NOTES

During the last two decades high quality digital elevation data have become available for many parts of Canada. Using modern digital processing and display technologies these data can be manipulated to develop elevation models tuned to the needs of specific user groups. Here we show a digital elevation model for a portion of the Nechako Plateau in central British Columbia. The model was developed to aid geoscience investigations being undertaken in the region under the auspices of the Geological Survey of Canada's Nechako NATMAP project. The accompanying text details the utility of the model to the surficial and bedrock mapping components of the project.

General physiography of the Nechako River map area

Most of the Nechako River 1:250 000 map area (NTS 93F) lies within the Nechako Plateau subdivision (Fig. 1) of the Interior Plateau physiographic region (Holland, 1976). The Nechako Plateau is an area of low relief with flat or gently rolling topography. Most of the region is covered with thick glacial sediments and very little bedrock is exposed (Fig. 1). The area has been heavily glaciated and is characterized by broad valleys, rounded hills and isolated mountain ranges such as the Fawnie and Nechako ranges in the southern part of the map area. Typical topography of the region is shown in Fig. 2. Surface elevations typically range from 850 to 1200 m. Peaks are about 500 to 650 m higher in the north-trending Nechako (e.g. Kuyakuz Mountain, 1781 m) and northwest-trending Fawnie (e.g. Mount Swannell, 1821 m and Mount Davidson, 1861 m) ranges. The extreme northeast and southeast portions of the map area lie within the Fraser Basin, and here, topography is even more subdued, with surface elevations rarely exceeding 760 m.

The entire map area is within the Fraser River catchment area. The natural drainage of this region was profoundly modified in 1952 with the construction of the Kenney Dam, located at the north end of Knewstubb Lake (see Anthropogenic Activity below). Today, the Nechako River originates at Kenney Dam and flows northeastward for nearly 340 km before joining the Fraser River at Prince George. The Blackwater and Euchiniko rivers also flow eastward joining the Fraser River southwest of Hixon (Fig. 1).

What does the map show?

The digital elevation model (DEM) shown on the right was compiled from a 25 m grid supplied by Land Data BC. Details on the raw data, as well as the gridding routine are given on the Land Data BC web site (http://home.gdbc.gov.bc.ca/). In this image, the vertical scale has been exaggerated 2:1 to enhance small-scale features within the topographically subdued landscape. The data are displayed with an illumination from the north, and as a consequence, west-trending topographic features are preferentially enhanced. The image shows clear evidence of the impact of the last glaciation, landslide activity, anthropogenic activity, and bedrock controls on topography. As such, it is a useful tool for a variety of geoscience specialists. For example, exploration geologists who use till geochemistry or other drift prospecting methodologies, require detailed knowledge of the direction of ice flow. Several types of subglacial flow indicators (e.g. flutes, crag-and-tails and drumlins) are readily observed in this DEM image providing useful information on both local and regional ice-flow variations. It is important to note however, that streamlined landforms may be present in an area, and visible in airphotos, but not discerned on this DEM, either because the features are oriented parallel to the selected angle of illumination, or because of the small scale of the DEM. As a consequence, ground investigations should be used in conjunction with any analysis of remotely sensed data to reconstruct ice-flow histories. Field data (e.g. striae) invariably provide more detailed and complete information.

The small scale of the image is a useful tool for reconnaissance surficial geology studies, as large landforms and terrain patterns, not commonly imaged on standard aerial

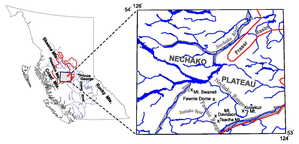


Figure 1. Left: Physiographic subdivisions of central British Columbia from Holland (1976). The Nechako Plateau is outlined in red. Right: Major ranges, peaks and drainage features of the Nechako map area. Grey arrows indicate drainage directions.

