Alaska Division of Geological & Geophysical Surveys Annual Report 2011

State of Alaska
Department of Natural Resources
Division of Geological & Geophysical Surveys
January 2012

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Front photo: *Alaska Division of Geological & Geophysical Surveys (DGGS) geologists Bob Gillis (left), Dave Mauel (right), and student intern Keane Richards (center) stand atop a west-facing cliff supported by sandstones, conglomerates, and volcanic deposits of the West Foreland Formation (late Eocene, or ~42 million years old) near Straight Creek in the Tyonek Quadrangle, about 65 miles west of Anchorage. The light-colored granitic rocks forming the high topography in the distance are part of the Alaska–Aleutian Range batholith (~60 million years old), which forms part of the volcanic arc that rims south-central and southwestern Alaska. Exhumation of these granitic rocks along high-angle faults, combined with contemporaneous arc volcanism, provided abundant sediment to the West Foreland Formation. The structural geology and stratigraphy of this region are part of the focus of DGGS's Cook Inlet Geology program, described on pages 32 and 33. Photo by David LePain.*

State of Alaska
Department of Natural Resources
Division of Geological & Geophysical Surveys
January 2012

STATE OF ALASKA
Sean Parnell, *Governor*

DEPARTMENT OF NATURAL RESOURCES
Daniel S. Sullivan, *Commissioner*

DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
Robert F. Swenson, *State Geologist and Director*

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Alaska Division of Geological & Geophysical Surveys
3354 College Rd., Fairbanks, Alaska 99709-3707
Phone: (907) 451-5020   Fax (907) 451-5050
dggspubs@alaska.gov
http://www.dggs.alaska.gov

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333 Willoughby Avenue
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3211 Providence Drive
Anchorage, Alaska 99508-4614

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Director's Foreword

Every year I am taken aback by the tremendous opportunities we are afforded here in Alaska. Very few states, or countries for that matter, are similarly endowed with the abundance of natural resources we all enjoy and from which we benefit. Similar in scope to our opportunities, our challenges can be "world class" as well. Diverse geology, remoteness, environmental concerns, and limited infrastructure all have the ability to affect our lives and livelihoods in many ways. From high energy and transportation costs to hazards posed by volcanoes and earthquakes to environmental change in the arctic, managing our finite resource base in a responsible and sustainable manner will require perseverance and a long-term outlook.

Ever-increasing global population and economic development will undoubtedly continue the acceleration of global demand for finite natural resources. With increased demand comes increased prices, and because of its bounty, Alaska will remain in the 'resource spotlight' for the foreseeable future. Evidence of this can be seen in all sectors of exploration and development in the state with near record activity in most. It will be critically important that we maintain a strong resource-management structure that facilitates responsible development through information and appropriate regulation, and at the same time protects and stewards all our natural resources for the benefit of present and future generations alike.

Advancements in technology will undoubtedly help to soften the steep climb of global demand by developing resources once thought unrecoverable. The 'shale phenomenon' we have witnessed over the last few years in the oil and gas sector is a clear example of the demand–supply–price–technology relationship. Significant increase in the development of alternate forms of energy underscores the beneficial aspects of this 'D-S-P-T' relationship. Nevertheless, the clear message we must take away from recent developments is that very little, if any, natural-resource exploitation occurs without environmental impact and risk. Additionally, the ability of any non-carbon energy source to satisfy the growing global demand in the foreseeable future is limited at best, and will require a paradigm shift in how we consume and develop our energy resources. Alaskans should remain very attentive, and educate themselves with the facts that underpin the omnipresent debates over hydrofracturing ('fracking'), water resources, seismicity, viewsheds, ecological impact, conservation, and energy-consumption trends.

The staff at DGGS works very hard to provide unbiased scientific information that is essential for sound policy decisions and public education. The information that our work generates can, at times, be somewhat controversial, but the Alaska public can be assured the data is of the highest quality and absent political or special-interest influence. Our teams of scientists work on a number of geologic issues of importance to the state. We are leading, or are involved in, projects covering a wide range of topics that address geologic energy-resource potential at the industrial-export to local-consumption scales; solid-minerals geologic assessments that will help the State identify our resource endowment in precious and strategic minerals; and natural-hazards assessments that are crucial to adapting to environmental change, securing public safety, and protecting the State's investments in infrastructure.

