold per tonne over less than meter thicknesses; Gosse, 1987; 1988) but the mineralization was highly irregular.

In 1994, Beaton Engineering purchased the property and optioned it to Claimstaker Resources Ltd. At that time a 3700 tonne bulk sample was removed from the Grey Jay and Crow veins and shipped to the Cominco smelter at Trail, B.C. It yielded ~98 kg of gold, equivalent to a grade of 26.5 g/t Au (Beaton, 2011). Additional work between 1994 and 1995 by Claimstaker Resources included 25 diamond-drill holes totalling 1185 m. The claims reverted back to Beaton Engineering in 1997, and in 1998, Orko Gold Corporation purchased the property and completed 23 diamond-drill holes totalling 1171.3 m (Livgard, 1998). Additional trenching and diamond drilling were completed by North American Gems Inc. in 2003 (Beaton, 2011).

In 2009, Encore Renaissance Resources Corp. acquired an option to purchase 60% of the property. As part of the option agreement, Encore Renaissance agreed to extract a permitted 10,000 tonne test sample, in part from a decline to be driven on the Raven vein (Fig. 3). A total of 364.61 tonnes of this vein material was shipped to Kinross Gold's mill in Washington State in September of 2009. The material, most of which was derived from surface trenching north of the decline portal, yielded ~5 kg of gold, equivalent to 16.28 g/t. Underground developments to date have produced a 3 by 3 m 15% decline that is 161 m long (Fig. 3; Beaton, 2011).

3. Regional setting

The oldest rocks at the Bonaparte property include a succession of rusty-weathering, graphitic, and siliceous sedimentary rocks of uncertain age. They have been correlated with the Carboniferous to Permian Harper Ranch Group (Massey et al., 2005) which, at this latitude, are basement to Mesozoic volcanic and sedimentary rocks of the Quesnel terrane (Fig. 2). The Harper Ranch Group rocks were hornfelsed during emplacement of a composite quartz diorite to monzodiorite porphyritic intrusion and dike complex, which is mineralized. These intrusive rocks have been correlated with the Early Jurassic Eakin Creek suite of the Late Triassic to Middle Jurassic Thuya batholith (Anderson et al., 2010; Schiarizza and Israel, 2001), which is part of the regional Early Jurassic Wildhorse-Takomkane plutonic suite of Breitsprecher et al. (2010). Harper Ranch rocks are exposed as inliers near the southeastern margin of an extensive sheet of Chilcotin Group flood basalts (Miocene) that form much of the Bonaparte Plateau.

4. Property geology

The country rock consists of dark, rusty-weathering, polydeformed argillaceous sedimentary rocks of the Harper Ranch Group. These rocks crop out north of the "Discovery Zone" (Fig. 3). At least three discrete intrusive phases cut the Harper Ranch Group rocks; all are overprinted by late hydrothermal quartz and quartz-carbonate veins. Relative ages of the intrusions are readily established from cross-cutting relationships. Brown quartz diorite is the oldest and the most intensely foliated, lineated, and altered. It is cut by the moderately to unfoliated and typically moderately to weakly altered monzodiorite. Aplitic dikes cut the monzodiorite and are unfoliated.

4.1.1. Quartz diorite

The oldest intrusive phase is mafic quartz diorite porphyry ('dark matrix porphyry' of Peatfield, 1986). It is coarse grained with white plagioclase, altered hornblende, and distinctive, sparse blue quartz eyes. Plagioclase crystals are stubby, euhedral, and display oscillatory zoning; crystal glomerocrysts comprise up to 25% of the rock. Matrix minerals are fine-grained prismatic hornblende (20%), and intra-crystalline plagioclase-feldspar ±quartz containing minor to trace biotite, apatite, titanite, magnetite and pyrite (Fig. 4a). The diorite is blocky to slabby weathering, where most intensely foliated and lineated. It is typically biotite-altered and brown, but green where least altered. Black and brown xenoliths of hornfelsed argillaceous country rock are common.

