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A Brief History and Progress of Mountain Cartography in Canada

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Abstract

Canada's mountain ranges offer great opportunities in high-mountain cartography, but also great challenges, given limited national mapping resources to deal with such extensive areas. Following post-war initiatives that introduced Swiss mapping styles into Canadian cartography, federal cuts and restructuring diverted resources to the generation and management of digital data. The increasing accessibility to GIS and mapping software and digital elevation data are enabling progress from government agencies, private companies, and university researchers, albeit to a relatively limited degree, when compared to the terrain to be mapped.

Introduction

Mountainous areas in Canada can be divided into three main regions (representing different mountain-building periods):

1. The (northern) Arctic islands in Nunavut: Ellesmere, Baffin, Axel Heiberg, and Devon
2. The eastern mountains in Quebec and Newfoundland/Labrador containing the Appalachians, Laurentians, and Torngats
3. The western Cordillera in Alberta, British Columbia (BC), Yukon, and Northwest Territories including the Coastal, Columbia, and Rocky Mountains in the provinces, and the Mackenzie and St. Elias Mountains in the territories (north of 60 degrees latitude)

The country's low population density, and limited resources, access, and usage have restricted both large-scale access and specialized mountain cartography to primarily the most visited areas of the south and central Columbia and Rocky Mountains. For example, by comparison, the newly established special management area of the Muskwa-Kechika in the Northern Rockies, covering over 64,000 square kilometres, is larger than Switzerland but has only a few family ranches as year-round inhabitants and no public road access.

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Mountain Cartography in Canada 1900–1980

Although most of Canada's mountain areas have seen barely a century of European settlement, there are some excellent examples of early mountain cartography and surveying, mostly from western Canada, a selection of which are described below.

SELKIRK RANGE OF BRITISH COLUMBIA: THE TOPOGRAPHIC SURVEYS OF A.O. WHEELER

Arthur O. Wheeler's extensive report and a collection of maps was published by the Department of the Interior in 1906 under the title of *The Selkirk Range.* The first volume was an extensive written report; the second volume contained many reproductions of historic maps of surveys of the Selkirk Mountain Range.

Sketch maps, diagrams, panoramic photo views, and a four-panel topographic map of part of the Selkirk Range were published. This map was the result of extensive photo-topographical surveys conducted by Wheeler and others. Wheeler started receiving training in photo-topographical surveying in 1885 then being applied by Dr E. Deville, surveyor general of Canada, to the mapping of the Canadian Cordillera. The topographic map of the Selkirk Mountain Range is a fine example of that period for contours and shaded relief mapping (Figure 1).

AMETHYST LAKES OF ALBERTA: PHOTOGRAPHIC SURVEYING BY M.P. BRIDGLAND

Under the Department of the Interior, the Topographic Survey of Canada published a bulletin in 1924 entitled *Photographic Surveying* by M.P. Bridgland. This contained a

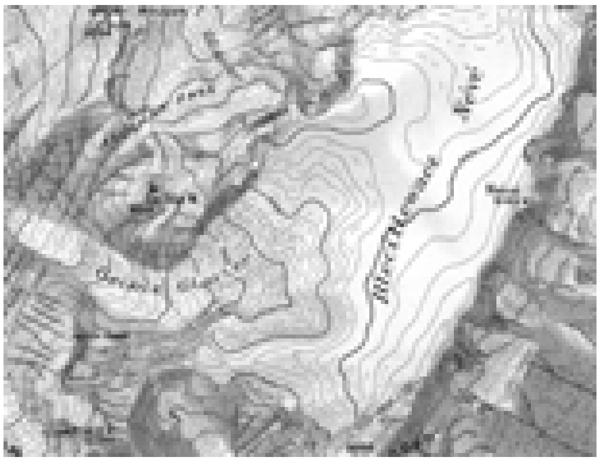

Figure 1. Selkirk Mountains, 1:60,000, contour interval 100 feet, Topographical Surveys Branch, 1906 (which may also be viewed at the National Archives of Canada website).

