NECHAKO NATMAP PROJECT, CENTRAL BRITISH COLUMBIA 1998 OVERVIEW

D.G. MacIntyre and L.C. Struik (Cordilleran Section, GSC Vancouver, British Columbia)

KEYWORDS: Nechako plateau, Eocene, extension, Natmap, Babine porphyry belt, Sitlika Assemblage, Nechako map, Fort Fraser map, Endako, plutonism, multidisciplinary, bedrock mapping, surficial mapping, biogeochemistry, till geochemistry, geochronology, conodonts, radiolarian, geophysics.

INTRODUCTION

The Nechako NATMAP project (Figure 1) is a joint mapping venture between the Geological Survey of Canada (GSC) and the British Columbia Geological Survey Branch (BCGSB) (McMillan and Struik, 1996; Struik and McMillan, 1996; Struik and MacIntyre, 1997; MacIntyre and Struik, 1997; Struik and MacIntyre, 1998). This was the fourth and final year of field work for the project which has encompassed more than 30 000 km^2 in central British Columbia (Figures 1 and 2). Its main focus is to improve the quality and detail of bedrock and surficial maps to help resolve several geological problems. In particular it addresses the following questions: 1) the extent and nature of Tertiary crustal extension, 2) Mesozoic compression and the manner of accretion of exotic terranes, 3) the geological and geophysical definition of the terranes, 4) the sequence of changing Pleistocene glacial ice flow directions, and 5) the character and dispersion of glacial deposits.

In this fourth field season of the Nechako NATMAP project, staff geologists from the GSC and BCGSB, with the assistance of students and researchers from Simon Fraser University (SFU), University of Alberta (UA), University of Bristol, England (UB), University of British Columbia (UBC), University of Guelph (UG), University of New Brunswick (UNB), University of Ottawa (UO), University of Victoria (UVic), University of Waterloo (UW), and University of Wisconsin-Eau Claire, USA (UWis), completed bedrock mapping in 14 and surficial mapping in 6 1:50,000 scale map areas (Figures 2 and 3). In addition, researchers sampled till, silt, lodgepole pine, and rocks in various geochemical studies. Others measured magnetic signatures; studied biostratigraphy; sampled for isotopic-age dating; and conducted detailed sedimentological and stratigraphic studies. Stratigraphic studies concentrated on sections within the Hazelton Group south of Burns Lake and mainly volcanic sequences of the Ootsa Lake Group. Digital Geographic Information System (GIS) projects included construction and addition to the digital field mapping databases, cartography of geological maps, internet GIS data sharing, surficial geology GIS data sets, analysis of RADARSAT and LandSat imagery, generation of Digital Elevation Models and creation of a general interest geological map of the Fort Fraser map area (Hastings *et al*., 1998). New geoscience contributions include: 1) extending southeastward the distribution of the Sitlika Group sediments and volcanics through the Fort Fraser map area (NTS 93K), 2) redefining large tracts of western Cache Creek Group as Stikine and Sitlika assemblages, 3) recognition of Jura-Cretaceous contraction structures which may be correlative with Skeena Fold Belt structures to the north, 4) better definition of the nature, distribution and tectonic setting of the Miocene and Eocene basalt, andesite and felsic volcanic and associated intrusive suites, 5) characterizing the geophysical and geochemical signature of the Endako Batholith and adjacent suites, and 6) establishing an area of high background mercury in till and lodgepole pine bark in the area north of Ootsa Lake in NTS map area 93F.

This paper outlines research that is in many cases preliminary. References are given to more in depth summaries in this volume and Current

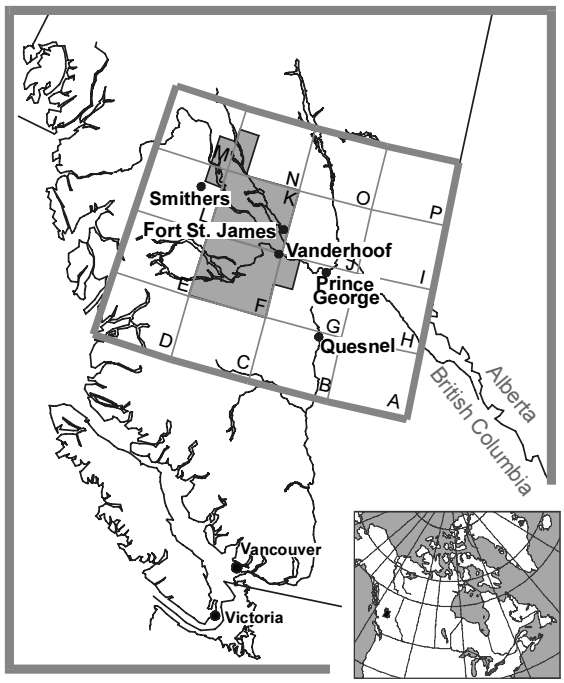

Figure 1. Location of the Nechako NATMAP project area within British Columbia. The Parsnip River (NTS 93) 1:1 000 000 scale map area and it's 1:250 000 scale component map areas are shown for reference.

Research 1999 of the Geological Survey of Canada. For others the continuing research will lead to more comprehensive government and journal reports and maps. Analytical data is not reported in this paper.

OVERVIEW OF 1998 NECHAKO PROJECT RESULTS

Babine Porphyry Belt and Sitlika Studies

In the 1998 field season, the B.C. Geological Survey Branch focused on bedrock mapping in the Babine-Takla lakes area. Don MacIntyre and Paul Schiarizza were co-leaders of the bedrock mapping crew, which included geology students Angelique Justason (2nd year Camosun), Sheldon Modeland (4th year UVic), Stephen Munzar (4th year UBC) and Deanne Tackaberry (4th year UVic).

Accomplishments

From early June until the end of August, the bedrock geology of NTS map sheets 93K/11, 12, 14 and 93N/3 (Figures 2 and 3) were mapped at 1:100 000 scale. In addition, fill-in mapping was done in areas mapped in previous summers including map sheets 93K/13, 93N/4 and 5. In the Babine Porphyry belt bedrock mapping was extended into adjoining map sheets 93L/9, 93M/2 and 93M/7. This work built on previous mapping in the Babine Porphyry belt (MacIntyre *et al*., 1996; MacIntyre *et al*., 1997; MacIntyre, 1998) and in the Sitlika belt east of Takla Lake (Schiarizza and Payie, 1997; Schiarizza *et al*., 1998; MacIntyre *et al*., 1998).

