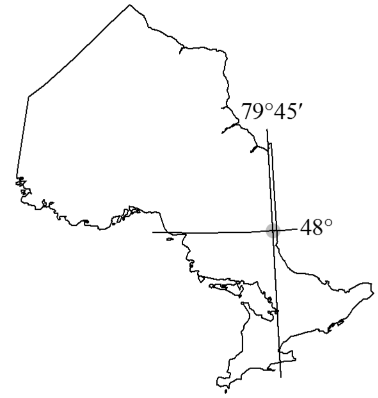
39. Geological Mapping of Timiskaming-age Intrusions Along the Lincoln–Nipissing Shear Zone, Larder Lake, Ontario



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INTRODUCTION

This report summarizes the results of the second summer of field work conducted in Skead Township, northern Ontario, as part of Metal Earth's Larder Lake transect. The results of this project will be used as part of the senior author's MSc thesis. This work is part of the multi-year Metal Earth project carried out by MERC (Mineral Exploration Research Centre, Laurentian University, Sudbury). Regional field work in conjunction with geophysical data from the Metal Earth aeromagnetic surveys in 2017 will assist in understanding the geology of the Larder Lake area and the nature of the Lincoln–Nipissing shear zone.

An important part of the Metal Earth transect mapping project is to address aspects of the geology that relate to gold mineralization. As part of the Larder Lake transect mapping, detailed work was carried out along the Lincoln–Nipissing shear zone (LNSZ), which was chosen for study because of the localization of mafic to felsic intrusions along this structure. As these felsic intrusions have been the focus of gold exploration activity in recent years (Zeman and Sherlock 2017), and there is a well-known association of similar intrusions with gold mineralization regionally (e.g., Robert 2001), it was decided to pursue an examination of the petrological nature of these intrusions in this context. Hence, the main objectives of this study are to document the field setting, petrology and relationships of these intrusive rocks, to assess the nature of the gold enrichment, to determine the relationship between the intrusions and gold mineralization, and to integrate the data acquired into a theory of the geologic evolution of Skead Township.

This report presents an update of this two-year study and incorporates the results of the 2018 mapping program with previous work. There is herein an emphasis on the nature of the intrusions and aspects related to the gold mineralization, such as alteration and presence of quartz veins. Further relevant work will be reported elsewhere (i.e., MSc thesis of Brace) and will include the results of U/Pb zircon geochronological analyses of the intrusive rocks, in addition to a full petrological study of these units.

REGIONAL GEOLOGY

The study area lies in the southern part of the Abitibi greenstone belt (AGB), which covers an area extending approximately 800 km from east to west and 300 km from north to south (Figure 39.1). The southern part of this greenstone belt is characterized by several volcanic assemblages (or episodes) referred to as the Pacaud, Deloro, Stoughton–Roquemaure, Kidd–Munro, Tisdale and Blake River assemblages (Ayer and Calhoun 2005; Thurston et al. 2008). These volcanic rocks were intruded by granitoid batholiths. Intrusion was followed by the development of 2 types of successor basins—the turbidite-dominated Porcupine assemblage (2690–2685 Ma) and the fluvial-lacustrine–dominated

Summary of Field Work and Other Activities, 2018,
Ontario Geological Survey, Open File Report 6350, p.39-1 to 39-11.

Timiskaming assemblage (2679–2669 Ma). These sedimentary basins are spatially associated with major regional structures that are important for localizing gold mineralization, including the Porcupine–Destor and Larder–Cadillac deformation zones (Frieman et al. 2017).

GEOLOGY OF SKEAD TOWNSHIP

The geology in the study area (Figure 39.2) is dominated by ultramafic to felsic volcanic and volcaniclastic rocks of the Larder Lake group (2710–2704 Ma). The mafic volcanic rocks are locally pillowed, and the ultramafic rocks commonly show well-preserved spinifex texture and polyhedral jointing. The felsic volcanic rocks are fine-grained, aphyric rhyolite, and the various felsic volcaniclastic rocks include heterolithic rhyolite lapilli tuff, rhyolite lapillistone, bedded ash and tuff units, feldspar crystal tuffs and heterolithic pyroclastic flows.

These rocks are unconformably overlain by younger clastic sedimentary rocks of the Hearst assemblage (2709.5–2700 Ma: M.A. Hamilton, Jack Satterly Geochronology Laboratory, personal communication, 2018), which are dominantly clast-supported conglomerates, sandstone and siltstone (Hewitt 1949, 1951; St-Jean et al. 2017). Intruded into the volcanic and sedimentary rocks are mafic to felsic stocks, which are focussed along and adjacent to the LNSZ. These intrusions are analogous to ones along the Larder–Cadillac deformation zone (*see* Figure 39.2), such as the Murdock Creek pluton, south of Kirkland Lake (Rowins et al. 1993). Importantly, the intrusive rocks along the LNSZ are spatially associated with gold mineralization, which manifests as quartz ± carbonate veins and zones of disseminated pyrite in areas where the intrusions are altered.

