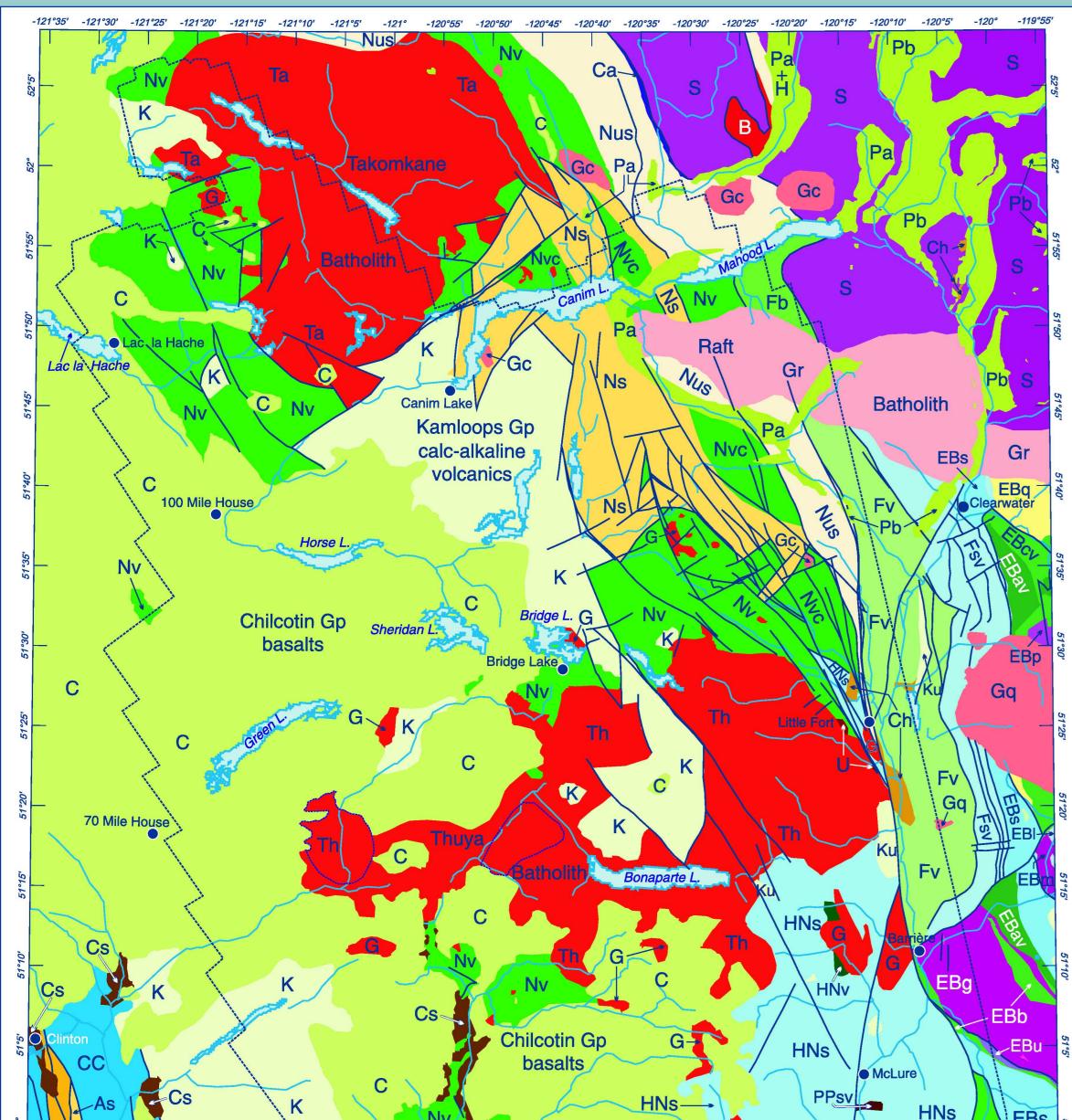
Thomas, M.D. and Pilkington, M.

