

# Yukon Geological Survey 2021 overview

*Carolyn Relf\**  
Yukon Geological Survey

Relf, C., 2022. Yukon Geological Survey 2021 Overview. In: Yukon Exploration and Geology Overview 2021, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 1–15.

## Introduction

Following a challenging year in 2020, activities at the Yukon Geological Survey (YGS) began to return to near-normal in 2021. While a number of provisions related to COVID remained in place, staff returned to working at the office, field activities proceeded without significant delays, and access to core library services for clients resumed. Visits to hard rock exploration projects also picked up over the summer, and face-to-face meetings were held with a few First Nations representatives.

In November, Yukon government announced a state of emergency in the territory as a result of a sharp increase in COVID cases. At the time of writing, staff are working mainly from home, although they are still available to respond to client requests and the Core Library remains open. Clients accessing the Core Library facilities must wear a mask, and access is limited to no more than two clients.

\* [Carolyn.Relf@yukon.ca](mailto:Carolyn.Relf@yukon.ca)



**Table 1.** Summary of YGS operating budget and sources of funds.

Source	Supported activities	Amount
YGS O&M	Geoscience program, core library facilities, information services, administration, building maintenance	\$1345K
YMEP	Grants in support of early stage exploration	\$1400K
CanNor	Top-up funding for YMEP	\$80K
Yukon's Our Clean Future	Geothermal research, permafrost studies, glacier monitoring	\$470K
NRCan	Funding for targeted geothermal studies (under Emerging Renewable Power Program)	\$955K
CIRNAC	Permafrost monitoring (under Climate Change Program)	\$55K
<b>Total</b>		<b>\$4305K</b>

Abbreviations: O&M – Operations and Maintenance; YMEP – Yukon Mineral Exploration Program; CanNor – Canadian Northern Economic Development Agency; NRCan – Natural Resources Canada; CIRNAC – Crown-Indigenous Relations and Northern Affairs Canada.

## Current bedrock activities

### Bedrock mapping

YGS carried out four regional bedrock mapping projects in 2021. Project highlights are summarized below and locations are shown in Figure 2.

Tyler Ambrose completed a third year of 1:50 000 scale bedrock mapping in the area around Rackla and Bonnet Plume rivers in 2021 (Fig. 2). The work extended his 2020 mapping northward to include the area surrounding the North Rackla lead-zinc-silver-copper-manganese occurrence. The occurrence is hosted in Mesoproterozoic rocks of the Wernecke Supergroup that are exposed in erosional inliers beneath early Paleozoic sedimentary rocks.

Mapping around the North Rackla property revealed evidence suggesting that faulting may have played a role in mineralization. Galena samples were collected to

compare sulphur isotope compositions to other deposits in the region and identify potential sources of ore fluid; this work will be carried out in collaboration with Patrick Sack. Other analytical work includes geochronology to better constrain the timing of deposition of the various Proterozoic units in the region.

An update on the North Rackla project is presented in Ambrose (2022).

Diane Skipton continued mapping in the Nash Creek area between the Tiger gold deposit and the McKay Hill polymetallic occurrences (Fig. 2). The map area is underlain by rocks of the Neoproterozoic to Cambrian Hyland Group, the Devonian-Mississippian Earn Group, and the Mississippian Keno Hill Quartzite. The units are imbricated in a series of northeast-verging thrust panels. Folds associated with faulting are characterized by a penetrative cleavage defined by greenschist facies minerals. Samples of white mica have been collected for  $^{40}\text{Ar}/^{39}\text{Ar}$  thermochronology to determine the timing of fabric development. The thermochronology work is being carried out by Dr. Alfredo Camacho at the University of Manitoba. Highlights of 2021 fieldwork are presented in Skipton (2022).

David Moynihan carried out a second season of mapping in the Yukon-Tanana terrane in the Big Salmon Range of south-central Yukon (Fig. 2). Mapping defined three northwest-striking panels of rocks separated by two faults which appear to be regional features. The central panel comprises low grade Devonian to Carboniferous metavolcanic rocks (Fig. 3). It is flanked to the northeast and southwest by Paleozoic metasedimentary rocks that are intruded by Devonian-Mississippian plutons of the Simpson Range suite. The faults separating the three panels may be as young as mid-Cretaceous, but evidence was found to suggest they could be Early Jurassic in age.

Younger features in the area include the north-striking d'Abbadie fault, which offsets units within the northeastern panel, and the late Cretaceous Red Mountain molybdenum porphyry deposit, which intrudes the northeastern panel. More detailed descriptions of the geology are presented by Moynihan (2022).

