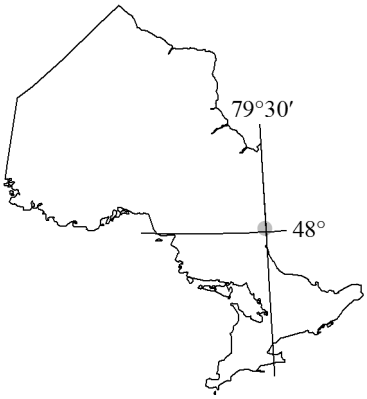
41. Regional and Detailed Structural Mapping of the Timiskaming Assemblage–Larder Lake Group Contact Between the Kerr–Addison and Cheminis Mine Sites, Northeastern Ontario



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INTRODUCTION

This paper summarizes the results of the second summer of field work related to the senior author's MSc thesis. The main objectives of the field season focussed on regional to detailed structural mapping of the Timiskaming group–Larder Lake group contact between the Kerr–Addison and Cheminis mine sites located in northeastern Ontario, along Highway 66. The study area lies within the southern Abitibi Subprovince of the Superior Province, along the Larder–Cadillac deformation zone (LCDZ). This work is part of the multi-year multi-disciplinary Metal Earth project carried out by Mineral Exploration Research Centre (MERC) at Laurentian University, Sudbury.

The LCDZ is a 250 km long linear structural feature which extends from Matachewan, Ontario, to Val d'Or, Quebec. In Quebec, it separates the Abitibi Subprovince from the Pontiac Subprovince, whereas, in Ontario, it lies entirely within the Abitibi Subprovince and is the main control on the distribution of gold deposits. In the Larder Lake area, the LCDZ is defined as the northern contact between sedimentary rocks of the Timiskaming assemblage (*circa* 2679–2669 Ma: Ayer et al. 2005) and volcanic rocks of the Larder Lake group (*circa* 2705 Ma, 2710–2704 Ma: Ayer et al. 2005). Bedding (S_0) is expressed in the volcanic rocks by primary layering and pillow basalts, but fabrics related to early regional folding of the volcanic rocks (D_1 deformation event) are not observed. A well-recognized structural paragenesis has been established by multiple authors outlining the structural history of the LCDZ from D_2 through D_4 (Wilkinson, Cruden and Krogh 1999 and references therein), but contact and/or structural relationships earlier than the D_2 event are unclear. The senior author's thesis sets out to characterize the contact between these 2 assemblages in order to understand their primary relationship.

REGIONAL GEOLOGY

The southern Abitibi Subprovince is a metavolcanic belt composed of 6 major volcanic assemblages, including from oldest to youngest: Pacaud (2750–2735 Ma), Deloro (2730–2724 Ma), Stoughton–Roquemaure (2723–2720 Ma), Kidd–Munro (2719–2711 Ma), Tisdale (2710–2704 Ma) and the Blake River (2704–2696 Ma) (Ayer et al. 2005). These volcanic assemblages were intruded by calc-alkalic to alkalic composite stocks, which were contemporaneous with the deposition of the 2 successor basins in the area. These successor basins are a Timiskaming-type clastic-dominated basin (2679–2669 Ma) and a

Summary of Field Work and Other Activities, 2018,
Ontario Geological Survey, Open File Report 6350, p.41-1 to 41-8.

Porcupine-type turbidite-dominated basin (2690–2685 Ma). The regional significance of these basins is their spatial association with the major trans-lithospheric crustal structures, notably the LCDZ and the Porcupine–Destor deformation zone (PDDZ) (Frieman et al. 2017).

