Glacial and Stream Sediments Sampling in Support of Kimberlite Exploration in Northeastern British Columbia[1]

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INTRODUCTION

The objective of this project is to evaluate the mineral potential of the region northeast of Fort Nelson, BC, in particular the potential to host diamondiferous kimberlites, with the intended benefit of promoting future investment in natural resources exploration. The project is funded by the Geological Survey of Canada (GSC) and by Geoscience BC (GBC). The Resource Development and Geoscience Branch (RDGB) of the BC Ministry of Energy, Mines and Petroleum Resources (BC MEMPR) also has been conducting Quaternary geology studies in the region and in collaboration with the GSC have undertaken a surficial geology mapping project in this area since 2003. The new project outlined here builds on that collaborative work and receives additional benefit from two Masters theses projects, which are aimed at mapping surficial geology and reconstructing the glacial history of regions on and adjacent to the Etsho Plateau (Demchuk *et al.*, 2005; Trommelen *et al.*, 2005).

This project was stimulated by the announcement of the first recorded occurrence of kimberlite indicator minerals (KIMs) in northeastern BC by members of this joint provincial-federal research group at the Mineral Exploration Roundup 2005 (Simandl, 2005). KIMs were found in 14 out of 22 samples of glaciofluvial sediment submitted for analysis (Levson *et al.*, 2004; Fig. 1). Soon after the official release of results, mineral staking occurred in six areas of northeastern BC.

The current GBC project builds on activities conducted as part of the existing collaborative surficial geology project by the BC MEMPR and the GSC. British Columbia Oil and Gas Development Strategy funding was provided to the RDGB in 2002 to initiate a project with the principal objective of identifying new granular aggregate resources to improve and develop access roads in the extensive gas fields of northeastern BC (Johnsen *et al.*, 2004; Levson *et al.*, 2004, 2005; Ferbey *et al.*, 2005). In the following year, the GSC and BC MEMPR instigated a four-year collaborative project in northeastern BC under the GSC's Northern Resource Development Program and the Targeted Geoscience Initiative (TGI-2) to provide geoscience information in support of exploration for not only granular aggregate resources, but also shallow gas reservoirs in unconsolidated Tertiary – Quaternary sediments, and the potential presence of kimberlites. The study area of this collaborative project extends into northwestern Alberta where similar objectives are being pursued by the GSC and the Alberta Geological Survey (for an example of results, see Smith *et al.*, 2005).

The composition of KIMs in glaciofluvial sediment samples collected as part of this collaborative project (Levson *et al.*, 2004) was reported by Simandl *et al.* (2005a, b). Simandl *et al.* (2005b) suggested that northeastern BC "could be more favorable for diamond exploration than previously thought." The authors indicated that the source of the KIMs is still unknown and that they could be derived locally, from the Northwest Territories to the northeast and/or Alberta to the east. In light of the initial positive KIMs results, it was decided that additional sampling of glacial sediments and stream sediments and waters in the Etsho Plateau region would help elucidate potential sources of the KIMs, and in so doing, help to encourage investment in this area by the diamond exploration industry.

PHYSIOGRAPHY AND GEOLOGY OF THE STUDY AREA

The study area lies within the Fort Nelson Lowlands, part of the Alberta Plateau, which is a dominantly flat to gently rolling region situated below an elevation of 600 m above sea level. More specifically, it is centred on the Etsho Plateau, a subdivision of the Fort Nelson Lowlands, where KIMs were first reported in glaciofluvial sediments (Fig. 1; Simandl *et al.*, 2005a). The subdued topography of the region is inherited from the underlying horizontal to gently dipping sedimentary bedrock. The region is poorly drained, secondary streams are not deeply incised, except those situated in former glacial spillways, and organic deposits abound. In contrast, the Etsho Plateau stands approximately 300 m above the surrounding lowlands with a denser network of streams along its flanks compared to the adjacent lowlands. Drainage radiates from the Etsho Plateau into the Petitot River to the north, Sahtaneh River to the west, Kotcho River to the southeast and Shekilie River to the east. The Petitot and Sahtaneh rivers ultimately drain

