



Yukon

Exploration & Geology Overview

2021

- Yukon Geological Survey Activities
- Hard Rock Mining, Development & Exploration
- Yukon Mineral Exploration Program
- Placer Mining Development & Exploration
- YGS Publications
- Yukon Geological Survey Outreach



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Yukon
Exploration
& Geology
Overview
2021

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Front cover photograph: Looking west, up to the headwaters of Britnell Creek. J. Charlton is measuring the foliation in the Rabbitkettle Formation.

Back cover photograph: Galena, Logan and Mary Ann Roots seated on the commemorative bench installed for the late Charlie Roots.

Preface

Yukon Exploration and Geology (YEG) papers and the Yukon Exploration and Geology Overview are two of the main publications of the Yukon Geological Survey (Energy, Mines and Resources, Government of Yukon). Individual YEG papers, with colour images, are available in digital format and can be downloaded from our website. The YEG Overview is available in digital format and in a limited colour print run.

YEG 2021 contains up-to-date information on mining and mineral exploration activity, studies by industry, and results of recent geological field studies. Information in this volume comes from prospectors, exploration and government geologists, mining companies, and students, all of whom are willing to contribute to public geoscience for the benefit of the scientific community, general public and mineral industries of Yukon. Their work is appreciated.

In this last revolution of Earth around the sun, not much seems to have changed. Okay, so we can say the Yukon experienced above average amounts of precipitation during the cold months that resulted in above normal water levels in many lakes and rivers during the summer. And, maybe we can also say that our summer seemed a little warmer and drier compared to previous years. But, what didn't change was the continued efforts of my colleagues at the Yukon Geological Survey to provide geoscience information and support to our clients. Although YEG season may seem like a love-hate relationship to many, I do appreciate the work of all those who have authored and/or reviewed papers in this year's volume. Thank you all.

Input or suggestions that you may have to improve future YEG publications are welcomed. Please contact us at (867) 667-8519, or by email at geology@yukon.ca.



Karen MacFarlane

Yukon Exploration and Geology Overview 2021

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Yukon Geological Survey 2021 overview

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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.

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Snapshot of YGS

YGS' organizational chart is shown in Figure 1. Two new staff joined the survey in 2021 on a term basis. Sarah Sternbergh was hired in January, 2021 to support the survey's geothermal research program. She will be lead on managing the thermal gradient drilling program and associated aspects of the project. Derek Cronmiller was hired in April, 2021 to lead work on geohazards related to permafrost in communities and along highway corridors. His work also involves assessing thaw impacts of glaciers. Both new employees will be contributing to commitments made under Yukon's "Our Clean Future" initiative, which was launched in 2020.

Temporary assignments for Olwyn Bruce and Tiffani Fraser were both extended for a year; they are scheduled to return to YGS in the fall of 2022 and 2023, respectively.

YGS budget

YGS' operating budget for 2020-21 totaled \$4.3M. Table 1 presents a breakdown of these funds and the activities they support.

Funding for the Yukon Mineral Exploration Program was returned to its pre-COVID level of \$1.4M in 2021. Mid-way through the fiscal year, the Canadian Northern Economic Development Agency (CanNor) provided an additional \$80K to support a modest increase in the number of supported projects.

Funding to support geothermal studies was received from two sources: Natural Resources Canada (\$955K under their *Emerging Renewable Energy Program*) and Yukon government as a commitment under *Our Clean Future* (\$345K).

Permafrost studies and glacier monitoring are funded through *Our Clean Future* (\$125K) and Crown-Indigenous Relations and Northern Affairs Canada's *Climate Change Program* (\$55K).

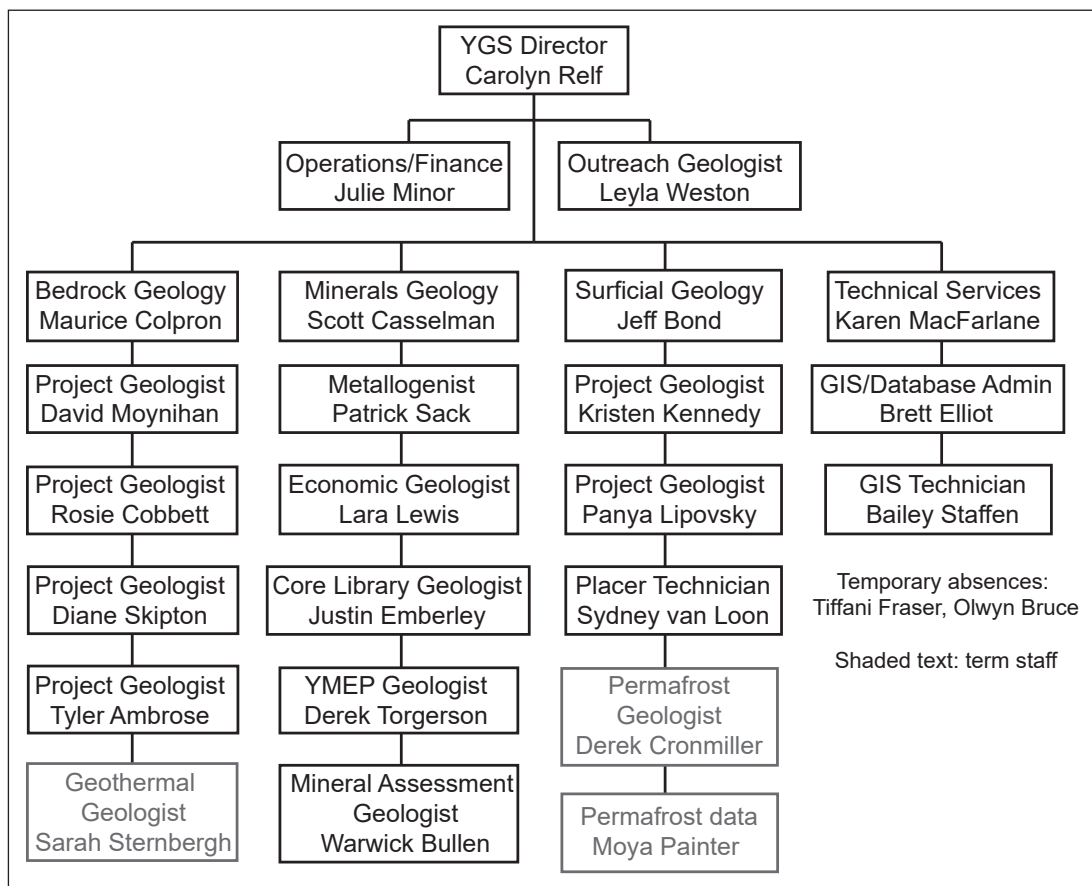


Figure 1. Organizational chart for Yukon Geological Survey, November 2021.

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
Total		\$4305K

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).

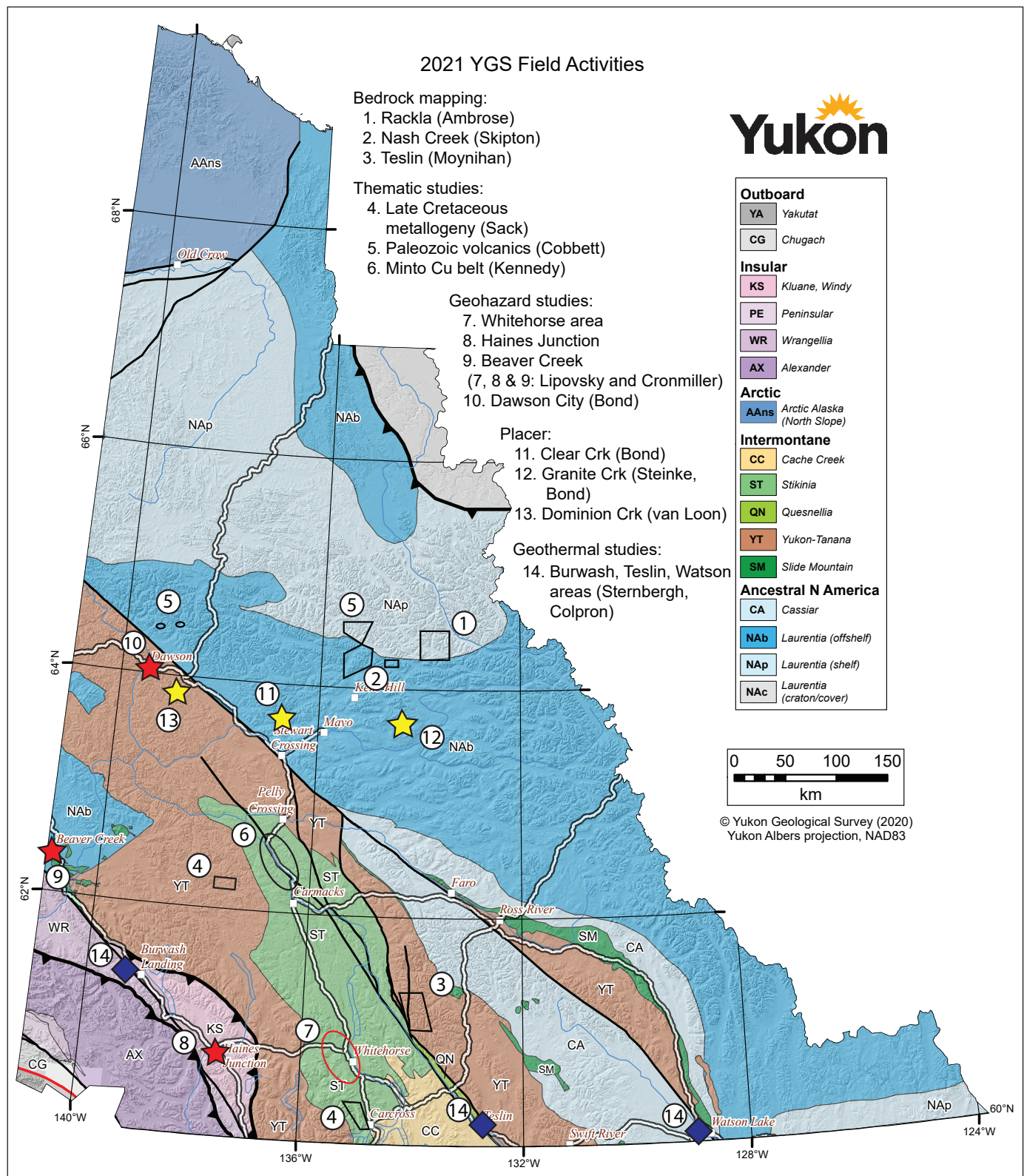


Figure 2. Map showing locations of 2021 field work by YGS staff.



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).

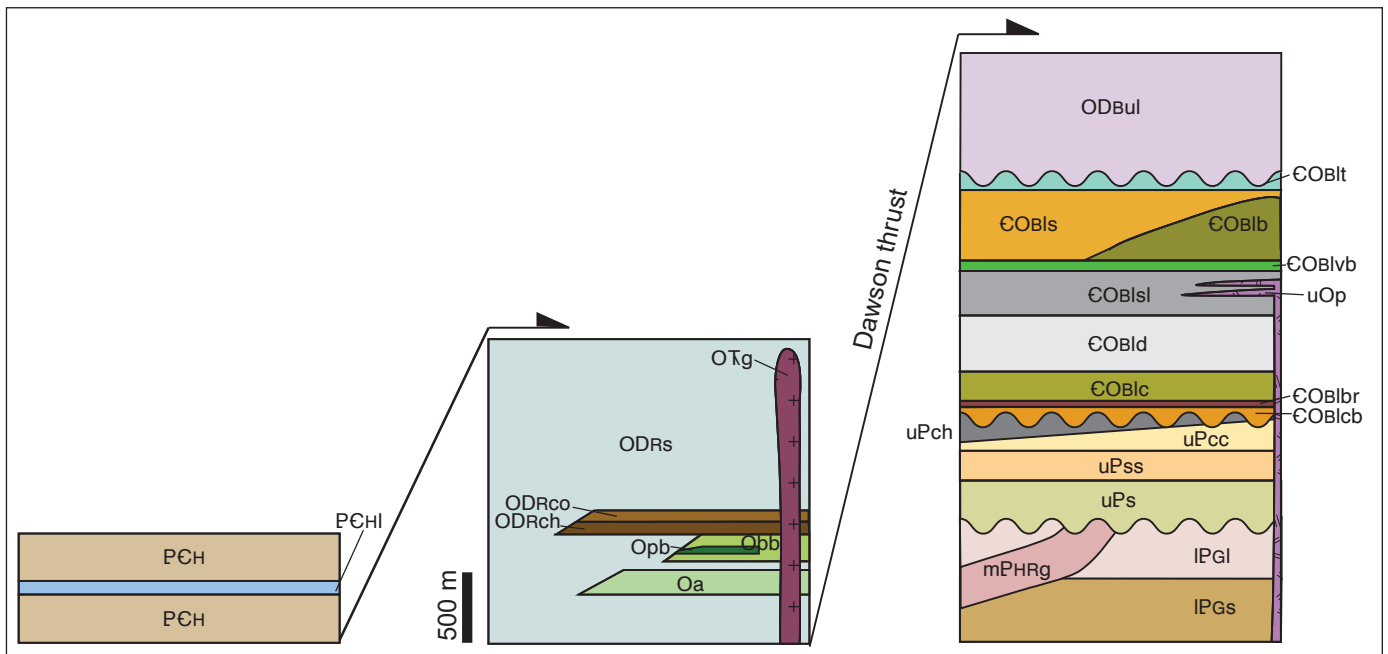


Figure 4. Updated stratigraphic section for the Castle Mountain and McKay Hill areas. For detailed description see Cobbett (2022).

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.

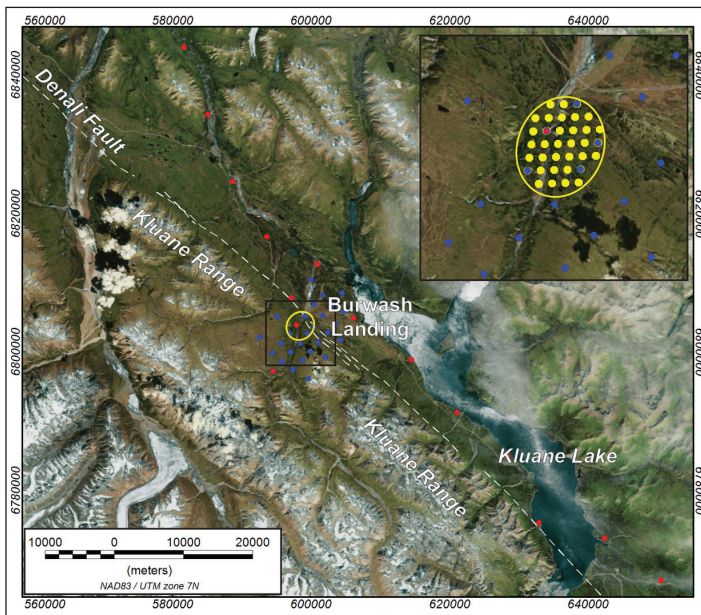


Figure 5. Locations of MT stations deployed in the Burwash Landing area. Symbols: yellow dots - detailed grid of audio-frequency MT stations near drill target; blue dots - broader array of MT stations surrounding drill target; red dots – regional MT stations.

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).

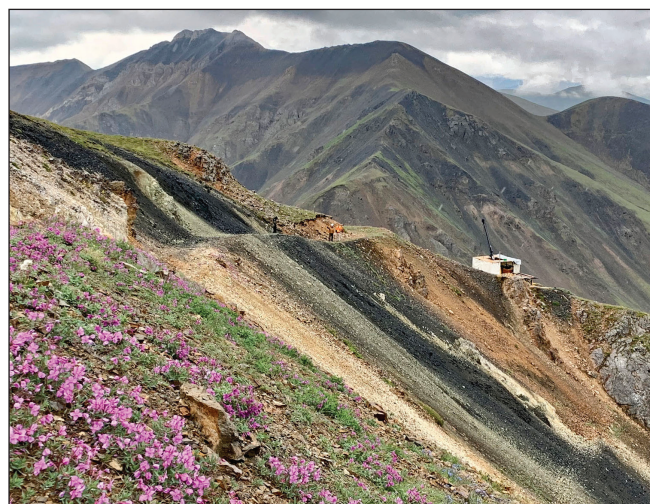


Figure 9. Drill working at Nickel Creek Platinum Corp.'s Nickel Shāw Ni-PGE-CO-Cu deposit.

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)). 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.

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Yukon placer mining 2021 development and exploration overview

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van Loon, S. and Bond, J.D., 2022. Yukon placer mining 2021 development and exploration overview. In: Yukon Exploration and Geology Overview 2021, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 17–27.

Introduction

Yukon's placer mining industry continues to display its resilience through another mining season during a worldwide pandemic. The pandemic continues to bring delays and challenges that affect many facets of the industry, ranging from interruptions in the supply chain to isolation requirements for workers. Despite these challenges, production value remained high, and new production was noted from a number of creeks that have not produced in the recent past. With an expanding number of placer creeks producing and stable production from the traditional mining areas, the industry continues to display its economic significance for the territory.

Climate for mining

The 2021 mining season was delayed in most districts due to high precipitation throughout the winter months. Favorable sluicing conditions arrived by early May in Dawson, with average daily high temperatures of 15°C. Southern Yukon also experienced warm spring conditions, which prompted rapid snowpack melt, causing high water levels in most prominent drainages. The Yukon River swelled, and flooding occurred in the Southern Lakes region including Lake Laberge, Marsh Lake and in several Yukon communities. As high temperatures continued throughout summer, water levels subsided and precipitation remained low across the territory. In Dawson, only 33 mm of precipitation was recorded in the two-month period from June 7 to August 7. Favorable weather across the Yukon continued into the fall, with a late onset to winter. The first temperature reported below -10°C was recorded on October 18. Minimal precipitation accumulated in late fall and several operators in the Dawson area sluiced later than anticipated.

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Gold production and value summary

Based on export tax reporting, as of November 8, 2021, Yukon placer gold production is 77,695 crude ounces, (Fig. 1). The average gold price this season was CDN\$2243, which amounts to CDN\$139 million in production revenue. This marks the fifth year in a row where production exceeded 70,000 crude ounces, which speaks to the industries stability. Production remained high despite challenges and growing mining costs; diesel price is up 12% this year compared to last year.

