Sulphide clast-bearing felsic volcaniclastic units of the Rouyn-Pelletier Formation: Comparison with similar units of the Horne Block, Rouyn-Noranda, Abitibi greenstone belt, Quebec

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ABSTRACT

Sulphide clast-bearing volcaniclastic units are a key exploration vector towards volcanogenic massive sulphide deposits. These marker units are commonly associated with base and precious metal-rich volcanogenic massive sulphide deposits of the Archean Abitibi greenstone belt. One such sulphide (pyrite ±sphalerite-chalcopyrite) clast-bearing felsic volcaniclastic unit is present in the uppermost part of the Rouyn-Pelletier Formation of the Blake River Group in Rouyn-Noranda. The Rouyn-Pelletier Formation is in faulted contact (Andesite fault) with the rocks of the Horne Formation, which are of the same age and style, are sulphide clast-bearing, and host to the giant Horne Au-rich volcanogenic massive sulphide deposit. This raises the question of a possible stratigraphic correlation between the Rouyn-Pelletier (upper part) and Horne formations, with the potential for major implications for exploration in the Rouyn-Pelletier Formation.

The study area is composed of broadly coeval extrusive felsic facies with mafic to intermediate extrusive and intrusive facies. Felsic units range from flows with lobate, flow banding and in situ brecciated textures to dominantly sulphide clast-bearing volcaniclastic units with tuff breccia, lapilli tuff and lesser tuff facies. Rocks of the upper portion of the Rouyn-Pelletier Formation and the Horne Block are of similar age and show similarities in volcanic facies. However, there are subtle but significant geochemical differences that suggest that it may not be possible to directly correlate their stratigraphy. The uppermost Rouyn-Pelletier Formation could represent a distal, poorly mineralized equivalent to the Horne West or Horne 5 zones, or it could be an unrelated succession.

INTRODUCTION

Context and Objectives

The Archean volcanic sequences of the Blake River Group in the Abitibi host one of the highest concentrations of volcanogenic massive sulphide (VMS) deposits and Au-rich VMS deposits ever found (Mercier-Langevin et al., 2011, and references therein). The Horne Formation, which is part of the Blake River Group, hosts the giant Horne VMS deposit (Goutier et al., 2009), which has a combined past production (Horne mine) and current resources estimate (Horne 5) of approximately 16 Moz Au (~500 metric t: Krushnisky et al., 2020). The host successions of the Horne deposit are characterized by felsic volcaniclastic rocks containing a high proportion of massive sulphide clasts, which were documented around the Upper and Lower H zones (Price, 1934; Kerr and Mason, 1990; Cattalani et al., 1993), the Horne 5 zone (Sinclair, 1971; Krushnisky, 2018; Krushnisky et al., 2020), and the Horne West zone (Monecke et al., 2008; Laurin, 2010; Goutier, 2017).

The Rouyn-Pelletier Formation is located immediately south of the Horne Formation and is separated from it by the Andesite fault (Goutier et al., 2009). Felsic volcaniclastic rocks of the upper portion of the Rouyn-Pelletier Formation also contain massive sulphide clasts and show obvious similarities with the volcaniclastic rocks of the Horne Formation. This study investigates the possible stratigraphic correlation between the upper portion of the Rouyn-Pelletier Formation and the felsic rocks of the Horne Formation by documenting volcanic facies, hydrothermal alteration, and the nature of the massive sulphide clasts in select localities within the Rouyn-Pelletier Formation (Boudreau, 2013) and comparing these with sulphide clasts from the Horne Formation. If correlation

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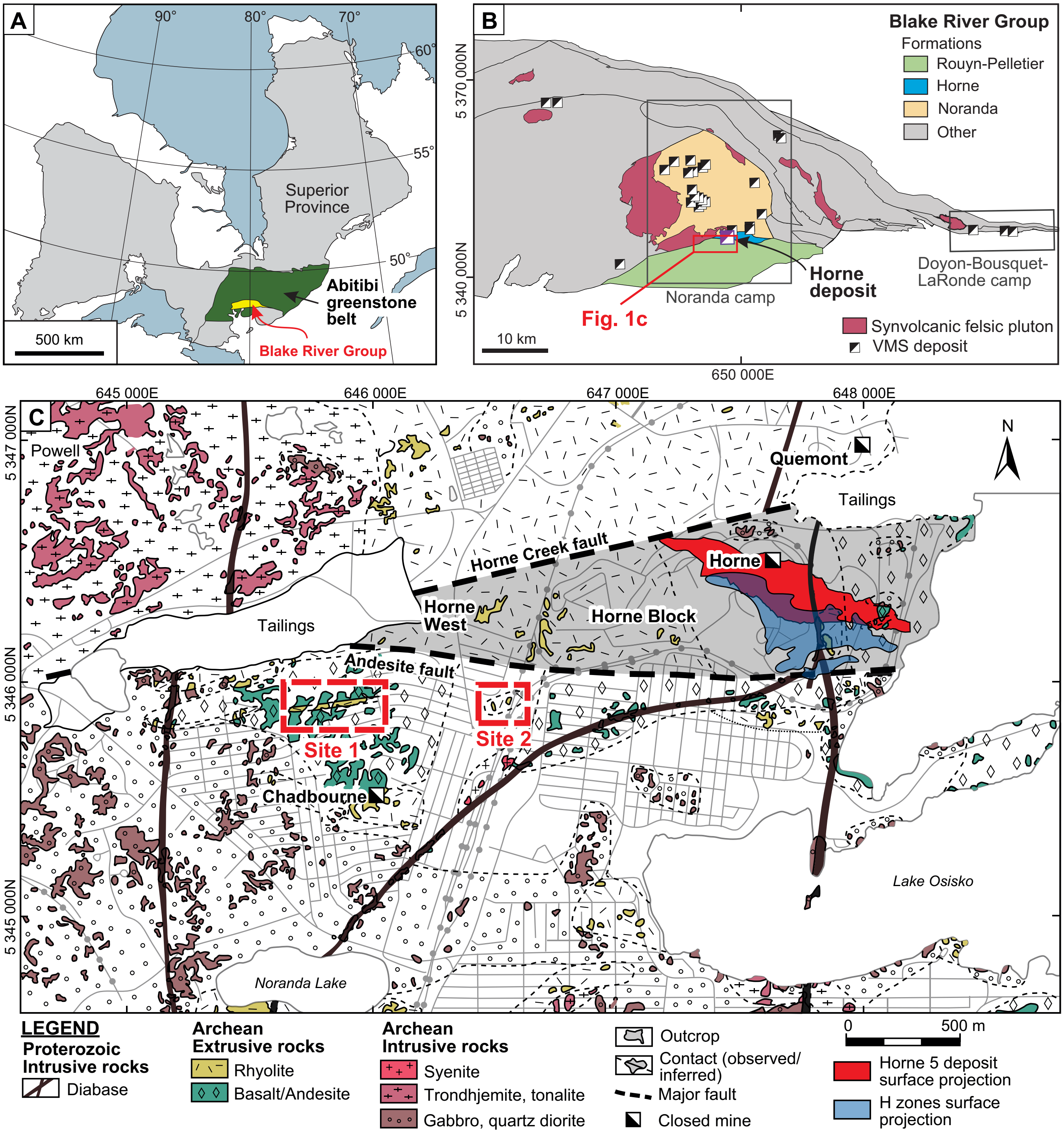

Figure 1. a) Location of Abitibi greenstone belt in the Superior Province of Canada. **b)** Simplified map of the Blake River Group and distribution of the Rouyn-Pelletier, Horne, and Noranda Formations (*modified from* Mercier-Langevin et al., 2011). **c)** Geological map of the Horne Block (*modified from* Monecke et al., 2008). The locations of study sites 1 and 2 are shown. Map coordinates are in UTM NAD83, zone 17.

between the two formations can be established, it would have positive implications for the mineral potential of the Rouyn-Pelletier Formation, which is currently viewed as being limited.

