Search Project: Phase III Activities in North-Central British Columbia (Phase III, Covering NTS 094C, D, E, F, 093M, N)

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Introduction

The Search project was conceived by Geoscience BC's Minerals Technical Advisory Committee to generate regional magnetic data and complementary earth science for prospective mineral-exploration areas of the province. The exploration sector will use this new information to focus or renew its efforts in discovering and developing opportunities within the province. First Nations, communities and governments will also benefit from new earth science because it will help them make more informed resource-management decisions and will highlight economic opportunities.

The name 'Search' was selected as it contains the word 'arch', a reference to the program's initial focus on the Skeena arch—a paleotopographic high whose erosion created the sediments found in the Bowser and Nechako basins (Tipper and Richards, 1976). Today, this arch bridges the gap between the Stikine and Quesnel geological terranes.

The Search project is, in part, a generation of airborne geophysical surveys with a line spacing of 250 m that creates opportunities for geological interpretations at a property scale. The large scale of the surveys can also support the development of refined tectonic frameworks. Other Geoscience BC projects with similar-style surveys are the TREK, Northern Vancouver Island, QUEST-Northwest and Jennings River (partnership with Natural Resources Canada) projects (Figure 1).

The Search project in 2017 departed from plans by surveying an area farther to the north than was forecasted for the year (Madu, 2017). This change was proposed by Geoscience BC's Technical Advisory Committee to stimulate exploration interest in an area where the organization had never before conducted an airborne survey (i.e., north of the original QUEST survey). The project boundary was designed to complement the joint BC Geological Survey–Geological Survey of Canada Toodoggone survey completed in 2003 (Shives et al., 2004).

The approximate centre of the survey area is located 250 km north of Fort St. James, 225 km northwest of Mackenzie, 200 km northeast of Smithers and 325 km west of Fort St. John (Figure 2). Closer to the survey are the communities of Fort Ware (known locally as 'Kwadacha'), Tsay Key Dene and Takla Landing, where many of the region's indigenous residents live.

As the survey area is remote and the terrain rugged, a budget of $1.7 million was identified for this year's program. Significant support of $250 000 from the Northern Development Initiative Trust allowed the survey to expand to the north and include the proposed Kemess underground mine (Figure 3), located within the Peace River Regional District (MINFILE 094E 021; BC Geological Survey, 2017). The extension will provide valuable new data on this important mining camp for explorers to interrogate in their regional programs (for background on the Kemess camp, see Rebagliati et al., 1995).

In addition to the proposed mine area, the survey flew the greater 'camp', where encouraging potential is being recognized in areas such as the Kemess East project (AuRico, 2017; MINFILE 094E 315). The survey also overflew several significant projects, such as the Kliyul, Lorraine and Sustut (Figure 3; MINFILE 094D 023, 094D 113, 093N 002, 094D 063).

Regional Geology

The regional geology of the survey and surrounding area is unique, since it is here that two of British Columbia's (BC's) metal-endowed geological terranes, the Quesnel and Stikine, come into contact (Figure 3; Monger et al., 1991; Nelson et al., 2013). The majority of the province's operating copper-molybdenum-gold mines are located within these terranes. The Quesnel terrane is at its northernmost extent in the survey area, while the Stikine terrane is at its easternmost extent. These terranes are separated by the regional-scale Pinchi-Ingenika-Finlay fault system, which traverses the approximate centre of the survey area in a north to northwest orientation. A section of the Cache

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Figure 1. Location of other Geoscience BC airborne geophysical surveys with 250 m line spacing include the Search Phases I and II, TREK, Northern Vancouver Island, QUEST-Northwest and Jennings River (with Natural Resources Canada) projects. Blue outline, Search Phase III survey area; red outlines, coverage of previous airborne geophysical surveys conducted or funded by Geoscience BC.