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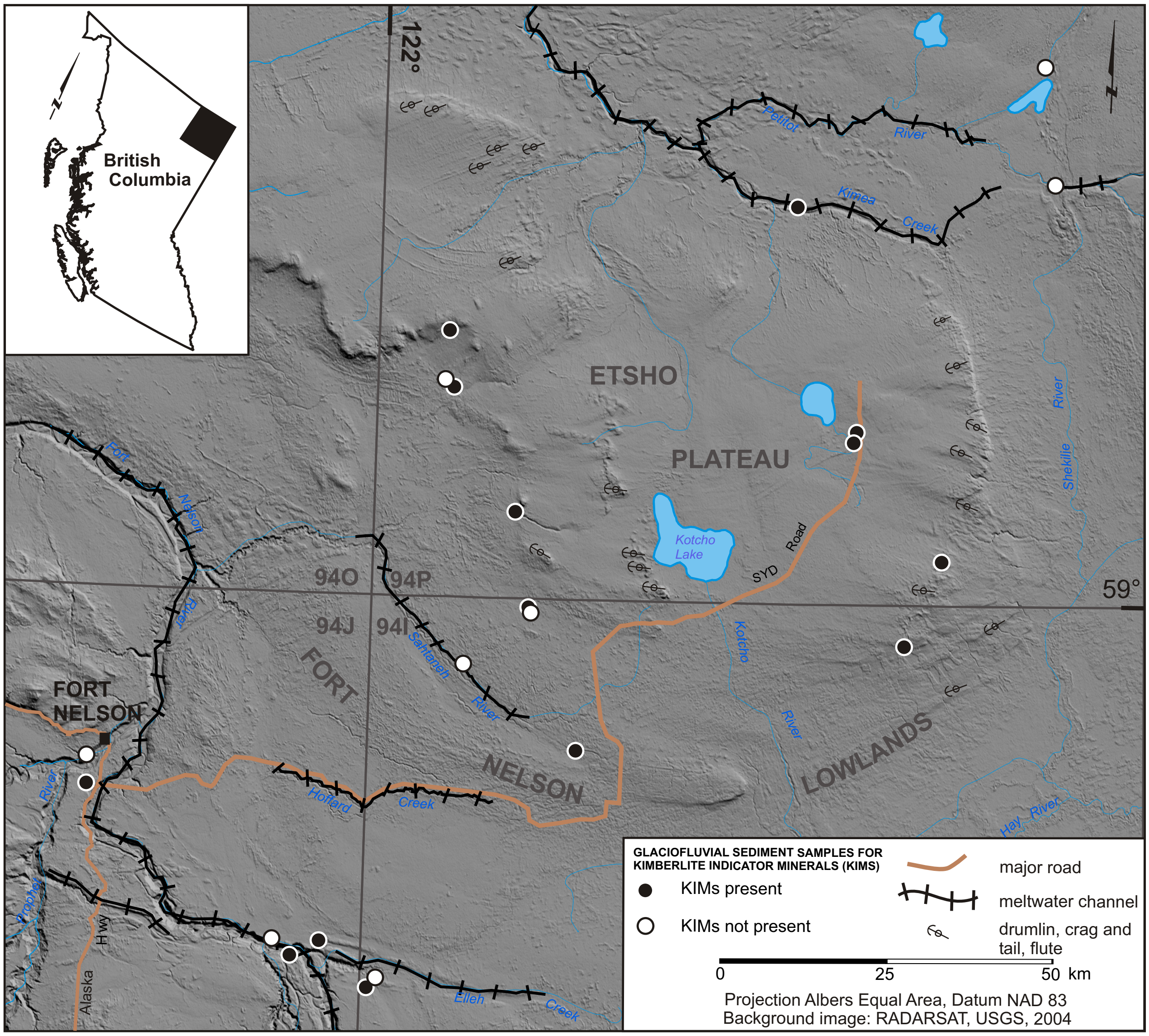

Figure 1. Location map of study area showing major ice-flow direction indicators and glaciofluvial sample sites. See Simandl *et al.* (2005a, b) for details on the KIM survey results.

to the Liard River while the Kotcho and Shekilie rivers flow to the Hay River, and then ultimately into the Mackenzie River and Beaufort Sea. Access to the region is limited to the Sierra-Yoyo-Desan (SYD) Road and a limited number of secondary all-season roads, which can rapidly deteriorate in wet weather conditions owing to their construction with clay-rich glacial sediment.

