Mineralization and Alteration Associated with an Hypothesized Copper (Molybdenum) Porphyry System in the Taseko Lakes Area, Southwestern British Columbia (NTS 092O/04)

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Introduction

Porphyry copper deposits are one of the world's primary sources of Cu, Mo and, to a lesser degree, Au (Lowell and Guilbert, 1970; Sillitoe, 1979). They are typified by large regions of hydrothermally altered rock that extend outward from a causative intrusion (Lowell and Guilbert, 1970; Dilles et al., 2000; Seedorf et al., 2005; Cannell et al., 2005). Alteration zone patterns are commonly complex owing to multiple pulses of hydrothermal flow that result in multiple, overprinting, alteration events and/or complex fluid flow paths. Being able to recognize the distal hydrothermal footprint of a porphyry system and understand its spatial and temporal relationships to the mineralized core is fundamental to understanding the development of, and exploring for, such systems.

The Taseko Lakes area of British Columbia is located near the eastern limit of the Coast Plutonic Complex, and it is along this boundary that many important subalkaline Cu-(Mo-Au) porphyry deposits are located. Examples of porphyry deposits include the Prosperity deposit, formerly known as Fish Lake, and the Taseko Empress and Chita showings (Figure 1). This study focuses on a porphyritic intrusion, informally named the Hub, exposed along the Tchaikazan River near Fishem Lake (Figure 2). The mountains immediately north of this exposure are characterized by large expanses of largely propylitically altered Cretaceous andesitic and marine sedimentary rocks. Small copper mineral showings are known within this expanse of altered rock. Three of these showings — the Hub, Charlie and Northwest Copper — have been examined as part of this study. The Charlie and Northwest Copper showings were named by International Jaguar Equities Inc. (MINFILE 092O 043; MINFILE, 2007).

The main objectives of this study, which has been undertaken as an M.Sc. project by the senior author, are to develop a framework for the evolution and development of the showings and assess their relationships to conceptual models of porphyry mineralization within a magmatic-hydrothermal system. To attain these objectives, detailed maps of geology, alteration and mineralization of selected areas will be produced. Petrographic analysis is key in order to recognize subtle variations in mineral assemblages and textures. Fluid inclusions will be used to determine the physical conditions of mineralization. Geochronology will be used as a tool to determine the age of mineralization by isotopic dating of intrusions, country rocks and alteration assemblages. The current paper is a summary of the second season of field work.

Integration of detailed geological and alteration mapping, geochronological and geochemical information is essential to fully understand the magmatic-hydrothermal system within the Taseko Lakes region.

Regional Geological Setting

The Taseko Lakes area of British Columbia is located near the eastern limit of the Coast Plutonic Complex, and it is along this boundary that many important subalkaline Cu-(Mo-Au) porphyry deposits are located, including the Prosperity and Taseko Empress deposits and the Chita showing.

The study area straddles the boundary between the southwest and southeast Coast Belt. The southwest Coast Belt consists of Middle Jurassic to mid-Cretaceous plutonic rocks and Early Cretaceous volcanic rocks (McLaren, 1990). The southeast Coast Belt includes rocks of the Bridge River accretionary complex, the Cadwallader arc terrane and overlying clastic rocks of the Tyaughton-

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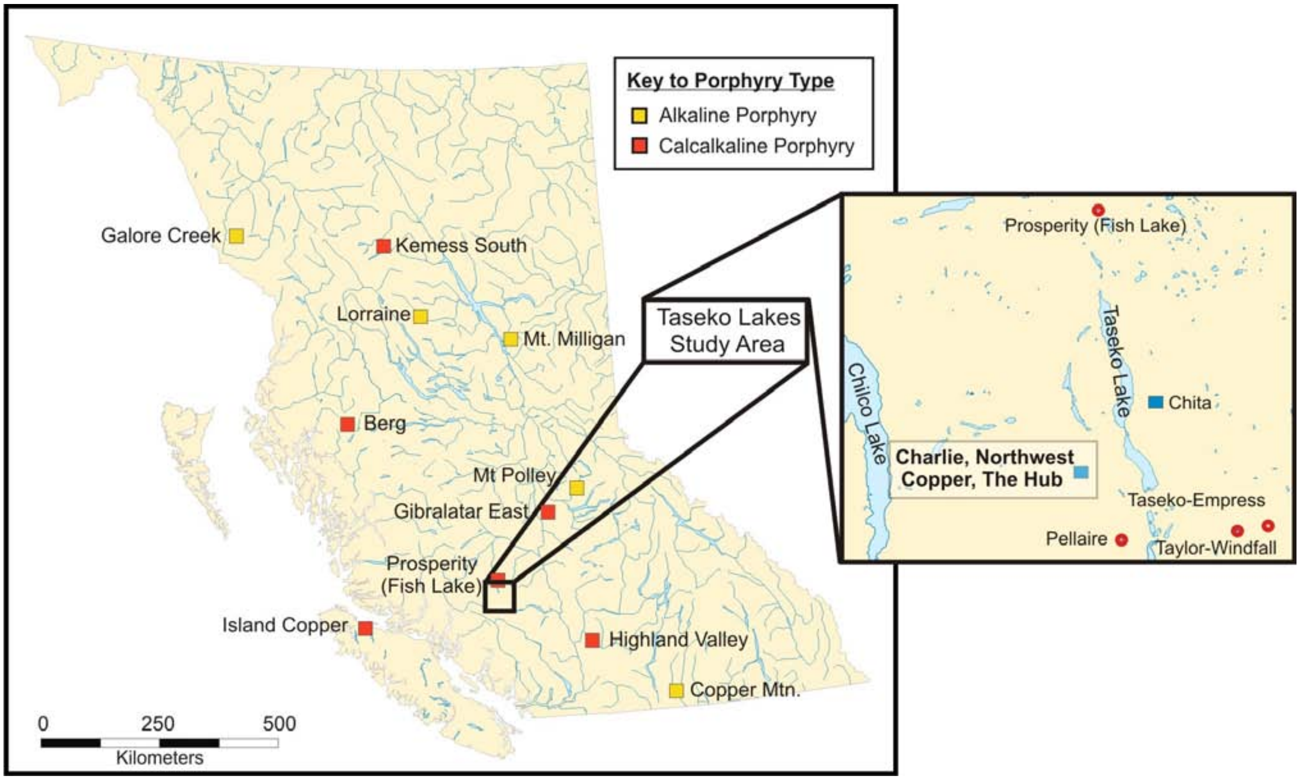

Figure 1. Locations of major alkaline and calcalkaline porphyry copper deposits in British Columbia. The inset map shows the location of major deposits within the Taseko Lakes study area.

Methow Basin (Schiarizza et al., 1997; Monger and Journeay, 1994).

