Alaska Division of Geological & Geophysical Surveys

2021 ANNUAL REPORT

State of Alaska
Department of Natural Resources
Alaska Division of Geological & Geophysical Surveys

Contents

MISSION

Determine the potential of Alaskan land for production of metals, minerals, fuels, and geothermal resources, the locations and supplies of groundwater and construction material, and the potential geologic hazards to buildings, roads, bridges, and other installations and structures (AS 41.08.020).

BACKGROUND

The Alaska Division of Geological & Geophysical Surveys (DGGS) is part of the Alaska Department of Natural Resources (DNR) and is organized into six program sections: Energy Resources, Mineral Resources, Engineering Geology, Volcanology, Geologic Information Center (GIC), and the Alaska Geologic Materials Center (GMC). In FY2019, the division had 36 full-time permanent positions, one part-time position, and 8 non-permanent positions. The total FY2019 expense budget for the division was $8.31 million, consisting of $3.56 million state general fund receipts, $2.1 million federal receipts, $2.14 million capital improvement projects and interagency receipts, and $529 thousand in designated general fund and publication sales. DGGS maintains a website at dggs.alaska.gov, which provides access to its publications and digital data as well as to all pre-digital USGS publications on Alaska geology. DGGS also administers websites for the Alaska Volcano Observatory (avo.alaska.edu), the Alaska Seismic Hazards Safety Commission (seismic.alaska.gov), and the Alaska Geospatial Council (agc.dnr.alaska.gov).

STATE OF ALASKA
Mike Dunleavy, Governor

DEPARTMENT OF NATURAL RESOURCES
Corri A. Feige, Commissioner

DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
Steve Masterman, State Geologist and Director

Publications produced by the Division of Geological & Geophysical Surveys (DGGS) are available for free download from the DGGS website (dggs.alaska.gov). Publications on hard-copy or digital media can be examined or purchased in the Fairbanks office:

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DGGS publications are also available at:

Alaska State Library,
Historical Collections & Talking Book Center
395 Whittier Street
Juneau, Alaska 99811

Alaska Resource Library and Information Services (ARLIS)
3150 C Street, Suite 100
Anchorage, Alaska 99503

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Front cover (top). Tim Tannenbaum (DOT) and Marlee Haralson (DGGS) use a power auger to drill for a sand and gravel resource assessment in the North Slope, near Wainwright, Alaska.
Front cover (bottom). Alec Wildland (DGGS) searches for outcrops during fieldwork northwest of Taylor Mountain.

Back cover. Barry Arm Glacier during summer fieldwork.

MESSAGE FROM THE DIRECTOR

Greetings,

I had thought that I would not be writing this introductory letter this year, but not everything appears to go according to plan!

2021 was a very busy year for DGGS, as much of the fieldwork that was postponed in 2020 due to the COVID-19 pandemic was conducted in 2021. For most projects this meant completing two years of field-work in one summer. That this occurred safely and efficiently is a testament to the professionalism of DGGS staff. Increased field time in summer 2021 included major efforts across multiple sections:

- Volcanology continued replacing outdated equipment and adding new instruments along Alaska's volcanic arc.
- The Energy Section completed mapping of two STATEMAP projects in the North Slope Foothills, discovering previously unknown oil stained sections.
- The Mineral Resources Section completed two mapping projects in the Yukon-Tanana Upland covering 6,700 square km and collected magnetic and radiometric data over 23,000 square km.
- The Engineering Geology Section initiated a landslides program in Prince William sound, conducted a sand and gravel and hydrology field program on the western North Slope, and continued coastal mapping projects and bathymetric surveys in coastal communities.
- The Geologic Material Center ingested over 45,000 boxes of donated and proprietary materials.

In addition to these field programs, the Division took significant strides forward in making data more available by assuming hosting state-wide imagery services and launching new data services to the DGGS web site.

While this is all very encouraging, DGGS does face challenges. The Division's recent growth presents issues with balancing, database, GIS, website, and administrative support for projects. Another challenge is our aging workforce. Most of DGGS' section chiefs will retire within the next five years, so transition planning has been on our minds as we look to the future. Finding qualified candidates for our technical and administrative positions is getting harder with the general labor shortages. Difficulties with this are compounded by internal hiring policies that lengthen recruitment timelines.

Despite these challenges, the Division is in great condition, with well-supported and expanding programs. I feel very encouraged about the future, and that the many great cooperative relationships we have with sister agencies will continue to strengthen as we expand our impactful work that meets the needs of Alaska and our nation.

As it must, DGGS continues to evolve to meet the needs of Alaskans. This year we initiated a landslide mapping program to meet this ever-present, but growing hazard as our climate changes. Additional initiatives like scanning the GMC collection and furthering research of renewable energy are on the horizon, broadening our impact. I feel confident DGGS will continue to evolve as it adapts to societal and industrial needs within the confines of our broad statutory mandate of "all of the above" geoscience in Alaska. What a wonderful mandate to have, in such a special place, with incredibly rich geological diversity.

Respectfully yours,

S. Masterman

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Nat. Res. Tech

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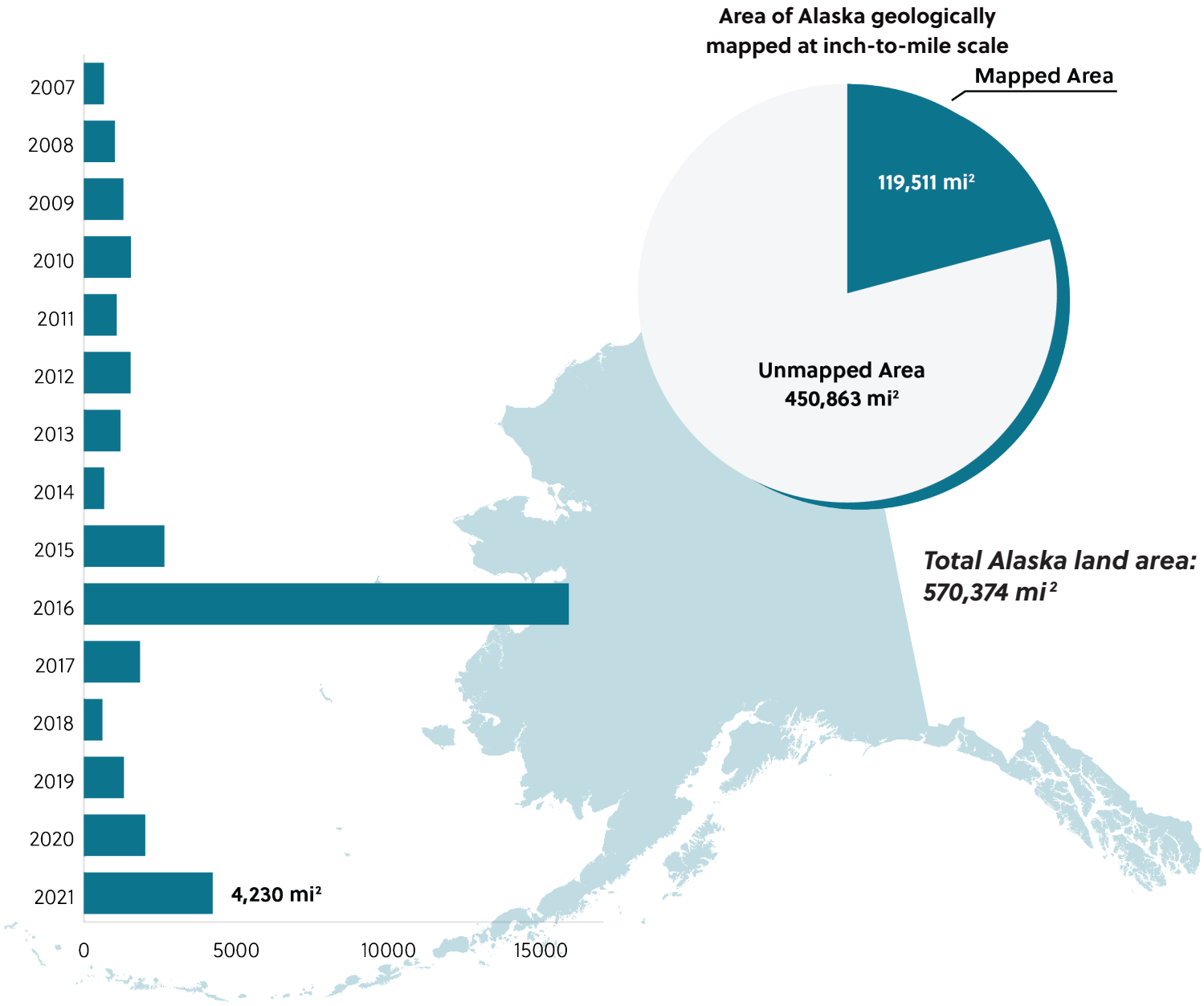
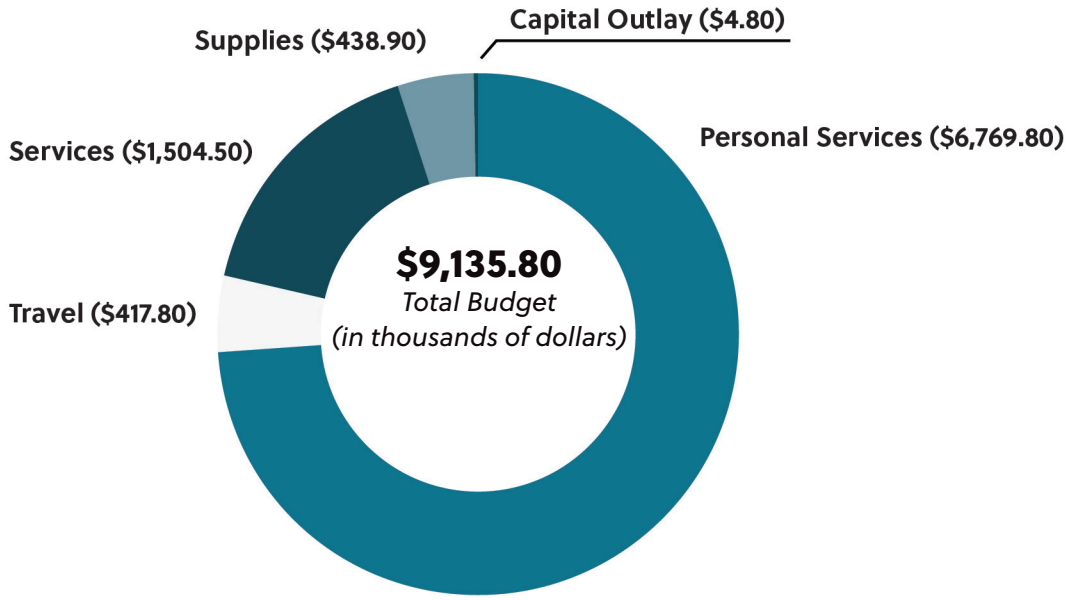
Geologic Mapping

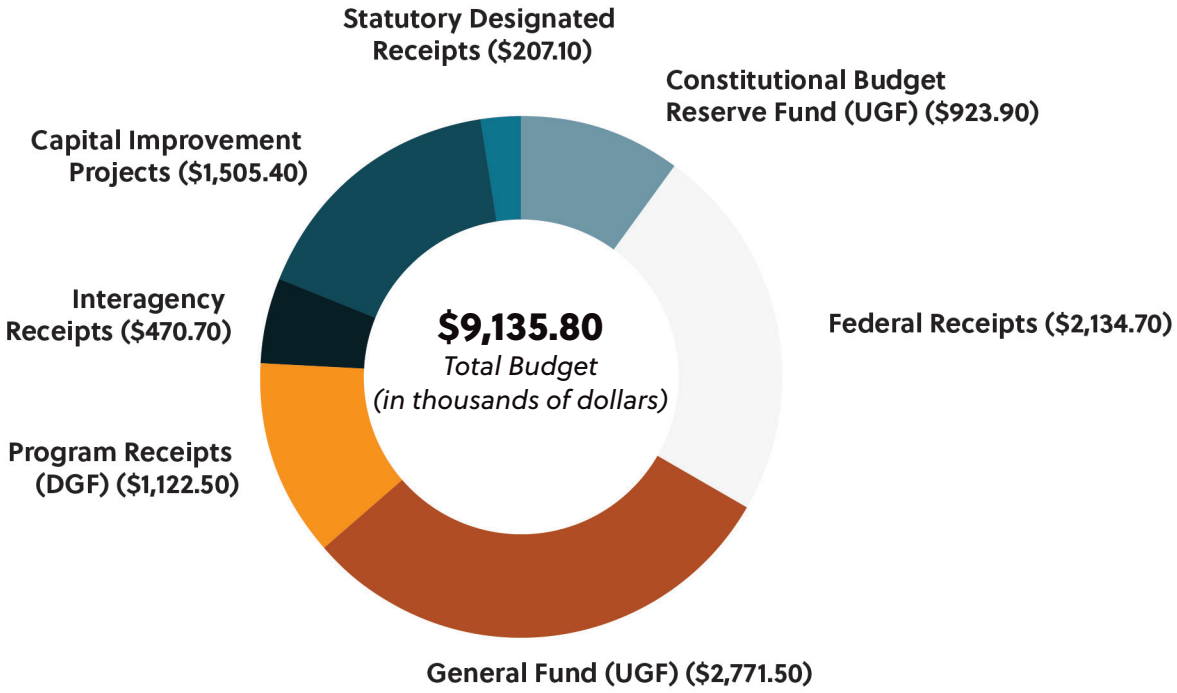
Detailed geological and geophysical maps of Alaska at scales needed for resource exploration, land-use management, and geologic-hazards assessment are currently available for only about 20 percent of the state, but our field programs are increasing this coverage gradually each year. DGGS prioritizes the selection of new mapping areas in consultation with other state agencies, appropriate state boards and commissions, its Geologic Mapping Advisory Board, industry resource-interest groups, and other stakeholders. The survey is committed to delivering the results of its extensive field mapping programs to the public in a timely manner. In FY2021 DGGS published **geologic mapping for a total of 4,230 mi²** of Alaskan lands. Over the past 10 years, **DGGS has published an annual average of 3,005 mi²** of peer-reviewed geologic mapping.



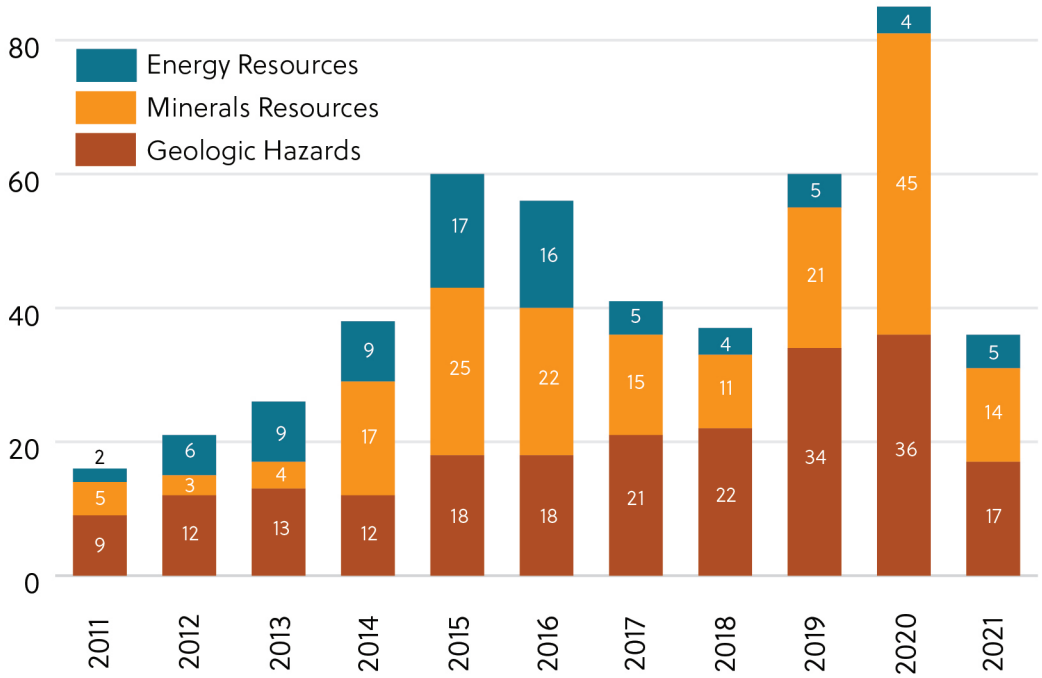
FY21 Authorized Budget



FY21 Funding Sources

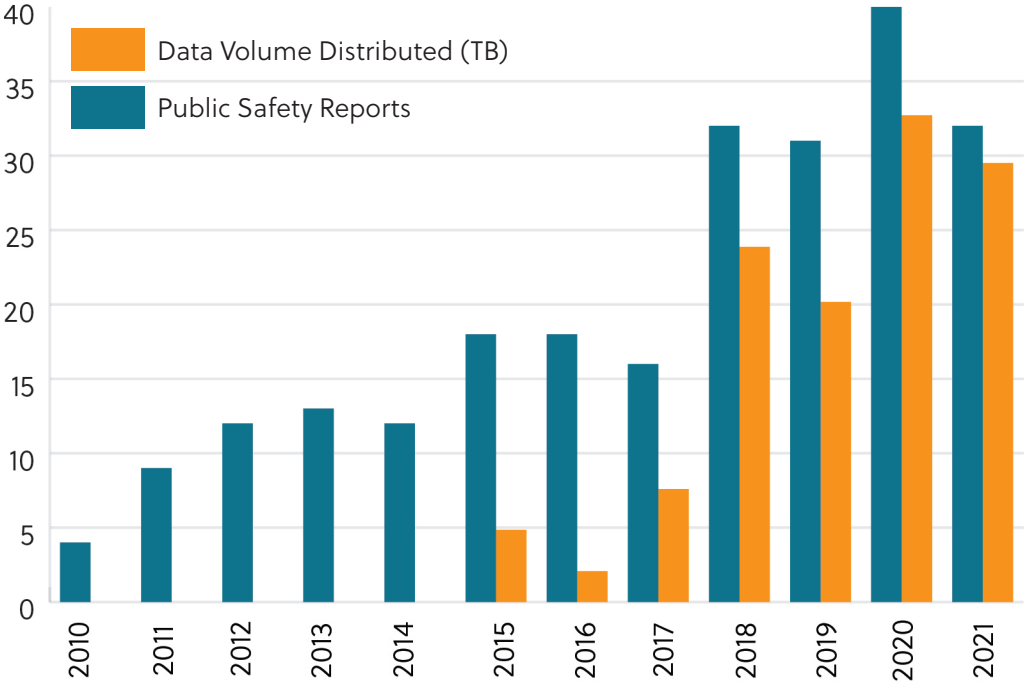


Published Reports FY21



2021 included 20+ GeMS-compliant conversions of previously published geologic maps. These time-consuming and essential projects are not included in the 2021 publication numbers. For more information about these conversions, see the GIC section.