The degree of alteration is directly related to the intensity of foliation development. In weakly foliated diorite, the hornblende is replaced by patchy biotite and chlorite. In well foliated rocks, biotite ±chlorite pseudomorph hornblende. In shear zones, hornblende has been totally replaced by fine-grained biotite-quartz-white mica-carbonate and opaque minerals that define micrometre-thick lamellae that wrap around porphyroclasts of plagioclase (Fig. 4b). In strongly foliated sections plagioclase phenocrysts are rounded and saussuritized to an assemblage of epidote + clinozoisite + white mica.

4.1.2. Monzodiorite

Holocrystalline biotite-hornblende monzodiorite to granodiorite is white to pinkish grey weathering (rusty where pyritic) and grey to greenish-grey on fresh surfaces (Fig. 4c). It is typically medium grained. Quartz comprises ~20% of the rock, locally as rounded quartz eyes and matrix. Up to 10% of the rock is biotite, both as euhedral books and replacements of hornblende. Hornblende and K-feldspar occur as sparse, out-sized crystals up to 1 cm long. Chloritized mafic xenoliths are common, comprising several percent of some outcrops; where less altered, the xenoliths can be recognized as having been originally composed of fine-grained hornblende and biotite.

4.1.3. Granite - aplite

Grey to tan, quartz- and plagioclase-phyric granite dikes are the youngest intrusive phase. They are unfoliated, typically less than 5 cm thick, spaced 10's of cm to 1 m apart, and cut foliation at a high angle. In hand sample, the groundmass is fine grained, and contains minor biotite, and sparse 0.5-1 mm, rounded quartz and euhedral plagioclase phenocrysts (<10%), except at chilled margins (Figs. 4d, e). Sodium cobaltinitrite staining reveals that about 40-45% of the groundmass is K-feldspar. In thin section, the aplite consists of very fine-grained (<0.2 mm) interlocking crystals of quartz and K-feldspar and rare interstitial biotite (Fig. 4d). Disseminated pyrite and chalcopyrite grains are concentrated in the monzodiorite at the contact with aplite, but apparently not within the aplite that we sectioned (Fig. 4e).

5. Structure

Paleozoic sedimentary rocks are folded and foliated; the foliation is cut by a crenulation cleavage. Intrusive rocks cut and thermally metamorphose the structures in the sedimentary rocks and are cut by shear zones.

The main workings ("Discovery Zone") occupy a north-trending, greenschist grade, mylonitic shear zone. Rocks in the shear zone display discrete, meter-wide zones with a well developed fabric that is locally accompanied by a prominent down-dip (east) lineation. The foliation is defined by biotite, quartz, white mica, and carbonate laminae. Preliminary analysis of kinematic indicators including displaced broken grains and feldspar porphyroclasts with sigma- and delta-type geometries (Fig. 4b) suggest an east side-up (reverse) sense of movement. Medial to the shear zones in the plutonic rock are north-trending, (~026^o) east-dipping, decimetre- to metre-thick auriferous quartz veins that continue along strike for up to 250 m (Fig. 3). Younger brittle faults and carbonate-altered quartz veins cross-cut the mylonitic fabric and attest to ongoing hydrothermal alteration and mineral deposition.

6. Alteration

Within the area of the main workings, pyritic, carbonaceous, and calcareous siltstone is locally hornfelsed to pyroxene-diopside facies in some xenoliths, although biotite hornfels is more common for the country rock surrounding the intrusion. East of the main workings, monzodiorite is altered along quartz-lined fractures to a propylitic assemblage of epidote-chlorite-magnetite-pyrite ±actinolite. Locally, irregular patches of very fine grained biotite overprints this assemblage.

Both the quartz diorite and monzodiorite are biotite-altered, but this alteration is especially prevalent and pervasive in the older quartz diorite. Synkinematic potassic alteration is manifested as secondary biotite and orthoclase within gaps between fragments of extended plagioclase porphyroclasts or as a replacement of hornblende.

