UPDATE ON 1994 LAKE SEDIMENT GEOCHEMISTRY STUDIES IN THE NORTHERN INTERIOR PLATEAU, CENTRAL BRITISH COLUMBIA (93F)

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INTRODUCTION

Most Canadian studies of lake sediment geochemistry have focused on Shield and Appalachian environments of eastern and northern Canada where there are considerable differences in climate, physiography and surficial geology relative to the Cordillera. Here, prospects such as the Wolf (Dawson, 1988) and Fawn (Hoffman and Smith, 1982) epithermal precious metal occurrences in the northern Interior Plateau were discovered by mineral industry regional lake sediment surveys, but there have been few detailed orientation studies and case histories from which to formulate exploration models for the area. These studies are important for successful application of lake sediment geochemistry surveys at both regional and property scales.

Interior Plateau field studies were first conducted in 1992 as part of the Canada - British Columbia Mineral Development Agreement (MDA). Their purpose is to investigate the effectiveness of lake sediment geochemistry in reflecting the presence of known mineral prospects, and to guide the design and implementation of provincial regional geochemical surveys (Cook, 1993). Results were applied to regional lake sediment surveys conducted the following year, which indicated the locations of most known prospects and delineated several new anomalous areas (Cook *et al.*, 1994). To date, regional coverage of approximately one-quarter of the Nechako River map area (NTS 93F) has been completed at an average sampling density of one site per 7.7 square kilometres (Cook, 1995; Cook and Jackaman, 1994a,b). In order to better interpret regional lake sediment data and to design more effective follow-up geochemical surveys, differences in metal distribution patterns in lakes with differing stream water and ground water flow patterns were investigated during 1994. This paper outlines the objectives of the study and describes fieldwork conducted. No results are reported here.

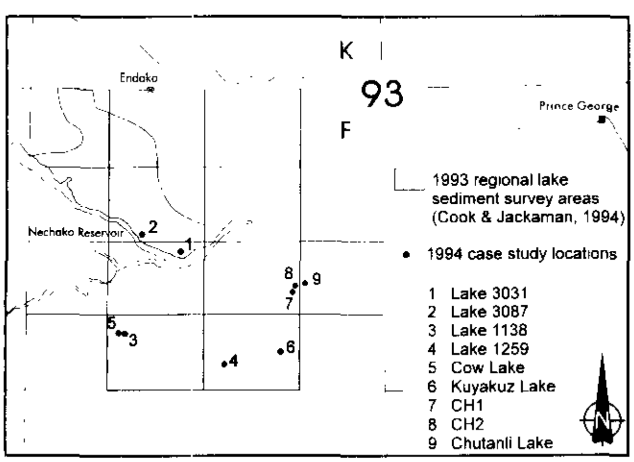

Figure 1. Location map of 1994 lake sediment survey areas in the Nechako Plateau, showing their relation to 1993 regional lake sediment survey areas of Cook and Jackaman (1994a).

OBJECTIVES OF THE INTERIOR PLATEAU LAKE SEDIMENT STUDY

Geochemical dispersion of gold and other metals into lake basins in the study area typically occurs in ground water, stream water, or a combination of the two. The metals subsequently accumulate in organic-rich sediments within diverse lake basins of varied size, depth, physiography and hydrology, among other factors. For example, while 60% of sites in the Fawnie regional survey area (Cook and Jackaman, 1994a) are in basins of pond size or smaller (<0.25 km^2), 8% are located in large lakes (>5 km^2). Little research has been conducted on the most appropriate methods of locating potential sources of elevated metal abundances within the often-extensive watersheds of different lake types. Whereas previous studies were designed to guide the design and implementation of regional geochemical surveys, this study examines interpretive and sampling techniques for optimal follow-up of regional anomalies.

The main objective of the 1994 lake sediment study was to characterize differences in sediment metal distribution patterns within lakes with differing ground water and stream water flow patterns. Results of earlier work (Cook, 1995) indicated that differences in metal distribution patterns and elevated geochemical signatures might be related to differences in metal input and accumulation between seepage lakes and drainage lakes. Differences in water income and loss in these two lake types are outlined by Wetzel (1983). *Seepage lakes* are those basins receiving predominantly ground water seepage or spring input below the lake surface, but lacking significant stream outflow. Water loss in these lakes, other than that due to evaporation, is restricted to seepage back into ground water. For the purpose of this study, lakes lacking significant stream inflows were included in this category. *Drainage lakes* lose water by stream flow from an outlet. In the context of this study, they include those lakes with relatively large watersheds receiving water from both surface influents and subsurface seepage. The influx of suspended particulate mineral and organic matter in stream waters is a major difference between these and seepage lakes. Ground waters play a major role in transporting metals to all lake basins (Hoffman and Fletcher, 1981) and there is a certain amount of overlap between the two lake types. For example, Boyle (1994) has further subdivided lakes into six varieties on the basis of relative ground water and surface water input. A useful discussion on variations in geochemical input to lake basins is provided by Earle (1993).