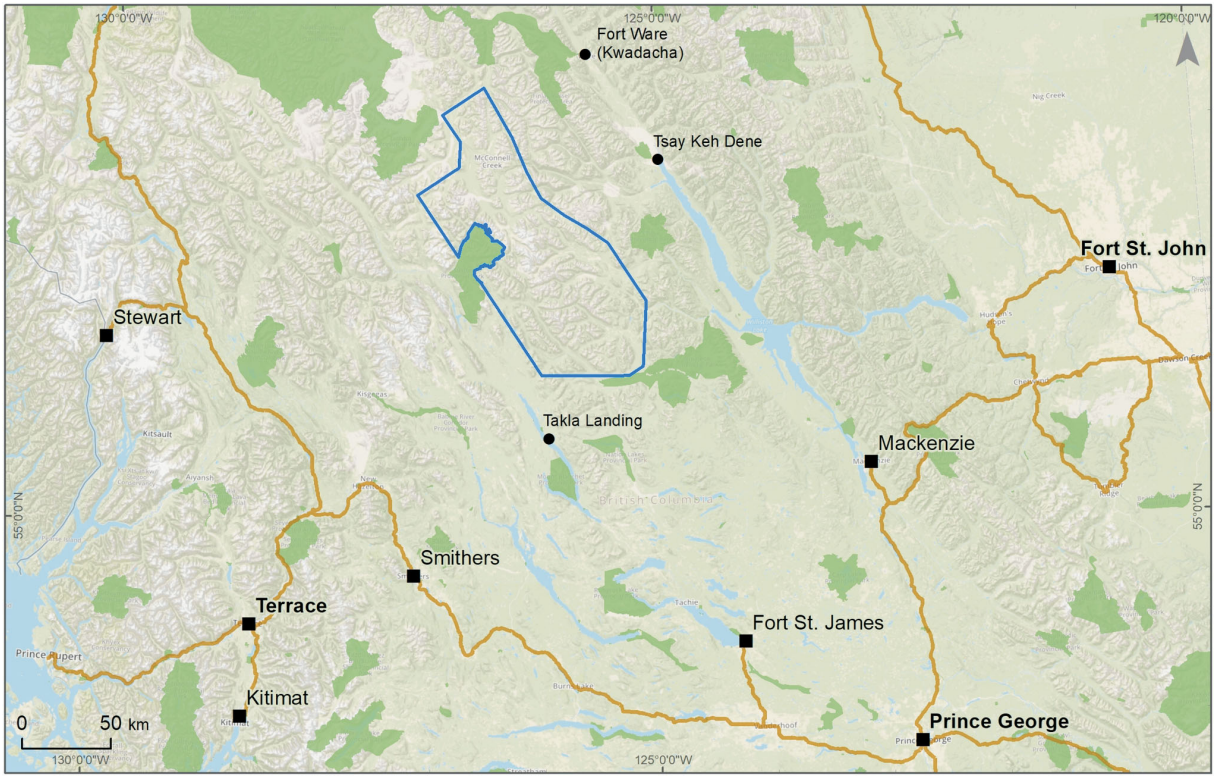

Figure 2. Location of the Search Phase III project in relation to communities of north-central British Columbia. Blue outline, Search Phase III survey area.