Data and Public Safety Reports Distributed FY21



ENERGY RESOURCES

The Energy Resources Section generates new geologic information about Alaska's oil, natural gas, coal, and geothermal resources and presents this information to industry, the public, and state and federal agencies through formal reports and presentations. DGGS collaborates with the Alaska Division of Oil & Gas (DOG) and other academic and government agencies to integrate outcrop and subsurface data in the analysis and interpretation of complex depositional and tectonic settings to better understand hydrocarbon systems.

Applied energy research on the North Slope is supported by the U.S. Geological Survey (USGS) STATEMAP program, the state of Alaska, and our long-running industry-supported Sponsor's Program. In June and July 2021, the DGGS team conducted three weeks of helicopter-supported fieldwork, including detailed geologic mapping of more than 500 square miles on the central North Slope and undertaking topical studies to evaluate petroleum systems relevant to exploration on state lands, the National Petroleum Reserve-Alaska (NPRA), and the Arctic National Wildlife Refuge (ANWR). This work included a measured section of newly recognized oil-stained Nanushuk Formation and the first collection of drone-based photogrammetry to aid in visualization and quantitative assessment of potential reservoir geometries. The Energy Resources Section

DGGS geologist Mandy Willingham pilots a drone photogrammetry survey of a newly discovered outcrop of the Nanushuk Formation within the 2021 map area. The geologist on the outcrop (Marwan Wartes) is near beds that yielded prominent hydrocarbon odor, confirming the unit's reservoir potential. Photo: Trystan Herriott.

continues to modernize its field data collection, and collaborated with other DGGS professionals to hone digital field data capture methodology using tablet devices, including integration of varied software into the data collection workflow.

A major collaborative project with the USGS to drill stratigraphic test cores on the North Slope was delayed due to COVID-19 and then subsequently canceled due to the loss of USGS project funding. The section, however, remains busy with receipt in September of a competitive award from the U.S. Department of Energy to assess the potential of Alaska's carbon ores as a source of rare earth and other critical minerals (see CORE-CM highlight, page 11). This 2-year $1.5 million project is in collaboration with the University of Alaska as well as private and Native partners.

DATA DISTRIBUTION AND PUBLICATIONS

DGGS has accumulated a vast amount of relevant petroleum-related geologic data over the past few decades and aims to release both new and legacy information in appropriate formats. For example, the Energy Resources Section worked with a petrology expert at DOG to compile and review 264 legacy thin sections from the Nanushuk Formation; the main reservoir in several recently announced discoveries on the North Slope. This project resulted in the publication of key photomicrographs to accompany a qualitative assessment of the composition and reservoir quality parameters of each thin section; most of which are tied to detailed measured sections described by DGGS. Important progress also continues on creating a division-wide energy resources geodatabase that will eventually allow industry and the public to search for relevant geologic data from throughout the North Slope, Cook Inlet, and other Alaska frontier basins. An example of this effort is the recent release of a statewide geothermal dataset as a digital publication and interactive map, which are accessible through the DGGS website. Another effort in this area is DGGS' participation in the USGS' National Coal Resources Database System. The ultimate goal of this cooperative program is digital compilation of all known coal occurrences and associated data. The preliminary in-house version of the coal database will prove helpful in collating existing geochemical data as part of our major Department of Energy (DOE) project—assessing the potential of Alaska basins to host rare earth and critical minerals in carbon ores.

READ MORE
RDF 2021-13
doi.org/10.14509/30746

Despite the challenges associated with COVID-19, the section produced a series of important publications

View of the north limb of Twin Bluffs syncline, which exposes an important section of the Upper Cretaceous Schrader Bluff Formation within the 2021 map area on the central North Slope. Photo: Trystan Herriott

READ MORE

Geothermal Sites of Alaska
maps.dggs.alaska.gov/geothermal

relevant to the petroleum geology of Alaska. Publications related to the North Slope include a detailed measured section of one of the more complete exposures of the Nanushuk Formation southeast of Umiat. This paper supplements prior syntheses of regional sedimentary facies by DGGS and serves as an analog and valuable aid in industry's efforts to explore and develop resources from this unit. We also published detailed stratigraphic work from the Upper Cretaceous Schrader Bluff Formation—another important reservoir on the North Slope and the host to billions of barrels of heavy oil. Our group also co-authored a research modeling paper in the journal *Basin Research* that will improve regional exploration concepts in northern Alaska. This work was the culmination of an industry-funded collaboration with the Texas Bureau of Economic Geology and the University of Alaska Anchorage.

The section continued reconnaissance evaluations of frontier regions of the state that have hydrocarbon potential but no production. This ongoing work is in collaboration with various academic institutions working in the Alaska Range and Talkeetna Mountains and is improving understanding of the evolution of the nearby Susitna and Copper River basins. Recent results from this effort include a co-authored paper, published in the journal *Geosphere,* that analyzes sedimentary basins to better understand the tectonics of southcentral Alaska.

Finally, the team continued to release important data for Cook Inlet, taking advantage of our expertise developed over many field seasons of investigations in the region. We published a substantial new synthesis of pollen age data and vitrinite analyses from Cenozoic outcrop samples around the basin. We also released a major milestone professional publication that highlights more than 100 new $^{40}Ar/^{39}Ar$ and U-Pb ages from sedimentary and igneous rocks in the south-central Tyonek Quadrangle in southern Alaska. These data dramatically improve the age constraints of geologic units in Cook Inlet and provide the temporal foundation for understanding the basin's Cenozoic tectonic, thermal, and petroleum systems evolution.

Selected Energy Section 2021 Publications

RDF 2021-8 | doi.org/10.14509/30660

Palynological and thermal maturity analysis of outcrop samples from the Kenai, Seldovia, and Tyonek quadrangles, Cook Inlet region, Alaska

PIR 2021-3 | doi.org/10.14509/30693

Measured stratigraphic section in the upper Schrader Bluff Formation (Late Campanian-Maastrichtian?), Ivishak River, Alaska

PIR 2021-6 | doi.org/10.14509/30762

Measured stratigraphic section, lower Nanushuk Formation (Albian), Arc Mountain anticline, Nanushuk River, Alaska

View toward the north-northwest showing the upper few hundred meters of the upper Schrader Bluff section addressed in PIR 2021-3 (doi.org/10.14509/30693).

HIGHLIGHT

Bringing Alaska's Carbon Ore, Rare Earth Elements, and Critical Minerals into Perspective

Critical minerals (CM), including rare-earth elements (REE), are essential components in many modern products: from cell phones to clean energy technology. However, the United States lacks sufficient domestic sources for many of these minerals, which causes elevated economic and national security risks due to potential supply-chain disruptions. To address this growing challenge, several federal programs have been created to help stimulate domestic exploration and production of critical minerals (see Earth MRI summary). The Department of Energy's (DOE) National Energy Technology Laboratory (NETL) announced a three-phase Carbon Ore, Rare Earths and Critical Minerals (CORE-CM) initiative and solicited proposals from U.S. regions with significant coal-bearing sedimentary basins. The Alaska Division of Geological & Geophysical Surveys (DGGS) and the University of Alaska assembled a team that includes several private and Native partners, and were awarded $1.5 million over two years to assess the potential of Alaska's carbon ores as a source of rare earth and other critical minerals.

DGGS' primary task involves compiling all available published and unpublished geochemical data from coal or other carbon-rich rocks. New data will be generated from existing samples—relying heavily on rocks and core archived at the Geologic Materials Center. Additional new samples will be collected and analyzed from select carbon-rich basins around the state to fill data gaps. This work is cross disciplinary and requires collaboration between the Energy and Mineral Resources sections at DGGS to leverage their respective expertise. All sample information and resulting organic and inorganic geochemical data will be captured in DGGS databases and publications and will be exported to NETL's Energy Data Exchange platform.

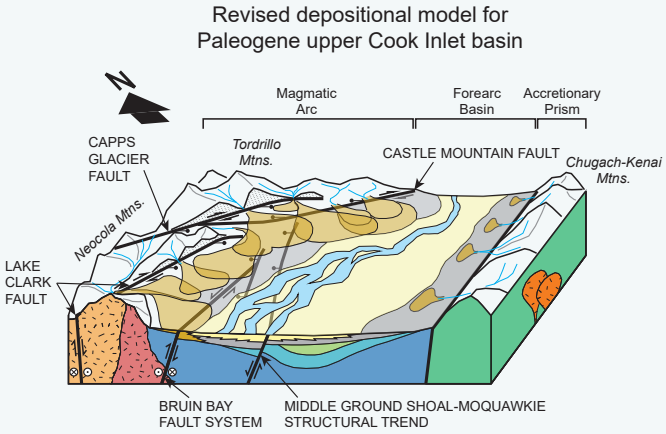
Phase one of the project, which runs through August 2023, will devise a priority matrix that considers the potential of different regions to produce REEs, CMs, or high-value, non-fuel, carbon products. The matrix will also evaluate infrastructure, technology readiness, environmental factors, and market potential to ultimately select the most promising basin(s) for more in-depth characterization and study during DOE-grant phases 2 and 3, if awarded. An important goal of this project will be to establish a technology innovation center to help nurture the development of this key industry in Alaska, eventually catalyzing job creation and economic growth.

DGGS geologist Marwan Wartes and USGS geologist Richard Stanley examine a thick coal bed south of the Usibelli coal mine. Analysis of rare earth element and critical mineral content of this and other coal seams around the state will provide the basis for an initial assessment for the CORE-CM project.

HIGHLIGHT

Age Does Matter—A Milestone Publication Offers New Tectonic Model for the Cook Inlet Petroleum Basin

Cook Inlet is a major petroleum basin that has produced more than 1.3 billion barrels of oil as well as 8.0 trillion cubic feet of natural gas, much of which serves as the major energy source in south-central Alaska. Despite this, there are many important elements of the basin's geology that remain poorly understood, often due to a lack of publicly available data. With a goal of reducing risk and attracting exploration investment in the basin, DGGS has a Cook Inlet basin analysis program that has been conducting geologic mapping and targeted studies of important stratigraphic and structural elements.



A major milestone of this program was reached with the recent release of DGGS Professional Report 125, a publication that dramatically improves age constraints on economically significant units, and provides the basis for a substantial new tectonic model.

The new data include more than 100 $^{40}Ar/^{39}Ar$ and U-Pb dates that provide precise constraints on the age of Cretaceous and Cenozoic arc magmatism, as well as the depositional age and provenance of key reservoir units in the adjacent forearc basin. Previous DGGS work has established that the timing of arc volcanic activity is critical because the presence of significant volcanic material negatively impacts the reservoir quality of sandstones in the basin. The new stratigraphic age control builds upon another major recent publication from the group that synthesizes an extensive palynology and thermal maturity dataset. Collectively, these papers build a detailed framework for understanding the evolution of the basin and its petroleum potential.

Professional Report 125 combines the new age data with detailed mapping and structural data from the northwestern margin of the basin to arrive at a new model to explain the tectonic evolution of the basin during the Cenozoic Era—when all of the producing reservoirs were deposited. This work revealed the previously under-recognized role of right-lateral strike slip faulting between about 60 and 40 million years ago, which produced localized pull-apart basins. These faults appear to have been linked, producing extension in the arc and forearc margin as a consequence of laterally variable fault slip during counterclockwise rotation of western Alaska. By approximately 35 million years ago, the arrival of the Yakutat terrane appears to have resulted in shallow subduction and cessation of arc volcanism. The progressive collision of the terrane eventually resulted in inversion of some of the pre-existing extensional faults and the development of most of the fold structures that serve as hydrocarbon traps in Cook Inlet.

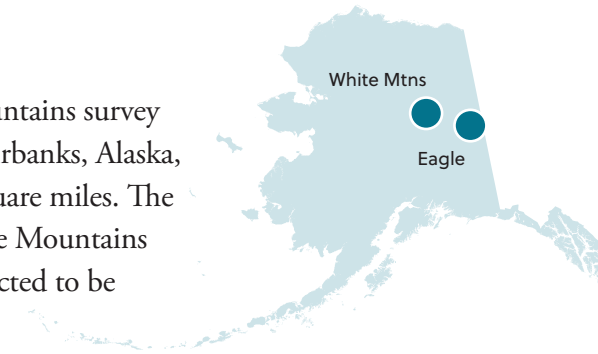
LOOK OUT FOR PR 125 EARLY IN 2022

MINERAL RESOURCES

DGGS conducts geological mapping and geochemical and geophysical surveys of the most prospective Alaska lands that are open for resource development to attract interest in mineral exploration and to support responsible development of Alaska's mineral endowment. Since 1993 the data products of the Airborne Geophysical/Geological Mineral Inventory (AGGMI) program have been an important component of successful resource exploration programs. DGGS products have contributed to the private-sector discovery of more than 22 million ounces of gold in the Salcha River–Pogo and Livengood areas since 2004.

GEOPHYSICAL SURVEYING

DGGS collected two new airborne magnetic and radiometric surveys from May 24 to August 22, 2021. These surveys were funded by the USGS Earth Mapping Resources Initiative (Earth MRI) program and the U.S. Bureau of Land Management. The Eagle survey, located near Eagle, Alaska, covers 3,757 square miles. The White Mountains survey just north of Fairbanks, Alaska, covers 5,186 square miles. The Eagle and White Mountains surveys are expected to be published in early 2022.

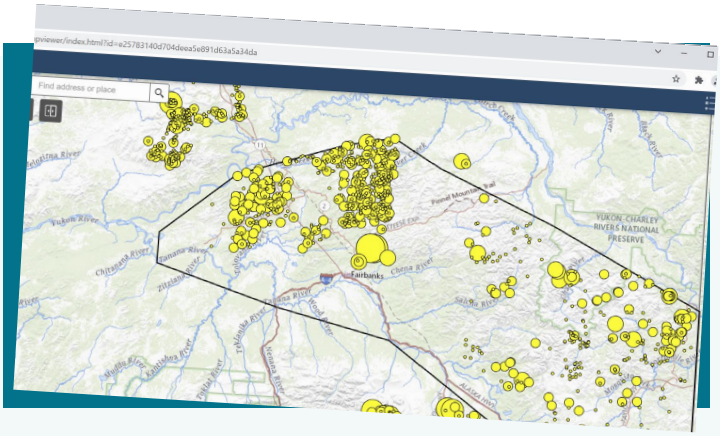


The startup of the planned Earth MRI-funded Lower Tanana and Big Delta airborne magnetic and radiometric surveys is delayed until May 2022 due to COVID-19. When completed, these surveys will provide full magnetic data coverage of the Yukon Tanana Uplands except for Yukon-Charlie Rivers National Preserve.

GEOLOGIC MAPPING

DGGS performs Alaska's portion of the critical-minerals-focused Earth Mapping Resources Initiative (Earth MRI), the purpose of which is to

EXPLORATION GEOCHEMISTRY MAP OF ALASKA



maps.dggs.alaska.gov/geochem

The online Exploration Geochemistry Map of Alaska presents a visualization of elements of economic interest for Alaska stream sediment samples, which best represent bedrock that is actively weathering and includes all the mineral phases contributing to the elemental compositions. The map presents the most precise and accurate values available for each element in the sample, all obtained using modern analytical methods. As of September 2021, the database consists of 3,311 individual stream sediment samples pulled from USGS archives and re-analyzed in 2020 as part of the Earth MRI Program, Stream Sediment Reanalysis Project, as well as 4,558 samples re-analyzed as a part of the State of Alaska's Strategic and Critical Minerals Project. The ongoing geochemical re-analysis projects are a joint effort between DGGS and the USGS to obtain modern elemental analyses for historical USGS stream sediment samples in Alaska. This exploration-focused database will expand as more stream sediment geochemical analyses become available. Eventually the database will include all modern geochemical analyses of stream sediments as well as other geologic materials from Alaska and will be hosted by DGGS and USGS.

...BY THE NUMBERS

320 field person days

2,630 mi² mapped

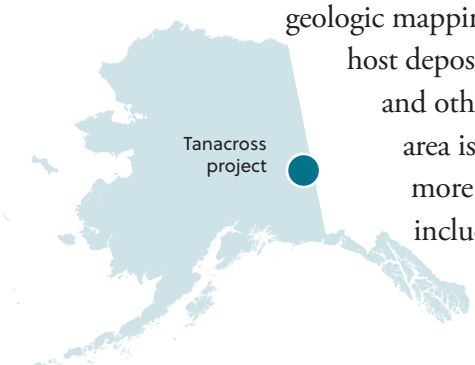
3,310 stream-sediment pulps re-analyzed

increase the nation's mineral security by conducting geophysical surveys, geologic mapping, and lidar surveys. This primarily federally funded project, supplemented with state matching funds, allows DGGS Mineral Resources geologists to create and disseminate geophysical and geological map products. These types of products have historically been shown to stimulate mineral industry interest, staking, and exploration activity in Alaska, as well as to increase revenue to the state. The Earth MRI project is being implemented in cooperation with the USGS and is expected to be a 10-year national program (beginning in 2019) funded at greater than $10 million per year. In FY2021, Alaska received $1.1 million in federal funds under this program.