The field area was mapped by Tipper (1969) at a scale of 1:1 000 000 as part of a regional mapping project. More recently, McLaren (1990) and Israel (2001) have mapped parts of the area. A short study of alteration assemblages in the vicinity of the Northwest Copper showing was done as part of an undergraduate honours thesis at the University of British Columbia (Bruce, 2000). The study area is located approximately 10 km south of the well-defined Prosperity Cu-Mo porphyry deposit and 50 km south of Williams Lake (Figure 1). Several past-producing deposits, including the Pellaire (Au) and Taseko Empress (Cu-Au) mines, are located within the district, in a zone that has been explored for potential economic targets for over a century.

Geological Setting of the Study Area

Introduction

The study area is underlain by several rock units of Cretaceous age. These include volcanic and volcano-sedimentary rocks of the Early Cretaceous Tchaikazan River succession and Late Cretaceous Powell Creek Formation (McLaren, 1990; Israel, 2001). The three mineral showings that are the focus of this study are hosted by these Cretaceous rocks. In this report, the Charlie and Northwest Copper mineral prospects are described together, separately from the description of the Hub showing. This separation is based upon differences in rock types, mineralization and alteration observed at the three showings. Hub is the informal name given to a series of geological trenches that parallel the Tchaikazan River (Figure 2). Rocks present in these trenches are an altered porphyritic granodiorite, a diorite, a magnetite±biotite–cemented igneous breccia, and a late-stage, altered quartz-feldspar (QF) porphyry dike that cuts the granodiorite and the breccia. Copper-molybdenum mineralization at the Hub showing is disseminated within all three of these rock types. The Charlie and Northwest Copper prospects are located approximately 300 m topographically above the Hub showing. Copper-molybdenum mineralization at these showings occurs in veins that are typically within the volcanic facies of both the Tchaikazan River succession and the Powell Creek Formation.

Hostrocks

Powell Creek Formation

The Powell Creek Formation was previously described by Hollis et al. (2007). Simply, it is an extensive package of interbedded, nonmarine volcanic and volcaniclastic rocks of Late Cretaceous age (Schiarizza et al., 1997). Hostrocks to the Northwest Copper prospect are massive, maroon andesite flows; volcanic breccias; and resedimented volcanic

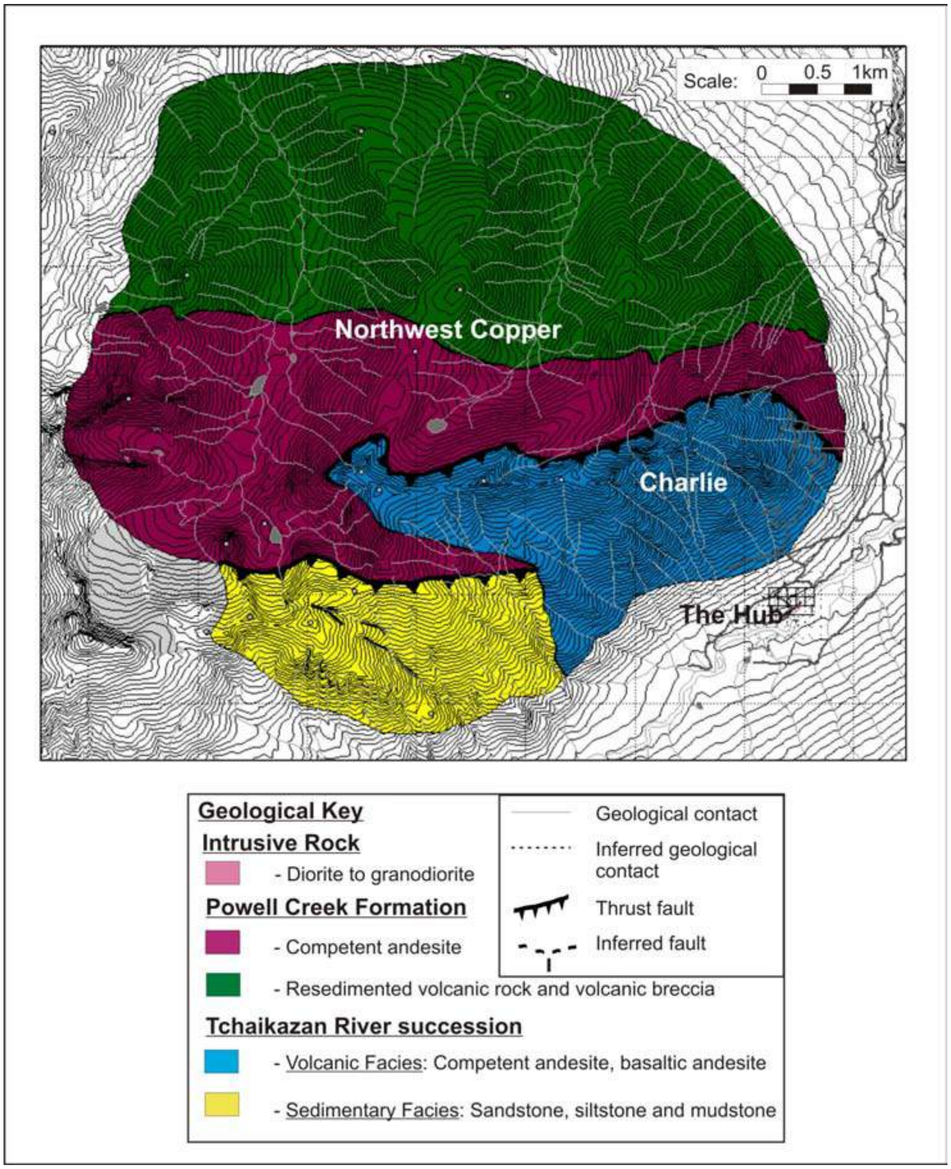

Figure 2. Geology of the Taseko Lakes study area.

flow units. The massive facies consists of large packages of volcanic rocks characterized by porphyritic or aphyric textures. Andesite is the dominant rock type in the massive facies. Plagioclase and hornblende are the dominant phenocryst components in the andesite and are typically altered to chlorite. The age of the Powell Creek Formation is interpreted to be Cenomanian (Schiarizza et al., 1997). Intrusive rocks are present throughout Northwest Copper prospect; these are typically feldspar-hornblende porphyry dikes and diorite intrusions. The age of the intrusive rocks is as yet unknown but they may be as young as Eocene. The base of the Powell Creek Formation is intruded by the 92 Ma Dickson-McClure batholith and Schiarizza et al. (1997) noted that the formation overlies Albian–Cenomanian rocks. The base of the Powell River Formation must therefore be Turonian (93.5 ±0.8 to 89.3 ±1 Ma) in age.