The relationship between the older Blake River group and the younger Timiskaming assemblage sediments is an angular unconformity (Wilson 1956, 1962; Thomson 1943; Poulsen 2017). Whereas the Larder Lake group, equivalent of the Tisdale assemblage, is interpreted as fault-bounded segments or slivers from deeper portions of the crust which have been structurally juxtaposed against the Timiskaming assemblage sedimentary rocks (Bedeaux et al. 2018, and references therein). The Timiskaming assemblage sedimentary rock, which range from marine facies to alluvial–fluvial facies, represents an important marker unit because its distribution defines the LCDZ. This spatial association has been interpreted as local sedimentation in an isolated basin associated with the fault zone, either as an extensional (Dimroth et al. 1982) or as a piggyback basin (Diop 2011; Bedeaux et al. 2018) on the margins of the LCDZ. Subsequent alteration and development of the LCDZ has obscured the contact between the Timiskaming assemblage and the Larder Lake group, as strain typically increases toward this contact. The extensive history of deformation and alteration are considered to be key components in the formation of gold deposits along the LCDZ, because it is 1 of the 2 economically well-endowed structures in the Abitibi Subprovince, and in the Superior Province as a whole.

LOCAL GEOLOGY

The study area consists of 4 locations along the LCDZ where the contact between the Timiskaming assemblage sediments and the Larder Lake group is well exposed (Figure 41.1). These locations are in the south-central portion of McGarry and McVittie townships, between the communities of Larder Lake and Kearns in northeastern Ontario, approximately 40 km west of Rouyn-Noranda, Quebec.

The 2 dominant lithologies that characterize the study area are sedimentary rocks of the Timiskaming assemblage and volcanic rocks of the Larder Lake group. The Timiskaming assemblage comprises mainly fine-grained marine turbidite sedimentary units, typically sandstone to mudstone. These are clastic sediments that are interpreted to have been deposited in a deep marine setting. Less commonly observed in the area are conglomerates, which are a polymict, poorly sorted and well-rounded, cobble- to pebble-dominated facies representing a proximal deltaic depositional environment. The Larder Lake group consists of ultramafic and mafic volcanic rocks, which are overlain to the southeast by sedimentary rocks of the Huronian Supergroup. Ultramafic komatiite flows are generally homogeneous, locally showing spinifex texture. In contrast, the mafic volcanic units show a much higher degree of variation in texture and lithofacies. Mafic units include variolitic, pillowed and autobrecciated flows with minor interflow sedimentary units, such as graphitic mafic mudstone. The mafic and ultramafic flows are intercalated, yet the contacts between the 2 flow types are commonly faulted or sheared; thus, their stratigraphic relationship remains unclear. However, younging directions from pillows indicate tops-to-the-south away from the main ultramafic package, suggesting that, in general, they overlie the ultramafic flows.

The same volcanic stratigraphy, although a thinner panel, is observed at Bear Lake and on the Cheminis Mine site. At these localities, both in McVittie Township, the Larder Lake group is bounded to the north and the south by Timiskaming assemblage marine turbidites. At the Cheminis Mine site, both the northern and southern contacts between the 2 assemblages were exposed during the 2018 summer field season.

Mapping for the present study focussed on the newly exposed outcrops of the contact and of structural complexities within the surrounding Timiskaming assemblage sedimentary rocks. Supplementary core logging at the Cheminis Mine site was completed to support field observations.

FIELD WORK AND OBSERVATIONS

Cheminis

Detailed geologic mapping was conducted on the Cheminis Mine site, approximately 10 km west of the Virginiatown outcrops described below. At this locality, the north and south contacts between the Timiskaming assemblage sedimentary rocks and the Larder Lake group were exposed and mapped. Field mapping was supplemented with observations from drill-hole cores that intersect these contacts.

At the north contact, which typically defines the location of the LCDZ, a fine-grained siltstone is in gradational contact with a volcanic flow of the Larder Lake group. The volcanic flow is strongly carbonatized and shows no primary textures. At the contact between the 2 rock units is a fragmental unit, termed “transition zone”, which has a sedimentary matrix with rounded to subrounded carbonatized fragments (Photos 41.1A, 41.1B and 41.1C). These fragments or clasts are interpreted as eroded Larder Lake group because the composition of the fragments clearly differs from that of the matrix and is similar to the adjacent volcanic flow. The abundance of these fragments gradually decrease to the north away from the contact.

