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SPECIAL REPORT 96

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A. Plouffe, R.C. Paulen, I.R. Smith, and I.M. Kjarsgaard

2008

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Abstract

This report presents the results and interpretations of the heavy mineral assemblages and pebble lithologies of 19 bulk till samples collected in northwest Alberta, from the region of a sphalerite dispersal train originally reported by Plouffe et al. (2006a). Indurated pebbles in the 4-8 mm sized fraction of till dominantly consist of distally-derived bedrock lithologies: Canadian Shield rocks, Paleozoic carbonates, and quartzite. Three till samples contain mineralized clasts with visible pyrite and marcasite. Kimberlite indicator minerals (KIMs) in till, including Cr-pyrope, Cr-diopside and chromite are present in trace amounts (1 to 2 grains) in nine samples. Although the KIM counts are low, the samples with KIMs do cluster in the Zama Lake – Zama City area. The source, proximal or distal, is unknown and remains to be identified. Seven out of the 19 till samples contain sand-sized sphalerite grains, with the strongest anomaly consisting of 989 sphalerite grains recovered from a 34 kg till sample. The sphalerite is dominantly in the 0.25 to 0.5 mm fraction (900 grains) with smaller amounts (89 grains) in the 0.5 to 1.0 mm size range. The new data indicate that the sphalerite dispersal train first identified by Plouffe et al. (2006a) could cover an area of over 4000 km^2. The bedrock source(s) of the sphalerite in till remains to be discovered.

Introduction

Plouffe et al. (2006a; 2007) and Paulen et al. (2007) have reported a sphalerite dispersal train in till from the Zama Lake – Zama City region of northwest Alberta (Fig. 1). Dark grey to black, angular, brittle grains of sphalerite were found in high concentrations (>100 grains) in seven till samples from this region; one till sample had 1047 sphalerite grains (normalized to 30 kg). Trace amounts of galena grains are present in association with the sphalerite grains. Kimberlite indicator minerals (KIMs) have been reported from till samples by Plouffe et al. (2006a; 2007) in the same region. At least one KIM was observed in 38 out of 67 till samples. The first release of the till mineralogical and geochemical data in 2006 (Plouffe et al., 2006a) triggered mineral staking in northwest Alberta over 64 townships (Fig. 2).

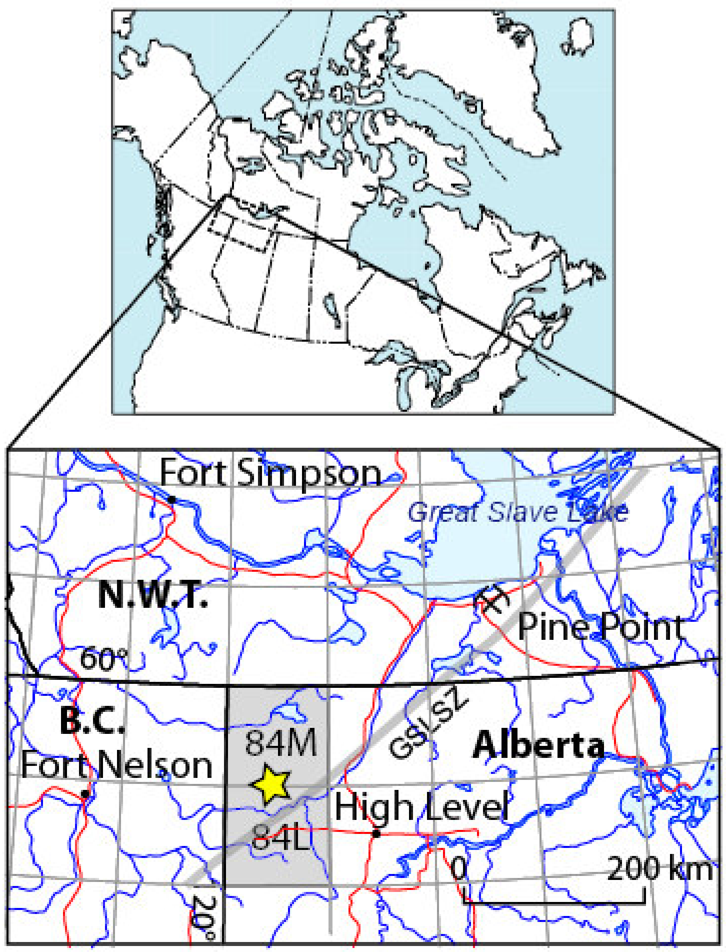

Figure 1. Location of study area: National topographic system map sheets 84 L (Zama Lake) and 84 M (Bistcho Lake) in northwest Alberta. The yellow start represents the location of a sphalerite dispersal train reported by Plouffe et al. (2006a; 2007) and Paulen et al. (2007). GSLSZ – Great Slave Lake Shear Zone; Pine Point – Mississippi Valley Type deposit.

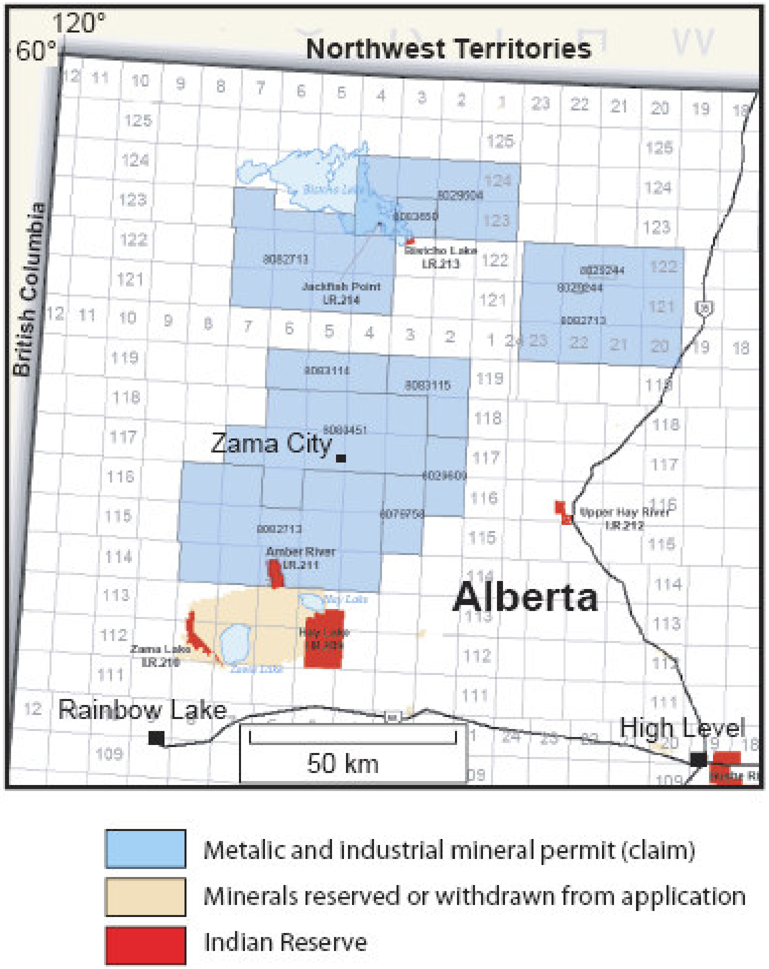

Figure 2. Mineral staking in NW Alberta shaded in blue as of Nov. 28, 2007. Data from the Alberta Energy web site: www.energy.gov.ab.ca/OurBusiness/1072.asp.

To better define the extent of the sphalerite dispersal train and the distribution of KIMs in till, an additional 19 till samples collected within the region of the sphalerite anomaly were processed to recover indicator minerals (Fig. 3). The objective of this report is to present and interpret the new data for the 19 till samples in a regional context.

This research was conducted as part of a four year collaborative project (2003-2007) between the Alberta Geological Survey (AGS) and the Geological Survey of Canada (GSC). The project entitled Shallow Gas and Diamond Opportunities in Northern Alberta and British Columbia terminated in March 2007 and was conducted as part of the Northern Resources Development Program of the GSC. Some of the project activities extended into northeastern British Columbia and involved the participation of the British Columbia Ministry of Energy, Mines and Petroleum Resources.