During the Late Wisconsinan glaciation, northeastern BC was completely covered by ice which flowed west and southwest across this region from the Keewatin ice divide of the Laurentide ice sheet (Fig. 1). The glaciers eroded the soft fine-grained Cretaceous sedimentary bedrock along with the glaciolacustrine sediments deposited at the advancing ice margin, resulting in a fine-grained silt and clay-rich regional till cover. The clast content in the tills is generally low (<10%), and rock fragments largely consist of the harder rock types derived from the Canadian Shield to the northeast with lesser amounts of carbonate and sandstone clasts derived from Cambrian to Devonian strata situated along the western Shield margin. Clasts of local sandstone and shale are found in small amounts. During deglaciation, large glacial lakes formed along the glacier margins where ice blocked the regional eastward drainage of rivers (Mathews, 1980). Extensive meltwater channels flowing from the retreating ice front and outlets of glacial lakes were incised into the glacial sediments and in some places bedrock (Fig. 1). Glaciofluvial sediments associated with these former meltwater channels are the focus of some KIM sampling as they are thought to provide a greater regional signature compared to till samples and is appropriate to the reconnaissance-scale exploration being conducted here. Nonetheless, in much of the study area, extensive bogs and fens with more than a metre of accumulated organic material greatly impede the systematic sampling of glacial sediments.

Northeastern BC is underlain by Archean and Proterozoic basement rocks (Gehrels and Ross, 1998; Simandl, 2004; Simandl *et al.*, 2005b) that extend into Alberta where diamondiferous kimberlites have been reported (Dufresne *et al.*, 1996; Carlson *et al.*, 1999; Eccles *et al.*, 2003;