Impact of the last glaciation

During the Late Wisconsinan Fraser Glaciation, ice covered all of central British Columbia. The ice first accumulated at high elevations in the Coast, Hazelton and Skeena Mountains (Fig. 1) and local alpine glaciers probably also developed in lower mountains such as the Fawnie and Nechako ranges. As glaciers grew in these areas, they advanced down slope into the Nechako Plateau, coalesced and flowed easterly and northeasterly towards the Rocky Mountains (Armstrong and Tipper, 1948; Tipper 1971). During the early phases of glaciation, there was significant topographic control on ice flow, but as the ice thickness increased, glaciers covered the highest peaks of the region and flowed in a general northeasterly to east-northeasterly direction (Levson and Giles, 1994; Giles and Levson, 1995; Weary et al., 1995; Plouffe, 1998; Mate and Levson, 2000; Plouffe and Levson, 2001). At glacial maximum, the ice divide located over the Coast Mountains migrated easterly as far as the western sector of the Nechako River map area (Levson et al., 1999; Stumpf et al., 2000). The area over which the ice divide migrated experienced a shift from easterly to westerly ice flow. Westward ice flow probably only affected the western most part of the study area during the last glaciation (Levson et al., 1999; Mate and Levson, 2001). As glaciers thinned during the later stages of the last glacial period, ice-flow was again modified by topography.

Flutings, drumlins, and crag-and-tail ridges are common glacial streamlined landforms throughout the Nechako Plateau and this area is no exception. They form at the base of active glaciers and are typically oriented parallel to the direction of ice flow, providing an important record of local and regional variations in the ice-flow direction. In the Nechako Plateau these landforms are often accentuated by horseshoe-shaped depressions that wrap around them and point in the down-ice direction (Mate and Levson, 2000, 2001). The origin of these depressions is currently the subject of much debate but there is growing evidence that they form as a result of water erosion during catastrophic subglacial flood events (e.g. Shaw et al., 2000). Many streamlined landforms have been mapped in this area (e.g. Levson and Giles, 1994; Diakow and Levson, 1997; Plouffe, 1998; Mate and Levson, 2000). Drumlins and crag-and-tail features are readily discernible in this DEM, but flutings are more subtle because of their generally lower topographic expression. Examples of drumlins are present to the north and east of Ootsa Lake and crag-and-tails are found northeast of Murray Lake and north of Natalkuz Lake. The strike of these features (indicated with large red arrows), delineates the regional northeasterly ice-flow of the area, and variations in trend from one recognizable cluster to another provide an excellent record of local flow variations.

An interesting landform in this area, that is readily visible at the scale of this DEM but is not easily seen on air photos, occurs in the area between Takysie Lake and Ootsa Lake. The landform consists of a series of regularly spaced, linear depressions that trend southeasterly across this area, perpendicular to the regional ice flow direction. The depressions are spaced about 1 km apart and individual depressions are up to several kilometres long. The depressions are commonly poorly drained and seldom occupied by streams, indicating that they were not cut by Holocene drainage systems. The high areas between depressions are often fluted and drumlinized. Horseshoe-shaped scours at the stoss ends of the drumlins commonly merge with the larger scale depressions. These landforms can also be recognized in other areas such as in the lower Chedakuz Creek region. The formation of the depressions may be related to the development of regularly-spaced eddy currents in large subglacial flood flows. Erosion by ice seems less likely because of the regular spacing of the depressions and because they are oriented perpendicular to the regional ice-flow direction.

Eskers have a distinct, narrow (<500 m wide), sinuous ridge morphology, and are also common throughout the Nechako River map area. Most obvious, in this image, are those that occur along lake and river valleys, including the Euchiniko Lake and Blackwater River valleys in the southeastern part of the map area, as well as, the anastomosing network of northeast-trending eskers south of Chedakuz Creek. An east-northeast-trending esker forms a spectacular series of small islands in the eastern part of Natalkuz Lake. Esker lengths are highly variable, ranging from less than a kilometre (southeast of Laidman Lake) to more than 10 km (in the Euchiniko Lakes and the Blackwater River valleys). Comprised of stratified glacial meltwater deposits, eskers usually form beneath, or within slow moving or stagnant ice, and are commonly oriented perpendicular to the ice margin. The variation in trend of those imaged in this map area records local variations in sub-glacial water drainage directions.

