Updating the British Columbia Regional Geochemical Survey Database with New Field Survey and Sample Reanalysis Data to Support Mineral Exploration (NTS 082F, K, 092K, L, 093J, 102I)

W. Jackaman, Noble Exploration Services Ltd., Sooke, BC, wjackaman@shaw.ca

R.E.W. Lett, Consultant, Victoria, BC

Jackaman, W. and Lett, R.E.W. (2013): Updating the British Columbia Regional Geochemical Survey database with new field survey and sample reanalysis data to support mineral exploration (NTS 082F, K, 092K, L, 093J, 102I); *in* Geoscience BC Summary of Activities 2012, Geoscience BC, Report 2013-1, p. 5–10.

Introduction

Results compiled from government-funded regional geochemical surveys are routinely used by the mining sector to focus and support mineral exploration projects throughout British Columbia. Introduced in 1976, efforts to develop and maintain survey results as a consistent and functional multi-element geochemical database have been ongoing. Currently, the BC Regional Geochemical Survey database has analytical results and site information for more than 63 000 sediment and water samples and sample locations that cover approximately 80% of BC at an average density of one site every 12 km^2.

For several years, Geoscience BC has advanced the utility of the provincial Regional Geochemical Survey database by supporting new field surveys and the reanalysis of sample material saved from previously completed programs. Since 2005, a total of 12 000 new drainage samples have been collected and more than 35 000 pulps from previous government programs, including the BC Geological Survey's Regional Geochemical Survey (RGS) and the Geological Survey of Canada's (GSC) National Geochemical Reconnaissance (NGR) programs have been analyzed using up-to-date laboratory techniques. In 2012, Geoscience BC supported the following upgrades to the BC RGS database (Figure 1):

- reanalysis of approximately 1150 stream sediment samples originally collected in 1985 from sites located in the McLeod Lake (NTS 093J) map area (W. Jackaman, unpublished data, 2012). The samples have been analyzed for 35 elements by instrumental neutron activation analysis (INAA);
- reanalysis of approximately 2690 stream sediment samples originally collected in 1977 from sites in the Nelson (NTS 082F) and Lardeau (NTS 082K) map areas (W. Jackaman, unpublished data, 2012). The samples have been analyzed for 51 elements by aqua-regia digestion followed by inductively coupled plasma–mass spectrometry (ICP-MS); and
- new sample collection and till sample reanalysis covering parts of the Alert Bay (NTS 092L), Bute Inlet (NTS 092K) and Cape Scott (NTS 102I) map areas as part of the Northern Vancouver Island Exploration Geoscience Project (W. Jackaman, unpublished data, 2012).

Keywords: *Vancouver Island, Nelson, Lardeau, McLeod Lake, mineral exploration, geochemistry, Regional Geochemical Survey, RGS, multi-element, reanalysis, stream sediment, moss mat*

This publication is also available, free of charge, as colour digital files in Adobe Acrobat® PDF format from the Geoscience BC website: http://www.geosciencebc.com/s/DataReleases.asp.

Geoscience BC 2012 Projects

McLeod Lake Sample Reanalysis by INAA

Bedrock in the McLeod Lake map area has the potential to host different types of economically important mineral deposits. These include Cu-Au-porphyry–style mineralization in Triassic deposits, calcalkaline volcanic and sedimentary rocks similar to the Mount Milligan Cu-Au deposit northwest of the map area and Pb-Zn sulphide mineralization in Paleozoic sedimentary rocks in the eastern part of the map area. However, successful exploration for new deposits is challenged by the thick, extensive glacial sediments that cover much of the bedrock. Stream sediment, lake sediment, heavy mineral concentrate and glacial sediment sampling have all been used to detect the existence of new sulphide mineralization. The first regional geochemical survey of the McLeod Lake map area carried out in 1986 was jointly managed by the then BC Ministry of Energy, Mines and Petroleum Resources and the GSC. At that time, a total of 1152 stream samples were collected and the sediment material was analyzed for 18 metals (Ag, As, Ba, Cd, Co, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, Sn, U, V, W and Zn). In 2006, the sediment samples were recovered from storage and a 0.5 g portion of each pulp was analyzed by an aqua-regia digestion followed by ICP-MS for 37 elements (Lett and Bluemel, 2006). Unfortunately, the samples were not included in recent INAA reanalysis initiatives and remained the only area surveyed prior to 1989 that did not include this important analytical information. To close this

