

# Yukon Geological Survey: Planning for the future

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Relf, C., 2020. Yukon Geological Survey: Planning for the future. In: Yukon Exploration and Geology Overview 2019, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 1–22.

## Introduction

The Yukon Geological Survey (YGS) had a busy year in 2019, welcoming seven new staff and initiating several new projects. In addition to its regular activities, the survey hosted a planning workshop with clients and stakeholders in April to identify gaps in Yukon’s geoscience knowledge base and engage participants in a discussion about their current and future information needs. The YGS holds these workshops every five years, and they are valuable for providing insights into research and exploration trends, generating ideas for new projects, and identifying opportunities for collaborative partnerships. As a backdrop for these discussions, participants were asked to consider how existing and emerging markets, climate change, societal needs and new technologies might influence how the YGS collects, manages and disseminates information.

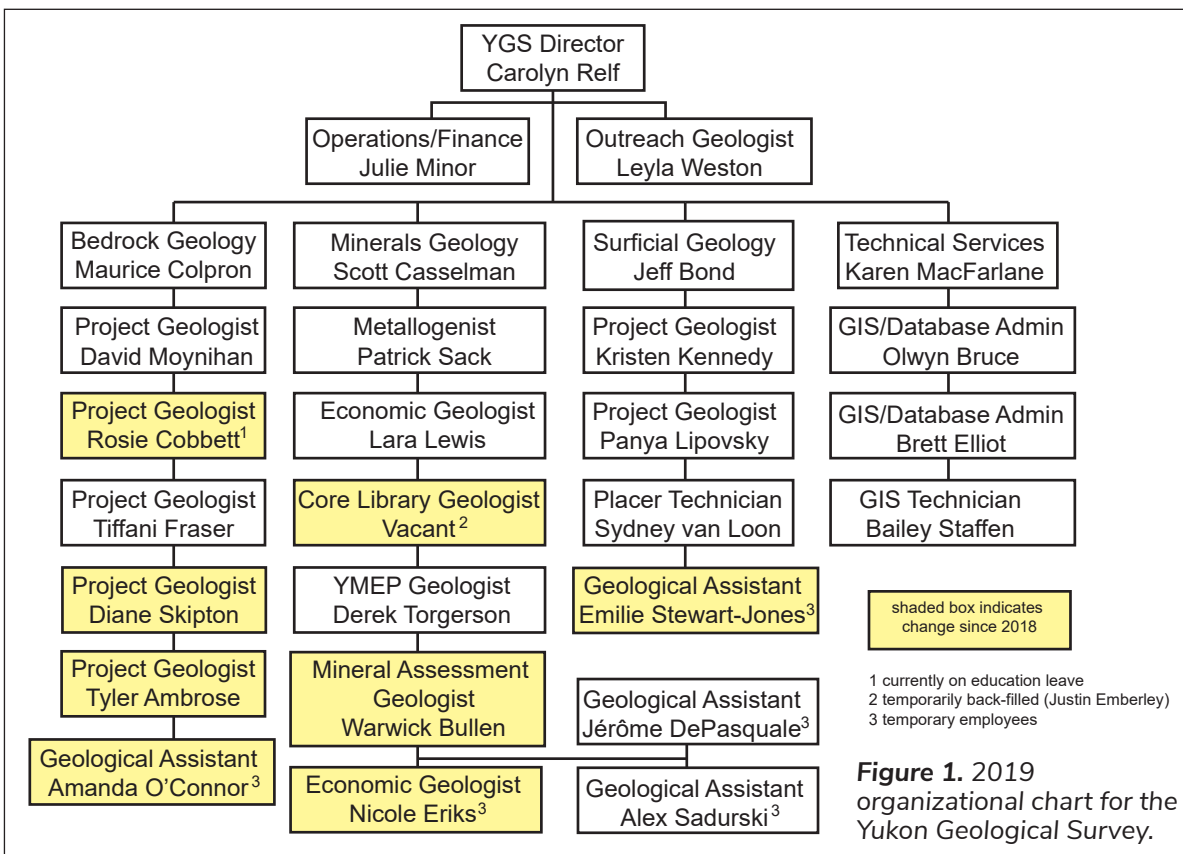
This paper provides both a brief overview of 2019 program activities and a summary of what was heard at the April planning workshop. Workshop discussions covered a broad range of topics and included both specific project ideas as well as general themes. The YGS has already initiated some of the projects that were proposed in April. The paper is organized based on the thematic breakout sessions at the workshop; current activities underway under each of the themes are presented first, followed by a summary of the input heard at the workshop.

## Snapshot of YGS

An organizational chart for YGS’ current staff is presented in Figure 1. Three new staff joined the Minerals Services unit in 2019. Warwick Bullen was hired in April and will be the lead for mineral resource assessments to support land use planning. Nicole Eriks was brought on board in August as a term Economic Geologist (to March 2021) to assist with MINFILE work, track industry activities and contribute to mineral deposit research projects. Justin Emberley transitioned from a part-time position organizing geochemical data to a temporary back-fill as the Core Library Geologist following the retirement of Craig Nicholson.

The Bedrock Geology unit hired two new bedrock mapping geologists in 2019. Diane Skipton started in February, and Tyler Ambrose in May. Both have initiated new mapping projects in central Yukon (described briefly below). Skipton is currently on maternity leave and will be resuming her duties in October 2020.

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In addition to the above, two temporary staff joined the Surficial Geology unit in May 2019. Kisa Elmer, a geotechnical engineer from Yukon’s Department of Highways and Public Works, was appointed to the survey on a temporary assignment for the summer, and Emilie Stewart-Jones was hired for a year. Both were brought on board to work on a permafrost database project (described below).

The YGS has an operating budget of \$3.33M for fiscal year 2019-20. This includes core operational funding of \$1.265M and \$665K in federal funding. The federal funds include a \$595K grant from CanNor under their Strategic Investments in Northern Economic Development program (year two of a two-year grant), and a \$70K grant from Indigenous and Northern Affairs Canada under a program called Climate Change Preparedness in the North (year three of a four-year grant). Funds from the latter grant are transferred from the YGS to Yukon College to support permafrost scientists at the college’s Research Centre. In addition to operating funds, the survey administered \$1.4M in grants under the Yukon Mineral Exploration Program in 2019-20.

With respect to the YGS’ broader operating environment, Yukon government is currently working on two major initiatives that will influence priorities for the YGS in the coming years. The first is “Our Clean Future” strategy (<https://yukon.ca/sites/yukon.ca/files/env/env-summary-our-clean-future.pdf>) which is currently in the final public engagement stage. The strategy’s action plan focuses on reducing carbon emissions and adapting to climate change impacts, with the YGS identified as lead for geothermal and permafrost/geohazard studies. To support this work, the YGS will continue to seek external sources of funding and leverage research partners to participate in these studies.

The second Yukon government initiative, for which stakeholder engagement is just getting underway, is the Yukon Mineral Development Strategy. It is anticipated that geoscience will be a component of the Strategy and that the provision of public geoscience to support exploration efforts and reduce investment risk will continue to be a priority. Information on this initiative can be found at <http://yukonmnds.com/>.

## Current bedrock activities

Two new 1:50 000-scale bedrock mapping projects were initiated in 2019 in the Beaver River watershed. Both projects are designed to upgrade existing 1:250 000-scale maps and improve our understanding of the regional stratigraphic and structural framework of the areas. The primary driver for new mapping in the Beaver River area is to support the assessment of mineral potential for the subregional land use planning process that is underway (currently scheduled to wrap up in fall 2020).

