



**BRITISH
COLUMBIA**

Ministry of Energy and Mines
Energy and Minerals Division
Geological Survey Branch

Lake Sediment and Water Geochemistry of the Cape Caution Area

NTS 92L/13, 14, 15; 92M/3, 4

Wayne Jackaman and Stephen J. Cook

RGS
B.C. Regional Geochemical Survey

Open File 2000-11

Canadian Cataloguing in Publication Data

Jackaman, W. (Wayne)

Lake sediment and water geochemistry of the Cape Caution area, NTS
92L/13, 14, 15; 92M/3, 4

(Open file, ISSN 0835-3530 ; 2000-11)

Issued by Geological Survey Branch.

"B.C. Regional Geochemical Survey."

Includes bibliographical references: p.

ISBN 0-7726-4196-X

1. Water - Composition - British Columbia - Cape Caution Region. 2. Sediments (Geology) - British Columbia - Cape Caution Region. 3. Geochemistry - British Columbia - Cape Caution Region. 4. Geology, Economic - British Columbia - Cape Caution Region. I. Cook, S. J. (Stephen John). II. British Columbia. Ministry of Energy and Mines. III. British Columbia. Geological Survey Branch. VI. Title. V. Title: B.C. Regional Geochemical Survey. VI. Series: Open file (British Columbia. Geological Survey Branch); 2000-11.

QE515.J32 2000

551.9'09711'1

C00-960117-1



VICTORIA
BRITISH COLUMBIA
CANADA

MARCH 2000



LAKE SEDIMENT AND WATER GEOCHEMISTRY OF THE CAPE CAUTION AREA

NTS 92L/13, 14, 15; 92M/3, 4

RECEIVED
MAY 4 2000
E. M. ...

OPEN FILE 2000 - 11

TABLE OF CONTENTS

	page		page
INTRODUCTION	1	FIELD OBSERVATIONS	APPENDIX A
OPEN FILE FORMAT	1	ANALYTICAL DATA	APPENDIX A
SAMPLE COLLECTION	2	SUMMARY STATISTICS	APPENDIX B
SAMPLE PREPARATION	3	MAPS	APPENDIX C
SAMPLE ANALYSIS	3	DISKETTE	POCKET
ACKNOWLEDGMENTS	5		
REFERENCES	6		

INTRODUCTION

This report presents new analytical data for 43 different elements from a regional lake sediment and water geochemical survey (Figure 1) conducted by the British Columbia Geological Survey Branch in the Cape Caution area during 1999. The survey covers parts of four 1:50,000 NTS map sheets in the Alert Bay (NTS 92L) and Rivers Inlet (NTS 92M) areas of B.C.'s central coast: 92L/13 (Shushartie), 92L/14 (Bradley Lagoon), 92L/15 (Broughton Island), 92M/3 (Belize Inlet) and 92M/4 (Cape Caution). Details of the geology and mineral potential of this segment of the Southern Coast Mountains are described by Pinsent (2000). The lake sediment survey was designed to cover a region of NW-SE trending geological structures and associated shear-hosted gold mineralization.

Extending from Cape Caution to Broughton Island, this portion of the Hecate Lowland physiographic region (Holland, 1976) is characterized by subdued topography, poor drainage and abundant lakes which make lake sediments an ideal geochemical exploration sample medium. Lake sediment surveys are an effective tool to delineate regional geochemical patterns and anomalous metal concentrations related to mineral occurrences. Most examples of the successful application of lake sediment geochemistry to Cordilleran mineral exploration come from the Nechako Plateau in central B.C. where topography is more subdued than in most parts of the Coast Mountains. For example, epithermal precious metal prospects such as the Tsacha (Cook *et al.*, 1995) and Wolf prospects in the Nechako Plateau (Dawson, 1988) and, further to the north, porphyry molybdenum mineralization at the Mac deposit (Cope and Spence, 1995) were discovered following up lake sediment geochemical surveys.

