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TABLE OF CONTENTS

Gold grains in till samples from the southern Core Zone, Quebec and Newfoundland and Labrador (NTS 23-P and 23-I): potential for new undiscovered mineralization

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ABSTRACT

This report presents the indicator mineral content of till samples (n=86) collected during the summer of 2016, in the southern sector of the Core Zone located within Woods Lake (NTS 23-I) and Lac Résolution (NTS 23-P) map areas, approximately 50 km east of Shefferville, Quebec. Of potential interest for mineral exploration in this region is the presence of gold grains (7 to 63 grains /10 kg) in 15 till samples principally collected over the Doublet Zone mafic volcanic rocks. One sample located over the Core Zone orthogneiss contains a noticeably large sand-sized gold grain, which is in contrast with the silt-sized gold particles in the other till samples. The source(s) of gold in the till is unknown. The 2016 till sampling survey was the third of three field seasons of reconnaissance-scale surficial mapping and till sampling in the south part of the Core Zone and was conducted as part of the GSC's Core Zone Surficial Activity (2014–2017) of the Geo-mapping for Energy and Minerals 2 (GEM 2) Program. Indicator mineral results for the 2014 and 2015 till samples, which were originally presented in McClenaghan et al. (2016) and Rice et al. (2017), are included for completeness.

INTRODUCTION

The southern Core Zone has a complex glacial history related to the buildup, migration, and demise of the Labrador sector of the Laurentide Ice Sheet (Dyke and Prest, 1987; Vincent, 1989). Bedrock mapping and mineral exploration in the region has been challenging, in part due to the glacial sediments of varying thickness that cover the region. Significant portions of northern Quebec and Labrador have neither surficial geology maps nor regional till geochemical and mineralogical data to aid in the evaluation of mineral potential or to support mineral exploration programs (Corrigan et al., 2015, 2016).

To address the paucity of geoscience knowledge within the area, the Geological Survey of Canada (GSC), as part of its Geo-mapping for Energy and Minerals 2 (GEM 2) program, in collaboration with the Ministére de l'Énergie et Ressources naturelles du Québec (MERNQ) and the Geological Survey of Newfoundland and Labrador (GSNL), is conducting new integrated regional mapping and surficial geochemical studies centred on the Archean "Core Zone" rocks between the Torngat Orogen to the east and New Quebec Orogen to the west (Wardle et al., 2002) (Figs. 1, 2). These surficial studies, coupled with bedrock work (Corrigan et al., 2015, 2016; Sanborn-Barrie et al., 2015) will produce new regional geoscience data that will increase geological understanding and support natural resource exploration and responsible resource development in the region.

This open file reports preliminary indicator mineral data for 86 till samples that were collected in the south Core Zone (NTS sheets 23-I and 23-P) during the 2016 summer field season. For data completeness, we have included the listings of till indicator mineral data from the 2014 (previously reported in McClenaghan et al., 2016) and 2015 (previously reported in Rice et al., 2017) sampling surveys. The data for all three years have been plotted on the accompanying mineral maps (Appendix C).

LOCATION AND ACCESS

Straddling the border between Quebec and Newfoundland and Labrador, the study area is located east of the town of Schefferville, Quebec, in the Lac Résolution (National Topographic System NTS 23-P) and Woods Lake (NTS 23-I) map sheets, between latitudes 52°N and 57°N and longitudes 57°W and 70°W. It spans the drainage divide that designates the provincial boundary between Quebec and Newfoundland and abrador, separating northern flow to Ungava Bay, and southern flow to the Labrador Sea. Due to the lack of transportation infrastructure, the remoteness, and the rugged terrain of the study area, field sites were only accessible via helicopter. Site selection was therefore limited to locations that allowed for safe helicopter

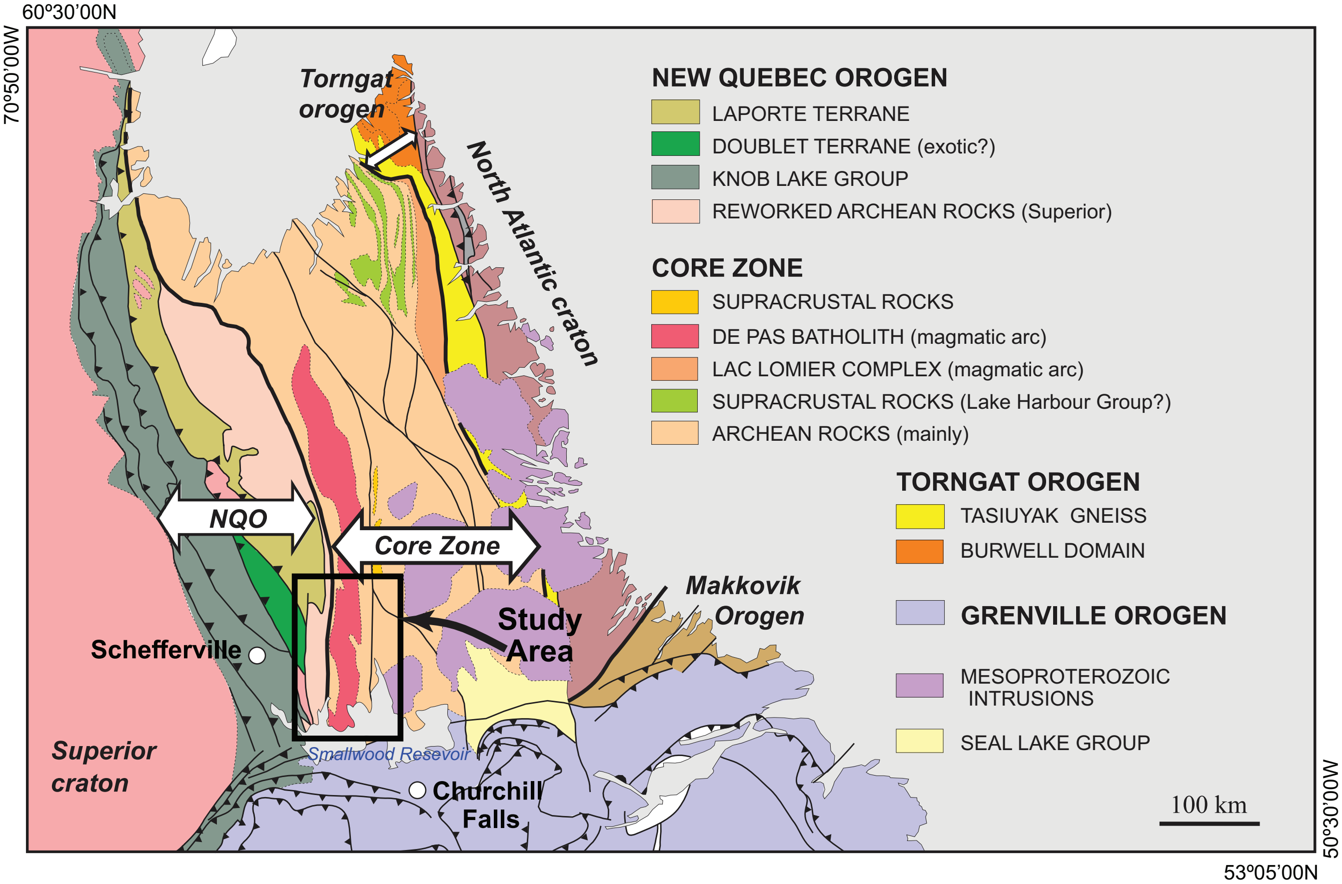

Figure 1. Simplified bedrock geology map of the Core Zone and bounding orogens in Quebec and Newfouldland and Labrador. The southern Core Zone surficial mapping areas (NTS 23-P and 23-I) are highlighted in black. Modified after James et al. (2003).

operation — treeless highlands, large bedrock outcrops, edges of wetlands, and open lake shorelines.

BEDROCK GEOLOGY

The southern Core Zone is located just east of the Schefferville iron-ore district. It is the southern extent of the 300 km long by 40 km wide Core Zone that extends south-southeast from Ungava Bay in the north to the Grenville Orogen in the south. The Core Zone, a Precambrian lithotectonic terrain at the eastern edge of Canadian Shield, is bounded to the west by lithologies associated with the New Quebec Orogen and to the east by the Torngat Orogen (Fig. 1). Two major shear zones transect the region, the dextral Lac Tudor shear zone and the dextral Rivière George Shear Zone (Sanborn-Barrie, 2016). The Core Zone is centred along the Archean cratonic Meta Incognita rocks, which are dominated by basement rocks of the Churchill Province that are overlain by Doublet Zone fine-grained mafic metavolcanic rocks in the north (Corrigan et al., 2015). The Smallwood Reservoir separates the Core Zone rocks from the Grenville Orogen rocks of southern Quebec and Newfoundland and Labrador.

