Structural geology of the Timiskaming and Cadillac groups along the Malartic segment of the Larder Lake–Cadillac deformation zone and implications for gold mineralization, Abitibi greenstone belt, northwestern Quebec

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INTRODUCTION

The Larder Lake–Cadillac deformation zone (LLCDZ; Figure 1) in the Abitibi greenstone belt of the Archean Superior Province is a major crustal-scale deformation zone hosting numerous world-class gold deposits. Little work has been done on gold mineralization hosted by metasedimentary rocks of the Timiskaming and Cadillac groups along the Malartic segment of the LLCDZ due to the lack of outcrops. However, new outcrops stripped mechanically by Midland Exploration Inc. over the last two years provide a great opportunity to study gold mineralization in this prospective district. An area along the Malartic segment of the LLCDZ (Figure 2) was mapped in the summer of 2017 as part of the Malartic seismic-transect mapping project of the Metal Earth initiative. The goals of the 2017 mapping project were to establish the structural history of the supracrustal rocks, determine the structural timing of gold-bearing quartz veins and establish the relationship between the Timiskaming Group and Cadillac group in the study area. This report focuses on the structural evolution of these rocks and their gold-bearing veins.

REGIONAL SETTING

The Abitibi greenstone belt comprises volcanic and sedimentary assemblages intruded by large granitoid bodies. Four volcanic units occur in close proximity to the LLCDZ: the Piché (>2709 Ma; Pilote et al., 2014), Malartic (2714–2702 Ma; Pilote et al., 1997, 1998, 1999), Louvicourt (2704 Ma; Pilote et al., 2014) and Blake River (2703–2695 Ma; Corfu et al., 1989, 1993; Mortensen, 1993 ; Moore et al., 2016) groups (Bedeaux et al., 2017). The Piché group occurs along the LLCDZ and consists mainly of strongly deformed ultramafic and mafic volcanic rocks (Latulippe, 1976; Simard et al., 2013), with minor intermediate andesitic rocks (Landry, 1991). All the other groups consist of ultramafic and mafic volcanic rocks intercalated with minor intermediate to felsic volcanic rocks, with the exception of the Blake River group, which consists mostly of mafic and felsic volcanic rocks (Bedeaux et al., 2017).

Two Archean sedimentary successor basins overly the volcanic assemblages (Figure 1; Thurston et al., 2008). Rocks of the Cadillac group (Dimroth et al., 1982) occupy a 150 by 5 km basin unconformably overlying older volcanic rocks of the Blake River group, north of the LLCDZ (Goutier, 1997; Lafrance et al., 2003; Mercier-Langevin et al., 2007; Thurston et al., 2008). The Cadillac group was deposited <2686 Ma ago (Davis, 2002) and is equivalent to the Porcupine group in Ontario (Ayer et al., 2002; Thurston et al., 2008). Younger (<2676 Ma) fluvial conglomerate, sandstone and shallow marine turbidites of the Timiskaming Group were unconformably deposited over the Cadillac group (Corfu and Davis, 1991; Davis, 2002; Pilote et al., 2015).

The Pontiac Subprovince, which lies immediately south of the LLCDZ and the Abitibi greenstone belt, consists of turbiditic sandstone and minor conglomerate (Goulet, 1978; Dimroth et al., 1982). It was deposited between ca. 2685 Ma, the age of the youngest detrital zircons in the metasandstone of the northern part of the Pontiac Subprovince, and ca. 2682 Ma, the crystallization age of the Lac Fournière pluton that intruded Pontiac metasedimentary rocks. It is similar in age and rock type to the Cadillac group (Mortensen, 1993; Davis, 2002).

LITHOLOGICAL UNITS IN THE STUDY AREA

The Cadillac and Timiskaming groups are the two main rock assemblages in the study area (Figure 3). The Cadillac group consists of turbiditic sandstone, with minor iron formation. Individual sandstone beds are 2–20 cm thick, generally top to the north or south, based on normal grading, and alternate with mudstone beds 1–5 cm thick. The Timiskaming Group includes polymictic conglomerate, sandstone and minor turbidites. Polymictic conglomerate beds, typically 1–5 m thick, contain clasts of mafic and felsic volcanic and granitoid rocks, minor chert and smoky quartz clasts. Sandstone beds are massive to trough crossbedded and metres thick. Erosional channelling at the base of conglomeratic beds, normal grading in turbidite beds and trough crossbedding in sandstone bedding suggest younging direction is generally to the north. Younging reversals are commonly present due to well-developed isoclinal folds.