Volcanic Facies of the Tchaikazan River Succession

The volcanic facies of the Tchaikazan River succession is dominated by the intercalation of subaqueous to subaerial volcanic rocks, typically andesite in composition (Israel, 2001), with minor, shallow marine, clastic sedimentary rocks. The volcanic facies stratigraphically overlies the sedimentary rocks of the Tchaikazan River succession. Massive andesite flows, some greater than 50 m thick, dominate the upper part of the volcanic facies (Figure 3a). Peperitic contacts (Figure 3e) with the sedimentary rocks are also present at higher elevations, particularly near the Charlie showing. Since peperite textures form as a result of

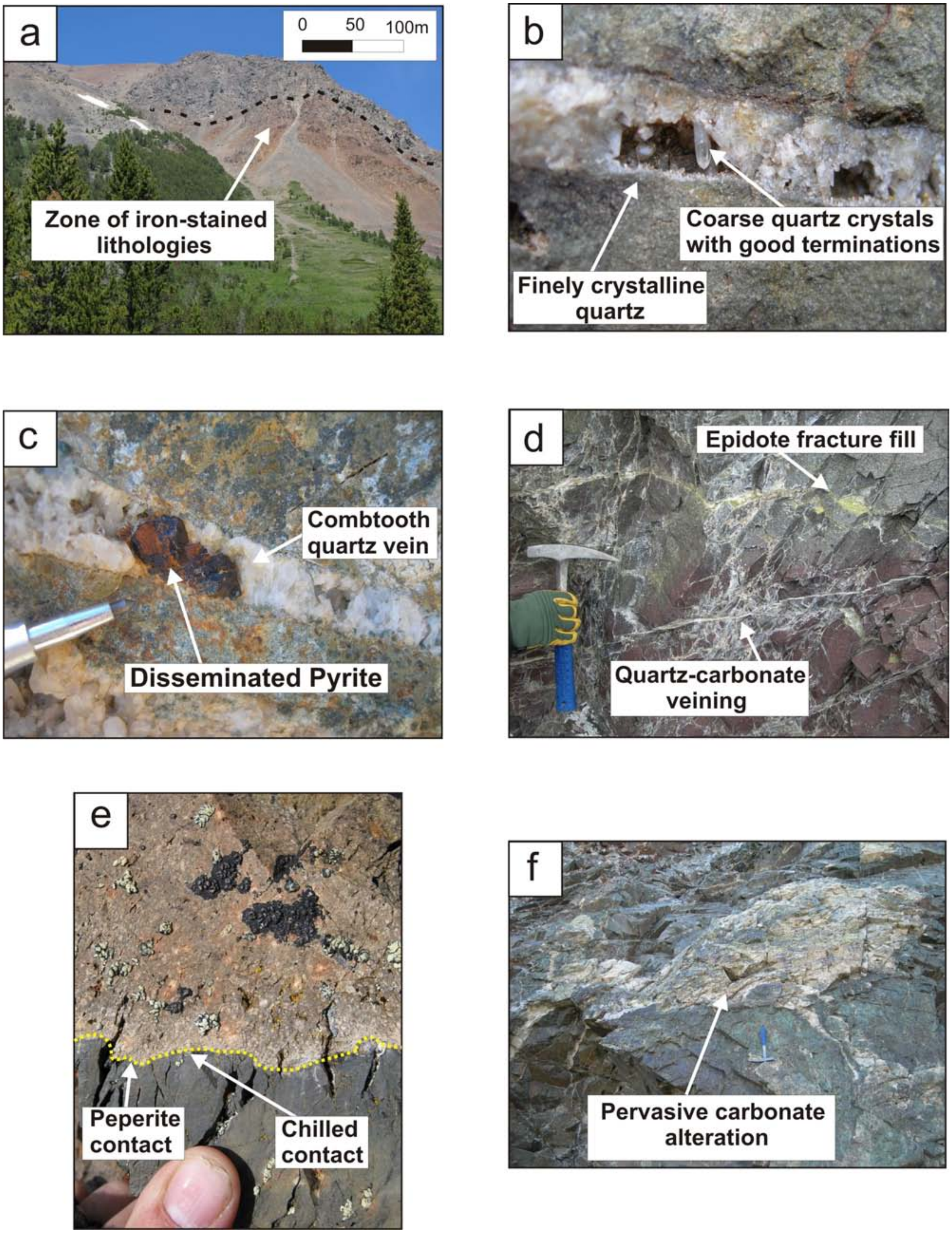

Figure 3. Photographs of the Charlie showing: **a**) view of the Charlie showing, taken from the Hub showing; the rusty red outcrops are phyllic altered rocks, contrasting with the propylitic altered andesite; **b**) comb tooth quartz vein in andesite hostrock; **c**) comb tooth quartz vein with centre fill of coarse, disseminated chalcopyrite centre fill; **d**) epidote and quartz-carbonate stock work veining; **e**) peperite contact between sediments and an andesite; and **f**) area of pervasive carbonate alteration in propylitic altered andesite of the Tchaikazan River Succession.

the intrusion and subsequent mingling of magma with unconsolidated or poorly consolidated, typically wet, sediments (White et al., 2000), their occurrence in the study area indicates the close relationship between subaqueous and volcanic environments in the Early Cretaceous rocks.

Sedimentary Facies of the Tchaikazan River Succession

The sedimentary facies of the Tchaikazan River succession is highly variable in grain size, bed thickness, sedimentary structure and rock type. Common rock types include medium- to coarse-grained, well-sorted sandstone, conglomerate, siltstone and mudstone. Soft sediment deformation is common, particularly in interbedded sequences of mudstone and medium- to coarse-grained sandstone. Bedding is often planar and sometimes undulating, but contacts are generally sharp. Black mudstone dominates and is often found in association with lenses of fine sandstone. Rocks of the sedimentary facies are often intercalated with minor volcanic rocks of the Tchaikazan River succession, especially toward the inferred upper parts of the sedimentary facies.

Many parts of this sedimentary sequence have been interpreted in this study as parts of a Bouma Sequence. In theory, a Bouma Sequence comprises clastic sediments deposited in response to a waning turbidite flow. A complete Bouma Sequence, from base to top, consists of laminated siltstone and fine pelagic mudstone, crosslaminated sandstone with ripple mark, parallel-laminated sandstone, massive sandstone and a highly erosive base with tool mark (Shanmugam, 1997). The sedimentary facies of the Tchaikazan Succession consists of coarse, chaotic clastic sedimentary rocks, often overlain by successively finer grained, well-bedded sandstone and mudstone. The B, C and E facies of a Bouma Sequence were frequently observed in the sedimentary facies of the Tchaikazan River succession. The B facies was the most common, forming well-bedded, parallel-laminated sandstone. Fossil material was observed within the sedimentary rocks, typically consisting of crinoids, bivalves and brachiopods, together with abundant trace fossils. Bioturbation occurs in finer grained units.