The following are the main highlights of work completed in 1998.

- significant revisions and refinements were made to the existing bedrock geology maps for the northwest quadrant of the Fort Fraser map sheet (93K/11,12,13 and 14), most of which were based on Armstrong's mapping and compilation (Armstrong, 1949).
- an area of limestone, metavolcanic and metasedimentary rocks intruded by pyroxenite and amphibole gabbro was mapped in the northwest corner of the 93K/12 map sheet. These rocks, previously mapped as Jurassic Hazelton Group, are tentatively correlated with the Permian Asitka Group. They appear to stratigraphically underlie pyroxene porphyry flows of the Takla Group that are exposed further to the east.
- additional mapping in the western parts of 93N/4 and 93N/5 has revealed that the Takla Range, previously mapped as Upper Triassic Takla Group, also includes Jurassic strata of the Hazelton and Bowser Lake groups.
- mapping in the vicinity of the Fort prospect suggests mineralization formed as a result of relatively low temperature open space filling in a dilational breccia zone along the fault contact between a pyroxenite-gabbro-diorite-tonalite intrusive complex and Takla volcanics. The pyroxenite intrusive complex intrudes chlorite schists and pyroxene-phyric metabasalts that may correlate with the Takla Group and/or the Asitka or Sitlika assemblages.
- the Sitlika eastern clastic unit was traced southeastwards from 93K/13, into the 93K/14, 93K/11 and 93K/12 map sheets, where it was previously mapped as Cache Creek Group. Felsic and mafic metavolcanic rocks that form a narrow belt directly west of the eastern clastic unit are correlated with

the Sitlika volcanic unit; a U-Pb geochronology sample was collected from one of the felsic volcanic members to test this correlation.

- new mapping in the southern part of 93N/4, together with visits to previously mapped outcrops in 93N/4 and 5, has resulted in an improved understanding of the Sitlika western clastic unit. Most of the unit is now interpreted as a structural repetition of the eastern clastic unit within a west-vergent fold-fault system. Chert pebble conglomerate that dominates the unit where it was originally defined in 93N/12 is interpreted as a fault-bounded panel derived from the Stikine terrane (Bowser basin), which forms the footwall of this west-vergent thrust system.
- the ultramafic unit that marks the boundary between the Sitlika assemblage and Cache Creek Group in 93N continues southward along the contact through 93K/13 and 14 and into 93K/11. This unit includes serpentinite melange, as well as coherent sections of tectonized harzburgite with dunite pods, gabbro-diorite intrusive complexes and mafic volcanic rocks. A sheeted diabase dike complex was discovered along the eastern margin of the unit in 93K/11, consistent with an ophiolitic origin for the ultramafic unit. Tonalite, which occurs locally as a late stage differentiate within some of the gabbro-diorite intrusive complexes was sampled for U-Pb dating in an effort to determine the age of the ophiolite complex.
- from Stuart Lake to Tsitsutl Mountain, the Cache Creek Group directly east of the ultramafic unit is represented by a belt of mafic metavolcanic rocks and associated chert, phyllite and minor limestone, that is intruded by numerous mafic (locally ultramafic) sills and dikes. The dikes and sills are similar to intrusive rocks found within the adjacent ultramafic unit, suggesting that these rocks may represent the upper part of the ophiolite succession. The volcanic-sedimentary succession is, at least in part, Late Triassic in age, and displays evidence of syn-sedimentary intrusion and faulting. It represents the remnants of an active (back arc?) basin that may have potential for VMS deposits of the Windy Craggy type.

Cache Creek Group tectonostratigraphic studies

Studies this season in the Cache Creek Group of Fort Fraser and Manson River map areas consisted of improving fossil collections. This work was conducted by Hilary Taylor (GSC) with assistance of Mike Hrudey (UA), Kelly Franz (UBC), and Paul Schiarizza (BCGSB). Primary access was by forest service roads branching from Fort St. James, and the extensive lake system.

Accomplishments

This sampling is meant to confirm and increase the size of unique conodont fossil collections made in previous years in the Cache Creek Group, Sitlika Formation and Stikine Terrane. These collections contain Permian and Early Triassic faunal assemblages rare or previously unknown in western North America and in particular to these rock assemblages (Orchard *et al*., 1999).

Endako Plutonism and Tectonics

Bedrock was mapped in detail within the Tchesinkut (93K/4), Burns Lake (93K/5), and Tintagel Lake (93K/6) map areas (1:50 000 scale, Figures 2, 3). This mapping built on previous mapping by the British Columbia Geological Survey, the Geological Survey of Canada and the Endako Mines group (Kimura *et al*., 1980; G. Johnson, pers. comm., 1997). Joe Whalen (GSC) and Bert Struik (GSC) were ably assisted by Karen Fallas (UA), Mike Hrudey (UA), Marianne Quat (GSC), Crystal Huscroft (UBC), Selena Billesberger (UBC), Kelly Franz (UBC) and Matthew Clapham (UBC). Carmel Lowe (GSC) augmented investigations of the magnetic signature of the Endako molybdenum camp through detailed magnetic measurements within the Endako Mine. The area was accessed through forest roads and highways.

Accomplishments

Detailed bedrock maps of southwestern Fort Fraser map area (93K/4, 5 and 6) were completed. Stratigraphic sequences in the Ootsa Lake and Endako groups were constrained within the limits of the poor exposure. Nancy Grainger (UA, M.Sc.) and Mike Villeneuve (GSC) sam-

