19. Project Unit 07-032. Surface Media Geochemical Sampling at the Victor Kimberlite Region, Northern Ontario, and the Kirkland Lake Kimberlite Region, Northeastern Ontario

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INTRODUCTION

Kimberlites represent ultramafic bodies that can drastically alter the chemistry of meteoric waters flowing through them. The process of low-temperature serpentinization of kimberlites can cause high pH values and extreme low Eh values (Sader et al. 2007). This unusual natural water chemistry, when compared with the compositions of waters flowing through volcanic rocks or limestone, may show surface geochemical anomalies in soil, surface and shallow groundwaters, and soil gas where kimberlites are overlain by thick (10 to 40 m), dry glaciolacustrine, glaciofluvial and glacial till sediments. However, methods have not been established to determine if geophysical anomalies indicate kimberlites where these features are overlain by substantial thicknesses of peat dominant wetlands.

This project focusses on exploration of kimberlites in wetlands. One of the purposes of this project is to identify the surficial media that yield geochemical anomalies and to develop surficial geochemical exploration methods for kimberlite. In addition, the 2 regions involved in this study (Kirkland Lake, in northeastern Ontario and the kimberlites from the area surrounding the DeBeers' Victor mine site in the James Bay Lowland) will provide excellent comparison because of the differences in terrain, host rock geology, surficial mediums, climate and possibly biological activity. Samples collected (and to be collected) for this study consist of peat, peat water, shallow groundwater, soil gas hydrocarbons (SGH), dissolved gas within groundwater and spontaneous potential (SP) surveys.

LOCATION

Field work was conducted at kimberlites within close proximity of the DeBeers' Victor mine site. The kimberlites are located in the James Bay Lowland approximately 90 km west of the community of Attawapiskat (Figure 19.1). The field work at the Victor site was conducted between August 14 and 22, 2007. The kimberlites are mid-Jurassic (~170 Ma) in age and have been emplaced into Paleozoic limestone (Webb et al. 2004). Clay and fine-marine sediment deposited in the Tyrell Sea (~6000 to 12 000 years BP) and 1 to 3 m of peat overlie and cover kimberlites in this region (e.g., Fraser, Hill and Allard 2005).

At 2 of the kimberlites in the region, named Zulu and Yankee (*see* Figure 19.1), shallow piezometers were installed every 50 m along a transect across each kimberlite and at least 200 m beyond the kimberlite margins (based on geophysical data). Transects at these sites were determined based on airphotos and

Summary of Field Work and Other Activities 2007,
Ontario Geological Survey, Open File Report 6213, p.19-1 to 19-6.

satellite images showing areas that were wet, yet were not covered in standing water or floating bogs. The water levels were recorded for all shallow piezometers and the top of casings were surveyed for elevation to determine the direction of groundwater flow. In addition, 3 monitoring wells (MW) were installed at each kimberlite: 2 within the kimberlite and one monitoring well outside the kimberlite. Water levels from the monitoring well were collected, but are not reliable because of the extremely slow recovery due to installation into fine-textured marine sediment. More reliable water levels will be collected during field work to be completed in the fall of 2007.

