The use of hillshading in Canadian mountain cartography: the western cordillera of British Columbia and Alberta

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Abstract

Hillshading was first seen in Canadian mountain cartography towards the end of the nineteenth century, but was not used again until the 1960s on specialised maps depicting glaciers, or national and provincial parks in Alberta and British Columbia (the two westernmost provinces). With the growth of aviation, aeronautical charts also incorporated hillshading starting in the 1970s and are the only national series which are regularly updated. In the new millennium, digital elevation data are available from provincial and federal sources at 1:20,000 and 1:50,000 respectively for the western cordillera. However these agencies focus on data management, leaving the task to private companies and researchers to create hillshaded recreation maps in popular hiking and skiing areas.

1. Introduction

The advantages of hillshading are well documented in landscape visualisation and in its ability to portray terrain details between contours, especially in high mountain cartography. It became possible only after the 1870s when the development of the lithographic process enabled the full range of tones (Raisz, 1935). Three main periods can be recognised in Canadian cartography in which hillshading has been applied on map sheets and series: 1885-1910, 1965-1995 and in the modern digital era (1995-), using three different methods: wax crayon, pencil or airbrush and digital elevation models (DEM), and applied to three application areas: general (park) recreation and tourism, the realms of snow and ice for glaciers and skiing, and aeronautical navigation.

2. Early history (1885-1910) - photo-topography and wax crayon

Hillshading made an early debut in the 1:40,000 series of the Rocky Mountains (1888-1892). These first Canadian topographic maps were limited to a small part of one province (Alberta) and covered a portion of the Rocky Mountains National Park, later reduced in size and renamed as Banff National Park (figure 1). Prior to this series, the mapping authorities considered the notion of surveying contours to depict the terrain as too expensive for a country the size of Canada. No doubt, the motivation for the series derived from the area's popularity with alpine climbers from Europe. Some of the sheets were surveyed by A.O.Wheeler, founder and first president of the Alpine Club of Canada in 1906. Rock drawing was not attempted and so some of the ruggedness of the mountains was lost (Nicholson and Sebert, 1981). The hillshading was realised on specially prepared lithographic stones with a greasy wax crayon, although a similar result could be achieved using zinc plates (Curran, 1967). This was a precursor to using pencils prior to the full development of photo-lithography.

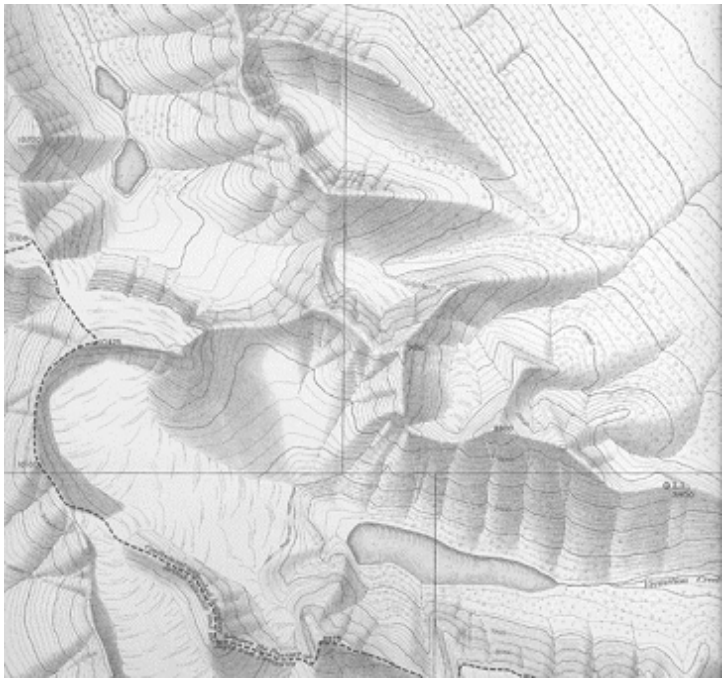

Figure 1: Portion of the Eldon sheet, 1:40,000 series, 1888 (Vermillion Lake to the south)

This mapping of the Rockies employed the photo-topographical method which was developed in Europe but was more widely used in western Canada. It involved surveying locations and altitudes by intersection from two or more oblique photographs taken from vantage points, generally mountain tops, and after 1925 also employed oblique aerial photography. The photo-topographical method remained in use through the first half of the twentieth century and was described in the Mt. Hood workshop (Fisher, 2002). Hillshading was also employed in the 1905 map of the Selkirk Mountains of southern British Columbia by A.O. Wheeler (figure 2).

