Mapping the Chibougamau transect in the Abitibi Subprovince: the limit between volcanic cycles 1 and 2

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INTRODUCTION

Results of summer 2019 mapping in the Chibougamau area northeast of the Abitibi Subprovince, as a follow-up to 2018 fieldwork, are presented in this report. The goal of the work was to define the transition between Roy Group volcanic cycles 1 and 2. This group hosts most of the Archean volcanic rocks observed in the Chibougamau area.

The work done in 2018 focused on the Obatogamau formation, which was studied as part of a M.Sc. project undertaken at the Université du Québec in Chicoutimi. This formation is composed mainly of tholeiitic basalt flows and basaltic andesite containing 0 to 20% of millimetre-sized plagioclase glomerocrystals (Cimon, 1977; Ludden et al., 1984; Leclerc et al., 2011). The 2018 fieldwork served to document the interruptions in mafic volcanism in the Obatogamau Formation and to sample the lavas to determine their chemistry and petrology. A sample from a felsic level reveals an interruption in mafic volcanism in a strongly deformed area. This sample will help constrain the age of the formation. The results of this work will be presented in a publication currently in preparation.

Fieldwork in 2018 also focused on the rocks in the Muscocho Syncline sector (Figure 1). The work allowed to better define the interfingering (Cimon, 1977; Legault, 2003) observed between the lavas at the top of the Obatogamau Formation and the volcaniclastic deposits of the Waconichi Formation. They also allowed to identify levels of lapilli tuff, crystal tuff and ash tuff associated with calcalkaline mafic lavas intercalated with lavas from the Obatogamau Formation. South of the Muscocho Syncline, south-striking stratigraphic polarity markers were observed in the pillowed lavas on either side of a band of intermediate to felsic volcaniclastic rocks oriented east–west (Figure 1). This unit has been linked to the Waconichi Formation and is known as the 'Winchester Member' (F. Leclerc, pers. comm., 2018). This observation casts doubt on mafic lavas south of the unit belonging to the Obatogamau Formation.

In summer 2019, the work mainly focused on mapping the volcanic rocks southeast of the Muscocho Syncline, in the Joe Mann mine area. Old strippings (no. 1 and 2, Figure 1) show potential stratigraphic continuity of the Waconichi Formation in that area. Other work done in parallel focused on the greenstone belt located south of the Winchester Member in the Caopatina Basin area (no. 3, 4 and 5, Figure 1). Finally, to better document the structure of the Obatogamau Formation in this sector, mapping was carried out west of the Muscocho Syncline (no. 6, Figure 1), near the felsic unit sampled in 2018 for age determination.

LOCAL GEOLOGICAL SETTING

Much of this section borrows from the report on fieldwork done in 2018.

The Roy Group, the stratigraphy of which was recently revised, makes up the major portion of the Archean volcanic assemblage in the Chibougamau area (Leclerc et al., 2011, 2017). This assemblage is part of the units that form the greenstone belt of the Abitibi Subprovince. It consists of two volcanic cycles, each one comprising two formations. Before the revision, these formations were, from the base to the top, the Obatogamau and Waconichi formations in the case of volcanic cycle 1, followed by the Gilman and Blondeau formations for volcanic cycle 2 (Daigneault and Allard, 1990). When they revised the Roy Group stratigraphy, Leclerc et al, (2008, 2011) correlated the base of the Gilman Formation with the top of the Obatogamau Formation based on geochemical and geochronological considerations and referred to it as the 'David Member'. In addition, these authors proposed renaming the remaining portion of the Gilman Formation, which is now known as the 'Bruneau Formation' and forms the base of volcanic cycle 2 according to this stratigraphic interpretation.

Rocks belonging to volcanic cycles older than those of the Roy Group are also found in this sector. These are the Chrissie (dated at 2791.4 ±3.7 Ma by David et al.,2011) and des Vents (dated at 2798.7 ±0.7 Ma by Davis et al., 2014; and at 2759 ±2 Ma by Mortensen, 1993) formations, which lie stratigraphically below the Obatogamau Formation (Leclerc et al., 2017) and are located west of the Muscocho Syncline, along the margins of the Eau Jaune Complex (Figure 1).

The Muscocho Syncline (Figure 1) is a north–south-striking structure and corresponds to a fault that predates regional D_2 deformation (Daigneault et al., 1990; Legault, 2003). The transition between the first and the second volcanic cycle was observed in this structure. In addition, interdigitations between the top of the Obatogamau Formation and the base of the Waconichi Formation occur in the same location. The southern end of the syncline is hiden by the Verneuil Pluton (Figure 1). Except for the Coapatina Basin sedimentary rocks, all the volcanic and sedimentary rocks south of the Muscocho Syncline and the Winchester Member have been mapped as belonging to the Obatogamau Formation on a departmental map (SIGÉOM, 2019). Southwest of this sector, a band of volcaniclastic rocks about 1.8 km thick (Figure 1), referred to as the 'Phooey Member' is interpreted as belonging to the Obatogamau Formation (Midra et al., 1992).

