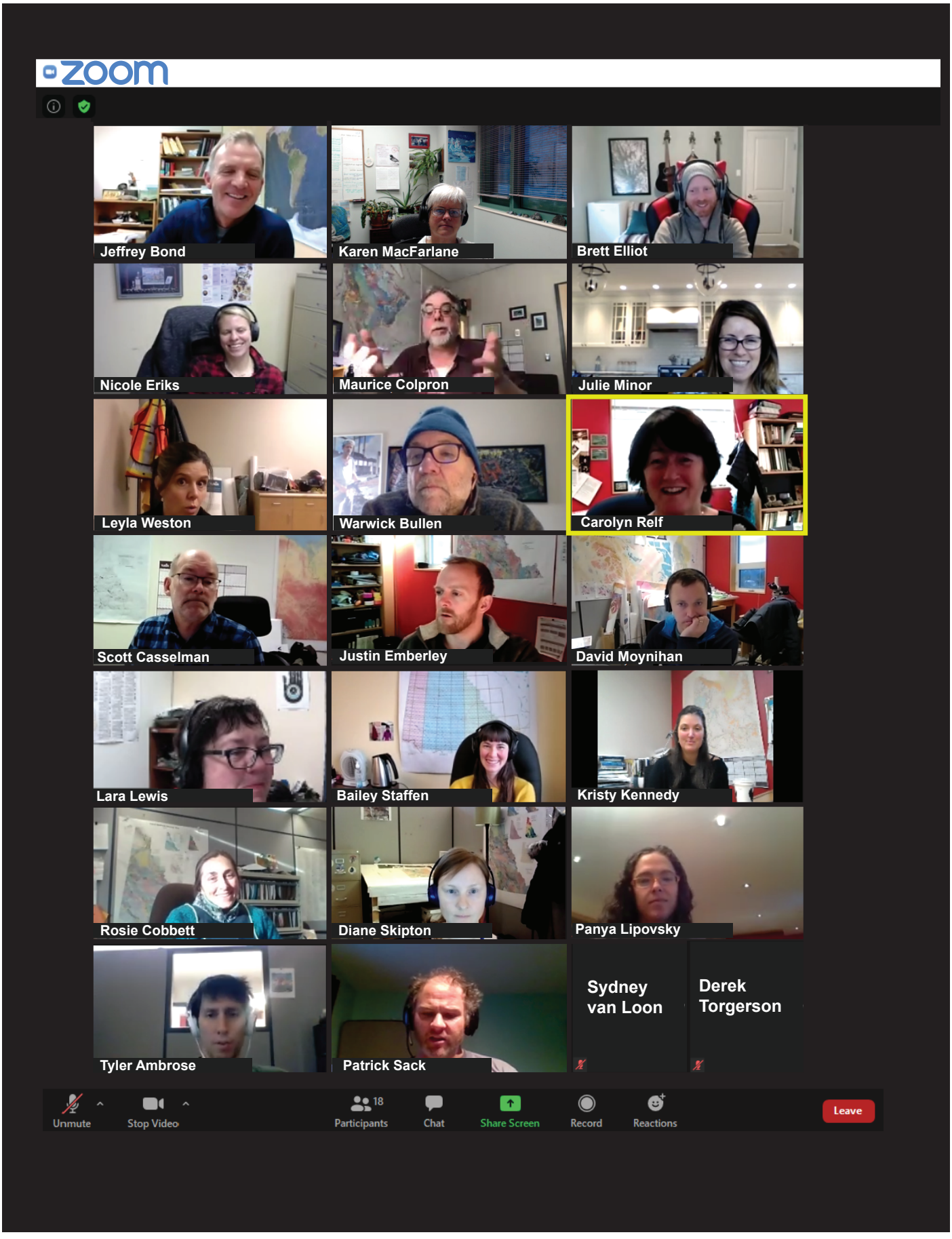
Yukon

Yukon
Exploration & Geology Overview
2020

- Yukon Geological Survey Activities
- Placer Mining Development & Exploration
- Hard Rock Mining, Development & Exploration
- YGS Publications
- Yukon Mineral Exploration Program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Jeffrey Bond
Karen MacFarlane
Brett Elliot
Nicole Eriks
Maurice Colpron
Julie Minor
Leyla Weston
Warwick Bullen
Carolyn Relf
Scott Casselman
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Bailey Staffen
Kristy Kennedy
Rosie Cobbett
Diane Skipton
Panya Lipovsky
Tyler Ambrose
Patrick Sack
Sydney van Loon
Derek Torgerson
Unmute
Stop Video
18
Participants
Chat
Share Screen
Record
Reactions
Leave

Yukon

Yukon Exploration & Geology Overview 2020

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Yukon Geological Survey

Energy, Mines and Resources

Government of Yukon

Published under the authority of the Department of Energy, Mines and Resources, Government of Yukon, https://yukon.ca.

Printed in Whitehorse, Yukon, 2021.

Publié avec l'autorisation du Ministères de l'Énergie, des Mines et des Ressources du gouvernement du Yukon, https://yukon.ca.

Imprimé à Whitehorse (Yukon) en 2021.

ISSN 1718-8334 (print version), 1718-8342 (online version)

Yukon Geological Survey publications can be obtained from:
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Yukon Geological Survey website https://yukon.ca/en/science-and-natural-resources/geology.

In referring to this publication, please use the following citation:
Yukon Exploration and Geology Overview 2020. K.E. MacFarlane (ed.), 2021. Yukon Geological Survey, 65 p.

Front cover photograph: YGS staff atop an outcrop of Jurassic conglomerate; Bonneville Lakes in the background.

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 2020 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.

Despite the uncertainties of 2020, my colleagues at the Yukon Geological Survey continued to provide geoscience information to support informed decision making. For those who authored or reviewed YEG papers this year (and in some instances both), thank you. A special thank you to Nicole Eriks for being an extra set of eyes...

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

Karen MacFarlane

Yukon Exploration and Geology Overview 2020

Table of Contents

Yukon Geological Survey 2020 overview

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Yukon Geological Survey

Relf, C., 2021. Yukon Geological Survey 2020 overview. *In:* Yukon Exploration and Geology Overview 2020, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 1–17.

Introduction

Like everywhere else around the world, 2020 was underscored in Yukon by the sudden spread of the COVID-19 virus and the drastic social and economic changes it precipitated. For Yukon Geological Survey (YGS), this meant a hasty retreat from offices in March, a reduced and modified field season, disruption of our client services, and uncertainties about the duration of the "new normal" and the impact it might have on Yukon's communities and minerals sector in the long term.

Relative to most regions of Canada, Yukon has fared relatively well and by June, the minerals sector was focused on how they could undertake exploration rather than how they might recover from a cancelled field season. Similarly, YGS managed to complete most of its planned field activities (albeit with a reduced scope), and to administer an expanded Yukon Mineral Exploration Program.

Snapshot of YGS

Figure 1 shows the current YGS organizational chart. In the spring, YGS welcomed a new Core Library Geologist, Justin Emberley, whose duties include the curation of sample collections and management of the core library facilities and services. He also plays a key role as a member of YGS' Health and Safety Committee. Diane Skipton completed her maternity leave at the end of September and returned full time to the survey. She will be resuming work on her mapping project next field season, and in the meantime is writing up results from her 2019 fieldwork.

Two YGS staff accepted temporary assignments with other work units this year. Olwyn Bruce is on a one-year assignment (to September 2021) with Yukon government's central Information and Communications Technology branch. Among her new responsibilities is the management of their online spatial data infrastructure, which allows public access to various Yukon government data sets. In October, Tiffani Fraser started an eleven-month temporary assignment as a senior policy analyst with Energy, Mines & Resources' Oil and Gas branch. She will be working on offshore oil and gas files and will help build a policy framework for a new geothermal resources act. Following her assignment she will be away on a year's deferred leave, returning to YGS in the fall of 2022. YGS wishes Olwyn and Tiffani the best as they undertake these new challenges.

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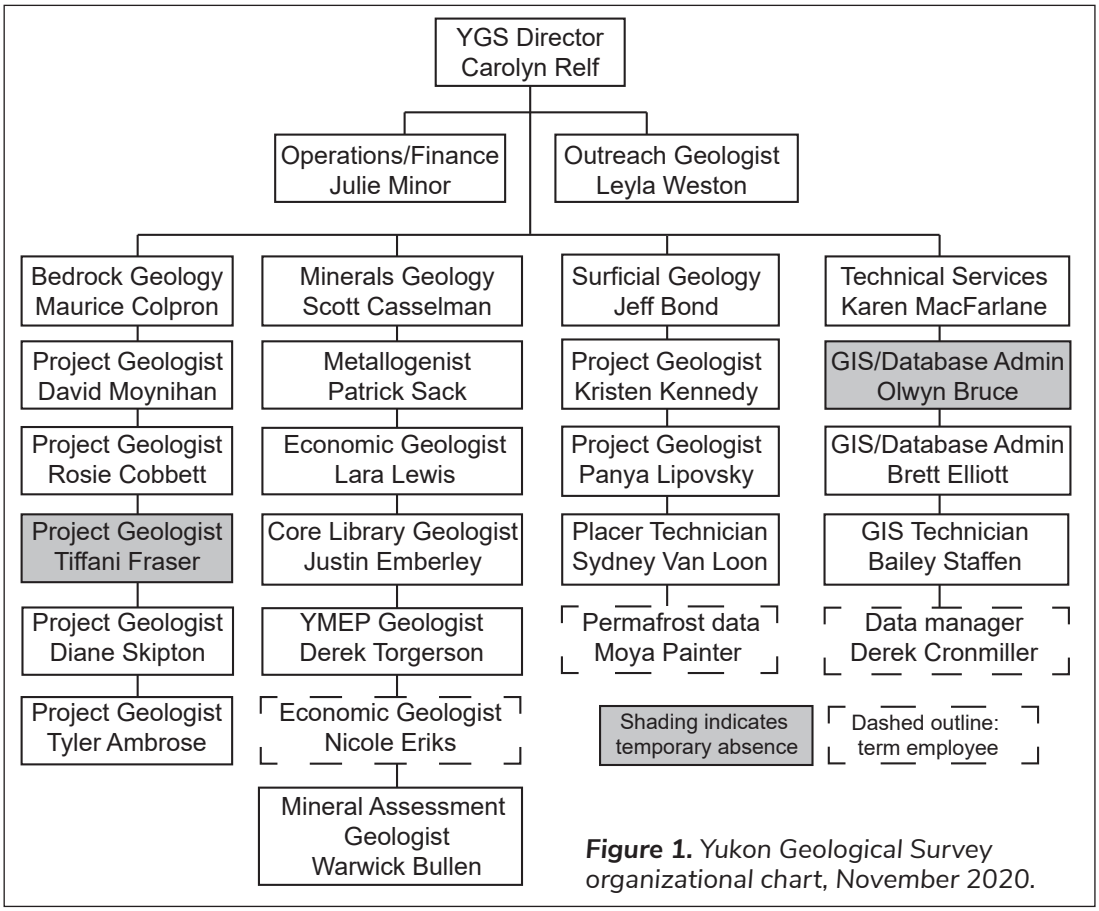

Figure 1. *Yukon Geological Survey organizational chart, November 2020.*

Amanda O'Connor will be leaving her casual position with YGS at the end of 2020 to lead the Science, Technology, Engineering and Math (STEM) Program at Yukon University. In addition to field assistance, sample management and data compilation work, she has been a big contributor to YGS' outreach work over last two years and she will be missed.

Seasonal staffing at YGS was significantly impacted by COVID-19 this year. With the closing of Yukon's borders to non-essential workers in the spring, YGS was able to hire three local geology students but cancelled plans to hire an additional five from southern Canada. The reduced number of students resulted in shortened field seasons, as some projects shared assistants and other projects acquired field support internally by re-assigning full-time staff to projects. By July, travel restrictions had softened and YGS was able to hire a fourth student from Vancouver and fulfill a commitment to support his graduate thesis project.

YGS budget

YGS' operating budget for 2020–21 totaled $3.65M. Table 1 presents a breakdown of these funds and the activities they support.

Funding for the Yukon Mineral Exploration Program (YMEP) was increased significantly this year, from $1.4M in 2019 to $2.5M. This bump in funding was part of Yukon government's commitment to support economic recovery from the COVID-19 pandemic; some of the highlights of this year's program are presented below.

Funding from external sources includes $90K from NRCan's Emerging Renewable Energy Program for geothermal studies (year one of a three-year grant), and a $35K grant from Indigenous and Northern Affairs Canada under a program called Climate Change Preparedness in the North (year three of a four-year grant). Funds from the latter grant are transferred from YGS to Yukon University to support permafrost

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	$1024K
YMEP	Grants in support of early stage exploration	$2500K
NRCan	Funding for targeted geothermal studies under the Emerging Renewable Energy Program	$90K
CIRNAC	Climate Change Preparedness in the North Program	$35K
Total		$3649K

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

scientists at the univerity's Research Centre. In contrast to previous years, YGS did not receive any funds from the Canadian Northern Economic Development Corporation (CanNor) in 2020.

Two Yukon government initiatives that have implications for YGS advanced over the past year. In September, Yukon announced its "Our Clean Future" Strategy, an initiative focused on climate change adaptation, greenhouse gas reduction, and transitioning to a green economy. Under the Strategy, YGS anticipates receiving some additional resources to support geothermal energy and permafrost studies over the next few years; funding will begin in April 2021. Progress was also made on the Yukon Mineral Development Strategy. Although engagement, particularly with communities, was delayed by the pandemic, the Panel managed to complete their "What We Heard" report in November (http://yukonmds.com/what-were-hearing/). Their Draft Recommendations document was released on December 28, 2020.

Current bedrock activities

The start-up of fieldwork was delayed this year as YGS developed, and sought approval for, modified field safety protocols to accommodate COVID-related directives put in place by Yukon's Chief Medical Officer of Health. Once approved, fieldwork ramped up and staff completed work on five bedrock projects (Fig. 2).

Tyler Ambrose continued 1:50 000 scale bedrock mapping in the Rusty Mountain area (North Rackla) in 2020, extending map coverage northward from his 2019 fieldwork. The area mapped this year is underlain primarily by shale and siltstone of the Quartet Group and dolostone of the overlying Gillespie Lake Group (both are part of the uppermost Paleoproterozoic Wernecke Supergroup). These rocks host the North Rackla Ag-Pb-Zn-Cu-Mn discovery; mapping will help to provide some stratigraphic context for the mineralization.

Northwest-vergent folds and thrusts deform rocks of the Wernecke Supergroup but do not appear to affect rocks of the overlying Pinguicula Group. Figure 3 shows a thrust-stacked section of Quartet Group structurally overlying Gillepsie Lake Group dolostone. Two sets of mafic intrusions cut the Rusty Mountain area: gabbro dikes and sills of the ca. 1.38 Ga Hart River suite, and a previously unreported suite of narrow (2–3 m), vertical, east-west striking dikes of unknown age and origin. Hart River suite dikes and sills intrude the Wernecke Supergroup and are deformed by northwest-vergent folds and thrusts. The east-west dikes preserve no evidence of deformation and are therefore interpreted to be younger. Detailed descriptions of rock units and their field relationships are presented by Ambrose (2021) elsewhere in this Yukon Exploration and Geology volume.

Rosie Cobbett completed a second year of fieldwork examining Paleozoic volcanic sequences across Selwyn basin. She measured sections, produced detailed geologic maps and collected samples from the Castle Mountain, McKay Hill, Camp Creek and Little Hyland River areas. The former two sites are located on the Ogilvie platform and adjacent Selwyn basin, respectively, in central Yukon. The latter sites are located in Selwyn basin farther to the southeast (Fig. 2).

Cobbett's recent work in the Castle Mountain area pinned the age of volcanic rocks at 445 Ma (unpublished data); an age that is corroborated by fossil assemblages in associated sedimentary rocks (trilobites, brachiopods, graptolites). In the McKay Hill area to the south, volcanic rocks have been extensively reworked. Corals found in

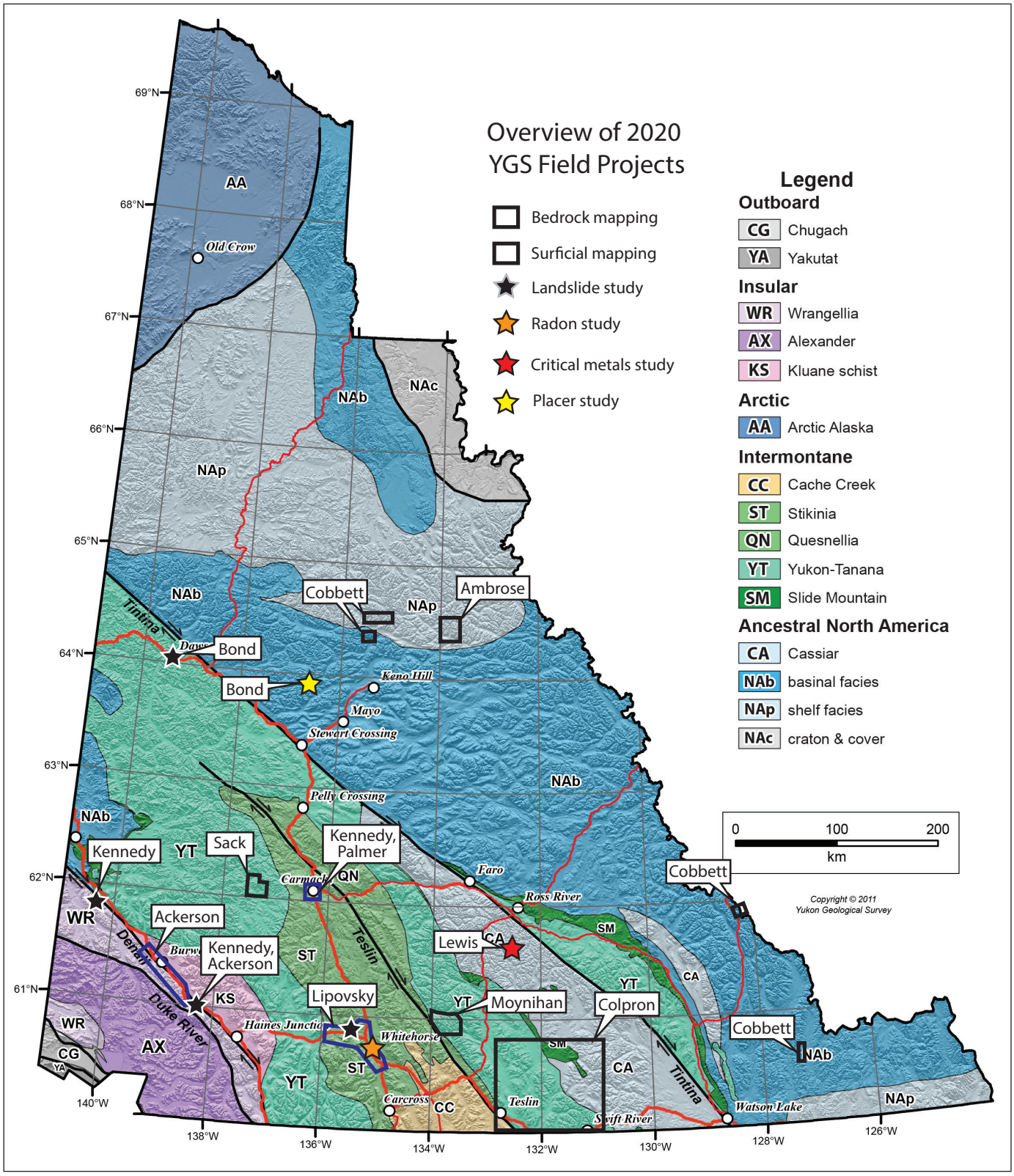

Figure 2. *Locations of YGS' 2020 field projects.*

Figure 3. *View looking west at thrust-imbricated units in the Rusty Mountain area.*

locally interbedded limestone suggest deposition here occurred in the Middle Ordovician or later. Based on age constraints and field relationships, Cobbett has tentatively interpreted the McKay Hill volcanic sequence to be sourced from eroded Castle Mountain-equivalent volcanic rocks from the platform. Geochemical and geochronological analyses will test this idea.

Cobbett's fieldwork in southeastern Yukon focused on a package of volcanic rocks of uncertain age. Previous mappers have assigned these rocks to the early Cambrian Vampire Formation; however, evidence suggests that they may part of the younger Gull Lake Formation (also lower Cambrian). Samples were collected for zircons to resolve this question.

Results of 2020 fieldwork will be published in next year's Yukon Exploration and Geology volume, as Cobbett is currently writing a paper on the petrology of Menzie Creek volcanic rocks and preparing for her comprehensive exam and thesis proposal submission at Memorial University.