K-feldspar "pinking" and magnetite veins are conspicuously absent in the areas visited during our work, which included a cursory look at core in collapsed racks. Preliminary lithogeochemistry, thin section, and off-cut staining also indicate low potassium feldspar content for unaltered quartz diorite and quartz monzodiorite. However, positive sodium cobaltinitrite staining of the "grey" aplite suggests it may be a late potassium-rich phase, and that potassium enrichment does not necessarily impart pink colouration.

Carbonate ±pyrite introduced along fractures and quartz vein margins has altered and bleached both quartz diorite and quartz monzodiorite. Sparry calcite fills open spaces between euhedral quartz crystals and is locally accompanied by disseminated arsenopyrite ±gold and perhaps bismuth tellurides (Fig. 5). Probably closely following or accompanying carbonate alteration are discrete narrow zones of carbonate-quartz-pyrite and coarse well-formed books of muscovite. This last alteration type is not widespread or well endowed with sulphide mineralization, but does attest to an evolving hydrothermal system likely related to the intrusive complex.

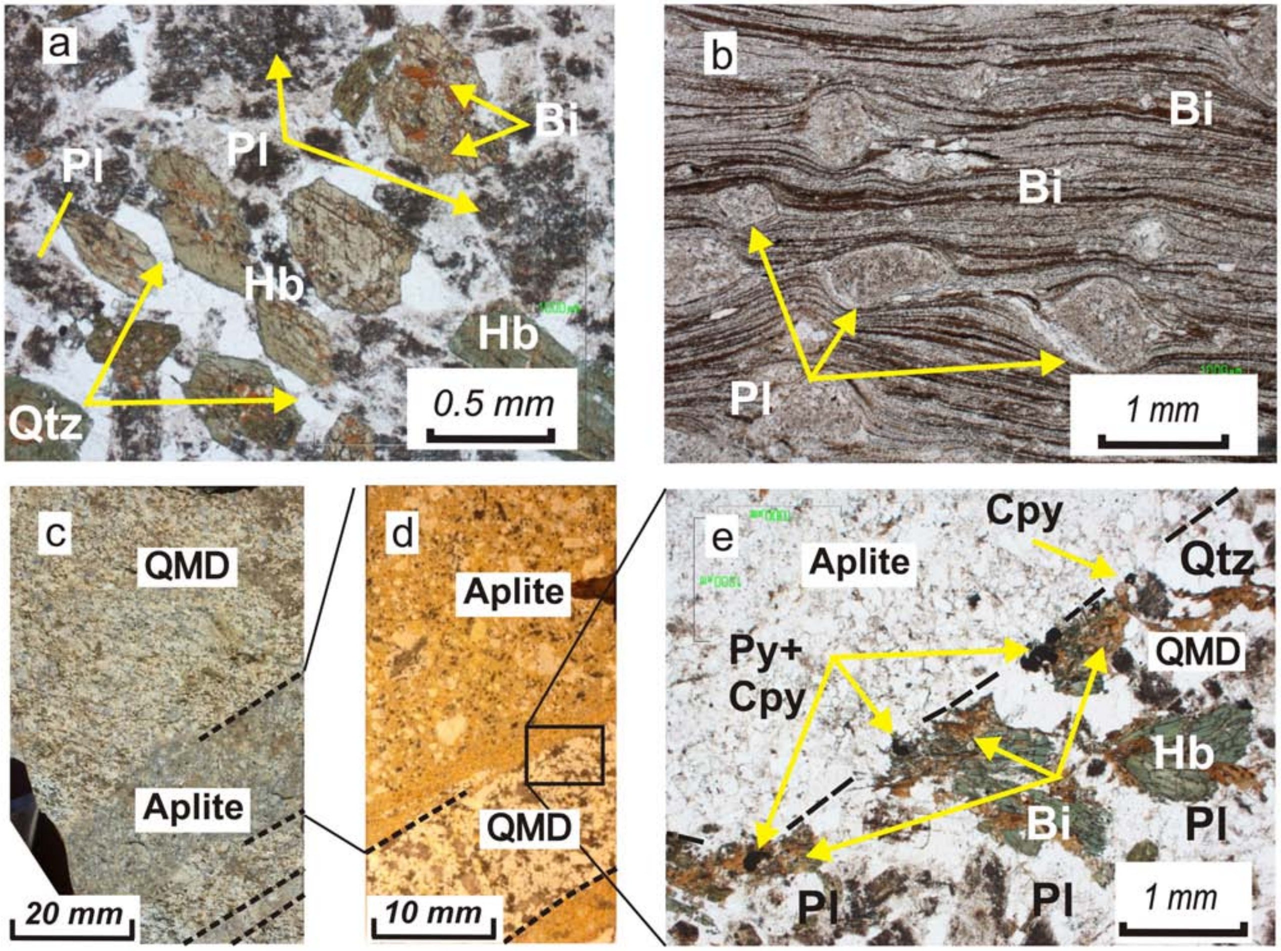

Fig. 4. "Discovery Zone" quartz diorite photomicrographs. **a)** Weakly altered (hornblende replaced by biotite) quartz diorite porphyry, plane polarized light. **b)** Mylonitic quartz diorite footwall to Owl vein displays delta- and sigma-type plagioclase porphyroclasts indicating top to the left movement (in outcrop: up-dip, westward thrust sense), plane polarized light. Mylonitic fabric is defined by laminae of biotite-quartz-sericite-carbonate and opaque minerals. View is to the north, perpendicular to foliation, and containing the mineral lineation. **c)** Thin section offcut showing quartz