Geological Setting

The 2704 to 2695 Ma Blake River Group is located in the southern Abitibi greenstone belt (Fig. 1a; Monecke et al., 2017 and references therein). It consists of a sequence of subalkaline mafic to felsic volcanic rocks intruded by syn- to post-volcanic plutons and dykes (Dimroth et al., 1982; Piercey et al., 2008; Mueller et al., 2012; McNicoll et al., 2014). The Rouyn-Pelletier Formation (2703–2701 Ma: Mueller et al., 2012;

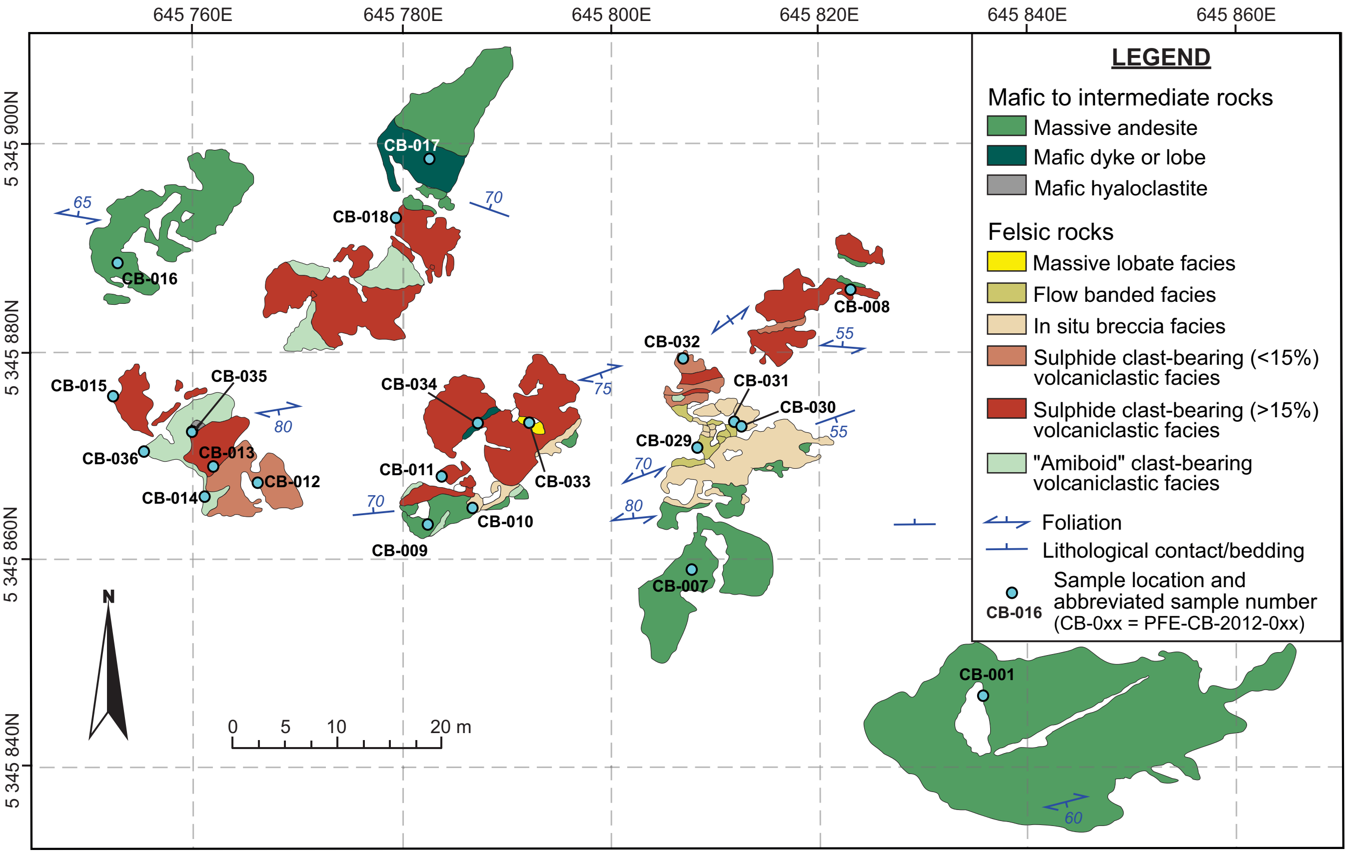

Figure 2. Geological map of site 1 of the study. *See* Figure 1 for a broader location of the study area (*from* Boudreau, 2013).

McNicoll et al., 2014) comprises the southernmost portion of the Blake River Group (Fig. 1b) and is dominated by andesitic to basaltic volcanic rocks with tholeiitic to transitional affinities and minor felsic lavas (Sterckx, 2018). The entire volcanic rock package generally faces north (Goutier et al., 2009; Moore et al., 2012). This area has also been referred to as the southern New Senator caldera (Moore et al., 2012) and the Rouyn-Pelletier caldera complex (Moore et al., 2016). The Andesite fault delineates the structural contact between the upper portion of the Rouyn-Pelletier Formation and the Horne Formation (Fig. 1c).

The Horne Formation (2702.2 ± 0.9 Ma: McNicoll et al., 2014), also referred to as the Horne Block, consists of a structural wedge of mafic to intermediate rocks and thick (100s of metres) felsic volcanic units. The volcanic rocks hosting the Horne deposit consist of dacitic to rhyolitic flows and domes and large volumes of associated volcaniclastic rocks that are interpreted as mass flow deposits (Price, 1934; Sinclair, 1971; Kerr and Mason, 1990; Kerr and Gibson, 1993). The Horne West zone is characterized by a similar volcanic succession composed of alternating felsic volcaniclastic rocks, felsic intrusions, and local extrusive rhyolite flows (Monecke et al., 2008; Laurin, 2010). Massive sulphide clasts, predominantly composed of pyrite with local traces of sphalerite and chalcopyrite, are ubiquitous within the felsic volcaniclastic rocks of the Horne Block.

RESULTS

Seven outcrops within the uppermost (northern) part of the Rouyn-Pelletier Formation (an area also referred to as the Chadbourne Block: Moore et al., 2016) were mapped in detail as part of this study. These outcrops are distributed in two separate areas, referred to as site 1 and site 2 (Fig. 1c). Representative samples of the principal volcanic facies were collected for petrographic study and whole rock lithogeochemical analyses. Two samples of massive sulphide clasts were also isolated to assess their metal content.

