Ice-flow indicator compilation for the Cordilleran ice sheet

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Summary

Surficial geology (at 1:50,000-scale) maps for large areas of northern British Columbia (BC) do not exist. As a result, local glacial transport histories are poorly understood, thus hindering the use of mineral exploration methods that utilize glacially transported sediments. Detailed Quaternary geology studies conducted in BC have revealed complex glacial flow history issues that must be understood for drift prospecting programs to be successful (e.g., Stumpf et al., 2000; Ferbey & Levson, 2007; Plouffe et al., 2011). A revised Quaternary ice-flow indicator compilation, based on existing and new infill feature mapping, is required to improve our understanding of Cordilleran ice sheet movements and the effectiveness of surficial sediment geochemistry and mineralogy exploration methods.

Objectives

The primary objective of this initiative was to build on the success of the ice-flow indicator compilation for BC by Ferbey et al. (2013) and produce an ice-flow indicator compilation for the Cordilleran ice sheet. This larger compilation will better illustrate major ice-flow directions for the northern sector of Cordilleran ice sheet during the Late Pleistocene.

The compilation, and subsequent interpretations, will contribute to a better understanding of the Cordilleran ice sheet flow history, which is a critical parameter for interpreting geochemical and mineralogical data on glacially transported sediments. Further, these data will support the mineral exploration industry with the design and implementation phases of drift prospecting surveys by providing important base-line data on till transport direction.

The first phase of the initiative is complete and existing and independent ice-flow indicator databases put together by the British Columbia Geological Survey (BCGS) and Yukon Geological Survey (YGS) are integrated. In both cases, these data are from published and unpublished surficial geology, terrain, and glacial features maps.

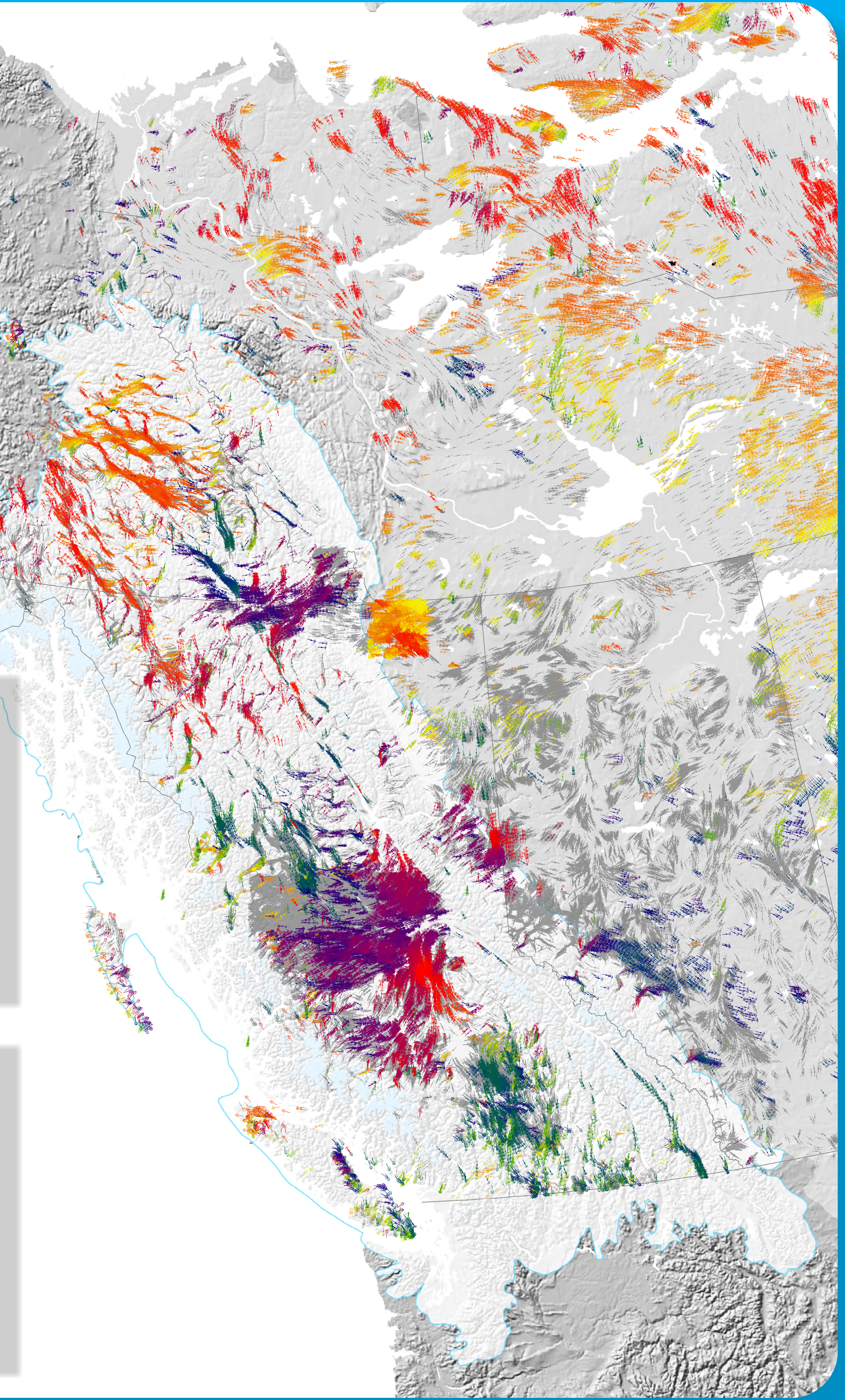
The second phase (currently underway) is focusing on areas of northern BC where there is a low spatial density of ice-flow indicator data. The compilation will incorporate new data that is being captured from digital stereo airphotos and derived-stereo orthophoto mosaics and Satellite Pour l'Observation de la Terre (SPOT) imagery. These imagery data, and shuttle radar topography mission (SRTM) digital elevation models (DEMs) used to produce the derived-stereo imagery, will be evaluated to determine the scale at which macro-scale ice-flow features can be mapped and their suitability to other surficial geology applications (e.g., 1:50,000-scale mapping). These data will also be used to assess, where possible, the quality of the existing ice-flow data from the BCGS and YGS data sets.