monzodiorite intruded by aplite. **d)** Offcut stained with sodium cobaltinitrite to highlight K-feldspar (yellow); note chilled contact of aplite. **e)** Photomicrograph in plane polarized light of contact zone between quartz monzodiorite and aplite showing biotite alteration of hornblende and concentration of pyrite and chalcopyrite (sulphides are opaque). Abbreviations: Pl, plagioclase; Hb, hornblende; Qtz, quartz; QMD, quartz monzodiorite; Py, pyrite; Cpy, chalcopyrite.

Secondary muscovite has been separated from alteration vein envelopes cutting the monzodiorite for $^{40}Ar/^{39}Ar$ isotopic analysis to determine its cooling age.

7. Mineralization

High-grade gold at the Bonaparte property has been demonstrated by bulk sampling and previously reported geochemical results (Lee, 1989; Livgard, 1998), and our petrographic analyses (Fig. 6d) and analytical results (see below). Porphyry molybdenum mineralization is reported within and adjacent to the porphyritic hornblende quartz diorite and biotite-hornblende quartz monzodiorite plug. However, drilling and surface sampling to date have returned very low molybdenum values (McClintock, 1987).

The "Discovery Area" (Fig. 3) is 300 m wide and 350 m long. It contains at least eight semi-parallel veins and areas of quartz stockwork. These have been variably exposed at surface by past trenching or defined by drilling. The eight veins include; the Grey Jay, Owl, Crow, Nutcracker, Raven, Eagle-Chickadee, Flicker and Woodpecker. To date, 112 diamond-drill holes totalling over 6784 meters have been completed (Beaton, 2011). The drilling was almost entirely restricted to the Crow, Nutcracker and Grey Jay vein systems to a maximum depth of ~250 m. Most holes were drilled at -45^{o}, effectively testing the intrusion only to a depth of 212 m from surface.

