

Nechako NATMAP Project, Central British Columbia - 1999 Overview

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INTRODUCTION

The Nechako NATMAP project is a joint mapping venture between the Geological Survey of Canada (GSC) and the British Columbia Geological Survey Branch (BCGSB). This was the fifth and final year of the project which encompasses more than 30 000 square kilometres in central British Columbia (Figure 1). The primary objective of the project has been 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.

This final year of the Nechako NATMAP project was used to research information collected in the field and laboratory, to compile and document the study results through various publications, and to present ideas on the geology at various conferences. In addition we have enhanced our website to include more output from the project including complete published articles, viewable maps and photographic images. The website address is <http://www.em.gov.bc.ca/natmap/>

As this is the last year of the project and essentially no fieldwork was done, efforts have gone into producing open file and final maps, articles for refereed journals, government bulletins and conference presentations. This article reviews the upcoming products and provides a directory of new and future sources of information on project results.

PROJECT OUTPUT (1999-2000)

Maps

Bedrock, surficial, combined bedrock and surficial, biogeochemistry, and geophysical maps are being completed and will be released as colour open file maps (Figure 2). Drafting of these maps is being done mainly by Steve Williams and Nicky Hastings at the Vancouver office of the Geological Survey of Canada (GSC), Don MacIntyre and Paul Schiarizza at the British Columbia Geological Survey (BCGS), Carmel Lowe at the Pat Bay office of the GSC, and staff of the Geoscience Information Division of Earth Science Sector Ottawa

An annotated lithology map that addresses the relationship between geology and the natural environment has been released for the Fort Fraser map area (93K; Hastings *et al.*, 1999). The map, Geoscape Fort Fraser, is 1:250 000 scale, has a pictorial legend and addresses issues such as material properties, molybdenum and mercury in the environment, impact of geology on fish habitat and the dispersion of glacial material.

Several bedrock geology maps have been, or will be, open filed this year. These are summarized in Table 1.

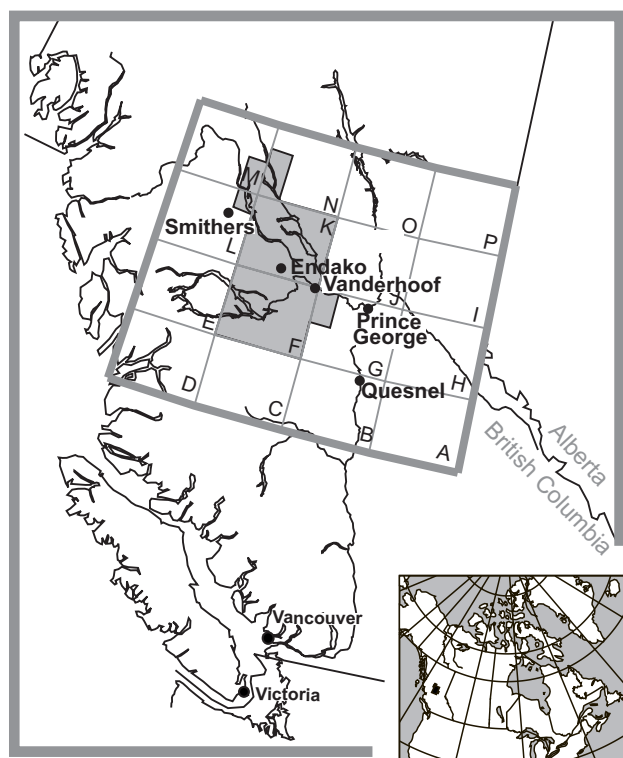


Figure 1. Location of the Nechako NATMAP Project in central British Columbia, as displayed on the Parsnip River NTS map area (93).