The first project, led by Diane Skipton, is in the Scougale Lakes area west of the Tiger deposit (Fig. 2). The map area straddles the northern edge of the Selwyn basin and southern margin of the Ogilvie platform. Mapping in 2019 subdivided the Neoproterozoic Yusezyu Formation into four units that preserve an overall coarsening-upward sequence. Skipton also modified the trace of the Dawson thrust fault in the area and found metamorphic evidence for a buried pluton, which could have implications for mineralization. Results of her 2019 field work were presented at the Yukon

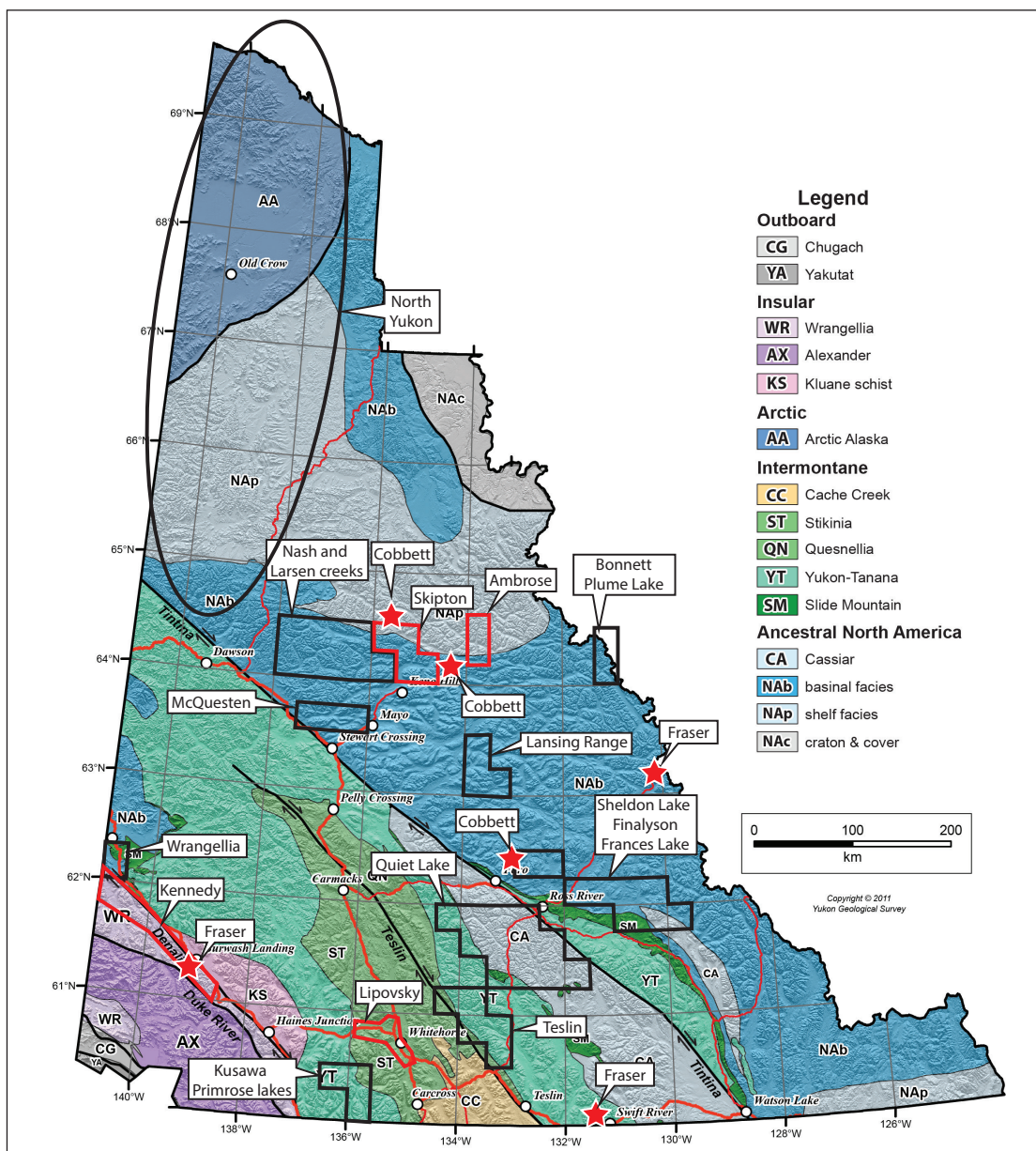


Figure 2. Locations of 2019 YGS field activities (red), and footprints of bedrock mapping project areas proposed at workshop (black).

Geoscience Forum in November. Mapping in this region could extend westward over the next several years into the western Nash Creek and Larsen Creek areas (106D, 116A; Fig. 2), as the stratigraphy to the west is poorly known. Additionally, although the Dawson fault exerts significant control on various styles of mineralization in the region, the timing of displacement is unknown.

The second mapping project is being led by Tyler Ambrose. The map area is located in the southern Wernecke Mountains (Fig. 2) near the recently discovered North Rackla Pb-Zn-Ag occurrence. Rocks here range from Paleoproterozoic to lower Paleozoic and are stratigraphic equivalents to parts of the Wernecke and Windermere supergroups. Ambrose's work extended the mapping of Colpron et al. (2013) northward, documenting the characteristics and contact relationships of units in this part of the belt. In collaboration with David Moynihan (YGS) and Justin Strauss (Dartmouth College), he made a number of revisions to stratigraphic units in the area (Fig. 3). A summary of project results to date is presented in this volume (Ambrose, 2020).

Paleozoic	Cambrian-Devonian		Bouvette Formation	Upper mbr Volc mbr Lower mbr	
		Upper	Windermere Supergroup	Rackla Group	Blueflower Fm Gametrail Fm
	Hay Creek Group			Ravensthorpe Fm Mt. Profit/IB	
	Rapitan Group			Callison Lk Fm	
	Mackenzie Mtns Supergroup		Hematite Creek Group		
	Middle		Pinguicula Group (?)	"Val dolostone"	
		Lower	Wernecke Supergroup	Gillespie Lake Group (?)	lower carbonate unit
				Quartet Group (?)	lower clastic unit Hart River Sills

**Figure 3.** Simplified stratigraphy of the southern Wernecke Mountains area, from Ambrose, 2020.

Tiffani Fraser continues to lead a multi-disciplinary project characterizing the geothermal potential of Yukon. The 2019 activities focused in two areas: along Denali fault near Burwash Landing and in the area east of Teslin (Fig. 2). The Denali fault site was selected because southwestern Yukon records some of the shallowest Curie point depths in the territory (Witter and Miller, 2017; Witter et al., 2018), suggesting a high geothermal gradient here. The Teslin area is of interest due to the anomalously high radiogenic heat generative potential values recorded in the Seagull batholith (Friend and Colpron, 2017).

Work in the Burwash Landing area involved gravity and extremely low frequency electromagnetic (ELF-EM) surveys along a number of Denali fault strands to better delineate their geometry and identify locations of enhanced permeability such as along a fault bend. Upon completion of the geophysical surveys, fieldwork was carried out to examine exposed fault strands and collect samples for physical rock property measurements (Fig. 4). Near Teslin, granitoid samples were collected for geochemical analysis to confirm the high heat values documented by Friend and Colpron (2017) and fill gaps in the existing geochemical data set. The new analyses have been incorporated into an updated radiogenic heat map (Colpron, 2019) that also incorporates recently released GSC data (Ryan et al., 2019). Fraser presented a paper highlighting the YGS' geothermal research activities as part of a Geothermal Canada presentation at the annual Geothermal Research Council meeting in September.



**Figure 4.** Jeff Witter (Innovate Geothermal) examining a strand of the Denali fault in outcrop along the Duke River.

In addition to the geothermal project, Fraser spent several days in the field in the Macmillan Pass area, measuring stratigraphic sections and collecting samples to characterize their chemistry as part of a regional chemostratigraphic study focused on characterizing Middle Devonian sediments in Selwyn basin. This project is an extension of the shale studies conducted in northern Yukon from 2013 to 2017 that defined the Middle Devonian hyper-enriched black shale unit (locally the NiMo or Nick horizon) with Mike Gadd of the Geological Survey of Canada (GSC). Fraser continues to collaborate with researchers from Standford, Dartmouth College and St. Frances Xavier universities on the compilation of the Cambrian-Devonian Road River Group strata in the Peel River area. This multi-year (2015 to present), multi-agency project aims to integrate geological mapping, facies analysis, isotope chemostratigraphy and biostratigraphic results to provide a revised paleoenvironmental reconstruction and new age model for the Road River Group.