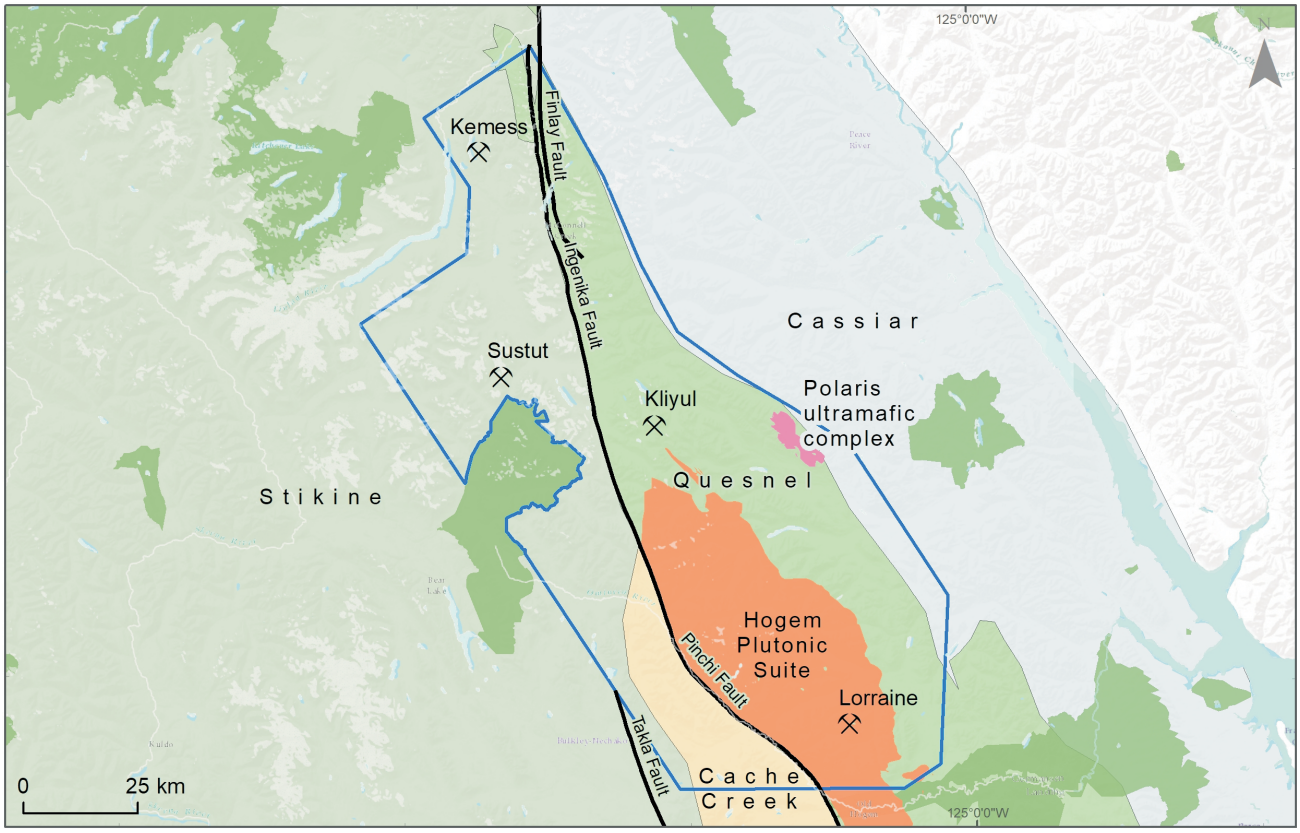

Figure 3. Regional tectonic setting surrounding the Search Phase III survey area, showing the contact between the Quesnel and Stikine terranes, and the locations of the Hogem Plutonic Suite and Polaris ultramafic complex.

Creek terrane is found in the southwestern portion of the survey area.

The Hogem Plutonic Suite is a regional-scale igneous body that intrudes the Quesnel terrane and is bounded on the west by the Pinchi-Ingenika fault (Garnet, 1978). It has been subdivided into three phases based on age and composition. Phase I is oldest (212–176 Ma), calcalkaline in composition and reportedly poorly mineralized. Phase II is dated at 182–162 Ma, alkaline in composition and of significant interest to explorers where its syenitic rocks and related potassium-feldspar alteration are spatially associated with numerous copper occurrences (e.g., Duckling Creek syenite). Phase III, the youngest, is dated at 126–108 Ma, calcalkaline in composition and spatially associated with copper and molybdenum mineralization. Although there is already a considerable amount of knowledge concerning the Hogem Plutonic Suite, new insights will be gained from the Search Phase III survey that should stimulate explorers to challenge current assumptions of mineral potential and test new ideas. In particular, the collection of radiometric data over the survey area may provide new discrimination of the batholith's phases, including the alteration signatures that are key in identifying areas with higher mineral potential.