The northern portion of the study area (NTS 23-P) is centred on the De Pas Batholith, a felsic plutonic lithology that divides the map sheet east to west and is topographically the highest bedrock unit in the northern map sheet, and a prominent topographic feature in the south. The geology in the study is dominated by the De Pas Batholith, a felsic granitic unit characterized as a K-feldspar porphyritic monzogranite-granodiorite-syenogranite. The mineralogy changes across the batholith from more orthopyroxene-rich assemblages in the western half to more hornblende-biotite-rich in the eastern half (Sanborn-Barrie, 2016). A broad band of Archean orthogneiss flanks both the western and eastern margins of the De Pas Batholith (Fig. 2). In the western portion of the map sheet, Churchill Province basement rocks are overlain by fine-grained mafic metavolcanic rocks of the Doublet Zone in the south and metasedimentary rocks of the Laporte domain to the north. The Tudor Lake shear zone separates these domains along a general north-northwest/south-south-east vector (Corrigan et al., 2015; Sanborn-Barrie, 2016). East of the De Pas Batholith and associated eastern orthogneiss, the study area is underlain by supercrustal rock assemblages, including the Ntshuku,

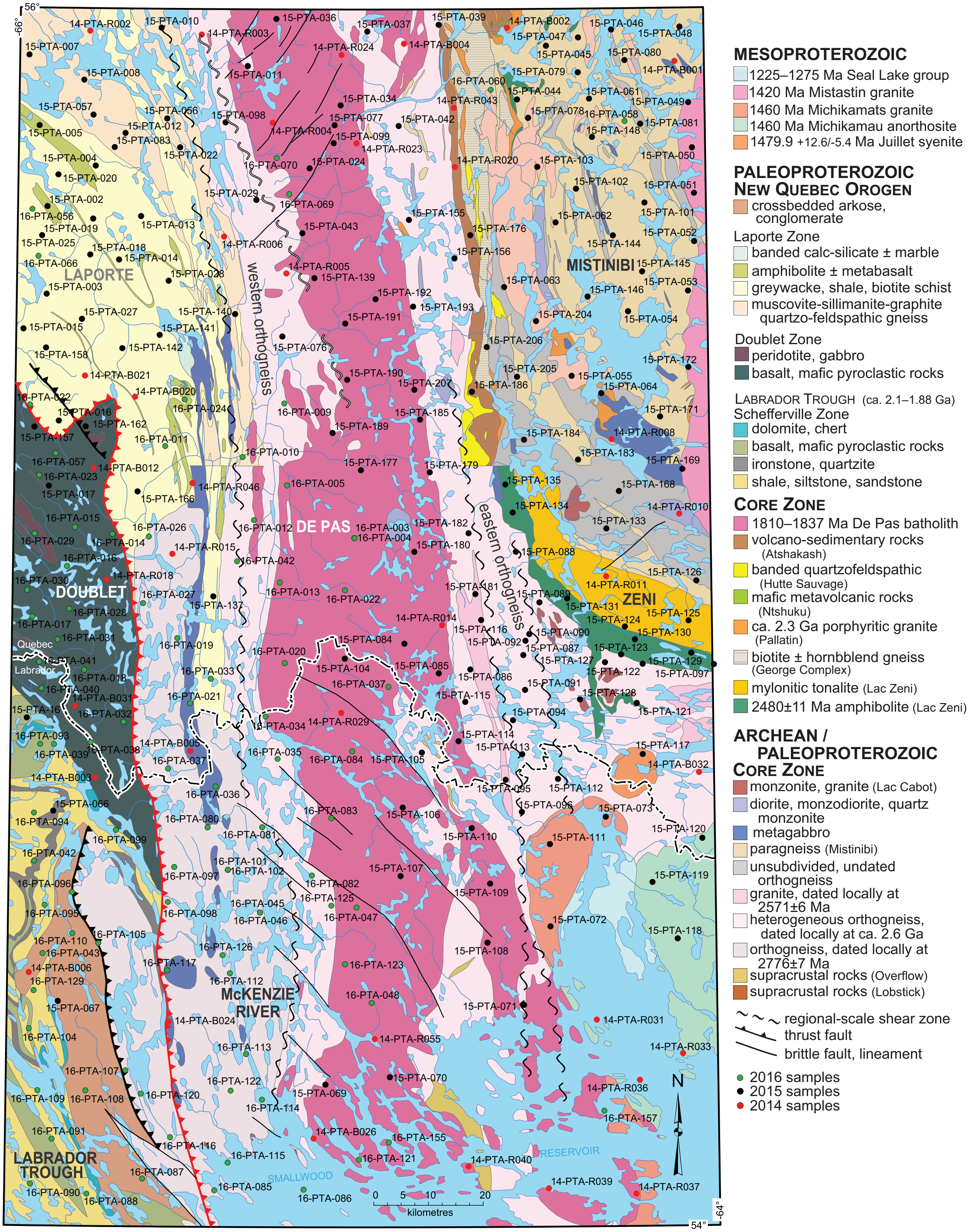

Figure 2. Locations of GSC till samples collected in 2014, 2015 and 2016 shown on the bedrock geology of the GEM 2 southern Core Zone project area (NTS 23-P and 23-I), highlighting crustal domains within the New Quebec Orogen and southern Core Zone (geology from Wardle et al. (1997) and Ministère de l'Énergie et des Ressources naturelles (2010)).

Atshakash, and Zeni assemblages (Girard, 1990; van der Leeden et al., 1990) that comprise interbedded graphitic schists, cherty quartz arenite, schistose metatuff, and metabasalt. To the southeast is the Mistinibi-Raude migmatite domain, which is distinguished by its high-grade magmatic character (van der Leeden et al., 1990).

In the southern part of the study area (NTS 23-I), as in the north, the De Pas Batholith and associated orthogneiss bisect the map sheet. The fine-grained mafic metavolcanic rocks of the Doublet Zone extend from NTS 23-P into the northwest portion of NTS 23-I, where they are bounded by lithologies associated with the Labrador Trough (Knob Lake Group) and the Kaniapiskau Supergroup (Wardle, 1982; Sanborn-Barrie, 2016). The south-central portion of the map sheet, just west of the De Pas Batholith on the northwestern shores of the Smallwood Reservoir, is characterized by semipelite, iron-rich metasedimentary, and mafic volcanic rocks of the Lobstick group. East of the De Pas Batholith on the northeastern shore of the Smallwood reservoir, Mesoproterozoic intrusions cut into the aforementioned Archean lithologies of the Core Zone. For a detailed summary of lithological assemblages and their lithotectonic significance and relationships see James et al. (1992) and Sanborn-Barrie (2016).

SURFICIAL GEOLOGY

The study area was subjected to extensive glacial modification due to continuous ice cover throughout the Wisconsin glaciation. Specifically, northern Quebec was covered by a major ice dispersal centre of the Quebec-Newfoundland and Labrador sector of the Laurentide Ice Sheet (LIS), often referred to as the New Québec dome, with the Ancestral Labrador Divide extending into the study area (Vincent, 1989). Proximity to a former dynamic ice centre has resulted in a complex history of glacial deposition and dispersal (Fig. 3) An understanding past ice-flow trajectories and their associated landforms, bedrock erosion, and glacial drift transportation and its eventual deposition are all vital for successful mineral exploration using drift prospecting.

The oldest documented ice-flow phase in the region was to the northeast and likely originated somewhere in the Laurentian highlands of southern Quebec (Veillette et al., 1999). This ice-flow event was only sporadically (yet consistently the oldest phase) observed within the study area, as it has been largely eroded by later ice flows. The second oldest phase was due to radially flowing ice from the Labrador ice centre, with the Ancestral Labrador Ice Divide position on the east side of the De Pas Batholith. This second phase was responsible for the majority of the erosional landforms in the study area. The third ice-flow erosional phase was imparted onto the landscape after the westward migration of the ice divide, west of the De Pas Batholith. Evidence of the shift in the ice centre was observed in several opposing bi-faceted outcrops in the north-central part of the northern map sheet (Rice et al., 2016) and resulted in a number of areas experiencing a complete reversal of ice flow. The fourth phase occurred in the early stages of deglaciation, as ice flowed to the Labrador Sea and reduced the ice-sheet profile in the eastern section of the LIS (Margold et al., 2015), which remobilized the previously deposited tills