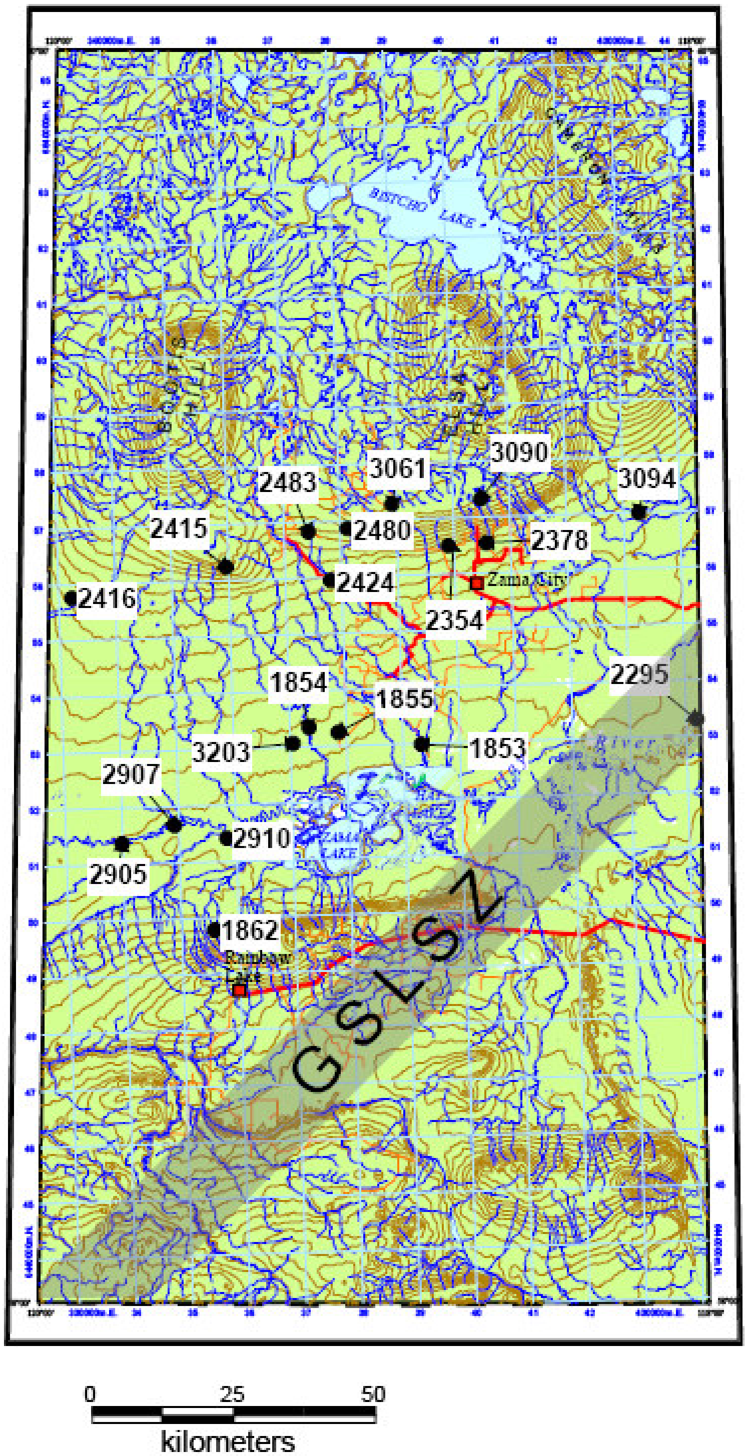

Figure 3. Location of the 19 till samples processed to recover indicator minerals and reported here. GSLSZ – Great Slave Lake Shear Zone (Eaton and Hope, 2003).

Study area

The study area as defined in this report includes the national topographic system (NTS) map sheets 84 L (Zama Lake) and 84 M (Bistcho Lake) of northwest Alberta (Fig. 1). The samples presented in this report were collected from the northern portion of 84L and the southern portion of 84M map sheets. This region lies within the Fort Nelson Lowlands of the Alberta Plateau physiographic region (Bostock, 1967) which is a region of subdued to flat relief with an elevation varying from 350 m to 750 m above sea level (asl).

Smith et al. (2005a), Plouffe et al. (2006a; 2007), and Paulen et al. (2007) present a general overview of the bedrock and surficial geology of the study area. Only a few details about the regional geology pertinent to this report are described below.

Bedrock in the study area consists of nearly horizontal and poorly indurated Cretaceous Shaftesbury Formation shale overlain by Cretaceous Dunvegan Formation sandstone (Okulitch, 2006) at an elevation of approximately 700 m asl. The Great Slave Lake Shear Zone (GSLSZ), a major basement structural break, crosses the southern part of the study area (Pana et al., 2001; Eaton and Hope, 2003; Pana, 2006) (Fig. 3). Bedrock outcrops are rare and are dominantly present in meltwater channels, along modern stream valleys, and on hilltops. Overlying Cretaceous rocks, unconsolidated sediments are extensive and highly variable in thickness from 0 to 450 m (Pawlowicz et al., 2005a; 2005b; 2007a; 2007b). During the Late Wisconsinan glaciation, ice derived from the Keewatin Sector of the Laurentide Ice Sheet flowed west to southwest over the study area (Fig. 4). The details of the ice-flow history are depicted on the recently published surficial geology maps of this region: Paulen et al. (2005a; 2005b; 2006a; 2006b), Plouffe et al. (2004; 2006b), Smith et al. (2005b; 2007).

Methodology

The 19 till samples (25 to 40 kg) were collected in hand-dug pits, borrow pits, sump pits, and natural sediment exposures. In hand dug pits, samples were collected in the C-horizon, below the zone of most intense oxidation at an average depth of one metre. In borrow and sump pits, samples were taken near the base of the excavations at depth of three to four metres. Samples were collected in 15 gallon rock pails (plastic and metal) lined with a plastic bag (metal pails only). Sample location information is provided in Appendix 1. At each site, a second till sample (ca. 2 kg) was collected in a plastic bag and was submitted for geochemical analyses on the silt and clay-sized fraction (<0.063 mm). Geochemical results of the 19 till samples are part of the regional till geochemistry report presented by Plouffe et al. (2006a).

The bulk till samples were processed to recover the heavy mineral fraction at Overburden Drilling Management Ltd. (ODM), in Nepean, Ontario following the procedure outlined in Plouffe et al. (2006a). Basic information on sample weight processed and semi-quantitative information on till pebble lithologies and till texture are provided in Appendix 2. Samples were examined for their gold grain content, kimberlite indicator minerals, and metamorphosed/magmatic massive sulphide indicator minerals (MMSIM) at ODM. For a limited number of grains, heavy mineral identification was assisted by use of a scanning electron microscope (SEM). During sample processing, pebbles from the 4-

8 mm sized fraction were separated and washed with oxalic acid at ODM to clean the pebble surfaces, facilitating their lithological identification. Pebble counts were conducted by A. Plouffe using a binocular microscope.

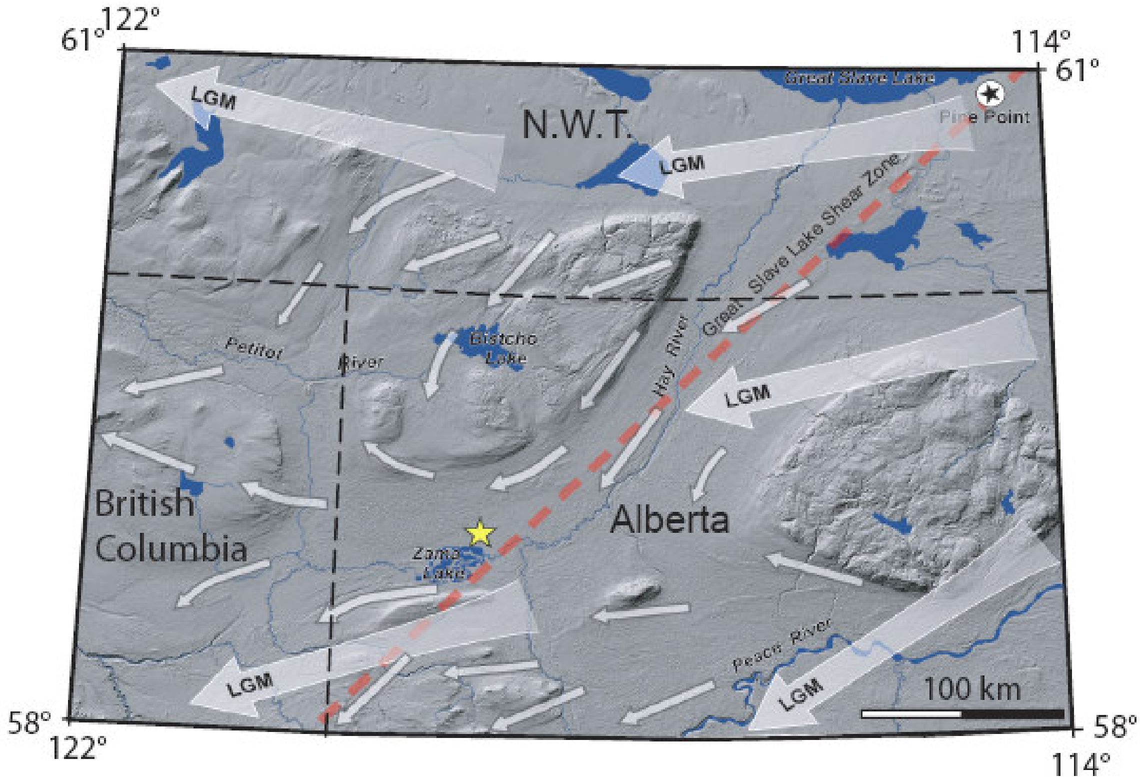

Figure 4. Regional ice-flow patterns in northwest Alberta, northeast British Columbia and southern Northwest Territories. Large arrows depict regional ice flow during the Last Glacial Maximum (LGM) and small arrows depict ice movements during deglaciation (Paulen et al., 2007). The yellow star indicates the location of the sphalerite anomaly in glacial sediments reported by Plouffe et al. (2006a; 2007). The red dashed line indicates the location of the Great Slave Lake Shear Zone (Eaton and Hope, 2003).

To monitor the efficiency of the heavy mineral separation and mineral identification procedures one spiked till sample was included in the sample set (Appendix 3). The spiked sample consisted of till from the Brownvale area in Alberta (c.f. Prior et al., 2005) into which ten pyrope garnets, eight Cr-diopsides, nine chromites, and nine forsterites of two different sand-sized fractions were added. Thirty two out of 36 grains were recovered (89% recovery) with the best results being achieved with garnet pyrope (ten grains out of ten recovered), Cr-diopside (eight out of eight), and forsterite (eight out of nine) (Appendix 3). Chromite seems to have been more difficult to identify in these samples (six out of nine). Twelve grains of pyrope garnet were recovered from the spike but only ten were added to the sample. The additional two grains could either be derived from cross-contamination from previous samples processed at ODM or they may indicate that the till from Brownvale, originally thought to be KIM free, might include trace amounts of garnet pyrope.

