Preliminary results from detailed geological mapping of the contact zone between metavolcanic and metasedimentary rocks in the Pontiac Subprovince, Lac Bellecombe area, Quebec

Adrian Rehm, Taus Jørgensen, Harold Gibson and Bruno Lafrance

Mineral Exploration Research Centre, Harquail School of Earth Sciences and Goodman School of Mines, Laurentian University, Sudbury, Ontario, P3E 2C6, Canada

INTRODUCTION

This report summarizes preliminary results from the first field season of a two year M.Sc. research project conducted by the first author. The research is part of Metal Earth, a large seven-year project headed by the Mineral Exploration Research Centre at the Harquail School of Earth Sciences in Sudbury, Ontario. The study area is located ~17 km south of Rouyn-Noranda, near Lac Bellecombe, Quebec, where mafic–ultramafic metavolcanic rocks occur within metasedimentary rocks of the Pontiac Subprovince (Figure 1).

Mafic and ultramafic metavolcanic rocks occur as a narrow (50–1000 m) but laterally extensive (10–25 km) east-northeast-trending belt within metasedimentary rocks of the Pontiac Subprovince, south of Rouyn-Noranda. The objective of the research is to determine whether emplacement of the metavolcanic rocks into the Pontiac metasedimentary rocks occurred during deformation or during deposition of the metasedimentary succession. A secondary goal is to characterize the metavolcanic succession, its stratigraphy and deformation history. Previous work elsewhere in the Pontiac Subprovince interpreted the contact between the mafic–ultramafic metavolcanic and metasedimentary rocks as structural (Camiré et al., 1993; Camiré and Burg, 1993). This interpretation was based on sheared contacts between metasedimentary rocks and mafic–ultramafic metavolcanic rocks (Camiré and Burg, 1993), and the uncontaminated rare-earth element pattern of the metavolcanic rocks (Camiré et al., 1993).

Fieldwork involved 1:2000 scale mapping of the metavolcanic succession and surrounding metasedimentary rocks, and 1:100 grid mapping of outcrops located at or near the contact between the metasedimentary and metavolcanic rocks. Samples of the different rock types were collected for petrographic and lithogeochemical analysis. Samples collected for geochronology were obtained from a tonalitic dyke that crosscuts bedding to help constrain the age of deformation events and of undisturbed Pontiac metasedimentary rocks. The metavolcanic and metasedimentary rocks have been regionally metamorphosed from upper-greenschist to upper-amphibolite facies; however, the 'meta'- prefix has been omitted to improve the readability of the text.

GEOLOGICAL SETTING

The Pontiac Subprovince is an Archean successor basin dominated by a thick, metamorphosed, turbiditic greywacke succession, with intruding felsic–intermediate plutons and thin, discontinuous ultramafic bodies (Davis, 2002). It is situated at the southern margin of the Superior Province, south of the Abitibi greenstone belt and north of the Grenville Province. The turbidite successions of the Pontiac

Subprovince are thought to have been deposited ca. 2682 Ma (Mortensen and Card, 1993; Davis, 2002; Frieman et al., 2017), after the similar Porcupine assemblage (in Ontario), but before the Timiskaming assemblage of the Abitibi Subprovince (Mortensen and Card, 1993; Davis, 2002). The metamorphic grade is lower- to medium-amphibolite facies at the northern contact with the Abitibi greenstone belt and increases to upper-amphibolite facies to the south, near the Lac Decelles plutonic complex (Davis, 2002).

The depositional age of the Pontiac metasedimentary rocks is constrained by U-Pb detrital zircon ages and magmatic U-Pb zircon ages from crosscutting intrusive bodies. The oldest U-Pb detrital zircon ages obtained were ca. 2750 Ma and the youngest, 2682 Ma. The metasedimentary rocks are cut by the 2682 ±1 Ma Lac Fournière pluton (Davis, 2002; Frieman et al. 2017), the 2679–2676 Ma Sladen intrusion (Helt et al., 2014) and the 2668–2663 Ma Decelles batholith (Mortensen and Card, 1993).