DEFORMATION, ALTERATION AND MINERALIZATION

Regional Folding

A regional cleavage strikes west-northwest and dips steeply to the north and locally to the south. It is expressed as a continuous slaty cleavage in mudstone, as a spaced disjunctive cleavage in sandstone, and by the flattening and elongation of clasts in conglomerate (Figure 4a). It is oriented anticlockwise to north-facing beds and clockwise to south-facing beds. The cleavage is axial planar to west-northwest-striking folds plunging moderately to shallowly to the east-southeast. The folds are tight to isoclinal, with amplitudes varying in size from centimetres to metres (Figure 4b). An intersection lineation defined by the intersection of bedding with the regional cleavage plunges moderately to the east-southeast, parallel to the fold axes. Younging reversals within the Timiskaming and Cadillac groups, the presence of S- and Z-shaped asymmetrical folds and changes in structural facing of the regional cleavage suggest that the Cadillac and Timiskaming groups were overprinted by regional folds, with amplitudes measuring metres to hundreds of metres.

Sinistral Movement

Arrays of en échelon quartz veins crosscut bedding and the regional cleavage (Figure 4c, d). The veins are typically 5–30 cm thick and vary in length from a few metres to hundreds of metres. They are oriented anticlockwise to bedding and to the regional cleavage on both limbs of the regional folds. The orientation of these veins and the presence of sigmoidal S-shaped tension gashes (Figure 4e), with similar orientation as the en échelon quartz veins, suggest that these veins were emplaced during sinistral shearing. The veins are present on several outcrops, suggesting that this sinistral shearing event was not a localized deformation event.

The veins are surrounded by chlorite+sericite+biotite+arsenopyrite alteration haloes that extend over 10–20 cm in the wallrocks. Assays of the veins and their alteration haloes returned values of 1.7–41 g/t Au (Midland Exploration Inc., 2016).

Dextral Movement

The en échelon veins are boudinaged (Figure 4d, f), cut by dextral shear bands (Figure 4f) and overprinted by Z-shaped folds (Figure 4g). The shear bands are steeply dipping and strike to the northwest. The Z-folds range in amplitude from 10 to 30 cm and are generally steeply dipping, east- to east-northeast-striking and moderately east-plunging. They have an axial plane cleavage expressed as a fine differentiated foliation, which is oriented anticlockwise to bedding. Some Z-shaped flanking folds are present adjacent to the quartz veins (Figure 5a). These structures are well-developed in the turbiditic sandstone and collectively suggest that the quartz veins were deformed during a superposed younger dextral shear event. The occurrence of Z-shaped tension gashes (Figure 5b) with similar orientation to the dextral shear band also suggests emplacement during dextral shearing. Granitic clasts in the Timiskaming conglomerate are surrounded by asymmetrical dextral strain shadows (Figure 5c), suggesting that the conglomerate was also deformed during dextral shearing.

DISCUSSION AND CONCLUSION

Gold mineralization at the nearby Canadian Malartic mine is controlled by the Sladen fault and by other faults and shear zones that cut the hinge of major folds (De Souza et al., 2015). The mineralized zones are oriented subparallel to the northwest-striking axial planar cleavage to the folds and to the east-striking and south-dipping Sladen fault. The gold mineralization was emplaced within these faults and shear zones as a result of the remobilization of gold that was introduced earlier through a magmatic or hydrothermal system related to porphyritic intrusions of Timiskaming age (De Souza et al., 2015).

The faults associated with gold mineralization at the Canadian Malartic deposit have reverse sinistral-slip kinematics and a moderately to steeply northeast-plunging lineation (De Souza et al., 2015). As the gold-bearing veins in the study area also formed during a sinistral shearing event, they may be coeval with the mineralization at the Canadian Malartic deposit. This interpretation will be investigated further during a follow-up field season.