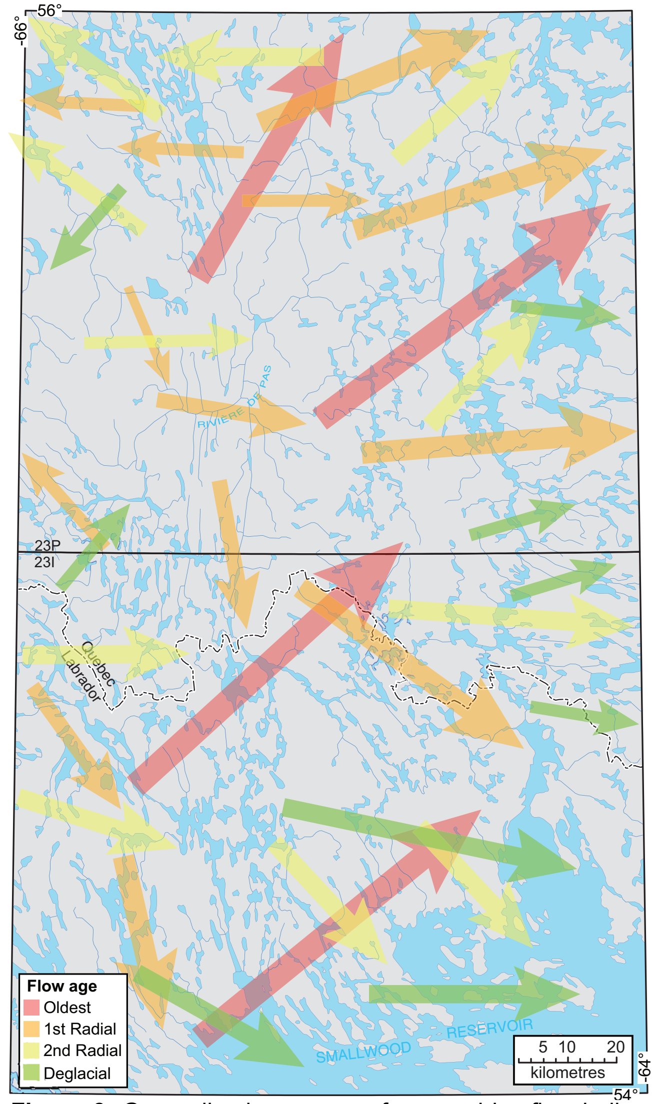

Figure 3. Generalized summary of mapped ice-flow indicators in the study area. Red arrows indicate the oldest flow direction observed in the region' this flow was likely from the Quebec Laurentian highlands (*cf.*, Veillette et al., 1999). Orange arrows indicate the earlier phase of radial flow from the Labrador ice centre during the main Wisconsin phase of the Laurentide Ice Sheet. Yellow arrows indicate a later phase of radial flow from the ice centre. Green arrows indicate deglacial flow trajectories, including the ice streams that were directed eastward towards the northeastern coastline of Newfoundland and Labrador .

Figure 4. A) Mudboil typically observed in the northern portion of the study area where permafrost is discontinuous; **B)** sample pit in a mud boil, and routine geochemistry (small) and indicator mineral (large) samples; **C)** typical sample pit in the southern portions of the study area where there is no permafrost and a natural soil horizon has developed.

and created cross-cutting landforms and elongated mega-scale glacial lineations in corridors of fast-flowing ice. After the paleo ice-stream network shut down, a deglacial landsystem prevailed, dominated by radial esker networks in the eastern half of the map area, with local deviations that resulted from topographically controlled ice flow recording the last glacial events in the region. In the western part of the map area, meltwater channels impacted the landscape during the stagnation and ablation of remnant ice masses.

During deglaciation, three glacial lakes formed in the study area. Below an elevation of 450 m asl in the George River basin in the northeast part of the study area, till was winnowed such that the fines were washed away and large expanses of bedrock were washed clean. As a result, finding till to sample in this part of the study area is difficult.

METHODS

Field methods

All till samples were collected following established GSC protocols (Spirito et al., 2011; McClenaghan et al., 2013). Where possible, active mudboils were targeted for till collection at depths between 0.2 and 1.0 m (Fig. 4A,B). Sample collected from mudboils were mostly within NTS sheet 23-P, where permafrost is discontinuous at higher. In the southern NTS sheet (23-I), beyond the limit of discontinuous permafrost, till samples were collected from unoxidized till (C horizon) in holes through the naturally developed soil profile (Fig. 4C). Cobbles (clasts >64 mm) and larger pebbles were removed by hand from the till to maximize the amount of matrix material being sampled. At each sample site, two types of samples were collected: a large till sample (7 to 13 kg) for recovery of indicator minerals, and a ~3 kg sample for till matrix geochemical analysis. A total of 260 till samples were collected over the three field seasons. Location and metadata for all till samples collected in the 2014, 2015, and 2016 field seasons are reported in Appendix A and plotted in Figure 2. In 2016, field duplicates were collected at three sites: sample 16-PTA-004 is a duplicate of 16-PTA-003, sample 16-PTA-046 is a duplicate of 16-PTA-045, and sample 16-PTA-102 is a duplicate of 16-PTA-101.

Sample processing and indicator mineral picking

All till samples collected for heavy mineral analysis were shipped to Overburden Drilling Management Limited (ODM), Ottawa, for heavy mineral separation and analysis. The unmodified laboratory reports produced by ODM are presented in Appendices B1 (2014 samples; McClenaghan et al., 2016), B2 (2015 samples; Rice et al., 2017), and B3 (2016 samples). Samples are listed in these ODM reports in the order in which the samples were processed, and not in numerical order.

Each year, blank samples were inserted into the till batch prior to shipping and processing, to monitor carry-over contamination in the indicator mineral processing laboratory. Blank samples are labeled “Bathurst blank” (samples) and “Linton blank” in Appendix A. In the batch for 2016, samples 2016-PTA-001, -172, and -173 are Bathurst blanks and samples 2016-PTA-100, -111, and -174 are Linton blanks. Bathurst blanks are weathered Silurian-Devonian granite (grus) of the south Nepisiguit River Plutonic Suite (Wilson, 2007) collected in the Miramichi Highlands, New Brunswick (McClenaghan et al., 2012; Plouffe et al., 2013). The material is unconsolidated and has the appearance of moderately sorted monolithic sand; it has no precious or base metal indicator minerals, except for rare gold grains (Plouffe et al., 2013). Results for these three samples have been included with all other till samples being analyzed. The Linton blanks (Almonte Blank, *cf.* Plouffe et al. 2013) are till samples recovered from a borrow pit near Almonte, Ontario. The till is consistent with tills sourced from the southern Canadian Shield, and is typically used by the GSC as base material for quality assurance/quality control (QA/QC) of samples submitted for heavy mineral assessment (Plouffe et al., 2013). The Linton blank is known to contain traces amount of chalcopyrite (1 grain / 10 kg) and up to 70 pyrite grains per 10 kg (Plouffe et al., 2013).

The <2.0 mm fraction of each sample was processed to produce a non-ferromagnetic heavy mineral concentrate, from which indicator minerals can be identified, following the procedures outlined in Figure 5. Weights for all products are reported in Appendix B. First, the <2.0 mm material was passed over a shaking table and then the heavy table concentrate was micropanned to recover fine-grained (typically <0.25 mm) gold, sulphide minerals, and other indicator minerals. The minerals in the panned concentrates were counted and their size and shape characteristics recorded. These minerals were then returned to the sample and the concentrates sieved at 0.25 mm. The 0.25 to 2.0 mm pre-concentrate was further refined using heavy liquid separation in methylene iodide diluted to a specific gravity (SG) of 3.2. The ferromagnetic fraction was removed from the 0.25 to 0.5 mm, >3.2 SG fraction using a hand magnet. The remaining non-ferromagnetic heavy mineral fraction was sieved into three size fractions: 0.25–0.5, 0.5–1.0, and 1.0–2.0 mm. The <0.25 mm fraction of each sample was processed to recover the non-ferromagnetic fraction and then archived. The 0.25–0.5 mm, >3.2 SG fraction was further subjected to paramagnetic separations using a Carpco® magnetic separator to produce <0.6 amp (strongly paramagnetic), 0.6 to 0.8 amp (moderately paramagnetic), 0.8 to 1.0 amp (weakly paramagnetic), and >1.0 amp (non-paramagnetic) fractions to assist counting and picking indicator minerals in this fine-grained fraction. The 0.25–0.5 mm fraction was cleaned with oxalic acid to remove oxidation stains (tarnish) from the grains and restore their natural colour, a critical step to facilitate optical mineral identification of easily oxidized sulphide minerals.

Mineral picking

The 0.25–0.5, 0.5–1.0, and 1.0–2.0 mm non-ferromagnetic fractions of each sample were examined under a binocular microscope by trained personnel at ODM. Indicator minerals, including sulphide minerals and select oxide and silicate minerals, as well as ODM’s suite of magmatic or metamorphosed massive sulphide indicator mineral (MMSIM®; Averill, 2001) were counted. The visual identification of a limited number mineral grains was verified with a scanning electron microscope (SEM).