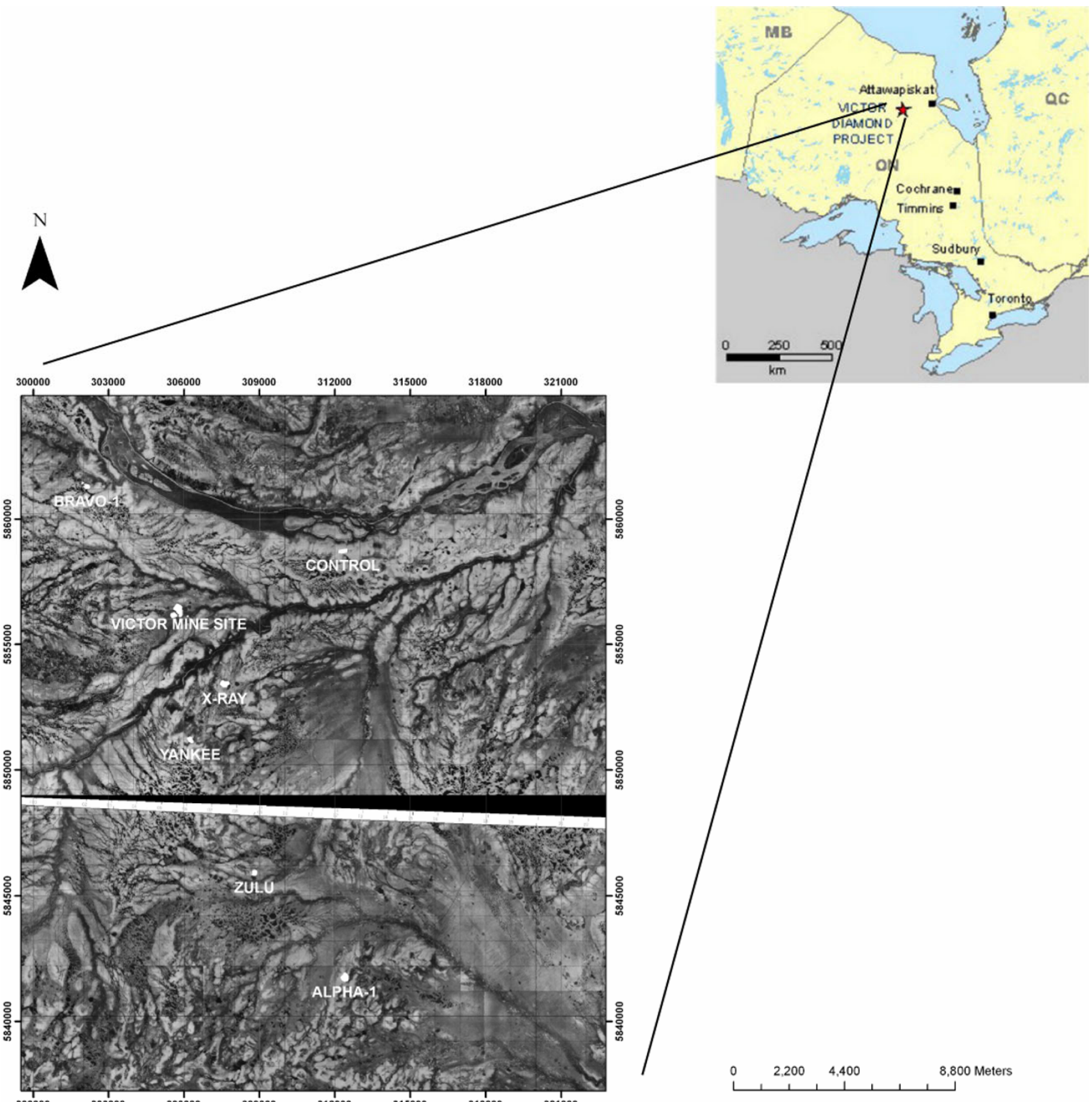

Figure 19.1. Map of the location of the Victor kimberlite field in northern Ontario. Five kimberlites plus a control site were sampled during the summer 2007 field season.

At the kimberlite sites known as Bravo-1 and X-Ray (*see* Figure 19.1), shallow piezometers and monitoring wells were installed (each monitoring well directly adjacent to each shallow piezometer) in 2 locations above each of the kimberlites, and 1 location outside each of the kimberlites. Shallow piezometers were not installed along a transect. At the Alpha kimberlite, shallow piezometers were installed directly adjacent to 3 monitoring wells (2 in the kimberlite and 1 out) in the fall of 2006. At the Control site, only 1 monitoring well and 1 shallow piezometer beside it were installed.

Soil samples were collected along transects at spacing of 25 m at sites Zulu, Yankee, Bravo, X-Ray and Control. At Zulu, Yankee and control, a spontaneous potential survey was also conducted along the same transect that soil samples were collected. Diffusion gas samplers were installed in all monitoring wells.

