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GEOLOGY OF THE SOUTHERN MAIN RIVER MAP AREA (NTS 12H/14), LONG RANGE INLIER, WESTERN NEWFOUNDLAND

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ABSTRACT

The Long Range Inlier is a massif of Grenvillian crystalline basement rocks in western Newfoundland. Parts of the inlier were previously mapped at 1:50 000-scale, but significant portions were mapped at reconnaissance scale (1:250 000) and key questions remain regarding the inlier's crustal and tectonic evolution and potential to host mineralization. The inlier locally hosts gold mineralization near its eastern margin, which is marked by the crustal-scale Doucers Valley Fault system. This report presents the results of 1:50 000-scale bedrock mapping conducted in the southern part of the inlier in the Main River area (part of NTS 12H/14) in the summer of 2025. The study area is largely composed of gneissic basement rocks, including felsic orthogneiss with lesser amounts of intermediate and mafic orthogneiss and metasedimentary rocks. These gneissic rocks are interpreted to form part of the late Paleoproterozoic to early Mesoproterozoic Long Range Gneiss Complex. The Main River area also includes an early Neoproterozoic composite felsic pluton (Potato Hill Pluton) and other felsic metaplutonic rocks that likely correlate with the late Mesoproterozoic to early Neoproterozoic Grenvillian plutons in the surrounding region. Smaller intrusions of hornblende gabbro and diorite have a range of relative ages, based on field relationships, but may also be broadly Grenvillian. In the southeastern Main River area, a heterogeneous mafic intrusive suite shares many lithological similarities with the Silurian Taylor Brook Gabbro Suite to the south and is similarly flanked by metasedimentary rocks that may represent late Neoproterozoic to Ordovician cover sequences. The study area records a complex, polyphase tectono-metamorphic history that includes high-grade regional metamorphism and deformation of the Long Range Gneiss Complex (M_1 + D_1) and a subsequent high-grade regional tectono-metamorphic event (M_2 + D_2) that occurred syn- to post-emplacement of the intrusions that are inferred as Grenvillian. Late brittle and brittle–ductile structures occur locally and are associated with greenschist-facies minerals. Additional research is required to constrain the ages of the geological units and to decipher the crustal and tectonic evolution of the Long Range Inlier in the Main River area.

INTRODUCTION

Newfoundland forms part of the Appalachian orogen and historically has been subdivided into four tectonostratigraphic zones (Humber margin, peri-Laurentian tectonic elements, Ganderia and Avalonia) that record terrane accretions to the Laurentian margin as the result of early to late Paleozoic closure of the Iapetus Ocean (van Staal and Barr, 2012; Waldron *et al.*, 2022). In the Humber margin of western Newfoundland, the Long Range Inlier (Figure 1) is a massif of Proterozoic crystalline rocks having Grenvillian affinity that forms the basement to late Neoproterozoic to Ordovician cover sequences, which were structurally overlain by allochthonous rocks during the Appalachian (Taconic; ~495–450 Ma) orogen (Owen, 1991; van Staal and Barr, 2012). As the most extensive area of basement rocks in Newfoundland, the geology of the inlier is important for understanding tectonic links with Grenvillian rocks elsewhere along the Laurentian margin, with implications for the evolution of both the Grenville and Appalachian orogens. The Long Range Inlier hosts mineralization, including gold occurrences along its eastern margin bordering the Doucers Valley Fault system (DVFS; Figure 1; Kerr and van Breemen, 2007; Minnett *et al.*, 2010) and in the interior of the inlier in the Main River area (Figure 2). However, several important aspects of the geological evolution and mineral potential remain uncertain, as parts of the inlier have only been mapped at reconnaissance-scale (1:250 000-scale; Owen, 1991) and the ages of the rocks are largely unknown, owing to sparse coverage by geochronological samples (15 rock samples dated across ~8500 km^2; Heaman *et al.*, 2002). Detailed (1:50 000-scale) mapping and research in the Silver Mountain area (Figure 1) have demonstrated the lithological complexity of the inlier and shed light on its evolution during Appalachian orogenesis (Hinchey, 2010, 2020; Hinchey *et al.*, 2025a, b). Research studies in the eastern part of the inlier and in Paleozoic strata in White Bay have shown that gold mineralization formed during the Devonian, resulting from fluxing of auriferous fluids along the DVFS (Minnett *et al.*, 2012; Sandeman *et al.*, 2022,

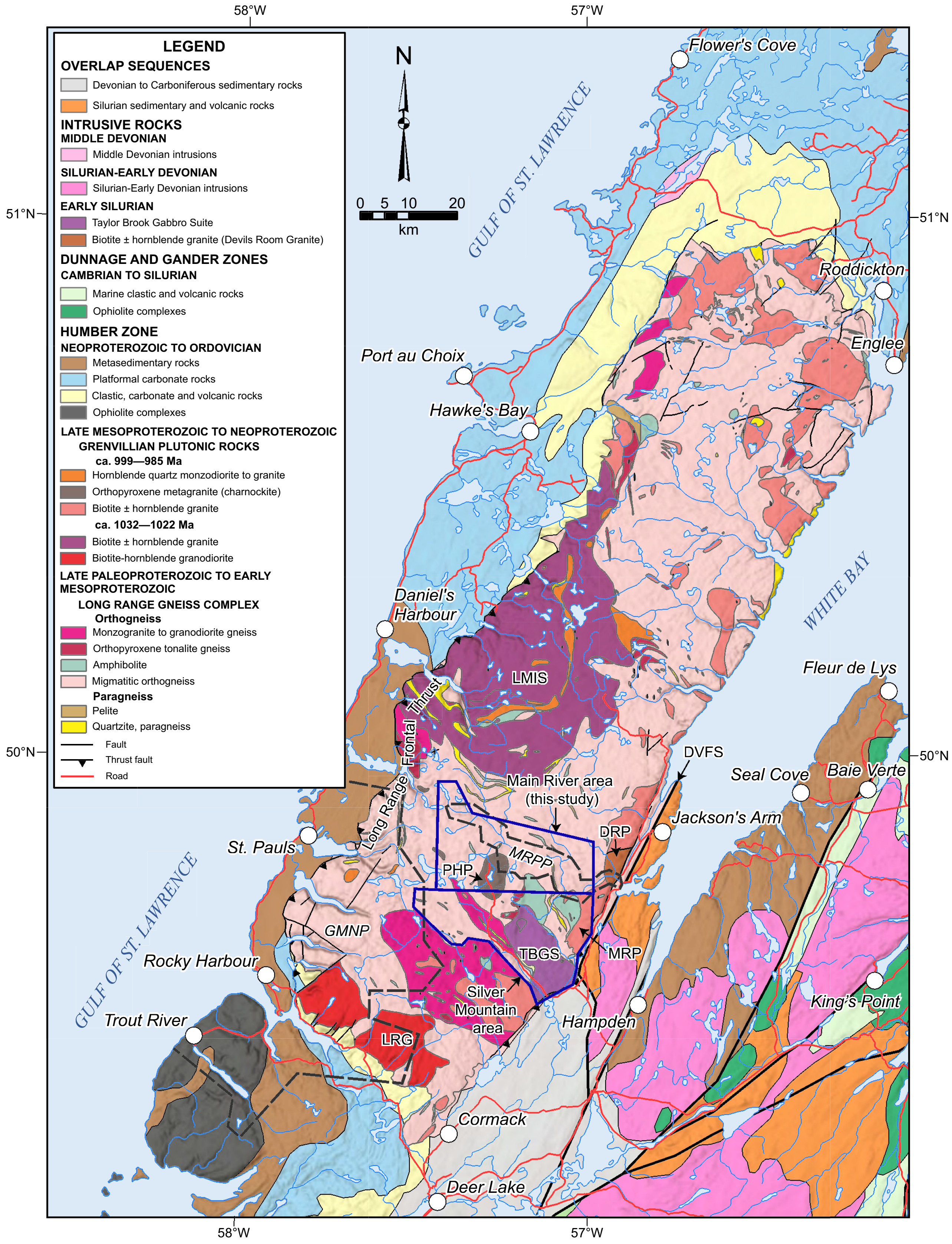

Figure 1. *Caption on following page.*

2024). Additional detailed mapping and research in the Long Range Inlier are necessary for understanding its geological evolution, deciphering tectonic links with the Grenville and Appalachian orogens, and building an accurate geological framework to serve as the foundation for mineral exploration. Therefore, the Geological Survey of Newfoundland and Labrador is conducting a multi-year (2025–2027) bedrock mapping and research project, focusing on the southern part of the inlier. This report presents the results of 1:50 000-scale bedrock mapping conducted in the summer of 2025 in the southern part of the Main River map area (NTS 12H/14; Figures 1 and 2).

GEOLOGICAL SETTING

The western margin of the Long Range Inlier is marked by the Long Range Frontal Thrust (Figure 1), a southeast-dipping thrust fault that transported the Proterozoic rocks of the inlier over autochthonous Cambro-Ordovician platform sequences and Taconic allochthonous rocks (Owen, 1991; Erdmer and Williams, 1995). Along its eastern margin, the inlier is bound by the DVFS (Figure 1), a long-lived, northeast-striking, crustal-scale fault system comprising several anastomosing faults, which may have initiated as extensional faults during the Ediacaran opening of the Taconic seaway (Smyth and Schillereff, 1982; Tuach, 1987; Hyde *et al.*, 1988; Sandeman *et al.*, 2024). Due to re-activation of the DVFS during the Paleozoic assembly of the Pangean supercontinent and Appalachian orogenesis, early ductile and brittle–ductile shear zones have mostly been overprinted by brittle–ductile and brittle structures during later phases of deformation (Lock, 1969; Smyth and Schillereff, 1982; Hyde *et al.*, 1988; Sandeman *et al.*, 2024).

The Long Range Inlier dominantly comprises the late Paleoproterozoic to early Mesoproterozoic Long Range Gneiss Complex (LRGC), which mainly consists of felsic gneiss, with lesser amounts of intermediate and mafic gneiss and metasedimentary rocks (Figure 1; Owen, 1991; Hinchey, 2010). Two samples of granite gneiss yielded crystallization ages of 1466 ± 10 Ma and 1530 ± 8 Ma, indicating that the protoliths of LRGC orthogneiss formed during the early part of the Pinwarian phase (*ca.* 1.51–1.45 Ga) of the Grenville orogen, whereas a minimum age of *ca.* 1631 Ma from a third sample of granite gneiss implies that some LRGC protoliths formed during (or prior to) the Labradorian phase (*ca.* 1.71–60 Ga) (Heaman *et al.*, 2002).

The LRGC was intruded by granitoid plutons during two pulses of Grenvillian magmatism at *ca.* 1032–1022 and *ca.* 999–985 Ma (Heaman *et al.*, 2002). The earlier plutonism includes the *ca.* 1022 Ma Lac Michel Intrusive Suite and the *ca.* 1032 Ma Lomond River Granite (Figure 1; Owen, 1991; Heaman *et al.*, 2002). In addition to plutons in the northern part of the inlier, the *ca.* 999–985 Ma group of intrusions includes the Potato Hill Pluton in the Main River area (Figure 1), from which a sample of orthopyroxene granite yielded a crystallization age of 999 ± 4 Ma (Heaman *et al.*, 2002). The Potato Hill Pluton is a composite granitoid intrusion containing K-feldspar megacrysts, pyroxene and/or garnet, as well as hornblende and biotite (Owen, 1991; Owen *et al.*, 1992). The different phases of the Potato Hill Pluton were generated by crystal fractionation processes and have trace-element signatures indicative of a within-plate, late-orogenic setting (Owen *et al.*, 1992).

The Long Range Inlier hosts a swarm of Ediacaran, north to northeast-striking tholeiitic dykes (Long Range Dykes), which are concentrated in the northern part of the Inlier, where individual dykes are up to 50-m wide and >5-km long (Owen, 1991). Compositionally similar, northeast-trending dykes up to 5-m wide occur in the southern part of the inlier in the Silver Mountain area and have been correlated with the Long Range Dykes (Owen, 1991; Hinchey, 2010). Two Long Range Dykes in the Grenville Province of southeastern Labrador produced U–Pb baddeleyite ages of *ca.* 615 Ma (Kamo *et al.*, 1989; Kamo and Gower, 1994).