Growth in the industry is evident; one new and five formerly dormant creeks report production this year. Twelve Mile Creek, in the West Yukon district, is a new placer drainage reporting production. Creeks that have been dormant for many years, but recorded production this season are Australia Creek (Indian), Boucher Creek (West Yukon), Gem Creek (Mayo), Bennett Creek (Mayo) and Webber Creek (Nansen). The price of gold remains high, which promotes strong and consistent production, and when paired with exploration occurring in most placer districts, suggests an increase in production is likely into the near future.

Development highlights

Indian River

The Indian River drainage continues to be the main placer producing district, yielding a total of 26,698 crude ounces this season. This accounts for 34% of the Yukon's total placer gold production (Fig. 2). Production decreased by 12% this season when compared to production in 2020. The main stem of the Indian River remains the largest contributor, producing 56% of the gold derived from the district. Dominion Creek is the second largest contributor, reporting 19% of the reported production from the Indian River drainage. The third largest contributor to Indian River production is Sulphur Creek producing 8%, followed closely by Wounded Moose Creek at 7%.

Slate River Mining, operating on lower Indian River, is recognized this season for their exceptional reclamation work, and they were the recipients of this years' Robert E. Leckie award. The three-person operation uses excavator mounted conveyors, which reduces fuel consumption. The operation uses efficient mining techniques allowing them to process and reclaim a

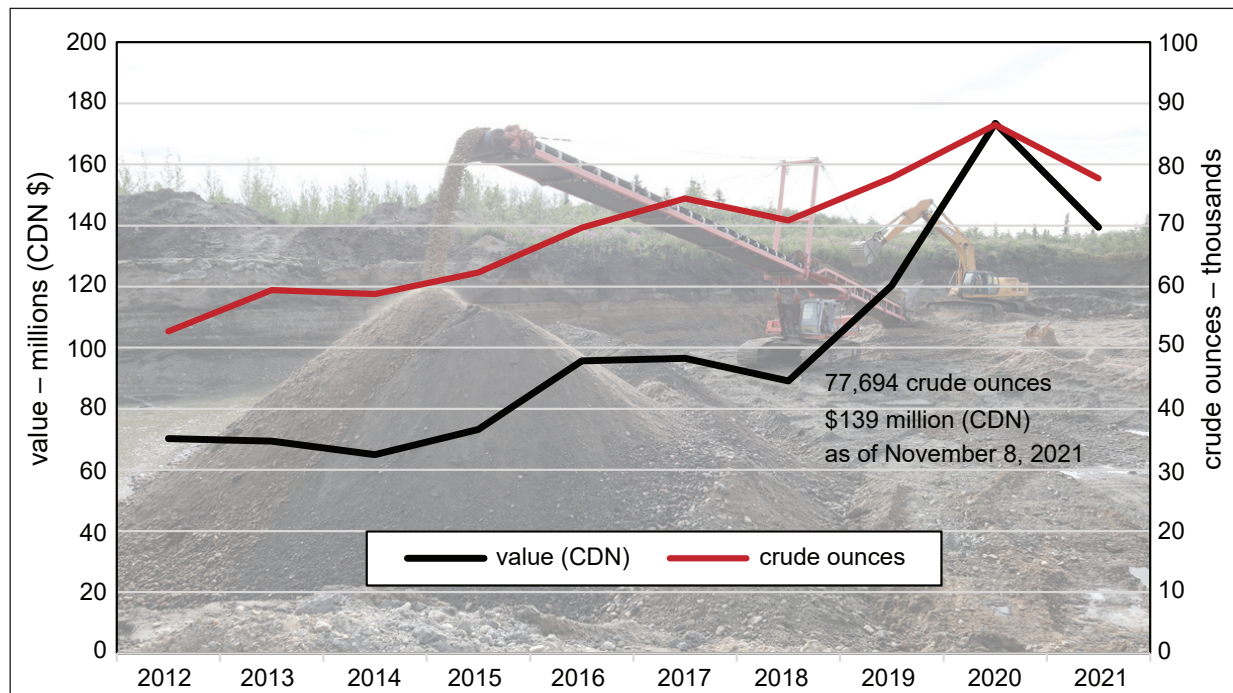


Figure 1. Total placer gold production in crude ounces and its value in Canadian dollars from 2012 to 2021.

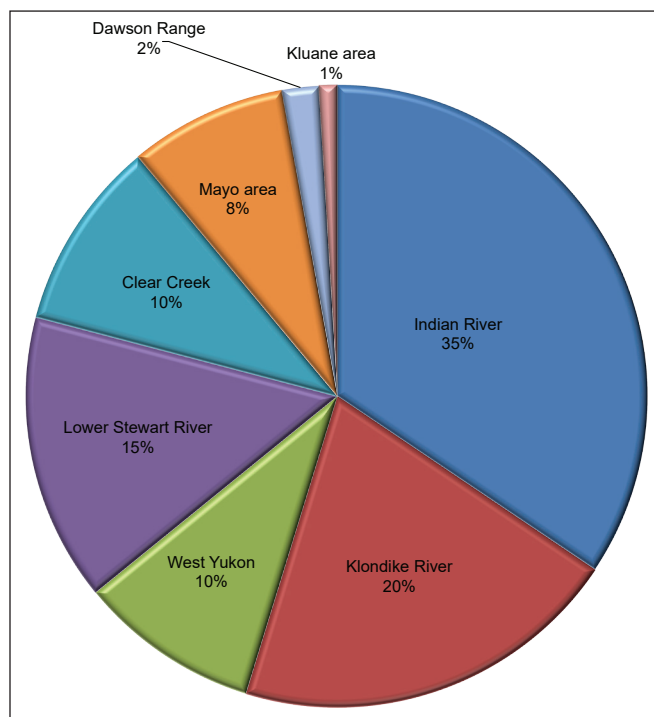


Figure 2. Distribution of placer gold production by district in 2021.

substantial amount of ground effectively (Fig. 3). Having been active on the lower Indian River since 1994, they are a long-standing operator that takes pride in their mining techniques and reclamation work.

A significant geologic discovery occurred on the left limit bench of Indian River in the fall, on Fine Gold Resource's property. As the operator continued to mine laterally into the limits of the valley, a White Channel gravel terrace was encountered. The Indian River and local tributaries have eroded into the White Channel terrace and reworked gold from the deposit (Fig. 4). The thickness of the terrace deposit is 14 m (45 ft) and possibly increases farther into the hillside. The White Channel paystreak volume within the terrace remains unknown, however strong production in recent years adjacent to the terrace suggests some of it has been reworked. Trending upstream into the Australia Creek drainage, this Pliocene deposit could be extensive and become a significant gold contributor to the Indian River drainage.



Figure 3. Slate River Mining's cut and processing plant on the lower Indian River.



Figure 4. Fine Gold Resources cut in 2021 where they exposed a White Channel terrace on the left limit of Indian River.

There was a hub of activity this season near the mouth of Australia Creek: Lonesome Dove Mining was sluicing on the lower portion and Metallic Minerals was exploring farther upstream. Two drill campaigns were undertaken, and a total of 21 auger, 155 sonic and 49 reverse circulation drillholes completed. In the headwaters of Australia Creek, drilling targeted the modern valley, which could consist of reworked portions of the Pliocene deposit found upper Indian River. The White Channel gravel deposit that was exposed on the Indian River is believed to be the same deposit that the drilling campaigns were targeting.

This year was the second season for NBC Contracting, who was operating on lower Dominion Creek, leasing claims from Gimlex. A left limit cut with a 3.6 m (12 ft) sluice section was the target for the season, and they sluiced over 200,000 yd³ (152 910 m³) of material. A project funded by a Yukon Mineral Exploration Program (YMEP) grant last year delineated the cut worked this season. Later in the 2021 season the company explored for potential *in situ* gravel preserved beneath dredge tailings and had encouraging results. As exploration continues the far limits of the valley continue to prove economic and they extend their operations farther laterally in the valley.

Whitman Gulch, a left limit tributary of Gold Run Creek operated by 536784 Yukon Inc. is one of three monitoring operations in the district (Fig. 5). This season the two-person operation sluiced 4000 loose yd³ of material from the narrow drainage. Pay gravel thickness varies from 0.3 to 1.5 m (1–5 ft) in the narrow gulch. Numerous old-timer workings such as ladders and shafts were encountered, along with an abundance of Ice Age mammal fossils.

Treadstone Aggregate is not new to working the upper Eureka Creek drainage, but the placer setting they targeted this season was. For the first time, the modern gulch bottom of upper Eureka Creek was mined by the 12-person crew. Old-timer shafting was encountered, but this season was the first time any mechanized mining has occurred in that locale. Overlying the coarse, muddy gravel was a thick section of loess containing massive ice. A cut from last year on the left limit Pliocene bench deposit was extended.

Favron Enterprises mined two different dredge deposits on Sulphur Creek this season. The first cut they mined was a continuation of last years work and targeted virgin Sulphur Creek gravel under dredge tailings (Fig. 6). A sonic drill program completed in the spring



Figure 5. Monitoring at Whitman Gulch conducted by 536784 Yukon Inc.; one of three monitoring operations in the Indian River drainage.

discovered a lateral continuation of 1.2 m (4 ft) of virgin gravel, which allowed delineation of a cut. The second setting they mined was on the left limit, outside of the dredged area. Despite lower Sulphur Creek undergoing significant dredge activity in the past, minable deposits continue to be discovered. With a crew of eight employees, they sluiced 180,000 yd³ (137 620 m³) of material, and exploration within the dredge limits is expected to continue next year.

Klondike River drainage

The Klondike River is the second highest placer gold producing district in the Yukon; 15,773 crude ounces were reported, which accounted for 20% of the total production in 2021. The top three Klondike River drainages are Paradise Hill, Lovett Hill and Hunker Creek with 4156, 2734 and 2705 crude ounces reported respectively.

Minimal activity has occurred on All Gold Creek in recent years, but a new operation commenced this season. M&M Mining initiated operations on the high-level bench deposit on the left limit of the drainage



Figure 6. Right limit cut on lower Sulphur Creek at Favron Enterprises Ltd. In situ Sulphur Creek gravel is situated on bedrock under dredge tailings.

that Dulac Mining last pursued in 2016. Leasing from Dulac Mining, M&M Mining completed a sizable cut using two mini-excavators. The father-and-son team began to understand the characteristics of the heavy pay channel as the season progressed and they panned their way throughout the cut to determine the limits of the pay channel.

Kohlman Exploration leased a portion of their property to J. McIntyre this season, and he was able to expose virgin Bonanza Creek gravel. Outside of the dredge limit an 18 by 55 m (60 × 180 ft) cut was made on an outside bend of Bonanza Creek, downstream from the mouth of Fortynine Gulch. Bonanza Creek pay gravel was up to 2 m (6 ft) thick and consisted of very coarse boulders, overlain by colluvium and organics (Fig. 7).

On upper Eldorado Creek, Bear Creek Logging spent their first season mining at the confluence of Chief Gulch and Eldorado Creek, under an option agreement

with Dulac Mining. The three person operation focused on mining the bedrock surface, and sluicing up to 1.2 m (4 ft) of bedrock. Cumulatively they sluiced 8000 loose yd³ of material and also completed reclamation on ground previously mined by Dulac Mining.

Unusual bedrock was uncovered at the mouth of Last Chance Creek by Ace Placer Mining Ltd. this season. A basalt flow was revealed when a cut on a low-level bench of Hunker Creek was stripped to bedrock. The basalt is a unit of the Carmacks Group, which is a Late Cretaceous volcanic group (72 Ma). As the basalt was deposited, it flowed over a laminated, fine-grained sediment (Fig. 8). This was the second season that the Sailors targeted a series of low-level benches on the left limit of Hunker Creek that have been buried by a thick section of frozen black muck. On the downstream side of the bench, flow direction indicates the gravel is



Figure 7. Virgin Bonanza Creek gravel exposed at J. McIntyre's cut in 2021. Jeff Bond is used for scale to depict the coarseness of the gravel.



Figure 8. The bedrock exposure on the low-level Hunker Creek bench targeted by Ace Placer Mining Ltd. in 2021.

derived from Last Chance Creek, suggesting that the tributary eroded and reworked the continuous Hunker Creek bench that was once present. Not only did they uncover intriguing bedrock, but a considerable amount of old-timer workings were also found.

A new operation moved into the mouth of Hunker Creek last year, and a first full season of sluicing commenced this spring. Slonski and Elgie operated with a five-person crew and sluiced 200,000 yd² (167 225 m²) of material. The main target for the operator is Klondike River gravel situated on the bedrock contact, which is overlain by 3 m (10 ft) of sand derived from Hunker Creek (Fig. 9).



Figure 9. Slonski and Elgie's cut on the left limit of the Klondike River valley. The stratigraphy consists of Klondike River gravel overlain by sand derived from Hunker Creek.

West Yukon

The Sixty Mile River accounts for the majority of production from West Yukon, with 4831 crude ounces reported this season. Production from its tributaries remain steady with 559 crude ounces from Bedrock Creek, 522 crude ounces from Ten Mile Creek and 353 crude ounces from California Creek. Two drainages to highlight for their production in West Yukon this season is Boucher Creek, which was previously dormant; and Twelvemile Creek, a new placer producing drainage for the territory.

K-1 Mining focused their efforts in the modern valley of Bedrock Creek this season. With a crew of up to four employees they spent 500 hours sluicing (Fig. 10). Exploration has been conducted on the left limit bench in the drainage. A season mining in the valley bottom resulted in intermittent gold distribution, indicating that the main pay channel may partially remain locked up on the bench.

Hardclay Resources Services was active for their sixth year on California Creek. Since 2016, they have optioned the claims from Yukon Exploration Green Gold Inc. and mined in the valley bottom and a right limit bench deposit. This season they formed a partnership with F. Lewis of the Gold Rush TV show, which increased activity in the drainage.

Lower Stewart River

Production from lower Stewart River has slightly decreased from last year, but still reported 11,602 crude ounces this season. Henderson Creek is the major contributor with 5332 crude ounces, following with Barker Creek (1643 crude ounces), Kirkman Creek (1003 crude ounces) and Scroggie Creek (947 crude ounces). Production has been cumulatively increasing in lower Stewart River since 2018, and is the third highest gold producing district in the Yukon.



Figure 10. K-1 Mining & Services sluicing at their operation on Bedrock Creek. The view is looking upstream.

Schmidt Mining relocated their Barker Creek operation from mid-drainage to the mouth, near its confluence with the Stewart River. A 450,000 ft² (41 806 m²) cut, ranging in thickness from 3.7 to 4.3 m (12–14 ft) was completed. The new location is much shallower compared to their previous location 12 km upstream where overburden was up to 11 m (36 ft) thick.

HC Mining had a successful season on Henderson Creek, completing two large cuts lower in the drainage. The larger cut was located on the right limit, and extended a length of 1.5 km. Up to four wash plants were employed at the same time and enabled the operator to sluice material at a rate of up to 500 yd³ (382 m³)/hr. A second cut on the left limit of the drainage was located at the mouth of a small unnamed tributary. Grades increased at this location because the tributary had reworked high-level bench gravel into the valley bottom.

In Black Hills Creek, Stuart Placer Ltd. mined upstream from Kernine Creek and sluiced a total 100,000 yd³ (76 455 m³) of material this season (Fig. 11). Stratigraphy in Black Hills Creek is consistent except where tributary confluences are encountered; tributaries contribute local gulch gravel to the drainage and overlie modern Black Hills Creek gravel. At the end of April 2021 the drainage lost long-time miner Richard Cull. His legacy will remain along dozens of Yukon placer creeks.



Figure 11. A large cut on the right limit of Black Hills where Stuart Placers spent the season mining.

Clear Creek and Mayo areas

Production in Clear Creek progressively increased from 2018 to 2020. Several large operators in the area were responsible for the districts growth. With changes in mining locations and scale of operations this year, production decreased by 25%. The major contributors in the Clear Creek and Mayo areas are Josephine Creek, Granite Creek and Clear Creek.

Josephine Creek was the top producer in the Clear Creek and Mayo districts, reporting 3863 crude ounces this season. Schmidt Mining Corp. spent several seasons preparing to mine the drainage, but did not conduct extensive sluicing until this season (Fig. 12). The drainage is a glaciated valley, with and the majority of placer gold is situated in till. Surficial material thickness is shallow, with only 5 m (16 ft) of overburden. The pay unit, a matrix-supported till is up to 0.9 m (3 ft) thick and situated on the bedrock contact. Two populations of gold are recovered from Josephine Creek; flattened nuggets and subangular, chunky gold with quartz inclusions.



Figure 12. Schmidt Mining processing up to 150 yd³/hr on Josephine Creek in 2021.

P. Phillips continued to progressively mine upstream at their property on right fork Clear Creek. This year they intercepted an alpine till on the left limit, which they had not encountered before. This marks the limit for the maximum extent of locally derived ice from the headwaters of Clear Creek. Stratigraphy changes at this limit as the till overlies local Clear Creek gravel, and may be responsible for, or a contributor of the gold in the drainage. The Phillips mined with a crew of five employees and sluiced material at a rate of up to 80 yd³ (61 m³)/hr with their trommel.

Bennett Creek, is a tributary of Minto Creek in the Mayo Mining district. The creek has been historically worked but more recently explored by S. Wozniak and K. Wilson. This season marks the first time that the creek has been mechanically mined. K. Wilson relocated from Minto Creek and began test mining the lower portion of the drainage where it empties from the confines of a narrow valley. Sonic drilling was completed to map gold distribution in the lower portions of the drainage.

Lower Hight Creek was dormant for several decades until Stepler Mining moved in early this spring. They optioned the ground from M. Powers and with a three person crew sluiced 15,000 yd³ of material from a right limit bench (Fig. 13). Stepler Mining is not new to the district; they previously mined on the upper end of Hight Creek and on a tributary to Mayo Lake.

Granite Creek continues to have strong production, producing 3120 crude ounces this season from four operations (Fig. 14). The main claim owner, J. Davies,



Figure 13. Stepler Mining spent the season on Lower Hight Creek working ground leased from M. Powers.

leases ground to Earth and Iron, Dulac Mining and Gem Steel. Operations in Granite Creek continue to target till overlain by a thick package of outwash gravel and glaciolacustrine sediment. Earth and Iron worked an 80 by 130 m (262 × 426 ft) cut throughout the season and processed material at 200 yd³ (153 m³)/hr in their double screen deck. Dulac Mining operated with a crew of up to eight personnel and targeted a sluice section 6 m (20 ft) thick. Gem Steel was active on Albert Creek, a right limit tributary to Granite Creek. This year was their first season sluicing in the drainage and they processed the coarse pay gravel with a custom built Derocker that fed into a screen deck.