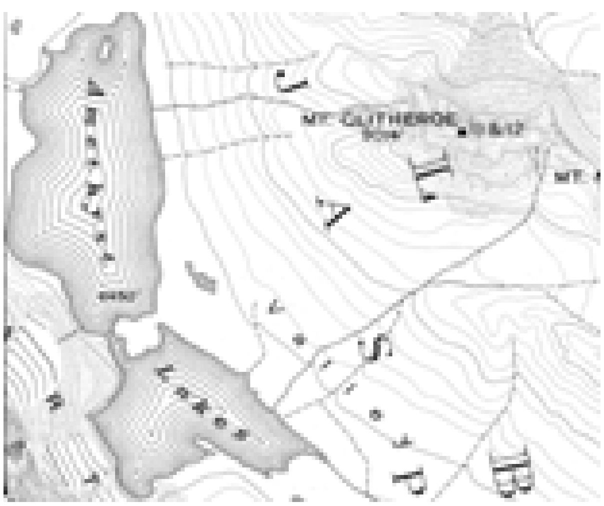

Figure 2. Amethyst Lakes, 1:62,500, contour interval 100 feet, Surveyor General's Office, 1924.

practical presentation of methods and instruments used in the field and in the mapping office. Bridgland gave technical details of photographic methods of surveying used by the Department of the Interior in order to produce accurate and economical methods of mapping in the Canadian Cordillera. In the historical notes, Dr E. Deville was again acknowledged as contributing to the introduction of photographic surveying into Canada.

As a practical example of a field survey, Bridgland selected the Amethyst Lakes of Alberta. Mountain peaks or other station points were used for triangulation and topographic surveys; where practical, triangulation and photography were executed at the same time. After the topographic survey had been completed in the field, the photographic plates and field data were brought back into the mapping office. Triangulation and control, scale, geometry of perspective applied to the photographs, plotting of points, and the determination of elevations were part of the requirements in the mapping production (see Figure 2).

Custom drafting instruments were designed for specific purposes; an instrument called the perspectometer was used when relatively level features such as swamps, lakes, or rivers with comparatively small fall were mapped. The plotting of points and determination of elevations were made with custom instruments originally created by D.B. Dowling and H. Matheson, of the Canadian Geological Survey (Bridgland 1924). Bridgland's other contributions such as the topographic surveys of Jasper National Park and the archive of photographic plates are also a heritage of our mountain cartography in Canada.

Surveying Glaciers on Axel Heiberg Island: National Research Council of Canada/McGill University

The surveying and mapping of glaciers on Axel Heiberg Island at 80 degrees north represents an early achievement of mountain cartography in the High Arctic of Canada. The maps were produced by the Photogrammetric Research Section of the National Research Council of Canada, in conjunction with the Jacoben-McGill Arctic Research Expedition to Axel Heiberg Island (Haumann 1963).

The main effort centred on the Thompson Glacier region: the first field survey started in the summer of 1960 in order to establish the basic ground control for measurements and mapping by aerial photography. A Wild T2 theodolite was used for the ground survey; tripod signals were used for the main points of triangulation. Targets made of aluminum foil and painted orange were placed on the ground and weighted down with stones; stone cairns were also made and painted yellow, giving visibility over distances of 20 kilometres. Photogrammetric work was done on a Zeiss stereoplanigraph C-8 compiled from vertical aerial photographs taken during July and August 1959 with a flying height of 9000 metres (30,000 feet). The final printing of the maps was done by the Army Survey Establishment, Royal Corps of Engineers in 1962, and their significance described as follows (see Figure 3):

> From a purely cartographic point of view the map is a novelty in North America. It is the first map at this scale produced on this continent that employs not only relief shading but also rock drawings, and is probably the first map of its kind of the Arctic and Antarctic regions. (McKortel 1963, 93)

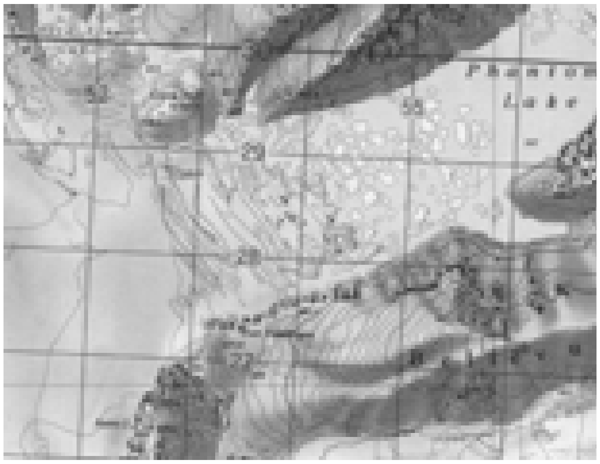

Figure 3. Thompson Glacier, Axel Heiberg Island, 1:50,000, contour interval 10 metres, Army Survey Establishment, 1962.

