Yukon Geological Survey 2020 overview

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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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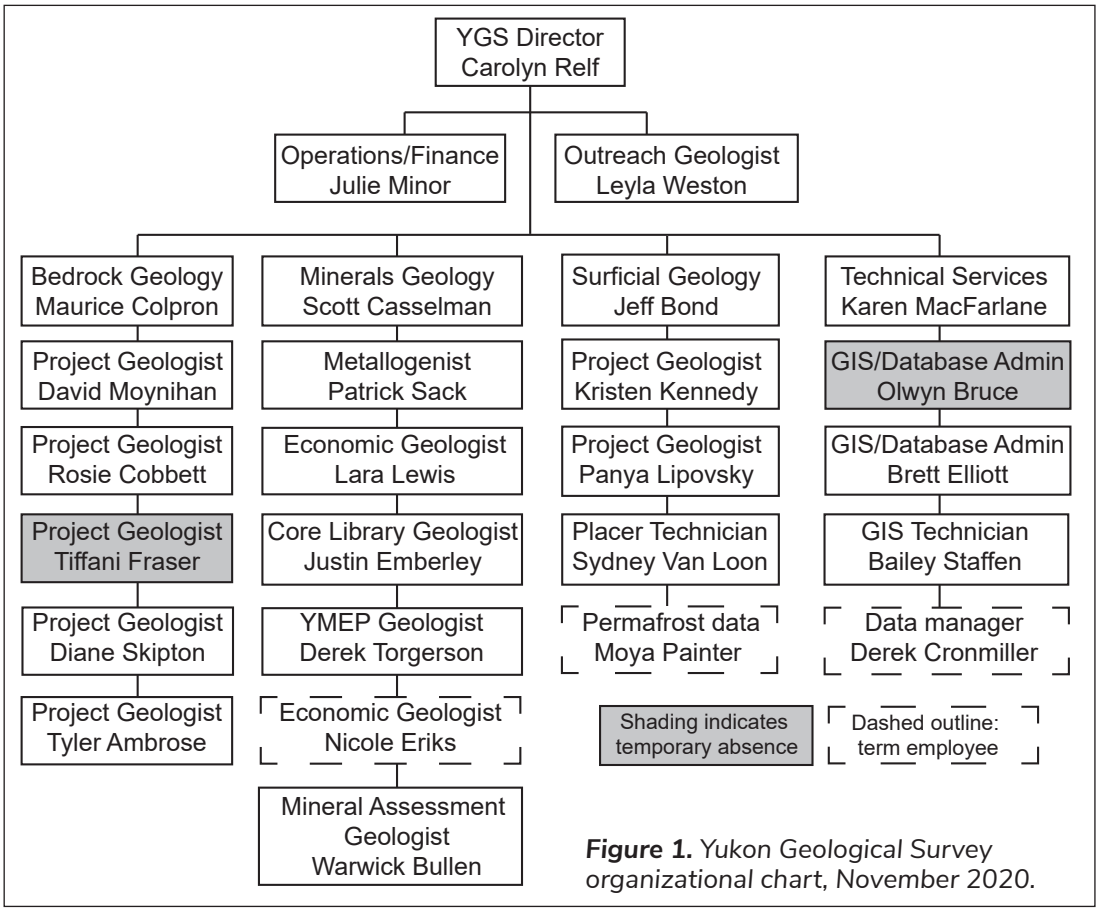