WORK COMPLETED

Joe Mann Mine Sector

Several levels of fine-grained tuff were observed west of Joe Mann mine (no. 1, Figure 1). These levels exhibit a few quartz eyes and layering (difficult to examine as the rock surface is covered by lichen), and locally can contain rock fragments. These tuff levels are hosted in aphanitic mafic lavas crosscut by many fine-grained felsic dykes and a few tonalite dykes. These rocks are strongly deformed by a generally east–west-trending subvertical shear zone, which extends toward Joe Mann mine. Layering in the tuff levels is parallel to the shear zone. The felsic dykes are subparallel to this zone. The most highly deformed zones are strongly carbonated and sericitized, and host quartz veins as well as sulphidic levels (mainly pyrite) at the margin of the dykes (Figure 2a) or as isolated bodies. This mineralization and associated alteration are interpreted as part of the Joe Mann mine mineralized vein system.

Northeast of Joe Mann mine (no. 2, Figure 1) locally altered and mineralized rocks interpreted as mafic tuff suggest an east–west extension of the tuff facies of the sector. Silicification was observed that stains the rock or manifests itself in the shape of rare quartz veins. The mineralization, mainly consisting of semi-massive to massive pyrite/arsenopyrite and chalcopyrite, is found exclusively in the silicified zone (Figure 2b). Rocks observed in the stripping backfills point to the potential presence of a gabbro sill

north of the tuff levels. A tonalite dyke crosscuts the altered and mineralized zone. The metallogenic model is probably identical to that of the Joe Mann mine.

The mafic lavas observed northeast of Joe Mann mine display the typical facies of the Obatogamau Formation, which consist of pillow lavas with plagioclase megacrysts. The polarity markers strike to the south. The volcanic facies revealed no polarity observation in support of a hypothetical termination of the Muscocho Syncline at the Verneuil Pluton. The volcano-sedimentary levels located in the Joe Mann mine sector may belong to the Waconichi Formation and laterally extend the facies of the eastern limb of the Muscocho Syncline. Detailed mapping is required to confirm this hypothesis.

Caopatina Basin Sector

The aim of the work was to refine the volcanic stratigraphy of the region between the Winchester Member (no. 3, Figure 1) and the Caopatina Basin. However, an east–west-trending, shallowly north-dipping (50–70°) fault network interrupts stratigraphic continuity in this sector. These structures are probably linked to the Opawica–Guercheville deformation corridor that extends from Shortt Lake to the Grenville front through Joe Mann mine (Dion et Maltais, 1998). The deformation observed in recent roadcuts is associated with very strong carbonation of lavas, with local sericitization. The lavas contain amphibole porphyroblasts 0.5 to 1 cm in length resulting from amphibolite-facies high-grade metamorphism (Figure 2c). These porphyroblasts are of lesser size outside of the strongly altered zones. The mostly greyish quartz veins with local tourmaline crosscut the altered zone perpendicularly to the fault plane; sulphides are associated with these veins.

Southwest of the Caopatina Basin, mapping was briefly undertaken in the Phooey member sector. In this sector, an intermediate to felsic tuff level (no. 4, Figure 1), rich in quartz eyes (Figure 2d), is intercalated between levels of mafic tuff. This level has been sampled for U-Pb geochronology to establish its location within the regional stratigraphy and confirm that it is related to the Obatogamau Formation. The mafic lavas at the contact with the southern limit of the Phooey member (no. 4, Figure 1) are massive mafic pillow lavas having undergone amphibolite-facies metamorphism. These lavas are only slightly deformed, and the shape of the pillows has been preserved. The lavas north of the Phooey Member (no. 5, Figure 1) have also undergone amphibolite-facies metamorphism but are strongly deformed, which renders identification of initial structures impossible. No plagioclase glomerocrystals have been identified in the lavas of this sector during fieldwork, therefore whether the lavas belong to the Obatogamau Formation or not remains to be confirmed.

Western Sector of the Muscocho Syncline

Recent strippings (no. 6, Figure 1) made it easier to examine the deformation corridors that affect the Obatogamau Formation mafic lavas and the dykes that crosscut them in this sector. The deformation is located in neatly defined, subvertical zones 20 m thick striking N115 (similar to the stratigraphic polarity observed in the lavas): slightly deformed pillow lavas (Figure 2e) abruptly trend into a zone of intense deformation, in which mafic lavas and dykes are completely transposed. Some competent tonalite dykes are boudinaged and dismembered. The lavas display facies typical of the Obatogamau Formation, with aphyric flows and lava flows that contain from 1 to 3% plagioclase glomerocrysts. Locally intense iron carbonate alteration is found in these deformation corridors (Figure 2f) as well as gold mineralization-bearing quartz veins (P. Houle, pers. comm., 2019); these quartz veins are also transposed in the deformation corridors.