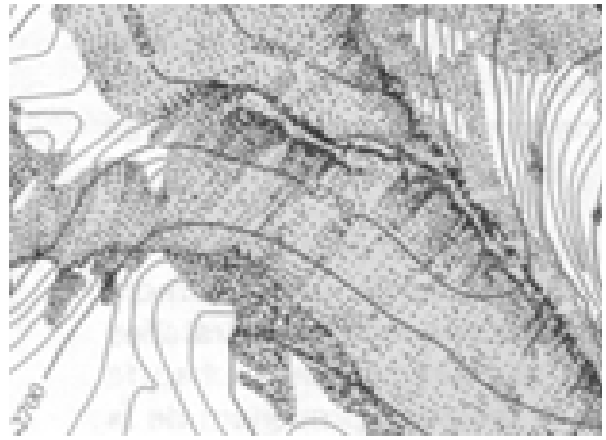

Figure 4. Peyto Glacier – provisional edition, 1:10,000, contour interval 10 metres (100 metres on bedrock), Inland Waters Directorate, 1970.

Table 1. Comparison of three Canadian examples of specialized mountain cartography.

	Thompson Glacier	**Peyto Glacier**	**Columbia Icefield**
Scale	1:50,000	1:10,000	1:50,000
Contour interval	25 metres	10 metres	20 metres
Contour colour	Brown	Brown/blue (ice)	Brown/blue (ice)
Vegetated areas	Brown	Dark/light green	Dark/light green
Hill shading	Blue	Grey and blue	Grey

GLACIER MAPS IN THE CANADIAN CORDILLERAS: INLAND WATERS DIRECTORATE, DEPARTMENT OF THE ENVIRONMENT, OTTAWA

Prior to the mid 1960s, high-mountain cartography in the Swiss style had not been attempted in Canadian mapping; training and skills were required for such complex maps with contours, hatched bedrock portrayal, and shaded relief. Peyto Glacier was chosen for mass-energy and water-balance studies as part of Canada's participation in the International Hydrological Decade (1965–1974). The initial studies were by the Geographical Branch, Department of Energy, Mines, and Resources in 1964, after which the Glaciology Division, Inland Waters Directorate, Department of the Environment, continued the work.

Professor R. Dauwalder of the Swiss Federal Topographic Service was invited to Ottawa to conduct an extensive training in hachured bedrock portrayal for several staff members of the Surveys and Mapping Branch, and the Glaciology Division, Inland Waters Directorate, Department of the Environment. Additional training in shaded relief was also given to a selected staff member for a seven-month training period in Switzerland. The Swiss cartographers taught the necessary skills and expertise in high-mountain cartography for Canadian cartographers to produce their own work (Figures 4 and 5). The final map was accompanied by a 30-page interpretive booklet and further documented by Henoch and Croizet (1976).

Considerable experience and expertise was acquired in the production of the Peyto Glacier map. The ultimate result was the later production and printing of the Columbia Icefield map in 1980, a further example of the workmanship in high-mountain cartography in Canada (Figure 6). The Thompson Glacier, Peyto Glacier, and Columbia Icefield maps all used the combination of hachuring, contours, and hill shading and incorporated symbols to show bedrock, moraines, and other depositional landforms, ice-falls, crevasses, and surface expression of ice flow. Table 1 compares some of their characteristics.

The publication of the Columbia Icefield map marked the end of this period of specialized mountain cartography in Canada. Many more contoured glacier maps in the western Cordillera and Arctic were produced between 1960 and 1980 for glacier inventory, as a consequence of the initiative from the International Hydrological decade: 60 at small scale (1:500,000 or

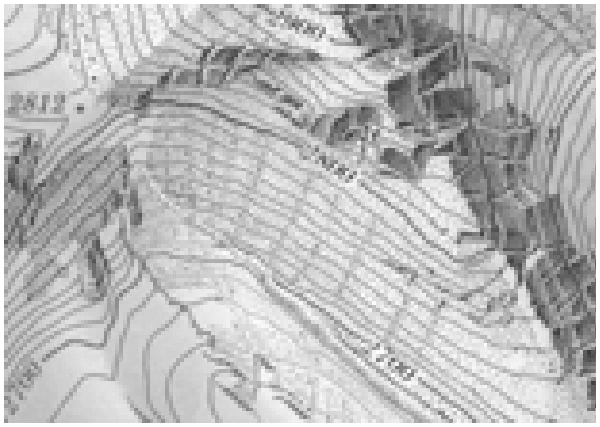

Figure 5. Peyto Glacier – final version, 1975.