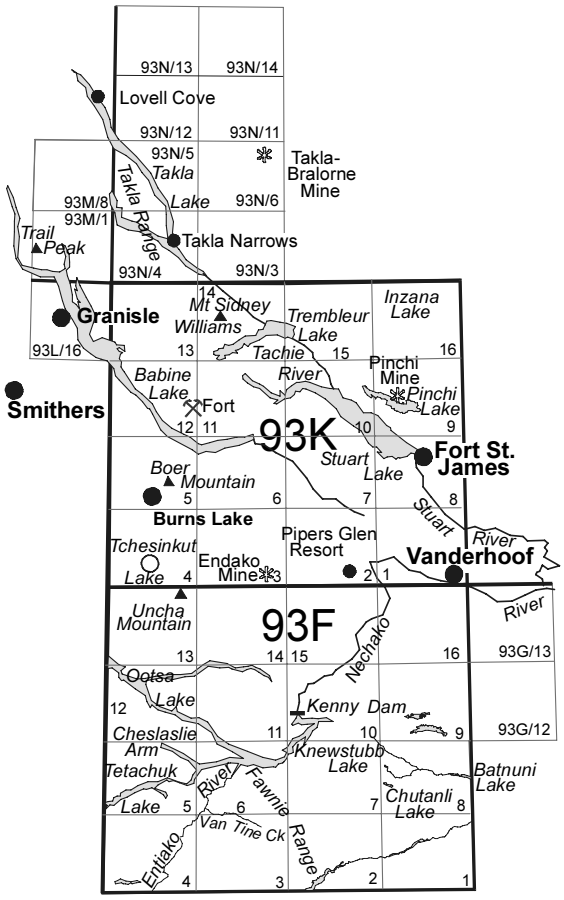

Figure 2. Reference map of geographic and NTS map locations mentioned in the text. See Figure 1 for the location of the Nechako NATMAP project area within central British Columbia.

pled igneous suites for U-Pb and Ar-Ar isotopic dating in key areas concentrating on the Tertiary volcanic units to constrain their stratigraphy and the tectonic events that generated them. Representative samples of each of the Tertiary volcanic units and the Jura-Cretaceous plutonic phases were taken for detailed lithogeochemistry to constrain interpretations of the genetic history of those rocks. Samples were taken from within the Endako Mine and from Tertiary dikes and flows of the surrounding area for magnetic measurements to quantitatively constrain detailed aeromagnetic interpretations.

The following are the main highlights of the Endako study of 1998:

- Endako Group basalt occurs in small areas mainly in the southern and western parts of southwestern Fort Fraser map area. At one locality Endako Group basalt is cut by rhyolite typical of the Ootsa Lake Group; previously considered to be entirely older than the Endako
- The Eocene age Ootsa Lake Group in southwestern Fort Fraser map area contains rhyolite, rhyodacite and dacite flows, crystal tuffs, agglomerates, breccias and conglomerates. Andesite and some dacite previously interpreted to be within the Ootsa Lake Group (Whalen *et al*. 1998) are now considered older; probably Cretaceous. Rhyolite of the Ootsa Lake Group around Tchesinkut Lake commonly shows textures associated with deposition in shallow water environments.
- The Boer pluton at Boer Mountain was determined to be gabbro to diorite that is different from the various plutons mapped as Boer phase to the east and northeast.
- The Tintagel phase of the Endako Batholith occupies a much smaller area than previously mapped; much of the Tintagel phase appears to be a more foliated variation of the McKnab or Shass Mountain phases.
- Sitlika assemblage andesite and sedimentary rocks mapped to the north (Schiarizza *et al*., 1998; Schiarizza and MacIntyre, 1999) continue southeastward through the Tintagel map area (NTS 93K/6; Hrudey *et al*., 1999). They were previously mapped as Cache Creek Group in the Fraser Lake area (Struik, 1997).
- Amphibolite, marble, quartzite and various foliated diorites of the Babine Lake area appear to be part of Stikine Terrane and are of higher metamorphic grade than to the northwest or southeast (Hrudey *et al*., 1999). No clearly defined structures bound these medium grade metamorphic rocks.

Nechako River Map Area Bedrock Mapping

Bob Anderson, Bert Struik (GSC) and crews continued bedrock mapping in the Nechako River (NTS 93F) map area at 1:100 000 and 1:50 000 scales. Carmel Lowe and Judith Baker recorded additional geophysical data to augment profiles previously initiated across the various shear zones surrounding the Vanderhoof Metamorphic Complex. Mapping concentrated

on the Knapp Lake (NTS 93F/14; Anderson *et al*., 1999a), Takysie Lake (NTS 93F/13), Marilla (NTS 93F/12), Cheslatta Lake (NTS 93F/11) and Tetachuck Lake (NTS 93F/05) map areas. Contributions were made to improve the detail of the bedrock mapping in the Euchiniko River (NTS 93F/08), Qualcho Lake (NTS 93F/4) and Suscha Creek (NTS 93F/01) map areas (Struik *et al*., 1999). Bob Anderson's core crew of senior mappers, Lori Snyder (UWis), Nancy Grainger (UA), and Jonah Resnick (UBC) was augmented by volunteers Elspeth Barnes (University of Glasgow), Tina Pint (UWis), Stephen Sellwood (UWis), Amber McCoy, Daniella Jost and Nancy Anderson. Assisting Bert were the Endako crew and Steve Williams (GSC) and volunteers, Ruth Paterson (University of Melbourne) and Christina Struik.

Accomplishments

In addition to completion of bedrock mapping in most of Nechako River map area (Anderson *et al*., 1999a, 1999b; Struik *et al*., 1999), several theses and directed study projects were undertaken, and additional magnetic and gravity readings were taken along profiles crossing the Nulki Shear zone (Wetherup, 1997) in northeastern Nechako River map area. Profiles were extended to the west and south and the density of the measurements increased in the vicinity of the suspected positions of buried shear zones. The university theses and directed studies include the petrogenesis of Miocene basalts (Resnick *et al*., 1999), geochronology and genesis of the Ootsa Lake Group felsic volcanic and related plutonic rocks (Grainger and Anderson, 1999), structural and stratigraphic mapping of the Jurassic and Tertiary volcanogenic and plutonic suites of Uncha Mountain in the northwest (Barnes and Anderson, 1999), structural studies of deformed Hazelton Group rocks, plutonic studies (Sellwood *et al*., 1999; S. Billesberger, UBC) and sedimentological and stratigraphic studies of the Hazelton Group to the southwest (M. Quat, GSC). Detailed laboratory studies included investigation of the development of saprolitic horizons beneath Miocene basalt by Resnick and mineralogical identifications by Barnes of the large variety of zeolite and other minerals that fill vesicles of basalt flows in the Ootsa Lake and Endako groups and less commonly in Miocene basalt.