Diane Skipton resumed work on her mapping project in the Clark Lakes area following her return from maternity leave in September. She has published a summary of 2019 field results in this volume (Skipton and Maw, 2021). The map area is underlain primarily by Neoproterozoic to Cambrian rocks of the Hyland Group. Fieldwork in 2019 focused on subdividing the Hyland Group into the Yusezyu, Algae and Narchilla formations, in part using detrital zircon data (in collaboration with Jim Crowley, Boise State University). Mapping identified local intrusions of gabbro and quartz monzonite; however, sampling of the unit failed to yield any zircons so the age of these intrusions remains unknown. The predominant structures in the area are north-northeast verging folds and thrusts that are likely related to the Dawson thrust zone (and, potentially, the Tombstone and Robert Service thrusts). A regional axial planar cleavage indicates that folding occurred under greenschist-facies conditions. Skipton has collected oriented samples for *in situ* Ar-Ar thermochronology on white mica to determine the timing of fabric development and metamorphism (in collaboration with Alfredo Camacho, University of Manitoba and the Geological Survey of Canada). Results are expected by spring 2021.

David Moynihan delayed the start of his 2020 fieldwork to August; in part to accommodate shared field assistants, and in part to invest time in writing up his Hyland River project Bulletin. In August he spent three weeks mapping in the northwestern part of the Teslin map sheet (Fig. 2) as part of a new, multi-year project. The area is underlain by rocks of the Yukon Tanana terrane and is host to the Late Cretaceous Red Mountain molybdenum porphyry deposit (Fig. 4). Recent reconnaissance work revealed a number of metamorphosed plutons in the area that do not appear on existing maps. Moynihan's new mapping will upgrade map units, including new units that are missing from the map, and address questions about the age, tectonic setting and structural framework of the area.

Patrick Sack initiated a multi-year study of Late Cretaceous plutons in 2020 (Fig. 2). The project includes new mapping to upgrade existing bedrock geology maps in the Mount Freegold-Mount Nansen area, as well as targeted geochemistry and geochronology to characterize Late Cretaceous magmatism and mineralization in the Dawson Range. The scope of the project will be similar to that of the recently completed metallogenic study of Late Triassic to Jurassic plutons (Sack *et al.*, 2020). Opportunities to collaborate with the Geological Survey of Canada to apply low-temperature thermochronology are being explored for future years of this project.

Tiffani Fraser worked on geochemical data from drill core sampled from the Tom SEDEX Pb-Zn-Ag-Ba deposit at MacMillan Pass (see Fraser, 2021, this volume). Although it did not involve fieldwork in 2020, the project is part of an ongoing regional study of black shales of the Devono-Mississippian Earn Group, and builds on previous work she has been doing on the genesis of hyper-enriched Devonian shales (e.g., Gadd *et al.*, 2020; Gadd *et al.*, 2019).

Maurice Colpron led a project to further assess potential heat production from plutons of the Seagull and Teslin suites north of Swift River (Fig. 2). The study follows up on work by Friend and Colpron (2017) in which radiogenic heat production was calculated

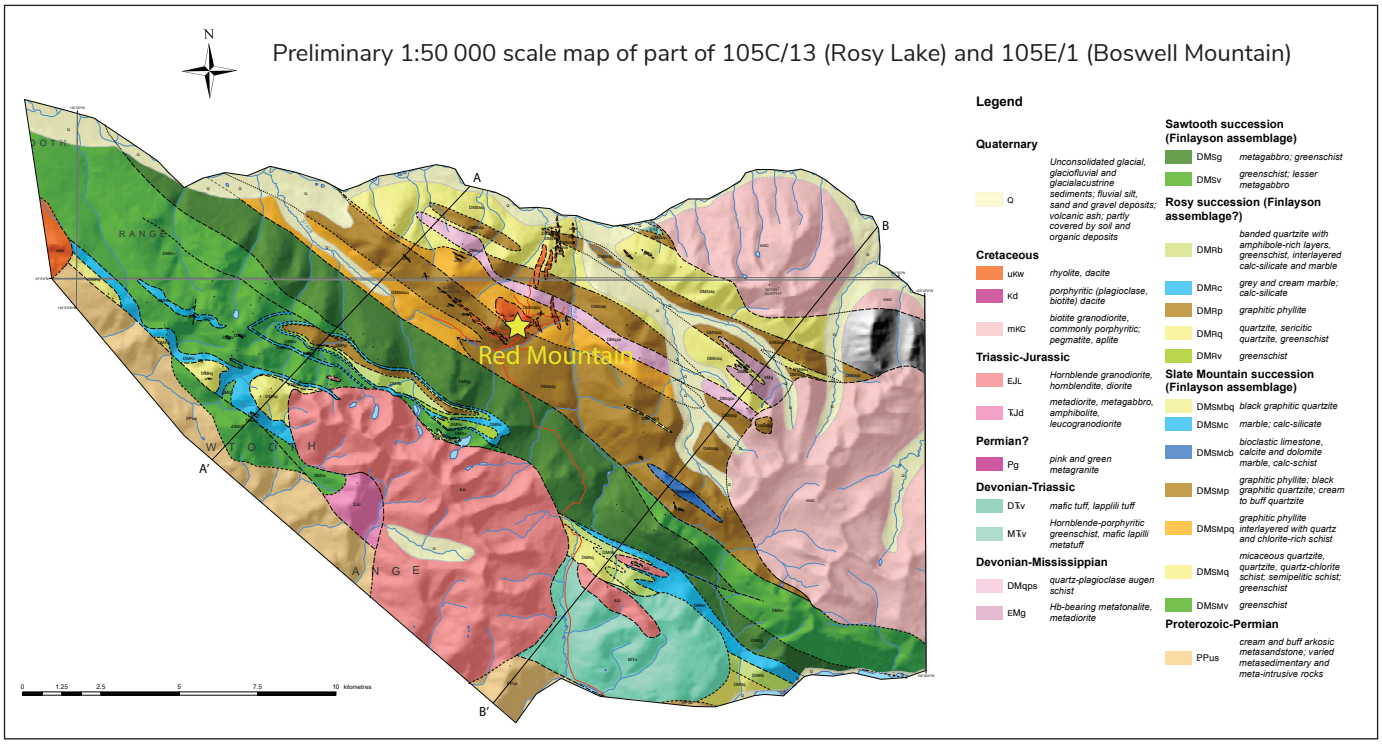

Figure 4. *Geology map, reproduced from David Moynihan's Yukon Geoscience Forum, 2020 technical poster "Preliminary Bedrock Geology of the Sawtooth Range".*

from lithogeochemical data for plutons across Yukon, based on their abundances of U, Th and K. The study revealed anomalously high heat production values for Seagull suite samples (locally greater than 10 μW/m^3, *vs.* ~2.5 μW/m^3 for the average crustal granite). Based on these results, Colpron undertook further sampling in 2019, collecting rocks from plutons of both the Seagull and Teslin suites, as the latter crop out closer to the community of Teslin. His study corroborated the promising heat potential of the Seagull suite, with values locally as high as 16 μW/m^3 (Colpron, 2019). In the current study, regional gravity data, constrained by density measurements taken from hand samples, were used to calculate the volumes, and therefore the total contained heat potential, of two batholiths of the Seagull suite: the Hake and the Seagull batholiths. Their high radiogenic heat values and near-surface setting, coupled with shallow Curie point depths documented in this part of Yukon (Witter *et al.*, 2018) suggest that the geothermal gradient in rocks adjacent to these batholiths could be elevated and warrant further exploration. Results of this project are presented by Colpron *et al.* (2021).

A new geothermal study was initiated this year and is currently being led by Colpron. It is a multi-year study supported by NRCan that focuses on assessing the geothermal potential of major fault systems in Yukon. It will have two components. The first is a reconnaissance study to identify favourable locations along faults where local extension may enhance permeability, with the ultimate goal being the definition of targets for temperature gradient drilling. The second component will involve drilling on the Denali fault near Burwash Landing, where recent studies identified seven targets for temperature gradient wells (Witter, 2020). The timeline for the project is between now and March 2023. YGS is in the process of hiring a term geologist with experience in geothermal exploration to participate in the project.

In mid-September, Justin Emberley worked with local consultant Michael Schmidt to decommission four seismic monitoring stations in southeastern Yukon/northeastern British Columbia. These instruments were installed in 2016 in response to recommendations from Yukon's Select Committee on the risks and benefits of hydraulic fracturing. They were part of a larger array deployed by British Columbia's Oil & Gas Commission to monitor baseline seismic activity in the region and enable subsurface mapping of faults. This information was of interest to Yukon government to support management decisions regarding shale gas development interests in Liard Basin. As the Yukon portion of this basin is not currently a priority for petroleum development, YGS has retrieved the instruments. Next year, as the US Array decommissions its Yukon stations, YGS will work with the Geological Survey of Canada (GSC) to re-occupy selected sites with YGS instruments to continue monitoring in priority areas.

In addition to field-based studies, the Bedrock unit worked with Technical Services to release a lithogeochemical data set this year (http://data.geology.gov.yk.ca/Compilation/35#InfoTab). It includes over 3400 whole rock analyses of plutonic, volcanic, metamorphic and sedimentary rocks, derived primarily from YGS and Geological Survey of Canada data (with additional data from published literature). The data include information on sample location, lithology, igneous suite/stratigraphic unit, chemical composition, and analytical metadata and can be downloaded in several formats: CSV, shapefile, KMZ, PDF, Excel or as a geodatabase. The data set will be updated periodically as new data are generated.

Surficial geology activities

Permafrost studies

Panya Lipovsky continued to lead efforts to populate the Yukon Permafrost database in 2020. The database centralizes geotechnical borehole and ground temperature data, as well as spatial footprints of documents that reference Yukon permafrost (e.g., published papers, academic theses, geotechnical reports, maps). To date, the bulk of the data are from YGS, Department of Community Services, and the Transportation & Engineering Branch of Highways and Public Works. This year, Moya Painter focused

on integrating data contributions from the mineral industry; specifically data from Casino, Kudz Ze Kayah and the abandoned Clinton Creek and Faro mines. YGS thanks Western Copper and Gold Corporation and BMC Minerals for sharing their data and would welcome further contributions from industry. Of particular interest are data with the following attributes:

- Data from deep (>20 m) boreholes that span most or all of the entire thickness of permafrost;
- Data from relatively undisturbed sites;
- Geotechnical data including stratigraphic soil descriptions, sample geotechnical properties, grain-size analyses and ice-content;
- Long-term (1 year +) thermistor data from multiple depths within permafrost.

Although the data are not yet publicly available, Technical Services staff have initiated the design of a portal to enable online access to the data.

In addition to permafrost compilation work, YGS is supporting a permafrost study in the greater Whitehorse area. The project, led by colleagues at Yukon University's Research Centre, includes the establishment of six new long-term permafrost monitoring stations and several detailed case studies of permafrost. One area of particular interest is located at Km 1456 along the Alaska Highway, where the researchers have been working with Lipovsky to monitor a thaw slump. The slump, originally documented in 2014, has been advancing toward the Alaska Highway at an increasing rate over the last year and half (Fig. 5). The slump and its pending impacts have been brought to the attention of the Department of Highways and Public Works.

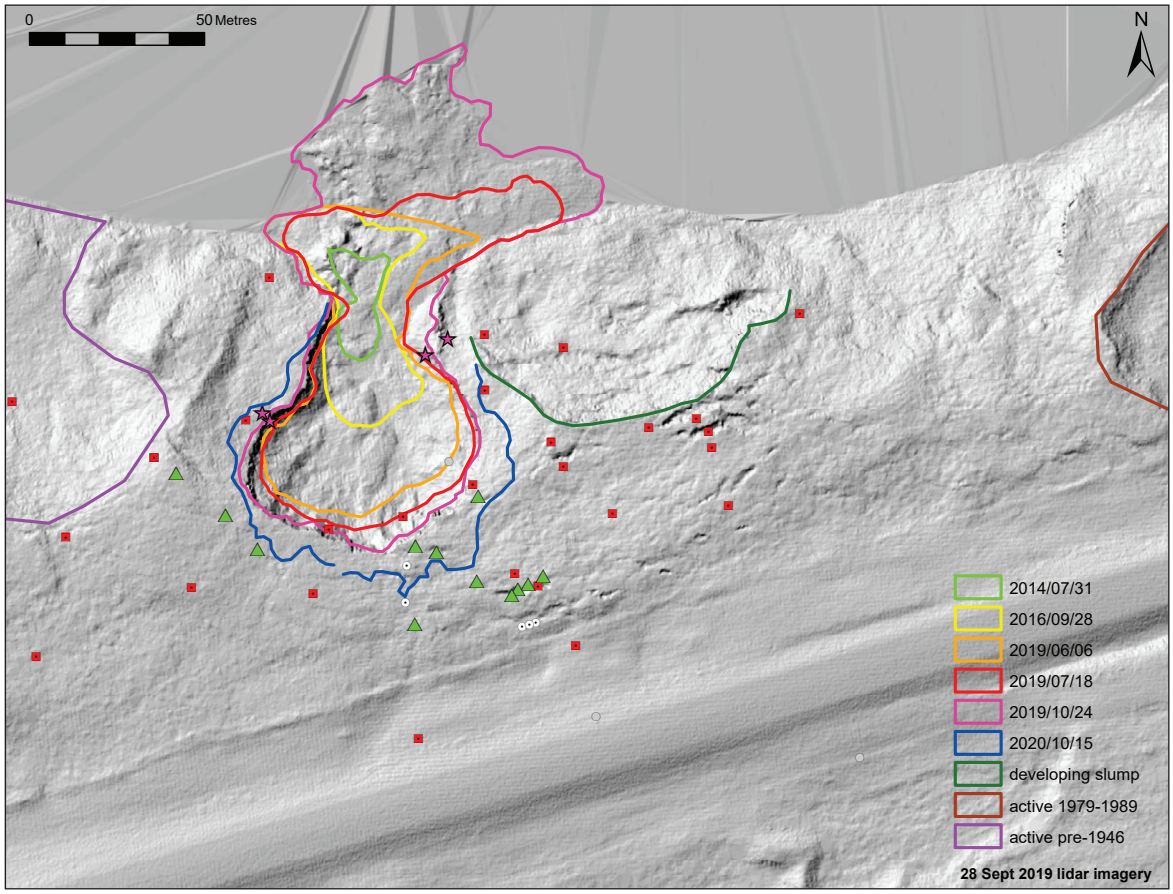

Figure 5. *LiDAR image of Takhini River thaw slump (AK Highway Km 1456). Coloured lines indicate the footprint of the slump area between 2014 and 2020. Historic slumps are outlined to the east and west, and the head scarp of a developing slump (along with tension cracks upslope) is visible immediately to the east of the Takhini slump. Symbols: red squares: rebar survey monument locations; green triangles: locations of trees that have been split by tension cracks; pink stars: locations of time-lapse cameras monitoring the slide; white circles: boreholes.*

Outside the Whitehorse area, YGS is seeking to extend the reach of its permafrost monitoring network beyond communities and highway corridors. YGS has a number of thermistors available to install in abandoned industry boreholes; companies are encouraged to contact Lipovsky directly if they are willing to host an instrument (panya.lipovsky@yukon.ca). Data from remote exploration sites would help to fill gaps in regional permafrost data coverage and support climate change modeling, infrastructure planning, environmental assessments, and geohazard risk evaluations.

Starting in April 2021, YGS will be initiating work to fulfill a number of commitments under Yukon government's "Our Clean Future" strategy. One of the goals of the strategy is to support climate change adaptation planning, and to this end, YGS plans to complete surficial geology maps for communities that have not yet been mapped (e.g., Haines Junction, Teslin, Beaver Creek), focusing on documenting permafrost and identifying thaw-related geohazards. YGS will also be working with Highways and Public Works to study permafrost along highway corridors and assess the risk to infrastructure where permafrost is present. The survey plans to run a competition to hire a permafrost scientist in the spring to lead this work.

Landslide monitoring

Crey Ackerson, a student from Simon Fraser University, is studying active layer detachments in the Kluane Lake area (Fig. 2) to assess whether their frequency is increasing as the climate changes. Record-setting rainfall in the Kluane region in August triggered several landslides (Fig. 6), a few of which reached the Alaska Highway, blocking traffic. Kristy Kennedy visited a number of these sites with Ackerson to observe the downslope runout and collect images. An overview of

Figure 6. *Active layer detachment slides on the north face of Outpost Mountain. Slides occurred on August 18, 2020. Helicopter for scale (red circle).*

project results to date was written up in Simon Fraser University's Centre for Natural Hazards Research September Newsletter.

A large bedrock slide was discovered in the Koidern River area this summer by a local outfitter, who brought it to the YGS' attention. Kristy Kennedy and Brent Ward (Simon Fraser University) visited the site to measure the runout and collect drone imagery (Figs. 2 and 7). The event released roughly 1.5 million cubic metres of rock that moved two kilometres downslope, damming the Koidern River and creating a lake behind the debris. Deep bedrock fractures were observed in the headscarp, suggesting that further rockslides are likely before the ground stabilizes. Seismic records reveal an event on December 19, 2019 that is interpreted to record this landslide. A slide of this magnitude is globally significant and would have been catastrophic had it occurred in a populated area. John Cassidy and Camille Brillon with the Geological Survey of Canada's Earthquake Hazards program are collaborating with Kennedy and Ward to see if seismic tremors preceded the slide and to determine whether their signal can be distinguished from tectonic-related seismicity. If so, perhaps seismic instruments could be used as a tool to help predict major landslides before they occur. A description of the slide was posted on the American Geophysical Union's landslide blog (https://blogs.agu.org/landslideblog/2020/09/07/koidern-landslide/).

Evidence for a potential new landslide near Dawson City was discovered this summer by a local resident. The site, located on the west shore of Yukon River opposite the community, is characterized by a series of arcuate bedrock fractures about 500 m upslope from the riverbank. These fractures define a headscarp roughly 340 m across that transects the Top of the World Highway and Sunnydale Road. Upon discovery of the potential slide, YGS engaged BGS Engineering, who, along with Jeff Bond and Brent Ward (Simon Fraser University) visited the site. Field observations revealed evidence for several small, incremental ground movements. Although BGS concluded that the likelihood of a sudden, catastrophic release of material is low, should the slide release suddenly, the displacement would produce a wave that would cause

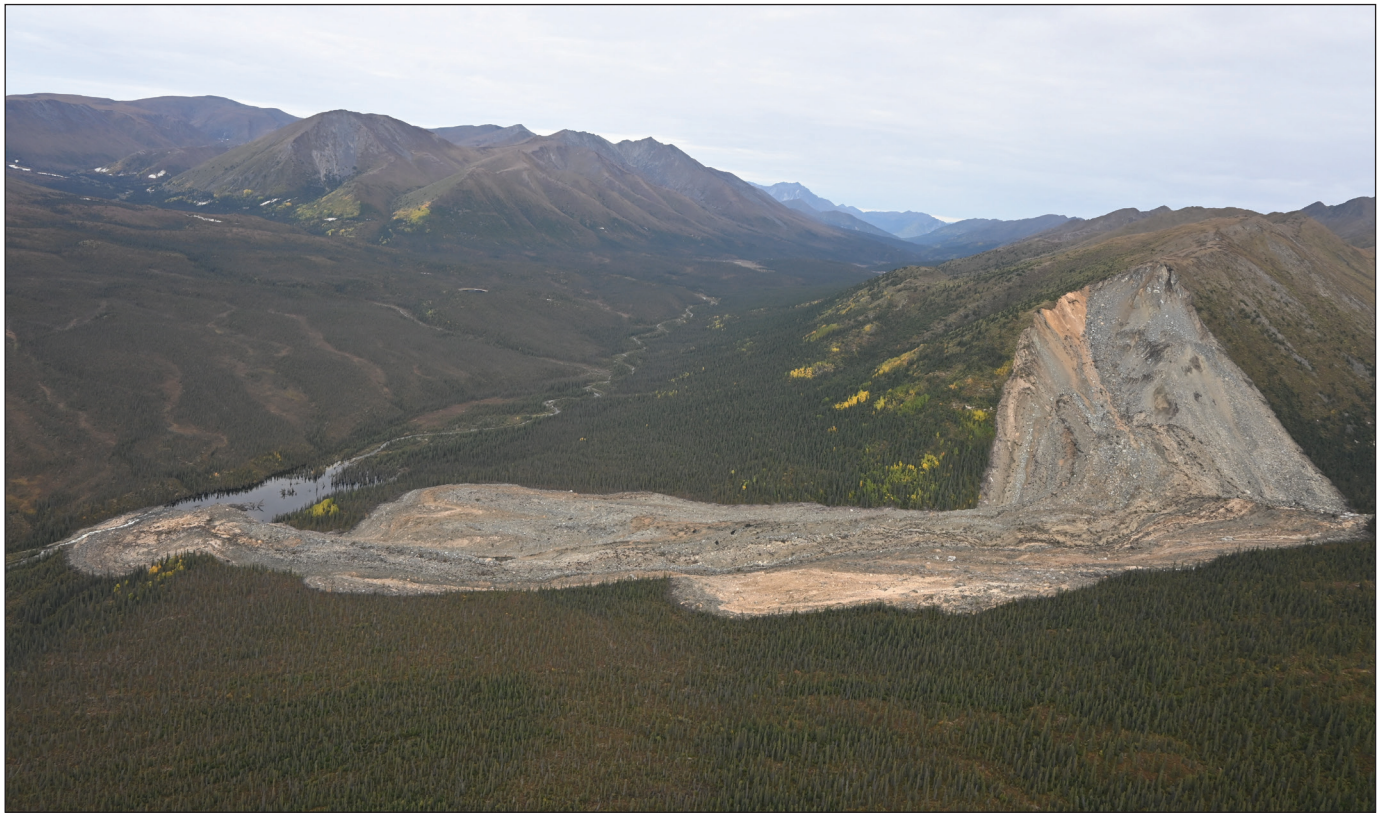

Figure 7. *Aerial view of Koidern slide looking northwest along Koidern River valley. Note the accumulation of water upstream from the toe of the slide.*

severe damage to the community. Bond is working with the Department of Community Services and the municipality to develop a monitoring program to be initiated next summer (2021).

