Stratigraphic and structural setting of gold and nickel deposits in the La Motte–Malartic area, southern Abitibi and Pontiac subprovinces, Superior Province, Quebec

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INTRODUCTION

The Superior Province is the largest exposed Archean craton in the world. It consists of generally east-striking subprovinces (e.g., Abitibi, Uchi) consisting of metavolcanic and granitoid rocks separated by subprovinces (e.g., Pontiac, English River) dominated by metasedimentary and gneissic rocks (Robert et al., 2005). Numerous world-class gold, volcanogenic massive sulphide and less-common magmatic nickel-copper deposits are spatially associated with east-striking subvertical crustal-scale fault zones along the subprovince boundaries (e.g., Cadillac–Larder Lake fault zone), or along the contact zones (Porcupine–Destor–Manneville fault zone) between metavolcanic and metasedimentary rocks within subprovinces (Robert and Poulsen, 1997; Hannington et al, 1999). These province-scale faults exert key controls on the formation of deposits since they act as conduits for the flow and migration of ore-forming fluids. In addition, post-mineralization deformation can subsequently modify geometry and metal grade of ore deposits.

In order to reveal the fundamental geological processes that were responsible for the formation of mineral deposits in southern Superior Province, the Mineral Exploration Research Centre at the Harquail School of Earth Sciences launched four mapping projects in the area of seismic-magnetotelluric transects in Malartic, Rouyn-Noranda, Larder Lake and Swayze in the summer of 2017. This contribution highlights preliminary results from the first field season in the LaMotte–Malartic area along the central and southern Malartic transect (Figure 1). In this article, the stratigraphic and structural setting of vein-type and disseminated gold deposits hosted in metasedimentary and metavolcanic rocks (Pontiac, Cadillac, Timiskaming and Piché groups) at or near the Cadillac–Larder Lake fault zone are examined, as well as little-known nickel-copper mineralization in metavolcano-sedimentary rocks (Malartic group) at the Southern Manneville fault zone.

REGIONAL GEOLOGICAL SETTING

The volcanic stratigraphy of the Abitibi greenstone belt is divided into seven episodes (Ayer et al., 2002, 2005; Thurston et al., 2008), based on similarity of age intervals, stratigraphy and geochemistry (Figure 1): <2750 Ma (unnamed assemblage), 2750–2735 Ma (Pacaud assemblage), 2734–2724 Ma (Deloro assemblage), 2723–2720 Ma (Stoughton–Roquemaure assemblage), 2719–2711 Ma (Kidd–Munro assemblage), 2710–2704 Ma (Tisdale assemblage) and 2704–2695 Ma (Blake River assemblage). In the La Motte–Malartic area (Figures 2, 3), the ca. 2714 Ma (Pilote et al., 1999) La Motte–Vassan formation of the Malartic group is composed mainly of komatiite and basalt corresponding to the upper Kidd–Munro assemblage. The Piché group consists largely of ultramafic to mafic intrusions and schist, with minor felsic volcanic rocks and sediments. Ultramafic rocks of the Piché group are intruded by a tonalite dyke, which gives a minimum age constraint of ca. 2709 Ma to the Piché group (Pilote et al., 2014). The ca. 2704–2702 Ma (Pilote et al., 1999) Louvicourt group is composed of mafic to intermediate volcanic rocks and minor intermediate to felsic volcaniclastic rocks, and is equivalent to the lower Blake River assemblage. These older volcanic rocks are overlain by three metasedimentary packages: the <ca. 2691–2685 Ma Kewagama group (Feng and Kerrich, 1991; Davis, 2002), composed chiefly of mudstone and wacke typical of a turbidite sequence; <ca. 2690–2686 Ma Cadillac group (Davis, 2002), constituted largely of turbiditic siltstone and wacke, with minor biotite-chlorite-actinolite schist and felsic volcaniclastic rocks; and <ca. 2677–2672 Ma Timiskaming Group (Davis, 2002; Pilote et al., 2015), composed of crossbedded siltstone and sandstone, and polymictic conglomerate, which is typical of a fluvial–alluvial depositional environment (Hyde, 1980). These metavolcano-sedimentary rocks are intruded by several felsic plutonic suites: the ca. 2681–2660 Ma Preissac pluton (Ducharme et al., 1997), ca. 2680–2640 Ma La Corne pluton (Machado et al., 1991) and ca. 2647–2642 Ma La Motte pluton (Machado et al., 1991; Ducharme et al, 1997). All these plutonic suites consist of various felsic intrusive phases and are crosscut by pegmatitic and aplitic dykes (Mueller et al., 2008).

The <ca. 2697–2685 Ma Pontiac Subprovince (Davis, 2002) to the south of the Abitibi Subprovince is mainly composed of mafic and ultramafic flows, turbiditic mudstone and wacke, and rare conglomerate, with minor iron-rich amphibolite and garnetite (e.g., Perrouty et al., 2017). The supracrustal rocks are intruded by several felsic plutons: the ca. 2682 Ma Lac Fournière pluton (Davis, 2002), ca. 2679–2676 Ma Sladen intrusion (Helt et al., 2014; De Souza et al., 2015, in press) and ca. 2668–2663 Ma Decelles batholith (Mortensen and Card, 1993).