In June 2019, DGGS Mineral Resources geologists began their first Earth MRI field project by conducting 1,900 square miles of geologic mapping in the eastern Tanacross region. In 2021, DGGS published:

- A report on Mount Fairplay's rare earth-element potential: dggs.alaska.gov/pubs/id/30736
- A geologic map and report for the eastern Tanacross area: dggs.alaska.gov/pubs/id/30734
- Multiple reports on the geochronology of the eastern Tanacross region: doi.org/10.14509/30732; doi.org/10.14509/30683.

Due to COVID-19, fieldwork planned for summer 2020 was delayed until summer 2021. During June and early July, Mineral Resources section geologists conducted field mapping in the western Tanacross region; an area of 1,730 square miles. The project targets a region of the state that has reconnaissance geologic mapping and the potential to host deposits of rare earth elements and other critical minerals. The area is also prospective for more conventional minerals including copper, gold, and molybdenum. Mineral Resources geologists logged 217 person-days of helicopter-supported field work in the western Tanacross map area. A geologic map for the area is scheduled to be published by December 2022.



In mid-July, fieldwork shifted to the Taylor Mountain region near Chicken, Alaska; an area of 900 square miles. This area includes the remainder of the Tanacross Quadrangle that had not previously been mapped by DGGS geologists, as well as part of the Eagle Quadrangle. Known mineral systems within and in the Taylor Mountain map area include quartz veins with gold (Au) mineralization, intrusion-related Cu-Au deposits, and multiple placer Au deposits in the Fortymile Mining District. The area has the potential to host deposits of copper and gold, rare earth elements, and other critical minerals. Mineral Resources geologists logged 103 person-days of helicopter-supported field work in the Taylor Mountain map area. A geologic map for the area is scheduled to be published by May 2023.

As part of the Earth MRI program, DGGS selected ~3,310 historical USGS stream-sediment pulps from across the Yukon–Tanana upland for

SCAN TO READ MORE: RI 2021-5 EASTERN TANACROSS GEOLOGIC MAP

re-analysis with modern techniques, including a full suite of elements. These data have been published and are available for download through the USGS website: doi.org/10.5066/P9WHRLXH; DGGS website: maps.dggs.alaska.gov/geochem; and for viewing through the DGGS Exploration Geochemistry Web App: dggs.alaska.gov/maps-data/interactive-maps.html.

DATA DISTRIBUTION AND PUBLICATIONS

The Mineral Resources Section is in the process of finalizing Alaska's Mineral Industry 2020, an annual summary of activity in the mining sector during the previous calendar year. The report provides a consistent, factual snapshot of exploration, development, and production of Alaska's mineral resources, and serves as the authoritative historical record of mining in the state.

GEOLOGIC HEALTH HAZARDS

Naturally occurring radon gas is the second leading cause of lung cancer—after smoking—and an under-recognized health risk in the state. DGGS runs the Alaska Radon Program in cooperation with the University of Alaska Fairbanks Cooperative Extension Service. Federal Environmental Protection Agency (EPA) funding for this work through the State Indoor Radon Grant comes to DGGS from the Alaska Department of Environmental Conservation's Division of Air Quality. Alaska's radon program provides education and outreach about radon to the public and organizations related to housing and health, as well as free radon testing for homes. The radon program strives to connect with all Alaskans and recently created a video (dggs.alaska.gov/pubs/id/30745) to engage communities outside of the state's main transportation corridors.

Poor groundwater quality in Alaska affects many homes and neighborhoods with private wells. With EPA funding, DGGS is collecting groundwater quality data and creating statewide maps of natural contaminants like arsenic and nitrate. The project will also develop online tools to help the public better understand the water quality data they receive from the laboratory and to visualize natural contaminant distribution around the state. DGGS also provides geologic expertise to other Alaska agencies that handle or regulate water quality issues.

Select Minerals Resources 2021 Publications

RDF 2021-9 | doi.org/10.14509/30676

Preliminary bedrock geologic map database, northeastern Richardson mining district, Alaska

PIR 2021-4 | doi.org/10.14509/30732

U-Pb zircon ages from bedrock samples collected in the Tanacross and Nabesna quadrangles, eastern Alaska

RI 2020-9 | doi.org/10.14509/30537

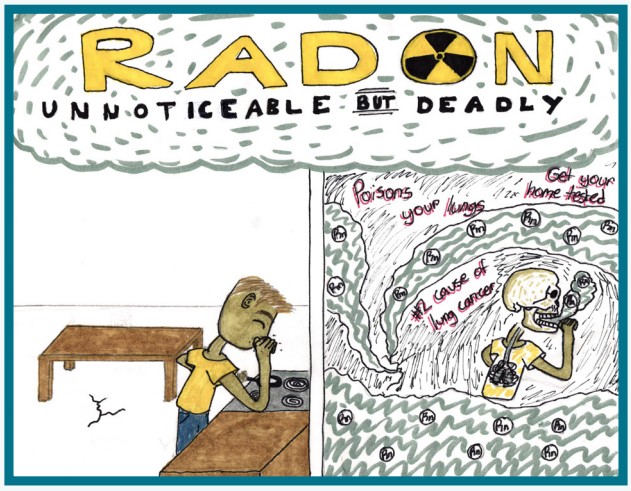
Northeast Tanacross geologic mapping project, Alaska

Visit dggs.alaska.gov/pubs for more

ALASKA RADON POSTER CONTEST

This year, the first annual Alaska Radon Poster Contest was held for students ages 9–13. To increase awareness in Alaska, students were asked to research and design posters illustrating radon's impact. Prizes were awarded to the top three entrants, and the winning poster moved on to the National Radon Poster Contest.

The posters submitted were creative, fun and, most importantly, helped spread awareness of radon. We are looking forward to next year's submissions!



COMPILING A GEOLOGIC MAP OF ALASKA

One of DGGS' long-term goals is to create a seamless 1:100,000-scale geologic map of the state. Mapping at this scale optimizes the detail needed by researchers and resource developers while allowing geologic mappers to cover a reasonable area each year. Although about 80 percent of the state remains unmapped at this scale (level of detail), DGGS is laying the groundwork for a statewide map compilation by standardizing digital geologic data from new and legacy mapping and making it accessible from a single database. Through funding from multiple federal sources, more than 50 maps are slated to be standardized by the end of 2022. Future work includes the development of a dynamic process that geologist compilers can harness to iteratively build the compilation as new mapping becomes available, thereby creating a seamless statewide map with unified geologic unit descriptions and connecting unit boundaries.

Top left. DGGS geologists Michelle Gavel and Alicja Wypych collecting rocks from Taylor Mountain as part of the Taylor Mountain Project. Photo: Michelle Gavel. **Bottom left.** DGGS geologist Alicja Wypych on a basalt dike outcrop in Central Alaska Range as part of the Western Tanacross Project. Photo: Evan Twelker. **Right.** DGGS geologist collecting rocks as part of the Taylor Mountains Project.

ENGINEERING GEOLOGY

The Engineering Geology Section is structured around individual programs that focus on specific geologic hazards and resources as well as collection of baseline data to support multi-program activities. Many projects require overlap between programs to boost scientific expertise and maximize individual staff contributions. Each program is not only collaborative among the section but also maintains relationships with other state and federal agencies, regional and local governments, tribal and Indigenous organizations, academic institutions, non-profits, and others. Alaska is too big to do our work any other way.

By the Numbers

70
Linear Miles of Bathymetry

45
Public Presentations

32
Publications

650+
Public Information Requests

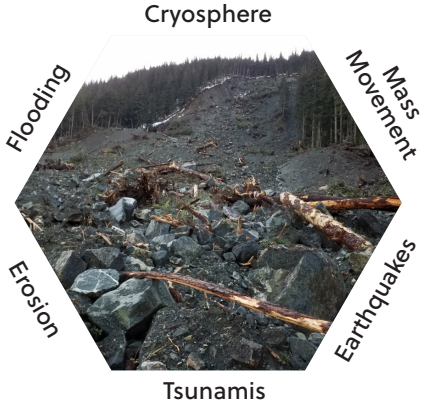
3,400
Sand & Gravel Shothole Descriptions

~75
Communities in which we worked

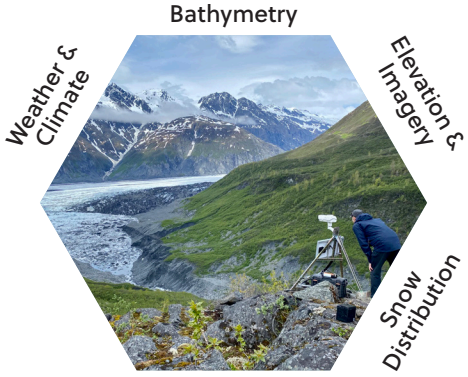
The Engineering Geology Section strives to understand the engineering considerations of geologic materials and geologic hazards for society. Engineering geologists identify where geologic processes are most likely to have an adverse impact on humans and the structures we build and assure that the geological factors relevant to the location, design, construction, operation, and maintenance of engineering works are recognized and accounted for.

In many areas of the state, Alaska lacks the fundamental geologic data needed to guide the proper development and implementation of building codes, land-use zoning, right-of-way siting, and hazard mitigation planning for natural hazards and disastrous events. We develop baseline data, monitoring systems, and provide maps or tools to assist in these efforts.

HAZARDS



MAPPING & MONITORING



RESOURCES

Lidar collection during a field trip to Napakiak.

MAPPING WITH LIDAR

The Engineering Geology Section continues to mobilize the power of lidar (light detection and ranging) elevation mapping in response to strategic mapping priorities across the state. Our system is capable of collecting several square miles of centimeter-scale accuracy airborne survey information in just a few hours of flying. This year, DGGS filled critical data gaps by acquiring lidar at communities that have never been mapped to this standard. DGGS also re-collected lidar data in some areas to monitor snow depth and measure elevation change.

In spring of 2021, DGGS performed airborne surveys over avalanche-prone sites along the Seward Highway and around Juneau. Shortly after, the system was taken to Barry Arm in south-central Alaska, the site of a potential tsunamigenic landslide, for a second and third time (see Landslide Hazards Program Highlight). In May, DGGS used a terrestrial configuration to further investigations on a frozen debris lobe (FDL) near the Dalton Highway in the southern Brooks Range. Areas in and around Deadhorse were flown in August as part of an ongoing hydrogeological study. Later in the same month, the communities of Tuntutuliak, Kipnuk, Kwigilingok, and Napakiak on the Yukon-Kuskokwim Delta were surveyed to provide baseline data for coastal inundation mapping. Finally, DGGS traveled to Haines in September to collect follow-on data—nine months after the initial response to the 2020 landslide.

CLIMATE & CRYOSPHERE

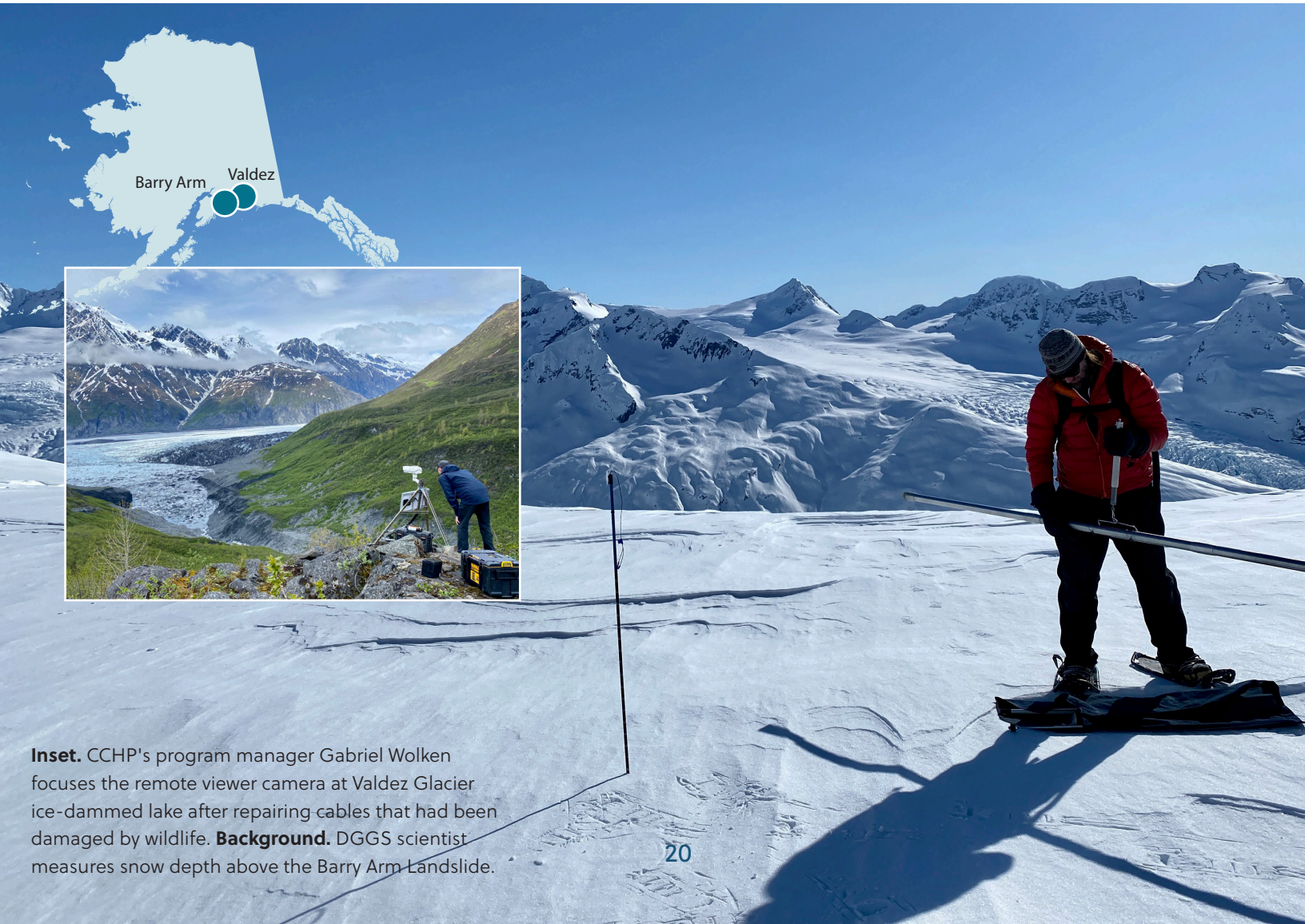
The Climate and Cryosphere Hazards Program (CCHP) works with a diverse group of partners and local stakeholders to assess, monitor, and predict the impacts of a changing cryosphere on communities, infrastructure, and resources in Alaska. This year CCHP focused on developing and delivering actionable science in snow distribution, snow avalanche, and glacier- and permafrost-related hazards research.

During the winter of 2021, CCHP continued our snow distribution and snow avalanche research; conducting fieldwork, including aerial lidar surveys, in multiple locations in southcentral and southeast Alaska and working with partners from Alaska Railroad, University of Alaska, Alaska Energy Light & Power, Alaska Department of Transportation and Public Facilities, and Alaska Department of Fish and Game. In February and March, CCHP used aerial lidar techniques to map the dangerously unstable snowpack in the Juneau area and gathered metrics on snow avalanches generated during mitigation activities. These metrics help to validate CCHP's regional-scale snow avalanche simulation and mapping data. In 2021,

CCHP, along with the Swiss Institute for Snow and Avalanche Research (SLF) and the UAF Climate Adaptation Science Center, was awarded funding to evaluate future changes in snow avalanches in southeast Alaska.

CCHP's Community Snow Observations project (CSO; with multiple collaborators) continues to be a huge success. This year, with the help from crowd sourcing, we gathered more snow observations in Alaska and logged more observations for the project than ever before. As CSO grows so does our group of dedicated ambassadors for the project, and the number of snow distribution modeling domains. This year CSO introduced the near-real-time operational snow distribution product (www.mountainsnow.org). New domains for southeast Alaska are being developed and will be included in the web application in 2022.

Changes in glaciers and mountain permafrost continue to be important topics for Alaska. In 2021, DGGS participated in the multi-agency effort to characterize and assess the Barry Arm landslide. DGGS deployed weather stations to monitor weather and evaluate environmental conditions, and collected lidar to evaluate snow distribution and assess deformation of the unstable slope (Landslide Hazards Program Highlight). CCHP is also co-investigating hazards associated with the Grewingk Glacier unstable slope near Homer, Alaska, and collected repeat lidar for the project in October. CCHP continues to work with partners to monitor glacier-dammed lakes and glacial lake outburst floods (GLOFs) in several locations in the state. In December, program manager Gabriel Wolken co-led an international team of co-authors on a contribution to the 2021 Arctic Report Card on the topic of glacier and permafrost hazards (arctic.noaa.gov/Portals/7/ArcticReportCard/Documents/ArcticReportCard_full_report2021.pdf).