Geological Survey of Canada

Sheet 1

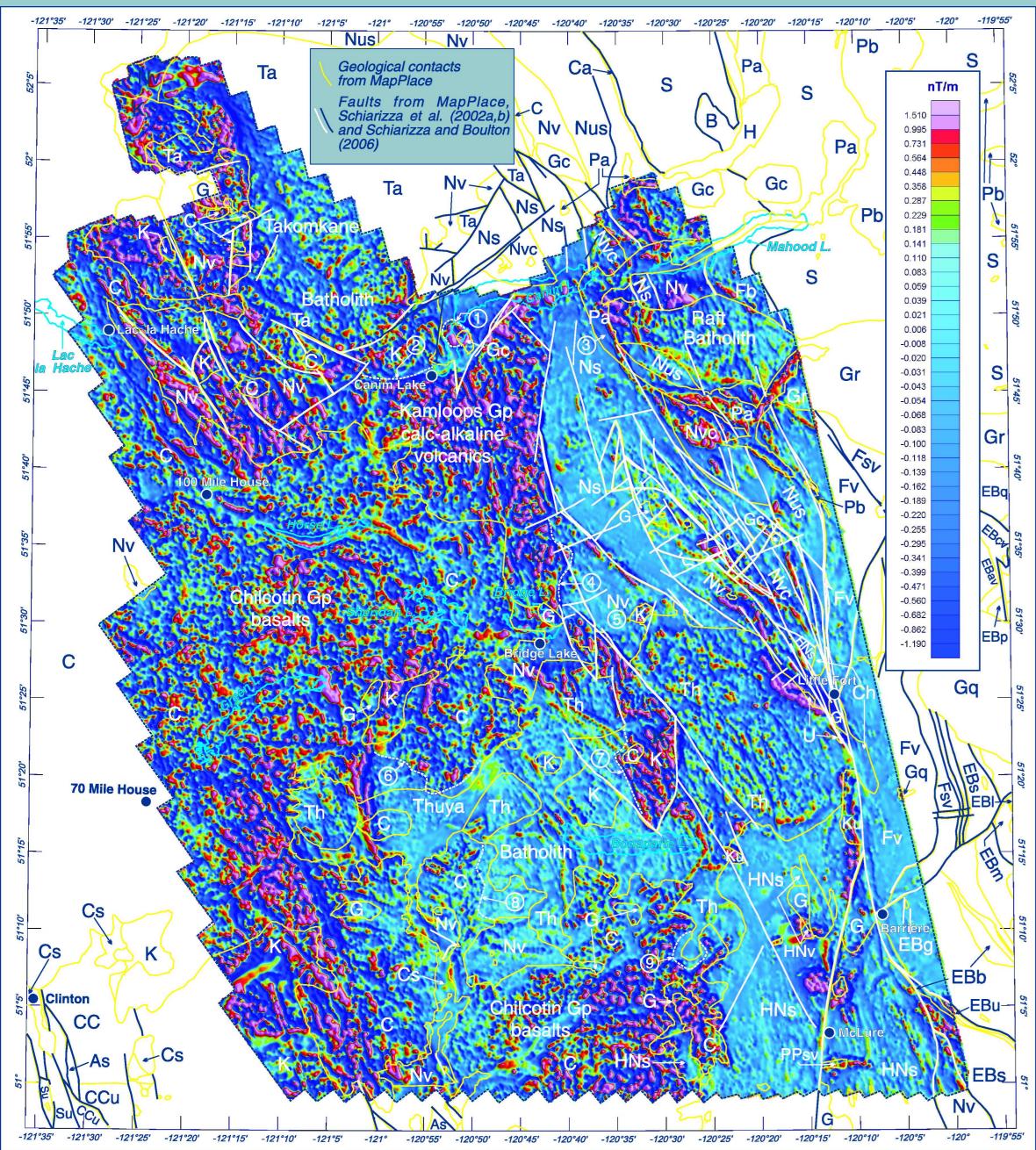
(1) Geological Map



20 km

(3) Map of the First Vertical Derivative of the Residual Total Magnetic Field

-121°35' -121°30' -121°25' -121°20' -121°15' -121°10' -121°5' -121°5' -120°55' -120°50' -120°45' -120°40' -120°35' -120°30' -120°25' -120°20' -120°15' -120°10' -120°5'