Gold mineralization is hosted in a series of eight north-trending, east-dipping quartz veins (Figs. 3, 6a). The veins cut biotite-altered and silicified diorite porphyry, with the possible exception of the Crow N that is shown extending north into Harper Ranch sedimentary rocks (Beaton, 2011). According to Peatfield (1986) these major veins crosscut the quartz stockwork and therefore

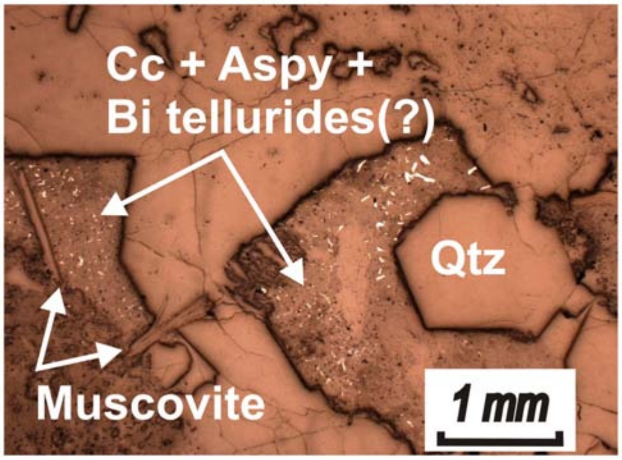

Fig. 5. Plane polarized reflected light photomicrograph of white mica in mineralized quartz-carbonate vein collected from stockpiled ore. Late stage calcite fills open spaces between euhedral quartz crystals. Fine bright white needles of arsenopyrite and possibly bismuth tellurides intergrown with calcite. Abbreviations: Qtz, quartz; Cc, calcite; Aspy, arsenopyrite; Bi, bismuth.

post-date the molybdenum mineralization. Gold grade is generally correlated with sulphide content in the veins (Leitch, 1988; Gosse, 1988); however, restriction of gold mineralization to the quartz veins has not been confirmed. Disseminated chalcopyrite is prevalent in the brown quartz diorite adjacent to the “Crow vein zone”, especially near its contact with younger monzodiorite. A grab sample (MMI12-16-2) of disseminated mineralization from this location returned values of 0.12% Cu, 0.26 g/t Au and 2.2 g/t Ag (Table 1). Chalcopyrite is reported together with molybdenite in silicified zones at the intrusive-country rock contact (Livgard, 1998).

Primary sulphides at Bonaparte include pyrite, pyrrhotite, chalcopyrite, arsenopyrite, (Figs. 6b, c, d,) sphalerite, bismuth-tellurides (Fig. 5) and molybdenite. Scanning electron microscopy has been used to identify gold-, lead- and bismuth- tellurides and native gold of high fineness (no copper and only minor silver, Leitch, 1988). Gangue minerals recognized in thin section include quartz, chlorite, epidote, carbonate, hematite, and white mica.

Peatfield (1986) reported 30 meters of polylithic breccia intersected in DDH NTM86-004 (85.4-115.0 m). Breccia fragments include argillite, hornfels, and intrusive and vein quartz. Sulphides (pyrite, pyrrhotite, ±chalcopyrite) are both in the matrix and fragments, suggesting repeated hydrothermal mineralization and brecciation. Geochemical analyses of this intersection failed to return elevated base or precious metal values (Peatfield, 1986). Nonetheless, this hole is important because it demonstrates the presence of high-level porphyry processes west of the Grey Jay vein and north of the contact with the main intrusion.

8. Summary and conclusions

Our preliminary study reveals the following sequence of events at the Bonaparte property (Fig. 7).

1) Deposition of Paleozoic (?) carbonaceous and calcareous mud to fine sandstone.

2) One, possibly two phases of deformation.

3) Intrusion of quartz diorite and biotite hornfelsing of adjacent country rock.

4) Coincident with 3), east-side up motion along north-trending reverse shear zones (mylonitic fabric; stage 4 in Fig. 7) and alteration.

5) Continued deformation and intrusion of monzodiorite (stage 5 in Fig. 7). Alteration of diorite to secondary biotite and chlorite assemblages and introduction of disseminated chalcopyrite with gold and silver values (stage 5a in Fig. 7).

6) Brittle deformation and dilation adjacent to contact zones with diorite and focusing of quartz-pyrite and chalcopyrite veins.