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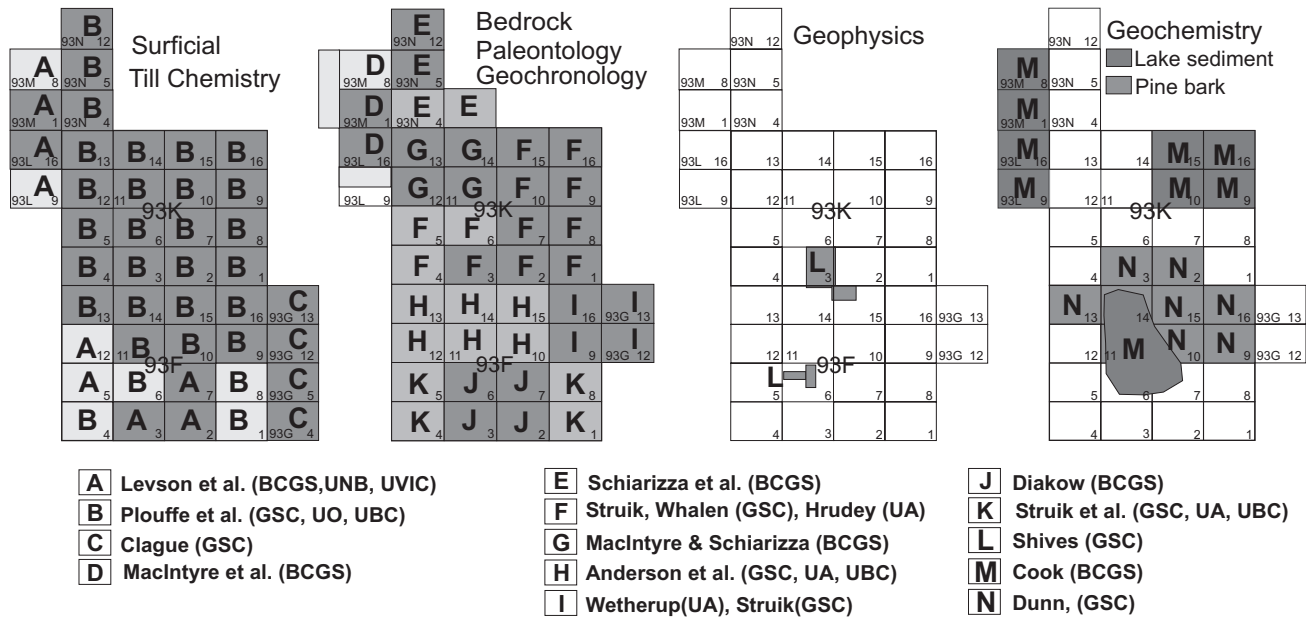


Figure 2. Status of Nechako NATMAP project mapping, displayed on an NTS 1:50 000 scale grid. Maps published as open files or final maps are shown in dark shades and areas mapped and yet to be published are in lighter shades. Unmapped areas are in white.

These maps are being supplemented with data tables that elaborate on fossil sites, isotopic age dates and mineral occurrence information (MINFILE database of the British Columbia Ministry of Energy and Mines). In some cases data tables of lithochemistry will also be included.

Surficial geology maps include that of the 1:50 000 scale Marilla map area (93F/12; Mate and Levson, 1999a), and the 1:100 000 scale Nechako River southeast map area (93F/1, 2, 7, 8; Plouffe and Levson, in prep.)

Maps of biogeochemical survey data have been made available for 2 more areas. The maps include a bedrock geology base of 1:250 000 scale derived from the most current complete compilation, and panels that contain

from 6 to 9 maps, each showing the chemical concentrations of a particular element. Areas covered include Nechako River northeast map area (93F/9,10,15,16; Dunn and Hastings, in prep.), and Fort Fraser south-central (93K/2,3; Dunn and Hastings 1999).

Steve Cook (BCGS) is preparing a series of 1:100 000 geochemical compilation maps for the Babine porphyry belt, incorporating available stream sediment, lake sediment, lake water and till geochemical data for the area. Release is tentatively scheduled to coincide with the Minerals North annual meeting in the spring of year 2000.

A number of integrated geological and geophysical images are in preparation and are tentatively scheduled to

TABLE 1
BEDROCK GEOLOGY MAPS SCHEDULED FOR RELEASE IN 1999-2000

be released as open files. These include combined RADARSAT and Digital Elevation Model (DEM) images which provide useful information for analysis of ice flow directions and surficial structures (E. Grunsky, O. Niemann, C. Lowe and V. Levson); artificially-illuminated aeromagnetic base maps with bedrock lithology overlays (C. Lowe, L. Struik, and R. Kung) which provide insight on the shallow crustal structure; and artificially-illuminated aeromagnetic base maps with gravity overlays which emphasize deeper crustal structures (C. Lowe, L. Struik and R. Kung).

Articles

Several manuscripts deal with the economic geology of the region, particularly the Endako molybdenum camp (93K/3). The latter describe the hydrothermal alteration and fluid chemistry (Selby *et al.*, 1999), the plutonic geochronology (Villeneuve *et al.*, in prep.) genesis of the Endako Batholith (Whalen *et al.*, in prep.), molybdenum distribution in local lake sediments (Cook, in press), and structure of the Endako mine area and batholith using paleomagnetic and aeromagnetic data (Lowe *et al.*, in prep). Work continues on dating molybdenite from the Endako mine and surrounding François Lake Plutonic Suite using the Re-Os technique (D. Selby, personal communication, 1999).