I hope you will take time to read the program descriptions included in this report; we welcome any feedback you might have. The staff at the Alaska Division of Geological & Geophysical Surveys is working very hard to meet the geologic challenges that face Alaskans. We will succeed only by providing unbiased geologic information to make sound, science-based policy and development decisions. We must remain diligent in this effort to help ensure Alaska remains prosperous, safe, and environmentally sound—well into the future.

Robert 'Bob' Swenson, State Geologist and Director, Division of Geological & Geophysical Surveys

DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
ANNUAL REPORT 2011

INTRODUCTION

MISSION STATEMENTS

DEPARTMENT OF NATURAL RESOURCES

Mission: Develop, conserve, and enhance natural resources for present and future Alaskans

DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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)

HISTORY

The present Division of Geological & Geophysical Surveys (DGGS) evolved from Alaska's Territorial Department of Mines. That heritage is reflected in the Division's ongoing commitment to the application of geology to improve the welfare of Alaska citizens. The current name and mission of the Division were established in 1972 with the passage of Alaska Statute AS 41.08.

Territorial Department of Mines, 1959
Division of Mines and Minerals, 1959–1966
Division of Mines and Geology, 1966–1970
Division of Geological Survey, 1970–1972
Division of Geological & Geophysical Surveys, 1972–Present

LEADERSHIP

Ten qualified professional geoscientists have served as State Geologist:

- Jim Williams, 1959–1971
- William Fackler, 1971–1973
- Donald Hartman, 1973–1975
- Ross G. Schaff, 1975–1986
- Robert B. Forbes, 1987–1990
- Thomas E. Smith, 1991–1995
- Milton A. Wiltse, 1995–2002
- Rodney A. Combellick, 2003–January 2005
- Mark D. Myers, February–October 2005
- Robert F. Swenson, November 2005–present

By statute the State Geologist serves as the Director of the Division of Geological & Geophysical Surveys in the Department of Natural Resources (DNR) and is appointed by the DNR Commissioner. Since the early 1970s, the State Geologists have been selected from lists of candidates prepared by the geologic community and professional societies within Alaska. A department order in 2002 formalized a process whereby the Geologic Mapping Advisory Board oversees evaluation of candidates and provides a list to the Commissioner. The qualifications and responsibilities of the State Geologist and the mission of DGGS are defined by statute.

STATUTORY AUTHORITY

Alaska Statutes Sec. 41.08.010. Division of geological and geophysical surveys. There is established in the Department of Natural Resources a Division of geological and geophysical surveys under the direction of the state geologist. (1 ch 93 SLA 1972)

Sec. 41.08.015. State geologist. The commissioner of natural resources shall appoint the state geologist, who must be qualified by education and experience to direct the activities of the Division. (1 ch 93 SLA 1972)

Sec. 41.08.020. Powers and duties. (a) The state geologist shall conduct geological and geophysical surveys to determine the potential of Alaskan land for production of metals, minerals, fuels, and geothermal resources; the locations and supplies of groundwater and construction materials; the potential geologic hazards to buildings, roads, bridges and other installations and structures; and shall conduct such other surveys and investigations as will advance knowledge of the geology of Alaska. With the approval of the commissioner, the state geologist may acquire, by gift or purchase, geological and geophysical reports, surveys and similar information.

Sec. 41.08.030. Printing and distribution of reports. The state geologist shall print and publish an annual report and such other special and topical reports and maps as may be desirable for the benefit of the State, including the printing or reprinting of reports and maps made by other persons or agencies, where authorization to do so is obtained. Reports and maps may be sold and all money received from these sales shall be paid into the general fund. (1 ch 93 SLA 1972)

LOCATION

The Division's administrative headquarters and personnel moved from Anchorage to Fairbanks in 1987. The close proximity of the Division to the earth science research laboratories of the University of Alaska Fairbanks campus has a strategic benefit to the DGGS program. University faculty and students are important adjunct members of many DGGS project teams.