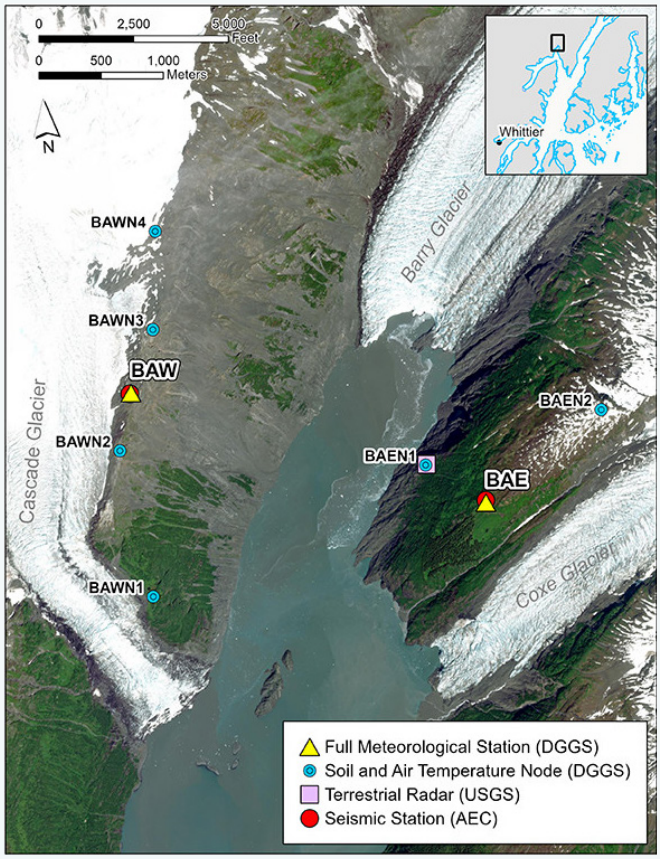
Inset. CCHP's program manager Gabriel Wolken focuses the remote viewer camera at Valdez Glacier ice-dammed lake after repairing cables that had been damaged by wildlife. **Background.** DGGS scientist measures snow depth above the Barry Arm Landslide.

PROGRAM HIGHLIGHT

Alaska Landslide Hazards Program

Landslides can lead to loss of life and significant damage to property and infrastructure. Alaska is particularly susceptible to landslides because of the region's complex glacially influenced terrain, geology, seismic activity, and climate. Ongoing atmospheric warming is having a dramatic influence on weather patterns and on the cryosphere of Alaska; leading to atmospheric rivers (long, narrow bands of moisture in the atmosphere that carry water from the tropics and subtropics toward the poles, causing heavy rainfall), continued mass loss of glaciers, and the widespread warming and thawing of permafrost. As permafrost thaws and glaciers thin and retreat, support of valley walls is greatly diminished or removed, leading to slope failure and the potential for complex hazard cascades (e.g., damming and outburst flood events, glacier collapse, and tsunamis). Landslides from steep mountainsides into fjords have produced destructive tsunamis in the past in coastal areas of southern Alaska such as the 1958 Lituya Bay and the 2015 Taan Fjord tsunamis. Landslide-generated tsunamis are more localized than earthquake-generated tsunamis, are more destructive locally, and can occur with little or no warning.

On January 5, 2021, the National Landslide Preparedness Act (P.L. 116-323) was signed into law. It authorized a national landslide hazards reduction program within the U.S. Geological Survey (USGS), along with substantial federal funding to support the work. In partnership with the USGS, DGGS is standing up a critically needed Alaska Landslide Hazards Program (ALHP) whose mission is to systematically map and assess Alaska's landslide hazards to support community resilience and reduce near and long-term losses from landslides. By leveraging diverse state and federal funds and developing synergy among state, federal, and university entities, the program seeks to promote the safety, health, and welfare of citizens, protect the environment, and support the economy of Alaska. Still under development, ALHP will consist of a core team of three full-time geoscientists along with additional nonpermanent scientific staff and interns as needed to handle the evolving workload. Additional technical expertise will be provided through participation of multidisciplinary staff from other DGGS programs, including the Climate and Cryosphere Hazards Program, Geohydrology Program, and Volcanology Program (AVO-Alaska Volcano Observatory).



Instrumentation in the immediate vicinity of Barry Arm landslide, including meteorological stations installed by DGGS in July and August, 2021

PROGRAM HIGHLIGHT
Alaska Landslide Hazards Program

Goals of the Alaska Landslide Hazards Program include:

Landslide inventory for Alaska

Develop a statewide database of landslides that feeds data into the USGS National Landslide Database

Identify known/ unknown hazards

Using remote sensing and other technologies, evaluate the potential for and relative threat from known and unknown landslide hazards

Prioritize communities/ infrastructure for study

Prioritize communities based on the presence of known or likely landslide hazards as well as engagement and desire for study

Landslide mapping and hazard assessment

Map and assess landslide hazards throughout Alaska

Weather stations

Work toward a landslide early warning system by developing a network of weather stations

Partner Agencies include:

- **U.S. Geological Survey (USGS)**—A cooperative effort to identify, assess, and monitor unstable slopes in Prince William Sound and to begin developing a database to hold statewide information on Alaska landslides.
- **University of Alaska Fairbanks (UAF)**— With university research staff and students, to complete a regional landslide inventory map and catalog for areas of concern in the Haines Borough
- **Alaska Division of Mining, Land, and Water (DNR-DMLW)**— With the Surveying Section to take advantage of professional surveyors to collect ground control for lidar surveys.
- **Alaska Department of Transportation and Public Facilities (AKDOT&PF)**— A cooperative effort to bring an intensive customized training course on slope stability and landslide hazard analysis to DGGS and AKDOT&PF technical staff.
- **U.S Forest Service**—A cooperative effort to collect high-resolution lidar in landslide-prone areas of mutual interest. A new cooperative agreement allows cost sharing of new DGGS lidar acquisitions.

In addition to State of Alaska funding through a Capital Improvement Project, the first phases of work to meet the Alaska Landslide Hazard Program's goals are being supported by a three-year, $2.15M cooperative agreement with USGS focusing on unstable slopes in Prince William Sound and to begin developing an Alaska landslide database. Funding has also been secured from the Federal Emergency Management Agency (FEMA) for targeted projects to assess landslide hazards at Cordova and Haines.

Since ALHP is still in its infancy, the DGGS Climate and Cryosphere Hazards Program is leading the DGGS component of the co-produced science effort at the Barry Arm landslide in Prince William Sound (dggs.alaska.gov/hazards/barry-arm-landslide.html)—installing instrumentation and completing the program's first field season of geological investigations.

HYDROGEOLOGY

The Hydrogeology Program (HP) has been working on a variety of projects with groundwater aspects—from landslides to permafrost degradation. These projects contribute to the understanding of groundwater effects on hazards and the effect of loss of permafrost on groundwater behavior, which will change stream and river runoff and flooding behavior in the future.

The HP is building the capacity to observe changes in groundwater behavior in steep terrain and is actively working to uncover the causes of landslides in Barry Arm and Haines areas. The 2020 Haines landslide exposed a gap in long-term weather observation, which is critical to assess the severity of weather conditions and their impact on the landscape. DGGS installed a new weather observation station in Haines to serve as early warning of future severe landslide hazard conditions. HP is helping the USGS and partners study the landslide dynamics at Barry Arm through the installation of a weather station network (see Landslide Hazards Program Highlight). Mountain freezing and thawing as well as permafrost degradation are concerns for the area.

HP has many ongoing projects to assess permafrost across arctic Alaska. With funding from the National Science Foundation (NSF), HP assisted on hydrological studies of ice-rich arctic tundra soils near Prudhoe Bay and Point Hope. During the summer of 2021, HP collected elevation data for the project using high density lidar over an area directly north of the airport in Deadhorse. The very high-resolution elevation dataset (>50 points per square meter on the ground) will help UAF study the relationship between vegetation, ice wedge degradation, and aggradation. DGGS is also planning to model the hydrology of the project area using WaSiM (a hydrologic model) to assess the consequences of ice wedge degradation on future hydrological conditions. The Alyeska Pipeline Service company funded a study in 2021 to evaluate what it would take to develop a model to simulate FDL movement, which is threatening the Dalton Highway. The plan that was created will be used as a guide to fund specific research projects over the next 10 years. The Alyeska Pipeline Service company also funded the first set of geophysical studies in 2021 to measure an FDL shear zone. HP is continuing to monitor ground temperatures and movement in the old road embankment in front of the FDL. DGGS predicts the old embankment will start to move with the lobe between winter and spring 2022.

HP acquired a high-resolution unmanned bathymetric survey system (Wally). The self-propelled surveyor scans the elevation of lake and river bottoms and uses a seismic chirp to visualize the structure of the sediment below the lake bottom for the assessment of mass movement. Initial pilot projects using Wally occurred over the summer of 2021 (see Wally Highlight).

DGGS Geologists install weather stations to monitor the Barry Arm landslide during the 2021 field season.

EYES IN THE WATER

New hydrographic survey system "Wally" supports hazard and resource mapping

In 2021 DGGS acquired an autonomous hydrographic survey system—a major piece of scientific equipment–to enhance emergency response, hazard mapping, and geoscientific investigations. Nicknamed "Wally," the new SR-Surveyor M1.8 is a highly capable man-portable survey vessel measuring just 6 feet by 3 feet and weighing only 115 pounds. It is tightly integrated with multiple high-resolution hydrographic sensors and a topographical mapping lidar to produce top quality, reliable bathymetry data and sub-bottom profiles. Using a technique similar to single-beam echo sounders, the sub-bottom profiling system identifies and measures various marine sediment layers that exist below the sediment-water interface. Wally's unique sensor suite makes it a versatile system for collecting a wide range of hydrographic data in inland and coastal waters. Its small size, light weight, and extremely shallow draft allow it to be rapidly deployed in difficult-to-access areas.

As with the terrestrial lidar elevation data we rely upon to map features and geohazards on land, bathymetric data over many areas and multiple time periods are a powerful tool for DGGS to carry out its statutory mission. Owning a hydrographic survey system enables DGGS geoscientists to efficiently, accurately, and cost-effectively generate underwater surface elevation models and snapshots of underlying sediment layers that are needed to develop inundation models for floodplain mapping, interpret geologic features for hazard assessment, assess construction materials resources necessary for building infrastructure to support resource exploration and development, and locate valuable placer-mineral deposits. Repeat high-accuracy surveys to detect changes in conditions are essential to aid in rapid emergency response after geologic hazard events like earthquakes, tsunamis, and mass movement events. Having in-house capacity to collect this data facilitates quick and effective responses to these events. Wally allows DGGS to cost-effectively collect high-resolution bathymetric data of targeted areas as well as repeat observations that were previously cost-prohibitive. The system is available to other divisions within DNR, as well as other departments' needs for small bathymetric surveys in areas of interest that align with DGGS project work.

In this first year of operation, DGGS successfully used Wally to determine water volumes and identify gravel in lake bottom and sub-bottom substrates for the ASTAR strategic transportation project, to delineate the submarine runout zone of the Beach Road landslide at Haines; and to map the submarine morphology of the Barry Arm landslide mass in Prince William Sound to help understand the structure of this potentially tsunamigenic unstable slope.

This significant piece of equipment allows DGGS to be a sought-after and valuable collaborator on numerous externally funded projects, which can be leveraged to sustainably maintain and operate the hydrographic survey system for the foreseeable future.

COASTAL FLOODING & EROSION

The Coastal Hazards Program (CHP) works collaboratively with state, federal, tribal, academic, public, and private institutions to map, monitor, and model flood and erosion hazards at Alaska's coastal communities. CHP provides technical guidance and decision-making tools to local and state leaders working to plan for, mitigate, and adapt to hazardous conditions in the coastal zone. The Denali Commission found that 144 communities are environmentally threatened by flooding, erosion, and permafrost hazards—yet minimal data and reporting are available to those communities.

CHP develops community-specific hazard exposure assessments and has ongoing erosion and flood monitoring programs in collaboration with communities. CHP has two publication types, which cover erosion (see Coastal Program Highlight) and flooding to help communities understand exposure to hazards. Flood reports are currently not available in many communities, however, CHP has received funding from the National Coastal Resilience Fund in partnership with the Alaska Native Tribal Health Consortium and the Alaska Division of Community and Regional Affairs to make progress on flood exposure mapping (dggs.alaska.gov/pubs/id/30573). CHP leads the Alaska Water Level Watch to monitor flood events using photographs taken during storms, which are organized in a high-water mark database (maps.dggs.alaska.gov/photodb/#show=96&search=storm), as well as through real-time water-level sensor observations (water-level-watch.portal.aoos.org/). With help from partners, CHP repaired water-level sensors at Deering, Nelson Lagoon, and Chignik River and installed a new sensor at Kwigillingok. The Alaska Ocean Observing System funded a new water-level sensor installation at Dillingham. All of these activities help to close gaps in the National Water Level Observation Network for Alaska. CHP continues to maintain and assist communities in monitoring erosion using simple measuring tape and time-lapse camera methods. Three new erosion monitoring sites were installed in 2021 at Alakanuk, Kotlik, and Napakiak. The North Slope Borough and Aleut Community of St. Paul Island have the capability to monitor erosion using unmanned aerial vehicles (UAVs). In 2021, CHP trained users on the operation of the UAVs and used the vehicles to conduct baseline surveys (see ASTAR section).

Alaska remains on the forefront of national initiatives to map our shoreline and nearshore. These efforts provide the opportunity to fill major data gaps for Alaska's communities that are facing flooding, erosion, and tsunami threats. CHP helps to lead the Alaska Mapping Executive Committee Coastal Subcommittee and worked to stand up the Alaska Geospatial Council Coastal & Ocean Technical Working Group in 2021 (see Alaska Geospatial Office [AGO] Section). These working groups facilitate communication between the multitude of diverse partners and encourage data collection and sharing, especially through events like the fourth Alaska Coastal Mapping Summit. In 2021 as a part of this coordination, the U.S. Army Corps of Engineers collected topobathymetric lidar and high-resolution aerial imagery at 29 Alaska communities—a huge contribution to closing data gaps.

Rich Buzard, a geologist with the Coastal Hazards Program conducts a drone survey in coastal Alaska.

COASTAL PROGRAM HIGHLIGHT

Enhancing Erosion Awareness and Statewide Decision-Making Capacity in 48 Alaska Native Villages

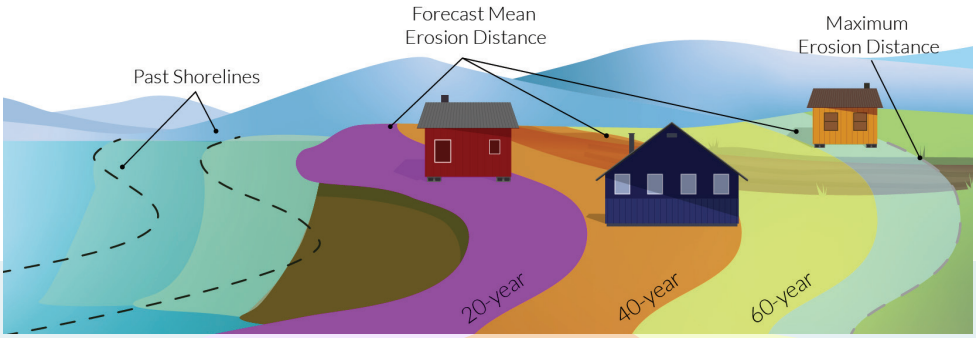
The DGGS Coastal Hazards Program (CHP) finalized a major publication designed to provide technical guidance to Alaska Native villages on erosion of local infrastructure. With funding from the Denali Commission, CHP was able to work over a 2-year period to:

- Delineate historical shorelines and calculate erosion rates
- Project erosion rates at 20-year intervals
- Quantify the amount of infrastructure (e.g., numbers of buildings, linear feet of utility lines, etc.) exposed to erosion

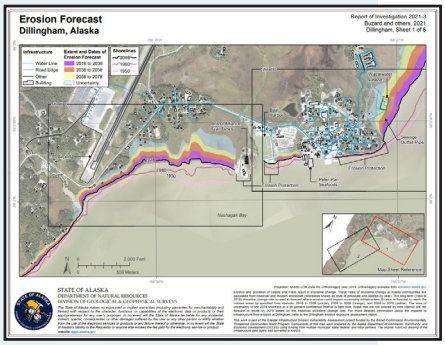
Results of the analysis are shown in forecast map sheets and tables, which allow community leaders to identify parts of their community that are potentially threatened by erosion and give an order of magnitude of the cost to replace infrastructure.

A summary table of all community results shows the relative quantity of exposed infrastructure across this region of Alaska (see excerpt of the table below). 80 percent of total estimated costs are in the Yukon-Kuskokwim Delta, and more than 40 percent of the estimated cost is forecast to occur by the late 2030s.

Location of erosion exposure assessments completed with this report, focused on northern and western Alaska Native villages.



Summary report and 48 community-specific reports are available at: dggs.alaska.gov/pubs/id/30672



	2015 to 2035	2035 to 2055	2055 to 2075
Napakiak	983 LF Power Line 598 LF Water Line 2,091 LF Road 19 Buildings	1,117 LF Power Line 288 LF Water Line 3,088 LF Road 25 Buildings 145,240 SF Landfill	1,222 LF Power Line 2,377 LF Road Line 19 Buildings 1 Tank Facility
Kotlik	892 LF Power Line 31 LF Water Line 242 LF Boardwalk 24 Buildings	955 LF Power Line 44 LF Water Line 500 LF Boardwalk 26 Buildings	430 LF Power Line 100 LF Water Line 480 LF Boardwalk 13 Buildings
Alakanuk	40 LF Power Line 10 LF Water Line 530 LF Road 2 Buildings	1,330 LF Power Line 280 LF Water Line 4,100 LF Road 4 Buildings	1,689 LF Power Line 3 LF Fuel Line 780 LF Water Line 1,250 LF Road 13 Buildings

EARTHQUAKES & TSUNAMIS

The Earthquake and Tsunami Program at DGGS specializes in neotectonic research: collecting high-resolution elevation data and making geologic observations along poorly understood or previously unknown active faults. Through ongoing projects in the Northern Foothills Fold & Thrust Belt and along the Kaltag-Tintina fault systems, DGGS assesses relative seismic hazards posed to Interior communities, statewide infrastructure, and planned future projects. DGGS collaborates on a state, federal, and international level to advance understanding of seismic hazards in Alaska and to increase seismic resilience in the arctic and subarctic in the face of a changing climate.