7) Continued brittle deformation and quartz-carbonate-sericite-chalcopyrite-arsenopyrite and -gold veining across early foliation in diorite (stage 7 in Fig. 7). Carbonate alteration along veins/intrusive contact (stage 7a in Fig. 7). Biotite alteration envelope around veins increasing biotite overprint; propylitic alteration of monzodiorite overprinted by biotite alteration.

8) Cooling and further brittle deformation with intrusion of porphyritic aplite dikes and sparse open-space quartz-carbonate-pyrite veins.

Previously reported quartz stockwork zones with molybdenum mineralization could not be confirmed. However, shear-hosted gold-chalcopyrite quartz veins have been verified by this study. Ever since gold-mineralized float was first discovered at the Bonaparte in 1985, work has focused primarily on evaluating the potential of the quartz vein mineralization. Nonetheless, the metal and alteration assemblages at Bonaparte are shared by porphyry deposits of the Early Jurassic Takomkane-Wildhorse magmatic belt (i.e. Brenda Cu-Mo porphyry and the Woodjam Au, Cu-Mo porphyry; Fig. 2), inviting speculation that the Bonaparte mineralization discovered to date represents an upper level of a buried porphyry system. This hypothesis is being addressed through ongoing U-Pb zircon and Ar^{40}-Ar^{39} white mica isotopic age determination aimed at testing the assumed Early Jurassic age of the Bonaparte intrusions and synchroneity of gold mineralization.

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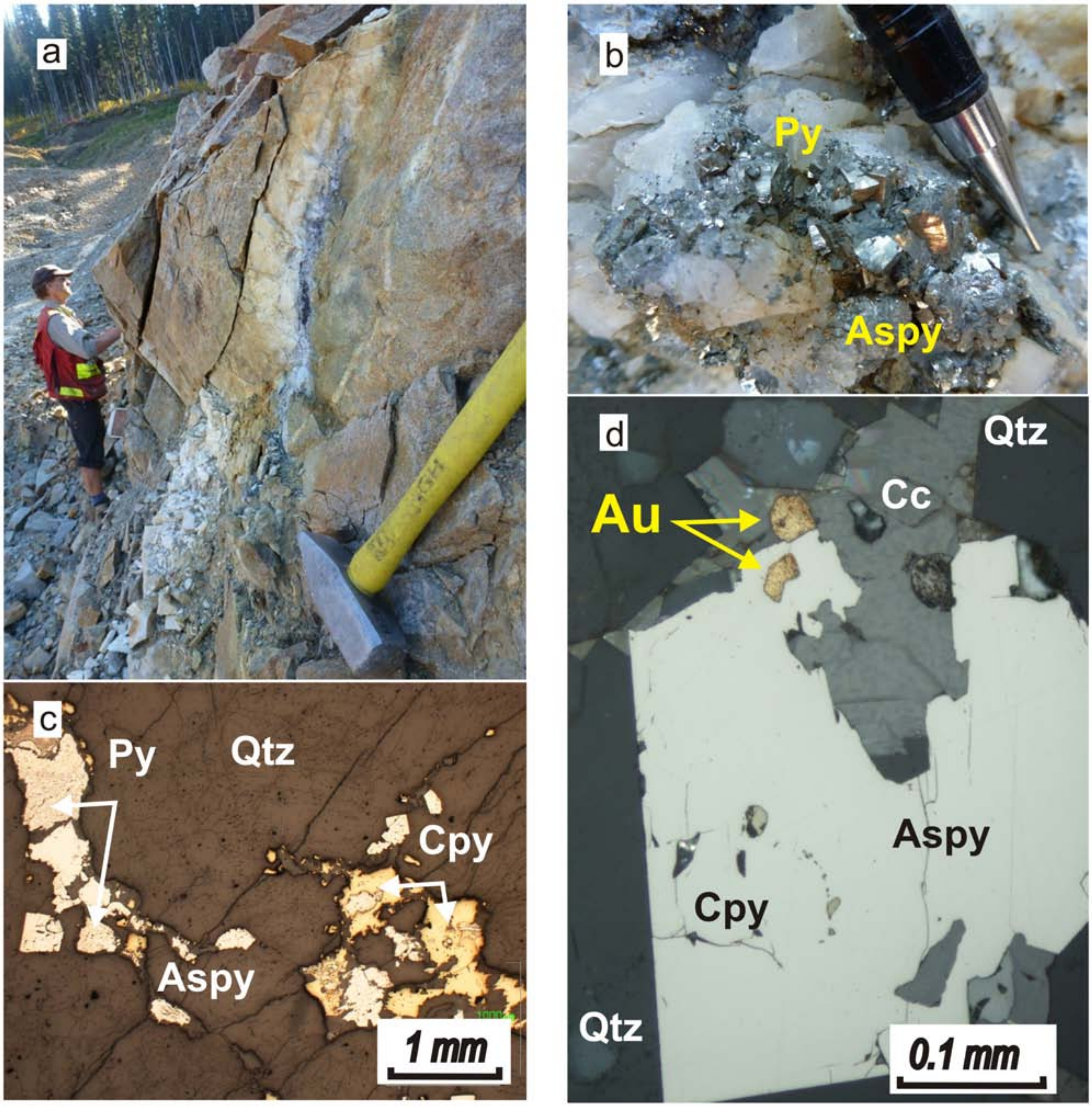