Community mapping

Panya Lipovsky completed the third year of a four-year surficial geology mapping project in the greater Whitehorse area in 2020 (Fig. 2). The mapping component involves both fieldwork and detailed interpretation of air photos and LiDAR imagery, with the end result being a surficial geology map. Two other studies are being integrated with the mapping project. The first is the permafrost study being led by Yukon University (described previously). The second is a radon study being undertaken by Michael Kischuk at Dalhousie University. Fieldwork for the latter was supported by Lipovsky and Jeff Bond, who assisted him with field planning, arranged access to equipment for measuring radon gas abundances in surficial materials and provided funds for geochemical analysis of samples. The intent of the study is to see whether radon risk can be predicted from geologic setting. Preliminary results of the study are presented in this volume (Kischuck *et al.*, 2021) and will be the foundation for a BSc thesis.

Palmer Environmental was contracted this year to complete a community-scale surficial geology map of Carmacks (Cronmiller, 2020). In the spring they completed a desktop study using air photographs and satellite imagery, identifying a number of potential flood risks. In September, Kristy Kennedy spent a few days with Palmer staff field checking the map and collecting data to support a geohazard assessment. A report and accompanying geohazard map were released this fall (Cronmiller *et al.*, 2020).

Although not directly linked to YGS' community mapping activities, Kennedy collaborated this year with staff from Yukon government's Waters Branch on a multi-year aquifer mapping project for Carmacks, Watson Lake and Whitehorse. The project, being coordinated by Golder Associates, will generate subsurface maps of water-bearing units for each community. Kennedy's contribution has included the provision of surficial geology maps, borehole data and assisting in the selection of sites for new water monitoring wells.

Minerals-related activities

Industry liaison

As a result of the pandemic, YGS staff carried out significantly fewer visits to hard rock exploration projects than usual. Most companies and prospectors were focused on operating in compliance with Yukon government directives, and hosting visits by YGS geologists was not a priority for them. While the number of in-person visits was down, Minerals staff still monitored exploration activity through tracking of press releases and correspondence by phone and email. Although the outlook for the field season was very dim during the first wave of the pandemic, many projects saw funding late in the field season and managed to complete some work. A summary of exploration and development activities is presented elsewhere in this volume (Casselman and Lewis, 2021).

While many mineral industry events were cancelled or scaled back to a virtual setting this year (such as the annual Investment Tours and YGS' Community Rocks events), there were still opportunities to liaise with industry colleagues. YGS staff participated in a virtual Cordilleran Workshop in October, attended by over 300 industry representatives. Staff also presented virtual talks and posters at the Geoscience Forum, and organized a short course in machine learning.

Land use planning

Work continued in 2020 on mineral potential studies for the Beaver River and Dawson land use plans, as well as a number of community and First Nation Traditional Territories local area plans. Warwick Bullen and Jeff Bond provided updated information on hard rock and placer mineral potential, respectively, to planning commissions and internal working groups. Bullen also generated derivative "opportunity cost" assessments from his mineral potential maps, using a machine learning algorithm to calculate optimization values for each cell in his block model. His algorithm can be applied to areas under consideration for withdrawal, enabling the economic impact of different planning scenarios to be quantified.

Yukon Mineral Exploration Program

As noted above, funding for the Yukon Mineral Exploration Program (YMEP) was increased to $2.5M this year to support early stage exploration activities and to help offset the economic impact of the pandemic. Derek Torgerson approved 102 projects in 2020 (61 hard rock and 41 placer); for comparison, over the past decade the average number of projects approved was 54 per year. The majority of active hard rock exploration projects (66%) received YMEP support this year, and they collectively generated $9M in spending. Total expenditures by YMEP-supported placer projects are estimated at over $3M. This marks a significant increase in the leveraging ratio of the program: most years the ratio of total spending vs. total YMEP investment is roughly 3 to 1: this year, it is almost 5 to 1.

With respect to YMEP projects' immediate impact on the Yukon economy, a survey of recipients revealed that as of the end of September, 62 of the YMEP projects had created employment for 148 Yukoners and generated $3.8M in direct spending on goods and services with Yukon businesses. Local businesses provided air charters, accommodation, vehicle rentals, drilling services and expediting among other services; they also supplied groceries, fuel and other critical supplies. Highlights of this year's projects are presented in Torgerson (2021; this volume).

In addition to an increase in funding level, YGS made some administrative changes to YMEP. For the Grassroots Module, which has seen a declining number of applications over the past several years, the requirement for a minimum number of days' work was eliminated and reporting requirements were simplified. These amendments were made following consultation with prospectors, and resulted in a modest increase in the number of Grassroots projects, from one or two in previous years, to five in 2020. A second administrative change involved a decrease in the proportion of costs paid by proponents under the Target Evaluation module, from 50% to 40%. This change was made in the spring, when it was clear that proponents would have difficulty raising matching capital for their projects.

MINFILE database

Nicole Eriks continued to lead progress on the MINFILE database in 2020: since January, 81 new MINFILE occurrences have been added and 267 have been updated. At the prompting of clients, YGS launched a form in September 2019 to enable companies to submit MINFILE data for their properties. Although the form itself has not seen a lot of use, companies have been submitting data to YGS in table format. These submissions have created efficiencies in the updating of data; in particular, location data provided by companies have been extremely useful as it eliminates the requirement to geo-reference source maps to locate showings. YGS would like to thank ATAC Resources, Go Metals, Klondike Gold, Rockhaven and Triumph Gold for contributing data.

Geophysical data project

Minerals staff oversaw a contract by Aurora Geosciences to generate shape files, tabular files and derivative images (geotiffs and *.pdfs of residual total magnetic field, reduced to pole, vertical derivative and tilt derivative maps) from industry aeromagnetic surveys that have been filed for assessment credit. The project also involved the levelling and integration of the surveys into YGS' 1:250 000-scale regional magnetic maps for the territory (e.g., Aurora Geosciences Ltd. and Bruce, 2020, Fig. 8). It is hoped that the files, and in particular the images, will be useful for clients who do not have the capacity or software to manipulate geophysical data themselves or generate maps. The compiled 1:250 000 magnetic "tiles" have been re-released (Open Files 2020-8 through 2020-41), and the individual maps and associated data files have been bundled with the original Assessment Reports – with notations indicating that these are not the original submitted files but have been modified. Users can find them here: https://yukon2.maps.arcgis.com/apps/webappviewer/index.html?id=5a7c8f1658514ddc8107c8a190b74799. The data and map products will also be useful in supporting future studies, such as the delineation of buried plutons.

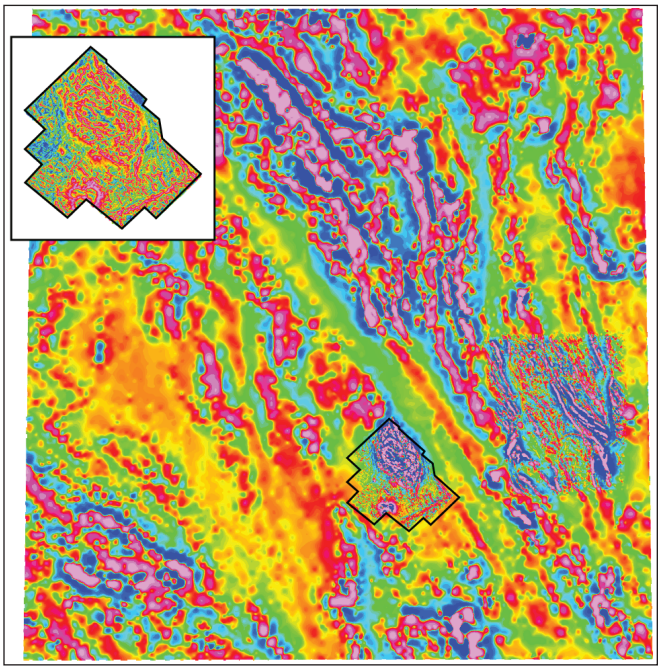

Figure 8. *Regional (1:250 000 scale) magnetic colour contour map of NTS map sheet 105E (Aurora Geosciences Ltd. and Bruce, 2020). Inset map is derived from data filed for the Mars gold occurrence (Wark, 1998; Assessment Report 093874); the Mars property survey has been levelled with and integrated into the regional map.*

Core library services

The core library and its facilities were closed to the public in mid-March in response to the pandemic. As COVID-related restrictions relaxed over the summer, the facilities re-opened for client use. Currently, clients may book the space to view and log core, and to use rock saws and other equipment (https://yukon.ca/en/yukon-geological-survey-core-library); however, access is limited to two people at a time and guidelines are in place for ensuring compliance with Yukon's COVID-19 restrictions. These guidelines are subject to change.

The core library received donations of diamond drill core from five properties this year. Eighteen holes were added to the collection from the Roop-Carlin (two holes), Meloy (three holes), LNPG (seven holes), Sixty Mile (one hole) and Heartless Joe (five holes) properties, totalling almost 4000 m of core. YGS thanks Archer Cathro and Associates Ltd. and Mayo Lake Minerals for their contributions.

Placer geology activities

Although the placer season started slowly, the lifting of COVID-related travel restrictions early in the field season allowed for a near-normal level of placer activity in 2020. High gold prices and low fuel costs led to a twenty-year high in gold production, as outlined elsewhere in this volume (Bond and van Loon, 2021). Jeff Bond and Sydney van Loon visited more than 90 placer operations to collect production information and document local geology; this information is being compiled into the upcoming Yukon Placer Industry Report, planned for release in May 2021.

Sydney van Loon continued to compile and digitize historic placer data in 2020. Since last spring, footprints for 70 new maps have been digitized, along with 835 drill holes and 595 polygons (dredge limits, historic workings), and the information has been added to the Historic Placer database (https://yukon.maps.arcgis.com/apps/webappviewer/index.html?id=33eb829c5f9d495894732443e2fbc319). Scanned copies of further maps are anticipated in the new year, including 114 from National Archives in Ottawa, and 17 from Parks Canada. In addition to maps, YGS has acquired a number of historic photographs of dredge operations (Fig. 9).

The cumulative impacts of placer mining, particularly in wetlands, has become an issue of increasing concern in Yukon over the past few years. Although YGS does not have a role in regulating placer activities, regulators do recognize the value of Jeff Bond's knowledge of wetlands — particularly in the Dawson region where much of the public interest is currently focused. In November, Bond was invited to speak at a Yukon Water Board hearing on placer mining in wetlands. He shared information on Indian River geology, including the subsurface structure of wetlands in the drainage, noting that such knowledge can be applied to reclamation practices to optimize the value of anthropogenic wetlands. Bond has also initiated discussions within Energy, Mines & Resources about the development of best practices guidelines and proposed some ideas for initiating a placer reclamation fund to clean up legacy sites. A working group has been formed to pursue this

Figure 9. *Historic photo: view looking southwestward at confluence of Klondike and Yukon rivers with Dredge No. 3 is in the foreground. Source: Library and Archives Canada, 2020.*

initiative, and potential funding partners are being sought. As envisioned, the program would include a component of monitoring to measure restoration success and aid in the tracking of cumulative effects.

Late in the summer Bond initiated a new placer study at Big Creek and Josephine Creek. These creeks share the same headwaters as Clear Creek, but their glacial history differs from Clear Creek, which presents some challenges for interpreting the geology and has implications for gold distribution. Schmidt Mining Corp. undertook an extensive sonic drilling program in the creeks this season, enabling Bond to document the glacial deposits and characterize the distribution of placer deposits in the valleys. He plans to publish the results next year in the Yukon Exploration and Geology volume.

Outreach

As always, public outreach and geoscience education remain a big part of YGS' program. Before the pandemic restricted in-person activities, YGS staff (Leyla Weston and Amanda O'Connor) participated in a two-day Mining Workforce Readiness workshop at Yukon University's Pelly Crossing satellite campus. The event featured an introduction to geology, covering topics such as rock and mineral identification, and the geologic time scale.

After mid-March, YGS outreach events were run virtually and materials were adapted for online delivery. For example, in lieu of in-person Mining Week activities, YGS partnered with the Yukon Chamber of Mines and the national Mining Matters program to deliver a Yukon WHERE Challenge. Students from grades three to

twelve were asked to select an object in their home, identify the non-renewable Earth resources it contains, and describe WHERE on Earth the resources came from. A total of twelve entries were received, including two from Del Van Gorder School in Faro. Virtual entries included videos, paintings and posters.

In the spring, Weston created digital information packages for teachers on a number of Earth science themed topics such as the Rock Cycle and Plate Tectonics. These included on-line quizzes using Kahoot, a game-based learning platform. Bailey Staffen helped Weston create learning activities such as word searches and fill-in-the-blank exercises on YGS' web site and Facebook page.

As Yukon started lifting COVID restrictions over the summer, Weston was able to start leading field activities again, including a day camp at the Yukon Wildlife Preserve and field trips to the Whitehorse Copper Belt and Miles Canyon. In addition to direct learning, YGS enhanced its social media presence over the summer with weekly Facebooks posts featuring images and descriptions of local geology along popular hiking and paddling routes in an effort to raise awareness of Earth science. Posts included the Grey Mountain cave, Takhini River, Miles Canyon, Spirit Canyon, and the Fish Lake trail, among others. YGS also acquired YouTube and Instagram accounts to post videos and images relate to Yukon geology; it is hoped that these additional social media platforms will enhance our visibility to all Yukoners.

As schools re–opened in the fall, many teachers sought experiential learning opportunities that would take their classes outdoors. Leyla Weston had an extremely busy fall, leading field trips both locally (Whitehorse Copper Belt, Miles Canyon, Grey Mountain Road) and outside of the Whitehorse area (Slims River, Carcross Desert, Moosehide slide in Dawson). The trips exposed students to geomorphology and bedrock geology, and taught them navigation and mineral identification skills (Fig. 10). Weston also delivered some in-class program activities to support Earth science curricula in the schools.

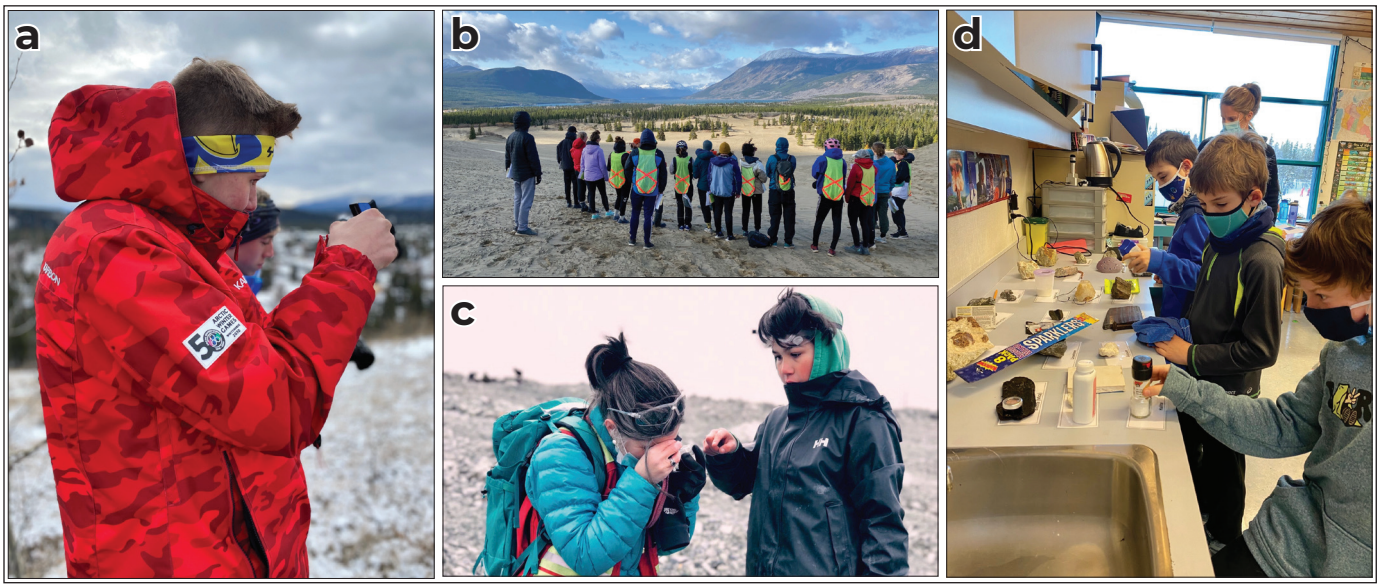

Figure 10. *Photos of YGS outreach activities.* ***(a)*** *Grade 11 student in the Experiential Science program learns to use a compass;* ***(b)*** *grade 10 French Achievement Challenge Environment Stewardship class field trip to the Carcross Desert;* ***(c)*** *Leyla Weston assisting a student with mineral identification at the Whitehorse Copper Belt; and* ***(d)*** *a grade 5/6 class participates in an exercise matching common household products with their source minerals.*

In addition to public education, YGS continued to work to strengthen our relationships with Yukon First Nations. Weston led the survey's efforts to seek input on program plans and share research results with communities. The frequency of meetings with each First Nation varied depending on the nature of YGS activities in each Traditional Territory and the capacity of each government to engage. YGS held a total of eleven meetings this year with seven First Nations, and is committed to continue to engage and share information.

Summary

Although this year had some unique challenges, YGS was able to deliver most of its planned program activities and continued to serve clients and release geoscience information. The overviews in this volume and the technical papers in the accompanying Yukon Exploration and Geology volume provide a more detailed summary of exploration and research highlights, and readers are encouraged to peruse them.

We appreciate clients' patience as we adjusted our services to meet our new pandemic-induced reality, and we apologize for any delays in service that these adjustments caused. We also would like to thank Yukon First Nations for their willingness to engage with us this year, given the challenges and uncertainties everyone faced.

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Yukon placer mining 2020 development and exploration overview

Jeffrey Bond and Sydney van Loon*
Yukon Geological Survey

Bond, J. and van Loon S., 2021. Yukon placer mining 2020 development and exploration overview. *In:* Yukon Exploration and Geology Overview 2020, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 19–32.

Introduction

The COVID-19 pandemic and associated economic recession has had a profound impact on Canada and the world. In Yukon, the tourism industry nearly vanished overnight as flights and RV traffic were reduced to a trickle. Fortunately, gold mining was given an essential service "green light" to continue, amid strict protocols to control the spread of the virus. The industry responded with an incredible year of production, spurred on by high gold prices and low fuel costs. This scenario, where gold mining provided a safe haven and economic opportunity during global hard times, has played out before in Canadian history. The great depression of the late 1800s contributed significantly to interest in the Klondike Gold Rush, the dirty 1930s saw a resurgence in placer gold mining in Yukon, and similarly, the recession of the early 1980s kick started the modern era of placer gold mining in the territory. The story of the 2020 pandemic is no different, highlighting the value of economic diversification and ability of a remote northern industry to contribute new wealth to a nation when it is needed most.

Climate for mining

Warm early season conditions across much of Yukon offset initial delays associated with navigating the pandemic. The average high temperature in Dawson for the month of May was 18°C. Temperatures stayed seasonal until abruptly ending on October 22 when temperatures decreased to -22°C.

The big story in parts of Yukon was the excessive and steady rain. For central Yukon, the rain was less constant; however, flood-like conditions were documented in many creeks when 37.5 mm was recorded on June 21. Similarly, 32.4 mm was recorded on August 6. Mountainous terrain that is susceptible to orographic precipitation was also impacted, with regular daily rainfall occurring in the Keno Hill mining camp. Total precipitation recorded in Mayo for June and July measured 192.7 mm, approximately double the seasonal average. For the Kluane Ranges, wet conditions were the norm in July and August with 297.7 mm falling in Burwash Landing, causing washouts on the Alaska Highway. This two month accumulation exceeded the annual average precipitation for the area.