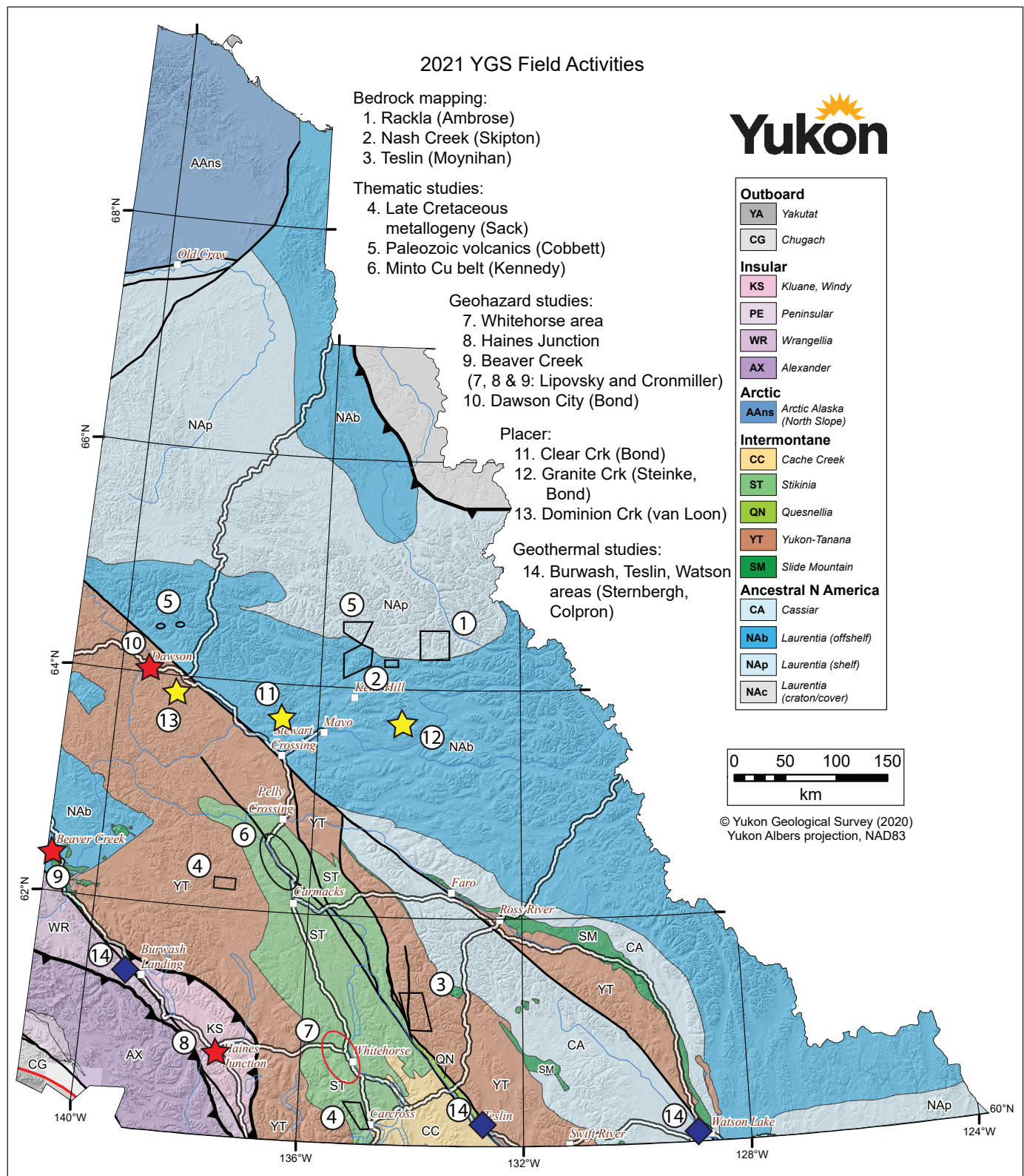


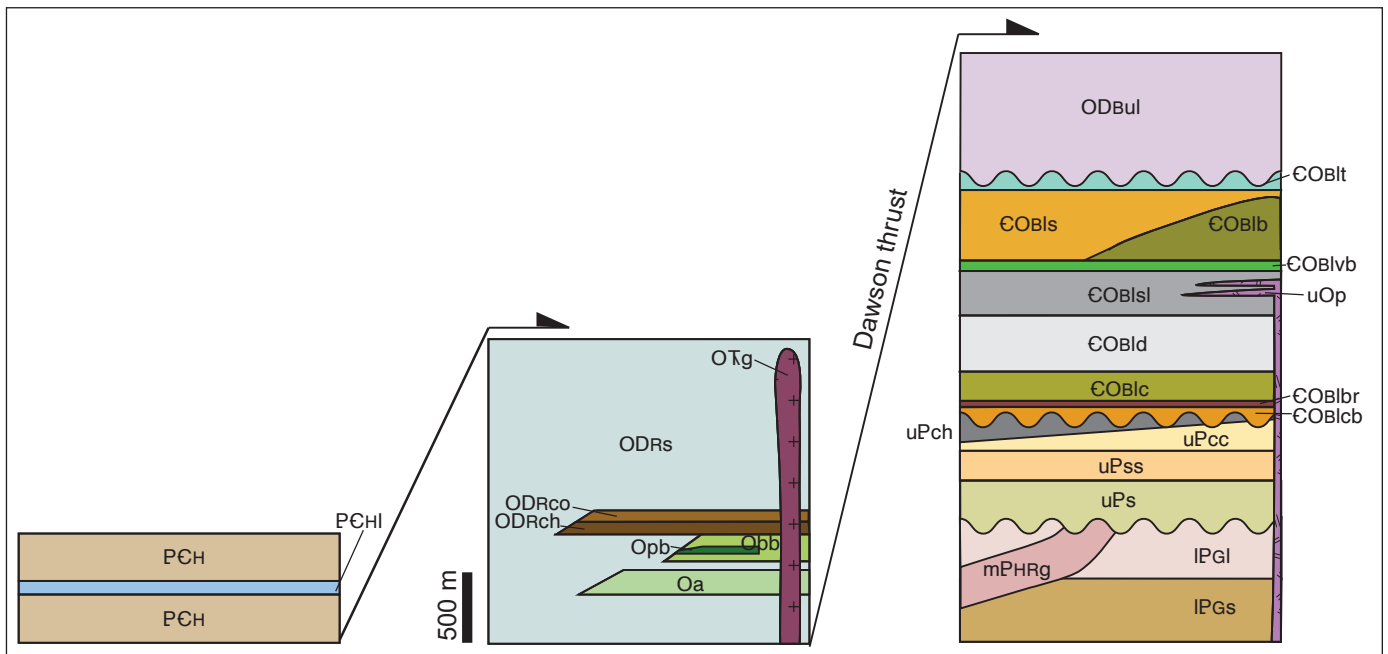
Figure 2. Map showing locations of 2021 field work by YGS staff.