Sample collection, preparation, analytical procedures and quality control conform to established standards of the National Geochemical Reconnaissance (NGR) and Regional Geochemical Survey (RGS) programs. Details of these procedures are given here, and in previous lake sediment geochemical reports such as Cook and Jackaman (1994) and Cook *et al.* (1997a,b; 1998). Results will be incorporated at a later date into ongoing regional lake sediment surveys as part of the RGS program. Analytical results and field observations compiled

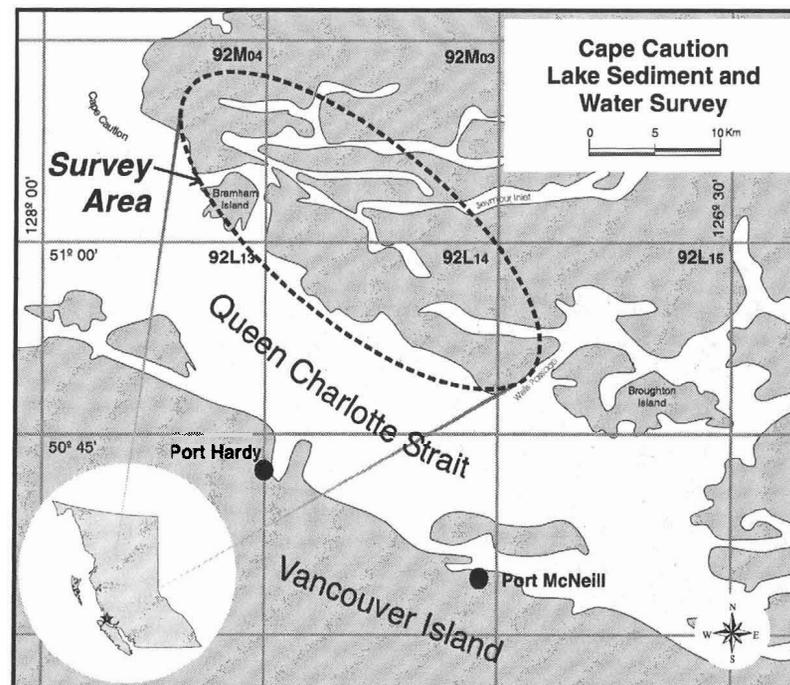


Figure 1. Location Map of Cape Caution survey area.

by the RGS program in British Columbia are used in the development of a high-quality geochemical database suitable for mineral exploration, resource assessment, geological mapping and environmental studies. Funded under the government's Corporate Resource Inventory Initiative (CRII), this survey is part of the Ministry of Energy and Mines' contribution to the Central Coast Land Resource Planning process.

REPORT FORMAT

This report is divided into the following sections:

- Introduction and survey methodology.

- Listings of field observations and analytical data (Appendix A).
- Summary statistics (Appendix B).
- Element and sample location maps (Appendix C).
- Analytical and field data are included on diskette in comma-delimited format.

SURVEY METHODOLOGY

SAMPLE COLLECTION

Helicopter-supported sample collection in the Cape Caution survey area was conducted by the authors during June 1999. A sediment centre-lake sample and a water sample were systematically collected at each site using a float-equipped Bell 206 helicopter. A total of 133 sites were sampled over an area of approximately 800 square kilometres at an average site density of 1 site per 6 square kilometres. Field duplicate sediment and water samples were routinely collected in every batch of twenty samples.

SEDIMENTS

Sediments were collected using a Hornbrook-type torpedo sampler and samples placed in large (5" x 6") Kraft paper bags. On the basis of results of prior orientation studies (Cook, 1995), regional surveys in British Columbia incorporate some departures from standard lake sediment sampling strategies used elsewhere in Canada for the National Geochemical Reconnaissance (NGR) program (Friske, 1991), particularly pertaining to overall site density and the number of sites sampled in each lake. First, every lake in the survey area is typically sampled, rather than sampling only a selection of lakes at a fixed density (ie. one site per 13 km²). Sediment in even small lakes and ponds may contain anomalous metal concentrations revealing the presence of nearby mineralization such as that at the Wolf and Tsacha prospects in the Nechako Plateau (Cook, 1995; Cook *et al.*, 1997). In practice, some lakes and small ponds were not sampled due to unfavourable landing conditions, particularly on high ridgetops which were obscured by thick cloud cover. Samples are not generally collected from the centres of very large and deep lakes (> 10 km²; > 40 m deep) and organic soils from shallow swamps and bogs were also avoided. In the Cape Caution area, all possible lakes were sampled in the vicinity of the

NW-SE trending structures around which the survey was designed. Sample density decreased with increasing distance from these structures. Secondly, centre-lake sediment samples were collected following standard NGR procedure, but sediment from the centres of all major known or inferred sub-basins were also obtained from lakes near the dominant geological structures to investigate the trace element variations which may exist among sub-basins of the same lake.