The LNSZ trends west-northwesterly through the north-central part of Skead Township. Exposures of this feature are very limited; it is better observed on geophysical maps as a pronounced magnetic feature. This structure is discrete, at less than 100 m wide, and can be traced for tens of kilometres using data from airborne magnetic surveys. Where exposed, it is in mafic to ultramafic rocks and shows a well-developed west-northwest-trending foliation, intense ankerite alteration and rare occurrences of fuchsite (Rubingh, Brace and Sherlock, this volume, Article 40). A key aspect of the LNSZ is that it marks a break

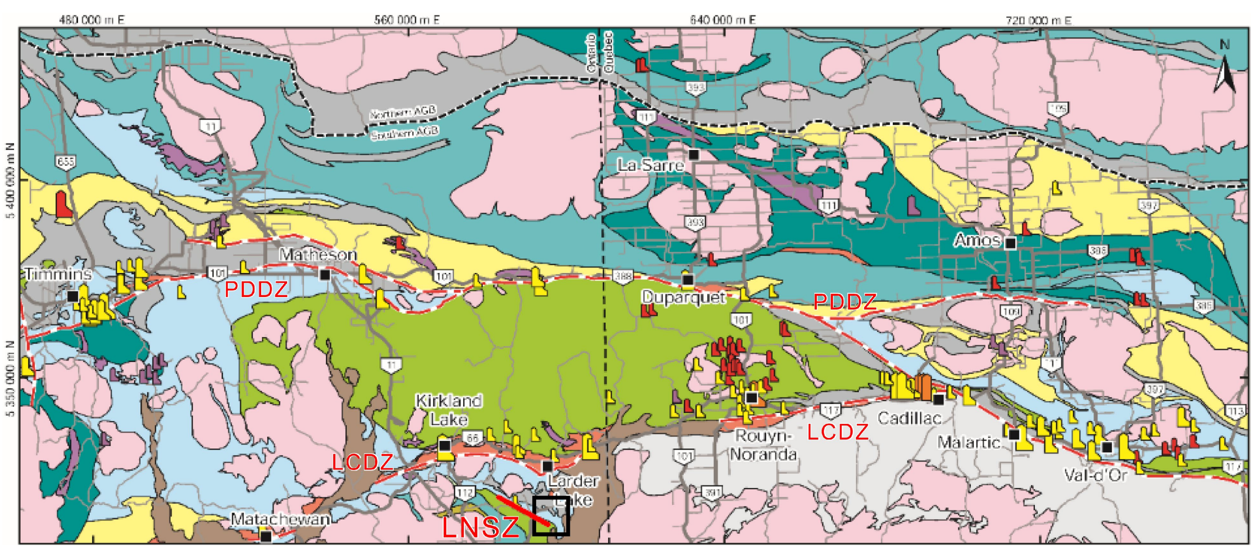

Figure 39.1. Regional geological map of the southern Abitibi Subprovince (*modified from* Poulsen 2017a) showing the distribution of supracrustal assemblages and major structures, such as the Porcupine–Destor deformation zone (PDDZ) and the Larder–Cadillac deformation zone (LCDZ). Volcanic rocks are shown in green, sedimentary rocks in blue and intrusive rocks in pink; also note the location of the various types of gold deposits (mine shaft symbols in various colours). The location of Skead Township (black box) and the Lincoln–Nipissing shear zone (LNSZ = solid red line) are shown. Universal Transverse Mercator (UTM) co-ordinates are provided using North American Datum 1983 (NAD83) in Zone 17N.

in stratigraphy, between the peridotite of younger assemblages and overlying volcanic strata of the Larder Lake group (*circa* 2705 Ma; Ayer et al. 2003). South of the shear zone, there is a uniform northwest-striking, northeast-younging volcanic succession (*see* Figure 39.2), with the Pacaud assemblage (*circa* 2750 Ma; 2750–2735 Ma volcanic episode) at its base and the Skead and McElroy assemblages (*circa* 2700 Ma; 2704–2695 Ma volcanic episode or Blake River assemblage) at the top (Jackson 1995; Thurston et al. 2008). To the north of the shear zone, the volcanic rocks are associated with the older Larder Lake group (2705 Ma). This assemblage is unconformably overlain by clastic sedimentary rocks of the Hearst assemblage. In addition to the juxtaposition of strata of different ages, the style of deformation is different north of the shear zone, with complex fold geometries to the north that are not recognized south of the shear zone.