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Gold production and value summary

Placer gold production according to export tax reporting totalled 84,900 crude ounces as of November 5, 2020 (Fig. 1). This was the highest production total since 1999. With an average season gold price of CDN $2506, this equalled CDN $170.3 million in production revenue. Approximately 87% of this value (CDN $148 million) enters directly into the Canadian economy within the mining season via goods, services and wages associated with mining. The high gold price, which increased by CDN $800/ounce compared to the 2019 season, was the clear advantage in 2020. Furthermore, a $0.25/litre drop in diesel prices heading into the mining season bolstered overall extraction costs. This price reduction was directly linked to reduced pandemic consumption leading to a surplus in stocks.

The distribution of placer gold production is illustrated in Figure 2.

Development highlights

Indian River drainage

Production from the Indian River recovered slightly from 2019 with a total of 29,294 crude ounces reported. More than half of this production originated from the Indian River main stem where 16,519 crude ounces was produced. Dominion, Eureka and Sulphur creeks also had a strong season with 4650, 2557, and 2458 crude ounces reported, respectively.

Slate River Mining consists of a two-person crew that operates on the lower Indian River (Fig. 3). They mine relatively shallow, point bar ground in strips along the margin of the river. Stripping benefits from the use of an excavator-mounted conveyor, which allows for convenient placement of overburden proximal to the cut. The strategic segregation of overburden facilitates backfilling and slope grading to produce excellent reclamation outcomes. Their left limit cut measured 1 km (3,280 ft) in length and 36 to 72 m (118–236 ft) in width. A New Zealand-style plant limits the need for hauling pay.

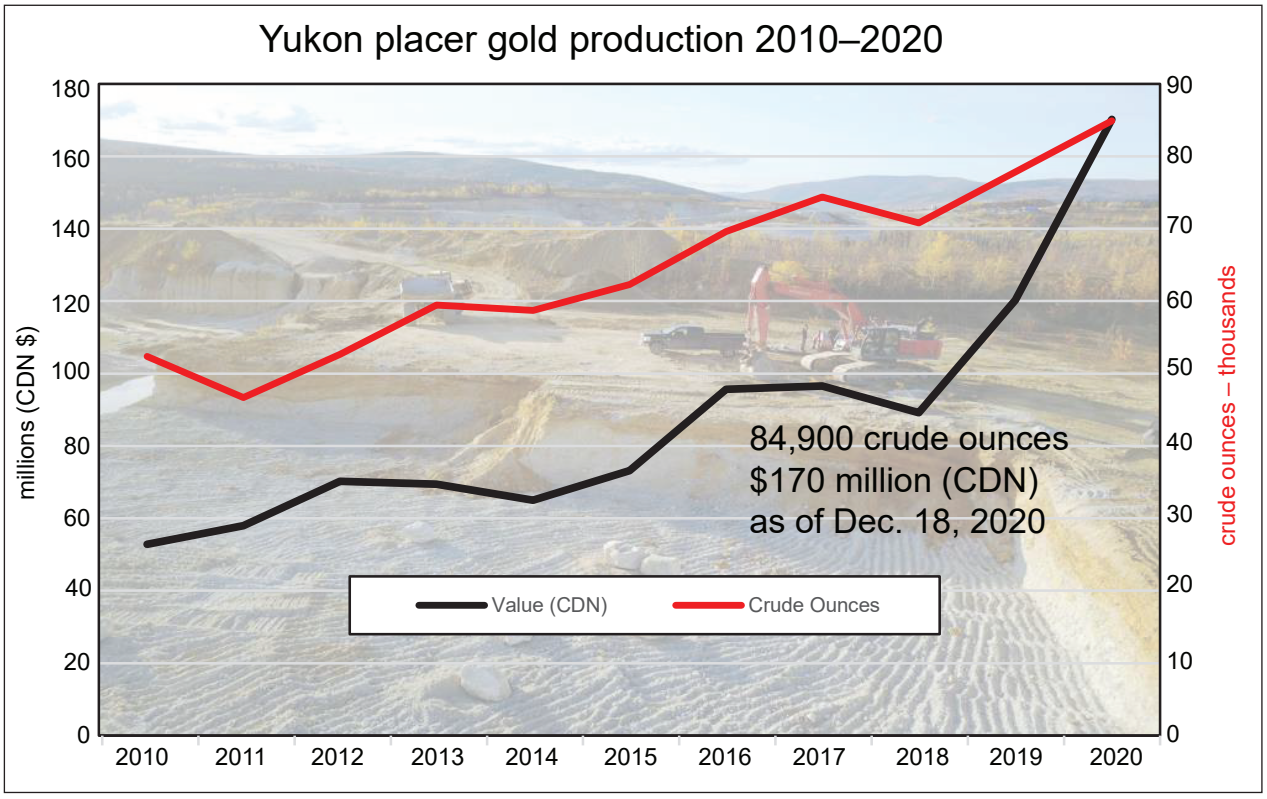

Figure 1. *Total placer gold production in crude ounces and its value in Canadian dollars for the last 11 years.*

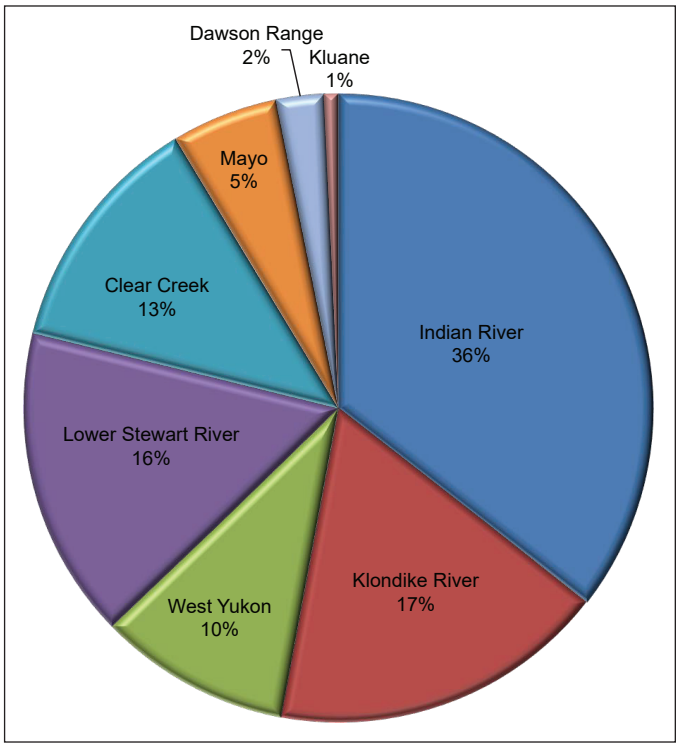

Figure 2. *Placer production distribution according to district. Production from the Clear Creek area nearly doubled in 2020.*

Figure 3. *A view looking up the Indian River over Slate River Mining's operation. Overburden is strategically stacked adjacent to the cut minimizing transport distances and facilitating reclamation.*

On upper Eureka Creek, Treadstone Aggregate continued to open up the left limit Pliocene bench deposit, extracting pay from two locations (Fig. 4). The 14-person crew excavated a 24 m (79 ft) deep cut at the back of the bench and sluiced the bottom 2 to 3 m (6–10 ft) of pay consisting of high-energy cobble gravel with small boulders. Bedrock faulting is present in one corner of the cut resulting in a large slab of decomposed bedrock being thrust over the gravel. The second cut was excavated on the outer edge of the bench and consists of 6 m (20 ft) of oxidized gravel. Gold was distributed throughout this unit suggesting it may be an intermediate-level bench deposit that reworked the high-level bench. Treadstone Aggregate's operation provides an upstream validation point on the Eureka bench, which is a significant deposit having a strike length of more than 3.0 km (1.8 mi).

Figure 4. *Treadstone Aggregates operation on the Eureka bench. Visible in the foreground is an oxidized pay gravel located on the rim of the bench.*

A new operation, Lonesome Dove Mining, commenced work on Wounded Moose Creek in 2020 (Fig. 5). The 17-person crew focused operations at the mouth of the creek where it dissects the Australia Creek bench. The Macon SD 300 plant screens material to ½", uses 2300 gal/min and was processing 190 yd^3/hr. The gold is 840 fine and 100,000 yd^3 of material was sluiced for the season.

Favron Enterprises mined on Sulphur Creek, initially focusing on left and right limit side pay, outside of the dredge limits. While doing so, the corner of their cut revealed a portion of the dredged ground indicating 0.6 to 1.2 m (2.0–3.9 ft) of virgin gravel remaining on bedrock. A decision was made to open up a cut within the dredge limits measuring 125,000 ft^2 (Fig. 6). Significant volumes of pay gravel were encountered making the project a success. In stripping the dredge tailings, permafrost was encountered 1.2 m (3.9 ft) below the surface making for difficult excavation due to the high ice content. Permafrost was unanticipated since the site was dredged in the 1960s and very little vegetation had regrown. The high quartz content in the gravel, and resulting high albedo effect, may be responsible for redirecting solar energy.

On Dominion Creek, a new operation commenced mining near Granville and the Dominion drain (Fig. 7). NBC contracting moved up to the Yukon Territory from Barkerville and optioned the ground from Gimlex. The project has received YMEP funding in the past, which helped delineate a sizeable resource on the property. The 10-person crew sluiced 180 yd^3/hr using a Macon triple deck plant and had a very successful first year of mining in Yukon.

Figure 5. *A view of Lonesome Dove Mining's plant on Wounded Moose Creek. A water recirculation system consisting of a long U-shaped settling pond is visible in the background.*

Figure 6. *A view to the north of Favron Enterprises dredge tailing cut on Sulphur Creek. Coarse dredge tailings are visible under the pickup truck. Side pay cuts, outside of the dredge limits are also visible in the photo.*

Figure 7. *A view over NBC Contracting's operation on Dominion Creek. The Dominion drain is visible to the right of the stripped area. Mining progressed from the downstream end of the property, visible in the distance.*

Klondike River drainage

Daval Mining had YMEP funding to conduct drilling on the limits of Hunker Creek near the mouth of Colorado Creek (Fig. 8). For the past number of years they have been targeting leftover pay within the dredge limits. Their 25-hole drilling program successfully identified a right limit bench on Hunker Creek under the road at the bottom of Trilby Hill. This discovery has significantly increased their mineable area on the property.

Figure 8. *A view looking up Hunker Creek near the mouth of Colorado Creek and Trilby Hill. A right limit bench was discovered under the Hunker Creek road, to the left of the workings visible in the photograph.*

Farther downstream on Hunker Creek, the Sailer family was mining a left limit cut near the mouth of Last Chance Creek (Fig. 9). They targeted a low-level bench that had been previously discovered by old-timers. Flow indicators within the bench gravel suggest that it may be originating from Last Chance Creek, which increases the area of the deposit. The four-person crew sluiced 150 yd^3/hr and hydraulic monitoring was used to strip the muck overburden.

Dulac Mining continued their second season of mining on upper Eldorado Creek under an option agreement with Klondike Gold Corporation. The ground had been previously mined in the 1980s; however, side pay gravel preserved under a colluvium of weathered bedrock (slide rock) provided additional placer gold resources. Pay gravel was trucked out of the gulch to a landing near the mouth of Chief Gulch that provided adequate processing and settling space. The gold is clearly derived from a nearby source having a hackly appearance with quartz attached (Fig. 10).

Figure 9. *A view to the north looking down the left limit of Hunker Creek near the mouth of Last Chance Creek. The excavators are sitting on a low-level bench, which was the target of operations for the Sailer mine in 2020.*

Figure 10. *Locally derived, hackly gold was extracted from upper Eldorado Creek on Klondike Gold Corporation's claims.*

A significant shift in ownership occurred in 2020 when Doug Jackson purchased Jim Archibald's French gulch and hill claims. Mr. Archibald staked his first claim in the Klondike in 1962, and placer mined every year until 2020 when he retired. Mr. Jackson has been focused on American Hill for many years so this property acquisition increases his holdings significantly. A left limit Eldorado Creek side pay discovery was made below the French Gulch road that was overlain by an accumulation of weathered bedrock colluvium (Fig. 11).

Figure 11. *An exposure below the French Gulch road with virgin Eldorado Creek deposits overlain by colluviated weathered bedrock. The buried gravel is the red unit near the base of the measuring tape.*

West Yukon

M2 Gold continued working their mining project on the Sixtymile River. They processed pay from both bench ground and the floodplain flats. Their primary focus has been on the left limit, however this year they discovered paying ground on a right limit bench, which could indicate new source contributions or a migrating pay streak (Fig. 12). The crew of 18 personnel operated 23 hours per day using a newly acquired Macon plant.

For the first time in many years placer mining activity occurred on Bedrock Creek. K-1 Mining has conducted a significant exploration program consisting of 80 drill holes near the mouth of Winters Pup (Fig. 13). Using the new drill data, old air photos and government documents they were able to identify a target and commence mining. This year they processed valley bottom left limit side pay and opened up a sizeable bench deposit on the left limit.

Figure 12. *A view of M2 Gold Mines' plant on the Sixtymile River. Their mobile trommel plant reduces costs associated with hauling pay gravel.*

Figure 13. *A view to the south of Bedrock Creek in the Sixtymile River drainage. K-1 Mining has exposed a left limit bench deposit at the mouth of Winters Pup.*

Fortymile Placers was active on Marten Creek, a narrow tributary to the Fortymile River. Their operation consists of a floating trommel-style plant (Fig. 14). The two-person operation processes ground that is between 1.8 and 4.6 m (6–15 ft) deep and is highly efficient. The trommel and excavator combined burn 4 gallons of fuel per hour and they process 50 yd^3/hr. Gold is primarily fine with 80% passing through a 10 mesh screen.

Figure 14. *Fortymile Placers floating trommel plant on Marten Creek. One crew member operates a series of winches that swivel the plant and control the tailings stacker.*

Lower Stewart River

HC Mining on Henderson Creek had a big year processing four cuts, each up to 518 m (1700 ft) long. Mining was focused on lower Henderson Creek where two new Macon SD-600 screen deck plants were introduced later in the season and operated adjacent to one another (Fig. 15). A single excavator fed both plants and had a combined production of 400 yd^3/hr. Production from Henderson Creek in 2020 was the highest recorded since modern recording started in 1978.

Bedrock Mining Company Inc. completed a 56 drill hole YMEP project on lower Maisy May Creek in 2020. The project was successful in delineating more right limit pay gravel than expected. This is the largest operation in the drainage consisting of a 4-person crew that excavated three cuts.

Figure 15. *HC Mining added two Macon SD-600 screen deck plants to their operation and had them running side by side later in the season. The plants are fed by a Hitachi ZX470-5 bucket.*

Clear Creek

Activity ramped up in the Big and Josephine creek drainages in 2020. Schmidt Mining Corp. conducted a two-phase sonic drilling program that consisted of 345 holes. This included an 18 hole program on Gem Creek. Northern Sonic was hired to complete the drilling, process the samples and map the pay streak. In Big Creek, mining continued below camp in ground that is 5 m (17 ft) deep and consists largely of high energy, oxidized gravel (Fig. 16). Placer gold has been found to be somewhat spotty in the drainage making drilling particularly necessary. Farther downstream, the ground is increasingly glaciated and becomes deeper. Till is present in the stratigraphy and contains much of the placer gold. A channel was delineated on the center-right limit of Big Creek immediately above the deep ground. On Josephine Creek, both production and exploration drilling was completed by Schmidt Mining Corp. Placer gold is largely contained in thin till deposits on the bedrock surface and subsequently overlain by mostly barren fluvial gravel (Fig. 17). Where mining occurred, the ground ranged from 3 to 6 m (10–20 ft) deep; however, this increases to 24 m (80 ft) deep at the mouth of valley and becomes uneconomic. The exploration drilling program on Gem Creek successfully identified a pay streak within the fluvial fan deposit at the mouth of the drainage.

Gordon Scott mined at the mouth of Left Clear Creek in 2020. This project targeted side pay gravel on both limits of the valley. The center of the valley, which has a high bedrock surface, had been cleaned out by old-timers. A right limit exposure contained 2 m (7 ft) of gravel overlain by a wedge of silt and organics up to 2.5 m (8.2 ft) thick (Fig. 18). All of the gravel was processed through a 6 × 20 ft double screen deck plant that operates for 600 to 800 hours per season.

Figure 16. *A view looking up Big Creek at Schmidt Mining Corporation's placer mine. In this section of the drainage the total gravel thickness is 5.2 m and a distinct high-energy, oxidized gravel measuring 2.8 m in thickness is present on bedrock and contains most of the placer gold.*

Figure 17. *A cut on Josephine Creek shows the schist bedrock overlain by 0.6 m of till, 1.2 m of oxidized gravel and 1 m of silt. The till on bedrock contains the placer gold and was deposited during an early to middle Pleistocene glaciation.*

Figure 18. *A view of Scott Mining's cut on the right limit of Left Clear Creek. Bedrock is exposed at the base of the cut and two gravel units are present in the cut. The basal, placer gold-bearing gravel is periglacial in origin, deposited during a cold climate. The upper gravel unit is considered a relatively modern gravel and was likely deposited during the current warm period.*

Mayo and Keno City

Activity increased on Granite Creek in 2020; there were six active operations in the area, the majority of which were leased from claim owner J. Davies. Dulac Mining excavated a cut below the last glacial end moraine exposing a complex stratigraphic sequence (Fig. 19). The pay unit consists of an oxidized till deposited by a glaciation prior to the last that originated from the Granite Creek cirque. This placer-gold bearing till was overlain by a weathering surface, outwash gravel and glaciolacustrine sediment. The total depth of the cut was 24 m (80 ft) to bedrock.

A new exploration program was initiated on Keystone Creek by Earth and Iron. Keystone Creek is a tributary to Mayo Lake and was identified as a potential placer target in Yukon Geological Survey Bulletin 13: Placer gold deposits of the Mayo area, central Yukon (Lebarge et *al.*, 2002). A YMEP drilling program was initiated at the apex of the fluvial fan delta and a clearing was constructed on the right limit for a future camp or processing option (Fig. 20).

***Figure 19**. Dulac Mining's cut on Granite Creek in 2020. The oxidized till exposed at the base of the cut represents the top of the pay unit and was deposited by a pre-last glacial advance of a local alpine glacier.*

***Figure 20.** A view to the southwest over Earth and Iron's exploration project on the Keystone Creek fan delta. Exploration drilling targeted the apex of the fan delta where Keystone Creek first empties into the Mayo Lake valley.*

Rally! Mining optioned lower Duncan Creek from the Taylor family in 2020 and commenced mining at two locations. Initial production targeted the modern valley fluvial deposits that overlie a false bedrock of glacial sediment. On the left limit, excavation commenced into the last glacial end moraine that was deposited by up-valley flowing ice. This event buried placer gold-bearing outwash gravel and is the target for future development.

Dawson Range

A second season of mining occurred on Canadian Creek by a New Zealand company called Batavia Mining (Fig. 21). Their operation is focused on upper Canadian Creek near the mouth of Patton Gulch and the Casino hard rock deposit. They sluiced 80,000 yd^3 this season from a boulder zone both in the modern creek valley and on a low-level, right limit Canadian Creek bench. Total depth to bedrock measured 7.6 m (25 ft). The placer gold is locally derived and is described as having a popcorn appearance.

Mining continued on Mechanic Creek after a difficult start to the season. Diane Gow, part of a long time placer mining family in the Freegold Mountain camp, passed away in the spring. Diane was an active and vocal proponent of the industry and worked many water licenses over the years. Her knowledge and experience will be missed. For the 2020 season, the Gow family mined two locations, a right limit cut on the middle section of Mechanic Creek and a cut in the fluvial fan deposit at the mouth of the drainage.

Figure 21. *Batavia Mining's operation on upper Canadian Creek near the Casino deposit. Production was focused on the right limit where a low-level bench was encountered.*

Kluane

Canyon Mining Ltd. started a new operation on Fourth of July Creek in 2020. The operation focused on a left limit tributary called Snyder Creek where they processed a boulder gravel ranging in thickness from 1.5 to 6.1 m (5.0–20.0 ft). Their plant consisted of a combination Derocker and screen deck that was connected by a nugget trap sluice run (Fig. 22). The sluice runs below the screen deck to target finer gold. The plant is capable of processing up to 200 yd^3/hr.

References

LeBarge, W.P., Bond, J.D. and Hein, F.J., 2002. Placer gold deposits of the Mayo area, central Yukon. Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, Bulletin 13, 209 p.

Figure 22. *Canyon Mining Limited's wash plant and sluicing configuration on Fourth of July Creek.*

Yukon Mineral Exploration Program 2020 update

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Torgerson, D., Casselman, S. and Relf, C., 2021. Yukon Mineral Exploration Program 2020 update. *In:* Yukon Exploration and Geology Overview 2020, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 33–41.