Digital data files

Overburden Drilling Management produced a digital data file of the processing weights and indicator mineral grain counts for the 2016 samples (Appendix B3). The weights of the fractions produced during sample processing are reported in four worksheets: “Primary weights & descriptions”; “Processing weights”; “HMC Processing Weights” (<0.25 mm table concentrate weights); and “Paramag weights” (weights for the paramagnetic fractions). The weight of the 2.0 to 5.6 mm pebbles and the >5.6 mm pebbles are reported in the worksheet “Pebbles”. Gold grain data generated from panning each table concentrate are reported in two worksheets: “Gold Summary” and “Detailed VG”, which describe the abundance, size, and shape of the visible gold grains as well as the size of any other fine-grained indicator minerals observed during panning (e.g. pyrite). The abundance of platinum group minerals (PGMs) are reported in the “PGMs” worksheet. The abundance of indicator minerals, including those indicative of metamorphosed massive sulphide

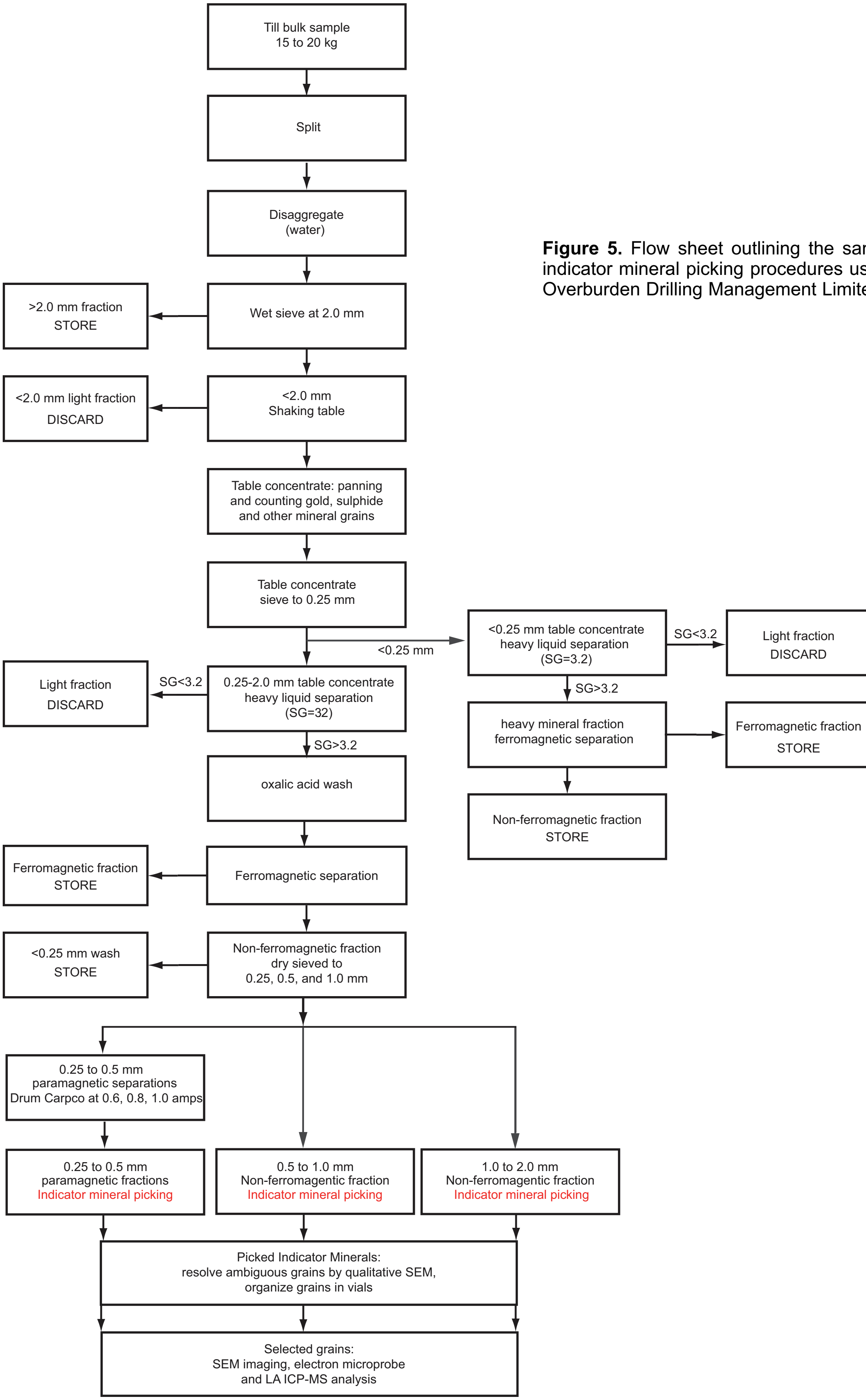

Figure 5. Flow sheet outlining the sample processing and indicator mineral picking procedures used for till samples at Overburden Drilling Management Limited.

deposits (MMSIM®), are listed in the worksheet entitled “MMSIM”.

RESULTS

Bathurst blank samples 2016-PTA-001, -172, and -173 contain no indicator minerals except for one grain of pyrite in sample 16-PTA-073. Linton blank samples 2016-PTA-100, -111, and -174 contain a few grains of chalcopyrite and pyrite. Sample 16-PTA-100 and -174 each contain one gold grain as well as other potential indicator minerals that are similar to those reported for the GSC Linton blank in Plouffe et al. (2013). These results for both blanks indicate that no external or carryover contamination between samples has been detected.

The abundances and distribution of selected indicator minerals in the 2014, 2015, and 2016 samples are presented in a series of maps in Appendix C. Map 1 shows the distribution of gold grains in the pan concentrate of samples normalized to 10 kg of the <2.0 mm fraction. Of potential interest for mineral exploration is the generally elevated gold grain content in 15 till samples (>6 gold grains / 10 kg) in the west-central part of the study area, principally overlying the Doublet Zone mafic volcanic rocks. Sample 16-PTA-057 contains a greater abundance of gold grains (66 grains equivalent to 63 grains / 10 kg) compared to the rest of the study area (Map 1, Appendix C).

One sand-sized gold grain was recovered from sample 16-PTA-112 (Fig. 6), which was collected over the Core Zone orthogneiss (Fig. 2; Appendix C Map 1). This gold grain is noticeably larger than the silt-sized gold grains observed in the rest of the till samples. The reshaped nature of this large grain (Fig. 6) suggests that it could be far-travelled (DiLabio, 1990). The source(s) of gold in till in this region is unknown.

Appendix C, Map 2 shows the distribution of sperrylite ($PtAs_2$) grains in heavy mineral pan concentrates of samples from across the study area. Appendix C, Maps 3 through 9 show the distribution of pyrite, chalcopyrite, Mn epidote, red rutile, low-Cr diopside, goethite, and orthopyroxene within the 0.25 to 05 mm non-ferromagnetic heavy mineral concentrates. Minerals reported as number of grains (i.e. not %) have been normalized to 10 kg of the <2.0 mm table feed. Note that only four of the nine mineral maps (gold, sperrylite, goethite, and orthopyroxene) report 260 samples, the remaining five minerals were unable to be reported for two samples (2015-PTA-139 and 2015-PTA-140) due to the contamination of part of the heavy mineral concentrate during the mineral picking process.

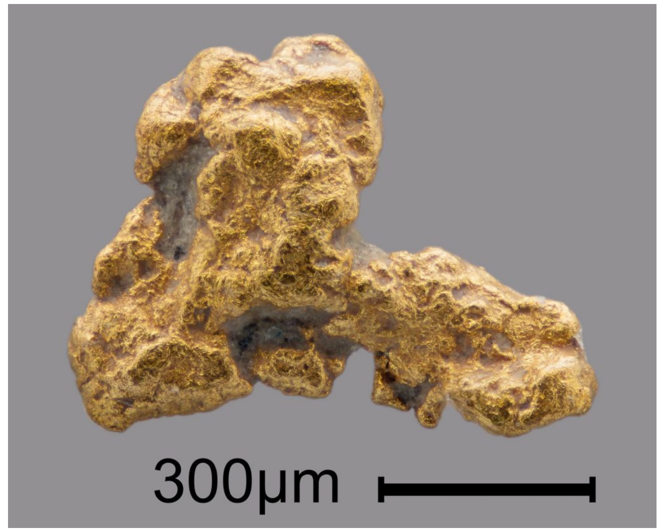

Figure 6. Photograph of the large reshaped gold grain recovered from till sample 16-PTA-112.