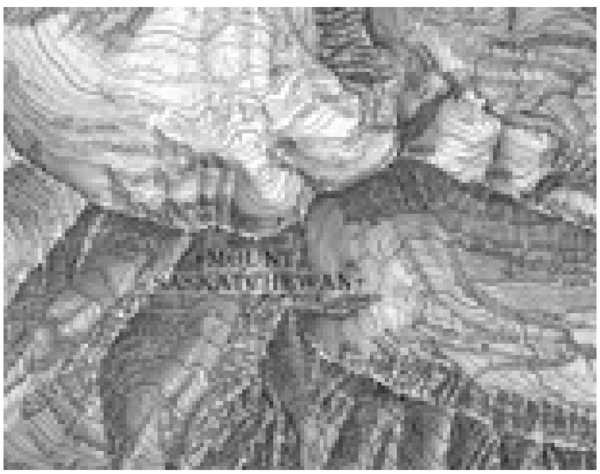

Figure 6. Columbia Icefield, 1:50,000, contour interval 20 metres (100 metres on bedrock), Inland Waters Directorate, 1980.

1:1,000,000), multiple editions of seven selected glaciers at large scale (1:2500 to 1:10,000), and approximately 50 miscellaneous glacier maps ranging in scale from 1:5000 to 1:50,000 and from monochrome to four-colour printing (Ommanney 2002). The map of Cathedral Massif Glacier near Atlin, BC (Slupetzky, Gruber, and Mauelshagen 1988), has since been updated using digital procedures by Gruber and Slupetsky and was presented at the Mountain Cartography workshop at Mt. Hood, Oregon, in 2002.

National and Provincial Mountain Park Maps 1970–1995

The 1970s and 1980s also saw the introduction of a greater use of hill shading on topographic maps of the Provincial and National Mountain Parks in the western

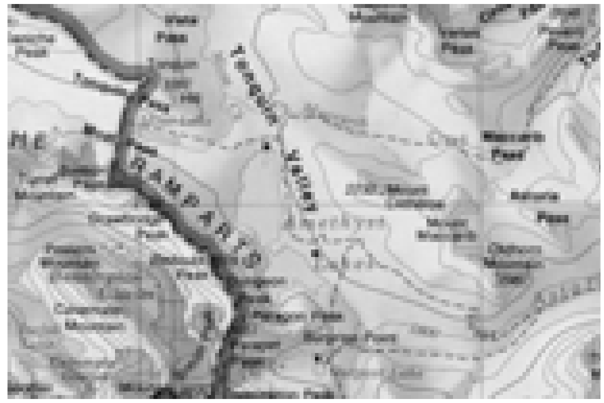

Figure 7. Jasper National Park, 1:200,000, contour interval 200 metres, Surveys and Mapping Branch, Department of Energy, Mines and Resources, 1985.

Cordillera. Despite criticism that hill shading can partially obscure other map elements, research demonstrated that it is compensated in the map-reading process by several advantages: faster visual interpretation, a meaningful structure for investigating terrain-associated elements, and an organizational background for all map elements (Castner and Wheate 1979). The main drawbacks with hill shading were the availability of suitably skilled artistic cartographers and the cost of execution, estimated at approximately 100 hours per square foot for each map (A. Maissoneuve 1977, personal communication).

From 1970 to 1995, the Surveys and Mapping Branch, Energy, Mines, and Resources (Ottawa), produced maps of the Rocky Mountain National Parks, which used hill shading and contours at medium scale (1:200,000) for the co-terminous Jasper, Banff, Kootenay, and Yoho, and larger scale for the smaller Mt. Revelstoke/Glacier National Parks (1:70,000). These incorporated brown hill-shading and depicted glaciers in purple, with a contour interval of 100 metres (Figure 7). The Waterton Lakes National Park edition in 1973 at 1:50,000 employed more detailed hill shading and depicted glaciers in green. The rationale and execution of the design of this particular map and National Park maps in general has been described by McGrath (1971).

The Surveys and Mapping Branch of British Columbia produced similar maps for provincial mountain parks such as Wells Gray, Mt. Robson, Mt. Assiniboine, and Manning Parks. These were last published in 1995, with contours and hill shading in brown or blue (on glaciers) and a general scale of 1:125,000 (Figure 8).