Although supracrustal rocks in the Abitibi and Pontiac subprovinces are metamorphosed to greenschist or amphibolite facies and variably deformed, primary volcanic and sedimentary structures are still preserved (Mueller et al., 2008). Multiple phases of ductile deformation are commonly present in the east-southeast-striking crustal-scale fault zones, namely the Destor–Porcupine–Manneville and Cadillac–Larder Lake fault zones (Figure 2). The Destor–Porcupine–Manneville fault zone has two splays in the La Motte area: the Northern and Southern Manneville faults. The Northern Manneville fault separates the volcanic rocks of the Kinojévis group from the metasedimentary rocks of the Caste formation of the Kewagama group, whereas the Southern Manneville fault separates metasedimentary rocks of the Caste formation from mafic and ultramafic flows of the La Motte–Vassan formation (Malartic group). The Cadillac–Larder Lake fault zone defines the boundary between the Abitibi and Pontiac subprovinces.

SUPRACRUSTAL ROCKS AND STRATIGRAPHY

Three metavolcanic-rock–dominated assemblages (Malartic, Piché and Louvicourt groups) and four metasedimentary packages (Kewagama, Cadillac, Timiskaming and Pontiac groups) were examined during the past field season along the central and southern Malartic transect (Figure 3). The most important features of these supracrustal rocks are briefly discussed in this section, based on new field mapping results and previous work by other researchers.

Malartic Group

The Malartic group is divided into three generally east-northeast-striking, steeply-dipping to subvertical formations: the La Motte–Vassan formation, Dubuisson formation and Jacola formation (Dimroth et al., 1983; Imreh, 1984; Pilote et al., 1997; Scott et al., 2002).

The La Motte–Vassan formation is located south of the La Motte, La Corne and Preissac plutons and east of the Preissac pluton (Figure 2). The formation consists mainly of komatiite, basalt and felsic volcaniclastic rocks. The pale to dark green komatiite occurs as sheet flows and tube-shaped flows (Gélinas et al., 1976; Imreh, 1978; Lajoie and Gélinas, 1978; Champagne, 2004). An individual komatiite sheet-flow unit contains two divisions: a spinifex-texture–dominated A-zone and a cumulate B-zone (Figure 4a; Pyke et al., 1973; Champagne, 2004). The A-zone consists, from bottom to top, of a layer of large V-shaped platy spinifex, a thin randomly oriented spinifex layer and a top chilled margin, with polygonal joints and hyaloclastite (Pyke et al., 1973; Champagne, 2004; Mueller et al., 2008). The B-zone is composed, from bottom to top, of a fine- to medium-grained cumulate layer with polygonal joints, a knobby cumulate layer, a fine- to medium-grained cumulate layer and a foliated skeletal-spinifex layer (Pyke et al., 1973; Champagne, 2004; Mueller et al., 2008). Tube-shaped flows have similar internal structures but their A-zone is typically poorly developed. Drainage cavities are locally present within the cumulate B-zone of tube-shaped flows (Sawyer et al., 1983; Champagne, 2004; Mueller et al., 2008). These internal characteristics and the shape of a single flow unit are common way-up indicators for komatiites. Basalt within this formation is characterized by dark green coherent flows and pillowed flows, with ellipsoidal epidote blocks in the centre of individual pillows, which are indicative of seafloor hydrothermal alteration (Figure 4b; Mueller et al., 2008). The geometry of a single pillow with a convex top and a cusp at the bottom is a common younging indicator. Volcaniclastic rocks in the La Motte–Vassan formation include garnet-bearing felsic lapilli tuff and tuff breccia, with stretched white quartzofeldspathic clasts within a dark grey, fine-grained groundmass (Dimroth et al., 1983; Imreh, 1984; Pilote et al., 2015). In the Spinifex ridge area (Figure 2; Daigneault et al., 2002, 2004), the younging direction is to the north, based on internal structures of complete komatiite flow units. In the Marbridge mine area, a type locality of less-strained pillowed basalt indicates younging toward the south (Figure 4b; Mueller et al., 2008). Younging reversals are commonly present as revealed by tight, east-striking, upright folds within the Southern Manneville fault zone (Mueller et al., 2008). The only age constraint of this formation is 2714 ±2 Ma (hereinafter reported as zircon and $^{207}Pb/^{206}Pb$ age results; Figure 2), which is the age of a felsic tuff unit intercalated with mafic flows (Pilote et al., 1997, 1998b, 1998c).

The Dubuisson formation is located south of the La Motte, La Corne and Preissac plutons. The Dubuisson formation consists mainly of dark green coherent and pillowed mafic flows, with ultramafic intercalations and minor felsic or intermediate volcaniclastic rocks. The pillows are strongly flattened and stretched, therefore a reliable younging direction cannot be determined. The felsic volcanic unit intercalated with ultramafic flows of this formation yielded a crystallization age of 2708 ±2 Ma (see Pilote et al., 2015).

The Jacola formation is located south of the Dubuisson formation and is composed mainly of mafic and ultramafic flows, with minor felsic volcaniclastic rocks. The shape of individual pillows in mafic flows, and rare scour and load structure in felsic lapilli tuffs, indicate tops to the south. The felsic volcaniclastic unit near the stratigraphic top of the formation yielded an age of 2706 ±1 Ma (Pilote et al., 1999).

Piché Group

The Piché group, a northwest-striking, subvertical, narrow band (<2 km thick) of mafic to ultramafic flows, with minor felsic volcanic rocks, lies between the metasedimentary rocks of the Cadillac group of the Abitibi Subprovince and turbiditic greywacke of the Pontiac Subprovince (Figure 2). Rocks in the Piché group are typically strongly foliated and folded. The mafic to ultramafic flows are composed of dark green, foliated, fine- to coarse-grained massive flows, with locally flattened pillows. The felsic light grey to green, foliated, thin-bedded (1–3 cm spaced) tuff is typically <0.3 m thick, and occurs as intercalations within the mafic to ultramafic flows. The facing of the Piché group is not well constrained due to the high strain along the Cadillac–Larder Lake fault zone.