FUTURE WORK

The northern contact of the Timiskaming Group with the Cadillac group is not well understood. The older Cadillac turbidites are located north of a sequence of Timiskaming conglomerate and crossbedded sandstone but as both are younging to the north, this contact must either be tectonic or conformable. Should the latter prove the case, the turbidites correspond to the marine facies of the Timiskaming Group, as described by Hyde (1980) for the Kirkland Lake–Larder Lake area. Samples were collected from both groups and will be submitted for lithogeochemicalanalysis and detrital-zircon geochronology to compare their geochemistry and zircon populations.

The focus of the 2018 field season will be to examine the stratigraphic and structural setting of gold mineralization within the metasedimentary rocks of the Timiskaming and Cadillac groups in a larger area north of the LLCDZ. Contacts between the Cadillac and Timiskaming groups with the Blake River and Piché groups will also be investigated.

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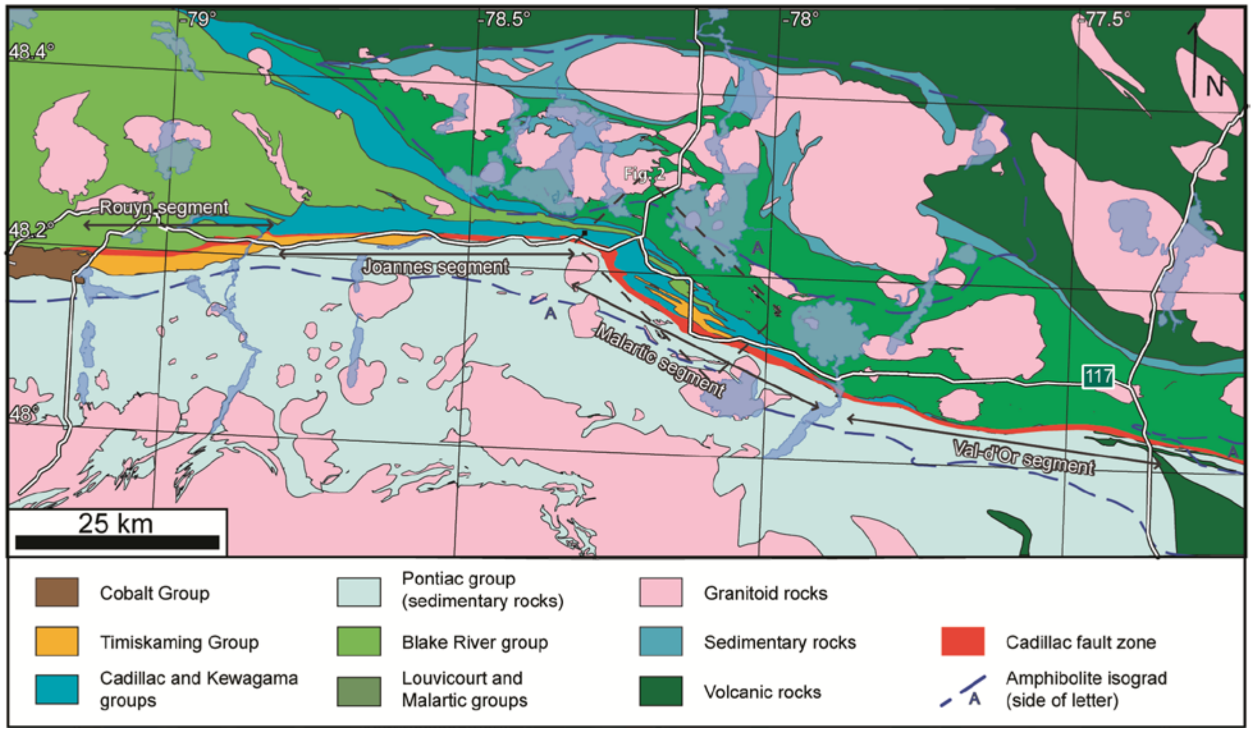

Figure 1. Regional geology, showing the four fault segments of the Larder Lake–Cadillac deformation zone in the Abitibi greenstone belt. Modified from Hubert et al. (1984), Imreh (1984), Desrochers and Hubert (1996), and Bedeaux et al. (2017).