The incorporation of hill shading on mountain park maps is not repeated on the National Topographic Series (NTS) 1:50,000 maps, which rely on contouring alone, and a variable interval (10–40 metres) depending on terrain. The vast size of the country requires over

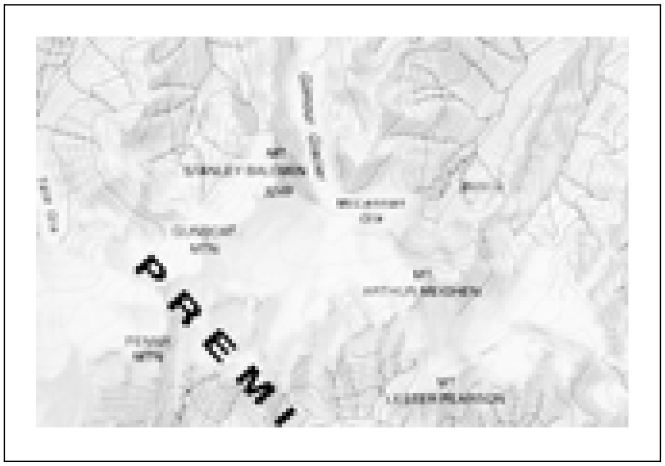

Figure 8. Wells Gray Provincial Park, 1:125,000, contour interval 100 metres, Ministry of Environment, Lands, and Parks, 1995.

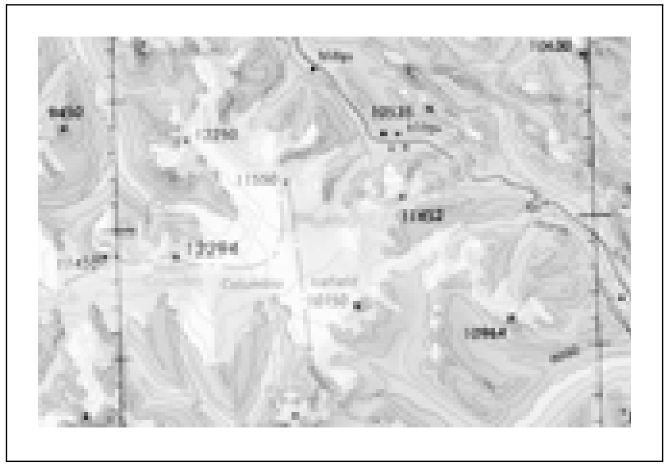

Figure 9. VFR navigation chart, Prince George sheet, 1:500,000, contour interval 500 feet, 1999.

13,000 sheets for full coverage (Sebert 1999), and this series for Canada is incomplete and updates are irregular; the main sheets remaining are primarily on Baffin Island and Ellesmere Island (McGrath and Sebert 1999). The maintenance of this series and the corresponding National Topographic Database (NTDB) currently leaves few resources for specialized projects such as glacier maps and mountain cartography.

An Overview of Current Mapping Activities at Natural Resources Canada

In 1995, following government restructuring and budget cutbacks, the Department of Energy, Mines, and Resources ceased to exist and was replaced by Natural Resources Canada (NRCan); government agencies shifted focus to supplying digital topographic data and investigating alternate technologies, especially Web-based mapping. At Natural Resources Canada there are several divisions involved in mapping activities, but two in particular that pertain to mountain cartography: the Centre for Topographic Information (CTI) and the Geological Survey of Canada (GSC).

The Centre for Topographic Information is Canada's national topographic mapping agency responsible for the acquisition, management, and dissemination of topographic information. CTI produces topographic maps at scales of 1:50,000 and 1:250,000 using information contained in the NTDB; an intermediate 1:100,000 scale is being considered to accommodate new client requirements and applications such as Web-based mapping.

The GSC developed the National Geoscience Mapping Program (NATMAP) in the 1980s to address changing cartographic needs of the geoscience community, including digital technologies. In recent years NATMAP has led to the publication of a series of three-dimensional geological maps of Canada from various projects based on digital elevation models (DEMS), including both static and animated displays of the eastern and Arctic mountain areas.

WORK ON 3-D TERRAIN REPRESENTATION

Dynamic terrain representation demonstrates how DEMS can be associated with orthomosaics and other data layers to generate virtual landscapes and animated fly-throughs for visualization over the Internet. They can provide new tools for decision support and applications such as mountain tourism and land development. Samples of prototypes generated in this project have focused on the new territory of Nunavut and its capital city, Iqaluit. The Terrain Sciences Division of the GSC has also developed a series of interactive maps for the Internet. The GeoServ mapserver provides access to key geosciences data in the form of dynamic maps and associated databases on Canada landscapes and landforms for visualization through the Web.

AERONAUTICAL CHARTS

Within CTI, the Aeronautical and Technical Services (ATS) has the oldest tradition of manual hill-shading on aeronautical or visual navigation charts (VNC). Terrain representation via shaded relief on ATS charts was produced manually between 1974 and 1994 with in-house techniques (pencils and airbrush), using photo-reduced 1:250,000-scale images and 1:50,000 and 1:250,000 topographic maps as guides (Figure 9). The shaded relief proofs were later scanned and stored as separate raster layers (TIFF files) to be incorporated into VNC maps at a scale of 1:500,000.