Drilling across this contact intersected the fragmental unit between the volcanic flow and Timiskaming assemblage rocks. Graded bedding suggests that the sedimentary rocks young to the north away from the volcanic flow (Photo 41.1D). However, within 10 to 15 m from the contact, the younging reverses to the south, indicating tight isoclinal folding in the sediments parallel to the contact.

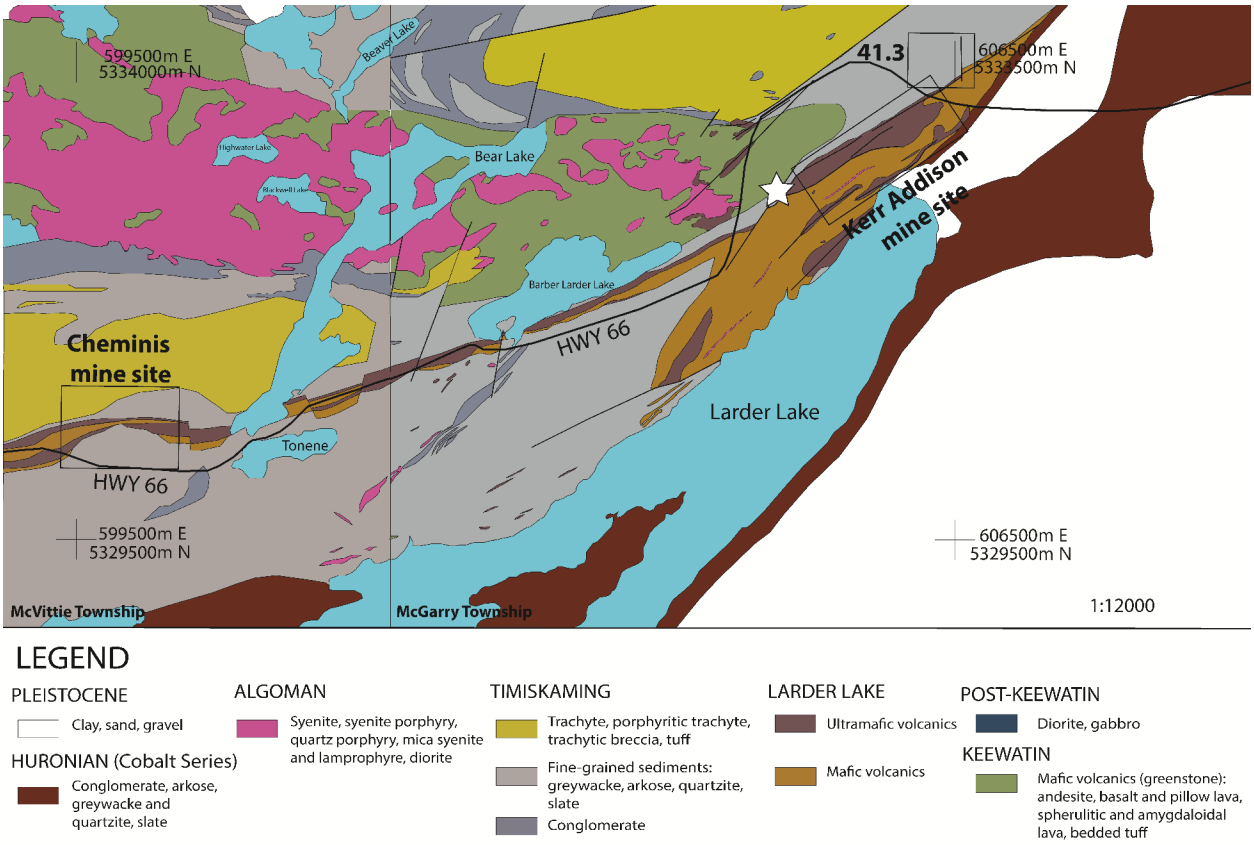

Figure 41.1. Geology and location of the study area (*adapted from* Thomson 1941a, 1941b, 1941c). Outlined in black are the specific study areas, including the area shown in Figure 41.3. A white star indicates the location of the Virginiatown outcrop shown in Figure 41.2. Universal Transverse Mercator (UTM) co-ordinates provided using North American Datum 1983 (NAD83) in Zone 17N.