Figure2: Portion of Selkirk Map, 1905 (depicting the Illecillewaet Icefield and Glacier).

Following these early successes in popular climbing areas, there were no further examples of hillshading for over 50 years as Canadian mapping agencies focused on designating national series in 1925 and completing their adopted metric equivalents in the postwar years (circa 1950-70). Hillshading was never added to 1:50,000 maps, due to the magnitude of the task in Canada (Henoch, 1969). It was added to some of the (now discontinued) 1:125,000 series, but none in the western cordillera. However hillshading reappeared in Canadian mountain cartography after 1965 on three types of map series using either pencil or airbrush renditions as described below.

3. Hillshading using pencil or airbrush, (1965-1990)

a. Glacier maps in the International Hydrological Decade (1965-75)

Canada contains over 200,000 square kilometres of glaciers and icecaps and some have been mapped in fine topographic detail, although only a select few incorporated hillshading to emphasize the relief and show the position of moraines and crevasses (Henoch, 1969). Predating this period, the Thompson Glacier on Axel Heiberg Island (Arctic Islands) was the first to utilise hillshading in 1962 (Ommanney, 2002). Another of the Mount Hubbard-Alverston and Kennedy area in the St. Elias Mountains, Yukon, was directed by Bradford Washburn and the National Geographic Society (1968). Expertise from Switzerland was imported to help generate glacier maps in the 'swiss-style' incorporating cliff hachures and shading, mostly by pencil. Canadian cartographers with Swiss training produced the Peyto Glacier map in 1975 with shading blue on glaciers, brown on moraines and gray on bare rock (Henoch and Croizet, 1976). The last map from this era was the Columbia Glacier map in 1980 (Wheate et al, 2001).

b. National and provincial parks (1965-95)

National Surveys and Mapping branches published special interest map sheets between 1965-95 in conjunction with other government agencies, notably National and Provincial Parks (and glacier maps with the Inland Waters Directorate). In the western mountains (Rockies and Coastal Mountain Ranges), these frequently included hill-shading rendered in either gray or brown (figure 3). Scales varied according to park size from 1:50,000 to 1:200,000. Provincial parks maps in British Columbia (B.C.) included Mt. Robson, Wells Gray, Manning and Mt. Assiniboine and national mountain parks in Alberta / B.C. notably Banff, Jasper, Yoho, Kootenay, Mt. Revelstoke, Glacier, and Waterton Lakes, with latest editions circa 1995.

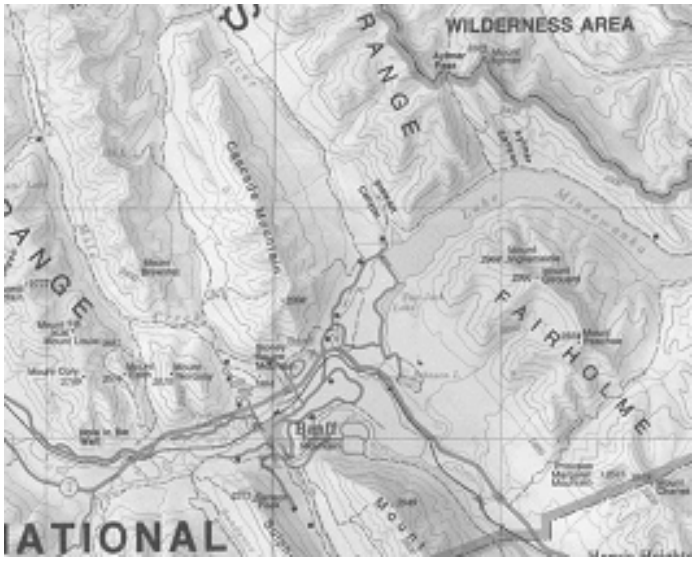

Figure 3: Portion of Banff National Park map, 1:200,000, 1985

c. Aeronautical Map series (1965- present)