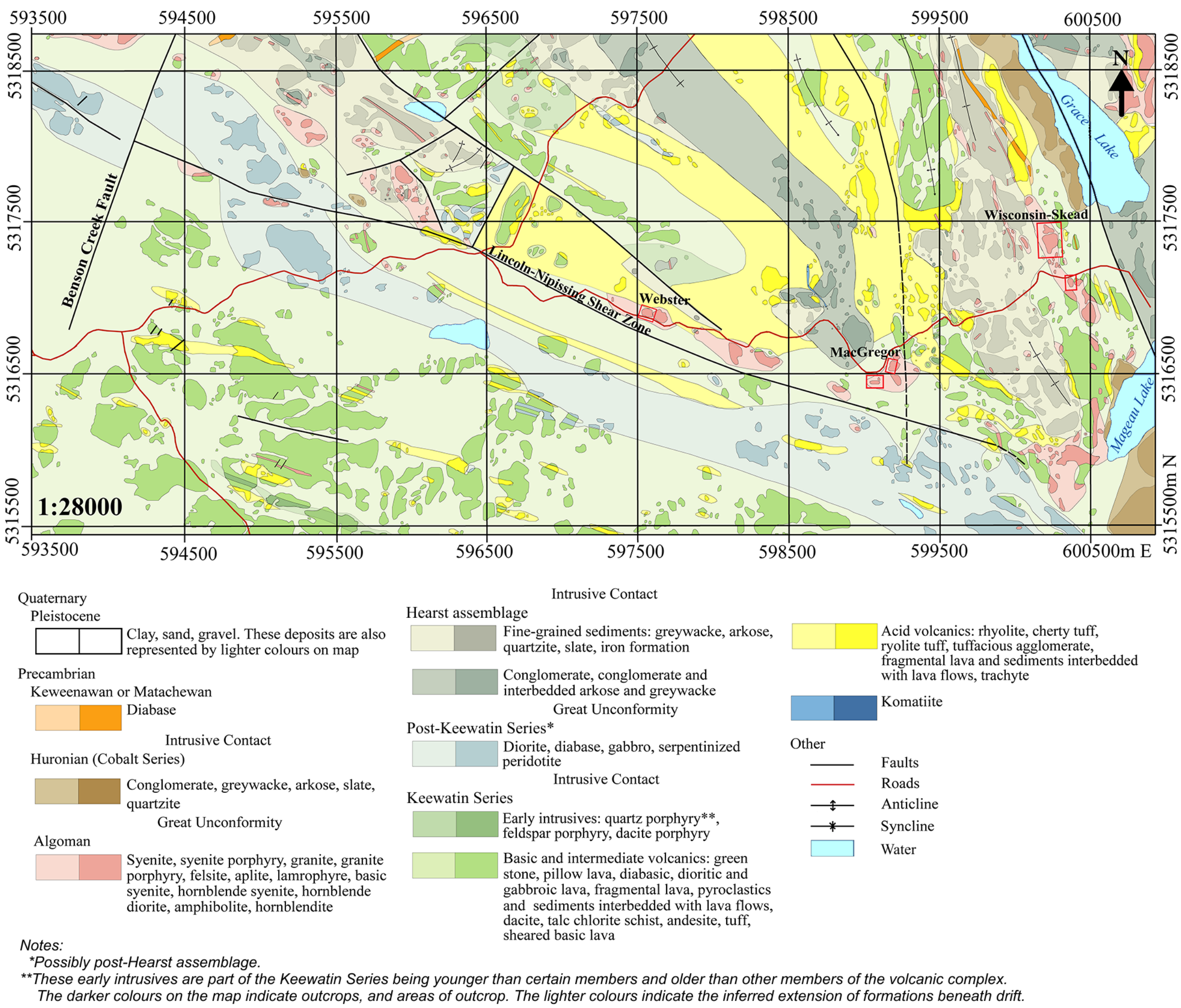

Figure 39.2. Geology of the Lincoln–Nipissing shear zone and study area, with locations of the weakly mineralized intrusions exposed in exploration trenches outlined by red boxes (geology *modified from* Hewitt 1949; with additional geology *from* Brace and Sherlock 2017; and 2017 and 2018 field work by S. Brace). All UTM co-ordinates are provided using NAD83 in Zone 17N.

GEOLOGY OF THE INTRUSIONS

Bedrock exposure in Skead Township is limited, so the authors studied outcrops of felsic intrusions exposed in exploration trenches on 3 properties within the study area: the MacGregor property, the Wisconsin–Skead property, and the Webster property (*see* Figure 39.2). Access to the trenches on these properties was kindly granted by Transition Metals Ltd.

The MacGregor composite stock is exposed in 2 trenches that reveal the presence of 2 suites of rocks of varying composition: a hornblende-rich diorite to leucodiorite, and a biotite-rich diorite (Figure 39.3A). Both suites of rocks are cut by relatively younger dike rocks; whether all these units are petrogenetically related remains to be assessed. The main mafic to felsic bodies appear to represent multiple injections of a magma that was initially mafic in composition, but which evolved into a felsic magma. This evolution in magma composition is represented by the presence of a medium- to coarse-grained, amphibole ± biotite–rich phase, a biotite diorite, and a later leucocratic diorite. The boundaries between the more mafic and felsic units are commonly defined by mafic pegmatite. The crosscutting dike rocks are mafic, carbonatitic and lamprophyric in nature. At the MacGregor trenches, at least 5 distinct phases—representing all the aforementioned rocks—were noted. These are, from oldest to youngest 1) coarse amphibole-plagioclase (Photo 39.1A) of appinitic affinity (Murphy 2013); 2) biotite diorite (Photo 39.1B); 3) carbonate-biotite facies; 4) leucodiorite (Photos 39.1C to 39.1F); and 5) biotite lamprophyre.