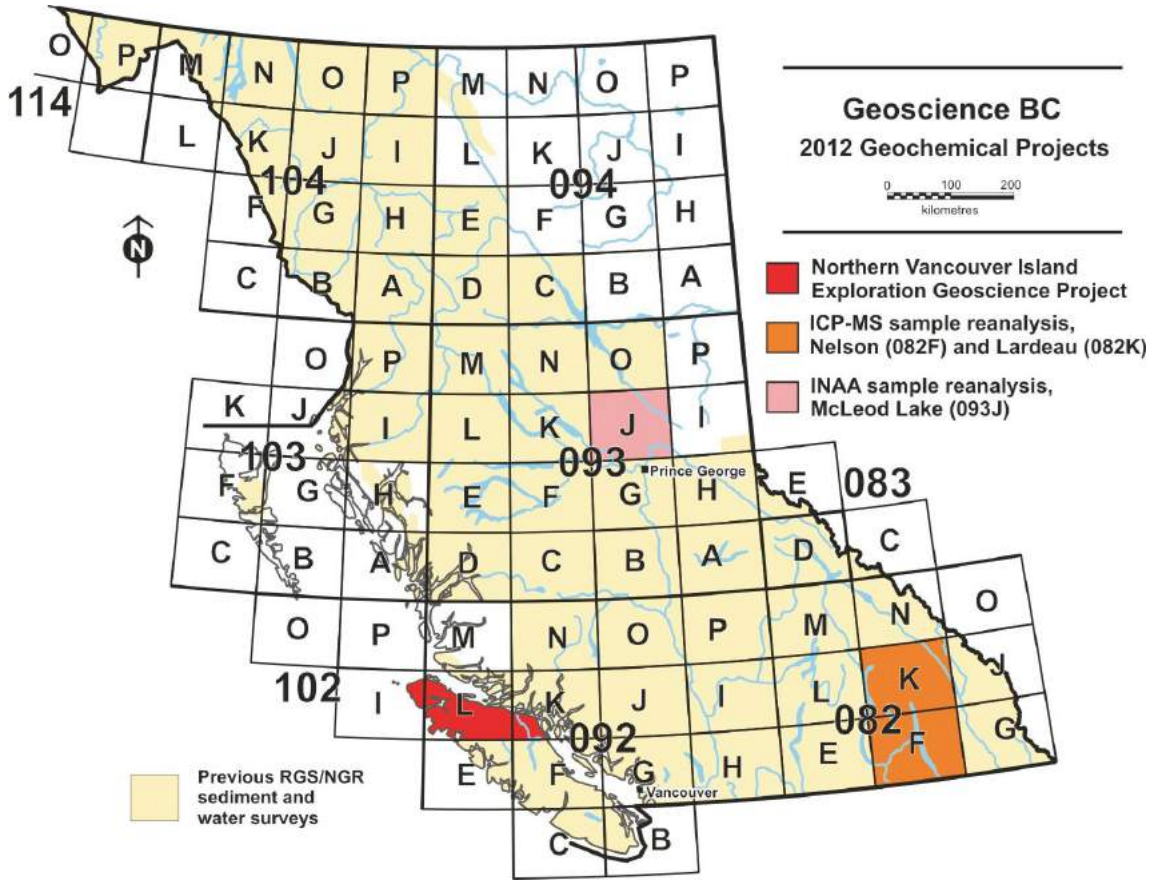

Figure 1. Location of the Geoscience BC 2012 sample reanalysis programs and the Northern Vancouver Island Exploration Geoscience Project in British Columbia. Abbreviations: ICP-MS, inductively coupled plasma–mass spectrometry; INAA, instrumental neutron activation analysis; NGR, National Geochemical Reconnaissance; RGS, Regional Geochemical Survey.