The Surveys and Mapping Branch began producing shaded relief for aeronautical charts in 1961, since quick visual interpretation of the landscape is crucial in aerial navigation. Personnel were selected and trained adopting pencil shading over airbrush due to easier use and greater detail, although airbrushing was applied on highlights. The most detailed shading on aeronautical charts was in the 'Joint Operations Graphic' 1:250,000 series, a world-wide initiative to provide aeronautical information on a map series (figure 4).

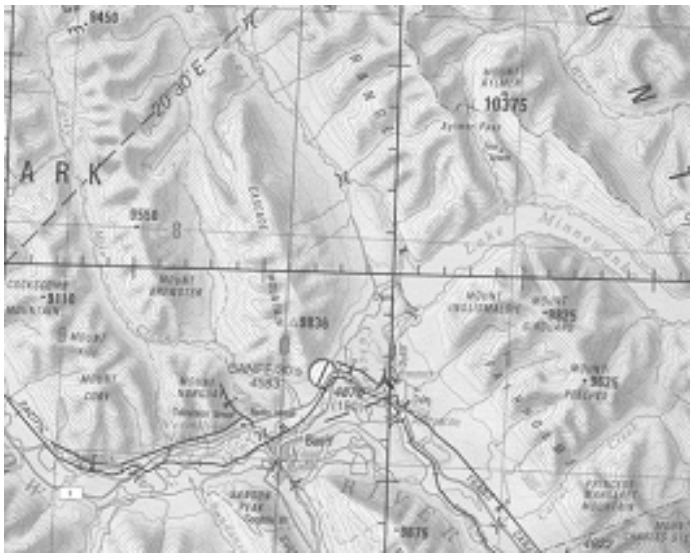

Figure 4: Joint Operations Graphic (JOG) 1:250,000 sheet NM 11-3, 1990 (incorporating Banff townsite and the same area shown in Figure 3)

The 1:500,000 and 1:1,000,000 series were initially designed for civilian and military use. They were identified as primarily aeronautical series after 1970, quadrupled in size to reflect greater flying distances and hillshading was added to the pre-existing hypsometric tints and intermediate contours. Where available, hillshading produced at 1:250,000 was photographically reduced for representation at 1:500,000. The 1:500,000 series remains the only Canadian series routinely updated since 1978 although the hillshading remains photographically reproduced from the original pencil and airbrush shading on the first edition sheets produced between 1974-95. The 1:1,000,000 series was completed as part of the Operational Navigation Chart (ONC) series produced by the US Defense Mapping Agency worldwide and is now distributed in the World Aeronautical Chart (WAC) series.

4. Digital hillshaded maps (post 1995)

Provincial and federal agencies began generating digital data including DEMs from the mid 1980s and have focused on data management over map production. For the western cordillera, there are two main sources of elevation models for hillshading: provincial data at 1:20,000 for British Columbia (BC), and federal data at 1:50,000 for the Rocky Mountain national parks in Alberta.

BC provincial elevation data are collected at 1:20,000 both as contours (20 metre interval), and as mass points, from stereo-photogrammetry in north-south lines at approximately 70 metre intervals (*http://srmwww.gov.bc.ca/bmgs/trim*). These can be enhanced with breakline data (e.g. streams and lakes). However derived hillshaded models can still show artifacts on glaciers, where

fewer points can be fixed due to saturation on snow covered surfaces and often using early summer photography. DEM data can be acquired as mass points per 1:20,000 map tile, or interpolated 25 metre raster grid models delineated by 1:250,000 map sheet grids.