Highlights of the Nechako River bedrock mapping for 1998 include:

- Recognition of important and widespread Cretaceous volcanic units in eastern Knapp Lake map area. They include felsic feldspar phenocryst-rich units and andesitic hornblende-plagioclase porphyry flows that strongly resemble the Upper Cretaceous Holy Cross porphyry andesite (Lane, 1995; Lane and Schroeter, 1997)
- A regional-scale reverse fault in the southern Takaysie (NTS 93F/13) and northern Marilla (NTS 93F/12) map areas juxtaposes Lower and Middle Jurassic Hazelton Group and Bowser Lake Group units, and is crosscut by a Cretaceous? porphyritic pluton (Anderson *et al*., 1999a). Up to 4 generations of ductile and or brittle minor structures were recognized by Tina Pint (UWis) in the Hazelton Group hangingwall rocks; equivalent Hazelton Group rocks elsewhere are comparatively undeformed. Interpreted thrust faulting in the Euchiniko River map area imbricated Lower and Middle Jurassic Hazelton Group volcanic and sedimentary rocks (Struik *et al*., 1999)
- Miocene basalt intrusive centres and associated lava flows are clearly distinguished from Eocene Endako Group basaltic andesite based on texture, the presence of olivine phenocrysts, megacryst and xenocryst content, and the common association of mantle and crustal xenoliths in the Miocene rocks (Resnick *et al*.,1999). Many centres occur along extensions of older fault systems, and locally, are themselves deformed, suggesting reactivation of Eocene faults and a Miocene extensional tectonic setting during emplacement.
- Ootsa Lake Group volcanic stratigraphy in northwestern Nechako River map area has been refined to include a generalized stratigraphy of amethyst-bearing amygdaloidal andesite and flow-layered rhyolite and rhyolitic tuff as well as a variety of flow-layered, aphanitic to porphyritic high level intrusions related to the volcanism (Grainger *et al*., 1999). Mafic rocks are rare but significant in the upper part of the Ootsa Lake Group because they may provide the strati-

graphic and petrological linkage to the Newman Volcanics recognized by D. MacIntyre of BCGSB.

- The distribution, composition, textures and intrusive relationships of high level, miarolitic leucogranite and associated porphyry phases in the Hallett Lake and Knapp Lake areas indicate that these intrusions are the closest plutonic analogues of the Ootsa Lake Group volcanic units (Sellwood *et al*., 1999).
- Similar plutonic rocks, as well as aphanitic and porphyritic felsic intrusions at Uncha Mountain, were shown to be clearly co-spatial and synkinematic with north-northeast-trending brittle faults and associated development of fracture cleavage (Barnes and Anderson, 1999). The orientations of the Tertiary faults and intrusions on Uncha Mountain suggests a rotation of the uniaxial extensional stress directions from NW-SE in the Hallett Lake area in the east to E-W at Uncha Mountain in the west.

Nechako River Map Area Quaternary Geological Mapping

Surficial mapping concentrated on the southwest and southeast quadrants of Nechako River map area and 93F/12. The mapping verified aerial photographic interpretations, catalogued Quaternary stratigraphy, studied landslide hazards and included collection of till samples for geochemistry. That work was done by Alain Plouffe (GSC) and student assistant Jean Bjornson (UO), and by Vic Levson (BCGSB), David Mate (Uvic, M.Sc.), Don McClenagan (Uvic, Ph.D.) and Andrew Stuart (University of Waterloo, M.Sc.) and involved staff of the British Columbia Ministry of Forests.

Accomplishments

Alain Plouffe and Jean Bjornson mapped surficial geology and sampled till at a regional scale (ca. one sample per 25 square kilometers) in the eastern and central part of Nechako River map sheet. They collected a total of 131 till samples for geochemical analyses that will be completed on the clay-sized (< 0.002 mm) and silt plus clay-sized (<0.063 mm) fractions. The samples were collected on the following 1:50 000 scale NTS map sheets: 93F/1, F/6, F/8, and F/9. Results of the 1996 and 1997 regional till sampling programs will be published as two sets of colored geochemical maps along with digital geochemical data (Plouffe, 1998a; Plouffe, in press).

One new surficial geology map was published in 1998 (Plouffe, 1998b) and a second one is in press (Plouffe, 1998c). With the combined effort of the British Columbia Geological Survey and the Geological Survey of Canada, by the end of the Nechako NATMAP project, four new surficial geology maps at a scale of 1:100 000 will be available for the entire Nechako River map sheet.

Glacial striations were measured on a total of 53 bedrock outcrops which included several sites that revealed more than one ice movement; for some of these, age relationships were established. Information on Quaternary stratigraphy was recorded at a limited number of sites located in the Batnuni Lake, Van Tine Creek, and Entiako River valleys. A site located on the shore of Cheslalie Arm of Ootsa Lake was revisited by A. Plouffe and V. Levson to sample nonglacial sediments that predate the last glaciation. The site was first described by Levson *et al*. (1998) who reported a single radiocarbon date of 27 790 ± 200 BP (Beta-101017) on the fine organic detritus of the nonglacial sediments.

Field work for two Bachelor's theses on Quaternary geology topics was completed during the 1998 field season. Crystal Huscroft (Huscroft and Plouffe, in press) studied the Pleistocene lake sediments deposited in the area of Knewstubb Lake. She investigated the sedimentology of the glacial lake sediments and took a series of elevation measurements of the glacial lake outlets and sediments to reconstruct the deglaciation history. Her work will contribute to the regional study of the glaciolacustrine deposits of central British Columbia (Plouffe, 1997). Her thesis will be completed at the University of British Columbia under the supervision of Dr. M. Church. Jean Bjornson completed a detailed investigation of ice-flow indicators (glacial striations, till fabrics, rat tail, flutes, drumlins, and crag and tail) for a 50 square kilometers area located along the western margin of 93 F/11 NTS map sheet. He will compare ice-flow data obtained from micro- and macro-landforms and will reconstruct the ice-