Description of Volcanic Facies

Site 1 is composed of steeply dipping bands of mafic rocks intercalated with massive to brecciated felsic rocks (Fig. 2). The rocks show very little deformation and exhibit a weak, steeply dipping foliation oriented N255° on average, which is consistent with the dominant east-west penetrative fabric. Site 2 consists mainly of layers of felsic volcaniclastic rocks hosting variable percentages of massive sulphide clasts, in addition to minor mafic rocks (Fig. 3). Strain is slightly stronger in this area and felsic fragments are aligned (flattened)

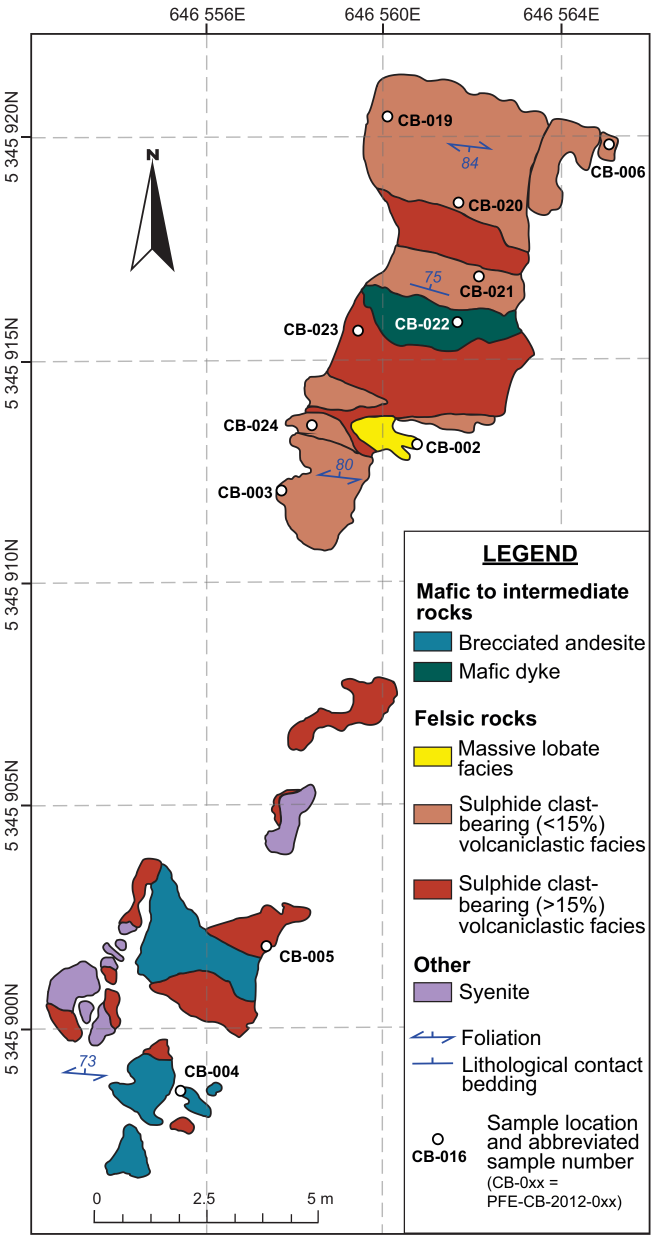

Figure 3. Geological map of site 2 of the study. *See* Figure 1 for a broader location of the study area (*after* Boudreau, 2013).

along a steeply dipping foliation oriented N277º on average.

Various facies of felsic volcanic rocks are present at the two sites: 1) lobate facies, which comprises lobes of rhyolite penetrating volcaniclastic rocks; 2) flow-banded facies; 3) in situ breccia facies (Fig. 4a); and 4) massive sulphide clast-bearing volcaniclastic facies (Fig. 4b,c). The felsic volcaniclastic rocks are grouped in two subfacies, based on the relative abundance of sulphide clasts. The first contains less than 15 vol.% sulphide clasts and is dominated by rhyolite fragments that range in size from 0.5 to 2 cm. The second is composed of more than 15 vol.% sulphide clasts with coherent rhyolite fragments, vesicular rhyolite fragments, and strongly silicified amoeboid fragments of mafic rocks measuring 0.1 to 1.5 m in size and exhibiting chilled margins. At site 2, massive sulphide clasts are mostly concentrated at the contacts between distinct layers of volcaniclastic rocks.

In the study area, the mafic to intermediate rocks predominantly consist of the following: 1) massive andesite flows and lobes that locally contain up to 1 vol.% disseminated pyrite (Fig. 4d); 2) mafic dykes and/or lobes that are up to 1 m thick and display irregular contacts with the surrounding felsic volcaniclastic rocks (Fig. 4e); and 3) oxidized, sericitized, and unmineralized volcaniclastic mafic rocks. Some of the clasts have a curvaceous, shard-like aspect, suggestive of hyaloclastites. Such rocks only appear very locally at site 1. Where present, mafic volcaniclastic rocks are completely enclosed by felsic volcaniclastic rocks. In the southern portion of site 2, massive andesite units are cut by a syenite intrusion. Angular fragments of andesite (10–40 cm in size) are enclosed within the syenite intrusion.

Felsic lobate, flow-banded, and in situ breccia facies

Felsic volcanic rocks from these facies are characterized by a weak foliation and a homogenous groundmass of microcrystalline quartz (65–80 vol.%), sericite (15–20 vol.%), locally up to 25 vol.% chlorite, and ≤3 vol.% garnet and Fe-Ti oxides. Sericite- and chlorite-altered plagioclase phenocrysts are rare (<3 vol.%). Relict perlite textures are present locally, as well as amygdules of quartz-calcite and quartz-calcite-epidote veins. Disseminated pyrite (1–5 vol.%) occurs throughout the groundmass, as well as local clusters of pyrite (2–3 vol.%) and trace amounts of sphalerite.

The flow-banded facies exhibit laminations measuring 0.1 to 1 cm in thickness. At site 1, in situ brecciated facies are in contact with the flow-banded facies, the sulphide clast-bearing volcaniclastic facies, and mafic to intermediate rocks. The felsic breccia is monomictic and consists mainly of fragments of rhyolite that measure 1 to 70 cm. The matrix represents 75 vol.% of the exposed surface and contains on average 3 vol.% pyrite fragments that measure between 0.5 and 5 cm. At site 1, the breccia is cut by thin andesite dykes and/or lobes near the contacts with the massive andesite.