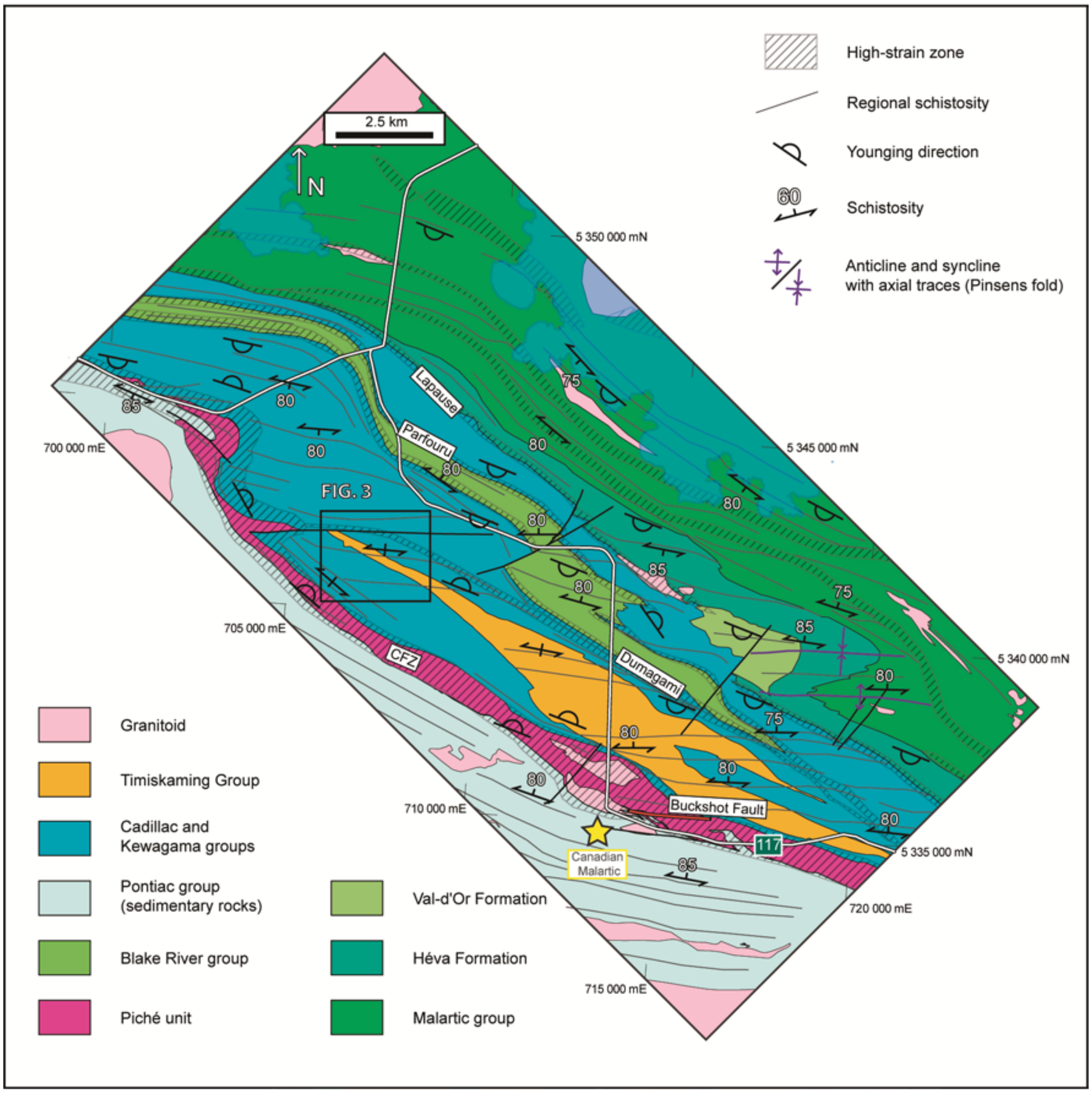

Figure 2. Geology of the Malartic segment of the Larder Lake–Cadillac deformation zone in the Abitibi greenstone belt. Modified from Desrochers et al. (1993), Desrochers and Hubert (1996), Pilote et al. (1999), Pilote (2013), Pilote et al. (2014), and Bedeaux et al. (2017). Abbreviation: CFZ, Cadillac fault zone.