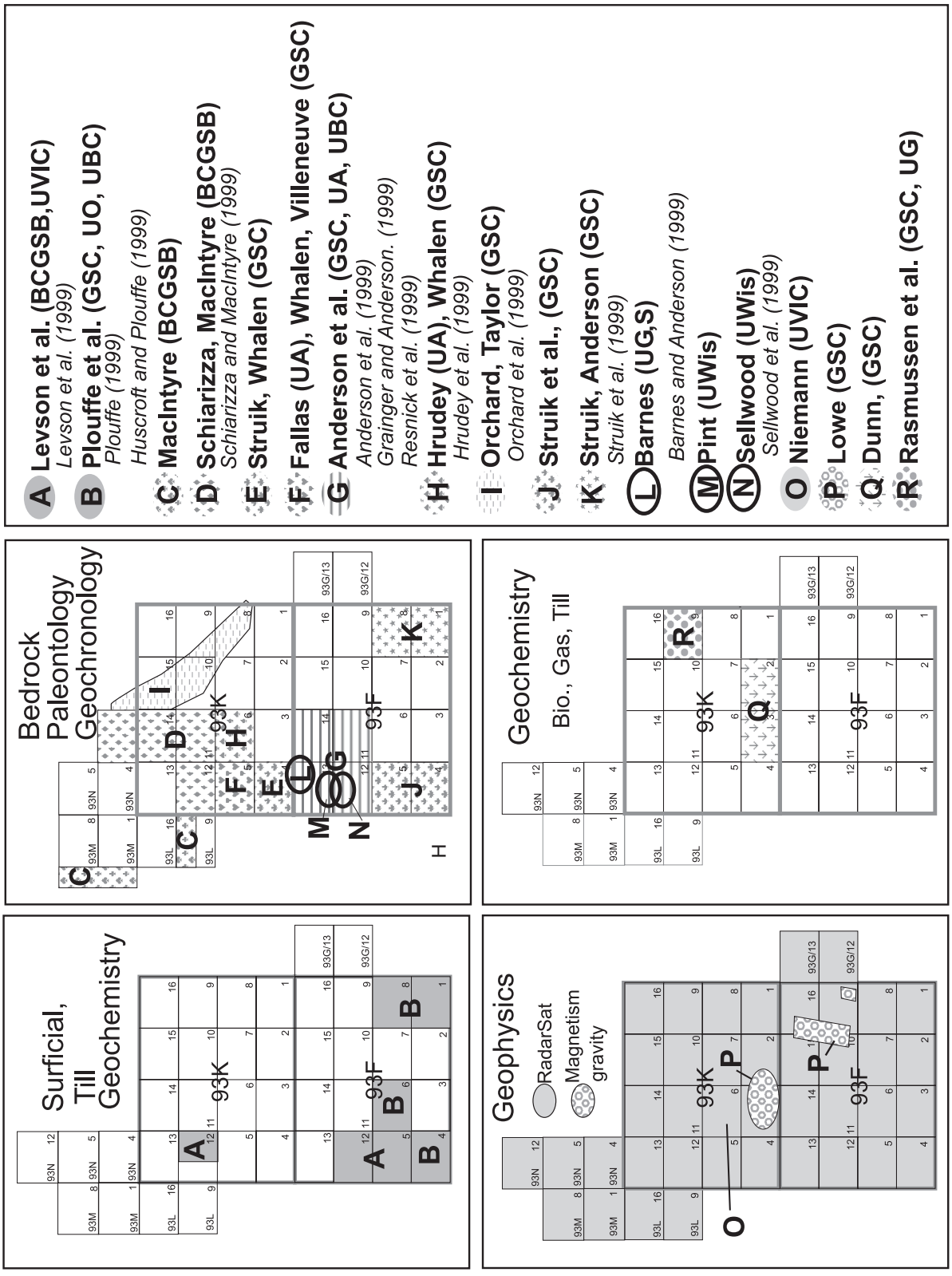

Figure 3. Location of various Nechako subprojects active in 1998.

flow history of that region. His research will be conducted at the University of Ottawa, under the supervision of Dr. B. Lauriol.

Surficial geological mapping conducted by the BCGSB concentrated on the Tetachuck Lake (93F/5) and Marilla (93F/12) 1:50,000 NTS mapsheets (Levson *et al*., 1999). Surficial geology studies in this area are a continuation of work started in 1997 (Levson *et al*., 1998).

Highlights of the Nechako River surficial geological mapping for 1998 include:

- Stratigraphic sections at Batnuni Lake, Van Tine Creek, and Entiako River valleys provide new information about the advance-phase paleogeography of the last glaciation.
- Preliminary results from ice flow indicators show an east-northeast ice flow, followed by an eastward movement. Glacial striations, roches moutonnées, and erratics found in the Fawnie Range all indicate a general eastward ice movement. This new information suggests that the ice divide identified by Levson *et al*. (1998) which extended from the Babine Lake to the Ootsa Lake valleys during the last glacial maximum, did not migrate as far easterly as the Fawnie Range.
- Anomalous westward ice flow during the Late Wisconsinan glaciation, recently described by Levson and Stumpf (1998), Levson *et al*. (1998), and Stumpf *et al*. (in prep) for the Babine Range and Hazelton mountains area, was also found this field season on the west side of the Marilla map sheet (93F/12). This indicates that a Late Wisconsinan ice divide was located east of the Tweedsmuir area, subjecting that region to westerly ice flow and consequent west-directed glacial dispersal. Westerly flow was independent of large topographic barriers such as the Tweedsmuir, Babine and Hazelton mountains and occurred when ice centers over the Hazelton and Coast mountains migrated eastward into the Interior Plateau. Evidence for westerly flow is most readily found in the western part of the map region and is absent in the east. Consequently, the effects of westward flow on geochemical dispersal are expected to diminish rapidly eastward.
- Westerly ice-flow locally continued to the end of the last glaciation as indicated by preservation of paleoflow indicators at unprotected, low elevation sites. These observations confirm that the maximum buildup of interior ice extended late into the last glaciation and that a topographically controlled, late-glacial, ice-flow phase was short-lived in this part of the Interior Plateau (Levson *et al*., 1998).

Geophysical Studies

In order to better constrain the geometry of Nulki Shear zone at depth Carmel Lowe and Judith Baker (GSC) extended gravity and magnetic traverses previously conducted across the structure (Lowe *et al*., 1998a). In addition they undertook detailed measurements of the magnetic field and the magnetic susceptibility of exposed rocks within the Endako Mine to augment existing airborne magnetic (Lowe *et al*., 1998a, b) and detailed paleomagnetic studies (Enkin *et al*., 1997, Lowe and Enkin, 1998). The magnetic data will be integrated with geochemical data to further explore the observed correlation between increasing molybdenum concentrations and decreasing magnetic susceptibilities (L'Heureux and Anderson, 1997). As a contribution to this work, magnetic susceptibility and density was measured for samples from a large part of the project area.

Geochemical Studies

Biogeochemical surveys

Colin Dunn (GSC), Rob Scagel (Pacific Phytometric Consultants, Surrey, BC) and a volunteer, Daniella Jost conducted a reconnaissance level, lodgepole pine sampling program surrounding the Endako Molybdenum camp (NTS 93K/02, 93K/03). The sampling extends 1996 and 1997 coverage throughout the northern half of the Nechako River map area. Samples were the outer bark of lodgepole pine. The bark was collected from sites at 2 km intervals along all driveable roads and trails.