Louvicourt Group

The Louvicourt group is divided into two generally northeast-striking subvertical formations: the Val d'Or formation and the Héva formation (Figure 2; Dimroth et al., 1982; Imreh, 1984; Pilote et al., 1997; Scott et al., 2002). The Val d'Or formation consists of dark green hornblende-phyric pillowed mafic flow, and light grey rhyolite and felsic lapilli tuff, with small (<10 cm) quartzofeldspathic clasts. The rhyolite unit of the Val d'Or formation yielded ages of 2705 ±1 Ma (Wong et al., 1991), 2704 ±1 Ma (Machado and Gariépy, 1994) and 2704 ±2 Ma (Pilote et al., 1998a, c). The Héva formation consists of dark green massive and pillowed mafic flows occurring with greyish white crudely bedded felsic lapilli tuff and thin-bedded tuff, and plagioclase-phyric crudely bedded felsic to intermediate volcanic rocks. Younging direction is generally to the south, based on normal grading within individual tuff beds. Felsic volcanic rocks in the Héva formation yielded an age of 2702 ±1 Ma (Pilote et al., 1999).

Kewagama Group

The Kewagama group consists of two generally east-striking formations: the Caste formation and the Mont-Brun formation (Figure 2; Pilote et al., 2015). The Caste formation is bounded by the Northern and Southern Manneville faults, which define the boundary between the Caste formation and metavolcanic rocks of the Kenojévis group to the north, and its boundary with ultramafic and mafic flows of the Malartic group to the south, respectively. It consists mainly of biotite±hornblende–bearing, thin-bedded graded greywacke and mudstone, with minor thick-bedded yellowish chert, and thin-bedded magnetite-bearing (or -rich) black chert. West of the La Motte pluton, the younging direction is to the southwest, based on normal grading and scours in several greywacke outcrops (Figure 4c). A sample of the Caste formation, which was collected north of the La Motte pluton, contains detrital zircons as young as 2694 ±3 Ma (Davis, 2002), which is interpreted as the maximum age of the Caste formation.

Cadillac Group

The Cadillac group is located between the volcanic-rock–dominated Blake River group to the north and the Piché group to the south (Figure 2). Its northern contact is defined by the Dumagami fault (Tourigny et al., 1988), whereas its southern contact is the Cadillac–Larder Lake fault zone. It consists principally of light to dark grey, thin-bedded (1–15 cm spaced) and graded greywacke and mudstone, with minor reddish brown, thin-bedded (1–3 cm spaced) magnetite-chert formations. Younging direction is generally to the north, based on scours and normal grading. However, younging reversals are commonly present due to isoclinal to tight folds. The maximum depositional age of the Cadillac greywacke near Cadillac and Joannès townships is 2687 ±3 Ma (Davis, 2002).

Timiskaming Group

The Timiskaming Group is surrounded by the Cadillac group and consists mainly of interlayered polymictic clast-supported conglomerate and coarse-grained, thin-bedded (1–5 cm spaced) graded sandstone and siltstone. They are typically interpreted to have been deposited in subaerial fluvial, alluvial and deltaic environments (Mueller et al., 1994; Born, 1995; Ayer et al., 2002). The conglomerate consists mainly of mafic and felsic volcanic clasts, with lesser sandstone, chert and tonalite clasts (Figure 4d). The clasts are variably stretched due to differences in their competency relative to that of the sandy and silty matrix of the rock. Tops are generally to the north, based on tabular and trough crossbedding, normal grading, and scours within, as well as between, sandstone and siltstone layers. Younging reversals are common due to isoclinal folding of the unit. The youngest detrital zircon age in a volcaniclastic unit interbedded with Timiskaming wacke in the Granada basin near Rouyn-Noranda is 2672.6 ±1.5 Ma

(Davis, 2002), 2678 ±4 Ma in conglomerate from the McWatters sector (Davis, 2002) and 2677 ±0.8 Ma in Timiskaming conglomerate northwest of Malartic (Pilote et al., 2015).

In the Malartic area, the conglomerate and sandstone described above were interpreted as part of the Cadillac group by Mueller et al. (2008) and Pilote (2013) but they have been more recently reassigned to the Timiskaming Group, based on new geochronology data (Pilote et al., 2015). In the Kirkland Lake area of Ontario, the Timiskaming Group includes both fluvial–alluvial-facies conglomerate and sandstone and submarine-facies turbiditic greywacke and mudstone (Hyde, 1980; Jackson and Fyon, 1991; Mueller et al., 1991; Legault and Hattori, 1994). It is therefore possible that the turbiditic greywacke and mudstone in the Malartic area, which are thought to represent the older Cadillac group, belong to the younger Timiskaming Group. An M.Sc thesis mapping project with Metal Earth was initiated this summer to solve this problem using detailed geological mapping, petrographic, lithogeochemical and geochronological analyses.