KIM and low Cr-diopside grains identified and picked by ODM were mounted on stubs and polished at SGS Lakefield Research Ltd. to expose a section of the mineral grains. Potential KIM grains (garnet, pyrope and chromite) were analyzed on a four-spectrometer wavelength dispersive CAMECA Camebax Electron Microprobe at Carleton University, Ottawa by I.M. Kjarsgaard. Overlap corrections were performed using the PAP procedure. Calibrations were checked by analyzing known USNM standards (not used for calibration) as samples. The grains were analyzed at 20 kV and 20nA with 10 to 20 seconds counting time. Standards used were $MgAl_2O_4$ for Mg and Al, Cr_2O_3 for Cr, MnTi for Mn, $CaSiO_3$ for Si and Ca, $FeTiO_3$ for Ti and Fe, NiO for Ni, $ZnAl_2O_4$ for Zn and V for V. The low Cr-diopside analyses were conducted at the GSC by K. Venance on a Cameca SX-50 electron microprobe fitted with 4 wavelength-dispersive spectrometers with a take-off angle of 40 degrees. Operating conditions were 20kV accelerating voltage, 10nA current, using a focused beam. Count times were 10s on peak and 5s off-peak. Standards used were a mixture of natural and synthetic pure metals, simple oxides and simple compounds. The matrix correction program used was that of Armstrong (1988).

Results

Pebble counts

The 4-8 mm pebbles were first separated into 12 lithological categories that reflect the local and regional bedrock geology (see Appendix 4 for results and description of each category). All lithological percentages presented in this report refer to the weight percent. This was done to accommodate the variation of the pebble size within the 4-8 mm size fraction. For graphic and interpretation purposes, the 12 pebble lithologies were regrouped into five categories (Fig. 5): Shield, carbonates, quartzite, local provenance (Cretaceous shale and ironstone), and mineralized clasts. Shield lithologies consist of intrusive rocks with abundant pink feldspars, minor metamorphic rocks (schist and gneiss), crystalline quartz, and small amounts of fine grained metasedimentary and metavolcanic rocks. The carbonate category includes a mixture of limestone and dolostone derived from the Paleozoic platform rimming the Canadian Shield. Few clasts with fossil fragments (mostly bivalves) were observed. The quartzite category includes generally well-indurated clasts of sedimentary quartzite with rounded quartz grains. Most of the quartzite is white but small amounts of maroon quartzite is present. Quartzite found in these samples may be derived from either the Proterozoic Athabasca Basin or from Tertiary to Quaternary gravels, initially derived from the Cordillera. Lithologies of local provenance (Cretaceous) are dominated by poorly-indurated black shale, hard fragments of ironstone, and trace amounts of coal. Occasional chert pebbles were

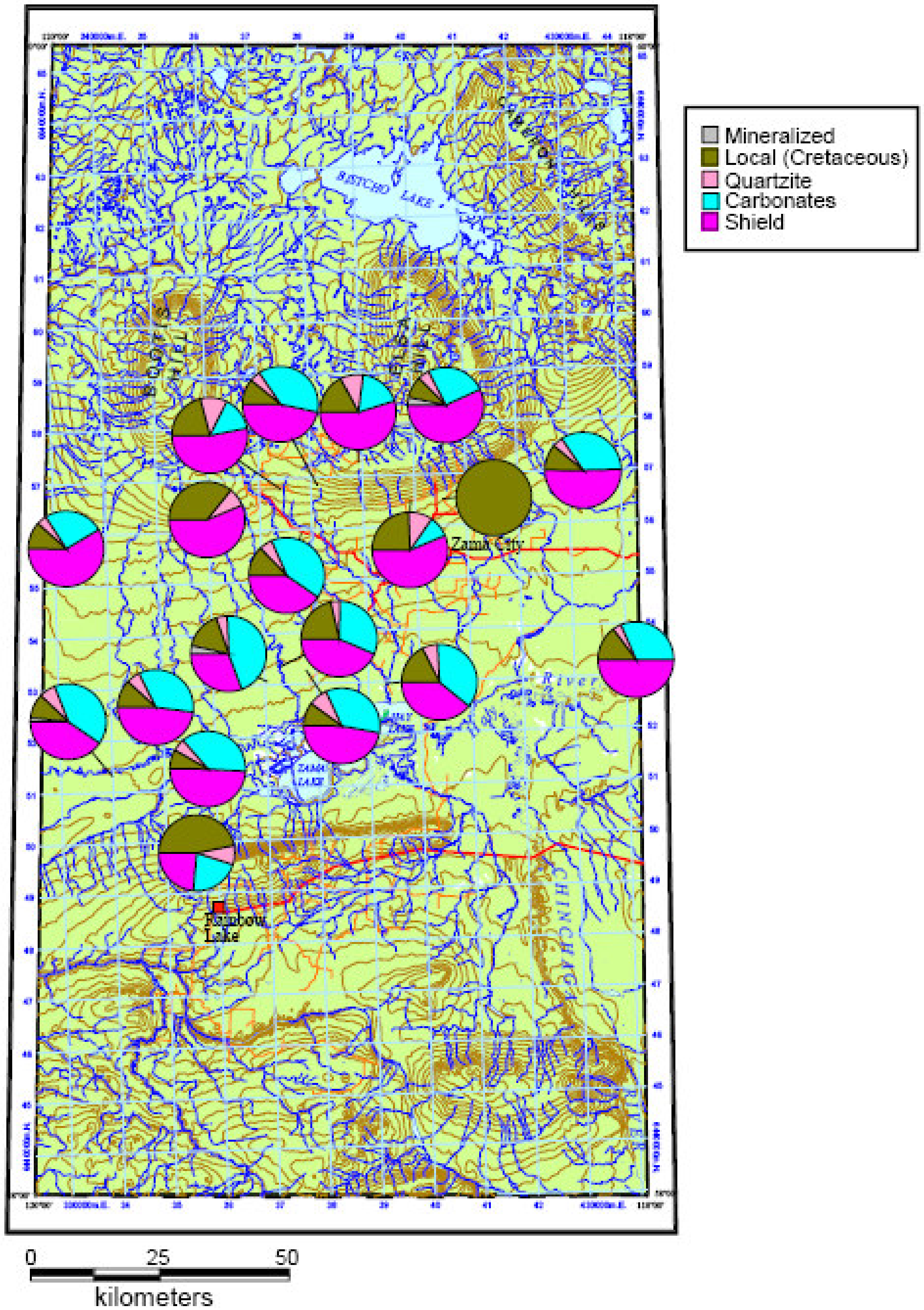

Figure 5. Relative proportion (weight percent) of bedrock lithologies in the 4-8 mm pebble sized fraction of the 19 till samples. See text for details. Centre of the pie corresponds to the sample location unless the pie is tied in to the sample site with a line.

included in local provenance category as they could have been derived from nodules in the Shaftesbury Shale Formation. Fragile euhedral to subhedral kaolinite pseudomorphs after gypsum were observed in the 4-8 mm sized fraction (Appendix 4). Those fragments were not included in the pebble counts because they are interpreted to have formed diagenetically within the till in postglacial time and therefore, do not result from glacial transport. Lastly, mineralized clasts are described as fine grained sedimentary rocks containing mostly iron sulphide in the form of marcasite and pyrite.

The 4 to 8 mm sized fraction of till is dominated by the well indurated and distally derived lithologies: Shield, carbonates, and quartzite. With only one exception, the samples do contain from 50 to 92 % distally derived clasts. Clasts of the poorly indurated and locally derived Shaftesbury Shale are under represented in the 4-8 mm fraction because they were broken or crushed to finer size fractions during the sample processing. Only the ironstone clasts are present in significant amount as a locally derived lithology generally varying in abundance from 6 to 30 %. Three samples (2905, 3090, and 3203) contain 2-3 % mineralized clasts with a mixture of pyrite and marcasite. The heavy mineral assemblages of those same samples are characterized with a large abundance (40 to 90 %) of pyrite and marcasite, of these, sample 3203 contains close to 1000 grains of sphalerite.

No strong spatial trend is observed in the till pebble lithologies except for a subtle lower Shield lithology content in the samples of the southwestern sector (generally <50%) compared to the northern sector (generally >50%) (Fig. 5). The nature of the till (lodgement versus meltout), its thickness, and the sampling depth (or the proximity of the sample to bedrock) are thought to have the greatest control on the lithologies of clasts in the till.

Heavy mineral assemblages

Results of the heavy mineral assemblage study are presented in Appendix 5, on the worksheet entitled MMSIM (metamorphosed massive sulphides indicator minerals®; Overburden Drilling Management Ltd.). Results of the kimberlite indicator mineral counts are discussed in a following section. Most heavy mineral assemblages do contain abundant barite which is thought to be derived from the local sedimentary bedrock. It is an indication that the local bedrock is well reflected in the heavy mineral assemblages but the large abundance of this mineral restrains its usefulness as a tracer. Other abundant heavy minerals include almandine garnet and epidote derived from the Canadian Shield, siderite and goethite most likely eroded from the ironstone beds of the Shaftesbury Formation shale, and pyrite (marcasite) potentially related to concealed low-temperature mineralization and development of concentrations within the local sulphur-bearing bedrock (Dufresne et al., 2001). The heavy mineral assemblages of the three till samples that contain mineralized clasts (2905, 3090, and 3203) are characterized with a large abundance (40 to 90 %) of pyrite (marcasite).

Gold grain content

Results of the gold grain counts are presented in Appendix 6. Only four samples contain a single gold grain and in all cases the gold is very fine (silt sized). The grains are modified or reshaped suggesting that they are not related to a proximal bedrock source. The estimated gold concentrations in the heavy mineral concentrates are low: 1 to 5 ppb (Appendix 6). None of these samples are thought to contain significant gold content that would indicate nearby gold mineralization.

Kimberlite indicator minerals

The kimberlite indicator mineral (KIM) content of the 19 samples is very low. Based on optical properties and semi-quantitative analyses with a SEM, one grain of pyrope garnet or chromite, in the 0.25 to 0.5 mm sized fraction, was identified in seven samples (Appendix 5; Table 1). In addition, one to two grains of low Cr-diopside in the 0.25 to 0.5 mm sized fraction were identified with the same method in five samples. This identification and classification of the diopside is qualitative only and is based on optical properties. To validate the results of the KIM counts, electron microprobe analyses were conducted on all these grains. Following the analyses, the minerals were labeled based on their chemical composition. The thresholds for mineral names used are Cr-diopside: >0.5 wt.% Cr_2O_3, Cr-pyrope: >2 wt.% Cr_2O_3. Cr-spinel is the label given to spinels with mole fractions of $Al_2O_3 > Cr_2O_3$, whereas chromite has $Al_2O_3 < Cr_2O_3$.