A final report on the Babine Porphyry copper belt (93L/9, 16; 93M/1, 8) will focus on new geochronologic dating and tectonic evolution of the district in Late Cretaceous to Eocene time (MacIntyre *et al.* in prep). A separate article will discuss the economic potential for volcanogenic massive sulphide deposits associated with mid Cretaceous felsic volcanic centers that were identified by geochronologic dating done as part of the Babine project (MacIntyre *et al.*, in prep.)

Studies of the chemical patterns within the Pinchi mercury belt (93K/8, 9, 14) have documented the distribution of mercury concentrations in lake sediments (Cook and Jackaman, in prep.) and till (Plouffe, 1999). As well, manuscripts describing the evolution of the Eocene felsic volcanic rocks and associated plutons (Grainger *et al.*, in prep.), mafic volcanic rocks of the Endako Group (Anderson *et al.*, in prep.) and Neogene nodule-bearing alkaline basaltic intrusive and volcanic rocks (Resnick *et al.*, in prep.) are expected. Lowe *et al.* (in prep.) assess the utility of airborne radiometric data for bedrock and surficial mapping and molybdenum exploration over the Capoose (93F/6) and Endako (93F/15; 93K/2, 3, 4, 5, 6, 7) batholiths.

A summary paleontology article for the Canadian Journal of Earth Science (CJES) is underway as a prelude to a thoroughly documented and fully illustrated GSC Bulletin (M. Orchard, F. Cordey, L. Rui, W. Bamber).

The Quaternary geology of the northern sector of the Nechako River map sheet (93F) is currently being documented (Plouffe, in prep.).

Presentations

Participants of the Nechako NATMAP project presented results of their mapping and research at several conferences and workshops throughout the year (Table 2). Project results will continue to be highlighted in the coming year. In particular, a symposium on the Nechako NATMAP project will be hosted at the Geological Society of America Cordilleran Section meeting to be held in Vancouver, April 27-29, 2000. The symposium is expected to consist of approximately 20 talks and a range of posters on the geological history and in part its metallogenic significance. Papers from the symposium are planned to be compiled and to appear as a special volume of the CJES to be released early in the year 2001.

TABLE 2
PRESENTATIONS MADE AT VARIOUS CONFERENCES APRIL TO OCTOBER 1999

CONFERENCE OR WORKSHOP	PRESENTATION	REFERENCES
19th International Geochemical Exploration Symposium (Vancouver, 04/99)	Talks, posters	Cook, S. (in press); Levson <i>et al.</i> , 1999b, c; Plouffe, 1999b; Plouffe and Hall, 1999b
Geological Association of Canada Annual Meeting (Sudbury, 05/99)	Talks, posters	Levson <i>et al.</i> , 1999d; Mate and Levson, 1999b
22nd General Assembly of the International Union of Geodesy and Geophysics	Poster	Anderson, 1999
Canadian Quaternary Association Biannual Meeting (Calgary, 08/99)	Talks, poster	Levson <i>et al.</i> , 1999e; Mate and Levson, 1999c, d; Plouffe, 1999a; Plouffe and Hall, 1999a
15th Annual International Congress on the Carboniferous-Permian (Calgary, 08/99)	Talks, posters	Orchard <i>et al.</i> , 1999b
9th International Terrane Conference (Vernon, 09/10/99)	Talks, posters, fieldtrip	Anderson <i>et al.</i> , 1999b; Lapierre <i>et al.</i> , 1999; Struik <i>et al.</i> , 1999a, b

Computer Products

CD-ROM

A CD-ROM product will be used to highlight the geochemical data collected through the Nechako NATMAP project area. All lake, till, biochemical, and MINFILE data have been compiled for the project area. Some of the lithochemical data has also been gathered. Geology base maps for the CD will be at 1:250 000 scale.

Surficial geological maps, reports, and till geochemistry for the Fort Fraser (93K) and Manson River (93N) areas are being compiled onto CD-ROM for interactive use with computers (Plouffe, A. and Williams, S.P., in prep.) The GIS product will include a Windows compatible map and data viewer; the reports are compiled in web browser format.

Internet

Nechako NATMAP project hosts a web site that contains project information and scientific results. The web site was revised this year, and new material and categories of material have been added. The site now hosts scientific reports, project area photographs, some internet viewable maps and updated lists of references to publications derived from the project (Williams and MacIntyre, 1999). The material on the project web site will be transferred to the CORDLink website when all the work on the project is over.