Rosie Cobbett initiated fieldwork on her PhD thesis this year, examining Paleozoic volcanic sequences in three locations: the Castle Mountain and Tiger areas at the southern edge of Ogilvie platform, and in Selwyn basin north of Faro (Fig. 2). Fieldwork focused on measuring sections and mapping field relationships both within the volcanic sequences and with surrounding sedimentary rocks. Graptolites recovered from sedimentary rocks below a pyroxene  $\pm$  olivine-phyric basalt at Castle Mountain pin the maximum age of the flows to post-early Silurian. Zircons recovered from volcanic horizons at both Castle Mountain and Tiger will provide further age constraints on the timing and duration of volcanism. At both of these locations volcanism occurred during a pause in the development of the carbonate platform (Fig. 5). Detailed descriptions of field observations are included in this volume (Cobbett, 2020).



**Figure 5.** Photograph of thick basalt flows at Castle Mountain. Flows are underlain by thickly bedded dolostone and overlain by reefal carbonate.

David Moynihan remapped the basal contact of the Bouvette Formation around Nadaleen Mountain to better document offset across the Kathleen Lake fault, and revisited the geology in the Bonnet Plume Pass area, reclassifying a number of units in the Bonnet Plume Pass and Goz map sheets. He also spent some time in the field with Skipton and Ambrose, helping to familiarize them with the geology of this region. The bulk of Moynihan's summer focused on writing a Bulletin and completing a Geoscience Map for the Hyland project, both on track to be released in 2020. He also published a paper on the stratigraphy of the Nadaleen/Rackla area (Moynihan et al., 2019).

The YGS also supported a number of bedrock studies by students in 2019. Colpron is liaising with two graduate students at Memorial University on two thesis projects: one is examining the geochemistry of Devonian-Mississippian igneous rocks in the Finlayson Lake area (Matt Manor), and the other is studying the stratigraphy of the Faro Peak formation (Adam Wiest). He is also supporting a study of Jura-Cretaceous basin evolution in the Kluane plateau area (Will McKenzie, Simon Fraser University) and a provenance study of sedimentary rocks of the Yukon-Tanana terrane (Emma Krueger, University of Iowa). Fraser supervised Hubert Langevin (Institut national de la recherche scientifique), who is documenting thermal conductivity and porosity/permeability of drill core from the temperature gradient well near the Takhini hot spring (see Langevin et al., 2020; this volume). Finally, Moynihan has a student in the final stages of a thesis on the petrology of deep crustal and mantle xenoliths and metamorphic processes related to orogenic gold formation in the Hyland area (Colin Padget, University of Calgary).

## **Bedrock geology workshop session highlights**

The bedrock geology breakout session covered ideas for future regional mapping and identified a number of thematic (e.g., tectonic, stratigraphic) questions. Participants also discussed energy geoscience opportunities and exchanged ideas for geophysical surveys and remotely-sensed data.

## **Ideas for new bedrock mapping**

Workshop proponents discussed a number of ideas for new bedrock mapping, defining the outstanding questions that mapping could address (Fig. 2). These are summarized below.

### ***McQuesten-Mayo-Lansing Range areas (115P, 105M, N)***

In contrast to southeastern Yukon, very little is known about the stratigraphy of the Hyland Group in central Yukon. In addition to stratigraphic questions, the extent of the Tombstone strain zone and the timing of southwest-verging folds in the McQuesten area remain unknown. Two priority areas have been identified for new mapping of the Hyland Group in central Yukon. In map sheet 115P, three 1:50 000 map sheets north of Stewart Crossing will extend the work of Murphy (1997) and address several structural and stratigraphic questions. In southwestern 105N, new mapping will reveal information on the relationship between Paleozoic volcanic rocks and units of the Hyland Group.

In terms of economic interests, a number of quartz vein-hosted gold occurrences have been documented in the area, including the Plateau occurrences in 105N. Additionally, several skarn-type occurrences (including tungsten and copper) are documented in the MINFILE database.

### ***Bonnet Plume Lake (106B)***

Mapping in 106B/3 and 6 would tie Rackla stratigraphy (Moynihan, 2016) to the Mackenzie Mountains and provide an opportunity to study the southern Snake River fault and its relationship to structures in the Selwyn and Mackenzie fold belts.

### ***Sheldon Lake–Finlayson River–Frances Lake area (105/K, J, H)***

New mapping in this area will help to resolve outstanding questions regarding the relationship between Selwyn basin and the McEvoy platform. For example, are Road River Group rocks of Selwyn basin the stratigraphic equivalents of Askin Group rocks

of the McEvoy platform, or are these two packages tectonically juxtaposed? If they are age-equivalent, understanding their paleogeographic setting will help to address the question of stratigraphic linkages between basin and platform.

Another outstanding question in this region relates to the southwest limit of 'classic' Selwyn basin stratigraphy. In the west part of the proposed map area this boundary is marked by the Twopete fault. To the southeast, in the Hyland River area, a fault that truncates the Hyland structural/metamorphic culmination appears to play a similar role. These two faults converge in the area around McEvoy Lake/Pelly Lake. New mapping here will better define the southern limit of Selwyn basin rocks and reveal the relationship between these two major structures.

### ***Quiet Lake area (105F)***

Fundamental questions about the relationships between the Cassiar and McEvoy platforms and the Cassiar platform and Selwyn basin exist in this map area. For example, the Cassiar platform appears to be underlain by the same Neoproterozoic basement rocks as Selwyn basin but their lower Paleozoic depositional histories differ. New mapping will characterize these differences and determine when their depositional histories began to diverge.

Characteristic Cambrian rocks of the Cassiar platform appear to be absent from McEvoy platform, yet the Silurian-Devonian Askin Group is common to both. Prior to displacement on the Tintina fault, the Cassiar-McEvoy platforms may have formed a continuous linear belt. Is the absence of Cambrian sediments on McEvoy platform a result of along-strike variation in the Cassiar/McEvoy belt, or is there a more fundamental flaw in the Cassiar-McEvoy correlation?

In addition to the area's depositional history, magmatic events in the Quiet Lake area are also poorly understood. New geochronological data will provide constraints on Paleozoic and Mesozoic magmatism and its role in mineralization (e.g., Ketz River) and regional metamorphism (e.g., Pelly Mountains).

Finally, current mapping in the Quiet Lake map area precludes a clear understanding of the timing and nature of many of the major structures that transect the area. These include the curious box-shaped uplift of rocks hosting the Ketz River deposit; the nature of the Cassiar-Yukon-Tanana boundary; and the lithological repetitions that may be caused by structural imbrication rather than stratigraphic repetition.

### ***Teslin area (105C)***

Recent field observations in the Teslin area suggest that a number of units shown on current maps need revision. For example, volcano-sedimentary rocks of Mississippian age are likely more extensive than currently shown, and several metamorphosed plutons are missing from the existing map. Field visits have also revealed felsic metavolcanic rocks of Permian age that were previously not documented in the area. The proposed map area includes the Late Cretaceous Red Mountain molybdenum porphyry; new mapping would present an opportunity to study this occurrence.

The YGS has been in contact with the Geological Survey of Canada (GSC) regarding new fieldwork to upgrade the geology map of this region. The GSC has archived field data and samples that will be useful for identifying units and prioritizing sampling.

### ***Kusawa-Primrose lakes area (SW 105D, 105E 115A)***

Mapping in this area would extend the recent work of Israel and Bordet (2014) and Bordet and Israel (2014) southward to the border of British Columbia. The area straddles the contact between the Yukon-Tanana and Stikinia terranes. Clues to the relationship between these terranes may be preserved within large roof pendants in Paleocene granites that intrude the contact.

### ***Western Wrangellia (115F)***

Another gap in the area covered by Israel's recent mapping (Israel et al., 2007a,b) is a small area of Wrangellia terrane in westernmost Yukon. The area, which could be mapped in one field season, lies north of the Klauene Park border and south of Beaver Creek.