Previous remote sensing mapping initiatives have used satellite imagery and DEMs to identify ice-flow features (e.g., McClenagan, 2005; Shaw et al., 2010). In this study, however, these two data types have been combined to create derived-stereo images.

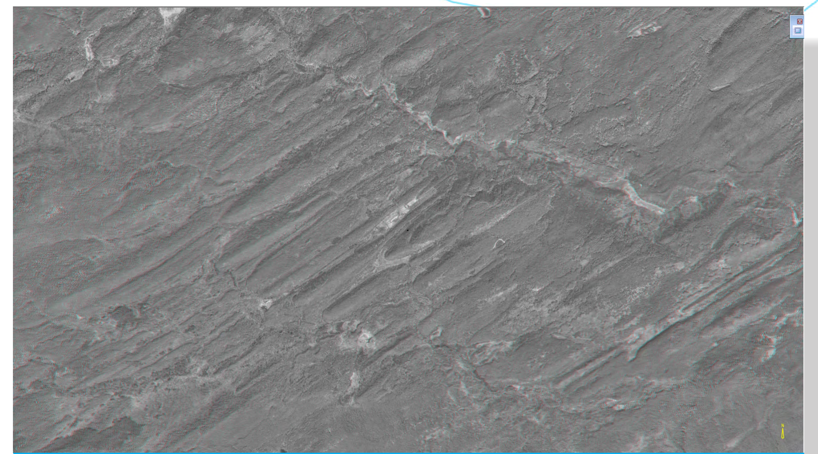
The areas of interest for the second phase of this initiative are those with in in northern BC without large-scale, 1:50,000-scale surficial geology maps. New digital derived-stereo orthophoto mosaics and digital derived-stereo SPOT imagery are being used to map ice-flow features in these areas. These newly digitized features will be added to the Cordilleran ice sheet compilation.