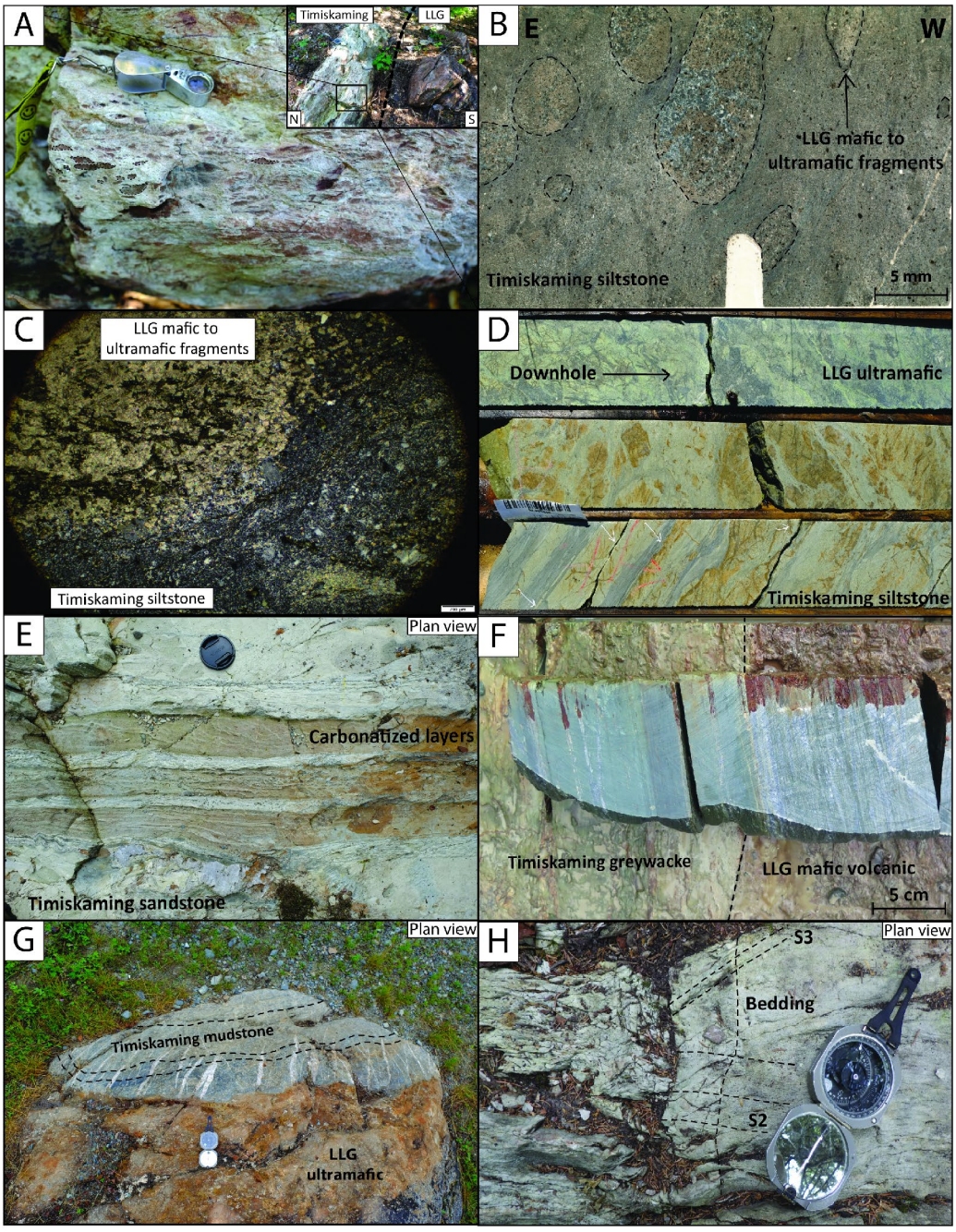

Photo 41.1. **A**) Carbonatized, rounded to subrounded fragments in Timiskaming assemblage sedimentary matrix marking the transition zone between Timiskaming assemblage and Larder Lake group ("LLG") at Cheminis. Fragments are outlined by dashed lines. Looking north, hand lens for scale. **B**) Thin section scan of fragmental unit at the Timiskaming assemblage–Larder Lake group contact. Rounded mafic to mafic fragments are outlined in dashed lines, composed primarily of chlorite-carbonate-quartz-albite. **C**) Photomicrograph of fragmental unit at the Timiskaming assemblage–Larder Lake group contact. Rounded mafic to ultramafic fragments within quartz- and sericite-rich siltstone matrix. **D**) Core from drill-hole GF-12-125, through the northern contact between Larder Lake group ultramafic flow (fuchsite altered) and Timiskaming assemblage sediments. Note the fragmental unit at the contact and graded beds younging downhole (to the north, away from ultramafic flow). Diameter of drill core is NQ (47.6 mm diameter). **E**) Bedding-parallel, strongly carbonatized layers alternating with sedimentary layers at Cheminis. Lens cap for scale. **F**) Southern contact between Larder Lake group volcanic rocks and Timiskaming assemblage sediments at Cheminis. Plan view. **G**) Timiskaming assemblage–Larder Lake group in sharp contact with perpendicular extensional quartz-carbonate veins in Virginiatown. Bedding form lines as dashed lines. **H**) Timiskaming assemblage sedimentary rocks north of Kearns. The S_2 fracture cleavage is axial planar to open fold planes defined by bedding. The S_3 fracture cleavage cuts across the F_2 fold.

Evidence observed at the north contact suggests that the contact relationship between the Timiskaming assemblage and the Larder Lake group is an unconformity. The contact is gradational with an agglomerate fragmental unit, containing mafic to ultramafic detritus, between the 2 assemblages and there is a lack of a major structure or shear zone. Consistent graded beds in the northern and southern sedimentary packages indicate that the sediments are overlying the mafic to ultramafic rocks.