The Wisconsin–Skead stock was mapped in all 3 trenches that are currently exposed on the property. The southern trench exposes a tonalite with hematite staining. The main trench exposes a tonalite (Figure 39.3B) with secondary ankerite. The tonalite intrudes altered basalt, and rafts of the basalt are incorporated into the tonalite along its western contact. Aplite dikes are common and predate quartz veining. A U/Pb zircon age of 2672.5±0.9 Ma was obtained for this tonalite (M.A. Hamilton, Jack Satterly Geochronology Laboratory, personal communication, 2018). The intrusion exposed in the northern trench also has hematite staining and is similar in nature to the intrusion exposed in the southern trench.

The Webster trench (Figure 39.3C) exposes quartz-feldspar porphyry intruding altered pillowed basalt and gabbro; the porphyry is cut by gabbroic and lamprophyric phases. The gabbro is differentiated, with grain size variability readily observed, as well as the presence of coarse biotite and intense chlorite alteration. The lamprophyre is medium grained, magnetite bearing, possesses coarse biotite and is hematite stained (Photo 39.1G). The pillowed basalts can be seen along the southern contact of the intrusion, whereas felsic volcaniclastic and gabbroic rocks are seen along the northwest and northeast contacts, respectively. Lastly, mafic dike rocks of lamprophyric nature cut all previous units (Photo 39.1H).

ALTERATION, VEINING AND GOLD MINERALIZATION

Alteration

All of the stocks studied show varying degrees of alteration, which relates, in some cases, to the presence of quartz ± carbonate veins. The Wisconsin–Skead stock is intensely metasomatized and altered, with an alteration assemblage that includes chlorite, sericite and iron carbonate. The alteration is associated with the quartz veins, but also affects both the intrusive rocks and the host pillow basalts. At the MacGregor trenches, the intrusive rocks have also been metasomatized and have undergone intense albitization. The alteration assemblage includes chlorite, iron carbonate, sericite and hematite. The iron carbonate is directly related to the quartz veins and is found proximal to them. At the Webster trench, the altered pillow basalt and gabbroic host rock are strongly chlorite altered. The altered pillow basalt also displays iron carbonate alteration. The alteration assemblage observed here is iron carbonate, chlorite, sericite, silica and minor hematite alteration. The iron carbonate and chlorite alteration is found in proximity to the quartz veins and mafic dikes, whereas the silica alteration is related specifically to the altered mafic dikes. The feldspar porphyry shows sericite and minor hematite alteration.