Field research towards a Masters of Science project was completed in Granite Creek this summer by Jessi Steinke. This project, under the supervision of Dr. Brent Ward (Simon Fraser University) and Jeff Bond (Yukon Geological Survey), aims to characterize the placer settings within the alpine glaciated environment. Her initial results are reported in this volume.

Dawson Range and Kluane areas

Production from the Dawson Range area decreased from 2274 crude ounces in 2020 to 1487 crude ounces in 2021. This 35% decrease in production could be contributed to a general decrease in activity in the Freegold and Nansen Creek area. Despite the decrease, strong production was reported from Canadian Creek. The next highest producing creeks are located in the Nansen district; Rabbit Creek and Nansen Creek.



Figure 14. View looking up Granite Creek valley with Dulac Mining's cut in the foreground.

With new exploration occurring in this area, growth is expected in the coming years.

Batavia Mining was active on the upper end of Canadian Creek for their third season. The New Zealand owned company had up to four employees and sluiced 80,000 yd³ (61 164 m³) of material this season. Two placer settings were mined; a low-level right limit bench of Canadian Creek, and the modern gulch bottom of the right limit tributary, Patton Gulch (Fig. 15). Gold in the drainage is sourced locally from the Casino copper, gold, molybdenum and silver deposit situated in its headwaters.

Placer activity increased in the Casino area, with exploration occurring on Sunshine Creek and Isaac Creek this season. These are two tributaries of the Yukon River that drain to the east, from the Casino deposit. Ryanwood Exploration conducted a geophysical survey and completed 61 drillholes on Sunshine Creek and 10 drillholes on Isaac Creek.

Webber Creek has been inactive for a number of years' until Capital Gold Mining Corp. moved in this season. Situated in the Nansen district, this large tributary to Nansen Creek contains the typical thick deposit of sand at the base of the north facing slope. The sand posed a challenge for the five person operation, but they had a successful season.

In the Ruby Range, Gladstone Creek and Rabbit Creek, a tributary to Forth of July Creek, were the main producers. They reported 383 and 312 crude ounces, respectively. Tic Exploration on Gladstone Creek has been present in the drainage for three decades and they continue to target low-level benches, reworked modern gravel, and historic tailings. This season they employed up to six people. Rabbit Creek, to the east of Gladstone Creek, was mined by FTG Placers for the first half of the season. Later in the season they relocated to the Mayo area.



Figure 15. Active cuts on upper Canadian Creek in 2021. The view is looking downstream with Patton Gulch on the right side of the photo (Photo credit: Patrick Sack).

Yukon Mineral Exploration Program 2021 update

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Torgerson, D., 2022. Yukon Mineral Exploration Program 2021 update. In: Yukon Exploration and Geology Overview 2021, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 29–34.

Program Summary

The Yukon Mineral Exploration Program (YMEP) is a Government of Yukon funding program which provides financial support to proponents exploring for minerals in Yukon. Individual prospectors, partnerships, private and publically listed companies are eligible to apply. YMEP funding has led to numerous discoveries and provided significant economic benefits to the territory through direct program spending and development investments.

There are four modules in the program: three modules (Grassroots, Focused Regional and Target Evaluation) support hard rock projects at different stages of exploration, and one module supports exploration for placer resources. Detailed information on project modules and levels of funding can be found in the YMEP guidebooks (<https://yukon.ca/en/mineral-exploration-funding>).

YMEP 2021

YMEP funding for the 2021–22 season was \$1.4M. The Canadian Northern Economic Development Agency (CanNor) contributed an additional \$80 000 to the YMEP budget. The funding ratio for Target Evaluation and Placer projects remained at a 60/40 (YMEP/proponent) for up to \$40 000 of funding for the 2021–22 season. The funding ratio for Focused Regional programs is 75/25 (YMEP/proponent) for up to \$25 000 of funding, and 100% for Grassroots projects for up to \$15 000 of funding.

The ongoing COVID-19 measures, while lessened, continued to affect exploration activities in 2021. The NRCan exploration spending projection for the territory was estimated to be \$98.5M for the 2021 season (<https://mmsd.nrcan-rncan.gc.ca/expl-expl/ExploTable.aspx?FileT=022020&Lang=en>). This estimate is slightly greater than the 2020 expenditures and indicated a recovery in exploration and a return to more normal, pre-pandemic levels.

In 2021, 76 applications were submitted, seeking in excess of \$2.4M of funding. These included 5 applications for the Grassroots module, 14 for the Focused Regional module, 24 for the Target Evaluation module and 33 for the Placer module. Fifty-two projects were selected for funding: 32 hard rock exploration projects (1 Grassroots, 9 Focused Regional, and 22 Target Evaluation); and 20 placer projects.

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Table 1 shows the project approval statistics from 2016 to the present. The table also shows the distribution of funding between individuals, private companies and public companies. Since the creation of the Placer module in 2015 there has been a steady increase in the percentage of funding allocated to placer projects. Prior to 2015 placer exploration was typically funded in the Target Evaluation module and historically averaged 25% of the allocated funding. In 2021, placer exploration accounted for 41% of YMEP funding; the same proportion as in 2020.

Figure 1 shows the location of the 52 active YMEP projects in 2021. The majority of placer projects are centered in the Klondike placer district (nine); one project is in the Fortymile area; four projects are in the Mayo/Keno area; two are in the Clear Creek area; two are in the Kluane region; one is in the Mt. Nansen area; and one is in the Livingstone Creek area. The majority of hard rock projects are concentrated in the area between Dawson and Mayo/Keno. The remaining projects are scattered from the Dempster Highway in the north to the Yukon-BC border in the south, and from the Alaska border in the west to the Northwest Territories border to the east. Gold is the most sought after hard rock commodity with seventeen proponents exploring for structurally-controlled, epithermal, Carlin

style, intrusion related, or orogenic gold. Other targets of interest include vein-hosted silver (5), porphyry copper (3), vanadium (1), cobalt (1), zinc (1), magmatic massive sulphide copper/nickel/PGE prospects (1) and rare earth elements (1). The distribution of targeted commodities is illustrated in Figure 2.

As of the end of November, the majority of YMEP projects have been successfully completed. Final results and reports are expected in early 2022.

Economic benefits of YMEP

The economic benefits of YMEP can be divided into three general categories: short-term local economic impacts, same-year discoveries, and longer term investment in successful discoveries.

Short-term local economic benefits

Short-term economic benefits of YMEP include spending by proponents on local hiring, local contracting and local purchasing. To help quantify these benefits YGS has added a survey to the Final Report Form, which is to be completed by grant recipients upon submission of their final report. This submission will quantify direct expenditures which benefit Yukon-based employees contractors, service and supply businesses.

Table 1. YMEP funding allocation from 2016–2021.

Approved projects	2016-17		2017-18		2018-19		2019-20		2020-21		2021-22	
	No. of projects	% of funding	No. of projects	% of funding	No. of projects	% of funding	No. of projects	% of funding	No. of projects	% of funding	No. of projects	% of funding
Placer	15	26	21	35	22	36	18	37	41	41	20	41
Hard rock	34	74	38	65	40	64	33	63	61	59	32	59
Total projects	49		59		62		51		102		52	
Prospectors/ individuals	24	39	18	29	28	46	19	37	38	37	21	37
Private companies	16	30	22	26	17	27	18	35	30	29	17	35
Public companies	17	31	19	45	17	47	14	28	34	34	14	28

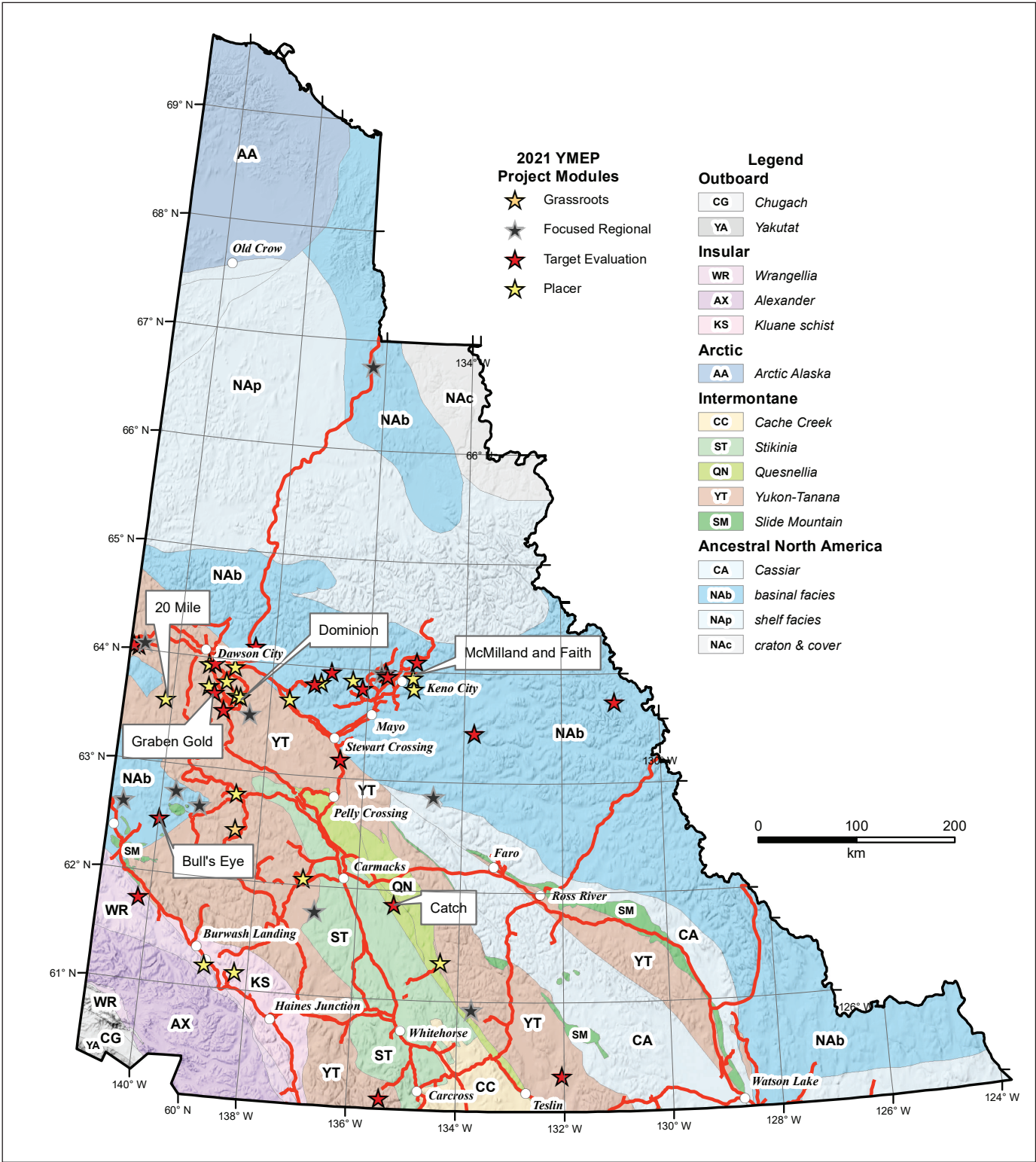


Figure 1. Approved YMEP projects in 2021.

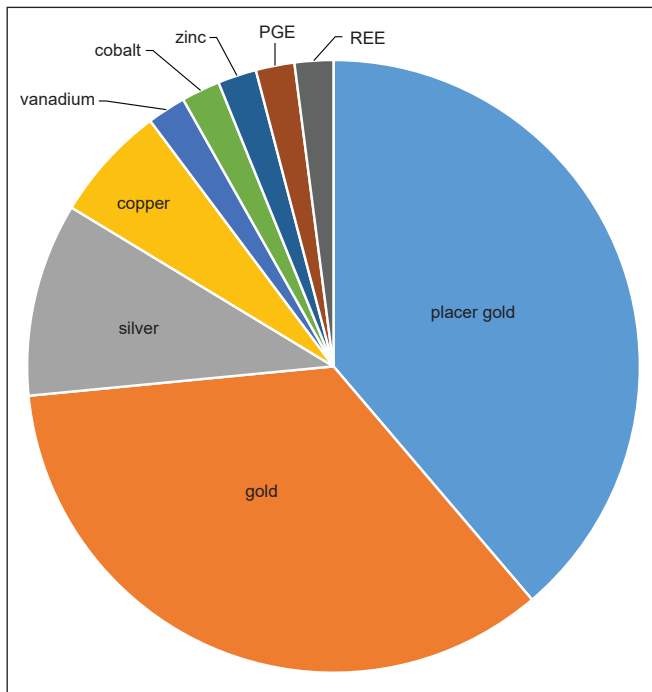


Figure 2. Commodities targeted by YMEP projects in 2021.

Same-year discoveries (2021 successes)

Exploration successes for 2021 are projects that have resulted in new discoveries or have made a significant advancement of an lesser understood previous discovery that we believe have potential to lead to further investment in mineral exploration. Every year a number of YMEP-funded projects stand out as having demonstrated exceptional initial results. Some of these projects are able to raise new funding on equity markets to conduct additional work in the same field season; others are able to enter into property option agreements. New discoveries commonly fuel property and district-scale exploration well into the future, and some progress to advanced stages of exploration. This section highlights some of the 2021 projects that yielded early success.

Bullseye Property

In 2021, Golden Sky Minerals Corp. completed a Target Evaluation-supported RC drilling program on their Bullseye property. The property is located in the newly emerging Wels gold district, north of Wellesley Lake.

The 384.05 m, 5 hole program was designed to test the Gold Crest Zone along a 150 m strike length and up to 100 m depth. The Gold Crest Zone is marked by a significant 500 × 200 m gold-in-soil anomaly with values up to 216 ppb gold. The soil anomaly is open to the north and south and appears to follow a major regional shear which has developed along a schist-mafic intrusive contact. Trenching in 2020 defined a significant mineralized zone that assayed 0.69 g/t gold over 78 m, including 1.03 g/t gold over 44 m. Highlights from the 2021 drill campaign include 25.91 m of 1.88 g/t gold, with a narrower interval of 12.19 m of 2.54 g/t gold in hole BERC-21-4 (<https://goldenskyminerals.com/golden-sky-minerals-corp-drills-1-03-g-t-au-over-80-77-meters-in-discovery-drill-hole-at-bullseye-property-yukon-territory/>).

Grabben Gold Project

Kestrel Gold Inc. received a Target Evaluation grant to support a program of RC drilling at their Grabben Gold property. The property, located in the heart of the Klondike, covers a sequence of mid-Cretaceous sedimentary rocks overlain and intruded by Late Cretaceous volcanic and intrusive rocks. The company targeted two areas in the Grid Zone, an open-ended 900 m long by 250 m wide gold-arsenic-bismuth-antimony soil anomaly. They drilled nine holes for a total of 557.9 m. Intervals of variably clay altered, bleached, limonitic and fractured intrusive rocks as well as a similarly altered and fractured sedimentary sequence consisting of alternating mudstone, siltstone and conglomerate were encountered in all of the holes. The geological setting and geochemical signature suggest the potential for an intrusion-related gold system. Highlights of the program include hole GRB21-007 which returned 6.1 m of 0.34 g/t gold and 66.12 g/t silver. The Grabben Gold project has advanced from a grassroots project which was discovered by a local Yukon prospector to a drilled prospect warranting further drill testing (<https://www.kestrelgold.com/news/august-03-2021>).

The Catch Property

Prospector Ryan Burke received YMEP funding for a grassroots exploration play north of Whitehorse in 2020. This led to the discovery of interesting soil

geochemical anomalies of gold and copper and the staking of quartz claims known as the Catch property. In 2021, Burke received a Target Evaluation grant to conduct further evaluation of the property. Fieldwork consisted of geological mapping, soil, till and rock sampling, and hand trenching of the copper-gold soil anomalies. The target at Catch is porphyry-style mineralization hosted by Triassic volcanoclastic rocks which may be intruded by a mid-Cretaceous intrusion. Assay results from 2021 rock sampling include values up to 52.4 g/t gold and 41.7 g/t silver. Till geochemical results have yielded significant geochemical responses in a number of areas, with peak values of 2.4 g/t gold and >10 000 ppm copper (Ryan Burke, personal communication).

Placer Successes

In addition to the hard rock successes outlined above, a number of YMEP-funded placer exploration projects have yielded early success from 2021 fieldwork. These include NBC Contracting's project on Dominion Creek, GroundTruth Explorations work on Twenty Mile Creek, and Earth and Iron's exploration on McMillan and Faith creeks. In all three cases, the exploration results have defined areas that have led to a mining decision. Details of these projects are presented in van Loon and Bond (2022).

YMEP successes over the long term

The impact of YMEP can be measured by projects that advance further along the exploration-mining cycle, to the resource definition, feasibility and/or production stages. The more a project advances, the more significant its impacts for Yukon in terms of employment, business opportunities and infrastructure development. An example of a longer-term YMEP success is presented below.

Aurex-McQueston (AurMac) Property

In 2016, StrataGold Corp. conducted a Target Evaluation-funded program in the amount of \$51 793 on its Aurex project, located near Keno. The program consisted of the collection of 757 soil samples and 8 rock grab samples. Assays up to 315 ppb gold were returned for soil samples. In 2017, Banyan

Gold Corp. optioned the property and completed an exploration program consisting of a property-wide soil geochemical survey (1114 soil samples), 464 m of trenching and 1422 m diamond drilling in 10 holes (<https://www.banyangold.com/news-releases/2017/banyan-completes-first-year-earn-in-commitments-on-the-aurex-mcquesten-gold-project-yukon/>).