Pontiac Subprovince

The Pontiac Subprovince consists of light to dark grey, thin-bedded (1–10 cm spaced), graded turbiditic wacke and mudstone (Figure 4e), with minor light grey polymictic conglomerate and pale grey to green komatiite sheet flows. In contrast to the Timiskaming conglomerate, the Pontiac conglomerate only contains large elongate (5–20 cm in length) sandstone clasts and small (<5 cm) subrounded granitoid clasts, within a coarse-grained sandy matrix (Figure 4f). The metasedimentary rocks in the Pontiac Subprovince belong to the Pontiac group. The komatiite sheet flows display classic spinifex-texture–dominated A-zones and cumulate B-zones. Younging direction is generally to the north, based on normal grading, scours and load structures at the base of turbiditic wacke beds. Younging reversals are present due to isoclinal S-folds in wacke. Komatiite flows face westward, with bedding almost orthogonal to the regional schistosity, indicating that they occupy the fold-hinge zone. The contacts between komatiite flows and metasedimentary rocks are not exposed. The youngest detrital zircon age in greywacke of the Pontiac Subprovince in the Malartic area is 2686.6 ±2.1 Ma (Davis, 2002). The metamorphic grade is typically greenschist facies but it increases southward to lower-amphibolite facies near major plutons.

INTRUSIVE ROCKS AND DYKES

There are three major plutons in the La Motte–Malartic area (Figure 2): the ca. 2681–2660 Ma Preissac pluton (Ducharme et al., 1997), ca. 2680–2640 Ma La Corne pluton (Machado et al., 1991) and ca. 2647–2642 Ma La Motte pluton (Machado et al., 1991; Ducharme et al., 1997). The Preissac pluton consists of an early, medium- to coarse-grained hornblende-bearing diorite-granodiorite-monzonite–phyric suite and a late biotite-muscovite-monzogranite suite (Pilote et al., 2015). The La Corne pluton consists of mutually crosscutting hornblende monzogranite, diorite and hornblende pegmatite (Pilote et al., 2015). The La Motte pluton includes an early monzodiorite-monzonite-granodiorite-syenite suite and a late biotite–muscovite–garnet-bearing granite-monzogranite suite (Rive et al., 1990; Feng and Kerrich, 1991). The late suite is intruded by a swarm of pegmatitic and aplitic dykes in the northern part of the La Motte pluton. The monzogranite of the late suite typically displays a subhorizontal magmatic foliation defined by compositional layering of thick bands (1–10 cm) of plagioclase-quartz alternating with thin bands (<1 cm) of garnet-biotite-muscovite.

Several small felsic plutons crosscut turbiditic wacke of the Pontiac Subprovince. An early monzogranite-granite-granodiorite suite is greyish white, medium to coarse grained and biotite-feldspar-quartz–phyric. It contains several nonfoliated and foliated mafic xenoliths. A late monzonite-diorite suite is dark grey, medium to coarse grained and plagioclase-quartz-biotite–phyric. It locally contains early angular granodiorite xenoliths and it occurs as sheeted dykes in the early intrusive suite.

STRUCTURAL GEOLOGY AND MINERAL DEPOSITS

Gold Deposits and Their Structural Setting

Several lode-gold vein occurrences are present in the supracrustal rocks adjacent to the Cadillac–Larder Lake fault zone. In the Pontiac Subprovince, south of the fault, both turbiditic wacke and the felsic dyke are tightly folded by outcrop-scale to map-scale S-folds with north-facing long limbs and south-facing short limbs (Figure 5a, b). The folds have an axial plane cleavage (striking 305–330°, subvertical) expressed by the preferred orientation of biotite and/or hornblende. Cleavage refraction is commonly present: cleavage is typically at a moderate angle (20–45°) clockwise to bedding in coarse-grained wacke beds and at a low angle (<20°) clockwise to bedding in finer grained mudstone beds. Late, locally developed, isoclinal to tight Z-folds with a new axial planar cleavage (279°/87°, right hand rule used hereinafter) anticlockwise to bedding (295°/89°) overprinted the principal cleavage that is axial planar to early tight S-folds. These Z-folds were likely formed during later dextral shearing. Quartz veins in competent felsic and mafic dykes typically occur as tension gashes in en échelon arrays, which are compatible with later dextral shearing. Veins within greywacke and mudstone are typically boudinaged along a dextral shear-band cleavage that is clockwise to bedding.

In the Cadillac metasedimentary rocks, the east-striking, subvertical (~100°/87°) regional cleavage is axial planar to nearly upright, east-plunging, isoclinal to tight folds. Smoky white sigmoidal tension gashes, locally in en échelon arrays, are commonly present in coarse-grained sandstone beds. The tips (~265–270° striking) of these tension gashes are oriented ~45° to bedding and are interpreted to be parallel to the maximum principal incremental strain axis, indicating that these tension gashes formed during sinistral shearing (Figure 5c). Some smoky white veins are at a very low angle (<30°) or subparallel to bedding. These veins are typically tightly sigmoidal (S-shaped). The orientation of these veins is inconsistent with their formation during principal cleavage development. Therefore, these bedding-subparallel veins were likely emplaced early during sinistral shearing. Assays of these veins returned gold values of 1.1–41 g/t (Midland Exploration Inc., 2016). Tightly to openly Z-shaped folding in these veins and cleavages produced a new east-striking (~258°) subvertical cleavage that is axial planar to the Z-folds and anticlockwise to bedding. These veins are asymmetrically boudinaged and displaced in a dextral manner along a “shear band cleavage” (Roper, 1972) that is at a low angle (<30°) clockwise to bedding (Figure 5d). The Z-folds and shear-band cleavages are interpreted to have formed during later dextral shearing. Some tension gashes appear to have formed during dextral shearing. Brittle deformation structures, such as conjugate sets of northwest-striking subvertical S-shaped and north-northeast-striking subvertical Z-shaped kink bands, and northeast-striking (~030°) subvertical sinistral Riedel-shear faults, postdate all precursor deformation structures.