Current DGGS staff totals 38 permanent full-time professional and support personnel, a Director, Division Operations Manager, five long-term nonpermanent staff, and seven student interns.

ORGANIZATION

DGGS is one of seven divisions and four offices in the Alaska Department of Natural Resources. Under the overall administration of the Director's Office, the Division of Geological & Geophysical Surveys is organized into five sections and the Geologic Materials Center. The Division also administers the 11-member Alaska Seismic Hazards Safety Commission.

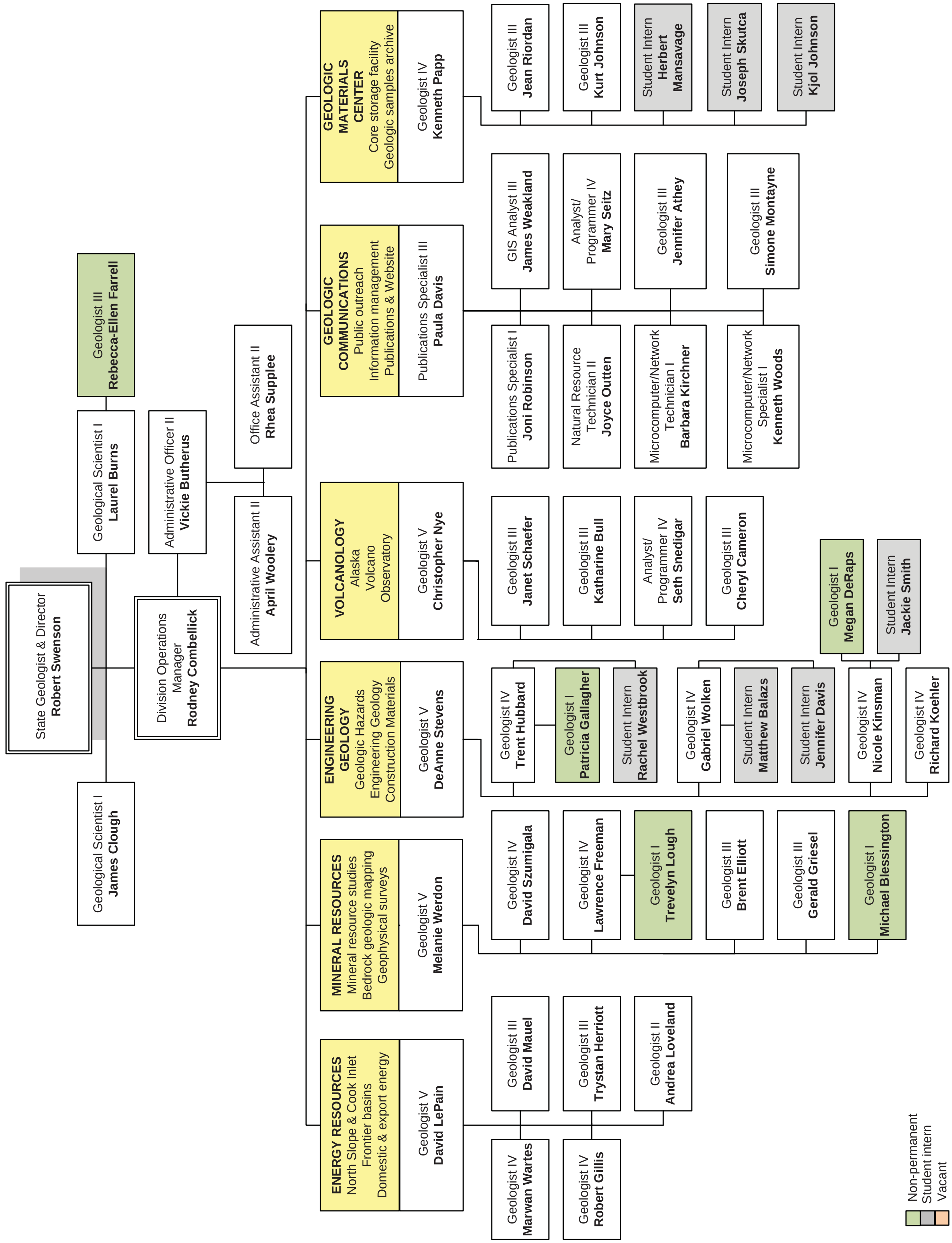
Division of Geological & Geophysical Surveys offices in Fairbanks