Kettle holes are basin- or bowl-shaped depressions that are produced by the melting of blocks of glacial ice that became buried, either wholly or partially, in glacial drift. Individual kettles are difficult to recognize in DEM's of this scale as they are typically just 10-15 m deep and 30-150 m in diameter. However, they commonly occur in groups forming knob and kettle topography that is very distinct and readily imaged at the scale of this DEM (see for example, Lowe et al., 2000). Plouffe (1998) mapped a large kettle cluster (> 40 km long and 4 km wide) in the northern part of the Nechako River map area, southeast of Francois Lake. Within that cluster, only the larger kettles are resolved individually (e.g. the eastern end of the outlined area) and the smaller ones appear as hummocky terrain in the valley. Furthermore, kettles in glaciofluvial and glaciolacustrine sediments also show up as hummocky topography in the valley at the east end of Knewstubb Lake. An area where individual kettles can be seen on the DEM, occurs in glaciolacustrine sediments northwest of Tachik Lake. Areas of more typical hummocky topography (i.e. without large kettles) occur southeast of Euchiniko Lake and south of Tetachuk Lake. These latter areas show up on the DEM as relatively low relief topography with numerous small hills.

Glaciolacustrine sediments, deposited in glacial lakes during the final stages of deglaciation, are widespread in low-lying areas along modern lakes in this area (Levson and Giles, 1994; Plouffe, 1998). In this image, they are most apparent, where they occur as thick (>10 m) blankets masking the underlying topography, such as in the northeastern part of the map area adjacent to Tachick and Nulki Lakes, and in the Nechako River Valley, northeast of Murray Lake.

Glacial meltwater channels of varying dimensions and trends are also common features in the Nechako River map area (Levson and Giles, 1994; Plouffe, 1998; Mate and Levson, 2000). Long, narrow and deeply-incised channels, such as those mapped south of Entiako Lake, south and west of Nulki Lake, and south of Ootsa Lake are distinct in this shaded-relief DEM. Others, with equal or even larger strike lengths, but which are broader and/or less deeply incised, are also well imaged, but their origin cannot be as reliably interpreted as the former from this type of data alone. A valuable aspect of the DEM , however, is the ability to visualize valley systems over large areas. For example, the valley defined by Ootsa, Natalkuz and Knewstubb lakes and the Euchiniko River crosses the entire map area. Another system that is narrower but nearly as long, extends from Johnny and Laidman lakes through the Fawnie Range to Tatelkuz Lake and east through the Nechako Range to the Blackwater River. The local presence of eskers within some of these valleys (such as along the Blackwater River) suggests that the valleys formed subglacially (i.e. tunnel valleys). DEMS's of this type, therefore can be a useful tool for reconstructing subglacial drainage patterns on a regional scale.

Figure 2. View east to Binta Lake (central right) showing the typical topography of the Nechako Plateau. Photograph by J. Resnick, July 1998.

Landslide activity

Typically, landslides in this region have resulted in the downslope transport of surficial materials only, bedrock failures being relatively rare. Large rotational landslides are most common, but not unique, to sediments underlain by glaciolacustrine sediments (Levson et al., 1998; Plouffe, 1998; Mate and Levson, 2000). A large rotational landslide complex, with an area of about 8 km , occurring along the Chesalie River close to the northwestern tip of Chesalie Arm, is apparent on the DEM image. Concave main scarps and hummocky displaced masses in the toe help identify this feature. The topography in the area is complex as several smaller slides have developed within the overall slide complex. The main slide probably developed in early post-glacial times but the area has been recently logged and smaller slides are currently active in the area. Small landslide scars that were mapped by Plouffe (1998) and Plouffe and Mate (2001) are locally visible in this image (e.g. along the southeast shore of Murray Lake and along the canyon about 1 km north of Kenney Dam).

Landslides are often initiated by undercutting of the slopes by rivers or by wave erosion in lakes. Failures are most common on steep slopes such as cutbanks along the outside edge of large river meanders. Actively failing slopes of this type are often bare, or relatively bare, steep surfaces that locally are readily discerned on this image. An excellent example is observed on the western shore of the Nechako River, due west of Tachick Lake, in the northeastern part of the map area. The failing slope, which is approximately 2 km long, has the classic arcuate shape of a meandering river cutbank. Directly southwest of this steep cutbank a large landslide scar is present to the west of another large meander of the Nechako River. Slope instability in this area may have originally been related to river undercutting, but the failure surface has propagated away from the river. The head of the landslide scarp is now mapped more than a kilometre from the river (Plouffe, 1998). Shallow translational failures are a specific type of landslide that are common in the area (e.g. along the shore of the Nechako Reservoir where wave erosion has undercut steep slopes) but these failures are not usually visible on the DEM. Active translational failures transport sediment into streams and lakes and may locally affect the fish habitat.