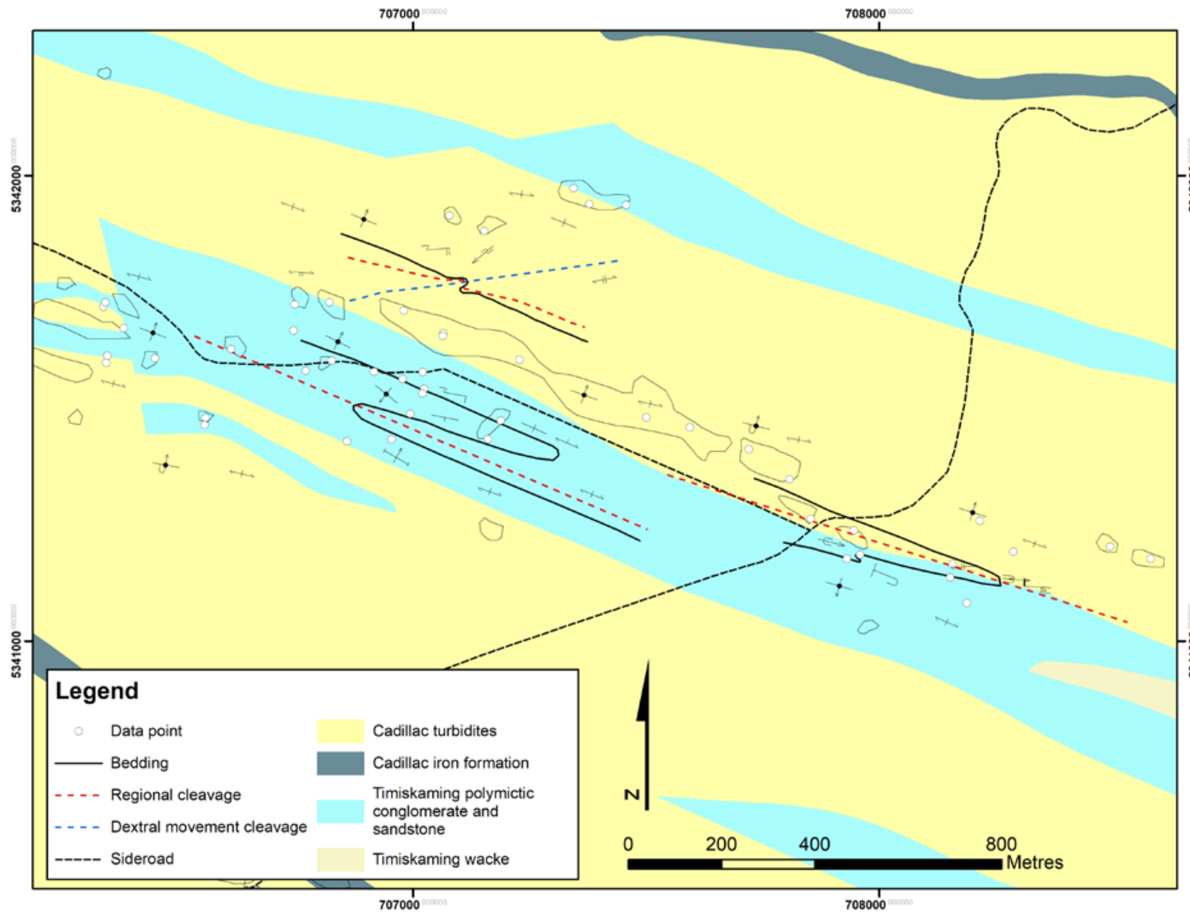

Figure 3. Geology of the study area of the Cadillac and Timiskaming groups within the Malartic segment of the Larder Lake–Cadillac deformation zone in the Abitibi greenstone belt (modified from interactive map developed by SIGÉOM, 2017).