Areally extensive packages of sediment-dominated facies and a volcanic-dominated facies of the Tchaikazan River succession dominate the Charlie and Northwest Copper showings, forming the hostrocks to porphyry-style mineralization and alteration. Fossil evidence from these units suggests an age as old as 140 Ma (Berrasian), whereas U-Pb dates from abraded zircon fractions from a crosscutting intrusion (McLaren, 1990; Israel et al., 2006)) suggest an age older than 102 ±2 Ma, which is consistent with fossil evidence.

Showings Studied

Hub Showing

The Hub mineral showing is a prospect that is exposed in geological trenches along the Tchaikazan River. Several igneous rock types, including a porphyritic granodiorite (Figure 4), a diorite, and a quartz-feldspar porphyry dike (QF porphyry) account for greater than 90 % of all exposure.

Intrusive Rocks

The intrusive rocks exposed at the Hub showing are granodiorite to diorite in composition. Several intrusive phases have been recognized:

1) The main phase is coarsely crystalline granodiorite with a strong porphyritic texture. The granodiorite is composed of zoned plagioclase (~50%), quartz (~20%), biotite (10–25%) and hornblende (5%) phenocrysts in an aphanitic, plagioclase-quartz–dominated groundmass (Figure 4a).
2) A diorite intrusion appears to crosscut the main phase granodiorite. The diorite is identifiable by changes in mineralogy that are in contrast to the granodiorite. The rock is darker than the granodiorite and appears to contain a greater percentage of biotite and hornblende.
3) Quartz-feldspar (QF) porphyry differs from other intrusive rocks in that it is clearly a linear intrusion, likely a dike, that trends approximately northwest and is approximately 3 m thick. The dike is highly altered. It has a strongly porphyritic texture with plagioclase (~35%) and hornblende phenocrysts (15–20%), with chlorite replacing primary hornblende. The groundmass is aphanitic and appears to be largely dominated by altered feldspar. The QF porphyry is younger than the other intrusive phases as it cuts across them and displays chilled margins.

The Hub granodiorite has a cooling age (Ar-Ar, biotite) of 80.53 ±0.42 Ma. The diorite yielded a cooling age (Ar-Ar, biotite) of 79.56 ±0.42 Ma (T. Ullrich, pers. comm., 2006). The late QF porphyry dike is unmineralized and crosscuts both these igneous phases, and is therefore younger and post-mineralization. A whole rock age of 77.2 ±2.8 Ma (T. Ullrich, pers. comm., 2006) was obtained for the Prosperity deposit by J.E. Harakal at the University of British Columbia. This is considered to be the age of mineralization at the Prosperity deposit and is similar to that inferred for mineralization at the Hub showing.

Hydrothermal Alteration

The granodiorite at the Hub showing is moderately to strongly altered. Primary plagioclase is typically silicified and may be replaced by secondary sericite (Figure 4b) and quartz–magnetite±K-feldspar alteration is extensive. This

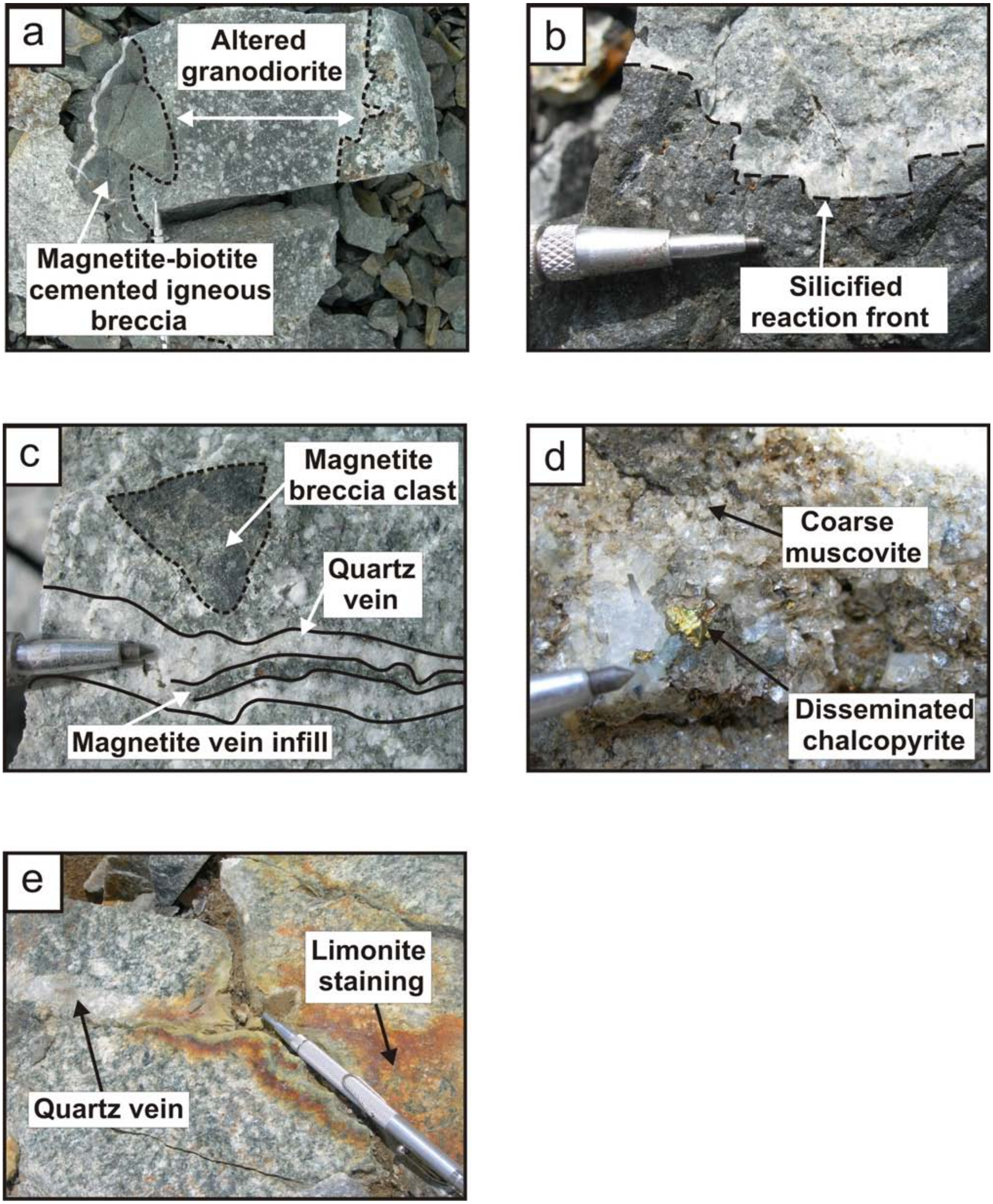

Figure 4. Photographs from the Hub showing: **a**) altered magnetite-biotite granodiorite in contact with magnetite-biotite–cemented igneous breccia; **b**) silicified reaction front with highly altered granodiorite and magnetite-biotite–cemented breccia; **c**) angular magnetite-altered clast in partially altered granodiorite; **d**) coarse disseminated chalcopyrite in centre of quartz-magnetite vein; and **e**) crosscutting quartz veins with secondary Fe-staining, probably a result of supergene weathering of pyrite.