DGGS manages the DNR portion of the federally funded National Tsunami Hazard Mitigation Program (NTHMP) that is increasing earthquake and tsunami hazard awareness across the state. Working closely with the UAF Geophysical Institute this year, DGGS published inundation maps and reports depicting areas that could be affected by potential future tsunamis at Akhiok, Chiniak, Old Harbor, Ouzinkie, and Port Lions on Kodiak Island (dggs.alaska.gov/pubs/tsunami). DGGS works with the Division of Homeland Security and Emergency Management (DHS&EM) to engage with local emergency planners in at-risk communities through Tsunami Operations and Rural Resiliency Workshops.

DGGS continues to administer the Alaska Seismic Hazards Safety Commission (ASHSC; seismic.alaska.gov/). The Earthquake and Tsunami program manager, Barrett Salisbury, represents the State Department of Natural Resources on the Commission—a panel of diverse professionals that provides information to the public after significant earthquakes, promotes public education and legislative policy to reduce the state's vulnerability to earthquakes, and distributes results of earthquake engineering resilience studies in Alaska. This year, the ASHSC supported development of two seismic demonstration displays for the UAA Civil Engineering Department: a shake table and real-time seismometers, which will be used for a variety of educational purposes not only for UAA students but also for the public and for middle- and high-school science and engineering programs.

GNSS survey base station (above)—providing ground control for a lidar survey of active faults in the Ray Mountains

CONSTRUCTION MATERIAL MAPPING

This year, construction materials mapping was focused on sand and gravel resource assessment on the North Slope as part of the ASTAR project. Read on to learn more.

ARCTIC STRATEGIC TRANSPORTATION AND RESOURCES PROJECT (ASTAR)

In 2021, DGGS made significant progress on multi-programmatic ASTAR project goals and objectives. DGGS collaborates with the North Slope Borough as well as community and regional stakeholders to strengthen community infrastructure and facilitate access to arctic resources while enhancing North Slope communities' quality of life and providing economic opportunities.

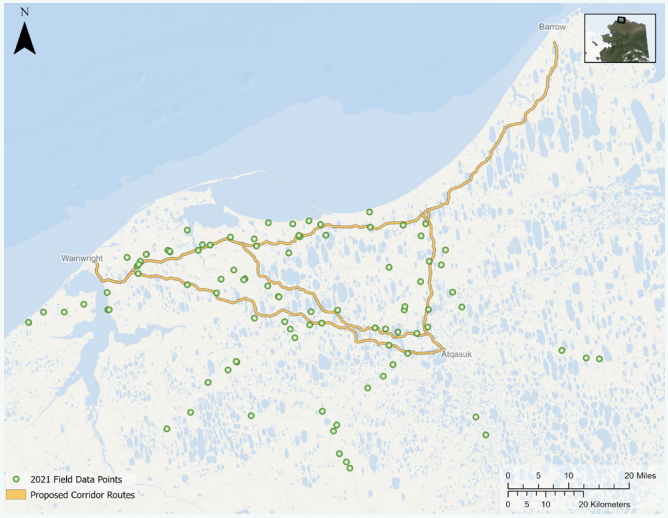
The DGGS Energy Section completed a successful summer field season of geologic mapping on the central North Slope improving our understanding of the distribution of potential reservoir units and hydrocarbon trap geometry. Following the field season, however, loss of federal funding put the North Slope Shallow Coring project at Slope Mountain on hold.

The Coastal Hazards component of ASTAR completed North Slope coastal community shoreline change and erosion exposure assessments (dggs.alaska.gov/pubs/id/30672). Contracts to collect tidal datums, which are critical for any future flood or wave analysis, were completed over the 2021 summer field season at Point Lay and Wainwright. Finally, in collaboration with the North Slope Borough, a pilot program was conducted to utilize UAVs in Wainwright. While on site, DGGS also collected other baseline data (nearshore coastal elevation profiles, beach sediment samples, and bathymetry) and installed community-based erosion monitoring equipment with the Native Village of Wainwright.

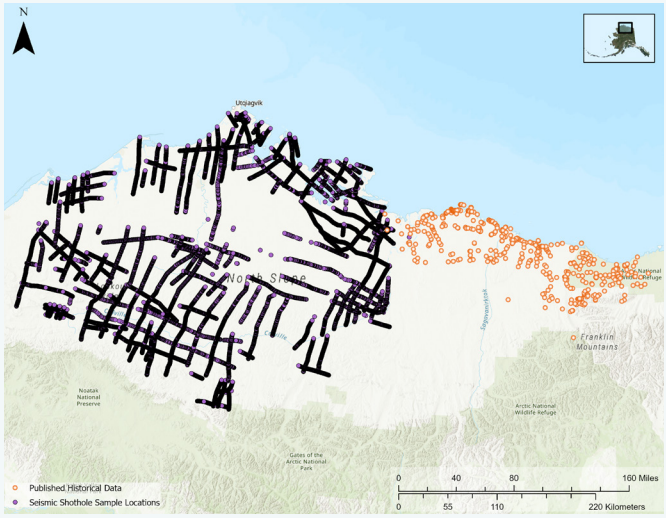
DGGS also made significant progress on its North Slope sand and gravel resource assessment. Project accomplishments included reconnaissance fieldwork between Atqasuk, Wainwright, and Utqiagvik to help validate terrain unit mapping, identify potential material resources along proposed transportation corridors, and gather information to inform more detailed helicopter-supported drilling investigations in 2022 (below left).

We visited over 100 sites to assess subsurface information using a power auger, evaluate outcrops, make surface observations, and collect samples for analysis. Additionally, resource assessment fieldwork by the DGGS hydrology team used a bathymetry drone to scan several lakes, determine depths, and gather information to characterize lake bottom and subsurface materials. Field data are being prepared for publication, to make this information available to the public, and benefit interested stakeholders. Data collected in 2021 will contribute to sand and gravel resource evaluation efforts and plans for infrastructure development.

In 2021, DGGS published historical field data that included site descriptions and geotechnical data from 467 field station locations between the Coleville and Hulahula rivers (doi.org/10.14509/30670; below right). We continue work on terrain unit mapping and developing a classification scheme to provide communities with maps that help identify sand and gravel resource areas. We also continue to populate our database with information about sand and gravel from seismic shothole samples that are archived at the Geologic Materials Center in Anchorage (top). We have now cataloged information from over 21,500 locations and are working toward publishing these data.



Field station locations (100) from the 2021 field season along with proposed corridor routes between Wainwright, Atqasuk, and Barrow.



Field station locations (orange dots) with historical field data information (amino acid, carbon-14, grain size, microfossil, pollen, and thermoluminescence data). Locations (purple dots) of seismic shothole samples, cataloged in the ASTAR shothole database.

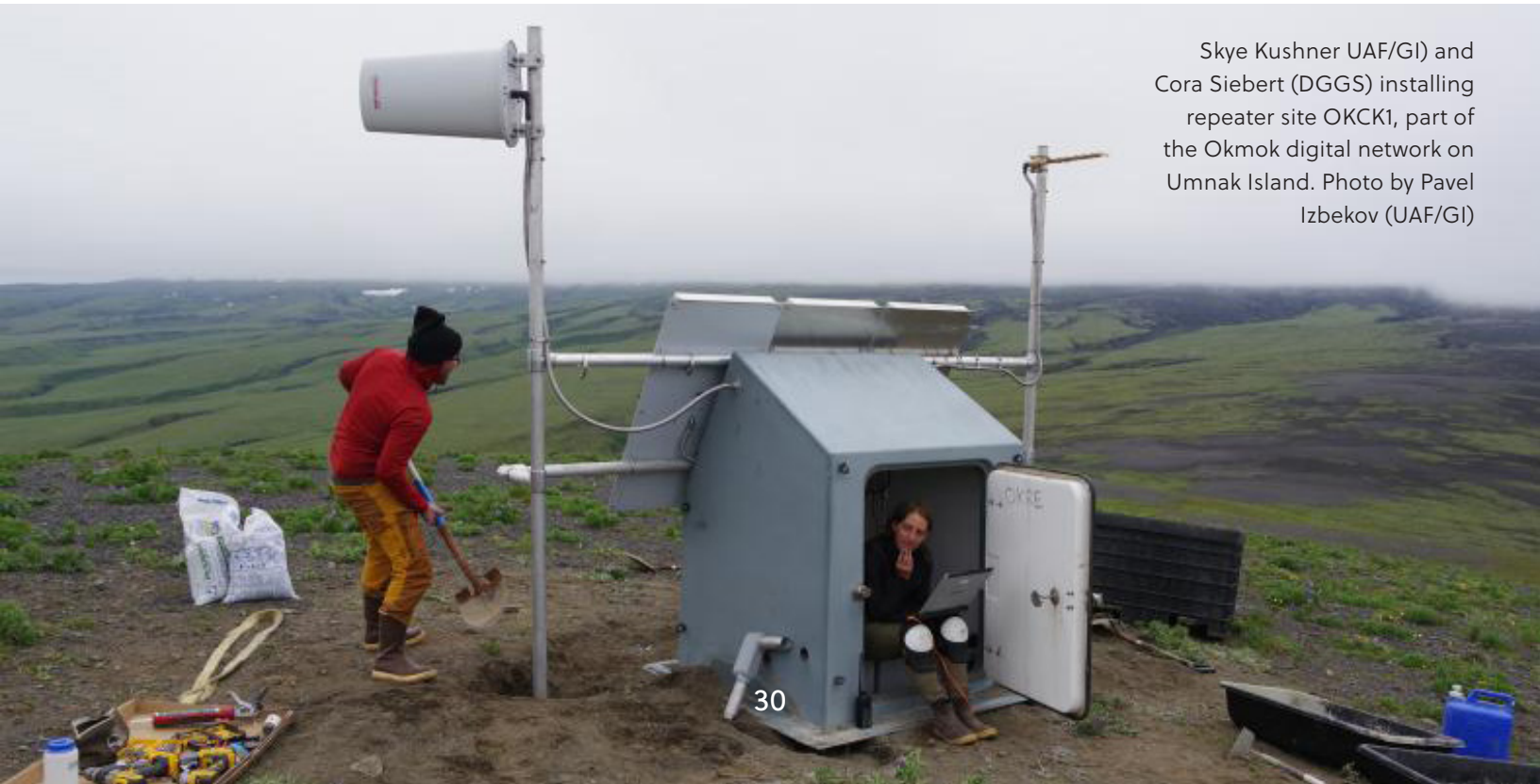
VOLCANOLOGY

The volcanology program of DGGS is part of the Alaska Volcano Observatory (AVO), an interagency consortium that mitigates hazards from Alaska volcanoes. AVO was formed by a Memorandum of Understanding in 1988 with its partners—the U.S. Geological Survey (USGS) and the University of Alaska Fairbanks Geophysical Institute (UAF/GI). The volcanology program is entirely funded by cooperative agreements with the USGS Volcano Hazards Program.

AVO's primary objective is to conduct monitoring and scientific investigations to assess the nature, timing, and likelihood of volcanic activity in Alaska. Knowledge of particular volcanic systems, combined with operational monitoring that includes satellite remote sensing, seismology, infrasound, gas emission, and ground deformation allows AVO to assess volcanic risk and provide timely and accurate information on impending hazardous volcanic activity.

Volcanic hazard information is communicated to local, state, and federal officials through formal interagency operation plans, and to the public via subscriptions to volcano alert messages (volcanoes.usgs.gov/vns/) as well as social media outlets such as Facebook, Twitter, and Instagram, and a public website (www.avo.alaska.edu). In addition, a weekly radio program ("AVO Radio") summarizing volcanic activity in Alaska is currently airing on 10 public radio stations across the state.

The Volcanology Section works with our AVO partners to maintain a robust network of volcano monitoring instrumentation across the Aleutian Arc. Monitoring instruments include seismometers, infrasound arrays, GPS instruments, web cameras, and power systems to support the incoming data and digital telemetry. In 2021, in the far western Aleutians, the Amchitka receive site had an overhaul and an infrasound array was installed. Analog-to-digital instrument upgrades were completed at Semisopochnoi and Little Sitkin volcanoes. In addition to the improved seismic data streams, two webcams were installed at Semisopochnoi, which will give AVO scientists and the public real-time views of ash emissions. Okmok volcano received a new communications infrastructure, and new monitoring sites were installed in addition to the analog-to-digital upgrades at existing sites. Work completed on Unimak Island included seismometer upgrades at



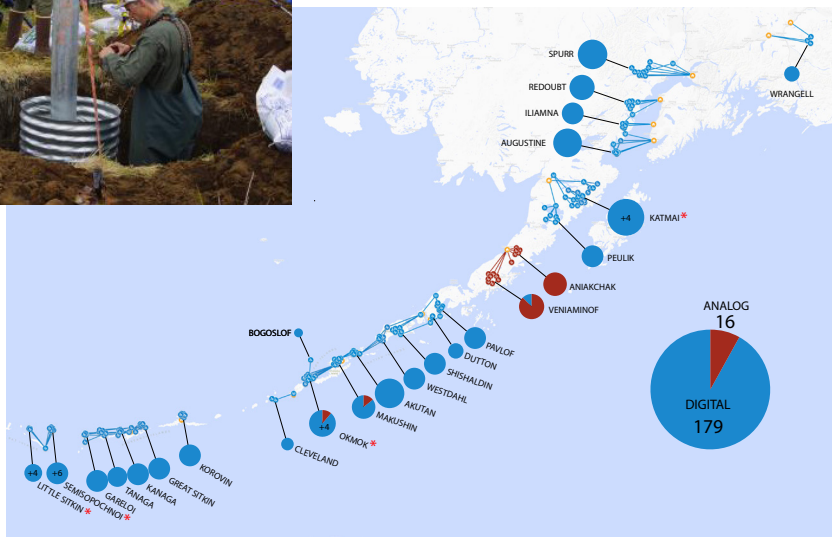
Skye Kushner UAF/GI) and Cora Siebert (DGGS) installing repeater site OKCK1, part of the Okmok digital network on Umnak Island. Photo by Pavel Izbekov (UAF/GI)

Shishaldin volcano and a GPS survey of Fisher Caldera. In the Katmai region, a new major repeater site was installed, and analog-to-digital conversions and antenna repairs were completed at several sites.

Volcanology Section staff maintain the most comprehensive volcano database in the world—the Geologic Database of Information on Volcanoes in Alaska (GeoDIVA). GeoDIVA serves as the back end of the AVO public website where users can find the latest information on volcanic unrest and eruption; search and download geochemical data and publications; search, view, and download thousands of well-captioned images of Alaska volcanoes; and learn about eruptive history and current hazards. In addition to its public-facing side, GeoDIVA has internal modules that store information that AVO scientists use to keep track of monitoring data and fieldwork operations.

Volcanology Section staff geologists are working on a variety of research projects to advance understanding of active volcanic systems. Geologic maps are in production for Okmok and Shishaldin volcanoes and several data releases are in the works. One recent publication summarizes major-element oxide, trace element, and glass compositional analyses from Holocene to historical eruptions from Pavlof Volcano.

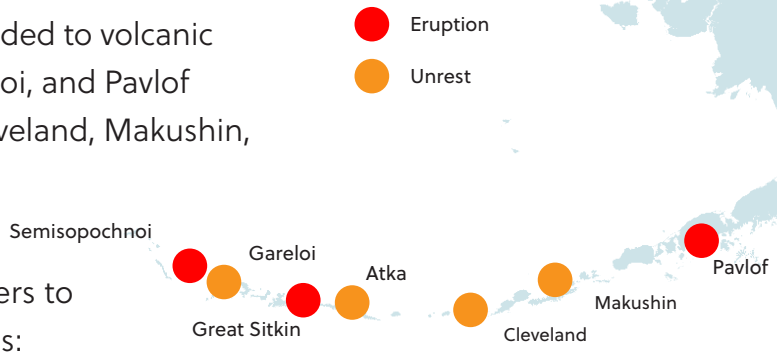
As part of the Alaska Volcano Observatory, DGGS Volcanology staff author annual summaries of volcanic activity. These documents describe notable volcanic activity in Alaska per calendar year and include information on AVO's response. Information about all volcanoes at elevated alert status and events that prompted increased attention from AVO staff are included, even if no formal public notification ensued. Observations, images, and data typically not published elsewhere are also included. AVO's annual summary publications are available at www.avo.alaska.edu/downloads/classresults.php?pregen=annsum.



Left. Installing the VSAT communications site at Fort Glenn on the Eastern flank of Okmok Caldera as part of the 2021 AVO analog-to-digital instrument upgrade campaign. Photo by Pavel Izbekov (UAF/GI). **Top Right.** P. Saunders-Shultz (UAF/GI) and Malcolm Herstand (DGGS) installing wind turbine at Ft. Glenn station, Okmok volcano. Photo by Skye Kushner (UAF/GI) **Bottom Right.** Status of analog to digital volcano monitoring telemetry and instrumentation upgrades at Alaska volcanoes. Figure by Dane Ketner, USGS/AVO.

2021 VOLCANIC ERUPTIONS AND UNREST IN ALASKA

In 2021, DGGS Volcanology staff responded to volcanic eruptions at Great Sitkin, Semisopochnoi, and Pavlof volcanoes, and significant unrest at Cleveland, Makushin, Atka, and Gareloi volcanoes.



During unrest and eruption, DGGS Volcanology staff work with AVO partners to complete the following response duties:

- Issue volcanic eruption alerts in collaboration with USGS and UAF colleagues
- Monitor satellite and seismic data streams 24/7
- Keep detailed records of eruption chronologies, impacts, and response activities
- Conduct outreach to engage citizen scientists
- Maintain current information on public and internal websites, Facebook, Twitter, and Instagram

Read on for more details about these events

Aerial view of Great Sitkin, November 17, 2021, showing lava flow lobes on the volcano's flanks. Photo: Angela McConnell.