In the Silver Mountain area, the southeastern margin of the Long Range Inlier hosts the Silurian Taylor Brook Gabbro Suite (TBGS; Figure 1), a texturally and compositionally heterogeneous suite of mafic intrusive rocks, including mainly gabbro, gabbronorite and olivine gabbro (Owen, 1991; Collins, 2007; Hinchey, 2010, 2020). The TBGS exhibits evidence of igneous layering, as well as repetitive injections and mingling of magma (Hinchey *et al.*, 2025b). Gabbro from different parts of the TBGS yielded similar crystallization ages of 431.0 ± 2.7/4.3 Ma (Hinchey *et al.*, 2025b) and 430.5 ± 2.5 Ma (Heaman *et al.*, 2002) and the TBGS is crosscut by monzogranite dated at 419.7 ± 3.0/4.5 Ma (Hinchey *et al.*, 2025b). East of the Main River area, the southeastern margin of the inlier hosts the Devil's Room Pluton (Figure 1), which has a poorly constrained zircon crystallization age of 425 ± 10 Ma (Heaman *et al.*, 2002). The TBGS is flanked by metasedimentary rocks,

Figure 1. *Geological map of the Long Range Inlier and surrounding rocks in western Newfoundland (modified after A. Hinchey,* pers. comm.*, 2026). The geology of the inlier shown here is from Owen (1991). The Main River area (this study) and Silver Mountain area (mapped at 1:50 000-scale by Hinchey, 2020) are outlined in dark blue. Dark-grey dashed lines indicate the boundaries of the Gros Morne National Park (GMNP) and the Main River Waterway Provincial Park and Special Management Area (MRPP). DRP–Devil's Room Pluton, DVFS–Doucers Valley Fault system, LMIS–Lac Michel Intrusive Suite, LRG–Lomond River Granite, MRP–Main River Pluton, PHP–Potato Hill Pluton, TBGS–Taylor Brook Gabbro Suite.*

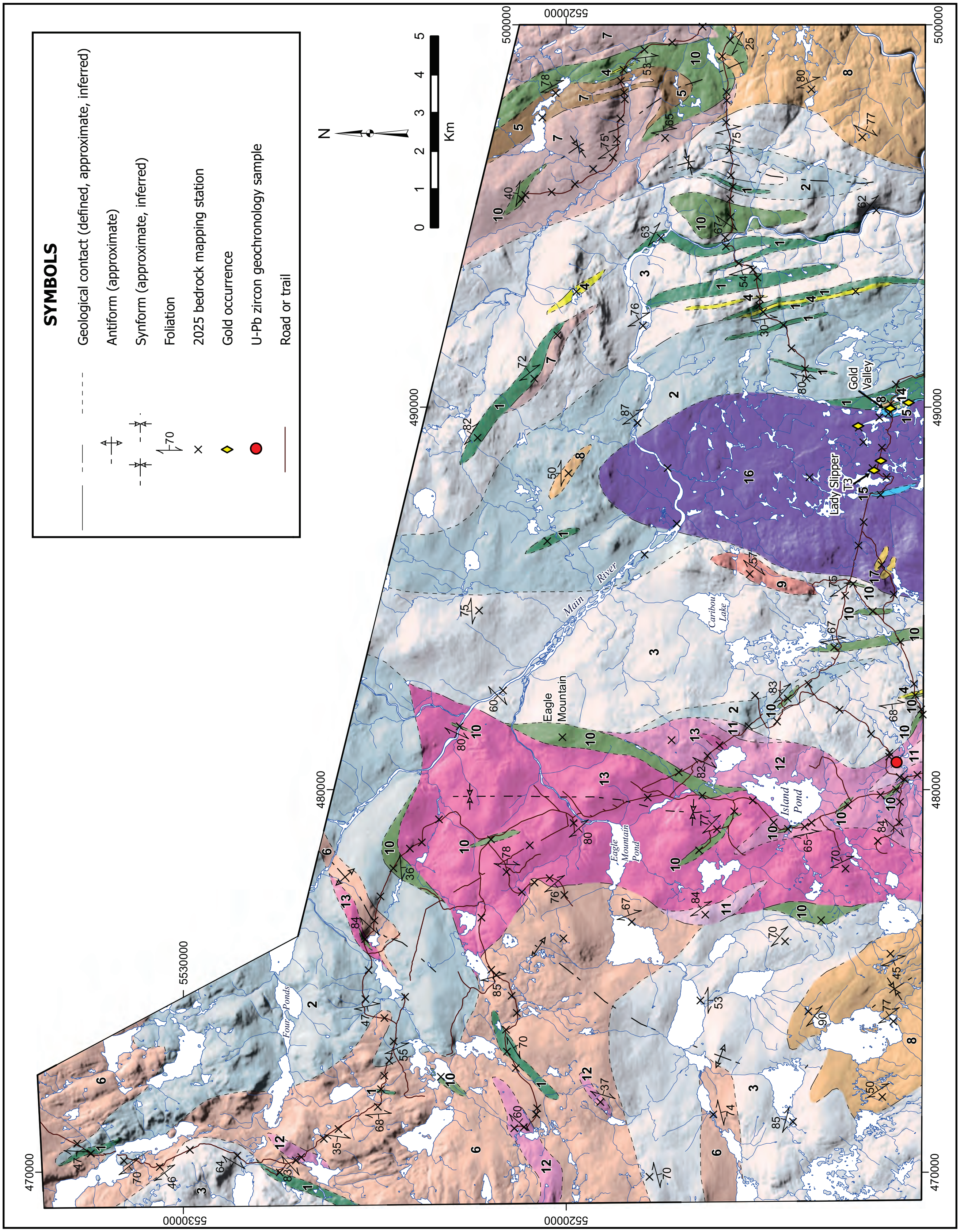

Figure 2. *Captions and Legend on following page.*

LEGEND

SILURIAN(?)

17	Biotite + magnetite ± hornblende monzogranite; fine to medium-grained, leucocratic, light pink weathered and fresh surfaces; forms dykes and plugs in gabbro–gabbronorite (Unit 16)
16	Medium to coarse-grained, dark-green to black gabbro and gabbronorite with lesser norite, olivine gabbro and leucogabbro; locally coarse grained to pegmatitic; typically contains hornblende + magnetite and locally contains disseminated pyrite; texturally and compositionally heterogeneous, with igneous textures and evidence of magma mingling

LATE NEOPROTEROZOIC TO ORDOVICIAN(?)

15	Humite + phlogopite marble; greyish-cream-weathered with light grey fresh surfaces; foliated and compositionally banded
14	Medium-grained quartzite with white to light-grey or rusty-orange weathered and fresh surfaces; contains disseminated pyrite

EARLY NEOPROTEROZOIC

POTATO HILL PLUTON

13	Feldspar-megacrystic monzogranite to granodiorite containing hornblende + biotite ± magnetite; K-feldspar or, less typically, plagioclase megacrysts (~0.5-4 cm long) comprise ~10-25% of the rock, within a medium to coarse-grained groundmass that is typically melanocratic; grey-weathered with a dark greenish-pink fresh surface; quartz is typically blue-grey; weakly to moderately foliated, locally lineated; locally contains enclaves of amphibolite and diorite
12	Hornblende ± biotite ± magnetite monzogranite to granodiorite; typically melanocratic; medium to coarse grained; grey-weathered with a dark greenish-pink fresh surface; locally contains clinopyroxene, orthopyroxene and/or minor amounts of fine-grained garnet; quartz is typically blue-grey; moderately foliated, locally lineated, locally contains amphibolite enclaves
11	Clinopyroxene + garnet + hornblende + magnetite ± orthopyroxene monzogranite to granodiorite; medium grained, moderately foliated with locally developed gneissosity; light greyish-buff weathered surface, greenish-pink fresh surface; quartz is typically blue-grey; garnet forms dark orange-red, ≤5 mm-sized crystals

LATE MESOPROTEROZOIC TO EARLY NEOPROTEROZOIC

10	Hornblende ± magnetite ± biotite gabbro, locally ranging to diorite; dark grey-weathered with dark greyish-green fresh surfaces; massive to weakly foliated, with igneous textures typically preserved
9	Biotite + garnet monzogranite; leucocratic with light pink to buff weathered and fresh surfaces; weakly foliated; garnet (≤5%) forms light pinkish to orange-red, ~1-5 mm-sized crystals
8	Biotite ± hornblende ± magnetite monzogranite; leucocratic with light pink to buff weathered and fresh surfaces; weakly to moderately lineated with local weak foliation
7	Biotite + hornblende monzogranite; medium-grained; grey weathered surface and pink-and-black fresh surface; moderately to strongly lineated and generally weakly to moderately foliated; variable abundances of mafic minerals (melanocratic to leucocratic); distinctive patchy, flecked or striped appearance due to elongate aggregates (up to ~1 x 5 cm) or ≤1 cm-thick bands or rods formed by mafic minerals
6	Biotite ± hornblende ± magnetite monzogranite to granodiorite; medium-grained, typically leucocratic, light pink to buff, weakly to moderately foliated and locally lineated; distinctive spotted or flecked appearance due to ~3 mm to ~1 cm-sized clots formed by mafic minerals; locally contains amphibolite enclaves

LATE PALEOPROTEROZOIC TO EARLY MESOPROTEROZOIC

LONG RANGE GNEISS COMPLEX

5	Biotite ± graphite ± muscovite psammite gneiss with local interbeds of biotite + garnet semi-pelite; grey to rusty-brown on weathered and fresh surfaces; medium-grained and moderately to strongly foliated; contains bands of medium to coarse-grained biotite ± graphite ± muscovite ± garnet leucogranite
4	White to light grey-weathered quartzite with grey fresh surfaces, containing minor amounts of feldspar ± biotite ± magnetite
3	Biotite ± hornblende ± magnetite ± orthopyroxene monzogranite gneiss, locally ranging to granodiorite gneiss; light pink or buff-weathered with dark grey-pink fresh surfaces; moderately foliated with variably developed gneissosity; locally contains amphibolite enclaves
2	Biotite + hornblende ± magnetite tonalite to granodiorite gneiss, locally ranging to dominantly quartz diorite gneiss; medium-grained, with local coarse-grained layers/patches; moderately to strongly foliated; typically heterogeneous, containing components (gneissic layers) of tonalite, granodiorite, quartz diorite, leucocratic tonalite/granodiorite, and enclaves of amphibolite
1	Amphibolite gneiss (± clinopyroxene); medium-grained and moderately to strongly foliated; weathered and fresh surfaces are dark green to dark grey-black; typically contains leucocratic (plagioclase-rich) bands or patches

Figure 2. *Preliminary geological map of the southern part of the Main River NTS map area 12H/14, based on 1:50 000-scale mapping conducted in the summer of 2025 (*this study*). Due to the scale of the figure, it is unfeasible to show all the structural measurements collected in the field, and only selected foliation measurements are plotted on the map. The locations of gold occurrences are from the Mineral Occurrence Data System (Geological Survey of Newfoundland and Labrador, 2025). The red circle shows the location of the only existing U–Pb date in the study area, from an orthopyroxene-bearing granitoid rock in the Potato Hill Pluton, which yielded a maximum zircon crystallization age of 999 ± 4 Ma (Heaman* et al.*, 2002). The coordinate system for the map is NAD 1927 UTM Zone 21N.*

including semipelite, psammite, quartzite and marble (Owen, 1991; Hinchey, 2020). U–Pb detrital zircon analyses from these sequences yielded maximum depositional ages of 996 ± 26 and 554 ± 15 Ma, suggesting that at least some of these rocks form part of Cambro-Ordovician cover sequences (Hinchey *et al.*, 2025a). A semipelite from a separate siliciclastic metasedimentary sequence, located ~1.5 km west of the TBGS and formerly considered as part of the LRGC, produced a maximum depositional age of 906 ± 7 Ma, suggesting that it was deposited during a post-Grenvillian rifting event that created a basin at *ca.* 900 Ma or that it is also part of the Cambro-Ordovician Laurentian cover sequence (Hinchey *et al.*, 2025a).

The Long Range Inlier records a complex, polyphase tectono-metamorphic history. Regional peak metamorphism occurred at amphibolite to granulite-facies conditions, and geothermobarometric estimates from the LRGC suggest an overall southwestward increase in metamorphic grade from ~550–700°C to ~700–800°C, at medium pressures of ~5–8 kbar (Owen and Erdmer, 1989; Owen, 1991). This metamorphism has been attributed to an early regional metamorphic event (M_1) that affected the LRGC prior to emplacement of Grenvillian intrusions, as supported by crosscutting relationships (Owen, 1991). The LRGC records early deformation (D_1) that has been considered synchronous with M_1 metamorphism and is characterized by folds with generally northeast-striking axial planes and by a moderate to steeply-dipping, generally northeast-striking foliation (Owen, 1991; Hinchey, 2010). The minimum age limit of M_1 is estimated at *ca.* 1032 Ma, which is the age of the oldest known Grenvillian pluton in the inlier (Lomond River Granite; Figure 1; Heaman *et al.*, 2002).

Amphibolite-facies metamorphic overprinting of LRGC pelite in spatial association with some Grenvillian intrusions has been interpreted as contact metamorphism (denoted as M_2 by Owen, 1991). Post-emplacement of the Grenvillian plutons, the Long Range Inlier was affected by regional amphibolite-facies metamorphism (denoted as M_3 by Owen, 1991) and coeval deformation, which produced folds in the Grenvillian plutons, as well as foliations and lineations that are defined by amphibolite-facies minerals (Owen, 1991; Hinchey, 2010). The U–Pb dating (TIMS) of metamorphic zircon, monazite and titanite suggest that M_2 and M_3 occurred at *ca.* 1022 and *ca.* 989 Ma, respectively (Heaman *et al.*, 2002).