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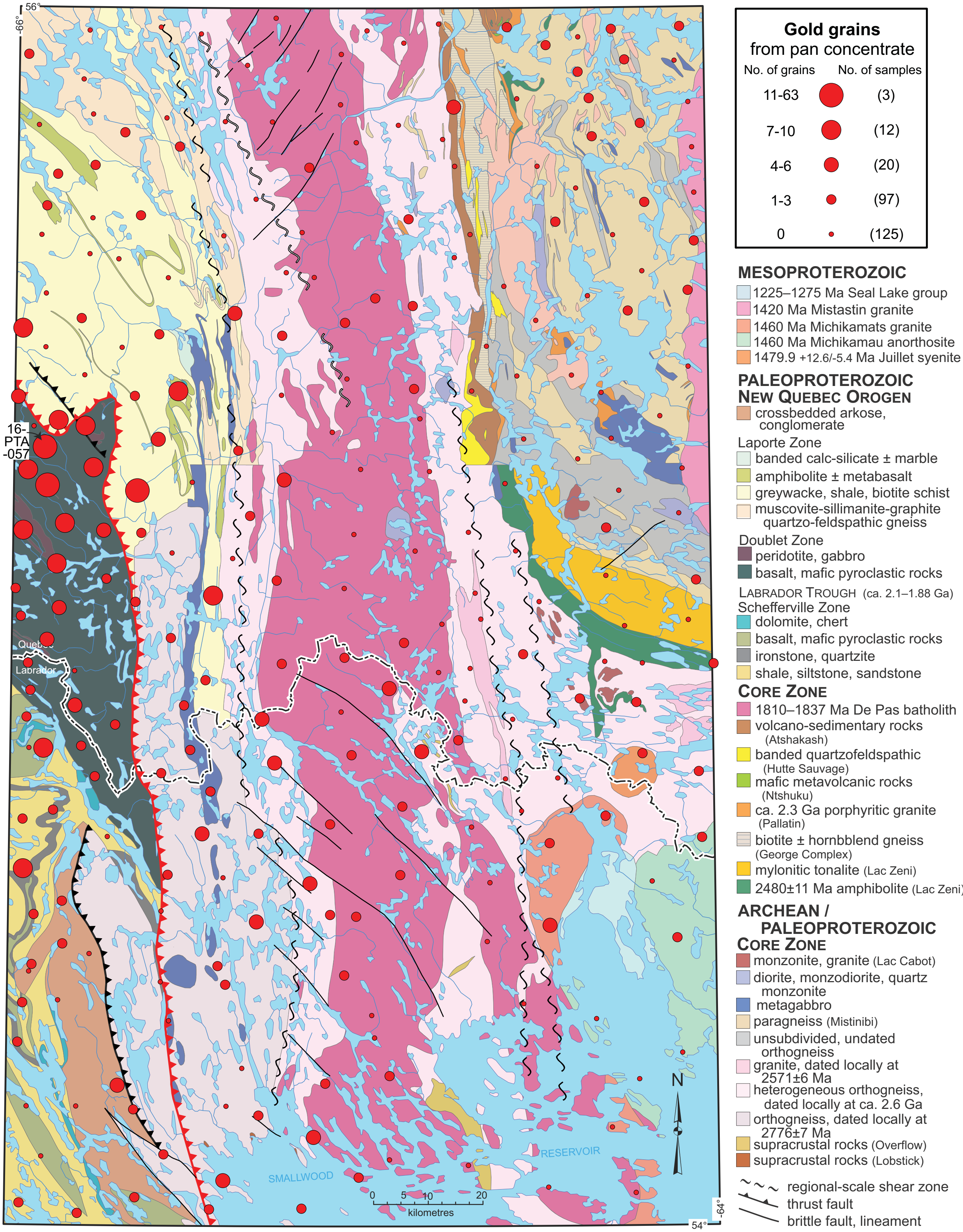
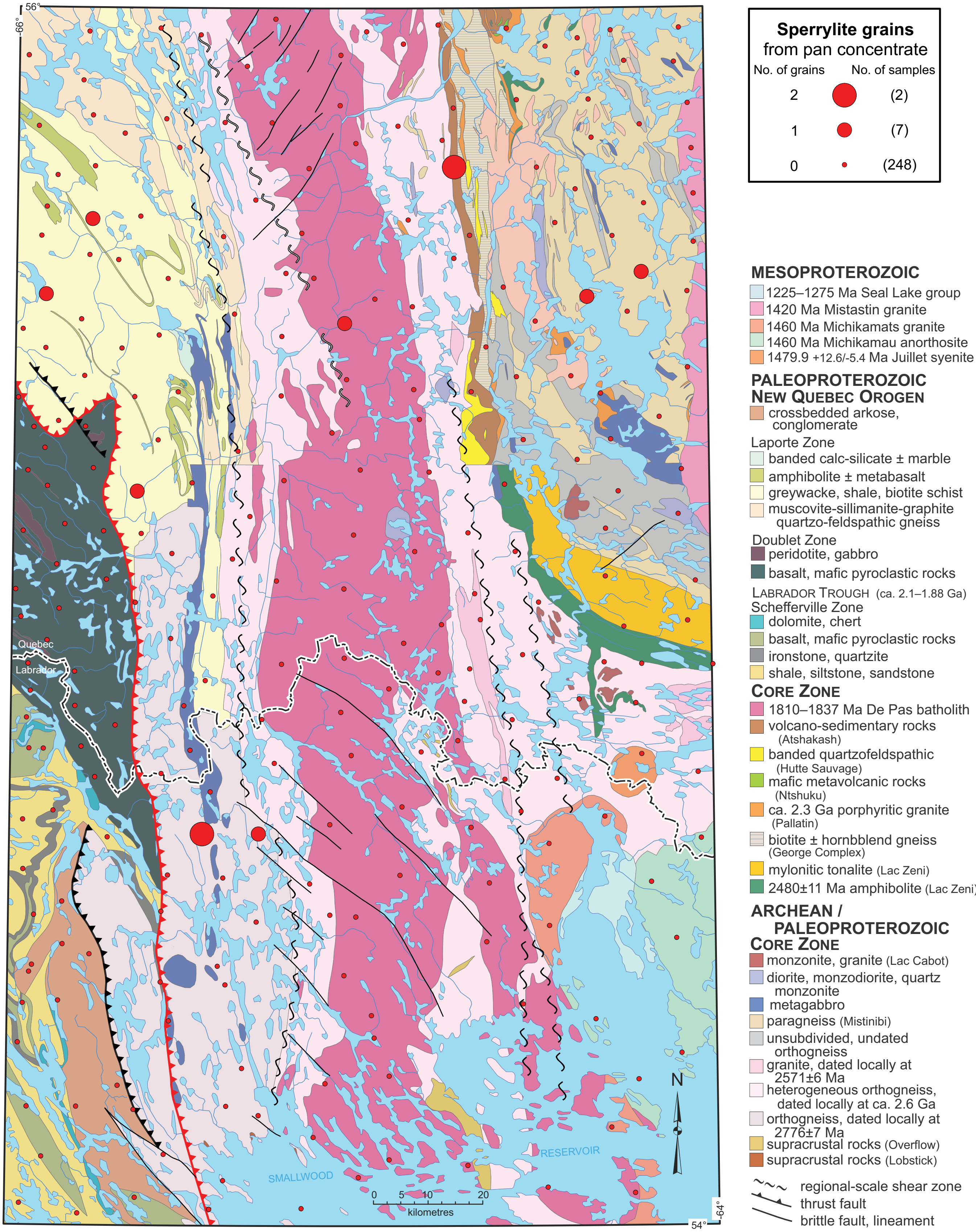
Appendix C. Maps showing the abundance of indicator minerals in the 0.25–0.5 mm non-ferromagmatic heavy mineral fraction of till samples collected in 2014, 2015, and 2016