Till samples collected in 1997 in the northwestern quadrant of Nechako River map area had high background concentrations of mercury.

To supplement that information all the lodgepole pine bark samples collected in that region (also in 1997) were analyzed for mercury. The analyses show that the pine trees are taking up high background levels of mercury and corroborate the till data (Plouffe, 1998a, 1999; Dunn, 1998).

Metals in the environment (MITE)

Pat Rasmussen, Colin Dunn, and Alain Plouffe (GSC) and Grant Edwards with 4 students: Jeff Kemp (Ph.D.), Laurie Halfpenny, Sophie Wong and Edwina Wong (University of Guelph) are working near the former Pinchi and Bralorne Takla mercury mines and at additional sites along the Pinchi fault zone. This work is part of the GSC Metals in the Environment (MITE) initiative. Objectives of this project are to determine if an anthropogenic signature is detectable around the mercury mine sites, to establish criteria that could be used to distinguish between natural and anthropogenic metal enrichments, and to identify the forms and phases in which metals are bound. Epiphytic moss and B horizon soil samples were collected in 1996 and 1997 at these locations and in 1998 Alain Plouffe continued this work collecting samples of humus, B-horizon, till, and glacial lake sediments along two transects near the Pinchi Mine. In addition, these orientation surveys found suitable sites for the in situ monitoring of mercury fluxes to the atmosphere, which was conducted in the summer of 1998.

Information on the natural air-surface exchange of mercury is relevant to risk assessors, in particular for apportioning exposure amongst natural and anthropopenic sources, and to provide a perspective for understanding releases from anthropogenic sources in the context of natural background variations.

The Pinchi mercury flux study is part of a larger survey of natural mercury emissions from representative geological settings across Canada (Rasmussen *et al*., 1998), a collaborative project between Geological Survey of Canada, University of Guelph, and Atmospheric Environment Service (Environment Canada). Two methods for determining fluxes are used: the micrometeorological gradient method and the dynamic flux chamber method. Both methods are coupled with Tekran Model 2537A cold vapour atomic fluorescence detectors. Time series measurements include wind speed and direction, net radiation, humidity, barometric pressure, air and soil temperature, and soil moisture. The focus of the current study is to develop methods to obtain reliable measurements of air-surface exchange of mercury representative of natural and perturbed surfaces in the vicinity of the Pinchi fault zone, and to understand factors causing temporal and spatial variations. In future, more portable methods are required to obtain spatially representative natural emissions data in remote areas.

Lake Sediment Geochemistry

Three regional lake water geochemical surveys are in the process of being written up. These studies were undertaken in conjunction with earlier lake sediment surveys in the southern Nechako, Pinchi Lake and Babine Porphyry Belt areas. This data (Cook *et al*., 1999), the first Geological Survey Branch release of regional multi-element lake water geochemical data in British Columbia, will be available at the 1999 Cordilleran Roundup. Several other geochemical studies are also in advanced stages of completion. These include studies of molybdenum distribution in lake sediments adjacent to porphyry molybdenum deposits of the Endako region, and studies of contamination of organic lake sediments during sample preparation. Interior Plateau lake sediment case study results from areas such as Hill-Tout and Chutanli lakes are also nearing completion, as are regional geochemical compilations of stream sediment, lake sediment and till geochemical data from the Babine Porphyry Belt and the Pinchi Fault Zone areas.

Industrial Minerals Investigations

Dani Hora and George Simandl (BCGSB) continued follow up on industrial mineral and precious stone sites previously known and newly reported during mapping of the Nechako project. Dimension stone, decomposed lapilli tuffs (for clays), ornamental and landscaping rock (basalts mainly), perlite, opal, and agate were investigated. In addition the hypothesis connecting diamonds to subduction generated and mantle derived high pressure rock types was explored.

Highlights of the 1998 mapping include:

- A fairly large area north of Mount Sidney Williams is underlain by soapstone altered ultramafic rocks. The stone is massive, with joints in rectangular systems allowing blocks of 1 cubic foot or more, macroscopically the stone is free of pyrite in most of the outcrops. The polished stone colour is mottled light green and grey. This is a very good potential source of carving material.
- The area of soapstone near Mount Sidney Williams also has outcrops of siliceous listwanite, locally very rich in bright green mica. The listwanite could provide an attractive facing stone. The area is very accessible.
- Scoracious rhyolitic volcanic rock south of Burns Lake may have pozzolanic properties. It resembles material quarried in Nisconlith Creek area south of Quesnel, which was successfully used by a local ready-mix operator some 20 years ago.

Geographic Information System Development

Stephen Williams and Nikki Hastings (GSC) continued development of the Nechako Project digital point, line and areal database and query system. This work produces and releases digital geological map and point data sets. In addition it contributes to the computer production of standard and thematic geological maps and reports.

Accomplishments

Work focused on the digitization and cartography of geological maps, the addition of GIS data to an intranet GIS data sharing system, generating a non-geoscientist readable geological map (GEOSCAPE) for the Fort Fraser map area (Hastings, 1999), production of a CD-ROM of all digital surficial geology data of the Fort Fraser and Manson River map areas, and production of internet readable Current Research Reports for the Project. Carmel Lowe generated Digital Elevation Models for the project area from British Columbia 1:20 000 scale TRIM data. Olaf Niemann (UVic) has continued work on the integration of the Digital Elevation Modeling (DEM) and RADARSAT thematic data for the Nechako project area. In turn this work is being integrated with surficial and bedrock geological mapping in the Nechako River map area.

Highlights from this year's GIS work include:

- Several new geological maps published as coloured 1:100 000 and 1:50 000 scale open file bedrock and surficial maps, and geochemical data sets.
- The MapGuide intranet GIS data sharing system is now operational for project participants. We continue to aspire to have this same information available to the public.
- Several Current Research reports previously published for the Nechako project are now available for use on the WEB at the Nechako Project WEB site (em.gov.bc.ca/natmap).
- The GeoScape map for the Fort Fraser map area is complete.
- Digital Elevation Models integrated with the geology and geophysics of the eastern Fort Fraser map area are completed and available (Lowe *et al*., 1999).
- The complete digital data set for the surficial geology of the Fort Fraser and Manson River map areas is ready to transfer to CD-ROM for publication this spring (Plouffe and Williams, 1999)

For monthly updates of Nechako NATMAP Project developments, see the Nechako Newsletters posted on the Nechako Project website (em.gov.bc.ca/natmap) during the life of the project.