FUTURE WORK

Future work will focus on the chemical characterization of the sampled lavas and tuff to verify and refine field observations, specifically to determine the location of the Waconichi Formation, which marks the transition between the Roy Group volcanic cycles. The intermediate to felsic tuff sample from the Phooey Member will be sent for U-Pb zircon analysis.

The Opawica–Guercheville deformation corridor interrupts volcanic stratigraphy continuity toward the south. Short-term fieldwork could be undertaken in the coming years, especially in the Phooey Member and Joe Mann mine sectors, to establish a better stratigraphic correlation between the two sectors. Similarities between the facies in these sectors and those of the Waconichi Formation justify further stratigraphic study of the area.

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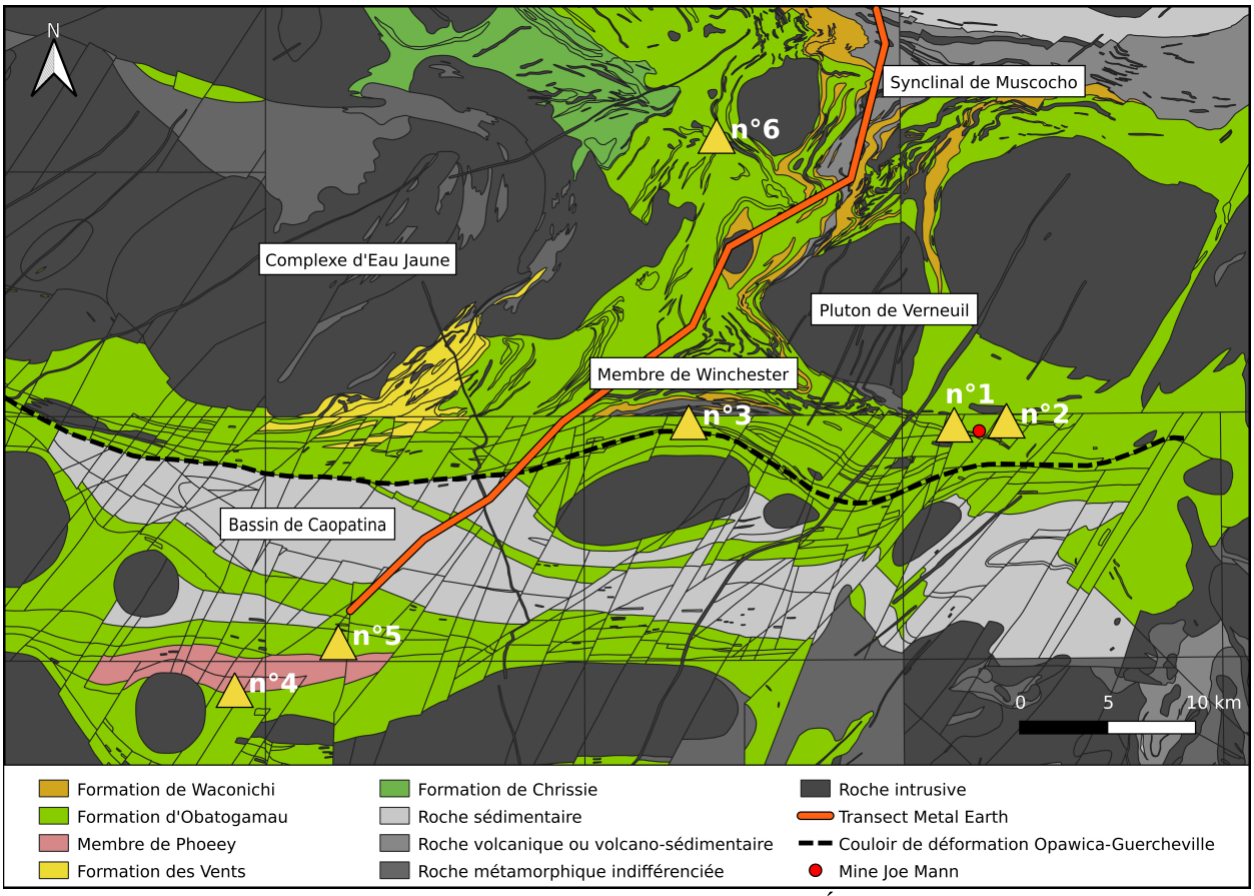

Figure 1. Map showing the 2019 field season study area (*modified from* SIGÉOM, 2019). The symbols (or groups of symbols) no. 1 and 2 correspond to the mineralized tuff strippings close to the Joe Mann mine. Symbol no. 3 corresponds to the fault zone interrupting stratigraphic continuity south of the Winchester Member. Symbols no. 4 and 5 correspond to the sectors studied in the Phooey Member zone. Symbol no. 6 west of the Muscocho Syncline corresponds to local strippings that show zones of very localized and intense deformation.