The charts display aeronautical information with sufficient topographic detail to facilitate visual air navigation by depicting terrain along flight corridors. Terrain visualization is crucial for visual navigation, especially for areas with mountains or thick land cover (forest). Terrain information including hypsometry, the highest terrain elevation, contours, and all-natural or synthetic obstructions are displayed on a shaded relief background.

ADDING SHADED RELIEF TO CTI TOPOGRAPHIC MAPS

CTI is currently investigating computer-assisted hill shading for its new topographic maps to improve their design and appearance; shaded relief has not been part of national map series, with the exception of aeronautical charts. Two options have been investigated in the production of shaded relief for CTI topographic maps: automated GIS-based hill shading and enhancement of a GIS-generated shaded-relief file with graphic software (such as Photoshop). The input data used are the Canadian Digital Elevation Data (CDED) derived from the NTDB, at scales of 1:50,000 and 1:250,000. These are used to produce 3-arc/second grid spacing DEMS, where the coverage of every CDED file corresponds to half an NTS map sheet (east and west).

The second option introduces an extra processing step in GIS-based hill shading. In this process the surface model (hill-shade raster file) generated in a GIS terrain-analysis module is transferred into graphic software for further processing. Such software has more flexible design options compared to GIS-based terrain analysis modules, such as colour integration schemes, smoothing, contrast, and variable illumination. As a result, the appearance of the final hill-shade map may be closer to manual shaded relief as exemplified by Imhof (1982), which remains the reference, although with corresponding greater time costs.

Private Mapping Initiatives

The generation of digital elevation data for mapping and GIS has enabled private and research ventures to engage in mapping mountain areas and to generate hill shading via software. For the western region, the provinces of British Columbia and Alberta have been covered at a mapping scale of 1:20,000, with DEM data equivalent to 20-metre contours. Private mapping initiatives, however, have been somewhat stifled by the high cost of purchasing data, unless exchange agreements have been established. While elevation points in British Columbia TRIM data (Terrain Resource Inventory Management) are reliable to within 10 metres, other features that may have changed, such as glacier fronts and new or disused roads, may not always be truly represented. The ease of generation of hill shading using GIS technology, compared to the previous requirement for specialized artistic skills, has resulted in a range of visual products of varying cartographic quality, which have tended to focus on the sections of the Rocky Mountain parks with highest visitor density.

OUTDOOR RECREATION MAPS

The most prolific publisher of mountain areas maps since 1993 has been Gem Trek Publishing Ltd., Cochrane, AB. They have produced 13 maps so far in the Canadian Rockies at scales ranging from 1:35,000 to 1:100,000. In addition to contour intervals between 25 and 100 metres, they include hill shading with an unorthodox southwest illumination designed to simulate lighting on a warm afternoon. Valley floors are depicted in a variable green colour, yielding to a strong yellow-brown above treeline. These include popular hiking areas within Banff and Jasper National Parks, including the Columbia Icefield area, Banff–Mt. Assiniboine, and Jasper–Maligne Lake, as well as the adjacent Kananaskis Country east of the parks. They are generated primarily from NTDB 1:50,000 data, since provincial data are not created for the national parks in Alberta.

Chrismar Mapping Services, Uxbridge, ON (founded 1982), have a larger selection mostly in eastern Canada, but include four maps in the western mountains, generally at 1:50,000: Revelstoke, Kootenay-Rockwall, and Glacier Park–Rogers Pass, and the very popular Lake O'Hara–Yoho area at 1:20,000. Contour intervals are 20 metres, forest versus non-forest is shown in green and yellow, with contour colour changing from blue (ice) to black (rock and forest) and brown (meadows). The map contents are generated photogrammetrically, rather than from existing digital data. They have also published one example, La Mauricie Provincial Park, from the Laurentian mountains in Quebec.

Clover Point Cartographics, Victoria, BC (1992), have produced several maps – mostly at 1:50,000 for mountain heli-skiing areas in the Columbia Mountains (from provincial 1:20,000 TRIM data, including GIS-generated hill shading), and ski runs, hiking routes, lodges, helicopter pickup and drop-off sites – which are linked to databases for updating and interactive mapping for customers (Figure 10).

Mountain recreation maps of the coastal Cordillera have been less numerous than those for the Rockies and Columbia mountains further inland. TerraPro GPS Surveys (Whistler, BC, 1993) have produced two maps for hiking and biking in the Whistler and North Shore (Vancouver) areas at a scale of 1:30,000 in 2000–2001. These feature 20-metre contours in black on glaciers and white on land, with hypsometric tints (100 metres) and grey hill-shading, all generated from BC TRIM 1:20,000 data.