Current tectonic models propose that the Pontiac Subprovince likely formed as a foreland basin or accretionary prism due to subduction-like processes (e.g., White et al., 2003; Frieman et al., 2017) or as a result of transient erosion during underplating, followed by orogenic collapse (e.g., Calvert, et al., 2004; Bédard and Harris, 2014). Another model suggests that the Pontiac Subprovince is an unrelated block that was tectonically juxtaposed (Card, 1990; Feng and Kerrich, 1992).

A mafic–ultramafic volcanic belt, which is the focus of this research, is well-defined on aeromagnetic maps, on which it is seen to extend for 10–25 km. The volcanic package is a thin, discontinuous and deformed body that consists of pillow flows, massive flows, ultramafic flows and ultramafic–mafic sills and dykes.

METASEDIMENTARY ROCKS

In the Lac Bellecombe area, the major sedimentary lithofacies is a fine- to medium-grained turbidite with muddy sandstone and mudstone layers that are part of the Pontiac group. A second minor sedimentary and/or volcaniclastic rock type is found near the contact zone with the volcanic rocks.

In the turbidites, small (<2 mm) garnet and/or staurolite porphyroblasts are concentrated in the silt-rich layers. The strike of the bedding is generally northeast trending and dip angles range from 70 to 90°. Graded bedding in this unit is poorly developed, making it difficult to determine younging direction. Figure 2a shows some of the best examples of graded bedding observed in the area.

At least two foliation generations appear to be present in the turbidites. The first generation (S_1) is a bedding-parallel foliation defined by compositional layering and biotite alignment. The second generation (S_2), defined by biotite alignment, is at an angle to the bedding and appears to be axial planar to F_2, which is shown locally by outcrop-scale, tight to isoclinal folding of the sedimentary package. North of the volcanic package, S_2 is generally clockwise to bedding (Figure 2b), but occurs on some outcrops in the south counterclockwise to bedding.

The secondary sedimentary lithofacies is a discontinuous volcaniclastic unit that occurs in the sedimentary succession near the southern margin of the volcanic package. It is a composed of fine-grained mafic minerals, and bands (5–10 mm) of pyrite and disseminated cubic pyrite (1–5 mm). The unit is weakly magnetic.

METAVOLCANIC ROCKS

In the map area, the mafic–ultramafic volcanic belt is on average 500 m wide and is centred on Lac Bellecombe. Although the lack of facing directions precludes stratigraphic subdivision, the volcanic belt is divisible into predominately basaltic northern and southern margins, and an interior of predominately ultramafic rocks. The basaltic margins consist of massive and pillowed flows, whereas the centre contains spinifex-textured ultramafic flows. The basaltic rocks are fine grained to aphanitic, and consist of amphibole and plagioclase. Large (2–8 mm) euhedral garnet porphyroblasts are abundant in basaltic rocks on the northern side of the lake but are uncommon to the south. Based on the flattening of pillows (Figure 2c), deformation appears to be stronger within basaltic rocks along the northern margin, near the contact with enclosing metasedimentary rocks. The ultramafic rocks are moderately to strongly magnetic, and are altered to chlorite, talc, calcite and possibly serpentine.

The volcanic rocks are intruded by gabbroic, monzogabbroic and monzodioritic sills that contain coarse-grained, bladed amphibole (and/or pyroxene) and tabular feldspar. The intrusions are laterally extensive and roughly parallel to foliation. At the margins, they are strongly deformed, otherwise they show almost no strain. These sills are thicker and coarser than all other intrusive units observed in the mapping area.

The contact between the basaltic volcanic and metasedimentary rocks was not observed; however, a northern contact zone is defined based on abundant mafic sills and dykes (Figure 3).