GEOLOGICAL SURVEY OF CANADA COMMISSION GÉOLOGIQUE DU CANADA

Introduction

In 2006 a high-resolution airborne geophysical (magnetic and radiometric) survey was completed over much of the eastern two-thirds of the Bonaparte Lake Map Area (NTS 92P), with a small northward incursion into the Quesnel Lake Map Area (NTS 93A). The survey was sponsored by Geoscience BC and the Targeted Geoscience Initiative III (TGI3) Program of Natural Resources Canada, with contributions from Amarc Resources Ltd., Candorado Operating Company Ltd., and GWR Resources Ltd. The survey is one of several TGI3 initiatives undertaken to combat the devastation inflicted by the Mountain Pine Beetle in central British Columbia. Geologically, the survey covers a significant portion of the prospective Quesnel terrane, which includes Upper Triassic-Lower Jurassic volcanic rocks of the Nicola Group and genetically related sub-volcanic plutonic rocks. These are prime targets for copper and gold exploration. Some preliminary observations with respect to the magnetic data are presented in this open file.

Geological Legend

basaltic volcanic rocks

basaltic volcanic rocks

EBs Eagle Bay Assemblage, Slate Creek Unit mudstone, siltstone, shale, fine clastic and important rocks

Devonian - Triassic

HNv Harper Ranch & (?) Nicola groups, basalti

Fb Fennell Assemblage, basaltic volcanic rocks

Bav Eagle Bay Assemblage, Foghorn Mountain Unit, andesitic volcanic rocks

EBcv Eagle Bay Assemblage, Skwaam Bay Unit,

Bb Eagle Bay Assemblage, Dixon Ridge Unit

EBu Eagle Bay Assemblage, serpentinit

B Black Riders Mafic - Ultramafic Complex

Ca Crooked Amphibolite, serpentinite ultramafic

EBg Eagle Bay Assemblage, Forest Lake Ur

EBm Eagle Bay Assemblage, Johnson Lake Unit,

EBI Eagle Bay Assemblage, limestone, marble,

EBP Eagle Bay Assemblage, paragneiss,

EBq Eagle Bay Assemblage, Graffunder Lake

Snowshoe Group, metamorphic rocks

Units, quartzite, quartz arenite sedimentary

Upper Proterozoic - Lower Cambrian

Upper Proterozoic - Palaeozoic

greenstone, greenschist metamorphic rocks

calc-alkaline volcanic rocks

pasaltic volcanic rocks

Upper Palaeozoic

Lower Palaeozoic

Lower Cambrian

A geological map of the survey area based principally on mapping at 1:250,000

scale is shown in the upper left panel (1). It was obtained from a website

(http://www.em.gov.bc.ca/Mining/Geosurv/MapPlace) maintained by the British

Columbia Geological Survey. The map legend is shown above. Mapping at 1:50,000

scale is available in northeastern and eastern parts of the area (Schiarizza et al.,

2002a,b; Schiarizza and Boulton, 2006). The survey area is underlain almost

exclusively by the north-northwest-trending Quesnel terrane, comprising Triassic-

Jurassic volcanic rocks of the Nicola Group and related sub-volcanic plutonic rocks,

such as the Late Triassic to Early Jurassic Takomkane and Thuya batholiths. Small

areas of the similarly trending, mainly Upper Proterozoic to Permian metamorphic,

volcanic, sedimentary and plutonic rocks of the Slide Mountain and Kootenay

terranes are present along the eastern margin of the survey area. Most of the western portion of the survey area is covered by a thin blanket of Miocene-Pleistocene

volcanic rocks of the Chilcotin Group, which obscure the presumably underlying

Quesnel terrane. A significant presence of Eocene volcanic rocks of the Kamloops

Group plays a similar role. Limited areas of Pleistocene volcanic rocks are mapped in

the northeast part of the area, along with some Cretaceous intrusions, notably the

Raft Batholith. Quaternary glacial cover is ubiquitous. Descriptions in this open file

A histogram-equalized colour map of the residual total magnetic field with

geological boundaries superposed is shown in the panel (2) to the upper right. There

is a marked improvement in the detail of the magnetic field provided by the new high

resolution survey compared to that provided by older regional surveys, a

consequence of mean terrain clearance and line-spacing being reduced from 305 m

to 125 m, and from 805 m to 400/425 m, respectively. A finer scale magnetic fabric is

apparent in the higher resolution map, and features that were relatively coarse in the

low resolution data are now sharper and more clearly defined. Good examples are

fault signatures, defined by narrow, linear magnetic lows. On a broad scale, two

notable changes are: (1) the presence of numerous high frequency anomalies in the

western half of the map having small aspect ratios, which impart a somewhat "spotty"

or variegated texture to the map, attributed to volcanic rocks of the Chilcotin Group.