WATERS

Lake water samples were collected at each site in 250-millilitre high-density polyethylene (HDPE) bottles using a custom-designed sampling apparatus. Waters were sampled from approximately 15 centimetres below the lake surface to avoid collection of surface scum, and precautions were taken to minimize collection of suspended solids. These waters were collected for determination of the standard RGS analytical suite (pH, uranium, fluoride and sulphate).

FIELD OBSERVATIONS

A variety of field variables and observations pertaining to sample media, site and local terrain were recorded at each site using Geological Survey of Canada lake sediment cards (Garrett, 1974). These included sample depth, colour and composition, as well as the general relief and potential sources of contamination. The absence or presence of suspended solids in water samples was also noted.

Site locations were marked on 1:50,000 scale NTS topographic maps in the field, transferred to master basemaps, and later digitized to obtain Universal Transverse Mercator (UTM) site coordinates (NAD27). Variables such as site geology, which reflects the dominant geological unit of the lake catchment, lake area and perimeter were coded after sample collection. Site geology was taken from Pinsent (2000), and manually verified to ensure that lake watersheds corresponded to the coded geological unit. Common lake names used on NTS topographic maps were included where applicable.

TABLE 1. ANALYTICAL SUITE OF ELEMENTS

Element	Analytical Method	Reported Detection Limit	Unit	
Antimony	Sb	INAA	0.1	ppm
Arsenic	As	INAA	0.5	ppm
Barium	Ba	INAA	50	ppm
Bromine	Br	INAA	0.5	ppm
Calcium	Ca	INAA	1	%
Cerium	Ce	INAA	3	ppm
Cesium	Cs	INAA	1	ppm
Chromium	Cr	INAA	5	ppm
Cobalt	Co	INAA	1	ppm
Europium	Eu	INAA	0.2	ppm
Gold	Au	INAA	2	ppb
Hafnium	Hf	INAA	1	ppm
Iron	Fe	INAA	0.01	%
Lanthanum	La	INAA	0.5	ppm
Lutetium	Lu	INAA	0.05	ppm
Neodymium	Nd	INAA	5	ppm
Rubidium	Rb	INAA	15	ppm
Samarium	Sm	INAA	0.1	ppm
Scandium	Sc	INAA	0.1	ppm
Sodium	Na	INAA	0.01	%
Tantalum	Ta	INAA	0.5	ppm
Terbium	Tb	INAA	0.5	ppm
Thorium	Th	INAA	0.2	ppm
Tungsten	W	INAA	1	ppm
Uranium	U	INAA	0.5	ppm
Ytterbium	Yb	INAA	0.2	ppm
Zinc	Zn	INAA	50	ppm
Antimony	Sb	AAS	0.2	ppm
Arsenic	As	AAS-H	0.2	ppm
Bismuth	Bi	AAS-H	0.2	ppm
Cadmium	Cd	AAS	0.2	ppm
Cobalt	Co	AAS	2	ppm
Copper	Cu	AAS	2	ppm
Fluorine	F	ION	40	ppm
Iron	Fe	AAS	0.02	%
Lead	Pb	AAS	2	ppm
Manganese	Mn	AAS	5	ppm
Mercury	Hg	AAS-F	10	ppb
Molybdenum	Mo	AAS	1	ppm
Nickel	Ni	AAS	2	ppm
Silver	Ag	AAS	0.2	ppm
Vanadium	V	AAS	5	ppm
Zinc	Zn	AAS	2	ppm
Loss on Ignition	LOI	GRAV	0.1	%
pH	pH	GCE	0.1	
Fluoride	FW	ION	20	ppb
Uranium	UW	LIF	0.05	ppb
Sulphate	SO4	TURB	1	ppm

AAS	atomic absorption spectroscopy	INAA	instrumental neutron activation analysis
AAS-H	hydride generation AAS	LIF	laser-induced fluorescence
AAS-F	flameless AAS	ION	specific ion electrode
GCE	glass combination electrode	TURB	turbidimetric

SAMPLE PREPARATION

SEDIMENTS

Sediment samples were field dried and, when sufficiently dry to transport, shipped to CanTech Laboratories Inc., Calgary, for final drying (max: 25-30°C) and sample preparation. The entire sample, to a maximum of about 250 grams, was pulverized in a ceramic ring mill and screened to minus 80 mesh (< 177 microns). Two analytical splits (10 - 15 grams each) were taken from the pulverized material for subsequent analysis. Control reference standards and blind duplicates were inserted into analytical suites in accordance with standard RGS and NGR protocols. Sample pulps were later archived.