**Figure 3.** Photo of deformed Paleozoic tuff with clasts of marble. Rocks are part of the central fault-bound panel in the Big Salmon Range (Moynihan, 2022).

Rosie Cobbett completed a third and final year documenting and sampling lower Paleozoic volcanic rocks in continental margin strata across Yukon. Her study, which is part of a PhD thesis being undertaken at Memorial University, is focused on documenting the age, petrology, and stratigraphic/structural settings of volcanic events that punctuated the depositional history of the Ancestral North American continental margin. Field observations coupled with new zircon geochronology data have identified at least three phases of magmatism ranging in age from Neoproterozoic (1.38 Ga) to latest Ordovician. Her work has led to significant revisions of existing maps, as well as new stratigraphic interpretations (Fig. 4).

A new 50 000-scale geology map covering the Castle Mountain, Carpenter Creek and McKay Hill areas is being prepared for release, and highlights of 2021 fieldwork are presented in this volume (Cobbett, 2022).



**Figure 4.** Updated stratigraphic section for the Castle Mountain and McKay Hill areas. For detailed description see Cobbett (2022).

## Geothermal studies

In 2021, YGS focused its geothermal research program on the evaluation of the geothermal energy potential of three major faults in Yukon: the Denali fault near Burwash Landing, the Tintina fault in the Watson Lake area, and the Teslin fault near Teslin. Funding for this research is provided through NRCan's Emerging Renewable Power Program and the Government of Yukon's *Our Clean Future* initiative. The project is being led by Maurice Colpron and Sarah Sternbergh, with the involvement of First Nation governments in each of the three communities. The Geological Survey of Canada is engaged in the project as well.

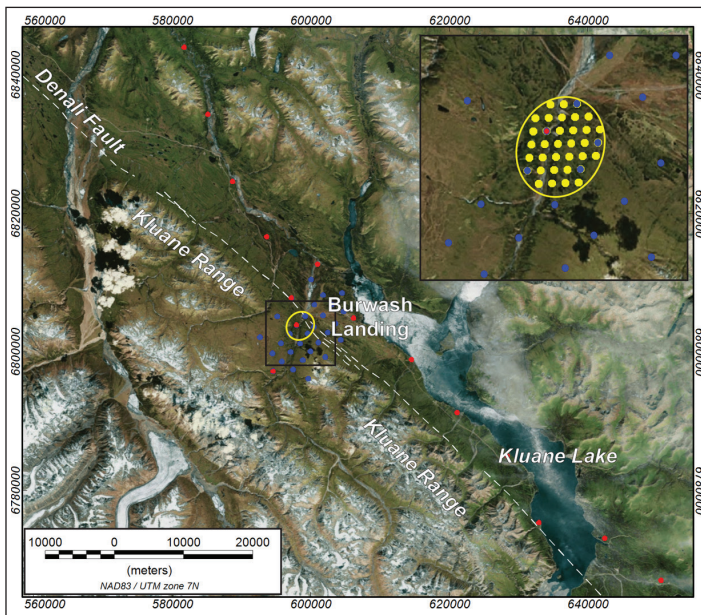
For the Watson Lake-area study, YGS signed a project Memorandum of Agreement with Liard First Nation in January 2021. The study got underway with the compilation of regional geoscience data in order to define the study area and identify data gaps. In 2021, new gravity data were collected by Aurora Geosciences and a magnetotelluric transect was completed by the University of Alberta over the study area (Erich Slobodian, MSc student, under the supervision of Martyn Unsworth). Over the winter, data from these surveys will be integrated with pre-existing data layers (magnetics, bedrock and surficial geology) to more accurately delineate fault strands and identify drill targets for future temperature gradient wells. In addition to the above activities, researchers at the University of Calgary deployed six broadband seismic stations along the Alaska, Cassiar and Robert Campbell highways in southeastern Yukon. These instruments will remain in place for two to three years to collect seismic data and enable a regional model of the crust in this part of Yukon. Seismic data interpretation will be led by Jeremy Gosselin under the supervision of Jan Dettmer and Hersh Gilbert (University of Calgary).