Geologic Materials Center in Eagle River

Back L to R: Rod Combellick, Bob Swenson
Front L to R: April Woolery, Vickie Butherus, Rhea Supplee

The **Director's Office** provides strategic planning for the Division's programs to ensure that DGGS is meeting the needs of the public under the guidelines of AS 41.08.020, manages the Division's fiscal affairs, and provides personnel and clerical services. The Director acts as a liaison between the Division and local, state, federal, and private agencies; seeks out and encourages cooperative geologic programs of value to the state; and advises the Commissioner of the Department of Natural Resources about geologic issues.

DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
CURRENT ORGANIZATIONAL CHART



L to R: Andrea Loveland, Dave LePain, Bob Gillis, Jim Clough, Marwan Wartes, Dave Mauel, Trystan Herriott

The **Energy Resources Section** generates new information about the geologic framework of frontier areas that may host undiscovered oil, gas, coal, or geothermal resources. Summary maps and reports illustrate the geology of the state's prospective energy basins and provide data relating to the location, type, and potential of the state's energy resources. The Energy Resources Section seeks to improve the success of state-revenue-generating commercial oil and gas exploration and development and to identify local sources of energy for rural Alaska villages and enterprises.

Back L to R: Brent Elliott, Gerry Griesel, Dave Szumigala, Larry Freeman, Michael Blessington
Front L to R: Laurel Burns , Melanie Werdon, Trevelyn Lough, Rebecca-Ellen Farrell

The **Mineral Resources Section** collects, analyzes, and makes available information on the geological and geophysical framework of Alaska as it pertains to the mineral resources of the state. Summary maps and reports illustrate the geology of the state's prospective mineral terranes and provide data on the location, type, and potential of the state's mineral resources. These data aid in the state's management of mineral development, and help to encourage mineral exploration in Alaska, which provides employment opportunities and revenue for Alaska's citizens.

L to R: Nicole Kinsman Richard Koehler, Trish Gallagher, Gabriel Wolken, Miriam Braun, Trent Hubbard, De Anne Stevens, Meagan DeRaps

The **Engineering Geology Section** collects, analyzes, and compiles geologic data useful for engineering and hazard risk-mitigation purposes. Surficial-geologic maps portray the distribution of unconsolidated surficial-geologic materials and provide information on their engineering properties and potential as sources of construction materials and placer minerals. Studies of major geologic hazards such as earthquakes, active faults, and tsunamis result in reports outlining potential hazards in susceptible areas. The section advises other DNR divisions and state agencies regarding potential hazard risks to proposed developments and land disposals.

The **Volcanology Section,** established in 2007, focuses on processes and hazards associated with the more than 50 active volcanoes in Alaska. The section is home for the DGGS participants in the Alaska Volcano Observatory (AVO), an interagency collaboration between the U.S. Geological Survey, University of Alaska Fairbanks Geophysical Institute, and DGGS. Volcanology Section staff conduct geologic studies of active volcanoes to estimate their future eruptive potential and behavior, thus aiding in mitigating volcano-hazard risks. Results of these studies are released as maps and reports. The section also creates and maintains a very large, public, web-accessible database of information on volcano history and current activity (http://www.avo.alaska.edu), as well as an internal website providing communication, record keeping, and data sharing within AVO. In 2008 the section became heavily involved in geothermal resource issues, providing information to other agencies and the private sector and participating in state activities leading up to the geothermal lease sale at Mt. Spurr and providing technical reviews of proposals to the Renewable Energy Fund established by HB152 in 2008.