Between 2018 and 2020, Banyan applied for, and received YMEP funding under the Target Evaluation module to advance exploration on the property. They conducted additional soil geochemical sampling, geological mapping, trenching, airborne geophysics and diamond drilling. This work eventually led to Banyan releasing a maiden resource estimate for Aurex. In 2020, Banyan released a NI 43-101 compliant inferred resource estimate of 52 576 520 tonnes grading of 0.535 g/t gold for a total of 903,945 contained oz of gold (<https://www.banyangold.com/news-releases/2020/banyan-files-technical-report-for-aurmac-property-903-945-gold-ounce-initial-mineral-resource-estimate-yukon-canada/>). This resource estimate represents an approximate contained value in excess of CDN\$2.0B at current gold prices. Since 2016 YMEP has invested \$145 896.50 in the Aurex project. This investment has resulted in total exploration expenditures of greater than \$18M to date and a leverage ratio of 126:1 (company investment: YMEP investment).

YMEP success can be measured by a number of indicators such as private sector dollars leveraged, numbers of new discoveries and the value of option agreements resulting from discoveries. Table 2 documents a number of successful YMEP projects. All were initially discovered by individuals with support from YMEP, and all are now held by publically traded exploration companies.

Summary

In an attempt to provide a level of certainty and confidence in investment the Government of Yukon includes mineral exploration and mining as essential industries and they continue to invest in the YMEP program. The 2021–22 YMEP programs made a substantial contribution to the Yukon economy by

leveraging an estimated \$4.3M in additional investment. In addition to this immediate-term benefit, a number of projects yielded discoveries that are likely to spur exploration and generate economic benefits well into the future.

References

van Loon, S. and Bond, J.D., 2022 (this volume). Yukon placer mining 2021 development and exploration overview. *In: Yukon Exploration and Geology Overview 2021*, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 17–27.

Table 2. Examples of successful YMEP projects.

YMEP successful options (2000-2021)				
YMEP#	Property name	Total YMEP contribution(s)	Optioned by	Company investment or work commitment
01-011 and 15-030	Ice/Red Mountain	\$52 500	St James Gold	~\$14.6M
03-079	White Gold	\$10 000	White Gold Corp Kinross Gold	~\$86M
04-072 and 05-043	Blende	\$30 000	Blende Silver Corp	\$7.3M
05-058	Andrew	\$14 400	Overland Resources	~\$35M
09-046 09-062 10-008 11-019 12-049	Golden Culvert	\$117 000	Stratabound Minerals	~\$6.77M
04-041 and 07-043	Coffee	\$35 000	Newmont/Gold Corp.	~\$382M
07-056, 08-012 and 09-112	Toni/Sixty Mile	\$33 000	Radius Gold	~\$4.9M
03-023, 06-033 and 09-137	Scheelite/Gold Dome	\$75 000	Golden Predator	~\$1.4M
09-015	Clear Creek	\$10 450	Victoria Gold	~\$4.2M
09-016 and 017	Ten Mile Creek	\$25 600	Radius Gold	~\$0.63M
09-158	Prospector Mountain	\$30 750	Silverquest Resources	~\$3.85M
09-116	Cynthia	\$15 350	Golden Predator	~\$1.7M
10-118 and 14-010	3ACES	\$93 130	Northern Tiger Golden Predator	~\$43M
10-097	Portland	\$14 320	Taku Gold	~\$1.25M
00-069, 06-005, 06-006 and 15-014	Mariposa	\$76 000	Pacific Ridge	~\$7.3M

Yukon hard rock mining, development and exploration overview 2021

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Yukon Geological Survey

Casselmann, S.G. and Lewis, L.L., 2022. Yukon hard rock mining, development and exploration overview 2021. In: Yukon Exploration and Geology Overview 2021, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 35–52.

Introduction

Yukon mineral exploration activity in 2021 continued to be affected by the COVID-19 pandemic. However, due to measures put in place by mining and exploration companies, contractors and suppliers, and supported by the Yukon Government, the 2021 season approached “normal”. These measures also allowed the operating mines to continue to ramp-up production.

Precious and base metal prices fluctuated throughout the year as pandemic and supply chain-related issues affected markets, but generally prices remained elevated. Expectations are that year-end exploration expenditures in Yukon will be approximately \$113 million (\$75.8 million in 2020). Development expenditures for the year are expected to be \$71.5 million, up from \$53.9 million in 2020. The value of year-end hard rock metal production for 2021 is expected to be approximately \$500 million, thanks to the continued ramp up of production at the Eagle Gold mine, the restart of mining at Keno and continued operations at Minto (Fig. 1).

The number of active exploration projects dropped slightly from 106 in 2020 to 91 projects in 2021 (Appendix 1, Fig. 2). Twenty-six of the 91 projects spent more than \$1 million, while 44 projects spent less than \$500 000. Many of the smaller projects received Yukon Mineral Exploration

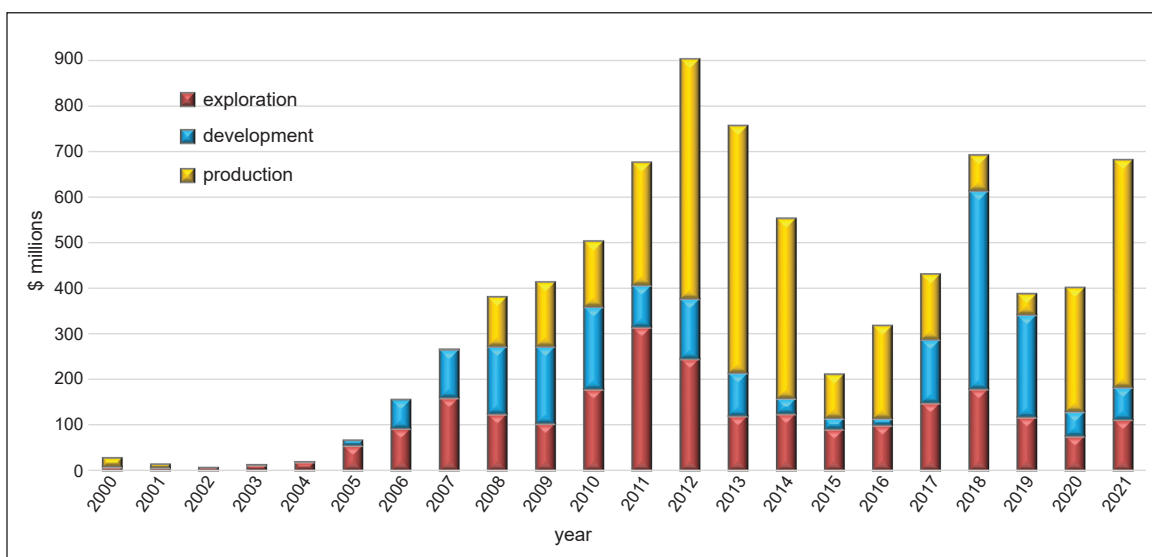


Figure 1. Estimated exploration and development expenditures on hard rock projects, and mine production values, 2000–2021.

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Yukon hard rock highlights

Program (YMEP) grant funding. YMEP funds were distributed to 32 hard rock and 20 placer exploration projects (see Torgerson (2022) in this volume for more information). In terms of all Yukon projects, gold continues to be the most sought-after commodity,

with 59% of the projects targeting the precious metal. The remainder of projects focused on exploring for copper (15%), lead-zinc (9%), silver (16%), nickel-PGEs (0.2%), and tin and others (0.2%; Fig. 3).

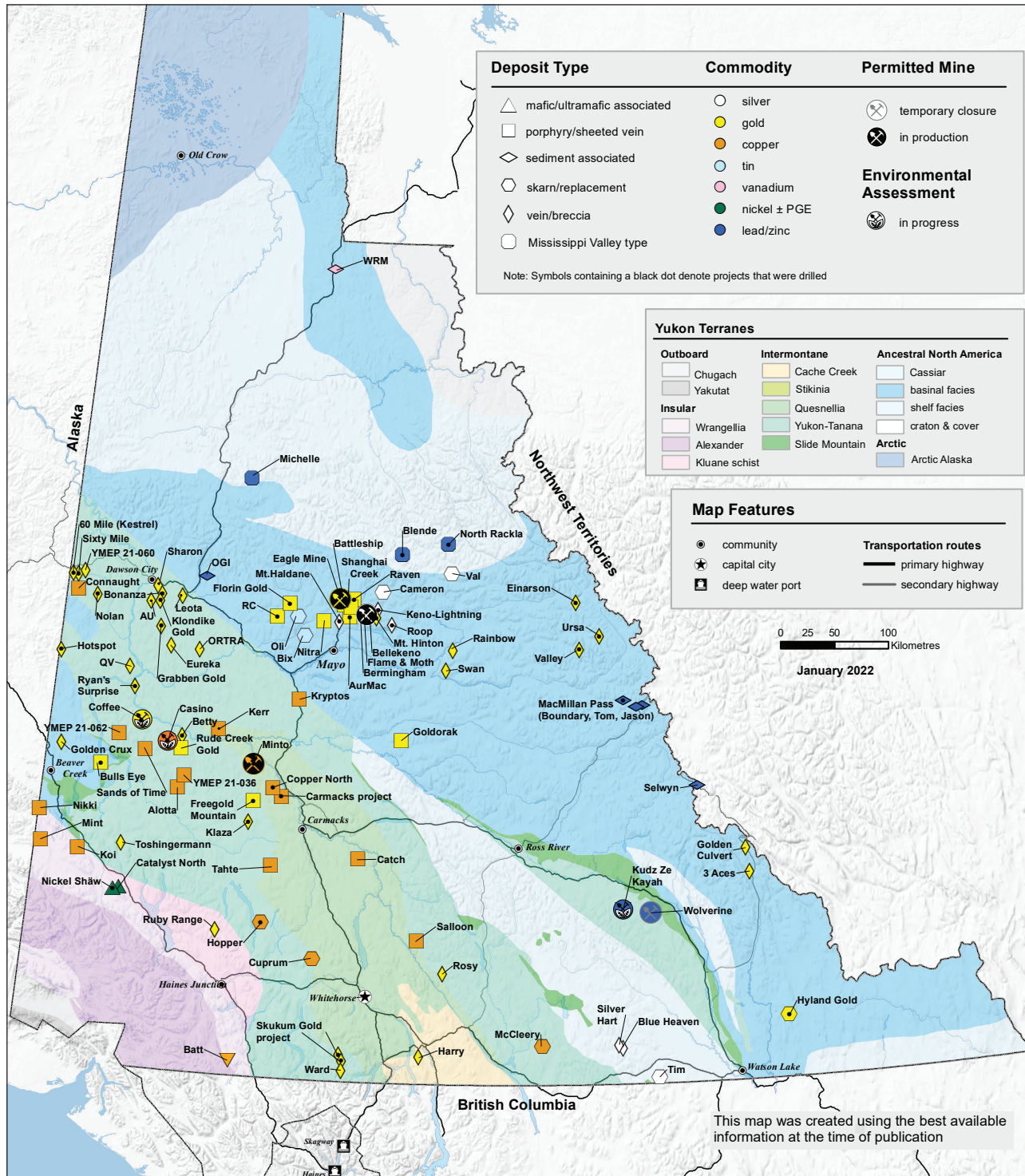


Figure 2. Yukon exploration and mining projects in 2021.

Claim staking activity increased in 2021 as compared to 2020; 3759 claims were staked as of November 10, 2021. The number of claims in good standing is 171 218, down from the all-time high of 252 902 in 2012 (Fig. 4). The majority of claim staking activity is

focused in the Mayo district; 69% of the claims staked are in that district (Fig. 5). There were no claims staked in the Watson Lake district as of November 10.

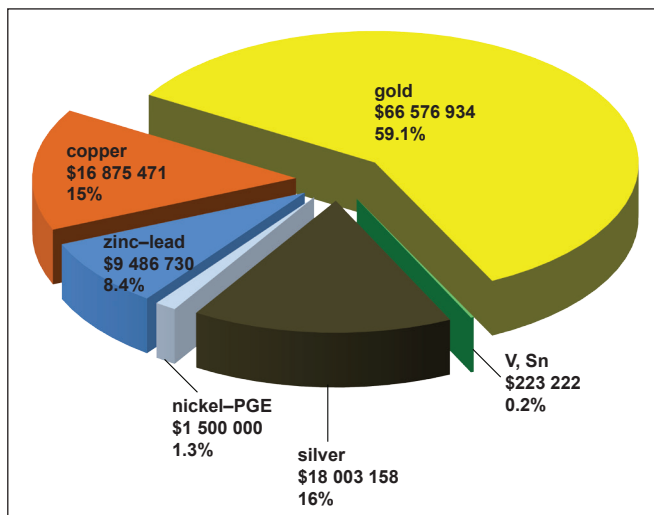


Figure 3. 2021 Distribution of exploration expenditures by primary commodity of interest.

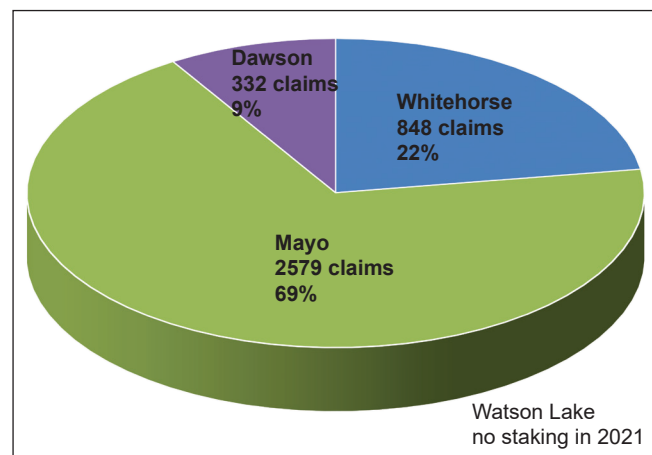


Figure 5. Distribution of claim staking by mining district.

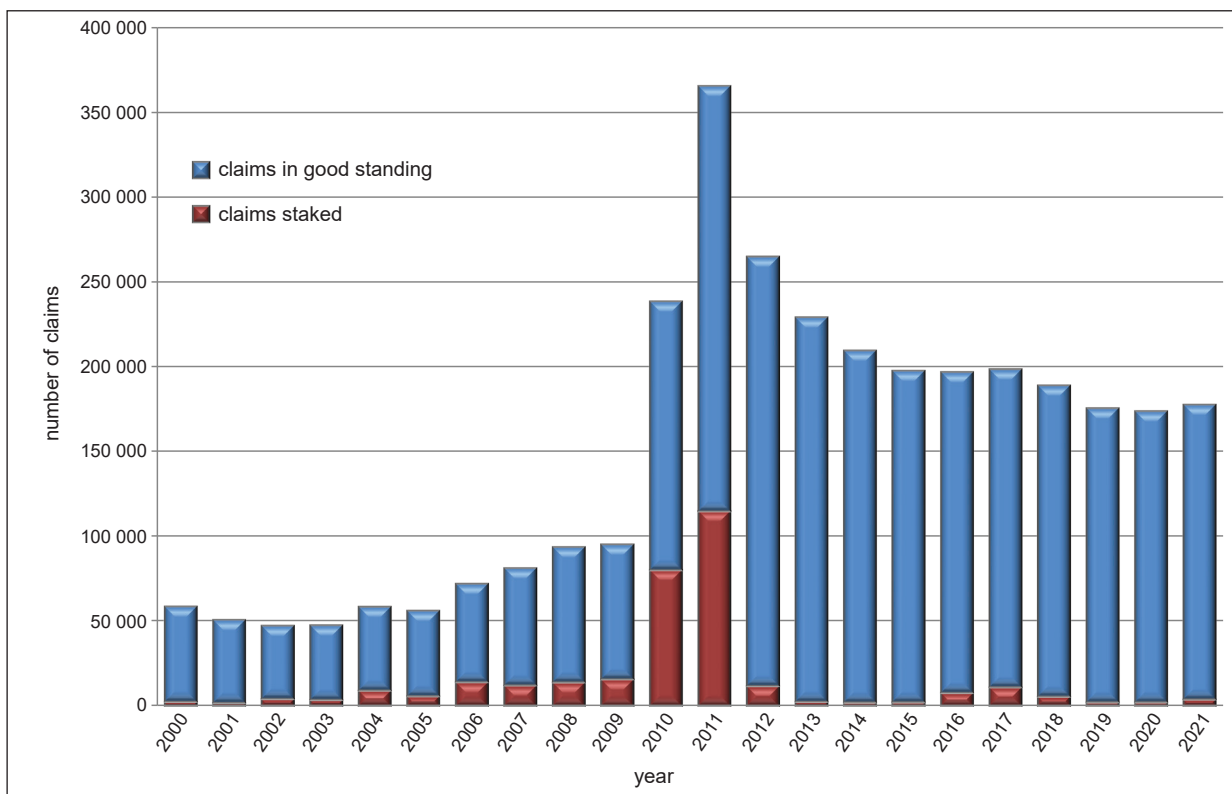


Figure 4. Hard rock claims staked and in good standing, 2000–2021.

There was an increase in diamond, reverse circulation and rotary air-blast drilling in 2021, with 187 587 m drilled in 613 holes (34 projects) as compared to 137 815 m in 2020 (Fig. 6).

Mining activity

Victoria Gold Corp. began commercial production at the Eagle Gold mine on its Dublin Gulch property on July 1, 2020 (Fig. 7). The deposit is an intrusion-related gold system. Gold production for Q1 to Q3 of 2021 was 114,726 oz and the company “guidance” for 2021 is that the mine will produce between 180,000 and 200,000 oz of gold. The company also carried out an exploration program consisting of diamond drilling, trenching, soil sampling, prospecting and mapping at the Raven showing. Results from this work are pending.

On November 24, Minto Explorations Ltd. completed a “reverse take-over” and merger with private company 1246778 B.C. Ltd. to become Minto Metals Corp. Minto Metals Corp. was listed on the Toronto Stock Exchange on November 29. The company operates the Minto copper-gold-silver mine north of Carmacks (Fig. 8). The company is currently mining ore from the underground Copper Keel deposit. In May, the company released a

preliminary economic assessment technical report, which included an updated mineral resource estimate. The total resource at the Minto site is 11 Mt at 1.46% Cu, 0.53 g/t Au and 4.75 g/t Ag (indicated), and 13 Mt at 1.29% Cu, 0.49 g/t Au and 4.55 g/t Ag (inferred). Total contained copper (open pit and underground) is 727 million lb.



Figure 7. Eagle mine ore dump (photo courtesy of Victoria Gold Corp. website).