In the Timiskaming conglomerate and sandstone, the main cleavage (~110° striking, subvertical) in coarse-grained sandstone is oriented clockwise to south-facing beds and anticlockwise to north-facing beds. A stretching lineation, which is defined by the elongation of granitoid clasts, plunges shallowly to the east (trend and plunge: 35°→112°). A slickenside striation, or slickenline, which is well developed on quartz-vein margins, is roughly parallel to the stretching lineation. The granitoid clasts are surrounded by asymmetrical strain shadows, which are locally filled with hydrothermal minerals, indicative of superposed dextral shearing. Bedding-subparallel veins are asymmetrically boudinaged along a shear-band cleavage, indicating these veins were emplaced before dextral shearing. Late S-shaped kink bands (325°/86°) overprint the veins and postdate the dextral shearing.

In the Piché group, the principal cleavage is an east-southeast-striking (~125–140°), subvertical and closely-spaced foliation, which is oriented clockwise to bedding in felsic tuff. A stretching lineation, defined by biotite and/or hornblende on the cleavage plane, plunges moderately (45–55°) to the east-southeast. Unlike the mineralized veins in the Cadillac or Timiskaming metasedimentary rocks, the veins within Piché mafic schist and intrusions are rich in tourmaline. They have sigmoidal shapes, suggesting that they were emplaced during sinistral shearing. Other veins display tight S-folds (Figure 5e), suggesting that their emplacement occurred early during sinistral shearing. The principal cleavage is folded by upright, tight to close, moderately east-plunging Z-folds. The latter have an axial plane cleavage oriented anticlockwise to the dominant cleavage. The veins are boudinaged along the late cleavage and offset by dextral shear bands, oriented at a low angle (~30°) anticlockwise to the late cleavage.

Nickel Mineralization and Its Structural Modification

The past-producing Marbridge nickel mine and Cubric nickel showing are hosted in the Malartic group along the Southern Manneville fault zone. Rocks at the Cubric showing include amphibolite-facies metamorphosed mafic and ultramafic rocks, chert and iron formation. They are intruded by various mafic and felsic intrusions: a coarse-grained mafic intrusion, a monzogranite pluton and mafic dykes. Pegmatitic pods occupy the centre of the mafic gabbroic intrusion. The ore zones, composed chiefly of pyrite-chalcopyrite-pyrrhotite-pentlandite-magnetite lenses, mostly occur near the contact between the gabbroic intrusion and the chert and/or iron formation. The oldest deformation feature is expressed as a foliation in mafic volcanic clasts within the gabbroic intrusion. All supracrustal rocks and felsic and mafic intrusions, including the ore zones, are isoclinally or tightly folded by later folds, with an axial planar cleavage striking west-northwest and dipping steeply to the north-northeast (290°/75°). This cleavage is crenulated and folded by upright, open folds with an axial-planar crenulation cleavage (330°/75°; Figure 5f). Dextral shearing, as suggested by the presence of S-C fabrics in deformed ultramafic rocks, is the youngest ductile deformation event at the Cubric showing.

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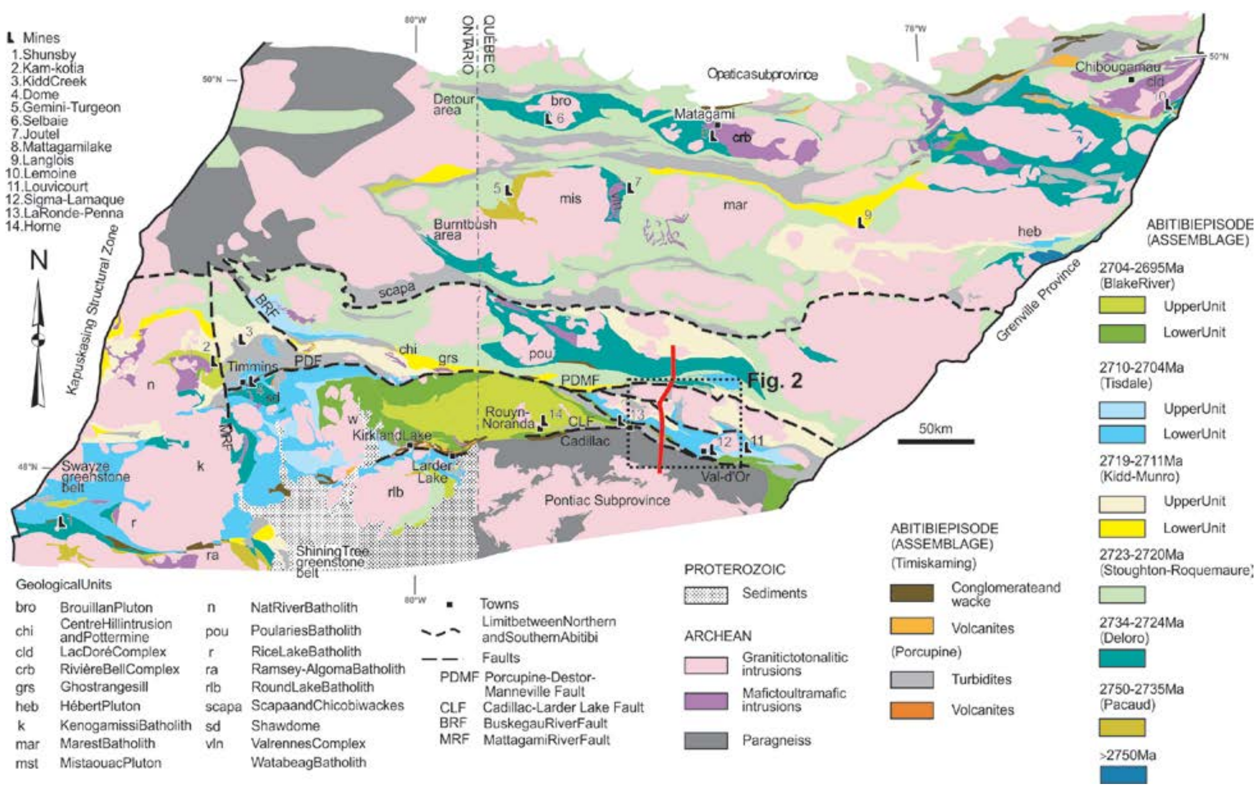

Figure 1. Tectonic framework of the Superior Province (modified from Thurston et al., 2008). The red solid line represents the Malartic transect. Location of Figure 2 is indicated.