alteration grades into hydrothermal biotite, K-feldspar, and magnetite alteration (Figure 4c) which extensively developed in the granodiorite, diorite and breccia with clasts showing pervasive quartz-biotite. K-feldspar crystals in this zone exhibit regular concentric zoning. Subeconomic quartz–pyrite±chalcopyrite±molybdenite veins with chlorite selvages are present in this altered zone (Figure 4d, e). Magnetite flooding appears to have affected the granodiorite along most of the trench exposures. The magnetite appears to be paragenetically associated with the K-feldspar, quartz, pyrite, chalcopyrite and molybdenite. The granodiorite shows moderate to weak potassic alteration containing the growth of secondary K-feldspar and biotite in the groundmass (Figure 3a).

The altered QF porphyry cuts the granodiorite, diorite, and magnetite±biotite–cemented breccia. The granodiorite, diorite and breccia are associated with porphyry style, stock work quartz veining, potassic alteration, silicification and disseminated Cu-Au mineralization.

Hydrothermal Breccia

A magnetite±biotite–cemented breccia is volumetrically the most abundant alteration facies. It is, however, poorly exposed and its geological architecture and extent are therefore ambiguous. The breccia is poorly sorted, containing up to 30% clasts (whose composition appears to be mostly intensely magnetite-flooded granodiorite) and is matrix-supported. Clasts are generally angular to subangular (Figure 4c) and appear to be highly altered (magnetite-biotite) granodiorite. The hydrothermal cement consists of fine-grained magnetite, biotite, quartz and sulphides. The magnetite±biotite–cemented breccia is characterized by a sometimes intensely brecciated or clastic texture. Parts of the granodiorite appear to be variously altered with infilling of biotite±magnetite in the groundmass. The original igneous texture of the granodiorite is still visible, although in places it has been obscured by pervasive and texturally-destructive biotite-magnetite-quartz alteration. The hydrothermal breccia cuts across the granodiorite and diorite.

Magnetite is abundant in both clasts and cement. The cement contains up to 40% crystalline quartz. In these zones, strong silicification and secondary magnetite are observed in the cement at what appear to be intrusive contacts with the granodiorite (Figure 4b).

Charlie and Northwest Copper Showings

Hostrocks to mineralization and alteration in the area of the Charlie and Northwest Copper showings are typically massive andesite, forming either part of the volcanic facies of the Tchaikazan River succession or the massive andesite of the Powell Creek Formation. These rocks overlie the granodiorite and other intrusive rock types observed at the Hub showing. Resedimented volcanic rocks, which form a large part of the Powell Creek Formation, have also been hydrothermally altered and host sulphide-bearing veins. Rocks of the sedimentary facies of the Tchaikazan River succession are characterized by packages of well-bedded, often fining upwards, clastic sedimentary rocks.

Intrusive Rocks

An intrusion, named here the Northwest Copper intrusion, crops out on the western fringe of the Northwest Copper showing (Figure 5a, b). It is granitic in composition, containing approximately 40% quartz, 30% plagioclase and 30% other minerals, including biotite and hornblende. The intrusion is complex with several compositional variations. The granite intrudes rocks of the Powell Creek Formation and therefore must be younger. The granite contains numerous round xenoliths of the Powell Creek Formation (Figure 5d).

Diorite dikes emanate from the main intrusion and intrude into the overlying rocks of the Powell Creek Formation (Figure 5c, e). These dikes appear to be unaltered and are composed of 25–30% plagioclase feldspar, 10–15% hornblende, and minor biotite, quartz and pyroxene (Figure 5c).

Aplite dikes are abundant and crosscut the granite and the diorite. These dikes are very fine grained and white, with quartz and feldspar being the major minerals. They are likely to have some affinity to the main intrusive body and to be the last part of the magma to crystallize.

A syenite first identified in the 2006 field season (S.K. Blevings, pers. comm., 2006) was also found in the vicinity of the Northwest Copper showings. It is a pink to grey, coarsely crystalline, and K-feldspar-rich with accessory phenocrystic hornblende. It is only exposed in a limited area at the surface (Figure 2) on the central ridge of the Northwest Copper showing. The contact relationship with surrounding rocks of the Powell Creek Formation is unclear. The syenite has yet to be dated, but is unmineralized, and therefore may be a pre- or post-mineralization intrusion.

Mineralization

Mineralization and alteration are similar at the Charlie and Northwest Copper showings and will be described together. Mineralization is typically vein hosted. Veinlets of native copper are hosted by quartz and carbonate composite veins. Copper typically forms veinlets less than 2 mm thick that are identified in the field as a result of the close association of the native copper with bright green malachite (Figure 6e).

Mineralization consists of chalcopyrite-bearing quartz veins. Chalcopyrite, pyrite and galena are the readily identified sulphides in comb-textured quartz veins. Sulphides are characteristically associated with magnetite and biotite.