At the south contact, a very fine-grained Timiskaming assemblage greywacke is in sharp contact with intercalated mafic to ultramafic volcanic flows to the north. The greywacke is green to grey with consistent graded beds, younging to the south, away from the Larder Lake group volcanic rocks. Locally, the sediments contain bedding parallel layers of strongly carbonatized material that appears to be mafic layers (Photo 41.1E). Geochemical samples were collected to determine the composition of these layers. The mafic and ultramafic rocks, bounded between sedimentary rocks of the Timiskaming assemblage, lack primary textures and have been strongly carbonatized. Locally, variolitic and pillowed textures are observed in the mafic volcanic flows.

The contact between the 2 assemblages varies from sharp (Photo 41.1F), with no obvious structure or shear sense indicators, to moderately strained, with sheared and attenuated beds proximal to the contact. A pervasive chloritic and sericitic S_2 foliation strikes east-northeast and is steeply dipping to the south. The S_2 foliation is generally subparallel to lithologic contacts. A weak to moderate chloritic and sericitic S_3 foliation strikes northeast, anticlockwise to bedding, and is steeply dipping. The S_2 foliation is sinistrally offset along the S_3 foliation.

A notable structural feature, consistent with previous mapping at Cheminis (Lafrance 2015), is the relationship of S_2 and S_3 foliations with respect to bedding. North of the Larder Lake group volcanic rocks, S_2 foliation is oriented clockwise, whereas S_3 foliation is anticlockwise, with respect to bedding. South of the Larder Lake group, S_2 and S_3 foliations are typically oriented anticlockwise to bedding (Lafrance 2015) where beds young to the south.