gap in the database, the samples and quality-control materials are being analyzed by INAA for 35 elements. These INAA results will significantly upgrade the Au values because of the larger sample analyzed and will report a range of other valuable metals such as pathfinder and rare earth elements. Near-total INAA element data will further refine the neural network approach to mapping bedrock geology developed by Barnett and Williams (2009) using the McLeod Lake stream sediment geochemical data. The INAA data will also offer greater survey continuity with previous geochemical survey work completed in adjacent map areas and will complement various Geoscience BC–supported and other exploration research conducted in the region, including lake sediment and till geochemical surveys (Jackaman, 2008a; Ward et al., 2012). The new INAA data is scheduled to be publically released in early 2013.

Nelson and Lardeau Sample Reanalysis by ICP-MS

The Nelson and Lardeau geochemical surveys were conducted 35 years ago as part of the original NGR program. During the 1977 surveys, a total of 2691 stream sediment samples were collected and analyzed for Ag, Co, Cu, Fe, Hg, Mn, Mo, Ni, Pb, V, W and Zn by an aqua-regia digestion followed by atomic absorption spectrometry (AAS) and for U by neutron activation and delayed neutron counting. Subsequent analyses of the archived pulps by INAA in the early 1990s provided additional analytical information to the geochemical database (Jackaman et al., 1991). As host to a number of important mining camps and exploration areas (Figure 2), the region has been identified as an important candidate for further upgrades to the related geochemical information by recovering and analyzing sediment pulps saved from the original survey work. These samples, with quality-control materials, have now been analyzed by an ultratrace aqua-regia digestion (0.5 g) ICP-MS package for 53 elements. This work is a continuation of a series of large-scale reanalysis initiatives that have been sponsored by Geoscience BC since 2007 and are recognized as a cost-effective means of updating older NGR and RGS information with a range of new analytical information at significantly improved detection levels (Jackaman, 2008b, c, 2009, 2010, 2011a). The new ICP-MS data is scheduled to be released in early 2013.

Northern Vancouver Island Exploration Geoscience Project

Regional Geochemical Survey and Till Reanalysis

The Northern Vancouver Island Exploration Geoscience Project includes new stream-based sampling and the reanalysis of approximately 480 till samples (Figure 3) collected during surveys conducted in the early to mid-1990s (Bobrowsky and Sibbick, 1996). The work will generate new geochemical information that will help stimulate mineral exploration in the region and complement other components of the initiative such as a high-resolution airborne geophysical survey and community workshops (Simpson, 2013) as well as earlier geochemical survey work and geological mapping.

The BC Ministry of Energy, Mines and Natural Gas (BCMEMNG) originally conducted stream-based RGS on northern Vancouver Island and the adjacent mainland in 1988 (Gravel and Matysek, 1989). The northern Vancouver Island portion of these surveys included the collection of moss-mat sediment and water samples. Moss-mat sediment has been collected in areas such as Vancouver Island where conventional stream sediment is scarce because of high-energy water flow. Living mosses found in the stream channel below the high water level have been found to capture sus-