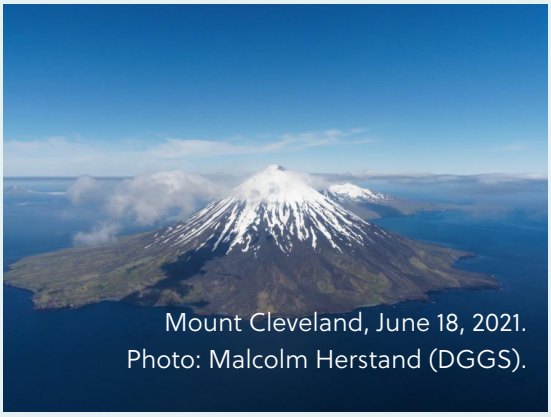
May 25

Great Sitkin explosive eruption began with reports placing the eruption plume as high as 15,000 ft above sea level

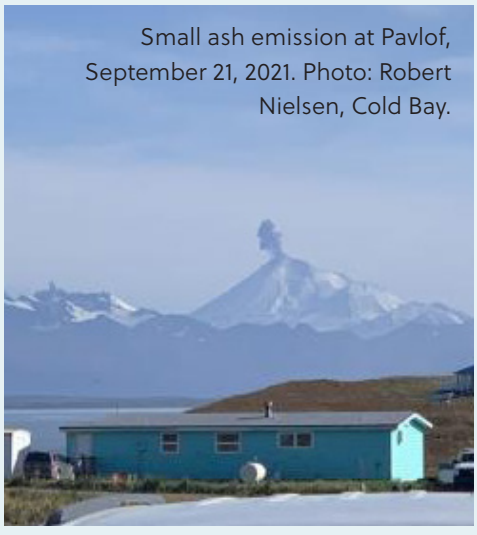
2021 — 2022

March

Increased seismicity, gas emissions, and surface temperature observed at **Cleveland**



Mount Cleveland, June 18, 2021. Photo: Malcolm Herstand (DGGS).



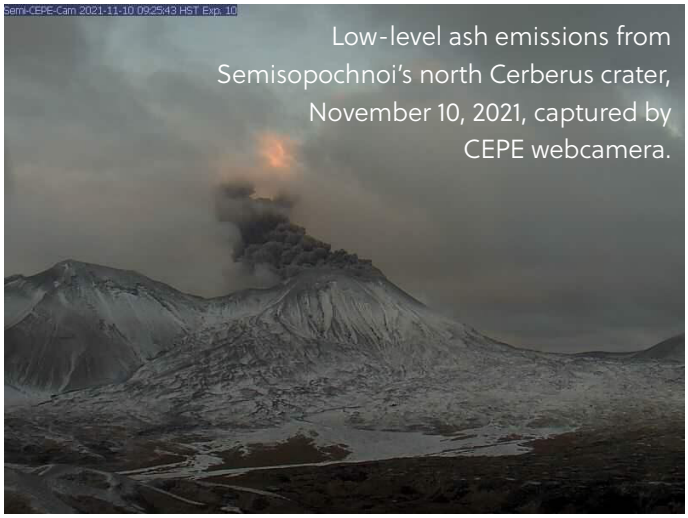
Small ash emission at Pavlof, September 21, 2021. Photo: Robert Nielsen, Cold Bay.

Great Sitkin 2021 eruption

Great Sitkin Volcano occupies most of the northern portion of Great Sitkin Island, approximately 26 miles east of the community of Adak and about 1,167 miles southwest of Anchorage. Great Sitkin has had numerous historical eruptions dating back to the 1700s, and at least three prior eruptions within the 20th century. The Great Sitkin 2021 eruption began in May, with precursory seismicity and elevated surface temperatures noted by AVO. On May 25, 2021, explosive eruption began with initial reports placing the eruption plume as high as 15,000 ft above sea level, followed by no further explosions and declining seismicity. By late July 2021, satellite radar images showed a small lava dome emplaced in the summit caldera of Great Sitkin sometime between July 14 and 22. By the end of July, this dome was ~425 ft in diameter. The lava dome continues to grow—by September 9 it had begun to advance through a small gap in the southern rim of the crater wall. By September 17, the lava dome had also advanced through a small gap in the west rim. As of this writing (late November 2021) it currently fills more than half of the summit crater, with two lobes of lava flowing over low points in the crater rim and extending downslope ~2000 ft to the south and west. Lava has also reached the crater rim on its northern edge. Seismicity remains above background levels.

Semisopochnoi 2021 eruption

Semisopochnoi Island is the largest young volcanic island in the western Aleutians. Although there are several volcanic vents on the island and a 5-mile-diameter caldera, most recent activity originates from the north crater of Mount Cerberus, on the southwestern portion of the island. Semisopochnoi is ~160 miles northwest of Adak and ~1,300 miles southwest of Anchorage. From 2018 through 2020, Semisopochnoi exhibited elevated seismicity, degassing, and anomalous surface temperatures, along with occasional small explosions and minor tephra deposits. In February 2021, high-resolution satellite images showed a small ash deposit extending less than 1,000 ft to the north from north Cerberus crater. AVO detected intermittent small explosions and ash emissions in April and May. Seismicity and small explosions increased again in late July. Throughout August and September numerous explosions were observed and small ash clouds reached 5,000–13,000 ft and drifted 50–185 miles. Many of these ash emissions were also observed in the two new web cameras installed by AVO field crews in June 2021. On September 20, AVO briefly raised the aviation color code and volcano alert level from ORANGE/WATCH to RED/WARNING, based on an increase in the intensity of ash emissions. Satellite images showed an ash cloud reaching 15,000 ft and extending 60 mi to the southeast. By September 20, activity had decreased to discrete explosions about once per hour and AVO lowered the alert status for Semisopochnoi to ORANGE/WATCH. As of late November, the eruption at Semisopochnoi continues with small explosions producing low-level ash clouds, often multiple times per day. Most ash emissions rise to less than 10,000 ft asl and dissipate within 30 miles of the volcano, and some may result in minor ash deposits within the vicinity of the active north crater.



Low-level ash emissions from Semisopochnoi's north Cerberus crater, November 10, 2021, captured by CEPE webcamera.

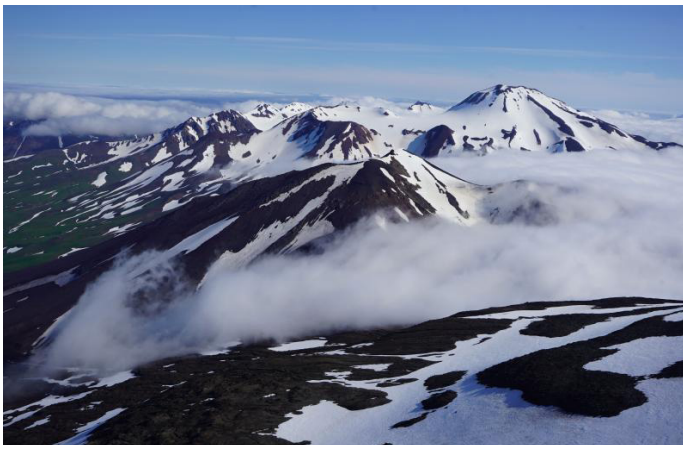
Pavlof 2021 eruption

Pavlof Volcano is one of the most frequently active volcanoes in Alaska, with more than 38 historical eruptions. It is a snow-covered stratocone on the Alaska Peninsula, about 23 miles northeast of King Cove and 590 miles southwest of Anchorage. In late September 2020, AVO noted an increase in seismicity, however, by October, the seismicity declined and no eruption occurred. Seismicity again increased in July 2021. Low-level ash emissions were observed in web camera views beginning on August 5, 2021. Intermittent bursts of ash produced diffuse ash clouds rising just above Pavlof's summit, dissipating within 6 miles. Intermittent, small, short-lived explosions detected in seismic and infrasound data and low-level ash plumes seen in web camera images continued

through August, September, and October 2021. Ash deposits have been confined to the flanks of the volcano. On November 8, 2021, a small lava flow was observed in satellite images. On November 10, a 1.2-mile-long lahar that extended below the southeast crater was also visible in satellite images. By November 11, the lava flow extended 650 feet below the active vent.

Cleveland 2020–2021 unrest

During the second half of 2020, Mount Cleveland entered a pause in eruptive activity, and no further explosions detected since June 2, 2020. Increased seismicity, gas emissions, and elevated surface temperatures observed in March 2021 subsided over the following months. AVO downgraded the Aviation Color Code and Volcano Alert Level at Cleveland to UNASSIGNED on October 20, 2021. Cleveland volcano is monitored with a limited real-time seismic network: This smaller network inhibits AVO's ability to detect precursory unrest that may lead to an explosive eruption, and consequently Cleveland was designated "UNASSIGNED" instead of the color code GREEN, which is assigned to quiescent volcanoes that have more ground-based instrumentation. Rapid detection of an ash-producing eruption may be possible using a combination of seismic, infrasound, lightning, and satellite data.



Atka 2021 unrest

Significant SO_2 emissions and seismicity increased at Korovin Volcano on Atka Island in late October 2020 followed by a decline in unrest. Additional seismicity was detected at the Atka Volcanic Complex in early August 2021. These earthquakes were shallow and located southwest of Korovin Volcano. Earthquake activity declined by late August, and AVO returned Atka Volcanic Complex to GREEN/NORMAL on August 27, 2021.

Gareloi 2020–2021 unrest

Increased seismicity was observed in mid-May 2021, which then declined, and reached background levels by the end of July.

Top. Atka Volcanic Complex, July 25, 2019. Photo: Taryn Lopez, UAF/GI.
Bottom. Aerial view of Gareloi's summit, May 23, 2021. Photo: Dane Ketner, USGS.

GEOLOGIC INFORMATION CENTER

The Geologic Information Center (GIC) provides the publication, geographic information system (GIS), and information technology support services that provide access to geologic information about Alaska's vast resources. The GIC's ability to publish, host, and distribute large volumes of data helps maintain collaborations with federal and other state organizations while minimizing duplication of effort and cost. This wide range of services helps better inform land management decisions and encourage investment, exploration, and development of the state's resources, resulting in billions of dollars of impact to Alaska's economy.

The quality of DGGS' Alaska geological database, the quality and scale of maps, and the ease of access were rated number one in the nation by the Fraser Institute's 2020 Annual Survey of Mining Companies!

GIC AT WORK

Publication Support Staff

(Sue Seitz, Simone Montayne, and Kristen Janssen)

Always working hard at a diverse set of core tasks to ensure that:

- Our publication database is up to date
- Our website provides easy access to DGGS' vast array of geologic information
- All published data include robust metadata
- Field and safety equipment is properly maintained and distributed to field crews
- The Publications Workflow and approval process is efficient and timely
- DGGS' public outreach efforts are managed effectively
- Illustration support is provided for publications.

IT Staff

(Christopher Ramey, Oralee Nudson, and Tom Cerny)

Build, manage, and maintain the critical IT infrastructure required by everyone at DGGS. Some of their core tasks include:

- Maintaining fast and reliable network capability
- Server design, operation, maintenance, and monitoring
- Database development and maintenance
- Software development, maintenance, and support
- Backup and disaster recovery planning
- New hardware and software support and documentation
- Desktop computer and printer support
- Coordinating with State of Alaska Office of Information Technology.

GIS Staff

(Mike Hendricks, Andrew Herbst, and Pedro Rivera)

We farewell to Trish Ekberg this year and welcomed Amy Macpherson as our new cartographer and geoportal administrator. The GIS group provides a number of core tasks:

- GIS and cartographic technical support and information dissemination
- GIS training and support that includes weekly GIS Tips and Tricks classes for DGGS staff
- GIS administration of DGGS' geoportals
- Geoportal web app development
- Technical support for AK GeMS single map and multi-map development and production
- Quality control/quality assurance for AK GeMS production
- Management of the Alaska elevation and imagery data storage and distribution
- Lidar/photogrammetry acquisition and processing support.

Through all their hard work and expertise, the entire staff of the Geologic Information Center plays an integral role in DGGS—providing access to valuable geologic information that highlights Alaska resources and hazards. Below you can find additional details about this past year's GIC projects.

A LOOK INSIDE PUBLICATIONS AT DGGS

The GIC oversees the publication and distribution of the division's numerous maps, reports, and data releases. Publications include everything from handouts on the dangers of radon to technical reports on coastal erosion to geologic maps. At any given time there are dozens of publications in the works; each requiring different review and editorial processes depending on the report series they will be published under. Numerous hours of review, layout, GIS work, editing, and metadata writing go into each—and that doesn't count the time the authors spend conducting fieldwork, preparing and analyzing data, and writing the reports! GIC staff is continually looking for ways to improve the efficiency of our publication process to ensure data releases are timely while maintaining rigorous scientific standards. Some of our recent improvements include drafting templates for authors to use for frequently published data release types, writing scripts to easily harvest metadata, and hosting teaching sessions on Illustrator and cartography so authors can confidently create their own figures and maps.

4,281
twitter followers

1,566
facebook followers

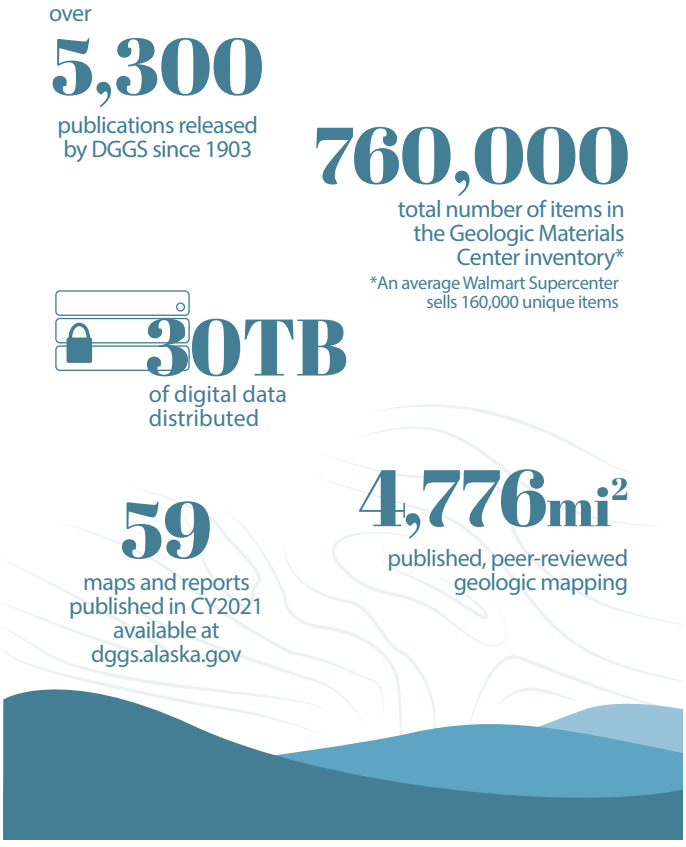
530
news feed subscribers

FIELD COMMUNICATION AND SAFETY

Fieldwork is the heart of geoscience research. GIC personnel support our scientists with training and equipment needed to operate safely in the field and respond to emergencies. Essential safety and communication equipment include helicopter helmets, radios and repeaters, satellite phones, GPS trackers, and emergency first aid bivouac kits to equip roughly 40 staff and up to five distinct projects engaged in simultaneous fieldwork. In addition to providing equipment support for this year's fieldwork, GIC leads an annual collaborative review of DGGS' Field Operation Safety Manual and field safety outcomes.

PROVIDING EASIER ACCESS TO FIELD SAMPLE INFORMATION

GIC personnel continue their hard work on the "where's my sample?" project, which has dramatically increased availability of this critical geologic data. Each field season, DGGS field crews collect hundreds of samples, along with copious descriptions of sample sites. After addressing longstanding challenges to sample metadata discoverability and using workflows developed in conjunction with previous years' federally funded data preservation projects, we now have a centralized sample-record management system. We have also improved programming to facilitate data compilation, quality control, and information retrieval. These samples, and their accompanying metadata, as well field stations, are now available as an online GIS feature service on our geoportal (geoportal.dggs.dnr.alaska.gov) and are available to the public through the GMC inventory catalog (maps.dggs.alaska.gov/gmc).



THE ALASKA GEOLOGIC MAPPING SCHEMA (AK GEMS)

After years of development, we published two critical standards documents used by DGGS and referenced by numerous other agencies: "AK GeMS Symbology: A description of the AK GeMS Style File" and "AK GeMS Data Dictionary: A description of the AK GeMS database schema." Our AK GeMS standard extends the USGS' GeMS basic standard by placing greater focus on modeling geologic features, and adding advanced capabilities. AK GeMS supports our single map production processes while also allowing for multiple maps in a modern enterprise database. With the AK GeMS standard in place, the division is now positioned to more efficiently create, store, and distribute meaningful geologic data to the public for visualization and analysis.

This year we developed and implemented a comprehensive AK GeMS Production Workflow and Task List that provides a graphical flow chart of production phases, and an associated detailed task and responsibilities list. Using this workflow GIC staff performed data quality control checks, created metadata, and packaged and distributed data to facilitate the nation's first Earth MRI submission of a GeMS-compliant database to the USGS. In addition, we published over twenty geologic map databases in our new modern format this year: dggs.alaska.gov/pubs/keyword/gems.

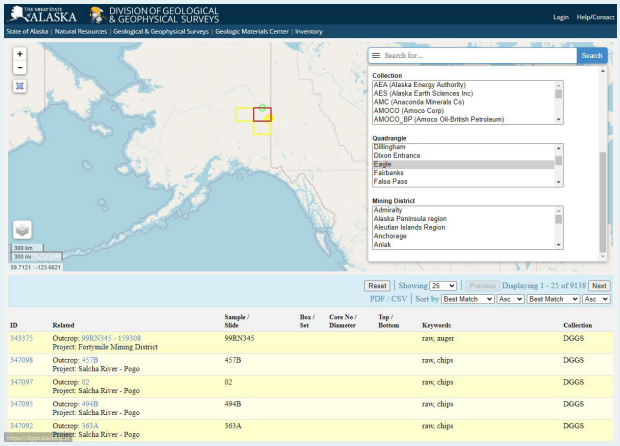
GIC staff developed and implemented a comprehensive semi-automated quality control process. We received training with an ESRI GIS expert and worked with DGGS geologists to develop and implement QC check rules with the Data Reviewer Extension as well as to integrate the use of GeMS validation scripts provided by the USGS.