Virginiatown

A newly mapped outcrop in Virginiatown, in the school yard of École Saint-Louis on old Highway 66, displays the contact between Timiskaming assemblage sedimentary rocks and ultramafic volcanic rocks of the Larder Lake group. The Timiskaming assemblage mudstone to sandstone is in sharp contact with strongly carbonatized ultramafic volcanic rocks (Figure 41.2). Graded beds are parallel to the contact and young to the southeast into the ultramafic rocks. The contact has been folded by F_2 folds with an axial planar east-northeast-striking S_2 foliation. These folds are refolded by F_3 folds with an axial planar S_3 fracture cleavage. The S_2 foliation is oriented clockwise to bedding, whereas the S_3 foliation is oriented anticlockwise to bedding, which is consistent with regional mapping relationships. Extensional quartz-carbonate veins cross the Timiskaming assemblage sedimentary rocks and end abruptly at the contact with the ultramafic rocks (Photo 41.1G). These veins are interpreted to be older than or coeval with the D_2 deformation structures because they follow the contour of the F_2 folded contact and have locally been offset by the S_3 fabric.

The contact between the Timiskaming assemblage sedimentary rocks and ultramafic rocks of the Larder Lake group have been folded by F_2 folds, indicating that these rocks had been juxtaposed together prior to the D_2 deformation event. There is no obvious structure or breccia at the contact; however, the younging directions in the sediments are not consistent with an unconformity.

Kearns

North of the town of Kearns, located along Highway 66, are fine-grained, marine-facies Timiskaming assemblage sedimentary rocks in contact with ultramafic to mafic volcanic rocks of the Larder Lake group. The Timiskaming assemblage sedimentary rocks are open to tightly folded, with a northeast-trending axial plane, parallel to the northern contact with the Larder Lake group, which is highly strained (Figure 41.3); the true thickness of the Timiskaming assemblage units is difficult to ascertain because of the complex folding and structural thickening. The sediments vary from medium-grained sandstone to mudstone and typically display consistently graded beds. A thin (20–40 m) ultramafic unit is directly in contact with the Timiskaming assemblage sedimentary rocks to the north and is bordered by the Larder Lake group mafic volcanic rocks to the south.

Detailed mapping revealed several key features. Bedding orientations and younging directions define a large-scale anticline with a northeast-trending axial plane (*see* Figure 41.3). The fold becomes tighter to the east and the number of parasitic folds increases with axial planes parallel to the LCDZ (*see* Figure 41.3). An east-northeast-striking fracture cleavage (S_2) is axial planar to these folds and is overprinted by a northeast-striking, spaced S_3 fracture cleavage (Photo 41.1H). The axial plane of these folds is parallel to the contact with the Larder Lake group, which is highly strained and locally mylonitic. The contact