As part of phase two, these three data types will be compared to assess the resolvable scale of macro-scale ice-flow features. The imagery and DEMs that are be used are as follows:

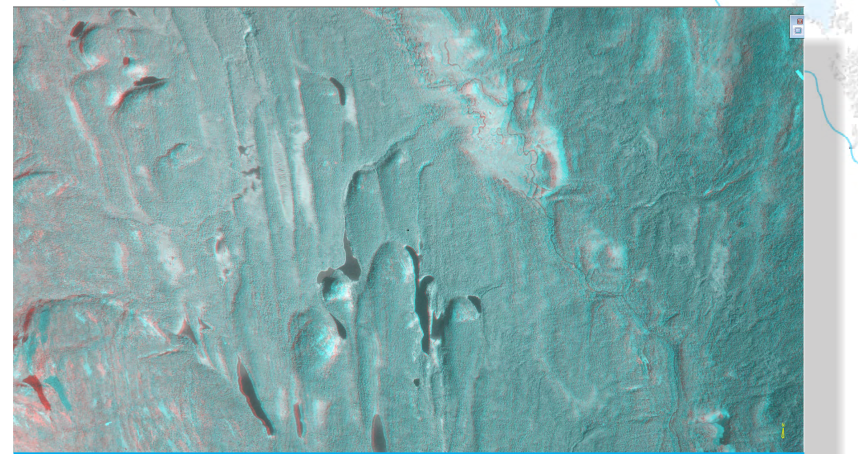
- 10 m SPOT data, from the Government of Canada;
- 1:20,000-scale orthophoto data, from the Government of BC;
- 1:70,000-scale airphotos, from the Government of BC; and
- 30 m SRTM DEM, from the United States Government.



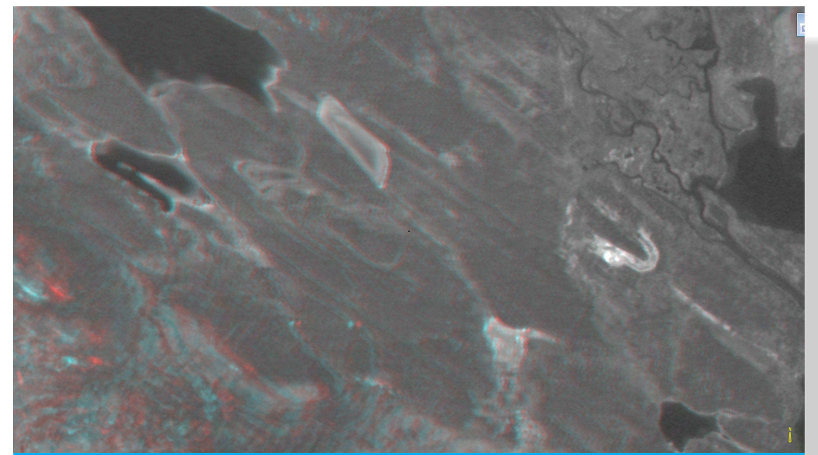
The three sources of data displayed in 3D with examples of ice-flow features in the study area.



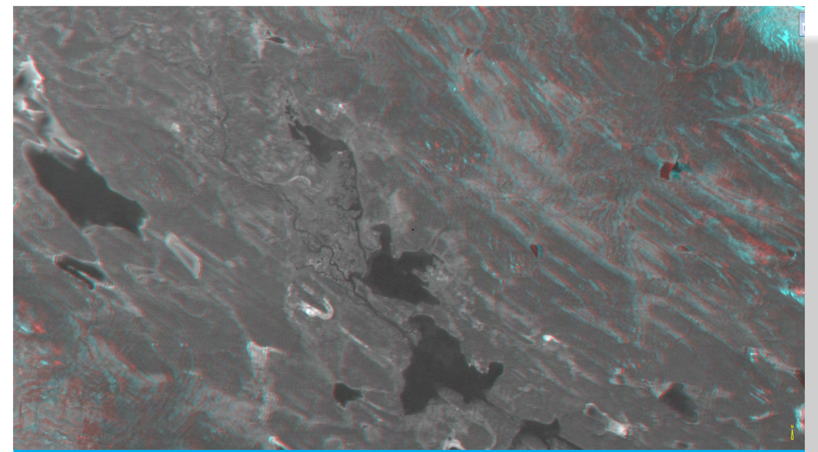
Derived-stereo orthophoto mosaic, scale 1:10,000



Stereo small scale (1:70,000) airphotos, scale 1:10,000



Derived-stereo SPOT, scale 1:10,000



Derived-stereo SPOT, scale 1:20,000

Methods

Using DAT/EM Summit Professional, geo-referencing of existing ortho-imagery (airborne or satellite based) was used to offset each of the images in the direction of the flight line. This produces a shift in X between the two images. The amount of shift between the derived and original images is a percentage of a pixel per elevation unit and is based on the resolution of the DEM. For a DEM of 5m, a pixel shift per elevation unit will shift the pixels 5m to the new image whereas a DEM of 25m and pixel shift of 0.2 will also shift the pixel 5m when forming the new image. The 'new images' were then draped over the DEM surface to spatially reference each of the pixels in the new image — effectively re-referencing the image.