Federal DEM data for the Rocky Mountains in Alberta are lower resolution compared to those for BC, since they are based on digitised 1:50,000 contours (*www.cits.nrcan.gc.ca*). Figure 5 depicts the same area shown in figure 1 from the 1888 1:40,000 sheet, using the 1:50,000 digital data for comparison. While some areas show greater detail, the gullies north of Vermillion Lake (near the bottom in figure 5) are evident on the 1888 map, but not on the modern hillshading. These can clearly be seen on the accompanying Landsat 7 satellite image (figure 6). One can also note the reduced size of glaciers from 1888 to the NTDB data (circa 1970) and further to the 2001 Landsat image. The smaller lakes north of Vermillion were also not apparent on the 1888 map, possibly appearing later as a result of accumulation of glacial meltwaters.

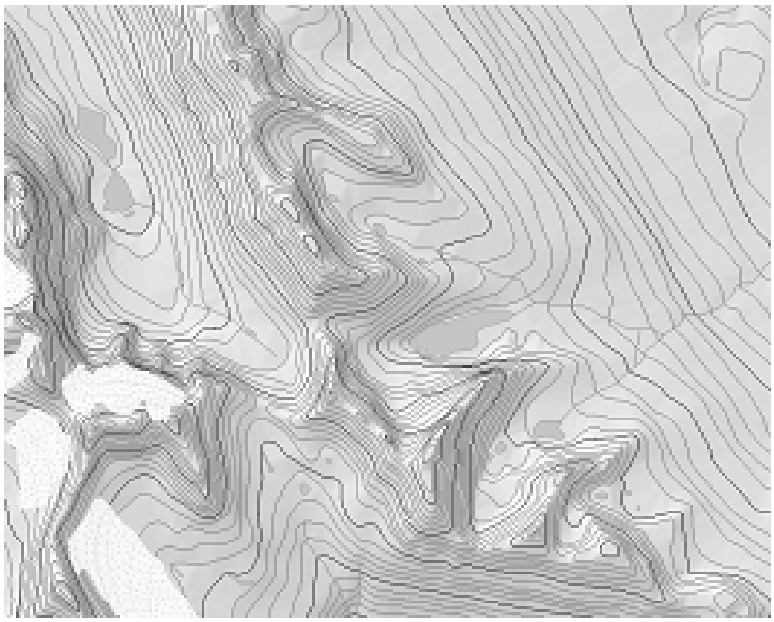

Figure 5: Portion of the area near Eldon, Alberta (corresponding to figure 1) using the 1:50,000 national topographic digital database (NTDB). Note the absence of gullies in the contours and hillshading north of Vermillion Lake (bottom centre of map) and smaller area of glaciers.