Cr-pyrope garnet. Based on microprobe analyses, the two garnets from samples 1855 and 2424 are Cr-pyrope with moderate Cr_2O_3 content (3.11 and 5.52 wt.%, respectively) (Appendix 7), that follow the lherzolite trend in the CaO versus Cr_2O_3 diagram (Fig. 6). They are most likely derived from aluminous mantle lherzolite xenoliths carried to the surface by kimberlite or a similar volcanic rock with deep mantle roots.

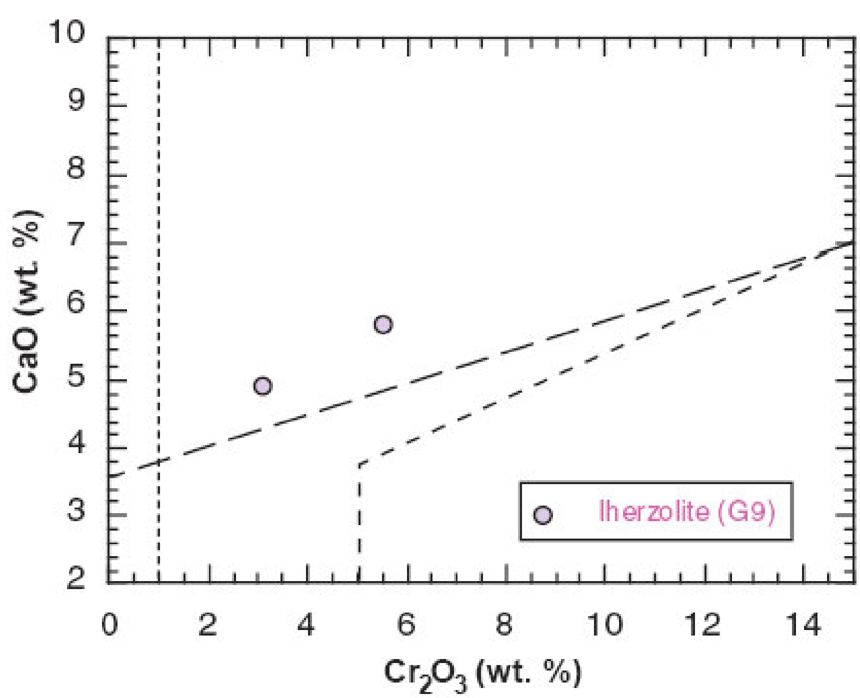

Figure 6. CaO versus Cr_2O_3 for pyrope garnets recovered from till. The long dashed diagonal line represents Gurney's (1984) 85% line essentially dividing lherzolitic G9 garnets (above) and subcalcic harzburgitic (G10) garnets from diamondiferous assemblages (below). The field starting at 5 wt.% Cr_2O_3 is Sobolev's (1977) more restricted field for diamondiferous subcalcic harzburgite assemblages. The vertical line at 1 % separates Cr-poor orange garnets of crustal, eclogitic, pyroxenitic or websteritic origin from more Cr-rich peridotitic garnets (Schulze, 1997).

Chromite. Results of the electron microprobe analyses of chromite grains are presented in Appendix 8. Of the five mineral grains optically identified as chromite, four were confirmed as chromite (samples 2354, 2480, 2910 and 3090) and one as hercynite ($FeAl_2O_4$) (sample 1853). The four chromite grains fall into the area of peridotitic chromite compositions commonly found in garnet- (and spinel-) peridotitic mantle xenoliths from kimberlites. However, they are not Cr-rich enough to plot within the diamond-inclusion or -intergrowth fields outlined by Fipke et al. (1995) (Fig. 7). The hercynite grain contains 0.17 wt.% Cr_2O_3 and 1.31 wt.% ZnO but only 4.85 wt.% MgO. Hercynite has been reported to occur in association with corundum in the Buffalo Head Hills kimberlites (Hood and McCandless, 2004) and since there is no other source for xenoliths in northern Alberta, it can be used as an indicator of intrusive activity, possibly kimberlites.

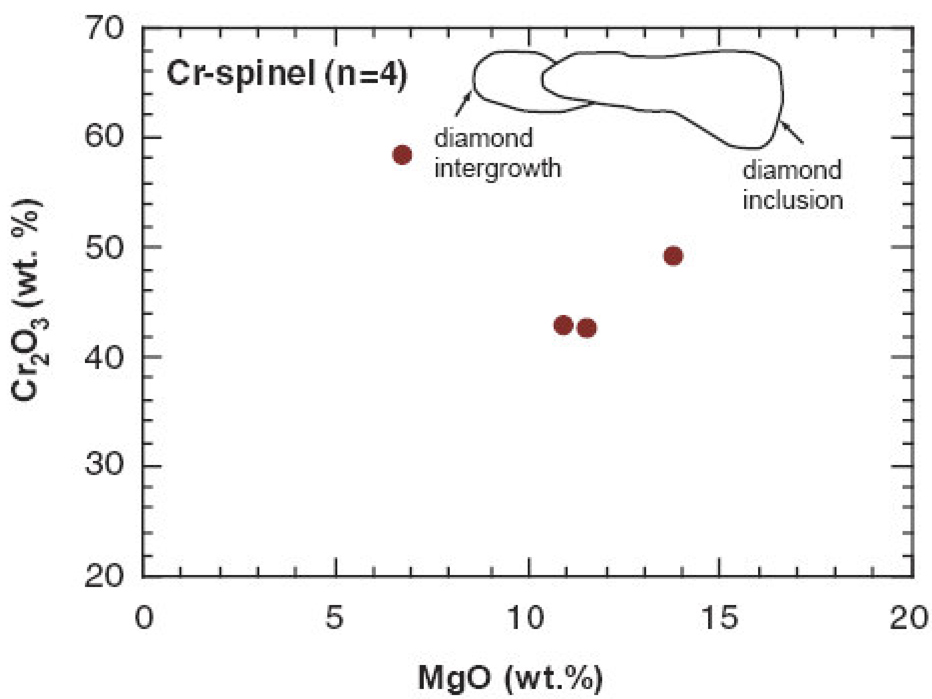

Figure 7. Cr_2O_3 versus MgO for chromite grains recovered from till. Diamond intergrowth and inclusion field from Fipke et al. (1995).

Cr-diopside. A total of six diopside grains were analyzed with the electron microprobe. Four of them are Cr-diopsides with Cr_2O_3 content ranging from 0.7 to 0.8 wt.% and Mg# from 84 to 91 (Appendix 9). The Cr-diopsides plot in the garnet peridotite field of Nimis (1998) (Fig. 8). Only one grain (sample 1854) has a Mg# high enough (>90) to have originated from a mantle assemblage. Following Nimis' (1998) MgO – Al_2O_3 classification, the Cr-diopside from sample 1854 having a low Al_2O_3 and MgO content is most likely a low pressure diopside derived from metasomatized garnet-free peridotites.

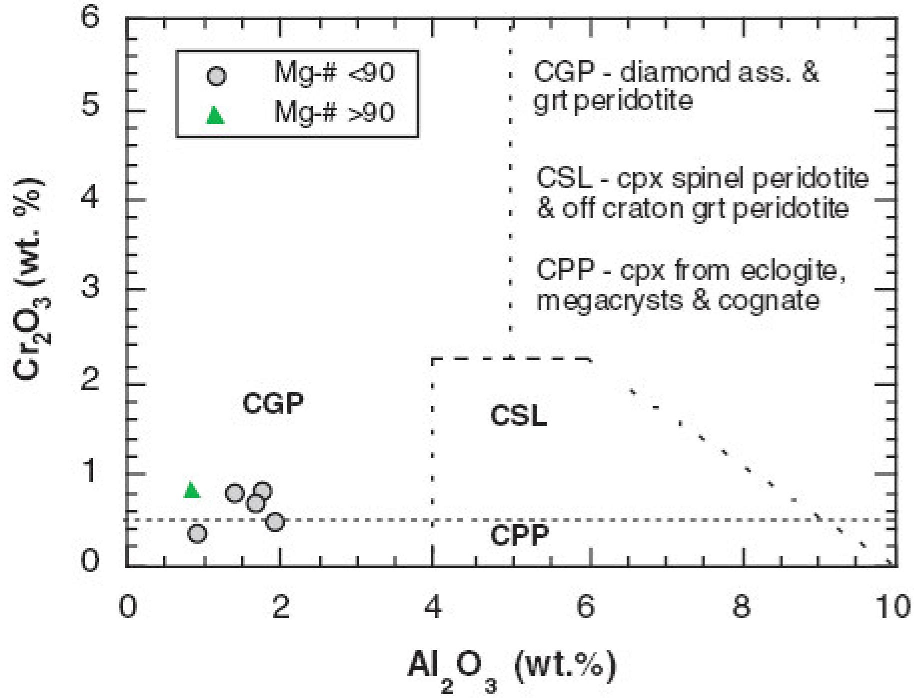

Figure 8. Cr_2O_3 versus Al_2O_3 for diopside grains recovered from till. The discriminatory fields are from Nimis (1998); grt – garnet; cpx – clinopyroxene.

Regional distribution. Table 1 presents a summary of the KIM grains of the 19 samples discussed in this report. Figure 9 depicts the regional distribution of KIMs in till within the Zama Lake and Bistcho Lake map areas (NTS 84L and M, respectively) plotted with data from Plouffe et al. (2007). The number of KIM grains reported on Figure 9 are not normalized to the amount of till processed for heavy mineral separation because of the low KIM counts and the low variation in the weight of till processed on the shaking table (Plouffe et al., 2007). In other words, normalizing the KIM counts on Figure 9 would not change the results.