Evidence of younger tectono-metamorphism has been identified locally in post-Grenvillian metasedimentary rocks in the Silver Mountain area (Hinchey, 2010; Hinchey *et al.*, 2025a). The rocks are foliated and contain small-scale folds, and the metasedimentary rocks that flank the TBGS exhibit a mylonitic contact with the LRGC, suggesting that the contact may represent a Paleozoic thrust fault (Hinchey, 2010; Hinchey *et al.*, 2025a). As granulite-facies assemblages with corona textures have been interpreted as the result of regional metamorphism overprinted by contact metamorphism from the Silurian TBGS (Ings and Owen, 2001), these rocks potentially record pre-TBGS, post-Grenvillian metamorphism (Hinchey, 2010).

Parts of the Long Range Inlier record evidence of Paleozoic tectono-metamorphism at greenschist- to lower amphibolite-facies conditions that has been linked with Appalachian orogenesis. For instance, some *ca.* 615 Ma Long Range dykes, have been overprinted by greenschist- to lower amphibolite-facies mineral assemblages (Owen *et al.*, 1989; Owen, 1991). The Grenvillian Main River pluton (Figure 1) records late, low-grade tectonic fabrics, including north-trending schistosity and east-plunging lineations, which may represent deformation associated with the DVFS (Hinchey, 2010). Localized brittle–ductile faults along the southeastern margin of the Inlier have been inferred as fault splays from the DVFS (Owen, 1991). The intensity of Paleozoic overprinting has been interpreted to progressively decrease from east to west across the inlier (Owen, 1991). It has been proposed that movement along the Long Range frontal thrust produced brittle structures in the western part of the inlier, including conjugate sets of brittle faults trending north-northeast and west-northwest in Gros Morne National Park and north-northeast-trending cataclasite zones that occur farther in the interior of the inlier, including in the Lac Michel Intrusive Suite (Erdmer, 1986).

GEOLOGY OF THE SOUTHERN MAIN RIVER MAP AREA

The geological units that comprise the Main River map area are described below, based on 1:50 000-scale bedrock mapping conducted in the summer of 2025. The corresponding preliminary map is presented in Figure 2 and summaries of tectono-metamorphism and mineralization in the study area are provided below. As the geology presented here is field-based without corresponding geochronology, geochemistry or petrography, it is provisional and may be modified following additional research.

LITHOLOGICAL UNITS

Late Paleoproterozoic to Early Mesoproterozoic: Long Range Gneiss Complex

Amphibolite Gneiss (Unit 1)

This unit consists of medium-grained, dark-green to dark-grey–black, moderate to strongly foliated amphibolite (Plate 1A, B) that locally contains clinopyroxene. In places,

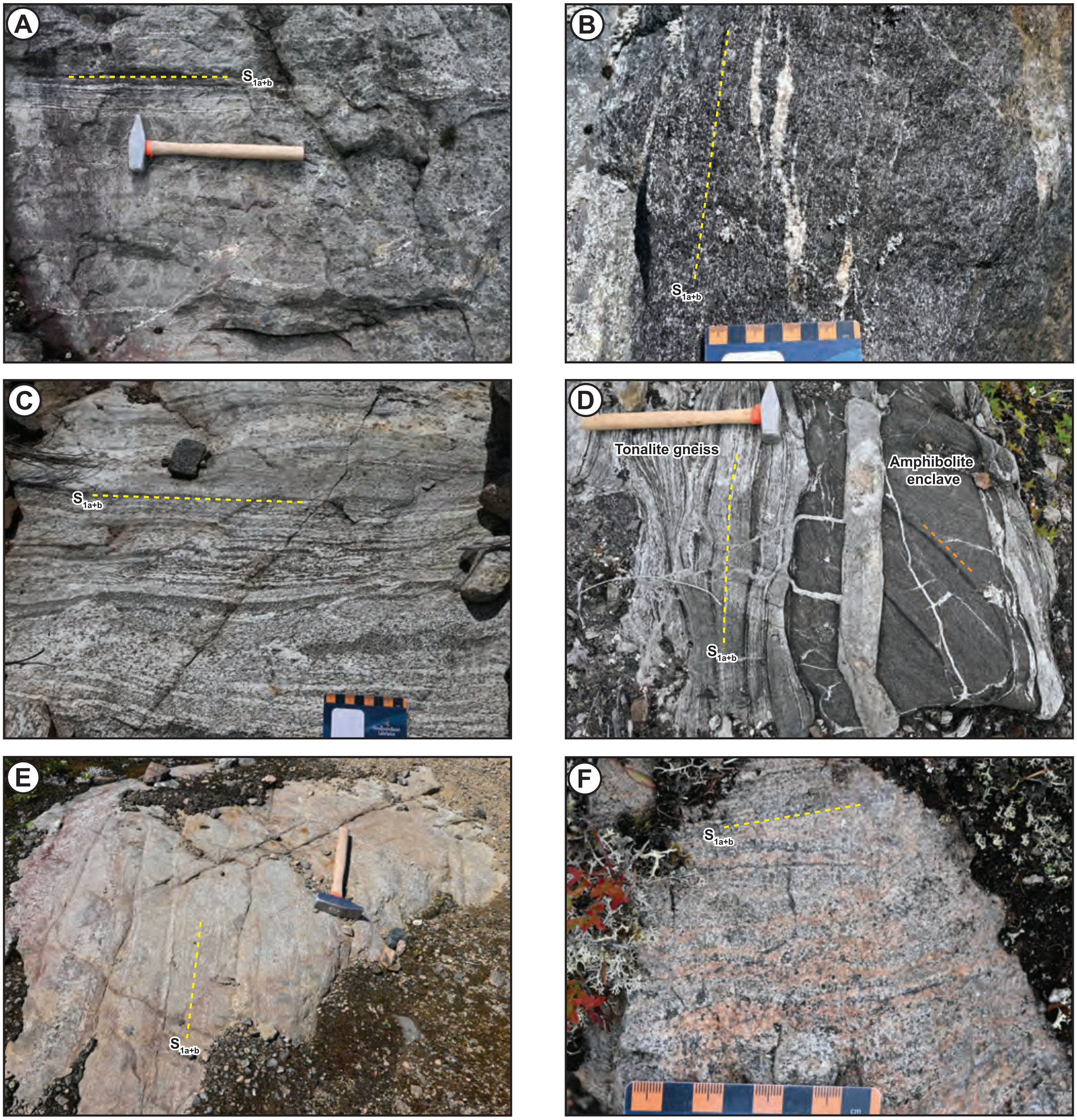

Plate 1. *Representative field photographs of orthogneiss in the Long Range Gneiss Complex. A, B) Amphibolite gneiss (Unit 1) containing leucocratic (plagioclase-rich) bands and patches aligned with foliation (composite foliation* S_{1a+b}, *discussed below; yellow dashed line); C) Tonalite gneiss (Unit 2) with characteristic compositional banding that includes bands of granodiorite and quartz diorite; D) Tonalite gneiss (Unit 2) containing an amphibolite enclave. The enclave is oriented parallel to foliation in the gneiss but records an earlier foliation (orange dashed line); E, F) Monzogranite gneiss (Unit 3) where gneissosity is defined by alternating bands with mostly monzogranitic to granodioritic compositions and various grain sizes.*

the amphibolite ranges to hornblende-bearing diorite (± clinopyroxene). The amphibolite typically contains leucocratic (plagioclase-rich), foliation-parallel bands or discontinuous patches that define a variably developed gneissosity (Plate 1B). This unit occurs as enclaves within felsic to intermediate gneiss units (described below) that form more extensive components of the LRGC.

Tonalite–Granodiorite–Quartz Diorite Gneiss (Unit 2)

This unit dominantly comprises tonalite gneiss but is heterogeneous and includes gneissic components (layers) of granodiorite, quartz diorite and leucocratic tonalite to granodiorite (Plate 1C, D). The tonalite–granodiorite–quartz diorite gneiss is moderately to strongly foliated, contains hornblende and biotite (± magnetite) and is light-grey-weathered overall, with a medium-grey fresh surface. The gneiss unit typically contains enclaves of amphibolite gneiss (Unit 1; Plate 1D).

Monzogranite Gneiss (Unit 3)

This unit consists of medium-grained biotite ± hornblende ± magnetite (± orthopyroxene) monzogranite gneiss with light pinkish or buff–grey-weathered surfaces and darker greyish-pink fresh surfaces (Plate 1E, F). The monzogranite gneiss locally ranges to granodiorite gneiss. This unit is moderately foliated, and gneissosity is defined by alternating ~1–10 cm thick bands of different grain sizes (medium or coarse grained) and/or different proportions of mafic and felsic minerals (Plate 1E, F). Gneissic banding is variably developed on the outcrop- and map-scales, and is weakly developed in places, forming wispy discontinuous bands. The gneiss locally contains amphibolite enclaves.

Quartzite (Unit 4)

Medium-grained, white to light-grey-weathered quartzite (Plate 2A, B) occurs in the eastern part of the mapped area, forming panels up to ~100-m across. The quartzite has a medium-grey fresh surface and contains minor amounts of feldspar ± biotite ± magnetite. Quartzite forms a ~100-m-wide panel in amphibolite gneiss (Unit 1, discussed above) in the eastern part of the study area, although the contact relationship with the amphibolite is unexposed where mapped. Additionally, a 2-m-sized block of quartzite is surrounded by hornblende gabbro (Unit 10, discussed below) and a ~10-m panel of quartzite is intruded by hornblende gabbro (Unit 10, discussed below) (Plate 2A, B). Elsewhere, contacts are loosely constrained, and the quartzite is presumed to be surrounded by tonalite gneiss (Unit 2) or monzogranite gneiss (Unit 3) of the LRGC.

Psammite–Semipelite (Unit 5)

This unit consists of medium-grained, light-grey to rusty-weathered biotite ± graphite ± muscovite psammite gneiss with local interbeds of biotite–garnet semipelite (Plate 2C–F). The psammite–semipelite gneiss also contains bands of medium to coarse-grained biotite ± graphite ± muscovite ± garnet leucogranite, which form ~10–25% of the rock volume. The leucogranite typically forms ~0.5–20-cm-thick bands oriented parallel to gneissosity and, in places, forms irregularly shaped, patchy bodies up to ~50 cm in diameter (Plate 2C, D). The psammite–semipelite gneiss forms a ~500-m-wide sequence that is bordered by monzogranite (Unit 7) and hornblende gabbro (Unit 10), although exposed contacts were not encountered during mapping.

Late Mesoproterozoic to Early Neoproterozoic (Grenvillian) Metaplutonic Rocks

Flecked/Spotted Leucocratic Monzogranite (Unit 6)

This unit occurs in the western part of the mapped area and consists of medium-grained, typically leucocratic, light-pink to buff, biotite ± hornblende ± magnetite monzogranite to granodiorite (Plate 3A–C). The mafic minerals form ~3-mm- to 1-cm-sized aggregates, resulting in a spotted or flecked appearance. The monzogranite is weakly to moderately foliated and locally lineated. It locally contains amphibolite enclaves and forms dykes intruding amphibolite (Unit 1; Plate 3B, C). Where the monzogranite contains amphibolite enclaves, it typically exhibits compositional banding defined by alternating layers of monzogranite, amphibolite and/or mafic schlieren.

Flecked/Striped Monzogranite (Unit 7)

Medium grained, leucocratic to melanocratic, pink and black, biotite–hornblende monzogranite occurs on the eastern side of the mapped area. The monzogranite is moderately to strongly lineated and weakly to moderately foliated (typically L>S). Mafic minerals form elongate aggregates up to ~1-cm thick and ~1–5-cm long, or form bands and/or rods up to ~1-cm thick, giving the rock a flecked, patchy or striped appearance (Plate 3D). The monzogranite locally contains amphibolite enclaves (Plate 3E), and has been intruded by hornblende gabbro (Unit 10; Plate 3F).