Anthropogenic activity

Although there are few communities or towns in the Nechako River map area, topography and drainage in the region have been profoundly modified by anthropogenic activity. The Nechako River was once a 462 km long stream rising in Eutsuk Lake in the Coast Mountains of western British Columbia. The drainage was dramatically altered in 1952 by the Kenney Dam, which was constructed as part of a major engineering project of the Aluminum Company of Canada (Alcan, Ltd). The dam reversed most of the river's eastward flow and created the 906 km Nechako Reservoir (including Ootsa Lake within the study area, and Whitesail and Tahtsa lakes farther to the west). The network of blue lines on this DEM image shows the pre-dam extent of several rivers and lakes. Water from the reservoir flows westward down a tunnel, through the Coast Mountains to Kemano on Canada's west coast, where it generates electricity for the Kitimat aluminum smelter. The dam is clearly visible in this image as a narrow northeast-trending, ridge-shaped, topographic lineament. With a height of 104 m it is among the highest dams in Canada.

The extensive and often thick, surficial cover in the map area is a valuable source of aggregate (Matheson et al., 1996). More than 50 gravel pits have been mapped in this region (Levson and Giles, 1994; Weary et al.,1995; Plouffe, 1998; Mate and Levson, 2000). They are particularly common in glaciofluvial or alluvial fan deposits adjacent to roads. Most are used to supply local projects and, consequently, are too small to be unambiguously recognized in this DEM image. It should be noted that eskers, including the ones visible in this DEM image, can represent important sources of aggregate.

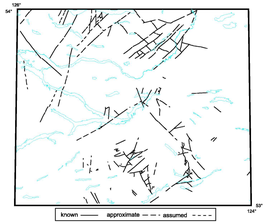


Figure 3. Mapped faults within the Nechako River map area from Anderson et al. (2001).

Bedrock controls on topography

Bedrock in the Nechako River map area has undergone a complicated evolution from Carboniferous (350 million years ago) to present time. Briefly, the early part of that history saw the deposition of volcanic and sedimentary sequences, and magmatic intrusions in various subduction and rift settings. The rocks were deformed during their formation, and during collision with the western margin of North America during the Middle Jurassic to Late Cretaceous (180 to 65 millions years ago). They were also deformed in the Eocene (55 to 45 million years ago) during strike-slip and extensional faulting that generated volcanoes and various polygonal basins into which volcanic flows and sediments were deposited (Fig. 3). Later, during the Miocene volcanic eruptions deposited thin flows of basalt, mainly in existing basins.

Bedrock influences topography both by its resistance to erosion, as well as, by the landscapes inherited from tectonic activity. Faults, horsts and grabens, tilted strata, volcanic flows and volcanic necks are visible on this DEM and a testament to the impact of bedrock geology and tectonic activity on topography. The Nechako River map area, and indeed the entire Nechako Plateau has been dissected by northwesterly, northeasterly, and easterly-trending fault systems (Struik and Wetherup, 1997; Lowe et al., 2001; Anderson et al., 2001; see Fig. 3). Most of these faults are poorly exposed and little is known of their individual geometries, timing, or sense of motion. However, some that are very closely associated with deformation of basement rocks and thick accumulations of distinct Eocene volcanic lithofacies are interpreted as syn-volcanic (Anderson et al., 1998). Comparison of Fig. 3 and the DEM shows that many of these mapped faults and associated horsts and grabens correlate with polygonal lineaments. The nature of these lineaments is variable. For instance, the surface trace of fault '1', southeast of Knewstubb Lake falls along a northwest-trending lineament that, for most of its length, is a gentle scarp separating elevated topography northeast of the fault from lower ground to the southwest. This and similar faults bound the horsts and grabens.