Sample #	KIM
1855, **2424**	1 pyrope grain each
2354, 2480, 2910, 3090	1 chromite grain each
1854, 2295, **2424**, 2907	1 Cr-diopside

Table 1. Summary of the KIMs content of the till samples; all KIMs are present in the 0.25 to 0.5 mm sized fraction. Only sample 2424 (bold) contains 2 KIMs.

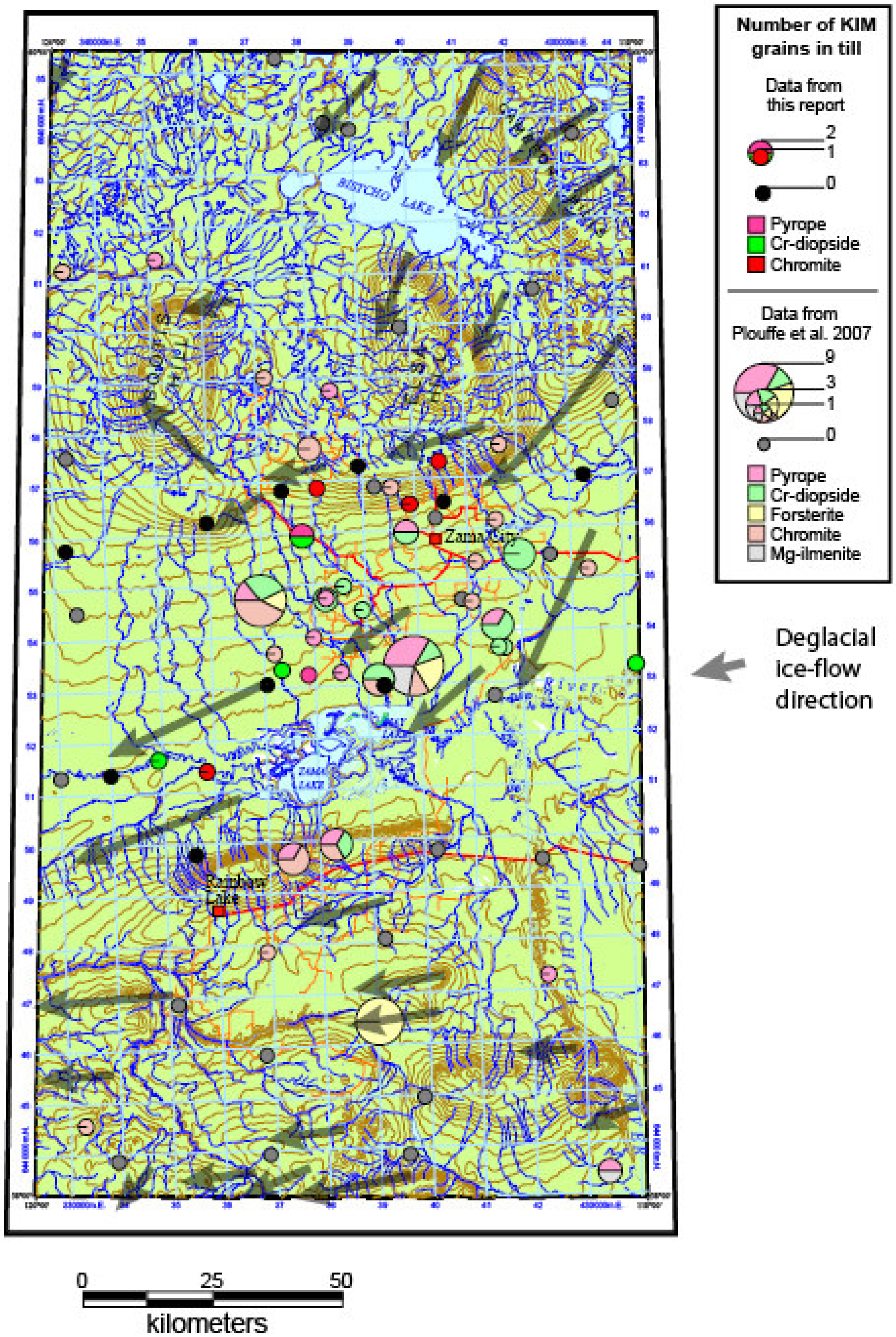
Number of KIM grains in till
Data from this report
2
1
0
Pyrope
Cr-diopside
Chromite
Data from Plouffe et al. 2007
9
3
1
0
Pyrope
Cr-diopside
Forsterite
Chromite
Mg-ilmenite
Deglacial ice-flow direction
BISTCHO LAKE
Zama City
Rainbow Lake
ZAMA LAKE
CHINCHAGA
0
25
50
kilometers

Figure 9A

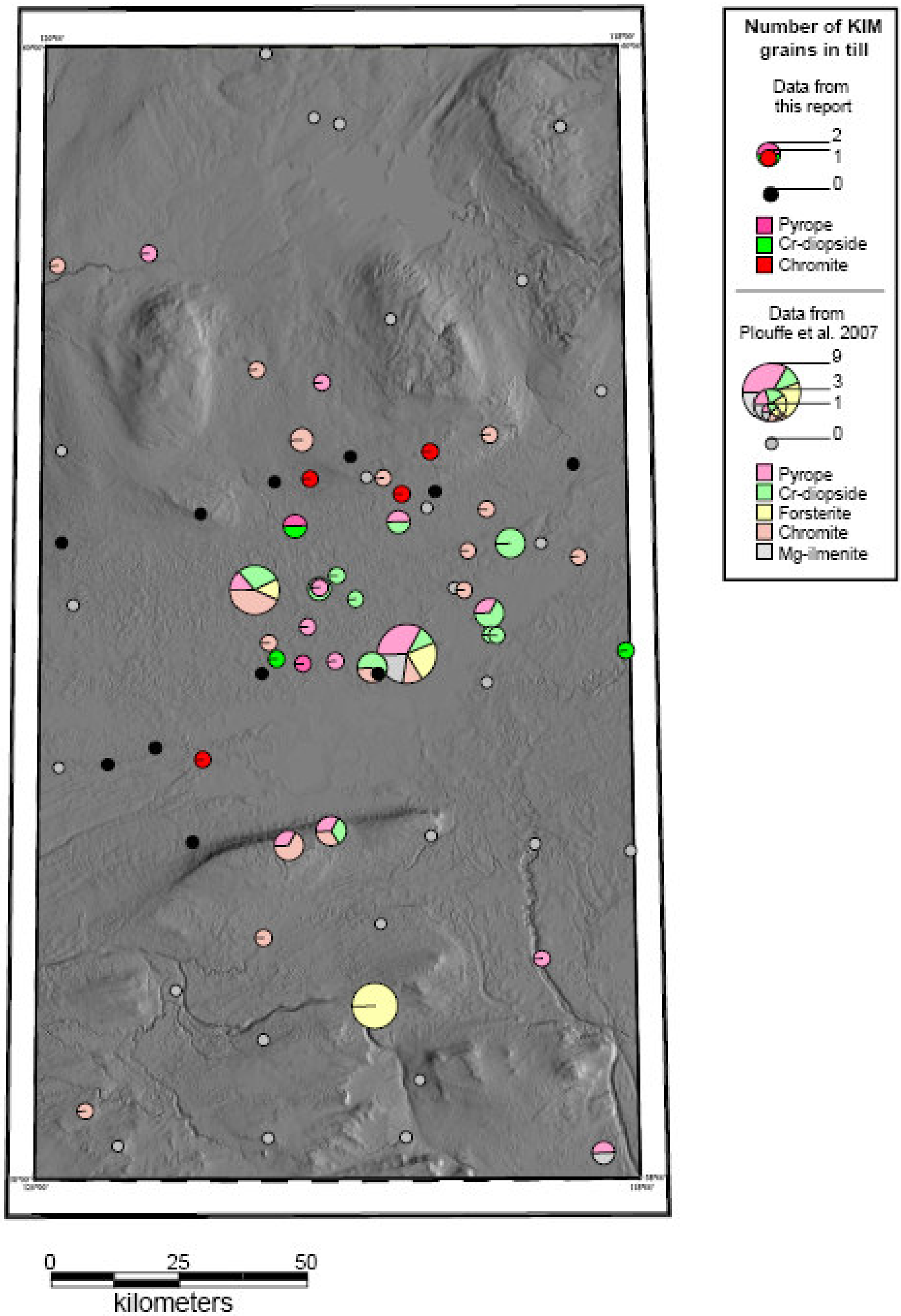

Figure 9B

Figure 9. (A) Un-normalized number of KIMs in till plotted on a topographic map base with regional ice-flow patterns obtained from the surficial geology maps (Paulen et al., 2005a; 2005b; 2006a; 2006b; Plouffe et al., 2004; 2006b; Smith et al., 2005b; 2007). (B) Un-normalized number of KIMs in till plotted on a digital elevation model constructed from 3-arc second (90 m resolution) shuttle radar topography mission data (SRTM). Data from the 19 till samples plotted together with data from Plouffe et al. (2007).

The bedrock source of the few KIMs in the till samples is unknown. Plouffe et al. (2007) suggested that samples containing 1 or 2 KIMs within the Zama Lake-Zama City region may represent background concentrations for a region 100s of kilometres southwest of known kimberlites in the Northwest Territories, in the general up-ice region. On the other hand, samples containing 6 to 9 KIMs are considered anomalous and might reflect the presence of an unknown kimberlite source closer to this region (Plouffe et al., 2007). Although the KIM counts for the 19 till samples reported here are low, all samples with one or two indicator minerals do cluster in the Zama Lake-Zama City region. A follow-up till sampling survey might be warranted to better constrain the distribution of KIMs in till in this region with no known proximal kimberlite occurrence.