GIC staff, specifically Pedro Rivera, worked on our multi-map geodatabase and development of multi-map services and web apps. We have developed scripts that automate the loading of single-map AK GeMS databases into our multi-map database schema, and have added more than 20 map databases into our multi-map PostgreSQL database. We have also begun working on symbolizing and creating web services of this data as well as developing a web app for public viewing.

Where's my Sample?

Did you know the thousands of samples and field stations from years DGGS of fieldwork are available in a centralized system accessible through our Geportal and the GMC inventory catalog? Compiling this resource has dramatically improved and increased availability and access to sample location information.

maps.dggs.alaska.gov/gmc



geoportal.dggs.dnr.alaska.gov

THE DGGS GEOPORTALS – EASY ACCESS TO DATA AND APPS

Over the years GIC personnel have built and now maintain a suite of geoportals to host and share hundreds of geologic, elevation, and imagery datasets, and interactive web apps for both the public and Alaska decision-makers. These geoportals allow users to share, discover, and access geologic data, maps, and interactive applications, and are part of the State of Alaska Spatial Data Infrastructure managed by the Alaska Geospatial Office.

DGGS Geoportal

The GIC staff has worked hard increasing the quality and quantity of data and web apps on the division's geoportal (geoportal.dggs.dnr.alaska.gov). We're excited that Amy Macpherson, our new GIS Analyst, has assumed as the role of geoportal primary administrator and has already made numerous improvements as well as enhancing integration with Alaska DNR's ArcGIS Online Portal and the newly updated State of Alaska Hub site (gis.data.alaska.gov). GIS and IT staff upgraded the geoportal's software and simplified our login process. We are ending the year by initiating a GIS Architecture review with ESRI technical experts that will improve our geoportals in the future. Spotlighted new content available to the public include:

Geologic Map Index Web App: The Map Index Web App is an online web application designed to explore DGGS' geologic map holdings. This online exploration tool provides the boundaries of most DGGS and USGS geologic maps of Alaska in a single, interactive web application.

Exploration Geochemistry Web App: The Exploration Geochemistry web app presents a visualization of the elements of economic interest for Alaska stream sediment samples.

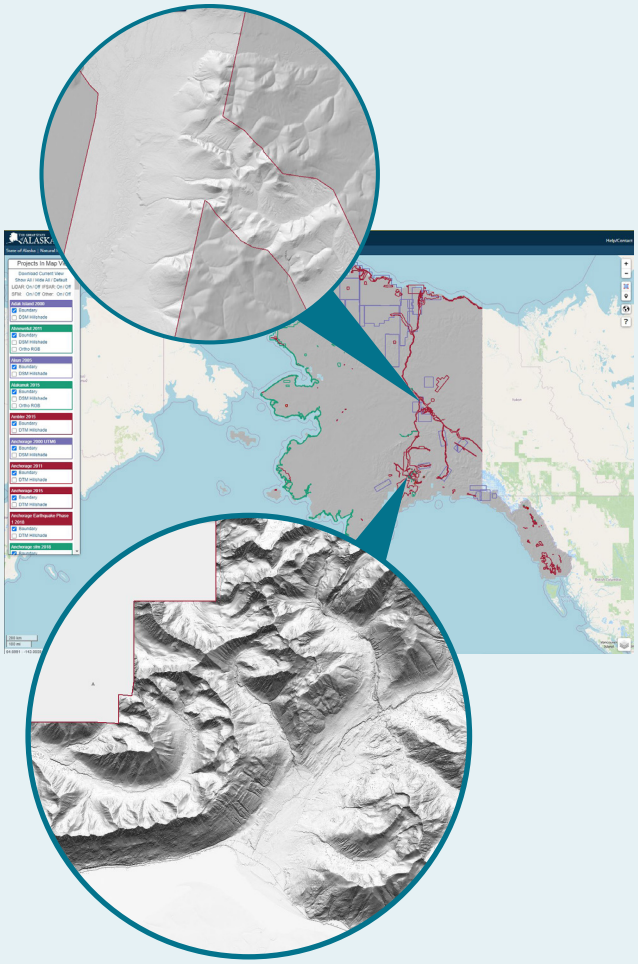
DGGS Field Geoportals

The GIC's IT and GIS staff worked to provide DGGS's geologists upgraded capability for long-term multi-user field GIS data collection in areas that have no internet access. We developed a set of rugged mobile field geoportals, which run an installation of ArcGIS Enterprise on a lightweight mobile server that can be disconnected and transported to remote field camps. These field portals allow geologists to use mobile data collection apps such as ESRI's Collector or Field Maps and upload, share, review, and backup their daily work while operating in remote locations anywhere in Alaska. These rugged mobile field geoportals also provide DGGS the ability to respond to hazard events and still collect, combine, and analyze data even if internet connectively is not available.

DGGS Geologist Trent Hubbard uses a mobile tablet to collect data and record observations in the field.

Alaska Elevation Portal

The GIC works in partnership with the Alaska Geospatial Office to consolidate public domain elevation data for the state. Roughly 12 TBs of point cloud, elevation model, and ortho-rectified imagery data are downloadable from our web app at elevation.alaska.gov—a 6.4 percent increase from last year. An additional 8 TBs of data can be accessed across 237 image services on our geoportal; 33 of which were added this year. To view the status of elevation data in production see the Alaska Elevation Production Status Dashboard on the geoportal.



elevation.alaska.gov

Alaska Imagery Portal

GIC staff successfully worked in coordination with the Alaska Geospatial Office to establish an Alaska Imagery Portal that, among other capabilities, allowed us to transition the multi-terabyte statewide imagery from a contracted solution to a state-hosted and managed solution. The supporting storage array is composed of more than 600 networked drives split across 20 computing nodes with a total storage capacity of approximately 10 petabytes (1 petabyte = 1,000 terabytes). Initially, we intended to host the hardware and software for the Alaska Imagery Portal within the DGGS Fairbanks Server Facility. Rigorous testing, however, determined that the facility's cooling capability was inadequate for this increased cooling requirement. After extensive testing, we determined that the most cost-effective solution to this problem was to leverage our strong relationship with UAF and host the Imagery Portal's hardware and software in UAF's Butrovich Computing Facility.

gis.data.alaska.gov

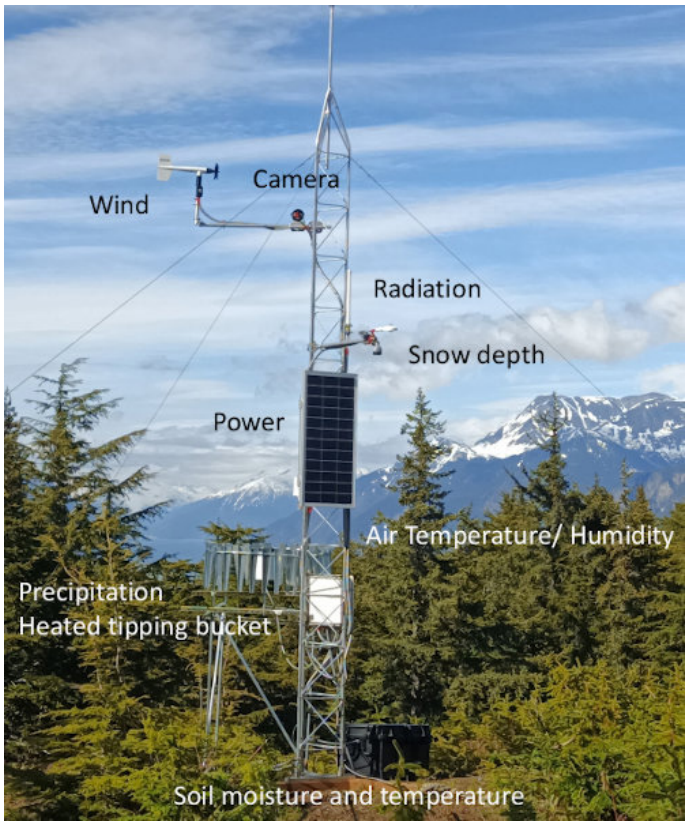
FAIRBANKS IT SUPPORT AND UPGRADES

The GIC's IT staff continues to provide support in this era of teleworking and its many challenges. They employ a support ticketing system that has handled over 500 hundred "trouble tickets" each year. The IT support staff quickly and professionally responds to these often-complex issues and ensures that the division's staff always have efficient and working computing resources available to them.

In addition to standing up the Imagery Geoportal, this year the IT staff completed numerous upgrades to the IT infrastructure in Fairbanks. They upgraded the efficiency of our server room's power circuits and refreshed our existing air conditioner units. They retired multiple ancient servers and installed two new server racks secured with anchoring bolts to meet earthquake safety standards. They also are migrating our virtualized servers to newer operating systems and planning the replacement of our server room's uninterrupted power supply; which soon will reach its end-of-life.

In addition, they upgraded the building's wireless and wired networks to significantly increase their speed. A centralized computer inventory management tool was deployed in both Anchorage and Fairbanks. They also deployed a local Windows Server Update Services (WSUS) Server to greatly reduce avoidable network congestion caused by individual Windows computers updating independently. The IT staff can now plan, test, and push out Windows updates on a controlled schedule.

Christopher Ramey worked with the Engineering Geology section to bring the Mount Riley weather station online, and rewrote the Alaska Geologic Data Index (AGDI) web app with an improved data model and more modern technologies.

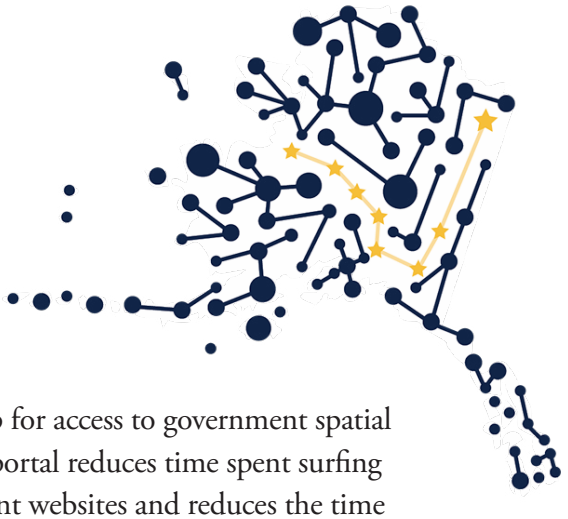


The Mount Riley weather station is located approximately 1.8 mi SE of Haines, AK, near the top of Mount Riley. Data from multiple weather stations across the state are viewable at dggs.alaska.gov/weatherstations.

GMC IT SUPPORT AND UPGRADES

Due to an increased volume of Anchorage-based projects, and the frequency with which we work with very large datasets, GIC staff completed significant upgrades to the Geologic Material Center's computing infrastructure. They completed hard-wired and wireless network upgrades that improved bandwidth up to 10 times the previous speed. They also replaced the GMC's aging backup server with one that provides four times the storage capacity. In addition, Christopher Ramey worked with GMC intern Tommy Folan to completely rewrite the GMC's handheld inventory management software.

ALASKA GEOSPATIAL OFFICE



THE ALASKA GEOSPATIAL OFFICE

In February of 2021 the State of Alaska Geospatial Information Officer (GIO) spearheaded the formal creation of the Alaska Geospatial Office (AGO). This office provides strategic oversight of the state's geospatial technology portfolio. AGO works to advance the use of geospatial technologies as a tool for better decision-making in Alaska. We accomplish this by coordinating statewide geospatial initiatives through the Alaska Geospatial Council resulting in cost-effective ways to create, access, and apply geospatial data and technology. Our goal is to ensure that current, reliable, high-quality geospatial data are available and are easily accessible to decision-makers.

AGO is tasked with coordinating, managing, and maintaining the following:

- Development of a modern and robust Spatial Data Infrastructure (SDI) for Alaska
- Facilitating inter-agency data sharing activities through the State of Alaska Open Data Geoportal (gis.data.alaska.gov)
- Providing enterprise-level coordination and services to state agencies
- Promoting and supporting Alaska's Imagery and Elevation Programs
- Administering and directing the Alaska Geospatial Council.

Overall, AGO strives to support existing and future efforts to improve the quality of geospatial data in Alaska through coordination and collaboration with the larger GIS community.

THE STATE OF ALASKA OPEN DATA GEOPORTAL

The state's Open Data Geoportal continues to provide access to location-based data, maps, and applications, which makes the state's vast collection of spatial data easier for the public to locate and use. As a one-stop shop for access to government spatial information, this portal reduces time spent surfing through department websites and reduces the time agencies spend responding to data requests. AGO continues to coordinate with data managers across the state to develop consistent standards and workflows; and to improve data quality, access, and management skills, thereby ensuring long-term viability of the state's geospatial data assets.

ALASKA GEOSPATIAL OFFICE IMAGERY PROGRAM

Imagery is widely used throughout every level of government in Alaska to support efforts such as economic development, infrastructure management, transportation planning, public works, public safety, and emergency management. AGO is now hosting access points to the new statewide high resolution (50 cm) satellite imagery. The new Imagery Portal (see highlight page) provides access to the most current statewide imagery and is the foundation for building a modern and robust imagery program for Alaska.

Acquisition and use of digital imagery are on the rise in all aspects of land and resource management. Government agencies are incorporating these data into daily workflows and realizing the full potential of this technology. This past year AGO coordinated across state agencies to conduct a pilot program with Planet Labs Inc. that provided access to daily satellite imagery across Alaska and enabled state employees to "task" a satellite to acquire high-resolution imagery over any area of interest. By putting this technology in the hands of state employees we explored solutions for workflows that have historically been challenged by Alaska's geography and remote landscapes. Notably, 82 percent of Alaskan communities are inaccessible by roads, and it is time consuming and costly to get

boots on the ground for evaluations. In previous years DNR employees would take small aircraft to monitor approximately 50 weather stations across 90 million acres of land to determine when a station became snow-free to support wildfire monitoring. With use of this technology and without leaving the office, in 2.5 hours DNR staff was able to use daily satellite imagery to determine the exact day a station became snow-free, saving substantial time and costs and significantly reducing remote travel risks to personnel. By decreasing the number of aircraft trips needed to monitor these remote regions, use of this technology also significantly reduces the risk to personnel.

Use of this technology also supported inspections of mining operations. With daily access to remote imagery, managers tracked mining activity on a frequent basis and used the data to plan inspections and support regulatory enforcement. DNR also utilized this information to provide environmental situational awareness for wildfires, reveal final fire perimeters, and to determine enforcement policies prior to on-site evaluations. Coordinated and led by AGO, procuring this contract under a multi-department license ensures these imagery data are shared through the state's Imagery Portal and can be used by various agencies. For example, the satellite imagery collected for mining inspection analysis and funded by the Department of Mining Land and Water is also open and accessible to all other state agencies. By sharing these data across agencies, there is increased project transparency to support economic development and substantial cost savings to the state.

ALASKA GEOSPATIAL COUNCIL COORDINATION

Alaska benefits from an engaged, enthusiastic, and cooperative geospatial community working in all parts of the state. The Alaska Geospatial Council (AGC) coordinates across federal, state, and local government agencies as well as academic, tribal, native corporation, and private-stakeholder groups to improve geospatial information availability and use. In January 2022 AGC released a new Charter, with new branding and websites to support its mission (see highlights page and visit agc.dnr.alaska.gov to learn more).

This year, the Alaska Geospatial Council added the Coastal & Ocean Technical Working Group (AGC C&O) to support ongoing efforts to map the coastline, nearshore, and Exclusive Economic Zone (EEZ) of Alaska. AGC C&O will support NOAA and the Alaska Mapping Executive Committee (AMEC) in implementing the 2020 Alaska Coastal Mapping Strategy and 2021 Implementation Plan through in-state coordination of partners, sharing of data, and outreach. AGC C&O helped facilitate the 2021 Alaska Coastal Mapping Summit with over 250 registrants, and is bringing together local stakeholders to support all coastal and ocean mapping initiatives in Alaska (visit agc.dnr.alaska.gov). Major progress in 2021 includes the collection of topobathymetric lidar at 29 coastal communities, 98,000 miles of bathymetry, 10,000 square miles of high-resolution coastal imagery, and many pilot projects using equipment or technologies new to Alaska.

IN 2021 AGO COLLECTED...

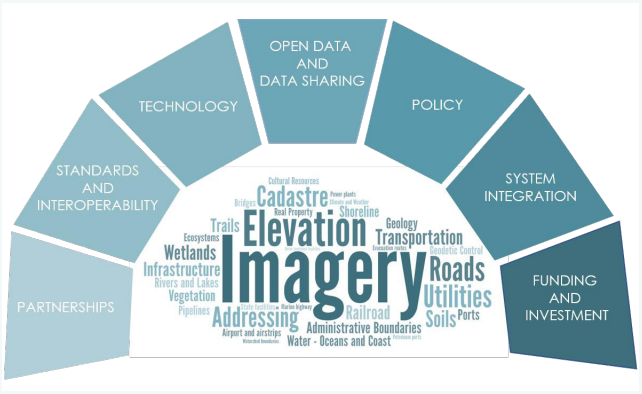
lidar at
29 communities

98,000 miles
bathymetry

10,000 square miles
high-res coastal imagery

Usibelli coal mine located in Lignite, Alaska © 2021, Planet Labs Inc. All Rights Reserved.

Alaska Geospatial Office: Modernizing Alaska's Spatial Data Infrastructure



Geospatial data is at the core of all government functions

High-quality geospatial data enable informed planning, public policy, and decision-making, which function together to improve the overall safety and economic prosperity of the State of Alaska and its citizens.