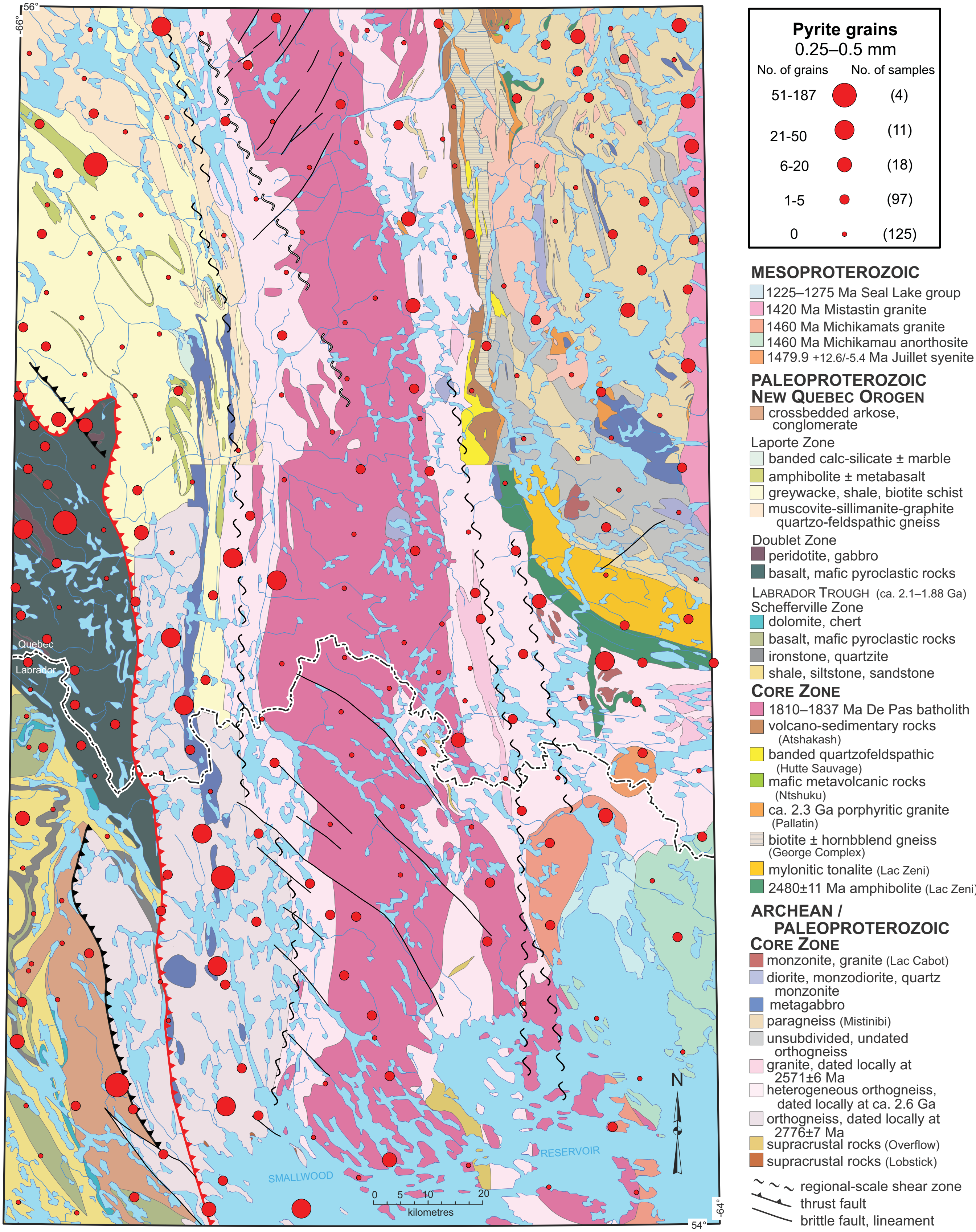
Appendix C, Map 1. Gold grains in the pan concentrate. Counts are normalized to 10 kg weight of <2.0 mm fraction.

Appendix C continued.



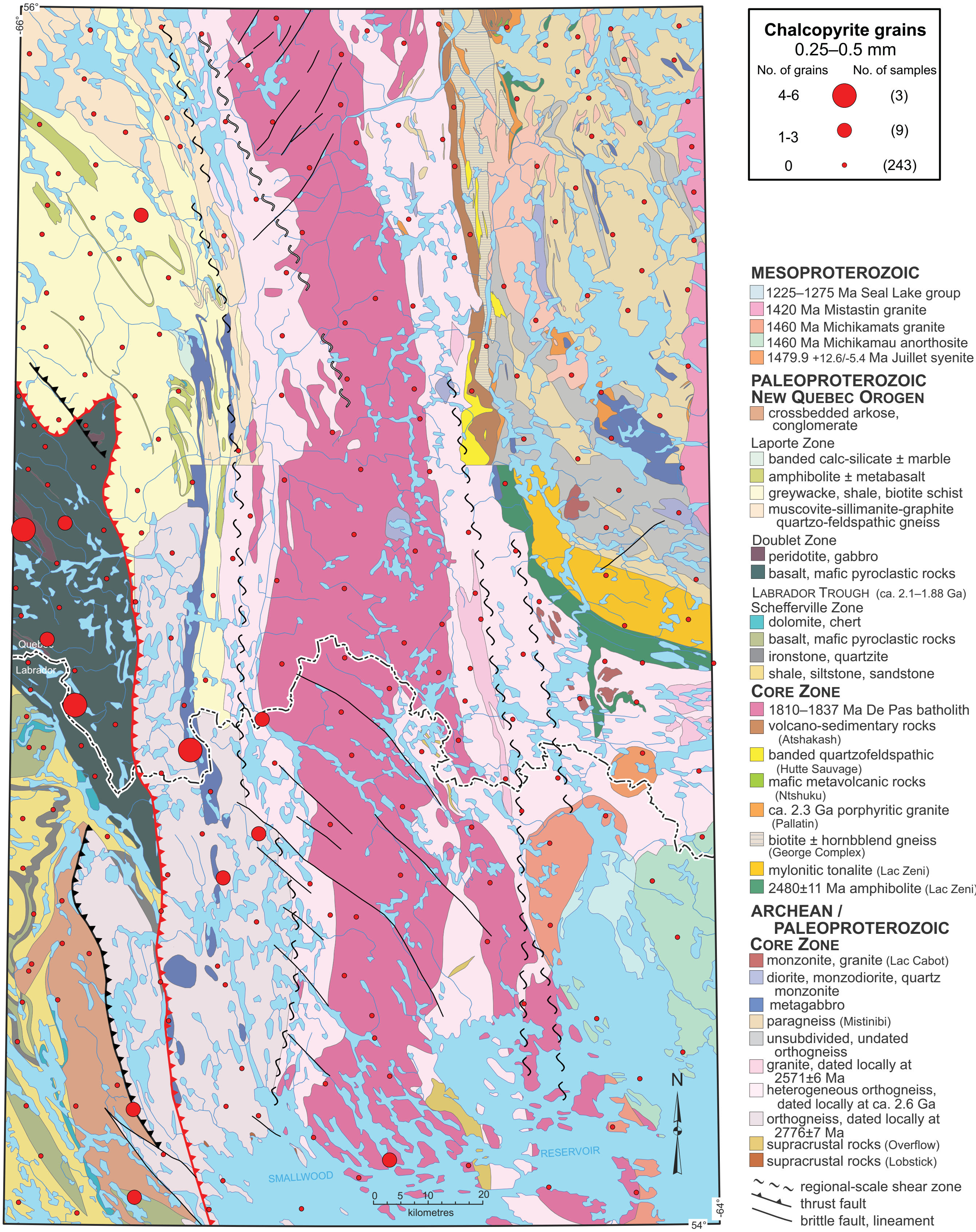
Appendix C, Map 2. Sperrylite grains in the pan concentrate. Counts are normalized to 10 kg weight of <2.0 mm fraction.

Appendix C continued.



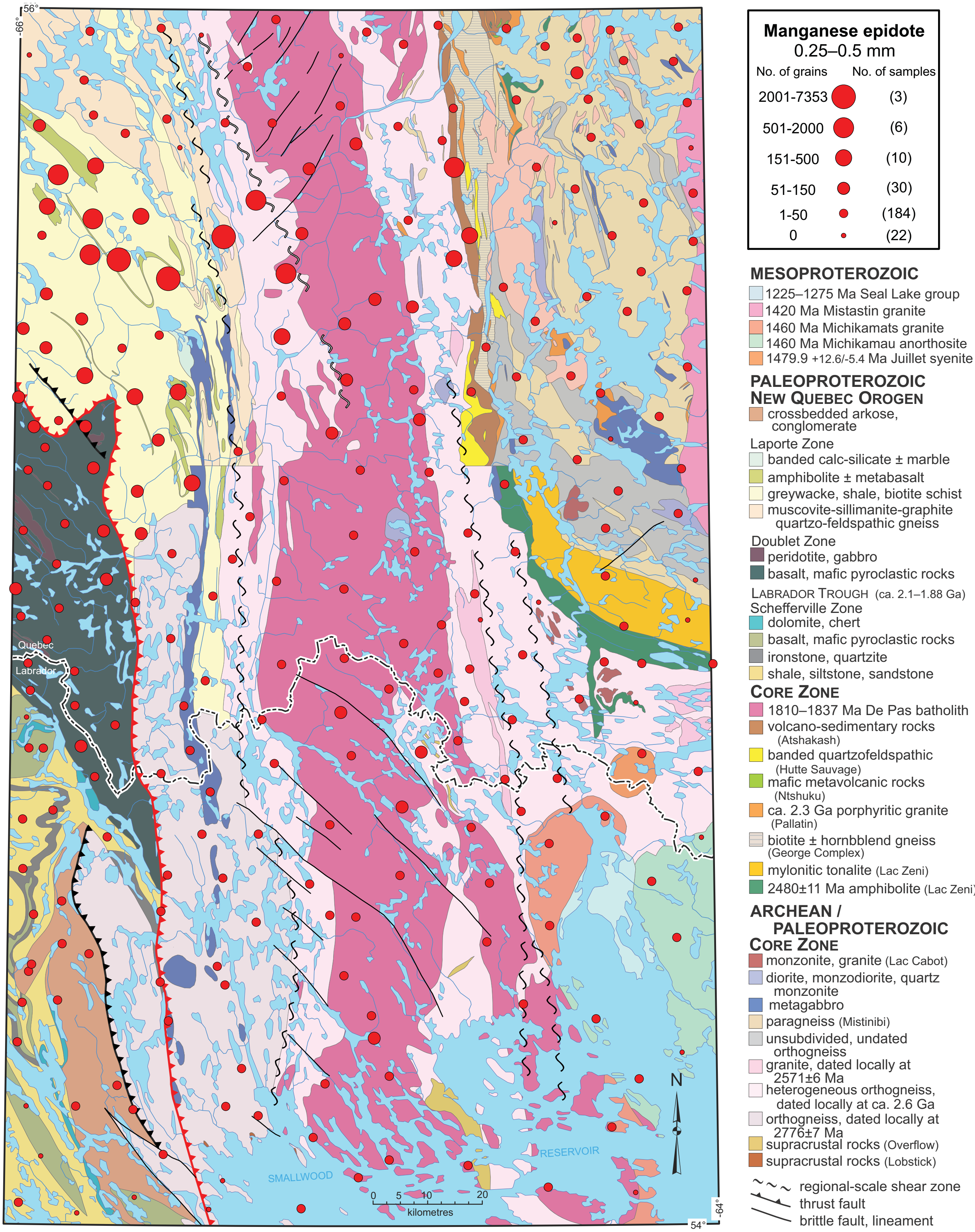
Appendix C, Map 3. Pyrite grains in the 0.25–0.5 mm fraction. Counts are normalized to 10 kg weight of <2.0 mm fraction.