Sphalerite and galena

Plouffe et al. (2006a; 2007) and Paulen et al. (2007) reported anomalous concentrations of sphalerite grains with traces of galena recovered from till in a region extending north of Zama-Hay lakes to the vicinity of Zama City, approximately 30 km NW of the Great Slave Lake Shear Zone (Figs. 10 and 11). Additional data on sphalerite and galena abundance in 19 till samples within the region of the anomaly including sample location, total number of sphalerite and galena grains, and the number of grains normalized to 30 kg till samples are presented in appendices 5 (see MMSIM sheet) and 10. These new results, along with those reported by Plouffe et al. (2007), are shown on figures 10 and 11. The recovered sphalerite grains are dark grey to black and angular to sub-angular (Fig. 12), which is similar to those described by Plouffe et al. (2007). Sphalerite was observed in seven out of the 19 till samples with the highest concentrations of 989 sphalerite grains in sample 3203, dominantly in the 0.25 to 0.5 mm sized fraction (ca. 900 grains) with fewer grains in the 0.5 to 1.0 mm size range (89 grains). Also, this sample contains 3% mineralized clasts with pyrite and marcasite (Appendix 4). Three samples contain only trace amounts of sphalerite (1853 2 grains, 2905 and 2907 1 grain each). Galena was observed in trace amounts in only one sample: two grains in the 0.5 to 1.0 mm size range in sample 3203 (Fig. 11).

Geochemical analyses were carried out on the silt and clay-sized fraction of the till samples collected over the study area, as part of this project, including the 19 samples herein reported [cf. Plouffe et al. (2006a) for results]. Within the sphalerite dispersal train, Zn levels are slightly elevated (>95th percentile; 145 ppm) compared to the surrounding regions but are not considered to be anomalous concentrations (Plouffe et al., 2006a). Furthermore, no Pb enrichment was observed in the silt and clay-sized fraction (Plouffe et al., 2006a).

The sphalerite and galena grain counts presented in this report are dominantly from samples north, west and southwest of Zama-Hay lakes. In addition, near the eastern limit of the study area, north of Hay River, sample 2295 contains 25 grains per 30 kg (Fig. 10). Originally, Plouffe et al. (2007) estimated that the sphalerite dispersal train extended over approximately 1200 km^2 but the new data reported here increases the train estimated extent to the southwest, in the general down-ice direction, to at least 4000 km^2 (Fig. 10A). The bedrock source(s) of the sphalerite and galena grains in till is unknown. It is unclear if the sphalerite/galena anomaly in till is derived from a single bedrock source or multiple sources. It is conceivable that the anomaly represents a cumulative dispersal

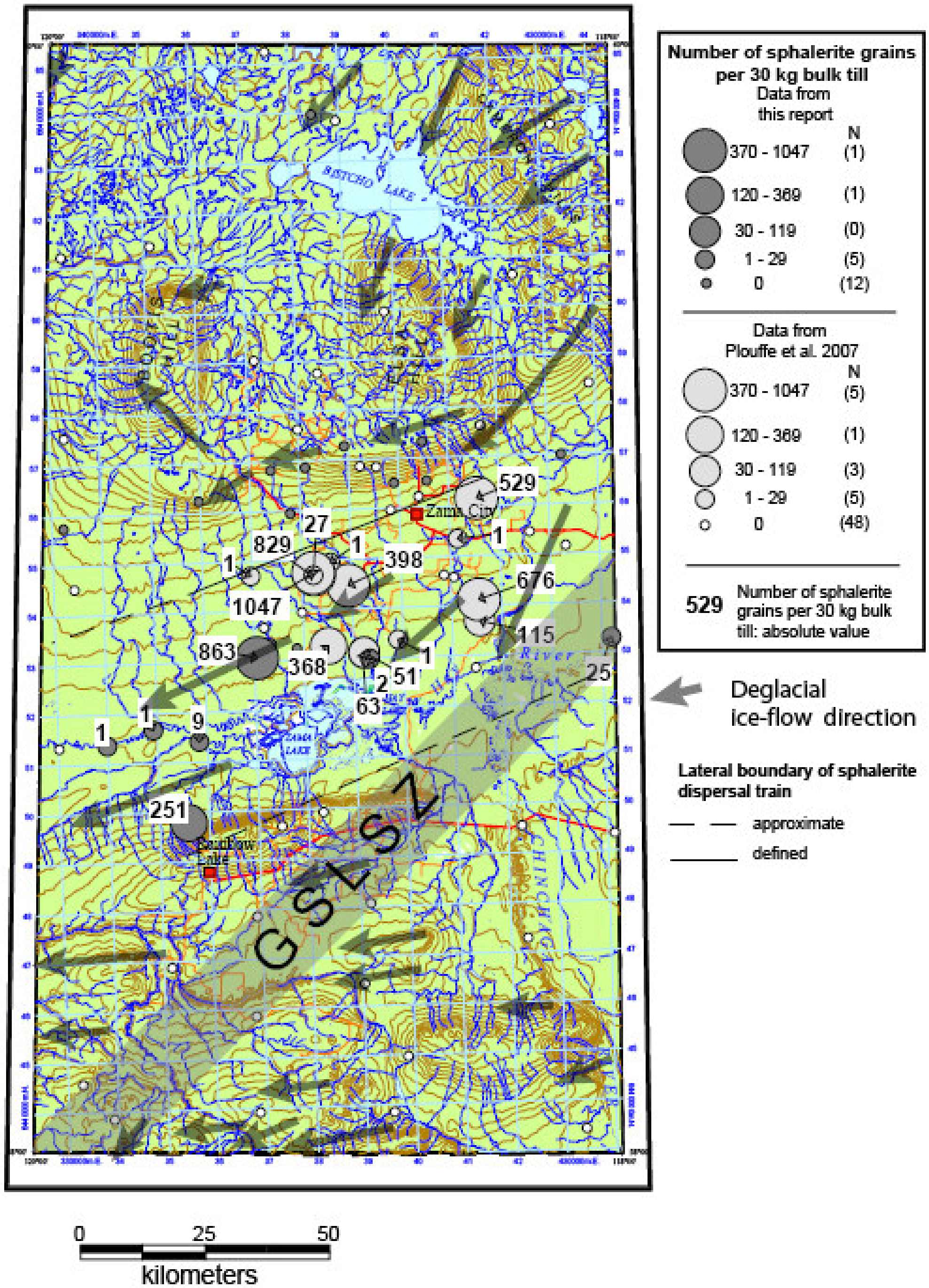
Number of sphalerite grains per 30 kg bulk till
Data from this report
N
370 - 1047 (1)
120 - 369 (1)
30 - 119 (0)
1 - 29 (5)
0 (12)
Data from Plouffe et al. 2007
N
370 - 1047 (5)
120 - 369 (1)
30 - 119 (3)
1 - 29 (5)
0 (48)
529 Number of sphalerite grains per 30 kg bulk till: absolute value
Deglacial ice-flow direction
Lateral boundary of sphalerite dispersal train
approximate
defined
BISTCHO LAKE
Zama City
Rainbow Lake
GSLSZ
529
27
829
1
398
1
1
676
1047
115
863
368
1
51
2
25
63
1
9
1
251
0
25
50
kilometers