At Teslin Lake a similar compilation exercise to that described above was completed to delineate an area of interest for geothermal study along the Teslin fault. Targeted mapping was done in July, 2021, and as the Watson Lake study wraps up over the next year, the intention is to ramp up work in the Teslin study area (including collection of gravity and magnetotelluric data) to support modeling and identify targets for temperature gradient wells near the village of Teslin.

Six seismometers were installed by University of Calgary researchers in the Teslin-Carcross area to support modeling of the crust.

The third geothermal study area is along the Denali fault near Burwash Landing. This work is advancing the study reported on by Witter (2020) in which seven potential drill targets were identified for temperature gradient wells. In 2021, YGS worked with Kluane First Nation to identify a priority target and design a well that will optimize the knowledge to be derived from drilling. RESPEC has been contracted to finalize the well design and aid with procuring a company to undertake drilling and downhole surveying. The intent is to initiate drilling in spring 2022, with completion sometime in April. The project includes plans to collect core samples for analysis by researchers at the Institut National de la Recherche Scientifique (INRS) in Québec, to document physical properties, and water samples, to estimate source temperature. The study will be part of a PhD thesis by Fiona Chapman, under the supervision of Jasmin Raymond. The completed well will be instrumented with fibre optic cables to enable the monitoring of downhole temperature, seismicity, *in situ* stress, and other data over the next few years.

As drill planning advances, geophysical studies continue in the Kluane region. In August, nine broadband seismic stations were deployed in a ~4 km area surrounding the Denali fault drill site. Although they are unlikely to have yielded enough data to model subsurface geology by the time drilling commences, over the next two to three years they will provide insights into thickness of overburden and the orientation of the fault at depth. In October, magnetotelluric (MT) surveys were completed along the Denali fault by Quantec Geoscience in collaboration with Jim Craven and Vicki Tschirhart of the GSC (under their GEM *GeoNorth* Program). The surveys include a detailed 500 m grid of audio-frequency MT stations centred on the drill site and surrounded by a broader array of MT stations (~2 km spacing within a 10 km radius). In addition, a regional MT transect with stations spaced every 10 km was completed along the Alaska Highway between the Donjek and Aishihik rivers. Together, these MT datasets will help refine the 3D architecture of the crust in this region (Fig. 5). Results of these studies will be released as analyses of the various datasets are completed.



**Figure 5.** Locations of MT stations deployed in the Burwash Landing area. Symbols: yellow dots - detailed grid of audio-frequency MT stations near drill target; blue dots - broader array of MT stations surrounding drill target; red dots – regional MT stations.

## Neotectonics

In addition to geothermal research, the Denali fault area was the focus of neotectonic studies by researchers from the University of Victoria (UVic) and the University of Northern British Columbia (UNBC). Detailed lidar survey data were acquired along segments of the fault using UVic's drone and will be integrated with airborne lidar data acquired in 2018 by UNBC, to identify recent tectonic features along the fault. Preliminary results of this work are presented in Finley et al. (2022).

Justin Emberly worked with Andrew Schaeffer from the GSC Pacific to install four new and repair four existing broadband seismic stations in northern and central Yukon (Fig. 6). The “new” stations are redeployments of YGS-owned instruments that were removed from southeastern Yukon in 2020 and are now re-occupying sites that were previously occupied by US Array instruments. These long-term installations are part of a broader Canadian network of instruments deployed to monitor earthquakes and determine the locations of epicentres. The work is part of GSC's Geohazards Program.



**Figure 6.** Justin Emberly setting up a solar panel to provide power to a remote seismic station at Wright Pass, Dempster Highway.

## Surficial geology activities

### Community-focused studies

Staff with the Surficial Geology Unit advanced several projects related to geohazards in and around communities in 2021 (Fig. 2). Most projects focused on documenting hazards associated with permafrost thaw, but other hazards, including landslides and flood risk, were also examined.

Panya Lipovsky completed work on a multi-year mapping project in the greater Whitehorse area. Under this project she has generated a preliminary 1:15 000 scale surficial geology map (targeted for release in spring 2022), installed thermistors in six new boreholes to monitor permafrost, and co-authored a report with Yukon University colleagues that characterizes Whitehorse-area permafrost (Roy et al., 2021). The project included a number of targeted hazard studies, including the Takhini thaw slump, slide risks along the clay cliff below the Whitehorse airport (Fig. 7), and agricultural lots within the new Murray Agriculture Subdivision north of Takhini River. Lipovsky's mapping also provided the geologic framework for two radon studies: a BSc thesis at Dalhousie University (Kishchuk, 2021) and a radon-in-groundwater study by Yukon University (publication pending).