A series of case studies were conducted to document the geochemical differences between seepage and drainage lakes, and to provide data on which to base geochemical exploration recommendations for these and other areas in the northern Interior Plateau. Two main issues were considered:

- The existence of systematic differences in metal distribution patterns between drainage lakes and seepage lakes. Spatial relationship of these patterns with basin morphology, topography and stream inflows will influence geochemical data interpretation and subsequent exploration methods.

- The form of gold transport into drainage lake basins by stream waters: in solution, suspension or some combination of the two.

SCOPE OF 1994 FIELD STUDIES

Orientation studies of nine lakes were carried out during the period late July to late September, 1994 (Figure 1). A total of 362 sediment samples were collected at 266 sites (Table 1). The lakes included:

- Four small unnamed seepage lakes.
- Two large drainage lakes (Kuyakuz Lake; Cow Lake).
- Three lakes sampled to provide data complementary to prior case studies of lakes adjacent to porphyry prospects (Cook, 1993), and to ongoing glacial dispersal studies of the Geological Survey Branch (Giles and Levson, 1995; Giles *et al.*, 1995) and the University of New Brunswick (O'Brien *et al.*, 1995; Weary *et al.*, 1995).

Surveys of the six seepage and drainage lakes are the main focus of this paper. These were chosen on the basis of apparent flow type and regional lake sediment geochemistry results (Cook and Jackaman, 1994a). All six contain elevated concentrations of gold and associated elements such as arsenic, antimony and/or molybdenum in centre-lake or centre-basin sediments. The four seepage lakes span a range of physiographic environments, and include both eutrophic and unstratified variants. No attempt was made to choose lakes from among the limnological groupings of Gintautas (1984) or Earle (1993). The third group of lakes are in the vicinity of the CH porphyry copper-molybdenum prospect (MINFILE 093F 004), where prior

TABLE 1. SUMMARY LISTING OF LAKES SURVEYED: 1994.

	Lake Name	NTS	Trophic Status	Lake Size (km2)	Maximum Sample Depth (m)	Sediment Sites	Sediment Samples	Temperature and Oxygen Profiles
A)								
Drainage Lakes	Kuyakuz	93F02	Unstratified	> 5	16	69	94	3
	Cow	93F03	Unstratified*	1 to 5	15	50	68	-
Seepage Lakes	Lake 3031	93F06	Eutrophic	< 0.25	5.5	13	17	4
	Lake 3087	93F11	Eutrophic	< 0.25	7.5	24	32	5
	Lake 1138	93F03	Unstratified	< 0.25	3.5	15	21	1
	Lake 1259	93F02	Unstratified	< 0.25	3	17	23	1
					Subtotal:	*188*	*255*	*14*
B)								
CH Area	Chutanli	93F08	Unstratified	1 to 5	10	50	70	7
	CH-1	93F07	Unstratified	< 0.25	6	19	25	4
	CH-2	93F07	Unstratified	< 0.25	4	9	12	2
					Subtotal:	*78*	*107*	*13*
					Total:	**266**	**362**	**27**

Numbered lakes refer to regional site locations of Cook and Jackaman (1993a).
*After data of Coombes (1986).

lake sediment studies have been summarized by Earle (1993). These will be the subject of a future paper.

LOCATION AND GEOLOGY OF THE STUDY REGION

The study region (Figure 1) is located approximately 100 kilometres southwest of Vanderhoof on the Nechako Plateau, the northernmost subdivision of the Interior Plateau (Holland, 1976). The low and rolling terrain generally lies between 1000 to 1500 metres elevation. Bedrock is obscured by an extensive drift cover. Till and glaciofluvial outwash are the predominant surficial sediments (Levson and Giles, 1994; Giles and Levson, 1994, 1995). Within the study region, volcanic and sedimentary rocks of the Middle Jurassic Hazelton Group are intruded by Late Jurassic, Late Cretaceous and Tertiary felsic plutonic rocks (Tipper, 1963; Diakow *et al.*, 1994, 1995a,b,c). These are overlain by Eocene volcanics of the Ootsa Lake Group, Oligocene and Miocene volcanics of the Endako Group, and Miocene-Pliocene basalt flows. Metallogeny and mineral deposits in the area have been outlined by Schroeter and Lane (1994), and epithermal gold deposits are a prime target of recent exploration. Regional lake sediment and till geochemistry results (Cook and Jackaman, 1994a; Levson *et al.*, 1994) indicate that elevated concentrations of gold and associated elements occur in areas of Jurassic as well as Eocene bedrock, enlarging considerably the potential target areas for these deposits. For example, four of the six lakes discussed here are situated above units of the Middle Jurassic Hazelton Group.