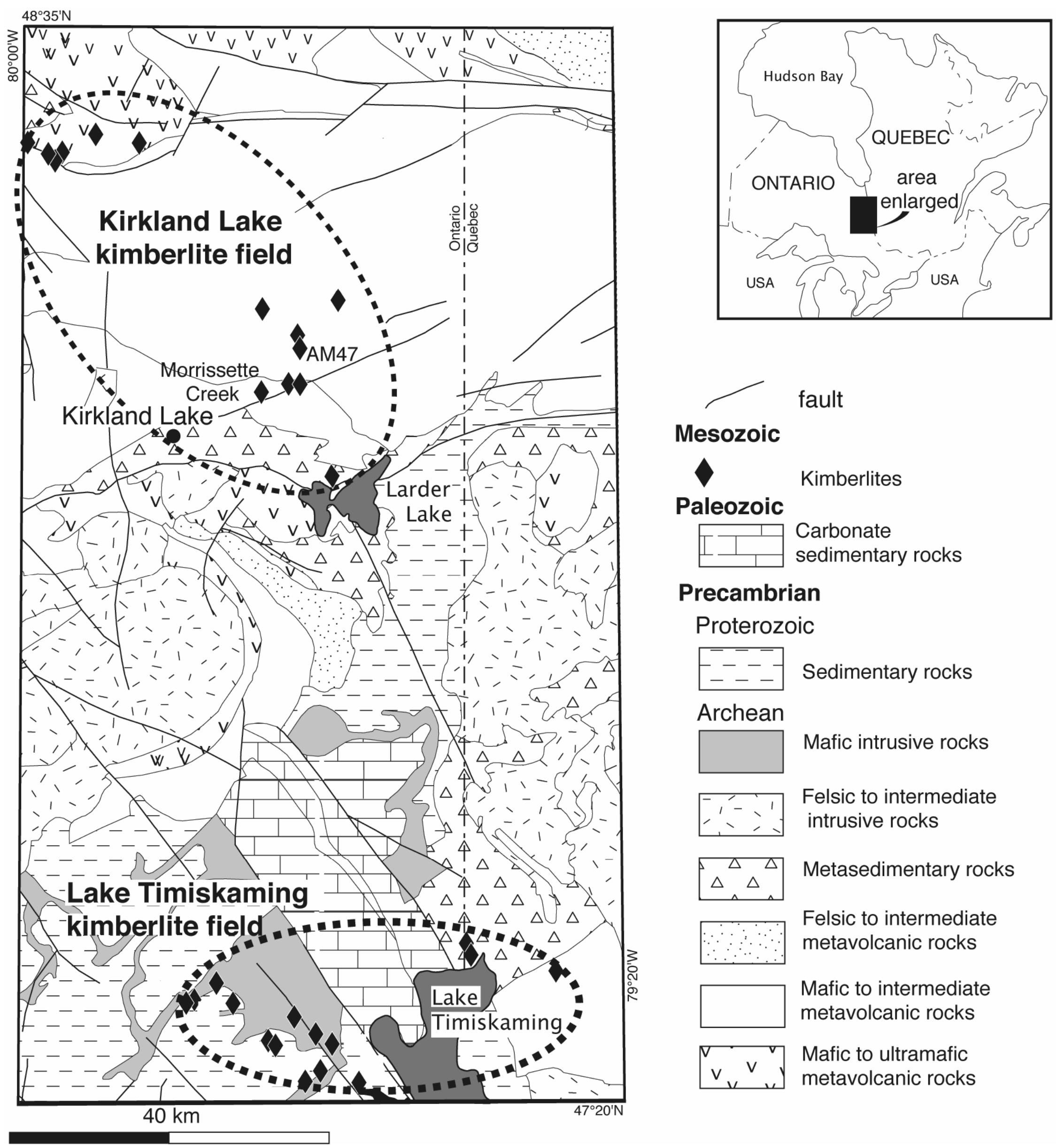

Figure 19.2. Map of location of the Kirkland Lake and Lake Timiskaming kimberlite fields in northeastern Ontario and the kimberlite (AM47) sampled in this study. Bedrock geology *from* Ontario Geological Survey (1991).

Field work was also conducted at 1 kimberlite (AM47) in the Kirkland Lake kimberlite region (Figure 19.2) between August 24 and 27, 2007. The kimberlites in the region yield slightly younger ages, 156 Ma, than the Victor area kimberlites (Heaman and Kjarsgaard 2000). Soil and peat samples were also collected along a transect at 25 m spacing. Monitoring wells were installed to an approximate depth of 2 m at 2 locations within the kimberlite and 2 outside of the kimberlite. Attempts were made to gain access to the Morrissette Creek kimberlite and the adjacent property west; however, overgrown access routes made entrance impossible.