Sulphide clast-bearing felsic volcaniclastic facies

Felsic volcaniclastic rocks comprise various layers of tuff, lapilli tuff, and tuff breccia. Although the variable alteration of the fragments gives the rock a polymictic appearance, it is largely dominated by rhyolite fragments (Fig. 4f). These rocks contain varying propor-

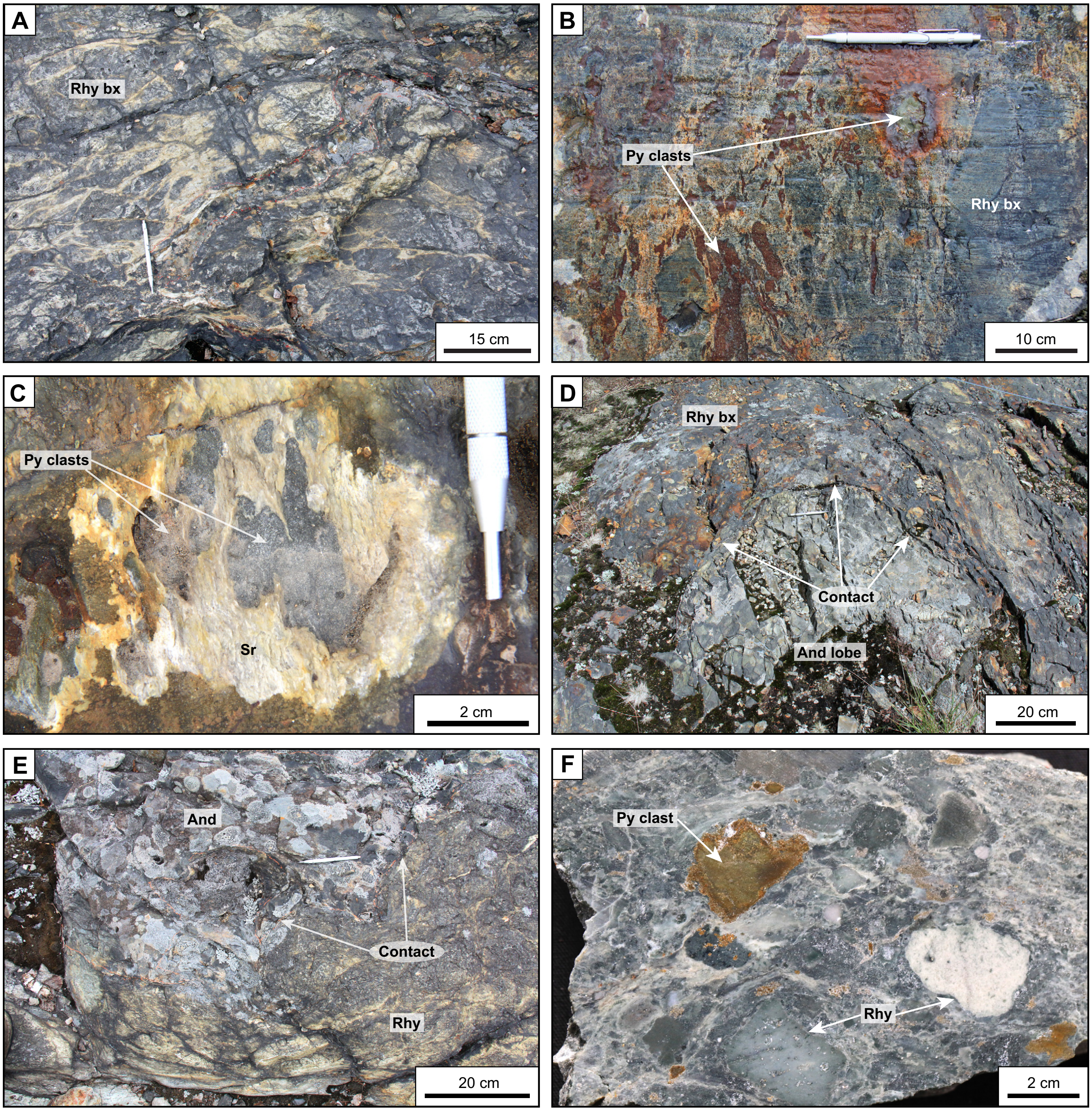

Figure 4. Photographs of representative outcrops at sites 1 and 2. **a)** Foliated and weakly sericite-altered rhyolite flow breccia in contact with in situ brecciated massive rhyolite (site 1). **b)** Polymictic rhyolitic tuff breccia with abundant, variably altered, angular to subangular rhyolitic clasts and flattened to amiboidal sulphide clasts (site 2). **c)** Amiboidal pyrite-rich sulphide clasts in a strongly sericite-altered matrix (felsic tuff to lapilli tuff; site 2). **d)** Andesite lobe intruding sulphide-rich clast-bearing fragmental rhyolite. The contact between the andesite and the rhyolite is sharp. The rhyolite is weakly to moderately sericite- and chlorite-altered, whereas the andesite is fresh (site 1). **e)** Andesitic dyke (or lobe) intruding rhyolite flow breccia deposits at site 1. The contact is highly irregular to peperitic, suggesting that the emplacement of the dyke was into the unconsolidated fragmental rhyolite unit (site 1). **f)** Rhyolitic lapilli tuff with angular sulphide clasts. The variably altered nature of the rhyolite clasts gives the impression that it is polymictic, although rhyolite clasts largely dominate (slab sample PFE-CB-2012-018, site 1). Abbreviations: And = andesite, Py = pyrite, Rhy = rhyolite, Rhy bx = fragmental rhyolite, Sr = sericite.

tions (15–65 vol.%) of four types of fragments, two of which are dominated by sulphides (Fig. 5a–c). The matrix is composed of foliated sericite, chlorite, and patches of fine-grained granoblastic pyrite, with local patches or irregular/discontinuous bands of coarse-grained (granoblastic) pyrite (Fig. 5d). The first type of fragment has a groundmass of microcrystalline quartz (50–65 vol.%), sericite (20–45 vol.%), chlorite (10–30