FIELD AND LABORATORY METHODOLOGY

SAMPLE COLLECTION

Systematic collection of lake sediments and waters, and measurement of temperature and dissolved oxygen content of the water column was conducted at each lake (Table 1). Lake sediments were sampled from a zodiac or canoe with a Hornbrook-type torpedo sampler. Standard sampling procedures, as discussed by Friske (1991), were used. Samples were collected in kraft paper bags and sample depth, colour, composition and odour recorded at each site. Sites were located along profiles traversing deep and shallow-water parts of main basins and sub-basins, and at all stream inflows. The number of sites on each lake (Table 1) ranged from a minimum of nine in small ponds up to a maximum of 69 in large Kuyakuz Lake, in order to evaluate the relationship between trace element patterns and bathymetry, drainage inflow and outflow, organic matter content and sediment texture.

An unbalanced nested sampling design, similar to that described by Garrett (1979), was used to assess sampling and analytical variation. A modified version of the Regional Geochemical Survey sampling scheme used for this has been described by Cook (1993). Each block of twenty samples comprises twelve routine samples and five field duplicate samples to assess sampling variability, two blind duplicate samples to determine analytical precision, and one control reference standard to monitor analytical accuracy.

Two water samples, each comprising three 250-millilitre bottles, were obtained from the centre of each lake. One was taken near the surface at approximately 15 centimetres depth, the second was collected to 2 metres above the lake bottom using a Van Dorn sampler. The boat was anchored in place during both water sampling and temperature/oxygen profiling to prevent movement, and observations of water colour and suspended matter were recorded. Water samples were also collected from streams flowing into Kuyakuz and Cow lakes in order to determine if metals were transported in solution or suspension. To minimize potential contamination, polyethylene bottles were pre-rinsed in the laboratory with distilled water, carried to the field in sealed plastic bags, and rinsed again in the water to be sampled prior to actual collection. Samples were subsequently resealed in plastic bags and stored in a cooler and refrigerator prior to filtration and analysis.

DISSOLVED OXYGEN AND TEMPERATURE MEASUREMENTS

Oxygen and temperature measurements were conducted to verify pre-existing Fisheries Branch (B.C. Ministry of Environment, Lands and Parks' data (Burns 1978a,b; Coombes, 1986), to determine the trophic status of smaller lakes for which no data are otherwise available, and to investigate the variability of these measurements within separate sub basins of individual lakes. Water column profiles of dissolved oxygen content and temperature were measured at one to seven sites on each lake except Cow Lake, using a YSI Model 57 oxygen meter with cable probe. Measurements were generally made, at 1-metre intervals, in the centre of all major sub basins and at two near shore sites. A total of 27 profiles were measured (Table 1). The instrument was calibrated for lake elevation and air temperature prior to measurement at each lake, and data collected only during the afternoon period so as to standardize measurement conditions. Prevailing weather conditions were also recorded at the beginning of each profile.

SAMPLE PREPARATION AND ANALYSIS

Lake sediment samples were initially field dried and, when sufficiently dry to transport, shipped to Cantech Laboratories, Calgary, for final drying and sample preparation. The entire sample, to a maximum of 250 grams, was disaggregated and pulverized to approximately -150 mesh in a ceramic ring mill. Two analytical splits were taken from the pulverized material. The first 30-gram subsample was submitted to Activation Laboratories, Ancaster, Ontario for determination of gold and 34 additional elements by instrumental neutron activation analysis (INAA). The second was submitted to Acme Analytical Laboratories, Vancouver, for determination of zinc, copper, lead, silver, arsenic, molybdenum, iron, manganese and 22 additional elements, plus loss on ignition, by inductively coupled plasma - atomic emission spectrometry (ICP-AES) following an aqua regia digestion. Blind duplicates and appropriate ranges of copper and gold-bearing standards were inserted into each of the two sample suites to monitor analytical precision and accuracy.

Two of the three water samples from each site were filtered in the field through 0.45 micron filters. The filtered waters were analyzed for a suite of trace and major elements by inductively coupled plasma - mass spectrometry (ICP-MS) and inductively coupled plasma - atomic emission spectrometry (ICP-AES) techniques, respectively, at Activation Laboratories, Ancaster. The third sample from each site was left unfiltered and submitted to Chemex Labs, North Vancouver, for determination of the standard RGS analytical suite of elements in water (uranium, fluoride, sulphate and pH). Standards and distilled water blanks were included in the sample suites to monitor analytical accuracy. The filters were dried and retained in sealed containers for future analysis of the lake and stream water suspended fractions.

SUMMARY

No analytical results for lake sediments and waters from the 1994 field season are available at the time of writing. Future geochemistry work will concentrate on the continuation of regional lake sediment surveys, with priority given to the completion of the Nechako River map area (NTS 93F), and on the development and refinement of geochemical methods for both regional and detailed exploration. The development of exploration models for lake sediment geochemistry surveys in the northern Interior Plateau is an eventual goal of the project.

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