and (2) the introduction of a fine northwest to north-northwest-trending linear fabric,

observed both within the sedimentary-volcanic rocks of the Nicola Group and the

Magnetic anomalies in the area range over 7500 nT from -1831 nT to 5669 nT, the

mean value being -23 nT. Because colour intervals are histogram-equalized, the

magnitude of some very large anomalies may not be readily estimated, since they

peak in the uppermost colour intervals, in which colours are gradational and not easily

distinguished from one another. Relative sizes of anomalies can be easily estimated,

however, in 3D images of the magnetic field. Some of the largest anomalies occur

along the eastern margin of the region, where the field is otherwise generally

comparatively low and fairly featureless. Near Canim and Mahood lakes, magnetic

highs H1 and H2 attain >5000 nT, and are attributed, respectively, to a unit of Middle-

Late Triassic mafic volcanic breccia of the Nicola Group, and to a Late Triassic-Early

Jurassic intrusion that includes clinopyroxenite, hornblendite and mafic gabbro. Near

Little Fort, magnetic high H3, >3500 nT, is associated with Late Triassic(?)-Early

Jurassic ultramafic rocks along the eastern margin of the Thuya batholith. Farther

south, the high H4 (values attain >3000) nT is likewise attributed to ultramafic rocks,

though only sedimentary rocks of the Harper Ranch and (?) Nicola groups are

Strong anomalies are observed all along the western margin of the survey area. In

the northwest, near the Takomkane batholith, magnetic highs H5, H6, H7 and H8

together with several other adjacent highs are clearly related to volcanic rocks of the

Nicola Group. Peaks within these highs are all generally >1000 nT, sometimes >2000

nT or 3000 nT, and exceptionally >4000 nT. Farther south, southeast of 100 Mile

House and 70 Mile House, respectively, magnetic highs H9 and H10 are located over

volcanic rocks of the Chilcotin Group (mainly), and of the Kamloops Group. Peak values within them commonly attain >1500 nT, and more rarely >2500 nT. The highs

are attributed to volcanic rocks of the Nicola Group buried beneath the Cenozoic volcanic cover. Although the general levels of the magnetic field over the main areas

of volcanic rocks of the Chilcotin and Kamloops groups (in the northern half of the

survey area) fall in different parts of the colour spectrum, a noticeable difference in the

pattern or texture of magnetic anomalies is still discernible. Anomalies over the

Chilcotin Group produce a variegated pattern of high frequency anomalies, as noted

above, whereas anomalies (magnetic highs) over the Kamloops Group tend to be

more extensive, more linear and interspersed with magnetic lows having similar

spatial dimensions. This pattern, which is somewhat "blocky", is well developed in

the large area of Kamloops Group in the north-central part of the area between Bridge

and Canim lakes. It is similar to the magnetic pattern present over volcanic rocks

mapped as Chilcotin Group south of Bonaparte Lake and west of McClure,

suggesting that these volcanic rocks may instead belong to the Kamloops Group.

are with respect to the MapPlace geological map, unless otherwise stated.

Pa alkaline volcanic rocks
Pb basaltic volcanic rocks
Pliocene - Pleistocene
PPsv marine sedimentary and volcanic rocks

Miocene -Pleistocene

C Chilcotin Group, basaltic volcanic rocks
Cs Chilcotin Group, coarse sedimentary rocks

Eocene

K Kamloops Group, calk-alkaline volcanic rocks

Division, marine sedimentary and volcanic rocks

HNs Harper Ranch & (?) Nicola groups, mudstone, siltstone, shale, fine grained sedimentary rocks

Devonian - Permian

Fsv Fennell Assemblage, Lower Structural Division, marine sedimentary and volcanic

Kamloops Group, calk-alkaline volcanic rocks
Ku Kamloops Group, undivided volcanic rocks
Ch Kamloops Group, Chu Chua Formation,

Gr unidivided intrusive rocks
Gr Raft Batholith (granite, granodiorite)

Gq quartz monzonitic intrusive rocks
Su unidivided sedimentary rocks
Lower Jurassic - Middle Jurassic
As Ashcroft Formation, sedimentary rocks
Late Triassic - Early Jurassic