Remarkably, Alaska does not have current and modern location-based data needed to adequately support decision-making. The Alaska Geospatial Office (AGO) is developing a strategic plan for Alaska to acquire data, and to modernize maps and Alaska's Spatial Data Infrastructure. The seven strategic goals shown on the left are the foundation for this work.

Alaska's New Imagery Portal

Alaska's new Imagery Portal is the second component of the State's growing Remote Sensing Program, which supports management and deliver of Alaska's Elevation and Imagery data assets. The goal of both programs is to streamline and improve the quality, acquisition, distribution, and use of valuable resources such as satellite and aerial imagery, IfSAR, lidar, training and education, technical support, and a shared statewide infrastructure to support the business needs of government to deliver services to the citizens of Alaska.

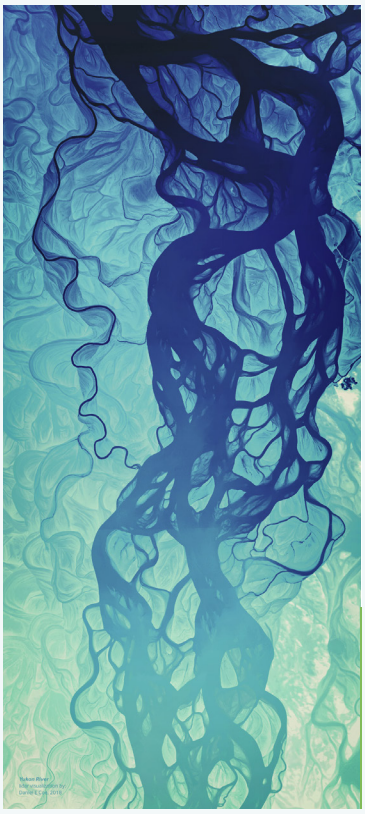
SPOT-5 Statewide Imagery | New AHRI Statewide Imagery

Comparison of 2013 SPOT-5 imagery and the state's improved 2020 AHRI imagery.

This year, in partnership with the GIC, the AGO launched the Alaska Imagery Portal with an initial 14 TBs of data available as map services. With a system designed to store and serve up to 10 PBs of data (1 PB = 1000 TBs), we have already supported over 600,000 client requests since launch in August 2021. Our portal debuted the two statewide imagery layers currently available for the state: the SPOT-5 (completed in 2013) 2.5-meter and the newer Alaska High Resolution Imagery (AHRI) 0.5-meter ortho-mosaics (completed in 2020).

The imagery is accessible as image map services through the State Open Data Geoportal (gis.data.alaska.gov). In 2022, we will embark on the next stage of this project, consolidating inter-agency, project-level data into a single access point. This massive coordination effort will be supported by the Alaska Geospatial Council Imagery Working Group.

Alaska Geospatial Office



The mission of the Alaska Geospatial Office is to coordinate, promote, and enhance the development and use of spatial information to enable all levels of government throughout the state to make better informed decisions.

The Alaska Geospatial Office improves statewide access to the most current geospatial data and facilitates cross-jurisdictional coordination, thereby decreasing data acquisition and creation costs through the realization of economies of scale. Our coordinated approach to data development also maximizes governmental efficiency through the standardization of data, which enables multi-jurisdictional interoperability—helping cities, boroughs, and regions work with each other and with state and federal agencies—to better drive economic development and responses to natural disasters, for example. In doing so, the AGC plays a key role in promoting the safety and economic vibrancy of all Alaska communities, while furthering the current administration's goal of creating transparency and leveraging technology to best utilize state resources.

1	2	3	4
Provide statewide coordination for geospatial community	Improve access to geospatial data and technologies	Advise geospatial data governance, standards, and policy	Communicate geospatial priorities for Alaska

The purpose of the Alaska Geospatial Council is to promote a greater understanding of the benefits and use of location-based data and technologies, and to facilitate stakeholder cooperation throughout Alaska by supporting the collection, acquisition, sharing, and dissemination of geospatial data, standards, and policies.

Guiding Principles for the Alaska Geospatial Council:

1. Promote effective investments in geospatial information
2. Promote geospatial information as a shared public resource
3. Support the establishment and use of geospatial standards and best practices
4. Champion collaboration across the geospatial community
5. Educate and inform policymakers about the value and use of geospatial technology
6. Provide a forum for policy development
7. Encourage all stakeholders to contribute to building a sustainable spatial data infrastructure for Alaska

Alaska Geospatial Council

Coordinating across agencies to provide public access to geospatial data and maps critical to decision making

Supporting economic development and the public safety and well-being of Alaskans

Visit agc.dnr.alaska.gov

ALASKA GEOLOGIC MATERIALS CENTER

The Alaska Geologic Materials Center (GMC), operated by DGGS, archives 75 years' worth of geologic data consisting of energy, mineral, and geologic collections with an estimated replacement value exceeding $35 billion. The facility provides a wide range of users (industry, government, academia, and public) access to samples for identifying new resource prospects and increasing our geologic knowledge of the state.

The new Anchorage repository opened on July 1, 2015 and has completed its sixth fiscal year. Fee collection began in fall 2018. There were 500 visits to the facility in CY2021. While this is about one-third of pre-pandemic client traffic, it marks a 20 percent increase from last year.

The GMC's database-driven search engine allows users to quickly and easily view real-time details of nearly 760,000 public sample items in the inventory before visiting the facility. This innovative and complex database and online search engine was developed in-house by DGGS staff and continues to serve user needs (there were 11,590 requests in 2021 to GMC web pages).

An overarching objective of the GMC is to physically and digitally curate the collection and expand global access to these materials to stimulate the exploration and development of Alaska's resources. Recent developments with automated nondestructive scanning equipment can allow visualization and distribution of these digital datasets to the global geologic community. Digitalization of GMC rock samples extends the reach of Alaska geologic datasets to the diversity of expertise and interests of worldwide explorationists and researchers. Local access to scanning equipment will also incentivize Alaska exploration companies to share their drillcore samples with the state geological survey, thereby benefiting both the company with more detailed datasets in the short-term and resource industries as a whole in the long-term. Online access to a new generation of multi-spectral geologic datasets will support applied industry, government, and university research to increase the understanding of Alaska's rich and complex geologic history.

2021 saw a major stride forward regarding the funding for this non-destructive scanning project with

...BY THE NUMBERS

500 visitors

90,000 square foot repository

760,000 public sample items in inventory

$1,290,000 in Capitol Improvement Project (CIP) funds approved by the legislature. These state CIP funds can serve as one-to-one match for federal funds made available by the Federal Infrastructure Investment and Jobs Act (H.R.3684), potentially doubling funds for the scanning project.

Geologists from independent and major energy companies continue to visit the GMC to sample and examine hundreds of feet of drill core and cuttings. As production declines within the mature Prudhoe Bay oil field, it is essential to diversify the oil industry in Alaska. The GMC hosted visits by major and independent oil companies, mineral companies, and government researchers operating in the North Slope, Cook Inlet, and state-wide regions. These agencies include Oil Search Alaska, Hilcorp Alaska, ConocoPhillips Alaska, 88 Energy, Geolog Americas, GreatBear Pantheon, Kinross Gold, Metallogeny, Millrock Resources, South32, Ucore, University of Massachusetts Amherst, University of Alaska, Western Colorado University, and the U.S. Geological Survey. Strong interest in the North Slope Nanushuk play continued. Mining industry visits increased for the second consecutive year.

What happens to samples collected during fieldwork?

1

Samples Collected in the Field

Geologists collect samples using various techniques during fieldtrips.

2

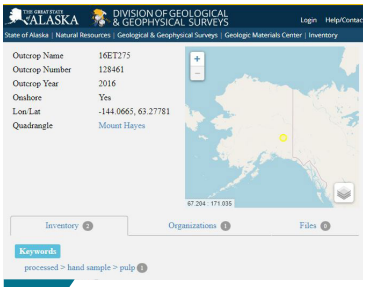
Data Analyzed + Published

Once back from the field, samples are prepared and sent out for analysis and the results are published.

3

Samples Archived at GMC

Following publication, samples are sent to the GMC in Anchorage where they are archived and added to their catalog.



GMC Inventory Search

maps.dggs.alaska.gov/gmc

WELCOME!

ALEC WILDLAND

Alec Wildland joined DGGS as a student intern geologist with the Mineral Resources section in the spring of 2019 to aid new mapping in the Yukon-Tanana Uplands. Alec has a B.S. degree in geology from the University of Oregon and is currently pursuing his M.S. degree at the University of Alaska Fairbanks focusing on metamorphic petrology, structure, and monazite geochronology. In Alec's current position with DGGS, he assists in developing a multi-map, multi-user database model based on the single-map Geologic Map Schema (GeMS). Specifically, he ingests legacy map data and creates geologic map databases that conform to the Alaska GeMS to be used in the multi-map.

Alec grew up in Soldotna, AK in the shadow of Mount Redoubt and has spent the last five years conducting field work in remote areas. He has always had a passion for earth science, hiking, and skiing and is happy to have settled down in Fairbanks with his partner and 2-year-old son. Alec hopes for many more amazing field seasons with DGGS helping complete EarthMRI and state-funded research and mapping projects.

AMY MACPHERSON

Amy Macpherson is a Certified GIS Professional who joined DGGS as a GIS Analyst II in March of 2021. She has a Master of Science in Geography with a focus on GIS and remote sensing from Murray State University. Amy has years of experience in hazard mapping and mitigation, big database creation and maintenance, and advanced cartographic techniques. She most recently worked as a GIS Specialist at the Earth Observatory of Singapore aiding hazard researchers in their mapping and surveying of remote SE Asia field sites, and as a GIS Analyst with the Alaska Earthquake Center at the University of Alaska Fairbanks aiding researchers in gathering elevation data in the field, creating integrated bathymetric/topographic digital elevation models, and running tsunami evacuation studies for remote coastal Alaskan communities. She now assists researchers at DGGS with GIS software and techniques, generating geologic map databases conforming to the Alaska GeMS schema, and acts as the DGGS Enterprise Geoportal manager ensuring data are delivered to the public and coordinating agencies in an organized and efficient manner. Amy enjoys all that Alaska has to offer and can often be found on a bike or skis on the trails around Fairbanks.

MICHELLE GAVEL

Michelle Gavel joined the DGGS Minerals section in spring of 2020 after serving as a Graduate Intern for the Energy section helping with summer field work on the North Slope in 2018. One summer in Alaska was not enough, and after finishing her M.S. degree in geology at New Mexico State University in 2019 she returned to DGGS and spent the next year searching for gravel as part of the Arctic Strategic Transportation and Resources project. Her research background in tectonics, low temperature thermochronology, and geochronology led her to join the Minerals section where she enjoys being a GIS project support person, collaborating on bedrock mapping projects, and doing summer field work.

Originally from North Carolina, Michelle caught the geology bug on a field trip to Big Bend National Park during her undergraduate studies at the University of North Carolina at Chapel Hill. She has since done field work in the Blue Ridge mountains of North Carolina, Banks Peninsula in New Zealand, and southern New Mexico. She looks forward to many summers of field work all over Alaska! Michelle loves to get outside year-round and enjoys biking, hiking, paddling, and running, but will also happily spend a weekend at home baking and relaxing with her partner and their two cats.

ERIN ANDERSON

The Engineering Geology Section welcomes Erin Anderson, the newest member of our ASTAR Project team. Erin graduated from the University of Alaska Fairbanks with a Bachelor of Science degree in Geological Engineering. Erin comes to us from the Alaska Department of Transportation and Public Facilities, where she spent 19 years developing transportation projects in Alaska. Prior to her career at the Department of Transportation, Erin worked on an underground mining crew at the Greens Creek Mine in Juneau, Alaska. We are excited to have Erin's expertise and enthusiasm on our team as we work with the North Slope Borough to develop a new and much needed transportation system to support Alaska's Arctic communities.

CHRIS WYATT

Chris Wyatt joined DGGS in 2021 as a geologist in the Minerals Section to support data migration, field mapping, and minerals industry reporting after working since 2018 on similar projects in temporary roles at DGGS. Originally from North Carolina, Chris grew up 10 miles from the site of the United States' first gold mine, rockhounded in the Piedmont and Blue Ridge, and earned degrees at UNC–Chapel Hill (Public Health–Environmental Science) and UNC–Wilmington (Geology) before coming to Alaska in 1993 for graduate school at the University of Alaska Fairbanks (UAF). At UAF he worked in the Remote Sensing Group at the Alaska Volcano Observatory, where he helped pioneer methods to systematically monitor Alaskan volcanoes using satellites and developed algorithms to detect and classify volcanic eruptions using thermal data from NOAA weather satellites.

After graduating with an M.S. in Geology, Chris worked at UAF's Alaska Satellite Facility applying synthetic aperture radar (SAR) techniques to a variety of research areas including volcanology, hydrology, digital elevation model mosaics, and the cryosphere. Following postgraduate studies in petrology and isotope geochemistry at the University of South Carolina, he returned to Alaska to serve as UAF's geology field camp manager and instructor in 2011. He then worked for several years in the mineral industry, supporting hard-rock and placer-gold exploration drilling throughout interior Alaska and managing mining claim staking and regulatory requirements for multiple clients. Chris has more than 25 years of experience working with spatial data and geographic information systems and has served as scientific crew member on research cruises to Antarctica and the western Aleutians, as a research diver for the UAF School of Fisheries and Ocean Sciences, and as field operations support and data analyst for the UAF International Arctic Research Center. Chris' wife, Alina, is an exploration geologist.They have two children, one dog, and not enough bikes or canoes!

KEITH HOREN

Keith Horen joined DGGS in December 2021 as a GIS Analyst II with the Coastal Hazards Program. Keith began his career in geomatics as an Engineering Assistant in the United States Air Force where he trained in land survey, drafting, GIS, soils classification, concrete testing, and construction management. After leaving Active Duty, Keith continued to serve in the U.S. Air Force Reserve earning an Associates of Applied Science in Construction Technologies and a Bachelor of Applied Science in Management. At the same time, he worked in the private sector as a cartographer and surveyor throughout Alaska. Over the last decade and a half, Keith gained experience surveying and mapping all over the world, often plying his trade in austere locations where he honed a unique set of skills from fieldcraft to computer programming. Most recently, Keith oversaw an engineering section within the Alaska Air National Guard, while also managing and automating GIS data processing in support of two of the largest offshore wind farm projects in U.S. history. With one foot in topography and the other in bathymetry, Keith is a perfect fit in the Coastal Hazards Program.

FAREWELL!

TRISH EKBERG

Trish joined DGGS as a student employee in January of 2009. At the time, she was finishing her undergraduate degree in Geology at the University of Alaska Fairbanks (UAF). After graduation, she continued on at DGGS as a long-term non-permanent geologist and spent the summer assisting field investigations along the Alaska Highway near Tok. Just before heading into the field, she adopted a 7-month-old red husky-dog named Aedan. Aedan was Trish's constant companion during that summer, where she discovered a budding interest in Geographic Information Systems (GIS) and started to realize that fieldwork involves a lot of rain and mosquitos. She continued to learn about GIS and assist with geologic mapping until 2012, when she accepted a permanent position at DGGS as a full-time cartographer. Over the next 10 years, Trish made many beautiful maps, earned her master's degree in GIS from Penn State, and helped advance cartography and GIS at DGGS.

Two of Trish's most popular maps are the Historically Active Volcanoes of Alaska and Alaska Mineral Resources maps, both of which continue to be updated annually. Other notable projects include her work to standardize DGGS data to conform to the USGS Geologic Mapping Schema (GeMS), to adopt standard symbols for geologic maps, and to streamline map production by creating map templates and new GIS workflows. Trish was always admired for her patience and ability to convey information to those new to GIS, especially at the weekly GIS Tips and Tricks sessions.

Trish had many close friends at DGGS was very active in cultivating a close family-like community. She was quick to participate in office shenanigans and never turned down a chance to make friends at a potluck, Christmas party, or quilting bee. In 2018, when Trish got married, almost the entire guestlist was from DGGS. Almost as popular, her dog Aedan grew from a troublesome pup to a dignified gentleman. Since 2009, Aedan spent every summer watching over the DGGS parking lot from the back of Trish's Red Toyota Rav 4.

In 2020, Trish moved on to a position at the Montana Bureau of Mines and Geology where she is using all she learned at DGGS to positively impact the geologic mapping efforts in Montana. She still works closely with her friends at DGGS, who miss her natural GIS talent and cheerful enthusiasm.

LEE ANNE KOZIE

LeeAnne joined DGGS in 2005 as a Natural Resource Technician 2 and worked in that capacity for two years. From 2007 through 2019 she worked for Health and Social Services, Vital Statistics, then moved on to work for 6 months for the Department of Transportation at the Fairbanks International Airport. We were fortunate to have her return to DGGS in July of 2020 where she excelled as our Natural Resource Technician 2, processing timesheets, PCards, travel, filling publication orders, and many other tasks. She was always ready to greet her co-workers and the public with her positive and welcoming personality. In November 2021, LeeAnne was presented with an opportunity and accepted a full time telework position with Health and Social Services, Child Care Administrative Support, as an Accounting Technician 1. This position provides her the flexibility and fit she was looking for and the ability to work in an area she feels passionate about. She will be greatly missed by our DGGS family and we wish her much success.

ANGIE HUBBARD

Angie Hubbard worked as a Natural Resource Technician II at the Alaska Geologic Materials Center in Anchorage. While there, she was tasked with the monumental job of transferring 40,000 well core samples (weighing ~ 1 million pounds!) to the racks in the GMC warehouse. She quickly and diligently learned SQL to improve database QA, initial audit, and sample storage metadata as each truck arrived. These skills greatly enhanced the organization and efficiency of inventory movement from the receiving bay to warehouse racks. In addition to this work at the GMC, Angie assisted the Minerals Resources section with geologic mapping in east-central Alaska and the Engineering Geology section with monitoring frozen debris lobes in the Brooks Range. Angie left the GMC to pursue her M.S. in Geology and hopes to return to DGGS and fieldwork in the future. We wish you good luck, Angie!

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