Back L to R: Chris Nye, Janet Schaefer, Seth Snedigar
Front L to R: Kate Bull, Cheryl Cameron

The **Geologic Communications Section** publishes and delivers Division-generated geologic information to the public and maintains and improves public access to Alaska's geologic and earth science information. Advances in computer technology have resulted in faster preparation of maps and reports and a wider awareness of DGGS's available Alaska geologic resources. This section designs, implements, maintains, and improves a database for the Division's digital and map-based geological, geophysical, and geochemical data; a database for the Division's physical samples that are housed in Eagle River; and websites for the Division (http://www.dggs.alaska.gov) and for the Alaska Seismic Hazards Safety Commission (http://www.seismic.alaska.gov).

Back L to R: Jim Weakland, Joni Robinson, Bobby Kirchner, Susan Seitz, Ken Woods
Front L to R: Joyce Outten, Jen Athey, Simone Montayne, Paula Davis

The **Geologic Materials Center** is the state's single central repository for representative geologic samples of oil- and gas-related well cores and cuttings, mineral deposit core samples, and regional geologic voucher samples. These materials are routinely used by industry to enhance the effectiveness and success of private-sector energy and mineral exploration ventures. New materials are continuously acquired; access to the materials at the GMC is free. To ensure that the value of the GMC holdings is maintained over time, any new data or processed samples generated from privately funded analyses of the geologic materials stored there must be donated to the GMC database.

L to R: Kjol Johnson, Joe Skutca, Kurt Johnson, Don Hartman, Jean Riordan, and Ken Papp

The Alaska Seismic Hazards Safety Commission is charged by statute (AS §44.37.067) to recommend goals and priorities for seismic risk mitigation to the public and private sectors and to advise the Governor and Legislature on policies to reduce the state's vulnerability to damage from earthquakes and tsunamis. The Commission is administered by DGGS and consists of 11 members appointed by the Governor from the public and private sectors for three-year terms. The Commission produces a separate annual report to the Governor and Legislature and has its own website, http://www.seismic.alaska.gov.

RELATIONSHIPS WITH OTHER STATE AGENCIES

DGGS provides other DNR agencies with routine analyses and reviews of various geologic issues such as geologic-hazards evaluations of pending oil and gas lease tracts; area plans; competitive coal leases; geologic assessments of land trades, selections, or relinquishments; mineral potential; and construction materials availability. The DGGS Energy Resources Section works closely with geologic personnel in the Division of Oil and Gas (DOG) on issues related to energy resources and in providing geologic control for the subsurface oil-related geologic analyses conducted by DOG. Each year DGGS prepares an annual report on the status of Alaska's mineral industry in cooperation with the Office of Economic Development in the Department of Commerce, Community & Economic Development. The Engineering Geology Section works closely with the Division of Homeland Security & Emergency Management (DHSEM) in the Department of Military and Veterans Affairs to evaluate hazards, develop scenarios for hazards events, and update the State Hazard Mitigation Plan. The Volcanology Section works with DHSEM and the Division of Environmental Conservation to mitigate effects of ongoing eruptions, and with the Alaska Energy Authority to provide technical expertise concerning geothermal resources. DGGS also evaluates resource potential around the state that may provide viable alternatives for energy development in rural Alaska. In recent years, DGGS has developed close working relationships with the Alaska Pipeline Project Office, Alaska Gasline Development Corporation, and the State Pipeline Coordinator's Office to assist in geologic data collection and hazards risk assessment for proposed natural gas pipelines.

Funding to support work requested by other DNR agencies mostly has been drawn from DGGS's annual general fund appropriation. However, for larger inter-division or other one-time efforts responding to special needs, the work is often supported by interagency fund transfers, Capital Improvement Project (CIP) funding, federal cooperative agreements, or private industry grants that supplement DGGS's general funds.