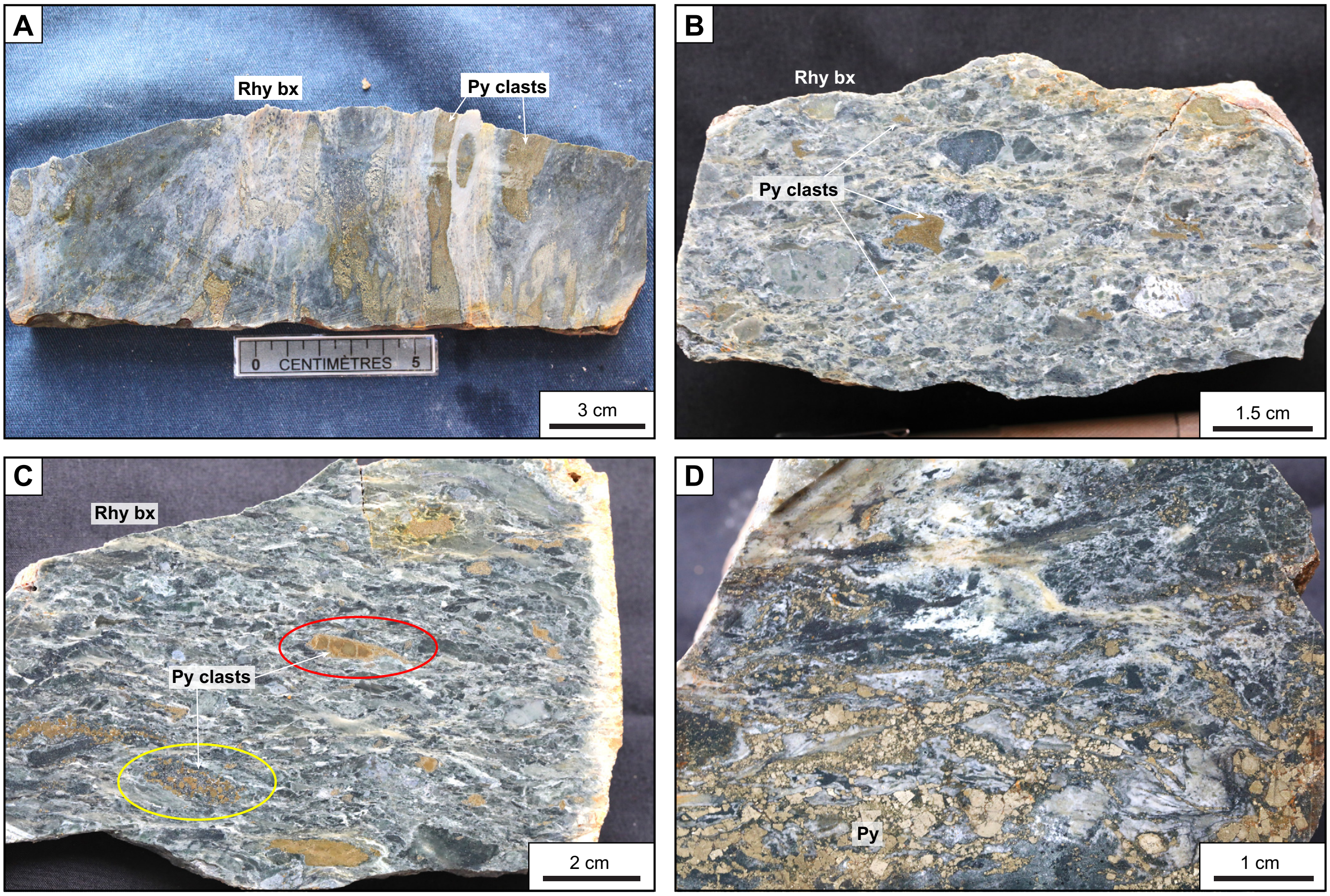

Figure 5. Photographs of representative slab samples from sites 1 and 2. **a)** Rhyolitic lapilli tuff to tuff breccia. The tuff is polymictic with abundant, variably altered rhyolitic clasts and flattened to amiboidal sulphide clasts. The matrix is sericite-±chlorite-altered with patches of fine granoblastic pyrite (slab sample from site 2). **b)** Rhyolitic lapilli tuff and tuff with abundant but very small sulphide clasts (slab sample PFE-CB-2012-012, site 1). **c)** Foliated rhyolitic lapilli tuff with abundant, flattened sulphide clasts. Some of the clasts consist of massive pyrite, whereas others consist of semi-massive pyrite (slab sample PFE-CB-2012-008, site 1). **d)** Granoblastic pyrite forming semi-massive bands in altered felsic lapilli tuff (sample PFE-CB-2012-005, site 2). Abbreviations: Py = pyrite, Rhy bx = fragmental rhyolite.

vol.%), disseminated pyrite (2–10 vol.%), and minor calcite (<5 vol.%), as well as sericitized plagioclase phenocrysts. These felsic fragments are mostly angular to subangular (Fig. 4b). The second type of fragment is darker in colour and contains plagioclase microlites within a strongly chlorite- and sericite-altered groundmass. The third type of fragment is composed of 30 to 40 vol.% sulphides (pyrite±trace sphalerite), quartz (40 vol.%), and chlorite (20–30 vol.%). The fourth type of fragment is very rich in sulphides (<80 vol.%) and contains mostly pyrite with traces of sphalerite±chalcopyrite, up to 15 vol.% epidote, up to 5 vol.% chlorite, and quartz-calcite-epidote-chlorite veins. The volcaniclastic rocks are cut by a silicified mafic dyke at site 1. In this area, sulphide mineralization is concentrated near the dyke contacts.

Mafic to intermediate rocks

Massive andesites are very weakly foliated and are characterized by a groundmass of 50 to 65 vol.% plagioclase and 10 to 20 vol.% quartz. Locally the rocks have a porphyritic texture with <5 vol.% relict plagioclase phenocrysts. Alteration phases include sericite (5–30 vol.%) and chlorite (15–30 vol.%), which replace plagioclase, as well as local epidote (3 vol.%) and calcite (≤5 vol.%). Up to 15 vol.% amygdules of quartz, chlorite, and calcite are present. Oxides and sulphides are disseminated throughout, including titanium oxide (≤5 vol.%), magnetite (≤5 vol.%), pyrite (1 vol.%), sphalerite (<1 vol.%), and chalcopyrite (<1 vol.%).

Mafic dykes are very weakly foliated and are composed of a groundmass of microcrystalline chlorite (35 vol.%), sericite (10–25 vol.%), and quartz (≤5 vol.%). Relict plagioclase phenocrysts (<5 vol.%), which are replaced by sericite and chlorite, are present locally. Veinlets of microcrystalline quartz and chlorite are common throughout, as well as local veins of calcite-chlorite-epidote.

Fine-grained volcaniclastic mafic rocks are characterized by angular clasts (shards?) of relict volcanic