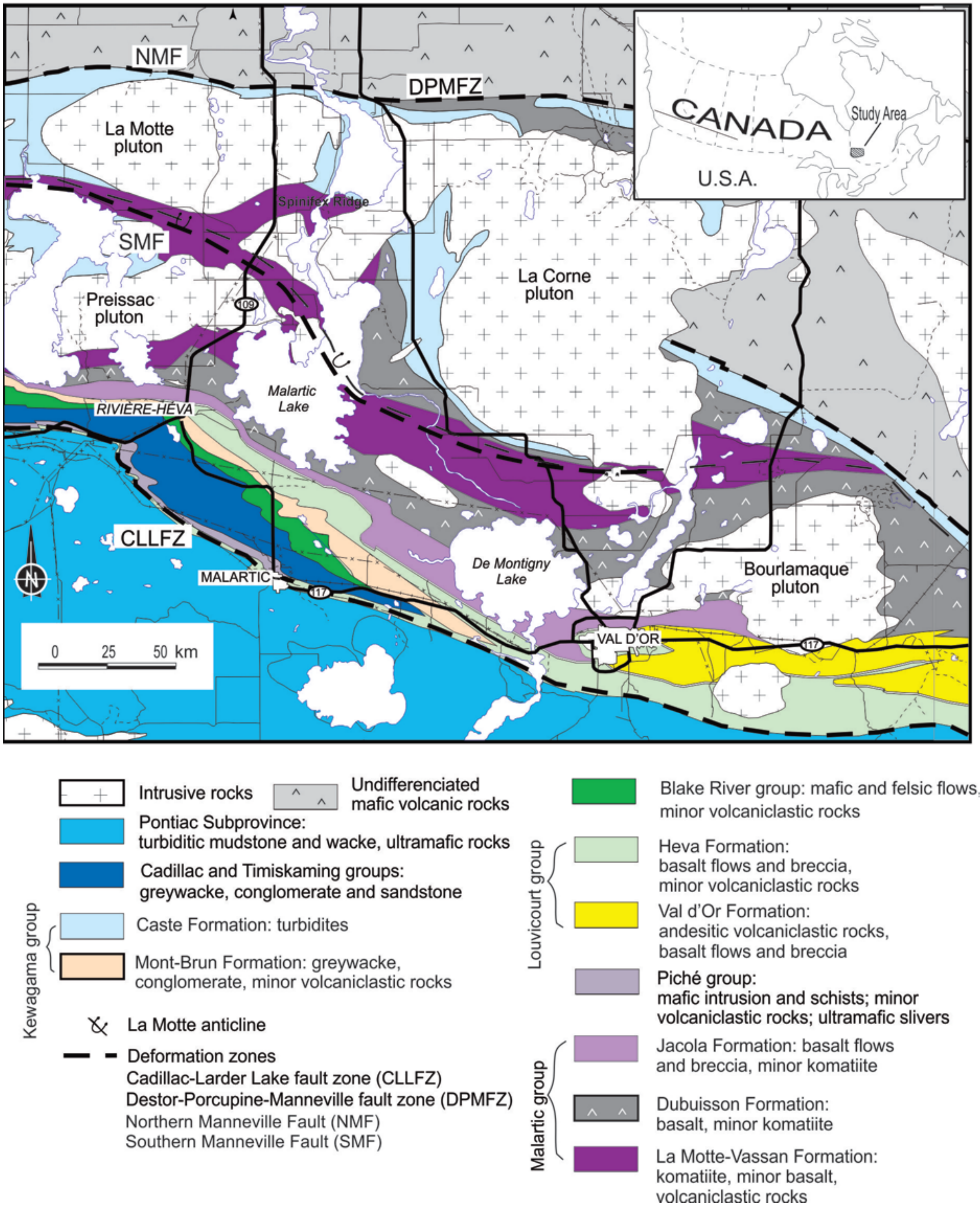

Figure 2. Simplified geology of the La Motte–Malartic area along the central and southern Malartic transect. Major lithostratigraphic units, felsic plutons and regional faults are shown (modified from Mueller et al., 2008).