Program summary

The Yukon Mineral Exploration Program (YMEP) is a funding program which provides financial support to proponents exploring for minerals in Yukon. Individual prospectors, partnerships, and 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 both 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 2020

Based on input from clients, in January 2020 YGS made administrative changes to the program. Anticipating challenges in raising capital, YGS increased the maximum YMEP contribution for projects in the Target Evaluation module from 50% to 60%. Based on this change, companies would be required to spend $66 667 to receive the maximum $40 000 grant; previously, the minimum spending requirement for a $40 000 grant was $80 000. The other program changes focused on the Grassroots module: the requirement for 30-person-days of fieldwork was eliminated, the confidentiality period for Grassroots reports was reduced to two years, and priority was given to applications for work in underexplored areas of the territory.

In the spring of 2020, financing of Yukon exploration projects on equity markets faced unprecedented levels of uncertainty due to the COVID-19 pandemic. The enactment of Civil Emergency Measures Acts across Canada led to border closures and self isolation measures, creating a challenging start to the 2020 exploration season. 2020 exploration spending projections, estimated at close to $100M for Yukon in February (https://sead.nrcan-rncan.gc.ca/expl-expl/ExploTable.aspx?FileT=032019&Lang=en) had dropped dramatically by late March.

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To help support exploration and sustain economic activity in the territory, Yukon government increased YMEP funding to $2.5M (up from $1.4M in 2019) in June. YGS had received 130 applications seeking in excess of $4.0M, including 11 applications for Grassroots grants. The latter is a significant increase over previous years. The bump in funding enabled one hundred and two applicants to be offered funding: sixty one for hard rock exploration projects (six Grassroots, thirteen Focused Regional, and forty-two Target Evaluation); and forty-one for placer. The success rate for funding and the breakdown of recipient classes is presented in Table 1. As the field season progressed ten proponents indicated they would not be proceeding with their projects, leaving 57 active hard rock and 35 active placer projects at the time of writing.

As the realities of the pandemic set in over the summer, money began rushing into safe haven investments such as precious metals. Gold and silver prices both went on runs with gold reaching approximately US $2065 and silver hitting around US $29. As a result of this trend, capital became available to many Yukon gold and silver exploration projects late in the season.

Figure 1 illustrates the locations of the ninety two active 2020 YMEP projects. The majority of placer projects (twenty) are centered in the Klondike placer district; three projects are in the Fortymile and Sixtymile areas; four projects are in the Mayo/Keno area; two are in the Clear Creek area; three are in the Kluane region; and three are in the Livingstone region. Hard rock projects are distributed across the territory and are targeting a variety of commodities. Gold is the most sought-after hard rock commodity with thirty proponents exploring for structurally-controlled, epithermal, Carlin-type, intrusion related, or orogenic gold. Other targets include vein-hosted silver (8), porphyry copper (7), vanadium (3), cobalt (2), tin (3), zinc (2), magmatic massive sulphide copper/nickel/PGE prospects (1) and tantalum (1). The breakdown of target commodities by YMEP projects is illustrated in Figure 2.

Table 1 shows the number of hard rock versus placer projects and the proportion of funding to each between 2015 and present. The table also records the breakdown among proponents. Since the creation of the Placer module in 2015 there has been a steady increase in the percentage of funding allocated to placer exploration. Prior to 2015, placer exploration was typically funded in the Target Evaluation module and historically averaged 25% of the allocated funding. In 2020, placer exploration accounted for 41% of YMEP funding; an increase of 4% over 2019.

Table 1. *YMEP funding allocation.*

Approved projects	2015-16		2016-17		2017-18		2018-19		2019-20		2020-21	
	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	28	15	26	21	35	22	36	18	37	41	41
Hard rock	47	72	34	74	38	65	40	64	33	63	61	59
Total projects	62		57		59		62		51		102	
Prospectors/ individuals	24	34	24	39	18	29	28	46	19	37	38	37
Private companies	21	32	16	30	22	26	17	27	18	35	30	29
Public companies	17	34	17	31	19	45	17	47	14	28	34	34

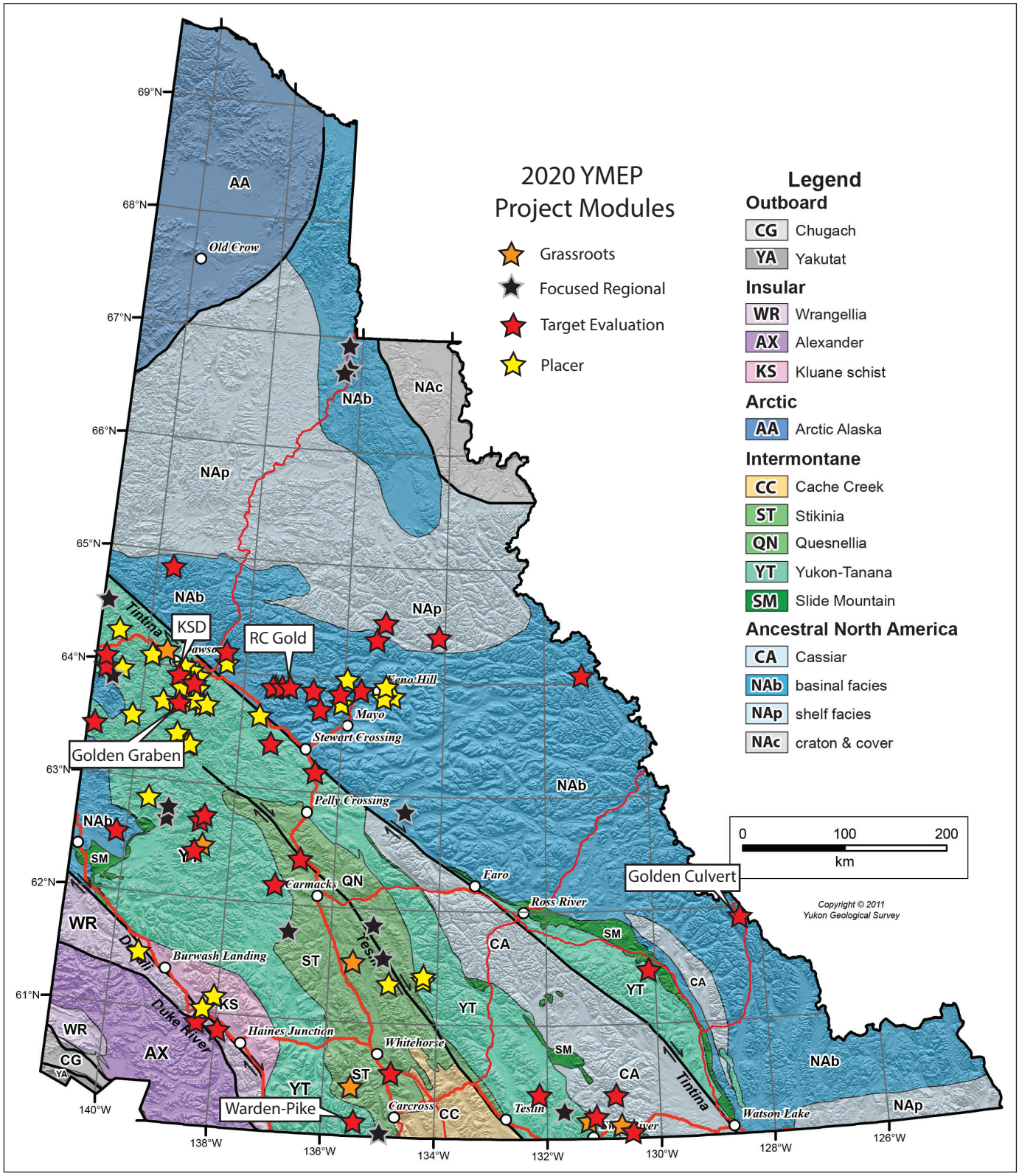

Figure 1. *Approved YMEP projects in 2020.*

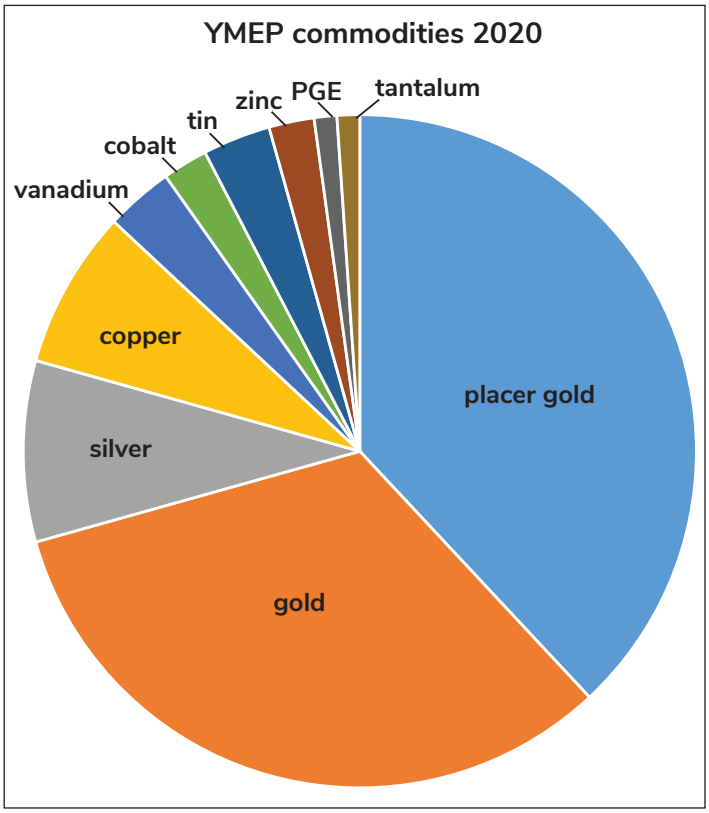

Figure 2. *Breakdown of targeted commodities by YMEP project.*

As of mid-December, the majority of YMEP projects have been successfully completed and preliminary results suggest there are several potentially significant discoveries resulting from the work. Many additional projects are still awaiting assay results.

Economic benefits of YMEP

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

Short-term local economic benefits

Short-term economic benefits of YMEP include spending by proponents on local hiring, contracting, and purchasing. To help quantify these benefits YGS and the Yukon Bureau of Statistics conducted a survey of 2020 YMEP recipients in September. The survey included questions on the number of Yukoners hired, the types and value of local services contracted, and value of goods purchased from local businesses. Respondents reported investing $3 795 132 in goods and services, and the employment of 148 Yukoners totaling $1 021 080 in salaries. This represents an immediate and direct $4.8M benefit to Yukoners and Yukon based businesses during the field season.

2020 YMEP successes

2020 exploration successes are those projects that resulted in new discoveries and those that have potential to lead to further exploration and discovery. 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 2020 projects that yielded early success (Fig. 1).

RC gold project

In 2020 Sitka Gold Corp. received Target Evaluation module funding for its RC gold project located in the Clear Creek area. Exploration on the property has been focused on identifying an intrusion-related gold system ("IRGS"). The RC property is part of the "Tombstone Gold Belt" which is host to a number of IRGS deposits in Yukon and Alaska (e.g., Fort Knox, Eagle, Red Mountain). Sitka's exploration program consisted of diamond drilling (6 holes, 1500 m), soil and rock sampling, trenching, a 42 km^2 LiDAR airborne survey, and additional claim staking. Due to strong initial soil and rock sampling results, Sitka was able to allocate additional funding for drilling; they also explored two other projects in the district and incorporated them into their 2020 drill program. By the end of the season, the initial YMEP investment had resulted in excess of $1.2M in exploration expenditures. Promising results from Sitka's drilling include gold grades locally as high as 9.57 g/t over 0.9 m and one interval of over 100 m at 0.82 g/t (https://www.sitkagoldcorp.com/news---12162020.html).

Golden Culvert project

Another successful 2020 YMEP project was Stratabound Minerals' Golden Culvert project (Fig. 1). The initial Target Evaluation grant supported the collection of 116 soil and 157 rock samples, ground geophysics and geological surveys on property-wide targets. This work delineated a 1 km long mineralized trend with gold grades up to 320 g/t gold (http://www.stratabound.ca/images/stories/2020/stratabound_corporate_presentation_december_2020.pdf).

Upon completion of the YMEP-supported work, Stratabound was able to leverage their strong results into a $6.7M dollar cash raise on equity markets and undertake a late season drill program. The diamond drilling program consisted of 17 holes for 3217 m. Due to bottlenecks at assay labs the results for this drilling are pending.

KSD project

In 2020 Kestrel Gold Inc. completed a Target Evaluation-supported program of prospecting, excavator trenching and RC drilling on their KSD property. The property is located in the Klondike (Fig. 1) at the headwaters of significant placer gold producers Hunker, Dominion and Gold Bottom creeks. Kestrel is exploring KSD for the hard rock source(s) of this placer gold. Prospecting yielded up to 305.7 g/t gold from a quartz vein at the historic Mitchell Shaft and 0.867 g/t gold and 1302 g/t silver from a quartz vein in the Sheba zone area. Trenching was undertaken to locate new mineralized showings distinct from existing occurrences. Numerous quartz veins were encountered with individual assays of up to 6.15 g/t gold and 99.2 g/t silver. Based on these promising results, a decision was made to conduct a late season 12-hole 515 m RC drill program. Core was sampled top to bottom yielding a total of 389 samples. Assays are still pending for this drilling (Bernie Kreft, personal communication).

Grabben Gold project

Bernie Kreft received a Target Evaluation grant to support a program of prospecting and hand trenching at his Grabben Gold property. The property, located in the heart of the Klondike (Fig. 1) covers a sequence of mid-Cretaceous sedimentary rocks overlain and intruded by Late Cretaceous volcanic and intrusive rocks. Soil samples returned up to 598 ppb gold while rock samples returned up to 1.17 g/t gold and 28.5 g/t silver. Pathfinder elements associated with precious metals include As-Bi-Sb. The Grabben Gold project has now advanced to a drill-ready stage with several well-defined geochemical targets with strong pathfinder support.

Warden and Pike projects

Prospector Ryan Burke explored his Warden and Pike properties in southwestern Yukon with support from a grant under the Target Evaluation module. Fieldwork consisted of soil and rock sampling, a ground magnetic survey, and a high resolution drone survey targeting polymetallic Au-Ag-Cu-Mo ± Pb-Ag quartz veins hosted by Eocene Mount Skukum and Bennett Lake volcanic complexes. Rock assays identified multiple mineralized areas on the properties with individual samples returning values up to 48.1 g/t Au, 643 g/t Ag, 7.49% Cu, 3.63% Pb, 0.27% Zn, 0.87% Mo, 0.12% Sb and 0.30% Bi. Till geochemical data have yielded moderate to strong geochemical responses in a number of areas, with peak values of 390.9 ppb Au, 1.2 ppm Ag, 28.7ppm Mo, 107.6 ppm Pb, 272 ppm Zn, 1.1 ppm Sb and 2.6 ppm Bi (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 2020 fieldwork. These include NBC Contracting's project on Dominion Creek, Daval Mining's work on Hunker Creek and Earth and Iron's exploration on Keystone Creek. In all three cases, their exploration results have led to a decision to proceed to mining in the future. Details of these projects are presented in Bond and van Loon (2021; this volume).

Longer-term YMEP successes

The YMEP projects above are examples of short-term successes that can be attributed to YMEP funding. They are only a few of the projects that yielded promising results this year. In the longer term, the impact of YMEP can be measured by projects that advance further

along the exploration-mining cycle: for example to the resource definition, feasibility and/or production stages. The further a project advances, the more significant its impacts for Yukon in terms of employment, business opportunities and infrastructure development. Two examples of longer-term YMEP successes are presented below.

Between 1986 and 2003, various owners of the Dublin Gulch claims received four YMEP grants totalling $44k; this funding supported the discovery of mineralization and led to the consolidation of the claims and ultimately, acquisition by Victoria Gold Corp. The company immediately began an aggressive exploration program on the property and went into production in the fall of 2019. To date, Victoria Gold has outlined 3.3 Moz of gold with a current value in excess of $6 billion (https://vgcx.com/site/assets/files/6480/jds-vit-eagle-gold-ni-43-101-fs-report-20191206.pdf). Victoria Gold currently employs approximately 200 Yukoners, of which half are members of Yukon First Nations. Since the initial $44k YMEP investment, exploration expenditures at Dublin Gulch are in excess of $110M and development expenditures are greater than $600M. The leveraged dollars on exploration expenditures alone represent a leverage ratio of 2517:1. To date, the Eagle Gold project has produced 70,925 oz of gold with an estimated value of $156M (https://vgcx.com/news/victoria-golds-eagle-gold-mine-produces-13-828-ounces-of-gold-in-june/; https://vgcx.com/news/victoria-gold-eagle-gold-mine-q3-2020-production-results/).

Another success story is that of Strategic Metals Limited's Mount Hinton project. Initial exploration, consisting of prospecting and soil sampling, began in 2018 with support from a YMEP grant. Early results yielded evidence of gold, silver and lead-rich quartz veins, leading to further exploration in 2019 and 2020. To date, Strategic has invested $2.5M in the project, corresponding to a YMEP leveraging ratio of more than 60:1. The exploration targets that were defined over the past three years will provide additional economic benefits well into the future.

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

Due to the global COVID-19 pandemic the Yukon exploration industry experienced unprecedented challenges in 2020. The Government of Yukon recognized these challenges early in the year and increased the funding for YMEP to support the mineral industry. This year's projects made a substantial contribution to the Yukon economy by leveraging $4.8M in direct investments into Yukon workers and businesses during the pandemic. 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

Bond, J. and van Loon S., 2021 (*this volume*). Yukon placer mining 2020 development and exploration overview. *In:* Yukon Exploration and Geology Overview 2020, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 19–32.

Table 2. *Examples of successful YMEP projects.*

YMEP Successful Options (2000–2020)				
YMEP#	**Property Name**	**Total YMEP Contribution(s)**	**Optioned by**	**Company investment or work commitment**
01-011and 15-030	Ice/Red Mountain	$52 500	AM Gold	~$7.7M
03-079	White Gold	$10 000	White Gold Corp. Kinross Gold	~$71.2M
04-072 and 05-043	Blende	$30 000	Blind Creek Resources	$5.5M
05-058	Andrew	$14 400	Overland Resources	~$16M
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	Gold Corp. Kaminak Gold Corp.	~$301M
07-056, 08-012 and 09-112	Toni/Sixty Mile	$33 000	Radius Gold	~$4.7M
03-023, 06-033 and 09-137	Scheelite/Gold Dome	$75 000	Golden Predator	~$1.4M
09-015	Clear Creek	$10 450	Golden Predator	~$4.1M
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 14-010	3 Aces	$93 130	Northern Tiger Golden Predator	~$32M
10-097	Portland	$14 320	Taku Gold	~$1.25M
00-069, 06-005, 06-006 and 15-014	Mariposa	$76 000	Pacific Ridge	~$4.9M

Yukon hard rock mining, development and exploration overview 2020

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Casselman, S.G. and Lewis, L.L., 2021. Yukon hard rock mining, development and exploration overview 2020. *In:* Yukon Exploration and Geology Overview 2020, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 41–56.

Introduction

Yukon mineral exploration activity was severely affected by the COVID-19 pandemic and associated travel restrictions early in the year. As the summer began, exploration and mining companies were able to adjust their operating procedures and develop plans to allow them to adapt to the new reality. Companies implemented measures such as limiting the number of persons in camps, hiring local Yukon-based employees and contractors, increasing work rotation times so that employees spent less time in self-isolation, arranging for hotels to be used for self-isolation centres, having self-isolation spaces and procedures in camps and limiting the number of non-project personnel on site. These measures were crucial in turning around what was looking like a bleak exploration season and allowing for some sense of normalcy.

An increase in precious and base metal prices in mid-summer provided a much-needed shot in the arm for junior exploration companies. Yukon Geological Survey (YGS) tracks mineral sector spending through press releases, SEDAR and correspondence with companies. Although spending projections were dire at the start of the field season, by year-end, exploration expenditures are expected to be between $70 and $80M (*vs.* $117M in 2019). Development expenditures for the year are expected to be $65M, down from $225M in 2019. The drop in development expenditures is primarily due to the completion of construction at Victoria Gold Corp.'s Eagle Gold mine. Year end metal production for 2020 is approximately $300M with production coming from Eagle Gold, Minto and the newly re-opened Keno Hill mines (Fig. 1).