***Yukon-Alaska border region in North Yukon between Yukon River and Arctic Ocean (116F–P, 117A–D)***

The border area with Alaska in North Yukon is one of the most poorly documented regions in the territory. In particular, stratigraphic questions remain between Old Crow and Kandik basins, and the relationship between north/south-oriented structures of the North Yukon fold belt and east/west-oriented structures in the Ogilvie Mountains needs to be resolved.

Several bedrock maps are pending release by the GSC, and their release will assist in refining questions and prioritizing future work. Given the remoteness of North Yukon and the high cost of working there, workshop attendees agreed that the YGS should wait for an opportunity to leverage resources from one or more partners before initiating work in this region.

**Ideas for new energy geoscience*****Regional shale chemostratigraphy***

The moratorium on petroleum exploration in Whitehorse trough and public concerns over hydraulic fracturing have rendered a number of Yukon's sedimentary basins 'closed' for exploration. At present, opportunities for oil and gas development in Yukon are limited to the Eagle Plain and Kandik basins.

Basin studies by the YGS have recently focused on Paleozoic shale chemostratigraphy across the Eagle, Peel, and most recently, Selwyn basins. While Selwyn basin is not a petroleum exploration target, regional stratigraphic correlations aid in basin reconstructions and have implications for Ni-Zn-Mo-PGE exploration in the region (e.g., Fraser et al., 2018; Gadd et al., *in press*).

Workshop attendees proposed extending the shale studies to include Middle Triassic and Cretaceous shales, as these are important source rocks in Alaska, northeastern British Columbia and Alberta, and therefore potentially in Yukon.

***Geothermal studies***

With respect to geothermal energy, Yukon has seen very little exploration for geothermal resources to date. A paucity of data, the lack of legislation to regulate

activity, and high up-front costs of development are all impediments to investment. The YGS began a geothermal research program in 2016, of which the most recent activities are described above. The new program is beginning to provide insights into the most geothermally prospective areas of the territory.

Workshop attendees were told that capacity and resources for geothermal research are growing among Canadian universities, and that this research momentum will enable Yukon to leverage resources and expertise. Given these opportunities, participants supported further geothermal studies and provided a number of ideas for new research.

Among the activities proposed was the continued collection of subsurface temperature gradient data. This could involve opportunistically measuring down-hole temperature profiles from existing mineral exploration drill holes, and the drilling of one or more temperature gradient wells. The latter would enable temperature gradient data to be collected in areas of high potential, whereas the former would provide more regional information on Yukon's thermal regime. Workshop participants suggested that a long-term goal of the geothermal program would be temperature gradient and heat flow maps for Yukon.

Workshop attendees also supported updating the radiogenic heat generative potential map (completed in November: Colpron, 2019), and they encouraged modelling of gravity data to estimate pluton volumes.

The GSC has been collecting water chemistry data from hot and warm springs across Canada, including some in Yukon (Grasby et al., 2000, 2012). Attendees suggested that a publicly available thermal springs geochemistry database would allow external researchers to access and model the data. Collection of permeability and porosity data from potential geothermal reservoir rocks was also discussed. The YGS does not have capacity for this type of work; however, research partnerships could be explored to generate this type of data. A map showing the distribution of carbonate rock and porous sandstone was proposed as a complement to the radiogenic heat map.

## Targeted bedrock studies

In addition to regional mapping and energy research, a number of topical studies were discussed at the workshop. Many are based on questions that emerged during mapping and could be resolved through targeted age dating or petrology. Examples of such questions include the following:

- Do the southwest-verging folds that deform rocks of the Cassiar platform in the Coal River area overprint the Cassiar/Yukon-Tanana boundary?
- What was the paleogeography of the Hyland and Ingenika groups in the Quiet Lake area?
- What is the age(s) of deformation across the Selwyn fold belt?
- What is the origin of ca. 215 Ma felsic volcanic rocks in the Donjek/White rivers area?
- What was the rate of exhumation of Whitehorse trough?
- What is the relationship between seismically active transcurrent faults in the Richardson Mountains and Blow trough, and structures in the Ogilvie Mountains?

Some of these questions would make good graduate student thesis projects.

## Geophysical surveys and remote sensing

Regional and targeted geophysical surveys add considerable value to mapping projects; for example, by enabling bedrock units to be traced through regions of poor outcrop exposure or quantifying offset across faults. Although the YGS does not have the capacity to run geophysical surveys or process and interpret data, the GSC does. Under the recent Geo-mapping for Energy and Minerals (GEM) program, the GSC collected new regional aeromagnetic data at 400 m-line spacing across much of southern Yukon. Workshop participants strongly supported these surveys and expressed interest in seeing the GSC continue this type of work.

A number of areas were identified that would benefit from more detailed regional aeromagnetic coverage, including northern Selwyn basin and the southern Ogilvie Mountains. Both areas currently are covered by regional surveys with line spacing between 800 m and 1 km; it was recommended that these areas be

resurveyed at 400 m-line spacing. Areas of highest priority are the Dawson fault corridor, Nadaleen River (106C), Nash and Larsen creeks (106D, 116A), Mayo–Lansing Range (105M, N), and the northeastern part of McQuesten (115P). In response, the GSC has tendered an aeromagnetic survey in the Nash Creek area, to be flown in winter/spring 2020 as one of the final GEM activities, as the program will wind down in March 2020.

Remotely-sensed data were discussed at length in several of the workshop breakout sessions. Data and associated imagery that would benefit bedrock projects and support mineral exploration are presented here. Data that were recommended for use in surficial geology applications (including placer mining) are presented in the section on the Surficial Geology breakout session.

Workshop attendees recommended that the YGS acquire LiDAR data to support mapping (e.g., to delineate structures with subtle topographic expressions, particularly in areas with poor exposure). Other high-resolution imagery, such as World View satellite data, was also recommended. Hyperspectral imagery was proposed for use in mapping alteration related to mineralization. No specific areas for imagery were recommended, but as field-based projects are planned the YGS could review available imagery and look for opportunities to acquire additional images based on the requirements of the project.

## Databases

Workshop participants proposed that the YGS create detrital zircon geochronology and whole-rock geochemistry databases to complement the existing bedrock geology and geochronology databases. With respect to the detrital geochronology database, it was suggested that data should be limited to those samples with a large number of analyses ( $n \gg 10$ , and ideally  $n > 100$ ). Both databases are currently being worked on, and the YGS anticipates displaying the data online via the same viewer as the digital bedrock geology map by spring 2020.

## Current activities of minerals services staff

YGS staff in the Minerals Services unit visited 39 hard rock exploration projects over the summer and early fall, documenting information on new discoveries and providing geologic advice to clients. Highlights of 2019 exploration and development activities are presented in this volume (Lewis and Casselman, 2020). In June, Scott Casselman and Warwick Bullen participated in the Yukon Mining Alliance's annual Investor and Media tour, providing insights into Yukon's geology and mineral resources to participants. In August, Lara Lewis, Patrick Sack and Jeff Bond organized a workshop and field trip ("Keno Rocks") to showcase the geology and mineral resources of the historic Keno district. The first day highlighted Alexco Resource Corporation's silver resources in the area (Fig. 6). Special thanks are extended to Al McConie and Peter Read for leading the Keno tour and presenting on the geology. The second day of the trip, led by Bond, featured tours of three placer operations in the Mayo area: Thunder Gulch, Duncan Creek and Minto Creek.

Warwick Bullen completed mineral potential assessments for the Beaver River and Dawson regional

land use planning areas. The results and methodology are presented in this volume (Bullen, 2020). The maps differ from previous regional mineral potential maps (Bradshaw and vanRanden, 2003) in that they are data-driven and use a block modelling approach to quantify categorical features. Polygons have been assigned both mineral potential rankings and confidence values. The maps are simple to understand for land use planners and highlight areas where further research is needed to ensure decisions are informed by strong evidence. Confidence values were derived from a database of metalotect values that link lithostratigraphic units from the YGS bedrock geology geodatabase to mineral deposit type potential. Jérôme de Pasquale presented a poster on the ranking system at the Yukon Geoscience Forum. He plans to release a paper describing the metalotect database in spring of 2020.