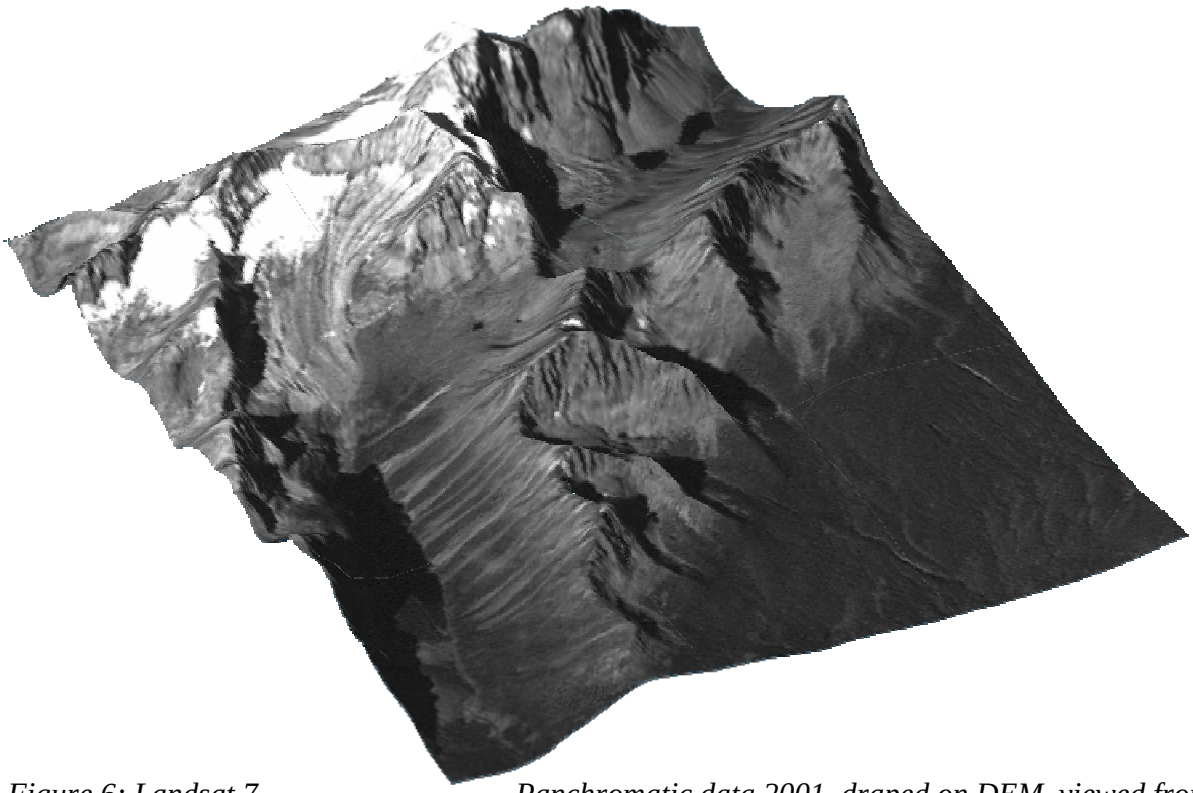

Figure 6: Landsat 7 Panchromatic data 2001, draped on DEM, viewed from the southeast.

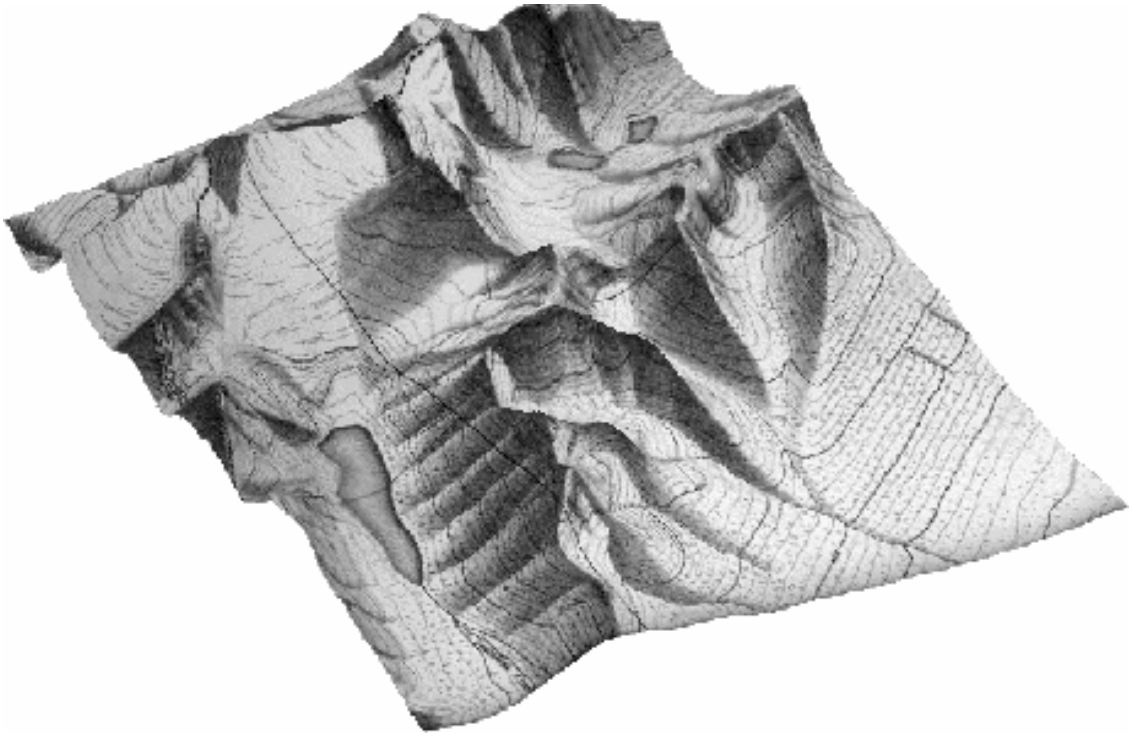

Figure 7: 1888 Eldon map draped on DEM, viewed from the southeast.