Fig. 6. Quartz vein mineralization. **a)** Biotite-altered, silicified, and mineralized quartz diorite footwall rock to the Crow S vein has been mostly removed from the trench now occupied by geologist, view to south. **b)** Detail of quartz vein in a) showing coarsely crystalline pyrite and arsenopyrite intergrowths. **c**) and **d)** Plane polarized reflected light photomicrographs of mineralized quartz vein material. In c), intergrowth of pale spongy pyrite, brassy chalcopyrite and lesser arsenopyrite (white). In d) arsenopyrite crystal with inclusions of chalcopyrite (appearing as very pale yellow against bright background) and irregular contact (? replacement) with carbonate and deposition of gold grains (~25 μ across). Abbreviations: Qtz, quartz; Cc, calcite; Py, pyrite; Aspy, arsenopyrite; Cpy, chalcopyrite; Au, native gold.

Table 1. Selected geochemical results of mineralized samples collected during the 2012 property visit.

		Analyte	Ag	As	Au	Ba	Bi	Ca	Cd	Ce	Co	Cr	Cu	Fe	Hf	K	La	Li	Mg	Mn	Mo
		Unit	PPB	PPM	PPB	PPM	PPM	%	PPM	PPM	PPM	PPM	PPM	%	PPM	PPM	PPM	PPM	%	PPM	PPM
		MDL	2	0.1	0.2	0.5	0.02	0.01	0.01	0.1	0.1	0.5	0.01	0.01	0.02	0.1	0.5	0.1	0.01	1	0.01
Station Number	Easting	Northing																			
12JLO50-30z	679297	5653683	399	8.1	38.3	96.2	0.02	4.03	0.1	5.2	4.8	34.1	131.1	1.55	0.03	0.18	2.5	5.4	0.4	614	5.12
12JLO50-38	679121	5653664	17	0.6	1.8	323.4	<0.02	1.74	0.05	39.4	7	43.3	4.09	3.23	0.32	1.58	20.3	15.6	1.17	718	0.03
12JLO50-39-2	679239	5653736	68	1.6	1.1	61.7	<0.02	1.07	0.02	5.8	8.8	55	111.04	2.13	0.08	0.16	2.9	7.4	0.54	376	4.79
MMI-12-16-2	679117	5653670	2202	9.9	261.3	201.1	0.18	1.46	0.46	36.8	9.8	28.2	1209.52	3.27	0.32	0.96	18.5	8.4	1.01	657	0.14