FIELD PROCEDURE

The shallow piezometers used in this study were 1.5 m lengths of either ¾-inch inside diameter (ID) white environmental-grade polyvinyl chloride (PVC) piping or ¾-inch ID grey PVC. They were typically pushed into the peat 1.2 m with a very loosely fitting plastic champagne cork at the end to prevent unwanted peat from entering the pipe while it was being pushed down. Subsequently, the pipe was pulled up 0.1 m so that it was installed approximately 1.1 m below the surface. As the pipe was pulled up, the plastic cork would become dislodged in the peat, thereby allowing a space of approximately 0.1 m for water to infiltrate into the pipe.

Monitoring wells were installed directly adjacent to the shallow piezometers. A soil sampler spoon was used to determine depth of peat and to collect a clay sediment sample. Typically, a peat thickness of between 2.2 and 2.9 m was observed. A slide hammer was used to drive the riser into the peat and the clay sediment. Most wells were installed 0.3 m deeper than the top of the stainless-steel drive point; however, occasionally refusal was reached with the slide hammer (could not advance the monitoring well any further). Refusal is generally attributed to especially well-consolidated clay sediment or permafrost.

The monitoring wells were constructed of ¾-inch ID riser iron pipe (black pipe) that was threaded onto the stainless-steel drive points (Figure 19.3). The drive point has a barbed fitting on one end onto which either low-density polyethylene (LDPE) or high-density polyethylene (HDPE) tubing can be pushed. The polyethylene tubing prevents water that enters through the drive point screening from contacting the black pipe. Once installed to 0.3 m below the top of the drive point, a diffusion gas sampler was hung in the tubing approximately 15 cm above the barbed fitting of the drive point. A check valve was then placed at the top of the polyethylene tubing. The function of the check valve was to allow the vapour to escape from the headspace as water levels fluctuate and to prevent atmospheric air from entering the headspace.

The diffusion gas sampler consists of two 10 cm lengths of copper tubing with a gas-permeable tube fastened between the 2 lengths of copper tubing with stainless-steel wire. The 2 outside ends of the copper tubing are soldered closed. The samplers are then fastened with a length of fishing line and are fed down the installed monitoring well or borehole. Care is taken not to allow the copper metal to make contact with the stainless-steel drive point in the event that the contact causes a reaction and the subsequent formation of gas. Gas will then diffuse into the sampler during the time between installation and retrieval (at least 1.5 months). When retrieved, the open ends of the copper tubing are crimped or clamped, thereby sealing the diffused gas within the copper tubing. One diffusion gas sampler, installed in September 2006, has been collected from a borehole at the Alpha kimberlite. Diffusion gas samplers installed during the recent field work will be recovered in the fall of 2007.

Peat was collected along each transect every 25 to 40 m at all sites and was collected at a depth of approximately 0.6 m. The pH and the oxidation–reduction potential (ORP) were determined on water that was squeezed out of the peat sample. Half of the peat was collected for soil gas hydrocarbon analysis and the other half was retained for analysis with partial leach extraction. Peat was additionally collected for analysis of microbiological study. Care was taken with these samples to keep them refrigerated. The spontaneous potential survey was conducted using the protocols outlined by Hamilton et al. (2004). It was only possible to conduct the survey where a cut line had been made or where there were few trees that could hinder movement of the wire attached between the probe and the base station. Therefore, spontaneous potential surveys were only conducted at the Zulu, Yankee and control sites.