Tallin Takomkane, Thuya batholiths

G granodioritic, syenitic, monzonitic intrusive rocks (may be satellites of Takomkane or Thuya batholiths)

Ns Nicola Group, sedimentary rocks
Noc Nicola Group, volcaniclastic rocks
Upper Triassic

Nv Nicola Group, basaltic volcanic rocks
Middle Triassic - Upper Triassic

Nus Nicola Group, undivided sedimentary rocks
Permian - Triassic

CC Cache Creek Complex, marine sedimentary

Pennsylvanian - Upper Triassic

CCu Cache Creek Complex, Eastern Belt, serpentinite ultramafic rocks

Pennsylvanian - Permian

Fv Fennell Assemblage, Upper Structural
Division, basaltic volcanic rocks

Fault Internal Contact

Residual Total Magnetic Field

eastern part of the Thuya batholith.

mapped in its vicinity.

Geology

In contrast to the strong magnetic signatures associated with volcanic rocks of the Nicola Group, magnetic anomalies over the Takomkane and Thuya batholiths are relatively subdued, and in the case of the former intrusion even relatively negative. The Takomkane batholith does, however, contain strong anomalies near its northwestern margin, for example *H6*, and exhibits a positive magnetic expression along its southern and eastern margins. It is speculated that all of these signatures are related either to unmapped tracts of volcanic rocks belonging to the Nicola Group,

or to such rocks underlying thin marginal portions of the batholith.

The magnetic response of the Thuya batholith is generally weakly positive, though the level of the field over much of its eastern segment between Bridge Lake and Little Fort merges with the typically flat and featureless magnetic field which characterizes much of the eastern margin of the survey area, and is associated with sedimentary rocks of the Nicola Group in the north, sedimentary rocks of the Harper Ranch and

Nicola (?) groups in the south, and basaltic volcanic rocks of the Fennell Assemblage along the eastern edge of the area. A noteworthy feature of the magnetic field over the eastern part of the Thuya batholith, from about the western end of Bonaparte Lake eastwards, is the fine linear magnetic fabric produced by a series of closely spaced, parallel linear magnetic anomalies oriented northwest to north-northwest. The continuity of this fabric from the batholith into an area of volcanic rocks mapped as belonging to the Kamloops Group indicates that the volcanic rocks may be more restricted than geological mapping implies.

First Vertical Derivative of the Residual Total Magnetic

The residual total magnetic field is generally the measured parameter in aeromagnetic surveys, maps of which provide a picture of relative strengths of magnetizations in the underlying rocks, and contribute to an understanding of the geology. Several magnetic parameters derived from this fundamental measured parameter are also very useful for mapping and enhancing knowledge of geology. The derived parameters may be simple gradients of the magnetic field, or mathematical expressions based on the gradients.

A common derivative is the first vertical derivative (= vertical gradient), which highlights short wavelength features of the magnetic field. This is useful where shorter wavelength features are superposed on longer wavelength anomalies, or fall in areas where the general levels of the magnetic field and local colour ranges are significantly different, and comparison of magnetic patterns becomes difficult. A vertical gradient map provides a more uniform background level and facilitates comparisons, and is useful also for examining variations in magnetic fabric within a region, because it emphasizes short wavelength, textural aspects of the magnetic field. An important characteristic of first and second vertical derivative

maps is that the zero value of these derivatives, in high magnetic latitudes, typically lies near the contact between magnetic units having different magnetizations. Thus, the zero value, or 'edge' of derivative anomalies is a good proxy for the location of a geological contact. An image of the first vertical derivative is shown in the lower left panel (3) with mapped geological contacts superposed. It displays short wavelength features of the magnetic field, which provide fine details of the structural fabric of the underlying geology.

The correlation of geological units with patterns of the magnetic fabric is generally good. The magnetic texture over volcanic rocks of the Chilcotin Group is characterized by positive features having generally small aspect ratios and lacking a preferred orientation, whereas that over volcanic rocks of the Kamloops Group is characterized by anomalies having generally larger aspect ratios, hence are more linear, and which locally develop a linear magnetic fabric. The range of gradient values over the Kamloops Group is typically larger than the range over the Chilcotin Group. This more intense pattern (higher range) observed over the Kamloops Group is also present over volcanic rocks mapped as Chilcotin Group south of Bonaparte Lake along the southern margin of the survey area. Possibly, these volcanic rocks also belong to the Kamloops Group.

northwestern part of the area is not unlike that over the Kamloops Group. The range of gradient values is similar, and many anomalies have a linear aspect. A broad belt having a similar fabric stretches south-southeastward from Green Lake over mainly the Chilcotin Group, and to a lesser extent the Kamloops Group. This coincides with the magnetic high *H10* on the residual total magnetic field map, lending support to the idea that the high is related to a buried volcanic unit belonging to the Nicola Group.