		Analyte	Na	Nb	Ni	P	Pb	Rb	S	Sb	Sc	Sn	Sr	Th	Ti	U	V	W	Y	Zn	Zr
		Unit	%	PPM	PPM	%	PPM	PPM	%	PPM	PPM	PPM	PPM	PPM	%	PPM	PPM	PPM	PPM	PPM	PPM
		MDL	0.001	0.02	0.1	0.001	0.01	0.1	0.02	0.02	0.1	0.1	0.5	0.1	0.001	0.1	2	0.1	0.01	0.1	0.1
Station Number	Easting	Northing																			
12JLO50-30z	679297	5653683	0.05	<0.02	3.3	0.05	1.29	3.4	0.13	1.67	1	<0.1	143.3	0.5	0.00	0.20	12	0.1	5.79	22.6	1.1
12JLO50-38	679121	5653664	0.15	0.14	3.1	0.12	2.12	71.1	0.04	0.1	11.4	0.7	80.5	7.2	0.21	0.80	98	<0.1	7.35	65	6.5
12JLO50-39-2	679239	5653736	0.15	0.05	5.2	0.06	0.77	5.2	0.61	0.13	1.2	<0.1	67.1	0.8	0.07	0.30	28	<0.1	2.44	25.7	1.3
MMI-12-16-2	679117	5653670	0.06	0.1	3	0.12	1.76	32.3	0.6	1.71	11.6	0.6	46.2	7.9	0.14	1.3	88	0.2	8.88	78.2	11.6

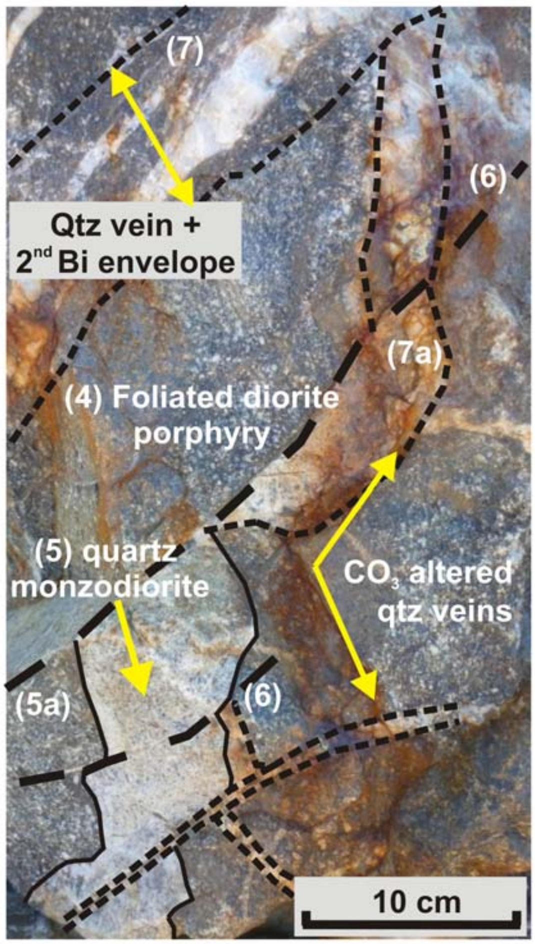

Fig. 7. Partial synopsis of Bonaparte intrusion, strain, alteration, and mineralization history (numbers correspond to events in text). Photograph of foliated brown quartz diorite porphyry **(4)** and quartz monzodiorite **(5)**. The quartz monzodiorite is chilled along its contact with biotite-altered quartz diorite **(5a)**. Quartz diorite and quartz monzodiorite are crosscut bybrittle faults **(6)**. Episodic quartz veining along north-trending lithologic contacts **(6a)**. Extension gashes with introduction of sulphides and gold; enveloped by secondary biotite **(7)**; carbonate alteration along veins/intrusive contacts **(7a)**. Abbreviations: Cc, calcite; Qtz, quartz; Bi, biotite.

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