ACKNOWLEDGMENTS

All project participants contributed to the success of this year's research and to this overview. Project funding comes directly through continuing GSC and BCGSB programs and the GSC NATMAP program. In addition, in-kind funding comes from the many universities and companies listed throughout the text.

REFERENCES

Anderson, R.G., Snyder, L.D., Grainger, N., Resnick, J., and Barnes, E.M., (1999b): Bedrock geology of the Takysie Lake and Marilla map areas, central British Columbia; *in* Current Research 1999-A, *Geological Survey of Canada*.

Anderson, R.G., Snyder, L.D., Resnick, J., Grainger, N., and Barnes, E.M. (1999a): Bedrock geology of the Knapp Lake map area, central British Columbia; *in* Current Research 1999-A, *Geological Survey of Canada*.

Armstrong, J.E. (1949): Fort St. James map-area, Cassiar and Coast Districts, British Columbia; *Geological Survey of Canada*, Memoir 252, 210 pages.

Barnes, E., and Anderson, R.G. (1999): Bedrock geology of the Uncha Mountain area, northwestern Nechako River map area, central British Columbia; *in* Current Research 1999-A, *Geological Survey of Canada*.

Cook, S.J., Jackaman, W., Lett, R.E.W., McCurdy, M.W. and Day, S.J. (1999): Regional Lake Water Geochemistry of parts of the Nechako Plateau, Central British Columbia (93F/2, 3, 93K/9, 10, 15, 16; 93L/9, 16; 93M/1, 2, 7, 8); *B.C. Ministry of Energy and Mines*, Open File 1999-5.

Dunn, C.E., (1998): Reconnnaissance biogeochemical survey in the Nechako area, central British Columbia (NTS 93F/15 and 16); *Geological Survey of Canada*, Open File 3594.

Enkin, R., Baker, J., Struik, L.C., Wetherup, S., and Selby, D. (1997): Paleomagnetic detmination of post-Eocene tilts in the Nechako region; *in* Abstract Volume 22, *Geological Association of Canada/Mineralogical Association of Canada*, Annual Meeting 1997, p.A-46.

Grainger, N.C., and Anderson, R.G. (1999): Geology of the Eocene Ootsa Lake Group in northern Nechako River and southern Fort Fraser map areas, central British Columbia; *in* Current Research 1999-A, *Geological Survey of Canada*.

Hastings, N.L., Plouffe, A., Struik, L.C., Turner, R.J.W., Williams, S.P., Anderson, R.G., Clague, Kung, R., and Taccogna, G. (1998): Development of a geoenvironmental map for the non-geoscientist, Nechako plateau, British Columbia; *Geological Society of America*, Abstracts of the Annual Meeting, Toronto, Canada.

Hrudey, M.G., Struik, L.C. and Whalen, J.B. (1999): Geology of the Tintagel map area, central British Columbia; *in* Current Research 1999-A, *Geological Survey of Canada*.

Huscroft, C.A., and Plouffe, A. (1999): Field investigations of a late glacial lake of the Fraser Glaciation, central British Columbia; *in* Current Research 1999-A, *Geological Survey of Canada*.

Kimura, E.T., Bysouth, G.D., Cyr, J., Buckley, P., Peters, J., Boyce, R., and Nilsson, J. (1980): Geology of parts of southeast Fort Fraser and northern Nechako River map areas, central British Columbia; *Placer Dome Incorporated*, Internal Report and Maps, Vancouver, British Columbia.

Lane, B. (1995): Preliminary bedrock geology, Holy Cross Mt. to Bentzi Lake, central Britsih Columbia (NTS 93F/14E and 15W); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open file 1995-22.

Lane, R.A. and Schroeter, T.G. (1997): A review of metallic mineralization in the Interior Plateau, central British Columbia (Parts of 93B, C and F); *in* Interior Plateau Geoscience Project: Summary of Geological, Geochemical and Geophysical Studies, L.J. Diakow and J.M. Newell, Editors, *B.C. Ministry of Employment and Investment*, Paper 1997-2, pages 237-256.

Levson, V., Stumpf, A., and Stuart, A. (1998): Quaternary geology studies in the Smithers and Hazelton map areas (93L and M): Implications for exploration; *in* Geological Fieldwork 1997, *B.C. Ministry of Employment and Investment*, Paper 1998-1.

Levson, V.M. and Stumpf, A.J. (1998): Quaternary geology and ice-flow studies in the Smithers and Hazelton map areas (93 L and M): implications for exploration; *in* Geological Fieldwork 1997, *B.C. Ministry of Employment and Investment*, Paper 1998-1, p. 5-1 - 5-8.

Levson, V.M., Mate, D. and Stuart, A.J. (1999): Quaternary geology and drift prospecting studies in the north central nechako plateau (93F and K); *in* Geological Fieldwork 1998, *B.C. Ministry of Energy and Mines*, Paper 1999-1, this volume.

L'Heureux and Anderson, R.G., (1997): Early Cretaceous plutonic rocks and molybdenite showings in the Nithi Mountain area, central British Columbia; *in* Current Research 1997-A, *Geological Survey of Canada*, p. 117-124.

Lowe, C. and Enkin, R.J. (1998): New constraints on bedrock geology and mineral exploration in central British Columbia: Analyses of aeromagnetic, paleomagnetic and gravity data; *in* Short Course on New geological constraints on Mesozoic to Tertiary metallogenesis and on mineral exploration in central British Columbia: Nechako NATMAP project, Extended Abstracts, Cordilleran Section, *Geological Association of Canada*, p. 110-117.

Lowe, C., Enkin, R.J., and Dubois, J. (1998a): Magnetic and paleomagnetic constraints on Tertiary deformation in the Endako region, central British Columbia; *in* Current Research 1998-A; *Geological Survey of Canada*, p.125-134.

Lowe, C., R.J. Enkin, J. Dubois, L. Struik, J. Baker, and R. Anderson (1998b): Magnetic constraints on Tertiary deformation in central British Columbia; Lithoprobe SNORCLE and Cordilleran Tectonics Workshop, Vancouver, pp. 274-275.