**Figure 7.** Aerial photo of a June 2021 landslide documented by Lipovsky on the scarp below Whitehorse Airport. View looking west; Robert Service Road in the foreground.

Lipovsky and Derek Cronmiller have begun planning for a new for mapping project in Haines Junction once the greater Whitehorse area project is complete. The area delineated for this new project is centred on the community and extends west to Bear Creek and east to Marshall Creek. Lidar imagery has been acquired for the study area and fieldwork is scheduled to begin in 2022. In advance of mapping, Cronmiller instrumented a new borehole in the community to initiate permafrost monitoring. He also collaborated with Carleton University colleagues to collect electrical resistivity tomography (ERT) data to map permafrost, using the borehole to “ground truth” the profiles.

Cronmiller is the lead for completing new community hazard maps for Beaver Creek, Teslin and Watson Lake over the next few years. In 2021 he initiated work in Beaver Creek and Teslin by instrumenting new boreholes in the communities (three in Beaver Creek; one in Teslin). He also worked with Carleton University to collect ERT profiles. Mapping is scheduled to get underway in 2022, and these subsurface datasets will be incorporated into his geohazard interpretations.

In addition to the above permafrost monitoring sites, Cronmiller drilled and instrumented new boreholes in Mayo, Carmacks, Watson Lake, and along the Dempster Highway in the Chapman Lake area (Fig. 8), where permafrost issues have plagued the highway for a number of years. He also upgraded thermistors in existing boreholes in Faro and Ross River.



**Figure 8.** Derek Cronmiller drilling a borehole near Beaver Creek. The borehole was instrumented with a thermistor and is part of YGS’ network of permafrost monitoring stations.

In Dawson City, Jeff Bond continued work to address risks from two potential landslides near the community: the Moosehide and the Sunnydale slides. He worked with BGC Engineering to quantify the risk posed by the Moosehide slide, and he is part of a working group (along with other Yukon government and municipal representatives) that is advancing mitigations to reduce the slide risk. BGC Engineering has been contracted to design a near-real time monitoring system at the head scarp of the Moosehide slide, and the working group will begin developing an emergency response plan over the winter. On the Sunnydale slide, Bond and a contractor installed and surveyed several monuments and set up tension crack monitoring stations. They also collected detailed drone images of the area. The slide will be visited annually to measure ground movement and develop a better understanding of displacement mechanisms and risk.

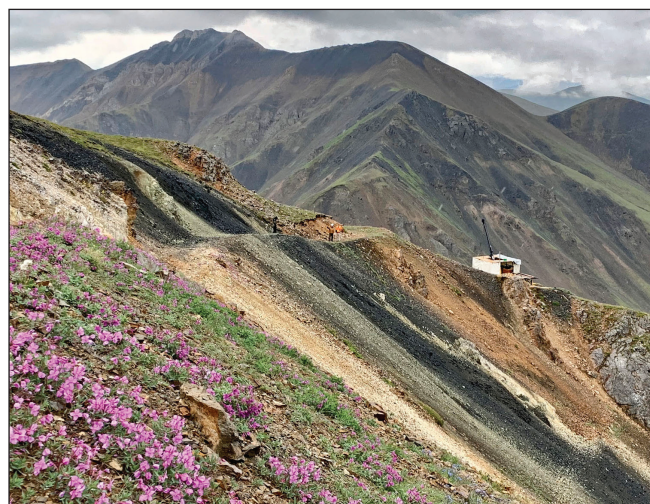
### Yukon Permafrost Database

Moya Painter continued to capture data and metadata in the Yukon permafrost database, and in the fall, launched a web application to enable public access to the data. The application allows users to download permafrost borehole and temperature data, and is intended to support both climate change research and infrastructure planning. A description of the database, including data descriptions and maps, is presented in this volume (Lipovsky et al., 2022).

## Minerals-related activities

### Industry liaison

In 2021, YGS staff carried out twenty-seven visits to hard rock exploration projects, including three to YMEP projects (Fig. 9). Staff also tracked exploration and development activities via press releases and correspondence with company geologists, and reviewed assessment reports. The level of exploration activity was up in 2021 relative to 2020, as COVID restrictions relaxed. Highlights of 2021 field season exploration and development activities are presented by Casselman and Lewis (2022).



**Figure 9.** Drill working at Nickel Creek Platinum Corp.'s Nickel Shāw Ni-PGE-CO-Cu deposit.

In January, YGS released an updated Yukon Mineral Deposits Summary (Casselman, 2021), providing the latest information on hard rock resources in the territory. The report is released every two to four years and is intended to provide a high level overview of Yukon's mineral endowment.

YGS continued to support client use of the core logging and lapidary facilities in 2021. Clients are welcome to use the facilities to access core in YGS' drill core collection and use physical rock property equipment. Limited access to rock saws is also available for rock and core cutting, although production cutting is discouraged due to noise. Access to facilities is subject to conditions based on direction from Yukon's Chief Medical Officer of Health.