PANORAMA IMAGE MAPS

A select group of cartographer-artists have recently produced several striking map posters and panorama maps, in the style of Heinrich Berann (see Patterson 2002), from topographic maps, sketches, and oblique aerial photographs. Eckhard Zeidler (Z-point Graphics) has created small-scale views of the western mountains (British Columbia and western Alberta), and localized views of Whistler. Murray Hay similarly has created perspectives of the Rocky Mountain National Parks: Banff, Yoho, and Kootenay and Jasper in the Altitude SuperGuide series (Figure 11).

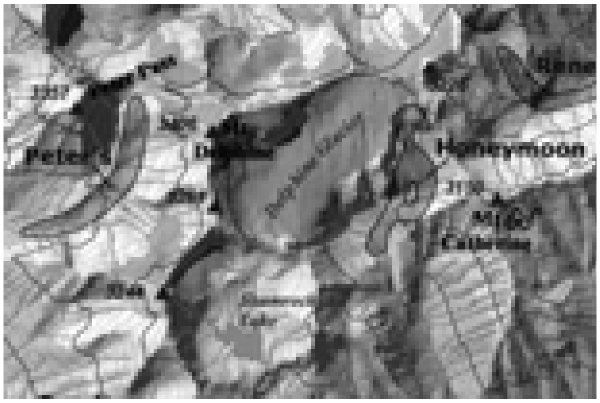

Figure 10. R.K. Heli-ski map by Clover Point Cartographics Ltd., 1:120,000, contour interval 100 metres (2001).

Figure 11. Panorama map of the Canadian Rockies, Altitude Superguide (portion of Yoho National Park) by Murray Hay, 1992.

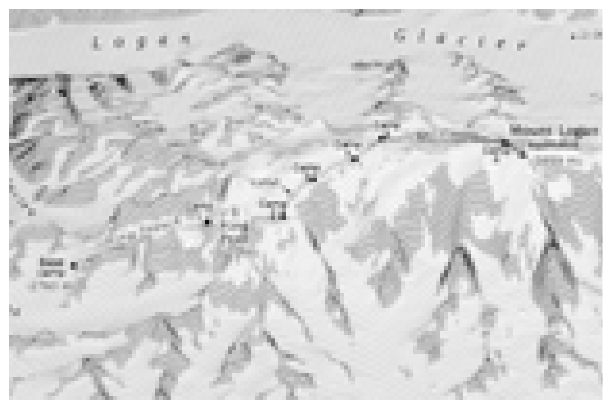

Figure 12. Mt. Logan and the St. Elias Mountains, approx. 1:250,000, David Douglas and Steven Fick, Canadian Geographic Magazine, *Sept/Oct 1992.*

Mountain Cartography Research

Although major contributions to research in digital elevation modelling were made by Canadians (such as Peucker 1980, Douglas 1986), they have not directly translated into major research in mountain cartography and relief representation in map production.

The Arctic Institute of North America, at the University of Calgary, published a map of Mt. Logan, Canada's highest point, at 1:75,000 in 1993, using the illuminated contour technique (Tanaka 1950) with a 40-metre contour interval and dark blue or white contours on a pale blue background, and including climbing routes and research sites (Holdsworth and Sawyer 1993). This technique, largely overlooked through the decades of automation, has recently been modified to visually depict light incidence (incorporating slope) as well as aspect (Kennelly and Kimerling 2001). Perhaps a more striking three-dimensional image of Mt. Logan, illustrated in Figure 12, appeared in *Canadian Geographic,* using Tanaka's earlier inclined (orthographic) contour method based on software written by David Douglas, then at the University of Ottawa, and final cartography by Steven Fick, *Canadian Geographic* (Schmidt 1992).

A consistent challenge with high-mountain cartography in Canada has been the infrequent updating of changing features such as glacier extent. Henoch (1969) made firm suggestions in this regard, but these are largely restrained by the size of Canada's land mass. In BC, the TRIM program was completed in 1996; TRIM II commenced almost immediately and was over 50% complete in 2002. However, aerial photography as the basis for feature updating is not usually captured at the end of summer, but is essential for discriminating between seasonal snow and ice (Sebert 1969). As a result, glacier outlines may be unreliable unless updated from more recent and seasonally appropriate satellite imagery such as Landsat Thematic Mapper.

These data can be used not only to monitor glacier retreat but also to depict glacier surface types and compensate for inadequate contour elevations on glacier surfaces due to saturated visible reflectance, which inhibits stereogrammetric heighting (Sidjak and Wheate 1999).