Draping the new image over the DEM is crucial to producing these derived stereo images. The edges of the new image are no longer straight; they are warped to follow where that pixel fit onto the DEM. This is essentially the reverse of generating an orthophoto. When you take a 'raw' image and ortho-rectify it or drape it over a 3D surface, the initial image becomes warped. IGI consulting reversed that process to create an image with a new perspective. Summit then takes the geo-referencing of each image and overlays them creating the 3D stereo model.

The 3D stereo models are then loaded into the DAT/EM Summit Evolution, running in tandem with ArcGIS, and streamlined landforms are mapped.

Although the areas of interest in northern BC do not have existing, large-scale, 1:50,000-scale surficial geology maps, some ice-flow indicator data are available. These data come from three different sources:

- Bedrock geology and terrain/bio-terrain maps;
- Small-scale, 1:1,000,000 and 1:5,000,000, surficial materials and glacial features maps (Mathews et al., 1975; Fulton, 1995); and
- Digital landform patterns of Canada (Shaw et al., 2010).

These data have been added to the Cordilleran ice sheet compilation but gaps in the spatial distribution of data remain. Data from Shaw et al. (2010) are used with caution as they often indicate ice-flow directions that are inconsistent with those presented by other data sources in addition to being low in density.

Work has begun along the Yukon/BC border and will extend approximately 300 km to the south.

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References:

Atkinson, N., Utting, D.J., and Pawley, S.M., 2014. Glacial landforms of Alberta, Canada; Alberta Energy Regulator, AER/AGS Map 604, scale 1:1 000 000.

Dyke, A.S., Moore, A., and Robertson, L., 2003. Deglaciation of North America; Geological Survey of Canada, Open File 1574, CDROM.

Ferbey, T. and Levson, V.M., 2007. The influence of ice-flow reversals on the vertical and horizontal distribution of trace elements in tills, Huckleberry mine area, west-central British Columbia. In: Paulen, R.C. and McMartin, I. (Eds.), Application of Till and Stream Sediment Heavy Mineral and Geochemical Methods to Mineral Exploration in Western and Northern Canada, Geological Association of Canada, Short Course Notes 18, p. 145-151.

Ferbey, T., Arnold, H., and Hickin, A.S., 2013. Ice-flow indicator compilation, British Columbia. British Columbia Ministry of Energy and Mines, British Columbia Geological Survey Open File 2013-06, 1:1 650 000 scale.

Fulton, R.J., 1995. Surficial materials of Canada. Geological Survey of Canada, Map 1880A, scale 1:5 000 000.

Plouffe, A., Bednarski, J.M., Huscroft, C.A., Anderson, R. G., and McCuaig, S. J., 2011. Late Wisconsinan glacial history in the Bonaparte Lake map area, south central British Columbia: implications for glacial transport and mineral exploration; Canadian Journal of Earth Sciences, v. 48, p. 1091-1111.

Mathews, W.H., Gabrielse, H., and Rutter, N.W., 1975. Glacial map of Beatton river map-area British Columbia; Geological Survey of Canada, Open File 274, scale 1:1 000 000.

McClenagan, J.D., 2005. The occurrence and origins of streamlined forms in central British Columbia. University of Victoria, unpublished PhD thesis, 371 p.

Shaw, J., Sharpe, D.R., Harris, J., Lemkow, D. and Pehleman, D., 2010. Digital landform patterns for glaciated regions of Canada - a predictive model of flowlines based on topographic and LANDSAT 7 data. Geological Survey of Canada, Open File 6190, 38 p.

Stumpf, A.J., Broster, B.E. and Levson, V.M., 2000. Multiphase flow of the Late Wisconsinan Cordilleran Ice Sheet in western Canada. Geological Society of America Bulletin, v. 112, p. 1850-1863.