The Stikine terrane is host to the Kemess mine camp at the northern end of the survey. South of this camp are portions of the Stikine terrane that are currently less explored and, at the time of writing, several MINFILE occurrences were untenured. The western survey boundary is roughly defined by the mapped transition from Stikine terrane to Upper Cretaceous Sustut Group.

The eastern survey boundary is roughly defined by the mapped boundary between the Quesnel and Cassiar terranes. Rocks of the Cassiar terrane were not targeted by the survey, but those of the Polaris ultramafic complex were included.

Terrain Contouring versus Preplanned Drape-Surface Surveying

The Search Phase III survey was the first time that Geoscience BC solicited proposals allowing for the option of either an 80 m clearance terrain-contouring survey or a preplanned drape-surface survey. This was undertaken in response to airborne-survey service providers suggesting that the higher quality of terrain-contouring survey data should be considered against the higher cost of acquisition.

Geoscience BC chose a terrain-contouring survey because of the benefit it would bring to both the magnetic-radiometric data and the end user. The lower and more consistent survey height above ground allows for increased data amplitude and improved resolution of near-surface complex

sources. Surveys conducted along higher preplanned drape surfaces risk complex or multiple-source responses coalescing into apparent single responses or poorly defined source responses due to excessive ground clearance. Preplanned drape surveys in rugged terrain can yield data that are highly attenuated in valleys due to the necessity of designing a flight surface within a specific aircraft's climb and descent limitations. Radiometric data benefit from terrain contouring by having less reliance on elevation-related data-attenuation corrections, as well as a reduction in data that are nulled because the maximum allowable effective height for spectrometer count-rate confidence was exceeded. A boom-mounted horizontal-magnetic-gradient system fixed to the aircraft was chosen over a towed-bird configuration. The anticipated benefits were better terrain contouring, increased spectrometer signal amplitude and pilot safety. Helicopter terrain-contour surveys result in increased cost and survey duration relative to the more common fixed-wing preplanned drape surveys. However, the extra cost results in superior data for both magnetic and radiometric surveys. An example of the various survey flight surfaces over rugged topography is shown in Figure 4. The red profile is actual survey height above Shuttle Radar Topography Mission (SRTM) topography, whereas the blue profiles are 2-D preplanned drape surfaces of 6% (fixed-wing aircraft) and 40% (helicopter) calculated using the Geological Survey of Canada's Drape DTM 2.0 software.

Geophysical Program

Search Phase III field activities began in early July 2017 after a contract was awarded to Ontario-based CGG Canada Services Ltd. The contract was to fly an estimated 42 286 line-km using two helicopters fitted with the proprietary Midas horizontal-gradient multisensor package for magnetic surveying (Figure 5) and acquire data at a nominal 80 m terrain-contouring height. Main flight lines trended 054° at 250 m intervals and tie lines trended 234° at 2500 m intervals. The survey also collected radiometric data as a secondary priority: flights were optimized for magnetic-data collection and not altered where radiometric data were expected to be compromised (e.g., rain-saturated ground). Quality assurance and control for the program data was provided by in3D Geoscience Inc.

Pilots followed operating procedures for wildlife observations and were authorized to deviate flight patterns to mitigate negative effects. A temporary program cessation in mid-September to accommodate the seasonal activities of an outfitting operator delayed program completion by nearly a month. Two base camps were established, at the Kemess mine and the Osilinka logging camp, with remote fuelling depots in additional locations.

Results of the 9600 km^2 survey are scheduled for release at AME RoundUp 2018 in map and digital format through the Geoscience BC website, and as an interactive map layer on the organization's Earth Science Viewer. The Earth Science Viewer allows a broad client base to immediately interact with Geoscience BC's data alongside other public information, such as current mineral tenures and the BC Geological Survey's geological, MINFILE and ARIS data.