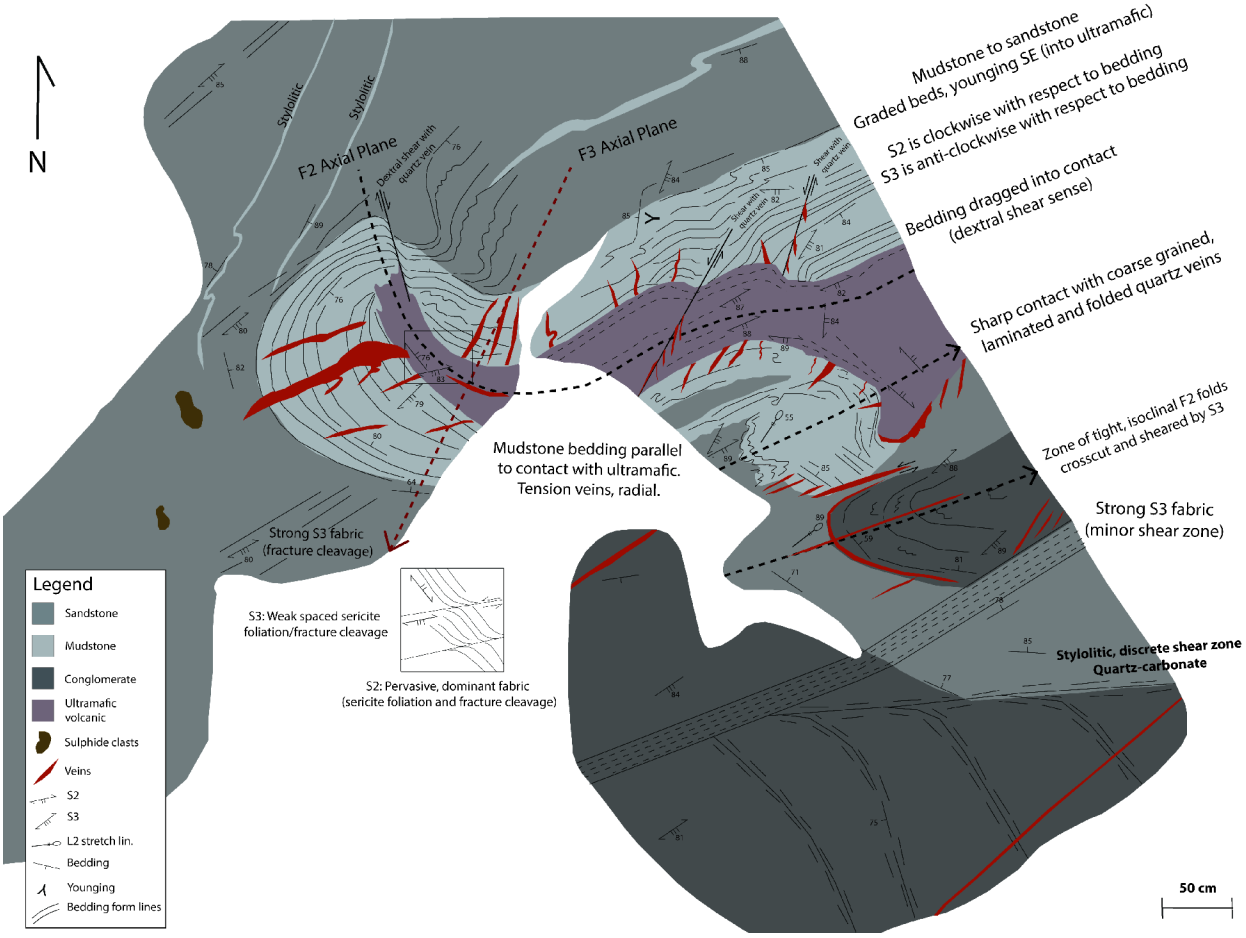

Figure 41.2. Detailed map of Timiskaming assemblage–Larder Lake group contact in Virginiatown. The contact between the 2 assemblages is sharp with no evidence of major faulting. Bedding in the sediments is parallel to the contact, which has been folded by both F_2 and F_3 folds. This outcrop is located at UTM 604947E 5332145N, NAD83, Zone 17N.

between the sediments and the ultramafic rocks has been tightly folded by F_2 folds and is likely transposed from its original orientation into parallelism with the fold limbs. This suggests that the contact relationship between the 2 assemblages predates the D_2 deformation event.

RELEVANCE

The main results of the 2018 summer field work were the detailed mapping and characterization of the Timiskaming assemblage–Larder Lake group contact at different locations along the LCDZ. The contact becomes gradually less strained toward the west, making the Cheminis Mine site an ideal locality to observe less-strained primary relationships between the 2 assemblages. The gradational contact between the 2 assemblages at Cheminis, the lack of major shear zones or structures at the contact and the consistent younging directions away from the volcanic rocks are strong evidence for an unconformable contact. Thin sections of the transition zone will further aid in describing and defining this texture and in determining whether this is a primary sedimentary feature or fault breccia. Finally, the F_2 folded contact relationships between the Larder Lake group volcanic rocks and Timiskaming assemblage sedimentary rocks in both Kearns and Virginiatown suggest that the Timiskaming assemblage and Larder Lake group were juxtaposed prior to the D_2 deformation event.