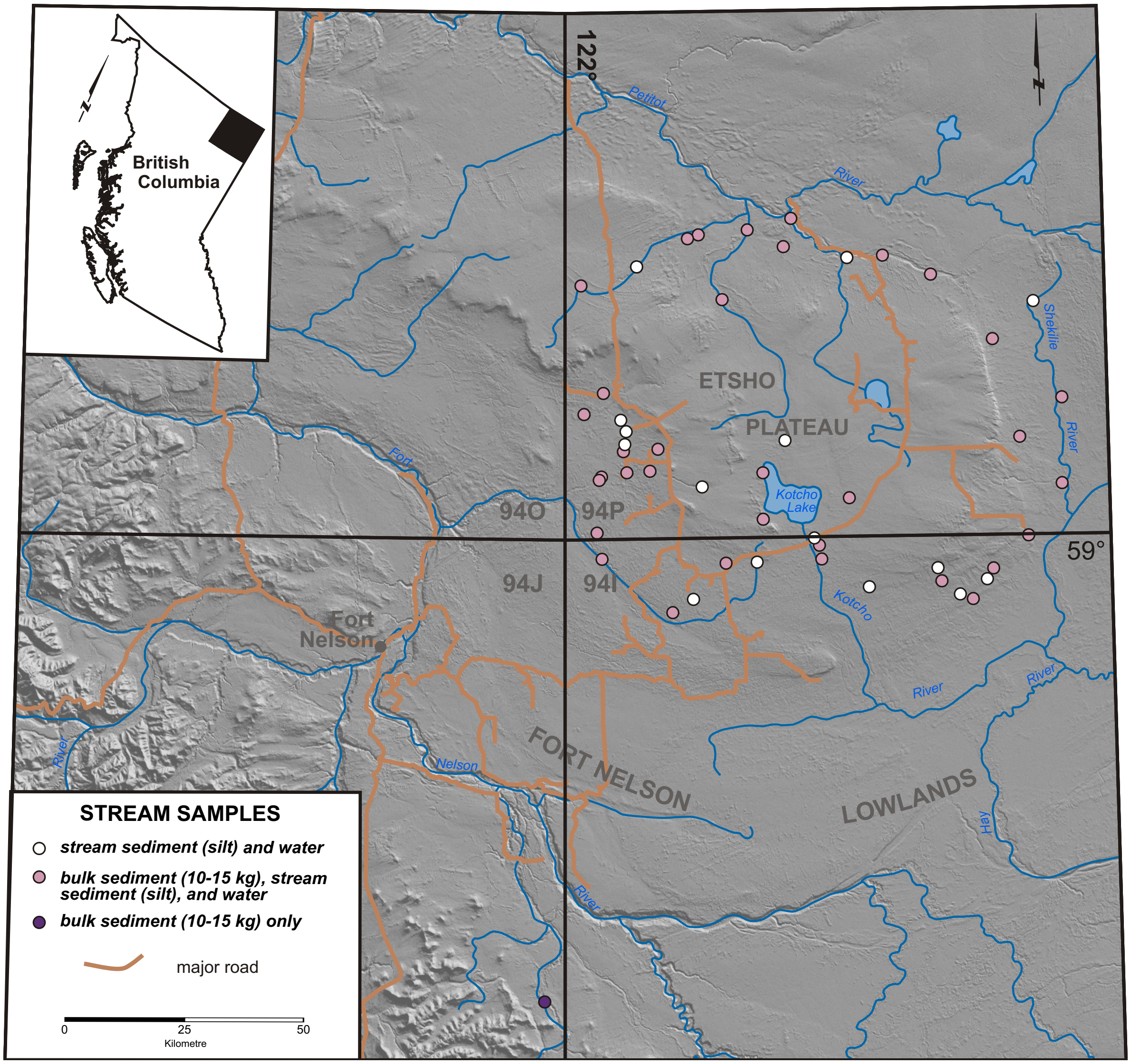

Figure 2. Location map of stream sediment and water sample sites, collected during the fall of 2005. Projection: Albers Equal Area, Datum NAD 83. Background image: RADARSAT, USGS, 2004.

Skelton *et al.*, 2003). The basement rocks are overlain by a succession of Paleozoic and Mesozoic sedimentary rocks including the Cretaceous Shaftesbury and Dunvegan formations, which outcrop in a limited number of places. As a result, the prospecting methodology used by this project restricts potential discoveries of kimberlites to those younger than or contemporaneous with the Cretaceous host rocks. Local kimberlites older than the Cretaceous rocks and thus overlain by them would not contribute indicator minerals to the surficial sediments. Furthermore, it is possible that older or Cretaceous kimberlites have been eroded and contributed KIMs into the Cretaceous bedrock. Consequently, the KIM content of a limited number of Cretaceous bedrock samples will be evaluated.

PROJECT DESCRIPTION AND OBJECTIVES

As part of a multidisciplinary effort to investigate the resource potential for kimberlite, diamonds, gold, base metal and other economic commodities in northeastern BC, an integrated glacial sediment survey over one year and a stream sediment, water and heavy mineral concentrate survey over two years are being completed in northeastern BC. Results obtained from both components of this project will complement each other.

Stream Sediment and Water Geochemistry

The main objective in the first year (2005) of this activity is to fully evaluate the effectiveness of stream sediment and water geochemistry at detecting potential kimberlites in the region of the Etsho Plateau. Based on the results of the sampling completed in 2005 (Fig. 2), a second year of stream sediment and water sampling (2006) covering the equivalent of one or two 1:50 000-scale map sheets will be undertaken. Geochemical surveys combining the collection of stream silt, water and coarse sediment for heavy mineral concentrates has proven effective at detecting kimberlites in the Buffalo Head Hills region of Alberta (Friske *et al.*, 2003), where the physiography is similar to the Etsho Plateau.