Porphyry Integration Project

Geoscience BC has supported the creation of two geoexploration atlases, for the Endako (Devine et al., 2015) and Mount Polley mines (Rees et al., 2014), and two more are in preparation, for the Mount Milligan mine and the Duckling Creek syenite. These atlases are compendiums of datasets (e.g., geology, geochemistry and geophysics) plotted at deposit and camp scales in a single document. These 'coffee table–style' atlases are reference books for the deposits or camps, intended as teaching aids for relevant mineral-deposit models and for exploration courses.

Production of the Duckling Creek atlas awaits magnetic and radiometric data from this survey for areas where the Duckling Creek syenite is known to exist. Once the data

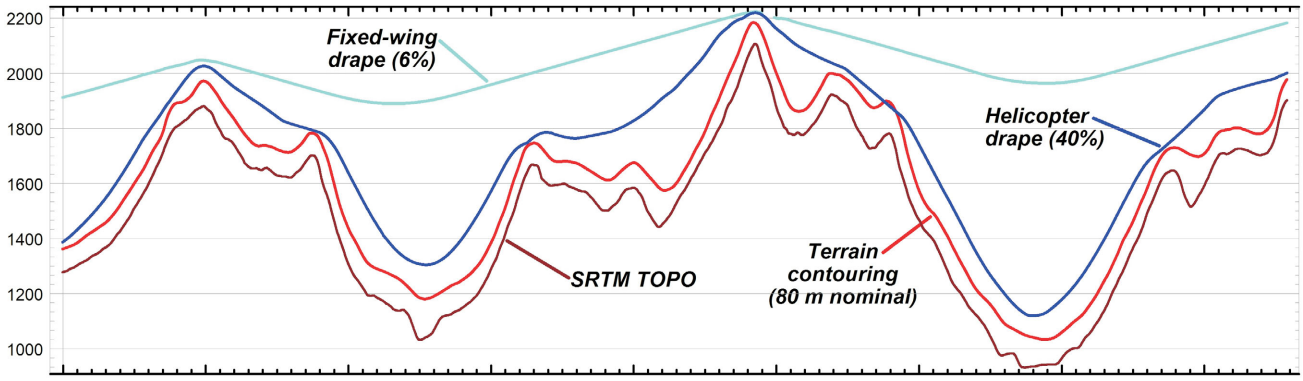

Figure 4. Example of improved airborne survey height above rugged topography using terrain contouring (red line) compared to the more common 2-D preplanned drape surveys: fixed-wing drape surface using 6% slope (light blue) and a hypothetical helicopter 40% drape surface (dark blue). The 2-D drape surfaces were calculated using the Geological Survey of Canada's Drape DTM 2.0 software. Note that the vertical axis is exaggerated. All survey heights are relative to Shuttle Radar Topography Mission topography (SRTM TOPO).

Figure 5. One of two helicopters used in flying the Search Phase III survey. The aircraft were fitted with booms to collect magnetic data using the proprietary Midas horizontal-gradient system of CGG Canada Services Ltd. Radiometric data were collected utilizing a Radiation Solutions Inc. RS-500 digital airborne gamma-ray spectrometer.

have been incorporated into the atlas, it is expected to be released in 2018.

Summary

The Search project is a multiyear project for Geoscience BC that is focused on generating regional magnetic-survey data and complementary earth science for prospective mineral areas of the province. In 2017, the project included an airborne survey covering 9600 km^2. Data from the survey will be made available through both Geoscience BC's website and on its web mapping application—the Earth Science Viewer.

Explorers will have access to new high-quality data from which they can both generate property-level targets for exploration and, since the survey is regional in scale, understand their projects in a broader context. Researchers will be able to develop new regional-scale frameworks to understand the geological history of the region and identify metallogenic trends and opportunities. Land-use planners, governments and First Nations will have modern data from which resource-management or economic-development opportunities can be identified.

Acknowledgments

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