WATERS

All lake water samples were kept cool following collection, and shipped to the Analytical Sciences Laboratory, Victoria, for insertion of control reference standards and distilled water blanks into the sample suite. No further preparation procedures were performed on routine raw lake water samples prior to analysis.

SAMPLE ANALYSIS

Analysis of routine lake sediment and water samples was conducted by contract laboratories in accordance with established RGS analytical methods. Analytical methods are strictly specified and carefully monitored to ensure consistent and reliable results regardless of the region, year or analytical laboratory.

SEDIMENTS - AAS

A split of each prepared sediment sample was analyzed by CanTech Laboratories Inc., Calgary, Alberta for 16 elements: zinc, copper, lead, silver, molybdenum, cobalt, mercury, iron, manganese, nickel, fluorine, cadmium, vanadium, bismuth, antimony and arsenic. Loss on ignition (LOI) was also determined. Stated analytical detection limits for each element are listed in

Table 1. Those concentrations below the stated detection limits are presented in data listings as a value equivalent to the detection limit.

For the determination of cadmium, cobalt, copper, iron, lead, manganese, nickel, silver and zinc, a 1 gram sample was reacted with 3 millilitres of concentrated HNO_3 for 30 minutes at 90°C . Concentrated HCl (1 millilitre) was added and the digestion was continued at 90°C for an additional 90 minutes. The sample solution was then diluted to 20 millilitres with metal-free water and mixed. Element concentrations were determined by atomic absorption spectroscopy (AAS) using an air-acetylene flame. Background corrections were made for lead, nickel, cobalt and silver.

Mercury was determined by the Hatch and Ott procedure with some modifications. A 0.5 gram sample was reacted with 20 millilitres concentrated HNO_3 and 1 millilitre concentrated HCl in a test tube for 10 minutes at room temperature and then for 2 hours in a 90°C hot water bath. After digestion, the sample was cooled and diluted to 100 millilitres with metal-free water. The mercury present was reduced to the elemental state by the addition of 10 millilitres of 10% weight-to-volume SnSO_4 in H_2SO_4 . The mercury vapour was then flushed by a stream of air into an absorption cell mounted in the light path of an atomic absorption spectrometer (AAS-F). Measurements were made at 253.7 nanometres. This method is described by Jonasson *et al.* (1973).

Molybdenum and vanadium were determined by aqua regia digestion - atomic absorption spectroscopy (AAS) using a nitrous oxide acetylene flame. A 0.5 gram sample was reacted with 1.5 millilitres concentrated HNO_3 at 90°C for 30 minutes. At this point 0.5 millilitres of concentrated HCl was added and the digestion continued for an additional 90 minutes. After cooling, 8 millilitres of 1250 ppm Al solution was added and the sample solution diluted to 10 millilitres before determination by AAS.

Arsenic and bismuth were determined by aqua regia digestion - hydride generation atomic absorption spectroscopy. A 1 gram sample was reacted with 3 ml of concentrated HNO_3 for 30 minutes at 90°C . Concentrated HCl (1 ml) was added and the digestion was continued at 90°C for an additional 90 minutes. A 1 ml aliquot was diluted to 10 ml with 1.5M HCl in a clean test

tube. The diluted sample solution was added to a sodium borohydride solution and the hydride vapour aspirated through a heated quartz tube in the light path of an atomic absorption spectrometer (AAS-H).

Antimony was determined as described by Aslin (1976). A 0.5 gram sample was placed in a test tube with 3 ml concentrated HNO_3 and 9 ml HCl . The mixture was allowed to stand overnight at room temperature prior to being heated to 90°C and maintained at this temperature for 90 minutes. The mixture was cooled and a 1 ml aliquot was diluted to 10 ml with 1.8M HCl . This dilute solution was determined by hydride evolution-atomic absorption spectroscopy (AAS).

Fluorine was determined by specific ion electrode as described by Ficklin (1970). A 250 milligram sample was sintered with a 1-gram flux consisting of two parts by weight sodium carbonate and 1 part by weight potassium nitrate. The residue was leached with water. The sodium carbonate was neutralized with 10 millilitres 10% weight-by-volume citric acid, and the resulting solution diluted with water to 100 millilitres. Fluoride was then measured with a fluoride ion electrode (ION) and a reference electrode.