Leucocratic Monzogranite (Unit 8)

This unit consists of medium-grained, leucocratic, biotite ± hornblende ± magnetite monzogranite with light-pink, pinkish-grey or buff-weathered and fresh surfaces (Plate 4A, B). The monzogranite is non- to weakly foliated,

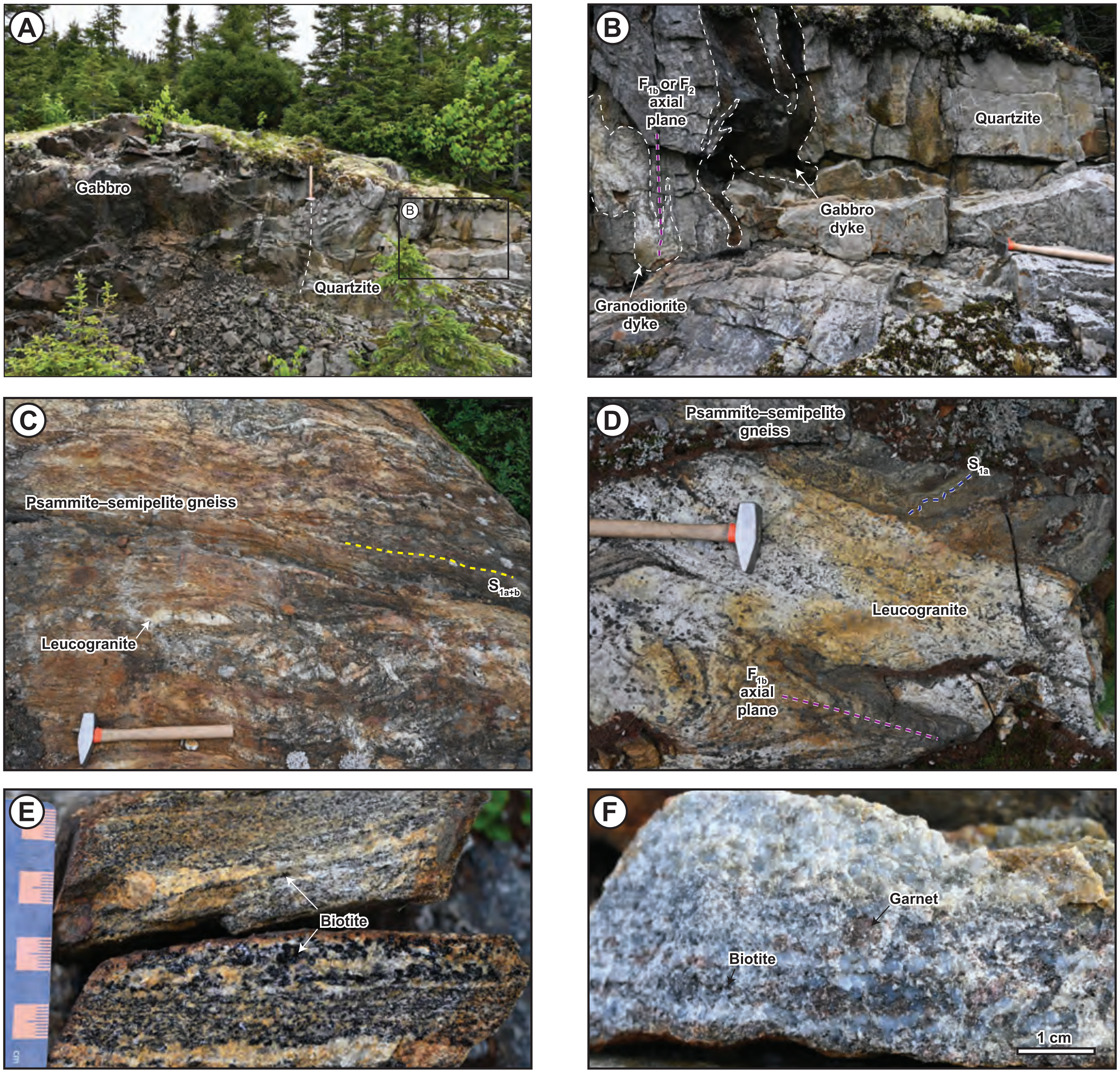

Plate 2. *Representative field photographs of metasedimentary rocks in the Long Range Gneiss Complex. A) Quartzite in contact with hornblende gabbro. Black square indicates location of (B); B) Quartzite intruded by a gabbro dyke, likely injected from the gabbro shown in (A). The quartzite was also intruded by a medium- to coarse-grained granodiorite dyke and subsequently folded (axial plane is indicated by purple dashed line). This fold is either* F_{1b} *or, if the granodiorite dyke is from a Grenvillian pluton,* F_2*; C, D) Psammite–semipelite gneiss containing leucogranite bands and dykes. In (C), compositional banding (including leucogranite bands) defines the foliation (*S_{1a+b}*; yellow dashed line). In (D), leucogranite is both concordant and discordant with the S1a foliation (blue dashed line), and the* S_{1a} *foliation is folded by a tight* F_{1b} *fold; E, F) Fresh surfaces of biotite–graphite psammite (E) and biotite–garnet semipelite (F). Mineral abbreviations in this report are from Whitney and Evans (2010).*

Plate 3. *Representative field photographs of monzogranite with flecked or spotted textures. A) Clots of hornblende, magnetite and biotite forming a spotted texture and defining* S_2 *foliation (black dashed line) in monzogranite (Unit 6); B) Spotted monzogranite (Unit 6) intruding amphibolite gneiss (Unit 1). Contacts are outlined in white dashed lines, except in areas with complex networks of small monzogranite dykes (*e.g.*, left side and centre of photo); C) Amphibolite enclaves in monzogranite (Unit 6). The enclaves have been disaggregated by the* S_2 *foliation defined by aligned clots of hornblende and biotite in monzogranite; D) Representative textures of flecked/striped monzogranite (Unit 7), including wispy or patchy flecks (left) and rods/bands (right) of hornblende and biotite aggregates aligned parallel to* L_2 *lineation and* S_2 *foliation; E) Amphibolite enclaves in flecked monzogranite (Unit 7), oriented parallel to* S_2 *foliation; F) Hornblende gabbro (Unit 10) crosscutting* S_2 *foliation in flecked monzogranite (Unit 7).*

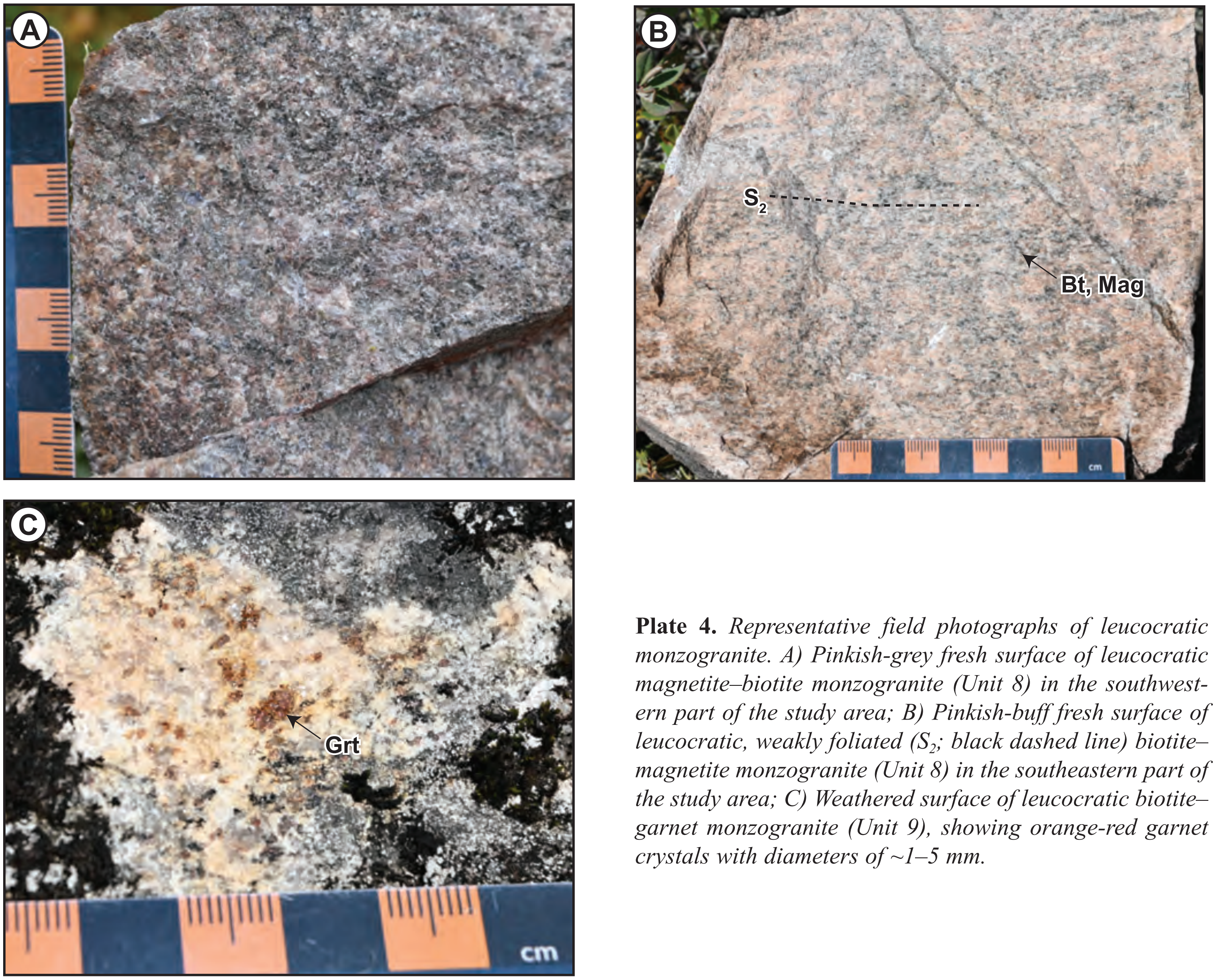

Plate 4. *Representative field photographs of leucocratic monzogranite. A) Pinkish-grey fresh surface of leucocratic magnetite–biotite monzogranite (Unit 8) in the southwestern part of the study area; B) Pinkish-buff fresh surface of leucocratic, weakly foliated (S_2; black dashed line) biotite–magnetite monzogranite (Unit 8) in the southeastern part of the study area; C) Weathered surface of leucocratic biotite–garnet monzogranite (Unit 9), showing orange-red garnet crystals with diameters of ~1–5 mm.*

weak to moderately lineated (typically L>S) and forms intrusions up to ~4 km across in the southeastern and southwestern parts of the study area, as well as smaller intrusions elsewhere (Figure 2). Although contact relationships were not observed during mapping, this unit is bordered by tonalite–granodiorite gneiss (Unit 2), monzogranite gneiss (Unit 3) or hornblende gabbro (Unit 10).

Leucocratic Garnet Monzogranite (Unit 9)

Medium-grained, leucocratic, biotite–garnet monzogranite occurs in the central part of the study area. The extent and field relationships of the intrusion are uncertain, mainly due to poor outcrop exposure. The monzogranite is weakly foliated and has light pink to buff weathered and fresh surfaces. Garnet has a modal abundance of up to ~5% and forms light pinkish-red to orange-red, round to oval-shaped crystals that are mostly 1–2 mm-wide and locally up to ~5 mm in diameter (Plate 4C).

Hornblende Gabbro to Diorite (Unit 10)

This unit consists of undivided intrusions of medium-grained hornblende gabbro, locally ranging to diorite, with dark-grey-weathered surfaces and dark greyish-green fresh surfaces (Plate 5A–E). The intrusions locally contain magnetite ± biotite and(or) in rare instances, up to 10% plagioclase phenocrysts (Plate 5E) that are up to 5-mm long. The hornblende gabbro–diorite intrusions are massive to weakly foliated (Plate 5C–E) and igneous textures are typically preserved, including euhedral plagioclase laths forming ophitic or subophitic textures (Plate 5C). Relative to the voluminous felsic rocks in the study area, the hornblende gabbro–diorite unit forms numerous smaller intrusions that are typically <1