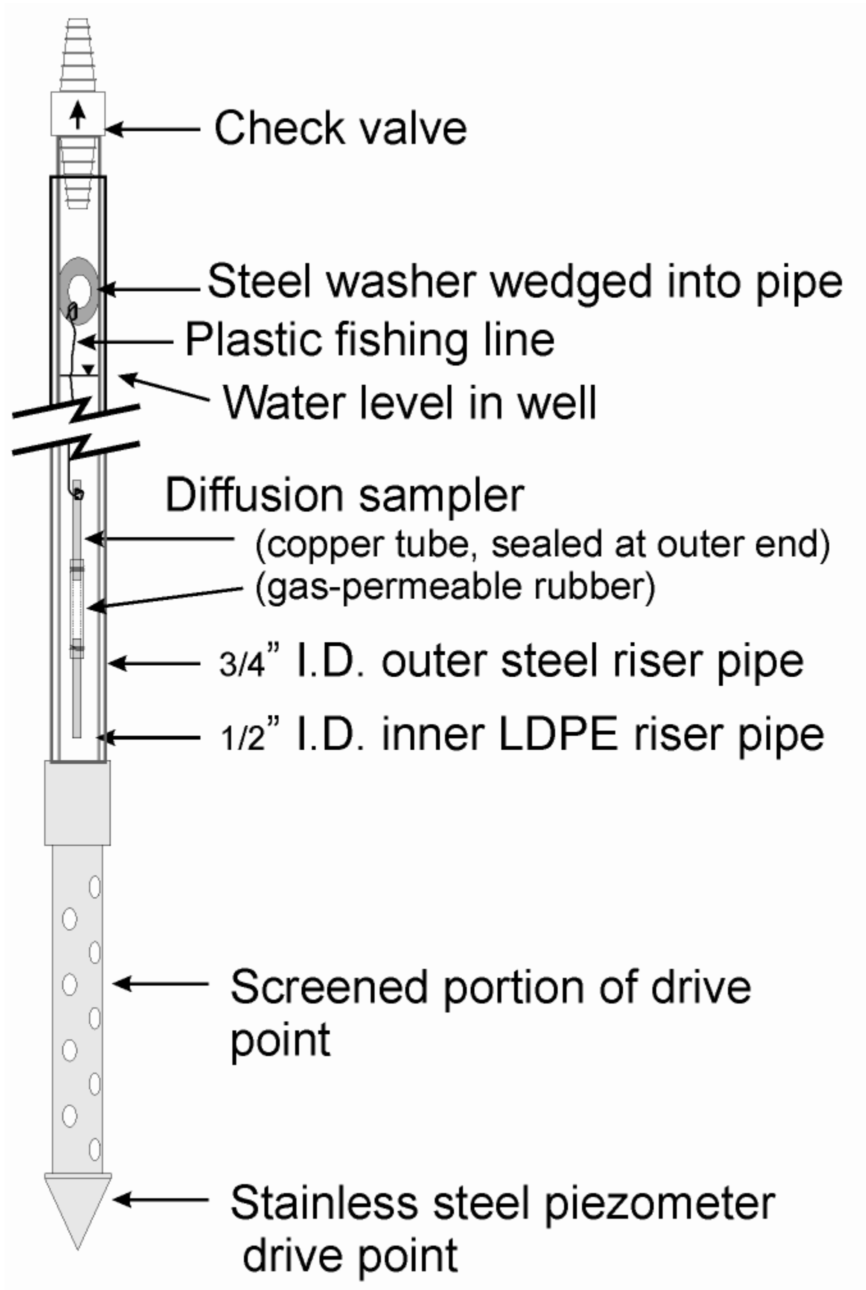

Figure 19.3. Design and installation of monitoring well and diffusion sampler (*from* Hamilton, Hattori and Clark 2005).

RESULTS

The pH, oxidation–reduction potential, electrical conductivity (EC), dissolved oxygen, temperature, alkalinity and H_2S (if present based on smell) were measured on-site at the time of collection for water samples. Peat waters were analyzed on-site for oxidation–reduction potential, pH and temperature. Where peat and/or soil samples were too dry to squeeze water out of for field analysis, distilled or deionized water was added 1:1 (by volume) to the soil to make a slurry. Measurements of pH and oxidation–reduction potential could then be made. This procedure was only required on samples from the AM47 kimberlite at Kirkland Lake.

The majority of water samples were collected from shallow piezometers during the August 2007 field work. However, some samples will be re-collected in the fall of 2007 due to sampling problems resulting from time constraints and slow recovery of some piezometers. Water samples will also be collected in fall 2007 from all monitoring well installed in August. Diffusion samples installed in August 2007 are scheduled to be collected in late September or early October 2007. The gas within these samplers will be analyzed for carbon and hydrogen concentrations and isotopes, and possibly hydrocarbons.

All water samples collected from both shallow piezometers and monitoring wells will be analyzed for major and trace ions, dissolved inorganic carbon (DIC) and dissolved organic carbon (DOC). Selected samples will also be analyzed for strontium, carbon, hydrogen and oxygen isotopes. In addition, kimberlite whole-rock geochemical analysis will be completed for sites where surficial media was collected. Soil gas hydrocarbon analysis and yet to be determined partial leach analyses will be conducted on each of the peat samples.

The results of field analysis of waters collected from shallow piezometers and peat should be available in early 2008. In addition, the results of spontaneous potential surveys will also be available in early 2008.

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