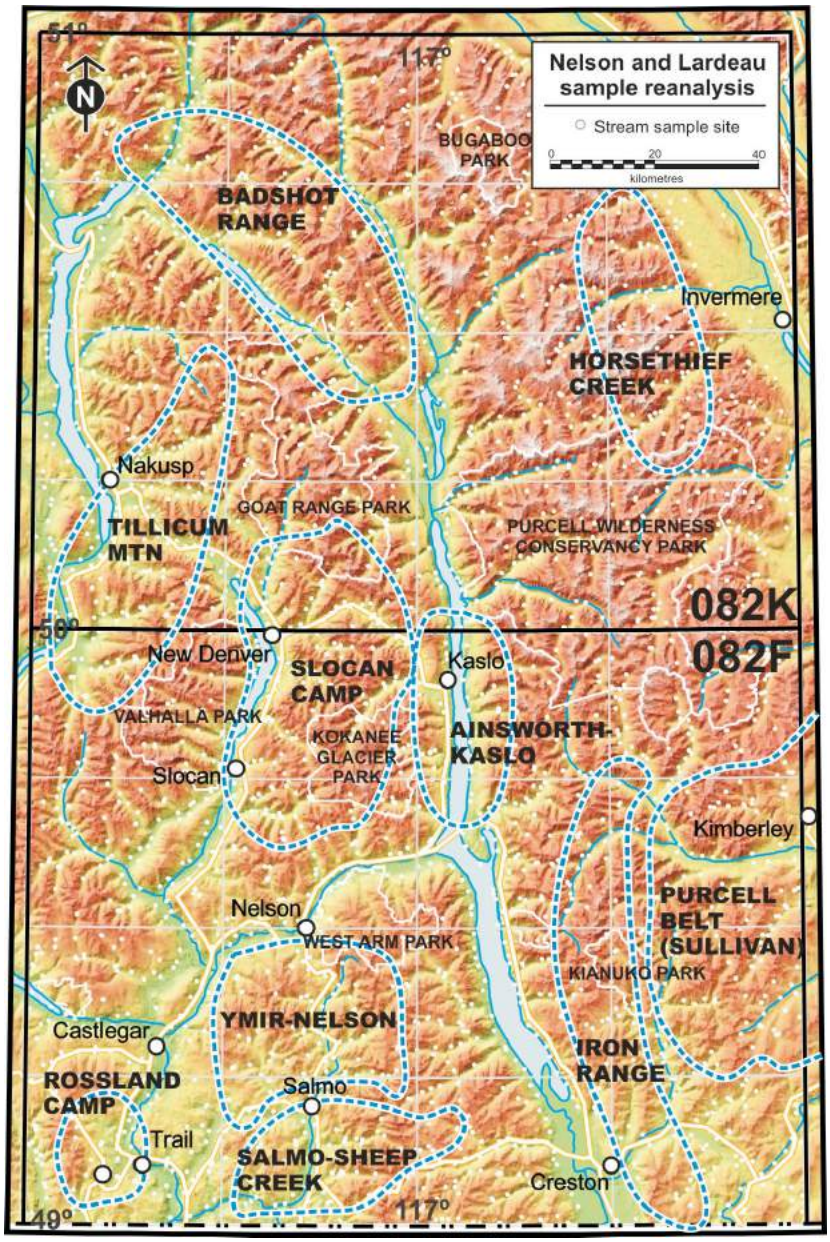

Figure 2. Location of the southeastern British Columbia study area, the stream sample site locations and the distribution of historical mining camps and exploration areas, indicated by the dashed lines.