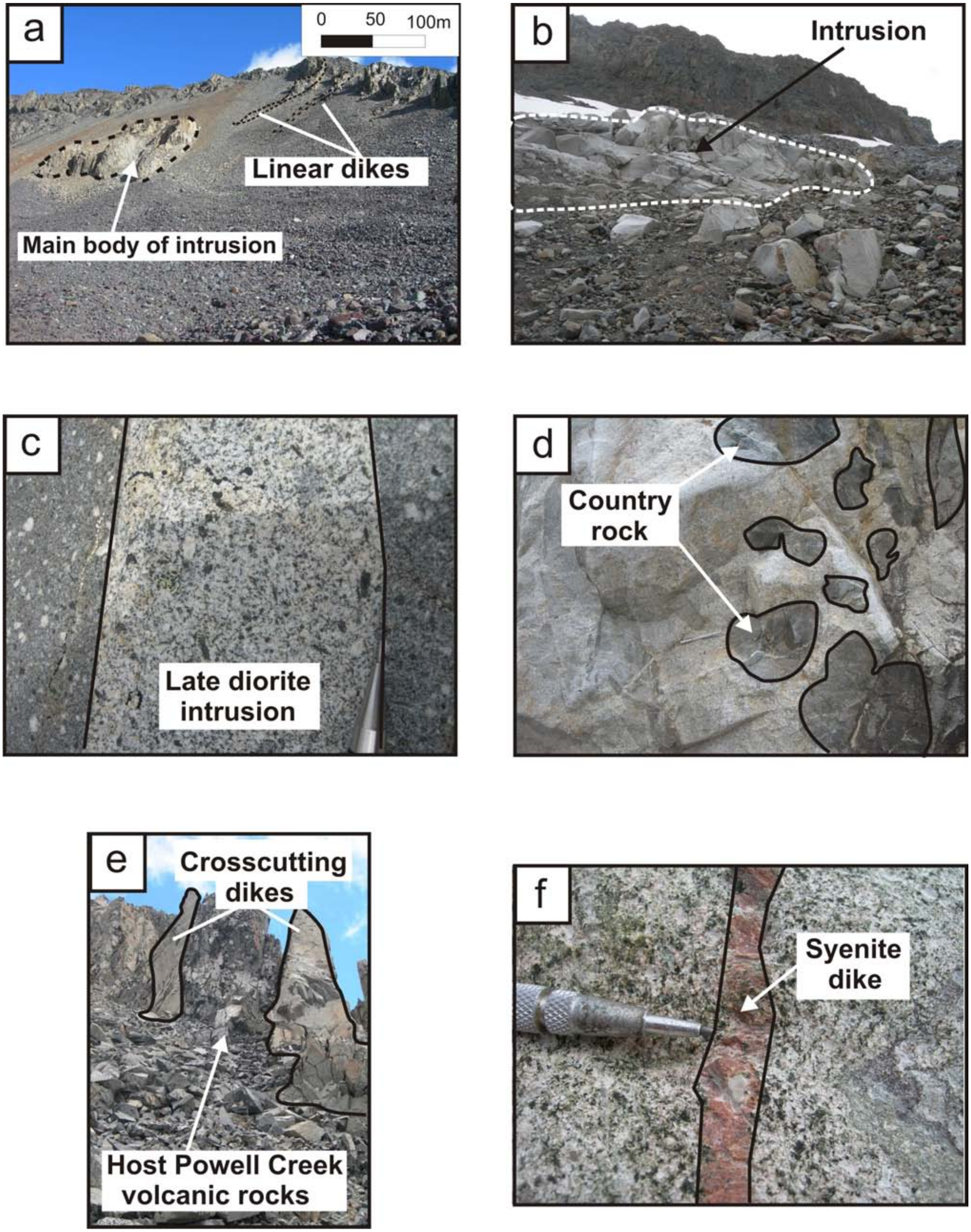

Figure 5. Photographs of the Northwest Copper showing: **a**) view facing north of the Northwest Copper intrusion and associated diorite dikes, **b**) view of the southern part of the intrusion, **c**) planar intrusive contact of diorite dike within host granodiorite intrusion, **d**) round xenoliths of wallrock within the intrusion, **e**) diorite dikes intruding the overlying resedimented volcanic rocks of the Powell Creek Formation, and **f**) syenite dike at the Northwest Copper showing.

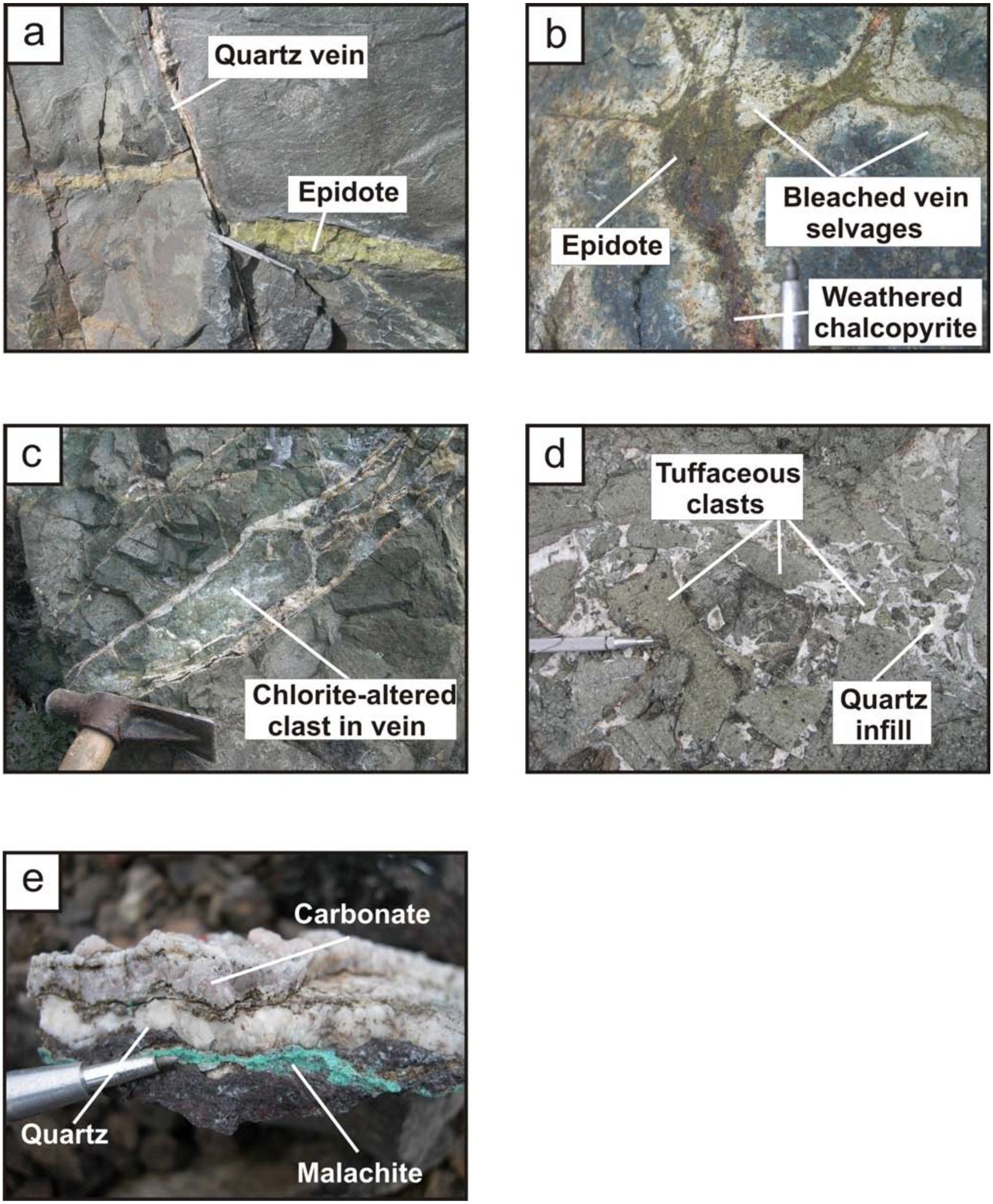

Figure 6. Features of mineralization and alteration at the Charlie and Northwest Copper showings: **a**) late-stage quartz vein offsetting massive epidote vein, **b**) well-developed alteration selvages associated with sulphide-bearing epidote veins, **c**) large clast within vein, **d**) hydrothermal quartz infill between tuffaceous clastic rocks, and **e**) quartz-carbonate vein with secondary malachite.