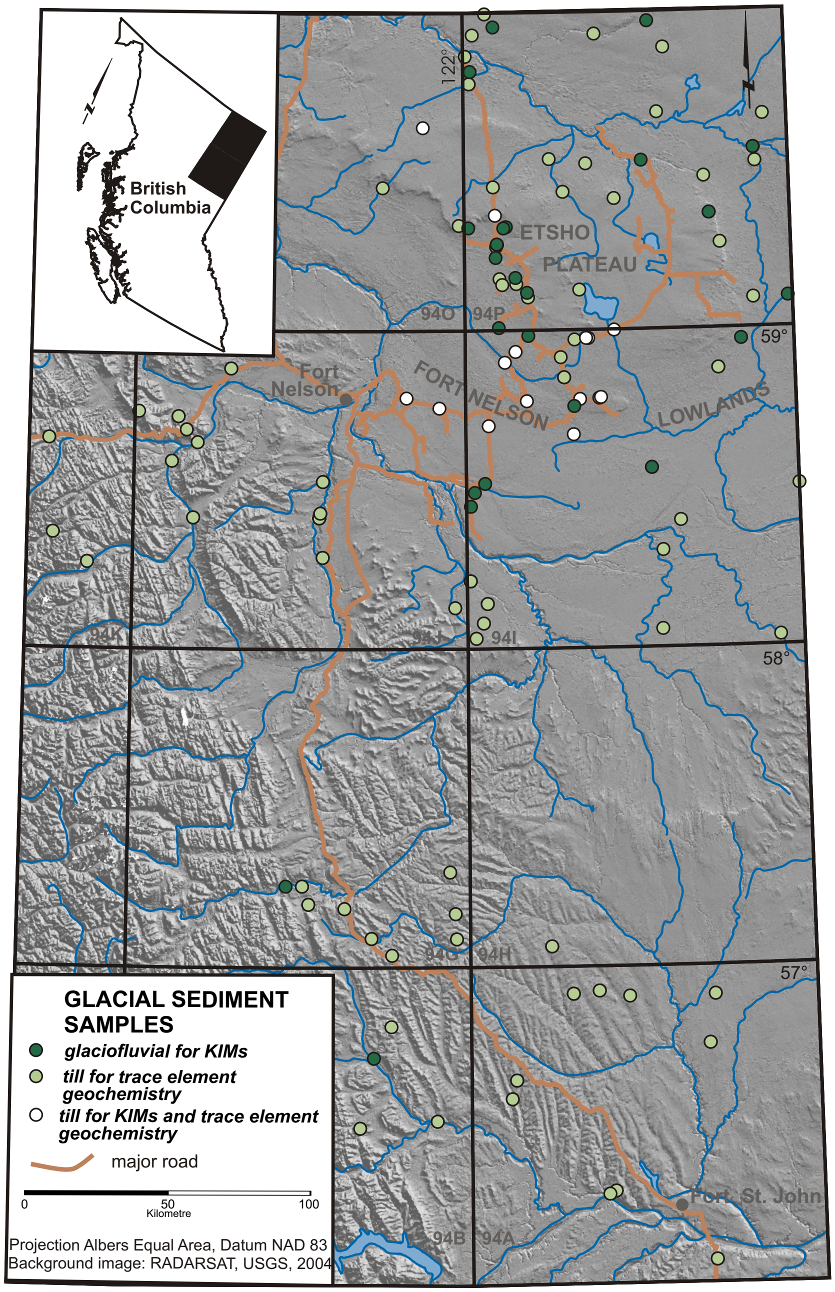

Figure 3. Location map of the glacial sediment sample sites, collected during the summer and fall of 2005.

Glacial Sediment Survey

Sampling of glacial sediments was completed during the summer and fall of 2005 (Fig. 3). It was principally focussed in the vicinity of the Etsho Plateau in the region where KIMs were previously reported. The main objective of this component is to better define the extent of the region where KIMs occur in glacial sediments and the potential source area. As part of the sampling program, till and glaciofluvial sediments have been sampled. Till samples generally reflect a more local source and glaciofluvial sediments can reflect a proximal or distal source depending on their nature and genesis. Therefore, sampling of these two sediments will provide additional information as to the source of the KIMs.