Figure 1. *Yukon Geological Survey organizational chart, November 2020.*

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

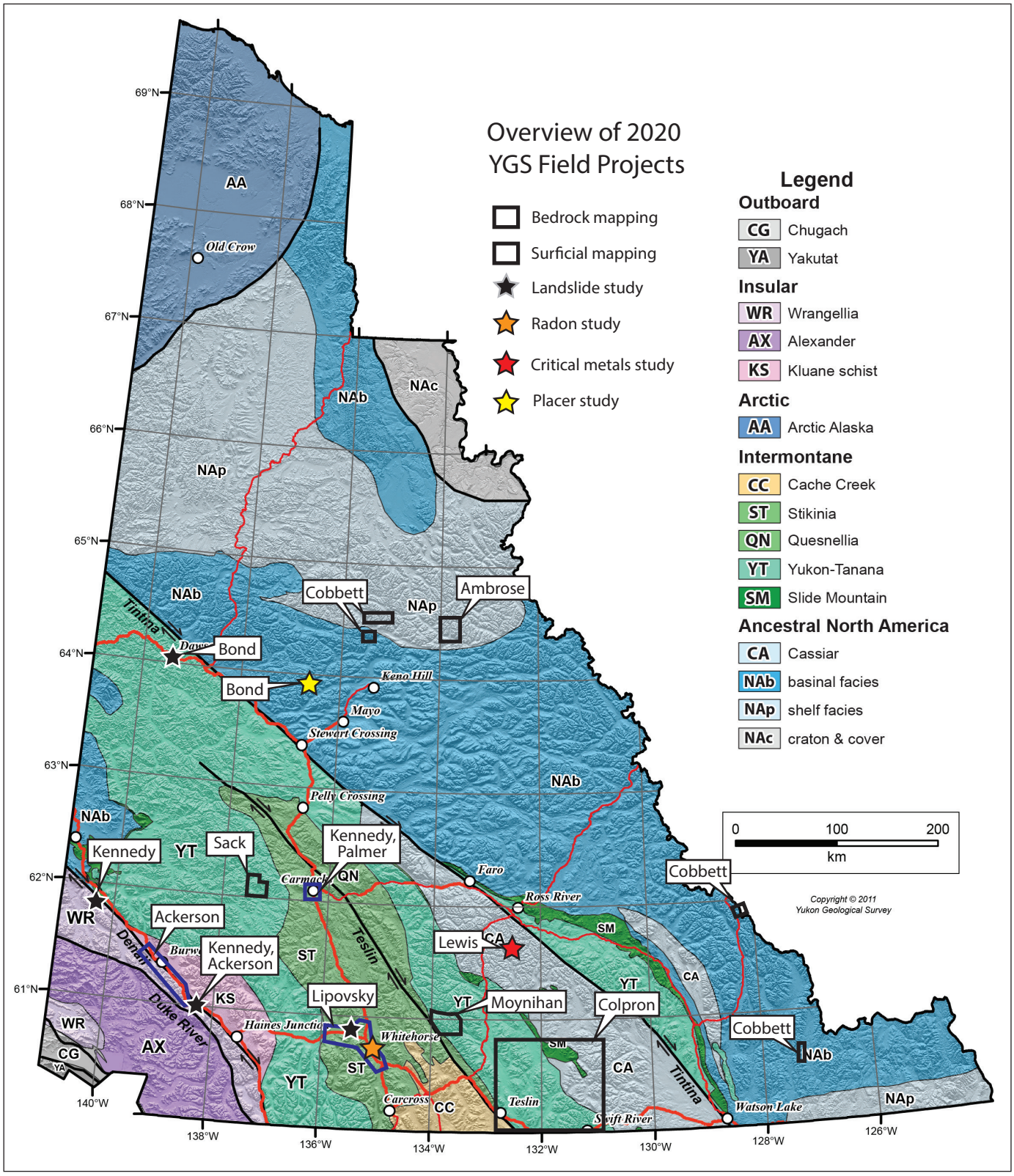

Figure 2. *Locations of YGS' 2020 field projects.*

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