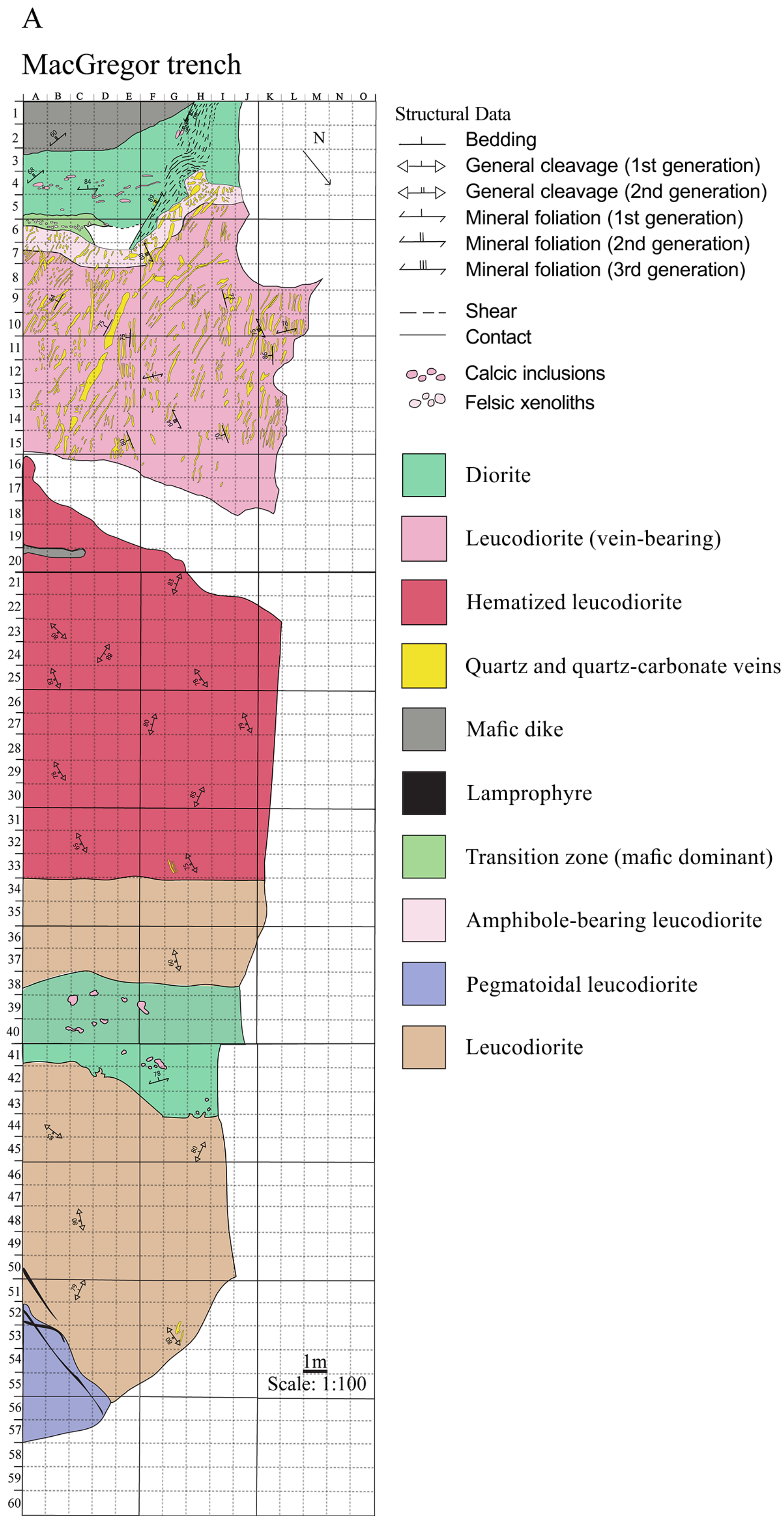

Figure 39.3. A) The MacGregor trench, showing distribution of diorite (green), pegmatoidal leucodiorite (purple) and leucodiorite (light brown) suites, hematized leucodiorite (pink and red), mafic dikes (grey), lamprophyre (very dark grey) and the distribution of quartz ± carbonate veining (yellow).