RELATIONSHIPS WITH LOCAL GOVERNMENTS

Most of the cooperative efforts implemented by DGGS with borough and municipal governments are conducted on a mutually beneficial but informal basis. For example, DGGS participates in a federally funded cooperative program to develop tsunami-inundation maps for coastal communities. In Kodiak, Homer, Seldovia, Seward, and Whittier, communities for which inundation maps have been prepared in recent years, the city and borough governments worked closely with DGGS and other project cooperators to help design the project outputs to best benefit their needs for planning evacuation areas and routes. Similar cooperative efforts are currently underway with Sitka and Valdez for the next tsunami-inundation maps to be generated by this program. The Engineering Geology Section has worked closely with several communities to develop a field-geoscience outreach program for middle- and high-school students in rural Alaska. Engineering Geology has also initiated a program working with coastal and river communities and several state and federal agencies to help assess hazards and alternatives for mitigating the effects of erosion, flooding, and other surface process that threaten sustainability of the communities. Similarly, the Energy Resources Section has worked closely with rural communities to help assess potential local energy resources as alternatives to importing expensive diesel fuel.

RELATIONSHIP WITH THE UNIVERSITY OF ALASKA

DGGS has had a long and productive professional association with geoscientists and students in various departments of the University of Alaska Fairbanks. UAF faculty work as project team members on DGGS projects and provide special analytical skills for generating stratigraphic, structural, geochemical, and radiometric-age data. Collaborative research projects and program oversight help provide both organizations with focused work plans that complement one another. University students employed as DNR/DGGS interns also are an important part

of the DGGS work force. While working on current DGGS projects, the students learn a wide variety of geology-related skills ranging from conventional geologic mapping and sample preparation techniques to modern digital database creation and geographic information systems. Some graduate students are able to apply their DGGS intern work to their thesis projects through a research intern program established recently through a Memorandum of Agreement. DGGS and the University make frequent use of each other's libraries and equipment. DGGS's Volcanology Section has a long-term cooperative relationship with the UAF Geophysical Institute resulting from partnership in the Alaska Volcano Observatory. University faculty and students occasionally visit the Geological Materials Center in Eagle River to study the geology represented in cores and surface samples from around the state.

RELATIONSHIPS WITH FEDERAL AGENCIES

DGGS often has cooperative programs with the U.S. Geological Survey (USGS), the U.S. Bureau of Land Management (BLM), and the U.S. Department of Energy. In the past, DGGS has also engaged in cooperative programs with the U.S. Minerals Management Service (MMS; now the Bureau of Ocean Energy Management, or BOEM), National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF). DGGS receives some federal funds from matching grants for which the Division must compete nationally with other organizations on a yearly basis. DGGS has been successful in securing federal funds to support mineral inventory mapping, surficial and earthquake hazards-related mapping, volcanic-hazards evaluations, and studies related to oil & gas and geothermal potential. Although DGGS has historically been very successful in receiving federal grants and appropriations, the process is highly competitive and these funds are therefore project-specific or complementary to state-funded programs and do not replace state General Fund money. Federal funding is pursued only for projects that are needed to advance the division's statutory mission.

Three ongoing cooperative programs with federal agencies have provided support for key elements of the DGGS mission for many years. One is the Alaska Volcano Observatory (AVO), a partnership established in 1988 and consisting of USGS, DGGS, and the University of Alaska Fairbanks Geophysical Institute. The USGS funds and administers the program for the purpose of providing a coordinated approach to mitigating volcano-hazard risks to the public, the state infrastructure, and air commerce. A second longstanding cooperative federal program is the STATEMAP component of the National Cooperative Geologic Mapping Program, established by Congress in 1992 and administered by USGS. STATEMAP provides matching funds for geologic-mapping projects according to priorities set by the Alaska Geologic Mapping Advisory Board (see below). A third major federal program is the Minerals Data & Information Rescue in Alaska (MDIRA) program, established by Congress in 1997. DGGS has completed numerous MDIRA projects, administered by USGS and BLM, for the purpose of recovering, indexing, archiving, and making publicly available minerals information at risk of becoming lost due to downsizing of public and private minerals-related programs. Although primary MDIRA funding for DGGS ended in early FY2010, in FY11 DGGS received a final allocation of remaining funds, which is being used to complete four MDIRA-related projects (see p. 15).