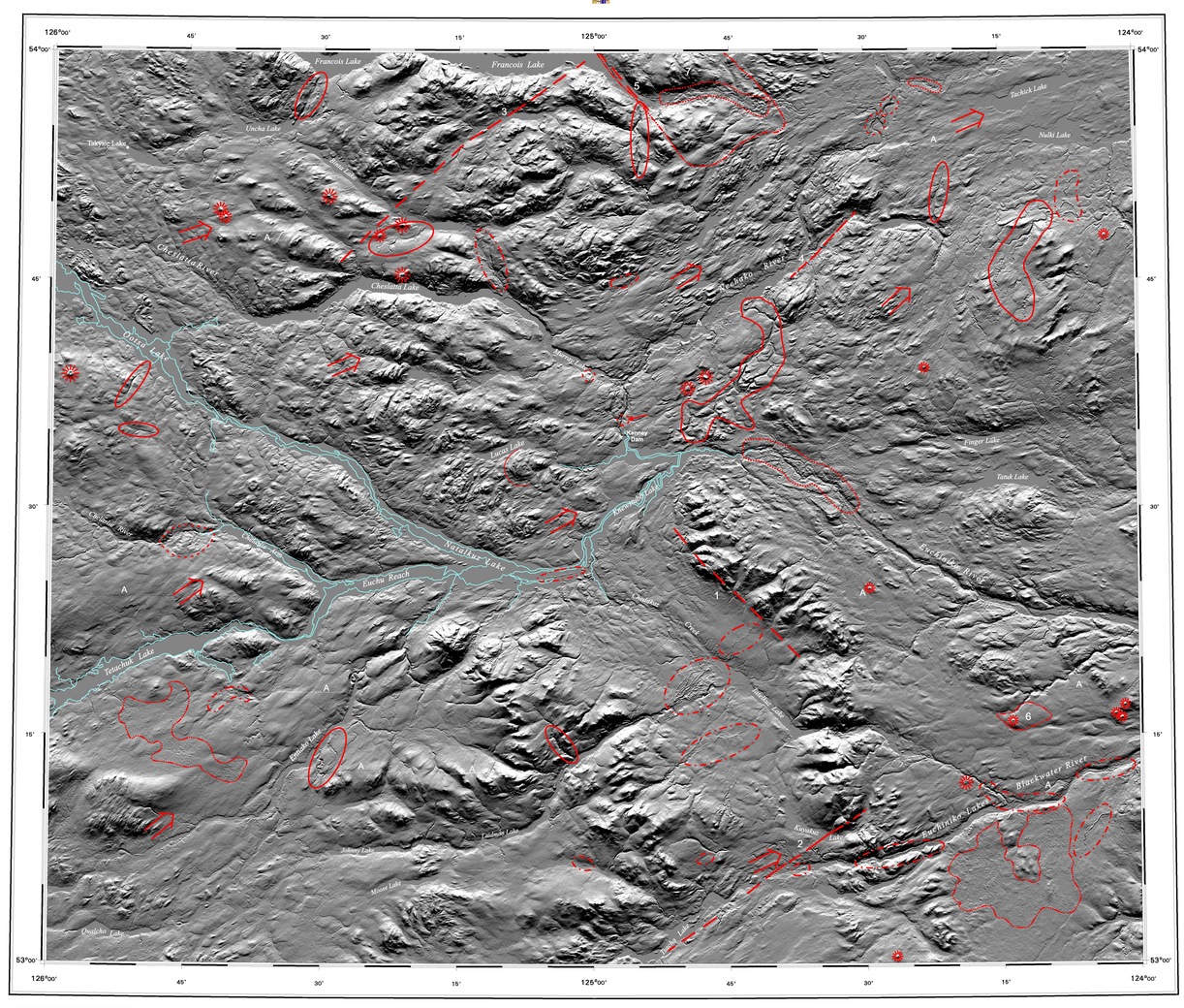
On the other hand, the surface traces of northeasterly-trending faults '2, 3 (the Anzus Lake fault of Anderson et al., 1999), and 4' and the northwesterly-trending Casey Fault, '5', lie along linear shallow valleys for most of their length. The latter fault zones generally were formed in weak material that was more easily eroded than the adjacent unfaulted rocks. They are interpreted to be like the faults that bound the horsts and grabens, but to have less vertical motion. There are many more northwesterly and northeasterly oriented lineaments recognized in the DEM than there are mapped faults. Most of these lineaments we would interpret as faults with tens to hundreds of metres of displacement. However, some visible lineaments are artifacts of digitization and gridding (see those labelled 'A' on DEM image) and unrelated to any tectonic structure. Although these artifacts invariably have a distinct scarp morphology and are typically oriented east-west, nonetheless, the user must exercise caution when interpreting lineaments.