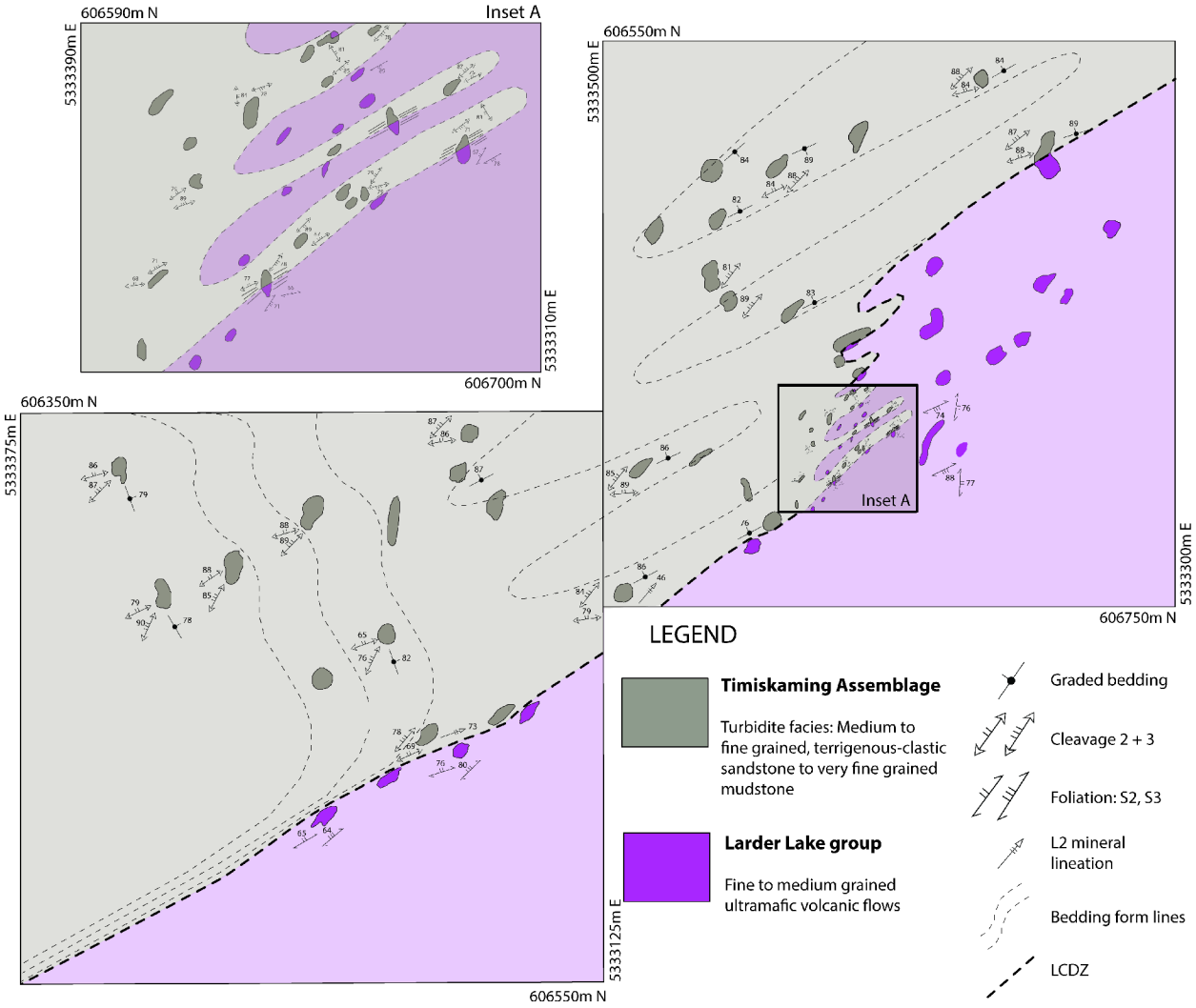

Figure 41.3. Detailed lithologic and structural map of the area north of Kearns (as indicated in Figure 41.1) showing the tightly folded Larder–Cadillac deformation zone (LCDZ) by F_2 folds. The UTM co-ordinates provided using NAD83 in Zone 17N.

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