DGGS has been successful in receiving cooperative agreements for two new key federal programs, the National Geological & Geophysical Data Preservation Program (NGGDPP) and the Coastal Impact Assistance Program (CIAP). The NGGDPP, established by the National Energy Policy Act of 2005 and funded by USGS, supports several DGGS projects to archive, catalog, and make publicly available inventories of geologic samples and data through a National Digital Catalog hosted by USGS. DGGS received major, multi-year CIAP support through a highly competitive proposal process administered originally by MMS and currently by the BOEM. CIAP funding supports

DGGS geologic mapping and hazards evaluations of coastal communities in western Alaska that are potentially impacted by Outer Continental Shelf petroleum development and face current risks from coastal erosion and storm-wave flooding.

ALASKA GEOLOGIC MAPPING ADVISORY BOARD

The Alaska Geologic Mapping Advisory Board guides DGGS in pursuing its goal of providing earth science information to the Alaska public. A number of prominent geologists and community leaders, with a variety of backgrounds and a broad spectrum of experience in Alaska, have agreed to serve on the advisory board. The purpose of the board is multifold:

- To identify strategic geologic issues that should be addressed by the state.
- To inquire into matters of community interest relating to Alaska geology.
- To provide a forum for collection and expression of opinions and recommendations relating to geologic investigation and mapping programs for Alaska.
- To make recommendations toward identifying Alaska's diverse resources and promoting an orderly and prudent inventory of those resources.
- To review and advise on priorities for geologic mapping recommended by the State Geologist and provide letters of support to accompany DGGS's annual STATEMAP proposals to the U.S. Geological Survey.
- To increase public awareness of the importance of geology to the state's economy and to the public's health and safety.
- To promote communication among the general public, other government agencies, private corporations, and other groups that have an interest in the geology and subsurface resources of Alaska.
- To facilitate cooperative agreements between DGGS and other agencies, professional organizations, and private enterprise to develop data repositories and enhance the state's resource inventory and engineering geology programs.
- To communicate with public officials as representatives of groups interested in the acquisition of Alaska geologic information.
- To enlist public and legislative support for statewide geologic resource inventories and engineering geology programs.

The board held its first meeting in Fairbanks on October 22, 1995, and meets usually three times a year to discuss state needs, review DGGS programs, and provide recommendations to the State Geologist. The members solicit and welcome comments and suggestions from the public concerning state needs and DGGS programs throughout the year. Board members nominate candidates to fill vacancies and the State Geologist makes the appointments with approval of the Commissioner of DNR.

Current members of the board are:

Curt Freeman, Chair
Avalon Development Corporation, representing the minerals industry.
Curt Freeman is President of Avalon Development Corporation, a consulting mineral exploration firm based in Fairbanks, Alaska.

Peter Haeussler
U.S. Geological Survey, representing the federal government, earthquake hazards, and mapping interests.
Peter Haeussler is a geologist in the Anchorage office of the USGS Geologic Division, specializing in earthquake hazards, tectonics, and geologic mapping.

Tom Homza
Shell Exploration and Production, Alaska, representing petroleum industry interests with emphasis on the North Slope.
Tom Homza is a Principle Regional Geologist for Alaska at Shell with 16 years experience in oil and gas exploration and development in Alaska and represents the oil industry in mapping advice and structural interpretation.

Paul Layer
University of Alaska Fairbanks College of Natural Science and Mathematics, representing the academic community.
Dr. Paul Layer is Dean of the College. a Professor of Geophysics, and former Chair of the Department of Geology and Geophysics.

Steve Masterman
Engineering Geologist, Alaska Department of Transportation & Public Facilities (DOTPF), representing state government and the engineering geology and geotechnical community.
Steve Masterman is Regional Engineering Geologist for the Northern Region office of DOTPF, overseeing geotechnical studies in support of development and maintenance of the region's highways and airports.

Lance Miller
Nana Regional Corporation, representing Alaska Native corporation interests.
Lance Miller is Vice President for Resources and a geologist with mineral exploration background.