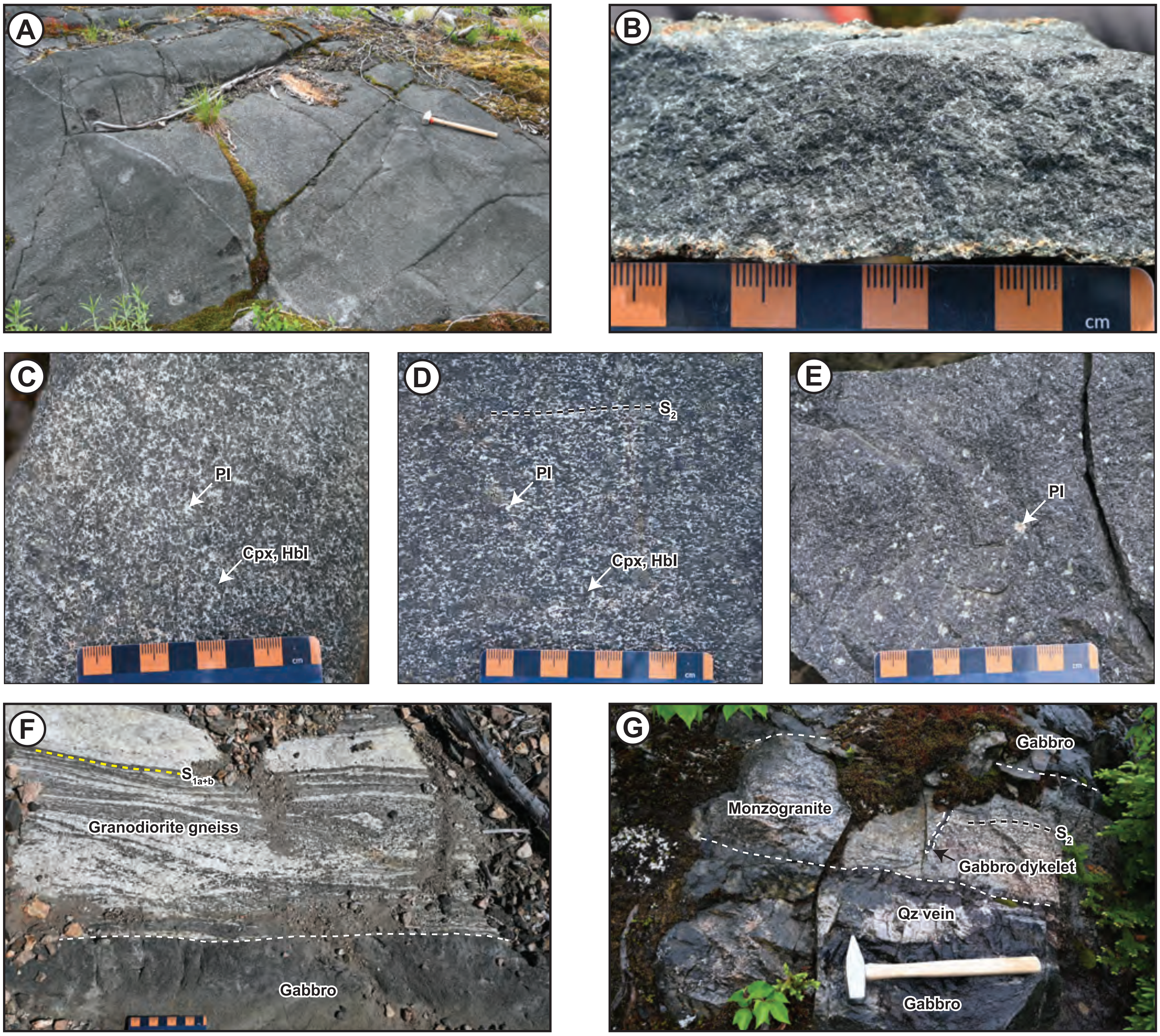

Plate 5. *Representative field photos of hornblende gabbro–diorite (Unit 10). Typical outcrop (A) and fresh surface (B) of hornblende gabbro; C) Hornblende diorite with euhedral plagioclase laths; D) Weak foliation (S_2; black dashed line) defined by aligned plagioclase, clinopyroxene and hornblende in hornblende diorite; E) Plagioclase phenocrysts in a fine- to medium-grained groundmass in hornblende gabbro; F) Dark-coloured margin of gabbro along the contact with a ~4-m-sized block of foliated (S_{1a+b}; yellow dashed line) granodiorite gneiss (Unit 2) within the gabbro; G) Raft of coarse-grained monzogranite in gabbro located <1.5 km east of the Potato Hill Pluton. Gabbro dykelets crosscut the S_2 foliation in the monzogranite.*

km wide and may be up to ~4-km long (Figure 2). They are bordered by the LRGC and by the Potato Hill Pluton and other felsic intrusions that are inferred as Grenvillian (late Mesoproterozoic to early Neoproterozoic). Contact relationships are well-exposed in several places, indicating that the gabbro–diorite intrusions postdate the LRGC and are both older than and younger than the felsic intrusions. For instance, hornblende gabbro exhibits intrusive relationships with quartzite of the LRGC (Unit 4; discussed above; Plate 2A, B) and surrounds a 4-m-wide raft of granodiorite gneiss (Unit 2), exhibiting sharp contacts with ~5-cm-wide darker margins, which may represent chilled margins that were recrystallized during subsequent metamorphism (Plate 5F). The flecked/striped monzogranite (Unit 7) in the eastern part of the study area has been intruded by hornblende gabbro (Plate 3F). Hornblende gabbro–diorite along the margin of the Potato Hill Pluton contains disaggregated rafts of coarse-grained monzogranite (Plate 5G) that may be xenoliths from the neighbouring Potato Hill Pluton. Elsewhere, hornblende gabbro has been intruded by a feldspar-megacrystic granodiorite dyke that is likely from the surrounding Potato Hill Pluton. Mafic to intermediate enclaves within the Potato Hill Pluton and other felsic intrusions that are inferred as Grenvillian may represent xenoliths from the hornblende gabbro–diorite unit. Therefore, the hornblende gabbro–diorite intrusions have various ages, but are nonetheless grouped together on the preliminary map in this study (Figure 2) and field relationships suggest that, as a group, they may have broadly overlapped in time with felsic intrusions that are provisionally considered to be late Mesoproterozoic to early Neoproterozoic.

Early Neoproterozoic (Grenvillian) Metaplutonic Rocks: Potato Hill Pluton

Garnet–Pyroxene Monzogranite to Granodiorite (Unit 11)

This unit occurs in a few localities in the central part of the study area. It consists of medium-grained, foliated, clinopyroxene–garnet–hornblende–magnetite ± orthopyroxene monzogranite to granodiorite (Plate 6A, B). Gneissic banding is locally developed, defined by alternating clinopyroxene–garnet-rich and quartz–feldspar-rich bands (Plate 6A). Quartz is typically blue-grey (Plate 6B). This unit locally contains patchy, ~10–50-cm-sized, medium to coarse-grained, quartz–feldspar-rich zones with hornblende-enriched margins (Plate 6A). The monzogranite to granodiorite has a light greyish-buff-weathered surface, a greenish-pink fresh surface and locally contains enclaves of fine to medium-grained hornblende diorite. Garnet is dark-orange-red and forms ≤0.5-cm-sized aggregates of <1 to 2-mm-sized crystals, as well as individual equant grains up to 5 mm in diameter (Plate 6B).

Melanocratic Monzogranite to Granodiorite (Unit 12)

This unit consists of medium–coarse-grained hornblende ± biotite ± magnetite monzogranite to granodiorite (Plate 6C, D) that is generally melanocratic and locally contains minor clinopyroxene, orthopyroxene and/or garnet. It has a grey-weathered surface and a dark greenish-pink fresh surface, and quartz typically exhibits a blue-grey hue (Plate 6D). Where present, garnet occurs as ≤2 mm-sized crystals that form partial coronas on hornblende and pyroxene. The melanocratic monzogranite–granodiorite is weak to moderately foliated and locally lineated. In some places, it contains amphibolite enclaves (Plate 6C). It is locally intruded by dykes of leucocratic biotite–magnetite monzogranite, which also forms <10-m-sized bodies within the unit.

Feldspar-megacrystic Monzogranite to Granodiorite (Unit 13)

Feldspar-megacrystic monzogranite–granodiorite contains hornblende and biotite ± magnetite and is generally melanocratic, with a grey-weathered surface and a dark greenish-pink fresh surface (Plate 6E). Surrounded by a medium- to coarse-grained groundmass, the feldspar megacrysts form ~10–25% of the rock and are comprised of K-feldspar or, less typically, plagioclase. They form subhedral to euhedral crystals with 2:1 or 3:1 aspect ratios and are mostly ~0.5–2-cm long and locally up to ~4-cm long. This unit is weakly to moderately foliated, lineated in places (locally L>S), and quartz tends to be grey–blue. It locally contains enclaves of amphibolite and hornblende diorite. At one locality near the Potato Hill Pluton margin, it forms a ~1 m-wide dyke that intruded hornblende gabbro (Unit 10; Plate 6F).

Late Neoproterozoic

Gabbro Dykes

Fine to medium-grained gabbro dykes up to ~2-m wide were observed in places but are too small to show on the geological map in Figure 2. The dykes are brownish-grey-weathering and have greenish-grey fresh surfaces. They dip moderately toward the northwest, crosscutting foliation in felsic plutonic host rocks that are inferred to be Grenvillian (Plate 7). As suggested for similar mafic dykes in the Silver Mountain area (Hinchey, 2010), the dykes in the Main River area may correlate with the *ca.* 615 Ma Long Range dykes, which occur extensively in the northern part of the inlier (Owen, 1991).

Late Neoproterozoic to Ordovician(?) Meta-Supracrustal Rocks

Meta-supracrustal rocks occur within and along the eastern edge of a gabbroic intrusive suite that is inferred as post-Grenvillian (Silurian(?) Unit 16, discussed below) in the southeastern part of the study area. Comprising mainly quartzite and marble, the meta-supracrustal rocks have limited outcrop exposure and are estimated to form intervals up to ~300-m wide bordered by amphibolite gneiss (Unit 1) or gabbroic intrusions (Unit 16). These strata are inferred as late Neoproterozoic to Ordovician based on similarities with supracrustal rocks of that age to the south in the Silver Mountain area (Hinchey, 2010, 2020; Hinchey *et al.*, 2025a), including comparable spatial associations with post-Grenvillian gabbroic intrusions, as well as lithological similarities and particularly the presence of marble, which is undocumented in metasedimentary rocks in the LRGC. This inference is supported by preliminary U–Pb detrital zircon dating of

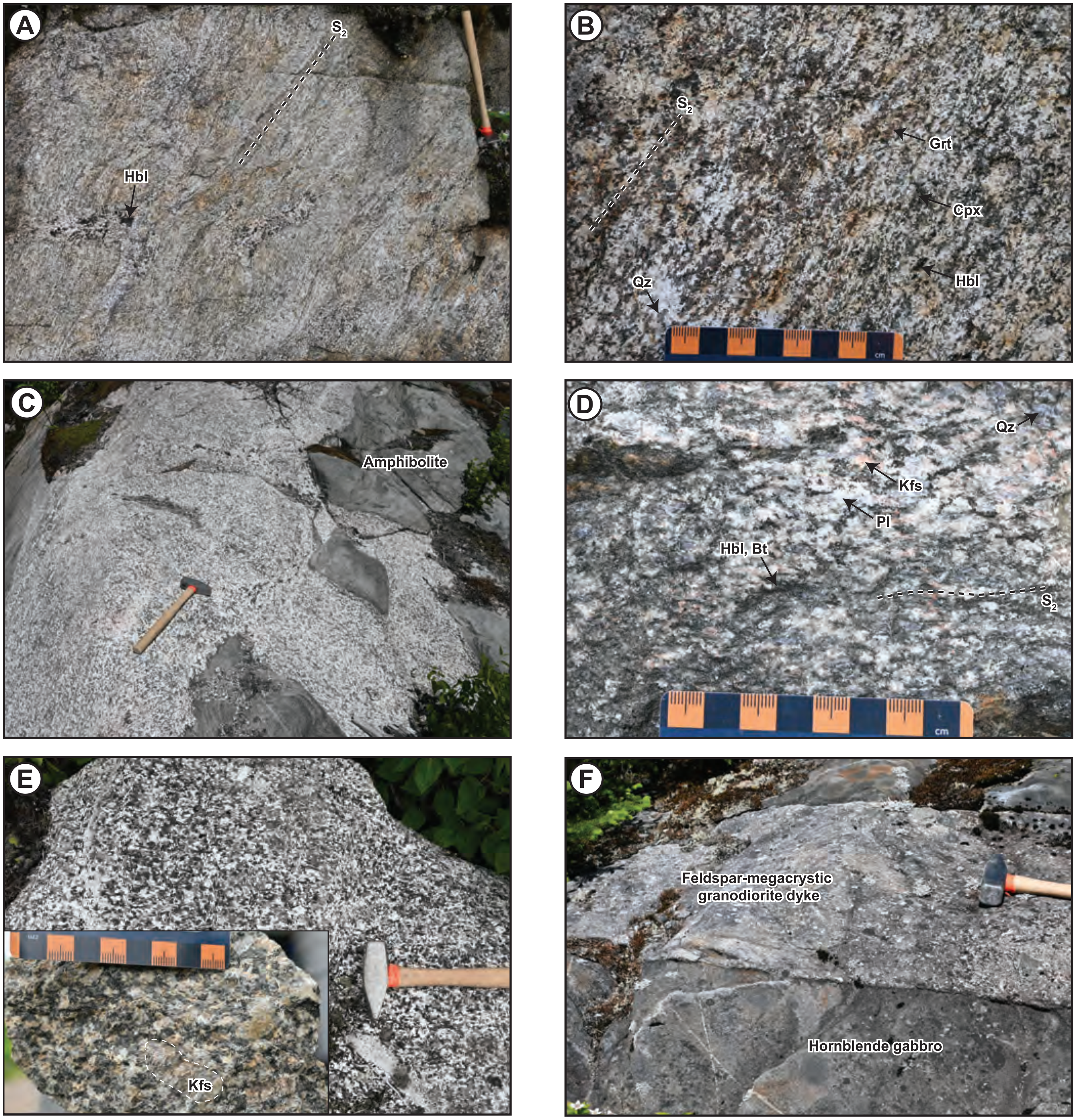

Plate 6. *Representative field photographs of the Potato Hill Pluton. A) Foliated (S_2; black dashed line) clinopyroxene–garnet–hornblende–magnetite monzogranite (Unit 11) exhibiting gneissic texture and containing coarse-grained patches enriched in quartz, feldspar and hornblende; B) Detail of outcrop in (A), showing dark bluish-grey quartz and aggregates of garnet, clinopyroxene and hornblende defining S_2 foliation; C) Coarse-grained biotite–magnetite–hornblende monzogranite (Unit 12) containing amphibolite enclaves; D) Detail of S_2-foliated medium to coarse-grained, relatively melanocratic hornblende–biotite granodiorite (Unit 12); E) Feldspar-megacrystic hornblende–biotite monzogranite (Unit 13). Inset photo shows a 3.5 cm-long K-feldspar megacryst on the fresh surface. F) A ~1 m-wide feldspar-megacrystic granodiorite dyke intruding hornblende gabbro. The gabbro outcrop is surrounded by feldspar-megacrystic monzogranite–granodiorite of the Potato Hill Pluton.*

metasedimentary rocks from the vicinity of the Gold Valley/Lady Slipper T3 gold occurrences (Figure 2), which yielded dates as young as *ca.* 900–700 Ma (Steele *et al.*, 2025).