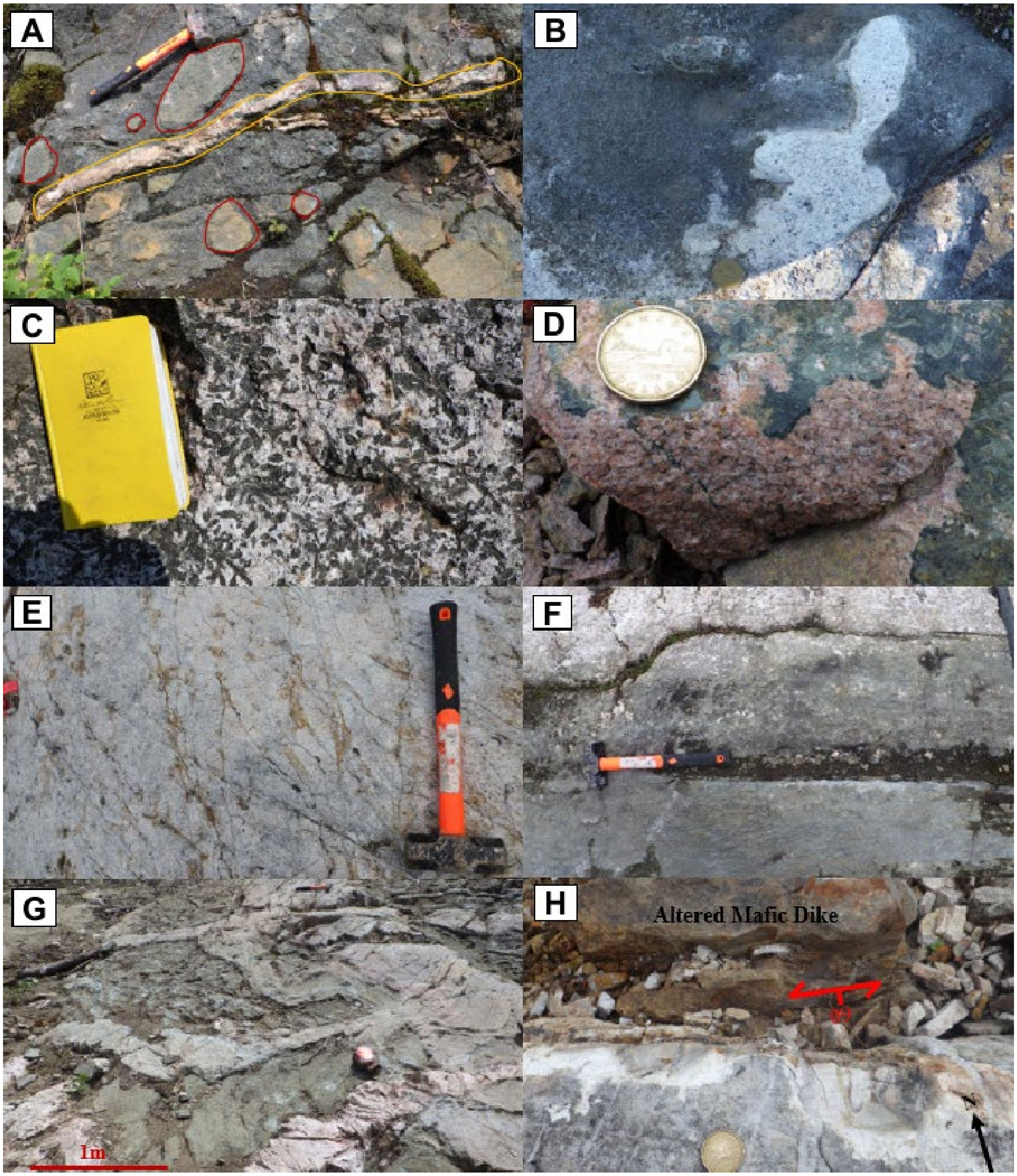

Photo 39.1. Photos 39.1A to 39.1F are from the MacGregor trenches; Photos 39.1G and 39.1H are from the Webster trenches. **A**) Outcrop of MacGregor stock, showing coarse-grained hornblende-rich melanocratic diorite unit with autoliths (circled in red). The diorite is cut by a plagioclase-amphibole–rich dike phase (circled in yellow). UTM 597585E 5316900N. **B**) Contact relationship between a diorite and leucodiorite. UTM 599134E 5316592N. **C**) Pegmatoidal hornblende leucodiorite; notebook for scale is 19 by 12 cm. UTM 599140E 5316601N. **D**) Hematized leucodiorite. **E**) Sheeted quartz ± carbonate veins cutting the leucodiorite phase of the MacGregor stock. UTM 599120E 5316561N. **F**) Contact between leucodiorite in Photo 39.1E and magnetite-bearing diorite. UTM 599125E 5316556N. **G**) Irregular lamprophyre dikes (light rock) cutting a chlorite-altered, mafic intrusive phase (dark rock). UTM 599141E 5316633N. **H**) Alteration assemblage of chlorite + ankerite + sericite + silica proximal to a foliated, altered and mineralized mafic dike. The fabric seen in the dike is an expression of the Lincoln–Nipissing shear zone. UTM 597538E 5316896E. Hammer for scale in Photos 39.1A, 39.1E, 39.1F and 39.1G is approximately 41 cm long; coin for scale in Photos 39.1B (along bottom edge of photo), 39.1D and 39.1H is 2.65 cm in diameter. All UTM co-ordinates are in NAD83, Zone 17N.