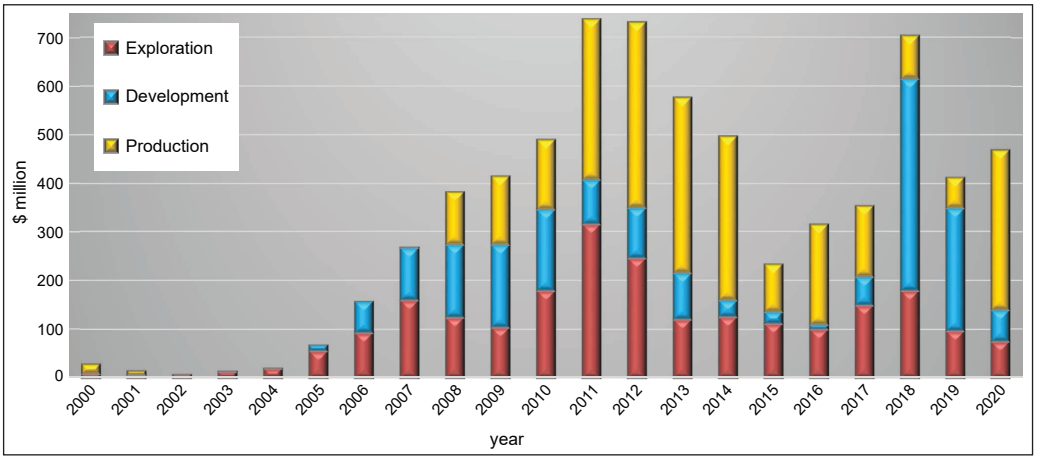

Figure 1. *Estimated exploration and development expenditures on hard rock projects and mine production values, 2000–2020.*

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The number of active exploration projects dropped significantly from 146 in 2019 to 93 in 2020 (Fig. 2). Twenty-two of the 93 projects spent more than $1M, while 61 projects spent less than $500 000. The majority of smaller projects received Yukon Mineral Exploration Program (YMEP) grant funding. In terms of all Yukon projects, gold continues to be the most sought-after commodity, with 58% of the projects targeting the precious metal. The remainder of projects focused on exploring for copper (18%), lead-zinc (10%), silver (11%), nickel-PGEs (2%), and tin, cobalt or vanadium (<1%).

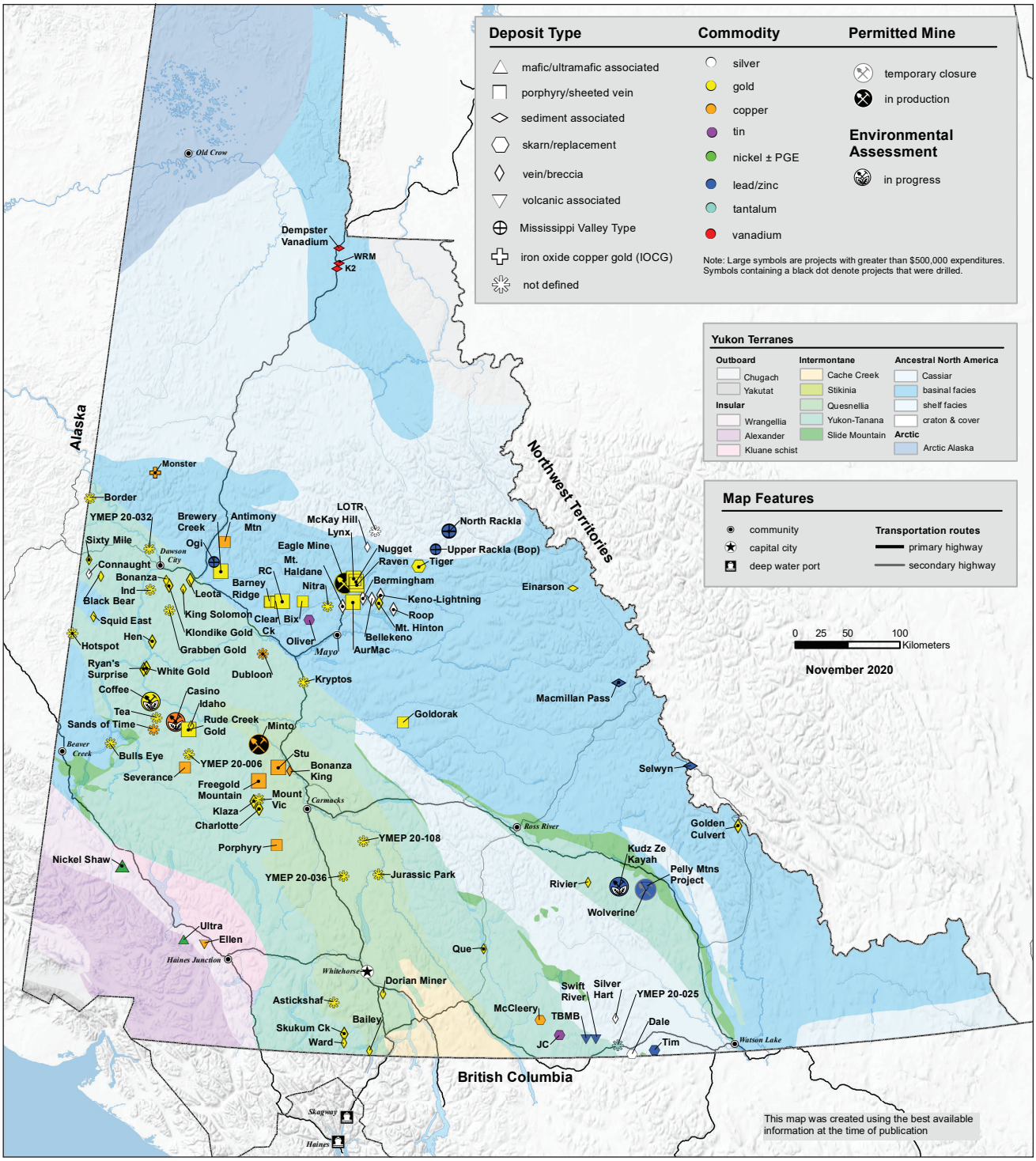

Figure 2. *2020 Yukon exploration and mining projects.*

Claim staking in 2020 was about the same as in 2019, with 2053 claims staked as of November 30. The number of claims in good standing is 171 218, down from the all-time high of 252 902 in 2012 (Fig. 3). Drilling numbers were down significantly in 2020, 120 000 m as compared to 226 250 m in 2019 (Fig. 4).

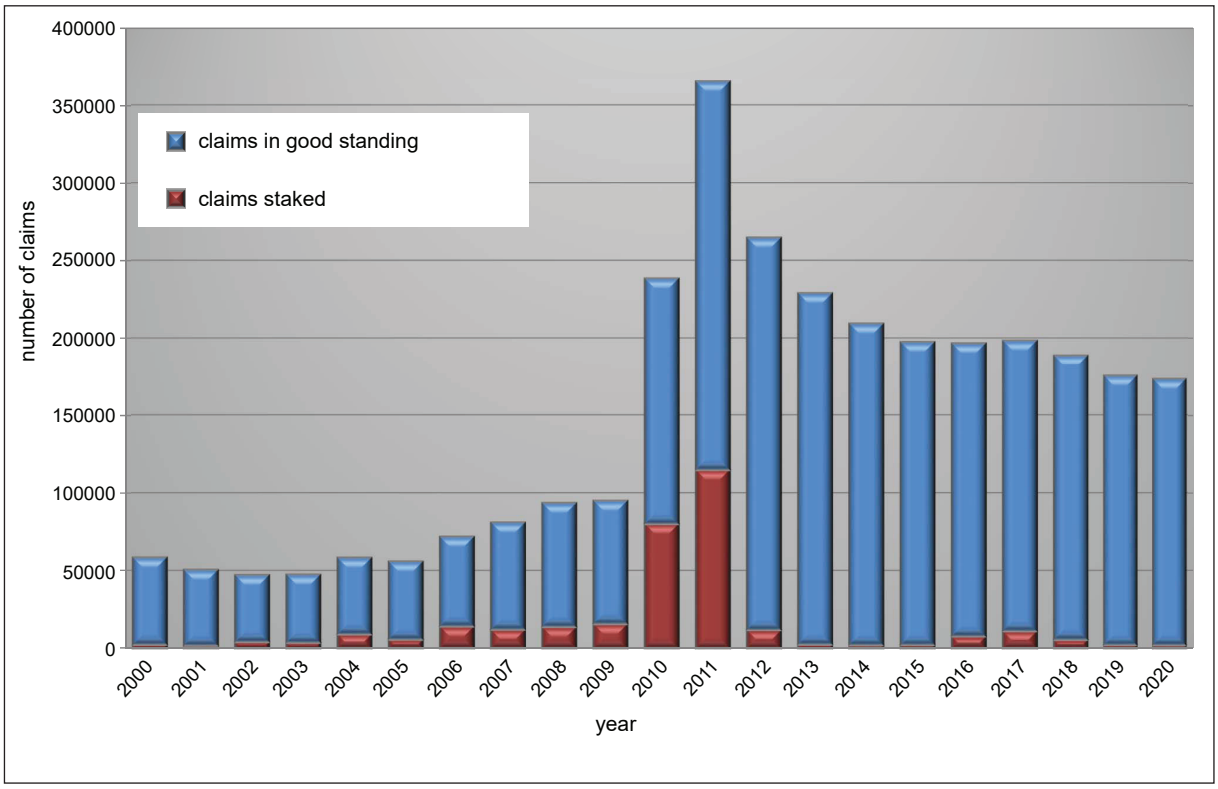

Figure 3. *Hard rock claims staked and in good standing, 2000–2020.*

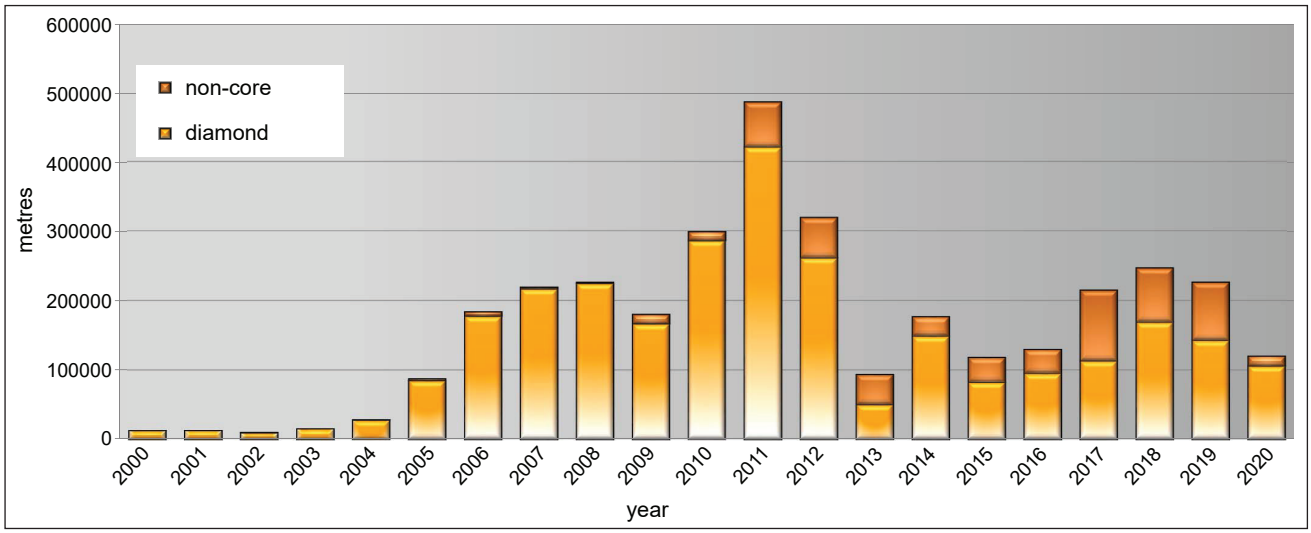

Figure 4. *Diamond drilling and reverse-circulation or rotary air blast drilling, 2000–2020.*

Hard rock mining

Victoria Gold Corp. (www.vgcx.com) completed development of its Eagle Gold intrusion-related gold deposit on its Dublin Gulch property after 26 months of construction (Fig. 5). The company announced commercial production on July 1, 2020. They are projecting 2020 gold production to be between 110,000 and 116,000 ounces and are expecting to be in full production in 2021 at 210,000 ounces of gold per year. The high gold prices in 2020 allowed the company to focus on early repayment of debt and they have been studying the possibility of production increase with year-round stacking. High gold prices also meant the company could convert lower grade resources into reserves, which has significantly extended the mine life.

Figure 5. *Victoria Gold's Eagle Mine ore dump. Photo from Victoria Gold Corp. website, accessed October 29, 2020.*

Victoria also completed exploration programs on their Raven and Lynx targets. At Raven, they conducted soil sampling, trenching and drilled 35 diamond drill holes (8040 m). At Lynx, they conducted soil sampling, geological mapping, trenching and drilled 4 diamond drill holes (594 m). The results at Raven more than doubled the strike length of the zone to over 450 m and returned numerous drill intercepts with grades ranging from 0.42 g/t Au over 240.8 m to 2.77 g/t Au over 65.7 m. At Lynx, the drill program returned 0.49 g/t Au over 153.8 m and 1.26 g/t Au over 11.9 m, while results from the trenching program include 4.64 g/t Au over 32 m, 3.33 g/t Au over 16.0 m, 1.62 g/t Au over 46.0 m and 1.35 g/t Au over 80.0 m.

The Minto Mine (www.mintomine.com) had its first full year of operations under new owner Pembridge Resources Plc (www.pembridgeresources.com). The production at the copper-gold-silver mine averaged 2000 tons per day (tpd) for much of the year. The company is working to increase production to 4000 tpd once it receives the water license for the Minto East II and Minto North II deposits (Fig. 6). The company also completed 21 411 m of diamond drilling in 132 holes from surface at the Minto North deposit and from underground at the Copper Keel deposit. Results from this drilling is pending.

Alexco Resource Corp. (www.alexcoresource.com) announced in June that they had received their amended water license and immediately began work to re-start the mining operation at their silver-lead-zinc Keno Hill mine site. On November 24, they announced the first concentrate production from the mill. The first ore to arrive at the mill was from the Bellekeno deposit. The company is ramping up for production from the Flame & Moth deposit and eventually from the Bermingham deposit, which it hopes to have fully operational in the first half of 2021. Reserves for the project currently stand at 1.2 million tonnes at a grade of 805 g/t Ag. The company is projecting 4.0M ounces

Figure 6. *Minto mine underground. Photo from Minto Mine website, accessed December 14, 2020.*

of silver production annually, once in full production, giving it an eight year mine life. Alexco also conducted deep drilling on the Bermingham "deep" target, drilling 7653 m in 11 holes this year.

In 2019, Yukon Zinc Corp. (www.yukonzinc.com) sold the Wolverine Mine to Phoenix Global Investments Inc. (https://www.phoenixinvest.ca). The mine is located in eastern Yukon and is a Zn-Pb-Cu-Ag-Au volcanogenic massive sulphide (VMS) deposit. The mine remains in temporary closure, as it has been since 2015. PricewaterhouseCoopers, the receiver, has taken over care and maintenance of the site. The Government of Yukon has been managing water issues at the site using some of the posted security.

Permitting and mine development

BMC Minerals Ltd. (http://bmcminerals.com), a private company, received the Final Screening Report from the Yukon Environmental and Socio-economic Assessment Board (YESAB) on the company's Kudz Ze Kayah mine proposal on October 21. The report recommended that the project should proceed, subject to 30 mitigative measures aimed at controlling, reducing, or eliminating significant adverse effects from the operation, and 6 monitoring measures aiding in adaptive management of the project. BMC released an updated feasibility study for the Zn-Pb-Cu-Au-Ag VMS deposit, incorporating the recommendations of the Screening Report, and the company is now preparing the development permit applications. Some of the key financial metrics for the project are (all dollar amounts are in $US):

Predevelopment capital cost to production	$376 million
Projected After Tax Net Present Value ($NVP^{7\%}$)	$617 million
After tax Internal Rate of Return (IRR)	45.9%
Operating cash flow margin	43%
Cash Cost of Production (Ag) after by-product credits	-$22.13/oz
Targeted first production	late 2023
Reserve life of Mine (ABM only)	9 years

Financial metrics from company website December 2020.

Newmont Corporation (www.newmont.com) submitted its application for the Coffee gold mine to the Yukon Environmental and Socioeconomic Assessment Board (YESAB) in the spring of 2017. The proposal is progressing through the assessment process and is now in the "Developing the Draft Screening Report" stage, which is scheduled for completion by January 25, 2021. Newmont announced an updated resource in June of 58.1M tonnes grading 1.43 g/t Au for a total contained 2.67M ounces of gold in the Measured, Indicated and Inferred categories. The company is working to update the feasibility study while they await a mine permit. In 2020, the company conducted soil sampling, trenching and ground geophysics on targets outside the deposit area.

Western Copper and Gold Corp. (www.westerncopperandgold.com) continues to advance its Casino porphyry Cu-Au-Mo project in western Yukon. The company updated the resource estimate in July with a Mill Resource in the Measured, Indicated and Inferred (M, I & I) categories of 3.6B tonnes containing 10.7B pounds copper and 19.1M ounces gold and a Heap Leach Resource (M, I &I) of 249M tonnes containing 2.0M ounces Au. Drilling in 2020 (22 diamond drill holes, 12 031 m) focused on targets peripheral to the deposit. The mine project was submitted to YESAB for assessment in January 2014 and the application was bumped up to the "Panel Review" process, the highest level of assessment under the Yukon Environmental and Socio-economic Assessment Act, in February 2018. The company is preparing the necessary documentation to initiate the Panel Review.

Golden Predator Mining Corp. (www.goldenpredator.com) is working to re-start the Brewery Creek gold mine, east of Dawson. The company was assigned the Quartz Mining License from the previous mine operator, Viceroy Resources, in July 2019. The license is due to expire in the spring of 2021. The company is working on a bankable feasibility study, which will include a multi-year mine plan. The company carried out an exploration program in the fall of 2020 consisting of 22 diamond drill holes (1332 m) and 39 RC holes (5800 m) of drilling.

Significant exploration projects

ATAC Resources Ltd. (www.atacresources.com) continue to work their Tiger deposit. The 464,000 ounce Au Tiger deposit lies at the western end of ATAC's extensive Rackla gold belt claim block within an area called the Rau Trend. ATAC continued to explore in 2020 focusing on the Airstrip anomaly; they completed trenching, 1876 m of diamond drilling (6 holes) and 1565 m of RAB drilling in 25 holes. Results include 0.51 g/t Au over 36.58 m (ASR-20-018), 3.1 g/t Au over 1.53 m (ASR-20-014) and 0.32 g/t Au over 22.86 m (ASR-20-019).

ATAC also completed a small program of prospecting, soil sampling and trenching at their Connaught property west of Dawson.

The focus of Strategic Metals Ltd.'s (www.strategicmetalsltd.com) activity in 2020 was the Mount Hinton property, east of Keno, where the company diamond drilled 6978 m in 32 holes in the Granite North zone and the Southwest zone. Results from the Granite North zone to date include 1.47 g/t Au over 7.13 m (MH-20-005) and 4.43 g/t Au over 0.62 m (MH-20-008). Results from the drilling at the Southwest zone are pending.

Banyan Gold Corp. (www.banyangold.com) started the season with plans for a small exploration program with a limited amount of drilling on their AurMac property at the junction of the Eagle Gold Mine access road and the Silver Trail Highway. They were able to raise additional funding mid-summer, which allowed them to expand their program. They drilled through the fall and into December and are expecting to complete approximately 10 000 m of diamond drilling at their Airstrip and Powerline zones:

Powerline zone

0.72 g/t Au over 128.5 m in AX-20-43
0.80 g/t Au over 29.8 m in AX-20-42
0.47 g/t Au over 30.5 m in AX-20-41
0.76 g/t Au over 13.0 m in AX-20-44
0.46 g/t Au over 27.0 m in AX-20-45

Airstrip zone

1.02 g/t Au over 47.7 m in MQ-20-67
0.53 g/t Au over 16.5 m in MQ-20-79
0.55 g/t Au over 12.0 m in MQ-20-79
0.51 g/t Au over 49.5 m in MQ-20-80
0.59 g/t Au over 114.8 m in MQ-20-82

West of Keno, in the Clear Creek area, Sitka Gold Corp. (www.sitkagoldcorp.com) worked its early-stage RC gold property with a diamond drill program of 1500 m in six holes (Fig. 7). Early results include 139.1 m of 0.61 g/t Au in DDRCCC20-004, 38 m of 0.67 g/t Au in DDRCCC20-003, and 57.5 m of 0.50 g/t Au in DDRCCC20-003.

Alianza Minerals Ltd. (https://alianzaminerals.com/) explored its Mt. Haldane property, a high-grade silver target, with four diamond drill holes (799 m) late in the season. The program tested the West Fault and Middlecoff targets; results from this work are pending.

Metallic Minerals Corp. (www.metallic-minerals.com) worked properties in the historic Keno silver district in 2020. They drilled 2674 m in 12 diamond drill holes and 2644 m in 30 RAB drill holes on their Keno-Lightning property. They also drilled 5 RAB holes for 392 m on their McKay Hill project. Results from these programs are pending.

Mayo Lake Minerals Inc. (https://mayolakeminerals.com) carried out a late-season diamond drill program at its Carlin-Roop gold project north of Mayo Lake (6 holes, 900 m). Results from this work are pending.