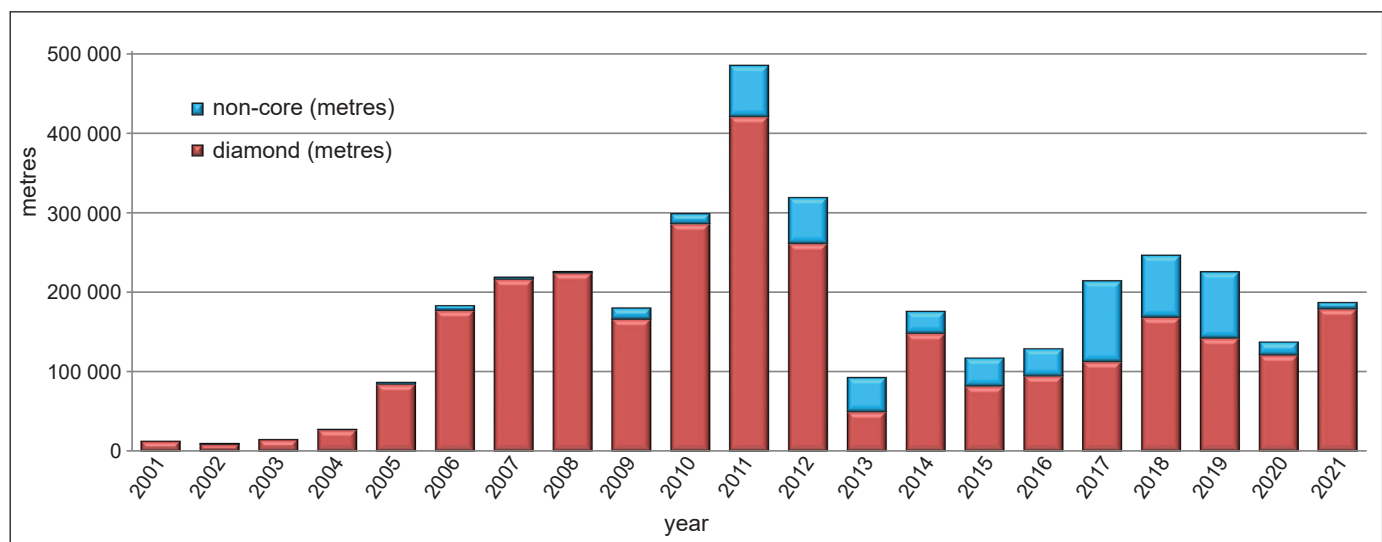


Figure 6. Diamond drilling and reverse circulation or rotary air blast drilling, 2001–2021.



Figure 8. Minto mine haul truck (photo courtesy of Minto Exploration website).

Alexco Resource Corp. restarted production at its silver-lead-zinc Keno Hill mine site, late in 2020, after having been closed for six years. At start up, production came from a small amount of ore remaining in the Bellekeno deposit. Bellekeno was depleted and shut down in August 2021, and production shifted to the Birmingham deposit. During this time, underground development work continued at the Flame & Moth deposit, and ore production is expected from there by the end of the year. Exploration drilling at Birmingham continued on deep targets throughout the year (50 holes, 19 000 m). The diamond drilling program targeted the Northeast Deep zone for infill and extension; highlights include hole K-21-0785 that intersected the Birmingham Footwall vein, with 2901 g/t silver over 4.42 m.

Permitting and mine development

Federal and territorial decision bodies are engaged in consultation with the local First Nations on the proposed terms and conditions recommended by the Yukon Environmental and Socio-economic Assessment Board (YESAB) on the Kudz Ze Kayah project. The project is owned by BMC Minerals Ltd. In October, 2020, YESAB recommended that the project be allowed to proceed subject to mitigative measures. The resource at Kudz Ze Kayah in the Measured, Indicated and Inferred categories (M, I & I) is 19.1 million tonnes grading 6.35% zinc, 1.9% lead, 0.93% copper, 148 g/t silver, and 1.39 g/t gold.

The Coffee Gold Mine project of Newmont Corporation is also working its way through the environmental assessment process. On October 12, the project received the final screening report from YESAB recommending the project proceed, subject to 44 mitigative measures and ongoing monitoring of the project. On review of the recommendations and in consultation with local First Nations, the Federal Decision Bodies (Transport Canada and Natural Resources Canada) referred the project back to the Executive Committee for further assessment of cumulative effects and decommissioning of the northern access route. The resource at Coffee (M, I & I) is 58.1 Mt grading 1.43 g/t gold for a total of 2.67 Moz of gold.

Western Copper and Gold Corp. continues to advance its Casino porphyry copper-gold-molybdenum project in western Yukon (Fig. 9). A preliminary economic assessment (PEA) was completed in June, and will form the basis of a feasibility study targeted for completion in Q2, 2022. The company undertook metallurgical and geotechnical drilling (3 holes, 1001.3 m); resource confirmation drilling (5 holes, 1484.1 m); exploratory diamond drilling targeting the periphery of the deposit (6 holes, 1634.7 m); grid soil sampling; and robotic scanning of all 2021 core and approximately 40% of historical core. The robotic scanning used GeologicAI instrumentation and measured a suite of metals by XRF, hyperspectral and geotechnical analyses as well as lidar (Fig. 10).



Figure 9. Quartz-molybdenite stockwork mineralization at Casino.



Figure 10. Geologic AI robotic scanner in operation at Casino.

2021 exploration activities

The Mayo-Keno-Clear Creek area was the most active area for exploration and mining in 2021. The area hosted 29% of the active projects and accounted for 65% of the exploration and development spending. As mentioned above, the Eagle Gold mine and Keno Hill silver mines are in this region, so gold and silver are the focus, but the area also has significant copper, lead, zinc and tin projects.

Banyan Gold Corp. conducted one of the larger exploration programs in Yukon in 2021 at the AurMac property west of Keno. AurMac is an intrusion-related gold occurrence. The company started their program in February and have been active throughout the summer with plans to shut down in mid-December. The company had completed 120 diamond drill holes (25 000 m) as of the middle of November (Fig. 11). The program has been a combination of infill drilling and step-out drilling at the Powerline deposit. Highlights of drilling include 0.75 g/t gold over 46.6 m in DDH AX-21-70 and 1.03 g/t gold over 81.4 m in DDH AX-21-88. The company also drill-tested the Aurex Hill target, located a short distance east of Powerline, and conducted an extensive soil sampling program at their Nitra property, located 20 km west of AurMac. Results from this work will be reported by the company as they become available.

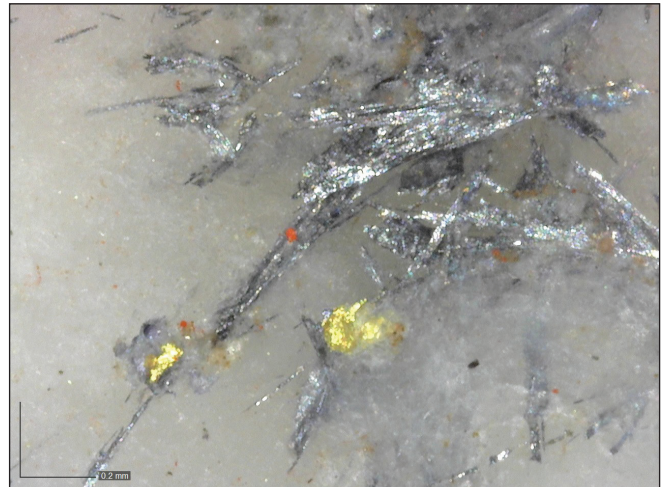


Figure 11. Visible gold and arsenopyrite in Aurmac drill core (photo courtesy of Banyan Gold website).

Cantex Mine Development Corp. conducted diamond drilling (32 holes, 11 263 m) at the lead-zinc-silver North Rackla property, located 85 km northeast of Keno. Drilling extended the strike length of the Main Zone mineralization to 2.1 km. Drill hole YKDD21-186 in the Main Zone intersected 6.06% lead, 9.48% zinc and 43.37 g/t silver over 4.8 m. Drilling at the Central Sector of the Main Zone intersected 6.17% lead-zinc, 36.82 g/t silver, 0.49% copper and 3.58% manganese over 3.5 m in hole YKDD21-190.

Blende Silver Corp., formerly Blind Creek Resources Ltd., completed an updated mineral resource estimate (NI 43-101) for the Blende silver-zinc-lead deposit in May (Table 1). The deposit is located 63 km north of Keno. The company conducted metallurgical and resource expansion drilling on the deposit in 2021, as well as 3D induced polarization geophysical surveying. Results from the summer program are pending and will be used in the preparation of a preliminary economic assessment of the project.

Table 1. Update NI43-101 Mineral Resource Estimate for the Blende deposit (at a cut-off of 1.5% ZnEq).

	k Tonnes	Zn (%)	Pb (%)	Ag (g/t)
Indicated	4 643	1.82	1.63	30.32
Inferred	42 243	1.83	1.62	27.48

Metallic Minerals Corp. has a number of mineral claims in the historic Keno silver district. The company planned a multi-rig 10 000 m diamond and reverse circulation drill program to expand advanced targets, follow-up on new discoveries and conduct reconnaissance drilling of soil and geophysical anomalies. Metallic also planned for soil sampling and geophysical surveys. Results from these programs are pending.

Alianza Minerals Ltd. explored its Mt. Haldane property, a high-grade silver vein target 27 km west of Keno, with six diamond drill holes (1576.4 m; Fig. 12). The program tested the West Fault target. Highlights include hole HLD21-24, which intersected 3267 g/t silver, 5.80% lead and 7.02% zinc over 2.1 m in siderite-galena-sphalerite vein and breccia mineralization. The intersection falls within a wider zone which averaged 1351 g/t silver, 2.43% lead and 2.91% zinc over 5.24 m.

Upper Canada Mining Inc. optioned the Mt Hinton property from Strategic Metals Ltd. and conducted a program of mapping, sampling and reverse circulation drilling (Fig. 13). The property is located 12 km east-southeast of Keno. Results from the summer program are pending.

Snowline Gold Corp., a newly listed company, was active on a number of properties 200 km east of Keno. The company drilled 21 holes for 2300 m at its Einarson gold property in the Rackla gold belt. Einarson is an epizonal orogenic gold prospect. Diamond drill hole J-21-013 at the Jupiter Zone had two intercepts: 2.59 g/t gold over 27.0 m and 4.02 g/t gold over 10.6 m. Snowline also explored its Rogue intrusion-related gold property south of Einarson with drilling (4 holes, 804 m) and its Ursa intrusion-related gold property with an airborne versatile time domain electromagnetic (VTEM) survey, soil sampling and prospecting. Results from the work at Rogue and Ursa are pending.

St. James Gold Corp. optioned the Red Mountain gold property, rebranding it as the Florin Gold project. The company completed 3613 m of diamond drilling in 15 holes with the aim of expanding the inferred gold resource. The company also carried out a lidar survey over the claim block and soil sampling. Results from this work are pending.



Figure 12. Galena-sphalerite mineralization in a siderite-quartz matrix, Mt Haldane.



Figure 13. Geologist Kelson Willms at the Granite North Zone, Mount Hinton property.

Sitka Gold Corp. conducted 5000 m of diamond drilling in 15 holes at its RC property in the Clear Creek area, 88 km west of Keno. RC is an intrusion-related gold target. Highlights from the program include 0.40 g/t gold over 402.5 m, including a narrow, higher grade interval of 1.65 g/t gold over 20.3 m in hole DDRCCC 21-010.

Strategic Metals worked two tin projects 50 km west of Keno, the Oli and Bix. At Oli, tin occurs as cassiterite in veins, breccias and skarns. Soil sampling and prospecting have shown a correlation between tin, silver and zinc. Although copper, cobalt and gold values are locally anomalous, they do not correlate with tin, which suggests there may be more than one phase of mineralization. Rock samples from trenches at Oli returned values of 0.33% tin, 4.0 g/t gold, 921 g/t silver and elevated values for lead, zinc, copper and tungsten. The nearby Bix project hosts tin-mineralized breccia zones, where rock sampling returned several assays greater than 200 ppm tin, including one sample that assayed 14.9% tin.

Moving westward into the Dawson area, the goldfields south of Dawson were slightly less active in 2021 than they have been in the past few years. The area hosted 20% of the active hard rock exploration projects, but represented only 4% of the total exploration and development expenditures.

White Gold Corp. was very active again this year on their extensive claim holdings in the Dawson region, working several properties. The company completed an updated resource estimate for the VG deposit on the QV property. The updated estimate is 5.26 Mt grading 1.62 g/t gold for a total of 267,600 oz in the inferred category. This represents a 16% increase over the 2014 resource estimate. The company also completed diamond drilling at Ryan's Surprise and Ulli's Ridge, 11 km south of the VG deposit. At Ryan's Surprise, all of the holes (8 holes, 2651 m) intersected gold mineralization: hole WHTRS21D026 had three intercepts — 10.36 g/t gold over 3.25 m, 2.07 g/t gold over 3.40 m and 2.09 g/t gold over 5.05 m.

At Ulli's Ridge and Minneapolis Creek, White Gold conducted rotary air blast drilling (937 m, 11 holes). This work intersected gold mineralization over a 500 m strike length and returned highlights of 4.43 g/t gold over 1.52 m, 1.53 g/t gold over 4.57 m and 2.26 g/t Au over 9.14 m in hole WHTULR21RAB009. On the Betty property, six diamond drill holes (1364 m) tested the target along an approximate 500 m strike length. Drilling intersected two styles of mineralization: broad zones of gold-silver mineralization in polyolithic breccia, and narrow zones of silver-zinc-lead mineralization.

Highlights included an intercept in hole D003 that returned 3.46 g/t gold over 50.0 m. Additional results are pending, including results from the Bonanza and Nolan properties.

Klondike Gold Corp. continued to explore its Klondike district gold property south of Dawson. Diamond drilling in 2021 was carried out in three phases, testing the historic Virgin/Lindow target, the Lone Star target and the Stander Zone (63 holes, 7765.62 m). Drilling at Lone Star intersected the deepest mineralization encountered to date: 0.62 g/t gold over 58.0 m down to 214 m (LS21-402). Hole LS21-389 at Lone Star returned 1.08 g/t gold over 49.65 m. Results will continue to be released over the winter, as they are received. The company also undertook re-analysis and re-interpretation of a 2019 lidar survey along with high-resolution orthophoto surveying, and has engaged SRK Consulting to prepare an NI 43-101 technical report.

ATAC Resources Ltd. switched its focus from the Rackla gold belt to the Connaught copper-molybdenum-gold porphyry project in the Sixtymile area, 65 km west of Dawson (Fig. 14). The company conducted soil sampling, mapping, ground magnetic and induced polarization (IP) surveys. Core from historical drilling completed in 2003 was relogged and resampled for its porphyry copper potential. Highlights from the program include rock grab samples from trenches that returned up to 1.38% copper. Trench 21-E returned 724 ppm copper and 139 ppm molybdenum over 84 m. Eight trenches within a 400 × 200 m area, where copper values and IP chargeability anomalies that are indicative of sulphide concentrations at depth, returned >325 ppm copper over lengths ranging from 75 to 108 m. ATAC also performed a geochemical sampling program at the Rosy epithermal gold-silver project in southern Yukon. In addition, the company relogged and sampled core previously not assayed from the Tiger deposit.

Southwest of Dawson, along the Yukon-Alaska border, Golden Sky Minerals Corp. conducted its first diamond drill program at the Hotspot gold property, a low-sulphidation epithermal target. The company drilled 1317.5 m in 4 holes following up on positive results from their 2020 program at the Sure Bet zone.



Figure 14. Connaught showing.

So far results have only been released from one drill hole, HS-21-02, which intersected 0.85 g/t gold over 102 m. The company also drilled five reverse circulation holes for 384.05 m at its Bullseye gold property near Wellesley Lake. This program returned a number of significant intercepts, including 1.03 g/t gold over 80.77 m in hole BERC-21-4 and 0.80 g/t gold over 44.2 m in hole BERC-21-2.

Flow Metals Corp. explored its Sixtymile Gold project west of Dawson with a RAB drill program targeting three gold zones: East Egg, Miller Creek and Glacier Creek (4 holes, 243.87 m). Highlights from this program include hole RAB 21-12 at East Egg, which intersected two gold-bearing horizons returning 1.02 g/t Au over 7.6 m and 0.75 g/t Au over 6.1 m. The company also re-assayed some historical core.

In the fall of 2021, Golden Predator Mining Corp. and Arizona Gold Mines Corp. merged to form Sabre Gold Mines Corp. Sabre Gold is now the owner of the past-producing Brewery Creek deposits, an intrusion-related gold system. The company commissioned an economic study on the deposit and is hoping to restart the heap leach operation.

South of the Yukon River, in the Dawson Range area, there were 15 exploration projects representing 16% of the hard rock exploration projects and 20% of the exploration and development expenditures. The Dawson Range area is known for its porphyry copper-gold-molybdenum potential as it hosts the producing Minto Mine and significant deposits at Carmacks Copper, Freegold Mountain and Casino. The area also hosts significant epithermal deposits.

Granite Creek Copper Ltd. released positive metallurgical results from its Carmacks copper-gold porphyry project. The testing on flotation of sulphide minerals determined that recoveries of 95% copper into a 25% copper concentrate can be achieved. In terms of exploration, a three-phase program consisting of 7742 m of diamond drilling in 23 holes and 1500 m of reverse circulation drilling in 17 holes was completed on the Carmacks and Carmacks North (Fig. 15: Carmacks Copper and Stu) properties. Phase 1 focused on expanding and upgrading the sulphide portion of resources in zones 1, 2000S and 13 by drilling below the oxidized zones. Phase 2 was a reverse circulation drill program on early-stage targets at Carmacks North. For phase 3, the company followed up on phase 1 results. Highlights from the program include 1.12% copper and 0.20 g/t gold over 43.5 m in hole CRM21-004 and 1.7% copper and 0.57 g/t gold over 23.3 m in hole CRM21-019, both of which are in Zone 1; and 0.96% copper and 0.18 g/t gold over 105.52 m

in hole CRM21-011 in Zone 2000S. Drill results from the program will be included in an updated NI 43-101 resource estimate. The company is also undertaking a new mine plan that will incorporate both the oxide and sulphide zones.