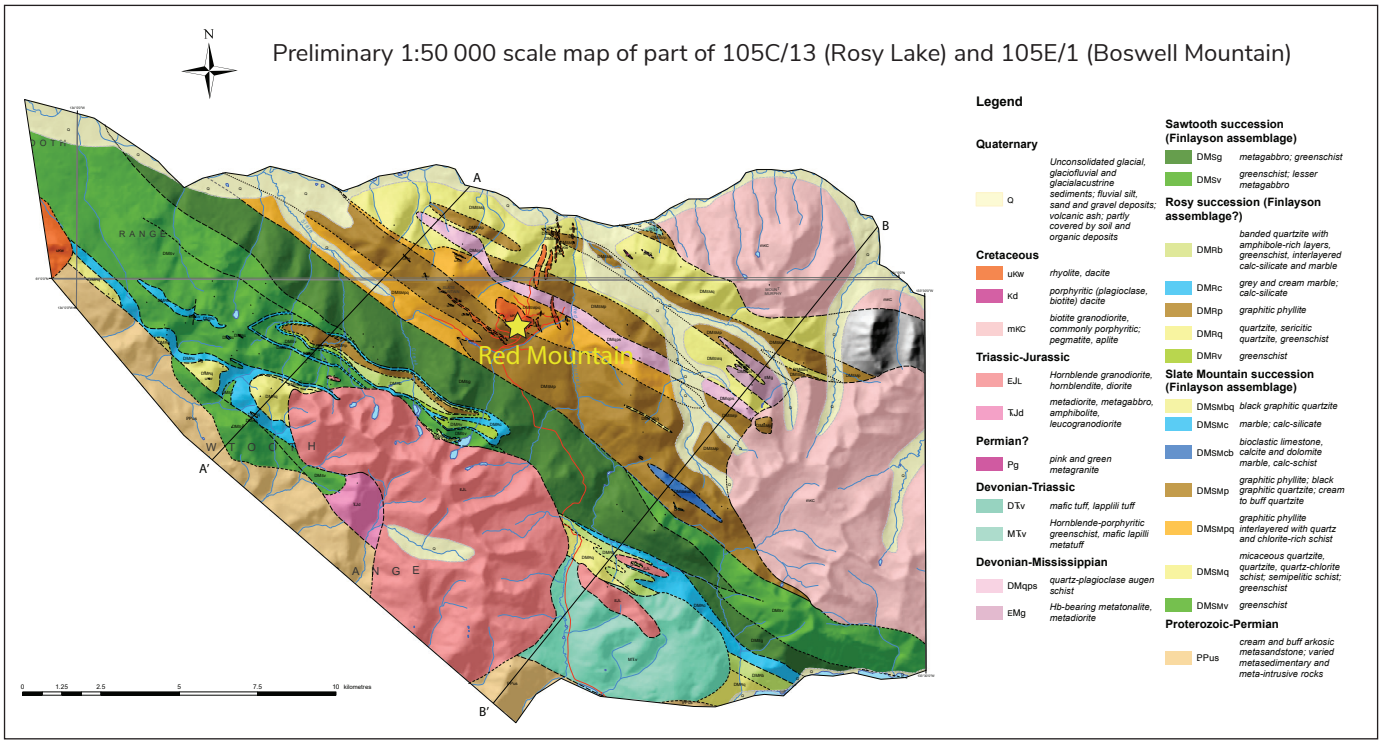

Figure 4. *Geology map, reproduced from David Moynihan's Yukon Geoscience Forum, 2020 technical poster "Preliminary Bedrock Geology of the Sawtooth Range".*

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.