MAFIC SILLS, DYKES AND BRECCIAS OF THE CONTACT ZONE

Exposures of sedimentary rocks along the northern contact of the metavolcanic rocks contain abundant, fine- to medium-grained mafic sills and dykes that are typically <1 m wide. The nature of the contact between sills and sedimentary rocks can be divided into four types: 1) straight and sharp contacts with sill margins locally showing chilled margins (Figure 2d); 2) fairly straight and sharp contacts with in situ brecciation of the sill margins, where the clasts show no rotation and form a jigsaw texture, presumably with sedimentary rock material composing the breccia matrix; 3) similar to 2) but where clasts from intrusions are rotated and surrounded by sedimentary rock; and 4) irregular contacts and locally ‘ghost-like’ appearance of the sills, where intrusion clasts are completely isolated in the sedimentary rocks and show amoeboid and wispy textures (Figure 2e). Sedimentary rocks in contact with the intrusions are generally massive, lack bedding and garnet porphyroblasts, and show a rusty colouration. Notably, the mafic intrusive and sedimentary rocks in the contact zone show no evidence of strain aside from the regional foliations.

Further north (10–30 m) of the contact between the volcanic and sedimentary rocks, several generations of centimetre-scale lamprophyre, tonalitic dykes, and gabbroic dykes and sills intrude, and are folded within, the Pontiac sedimentary rocks. In particular, one outcrop shows the crosscutting relationship of at least five different intrusions, most of which are folded and/or boudinaged within the sedimentary rocks (Figure 4). The abundance of sills and dykes decreases abruptly to the north, away from the contact zone.

DISCUSSION AND FUTURE WORK

The irregular, in situ brecciated contacts and brecciated margins of the mafic intrusions within the contact zone are consistent with peperite, a rock produced through the interaction of magma with wet, unconsolidated sedimentary rocks. The occurrence of peperite is restricted to intrusions and sedimentary rocks within metres of the volcanic rocks and indicates that the intrusions were emplaced during Pontiac sedimentation. The crosscutting relationship between intrusions and the variable contacts displayed by the intrusions, where intrusions with irregular and brecciated margins (e.g., Figure 2f) are interpreted as older and those with sharp, chilled margins as more recent, indicate multiple stages of dyke-sill emplacement and the formation of multigenerational peperite along the contact zone (e.g., Houlé et al., 2008).

The synsedimentary intrusions in the Pontiac Subprovince indicate a younger episode of mafic volcanism than that previously recognized in Ayer et al. (2005) for the Abitibi Subprovince. The localization of magmatism to the margins of a thin linear belt of mafic and ultramafic volcanic rocks suggests the presence of a deep, mantle-penetrating, northeast-trending structure during Pontiac sedimentation, some 20 km south of the Cadillac–Larder Lake break. The volcanic rocks may be related to the intrusions and localized along this structure; however, the relationship between the synsedimentary intrusions and the immediately adjacent volcanic rocks needs to be established. This will require additional focused mapping to establish field and contact relationships, and geochemical analysis to ascertain whether the mafic dyke and sill complex is genetically related to the mafic–ultramafic volcanic package.

In addition, a better understanding of the structure of the metavolcanic package and the surrounding metasedimentary rocks is also required. Peperite is observed at both the northern and southern contacts with the mafic volcanic rocks, and the ultramafic rocks are located at the centre of the package. Therefore, it is possible that the ultramafic rocks form the core of an anticline. Next field season will focus on further constraining the younging direction in the metasedimentary and metavolcanic rocks, establishing the relationship between the axial planar cleavage and bedding, and finding an unequivocal contact between the volcanic and sedimentary rocks.

The pyrite-rich sedimentary and/or volcaniclastic unit found in the contact zone may be a significant marker horizon. At this point, it has been grouped with the volcanic package, but it will be important to compare this rock type to the Pontiac group turbidites to see if they are related and have a similar provenance. Detrital zircon work on these rocks may be something to explore in the future. Another priority will be to determine whether there is a conformable contact or a sharp, structural contact between the turbiditic and volcanoclastic units.