Increased helicopter access, gained from the funding provided by GBC, will also allow an improvement in the quality and accuracy of the surficial geology maps produced as part of the ongoing GSC and BC MEMPR collaborative project. Surficial geology maps are one of the fundamental sources of information necessary to reconstruct the glacial and ice-flow histories of the region, which are crucial elements to trace mineralogical or geochemical anomalies identified in the surficial sediment cover. Two surficial geology maps have been released from this area (Bednarski, 2005a, b) while full coverage of NTS 094I and 094P is expected to be completed by spring 2007. A further added benefit of the improved regional access gained through this project is the support it provides for exploration and assessment of new granular aggregate resources in the more inaccessible areas. Local aggregate sources are critical to the promotion and sustainable development of petroleum resources in northeastern BC.

METHODOLOGY

Stream Sediment and Water Sample Collection

The integrated stream sediment, water and coarse sediment survey consists of two components:

- the collection of stream sediments and stream water samples at every site; and
- the additional collection of a bulk sediment sample (10–15 kg wet-screened through a 12-mesh [1.68 mm] sieve) from every second site (on average), from which the heavy mineral fraction is derived.

Stream sediment (silt) and water samples are collected at predetermined sites at an average density of one sample per 13 km^2. At the stream sites (first or second-order streams), a clean water sample(s) and a silt-clay – rich sediment sample are collected. Access is usually by helicopter, but also includes the more cost-effective use of trucks along existing roads, and all-terrain vehicle access along winter roads, pipeline right-of-ways and seismic lines. At sites selected for bulk sediment sampling (1 sample/25 km^2), coarse sediment (ideally from upstream points of mid-channel bars) is wet-sieved through a 12-mesh (1.68 mm) screen to collect 10 to 15 kg of material. Routine stream sediment samples (silt) and one or two water samples are also collected at the coarse sediment sample sites. Sample locations are recorded with a global positioning system (GPS) receiver, field observations are noted and the site is flagged.

Glacial Sediment Sample Collection

As with the stream sediment survey, two types of glacial sediment samples were collected:

- large bulk samples (equivalent to a 15 gallon pail) of till or glaciofluvial sediment for KIM analyses; and
- smaller samples (approximately 2 kg) of bulk till for geochemical analyses (Fig. 3).

The glacial sediment survey follows a methodology which has proven successful at identifying the presence of kimberlites throughout Canada; bulk glacial sediment samples are analyzed for their KIM content (McClenaghan *et al.*, 2002; McClenaghan, 2005). Using this method, bulk glacial sediment samples are collected below the depth of the oxidized soil horizon from road cuts, river bluffs, hand-dug pits, borrow pits and sump pits. Till sampling for geochemical analyses was completed in the Etsho Plateau region and was extended to the west and south of the study area to provide reconnaissance-scale evaluation of the mineral potential of this vast territory. Furthermore, in addition to the large bulk sediment samples collected in the Etsho Plateau region, two large glaciofluvial sediment samples were collected approximately 150 km northwest of Fort St. John (Fig. 3). Glacial sediment sample sites were recorded with a GPS receiver, field observations were noted, and sites were flagged.

Sample Processing and Analysis

Glacial and stream sediment samples are shipped to a commercial laboratory, which conducts the heavy mineral separation using a combination of a shaking table and heavy liquid to separate the nonferromagnetic heavy mineral fraction. This heavy mineral fraction is picked for KIMs and other indicators, such as gold, in the same laboratory. Potential KIMs are sent to the GSC for microprobe analysis. Spiked and duplicate samples are included in the samples sent to the laboratories to monitor analytical quality. Clasts from the glacial sediment samples are retained for glacial transport study.

Bulk sediment subsamples are sent to a separate laboratory for geochemical analyses. Inductively coupled plasma mass spectrometry analyses are conducted on the silt and clay-sized fraction (-250 mesh or <0.063 mm) of the till samples only. Analytical quality will be monitored with standard and duplicate samples.

ACHIEVEMENTS TO DATE

Field activities for both components of this project were conducted in the summer and fall of 2005. Stream sediment and water samples were collected at 51 sites including 36 sites with bulk sediment samples (10–15 kg; Fig. 2). A total of 123 glacial sediment samples were collected including 25 glaciofluvial samples and 98 till samples (Fig. 3). Sampling was hindered by wet weather conditions and the rarity of sediment exposures suitable for the collection of adequate KIM sediment samples.

The samples will be analyzed in the winter of 2006. Results will be released in 2006 in the form of open file reports.

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