White Gold Corp. (WGC; www.whitegoldcorp.ca) focused its exploration program on two areas of the company's large land holdings in the Dawson region: JP Ross and Golden Saddle. At JP Ross, the company conducted GT Probe, trenching, soil sampling, magnetics and VLF-EM surveys. Highlights from this work include 8.88 g/t Au over 2.5 m from a trench at the Stage Fright target; 3.40 g/t Au over 1.5 m and 1.15 g/t Au over 8.5 m from trenches at the Sabotage target; and numerous anomalous gold values ranging from 0.17 g/t Au to 24.4 g/t Au from top of bedrock GT Probe samples at the Notorious target.

Figure 7. *Drill rig at Sitka Gold Corp's RC property. Photo courtesy of Sitka Gold.*

At Golden Saddle, the company did 3000 m of diamond drilling and drilled 20 RAB holes (results pending). A short distance away, at the Ryan's Surprise target, the company drilled six diamond drill holes for 1632.5 m returning the following results:

Hole	Interval (m)	Gold (g/t)
WHTRS20D013	3.47	17.4
WHTRS20D014	6.50	3.28
WHTRS20D015	2.00	4.90
WHTRS20D016	22.00	1.19
WHTRS20D017	1.24	8.82
and	3.76	10.96
and	17.00	1.43
WHTRS20D018	12.30 8.69	

Klondike Gold Corp. (www.klondikegoldcorp.com) explored its Klondike Gold property south of Dawson with 52 diamond drill holes (4055 m) testing the Lone Star zone and Stander zone. Highlights from the Stander zone include 7.57 g/t Au over 10.5 m (hole EC20-350). Highlights from the Lone Star zone include 1.07 g/t Au over 61.10 m (LS20-337) and 5.82 g/t Au over 5.00 m (LS20-340).

Flow Metals Corp. explored its Sixty Mile gold project west of Dawson with RAB drilling (835 m), trenching, ground geophysics and re-sampling of historic drill core. Multiple zones with arsenic and gold were identified; assay results are pending.

Golden Sky Minerals Corp. (https://www.goldenskyminerals.com) conducted soil sampling and drilled 6 RC holes for 568 m at their Hotspot property south of Dawson, along the Yukon-Alaska border. Highlights of the work are:

Hole	width (m)	Au (g/t)
HSRC-20-01	6.10	1.13
HSRC-20-02	71.63	1.34
HSRC-20-03	39.62	0.39
HSRC-20-04	51.82	0.14
HSRC-20-05	18.29	0.37
HSRC-20-06	83.82	0.40

Golden Sky also completed trenching at their Bullseye property near Wellesley Lake, where they encountered 78.0 m grading 0.69 g/t Au.

Rockhaven Resources Ltd. (www.rockhavenresources.com) carried out a late-season diamond drilling program at its epithermal Au-Ag Klaza property (6042 m, 22 holes), which primarily focused on targets peripheral to the main deposit (Fig. 8). The company filed an updated Preliminary Economic Assessment (PEA) in July, which indicated a Post-Tax Net Present Value (NPV; 5%) of CAD $378M and an Internal Rate of Return (IRR) of 37%, using US $1450/oz Au and US$17/oz Ag.

In 2020, Triumph Gold Corp. (www.triumphgoldcorp.com) focused its exploration efforts on shallow high-grade gold targets on their Freegold Mountain project. The company diamond drilled nine holes (2069 m) to test the Irene-Goldstar epithermal gold-silver target, the Melissa epithermal target, the Keirsten zone, and soil geochemical anomalies east of the Blue Sky and WAu Breccia zones. Results from this program are pending.

Newly formed company, Taurus Gold Corp., conducted a late season drilling program at their Charlotte property in the Mt Nansen area, diamond drilling 2347 m in 11 holes. The drilling was on the Flex zone, an epithermal gold vein target. Results are pending.

Makara Mining Corp. (https://makaramining.com) drilled 17 RC holes (1994 m) and conducted an IP survey on their newly optioned Rude Creek gold property east of the Casino deposit. The drill program was designed to target a gold-in-soil anomaly. Drill results are pending.

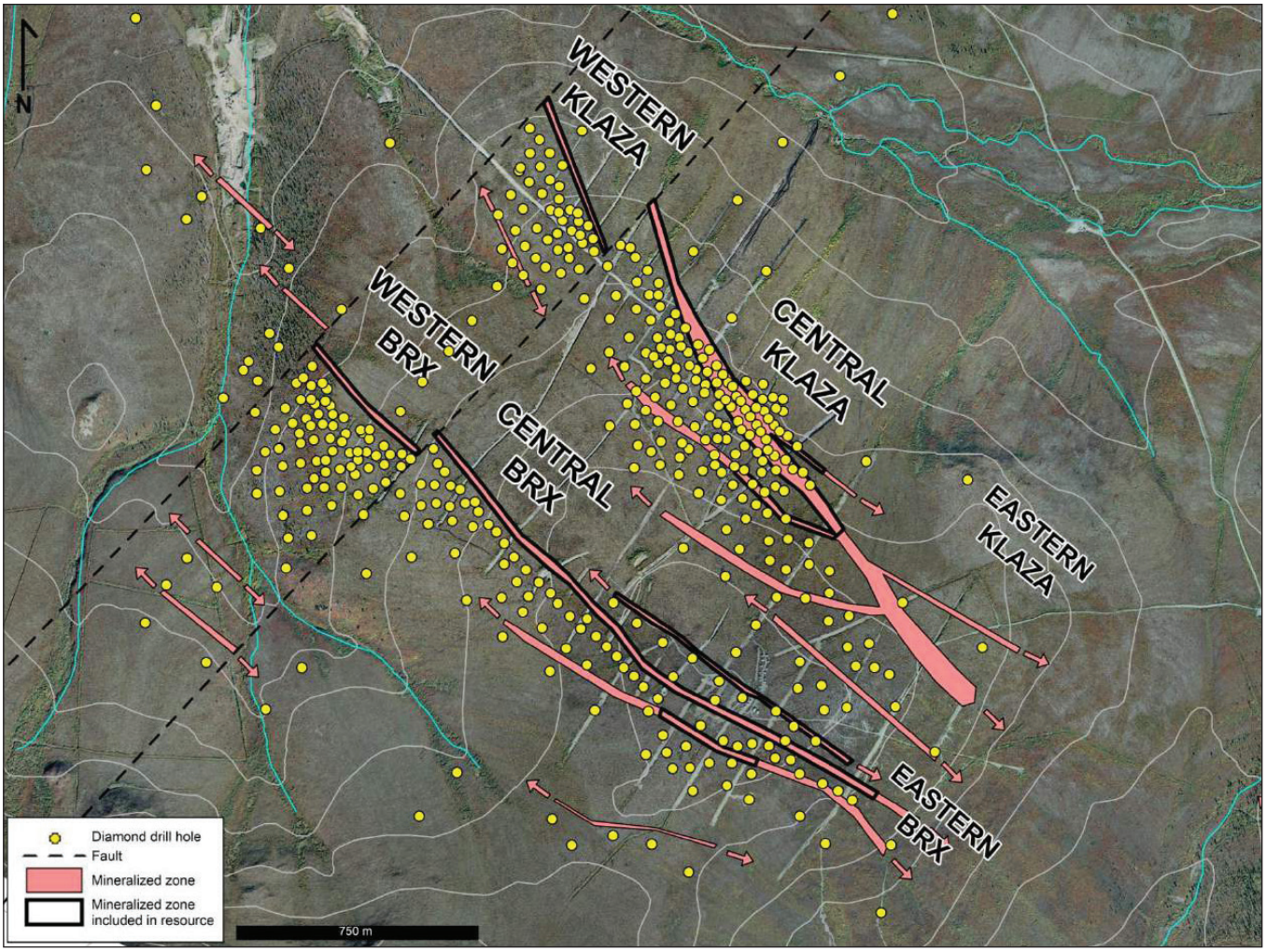

Figure 8. *Schematic of mineralized zones at Rockhaven Resources' Klaza deposit. Map from Rockhaven Resources Ltd. website, accessed December 15, 2020.*

Whitehorse Gold Corp. (www.whitehorsegold.ca), a spin-off company of New Pacific Metals Corp., revisited the Skukum Creek gold project in the Wheaton Valley outside of Whitehorse. The company drilled 4 diamond drill holes for 2091 m. Results are pending.

In southeastern Yukon, on the Nahanni Range road, Stratabound Minerals Corp. (https://www.stratabound.ca) initially planned a modest exploration program consisting of prospecting, soil sampling, ground magnetic surveying and minor drilling at their Golden Culvert property. As the summer progressed and investment interest in gold explorers increased, the company was able to raise additional funding and added a significant drilling program to their plans. In the end, they drilled 3217 m in 17 diamond drill holes. Results from the drill program are pending, but the company did receive analyses from their surface sampling. The results include surface grab samples containing 320.0 g/t Au, 155.0 g/t Au, 118.0 g/t Au, 92.0 g/t Au, 41.8 g/t Au, 26.6 g/t Au, 17.1 g/t Au and 16.55 g/t Au from a talus slope south of the Main showing.

Base metals

Fireweed Zinc Ltd. (http://www.fireweedzinc.com/) continued to advance its MacMillan Pass sediment-hosted Pb-Zn project (Fig. 9). Ten diamond drill holes (2948 m) were completed at the Boundary zone, predominantly targeting gravity anomalies. Reverse circulation (RC) infill holes (9 holes, 507 m) were drilled at the Tom and Jason deposits. All assays are pending. A late-season airborne VTEM-magnetic geophysics survey was also carried out over the western part of the claim block.

Selwyn Chihong Mining Ltd. continued working at their massive Pb-Zn SEDEX Selwyn Project in southeastern Yukon. The company did a small amount of surface work at the site in 2020.

Figure 9. *YGS property visit to Fireweed Zinc's MacPass Project.*

Cantex Mine Development Corp. (www.cantex.ca) worked its Pb-Zn-Ag North Rackla property, completing mapping, trenching and diamond drilling (Fig. 10). Drilling at the Main zone intersected visible mineralization to 680 m vertical depth. Drill results from hole DDH YKDD20-159 include 14.90 m of 66.70 g/t Ag, 25.55% Pb + Zn, and multiple shorter significant intersections.

Granite Creek Copper Ltd. (www.gcxcopper.com) completed the acquisition of Copper North Mining Corp. on November 27, adding the high-grade Carmacks Copper deposits to the company's portfolio to complement their Stu (now Carmacks North) Cu-Au-Ag property. The company carried out diamond drilling on both properties; two holes for 527 m at Zone 13 on Carmacks Copper, and four holes for 738 m at Carmacks North. Results are pending.

Nickel Creek Platinum Corp. (www.nickelcreekplatinum.com) performed a large loop transient EM survey and drilled 2 holes (675 m) at its Nickel Shäw ultramafic hosted Ni-Cu-Co-PGE property. Results are pending.

Go Metals Corp. (https://gometals.ca) explored its Monster iron oxide copper-gold property with a late season drill program (530 m of RC drilling in 5 holes; Fig. 11). Results are pending.

Other metals being explored for include shale-hosted vanadium in northern Yukon along the Dempster highway and skarn-hosted tin in southern Yukon.

The exploration season started slowly but gathered speed as the summer progressed. Late season programs overwhelmed the assay labs, and results continue to trickle in. The successes of the 2020 season will continue to reveal themselves in the coming months.

Figure 10. *Cantex's exploration camp at its North Rackla property.*

Figure 11. *RC drill rig at the Monster IOCG target. Photo from Go Metals Corp. website, accessed November 12, 2020.*

Appendix 1. Exploration projects 2020.

Project	Owner / Optioner	MINFILE	Commodity	Deposit type	Work type	YMEP funded
Alotta (Severance)	Strategic Metals Ltd.	115J 003	copper	porphyry/sheeted vein	P, SGC, RGC	yes
Oli	Strategic Metals Ltd.	115P 030	tin	skarn/replacement	P, SGC, G	yes
Antimony Mountain	RyanWood Exploration Inc.	116B 094	copper	porphyry/sheeted vein	P, SGC, RGC	no
Astickshaf	Williams, Matthew	-	unknown	unknown	P, SGC	yes
AurMac	Banyan Gold Corp.	105M 060	gold	porphyry/sheeted vein	GGP, DD, RGC	yes
Bailey (Benall)	Sans Peur Exploration Services Inc.	105D 177	gold	vein/breccia	CS, SGC, RGC	yes
Barney Ridge	Kestrel Gold Inc.	115P 034	gold	porphyry/sheeted vein	P, SGC	yes
Bellekeno Mine	Alexco Resource Corp.	105M 082	silver	vein/breccia	MD	no
Bermingham Mine	Alexco Resource Corp.	105M 086	silver	vein/breccia	DD, RGC	no
Bix	Archer Cathro and Associates (1981) Ltd.	115P 031	gold	porphyry/sheeted vein	P, SGC, RGC, G	yes
Blackbear (AMI)	Mann, Bill	115N 042	gold	vein/breccia	CS, P, SGC, RGC, G	yes
Bonanza King	Copper North Mining Corp.	115I 010	copper	vein/breccia	P, SGC, G	yes
Bonanza	White Gold Corp.	-	gold	vein/breccia	SGC, GGP	yes
Border	Mann, Bill	-	unknown	unknown	P, SGC, RGC, T	yes
Brewery Creek	Golden Predator Canada Corp.	116B 160	gold	porphyry/sheeted vein	DD, RGC, NC	no
Bullseye	Golden Sky Minerals Corp.	-	gold	unknown	CS, P, SGC, RGC, T	yes
Hotspot	Golden Sky Minerals Corp.	115N 101	gold	unknown	SGC, NC, RGC	yes
Carmacks Copper	Granite Creek Copper Ltd.	115I 008	copper	porphyry/sheeted vein	DD, RGC	no
Stu (Carmacks North)	Granite Creek Copper Ltd.	115I 011	copper	porphyry/sheeted vein	SGC, RGC, DD, CR	no
Casino	Western Copper and Gold Corp.	115J 028	copper	porphyry/sheeted vein	DD, RGC	no
Charlotte	Taurus Gold Corp.	115I 137	gold	vein/breccia	G, DD, RGC	no
Clear Creek	StrataGold Corp.	115P 023	gold	porphyry/sheeted vein	SGC, RGC, GGP, T	yes

Abbreviations

CS – claim staking
P – prospecting
G – geology
T – trenching
SGC – soil/silt geochemistry
RGC – rock geochemistry
AGP – airborne geophysics
GGP – ground geophysics
DD – diamond drilling
NC – non-core drilling
CR – road construction
MD – mine development

Appendix 1 (continued). Exploration projects 2020.

Project	Owner / Optioner	MINFILE	Commodity	Deposit type	Work type	YMEP funded
Clear Creek	Kreft, Bernie	115P 011	gold	porphyry/sheeted vein	P, SGC, RGC, T	yes
Coffee	Newmont Corp.	115J 110	gold	vein/breccia	SGC, RGC, GGP, T	no
Connaught	ATAC Resources Ltd.	115N 040	gold	vein/breccia	CS, P, SGC, RGC, T	yes
Rau Trend	ATAC Resources Ltd.	106D 005	gold	skarn/replacement	P, G, SGC, T, DD, RGC, NC	no
Dale	536005 Yukon Inc.	105B 007	silver	skarn/replacement	RGC, GGP, T	yes
Dempster Vanadium	DV196 Holding Corp.	116I 084	vanadium	sediment associated	SGC, RGC	yes
Dorian Miner	Schulze, Carl	105D 066	gold	vein/breccia	SGC, RGC, G	yes
Eagle Gold Mine	Victoria Gold Corp.	106D 025	gold	porphyry/sheeted vein	MD	no
Lynx	Victoria Gold Corp.	106D 029	gold	porphyry/sheeted vein	G, SGC, RGC, T, DD, CR	no
Raven (Erin)	Victoria Gold Corp.	106D 018	gold	porphyry/sheeted vein	G, SGC, T, DD, CR, RGC	no
Dubloon	Richards, Gord	-	unknown	unknown	NC, RGC	yes
Einarson	18526 Yukon Inc.	115O 017	gold	sediment associated	P, G, SGC, RGC	yes
Ellen	Group Ten Metals Inc.	115A 041	copper	volcanic associated	P, G, SGC, RGC	yes
Freegold Mtn	Triumph Gold Corp.	115I 107	copper	porphyry/sheeted vein	RGC, DD	no
Golden Culvert	Stratabound Minerals Corp.	105H 067	gold	vein/breccia	P, G, GGP, SGC, RGC, T, DD	yes
Goldorak	Hulstein, Roger	105L 051	gold	porphyry/sheeted vein	CS, P, G, SGC, RGC, T	yes
Grabben Gold	Kreft, Bernie	115O 054	gold	unknown	SGC, RGC, T	yes
Hen	White Gold Corp.	115O 168	gold	vein/breccia	GGP, SGC, RGC, T	no
Ind-WGC	White Gold Corp.	115O 095	unknown	unknown	AGP, GGP	no
White Gold	White Gold Corp.	115O 165	gold	vein/breccia	DD, RGC, NC	no
Idaho	ATAC Resources Ltd.	115J 099	gold	vein/breccia	P, G, SGC, RGC	yes
JC	Huber, Marty	105B 040	tin	skarn/replacement	P, SGC, RGC	yes
Joe (Lindsay)	Stuhini Exploration Ltd.	105C 022	unknown	unknown	AGP, DD	no
Jurassic Park	Burke, Ryan	-	unknown	unknown	P, SGC, RGC	yes

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Appendix 1 (continued). Exploration projects 2020.

Project	Owner / Optioner	MINFILE	Commodity	Deposit type	Work type	YMEP funded
K2	AKG Exploration Inc.	116I 071	vanadium	sediment associated	P, RGC	yes
Keno-Lightning	Metallic Minerals Corp.	105M 011	silver	vein/breccia	DD, NC, RGC	no
King Solomon Project	Kestrel Gold Inc.	115O 188	gold	vein/breccia	P, SGC, RGC, T	yes
Klaza	Rockhaven Resources Ltd.	115I 067	gold	vein/breccia	DD, RGC	no
Kryptos	Mieras, Jeff	-	unknown	unknown	P, SGC, RGC	yes
Kudz Ze Kayah	BMC Minerals (No. 1) Limited	105G 117	zinc-lead	volcanic associated	MD	no
Leota	Goldbank Mining Corp.	115O 074	gold	vein/breccia	P, G, SGC, RGC	no
Lone Star	Klondike Gold Corp.	115O 072	gold	vein/breccia	P, G, SGC, RGC, DD	no
LOTR	Metallic Minerals Corp.	106D 042	silver	unknown	SGC, RGC, T	yes
McCleery	Overland Resources (BC) Ltd.	105C 029	copper	skarn/replacement	P, SGC, RGC	yes
McKay Hill	Metallic Minerals Corp.	106D 038	silver	vein/breccia	P, G, SGC, RGC, NC	yes
Minto Mine	Pembridge Resources plc	115I 021	copper	porphyry/sheeted vein	DD, RGC	no
Monster	Go Metals Corp.	116B 102	copper	IOCG	NC, RGC	yes
Mount Hinton	Strategic Metals Ltd.	105M 052	gold	vein/breccia	P, G, T, DD, CR, RGC	no
Mount Vic	Hill 79 Gold Corp.	115I 068	gold	unknown	P, G, SGC, RGC, AGP	yes
Mt. Haldane	Alianza Minerals Ltd.	105M 032	silver	vein/breccia	DD, RGC	no
Nickel Shäw (Wellgreen)	Nickel Creek Platinum Corp.	115G 024	nickel-PGE	mafic/ultramafic associated	GGP, DD, RGC	no
Nidd (Boundary Zone)	Fireweed Zinc Ltd.	105O 024	zinc-lead	sediment associated	AGP, GGP, DD, RGC	no
Nitra	Banyan Gold Corp.	115P 001	gold	unknown	SGC, GGP	yes
North Rackla	Cantex Mine Development Corp.	106C 088	zinc-lead	Mississippi Valley-type	P, G, SGC, RGC, DD, T	no
Ogi	Fox Exploration	116B 165	zinc-lead	Mississippi Valley-type	NC, RGC	yes
Pelly Mountains (BMC)	BMC Minerals (No. 1) Limited	105G 040	zinc-lead	volcanic associated	RGC, GGP, G	yes

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DD – diamond drilling
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MD – mine development

Appendix 1 (continued). Exploration projects 2020.