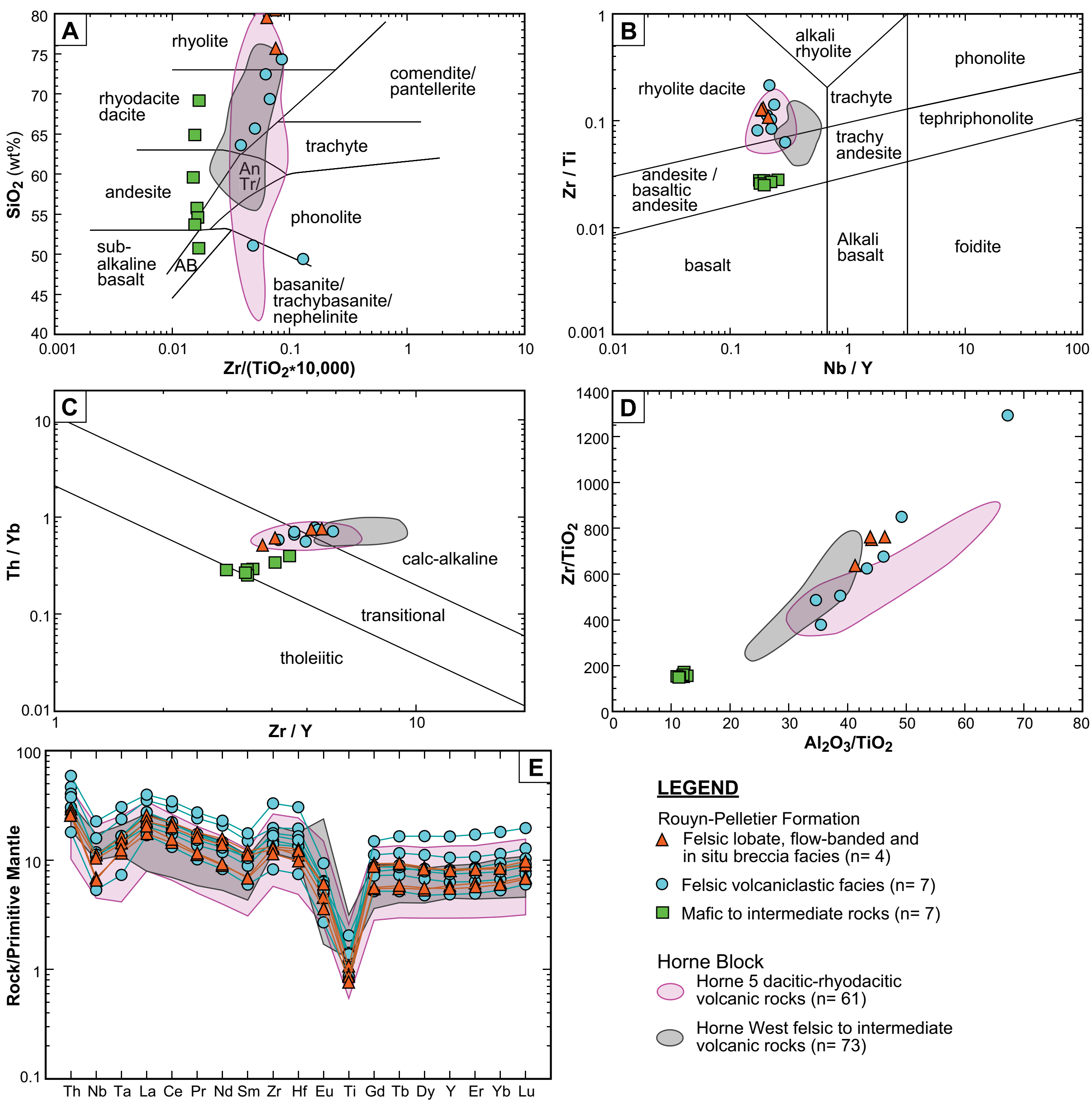

Figure 6. Major and trace element plots of the units mapped at sites 1 and 2, as well as a comparison with the Horne Block felsic volcanic units. **a)** SiO_2 versus $Zr/(TiO_2*10{,}000)$ classification diagram from Winchester and Floyd (1977). **b)** Zr/Ti versus Nb/Y classification diagram from Winchester and Floyd (1977). **c)** Th/Yb versus Zr/Y diagram for discrimination of magmatic affinities from Ross and Bédard (2009). **d)** Zr/TiO_2 versus Al_2O_3/TiO_2 discrimination diagram. **e)** Extended trace element profiles. Primitive mantle normalization values are from Sun and McDonough (1989). Data for the Rouyn-Pelletier Formation are from Mercier-Langevin et al. (2020), data for Horne 5 are from Krushnisky et al. (2018), and data for Horne West are from Laurin (2010).

glass (10–30 vol.%) arranged in a jigsaw pattern. These angular clasts are replaced by chlorite (20–60 vol.%), calcite (5–10 vol.%), and clusters of titanium oxide (10 vol.%). Locally, the rock has a groundmass of microcrystalline quartz (20–50 vol.%), chlorite (35 vol.%), and sericite (25 vol.%). Disseminated pyrite (<1 vol.%) containing traces of chalcopyrite inclusions is present locally.

Lithogeochemistry

To facilitate the geochemical characterization of the rocks, samples were grouped based on volcanic facies.

The first group consists of coherent felsic rocks (lobate and flow-banded facies) and related in situ breccia facies. These rocks are dacitic to rhyolitic in composition (Fig. 6a,b). Two samples have SiO_2 values exceeding 80 wt% (80.40 and 80.77 wt%: Mercier-Langevin et al., 2020). Rocks from this group have a transitional to calc-alkaline magmatic affinity (Fig. 6c). On a Zr/TiO_2 versus Al_2O_3/TiO_2 diagram (Fig. 6d), data points plot in a tight cluster at relatively elevated values of Zr/TiO_2 and Al_2O_3/TiO_2. Extended trace element profiles display a moderately steep light rare earth element (LREE) slope, flat heavy rare earth element (HREE) slope, a strong negative Ti anomaly, moderate negative Nb, Ta and Eu anomalies, and weak positive Zr and Hf anomalies (Fig. 6e).

The second group is composed of sulphide clast-bearing felsic volcaniclastic rocks. Rocks from this group are characterized by a dacitic to rhyolitic composition (Fig. 6a,b) and a transitional to calc-alkaline magmatic affinity (Fig. 6c). The spread of data along the y-axis in the SiO_2 versus $Zr/(TiO_2*10,000)$ diagram likely results from the variable but significant abundance of sulphide clasts and hydrothermal alteration, especially for samples displaying approximately 50 wt% SiO_2. Samples from this hydrothermally altered group plot in a linear trend on the Zr/TiO_2 versus Al_2O_3/TiO_2 immobile element diagram (Fig. 6d), supporting the interpretation of alteration-induced compositional variations rather than variations in the composition of the protolith. The extended trace element diagram shows profiles that are similar to the first group of felsic rocks, except for slightly weaker negative Ti anomalies and a pronounced vertical spread of profiles (Fig. 6e).

The third group consists of mafic to intermediate rocks that yield basaltic and andesitic compositions on the Zr/Ti versus Nb/Y diagram (Fig. 6b). Although the SiO_2 versus $Zr/(TiO_2*10,000)$ diagram (Fig. 6a) displays a strong spread of data along the y-axis (SiO_2), again likely due to hydrothermal alteration, clustering of data appears between the andesite and subalkaline basalt fields. These rocks have a tholeiitic to transitional magmatic affinity (Fig. 6c). Samples form a tight cluster of low Zr/TiO_2 and Al_2O_3/TiO_2 values (Fig. 6d), which is consistent with their more mafic trace element composition.

Hydrothermal Alteration and Sulphide Mineralization

Hydrothermal alteration of the felsic rocks in this area mainly consists of heterogeneous sericite and chlorite replacement of primary minerals in the matrix of the felsic volcaniclastic rocks. Coherent felsic units are generally weakly altered and are characterized by 15 to 20 vol.% foliated sericite in the groundmass, local chlorite, and plagioclase phenocrysts altered to sericite and chlorite. Vesicles present in these rocks are filled with calcite and quartz. Felsic volcaniclastic rocks are more strongly altered. Their matrix is composed of foliated chlorite and sericite that follow the contours of fragments, as well as disseminated sulphides and local calcite. Sulphide clasts are associated with strong halos of chlorite. All felsic rocks are crosscut by veins of quartz-calcite that locally contain chlorite, epidote, and sulphides. The sericite and chlorite alteration result in a significant increase in the Hashimoto alteration index (cf. Ishikawa et al., 1976) values and a moderate increase in the chlorite-carbonate-pyrite alteration index (cf. Large et al., 2001) values in the volcaniclastic rocks (not shown here; Boudreau 2013).