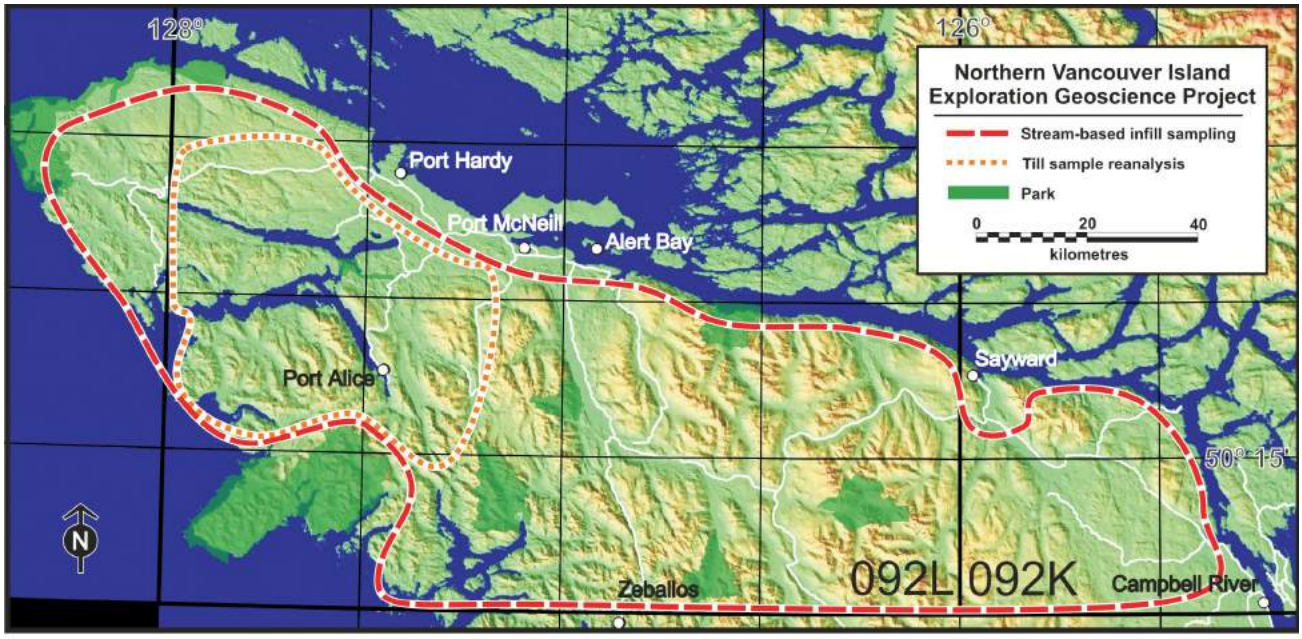

Figure 3. Location of the Northern Vancouver Island Exploration Geoscience Project study area.

pended fine-grained sediment from the streamwater (Figure 4). When the original data was published, the sediment analytical package included Ag, As, Bi, Cd, Cu, Co, Cr, Fe, Hg, Mn, Mo, Ni, Pb, Sb, Sn, U, V, W and Zn by aqua-regia digestion–AAS finish and Au by lead-collection fire assay. In 2010, as part of a Geoscience BC–supported initiative, the Vancouver Island moss-mat sediment with quality-control samples were reanalyzed for 51 elements by aqua-regia digestion (0.5 g) The inductively coupled plasma–mass spectrometry/inductively coupled plasma–atomic emission spectroscopy (ICP-AES) analysis and Pt and Pd by lead-collection fire assay (30 g) with an ICP-MS finish (Jackaman, 2011b).

In September and October 2012, infill sampling involving the collection of approximately 700 moss-mat sediment and water samples was conducted on parts of northern Vancouver Island (NTS map areas 092L, 092K and 102I). The new sampling has been designed to increase geochemical coverage by targeting primary drainages not previously sampled and adding more sample sites upstream from existing locations in secondary or larger drainages. To maintain continuity with the original surveys, 1–2 kg moss-mat sediment samples were collected from each site when available. In some cases, often due to stream channel disruptions associated with logging, conventional sediment (recently deposited, fine-grained material found within the active channel) was collected. Water samples were also collected, but due to the unusually dry weather, many of the sites were dry.

Figure 4. A typical moss-mat sediment sample, British Columbia, 3.8 cm (1.5 in) plastic putty knife for scale.

At the completion of the field program, moss-mat sediment and stream samples were dried and sieved to –80 mesh (<177 μm). Once processed, splits of the sediment samples were forwarded to commercial laboratories and analyzed for 53 analytes by ICP-MS using aqua-regia digestion and INAA for 35 elements. Loss-on-ignition and F content will also be determined for moss-mat and stream sediment samples. Streamwater was measured for pH and conductivity at each site and fluoride was determined in the laboratory from the raw streamwater samples.