Appendix C continued.



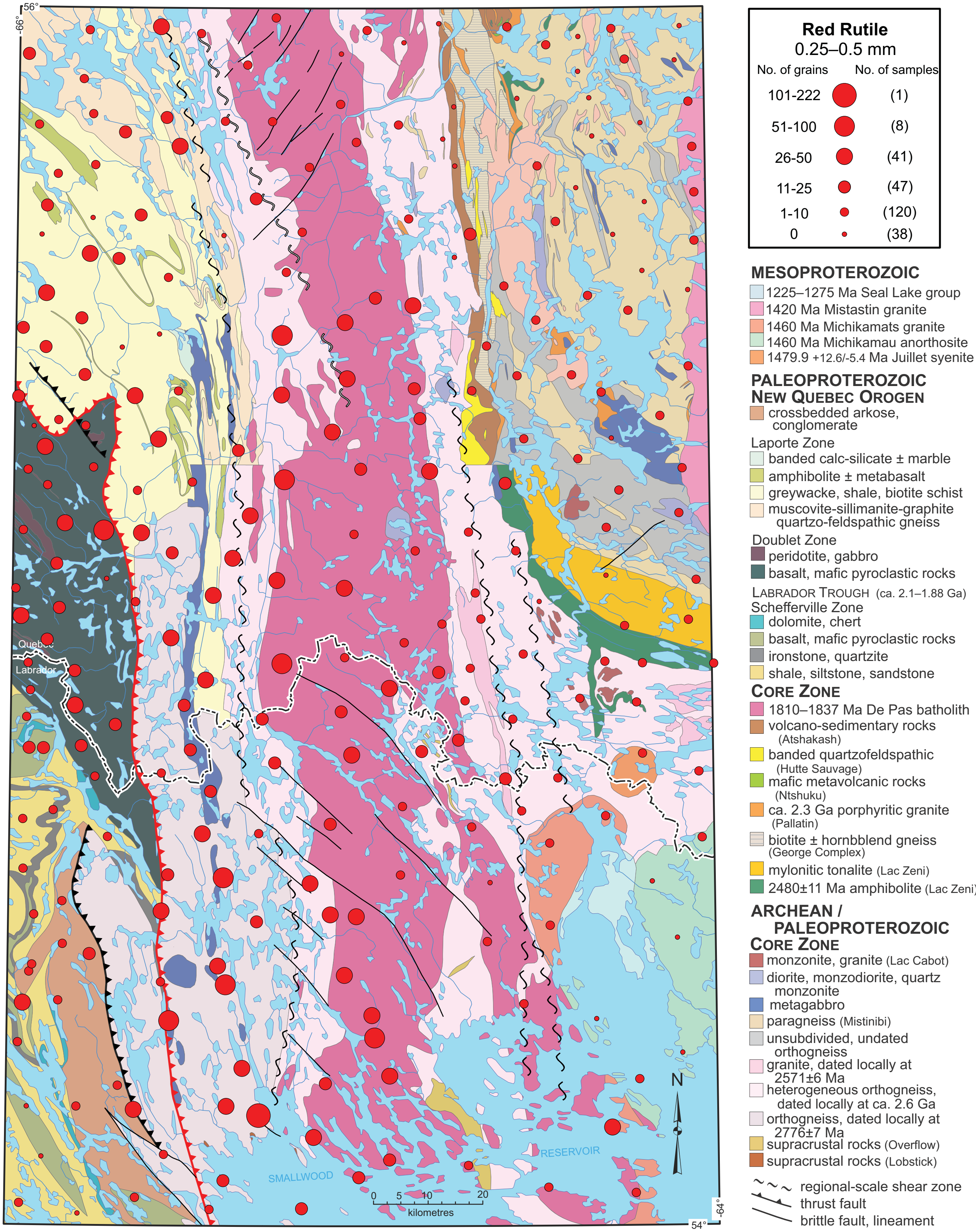
Appendix C, Map 4. Chalcopyrite grains in the 0.25–0.5 mm fraction. Counts are normalized to 10 kg weight of <2.0 mm fraction.

Appendix C continued.



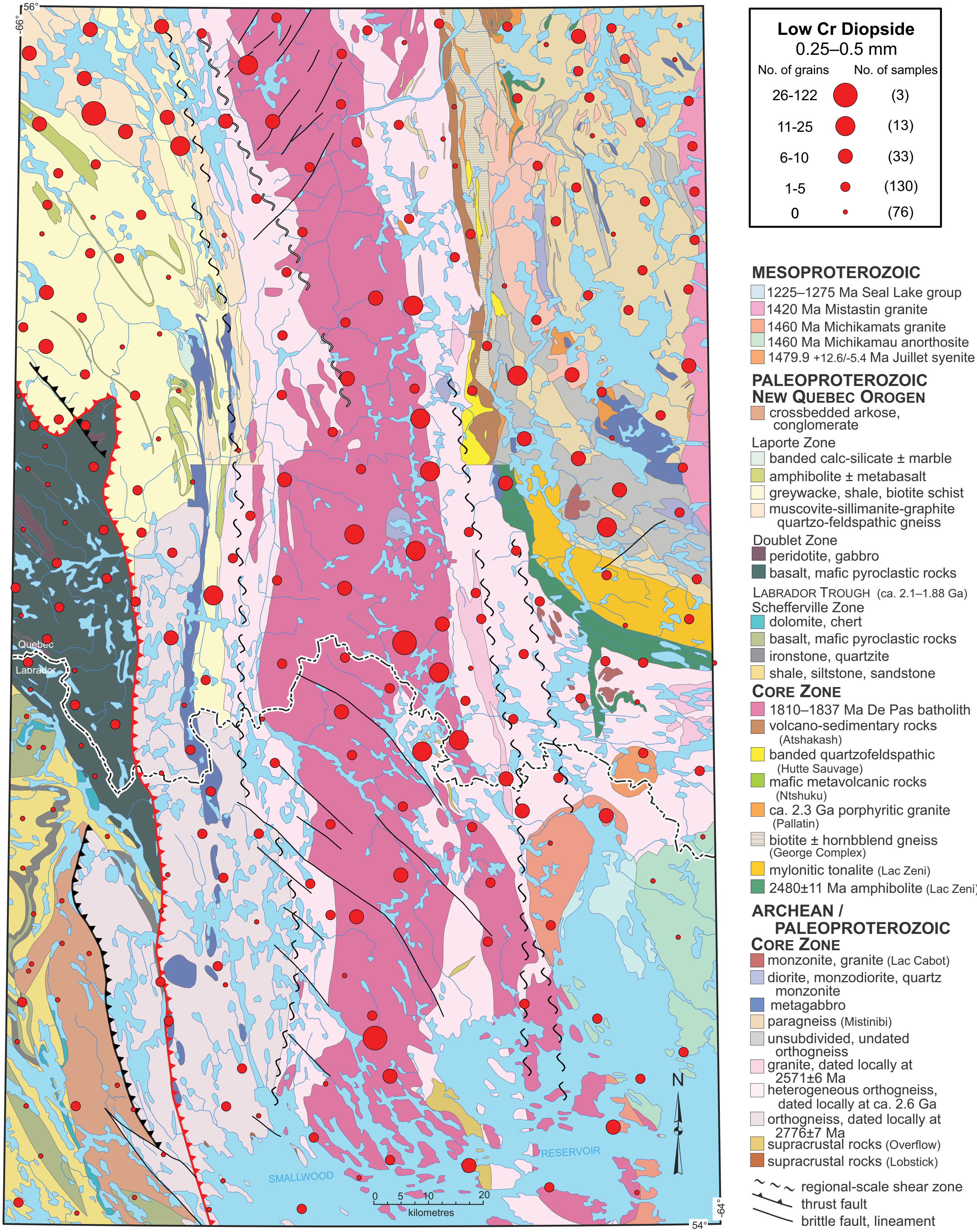
Appendix C, Map 5. Manganese epidote grains in the 0.25–0.5 mm fraction. Counts are normalized to 10 kg weight of <2.0 mm fraction.