The magnetic fabric associated with volcanic units of the Nicola Group in the

The magnetic texture of the Takomkane batholith is similar to that over the Chilcotin Group, in terms of range of values, aspect ratios, dimensions of anomalies and general lack of preferred orientation. It contrasts with textures within the Thuya batholith, which is characterized by two principal textural patterns. A relatively featureless pattern in the western part coincides with fine- to medium-grained, mainly felsic (monzogranite, quartz monzonite) and lesser intermediate (quartz monzodiorite) rocks (Bob Anderson, pers. comm., 2007). Compared to intrusive phases further east, these rocks are relatively mafic-poor, un-mineralized and unaltered. A variable linear pattern of relatively short, narrow anomalies striking north-northwest, best developed east of Bonaparte Lake, characterizes much of the eastern part of the batholith, which is heterogeneous (syenite, pyroxenite, hornblendite, diorite, quartz diorite, granodiorite, agmatite), medium- to coarsegrained and biotite- and hornblende-bearing. These rocks contain pervasive propyllitic alteration and copper mineralization related to quartz veins and fractures. A noticeable linear magnetic fabric developed near the west end of Bonaparte Lake may also signify the presence of such mineralization.

Extensive units (Ns) of sedimentary rocks belonging to the Nicola Group and striking south and then southeast from Canim Lake are characterized by a general lack of notable features in the vertical gradient image. A similar description applies to the sedimentary rocks of the Harper Ranch and (?) Nicola groups near Barriere and McClure in the southeast corner of the area, and to the basaltic volcanic rocks of the Fennell Assemblage along the eastern margin of the area. Nevertheless, in all of these units, sporadic development of generally weak, narrow linear features striking north to northwest in harmony with the regional geological strike is observed. The eastern area where the vertical gradient image is relatively featureless is

punctuated by relatively localized developments of moderate to strong linear anomalies coinciding with units of basaltic volcanic rocks (Nv) or volcaniclastic rocks (Nvc) of the Nicola Group. The Cretaceous Raft batholith also develops a magnetic fabric, similar in pattern and intensity to that present over the Takomkane batholith, with a hint of a linear fabric in places, though this may in part be fault-related.

Overall, most geological units produce a distinctive magnetic texture, though locally within them there may be executions. Examination of the correlations and

locally within them there may be exceptions. Examination of the correlations and apparent discrepancies leads to the following suggestions for revision to the geology. The areas for revision are indicated by circled numbers on the vertical gradient map:

(1) The magnetic signature indicates that a small Cretaceous 'granitic' stock is significantly larger than mapped.

(2) The limit of the Takomkane batholith may be farther southeast, under very thin

(3) A unit mapped as Pleistocene volcanic rocks in an area where Quaternary unconsolidated sediments are ubiquitous (Schiarriza and Boulton, 2006) may include non-magnetic volcanic rocks and/or significant amounts of sedimentary rocks, or may have a more limited distribution.

sedimentary/volcanic rocks of the Kamloops Group (Schiarriza and Boulton, 2006).

(4) The boundary position of volcanic rocks belonging to the Kamloops Group needs to be repositioned further west.(5) The relatively featureless magnetic texture of this volcanic unit (Nv) of the Nicola

Group conforms with its designation as a sedimentary unit (Schiarizza et al., 2002a).

(6) The Thuya batholith may extend north into an area mapped as volcanic rocks of the Chilcotin Group.

(7) An area of Kamloops Group immediately north of Bonaparte Lake is probably underlain mainly by the Thuya batholith, and the boundary between these two units is

probably farther to the east.

(8) The boundary between the Thuya batholith and Chilcotin Group west-southwest of Bonaparte Lake is probably father west than the mapped position.