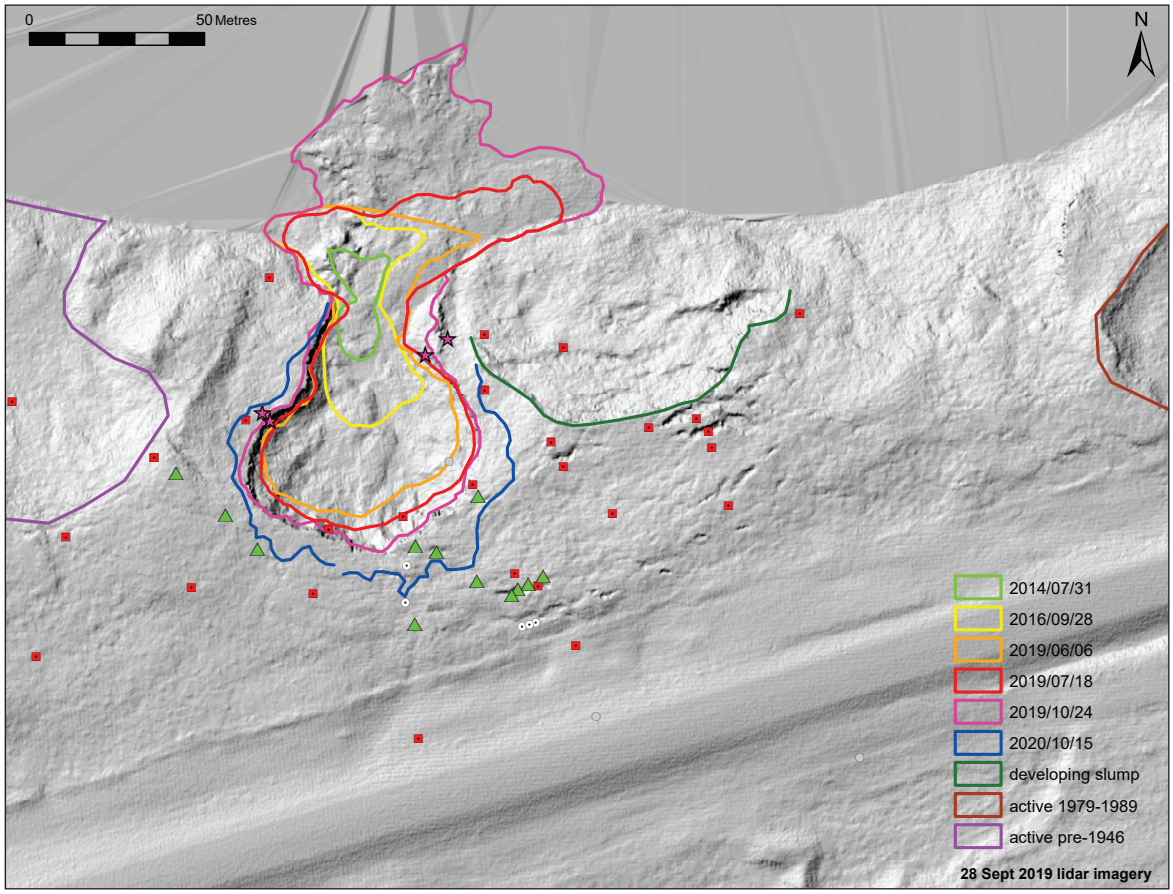

Figure 5. *LiDAR image of Takhini River thaw slump (AK Highway Km 1456). Coloured lines indicate the footprint of the slump area between 2014 and 2020. Historic slumps are outlined to the east and west, and the head scarp of a developing slump (along with tension cracks upslope) is visible immediately 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