Similar procedures are being used to update glacier extents and inventories in Switzerland (Paul and others 2002). Elevation data of higher quality can also be acquired through Light Detection and Ranging (LIDAR) technology and has been acquired for selected glaciers in the Rocky Mountains (Demuth and others 2003) as well as glaciers in northwest BC adjacent to Alaska (Echelmeyer and others 1996).

Combining remote sensing, GIS, and mapping technologies offers considerable prospects for future mapping of less-travelled mountain areas. In northern BC we have incorporated provincial TRIM vector data with updated vectors derived from Landsat image data for glaciers and vegetation boundaries (forested, meadows, and bare rock) for the newly established Kakwa Provincial Park. (This work was presented at the High Mountain cartography workshop, Mt. Hood, Oregon, 2002.) Merging hill shading with vegetation and glacier polygons as mask layers represents a GIS version of earlier analogue experiments by McGrath and Castner (1977), printing hill shading in grey for non-forested areas and in green for forests.

Conclusions

We have reviewed the early topographic surveys and mapping conducted by Wheeler and Bridgland, and glacier maps in the high Canadian Arctic and the western Cordillera. They show traditional skills and technology in producing contours, hatched bedrock portrayal, and shaded relief mapping. Subsequent maps in the western Cordillera have used hill shading produced both manually and digitally, but with generally lesser and mixed results.

While digital elevation data are widely available, visual terrain representation is at an early stage in Canada. Government applications of 3-D data are currently limited to visualization and animation; this may be explained either by the limited focus on research in mountain cartography, or a lack of mountain specialists. However, in Canada there is no lack of quality digital data and accessible and increasingly flexible software for available practitioners.

What does the future hold in high-mountain cartography in Canada? Are cartographers being trained with the skills required for the art and science of making maps with the new digital technology? There is great potential in high-mountain cartography in the research sciences and in the practical world of mountaineering, tourism, and recreation.

Acknowledgements

Our thanks go to Tom Patterson and Karel Kriz, organizers of the High Mountain Cartography workshop at Mt. Hood, Oregon, in May 2002, for bringing the authors together and providing the inspiration and impetus for this article, and also to Ken Francis (NRCan) for contributions to the section on current activities at NRCan.

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Résumé Les chaînes de montagnes du Canada sont une réelle opportunité pour la cartographie de haute montagne, mais sont aussi un véritable défi puisque les ressources cartographiques nationales sont très limitées pour décrire ces immenses secteurs. Après les initiatives d'après-guerre qui consistaient à introduire des techniques de cartographie suisses au sein de la cartographie canadienne, les restructurations fédérales favorisèrent plutôt une restructuration de ces ressources cartographiques vers la génération et la gestion de données digitales. L'accessibilité croissante aux Systèmes d'Information Géographique (SIG), aux logiciels de cartographie, et aux logiciels de traitement de données d'élévation, a permis de nombreux progrès au sein des agences du gouvernement, des sociétés privées et des chercheurs à l'Université, mais ces progrès restent cependant relativement limités en comparaison du terrain qui reste à cartographier.

Zusammenfassung Die Gebirgsketten Kanadas offerieren der Hochgebirgskartographie große Möglichkeiten, aber auch große Herausforderungen, wenn man die limitierten nationalen Mittel, die für so einen großen Raum zur Verfügung stehen, betrachtet. Nachkriegsinitiativen haben die Schweizer Darstellungsmethodik in die Kanadische Kartographie eingeführt, Budgeteinsparungen und Restrukturierungen verlagerten jedoch die Schwerpunktsetzung in Richtung digitale Datenerfassung und Datenmanagement. Die zunehmende Verfügbarkeit von GIS, digitale Kartographie und digitale Höhenmodelle ermöglichen den Fortschritt durch staatliche Institutionen, private Betriebe und universitäre Forschungseinrichtungen.

Resumen Las cordilleras de Canadá ofrecen enormes oportunidades en cartografía de alta montaña, pero a la vez presentan el reto de producir, con unos recursos limitados, mapas nacionales que recubran tan grandes extensiones. Siguiendo las iniciativas de la posguerra, se introdujo en la cartografía canadiense el estilo de los mapas suizos, se redujeron los presupuestos y se reestructuraron diversos recursos para la generación y gestión de datos digitales. Aunque la accesibilidad a los sistemas de información geográfica (SIG), al software cartográfico y a los datos digitales de elevaciones ha permitido el progreso de organismos gubernamentales, compañías privadas e investigadores universitarios, los recursos continúan siendo demasiado reducidos para la extensión del territorio a cartografiar.