Before the start of next field season, work will be done to study and gain a broad understanding of the lithogeochemistry of the various mafic and ultramafic rocks to see how they relate compositionally to one another, and of the published data for similar rocks elsewhere in the Pontiac Subprovince. Other tasks include petrography on the main rock types, geochronology of the intermediate–felsic intrusions and detrital zircon work on the sedimentary units.

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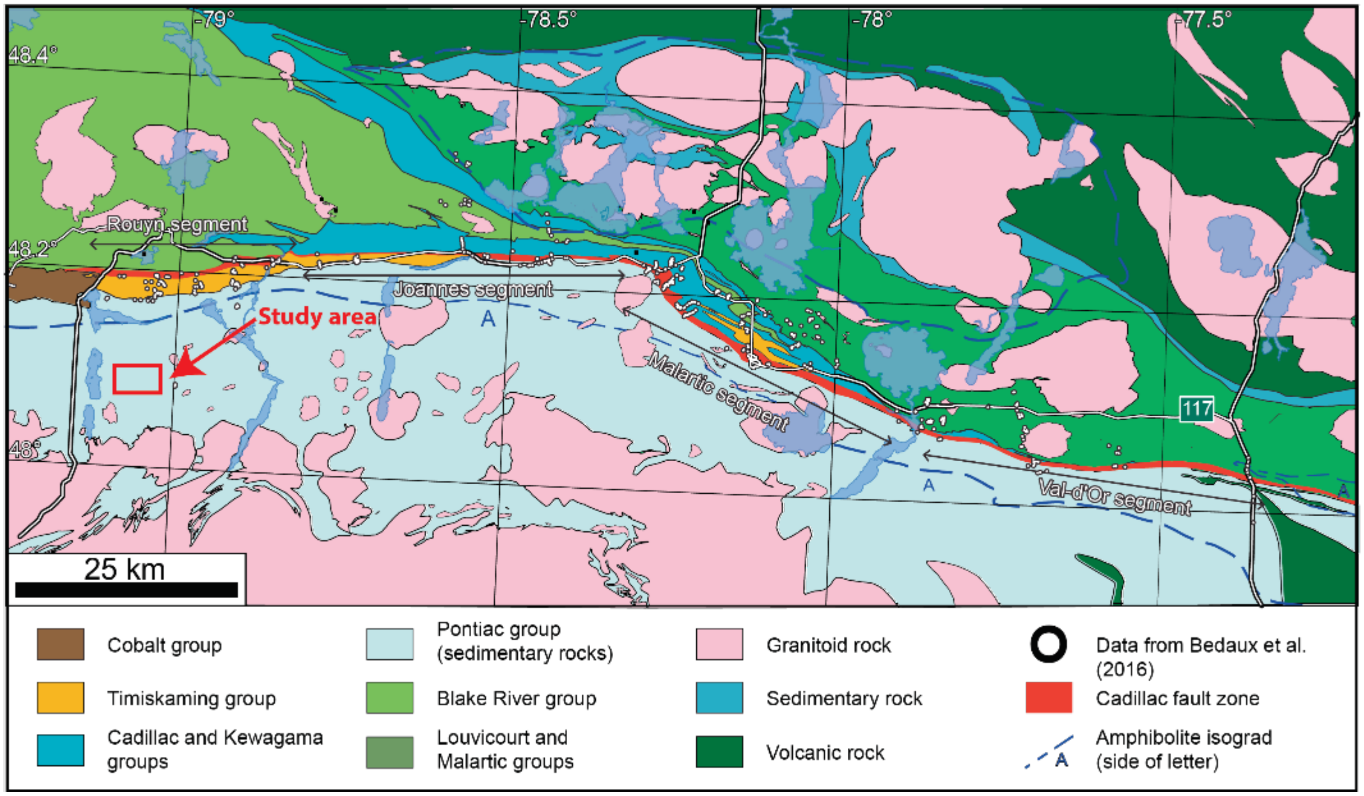

Figure 1. Geology of a segment of the Cadillac–Larder Lake deformation zone from Rouyn-Noranda to Val-d'Or, outlining the study area (modified from Bedeaux et al., 2016).