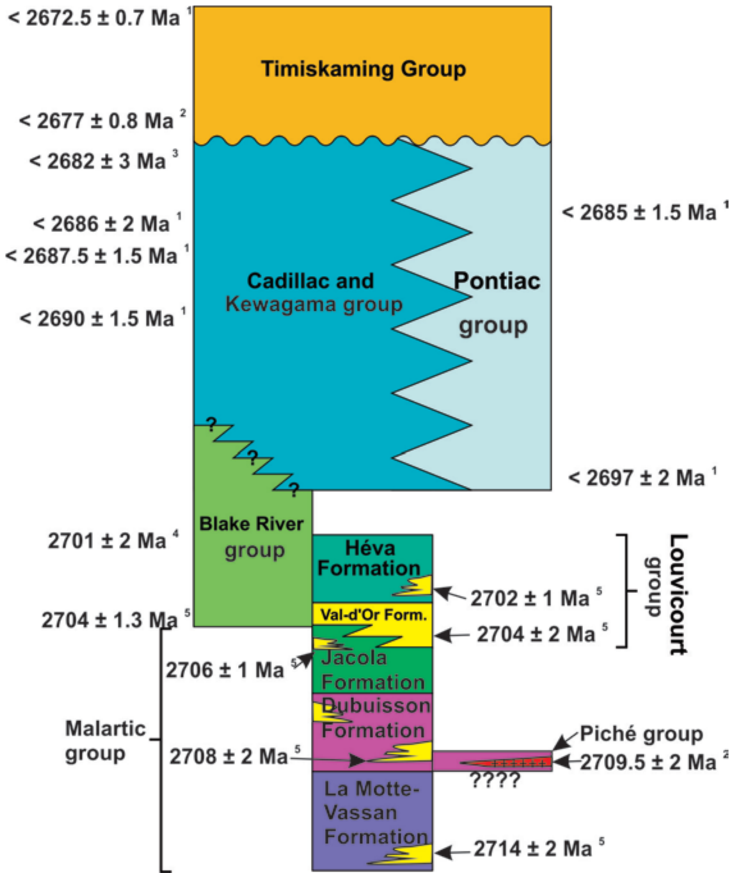

Figure 3. Stratigraphic chart of the La Motte–Malartic area (modified from Bedeaux et al., 2017 and Pilote et al., 2015). Age sources: [1] Davis (2002), [2] Pilote et al. (2015), [3] Mortensen (1993), [4] Corfu et al. (1989) and [5] Pilote et al. (1999).