### Critical minerals inventory

In the fall, YGS released an inventory of critical minerals in Yukon (Lewis and Relf, 2021). The report provides an overview of Canada's Critical Mineral list, highlights the alignment of Yukon's critical minerals endowment with the goals of Yukon's "Our Clean Future" strategy, and describes some of the opportunities that supply/demand projections could present for Yukon. The report includes data sheets that summarize key uses of each critical mineral, global production statistics, and information on geologic settings in which they occur.

## Thematic studies

Patrick Sack continued his investigations of Late Cretaceous rocks in southern Yukon, focusing work in two areas in 2021. He spent two weeks in the Wheaton River area (Fig. 10) mapping magmatic rocks to upgrade the existing geology map. His plan is to incorporate updated shape files and new age data into the next version of the Yukon bedrock geology compilation, rather than releasing a stand-alone Open File map. The rest of his fieldwork was focused in the Dawson Range, where he sampled selected Late Cretaceous mineral deposits and collected rocks for low temperature thermochronology analyses along orogen-parallel and orogen-normal transects. Dawn Kellet and Nicolas Pinet (GSC) will be carrying out the thermochronology work under GSC's GEM GeoNorth Program.

The intent of the Late Cretaceous project is to better characterize magmatic rocks of this age and

understand their associated metallogeny. The thermochronology study will aid in documenting the exhumation history of the region and the preservation potential of porphyry systems formed at high crustal levels. Together, these studies will improve the geologic framework for the Late Cretaceous and support mineral exploration and mineral potential evaluations.

Over the coming winter, Sack will be re-releasing his geology map for the Mount Nansen area (Sack et al., 2021) based on new age data for a number of the map units. Some of the map revisions and new geochronology data are presented by Sack et al. (2022).

Kristy Kennedy started a new project in the Minto Copper Belt in 2021 (Fig. 2). The project is intended to facilitate surficial geochemical exploration in the area by providing an improved understanding of the area's glacial history and surficial materials. Multiple glacial



**Figure 10.** Landis Smith, Leyla Weston, Sam Bonar and Patrick Sack (left to right) mapping Late Cretaceous granitoid rocks in the Wheaton River area.

limits occur within the study area, making it challenging for companies to interpret results of soil geochemistry. Compounding this challenge are the unique character of Minto-type copper mineralization, which differs significantly from traditional porphyry-style alteration (Kovacs et al., 2020), and the presence of Quaternary basalt and windblown silt and ash, both of which further mask the signal of bedrock geochemistry.

Kennedy initiated fieldwork, mapping glacial limits and examining Quaternary sections over the summer. She also collected samples both for geochemical analysis and indicator mineral studies. Preliminary results of the study are presented in Kennedy et al. (2022).

Warwick Bullen undertook a desktop study to generate a porphyry potential map for Yukon using deconstructed weights of evidence analyses. Multiple data layers were used in the assessment, which used conditional probability to quantify mineral potential. He calculated predictivity values for a range of geological features (e.g., host rock, proximity to faults and contacts, geophysical values and the geochemical character of stream sediments in watersheds) based on weights assigned to cells on a grid. Known mineral occurrences were used as training data to calculate the grid cell weights and spatially constrain areas of different mineral potential. The map and accompanying notes will be released this spring (Bullen, 2021a, 2022).

## Land use planning

In June, the Dawson Land Use Planning Commission released a Draft Land Use Plan for the Dawson Region. The Commission was supported by assessments of the region's hard rock and placer mineral potential, compiled by Warwick Bullen and Jeff Bond, respectively. A number of meetings were held over the summer to gather feedback on the draft plan, and YGS had an opportunity to provide input into Yukon government's response (Yukon Government Review of Draft Plan - Dawson Regional Planning Commission ([plan.yukon.ca](http://plan.yukon.ca))). The Final Recommended Plan is expected to be release in the spring of 2022. YGS will be publishing the Dawson planning area mineral potential map early in the new year (Bullen, 2021b).

In addition to working on the Dawson plan, Warwick Bullen prepared a preliminary mineral potential map for Teslin Tlingit Council's Traditional Territory to support land use planning in this area. He also developed machine learning algorithms to quantify the "opportunity cost" of land withdrawals, as a tool to support decision-making. This methodology was presented to attendees at the 2020 Mineral Exploration Roundup and published through the Geological Association of Canada's Mineral Deposits Division newsletter (Bullen, 2021c).

## Yukon Mineral Exploration Program

The Yukon Mineral Exploration Program (YMEP) committed \$1.4M in funding to 52 projects in 2021, broken down as follows:

- 20 placer projects
- 1 grassroots projects
- 9 focused regional projects
- 22 target evaluation projects

The corresponding funds committed by recipients this year was just over \$2.8M. Highlights of this year's program are presented in Torgerson (2022).

Last year, YGS compiled data on the amount of money invested by YMEP recipients in local employment and the provision of goods and services in Yukon. The data indicated that the program had a very positive impact on the local economy, and based on input from YGS' Technical Liaison Committee, YGS has committed to continue reporting this data. Starting in January 2022, YMEP recipients will be provided a template to capture data on local spending when they submit their final reports.