Triumph Gold Corp. completed a 19 hole, 6615 m diamond drill program at the Freegold Mountain property west of Carmacks. Highlights from the program include 1.52 g/t gold, 3.74 g/t silver, 0.18% copper, 0.011% molybdenum and 0.007% tungsten over 80.50 m in hole RVD21-003 in the WAu Zone, and 0.27 g/t gold, 5.43 g/t silver, 0.22% copper and 0.014% molybdenum over 106.5 m in hole RVD21-05 from the Blue Sky Zone. The company also engaged Minerva Intelligence Inc. to complete an Artificial Intelligence (AI) study on the Revenue-Nucleus area of the project. This study identified new vectors for gold and copper mineralization at the Nucleus deposit and identified drill targets at the northeastern and southern contact of the Revenue diatreme.



Figure 15. Migmatized porphyry rafts in Jurassic granodiorite at the Carmacks Copper discovery outcrop.

Rockhaven Resources Ltd. completed an extensive diamond drilling program at its epithermal gold-silver Klaza property west of Carmacks (71 holes, 14 256 m). Thirty-one holes were drilled to upgrade resources to the indicated category, 11 holes tested structures adjacent to the Klaza deposit, and 29 holes were drilled to evaluate targets outside of the Klaza deposit, including the Rusk, Kelly Porphyry, Western BRX Extension and Western Zone targets. The company also collected samples for metallurgical studies and has continued its environmental baseline studies. Results are pending.

At the Alotta porphyry prospect, 45 km south of the Casino deposit, Strategic Metals Ltd. conducted a program of prospecting and soil sampling. The soil sampling program expanded the coincident copper-gold-molybdenum anomaly area to 4200 by 1500 m. A rock sample collected this year returned 8.73 g/t gold.

In southwestern Yukon, in the Kluane ultramafic belt, there were seven exploration projects representing 8% of the total number of projects and 1% of the exploration and development expenditures. The focus of the activity in this region was on nickel-copper-cobalt-PGE and on porphyry copper projects. The main projects are highlighted below.

Nickel Creek Platinum Corp. completed a 12 hole (1257 m) diamond drilling program at the Nickel Shāw ultramafic-hosted nickel-copper-cobalt-PGE property. The property is located 26 km northwest of Burwash Landing. Drilling focused on the Arch and Burwash targets (Fig. 16) and tested conductors identified in a time-domain electromagnetic survey conducted in 2020. Massive sulphide nickel-copper mineralization was intersected in five of six holes drilled at Arch. Highlights from Arch include 1.41% nickel, 0.55% copper, 0.02% cobalt, 0.91 g/t platinum, 1.46 g/t palladium, and 0.12 g/t gold over 11.95 m in hole ASD21-004. Three holes were drilled at the Burwash target, however none of them intersected greater than 0.3% nickel.

Strategic Metals Ltd. conducted exploration at two porphyry copper targets in the northern Kluane area, the Nikki and Mint properties. At Nikki, the company did geological mapping and soil geochemical sampling.

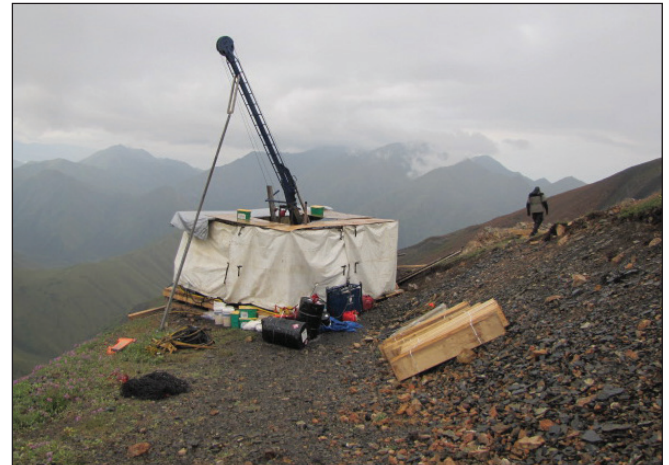


Figure 16. Diamond drill at the Burwash Target, Nickel Shāw project.

The soil sampling program identified a 2000 by 1100 m geochemical anomaly with copper-in-soil values up to 3060 ppm. The soil results also have elevated, but scattered, lead, zinc, silver and gold values up to 1590 ppb.

At the Mint property, the company mapped a 300 by 300 m zone of alteration with sheeted and stockwork veinlets. Rock samples within the alteration zone returned significant results, with one sample containing 2.3% copper, 1.365 g/t gold, 32 g/t silver and 0.337% molybdenum.

Strategic Metals also conducted mapping, prospecting and hand trenching on the Kluane gold project, east of Kluane Lake. Trenching on the Rikus vein returned 20.54 g/t gold over 2.1 m, 8.60 g/t gold over 5 m and 13.84 g/t gold over 2 m. The company also conducted a small exploration program on their Batt copper-cobalt property in the southern Kluane belt.

In south central Yukon, centered around Whitehorse, there were 10 exploration projects, representing 11% of the projects and 3% of exploration and development expenditures. The focus of the activity was on gold-silver and copper-gold projects.

South of Whitehorse, in the Wheaton River valley, Whitehorse Gold Corp. drilled 44 diamond drill holes (16 554 m) at its Skukum Gold project (Fig. 17). At the Rainbow Zone, hole SC21-008 intersected 2.5 g/t gold and 431.8 g/t silver over 6.17 m. Hole SC21-015 intersected 10.3 g/t gold and 93.9 g/t silver



Figure 17. Whitehorse Gold Corp. exploration camp in the Wheaton River valley.

over 2.41 m, and 27.1 g/t gold and 346.4 g/t silver over 4.24 m, 11 m farther down the hole. To date, only a few results have been released, with more results expected over the winter.

West of Whitehorse, CAVU Mining Corp. conducted an exploration program on the Hopper copper-gold-silver porphyry-skarn target. CAVU optioned the property from Strategic Metals Ltd. in the spring of this year and followed with a six hole, 1119 m diamond drill program. Highlights from this year's program include 0.209% Cu and 1.3 g/t Ag over 116.18 m in hole HOP21-DDH-06. Historically, the style of mineralization at Hopper has been skarn-type, but core from the latest drilling is exhibiting porphyry-style alteration and mineralization. The company also drilled the Copper Castle skarn target, extending skarn mineralization to the south.

In southeastern Yukon, there were 12 exploration projects, representing 13% of the projects and 6% of the exploration expenditures. Activity in the southeast was focused on sedimentary exhalative lead-zinc targets and orogenic gold targets in the Selwyn basin and silver-lead-zinc-bearing veins in the Rancheria area.

Fireweed Zinc Ltd. continued to advance its MacMillan Pass sediment-hosted lead-zinc project, which includes the Tom and Jason deposits. The drill program involved follow-up drill testing of the Boundary West discovery and step-out holes at Tom East and Jason

South with 3850 m in 13 holes, as well as a ground gravity geophysical survey and soil geochemical survey. Results at the Boundary Zone continue to provide encouragement that there is more to the story at MacMillan Pass. All ten holes at the Boundary Zone hit mineralization: NB21-001 returned 7.71% zinc, 0.70% lead and 32.1 g/t silver over 46.96 m; NB21-005 returned 1.54% copper, 5.42% zinc, 0.04% lead and 5.6 g/t silver over 2.00 m; and NB21-002 returned 23.77% zinc, 3.44% lead and 75.7 g/t silver over 10.42 m within a broader lower grade zone.

Seabridge Gold Inc. conducted a controlled-source electromagnetics and audio-frequency magnetotellurics (CSMAT) geophysical survey on their 3 Aces property, 190 km north of Watson Lake. The company will integrate these data with historical drill information to produce a 3D earth image, which they hope will identify new targets for drill testing.

Approximately 27 km north of 3 Aces, Stratabound Minerals Corp. conducted soil and stream sediment sampling and a UAV magnetic geophysical survey on their Golden Culvert property. The survey defined three significant gold-in-soil anomalies over a 14 km discontinuous corridor. Anomalous gold-in-soil values ranged from 20 to 1050 ppb Au.

At the Silver Hart property, 28 km north of Rancheria, CMC Metals Ltd. conducted an airborne SkyTEM geophysical survey, followed by a soil geochemical survey. The soil survey further defined anomalous silver, zinc, lead and manganese zones, and provided targets for future drill testing.

Summary

Exploration in 2021 continued to be constrained by COVID-19 restrictions, but due to high metal prices and increasing investor confidence, companies were able to raise money to conduct significant exploration programs. A number of advanced exploration projects progressed up the development chain, some old targets were revisited returning pleasant surprises and some new discoveries resulted. Appendix 1 lists all the exploration projects that the YGS was tracking this year. Appendix 2 shows the drilling statistics as of the end of November.

Appendix 1. Exploration projects 2021.

Project	Owner / Optioner	MINFILE	Commodity	Deposit type	Work type	YMEP funded
3 Aces	Seabridge Gold Inc.	105H 066	gold	vein/breccia	GGP	no
Alotta (Severance)	Strategic Metals Ltd.	115J 003	copper	porphyry/sheeted vein	P, SGC, RGC	no
AU	Coureur des Bois Ltee-Ltd.	–	gold	vein/breccia	P, RGC	no
AurMac	Banyan Gold Corp.	105M 060	gold	porphyry/sheeted vein	DD	no
Batt	Strategic Metals Ltd.	115A 005	copper	unknown	P, RGC	no
Battleship	Fekete, Mark	–	gold	porphyry/sheeted vein	P, RGC	no
Bellekeno Mine	Alexco Resource Corp.	105M 082	silver	vein/breccia	UW, MD	no
Birmingham Mine	Alexco Resource Corp.	105M 086	silver	vein/breccia	DD	no
Betty	White Gold Corp.	115J 074	gold	vein/breccia	DD	no
Bix	Strategic Metals Ltd.	115P 031	tin	skarn/replacement	P, SGC	no
Blende	Blende Silver Corp.	106D 064	zinc-lead	Mississippi Valley-type	RGC, DD, ES	no
Blue Heaven	CMC Metals Ltd.	–	silver	vein/breccia	AGP	no
Bonanza	White Gold Corp.	–	gold	vein/breccia	G, GGP, RGC, T	yes
Bulls Eye	Golden Sky Minerals Corp.	–	gold	porphyry/sheeted vein	RC	yes
Cameron	Guardian Exploration Inc.	106D 012	silver	skarn/replacement	G, GGP, SGC, RGC	yes
Carmacks	Granite Creek Copper Ltd.	115I 008	copper	porphyry/sheeted vein	RGC, DD, ES	no
Carmacks North	Granite Creek Copper Ltd.	115I 011	copper	porphyry/sheeted vein	RGC	no
Casino	Western Copper and Gold Corp.	115J 028	copper	porphyry/sheeted vein	SGC, DD, ES	no
Catalyst North	Group Ten Metals Inc.	–	nickel-PGE	mafic/ultramafic associated	P, RGC	no
Catch	Burke, Ryan	–	copper	porphyry/sheeted vein	P, T, RGC, SGC	no
Coffee Project	Newmont Mining Corp.	115J 110	gold	vein/breccia	DD	no

Abbreviations

CS – claim staking	SGC – soil/silt geochemistry	DD – diamond drilling
P – prospecting	RGC – rock geochemistry	RC – reverse circulation drilling
G – geology	AGP – airborne geophysics	CR – road construction
T – trenching	GGP – ground geophysics	MD – mine development
UW - Underground work	ES - economic studies	

Appendix 1 (continued). Exploration projects 2021.

Project	Owner / Optioner	MINFILE	Commodity	Deposit type	Work type	YMEP funded
Connaught	Atac Resources Ltd.	115N 040	copper	porphyry/sheeted vein	P, G, GGP, SGC, RGC, T	no
Cuprum	Coates, Jim	105E 008	copper	skarn/replacement	P, RGC	no
Eagle Mine	Victoria Gold Corp.	106D 025	gold	porphyry/sheeted vein	MD	no
Einarson	Snowline Gold Corp.	–	gold	unknown	P, G, GGP, SGC, T, DD	yes
Eureka	Trifecta Gold Ltd.	115O 057	gold	vein/breccia	G, RGC, T	yes
Flame & Moth	Alexco Resource Corp.	105M 087	silver	vein/breccia	UW, MD	no
Freegold Mountain Project	Triumph Gold Corp.	115I 107	gold	porphyry/sheeted vein	RGC, DD	no
Golden Crux	Druid Exploration Inc.	–	gold	unknown	P, RGC, SGC	yes
Golden Culvert	Stratabound Minerals Corp.	105H 067	gold	vein/breccia	SGC	no
Goldorak	Hulstein, Roger	105L 051	gold	porphyry/sheeted vein	G, P, RGC, SGC	yes
Grabben Gold	Kestrel Gold Inc.	115O 054	gold	vein/breccia	P, G, GGP, SGC, RGC	yes
Harry	Strategic Metals Ltd.	105D 157	gold	unknown	P, RGC	no
Hopper	CAVU Mining Corp.	115H 019	copper	skarn/replacement	G, AGP, GGP, DD	no
Hotspot	Golden Sky Minerals Corp.	115N 101	gold	vein/breccia	DD	no
Hyland Gold	Banyan Gold Corp.	095D 011	gold	skarn/replacement	DD	no
Keno-Lightning	Metallic Minerals Corp.	105M 011	silver	vein/breccia	GGP, SGC, DD	no
Kerr	Kreft, Bernie	115I 081	copper	porphyry/sheeted vein	P	no
Klaza	Rockhaven Resources Ltd.	115I 067	gold	vein/breccia	RGC, DD	no
Klondike Gold	Klondike Gold Corp.	115O 072	gold	vein/breccia	AGP, DD	no
Koi	Strategic Metals Ltd.	115F 037	copper	porphyry/sheeted vein	G, P, RGC, SGC	yes
Kryptos	Richards, Gord	–	copper	porphyry/sheeted vein	SGC, RGS, P	yes

Abbreviations

CS – claim staking

SGC – soil/silt geochemistry

DD – diamond drilling

P – prospecting

RGC – rock geochemistry

RC – reverse circulation drilling

G – geology

AGP – airborne geophysics

CR – road construction

T – trenching

GGP – ground geophysics

MD – mine development

UW - Underground work

ES - economic studies

Appendix 1 (continued). Exploration projects 2021.

Project	Owner / Optioner	MINFILE	Commodity	Deposit type	Work type	YMEP funded
Kudz Ze Kayah	BMC Minerals Ltd.	105G 117	zinc-lead	volcanic associated	ES	no
Leota	Goldbank Mining Corp.	115O 074	gold	vein/breccia	P, RGS, SGC	no
MacMillan Pass (Boundary, Tom, Jason)	Fireweed Zinc Ltd.	105O 001; 105O 024; 105O 019	zinc-lead	sediment associated	AGP, GGP, DD, RGC	no
McCleery	Overland Resources (BC) Ltd.	105C 029	copper	skarn/replacement	G, P, RGC, SGC	yes
Michelle	Silver47 Exploration Corp.	116A 016	zinc-lead	Mississippi Valley- type	G, P, RGC, SGC	no
Mint	Strategic Metals Ltd.	115F 087	copper	porphyry/sheeted vein	G, RGC	no
Minto Mine	Minto Explorations Ltd.	115I 021	copper	porphyry/sheeted vein	DD	no
Mount Hinton	Upper Canada Mining Inc.	105M 052	gold	vein/breccia	DD	no
Mt. Haldane	Alianza Minerals Ltd.	105M 032	silver	vein/breccia	DD	no
Nickel Shāw (Wellgreen)	Nickel Creek Platinum Corp.	115G 024	nickel-PGE	mafic/ultramafic associated	GGP, DD	no
Nikki	Strategic Metals Ltd.	115K 082	copper	porphyry/sheeted vein	G, SGC, RGC	no
Nitra	Banyan Gold Corp.	115P 001	gold	porphyry/sheeted vein	SGC	yes
Nolan	White Gold Corp.		gold	vein/breccia	P, G, AGP, GGP, SGC, RGC	no
North Rackla	Cantex Mine Development Corp.	106C 088	zinc-lead	Mississippi Valley- type	P, G, SGC, DD	no
Ogi	Sitka Gold Corp.	116B 165	zinc-lead	sediment associated	P, G, GGP, SGC, RGC	yes
Oli	Strategic Metals Ltd.	115P 030	tin	skarn/replacement	P, SGC	no
ORTRA	Kreft, Bernie		gold	unknown	P, SGC	no
QV	White Gold Corp.	115O 004	gold	vein/breccia	ES	no
Rainbow	Berdahl, Ron		gold	unknown	P, RGC	no

Abbreviations

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Appendix 1 (continued). Exploration projects 2021.

Project	Owner / Optioner	MINFILE	Commodity	Deposit type	Work type	YMEP funded
Raven	Victoria Gold Corp.	106D 018	gold	porphyry/sheeted vein	P, G, SGC, T, DD	no
RC Gold	Sitka Gold Corp.		gold	porphyry/sheeted vein	DD	no
Florin Gold	St James Gold Corp.	115P 006	gold	porphyry/sheeted vein	P, SGC, RGC, DD	no
Roop	Mayo Lake Minerals Inc.		silver	vein/breccia	DD	no
Rosy	Atac Resources Ltd.	105C 024	gold	vein/breccia	P, G, SGC	yes
Ruby Range (Kluane)	Strategic Metals Ltd.	115H 047	gold	vein/breccia	P, G, RGC, T	no
Rude Creek Gold	Makara Mining Corp.	115J 022	gold	porphyry/sheeted vein	AGP	no
Ryan's Surprise	White Gold Corp.	115O 012	gold	vein/breccia	RGC, DD	no
Salloon	Cypress Hills Resource Corp.	105E 003	copper	porphyry/sheeted vein	P, RGC	no
Sands of Time	Milton, Jack	115J 090	copper	porphyry/sheeted vein	P, RGC	yes
Selwyn Project	Selwyn Chihong Mining Ltd.	105I 037	zinc-lead	sediment associated		no
Shanghai Creek	Ryan, Shawn	105M 028	gold	porphyry/sheeted vein	SGC	yes
Sharon	Petroutsas, Erini		gold	unknown	P, RGC	no
Silver Hart	CMC Metals Ltd.	105B 021	silver	vein/breccia	P, G, AGP, RGC	no
Sixty Mile (Flow)	Flow Metals Corp.		gold	vein/breccia	RGC	yes
Sixty Mile (Kestrel)	Kestrel Gold Inc.	116C 146	gold	vein/breccia	P, G, GGP, SGC, RGC	yes
Skukum Gold	Whitehorse Gold Corp.	105D 022	gold	vein/breccia	G, AGP, RGC, DD	no
Swan	Archer Cathro and Associates (1981) Ltd.		gold	vein/breccia	P, RGC	yes
Tahte	Hulstein, Roger	115H 038	copper	porphyry/sheeted vein	P, RGC	yes

Abbreviations

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T – trenching	GGP – ground geophysics	MD – mine development
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Appendix 1 (continued). Exploration projects 2021.