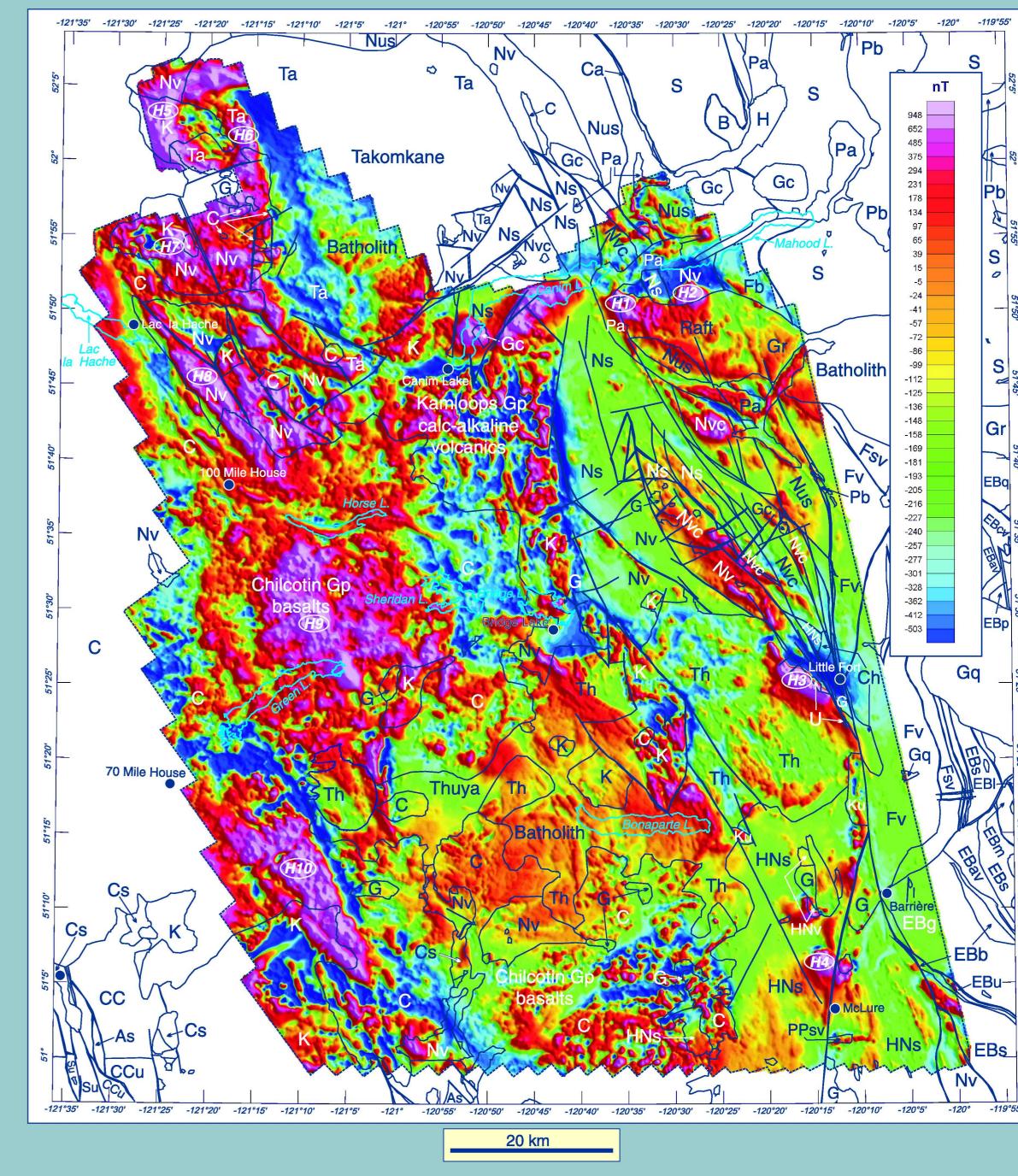
(9) A lobe of the Thuya batholith extending southwestward into the Chilcotin Group may be larger than current geological mapping suggests.