Patrick Sack and Maurice Colpron finished compiling a comprehensive atlas of late Triassic to Jurassic plutons in 2019. The atlas includes detailed field and petrographic descriptions, geochronology, geobarometry, geophysical characteristics, geochemistry and metallogeny of the nine suites that were studied. The volume is currently under review and will be released in spring 2020.



**Figure 6.** Keno Rocks participants gather near the Husky headframe at Keno.

Sack wrapped up a study of gold-bearing veins at the Plateau South property in central Yukon (Yukon MINFILE 105N 034, 035, 036). Results of U-Pb and  $^{40}\text{Ar}/^{39}\text{Ar}$  geochronology, Pb isotopes and mineralogy are presented in this volume (Sack et al., 2020) and provide insights into the possible age and origin of mineralizing fluids. Additionally, he assisted Well-Shen Lee (Laurentian University) with fieldwork and provided technical guidance for his study of the Klaza gold-silver-lead-zinc deposit in central Yukon. A summary of project results to date is presented in this volume (Lee et al., 2020).

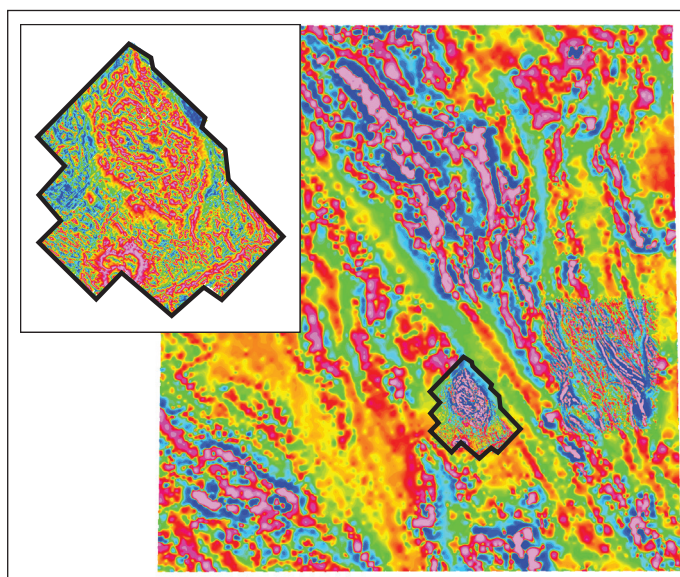
The Yukon Mineral Exploration Program invested \$1.4M in 33 hard rock and 18 placer projects in 2019. Spending commitments by recipients totaled more than \$4.82M, corresponding to a leveraging ratio of more than 3.4:1. Highlights of this year's projects are presented in Torgerson (2020).

Minerals staff invested significant time working on the MINFILE database in 2019. A number of changes were made to the database, including updated definitions of occurrence status (i.e., anomaly, showing, prospect, deposit) and changes to table structure (e.g., a hierarchical structure has been created for deposit types). Ongoing work will include changes to the resource/reserve tables and modifications to workflow so that occurrence data are captured in conjunction with updates to the Assessment Report Footprints database. Nicole Eriks and Alex Sadurski presented a poster on MINFILE updates at the Yukon Geoscience Forum, inviting clients to provide feedback on the changes.

Significant progress was also made on the MINFILE data entry front. Lara Lewis and Nicole Eriks created a database manual that enables multiple users to enter data, and four staff (Lewis, Eriks, Sadurski and Scott Casselman) invested time in capturing new, and updating existing occurrence data. Since January 2019, 117 new occurrences have been added and 240 occurrences have been updated. This work has been facilitated by industry clients who provided location data and occurrence descriptions to staff. This 'wiki' approach, discussed at the April workshop (see below), appears to be an effective way to accelerate data capture.

The YGS' Technical Services staff have been making a number of changes to YGS web applications and services, most of which impact the data used by mineral industry clients. The changes are required to meet Yukon government's new look and feel, and staff have made efforts to ensure that the changes do not create any loss of functionality of the web applications that serve YGS data.

A new project to enhance the value of digital geophysical data submitted for assessment credit was initiated in 2019. Aurora Geosciences was contracted to examine airborne magnetic surveys and generate standardized files that are levelled with the GSC regional airborne surveys. The intent of the project is to make these industry surveys accessible to clients who lack the software and capacity to process the data themselves and generate maps. Products will include data files and geotiffs; the latter as both stand-alone magnetic maps, and integrated into 1:250 000-scale magnetic tiles generated from GSC data (Aurora Geosciences and Bruce, 2017). In early 2020, the YGS expects to start releasing these products; they will be linked to the original assessment reports (Fig. 7).



**Figure 7.** Image of reduced-to-pole magnetic field shaded colour contour map for NTS 105E (Lake Laberge) generated from NRCan's regional data set (Aurora Geosciences and Bruce, 2017), with industry airborne survey from the Mars gold porphyry (Assessment Report 093871) levelled and integrated with the regional map.

Regarding the drill core program, new core from a number of the Mount Nansen deposits were added to the collection in 2019. Data from the new core have been entered into the drill core database and can now be accessed for viewing/logging by clients.

## **Minerals workshop breakout session highlights**

The Minerals Geology breakout session covered a wide range of topics including client services, minerals research and databases. Input provided by participants is summarized below.

### **Mineral industry liaison**

Mineral industry liaison activities collectively refer to information exchanges between YGS staff and clients that occur via property visits, meetings and correspondence. Liaison includes workshops, field trips and short courses developed to enhance knowledge of Yukon geology and mineral deposits. The information gathered by the YGS through its liaison with industry is extremely valuable as it enables the survey to provide senior levels of government with up-to-date information on industry investment and new mineral discoveries. It also informs mineral potential assessment work and helps the YGS define research priorities by identifying industry information needs.

Workshop attendees encouraged the YGS to increase the number of exploration property visits carried out by staff. Based on this input, the YGS reviewed the number of property visits over the past several years and evaluated the benefits to both the YGS and industry clients. Based on this assessment, a targeted approach to property visits has been developed. For companies new to the territory, the YGS will make every effort to visit them in the field to provide some regional geologic context to their properties and share information about YGS' information resources. When survey staff are working in the vicinity of an exploration project (e.g., carrying out bedrock mapping or assessing mineral potential), staff will visit properties to inform the companies of their work and familiarize themselves with property-scale geology. As staff update data in the MINFILE database (see below), property visits will

be carried out to improve occurrence location accuracy and collect representative samples for the MINFILE collection. The YGS does not have the staff resources to ensure that all exploration projects are visited every year, but staff will make efforts to visit a project as new results are generated or when a company requests a visit. The number of property visits completed in 2019 nearly doubled from 2018.

Workshop participants strongly supported YGS-sponsored short courses and the continuation of annual 'Community Rocks' forums (e.g., Keno Rocks). Field trips, which have become an integral part of these community forums, are excellent 'hands-on' learning opportunities for exploration geologists and YGS staff alike, and attendees emphasized that YGS should continue to organize them.

### **Online data services**

The provision of up-to-date, accurate data is ranked as a high priority by industry clients. In general, users appreciate the advances in web-based information services that the YGS has made over the past five years. Clients find the tools in the Web Map Gallery useful for displaying spatial data sets and discovering reports. However, workshop attendees emphasized that they want to be able to download entire data sets rather than simply view and query them. Specifically, requests were made for a spreadsheet extract of the drill core database, and a shapefile of assessment report footprints. A few participants noted that they have difficulty navigating some of the web maps and suggested that the YGS produce a simple guide or short video to demonstrate how to use the Map Gallery tools. As noted above, corporate changes to web services across Yukon government have rendered some YGS web content obsolete. An overview on how to navigate YGS databases using the new web tools was presented at the Yukon Geoscience Forum in November.

Workshop participants spent considerable time discussing the MINFILE database. They urged the YGS to accelerate data entry to ensure that MINFILE stays current, and they raised concerns about the location accuracy of mineral occurrences. In addition to data quality and quantity, some changes to how data are captured and stored need to be considered

(e.g., narrative fields could be replaced with data fields). Some attendees suggested MINFILE should be a purely descriptive database of occurrences, and exploration history could be captured in the mineral exploration database. Others proposed adding fields that describe the controlling features of mineral occurrences.