Quartzite (Unit 14)

Quartzite is medium-grained and has white to light-grey or rusty-orange weathered and fresh surfaces. The quartzite contains disseminated pyrite and is cut by numerous fractures with various orientations (Plate 8A).

Marble (Unit 15)

Marble is fine to medium grained with light-grey fresh surfaces and greyish-cream-weathered surfaces (Plate 8B, C). The marble is foliated and contains humite and phlogo-

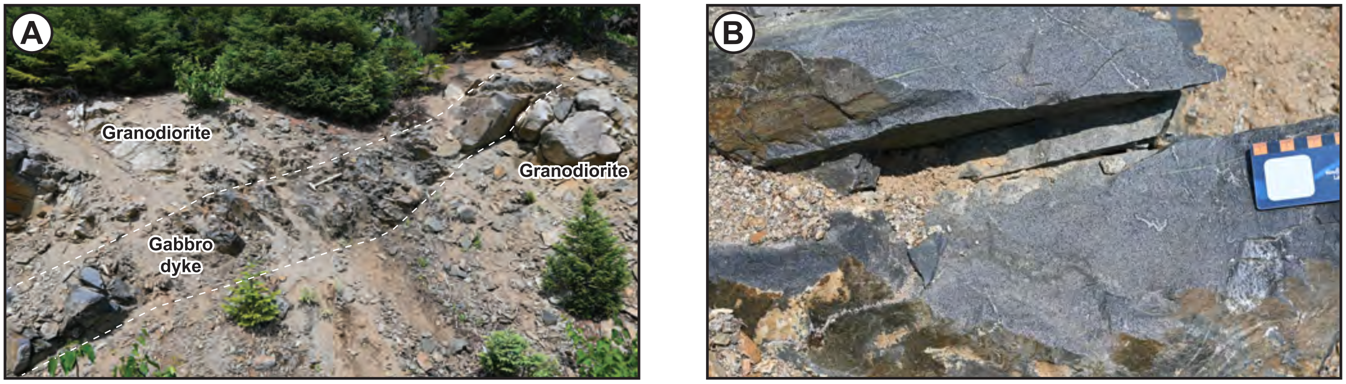

Plate 7. *A) Field photograph of a northwest-dipping gabbro dyke hosted by granodiorite; B) Detail of gabbro dyke shown in outcrop in (A).*

Plate 8. *Representative field photos of Neoproterozoic to Ordovician(?) supracrustal rocks. A) Fractured, grey to rusty-orange-weathered outcrop of quartzite; B) Greyish-cream-weathered marble with compositional banding cut by a gabbroic dyke; C) Detail of fresh and weathered surfaces of marble, showing compositional bands defined by varying abundances of humite and phlogopite that are aligned with foliation (green dashed line), which is cut by calcite–quartz veins.*

pite, and compositional banding is defined by varying abundances of these minerals. The marble contains patchy calcite veins (≤3 cm-wide) at various orientations, which locally range to coarse grained and contain aggregates of phlogopite. In places, the marble is cut by networks of quartz ± calcite veins that range in width from ~1-mm to ~1-cm. At one locality, gneissosity in the marble is cut by a ~10-cm-wide, fine-grained gabbroic dyke (Plate 8B). The marble locally contains interbeds up to ~1-m-thick of medium-grained biotite psammite and fine-grained hornblende gabbro.

Silurian(?) Intrusions

Mafic Intrusive Suite (Unit 16)

A suite of mafic intrusions occurs in the south-central part of the study area, forming a north-trending elongate shape that is ~4-km wide and at least 6-km long. The mafic suite consists of mainly dark-green-to-black gabbro and gabbronorite with lesser norite, olivine gabbro and leucogabbro (Plate 9). The intrusions are mostly medium to coarse grained, locally form coarse-grained to pegmatitic phases, commonly contain hornblende and magnetite and locally contain disseminated pyrite. The mafic suite is characterized by textural and compositional heterogeneity and evidence of magma mingling. Igneous layering occurs in places, typically defined by diffuse compositional layering within medium to coarse-grained gabbro to gabbronorite or by more distinct compositional layering and cumulate textures within coarse-grained to pegmatitic gabbro to gabbronorite (Plate 9A). Elsewhere, magma mingling is indicated by multiple mafic phases with different grain sizes and textures exhibiting complex crosscutting relationships, including dykes oriented subparallel to igneous layering (Plate 9A) or variably oriented xenoliths and dykelets (Plate 9B). The local preferred alignment of xenoliths (Plate 9C) and, less typically, of igneous minerals likely represent igneous flow fabrics, which dominantly dip toward the northwest or northeast, together with igneous layering. The lithologies and igneous textures exhibited by this unit are distinct from other mafic units in the map area and are similar to those of the Silurian TBGS, located ~2.5 km to the south (Figure 1; Owen, 1991; Collins, 2007; Hinchey, 2010, 2020; Hinchey *et al.*, 2025b). Based on these similarities and preliminary U–Pb zircon dates of *ca.* 425 Ma from the area around the Gold Valley/Lady Slipper T3 occurrences (Figure 2), it has been proposed that this mafic intrusive suite (Unit 16 in Figure 2) correlates with the TBGS (Markham *et al.*, 2026). Consequently, Unit 16 is provisionally inferred to be Silurian in age.

Monzogranite (Unit 17)

Fine to medium grained, light-pink, leucocratic, biotite–magnetite ± hornblende monzogranite occurs as dykes and relatively small intrusions hosted by medium- to coarse-grained gabbro in the southern part of the mafic intrusive suite (Unit 16, described above; Plate 9E, F). The monzogranite dykes are typically <20-cm wide, have variable orientations and locally contain ≤10% feldspar phenocrysts that are ≤5-mm long. Monzogranite also forms intrusive bodies that are up to ~150-m wide, exhibiting sharp contacts and injections into gabbroic host rocks (Plate 9F). Based on similarities in lithologies and field relationships, this monzogranite unit may correlate with Late Silurian monzogranite dykes and sills that intruded the TBGS (Hinchey, 2010, 2020; Hinchey *et al.*, 2025b).

TECTONO-METAMORPHISM

$M_1 + D_1$

In the LRGC in the Main River area, felsic to intermediate rocks are characterized by peak metamorphic mineral assemblages containing hornblende and biotite (± magnetite; Plate 1C). Clinopyroxene occurs locally, typically in tonalite to quartz–diorite gneiss. Orthopyroxene was observed in a few places in monzogranite gneiss in the central study area and locally co-occurs with clinopyroxene. Clinopyroxene is locally rimmed by hornblende. Amphibolite gneiss in the LRGC contains clinopyroxene in many locations. The peak metamorphic mineral assemblage in semipelite in the LRGC includes garnet, biotite and plagioclase, and leucogranite bands likely represent partial melt (leucosome; Plate 2C–F). The mineral assemblages in the LRGC are generally consistent with regional peak metamorphism at amphibolite-facies conditions, although granulite-facies conditions may have been reached in places. Regional metamorphism that affected the LRGC prior to Grenvillian plutonism is provisionally correlated with the M_1 metamorphic event described in previous studies (Owen and Erdmer, 1989; Owen, 1991; Hinchey, 2010).

An early regional deformation event (D_1) affected the LRGC and produced a regional foliation (S_{1a}) defined by aligned peak metamorphic minerals and gneissosity (Plates 2D and 10A–C). In places, the early foliation (S_{1a}) has been folded into tight to isoclinal folds (F_{1b}) (Plates 2D and 10A–C). A younger foliation (S_{1b}), also defined by peak metamorphic minerals, is axial planar to F_{1b} and is best developed in F_{1b} fold hinges (Plate 10A). The predominant foliation in the LRGC is interpreted as a composite S_{1a+b} foliation, which is parallel, overall, to F_{1b} axial planes and dominantly dips moderately to steeply towards the northeast or southwest. Mineral lineation occurs locally and is approximately parallel to F_{1b} fold hinges. As the D_{1a} and D_{1b} fabrics are defined by peak metamorphic minerals, they may represent different phases of regional deformation (D_1) that occurred during M_1 in the Main River area. This deformation is interpreted to

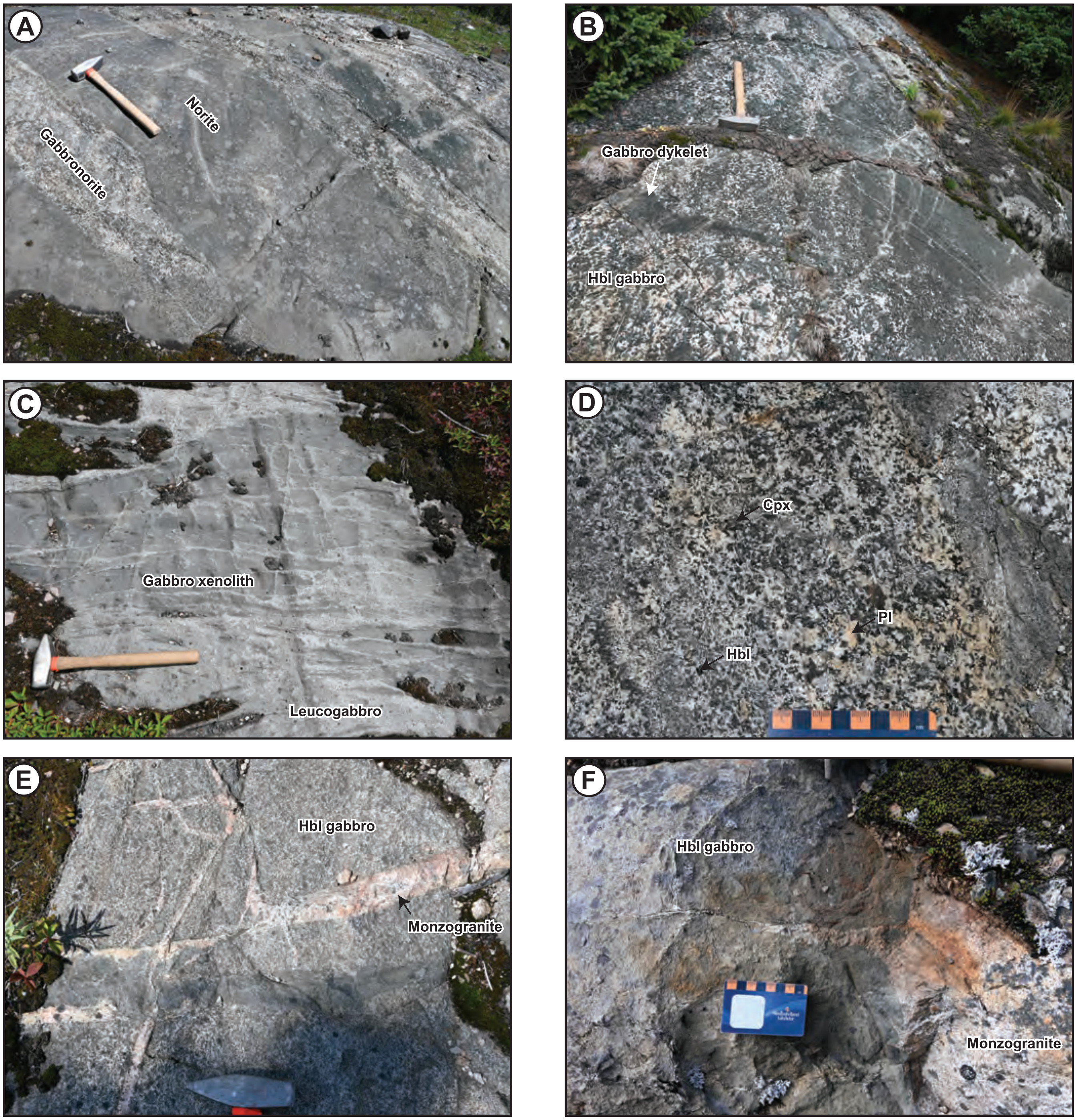

Plate 9. *Representative field photos of the Silurian(?) mafic intrusive suite (Unit 16) and monzogranite (Unit 17). A) Dykes of medium-grained norite oriented subparallel to compositional layering in coarse-grained gabbronorite host rocks; B) Heterogeneous outcrop comprised of coarse-grained to pegmatitic hornblende gabbro surrounding medium-grained hornblende gabbro and cut by fine-grained gabbro dykelets; C) Aligned fine to medium-grained gabbro xenoliths intruded by medium-grained leucogabbro; D) Detail of heterogeneous textures with various grain sizes in hornblende gabbro; E) Medium-grained hornblende gabbro (Unit 16) intruded by fine-grained biotite–hornblende monzogranite dykes; F) Contact between medium-grained hornblende gabbro (Unit 16) and a ~150 m-wide intrusion of medium-grained hornblende–magnetite ± biotite monzogranite (Unit 17), showing monzogranite injected into gabbro.*