Project	Owner / Optioner	MINFILE	Commodity	Deposit type	Work type	YMEP funded
Porphyry	Hulstein, Roger	115H 038	copper	porphyry/sheeted vein	SGC, RGC, AGP, G, P	yes
RC Gold	Sitka Gold Corp.	115P 061	gold	porphyry/sheeted vein	DD, RGC	yes
Rivier	Rackla Metals Inc.	105G 107	gold	vein/breccia	G, AGP	no
Carlin-Roop	Mayo Lake Minerals	-	silver	vein/breccia	DD, RGC	no
Rude Creek Gold	Makara Mining Corp.	115J 022	gold	porphyry/sheeted vein	CS, GGP, SGC, NC, RGC	yes
Ryan's Surprise	White Gold Corp.	115O 012	gold	vein/breccia	DD, RGC	no
Sands of Time	Milton, Jack	115J 090	copper	unknown	SGC, P	yes
Selwyn	Selwyn Chihong Mining Ltd.	105I 037	zinc-lead	sediment associated	MD	no
Silver Hart	CMC Metals Ltd.	105B 021	silver	vein/breccia	P, SGC, RGC	yes
Sixty Mile	Flow Metals Corp.	-	gold	vein/breccia	GGP, T, NC, RGC	yes
Skukum Creek	Whitehorse Gold Corp.	105D 022	gold	vein/breccia	G, DD, RGC	no
Squid East	Manning Ventures Inc.	115N 096	gold	vein/breccia	P	no
Swift River	Bojtos, Peter	105B 027	zinc-lead	volcanic associated	RGC, G	yes
TBMB	Liverton, Tim	105B 029	zinc-lead	volcanic associated	RGC, G	yes
Tea (Rockland)	White Gold Corp.	115J 038	unknown	unknown	SGC	yes
Ultra	Group Ten Metals Inc.	115B 008	nickel-PGE	mafic/ultramafic associated	G, SGC, RGC, NC	yes
Upper Rackla (BOP)	Kootenay Silver Inc.	-	zinc-lead	Mississippi Valley-type	P, G, SGC, RGC	yes
Ward (Sin)	Burke, Ryan	105D 190	gold	vein/breccia	P, RGC	yes
WRM	Prior, Glen	-	vanadium	sediment associated	CS, P, SGC, RGC,	yes
YMEP 20-006	Arsenault, Chris	-	unknown	unknown	P, SGC, RGC	yes
YMEP 20-025	Hood, William C.	-	unknown	unknown	CS, P, RGC	yes
YMEP 20-032	Arsenault, Chris	-	unknown	unknown	P, SGC, RGC	yes
YMEP 20-036	Jones, Clayton	105E 058	unknown	unknown	P, G, SGC, RGC	yes
YMEP 20-108	Burke, Ryan	-	unknown	unknown	P, SGC	yes

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GGP – ground geophysics
DD – diamond drilling
NC – non-core drilling
CR – road construction
MD – mine development

Appendix 2. Drilling statistics by project, 2020.

Property	Owner/Optioner	number of holes	number of metres
Diamond Drilling			
Minto Mine	Pembridge Resources plc	132	21 411
Casino	Western Copper and Gold Corp.	49	12 031
Aurex	Banyan Gold Corp.	50	10 000
Bermingham Mine	Alexco Resource Corp.	11	7653
Klaza	Rockhaven Resources Ltd.	22	6042
Raven (Erin)	Victoria Gold Corp.	31	7453
Lynx	Victoria Gold Corp.	4	594
Mount Hinton	Strategic Metals Ltd.	32	6978
Lone Star	Klondike Gold Corp.	52	4055
Golden Culvert	Stratabound Minerals Corp.	17	3217
Nidd (Boundary Zone)	Fireweed Zinc Ltd.	10	2948
Keno-Lightning	Metallic Minerals	12	2674
North Rackla	Cantex Mine Development Inc.	*not available*	*not available*
Mt. Haldane	Alianza Minerals Ltd.	4	799
Charlotte	Taurus Gold Corp.	11	2347
Freegold Mountain Project	Triumph Gold Corp.	9	2069
Skukum Creek	Whitehorse Gold Corp.	4	2091
Rau Trend	Atac Resources Ltd.	6	1876
Ryan's Surprise	White Gold Corp.	6	1633
RC Gold	Sitka Gold Corp.	6	1500
Brewery Creek	Golden Predator Canada Corp.	22	1332
Nickel Shäw (Wellgreen)	Nickel Creek Platinum Corp.	2	675
Roop	Mayo Lake Minerals Inc.	6	900
Stu	Granite Creek Copper Ltd.	4	738
Carmacks Copper	Granite Creek Copper Ltd.	2	527
Que	Stuhini Exploration Ltd.	2	
	Total	**506**	**101 543**

Appendix 2 (continued). Drilling statistics by project, 2020.

Property	Owner/Optioner	number of holes	number of metres
Percussive/Reverse Circulation			
Brewery Creek	Golden Predator Canada Corp.	39	4575
Keno-Lightning	Metallic Minerals Corp.	30	2644
McKay Hill	Metallic Minerals Corp.	5	392
Rude Creek Gold	Makara Mining Corp.	17	1994
Rau Trend	Atac Resources Ltd.	25	1565
Monster	Go Metals Corp.	5	530
Sixty Mile (McDougall)	Flow Metals Corp	15	835
Hen	White Gold Corp.		615
Tom and Jason	Fireweed Zinc Ltd.	9	507
Hotspot	Golden Sky Minerals Corp.	6	568
	Total	**151**	**14 225**

Yukon Exploration and Geology 2020 abstracts

The following abstracts are from the Yukon Exploration and Geology 2020 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 area, southern Wernecke Mountains, Yukon (parts of NTS 106C/4, 5, 12 and 106D/1, 8)

T. Ambrose

The Rusty Mountain area is underlain by sedimentary strata of the Paleoproterozoic Wernecke Supergroup, Mesoproterozoic Pinguicula Group, Neoproterozoic Hematite Creek Group and Windermere Supergroup, and Paleozoic Bouvette Formation. Three suites of intrusions are documented: (1) 10–200 m thick, subalkaline, mafic sills and dikes of the *ca.* 1380 Ma Hart River suite intrude the Wernecke Supergroup; (2) 2–3 m wide, vertical, east-west striking, alkaline, mafic dikes that are geochemically distinct from the Hart River suite intrude the Wernecke Supergroup; and (3) a 30 cm thick, mafic, porphyritic dike intrudes the Wernecke Supergroup at one locality. The main structures in the Wernecke Supergroup are northwest-verging folding and thrusting and a steeply dipping axial-planar cleavage. This deformation affected the Hart River sills, but not the east-west striking dikes. The main structures in the Pinguicula Group and younger strata are northwest-southeast trending gentle folds and a steeply dipping axial-planar cleavage.

Potential heat production from the Seagull and Teslin plutonic suites, southern Yukon: Geochemistry, geochronology, rock physical properties, and 3D Geophysical inversion of Bouguer gravity data

M. Colpron, N. Hayward and J.L. Crowley

Cretaceous granitoid plutons of the Seagull and Teslin plutonic suites, east of Teslin, are evaluated for their potential radiogenic heat production. The Seagull suite comprises ultra-fractionated, A-type granites dated at *ca.* 103–101 Ma that have anomalous average heat production values (*A*) of 7.9 to 9.9 μW/m^3. The Teslin suite is older (*ca.* 121–109 Ma) and characterized by more intermediate granodiorite compositions that mostly have average *A* values of 2.0 μW/m^3, closer to global averages. Locally, anomalous *A* values of 4.5 to 11.4 μW/m^3 are associated with younger (*ca.* 110–108 Ma), more evolved granitic phases of the Teslin suite. The 3D inversion of Bouguer gravity data provides models that constrain the subsurface density character and extents of the Hake and Seagull batholiths, and estimated volumes of ~4624 and 2744 km^3, respectively. The combination of these results suggests that potential heat energy of ~36.5 MWt may be contained in the Hake batholith, and as much as 27.2 MWt in the Seagull batholith.

New geochemistry from old drill holes at the Tom Property, Macmillan Pass, Yukon

T.A. Fraser, J. Milton and S.A. Gouwy

This paper presents new data from historical drill core and outcrop specimens from Macmillan Pass, Yukon. Whole rock lithogeochemical data are presented from analyses of core from three drillholes at the Tom Property. The core covers intervals ranging from the Middle Devonian Road River Group (Sapper Formation) to the Upper Devonian Earn Group (Portrait Lake Formation–Fuller Lake Member) and includes the Macmillan Pass volcanic suite that occurs at the Road River–Earn Group contact. Samples were collected to characterize the depositional history of Middle–Upper Devonian fine-grained rocks in the region to aid with paleogeographical reconstructions, depositional models, improve age control and to aid in correlation of thick shale units. Baseline geochemical profiles and sedimentology for all fine-grained units indicate turbidity current deposition in a range of shelf to basinal settings and variable oxic to anoxic conditions. Additionally, eleven existing Middle Devonian conodont collections were re-examined to provide better biozone refinements and a tighter constraint of the contact between the Road River Group (Sapper Formation) and Earn Group (Portrait Lake Formation) to the Late Eifelian *australis-ensensis* biozones.

Organic carbon isotope data from the upper Sapper Formation immediately below the Macmillan Pass volcanic suite display a negative 3.2‰ excursion. This thin (≤15 cm) interval coincides with enrichment of trace elements Mo, Ni, Zn, Se, P, As, Ag, Au, Zn and P_2O_5. Isotope data combined with the updated conodont ages indicates an anomalous shale interval age-equivalent to the 'NiMo' or hyper-enriched black shale horizon observed regionally in Selwyn basin, Richardson trough and Kechika trough at the contact between the Road River Group and Canol Formation/Portrait Lake Formation (Earn Group). This interval is also coeval with the Kačák Event, a global biocrisis that spans the Eifelian–Givetian boundary and is characterized in the marine realm by a condensed section of black shale sedimentation, sea-level instability, a negative isotopic excursion and pelagic faunal changes (*i.e.*, massive extinction followed by a radiation). Whether the strata at Macmillan Pass records this global event requires further biostratigraphic control; however, its presence would be a significant marker for the Eifelian–Givetian boundary in eastern Selwyn basin. Unlike other NiMo occurrences elsewhere in Yukon, this anomalous shale interval at Macmillan Pass is overlain by volcanic rocks. The local influence of the Macmillan Pass volcanic suite on metal concentrations and on the carbon isotopic signature in underlying shale also requires further examination.

The geometry and kinematic history of Cordilleran deformation at the Howard's Pass shale-hosted massive sulphide deposit, Yukon: 1st year progress report

D. Kamal and K.A. Hickey

The shale-hosted massive sulphide Zn-Pb deposits of Howard's Pass were deposited during the Silurian and subsequently deformed during the Cretaceous Cordilleran orogeny. A recent model proposes that the deposits are hosted within a regional thrust duplex with strong transposition of bedding. This study aims to test this model and is focused on the XY group of deposits. Lithostratigraphic mapping and structural observations indicate one main phase of folding, F_1, and the XY group of deposits is located on the southern limb of a macroscopic F_1 syncline. F_1 folds are steeply inclined and gently plunging to the WNW–NW. A regionally developed, steep, NE dipping, cleavage, S_1, is axial planar to the F_1 folds across Howard's Pass. S_1 manifests as a slaty cleavage comprising pervasively developed dissolution seams. WNW and NNE striking extensional faults overprint F_1 folds. No shear fabrics or evidence for transposition of bedding were identified.

Preliminary investigation of geological controls on radon concentration in surficial sediment in Whitehorse, Yukon (NTS 105D/11, 14)

M.J. Kishchuk, P.S. Lipovsky, J.D. Bond and J.C. Gosse

Although the presence of radon has been reported in Yukon, the controls on radon soil gas fluxes in Yukon have not been studied. Here we report 328 radon concentration measurements collected in surficial sediment at 30 sites throughout Whitehorse during the summer of 2020 for the purpose of examining the controlling factors. The sediment types include till, glaciofluvial sand and gravel, glaciolacustrine silt, fluvial sand and gravel, and eolian sand. Average radon concentrations were compared to bedrock lithology, thickness of surficial sediment, surficial sediment type, surficial sediment grain size distribution, sorting, sediment maturity, and soil moisture to determine the first-order geological controls. Pronounced interseasonal variation was observed, but intraseasonal summer readings were relatively consistent. Positive correlation is apparent between radon concentration and grain size distribution, as well as between radon concentration and soil moisture. No appreciable correlation was observed with depth to bedrock or with bedrock type. Additional data are being collected to complete the analyses in order to establish which geological and environmental factors are primary controls on radon concentration in near surface sediments.

Structural geology of the eastern Richardson Mountains, Yukon and Northwest Territories: Some field observations and a note of caution for palinspastic reconstructions

N. Pinet

The Richardson anticlinorium is a major tectonic feature marking the eastern limit of the Cordilleran orogen in northern Yukon and Northwest Territories. Limited structural observations on the eastern flank of the Richardson anticlinorium indicate that the strain intensity increases significantly close to major faults that are associated with deformation zones tens to hundreds of metres wide. A predominant dextral sense of motion is documented for several major faults belonging to the Richardson fault array. However, second-order features exhibit highly variable kinematics. In several cases, strike-slip faults cut shallower dipping faults and follow steep bedding planes, suggesting that dextral motion occurred in a previously deformed and tilted sedimentary succession. The amount of displacement along the Richardson fault array is poorly constrained. Further investigation is warranted as potential large displacements may bear significant consequences on palinspastic reconstructions.

Updated geology of the Clark Lakes area in central Yukon (parts of 106D/2,3,6 and 7)

D. Skipton and L. Maw

The Clark Lakes area is located along the northern boundary of the Selwyn fold belt and is underlain by the Ediacaran to Cambrian Hyland Group. In the surrounding region, the Hyland Group and Paleozoic platformal carbonate rocks host several Au and polymetallic mineral deposits. The Clark Lakes area is bordered by regional-scale, southeast-striking thrust faults, which include the Dawson thrust to the northeast, and the Tombstone and Robert Service thrusts to the southwest. Based on stratigraphic relationships identified during 1:50 000-scale bedrock mapping, Hyland Group rocks in the Clark Lakes area are considered to belong to the Cryogenian–Ediacaran Yusezyu Formation, the Ediacaran Algae Formation and the Ediacaran–Terreneuvian Narchilla Formation. The Yusezyu Formation has been subdivided into five units based on dominant siliciclastic lithofacies, which form a broadly coarsening-upward sequence. The Yusezyu and Narchilla formations host gabbro sills, and quartz monzonite occurs locally in the upper Yusezyu Formation. Rocks in the Clark Lakes area exhibit a steeply northeast-to-southwest-dipping foliation that is axial planar to southeast-trending folds.

YGS list of publications and maps for 2020

YGS released 47 publications in 2020: 43 Open Files, 2 Miscellaneous Reports and 2 Annual Reports

Open Files

Sack, P.J., Colpron, M., Crowley, J.L., Ryan, J.J., Allan, M.M., Beranek, L.P. and Joyce, N.L., 2020. Atlas of Late Triassic to Jurassic plutons in the Intermontane terranes of Yukon. Yukon Geological Survey**, Open File 2020-1**, 365 p.

Ambrose, T., 2020. Preliminary bedrock geology map of the southern Rusty Mountain area, southern Wernecke Mountains, Yukon (part of NTS 106C/4,5 and 106D/1,8). Yukon Geological Survey, **Open File 2020-2**, scale 1:50 000.

Witter, J.B., 2020. Early-stage exploration for geothermal energy resources along the Denali fault near Duke River, Yukon. Yukon Geological Survey, **Open File 2020-3**, 62 p.

De Pasquale, J., 2020. Lithostratigraphic metallotect ranking of non-plutonic rocks in Yukon. Yukon Geological Survey, **Open File 2020-4**, 31 p.

Kennedy, K.E. and Ellis, S.E., 2020. Surficial geology of the northern Kluane Ranges (parts of NTS 115G/5, 6, 11, 12). Yukon Geological Survey, **Open File 2020-5**, 4 sheets, scale 1:50 000.

Jackaman, W., 2020. Regional Stream Sediment Geochemical Data, Nash Creek and Larson Creek survey areas, Yukon (parts of NTS 106C, 106D and 116A). Yukon Geological Survey, **Open File 2020-6**.

Kiss, F., 2020. Aeromagnetic survey of the Nash Creek area, Yukon, parts of NTS 105M,N, 106C,D, 115P and 116A. Geological Survey of Canada, Open File 8728; Yukon Geological Survey, **Open File 2020-7**, scale 1:100 000.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 116I. Yukon Geological Survey, **Open File 2020-8**, scale 1:250 000, 2 sheets.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 95E. Yukon Geological Survey, **Open File 2020-9**, scale 1:250 000, 4 sheets.

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Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 105D. Yukon Geological Survey, **Open File 2020-12**, scale 1:250 000, 4 sheets.

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Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 105F. Yukon Geological Survey, **Open File 2020-14**, scale 1:250 000, 4 sheets.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 105G. Yukon Geological Survey, **Open File 2020-15**, scale 1:250 000, 4 sheets.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 105H. Yukon Geological Survey, **Open File 2020-16**, scale 1:250 000, 4 sheets.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 105I. Yukon Geological Survey, **Open File 2020-17**, scale 1:250 000, 4 sheets.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 105J. Yukon Geological Survey, **Open File 2020-18**, scale 1:250 000, 4 sheets.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 105K. Yukon Geological Survey, **Open File 2020-19**, scale 1:250 000, 4 sheets.

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Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 105M. Yukon Geological Survey, **Open File 2020-21**, scale 1:250 000, 4 sheets.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 105N. Yukon Geological Survey, **Open File 2020-22**, scale 1:250 000, 2 sheets.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 105O. Yukon Geological Survey, **Open File 2020-23**, scale 1:250 000, 4 sheets.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 105P. Yukon Geological Survey, **Open File 2020-24**, scale 1:250 000, 4 sheets.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 106B. Yukon Geological Survey, **Open File 2020-25**, scale 1:250 000, 4 sheets.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 106C. Yukon Geological Survey, **Open File 2020-26**, scale 1:250 000, 4 sheets.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 106D. Yukon Geological Survey, **Open File 2020-27**, scale 1:250 000, 4 sheets.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 115A. Yukon Geological Survey, **Open File 2020-28**, scale 1:250 000, 4 sheets.

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Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 115G. Yukon Geological Survey, **Open File 2020-31**, scale 1:250 000, 4 sheets.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 115H. Yukon Geological Survey, **Open File 2020-32**, scale 1:250 000, 4 sheets.

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Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 115K. Yukon Geological Survey, **Open File 2020-35**, scale 1:250 000, 4 sheets.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 115N. Yukon Geological Survey, **Open File 2020-36**, scale 1:250 000, 4 sheets.

Aurora Geosciences Ltd. and Bruce, J.O., 2020. Reprocessing of Yukon magnetic data for NTS 115O. Yukon Geological Survey, **Open File 2020-37**, scale 1:250 000, 4 sheets.

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Miscellaneous reports

Langevin, H., Fraser, T.A. and Raymond, J., 2020. Assessment of the thermo-hydraulic properties of rock samples near Takhini Hot Springs and in the Tintina fault zone, Yukon. Yukon Geological Survey, **Miscellaneous Report 19**, 30 p. plus appendices.

Cronmiller, D.C, McParland, D.J., Goguen, K.M. and McKillop, R.J., 2020. Carmacks surficial geology and community hazard susceptibility mapping. Yukon Geological Survey, **Miscellaneous Report 20**, 16 p. plus appendices.

Annual Reports

Yukon Exploration and Geology 2019. K.E. MacFarlane (ed.), 2020. Yukon Geological Survey 139 p., digital only.

Yukon Exploration and Geology Overview 2019. K.E. MacFarlane (ed.), 2020. Yukon Geological Survey, 78 p.

Annual Overview Papers (YEG)

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

Bond, J. and van Loon, S., 2020. Yukon placer mining 2019 development and exploration overview. *In:* Yukon Exploration and Geology Overview 2019, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 23–34.

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Ambrose, T. and Bowie, S., 2020. Preliminary report on the bedrock geology of the Rackla River area, southern Wernecke Mountains, Yukon (parts of NTS 106C/4, 5 and 106D/1, 8). *In:* Yukon Exploration and Geology 2019, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 1–21.

Bullen, W., 2020. New mineral potential mapping methodology for Yukon: Case studies from the Beaver River and Dawson regional land use planning areas. *In:* Yukon Exploration and Geology 2019, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 23–42.

Cobbett, R., 2020. Preliminary report on the bedrock geology of Castle Mountain area, Yukon (parts of NTS 105D/6). *In:* Yukon Exploration and Geology 2019, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 43–55.

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Bickerton, L., **Colpron, M.**, Gibson, H.D., Thorkelson, D. and Crowley, J.L., 2020. The northern termination of the Cache Creek terrane in Yukon: Middle Triassic arc activity and Jurassic-Cretaceous structural imbrication. Canadian Journal of Earth Sciences, vol. 57, p. 227–248. **YGS Contribution 041**, https://doi.org/10.1139/cjes-2018-0262.

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Pinet, N., **Sack, P.**, Mercier-Langevin, P., Colpron, M., Lavoie, D., Dubé, B. and Brake, V.I., 2020. Neoproterozoic-hosted Carlin-type mineralization in central Yukon, part 1: regional to prospect-scale geological controls. *In:* Targeted Geoscience Initiative 5: contributions to the understanding of Canadian gold systems, P. Mercier-Langevin, C.J.M. Lawley and S. Castonguay (eds.), Geological Survey of Canada, Open File 8712, p. 281–297. **YGS Contribution 2020-1**, https://doi.org/10.4095/326045.

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