With respect to prioritizing MINFILE data entry, clients advised the YGS to be both strategic and opportunistic in its approach. Strategically, data entry needs to focus on maximizing information that will support land use planning, as it is recognized that both the Beaver River subregional plan and the Dawson regional plan have tight timelines. To this end, it was proposed that updates could focus on known deposits, emphasizing controlling features to enable the identification of prospective areas with similar geological features. Occurrences that are poorly documented — for example, those with little descriptive data or uncertain location information — should be flagged so that users recognize the limitations of these entries, and a review of the deposit models was recommended. Some participants proposed an online form to enable clients to submit occurrence data to the YGS. Additionally, it was suggested that bedrock geologists should visit occurrences in areas where they are mapping to confirm and/or update location data and occurrence characteristics. As noted above (see “Current Activities of Minerals Services Staff”), the YGS has started making a number of these changes and will continue to work on database improvements in consultation with industry.

### **Minerals-related research**

A number of ideas were proposed at the workshop for research on Yukon’s mineral deposits. The proposed studies can be broken into three categories: regional metallogeny, mineral potential assessments and targeted studies. Some projects are mainly desktop compilations, whereas others involve fieldwork and new data collection. In addition to the project ideas presented here, many projects discussed in the Bedrock Geology breakout session were of interest to mineral industry clients.

### ***Regional metallogeny***

Attendees at the workshop strongly urged the YGS to undertake regional metallogeny studies. They noted that such studies are valuable both for identifying new exploration targets and for enabling companies to attract investors. Age and regional structural controls are two key elements required for metallogenic syntheses: this creates opportunities for collaboration with the Bedrock Geology unit and university-based researchers.

One project that was proposed involves the synthesis of Late Cretaceous magmatism and metallogeny across Yukon. The study would focus on the Dawson Range and be similar in scope to the recently completed Jurassic metallogeny study. Late Cretaceous plutons are currently being explored in Alaska, and the study has potential for cross-border collaborations with US Geological Survey (USGS) colleagues. It could also involve one or more university collaborators.

### ***Mineral potential assessments***

Doug Kreiner from the USGS gave a presentation at the workshop on the methodology used in Alaska for generating mineral prospectivity maps. The geodatabase integrates rock and sediment geochemistry, bedrock geology, and mineral occurrences (among other components) to generate a matrix that reflects both mineral potential and certainty. Certainty is quantified based on the number of data sets used to generate the mineral potential value.

Attendees at the workshop discussed the need for the YGS to generate mineral potential maps to support land use planning and highlight areas for future exploration. YGS’ new Mineral Assessment Geologist (Warwick Bullen) was hired shortly after the workshop. As noted above, his first priorities were to complete mineral potential maps for the Beaver River and Dawson regional land use planning areas.

### ***Targeted mineral studies***

A number of ideas for targeted mineral studies were discussed at the workshop, including thematic studies and deposit-specific questions. These are described briefly below.

Workshop participants proposed using existing or new geophysical surveys to generate a map showing buried intrusions. Such a map would be useful for identifying areas adjacent to plutons that may have been affected by intrusion-associated alteration. Additionally, geobarometry on exposed plutons would help to characterize their emplacement depths and associated mineralizing systems. Another thematic study proposed was a compilation of critical metals. Yukon currently has defined resources of tungsten, cobalt and PGEs, as well as historic (pre-NI 43-101) resources of tin, molybdenum, barite and antimony, but there is no easily accessible literature describing the host geology or features of these occurrences. Given the growing interest in these metals for clean energy and high tech applications, such information could help to attract new investment to the territory. Lara Lewis has begun compiling information on critical metals. The publication envisioned will be an overview booklet that presents commodity descriptions, uses, supply/demand outlook, and information on Yukon occurrences and their geologic settings.

Workshop attendees were told about a BC placer gold atlas being compiled by Robert Chapman (Leeds University). This thematic project, funded by Geoscience BC, will capture both physical parameters of placer gold (grain size, shape, character) and chemical properties. Such an atlas could be expanded to capture the abundant data available from Yukon's placer operations, and would be a useful hard rock exploration tool as certain placer gold deposits have very distinctive geochemical signatures.

Several area-specific project ideas were raised at the workshop as well. Questions that could be addressed include the following:

- Is the gold at Keno orogenic, or are the veins part of a reduced intrusion-related gold system (RIRGS)?
- What is the age and origin of gold along the Hyland thrust south of Mayo Lake?
- What is the age and origin of gold at 3 Aces? At Sprogge?

These questions could be resolved with some detailed mapping, petrology and targeted geochronology, either by YGS staff or through graduate student thesis projects.

## **Yukon Mineral Exploration Program (YMEP)**

Workshop attendees expressed strong support for YMEP, noting a number of successful projects it has supported, and commenting positively on Yukon government's commitment to the program. A few participants expressed concerns regarding the reduction in the amount of funding available for the 2019-20 fiscal year (\$1.4M versus \$1.6M the previous two years), although it was acknowledged that the reallocation of funds was necessary to support resource assessments.

As part of the YMEP discussion, it was noted that the number of applications submitted under the Grassroots module of the program has been declining over the last several years. Attendees offered opinions on the reason for this: some noted that the requirement for 30 days of work was excessive; others felt the application and reporting requirements were excessive given the size of the grants.

Based on this input, the YGS committed to take a critical look at the module and consider ways to modify it to increase its appeal. The YGS supports eliminating the requirement for a minimum number of work days, and is looking at how to reduce the rigour of reporting requirements. A list of proposed changes was presented at the Yukon Geoscience Forum in November and engagement is currently underway to finalize the proposed changes in time for the 2020 field season. Details of the proposed changes are summarized in this volume (Torgerson, 2020).

## **Core library services**

Use of the core library and its facilities has been increasing steadily over the last few years. Users include clients who access the YGS core collection for logging ( $\pm$  sampling), and clients who use the facilities

to log their own core. Workshop attendees advised the YGS to continue growing the drill core collection to capture a suite of representative samples from all major occurrences in the territory. They noted that a downloadable extract of the database would be useful, particularly when working offline in the field.

The YGS updated workshop attendees on the recently acquired physical rock property equipment and the status of rock property data collection. The YGS has set up a space for measuring magnetic susceptibility and specific gravity from hand samples, and in 2018 began to systematically collect data from the YGS' archived sample collections. The survey also has a core sample IP tester and a gamma ray spectrometer; all equipment are available for client use.

While rock property data collection has started, the data have not yet been imported into a spatial database or released publicly. The survey will continue to collect these measurements from hand samples as/when time allows, and when a significant volume of data have been collected the development of a database and associated web application will become a priority. In the meantime, clients can access the data upon request.

## Current surficial geology activities

Kristen Kennedy continued surficial mapping in the Klauane Ranges in 2019, moving northwestward from her 2017–18 mapping of the Burwash Uplands (Fig. 2). She is focusing her current research on delineating glacial limits, including targeted sampling for cosmogenic dating to constrain the timing of ice retreat. A final release of the Burwash Uplands surficial geology map and accompanying report is planned for release in spring 2020.

In addition to this ongoing work, Kennedy has compiled a preliminary Quaternary geology layer for Yukon to put the “Q” back on the bedrock geology map. The layer is a derivative product of the Digital Surficial Database, and was produced as a thematic query of regional surficial geology maps. The queried data could be used for planning stream and soil sampling programs or as a filter for evaluating the reliability of existing surficial geochemical data, as distally-derived material can not

be relied on to reflect bedrock signatures. This new digital layer was presented at the Yukon Geoscience Forum in November to gauge industry interest, and determine whether the layer should be edited and released as a shapefile.

Kennedy is also serving on a committee for a graduate student at Simon Fraser University (Nora Whelan) who is studying co-seismic landslides along the Denali and Duke River faults.