Figure 10A

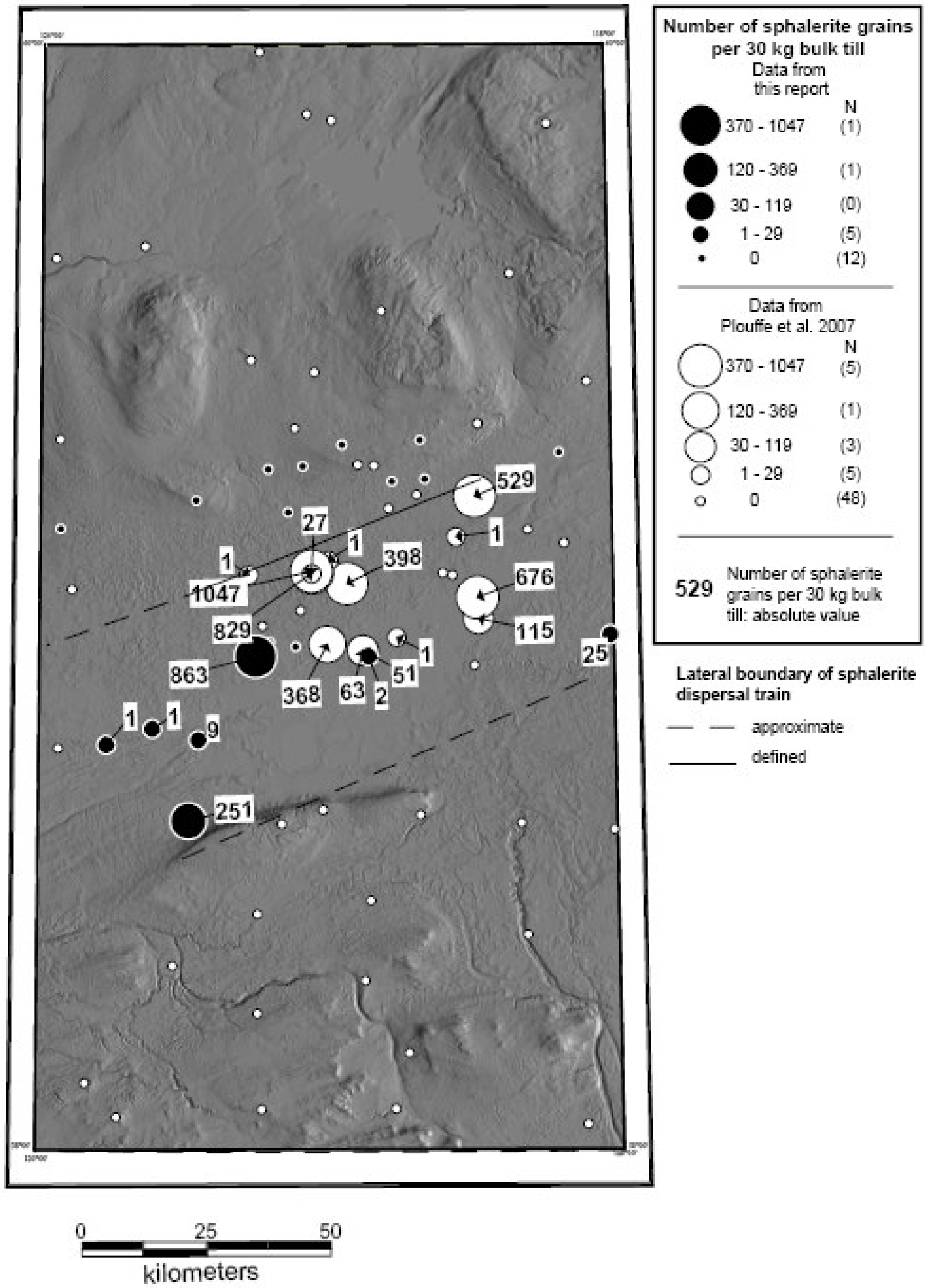

Figure 10B

Figure 10. (A) Number of sphalerite grains in till normalized to 30 kg sample weight plotted on a topographic map base with regional ice-flow patterns obtained from the surficial geology maps (Paulen et al., 2005a; 2005b; 2006a; 2006b; Plouffe et al., 2004; 2006b; Smith et al., 2005b; 2007). GSLSZ – Great Slave Lake Shear Zone (Eaton and Hope, 2003). (B) Number of sphalerite grains in till normalized to 30 kg sample weight, plotted on a digital elevation model constructed from 3-arc second (90 m resolution) shuttle radar topography mission data (SRTM). Data from the 19 till samples plotted together with data from Plouffe et al. (2007).

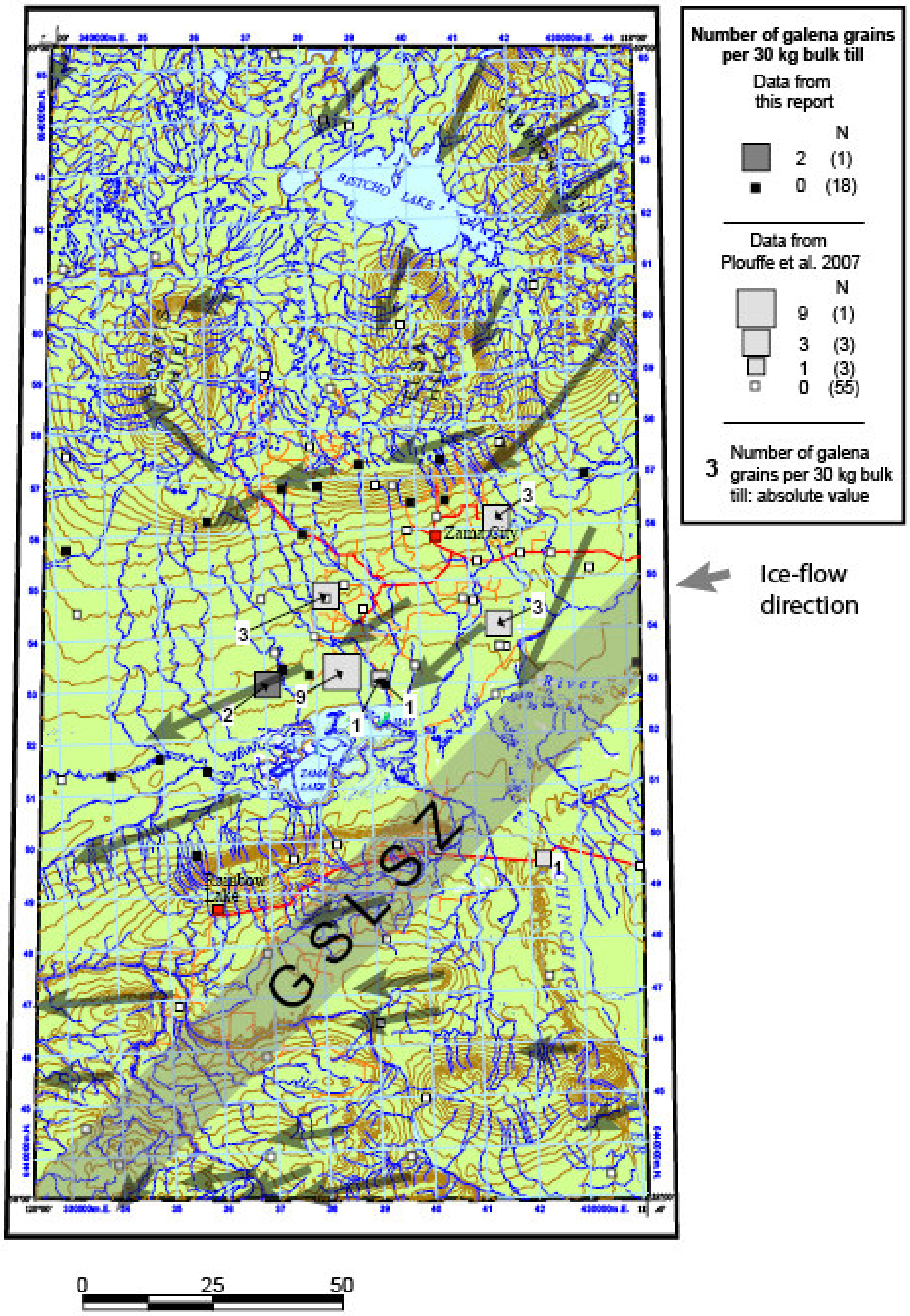
Number of galena grains per 30 kg bulk till
Data from this report
N
2 (1)
0 (18)
Data from Plouffe et al. 2007
N
9 (1)
3 (3)
1 (3)
0 (55)
3 Number of galena grains per 30 kg bulk till: absolute value
Ice-flow direction
BISTCHO LAKE
Zama City
Rainbow Lake
River
GSLSZ
0 25 50
kilometers

Figure 11A

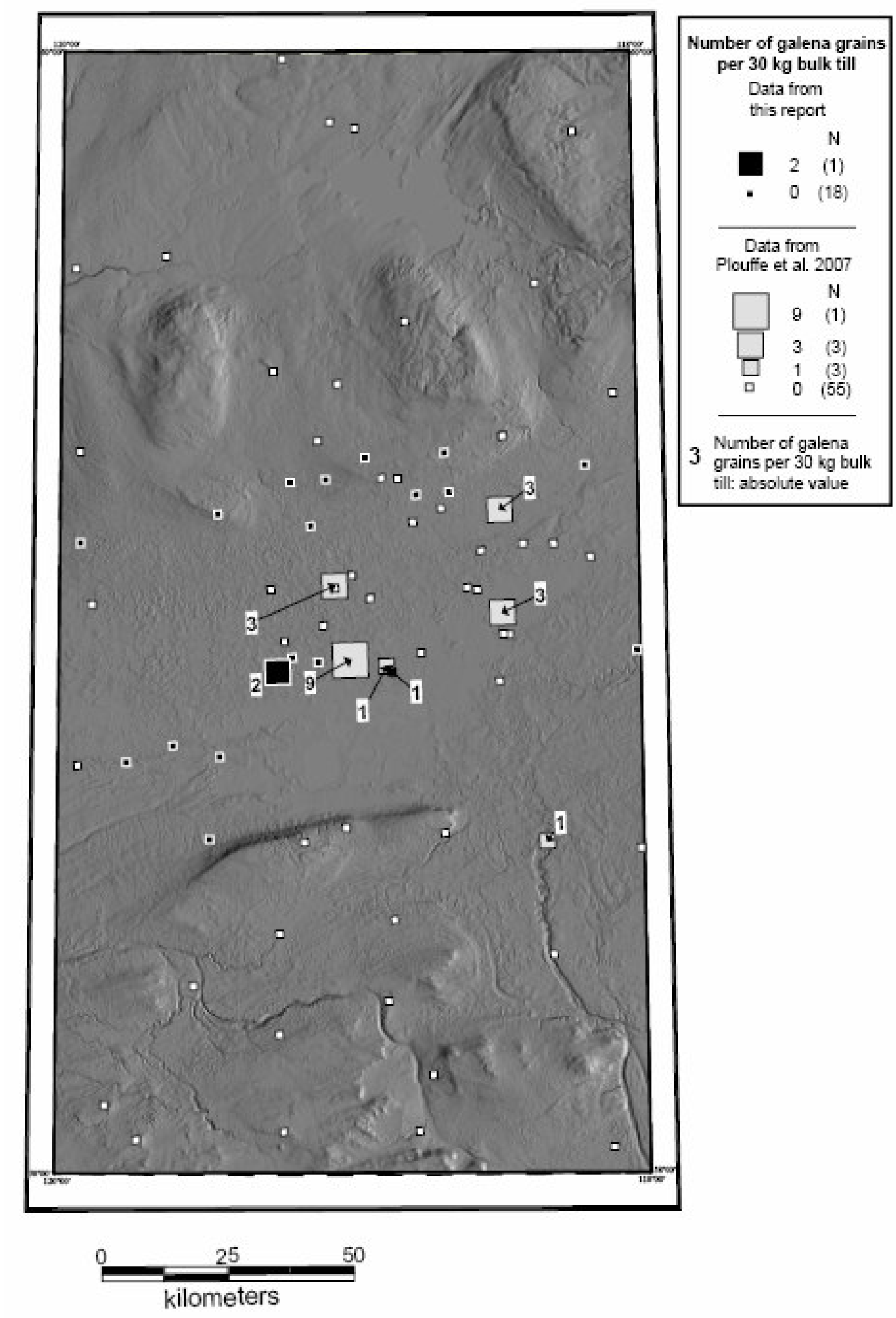

Figure 11B

Figure 11. (A) Number of galena grains in till normalized to 30 kg sample weight plotted on a topographic map base with regional ice-flow patterns obtained from the surficial geology maps (Paulen et al., 2005a; 2005b; 2006a; 2006b; Plouffe et al., 2004; 2006b; Smith et al., 2005b; 2007). GSLSZ – Great Slave Lake Shear Zone (Eaton and Hope, 2003). (B) Number of galena grains in till normalized to 30 kg sample weight plotted on a digital elevation model constructed from 3-arc second (90 m resolution) shuttle radar topography mission data (SRTM). Data from the 19 till samples plotted together with data from Plouffe et al. (2007).