Mafic to intermediate rocks are weakly hydrothermally altered. The groundmass contains variable quantities of sericite (5–30 vol.%), and plagioclase phenocrysts are locally partially replaced by sericite and chlorite. Alteration phases, including quartz, calcite, chlorite, epidote, and sulphides, also appear as infillings of vesicles and veins. Fine-grained volcaniclastic mafic rocks are more strongly chlorite and sericite-altered than the massive rocks.

Mineralization in this area consists of disseminated granoblastic sulphides and sulphide clasts. Disseminated pyrite and traces of sphalerite and chalcopyrite are present in almost all rocks but rarely exceed 3 to 5 vol.%. These sulphides occur in the groundmass, in the matrix of volcaniclastic rocks (Fig. 5d), in fragments, in amygdules, and in veins. Semi-massive (>30 vol.% sulphides) to massive (>70 vol.% sulphides) sulphide clasts are subrounded to rounded and are often strongly elongated into the main foliation (Fig. 5a). Clasts are mostly composed of recrystallized pyrite (Fig. 7a,b), but also contain chlorite, quartz, calcite, and traces (<5 vol.%) of sphalerite, chalcopyrite, and pyrrhotite. Geochemical analyses of massive sulphide clasts indicate that they contain very low concentrations of Au, Ag, Cu, Zn, and Pb compared to sulphide clasts from the Horne West and Horne 5 zones (Fig. 8).

DISCUSSION

Depositional Setting

The study area is composed of extrusive felsic facies with mafic to intermediate extrusive and intrusive facies. Lithogeochemistry results are consistent with grouping all felsic rocks as part of the same unit with a dacitic to rhyolitic, transitional to calc-alkaline signature. Felsic units range from flows with lobate, flow banding and in situ brecciated textures to dominantly volcaniclastic with tuff breccia, lapilli tuff, and lesser tuff facies. The volcaniclastic rocks, which host the bulk of massive sulphide clasts and occur as multiple layers intercalated with the felsic coherent facies, are interpreted as flow breccia and debris flows that are associated with the emplacement of the felsic lava flows and lobes. Mafic to intermediate rocks also have

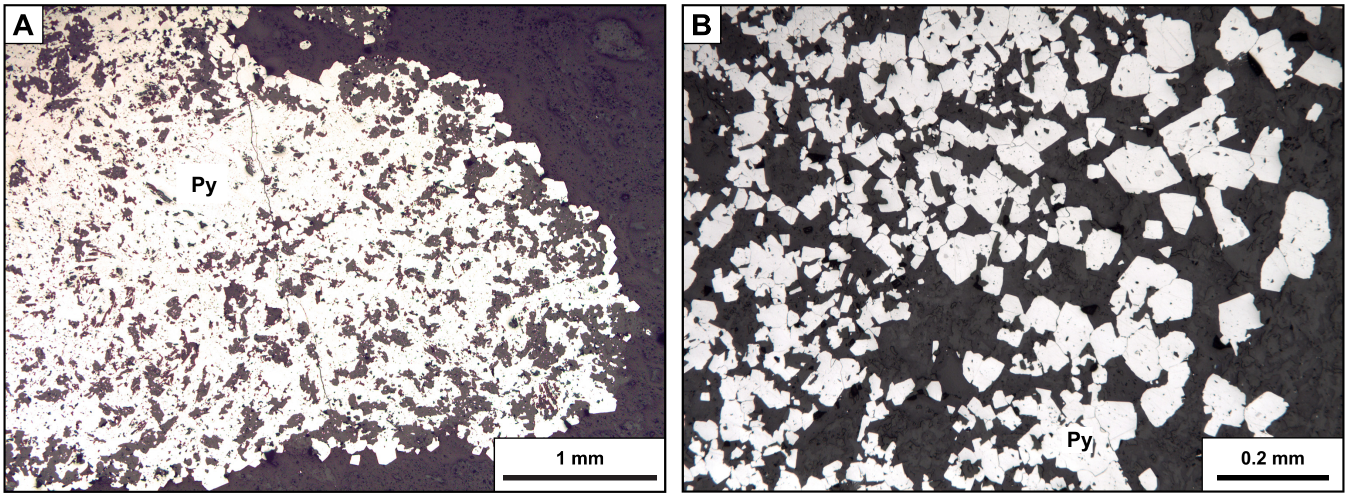

Figure 7. Photomicrographs (reflected light) of **(a)** massive and **(b)** semi-massive pyrite clasts. Abbreviation: Py = pyrite.

consistent geochemical signatures in this area, i.e., andesitic to basaltic andesitic, tholeiitic to transitional compositions. They occur as dykes, lava flows, and lobes, as well as local hyaloclastites that likely formed during quench fragmentation of subaqueous mafic flows (cf. Fisher and Schmincke, 1984).

Facies analysis of the felsic to mafic rocks reveals important crosscutting relationships. The contact between the massive andesite and the felsic in situ breccia at site 1, with bands of andesite intruding into the breccia, indicate that the mafic to intermediate rocks were emplaced after the felsic breccia. In addition, the presence of very irregular contacts between mafic dykes and felsic volcaniclastic rocks suggests that the dykes were emplaced in unconsolidated volcaniclastic debris. This is further confirmed by the