Hillshaded maps are not produced by either provincial or national agencies in the new millennium, leaving this task to a limited number of companies and researchers, who have focused on popular recreational areas, for the same reasons as those maps featuring hillshading in the two previous eras. These maps are gradually becoming more widespread with data distribution and lower cost.

The most prolific publisher of mountain areas maps since 1993 has been Gem Trek Publishing (Cochrane, Alberta). 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 25-100 metres, they include hillshading 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 yellow-brown above treeline. These include popular hiking areas within Banff and Jasper national parks, including the Columbia Icefield and Banff-Mt. Assiniboine areas. They are generated from federal 1:50,000 data since provincial data are not created for the National Parks in Alberta.

Clover Point Cartographics (Victoria, BC) has produced several maps mostly at 1:50,000 for mountain heli-skiing areas in the Columbia Mountains from provincial 1:20,000 B.C. 'TRIM' data, including hillshading, ski runs, hiking routes, lodges, helicopter pick-up and drop-off sites.

Other companies that provide a range of services in GPS and GIS consulting which have also produced hillshaded recreation maps of the Coastal mountains, include Terrapro GPS and Timberline Consultants (Vancouver, BC). The most faithful to the classic principles of high mountain cartography is the recent map of Mt. Waddington, the highest peak in the Coastal Mountains by Marcel Morin,Timberline (figure 8).

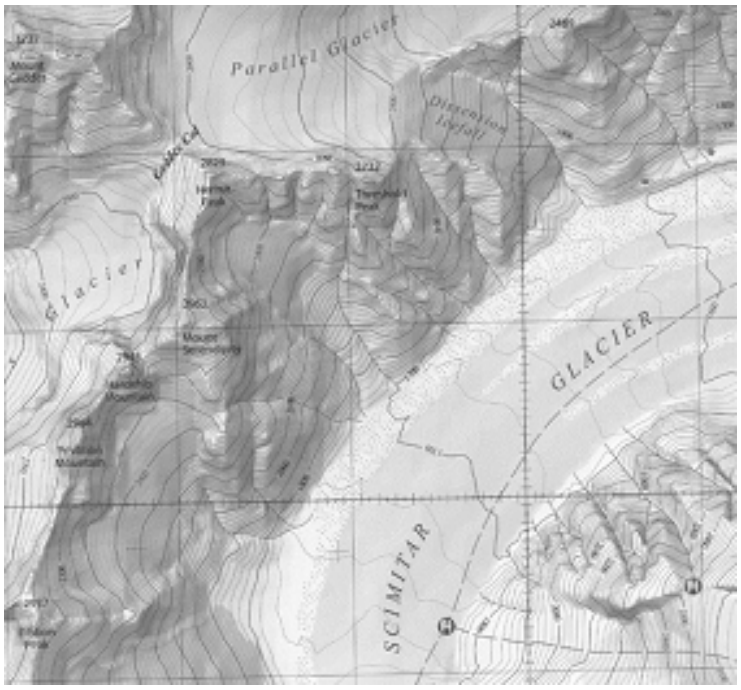

Figure 8: Portion of the Waddington map, 1:25,000, 2003.

Conclusions

Canada has enjoyed two periods in the past where hillshading was employed by national agencies to produce highly visual cartographic products depicting popular recreational areas in the western mountains. Current cartographic activity relies on individual researchers and cartographers in smaller companies utilising provincial and federal data, which are gradually becoming more accessible and affordable.

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