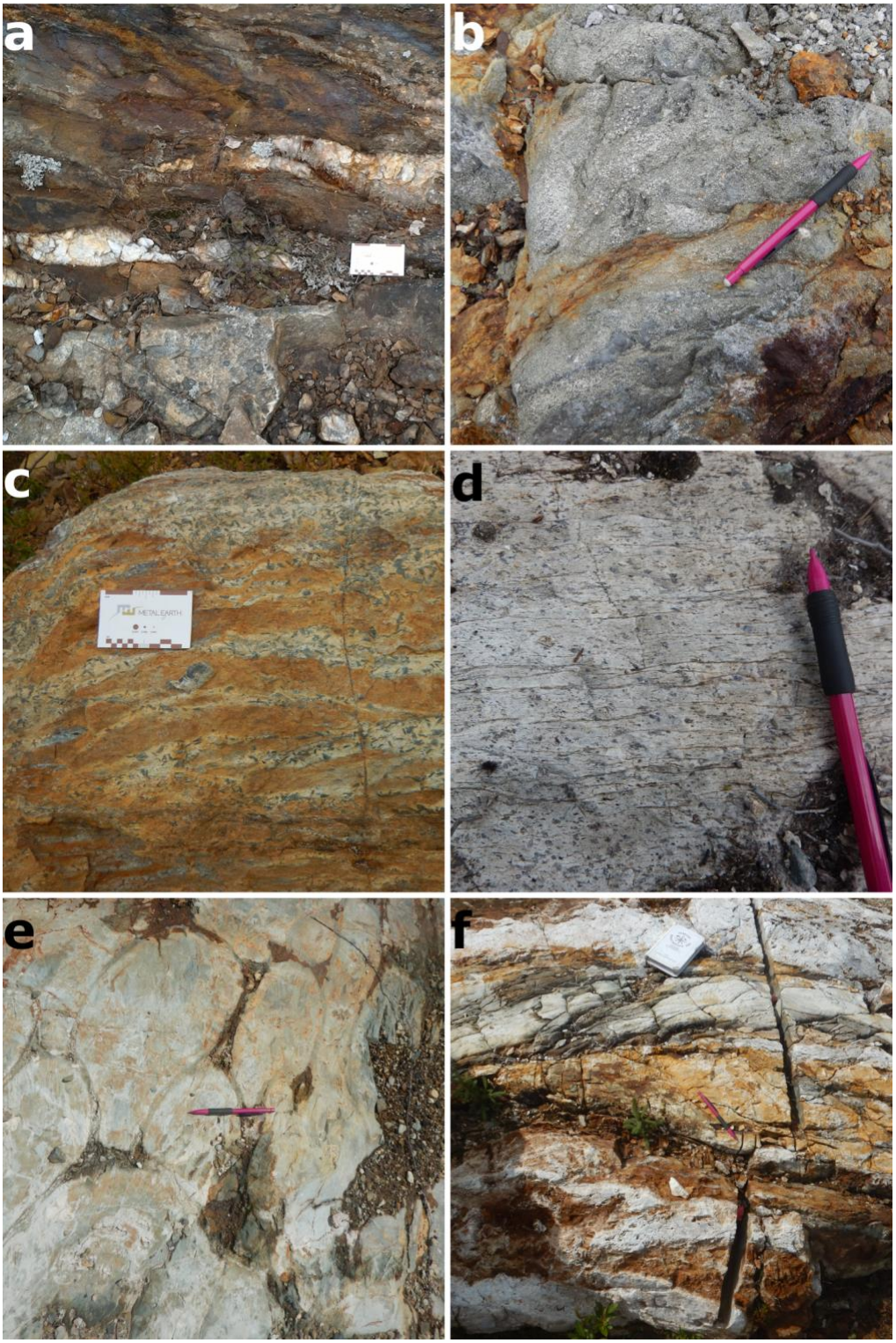

Figure 2. Outcrop photographs of the Chibougamau region showing: **a)** tuff or sheared lava with boudinaged quartz veins on the margin of a tonalite dyke (at the bottom of the photo), west of Joe Mann mine; **b)** semi-massive to massive sulphides in silicified tuff east of Joe Mann mine; **c)** shear zone carbonate-bearing lavas with amphibole porphyroblasts that formed during metamorphism in the Opawica–Guercheville deformation corridor; **d)** intermediate to felsic Phooey member tuff containing

many quartz eyes; **e)** Obatogamau Formation mafic pillow lava with plagioclase glomerocrysts bordering a shear zone; **f)** strongly carbonated shear zone hosting a dyke and quartz veins in Obatogamau Formation lava.