The most obvious horsts recognized in the DEM image lie along the northwesterly trending Nechako and Fawnie ranges, and the northwesterly trending bounds to the Nechako River and Johnny and Laidman lakes valley. Corresponding grabens lie along the Euchiniko River, Chelaikut Creek, Nechako River, Johnny and Laidman lakes valley and south of Tatcha Lake. The present-day relief between the tops of horsts and the bases of grabens is significantly less than the original relief because the grabens were filled with Eocene to Miocene volcanic flows and sediments. These horsts and graben were further modified during the Pleistocene when northeasterly moving glaciers scoured the region and by deposits left behind when the glaciers melted.

Tilted strata on the southside of Lucas Lake are readily imaged in this DEM. There, gently east-dipping Eocene volcanic flows show terraced western and northern scarps and a relatively smooth top. The flows wrap around a pinnacle of older Eocene lava to the east.

Throughout the map area, small circular peaks, are commonly, but not invariably, underlain by hard porphyritic basalt of Miocene (13-11 million years old; Anderson et al., 2001) age; indeed their physiographic expression was one parameter used in the formal definition of the map unit. These small peaks occur individually, or as small clusters. Locally, where larger, they show a depression at the peak denoting a crater-like form (see example to the SW of Ootsa Lake). In some places the basalt flows derived from these volcanoes are visible as smooth surfaces sloping gently away from the vent (see example labeled '6' on DEM image). These volcanoes and their associated flows are typically well preserved and do not show the glacially induced crag-and-tail features typical of other rocks in the map area.

Generally, highland areas that are underlain by plutonic rocks show gentle sloping topography (see feature labeled '7' on DEM image), whereas areas underlain by volcanic and sedimentary rocks show irregularly shaped peaks emerging from a widespread carapace of colluvium and other debris derived from erosion of those weak rocks (see features in the Fawnie Range on DEM image). 'Patterened' ground north of Ootsa Lake is underlain by recessive sedimentary rocks which represent the most extensive distribution of an important Middle and Upper Jurassic basin in the map area.



Compilation by C. Lowe, J.K. Porter and R. Kung, 2001

Coordinated through the auspices of the Nechako NATMAP Project

Digital cartography by J.K. Porter and R.G. Franklin, Geological Survey of Canada

Any revisions or additional information known to the user would be welcomed by the Geological Survey of Canada

OPEN FILE 4027

DIGITAL ELEVATION MODEL

NECHAKO RIVER

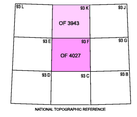
BRITISH COLUMBIA

Scale 1:250 000/Échelle 1/250 000

kilometres 5 0 5 10 15 20 25 30 kilomètres

Universal transverse Mercator Projection
North American Datum 1983
© Her Majesty the Queen in Right of Canada, 2001

Projection transverse universelle de Mercator
Système de référence géodésique nord-américain, 1983
© Sa Majesté la Reine du chef du Canada, 2001



LEGEND

- Landslide scar
- Glacial meltwater channels
- Kettled topography
- Eskers
- Ice flow direction
- Approximate extent of pluton
- Faults (known, approximate, assumed)
- Original pre-dam water level
- Digitization and/or gridding artifact — A
- Miocene basalt volcanic necks
- Miocene basalt flows
- Tilted strata

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GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA
12/2001

Recommended citation:
Lowe, C., V.M. Levson, L.C. Struik, A. Plouffe, R.G. Anderson and D. Mate
2001: Shaded-relief digital elevation model, Nechako River map area, British Columbia: an aid to geoscience studies; Geological Survey of Canada, Open File 4027, scale 1:250 000.

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