ON-GOING RESEARCH

Several avenues of research are being pursued in the final stages of the project. Each of these is intended to constrain interpretations of the field mapping and to understand the genesis and evolution of the various rock suites. The research includes isotopic chemistry and age dating, combined chemical and petrographic studies, fossil determinations, structural analysis, and ice flow and aquifer characterization.

Isotopic, Chemical and Petrographic Characterization

Several isotopic studies in Nd, Sr, Pb and O concentrations are being used to understand the genesis and sources of the Permian through Eocene magmatic suites (Lapierre *et al.*, 1999; R. Anderson, personal communication 1999; N. Grainger, personal communication, 1999). Age dating of these and other plutonic and volcanic suites continues to be used to constrain some of the more apparent critical events (N. Grainger and M. Villeneuve).

Petrographic characterization of the minerals in the Eocene Endako Group (primary and amygdaloidal) has been completed (Barnes and Anderson, 1999).

A detailed study of Eocene volcanic rocks within the Fort Fraser and Nechako River map areas by Nancy Grainger (University of Alberta), has included 4 U-Pb

and 7 Ar/Ar ages of units within the Ootsa Lake Group, 25 geochemical analyses, 28 Sm/Nd and Rb/Sr analyses of the Newman volcanics, and Endako and Ootsa Lake groups. An accompanying study of the Oligocene and Miocene volcanic rocks includes 4 Ar/Ar age determinations and Sr and Nd isotopic analyses of basalts and lherzolite xenoliths from three different volcanic centers. Those analyses complement extensive geochemical characterization of the suite and permit comparisons with apparently co-magmatic suites farther south (Resnick, 1999). Ar/Ar and geochemical analytical work was completed at the Geological Survey of Canada (Ottawa) and all other isotopic work was completed at the Radiogenic Isotopic Facility at the University of Alberta. Preliminary data was presented at the Cordilleran Tectonics Workshop (Grainger and Anderson, 1999) and complete data is reported in an unpublished thesis (Grainger, 1999).

A suite of newly recognized Late Cretaceous plutons in southwestern Nechako River map area extends the known distribution of the commonly-mineralized Bulkley plutonic suite farther east than previously known (Billesberger *et al.*, 1999; Friedman *et al.*, 1999)

Paleontology

Subsequent to data published by Orchard *et al.* (1999), an additional 22 conodont microfaunas were recovered from samples collected by Hillary Taylor during the summer of 1998, 6 of them in conjunction with field crews of the BCGS. In addition, BCGS geologists collected samples that added 5 additional conodont faunas. The collections included faunas with Late Carboniferous, Permian and Triassic ages which were not known in this area prior to the Nechako project. Amongst these were Middle to Late Permian conodonts both from Mount Copley, and from recollections in the Leo Creek area. More evidence of both Permian and Triassic conodonts were found in the Necoslie River breccia, and well defined Tethyan fauna were collected from west of Stuart Lake. Well-preserved Late Triassic fauna were recovered from limestone along Pinchi Lake. BCGS collections included new Middle to Late Permian and Late Triassic sites from the south shore of Trembleur Lake.

Preparation of these samples and SEM photography of key elements of the conodont fauna was undertaken during the Spring and a summary of the data was presented at the International Congress on the Carboniferous-Permian, held in Calgary, August 17-21 (Orchard *et al.*, 1999).

Research, evaluation and documentation continues on the radiolaria (Fabrice Cordey), fusulinid (Lin Rui), and coral and brachiopod (Wayne Bamber) collections from the Cache Creek Group of the project area. All the fossil studies will be integrated into an evaluation of the Cache Creek Group paleontological character.

Terrane characterization

As part of research on the Sitlika assemblage of Cache Creek Terrane, Nick Massey and Paul Schiarizza (BCGS) have been interpreting the geochemistry of Sitlika volcanic and plutonic rocks and diabase dikes and gabbros from the adjacent Cache Creek ophiolitic section. Petrography of the sedimentary and volcanic successions is being used to assist in establishing the depositional environments and to differentiate and correlate these successions with those to the southeast.

Tectonics and Structure

Analysis of the structural history and geometry, in combination with the genesis of the various rock suites is being done to further constrain the tectonic evolution of the central Canadian Cordillera. Particular attention has been focussed on the transtensional and magmatic events of the early Eocene, and the Jurassic imbrication of the Quesnel, Cache Creek and Stikine terranes (R.G. Anderson, D.G. MacIntyre, P. Schiarizza, L.C. Struik). Interpretation of paleomagnetic and aeromagnetic data (R.J. Enkin, C. Lowe) are being used to test and constrain the Eocene transtensional model. Cretaceous compression and possibly extension is less well understood due to poor exposure.