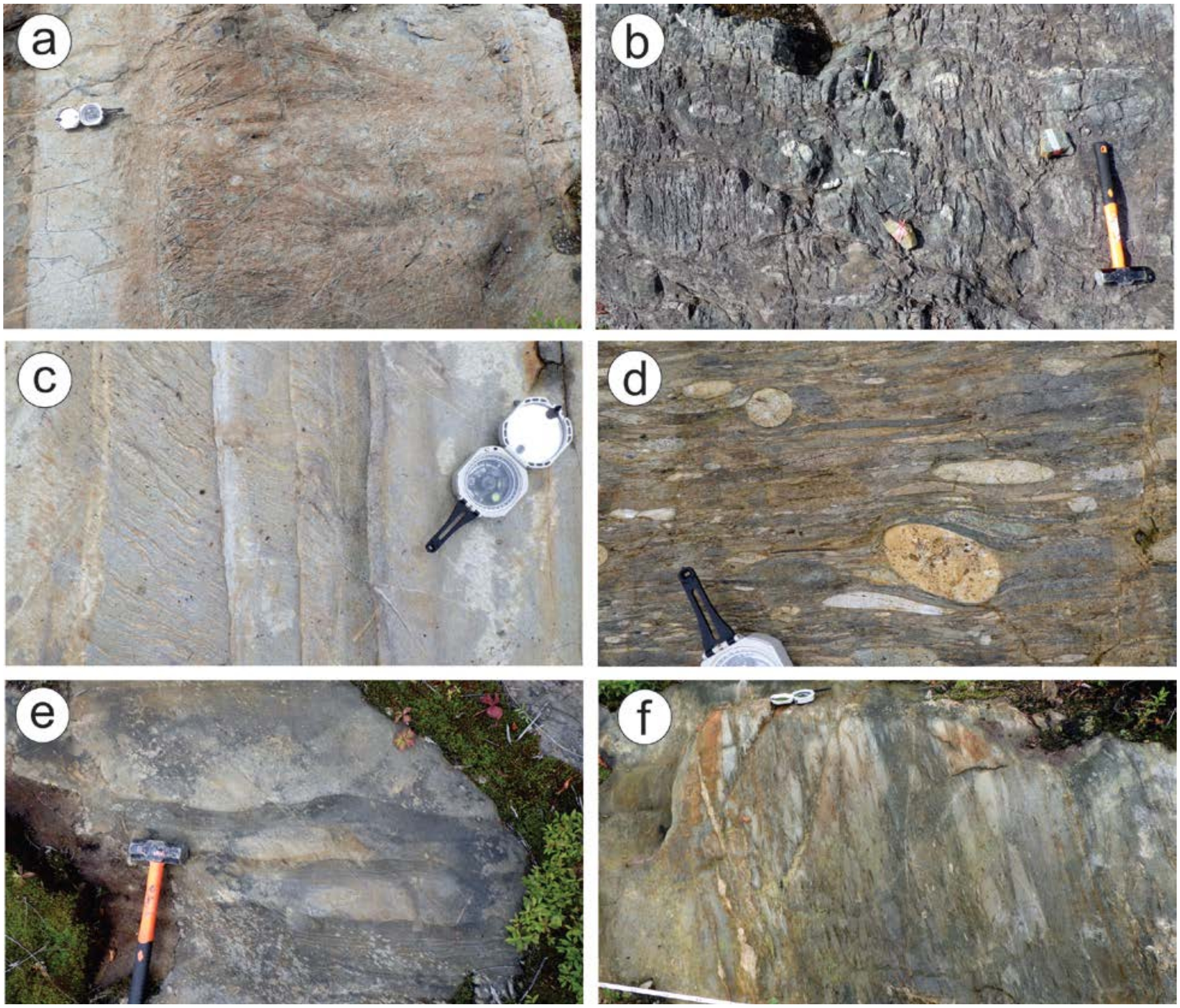

Figure 4. Field photographs of representative rock types in the La Motte–Malartic area, showing **a)** north-facing Malartic group komatiite sheet flows at the Spinifex ridge Highway 109 roadcut outcrop, with well-preserved cumulate B-zone and spinifex A-zone; **b)** south-facing Malartic group mafic pillows, with epidote hearts, in the Marbridge mine area; **c)** southwest-facing, thin-bedded, normal graded greywacke of the Caste formation, west of the La Motte pluton (note the west-striking, closely-spaced, continuous cleavage refraction in individual beds); **d)** deformed, polymictic and clast-supported conglomerate of the Timiskaming Group northwest of Malartic; **e)** north-facing normal graded wacke of the Pontiac group west of Malartic; **f)** stretched polymictic conglomerate of the Pontiac group southwest of Malartic. All plan view looking downward, except f) in section view looking west. Compass and hammer point to the north.

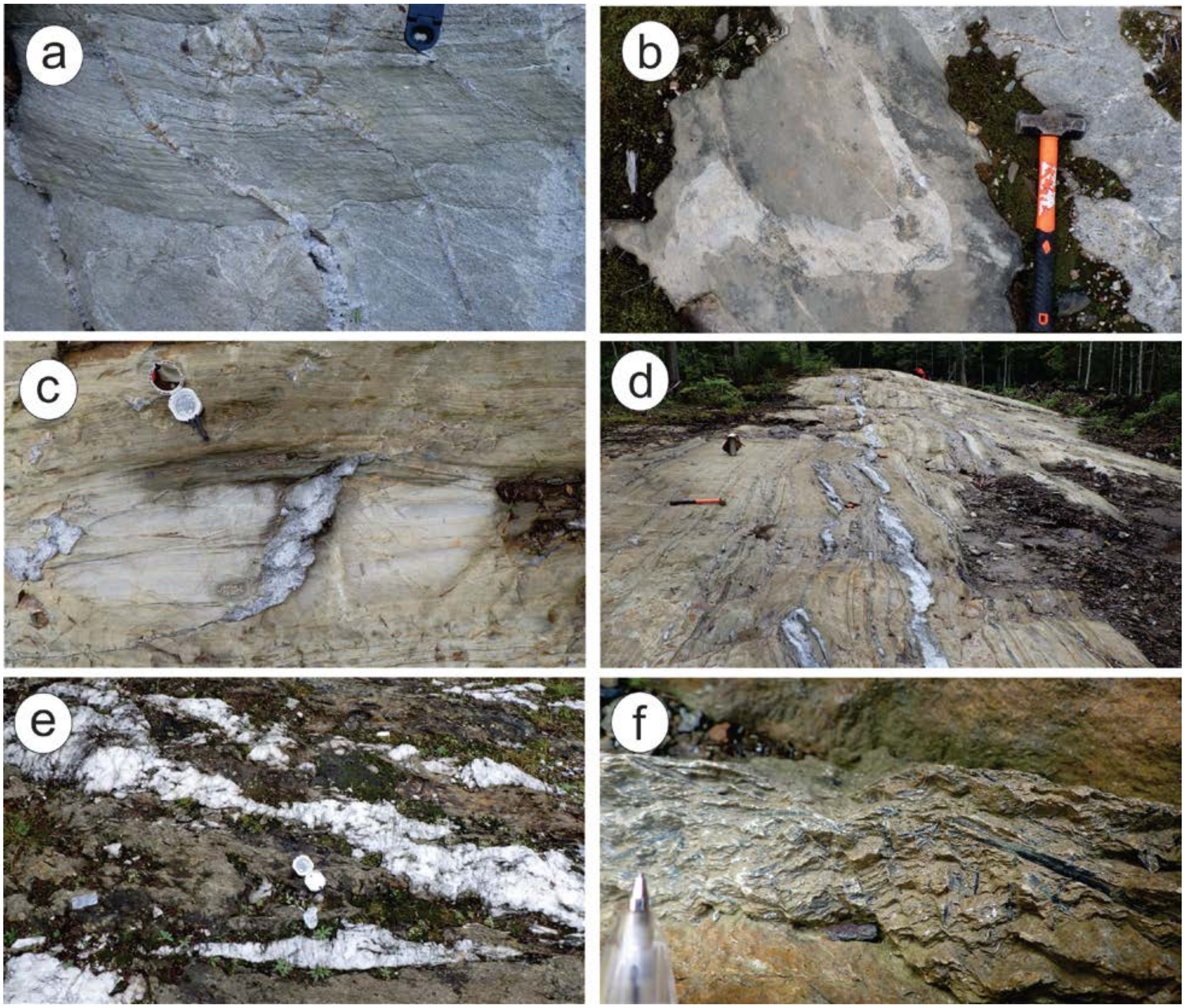

Figure 5. Field photographs of deformation structures near the Cadillac–Larder Lake fault zone and Southern Manneville fault zone in the La Motte–Malartic area, showing **a)** S-folds seen in greywacke and mudstone of the Pontiac group west of Malartic; **b)** folded granitoid dyke in greywacke of the Pontiac group west of Malartic; **c)** tension gash in graded sandstone of the Cadillac group northwest of Malartic; **d)** veins asymmetrically boudinaged along a dextral shear-band cleavage in graded sandstone of the Cadillac group northwest of Malartic; **e)** veins with S-folds in foliated mafic flows of the Piché group; **f)** principal crenulated cleavage in the sulphide zone at the Cubric showing displaced along a new crenulation cleavage. All plan view looking downward, except d) looking west. Compass, hammer or pencil point to the north.