Project	Owner / Optioner	MINFILE	Commodity	Deposit type	Work type	YMEP funded
Tim	Coeur Mining Inc.	105B 140	silver	skarn/replacement	G, AGP, SGC, RGC, T	no
Toshingermann	Berdahl, Ron	115G 106	gold	vein/breccia	SGC, RGC, P	no
Ursa	Snowline Gold Corp.	105O 040	gold	vein/breccia	P, AGP, SGC, RGC	yes
Val	Atac Resources Ltd.	106C 085	silver	skarn/replacement	P, RGC	no
Valley (Rogue)	Snowline Gold Corp.	105O 012	gold	vein/breccia	P, G, GGP, SGC, DD	no
Ward	Burke, Ryan	105D 190	gold	vein/breccia	P, RGC	yes
WRM	Prior, Glen		vanadium	sediment associated	P, RGC	yes
YMEP21-036 (Stevenson)	Arsenault, Chris		copper	porphyry/sheeted vein	P, RGC	yes
YMEP21-060 (Tow)	Mann, Bill	116C 135	unknown	unknown	P, RGC	yes
YMEP21-062 (Astrolabe)	Milton, Jack	115J 044	copper	porphyry/sheeted vein	P	yes

Abbreviations

CS – claim staking	SGC – soil/silt geochemistry	DD – diamond drilling
P – prospecting	RGC – rock geochemistry	RC – reverse circulation drilling
G – geology	AGP – airborne geophysics	CR – road construction
T – trenching	GGP – ground geophysics	MD – mine development
UW - Underground work	ES - economic studies	

Appendix 2. Drilling statistics by project, 2021.

Project name	Company name	DD holes	DD metres	RC holes	RC metres
AurMac	Banyan Gold Corp.	112	24 920		
Birmingham Mine	Alexco Resource Corp.	50	25 000		
Skukum Gold	Whitehorse Gold Corp.	46	16 400		
Raven	Victoria Gold Corp.		15 000		
Klaza	Rockhaven Resources Ltd.	72	14 256		
Minto Mine	Minto Explorations Ltd.	27	13 220		
North Rackla	Cantex Mine Development Corp.	32	11 263		
Carmacks	Granite Creek Copper Ltd.	23	7742	17	1500
Carmacks North	Granite Creek Copper Ltd.			3	245
Klondike Gold	Klondike Gold Corp.		8000		
Freegold Mountain Project	Triumph Gold Corp.	19	6615		
Keno-Lightning	Metallic Minerals Corp.	8	1900	45	4300
RC Gold	Sitka Gold Corp.	15	5000		
Einarson	Snowline Gold Corp.	21	4300		
Valley (Rogue)	Snowline Gold Corp.	4	804		
Casino	Western Copper and Gold Corp.	14	4120		
MacMillan Pass (Boundary Zone)	Fireweed Zinc Ltd.	10	2995		
MacMillan Pass (Tom Deposit)	Fireweed Zinc Ltd.	3	850		
Ryan's Surprise	White Gold Corp.	8	2651	11	937
Betty	White Gold Corp.	12	2500		
Florin Gold	St James Gold Corp.	15	3613		
Roop	Mayo Lake Minerals Inc.	4	3000		
Mt. Haldane	Alianza Minerals Ltd.	6	1576		
Hotspot	Golden Sky Minerals Corp.	4	1318		
Bulls Eye	Golden Sky Minerals Corp.			5	384
Nickel Shāw	Nickel Creek Platinum Corp.	12	1257		
Hopper	CAVU Mining Corp.	6	1119		
Grabben Gold	Kestrel Gold Inc.			5	558
Sixty Mile (Kestrel)	Kestrel Gold Inc.			?	?
Sixty Mile (Flow)	Flow Metals Corp.			4	244
Mount Hinton	Upper Canada Mining Inc.			?	?
		523	179 419	90	8168

Yukon Geological Survey's Outreach Program: 2021 highlights

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Weston, L., 2022. Yukon Geological Survey's Outreach Program: 2021 highlights. In: Yukon Exploration and Geology Overview 2021, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 53–62.

Introduction

Geoscience, which is the study of Earth systems, is complex and highly dynamic. It examines the interactions between the lithosphere, hydrosphere, biosphere and atmosphere – all of which are critical to sustaining our planet (AGI, 2012). The Yukon Geological Survey's mandate is to provide objective geological information to Yukon government, Yukon First Nations and the general public. This information underpins geoscience-related policy and investment decisions in the territory, and adds value to Yukon's geoscience knowledge base. With a staff of more than 15 geoscientists, the Yukon Geological Survey (YGS) conducts a wide variety activities from traditional bedrock and surficial mapping, to focused studies such as community hazards mapping (e.g., monitoring landslides and thawing permafrost), and mineral assessments, among others. As a government organization, it is our duty to not only engage with First Nations and other governments, but to also educate all citizens of the Yukon about the importance of geoscience in order to help society find and manage our natural resources for the present and future (Geoscientists Canada, 2018).

YGS recognizes the importance of having a geoscientist on staff who is dedicated to outreach and education. Communicating geoscience effectively, and educating Yukoners on how Earth systems work will help them to make informed judgements that affect our territory, as well as our planet (AGI, 2011). Despite the ongoing pandemic, YGS remained very active in public outreach and education; this paper provides a summary of activities for 2021.

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Earth science education in Yukon schools

Yukon schools follow the British Columbia curriculum with some Yukon-specific adaptations. Concepts of Earth science are introduced in grade three; however, the author has recognized from experience that some concepts of Earth's processes can be introduced as early as kindergarten. In Whitehorse, which is known as Canada's 'Wilderness City', teaching about geologic processes can take place right in our backyards. Today's students are the ones that will face future challenges of climate change and will need to make decisions about how we use our natural resources. We have an opportunity to connect our Yukon students to their environment and teach them about how Earth science affects their daily lives.

In order to support Yukon teachers, YGS designs geoscience education in the classroom in a way that enhances the school curriculum. Lessons are meant to be engaging and predominantly consist of hands-on activities as opposed to lecture-style (Fig. 1). Activities will vary depending on the request by the teacher and may include any number of Earth science topics such as the rock cycle, rock and mineral identification, geologic time, geohazards, glacial landforms, or the uses of mineral resources in our everyday lives (Fig. 2). Every attempt is made to feature rock samples from the local area.



Figure 1. Grade 5 students of Whitehorse Elementary School test their knowledge of the Rock Cycle to identify various samples of Yukon rocks.



Figure 2. Grade 10 and 11 students from Porter Creek Secondary's WILD program match everyday products with the mineral or rock specimen that is used to make them.

As with any science, the best way to engage Yukon students in geology is by bringing the classroom outdoors. Field trips allow students to experience the local environment first-hand and observe geological processes in the real world. Most trips in 2021 focused on sites within the city limits of Whitehorse: Whitehorse Copper Belt mineral occurrences and former mine sites; Miles Canyon basalt; Ibex Valley roadside geology; and glacial landforms of the Chadburn Lake area. These trips help students to develop a positive attitude towards science and a greater appreciation for nature. Where time allowed, field trips were preceded by classroom visits to teach basic concepts that could be highlighted in the field. Knowledge of the local geology will help students not only connect with their environment, but also give them the confidence to participate in community discussions related our changing climate and sustainable development.

Although most geoscience education takes place during the school year, the author is also actively involved in leading guided field trips in the summer for the Wildlife Preserve Day Camp (Fig. 3), as well as interpretive walks for the public at Miles Canyon organized by the Yukon Conservation Society.



Figure 3. Children from the Yukon Wildlife Preserve summer day camp visit the sites of the Whitehorse Copper Belt.

In 2021, the author, with support from other YGS staff, reached out to more than 500 Yukoners, including students and members of the public, through classroom visits and field trips (Fig. 4). Included in those were visits to the community schools in Faro (Del Van Gorder School) and Dawson (Robert Service School).

Annual events

Every year, YGS participates in, and/or facilitates several public geological events that highlight aspects of Earth science and Yukon geology. Due to the ongoing COVID-19 pandemic, many of these events were redesigned to a virtual format, or in some cases, were cancelled altogether (e.g., Yukon Mining Days, “YGS Rocks” August annual forum, and Yukon Geoscience Forum student tours).

Yukon-Stikine Regional Science Fair

For the past several years, the author has participated in many aspects of the Yukon-Stikine Regional Science Fair: as a member of the organizing committee; as a judge to both the Whitehorse school fairs and the regional fair; and as an organizer of science activities for participants on the day of the regional event (Fig. 5). In April 2021, the Yukon Regional Science Fair Society, together with the Science Fair Foundation of British Columbia (BC), put on a virtual fair due to the continuing pandemic. Hundreds of students from across the Yukon and northern BC showcased their projects over a two-day period. Students from grades 4 to 12 submitted a digital photo of their posters and a description of their projects ahead of time and then presented to a small panel of judges via Zoom on the days of the event.



Figure 4. (a) Grade 2/3 students from Selkirk Elementary School learn about glacial landforms in Riverdale. (b) Students from Golden Horn School visit the former Little Chief Mine site of the Whitehorse Copper Belt. (c) Jeff Bond of YGS explains the formation of the sand dunes at Bennett Lake to grade 10 students of the Wood Street FACES program. (d) Grade 11 students from Wood Street ES program measure movement along the Takhini thaw slump as evidenced by the split trees.



Figure 5. Staff of YGS put on various geological demonstrations and activities at the Yukon-Stikine Regional Science Fair.

The virtual platform, albeit not without some technical challenges, was a great success in that it attracted more participants from communities in Yukon, as well as the town of Atlin, since it did not require travel to Whitehorse.

Mining week

For the second year in a row, Mining and Geology Week was a virtual event. As part of this annual celebration, the Yukon Geological Survey, in partnership with the Yukon Chamber of Mines and Yukon Women in Mining, strives to raise awareness of the role that mining and geology plays in our society. Mining and Geology Week took place between May 31 and June 4 this year, commemorating the 125 anniversary of the discovery of gold in the Klondike. The main events included an evening public field trip with 12 participants (Fig. 6), and an industry luncheon with guest speakers.

The ‘Discovery Day Camp’ at the S.S. Klondike, which typically attracts over 300 students to the one-day event, was cancelled due to the pandemic. In its place, a virtual activity was designed that would engage not only Yukon students, but also their friends and families—essentially all Yukoners. It consisted of a ‘scavenger hunt’ with maps and locations of 61 geologic and mining-relevant sites; 18 sites were in Whitehorse and the remaining 53 sites were spread over 14 Yukon communities. The sites were diverse and included activities such as finding a rock in your community containing a specific mineral, visiting a mining history



Figure 6. Potential future geologists enjoy prospecting at the Whitehorse Copper Belt during an evening field trip celebrating Yukon Mining and Geology Week.

display at a museum, viewing ancient shorelines on the side of a mountain, or simply finding an appealing rock and writing a story about it. Prizes were donated by local businesses and awarded to participants who visited the most sites during the contest (Fig. 7). The virtual scavenger hunt was launched very late in the 2021 school year resulting in a low number of entries; however the organizers anticipate launching the “Yukon Rocks & Walks Scavenger Hunt” again in early May, 2022 in order to attract more participants.



Figure 7. Amber and Inara Church win “Geologists of the Year” for the best Yukon rock sample and field photos during the “Yukon Rocks & Walks Scavenger Hunt”. From L-R: Nicolette Dickson (YukonWIM), Anne Turner (YukonWIM), Inara Church, Amber Church and Leyla Weston (YGS).

Weekend on the Rocks

Tombstone Territorial Park, known as Ddhäl Ch'èl Cha Nän meaning “ragged mountain land” is situated on the Traditional Territory of the Tr'öndëk Hwëch'in First Nation. The park is a very popular destination for tourists and Yukoners alike and offers a variety of programming throughout the summer. Every weekend during the month of August, the Tombstone Interpretive Centre showcases a different aspect of the park's natural history. For the past several years, YGS has facilitated 'Weekend on the Rocks', a free public event that highlights the glacial history and geology of the park. This year, a special dedication was made to the late Charlie Roots, a former Geological Survey of Canada geologist who spent the better part of his career with the Yukon Geological Survey – working and raising a family in the Yukon. Charlie had an incredible passion

for geology and the outdoors and loved educating the public on the fascinating world of geology. Charlie, along with members of 'Friends of Dempster Country' founded 'Weekend on the Rocks'. This August, a bench was installed in Charlie's memory to honor his efforts and dedication to increasing our understanding and appreciation for the land in the park and along the Dempster Highway (Fig. 8).

Staff from YGS, including Don Murphy (YGS Emeritus Geologist) provided a weekend of activities including two evening talks and two interpretive hikes. Visitors learned about the geology, tectonic history, as well as the processes of glaciation in the park. This weekend is always a popular event and is well attended. Almost 40 people braved the cool autumn weather to take part in the guided hikes and various activities (Fig. 9).



Figure 8. Commemorative bench installed for the late Charlie Roots – one of the founders of 'Weekend on the Rocks'. Seated are his family, from left to right: Galena Roots, Logan Roots and Mary Ann Roots.



Figure 9. Weekend on the Rocks: **(a)** Hikers brave the rain, sleet and snow during an interpretive hike with YGS Quaternary geologist, Jeff Bond. **(b)** Participants take in the various activities in the Tombstone Interpretive Centre. **(c)** YGS geologist Leyla Weston and Emeritus geologist Don Murphy lead an interpretive hike along Lil Creek in Tombstone Territorial Park.

Training and inreach

The author and other YGS staff are often called upon throughout the year for their expertise on various geological topics and sites in the Yukon. This can be in the form of outreach for private, non-profit organizations (e.g., Yukon Conservation Society) or inreach for other Yukon government branches (e.g., Historic Sites and the Yukon Beringia Interpretive Centre). The author has been involved in providing non-technical geological descriptions for Historic Sites Branch for interpretive panels that have been designed for sites along Tintina Trench, Mt. Haldane near Mayo, and Montana Mountain. Every spring, the author trains summer staff of the Yukon Conservation Society (YCS) on the geological history of Miles Canyon in preparation for their summertime free guided hikes: “Created in the Canyon”. Additionally, she led guided hikes through the canyon for the public (Fig. 10). The author also contributed to a joint publication by the Canadian Parks and Wilderness Society (CPAWS) and YCS on the natural and cultural history of McIntyre Creek (CPAWS and YCS, 2021).



Figure 10. YGS geologist, Leyla Weston leads a public themed hike “Geology in the Canyon” for Yukon Conservation Society.

First Nations engagement

Yukon Geological Survey engages with Yukon First Nations with respect to our program activities. In order to build trusting and meaningful relationships with Yukon's First Nation governments, YGS endeavors to increase communication and seek input from First Nations (FN) early on in the planning stages of projects. Routine engagement includes spring and fall update letters to all affected FNs with respect to our program activities, as well as meetings with Lands and Resources staff of the FN governments. Due to the pandemic, in-person meetings have not been possible; however, meeting virtually via Zoom has proven to be quite successful, as it has provided much more opportunity to meet without the challenges and expenses of travel to and from the communities.

This year, YGS hired a youth from a Yukon First Nation for one week during the summer. Landis Smith of Carcross Tagish First Nation (CTFN) worked with YGS project geologist Patrick Sack in early June learning about some of the local geology on his Traditional Territory (Fig. 11).

Although Landis did not meet the requirements to work as a geological field assistant, this experience gave him an exposure to bedrock mapping and field geology, and was highly valuable to both the YGS and CTFN.

“Landis was a very nice addition to our crew. He shared some of his bush experience and wildlife knowledge with us. He learned from us and we learned from him – a very positive experience.” Patrick Sack, YGS Project Geologist.

YGS also continues to actively engage and collaborate with several First Nations with respect to ongoing geothermal research in southern Yukon. In 2020, YGS acquired \$2 million of funding (spread over three years) from Natural Resources Canada (NRCan) to explore for geothermal resources associated with crustal-scale fault systems. There is great interest from Yukon First Nations to become self-reliant and to move toward cleaner energy solutions; particularly those communities that rely on burning diesel fuel for heat and energy. Three First Nation communities that are situated along major fault systems were targeted for this research:



Figure 11. Field assistants Landis Smith of CTFN (left) and Sam Bonar (right) working on Mt. Stevens, southern Yukon; Bennett Lake in the background.

Kluane First Nation in Burwash Landing (Denali fault); Teslin Tlingit Council (Teslin fault); and Liard First Nation in Watson Lake (Tintina fault). All three First Nations have supported the survey's work and have been keen to engage in discussions about geothermal energy potential. Liard First Nation and YGS signed a project Memorandum of Understanding in January and have been co-managing the study near Watson Lake. Details of the geothermal research activities carried out to date are summarized by Relf (2022).

Special projects

Geological history of Whitehorse illustrations

For over a decade, the author has been leading field trips to various geological sites in the Whitehorse area for both students and the public. One of the most popular field trips is to the mineral showings and deposits of the former Whitehorse Copper Belt, which included an 1800-tonne-per-day mill at the Little Chief Copper Mine, which operated between 1967 and 1982 and was located only minutes from downtown Whitehorse. Despite having a mine in their backyard, many residents of Whitehorse are unaware that it even existed, nor do they know the significant role the discovery of copper played in the establishment of the City of Whitehorse. When people initially visit the local-area geology and learn about the processes that led to the formation of the copper-skarn deposits, they are always fascinated. Furthermore, when Yukoners are able to identify rocks and recognize different geologic features on the landscape, it creates a new connection to their environment. However, explaining the concepts of geologic time and the geologic history of a local area can often be very challenging to the layperson. To convey a proper understanding of the subject matter, it needs to be engaging, interesting and accessible (Dolphin, 2021). One method used to communicate complex subjects in an easily comprehensible way is through scientific illustration – it allows us to ‘see the unseeable’ – a critical element in the study of geology (Franklin Institute, 2021).