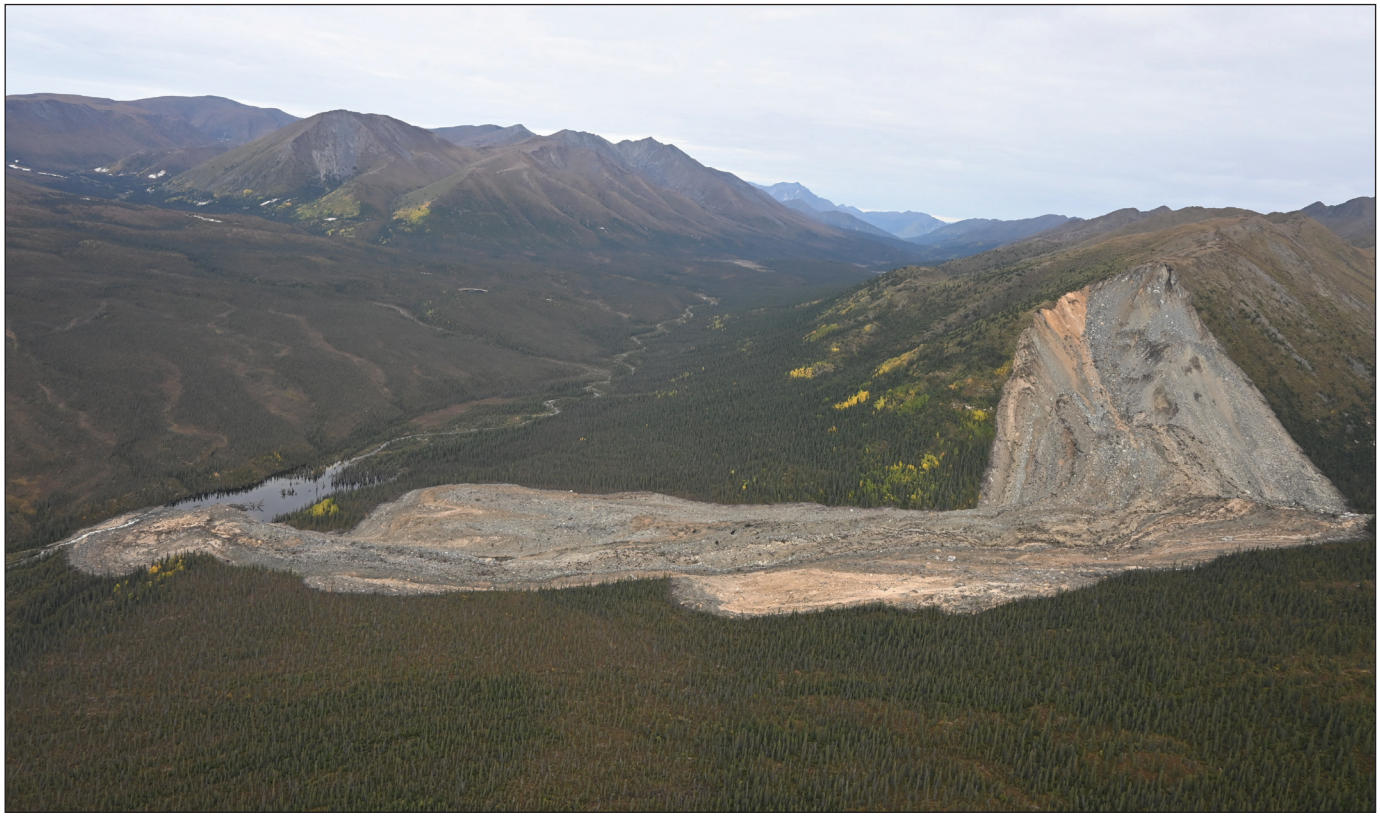

Figure 7. *Aerial view of Koidern slide looking northwest along Koidern River valley. Note the accumulation of water upstream from the toe of the slide.*

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.