Panya Lipovsky led two projects in 2019. The first was the continuation of a multi-year study of surficial geology in the greater Whitehorse area (Fig. 2). The project, which targets the most densely populated region of Yukon, has a number of components including detailed mapping of surficial materials and landforms, characterization of permafrost, aggregate potential, radon gas in soil, and hazards classification. The permafrost component of the project is being undertaken in collaboration with the Yukon Research Centre at Yukon College, who will publish summary reports for key case study sites in spring 2020. A highlight of the project from a public interest perspective was a major thaw slump documented by Lipovsky and her colleagues on the south side of Takhini River in September. The slump deposited debris halfway across the river (Fig. 8). It is being monitored closely as the headscarp is within 50 m of the Alaska Highway and is advancing upslope at a rate of roughly 10 m/year.

The second project Lipovsky is leading focuses on the development of a Yukon-wide permafrost database. The database captures both geotechnical borehole information (including data on surficial materials and ice content) and temperature data collected over time from data loggers. Two temporary employees have been working on data capture and cleaning: Emilie Stewart Jones has been lead on the temperature data, and Kisa Elmer has been lead on the borehole data compilation. The drivers for this project are twofold: (1) Yukon government has initiated a new initiative called “Our Clean Future”, which identifies adaptation as a fundamental pillar and necessitates the systematic capture and centralized storage of permafrost data; and (2) a university-based research network was



**Figure 8.** Drone photograph of a thaw slump along the Takhini River west of Whitehorse. View looking southward.

recently funded to undertake permafrost research across Canada. The network, called PermafrostNet, is being spearheaded out of Carleton University and has funding for five years (2019–2024). The Yukon permafrost database will provide PermafrostNet researchers with crucial baseline data to support the development of new tools for mapping permafrost and predicting thaw impacts.

In addition to compiling permafrost data, the YGS is involved in a number of permafrost studies. For example, Lipovsky retains several community-based permafrost monitoring stations and she has acquired additional thermistors to enhance data collection. Kennedy has been collaborating with colleagues from Yukon College and Yukon government’s Department of Highways and Public Works on thaw-related issues on the Dempster Highway, and with the GSC on sites along the North Klondike Highway. Demand for Kennedy’s and Lipovsky’s involvement in targeted permafrost studies is likely to increase over the next few years as PermafrostNet activities ramp up.

## Surficial geology workshop breakout session

Participants at the surficial geology breakout session discussed the YGS’ approach to surficial geology activities. There are pressures on the survey to upgrade regional surficial geology maps, improve the resolution of glacial limits, undertake geochemical studies to support till prospecting, document permafrost, and identify geologic hazards in and around communities and along transportation corridors. The range of activities eclipses the Surficial Geology unit’s capacity, requiring the YGS to prioritize activities. Defining criteria for setting priorities was not within the scope of the workshop, so attendees focused on the gaps in Yukon’s surficial geology data and provided ideas for research across a number of surficial geology sub-disciplines.

## Community mapping and geohazard studies

The YGS has published surficial geology maps for the communities of Old Crow, Dawson City, Mayo, Pelly Crossing, Faro, Ross River, Burwash Landing and Destruction Bay. The maps range in scale from 1:10 000 to 1:25 000 and include both surficial materials and derivative maps illustrating geologic hazards (e.g., landslides, permafrost, floods). The maps have been well received by communities and the YGS was advised to continue community-based mapping. Priorities for future community mapping include Carcross, Teslin, Carmacks, Watson Lake, Haines Junction, and the Haines Junction-Whitehorse corridor (the latter study is currently underway). Hazards vary by community, but include landslides (both tectonic and climate-change triggers), flooding, ground slumping (due to permafrost thaw), and radon gas emissions.

Although documenting permafrost has been a component of all community mapping projects to date, Yukon government's "Our Clean Future" initiative has raised the profile of the impact that thawing permafrost is having across the territory. Permafrost monitoring and the population of the Yukon permafrost database are anticipated to be priorities in the coming years. Attendees noted gaps in understanding groundwater-permafrost interactions, challenges in predicting impacts of ground thawing, and the lack of an accurate ground-ice map for Yukon. Areas of particular interest for study include Chapman Lake (along the Dempster Highway), the Moosehide slide in Dawson, and the Takhini River valley where the agriculture industry is growing. These all represent opportunities to collaborate with PermafrostNet researchers to support thesis projects. Attendees also suggested that the YGS could approach exploration companies and install thermistors in abandoned boreholes to expand its network of shallow ground temperature monitoring stations.

In terms of base data to support community mapping, high quality imagery is a critical requirement for interpreting landforms and identifying features associated with ground movement. LiDAR imagery is the standard for mapping (particularly for flood hazard mapping), and drone-based imagery is valuable as it

can target specific features over time (e.g., thaw-related slumping). The YGS' surficial geology group presently owns two drones and they are proving to be valuable mapping tools in a number of settings.

While not specifically part of the community mapping projects completed to date, aggregate resources are of interest to communities, and in some cases, identifying new sources of aggregate is a priority. The YGS does not have a systematic approach to carrying out aggregate inventories; nor does it have a formal mechanism for seeking requests for information on aggregate. The aggregate studies the YGS has completed to date have been local, on-demand, short-term projects, typically initiated by conversations with colleagues in other Yukon government branches (e.g., Lands, or Highways). These studies are generally not published; the information is provided directly to the party seeking the information. Although they may not warrant formal publication, there would be value to capturing the information in a corporate database. Workshop attendees suggested that community mapping projects could include an assessment of aggregate within the map area.

Workshop attendees also proposed that the YGS participate in studies to characterize the nature of deformation along Yukon's active faults (e.g., Denali and Duke River faults), to assist with earthquake hazard risk assessments and document areas susceptible to earthquake-induced landslides. They further recommended that the YGS continue to monitor the ice cave near Haines Junction and collaborate with Parks Canada to track glacier behaviour (e.g., surges, retreats) and contribute to public outreach on these topics.

## Regional surficial mapping

Some workshop attendees felt that regional surficial mapping (1:50 000) should be a priority for the YGS, as the regional context is the foundation for applied and thematic studies such as landslide mapping, drift geochemistry, etc. Given the current coverage of 1:50 000-scale surficial maps for Yukon, this goal is a challenging one for the YGS. Coordinating with YGS bedrock mappers to leverage logistical support was proposed as a means to support and advance mapping. Other participants felt that systematic mapping of areas on a map sheet-by-map sheet basis had less

value than targeting corridors of high interest such as the Nahanni and Mac Pass road corridors. Still other attendees noted that upgrading of the glacial limits map should be a priority, as the current ice limits are locally inaccurate and chronology data are minimal. A number of gaps in glacial chronology in southwestern Yukon were pointed out, including sites along Telluride and Wolverine creeks, and White and Donjek rivers. As a means to accelerate regional surficial geology mapping, it was suggested that graduate students could undertake mapping as part of their thesis work. The YGS has done this in the past and it has proven to be a cost-effective way to expand coverage. To ensure the geologic knowledge is retained by the YGS, it requires a commitment to supervise and engage with the student.

Although they recognize it as a long term goal, workshop attendees expressed interest in seeing a regional surficial compilation map of the Canadian Cordillera. Such a project would not only require significant upgrading of existing maps, but a change in how data (including legends) are managed; for example, Yukon's legend currently differs from that of BC's. While such an overhaul would require a lot of work, it would simplify map updates and enable the generation of thematic maps. In the meantime, the YGS has compiled a digital 'patchwork' surficial map that levels map units to the BC Terrain Classification System. A map index is available on the YGS' website with links to the original maps and GIS data (<http://yukon2.maps.arcgis.com/home/webmap/viewer.html?webmap=e819fd4b0e874422b0386270985d798a>).

## Thematic studies

Attendees raised a number of thematic surficial geology questions, such as:

- What are the ages of Quaternary glaciations?
- What do we know about Neogene environments in Yukon?
- How did Quaternary landscapes evolve?
- What are the primary controls of radon gas distribution in surficial materials?
- What are the key hazards associated with glaciers in Yukon?
- How effective are various geophysical tools for mapping permafrost?