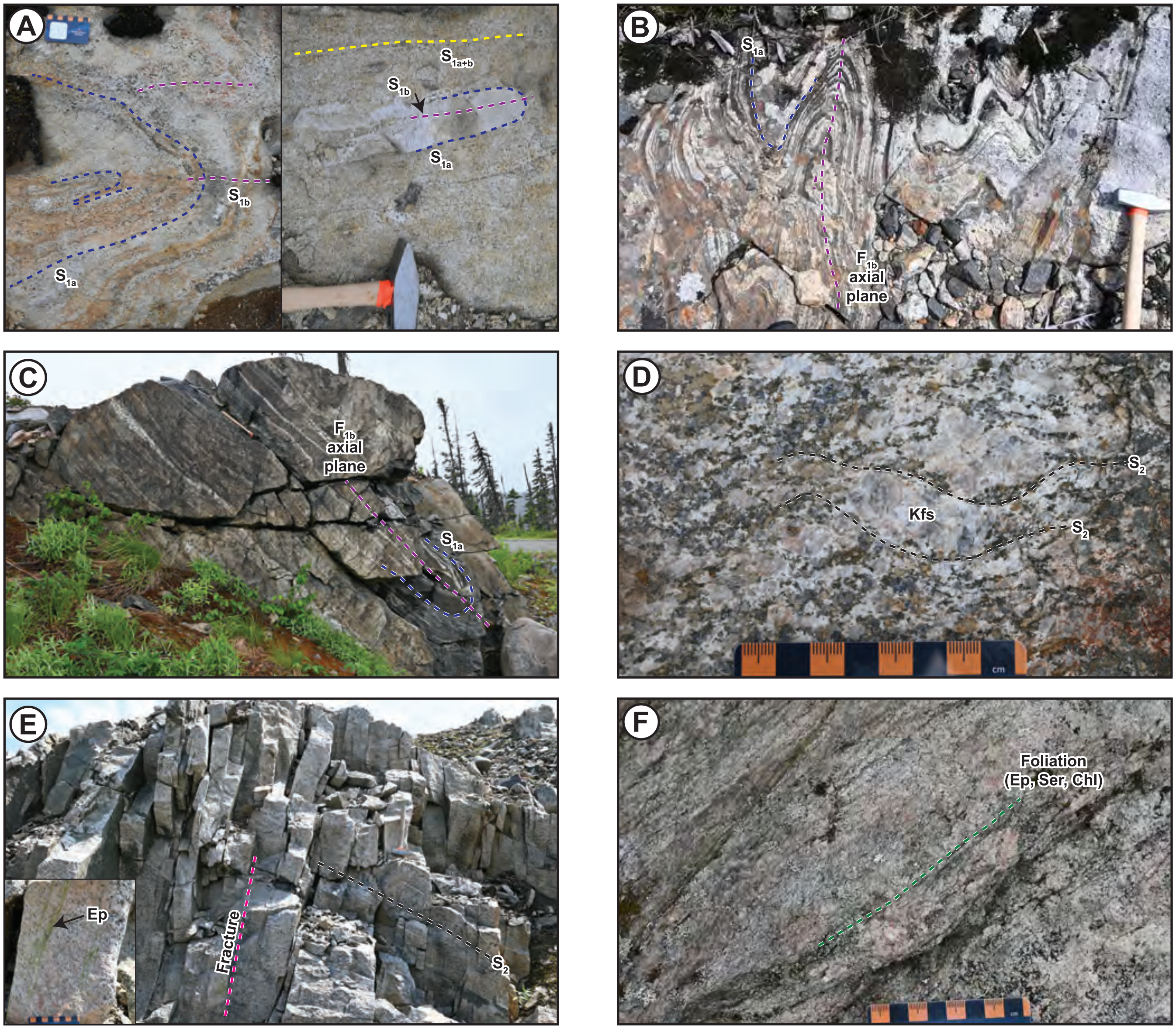

Plate 10. *Field photographs of deformation fabrics. A) Gneissosity and early foliation (S_{1a}; blue dashed line) folded by tight (left) to isoclinal (right) F_{1b} folds, with northeast-dipping axial planar foliation (S_{1b}; purple dashed line) in fold hinges and a composite S_{1a+1b} foliation (yellow dashed line) developed outside the folds, parallel to S_{1b}. Both photos are from the same outcrop of monzogranite gneiss (Unit 3); B) Gneissosity and early foliation (S_{1a}) folded by tight to isoclinal, northwest or southeast-plunging F_{1b} folds in tonalite gneiss (Unit 2), with northeast-dipping axial planes; C) Gneissosity and early foliation (S_{1a}) folded by an isoclinal F_{1b} fold with a southwest-dipping axial plane in quartz diorite gneiss (Unit 2); D) Northeast-dipping S2 foliation wrapping K-feldspar megacrysts in monzogranite. The megacrysts have been recrystallized into S_2-aligned sigmoidal shapes; E) Steeply east-dipping, epidote-filled fractures (pink dashed line) cross-cutting west-dipping S_2 foliation defined by aligned clots of hornblende + magnetite + biotite in leucocratic monzogranite (Unit 6); F) South-dipping foliation (green dashed line) defined by closely spaced fractures, with epidote + sericite ± chlorite on foliation planes, in monzogranite gneiss (Unit 3). The foliation crosscuts gneissosity (S_{1a+b}), which dips towards the northeast but is indiscernable in this photo due to the intensity of the younger foliation.*

correlate with the regional D_1 event described in previous studies (Owen, 1991; Hinchey, 2010), which was also characterized by foliation development and folding in the LRGC. In some amphibolite enclaves, a foliation that is at an angle to that of the surrounding tonalite–granodiorite–quartz diorite gneiss may be evidence of an early phase of S_{1a} foliation or pre-S_1 deformation (Plate 1D).

M_2+ D_2

Peak metamorphic mineral assemblages in plutons that are inferred as Grenvillian are typified by hornblende and biotite (± magnetite; Plate 3). In addition to these minerals, parts of the *ca.* 999 Ma Potato Hill Pluton contain clinopyroxene, garnet and orthopyroxene (Plate 6B), which have been interpreted as primary igneous minerals based on their chemistry and textures (Owen and Marr, 1990; Owen *et al.*, 1992). It has also been proposed that garnet in coronas around primary hornblende and pyroxene formed during subsolidus cooling of the pluton at amphibolite-facies conditions and that some non-coronitic garnet grew or re-equilibrated during subsequent tectono-metamorphism (Owen and Marr, 1990). The alignment of aggregates of clinopyroxene and garnet (± orthopyroxene) with foliation (Plate 6B) suggests that these minerals formed or re-equilibrated during tectono-metamorphism. Together, the peak metamorphic mineral assemblages imply regional metamorphism at amphibolite-facies conditions, although the possibility of local granulite-facies metamorphism requires further investigation. This metamorphic event (M_2) is tentatively correlated with the regional syn- to post-plutonic metamorphism described in previous studies (Owen and Erdmer, 1989; Owen, 1991; Heaman *et al.*, 2002; Hinchey, 2010).

The second regional deformation event (D_2) produced a foliation (S_2) and lineation (L_2) defined by aligned peak-metamorphic minerals in the Potato Hill Pluton and other intrusions that are inferred as Grenvillian (late Mesoproterozoic to early Neoproterozoic). The foliation is generally weak to moderate, but some locations are moderately to strongly foliated, particularly in parts of the Potato Hill Pluton. Lineations, where present, are weak to strongly developed and are more intense than the S_2 foliation in several places (L>S). The S_2 foliation generally dips moderately to steeply towards the northeast or southwest and the L_2 lineation plunges at a range of angles toward the northwest or southeast. In feldspar–megacrystic monzogranite to granodiorite in the Potato Hill Pluton, feldspar megacrysts are aligned with S_2 and L_2. They are wrapped by S_2 + L_2-aligned mafic minerals but have also been dynamically recrystallized, locally forming sigmoidal shapes aligned with S_2 and L_2 (Plate 10D). Gneissosity is locally developed, such as in the garnet–pyroxene monzogranite to granodiorite phase (Unit 11) in the Potato Hill Pluton (Plate 6A). In other intrusions (units 6 and 7), aggregates of mafic minerals (hornblende, biotite, magnetite) form clots or rods aligned with S_2 and L_2, resulting in a flecked or striped appearance (Plate 3A, C, D). The D_2 event is interpreted as syn- to post-emplacement of Grenvillian plutons and, as it is defined by peak metamorphic minerals in the plutons, it was accompanied by M_2 metamorphism. D_2 in the Main River area likely correlates with the regional deformation event that affected the Grenvillian plutons throughout the Inlier, as described by previous studies (Owen, 1991; D_2 in Hinchey, 2010).

Variations in fabric orientations suggest that the Main River area has been affected by map-scale synformal and antiformal folds with northeast- to northwest-trending axial traces (Figure 2). The existence of these folds is also supported by the folded map-patterns of lithologies in some areas, as interpreted from bedrock mapping (this study) and aeromagnetic data (Geological Survey of Canada, 1968). Map-scale folds may have developed during D_1, but at least some of them are interpreted as syn- to post-D_2, as they affect the Potato Hill Pluton (units 11–13) and other intrusions (units 6–8 and 10) that are inferred as Grenvillian.

D_1 fabrics in the LRGC are interpreted to have undergone variable overprinting by D_2, consistent with the variable intensity of D_2 fabrics affecting the Grenvillian plutons. It is likely that the S_2 foliation was developed in the LRGC, at least locally, although it is difficult to distinguish from the S_{1a+b} foliation because the foliations have broadly similar orientations and both are defined by peak metamorphic minerals (generally amphibolite-facies, as discussed above). Nonetheless, the D_{1b} deformation event is distinct from D_2, as it is characterized by intense, tight to isoclinal, decimetre to outcrop-scale folding (F_{1b}) in the LRGC, which is rare to absent in Grenvillian plutons.

M_3 + D_3 (?)

Ductile fabrics also occur in the late Neoproterozoic to Ordovician(?) metasedimentary rocks (units 14 and 15) that flank the eastern margin of the Silurian(?) mafic intrusive suite (Unit 16). Foliation in the marble is steeply dipping toward the east or northwest, and compositional layers in the marble are locally folded by tight to isoclinal folds with east-dipping axial planes. The foliation is defined by aligned phlogopite and compositional bands having varying abundances of humite (Plate 8C, D), suggesting that deformation occurred at relatively high temperatures. If these metasedimentary rocks are indeed late Neoproterozoic to Ordovician, as supported by preliminary detrital U–Pb dates (Steele *et al.*, 2025), it would seem they were metamorphosed and deformed (M_3 + D_3?) during Appalachian orogenesis. This has been suggested in late Neoproterozoic to Ordovician metasedimentary rocks in the Silver Mountain area, where a mylonitic contact with the underlying crystalline rocks of the inlier may represent an Appalachian (Taconic?) thrust fault (Hinchey, 2010; Hinchey *et al.*, 2025a), although it is uncertain whether a comparable structure exists in the Main River area.

Post-Grenvillian, Lower-grade Overprinting

The Main River area also records evidence of late (post-Grenvillian), relatively low-grade thermal and fluid activity, which is mainly associated with brittle or brittle–ductile structures. The northwestern study area is strongly affected by brittle deformation, characterized by a well-developed, regionally extensive, north-northeast-striking, steeply east-southeast-dipping fracture set with spacings of ~10–30-cm (Plate 10E). These fractures are typically filled with epidote veins (Plate 10E, inset), which are up to ~2 cm-wide and locally also include hematite and/or chlorite. Fracture sets occur locally on the eastern side of the study area, although they have various orientations, and some are parallel to ductile foliations in the surrounding rocks. In the southwestern study area, monzogranite gneiss (Unit 3) at one locality is pervasively altered by chlorite–sericite ± epidote, which are concentrated along south-dipping fractures and foliation planes that crosscut gneissosity. The foliation is an intense, tightly spaced (~mm to cm-scale), slightly anastomosing fracture cleavage (Plate 10F) that is consistent with brittle–ductile conditions and suggests that the study area was locally affected by late, intense greenschist-facies deformation. In several other areas, chlorite occurs in low abundances as a secondary mineral that is non-fabric-defining, forming aggregates around hornblende or biotite.