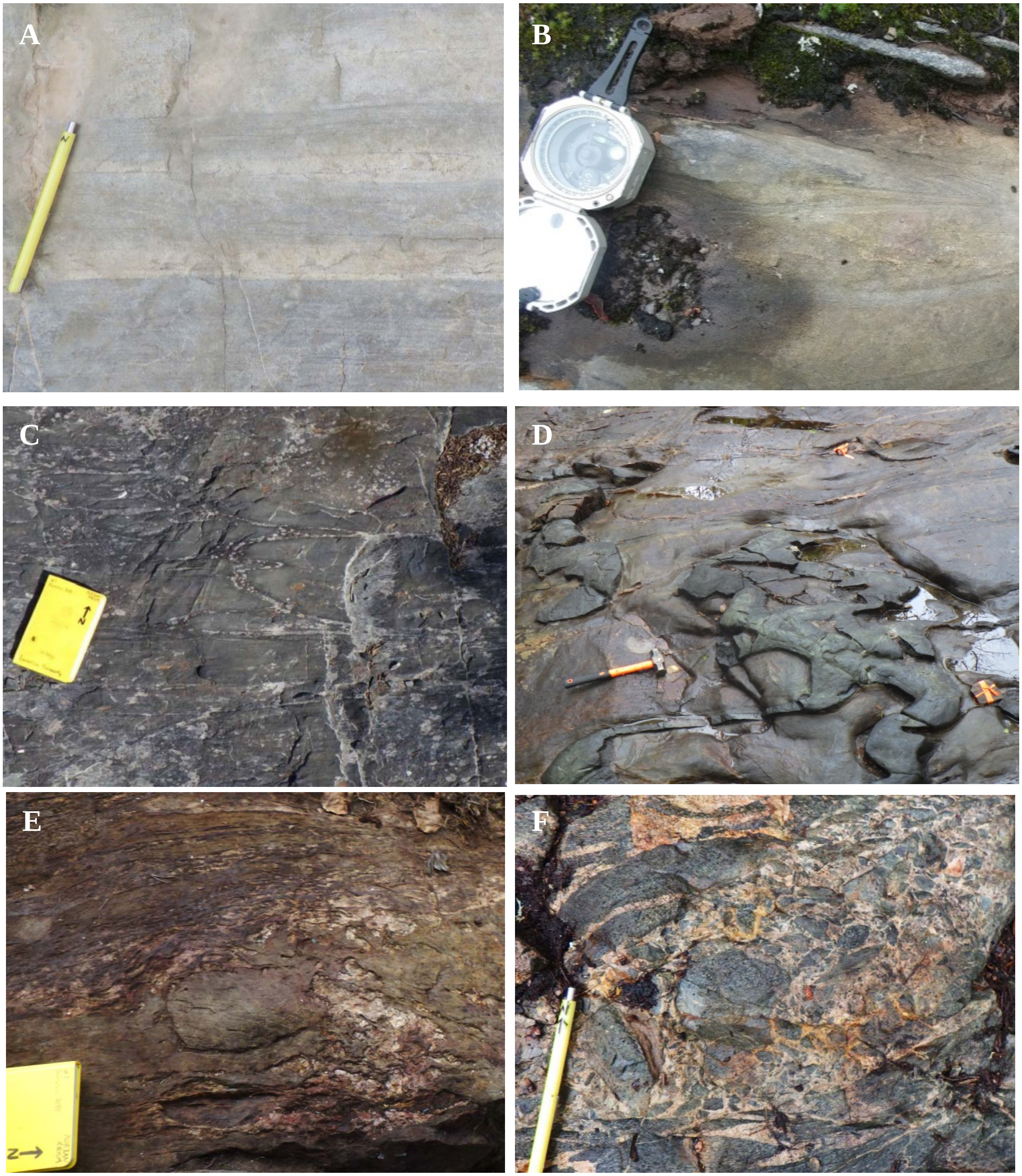

Figure 2. Field photographs from the Lac Bellecombe area, Quebec, showing **a)** graded bedding in turbidite (north younging); **b)** isoclinally folded bedding in turbidite; **c)** stretched pillows in metabasalt; **d)** an irregularly folded mafic dyke in sedimentary rock; **e)** fluidal peperite showing ‘ghost-like’ texture; **f)** strongly brecciated peperitic sill fragments in a metasedimentary matrix occurring in the contact zone between volcanic and sedimentary units.