Pyrite occurs as a secondary mineral disseminated in most of the intrusive phases as well as an alteration product in some of the Fe-bearing sedimentary rocks and propylitically altered andesite. Veins are typically up to 10 cm thick and are usually continuous for several metres. Several are laterally continuous for up to 30 m, but these are barren quartz veins, typically associated with large fault zones. Vein compositions include quartz-only and quartz-carbonate (Figure 4b). Quartz-carbonate is a late stage infill, filling voids between comb quartz crystals. Quartz veins with chlorite selvages (usually millimetre scale) are common.

Hydrothermal Alteration

The alteration mineral assemblages of the Charlie and Northwest Copper showings are dominated by propylitically altered andesite of both the Tchaikazan River succession and the Powell Creek Formation. Phyllic alteration, silicification and advanced argillic alteration are also present.

Chlorite-Epidote±Calcite (Propylitic)

Volcanic rocks are pervasively altered to propylitic mineral assemblages of chlorite-epidote-pyrite, calcite, sericite and magnetite. Hydrothermal minerals such as chlorite, epidote, actinolite, sericite and quartz commonly replace primary phases such as hornblende, biotite and plagioclase. An abundance of chlorite gives the andesite a distinctive dark green colour. Plagioclase crystals are replaced by aggregates of sericite, chlorite and calcite. Chlorite appears to be widespread as a dominant mineral phase but is typically extensively developed in the exterior parts of veins and as zones between veins. Areas adjacent to veins are often propylitically altered, in particular showing the development of chlorite vein haloes, predominantly associated with quartz-only veins. Epidote is commonly associated with chlorite-altered rocks, particularly along fractures (Figure 4d) and often related to quartz veining. Calcite alteration accompanies the propylitic mineral assemblage and areas of pervasive calcite alteration are found at high elevations at the Charlie and Northwest Copper showings (Figure 4g).

Quartz-Sericite-Pyrite (Phyllic)

The alteration assemblage of quartz-sericite-pyrite is manifest in rusty red outcrops of the lower parts of the volcanic facies of the Tchaikazan River succession (Figure 5), where it is pervasive. The porphyritic texture of the rock is often still visible, although sericite-quartz-pyrite mineral assemblages replace the primary components of the groundmass. The alteration is characterized by the substitution of plagioclase by sericite and the mafic components by quartz.

Veins

The northwestern portion of the area of the Charlie and Northwest Copper showings exhibits the highest density of veins in the study area. It also exhibits the widest variety of vein compositions, textures and forms. There are three main vein types: 1) quartz-only, 2) quartz-carbonate and 3) epidote veins. All three vein types may contain sulphides.

1) Quartz-only veins are rare at the Northwest Copper showing. The quartz is often massive (Figure 6a), and there are typically several crosscutting vein generations, with wallrock trapped between generations (Figure 6c). Quartz-only veins are locally common in areas of silicification and are typically associated with secondary malachite and, less commonly, azurite. These veins are altered along their margins, with chlorite selvages that sometimes extend several centimetres into the surrounding hostrocks. Quartz generally forms an hydrothermal fill to brecciated volcanic material. Quartz infill between clasts of a tuff (Figure 6 d) is widespread near the Northwest Copper showing, indicating fluid flow throughout the area.
2) Quartz-carbonate veins are common in the area of the Charlie and Northwest Copper showings. They are several centimetres thick, continue for no more than a few metres and are hosted within the volcanic facies of both the Powell Creek Formation and the Tchaikazan River succession. They typically are not mineralized.
3) Epidote veins are locally abundant, particularly in the altered andesite surrounding the Northwest Copper intrusion (Figure 6b). The epidote is fine-grained and massive and is often associated with minor quartz and disseminated chalcopyrite and pyrite. These veins exhibit well-developed alteration haloes, giving the surrounding, magnetite-rich andesite a bleached appearance that is possibly a result of the introduction of secondary sericite.

Interpretation and Discussion

The Taseko Lakes area is endowed with numerous metallic mineral showings that have yet to be fully described The objective of this study is to classify three of these showings.

The Hub showing is intrusion-related, porphyry Cu±Mo–style mineralization in a granodiorite stock and a stockwork of quartz+chalcopyrite±pyrite veins. The Hub granodiorite has a cooling age (Ar-Ar, biotite) of 80.53 ±0.42 Ma (T. Ullrich, pers. comm., 2006). The Hub diorite yielded a cooling age (Ar-Ar, biotite) of 79.56 ±0.42 Ma (T. Ullrich, pers. comm., 2006). The QF porphyry dike is unmineralized and crosscuts both the granodiorite and the diorite and is therefore younger and post-mineralization. A whole rock age of 77.2 ±2.8 Ma was obtained for the Prosperity deposit by J.E. Harakal at the University of British Columbia (MINFILE 092O 041; MINFILE, 2007), who considered this radiometric age to be the age of mineralization at the Prosperity deposit, and is similar to that determined for mineralization at the Hub showing. The mineralization and alteration style exhibited by the Hub showing shows several characteristics of classic porphyry-style mineralization. These include copper minerals disseminated throughout the intrusion and associated Cu-bearing quartz stockwork veins and the hydrothermal magnetite±biotite–cemented breccia that crosscuts the granodiorite and diorite. Sulphide mineralization, in particular chalcopyrite and molybdenite, is disseminated in the granodiorite and magnetite±biotite breccia and in quartz veins in these rocks. The magnetite±biotite breccia is exposed at the surface at the Hub showing, indicating that breccia emplacement may have been relatively shallow (<3 km). The diorite intrusion can be interpreted as a compositional variation of the granodiorite as a result of differentiation.

The Charlie and Northwest Copper showings are vein-hosted, with typical metallic minerals, including chalcopyrite, pyrite, galena and native copper. Alteration assemblages are different from those at the Hub showing. Propylitic mineral assemblages dominant in the Charlie and Northwest showings, with discrete areas of silicification and phyllic alteration also observed. This is in contrast to the potassic alteration and silicification observed at the Hub showing. These alteration assemblages are interpreted to be early alteration in the central parts of the mineralization at the Hub showing. An intrusion in the area of the Charlie and Northwest Copper showings has yet to be dated, but must be younger than the Powell Creek Formation since it intrudes these upper Cretaceous rocks.