To further augment the region's geochemical database, the –230 mesh (<63 μm) fraction of till samples collected in the 1990s as part of the northern Vancouver Island drift prospecting program (Bobrowsky and Sibbick, 1996) was retrieved from a storage facility in Victoria and a portion of each sample was recovered for analysis by an ultratrace aqua-regia digestion (0.5 g) ICP-MS package for 53 elements. Blind duplicate and control reference materials

were included with the submitted samples to monitor the quality of the analysis.

There is a high probability for new metal deposit discoveries on Vancouver Island because bedrock geology reflects periodic accretion of island arc–related volcanic rocks and related intrusive bodies and most of the area has considerably improved access by an extensive logging road network. There are numerous mineral occurrences, ranging from porphyry Cu-Mo to volcanogenic massive sulphides to skarn-type mineralization. Bedrock mapping by Nixon et al. (2008) has significantly improved an appreciation of northern Vancouver Island geology and has complementary lithogeochemical studies that suggest the volcanic rocks may also host Pt-Pd mineralization (Nixon et al., 2008). Geochemical information compiled from the Northern Vancouver Island Exploration Geoscience Project will be released in 2013.

Summary

Ongoing efforts by government-funded agencies such as the GSC, the BCMEMNG and Geoscience BC to update and maintain the provincial Regional Geochemical Survey database has helped produce one of the most comprehensive collections of field information and multi-element analytical data in Canada. The collection remains an important instrument for focusing and directing mineral exploration activities in the province and has been credited with locating many prospective areas as well as the discovery of new sources of metals. Its value is sustained by the fact that data has been acquired and maintained according to strict operational standards (Ballantyne, 1991; Friske and Hornbrook, 1991) and is provided to the public free of charge and in usable formats. With ongoing development and maintenance, the information will remain relevant and will contribute to the success of mineral exploration and mining initiatives.

Acknowledgments

The authors greatly appreciate contributions from E. Jackaman, S. Reichheld, J. Dimock, J. Constable and B. Elder to the field programs. A. Rukhlov of the BCMEMNG and M. McCurdy and A. Therriault of Natural Resources Canada are acknowledged for their ongoing support of the development and maintenance of the BC Regional Geochemical Survey database and archive storage facilities. The Northern Vancouver Island Exploration Geoscience Project is jointly funded by Geoscience BC and the Island Coastal Economic Trust. T. Höy's editorial comments are greatly appreciated.

References

Ballantyne, S.B. (1991): Stream geochemistry in the Canadian Cordillera: conventional and future applications for exploration; *in* Exploration Geochemistry Workshop, Geological Survey of Canada, Open File 2390, p. 6.1–6.7, URL <http://geoscan.ess.nrcan.gc.ca/cgi-bin/starfinder/ 0?path=geoscan.fl&id=fastlink&pass=&format=FLFULL&search=R=132388> [October 2012].

Barnett, C.T. and Williams, P.M. (2009): Using geochemistry and neural networks to map geology under glacial cover; Geoscience BC, Report 2009-3, 27 p., URL <http://www.geosciencebc.com/s/2009-03.asp> [November 2012].

Bobrowsky, P.T. and Sibbick, S.J. (1996): Till geochemistry of northern Vancouver Island area, (NTS 92L/5, 6W, 11W, 12); BC Ministry of Energy, Mines and Natural Gas Open File 1996-07, 26 p., URL <http://www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/OpenFiles/1996/Pages/1996-7.aspx> [October 2012].

Friske, P.W.B. and Hornbrook, E.H.W. (1991): Canada's National Geochemical Reconnaissance programme; *in* Transactions of the Institution of Mining and Metallurgy, Section B, v. 100, p. 47–56, URL <http://geochem.cgkn.net/cdogs/metadata_pub_e.php?id=01454> [October 2012].