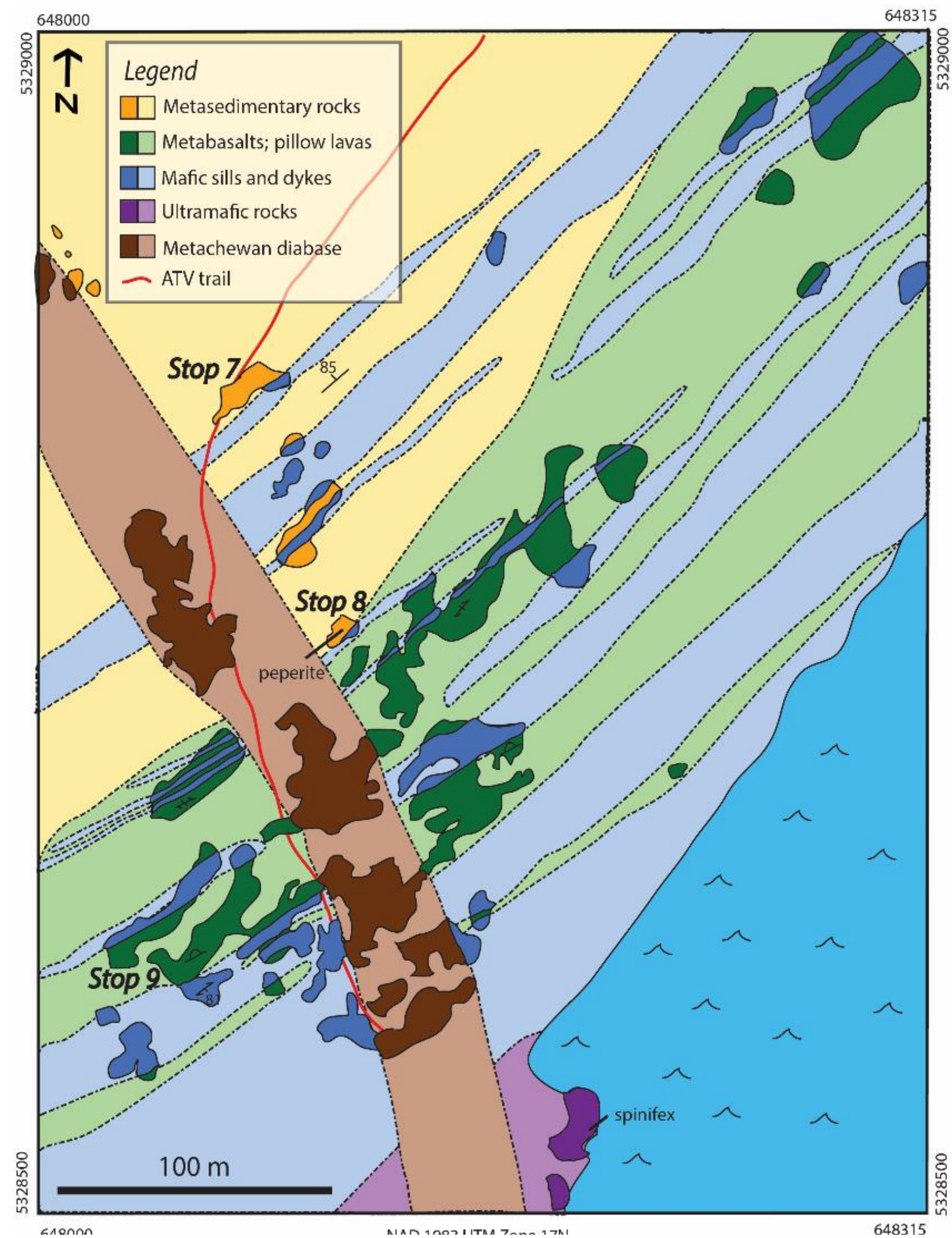

Figure 3. Geology of the northern contact area between the volcanic stratigraphy and the metasedimentary rocks of the Pontiac group in the Lac Bellecombe area, Quebec.