Appendix C continued.



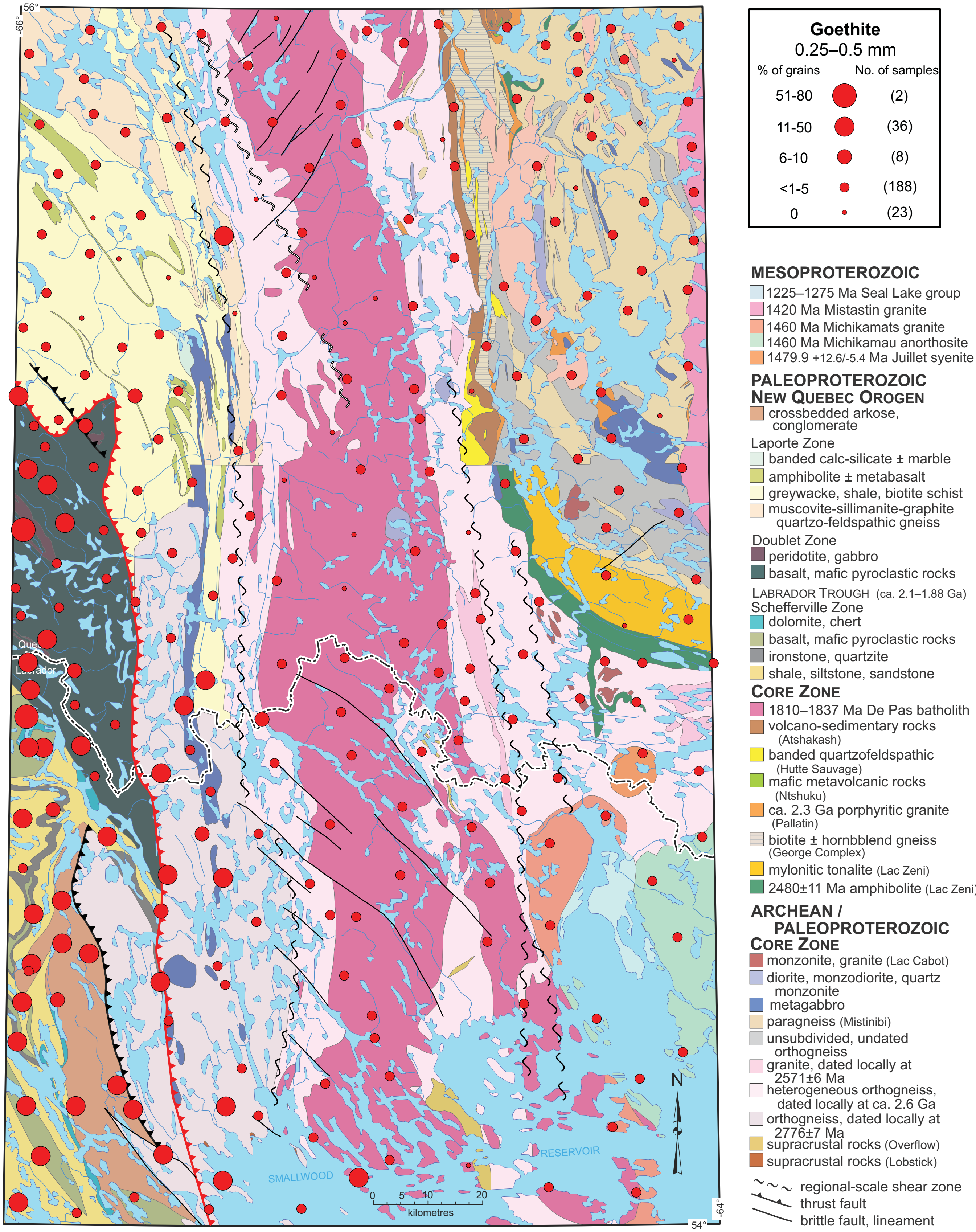
Appendix C, Map 6. Red rutile grains in the 0.25–0.5 mm fraction. Counts are normalized to 10 kg weight of <2.0 mm fraction.

Appendix C continued.



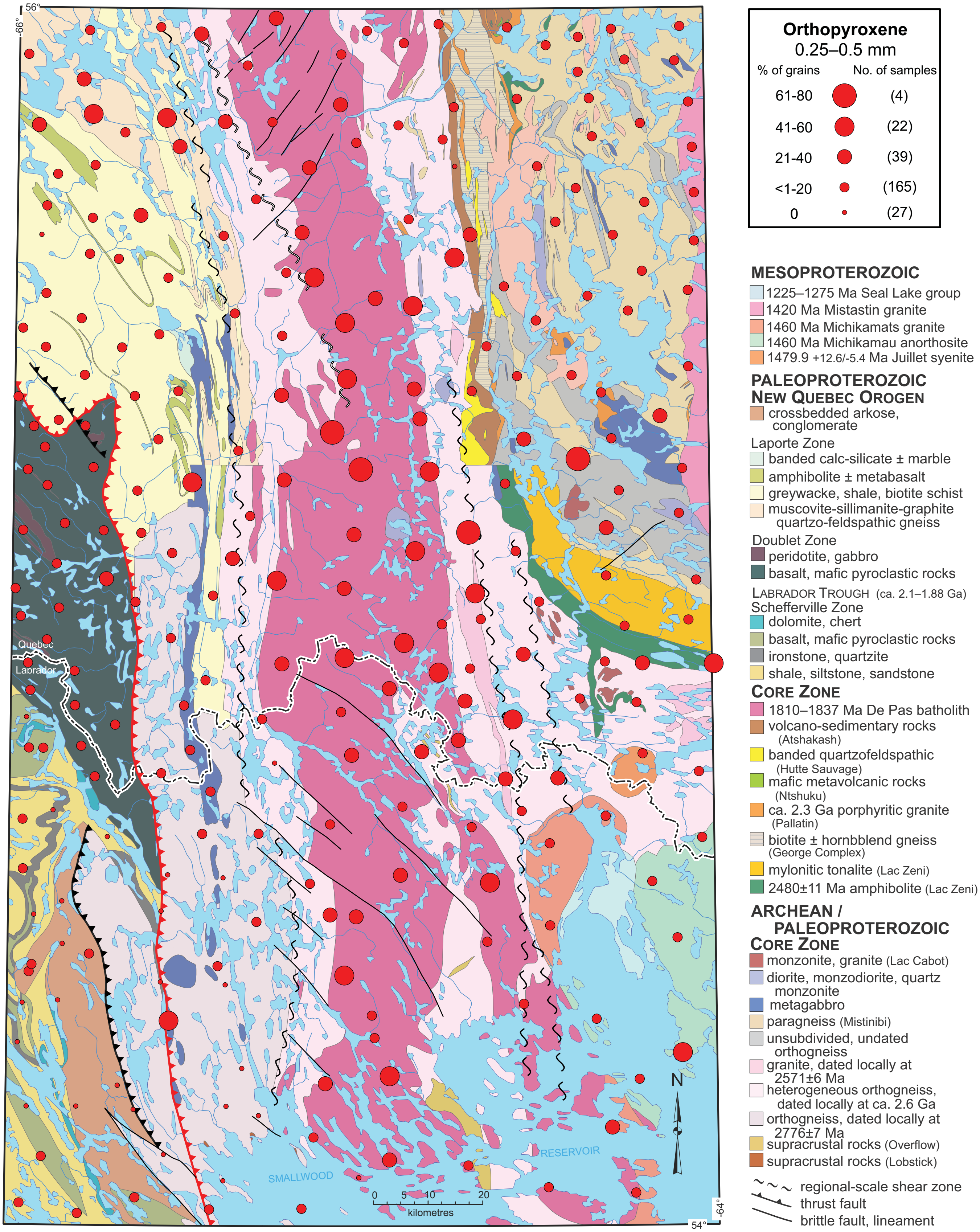
Appendix C, Map 7. Low Cr-diopside grains in the 0.25–0.5 mm fraction. Counts are normalized to 10 kg weight of <2.0 mm fraction.

Appendix C continued.



Appendix C, Map 8. Percentage of grains in the 0.25–0.5 mm fraction are goethite.

Appendix C continued.



Appendix C, Map 9. Percentage of grains in the 0.25–0.5 mm fraction that are orthopyroxene. Counts are normalized to 10 kg weight of <2.0 mm fraction.