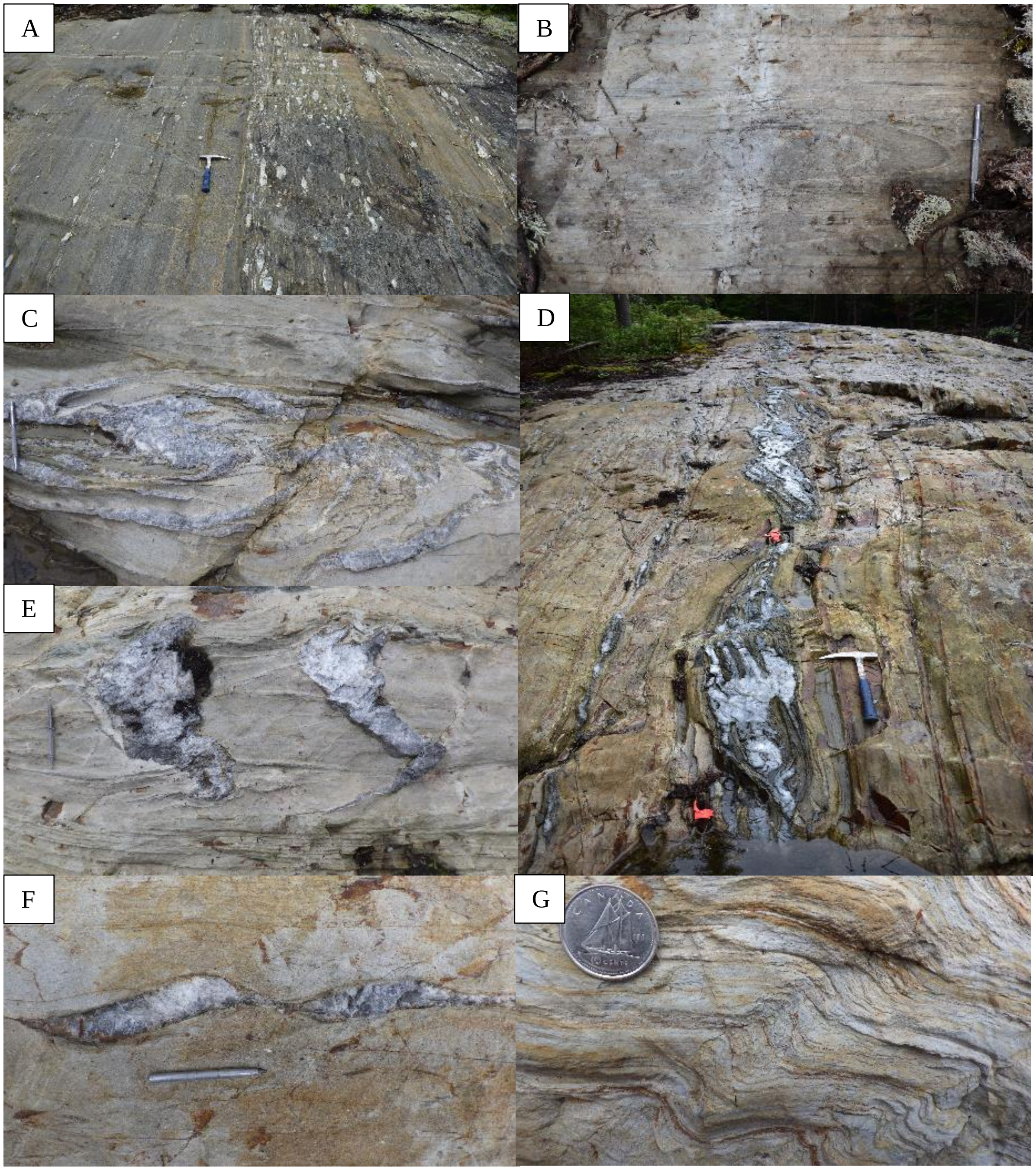

Figure 4. Selected photos of structural features in the Abitibi greenstone belt study area, showing **a)** Timiskaming polymictic conglomerate and bedded sandstone at UTM 706379E, 5341672N (flattened clasts of the conglomerate define regional cleavage); **b)** isoclinal U-shaped folds developed during regional folding within the Cadillac turbidites at UTM 707958E, 5341185N; **c)** S-folded en échelon quartz vein at UTM 708156E, 5341165N; **d)** S-folded and boudinaged gold-bearing en échelon quartz veins at UTM 708156E, 5341165N; **e)** S-folded quartz tension gashes at UTM 708156E, 5341165N; **f)** boudinaged quartz veins along a dextral shear-band cleavage at UTM 708156E, 