Magnetic Domains

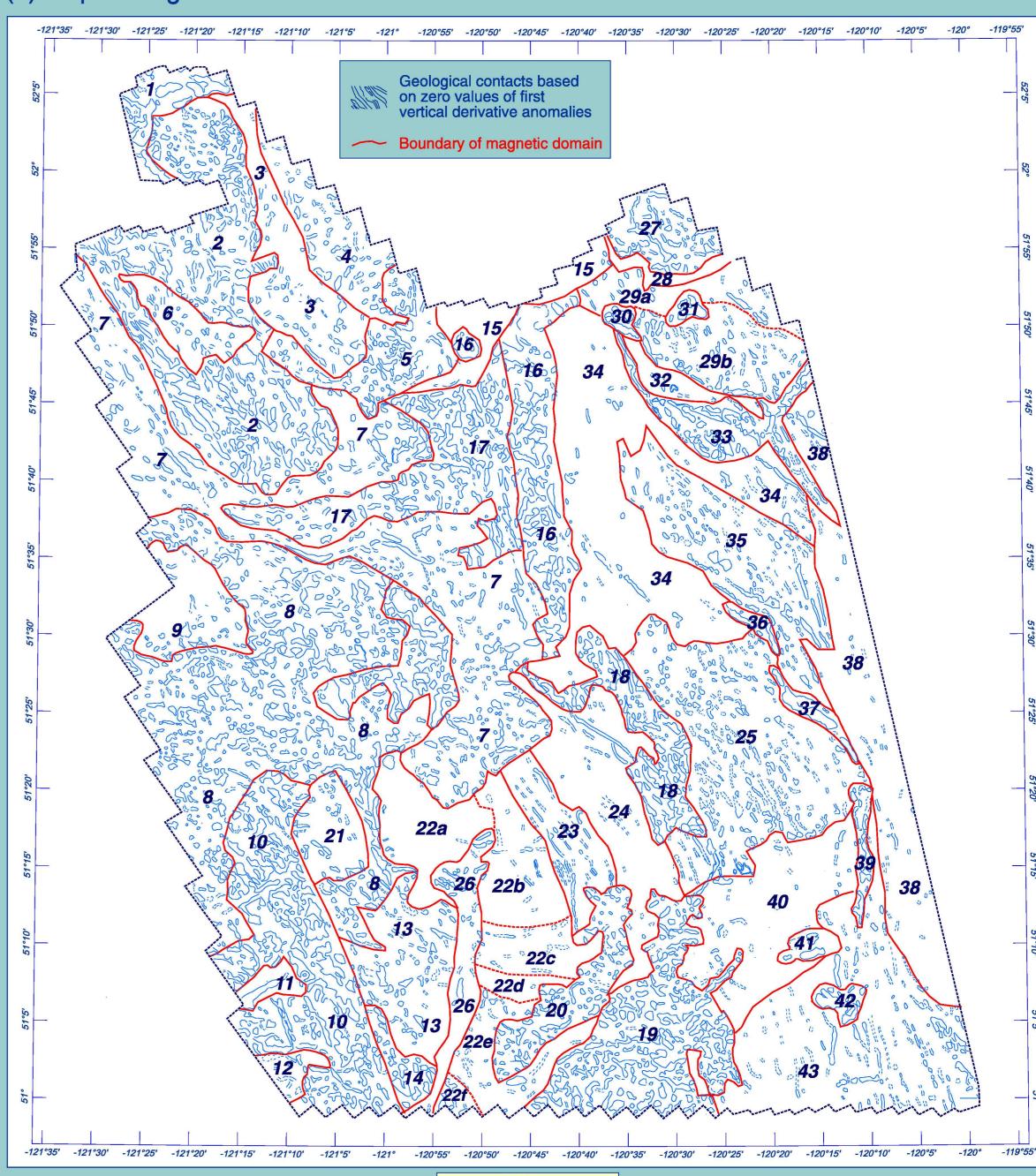
The attribute of the zero value of the vertical gradient was exploited to produce a contact map. Contacts were not drawn automatically along the length of all zero contour values, because some portions of the contours are not associated with the edges of significant vertical gradient anomalies. They were drawn, therefore, on the basis of visual inspection, along the edges of more prominent features. The patterns of contacts, which include their length, density of distribution, and orientations, define structural fabrics and faults. They have been used to define a series of magnetic domains, without consulting any geological maps. Contacts and magnetic domains are shown in the panel to the lower right (4).

The significance of the magnetic domains is discussed in more detail on Sheet 2 of this open file.

(2) Map of the Residual Total Magnetic Field



(4) Map of Magnetic Domains and Contacts Derived from the First Vertical Derivative



20 km

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2008

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20 km