Loss on ignition was determined using a 0.5 gram sample. The sample was weighed into a 30 millilitre beaker, placed in a cold muffle furnace and heated to 500°C over a period of 2 to 3 hours. The sample was maintained at this temperature for 4 hours, then allowed to cool to room temperature before weighing (GRAV).

SEDIMENTS - INAA

An approximately 15 gram split of each sample was analyzed for 29 elements (gold, antimony, arsenic, barium, bromine, calcium, cerium, cesium, chromium, cobalt, europium, hafnium, iron, lanthanum, lutetium, molybdenum, neodymium, rubidium, samarium, scandium, sodium, strontium, tantalum, terbium, thorium, tungsten, uranium, ytterbium and zinc) by Activation Laboratories, Ancaster, Ontario, using thermal instrumental neutron activation analysis (INAA). This technique involves irradiating a sample briquette for 30 minutes in a neutron flux of 7×10^{11} neutrons/cm²/second. After a decay period

of approximately 1 week, gamma-ray emissions for the elements were measured using a gamma-ray spectrometer with a high-resolution, coaxial germanium detector. Counting time was approximately 15 minutes per sample and the results were compiled on a computer and converted to concentrations. A complete list of elements and their stated instrumental detection limits are given in Table 1. Additional data for the six elements selenium, silver, mercury, irridium, nickel and strontium were not published because of inadequate detection limits and/or poor precision. Gold concentrations below the stated detection limits are presented in data listings as a value equivalent to one-half the detection limit. Analytical sample weights are also reported.

WATERS

Routine unfiltered lake waters were analyzed for the standard RGS water analytical suite of pH, uranium, fluoride and sulphate at CanTech Laboratories, Inc., Calgary. Stated detection limits are given in Table 2.

Hydrogen ion activity (pH) was measured, on a separate sample aliquot, with a Fisher Accumet pH meter with glass-calomel combination electrode (GCE).

Uranium was determined by laser-induced fluorescence (LIF) using a Scintrex UA-3 uranium analyzer. A complexing agent, known commercially as Fluran and composed of sodium pyrophosphate and sodium monophosphate (Hall, 1979), is added to produce a uranyl pyrophosphate species which fluoresces when exposed to the laser. As organic matter in the sample can cause unpredictable behaviour, a standard addition method is used. A total of 500 microlitres of Fluran solution was added to a 5 millilitre sample and allowed to stand for 24 hours, as the reaction of uranium with the complexing agent may be delayed or sluggish. At the end of this period fluorescence readings were made with the addition of 0.0, 0.2 and 0.4 ppb uranium. For high-concentration samples, the additions were 0.0, 2.0 and 4.0 ppb uranium. All readings are taken against a sample blank.

Fluoride was determined by ion selective electrode (ION). A 20 millilitre aliquot of the sample was mixed with 20 millilitres of TISAB II (total ionic

strength adjustment buffer) buffer solution. Fluoride was determined with an Orion fluoride electrode in conjunction with a Corning ion meter.

Sulphate was determined by a turbidimetric method (TURB). A 50 millilitre aliquot was mixed with barium chloride and an isopropyl alcohol-HCl-NaCl reagent, and turbidity of the resulting barium sulphate solution measured with a spectrophotometer at 420 nanometres.

ACKNOWLEDGMENTS

Survey design and implementation was by the authors. Sample preparation and geochemical analyses were conducted by the following companies:

Preparation:

CanTech Laboratories Inc., Calgary, Alberta

Sediment Analysis:

CanTech Laboratories Inc., Calgary, Alberta (AAS)

Activation Laboratories Ltd., Ancaster, Ont. (INAA)

Water Analysis:

CanTech Laboratories Inc., Calgary, Alberta

REFERENCES

- Aslin, G.E.M. (1976): The Determination of Arsenic and Antimony in Geological Materials by Flameless Atomic Absorption Spectrophotometry; *Journal of Geochemical Exploration*, Volume 6, pages 321-330.
- Balkwill, J.A. (1991): Limnological and Fisheries Surveys of Lakes and Ponds in British Columbia: 1915-1990; *B.C. Ministry of Environment, Lands and Parks, Fisheries Technical Circular*, No.90, 157 pages.
- Cook, S.J. (1995): Gold Distribution in Lake Sediments near Epithermal Gold Occurrences in the Northern Interior Plateau, British Columbia; in *Drift Exploration in the Canadian Cordillera*, Bobrowsky, P.T., Sibbick, S.J., Newell, J.M. and Matysek, P.F., Editors, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1995-2, pages 193-213.
- Cook, S.J. (1997): Regional and Property-Scale Application of Lake Sediment Geochemistry in the Search for Buried Mineral Deposits in the Northern Interior Plateau, British Columbia; in *Interior Plateau Geoscience Project: Summary of Geological, Geochemical and Geophysical Studies*, Diakow, L.J. and Newell, J.M., Editors, *B.C. Ministry of Employment and Investment*, Paper 1997-2, pages 175-203.
- Cook, S.J. and Jackaman, W. (1994): Regional Lake Sediment and Water Geochemistry of part of the Nechako River Map Area (93F/2,3; 93F/6,11,12,13,14); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1994-19.
- Cook, S.J., Levson, V.M., Giles, T.R. and Jackaman, W. (1995): A Comparison of Regional Lake Sediment and Till Geochemistry Surveys: A Case Study from the Fawnie Creek Area, Central British Columbia; *Exploration and Mining Geology*, Volume 4, pages 93-110.
- Cook, S.J., Jackaman, W., Friske, P.W., Day, S.J., Coneys, A.M. and Wong, H.F.N. (1997a): Preliminary Regional Lake Sediment Geochemistry of the Northern Kechika Trough, British Columbia; *B.C. Ministry of Employment and Investment*, Open File 1997-14.
- Cook, S.J., Jackaman, W., McCurdy, M.W., Day, S.J. and Friske, P.W. (1997b): Regional Lake Sediment and Water Geochemistry of part of the Fort Fraser Map Area, British Columbia (NTS 93K/9, 10, 15 and 16); *B.C. Ministry of Employment and Investment*, Open File 1996-15.
- Cook, S.J., Lett, R.E.W., Levson, V.M., Jackaman, W., Coneys, A.M. and Wyatt, G.J. (1998): Regional Lake Sediment and Water Geochemistry of the Babine Porphyry Belt, Central British Columbia (NTS 93L/9, 16; 93M/1, 2, 7, 8); *B.C. Ministry of Employment and Investment*, Open File 1997-17.
- Cope, G.R. and Spence, C.D. (1995): Mac Porphyry Molybdenum Prospect, North-central British Columbia; in *Porphyry Deposits of the Northwestern Cordillera of North America*, Schroeter, T.G., Editor, *Canadian Institute of Mining, Metallurgy and Petroleum*, Special Volume 46, pages 757-763.
- Dawson, J.M. (1988): Geological and Geochemical Report on the Wolf Property, Omenica Mining Division, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 16995.
- Ficklin, W.H. (1970): A Rapid Method for the Determination of Fluoride in Rocks and Soils, Using an Ion-Selective Electrode; *United States Geological Survey*, Professional Paper 700C, pages 186-188.
- Friske, P.W.B. (1991): The Application of Lake Sediment Geochemistry in Mineral Exploration; in *Exploration Geochemistry Workshop*, *Geological Survey of Canada*, Open File 2390, pages 4.1-4.20.
- Garrett, R.G. (1974): Field Data Acquisition Methods for Applied Geochemical Surveys at the *Geological Survey of Canada*; Geological Survey of Canada, Paper 74-52.
- Hall, G.E.M. (1979): A Study of the Stability of Uranium in Waters Collected from Various Geological Environments in Canada; in *Current Research, Part A*, *Geological Survey of Canada*, Paper 79-1A, pages 361-365.
- Holland, S.S. (1976): Landforms of British Columbia - A Physiographic Outline; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 48.
- Jonasson, I.R., Lynch, J.J. and Trip, L.J. (1973): Field and Laboratory Methods Used by the Geological Survey of Canada in Geochemical Surveys: No. 12, Mercury in Ores, Rocks, Soils, Sediments and Water; *Geological Survey of Canada*, Paper 73-21.
- Pinsent, R.H. (2000): Mineral Potential of the Southern Coast Belt, Cape Caution Area, British Columbia (92L, 92M); in *Geological Fieldwork 1999*, *B.C. Ministry of Energy and Mines*, Paper 2000-1.