The YGS has very limited capacity to take on new projects to address these and other questions, although the survey could support and/or facilitate university-based studies, or collaborate with other Yukon government departments who are lead on some of these issues. It was noted that high-quality imagery (especially LiDAR and ortho-rectified air photos) will be critical for many of the above studies, and the YGS should continue to collect imagery opportunistically as they become available.

## Current placer geology activities

In 2019 Jeff Bond and Sydney van Loon visited 88 placer operations, collecting geologic data and production information. An overview of 2019 placer industry activities is presented in this volume (Bond and van Loon, 2020).

Progress continued on the compilation of historic placer data; to date, 272 maps have been digitized, including 1427 points (drill holes, shafts) and 985 polygons (dredged ground, historic workings). The data have been posted on YGS' Historic Placer Data web map. Bond and van Loon visited Library and Archives Canada in Ottawa in December to search for additional maps and reports that could be added to the database. They identified 131 maps and have set them aside to be scanned over the next few months.

While the primary rationale for property visits is to collect information on placer operations, these visits also enable the collection of geologic data that support thematic studies. At the 2019 Yukon Geoscience Forum, Bond and van Loon presented a poster on Quaternary intermediate-level terrace deposits that may host placer gold concentrated from Pliocene high-level terrace deposits. Such deposits are commonly masked under hillside colluvium and are targets for modern placer miners. The poster was first presented at the International Quaternary Association meeting in Dublin, Ireland in July.

Bond also co-supervised an MSc student thesis (Derek Cronmiller; Simon Fraser University) that examined surficial stratigraphy and placer potential in the Gladstone Creek area.

## Placer workshop breakout session

The Placer breakout session focused on the needs of Yukon's placer miners, examining placer-related research and information services that would benefit this sector. The YGS' role in supporting placer mining has grown significantly in the last few years. Bond currently invests the bulk of his time in placer-related work, and van Loon is committed full-time to placer interests.

### Industry liaison

Workshop attendees expressed appreciation for the annual field visits by Bond and van Loon, and encouraged them to continue this work. They also noted that field trips are beneficial for learning about how different operators address different geological and technical challenges and they encouraged the YGS to organize trips during the annual Gold Show.

Participants expressed an interest in seeing additional information captured in the Placer Industry Report, such as cut sizes and volumes, and a glossary of geological terms. They would also like to see an expanded section on reclamation in the report, and information on different methods of defining a resource. The volume already includes information on stratigraphy, gold grade and characteristics, equipment and water treatment; the YGS committed to looking at adding this extra information, noting that some of it (e.g., the request for cut sizes and volumes) would be easy to accommodate.

The group also discussed the merits of developing a digital database that captures the information in the Placer Industry Report, supplemented with additional photographs (e.g., of gold grains) and stratigraphic sections.

Since it was initiated in 2009 the annual Placer Forum has grown in scope and has seen a steady increase in attendance. The forum features presentations on annual production, as well as new placer research, and provides a venue for placer miners, geologists, and regulators to exchange information on topics ranging from mining techniques to heritage assessments to regulatory changes. Workshop attendees agreed that the Forum should continue to be held on an annual basis and made a number of suggestions for future

agenda items, including presentations on production costs and geophysical exploration techniques. Some attendees proposed moving the Forum to late October, as many operators have wrapped up for the season by then. The YGS committed to considering an earlier date.

### Reclamation and wetland studies

Preservation of wetlands and mine site reclamation are becoming issues of increasing concern to the placer sector. While the YGS does not have a regulatory role, its frequent site visits and regular interactions with operators provide survey staff with first-hand knowledge of the nature of the ground being mined and the status of reclamation. Workshop delegates noted that the YGS could play a role in supporting a reclamation 'best practices' guide in collaboration with the Client Monitoring & Inspections Branch.

The YGS recognizes that helping industry showcase good reclamation practices would benefit the sector and address some of the public's concerns regarding the impacts of placer mining on wetlands. However, given other demands on staff time, the YGS will need to focus on supporting studies on reclamation best practices, while continuing to liaise with regulators who apply these studies. The YGS will keep working with the department of Environment to generate wetland distribution maps for the territory, and provide input and advice on wetland mapping.

### Communication/Outreach

Workshop participants noted that the public's understanding of modern placer mining is fraught with misperceptions. They would like to see the YGS undertake more public outreach, targeting youth to better inform them on the placer industry. They also felt that mining recorder staff would benefit from a "Placer 101" course similar to the "Mining 101" that is offered regularly to staff. In response to this input, Bond organized a September field trip for students at the Robert Service School in Dawson City. Students visited three placer operations in the area and had an opportunity to learn about the region's Quaternary geology (Fig. 9). This, and other outreach activities, are described in more detail in this volume (see Weston, 2020).

## **Placer geology research**

Several ideas for placer research were proposed at the workshop. Among the input were suggestions to acquire more LiDAR data and drone images along creeks, and use these data to generate detailed creek maps. Such maps could aid in identifying subtle topographic features such as benches, and would be useful for remediation planning.

Attendees also encouraged YGS to consider producing a synthesis publication of geophysical surveys of creeks. Many operators use geophysics — in particular, resistivity — to image subsurface geology. The surveys can reveal permafrost and groundwater-rich lenses as well as depth to bedrock, but interpreting the data can be challenging for miners. The study could include a compilation of case studies comparing survey results in different geologic settings, to assist miners in optimizing surveys. The YGS does not have internal capacity for such an undertaking but could coordinate the sharing of industry surveys and liaise with a contractor or graduate student to undertake the work.

Attendees also proposed a number of site-specific project ideas. These are detailed below.

### ***Stratigraphic study of the Wolfhead claims near Clear Creek***

Wolfhead Discovery and Mining recently drilled several 300-foot deep holes on their claims on the edge of Tintina Trench, intersecting a gravel of possible Pliocene age. The surficial geology in this area is poorly known. A detailed stratigraphic study would confirm the age of the gravel, enable an assessment of its placer potential, and allow regional stratigraphic correlation to other gold-bearing gravels in Yukon.

### ***Hydraulic conditions of Stewart River bars***

Significant amounts of fine gold have been recovered from bars on the Stewart River. Very little is understood about the hydraulic conditions that concentrated the gold, or whether the environment is unique to the Stewart River. A better understanding of the depositional environment of these gravel bars might help to identify analogous settings on bars in other large rivers.

### ***Potential for buried placer targets in the Ruby Range***

Mining along the Fourth of July and Twelfth of July creeks in the Ruby Range has yielded gold in the past, but in recent years, work has ceased. Potential for deeper targets exists along benches and at depth under the main creek channels, although current surficial maps do not provide sufficient detail to identify the most prospective areas. New mapping could open up new targets and re-invigorate interest in the area.

### ***Targeted mapping on Matson and Ladue creeks***

Workshop participants also recommended some new mapping along Matson and Ladue creeks. This area is currently inactive, but potential exists to identify prospective targets and stimulate new interest.

### ***Targeted mapping in the Big Creek–Hobo Creek area***

Recent placer activity in the Big Creek–Hobo Creek area has highlighted the inadequacy of the existing 1:250 000-scale surficial geology map. Alpine glaciation in this area has likely complicated gold distribution, although details of the glacial and interglacial environments are not well documented. New mining activity will create exposures and enable an improved understanding of the surficial history of the area.

## **Summary**

The YGS appreciates the time and effort invested by clients and stakeholders who participated in the planning workshop. The advice and feedback that was recorded will be valuable for work planning over the next five years and beyond. As noted in this overview, several of the project ideas discussed at the workshop have already been initiated by the YGS, and the survey will continue to engage with clients and stakeholders as current projects wrap up and new ones are started.

It is difficult to summarize all of the work being undertaken by the YGS in a single paper. Readers are encouraged to peruse the technical papers in this

year's Yukon Exploration and Geology volume to learn more about individual projects. On a similar vein, it is impossible to capture all of the discussion that led to the project ideas presented above. The workshop did not include a separate breakout session on information services; instead, data management and web services were discussed in each of the themed sessions. As a result, it is likely that some comments (e.g., feedback on YGS' Facebook site) were not shared and captured. While the next planning workshop will not be until 2024, the YGS welcomes discussion on ways to improve its services at any time.

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