The question remains whether the study area displays evidence for a single hydrothermal event or multiple events. Based on the alteration sequences, crosscutting veins and geochronology, alteration and mineralization appear to have formed as overlapping episodes during the evolution of an hydrothermal system. Mineralization is hosted by the main Hub granodiorite and the magnetite±biotite–cemented breccia, and vein-hosted sulphides are present in overlying andesite and basaltic andesite rocks of the Tchaikazan River Succession and Powell Creek Formation at the Charlie and Northwest Copper showings. The hydrothermal mineralization and alteration events consist of two spatially overlapping and overprinting stages: 1) potassic, propylitic and phyllic alteration with associated Cu-Mo mineralization, and 2) quartz-sulphide veins with associated magnetite alteration. Potassic alteration is represented by relicts of K-feldspar, magnetite and biotite, and appears to pass outwards into propylitic mineral assemblages of chlorite-epidote-calcite. Most of the copper mineralization occurs as disseminated chalcopyrite, accompanied by pyrite and magnetite, replacing mafic minerals in potassic-altered hostrock.

In conclusion, the rock types and alteration assemblages present at the Hub, Charlie and Northwest Copper prospects show evidence of porphyry-related mineralization and hydrothermal alteration. The question remains whether these showings are related to the same hydrothermal system at depth or whether they represent part of a proximal to distal facies of a large-scale, widespread porphyry system in which the rocks in the vicinity of the Charlie and Northwest Copper showings were altered in response to a large-scale system at depth.

Future Work

Much of what is known about the physical-chemical evolution of magmatic hydrothermal fluids between the plutonic regime of porphyritic granitoid bodies and the meteoric regime is based upon fluid inclusions in veins from porphyry-hosted ore deposits (Dilles et al., 2000). Following detailed petrographic study of fluid inclusions using transmitted light, further work in this study will be focused upon an in-depth study of the fluid inclusions themselves and what they can reveal about the conditions of formation of the veins in the region. Defining the hydrothermal features and related altered rock types of these showings will be of value for exploration in the Taseko Lakes region, especially given recent work on the advanced Prosperity deposit.

The further application of geochronological methods to date the Northwest Copper intrusion is of importance in relating this intrusion to those already identified in the study area and to those within the broader porphyry environment of southwestern British Columbia.

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References

Bruce, J.O. (2000): Alteration and mineralogy associated with the Northwest Copper prospect, Taseko Lakes region, south-central, British Columbia; undergraduate thesis, University of British Columbia.

Cannell, J., Cooke, D.R., Walshe, J.L. and Stein, H. (2005): Geology, mineralization, and structure of the El Teniente porphyry Cu-Mo deposit; Economic Geology, v. 100, p. 979–1003.

Dilles, J.H., Einaudi, M.T., Proffett, J and Barton, M.D. (2000): Overview of the Yerington Porphyry Copper District; magmatic to nonmagmatic sources of hydrothermal fluids; their flow paths and alteration effects on rocks and Cu-Mo-Fe-Au ores; Society of Economic Geologists, Guidebook Series, v. 32. p. 55–66.

Garver, J.L. (1992): Provenance of Albian–Cenomanian rocks of the Methow-Tyaughton basin, southern British Columbia; a mid-Cretaceous link between North America and the Insular Superterrane; Canadian Journal of Earth Sciences, v. 29, p. 1274–1295.

Hollis, L., Blevings, S.K., Chamberlain, C.M., Hickey, K.A. and Kennedy, L.A. (2007): Mineralization, alteration and structure of the Taseko Lakes region (NTS 092O/04), southwestern British Columbia: preliminary analysis; *in* Geological Fieldwork 2006, BC Ministry of Energy, Mines and Petroleum Resources, Paper 2007-1 *and* Geoscience BC, Report 2007-1, p. 297–306.

Israel, S. (2001): Structural and stratigraphic relationships within the Tchaikazan River area, southwestern British Columbia: implications for the tectonic evolution of the southern Coast Belt; M.Sc. thesis, University of British Columbia, 129 p.

Israel, S., Schiarizza, P., Kennedy, L.A., Friedman, R.M. and Villeneuve, M.E. (2006): Evidence for Early to Late Cretaceous, sinistral deformation in the Tchaikazan River area, southwestern British Columbia: Implications for the evolution of the southern Coast Belt; *in* Paleogeography of the western North American Cordillera, J. Haggart, R. Enkin and J.W.H. Monger (ed.), Geological Association of Canada, Special Paper 46, p. 331–350.

Lowell, J.D and Guilbert, J.M. (1970): Lateral and vertical alteration-mineralization zoning in porphyry ore deposits; Economic Geology, v. 65, no. 4, p. 373–408.

McLaren, G.P. (1990): A mineral resource assessment of the Chilko Lake planning area; BC Ministry of Energy, Mines and Petroleum Resources, Bulletin 81, 117 p.

MINFILE (2007): MINFILE BC mineral deposits database; BC Ministry of Energy, Mines and Petroleum Resources, URL <http://www.em.gov.bc.ca/Mining/Geolsurv/Minfile/>.

Monger, J.H.W. and Journeay, J.M. (1994): Guide to the geology and tectonic evolution of the southern Coast Mountains; Geological Survey of Canada, Open File 2490, 81 p.

Schiarizza, P., Gaba, R.G., Glover, J.K., Garver, J.I. and Umhoefer, P.J. (1997): Geology and mineral occurrences of the Taseko –Bridge River area; BC Ministry of Energy, Mines and Petroleum Resources, Bulletin 100, 291 p.

Schanmugam, G. (1997): The Bouma sequence and the turbidite mind set; Earth Science Reviews, v. 42, no. 4, p. 201–229.

Seedorf, E., Dilles, J.H., Jr., Einaudi, M.R., Zurcher, L., Stavast, W.J.A., Johnson, D.A. and Barton, M.D. (2005): Porphyry copper deposits: characteristics and origin of hypogene features; Economic Geology, 100th Anniversary Volume, J.W. Hedenquist, J.F.H. Thompson, R.J. Goldfarb and J.P. Richards (ed.), p. 485–522.

Sillitoe, R.H. (1979): Some thoughts on gold-rich porphyry copper deposits; Mineralium Deposita, v. 14, no. 2, p. 161–174.

Tipper, H.W. (1969): Mesozoic and Cenozoic geology of the northeast part of Mount Waddington map-area (92N), Coast District, British Columbia; Geological Survey of Canada, Paper 68-33, 103 p.

White, J.D.L. (2000): Subaqueous eruption-fed density currents and their deposits; Precambrian Research, v. 101, no. 2, p. 87–109.