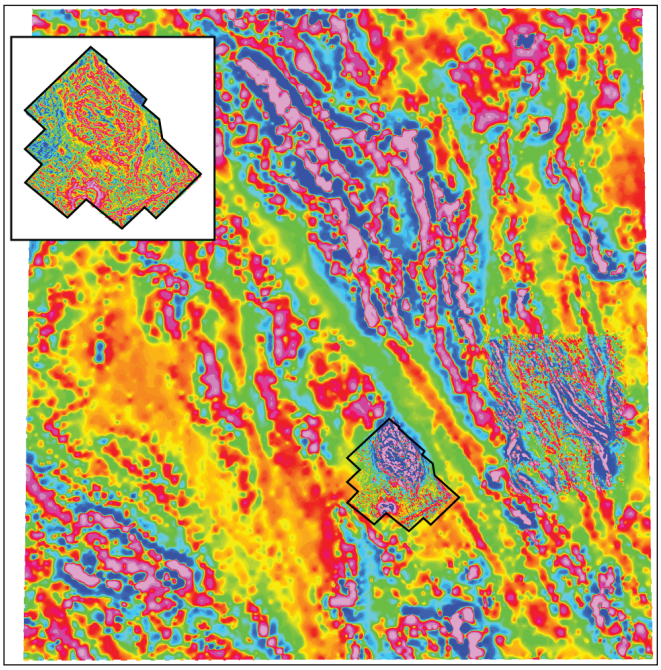

Figure 8. *Regional (1:250 000 scale) magnetic colour contour map of NTS map sheet 105E (Aurora Geosciences Ltd. and Bruce, 2020). Inset map is derived from data filed for the Mars gold occurrence (Wark, 1998; Assessment Report 093874); the Mars property survey has been levelled with and integrated into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

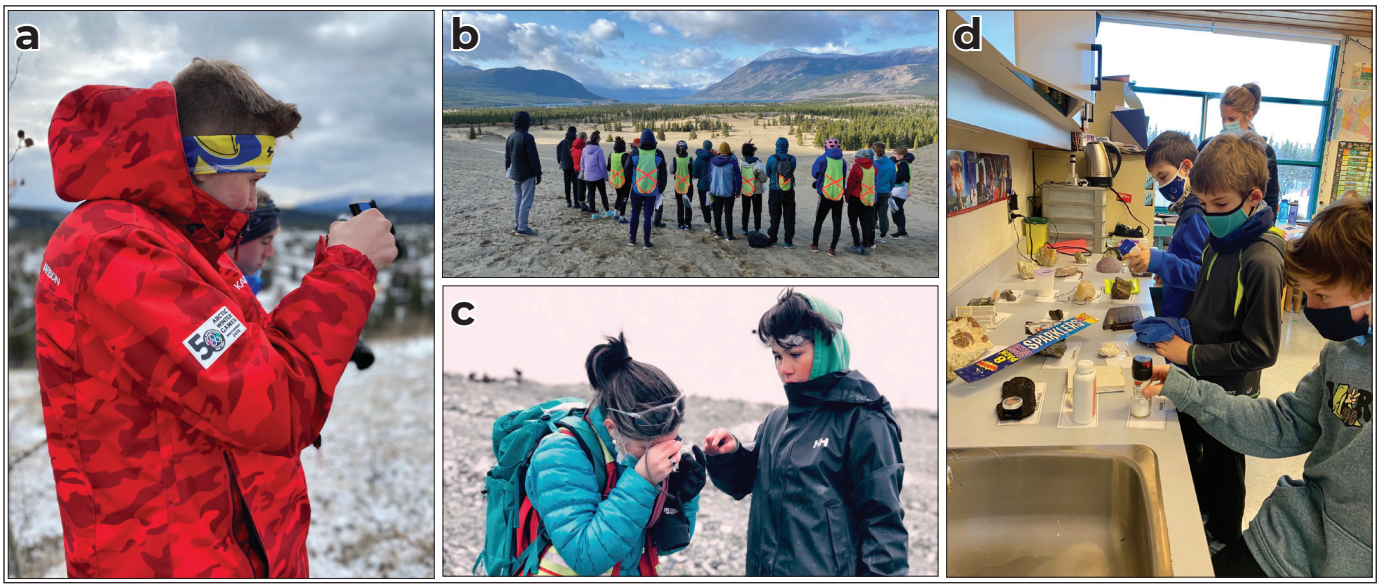

Figure 10. *Photos of YGS outreach activities.* ***(a)*** *Grade 11 student in the Experiential Science program learns to use a compass;* ***(b)*** *grade 10 French Achievement Challenge Environment Stewardship class field trip to the Carcross Desert;* ***(c)*** *Leyla Weston assisting a student with 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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