Quaternary Geology

Studies of the glacial materials and incorporation of field and high resolution DEM information constraining ice-flow directions are being used to assist in drift prospecting techniques in central British Columbia (V. Levson and A. Plouffe), and to constrain the source areas and distribution of anomalously rich concentrations of cinnabar (A. Plouffe and G. Hall).

Quaternary geology studies conducted by the BCGS in 1999 included the analysis of till geochemical data for the Babine porphyry belt (93 M/1, 2, 7, 8, L/9,16) and the west-central part of the Nechako map area (93F/5, 12). Other work analyses Quaternary stratigraphic data and ongoing landslide hazard studies (*e.g.* Levson, 1999; Levson *et al.*, 1999a; Mate and Levson, 1999a; Stumpf and Broster, 1999a, b, in prep; Stumpf *et al.*, in prep a, b).

Recent research has focused on landslide hazard studies including work towards a Ph.D. thesis by Don McClenagan and a M.Sc. thesis by Dave Mate. Both these theses will also contribute to regional Quaternary stratigraphic studies in central British Columbia.

A. Stumpf is completing an investigation of the Fraser Glaciation ice-flow history of west-central British Columbia (Stumpf and Broster, 1999a, b, in prep; Stumpf *et al.*, in prep a). New interpretations suggest that during the maximum-phase of glaciation, glaciers moved westward to the Pacific Ocean, and eastward into Alberta from an ice divide/dome situated over the interior of the province. These ice-flow directions are discordant with earlier and later glacier movements; in some areas ice-flow di-

rections shifted by up to 180 degrees). These results are significant, and have applications not only to drift exploration models/techniques, but also to our understanding of subglacial processes, dynamics of large ice sheets, paleoclimatic models, and isostatic tectonics.

D. Mate is currently investigating translational and rotational landslides along the shores of the Nechako Reservoir and banks of the Cheslatta River. Cross-sections compiled for rotational slides along the Cheslatta River show slumps up to 230 m wide and about 25 m high with main scarps as much as 6 m high. The slumps are active and characterized by amphitheatre-shaped main scarps, backward-tilted slump blocks, earthflows, small sag ponds, and slickensided basal slip surfaces in glaciolacustrine sediments (Mate and Levson, 1999d). These slides have been locally reactivated subsequent to logging and road construction (Levson *et al.*, 1999).

Surficial geological mapping of the Marilla map sheet (93F/12) is nearly completed. Compilation of one of the most complete Quaternary sections in the region shows the presence of two exceptionally rare stratigraphic units interpreted as: 1) a till deposited during the penultimate glaciation and 2) nonglacial, organic bearing, lacustrine sediments of probable Middle Wisconsinan age (Mate and Levson, 1999a, b, c). Large-scale troughs oriented transverse to the regional ice flow direction are readily apparent on small scale DEM's and air photos and are associated with ice-parallel, streamlined ridges (crag-and-tail forms) (Mate and Levson, 1999a, c).

In the Fulton River map area, a large area of hummocky moraine and associated incised meltwater channels has been identified (Stumpf, in prep). From the distribution of ice-contact sediments, the orientation of channels, and paleocurrents directions (in some areas evidence of stream piracy and reversals in flow), suggest that an ice lobe stagnated in the central Babine Lake valley during deglaciation (Stumpf in prep.; Stumpf and Broster, in prep.). Also, numerous, sinuous cross-valley ridges identified in the Bulkley River valley, near Smithers are similar to crevasse-squeeze or "De Geer" type moraines, possibly formed during glacier readvance and surging, or massive ice sheet drawdown.

Ten days of fieldwork were completed by A. Plouffe and J. Mayberry in the vicinity of Pinchi and Bralorne-Takla mercury mines, as part of the GSC Metals in the environment initiative. Soils weathering profiles were sampled in detail in the vicinity of both mine sites, but also at sites removed from the mines where mercury concentrations are known to be naturally high and low in till.

A study of the Vanderhoof groundwater aquifer (Jennifer Mayberry of GSC Pacific in Vancouver) will determine the feasibility of making contributions to the understanding of aquifers from existing data sets derived from regional surficial and bedrock mapping and well drilling.

Collaborative research between Andrew Stumpf (UNB) and A.J.T Jull (University of Arizona) was under-

taken to date carbonate concretions, sampled from proglacial glacial lake sediments in the Bulkley River valley. Using Accelerator Mass Spectrometry (AMS), ages of these concretions may provide a minimum date for glaciation in central British Columbia.

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