Figure 12. Representative dark grey to black sphalerite grains from till sample 3203. Note the angularity of the grains. Divisions between scale bars equal 1 mm.

train derived from multiple concealed bedrock sources. The current sample distribution does not allow determination of the up-ice limit of the dispersal train. Two samples located approximately 30 and 40 km NE of Zama City and two samples located close to the highway east of Zama City are barren of sphalerite suggesting that the dispersal train terminates. Because the sphalerite distribution in till is heterogeneous, as indicated by several samples within the dispersal train that do not contain any sphalerite grains, we conclude that the clear cut-off of the dispersal train remains to be identified.

As indicated by Plouffe et al. (2006a; 2007) and Paulen et al. (2007), and reiterated here, the mineralogical anomaly is not thought to be derived from the world class Pine Point Pb-Zn Mississippi Valley Type deposit located on the south shore of Great Slave Lake, 330 km to the northeast (Figs. 1 and 4) for several reasons:

1. Given the known ice-flow directions, sphalerite grains from the Pine Point Pb-Zn deposit could have been transported to the Zama Lake region only during the onset and retreat phases of the last glaciation (Fig. 4). At glacial maximum, mineralized debris from Pine Point was transported westerly (255°), measured from striations observed at the Pine Point abandoned mine, and not towards Zama Lake.

2. The sphalerite concentrations in till (several samples with more than 250 sphalerite grains per 30 kg of till) are too high to have been preserved without dilution over such a long distance of glacial transport (ca. 330 km). Plus, the nine sample sites with high sphalerite grain counts (and seven with lesser concentrations) are situated within a geographically restricted area near Zama and Hay lakes.
3. The vast majority of the sphalerite and galena grains are pristine and fragile (Fig. 12, see also photographs of sphalerite and galena in Plouffe et al., 2007) which suggest a short distance of glacial transport.
4. Geochemical analyses of the silt and clay-sized fraction of the till does not reveal proportionally elevated concentrations of lead and zinc, suggesting that glacial comminution, and potentially transport, of sand-sized sphalerite and galena has been limited.
5. Plouffe et al. (2007) reported that the sphalerite in till in the Zama region contains on average lower levels of Pb and Fe, and higher Cd concentrations, than sphalerite from Pine Point (Kyle, 1981).
6. Sphalerite colour from Pine Point varies from tan, yellow, light red-brown, dark red-brown to dark brown (Kyle, 1981). Dark grey sphalerite as observed in till in northwest Alberta was not reported at Pine Point.

These observations support the contention that the sphalerite in till in the Zama Lake – Zama City area comes from unknown sedimentary-hosted Zn mineralization within the Cretaceous bedrock.

Discussion

Pebbles in the 4-8 mm sized fraction of till are dominated by well-indurated and distally derived lithologies: Canadian Shield-derived gneiss and granite, as well as limestone, dolomite, and quartzite. This observation suggests long distance glacial transport of till deposited in the Zama City – Zama Lake region seemingly in contradiction to our conclusion that the sphalerite and galena in till is derived from the local bedrock. However, the low representation of Cretaceous shale (likely Shaftesbury Formation) in the 4-8 mm sized fraction of the till samples likely reflects the poor induration of the shale, its susceptibility to glacial comminution, and the destruction of shale clasts on the shaking table and sieves during processing for heavy mineral separation. Consequently, the dominant local bedrock lithology (shale) is grossly under-represented in the results of the pebble counts. Photographs of the till from this region support this interpretation because they reveal the presence of abundant shale fragments which are not readily visible macroscopically on moist, fresh sediment exposures (Fig. 13). Shale fragments, such as the ones shown on Figure 13, would not survive the washing of the sample on the shaking table and wet sieving. Note that the presence of sand-sized barite grains, a regional sedimentary mineral, does indicate that the local bedrock is well represented in the sand sized fraction of the till.

As discussed above, three till samples were found to contain mineralized shale clasts with pyrite and marcasite: samples 2905, 3090, and 3203. No direct relationship seems to exist

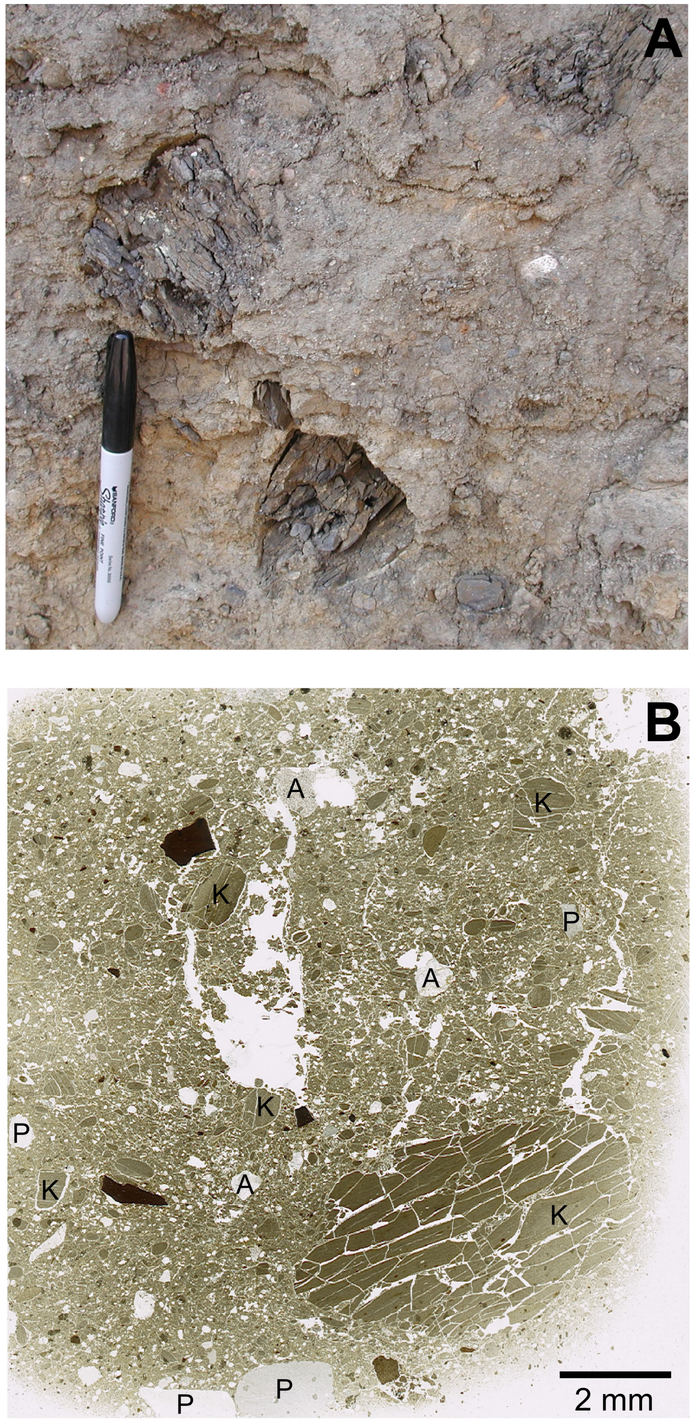

Figure 13. Clast-rich till derived primarily from soft, poorly-indurated Cretaceous shale. A: Shale cobbles and pebbles exposed in a section. B: Photomicrograph of till sampled from the Zama City region exhibiting abundant Cretaceous shale fragments (K) with minor Paleozoic carbonate (P) and Canadian Shield (A) derived clasts (photomicrograph courtesy of Mark Tarplee). Figure from Paulen (in press).

between the weight percentage of mineralized clasts and the abundance of sphalerite in the samples. Sample 3203 contains 863 sphalerite grains per 30 kg bulk till and 3% mineralized clasts. On the other hand, samples 2905 and 3090 contain 2% and 3% mineralized clasts respectively, but their sphalerite grain content is only 0 and 1 grain, respectively. Dufresne et al. (2001) report abundant disseminated sulphide (pyrite and marcasite) occurring within the Second White Specks Formation bone beds of the Shaftesbury Formation shale and as concretionary units within Dunvegan Formation sandstone. Dufresne et al. (2001) speculate that the potential exists for significant concentrations of metals to be correlated with the sulphide sources. However, it remains uncertain if the bedrock sources of the mineralized clasts with pyrite and marcasite are related to the presumed locally-derived bedrock source of the sphalerite grains found in till from the Zama Lake area.

Summary

1. Data from 19 additional till samples processed to recover heavy minerals confirm and further extend the limits to the southwest of a sphalerite dispersal train in the Zama Lake – Zama City area of northwest Alberta.
2. This mineralogical anomaly in till is not thought to be derived from the Pine Point Mississippi Valley Type deposit located approximately 330 km northeast in the Northwest Territories but is rather interpreted to result from glacial erosion of undiscovered proximal sedimentary hosted Zn mineralization.
3. KIMs are observed in till in the same region. A cluster of samples in the Zama Lake – Zama City area with one to nine KIMs per approximately 30 kg of till might warrant a follow-up investigation.
4. Pebbles in the 4-8 mm sized fraction of till are dominated by the well indurated and distally derived lithologies: Shield, carbonates, and quartzite. No strong spatial trend is observed in the till pebble lithologies except for a subtle decrease of Shield derived material to the southwest.

Future publication

Additional samples were collected in the Bistcho Lake (84M) and Zama Lake (84L) regions. Results from these samples may provide additional insight into the nature of the sphalerite dispersal train(s) and deciphering the possible sources of the KIMs; these results will be published at a later time.

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