5341165N; **g)** dextral movement Z-folds with an axial planar cleavage at UTM 708156E, 5341165N. All co-ordinates are in NAD83 UTM Zone 17N. Hammer is 33 cm long and pen magnet is 13 cm long.

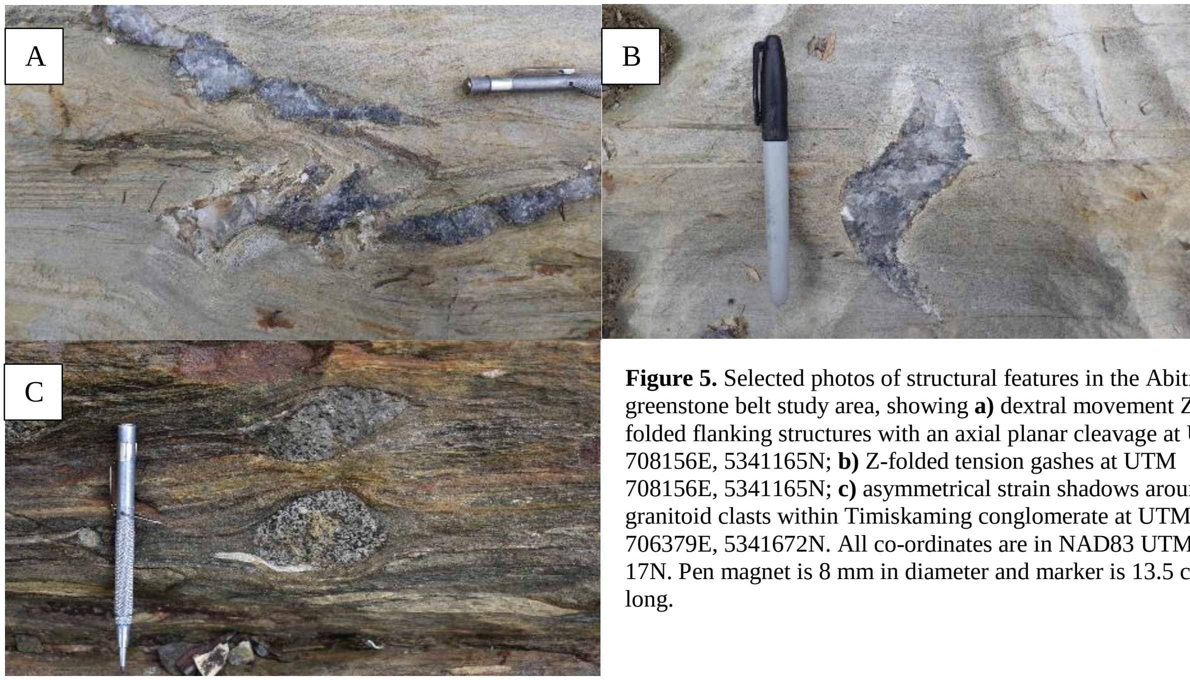

Figure 5. Selected photos of structural features in the Abitibi greenstone belt study area, showing **a)** dextral movement Z-folded flanking structures with an axial planar cleavage at UTM 708156E, 5341165N; **b)** Z-folded tension gashes at UTM 708156E, 5341165N; **c)** asymmetrical strain shadows around granitoid clasts within Timiskaming conglomerate at UTM 706379E, 5341672N. All co-ordinates are in NAD83 UTM Zone 17N. Pen magnet is 8 mm in diameter and marker is 13.5 cm long.