Lowe, C., Struik, L.C., Kung, R. (in prep): DEM and bedrock geology of eastern Fort Fraser map area, central British Columbia; *Geological Survey of Canada*, Open File.

MacIntyre, D.G. and Struik, L.C. (1998): Nechako NATMAP Project: 1997 Overview; *in* Geological Fieldwork 1997, *B.C. Ministry of Employment and Investment*, Paper 1998-1.

MacIntyre, D.G., Schiarizza, P. and Struik L.C. (1998): Preliminary bedrock geology of the Tochcha Lake map sheet (93K/13), British Columbia; *in* Geological Fieldwork 1997, *B.C. Ministry of Employment and Investment*, Paper 1998-1.

MacIntyre, D.G., Webster, I.C.L and Villeneuve, M. (1997): Babine Porphyry Belt Project: Bedrock Geology of the Old Fort Mountain Area (93M/1), British Columbia; *in* Geological Fieldwork 1996, *B.C. Ministry of Employment and Investment*, Paper 1997-1.

MacIntyre, D.G., Webster, I.C.L., and Bellefontaine, K., (1996): Babine Porphyry Belt project, Bedrock Geology of the Fulton Lake map area (NTS 93L16); *in* Geological Fieldwork 1995, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1996-1.

MacIntyre, D.G. (1998): Babine Porphyry Belt Project: Bedrock geology of the Nakinilerak Lake map sheet (93M/8), British Columbia; *in* Geological Fieldwork 1997, *B.C. Ministry of Employment and Investment*, Paper 1998-1.

Orchard, M.J., Struik, L.C., and Taylor, H. (1999): More new conodont data from the Cache Creek Group, central British Columbia; *in* Current Research 1999-A, *Geological Survey of Canada*.

Plouffe, A. (1998a): Regional till geochemistry of the northern sector of Nechako River map sheet (NTS 93F); *Geological Survey of Canada*, Open File, 2 sheets and one diskette.

Plouffe, A. (1998b): Surficial geology, Tahultzu Lake, British Columbia (93 F/NE); *Geological Survey of Canada*, Open File 3620, scale 1:100,000.

Plouffe, A. (1998c): Surficial geology, Binta Lake, British Columbia (93 F/11, 13, and 14); *Geological Survey of Canada*, Open File 3640, scale 1:100,000.

Plouffe, A. and Williams, S.P. (in press): Digital surficial geology data set for the Manson River and Fort Fraser map area; *Geological Survey of Canada*, Open File, 1 CD-ROM.

Plouffe, A. (1997): Ice flow and late glacial lakes of the Fraser Glaciation, central British Columbia; *in* Current Research 1997-A, *Geological Survey of Canada*, p. 133-144.

Plouffe, A. (1999): New data on till geochemistry in the northern sector of the Nechako River map sheet (NTS 93 F), British Columbia; *in* Current Research 1999-A, *Geological Survey of Canada*.

Plouffe, A. (1999): New data on till geochemistry in the northern sector of the Nechako River map sheet (NTS 93 F), British Columbia; *in* Current Research 1999-A, *Geological Survey of Canada*.

Rasmussen, P.E., Edwards, G.C., Kemp, J., Hubble-Fitzgerald, C., and Schroeder, W.H. (1998): Towards an improved natural sources inventory for mercury; *in* Proceedings of Metals and the Environment: An International Symposium, J. Skeaff, Editor, *Metallurgical Society of the Canadian Institute of Mining, Metallurgy and Petroleum* (CIM), Montreal, May 5-6, 1998, p. 73-83.

Resnick, J., Anderson, R.G., Russell, J.K., Edwards, B.R., and Grainger, N. (1999): Chilcotin Group basalt and related intrusions, northern Nechako River map area, central British Columbia; *in* Current Research 1999-A, *Geological Survey of Canada*.

Schiarizza, P. and Payie, G. (1997): Geology of the Sitlika Assemblage in the Kenny Creek - Mount Olsen Area (93N/12, 13); *in* Geological Fieldwork 1996, *B.C. Ministry of Employment and Investment*, Paper 1997-1.

Schiarizza, P. and MacIntyre, D.G. (1999): Geology of the Sitlika, Stikine and Cache Creek assemblages in northwestern Fort Fraser and southwestern Manson River map areas (93K/11, 12,14, 93N/3); *in* Geological Fieldwork 1998, *B.C. Ministry of Energy and Mines*, Paper 1999-1, this volume.

Schiarizza, P., Massey, N.W.D., and MacIntyre, D.G. (1998): Geology of the Sitlika assemblage in the Takla Lake area (93N/3,4,5,6,12); *in* Geological Fieldwork 1997, *B.C. Ministry of Employment and Investment*, Paper 1998-1.

Sellwood, S.M., Snyder, L.D., and Anderson, R.G. (1999): Geology of two high-level Tertiary granite plutons, northern Nechako River map area, central British Columbia; *in* Current Research 1999-A, *Geological Survey of Canada*.

Struik, L.C. and MacIntyre, D.G. (1999): Overview of the Nechako NATMAP Project, central British Columbia, year four: Part 2; *in* Current Research 1999-A, *Geological Survey of Canada*.

Struik, L.C. and MacIntyre, D.G. (1999): Overview of the Nechako NATMAP Project, central British Columbia, year four: Part 1; *in* Current Research 1999-A, *Geological Survey of Canada*.

Struik, L.C. and McMillan, W.J. (1996): Nechako Project Overview, central British Columbia; *in* Current Research 1996-A, *Geological Survey of Canada*, p. 57-62.

Struik, L.C. and McMillan, W.J. (1996): Nechako Project Overview, central British Columbia; *in* Current Research 1996-A, *Geological Survey of Canada*, p. 57-62.

Struik, L.C., Anderson, R.G. and Plouffe, A. (1999): Geology of the Euchiniko map area, central British Columbia; *in* Current Research 1999-A, *Geological Survey of Canada*.

Struik, L.C. (1997): Bedrock geology, Fraser Lake, central British Columbia; *Geological Survey of Canada*, Open File 3559.

Wetherup, S. (1997): Geology of the Nulki Hills and surrounding area (NTS 93F/9, 16), central British Columbia; *in* Current Research 1997-A, *Geological Survey of Canada*, p. 125-132.

Whalen, J.B., Struik, L.C., and Hrudey, M.G. (1998): Bedrock geology of the Endako map area, central British Columbia; *in* Current Research 1998-A, *Geological Survey of Canada*.