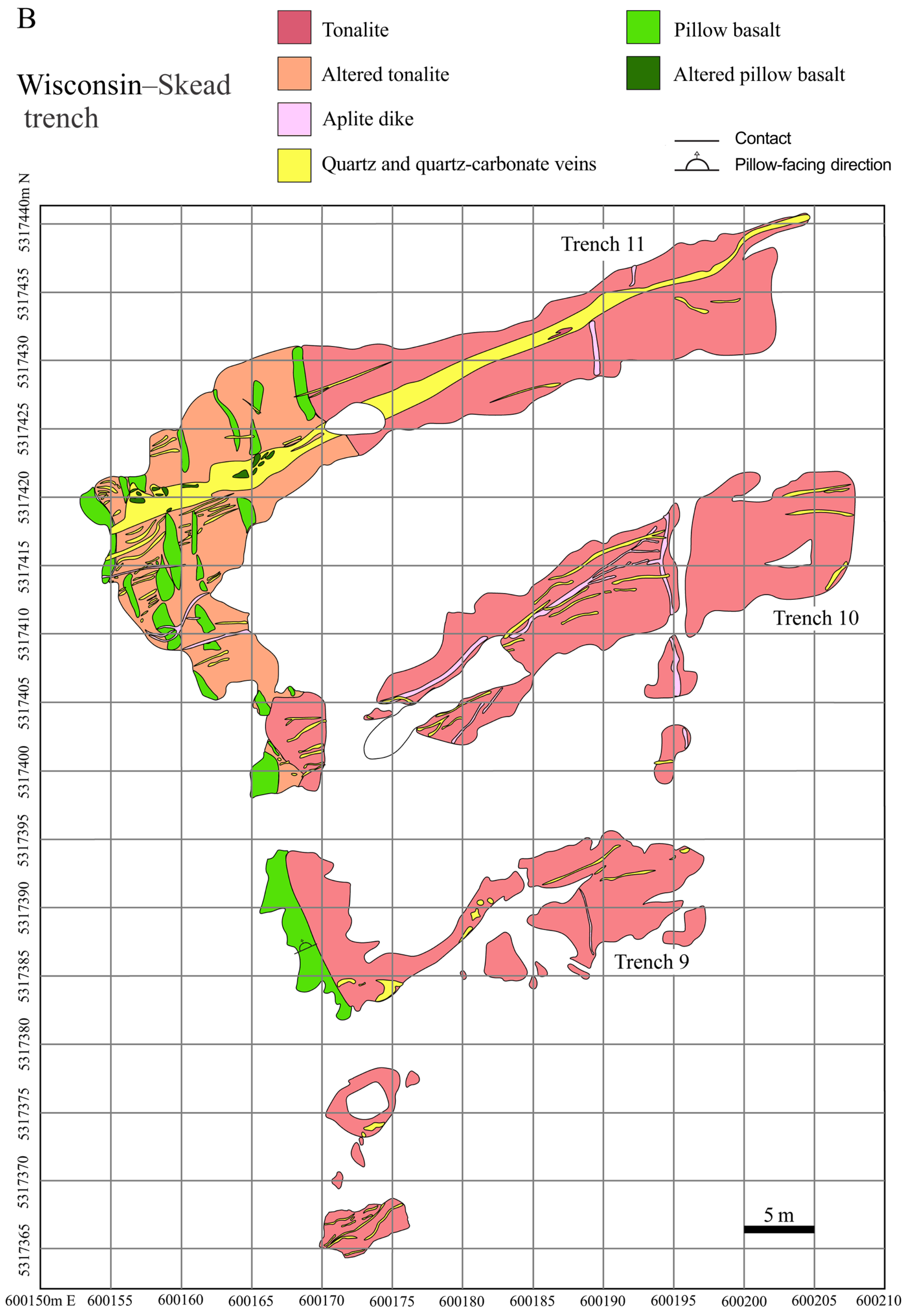

Figure 39.3, *continued*. B) The main Wisconsin–Skead trench, showing tonalite (red), altered tonalite (orange), pillow basalt (green), altered pillow basalt (dark green) and the distribution of aplite dikes (pink) and quartz veins (yellow). The geological data were provided by Transition Metals Ltd. All UTM co-ordinates are provided using NAD83 in Zone 17N.

Veining

At the Wisconsin–Skead trenches, quartz ± carbonate veins intrude the tonalite. The quartz veins, from centimetres to greater than 1 m width and thickest near the contact with altered basalt, are either planar zones with sharp boundaries or irregular.

Quartz ± carbonate veins at the MacGregor trench intrude the leucodiorite units, whereas the dominantly melanocratic mafic rocks are barren of veins. Assay results for samples of the veins in this area were uniformly low.