Scientific illustration requires a skilled artist who is also familiar with the subject matter. In February 2021, YGS contracted Esther Bordet to create a series of illustrations depicting those geologic time periods that capture the formation of the rocks in the Whitehorse area and the timing of the Whitehorse Copper Belt mineralization. Esther is not only an artist, but also a geologist who worked with the Yukon Geological Survey for four years mapping and working in the area south and east of Whitehorse, becoming an expert on the local-area geology.

From the inception of the project, it was very important for the author to work with the illustrator to create visuals that would depict the typical landscape and environment of the geologic time periods in question (e.g., Triassic, Jurassic and Cretaceous); the process known as paleogeographic reconstruction. It was essential to have illustrations that would make the geological concepts more accessible to the non-geologist and give the viewer an opportunity to ‘step back in time’. The illustrations not only capture the geological processes, but also the flora and fauna of the time (Fig. 12). A series of four illustrations (Triassic, Jurassic, Cretaceous and Late Miocene-Quaternary) will be completed by March 2022 and are anticipated to be used as interpretive panels in strategic locations around Whitehorse in the future.

Summary

Understanding geoscience is becoming increasingly vital for all citizens as it relates to climate change, finding and extracting natural resources safely, and having access to clean air and water. Furthermore, having geoscience knowledge is critical to making informed decisions with respect to land use planning and development. The Yukon Geological Survey views geoscience outreach and education as essential in providing all Yukoners and Yukon First Nations accurate geological information that will help our communities move toward greater sustainability.



Figure 12. Paleogeographic reconstruction of the Jurassic landscape (including fauna) that will be used for the 'Geologic History of Whitehorse' illustrations.

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Yukon Exploration and Geology 2021 abstracts

The following abstracts are from the Yukon Exploration and Geology 2021 volume. Full versions of the individual papers are available from the Yukon Geological Survey website, <https://data.geology.gov.yk.ca/>.

Update on the bedrock geology of the Rusty Mountain and Bonnet Plume Pass (west half) areas

T. Ambrose

The Rusty Mountain and Bonnet Plume Pass areas are underlain by sedimentary strata of the Paleoproterozoic Gillespie Lake Group, Mesoproterozoic Pinguicula Group, Neoproterozoic Hematite Creek Group and Windermere Supergroup, and Paleozoic Bouvette Formation. Gabbro and diorite of the ca. 1.38 Ga Hart River sills intrude the Gillespie Lake Group. A swarm of east-west striking, mafic dikes intrude strata as young as the Tonian Hematite Creek Group. The main structures in the area include a steeply dipping axial-planar cleavage and upright, gently plunging folds. The northwestern part of the map area is dominated by northeast-southwest oriented structures that affected the ca. 1 Ga Hematite Creek Group, but predate deposition of the ca. 780 Ma Callison Lake Formation (Windermere Supergroup). In the southern and northeastern parts of the map area, the structures are parallel to and likely related to younger Mesozoic–Cenozoic structures.

Updates to the Yukon Geological Survey's mineral potential mapping methodology

W. Bullen

This paper serves as an update to an earlier paper published by the Yukon Geological Survey in 2020: New mineral potential mapping methodology for Yukon: case studies from the Beaver River and Dawson regional land use planning areas. Since the release of the earlier paper, a number of the methods have been modified, and new techniques introduced. These are incorporated into this update paper – the reader is referred to the earlier paper for details of the method itself.

Mineral potential maps have thus far been completed for the Beaver River watershed, and the Dawson, Teslin, Na-Cho Nyäk Dun, and Ross River regions.

There have been significant updates made to the mineral potential mapping method:

1. Modifications to buffer distance and factors (these are an important fuzzy logic (*i.e.*, non-Boolean) component of the mineral potential mapping process) to enhance mapping outcomes.
2. The introduction of an in-house generated, machine learning algorithm (unsupervised, clustering-type) to classify mineral potential in order to remove the potential for human bias. The method replaces the statistical, areas-under-the-curve approach used previously.
3. A new method for delineating anomalous stream sediment data based on the lithological makeup of each watershed basin. The method computes and compares expected assay values to actual assay values, with values exceeding a certain threshold taken as anomalous. The previous method did not take lithology into account, relying on simple percentile methods only, and was considered insufficiently robust.
4. A new method for categorizing mineral potential confidence. Mineral potential maps produced by the Geological Survey contain measures of bedrock mapping confidence to facilitate land use planning. The updated method is significantly more robust than that used previously.
5. Revisions to the map legend to account for the new, machine learning-based mineral potential categorization methodology.
6. Revisions to the map colour scheme to make them colour blind-safe.

Geology of the Carpenter Creek and McKay Hill areas (NTS 106D/6, 11), central Yukon

R. Cobbett

The Carpenter Creek area straddles the Paleozoic basin-platform transition which is coincident with the Dawson thrust in north-central Yukon. North of the thrust, the strata can be broadly divided into two groups: (1) Proterozoic sedimentary and intrusive rocks, and (2) Paleozoic platformal strata with volcanic rock horizons. The two groups of rocks are separated by an angular unconformity. Below the unconformity, Hart River gabbro sills and dikes (ca. 1.38 Ga) intrude the Gillespie Lake Group. Younger Proterozoic rocks that are not intruded by the gabbro occur on the other side of a fault that traces through the Carpenter Creek valley. These rocks are interpreted to be younger than Gillespie Lake Group and are tentatively assigned to Pinguicula Group. Above the unconformity, Paleozoic volcanic and volcanoclastic rocks are interstratified with carbonate rocks. The volcanic rocks occur near the base and top of the Bouvette Formation.

South of the Dawson thrust, in the direct hangingwall, volcanic and volcanoclastic rocks are interlayered with shale, chert and sandstone and intruded by discontinuous gabbro bodies of unknown age. Rare limestone lenses within the volcanic rocks contain coral fossils that constrain the age of these rocks to Middle Ordovician or younger. Hyland Group rocks are thrust over the volcanic unit and comprise shale, quartz grit and limestone. Shale exhibits a well-developed foliation, oriented parallel to the northwest-trending structural grain. Tight folds with NW-SE-striking axial planes repeats stratigraphy south of the Dawson thrust.

Within the mapped area, Ag-Pb-Zn ± Au mineralization near Grey Copper Hill occurs right along the unconformity between Upper (?) Proterozoic rocks and the Bouvette Formation. Au-Ag-Cu-Pb-mineralization is spatially associated with a strike-slip fault that offsets shale, volcanic rocks and small gabbro bodies near McKay Hill.

The Yukon Digital Bedrock Geology compilation

M. Colpron

The Yukon Digital Bedrock Geology dataset was first released in 1999. It was rebuilt and expanded in 2016 and has since received regular updates. This paper summarizes the enhancements made to the bedrock geology dataset since 2016, the other ancillary geoscience datasets available, and the various ways to access and use the dataset.

Preliminary results and structural interpretations from drone lidar surveys over the Eastern Denali fault, Yukon

T. Finley, G. Salomon, R. Stephen, E. Nissen, J. Cassidy and B. Menounos

The Yukon Geological Survey and Kluane First Nation intend to drill a temperature gradient well near Burwash Landing, YT, to evaluate the geothermal energy potential of the area. The preferred drill site is located immediately southwest of the Eastern Denali fault (EDF), which has ruptured multiple times in the Holocene. The kinematics and recent activity of the fault are important factors to consider when developing a geothermal resource, for two purposes: (1) identifying zones of enhanced permeability due to local fault geometry and (2) assessing the seismic hazard of drilling and developing a geothermal system along an active fault. Here, we present new lidar data collected from a drone platform, which enabled the production of 30 cm spatial resolution bare-earth Digital Terrain Models (DTMs) over several segments of the EDF. These products offer a considerable increase in both spatial resolution and canopy penetration compared to existing spaceborne and airborne photogrammetric Digital Surface Models (DSMs) and DTMs of the area. We use hillshades to map segments of the EDF surface trace in detail, and we make preliminary interpretations about the structure and kinematics of the fault. Offset stream channels and hill slopes that cross the fault at high angles indicate dextral offsets ranging between 5 and 75 m. Vertical separation ranges between 0 and 20 m, varying between northeast and southwest-side up. We confirm previous interpretations that the geothermal drill site is located at a minor releasing bend in the fault. Previous fault maps based on ArcticDEM data showed multiple fault splays parallel to the EDF at the geothermal drill site, whereas the lidar data indicate strain is concentrated to a singular fault plane in this area. The EDF is characterized by a series of sediment mounds that we interpret to be positive flower structures. The higher spatial resolution achieved by the drone reveals possible compressional structures (fault tips or folds) consistent with dextral transpression on the surface of these mounds. We recommend additional drone lidar acquisition, field studies, geophysical analysis, and kinematic modeling to be carried out over the coming year.

Surficial geochemical setting of the southern Carmacks-Minto copper belt

K. Kennedy, P.J. Sack and H. Clarke

Preliminary surficial geological investigations of the southern Carmacks-Minto copper belt (NTS 115I/7) include material thicknesses, distribution and observations of thermal conditions. The Quaternary setting is discussed in relationship to material genesis and geomorphological processes operating on the landscape. Surficial material distribution is controlled by ice flow direction, prevailing wind direction, and aspect-related differences in gravity and thermal-driven surficial processes.

Valley bottoms and north-facing slopes have moderate to thick surficial cover that include far-travelled sediments such as till, loess and glaciolacustrine sand. Drainage can be poor in these landscapes and permafrost is present in many areas. Valley bottoms contain thick Quaternary fill and are unsuitable for traditional soil surveys. North-facing slopes may provide good geochemical results if sampled carefully for first-order bedrock derivatives. Upland and south-facing slopes have thin to moderate surficial cover and can provide good conditions for traditional C-horizon soil sampling surveys. Windblown sand, silt and volcanic ash are deposited thickly, but unevenly, across the landscape. These sediments dilute surficial geochemical samples and are often incorporated into other materials through cryoturbation, and fluvial and gravitational reworking. Geochemical dilution by eolian materials is more significant near the Yukon River floodplain and in the central Carmacks-Minto copper belt.

Future surficial geochemical surveys should use a variety of methods suited to landscape characteristics and well-described surficial material characterizations. Applying surficial landscape models to existing soils data may also improve their utility for exploration. High quality surficial mapping is a critical part of surficial geochemical surveys and new products in this area will benefit from the use of airborne lidar.

Yukon Permafrost Database: a new baseline data resource

P.S. Lipovsky, J.K. Humphries, E.T. Stewart-Jones and D.C. Cronmiller

The Yukon Geological Survey (YGS) has compiled available geotechnical and ground temperature data and related literature from government, industry and other contributors into the Yukon Permafrost Database. This paper reviews the database development process and structure, provides a snapshot of the primary data sets that have been loaded to date and discusses some of its limitations. The database is publicly accessible from an online portal (<https://yukon.ca/en/yukon-permafrost>) where data may be explored interactively in web maps, tables, and time series and ground temperature envelope graphics. Database contents are also available for download in a variety of formats. The Yukon Permafrost Database provides easily accessible data on permafrost distribution and thermal regime to support the assessment of thaw-related hazard and risk, and works towards the integration of disparate permafrost data at a territorial scale. The database will be maintained and updated regularly and YGS welcomes data contributions from government, industry and academic researchers to facilitate ongoing improvements to our collective knowledge of permafrost in Yukon.

Preliminary observations on the geology of the southern Big Salmon Range, south-central Yukon (Parts of NTS 105C/13, 105C/14, 105F/4 and 105E/1)

D. Moynihan and J.L. Crowley

The southern Big Salmon Range of south-central Yukon includes penetratively deformed Proterozoic-Permian rocks of the Yukon-Tanana terrane and Semenov block, and unfoliated Jurassic and Cretaceous intrusions. A newly mapped area, centred on the Boswell River, is divided into three panels by two regional-scale discontinuities, the Little Bear fault and the Sidney Creek fault.

The panel on the northeastern side of the Little Bear fault includes units dominated by metasedimentary rocks (Slate Mountain succession), mafic volcanic and volcanoclastic rocks (Wiley succession), and a varied metasedimentary/metavolcanoclastic unit (Livingstone Creek succession). Each of these is crosscut by intermediate-mafic intrusions of the Simpson Range suite and are therefore Early Mississippian or older. Fossiliferous limestone is interpreted to unconformably overlie phyllite of the Slate Mountain succession. Other units that crop out in this region are Permian augen schist and Cretaceous plutons, including Late Cretaceous quartz monzonite that hosts the Red Mountain Mo porphyry deposit.

The central part of the area, between the Little Bear and Sidney Creek faults, is dominated by mafic volcanic and plutonic rocks of the Sawtooth succession. These are along strike from, and provisionally correlated with the Moose Formation of the Boswell assemblage. The Sawtooth succession is overlain by a carbonate and chert-bearing metasedimentary unit (Rosy succession), which hosts a small foliated metagranodiorite intrusion. A younger, as yet undated, mafic metavolcanic package (Gunsight succession) is locally preserved above the Rosy succession. The metagranodiorite in the Rosy succession formed ca. 336 Ma and underwent metamorphic zircon growth in the Early Jurassic (~195 Ma). This zircon growth is interpreted to have accompanied regional, epidote-amphibolite to amphibolite-facies metamorphism and deformation.

Mississippian rocks of the Simpson Range suite dominate much of the southwestern domain, which is bounded to the northeast by the Sidney Creek fault. These intrusions crosscut quartzose schist, graphitic phyllite and metabasaltic rocks of the Flat Creek succession, which also hosts Middle Triassic metagabbro.

All pre-Jurassic rocks in the area are deformed, while post-tectonic intrusions include members of the Early Jurassic Lokken suite, the mid-Cretaceous Quiet Lake batholith and Iron Creek stock, and the aforementioned Red Mountain suite. Most Early Jurassic intrusions are undeformed, but deformation/hydration of some minor phases suggests they were intruded during the waning stages of deformation.

The Sidney Creek fault is cut by the Early Jurassic Sawtooth stock while the Cretaceous Iron Creek stock intruded across the trace of the Little Bear fault. The Little Bear and Sidney Creek faults are interpreted to define tectonic boundaries between Yukon-Tanana terrane and rocks of the Semenov block and may form part of a regional detachment between these units.

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)

P.J. Sack, J.L. Crowley, V. Bennett and J. Gabites

The Mount Nansen area in the Dawson Range comprises a metamorphic basement overlain and intruded by mid and Late Cretaceous magmatic rocks. Mid-Cretaceous epithermal deposits are recognized in the Brown-McDade cluster in the south and Late Cretaceous porphyry and epithermal occurrences in the centrally located Klaza cluster. Here we report eight new U-Pb zircon crystallization ages, two CA-TIMS and six LA-ICPMS, and Pb isotopic data for igneous feldspar from six samples. A 199.06 ± 0.96 Ma crystallization age demonstrates the host rock to the Brown-McDade deposit is the Late Triassic to Early Jurassic Minto suite. We report crystallization ages of 111 ± 1.8 Ma for the Dickson Hill porphyry, 107.96 ± 0.03 and 107.86 ± 0.03 for the central and border phases of the Bow Creek granite, respectively, and 107.0 ± 0.72 , 107.0 ± 0.78 and 107.5 ± 0.67 for equigranular and porphyritic phases of the Dawson Range granodiorite. These ages confirm a mid-Cretaceous Whitehorse suite affinity for these rocks with porphyritic textures suggesting high-level emplacement. Feldspar Pb isotopic data of igneous rocks in the Mount Nansen area become more radiogenic with time and are distinct for Late Triassic to Early Jurassic plutonic rocks versus Cretaceous rocks. Cretaceous feldspar isotopic data broadly overlaps Pb isotopic values of galena from deposits throughout the Dawson Range suggesting coeval magmatic rocks are a significant source of metals.

Updated bedrock geology of the southern Nash Creek area in central Yukon (parts of 106D/2, 3, 6 and 7)

D. Skipton

The southern Nash Creek area is located along the northern boundary of the Selwyn basin, and is underlain mainly by the Ediacaran–Cambrian Hyland Group, the Devonian–Mississippian Earn Group and the Mississippian Tsichu Group. Several Au and polymetallic mineral deposits are hosted by the Hyland Group and Paleozoic platformal carbonate rocks in the surrounding region. The southern Nash Creek area is bordered by regional-scale, southeast-striking thrust faults, which include the Dawson thrust to the northeast and the Robert Service thrust to the southwest. Based on stratigraphic relationships identified during 1:50 000-scale bedrock mapping, Hyland Group rocks in the area are considered to belong to the Cryogenian–Ediacaran Yusezyu Formation, the Ediacaran Algae Formation and the Ediacaran–Terreneuvian Narchilla Formation. Earn Group rocks include mainly shale and lesser amounts of interbedded dolostone, sandstone and shale. Tsichu Group rocks mostly comprise quartzite. The Yusezyu and Narchilla formations host (Paleozoic?) gabbro sills, and the Earn and Tsichu groups host gabbro–diorite sills that are considered to belong to the Triassic Galena suite. Rocks in the southern Nash Creek area exhibit a northeast-to-southwest-dipping foliation that is axial planar to southeast-trending folds.

Placer gold settings within an alpine glaciated environment, Granite Creek, Yukon (NTS 105M/14)

J.L. Steinke, J.D. Bond and B.C. Ward

Alpine glaciers from cirques of Granite and Albert creeks have deformed and reworked sediments in the Granite Creek valley and deposited locally sourced gold. Placer mining operations in the valley have allowed detailed study of sedimentary deposits. The main units identified are from at least two glacial episodes which advanced farther than the previously mapped limits. Thick sequences of advance and retreat outwash blanket the till and represent high energy depositional environments. At least one proglacial lake formed due to ice-damming of lower Granite Creek by the Cordilleran Ice Sheet. We provide a stratigraphic record extending approximately 130 000 years and have correlated alpine till units to MIS 4, which has not been found elsewhere in central Yukon. Multiple gold-bearing sedimentary units are found in the stratigraphy, representing glacial, interglacial/interstadial, and modern processes. This work highlights processes important to gold concentration that can be applied to other glaciated areas with proximal gold mineralization.

YGS list of publications and maps for 2021

YGS released 12 publications in 2021: 3 Open Files, 5 Miscellaneous Reports and 4 Annual Reports

Open Files

- Steiner, A.P. and Hickey, K.A., 2021. Bedrock geology map of the Nadaleen-Anubis fault corridor, eastern Rackla belt (parts of 106C/1,2). Yukon Geological Survey, Open File 2021-1, scale 1:20 000, 2 sheets.
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