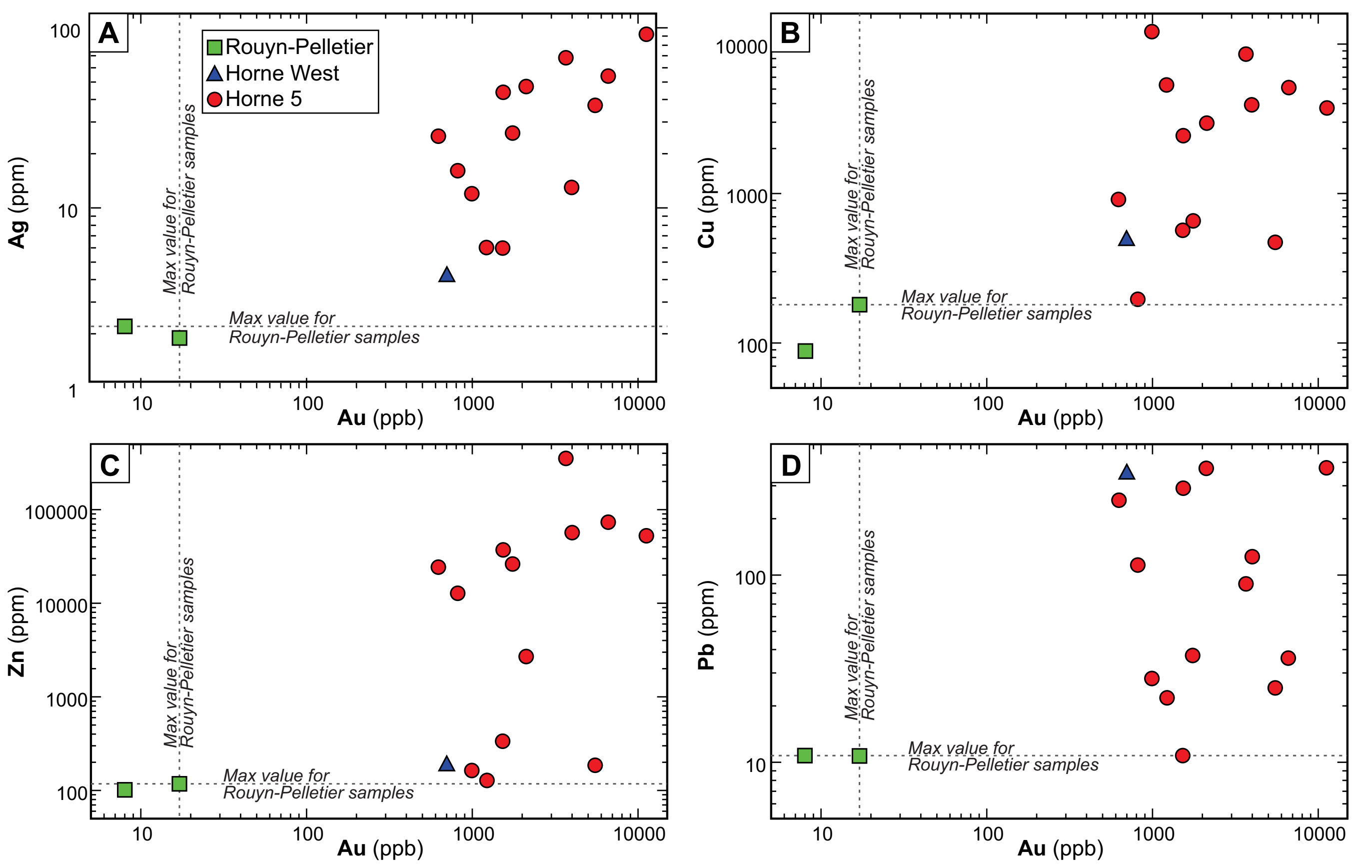

Figure 8. Metal biplots of massive sulphide fragments sampled in the Rouyn-Pelletier Formation, Horne West outcrops (Mercier-Langevin et al., 2020), and Horne 5 deposit (Krushnisky et al., 2018): **a)** Ag versus Au, **b)** Cu versus Au, **c)** Zn versus Au, and **d)** Pb versus Au.

presence of amoeboid andesite clasts in the felsic volcaniclastic rocks at site 1. These observations indicate that the mafic to intermediate rocks were emplaced shortly after formation of the felsic volcaniclastic rocks and the associated felsic lava flows, suggesting that felsic to mafic volcanism in this area was broadly coeval, as proposed by Moore et al. (2016).

Comparison with the Horne Block Felsic Rocks and Sulphide Clasts

The upper portion of the Rouyn-Pelletier Formation (*see* also Moore et al., 2016: stratigraphy of the Chadbourne Block) presents important similarities and differences with the rocks of the Horne Block. The felsic rocks in the study area and in the Horne Block share many textural similarities and the same facies are present in both areas, including lobate, flow-banded, and in situ breccia facies, as well as volcaniclastic rocks representing flow breccia and debris flows (Cattalani et al., 1993; Monecke et al., 2008; Laurin, 2010; Krushnisky et al., in prep). Both the upper portion of the Rouyn-Pelletier Formation and the Horne Block contain felsic volcaniclastic rocks that host massive sulphide clasts. Mafic to intermediate rocks are also present on both sides of the Andesite fault and were generally emplaced shortly after cessation of felsic volcanism (Kerr and Mason, 1990). Notable differences include, apart from the overall higher volume of felsic rocks in the Horne Block, the felsic facies that has been interpreted as pyroclastic flows in the Horne West zone (Monecke et al., 2008; Laurin, 2010) has not been correlated south of the Andesite fault in the study area. Additionally, the felsic volcaniclastic rocks at the Horne West zone span several dozen metres (Laurin, 2010), and up to 20 m and more in the Horne 5 zone (Krushnisky, 2018), however, beds of volcaniclastic rocks in the study area measure only a few metres thick. Hydrothermal alteration in the Rouyn-Pelletier rocks is similar to the alteration within the Horne Block (MacLean and Hoy, 1991), consisting primarily of sericite alteration with variable chlorite, epidote, and disseminated sulphides, but the alteration intensity is markedly lower.

The felsic rocks of the Rouyn-Pelletier Formation share certain compositional similarities with the host rocks of the Horne 5 deposit (e.g. Sterckx, 2018), as samples plot directly over the field of the Horne 5 felsic rocks in Figure 6a–c. Felsic rocks from Horne West have slightly higher Nb/Y ratios (Fig. 6b) and a more calc-alkaline character (Fig. 6c). On the Zr/TiO_2 versus Al_2O_3/TiO_2 diagram (Fig. 6d), felsic rocks from the Rouyn-Pelletier Formation form a trend that is intermediate between those from Horne 5 and Horne West, suggesting small compositional differences. Extended trace element profiles show similarities with the Horne 5 felsic rocks, whereas they vary quite significantly from the Horne West felsic rocks due to higher LREE values, stronger Ti and Nb negative anomalies, and weaker Zr and Hf positive anomalies (Fig. 6e). Rocks from the study area, therefore, share certain geochemical characteristics with rocks in the Horne Block, particularly those enclosing the Horne 5 deposit.

Sulphide mineralization in the upper portion of the Rouyn-Pelletier Formation does not appear to be associated with anomalous metal concentrations and instead are the result of sampling and transport of barren sulphide mineralization. Sulphide clasts in the Horne West and Horne 5 zones are significantly enriched in base and precious metals (Fig. 8); in comparison, sulphide clasts of the study area are extremely metal-depleted. Gold, Ag, Cu, Zn, and Pb grades in sulphide clasts of the Horne Block are often several orders of magnitude above those of the Rouyn-Pelletier clasts, which are completely barren.

Implications for Exploration

Rocks of the upper portion of the Rouyn-Pelletier Formation (or Chadbourne Block) and the Horne Block are of similar age (i.e. ca. 2702–2701 Ma: Mueller et al., 2012; McNicoll et al., 2014) and volcanic facies. However, there are subtle but significant geochemical differences that suggest their stratigraphy cannot be directly correlated. Moreover, the massive and volcaniclastic felsic rocks of the Horne Block form a much larger part of the stratigraphy than in the upper Rouyn-Pelletier Formation. The lower abundance of sulphide clasts, the absence of significant metal grades, the lower degree of hydrothermal alteration, and the limited thickness of the felsic volcaniclastic rocks in the uppermost Rouyn-Pelletier Formation suggest that the mapped area could represent a distal, poorly mineralized equivalent to the Horne West or Horne 5 zones, or an unrelated succession. Exploration in the uppermost part of the Rouyn-Pelletier Formation, therefore, should not be based solely on the premise that it is a direct continuity of the very prospective Horne Block stratigraphy.

The presence of sulphide clast-bearing felsic volcaniclastic units in the upper part of the Rouyn-Pelletier Formation indicates that there was hydrothermal activity before or during the emplacement of these rocks at ca. 2702 to 2701 Ma. Although the sulphide clasts at sites 1 and 2 do not carry significant base and precious metals, the hydrothermal activity responsible for the formation of sulphide zones from which they were sourced might have been fertile elsewhere along strike or similar time-stratigraphic intervals.

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