## MINFILE database

In 2021, 182 new MINFILE occurrences have been added to the database and 307 existing occurrences were updated. The majority of new occurrences were previously ones that were grouped on a property; information on individual occurrences and deposits were split out to provide more detailed information. In many cases, this has yielded information on the size and orientation of mineralized trends which were not previously visible when occurrences were grouped.

## Placer geology activities

In October, YGS released the tri-annual 2018–2020 Placer Industry Report (van Loon and Bond, 2021). The Report presents highlights of placer work history (including production data and equipment summaries) and provides a geological framework for gold-producing watersheds. Over the summer, staff completed visits to 70 placer operations to provide geologic advice and to capture data for the 2021–2023 Placer Industry Report. Highlights of the 2021 season are presented in this volume (van Loon and Bond, 2022)

### Thematic studies

Jeff Bond continued work on a study started in 2021 in the Clear Creek district. He is examining the glacial history and settings of placer gold at Big Creek and Josephine Creek, combining desktop mapping with sonic drill logs to better understand the influence of glaciation on gold distribution. Preliminary results of the study were presented at the 2021 Placer Forum in Whitehorse.

Bond is also involved in a study of placer deposits in at Granite Creek, where he is co-supervising an MSc thesis by Jessi Steinke (Simon Fraser University). Steinke's research focuses on the Quaternary history of the area and the distribution of gold. Results of her fieldwork are presented in this volume (Steinke et al., 2022).

Sydney van Loon initiated a new study in 2021 focused on lower Dominion Creek. The idea of re-mining dredge tailings is gaining momentum in the Klondike, and the local discovery by some miners of “pockets” of *in situ* gravels in valley bottoms adds to the appeal (Fig. 11). The intent of van Loon's study is to identify sites where historic dredge operations have left behind *in situ* gravels; the challenge is that valley bottoms are covered with dredge tailings. She chose to pilot this study in lower Dominion Creek because a rich dataset from historic workings is available (<https://yukon.maps.arcgis.com/apps/webappviewer/index.html?id=33eb829c5f9d495894732443e2fbc319>), enabling her to leverage drill records and information on dredge specifications and ground conditions. This data will be integrated



**Figure 11.** Jeff Bond and a student panning virgin gravels preserved below dredge tailings at Sulphur Creek.

with field observations on the characteristics of material in the dredge piles (e.g., the presence or absence of a matrix), and lidar imagery to see whether technogenic deposits can be mapped. Preliminary results of the study will be presented at a Placer Forum in spring 2022.

### Outreach

Leyla Weston liaised between Project Geologists and affected First Nations, providing information on preliminary project plans and seeking feedback to advance planning. She supported geothermal studies by generating a series of information brochures for posting on communities' Facebook sites; these brochures provided basic facts about geothermal

energy, as well as information on planned field activities and their impacts. She also assisted University of Calgary researchers in finding local First Nation citizens to monitor the seismic instruments that they deployed to support regional geothermal studies.

In addition to liaising with First Nation governments, Leyla visited classes and led numerous field trips for students in the Whitehorse area. She also organized the annual “Weekend on the Rocks” event at Tombstone Park in August. The two days included presentations and interpretive hikes led by current and retired YGS staff (Jeff Bond, Don Murphy, as well as Weston), and was very well attended (Fig. 12). During the weekend, Park staff unveiled a bench that was commissioned by the Friends of the Dempster in memory of GSC Geologist Charlie Roots, whose passion for Earth science education brought this themed weekend to life in 2011.

An overview of 2021 outreach activities is presented in this volume (Weston, 2022).

## Summary

In spite of the ongoing influence of COVID-19 on operations, YGS had a productive year. New investment in permafrost research has strengthened the survey’s capacity to predict landscape changes that could represent hazards. This capacity is becoming increasingly important given the impacts of climate change. The identification of renewable energy as a priority is driving interest in geothermal energy, which to date is an untapped resource in the territory.

In addition to the above areas of work, YGS continues to systematically map geology and document mineral occurrences, and provide expert advice on a variety of geoscience-related topics to industry clients, communities, Yukon government and the general public.

YGS appreciates clients’ understanding as we continue to adjust our services to meet evolving restrictions related to the COVID-19.



**Figure 12.** Outreach Geologist Leyla Weston (second from right) leads an interpretive hike along L'il Creek in Tombstone Park.