MINERALIZATION

In the southern study area, gold and minor base-metal (Cu–Pb–Zn) mineralization have been previously documented along the eastern margin of the mafic intrusive suite (Unit 16), including the Gold Valley and Lady Slipper T3 occurrences (Figure 2). Previous work has shown that the mineralization is concentrated in mesothermal quartz veins, occurs in lower grades in an alkali-carbonate alteration halo and is spatially associated with faults that may be splays from the DVFS (Fitzpatrick, 2010). As the area was under active exploration in 2025 (by Fishhawk Gold Corporation), fieldwork conducted in the present study in the Gold Valley–Lady Slipper area focused on regional-scale bedrock mapping and the mineralization was not sampled or studied in detail. The mineral occurrences encountered during mapping are generally hosted in mafic intrusive rocks (Unit 16) or in monzogranite dykes and small-volume intrusions (Unit 17) that were emplaced into the mafic rocks. For instance, at the Lady Slipper T3 occurrence, gabbro is cut by monzogranite dykelets, and both units exhibit gossanous weathering and host pyrite-bearing quartz veins (Plate 11A, B). Marble and quartzite (units 14 and 15) are spatially associated, locally exhibit gossanous weathering (Plate 8A), and quartzite contains disseminated pyrite.

Quartz veins and zones of gossanous weathering occur in a few places elsewhere. In the LRGC, tonalite and amphibolite gneiss (units 1 and 2) locally host quartz veins that are up to ~50-cm wide, are oriented subparallel to foliation and contain fine- to medium-grained pyrite with associated gossanous weathering in the veins and wallrocks (Plate 11C, D). Psammite–semipelite gneiss (Unit 5) locally contains disseminated pyrite and pyrrhotite and is typically rusty-orange-weathered (Plate 2C), with interior surfaces that are also affected by patchy, rusty-orange weathering or alteration (Plate 2E). Disseminated pyrite occurs locally in monzogranite gneiss (Unit 3), flecked/striped monzogranite (Unit 7), hornblende gabbro–diorite (Unit 10), and the heterogeneous mafic intrusive suite (Unit 16). Several samples have been sent for assay analysis as part of this project.

SUMMARY AND DISCUSSION

Bedrock mapping of the Main River area at 1:50 000-scale has shown it largely comprises the LRGC, which mostly consists of felsic gneiss with less extensive intermediate and mafic gneiss, quartzite and psammite–semipelite gneiss. These rocks are similar to the LRGC mapped elsewhere in the inlier (Owen, 1991; Hinchey, 2010), including felsic orthogneiss having protolith ages of *ca.* 1466 and 1530 Ma, supporting a correlation with the Pinwarian terrane in southeastern Labrador (Heaman *et al.*, 2002). A different sample of LRGC felsic orthogneiss yielded a minimum age of *ca.* 1631 Ma, implying an older (Labradorian) protolith or inheritance (Heaman *et al.*, 2002). However, with only three dates from orthogneiss from the entire LRGC, the age, evolution and crustal affinity of the LRGC remain poorly constrained, and the depositional history of the metasedimentary rocks in the LRGC is unknown.

The Main River area includes felsic metaplutonic rocks that are comparable to the Grenvillian plutons that have been mapped elsewhere in the inlier (Owen, 1991; Hinchey, 2020). Several Grenvillian intrusions outside the study area have been previously dated, indicating two phases of plutonism at *ca.* 1032–1022 Ma and *ca.* 999–985 Ma (Heaman *et al.*, 2002). Within the Main River area, the composite Potato Hill Pluton contains feldspar-megacrystic and garnet–pyroxene-bearing phases and has been dated at 999 ± 4 Ma (Figure 2; Heaman *et al.*, 2002), and mapping conducted in

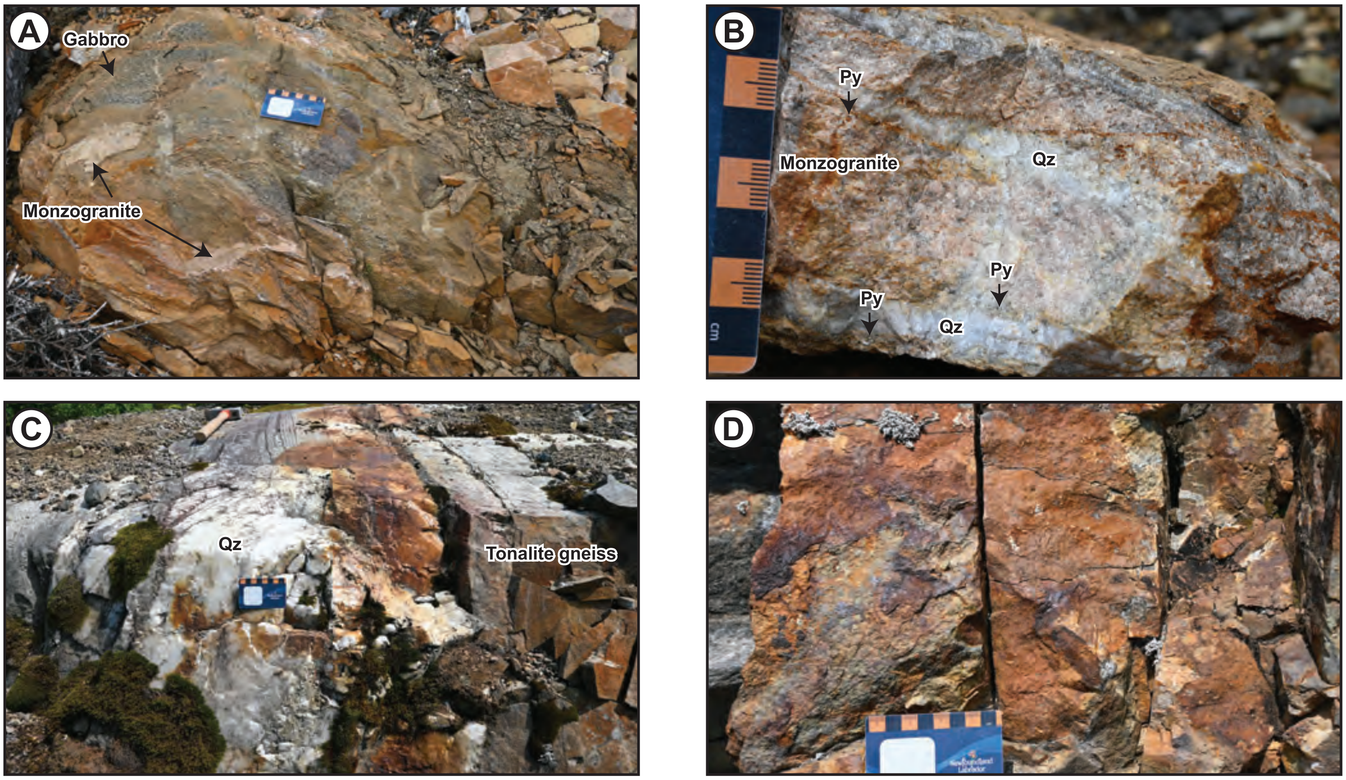

Plate 11. *Field photographs of quartz veins and zones of gossanous weathering. A) Gabbro (Unit 16) hosting monzogranite dykelets (Unit 17) at the Lady Slipper T3 gold occurrence. Both units exhibit gossanous alteration and host quartz veins; B) Detail of sample collected from the outcrop shown in (A), comprised of monzogranite and quartz veins with disseminated pyrite; C) Quartz vein hosted in tonalite gneiss (Unit 2), with associated gossanous weathering; D) The plane of the margin of a pyrite-bearing quartz vein hosted in amphibolite gneiss (Unit 1), showing gossanous alteration of the wall rock and vein remnants.*

this study shows that the pluton is significantly larger than previously mapped (Figure 1; Owen, 1991). The other felsic intrusions in the study area typically consist of medium-grained, relatively leucocratic monzogranite–granodiorite. These intrusions were included in the LRGC on the previous map (Owen, 1991), as part of the most extensive unit in the LRGC ("granitic to granodioritic biotite gneiss"; Pgn in Owen, 1991). They are provisionally inferred as Grenvillian (in the current study) based on lithological similarities with Grenvillian plutons elsewhere in the inlier, as well as their homogeneity and simpler structural history relative to rocks in the LRGC. Geochronology is needed to resolve whether these plutons are indeed Grenvillian, and geochemical analyses would shed light on their petrogenetic history and the overall crustal evolution of the inlier.

Hornblende gabbro to diorite intrusions occur in several places throughout the map area but are less extensive than the felsic intrusions. They range from massive to weakly foliated, and igneous textures are typically preserved. Overall, field relationships suggest that the hornblende gabbro to diorite intrusions are younger than the LRGC but have a range of ages relative to the felsic plutons inferred as Grenvillian and they could possibly be broadly contemporaneous with late Mesoproterozoic to early Neoproterozoic Grenvillian plutonism. However, tectono-metamorphic fabrics are indiscernible in some hornblende gabbro–diorite intrusions in the field, and crosscutting relationships imply that at least some of these intrusions postdate regional amphibolite-facies deformation (interpreted as D_2; Plate 3F). Therefore, the younger intrusions could plausibly share affinity with post-Grenvillian rocks in the study area, such as the mafic intrusive suite (Unit 16) or Long Range dykes. Petrographic and geochemical analyses are needed to investigate the petrogenesis of the hornblende gabbro to diorite intrusions.

A suite of mafic intrusive rocks was mapped in the southeast part of the Main River area. Characterized by textural and compositional heterogeneity, preservation of igneous textures and evidence of magma mingling, this mafic intrusive suite is distinct from other units in the study area, and its field characteristics are similar to the Silurian TBGS to the south. Rather than mafic gneiss of the LRGC, as previously interpreted (Owen, 1991), the mafic intrusive suite in the Main River area could represent the northern continuation of the TBGS, as proposed by Markham *et al.* (2026).

Meta-supracrustal rocks mostly consisting of quartzite, marble and psammite flank the eastern margin of the Silurian(?) mafic intrusive suite. This relationship is also demonstrated by lithologically similar strata in the Silver Mountain area, which are considered to form part of Cambro-Ordovician cover sequences based on detrital zircon ages (Hinchey *et al.*, 2025a). Preliminary U–Pb detrital zircon dating of metasedimentary rocks from the eastern flank of the mafic intrusive suite in the Main River area yielded dates as young as *ca.* 900–700 Ma (Steele *et al.*, 2025), supporting a post-Grenvillian depositional age and potential correlation with Cambro-Ordovician cover sequences.

The Main River area records a complex, polyphase tectono-metamorphic history that includes two regional high-grade tectono-metamorphic events (M_1 + D_1 and M_2 + D_2). The M_1 + D_1 event comprises pervasive, intense deformation and amphibolite-facies metamorphism of the LRGC and is considered to have ceased by *ca.* 1032 Ma, the age of the oldest known Grenvillian pluton in the inlier. The M_2 + D_2 event is characterized by deformation at various intensities and amphibolite-facies metamorphism of intrusions that are inferred to be Grenvillian, as well as the LRGC, and is interpreted as syn- to post-emplacement of the Grenvillian plutons. Both events may have reached granulite-facies conditions in places. Post-D_2 tectono-metamorphism (M_3 + D_3?) is suggested by evidence of high-grade metamorphism and deformation of the metasedimentary rocks that flank the mafic intrusive suite, as available evidence suggests that these strata are post-Grenvillian. Potentially correlative strata in the Silver Mountain area are similarly tectono-metamorphosed and may have been thrust onto the crystalline rocks of the inlier along an Appalachian (Taconic?) thrust fault (Hinchey, 2010; Hinchey *et al.*, 2025a).

The study area has also been variably affected by late (likely post-M_2 + D_2 or post-M_3 + D_3) greenschist-facies overprinting, fluid activity, brittle and brittle–ductile deformation. Chlorite partially replaces mafic minerals in several places and, at one locality in the southwestern part of the map area, chlorite + sericite + epidote are concentrated along foliation planes of an intense brittle–ductile fracture cleavage. Brittle fractures are also common and form a consistent fracture set filled with epidote (± hematite ± chlorite) veins in the northwestern part of the study area.

Additional research is required to fully characterize the thermal and structural events that affect the Main River area, especially as the M_1 + D_1 and M_2 + D_2 events appear to have overlapping regional footprints and similar peak metamorphic grades. Additionally, investigating the type and spatial extent of post-Grenvillian overprinting is important for understanding the evolution of the Long Range Inlier during Appalachian orogenesis and the potential for mineralization that may be associated with late structures, such as the DVFS.

As part of this study, samples were collected from the LRGC and felsic metaplutonic rocks for U–Pb zircon geochronology to determine crystallization ages. Samples were also collected from metasedimentary rocks in the LRGC for detrital U–Pb zircon geochronology. A suite of samples has been selected for geochronological and petrological analyses to help constrain the tectono-metamorphic history. Hand samples were collected extensively from every map unit to allow thorough geochemical and petrographic investigations.

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