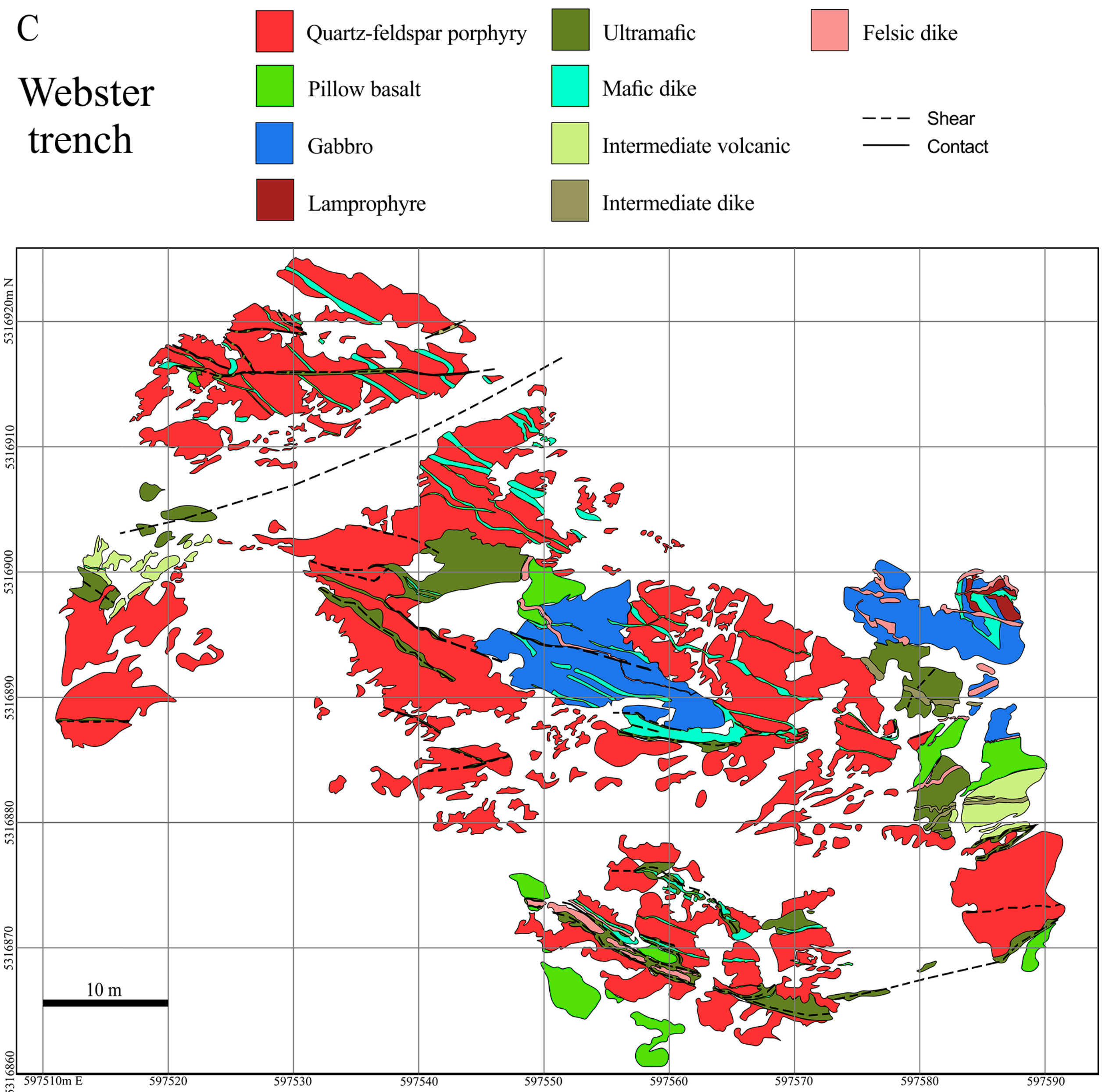

Figure 39.3, *continued*. C) The Webster trench, showing distribution of mafic phases of the intrusion (blue and green) and the large volume of felsic phases (red). The geological data were provided by Transition Metals Ltd. All UTM co-ordinates are provided using NAD83 in Zone 17N.

Rocks exposed in the Webster trench show a similar vein style to that of the Lafond trench (located 2.7 km west-southwest of the Wisconsin–Skead trenches), where the felsic intrusive hosts quartz ± carbonate veins, but the mafic rocks are barren of veins.

Mineralization

At the Wisconsin–Skead trenches, previous exploration identified low-grade gold mineralization of ≤1 g/t Au and rarely up to 10 g/t Au, associated with quartz ± carbonate veins and veinlets spatially related to fine-grained disseminated euhedral pyrite in the tonalite. This mineralization was found at 2 separate locations, on different west-trending quartz vein sets (Zeman and Sherlock 2017). Alteration associated with the mineralization was sericite, ankerite and chlorite.

The MacGregor stock is weakly mineralized, with historical assays indicating low-grade gold mineralization (<1 to 3.48 g/t Au) in the leucodiorites. The melanocratic mafic phases lack mineralization. Follow-up work at this site as part of the current project returned assay results of 0.024 and 0.113 g/t Au, much lower than the values of 0.96 and 1.01 g/t Au from historical assays recorded in assessment files for the same locations (UTM 599124E 5316559N and 599125E 5316560N, respectively, NAD83, Zone 17).

Gold assays at the Webster outcrop were acquired as part of the exploration by Transition Metals Ltd. and were similar to historical assays for samples hosted in quartz ± carbonate veins (i.e., <1 to 1.05 g/t Au) (T.R. Hart, Transition Metals Ltd., personal communication, 2018).

FUTURE WORK

Future work will focus primarily on the petrography and geochemistry of all the intrusive rocks in the 3 areas discussed above, to assess their origin in the context of other magmatic centres in this part of the Abitibi greenstone belt. To better constrain the time of mafic magmatism, a sample of leucodiorite from the MacGregor trench area has been submitted for U/Pb geochronological analysis (on zircon). The results of this analysis will complement the age for the felsic centre already obtained for the Wisconsin–Skead stock. Although not presently part of the thesis project, there is a need to carry out alteration, mineralogical and fluid-chemical studies, to better constrain the nature and origin of the gold mineralization related to the intrusive centres, and to compare these results to the types of known gold mineralization in the Abitibi greenstone belt.

DISCUSSION AND RELEVANCE

The work carried out in the area of the Lincoln–Nipissing shear zone, located in the southern part of Metal Earth's Larder Lake transect, provides an opportunity to examine the relationship between a number of gold prospects, an inferred fault zone and a chain of mafic to felsic intrusive rocks (Poulsen 2017b). By studying the intrusions along this structure, which is located south of the well-known Larder–Cadillac deformation zone, it may be possible to establish a genetic link between gold deposition and the intrusions (Cameron and Hattori 1987; Robert 2001), or determine if the intrusions behaved as a competent structural trap (i.e., passive participants) for later mineralization (Colvine 1989).

The 2017 and 2018 field mapping revealed that, within Skead Township, there is a much greater distribution of felsic volcanic and volcaniclastic rocks than originally thought. In addition, field mapping identified the unconformity between the Larder Lake group komatiite and Hearst assemblage basal conglomerate beyond the previously identified single occurrence. The unconformity can now be traced approximately 500 m (*see* Figure 39.2). This is relevant because this stratigraphic relationship is exposed very rarely throughout the southern Abitibi greenstone belt. This relationship furthers the understanding of the depositional environment of the Timiskaming basin during sedimentation, and could have implications for the development of the Larder–Cadillac deformation zone (St-Jean, Hunt and Sherlock 2017).

With respect to the intrusive rocks, field observations document a high degree of modification, indicating that all the rocks experienced extensive fluid–rock interaction and varying degrees of metasomatism. It is critical to examine the alteration history and fluid–rock interaction in greater detail, to assess the nature of the gold enrichment, to determine the relationship between the intrusions and gold mineralization and to understand the relative timing of these processes.

The intrusive rocks at the MacGregor and Webster trenches are unusual in that they are volatile rich. Also, the diorite and leucodiorite suite at the MacGregor trenches have a close timing relationship, indicated by irregular, diapir-like contacts. This relationship was interpreted as evidence that the mafic magmas were injected multiple times and into partially differentiated, but not fully consolidated, co-magmatic mushes.

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