## References

- Ambrose, T., 2022. Update on the bedrock geology of the Rusty Mountain and Bonnet Plume Pass (west half) areas. *In: Yukon Exploration and Geology 2021*, K.E. MacFarlane (ed.), Yukon Geological Survey.
- Bullen, W., 2021a. Data-driven early-exploration predictive indicators for porphyry-style mineralization in Yukon using deconstructed weights of evidence modeling. Yukon Geological Survey, Miscellaneous Report 24, 1 sheet.
- Bullen, W., 2021b. Mineral potential/confidence in geology mapping for the Dawson Region Land Use Planning area. Yukon Geological Survey, Miscellaneous Report 25.
- Bullen, W., 2021c. Using machine learning to categorize mineral potential and quantify the opportunity cost of land withdrawal alternatives. The Gangue, Geological Association of Canada, May 2021 Newsletter.
- Bullen, W., 2022. Updates to the Yukon Geological Survey's mineral potential mapping methodology. *In: Yukon Exploration and Geology 2021*, K.E. MacFarlane (ed.), Yukon Geological Survey.
- Casselman, S. (compiler), 2021. Yukon Mineral Deposits Summary 2020. Yukon Geological Survey, 26 p.
- Casselman, S.G. and Lewis, L.L., 2022 (*this volume*). Yukon hard rock mining, development and exploration overview 2021. *In: Yukon Exploration and Geology Overview*, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 35–52.
- Cobbett, R., 2022. Geology of the Carpenter Creek and McKay Hill areas (NTS 106D/6, 11), central Yukon. *In: Yukon Exploration and Geology 2021*, K.E. MacFarlane (ed.), Yukon Geological Survey.
- Finley, T., Salomon, G., Stephen, R., Nissen, E., Cassidy, J. and Menounos, B., 2022. Preliminary results and structural interpretations from drone lidar surveys over the Eastern Denali fault, Yukon. *In: Yukon Exploration and Geology 2021*, K.E. MacFarlane (ed.), Yukon Geological Survey.
- Kennedy, K., Sack, P. and Clarke, H., 2022. Surficial geochemical setting of the southern Carmacks-Minto copper belt. *In: Yukon Exploration and Geology 2021*, K.E. MacFarlane (ed.), Yukon Geological Survey.
- Kishchuk, M.J., 2021. Geologic controls on radon concentration in surficial sediment in Whitehorse, Yukon. Unpublished BSc thesis, Dalhousie University, Halifax, Nova Scotia, 68 p., including appendices.
- Kovacs, N., Allan, M.M., Crowley, J.L., Colpron, M., Hart, C.J.R., Zagorevski, A. and Creaser, R.A., 2020. Carmacks Copper Cu-Au-Ag deposit: mineralization and post-ore migmatization of a Stikine arc porphyry copper system in Yukon, Canada. *Economic Geology*, vol. 115, p. 1413–1442.
- Lewis, L.L. and Relf, C., 2021. Yukon Critical Minerals Inventory. Yukon Geological Survey, Miscellaneous Report 23.
- Lipovsky, P.S., Humphries, J.K., Stewart-Jones, E.T. and Cronmiller, D.C., 2022. Yukon Permafrost Database: A new baseline data resource. *In: Yukon Exploration and Geology 2021*, K.E. MacFarlane (ed.), Yukon Geological Survey.
- Moynihan, D. and Crowley, J.L., 2022. Preliminary observations on the geology of the southern Big Salmon Range, south-central Yukon (parts of NTS 105C/13, 14, 105F/4 and 105E/1). *In: Yukon Exploration and Geology 2021*, K.E. MacFarlane (ed.), Yukon Geological Survey.
- Roy, L.-P., Lipovsky, P.S., Calmels, F., Laurent, C., Humphries, J. and Vogt, N., 2021. Greater Whitehorse area permafrost characterization. Yukon Geological Survey, Miscellaneous Report MR-22, 185 p., including appendices.
- Sack, P., Eriks, N. and van Loon, S., 2021. Revised geological map of Mount Nansen area (NTS 115I/3 and part of 115I/2). Yukon Geological Survey, Open File 2021-2.

- Sack, P., Crowley, J.L., Bennett, V. and Gabites J., 2022. Geology and U-Pb zircon geochronology and Pb isotope geochemistry of mid-Cretaceous plutonic rocks in the Mount Nansen map area (NTS 115I/3 and part of 115I/2). *In: Yukon Exploration and Geology 2021*, K.E. MacFarlane (ed.), Yukon Geological Survey.
- Skipton, D., 2022. Updated bedrock geology of the southern Nash Creek area in central Yukon (parts of NTS 106D/2, 3, 6 and 7). *In: Yukon Exploration and Geology 2021*, K.E. MacFarlane (ed.), Yukon Geological Survey.
- Steinke, J., Bond, J.D. and Ward, B.C., 2022. Placer gold settings within an alpine glaciated environment, Granite Creek, Yukon (NTS 105M/14). *In: Yukon Exploration and Geology 2021*, K.E. MacFarlane (ed.), Yukon Geological Survey.
- Torgerson, D., 2022 (*this volume*). Yukon Mineral Exploration Program 2021 update. *In: Yukon Exploration and Geology 2021*, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 29–34.
- van Loon, S. and Bond, J.D., 2021. Yukon Placer Mining Industry 2019–2020. Yukon Geological Survey, 290 p.
- van Loon, S. and Bond, J.D., 2022 (*this volume*). Yukon placer mining 2021 development and exploration overview. *In: Yukon Exploration and Geology Overview*, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 17–27.
- Weston, L., 2022 (*this volume*). Yukon Geological Survey's outreach program: 2021 highlights. *In: Yukon Exploration and Geology Overview*, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 53–62.
- Witter, J.B., 2020. Early-stage exploration for geothermal energy resources along the Denali fault near Duke River, Yukon. Yukon Geological Survey, Open File 2020-3.