Gravel, J.L. and Matysek, P.F. (1989): 1988 regional geochemical survey, northern Vancouver Island and adjacent mainland (092E, 092K, 092L); BC Ministry of Energy, Mines and Natural Gas, Paper 1989-1, p. 585–591, URL <http://www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/Fieldwork/Pages/GeologicalFieldwork1988.aspx> [October 2012].

Jackaman, W. (2008a): Regional lake sediment and water geochemical data, northern Fraser Basin, Central BC (parts of NTS 93G, H, J, K, N & O); Geoscience BC, Report 2008-5, 4 p., URL <http://www.geosciencebc.com/s/2008-05.asp> [October 2012].

Jackaman, W. (2008b): QUEST Project sample reanalysis; Geoscience BC, Report 2008-3, 4 p., URL <http://www.geosciencebc.com/s/2008-03.asp> [October 2012].

Jackaman, W. (2008c): Regional stream sediment and water geochemical data: Terrace & Prince Rupert (NTS 103I & 103J), British Columbia; Geoscience BC, Report 2008-11, 4 p., URL <http://www.geosciencebc.com/s/2008-11.asp> [October 2012].

Jackaman, W. (2009): QUEST-West Project sample reanalysis; Geoscience BC, Report 2009-5, 4 p., URL <http://www.geosciencebc.com/s/2009-05.asp> [October 2012].

Jackaman, W. (2010): QUEST-South Project sample reanalysis; Geoscience BC, Report 2010-4, 4 p., URL <http://www.geosciencebc.com/s/2010-004.asp> [October 2012].

Jackaman, W. (2011a): Northern BC sample reanalysis project; Geoscience BC, Report 2011-2, 11 p., URL <http://www.geosciencebc.com/s/2011-02.asp> [October 2012].

Jackaman, W. (2011b): Regional stream sediment and water geochemical data, Vancouver Island, British Columbia; Geoscience BC, Report 2011-4, 5 p., URL <http://www.geosciencebc.com/s/2011-04.asp> [October 2012].

Jackaman, W., Matysek, P.F. and Cook, S.J. (1991): The regional geochemical survey program: summary of activities; *in* Geological Fieldwork 1991, BC Ministry of Energy, Mines and Natural Gas, Paper 1992-1, p. 307–318, URL <http://www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/Fieldwork/Pages/GeologicalFieldwork1991.aspx> [October 2012].

Lett, R.E.W. and Bluemel, B. (2006): Re-analysis of Regional Geochemical Survey stream sediment samples from the McLeod Lake area (NTS map sheet 093J); BC Ministry of Energy, Mines and Natural Gas, GeoFile 2006-09, 220 p.,

URL <http://www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/GeoFiles/Pages/2006-9.aspx> [October 2012].

Nixon, G.T., Larocque, J., Pals, A., Styan, J., Greene, A.R. and Scoates, J.S. (2008): High-Mg lavas in the Karmutsen flood basalts, northern Vancouver Island (NTS 092L): stratigraphic setting and metallogenic significance; *in* Geological Fieldwork 2007; BC Ministry of Energy, Mines and Natural Gas, Paper 2008-1, p. 175–190, URL <http://www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/Fieldwork/Pages/GeologicalFieldwork2007.aspx> [October 2012].

Simpson, K. (2013): Update on Geoscience BC's 2012 geophysical programs; *in* Geoscience BC Summary of Activities 2012, Geoscience BC, Report 2013-1, p. 1–4.

Ward, B.C., Leybourne, M.I. and Sacco, D.A. (2012): Heavy mineral analysis of till samples within the QUEST Project area, central British Columbia (NTS 093J); *in* Geoscience BC Summary of Activities 2011, Geoscience BC, Report 2012-1, p. 59–68, URL <http://www.geosciencebc.com/ i/pdf/SummaryofActivities2011/SoA2011_Ward.pdf> [November 2012].