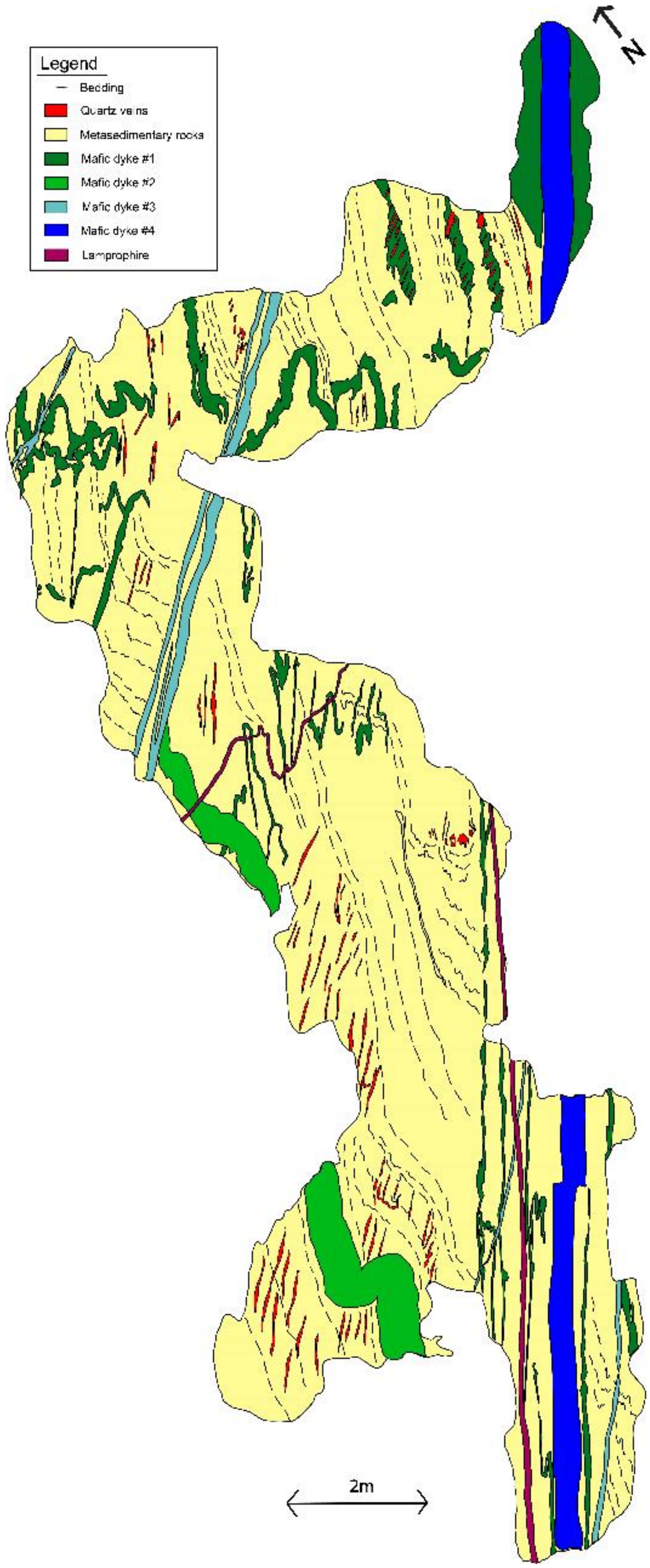

Figure 4. Detailed grid mapping in the Lac Bellecombe area, Quebec, of the different generations of folded mafic dykes and bedding near the contact zone.