2011 ACCOMPLISHMENTS

The Division of Geological & Geophysical Surveys (DGGS) is charged by state statute to generate new, objective, peer-reviewed information about the geology of Alaska, the potential of Alaska's land for production of minerals, fuels, and construction materials, and the potential geologic hazards to its people and infrastructure. As in past years, in 2011 the Division successfully performed geological and geophysical mineral inventory mapping, generated new geologic data to support energy exploration, conducted hazard investigations, performed geologic and hazards studies on active volcanoes, and streamlined geologic data archival and dissemination.

ENERGY RESOURCES

- Conducted field geologic mapping, structural, and stratigraphic studies in the Umiat–Gubik area on the North Slope in collaboration with the Division of Oil & Gas, and stratigraphic studies in the Brooks Range foothills to the south in collaboration with the U.S. Geological Survey, both for the purpose of evaluating oil and gas resource potential.
- Published a bedrock geologic map covering approximately 600 square miles of State land prospective for oil and gas in the Kavik River area of the eastern North Slope, adjacent to ANWR.
- Completed a draft bedrock geologic map covering approximately 600 square miles in the upper Ivishak River area of the east-central North Slope that integrates surface geology and available two-dimensional (2-D) seismic and well data.
- Completed a draft geologic cross-section for the Sagavanirktok River area near the Trans-Alaska Pipeline.
- Described a complete core from the recent U.S. Geological Survey core test near Franklin Bluff; the results are relevant to regional North Slope stratigraphy and exploration models predicting reservoir distribution.
- Co-led a core workshop for industry geologists examining the reservoir potential of the western North Slope.
- Presented new data relevant to oil and gas exploration on the North Slope at Pacific Section meeting of the American Association of Petroleum Geologists held in Anchorage, the Conference on Arctic Margins held in Fairbanks, and the 3-P Arctic conference held in Nova Scotia, Canada.
- Participated in State and Federal discussions surrounding shale oil potential in northern Alaska.
- Hosted information booth at the annual meeting of the American Association of Petroleum Geologists and discussed oil and gas opportunities in Alaska with meeting attendees.
- Attended two conferences that focused on Arctic geology and resource potential.
- Attended a three-day field seminar on unconventional mudstone reservoirs in south Texas, comparable to potential source reservoirs in Alaska.
- Co-led a field trip along the Dalton Highway to view northern Alaska geology in preparation for new collaboration with international scientists interested in studying the North Slope as a potential analogue for petroleum-bearing basins worldwide.
- Conducted geologic field mapping, structural, and stratigraphic studies in upper Cook Inlet basin in collaboration with the Division of Oil & Gas and the U.S. Geological Survey.
- Completed a draft bedrock geologic map of 875 square miles in the Tyonek area in upper Cook Inlet and submitted it to the U.S. Geological Survey in fulfillment of STATEMAP funding requirements.
- Published two reports on the geology of the Cook Inlet basin relevant to oil and gas exploration.
- Revised the bedrock geologic map of the Tyonek area in collaboration with the Division of Oil & Gas by incorporating licensed 2-D seismic data and publicly available well data.
- Presented new data relevant to oil and gas exploration in Cook Inlet at the Pacific Section meeting of the American Association of Petroleum Geologists, held in Anchorage.
- Described the Shell Middle Ground Shoal A43-11 core and collected samples from the core for reservoir quality analysis; results are relevant to the search for oil in Cook Inlet basin.
- Led a multi-day field trip for industry geologists to examine sand bodies exposed in the sea cliffs along the Kenai Lowland that also serve as gas reservoirs in the subsurface of Cook Inlet basin.
- Led a multi-day field trip in the Beluga–Capps Glacier area for Apache Corporation geologists to examine sand body geometries and structural relations relevant to oil production in Cook Inlet.
- Compiled and synthesized into a GIS database all publicly available geologic data for the Susitna basin and adjacent areas.
- Conducted structural and stratigraphic studies in the Susitna basin in collaboration with the Division of Oil & Gas and the U.S. Geological Survey to evaluate oil, gas, and coal resource potential.
- Performed community outreach by speaking to an Upward Bound group of Middle School Students about careers in the geosciences and providing information to college students on geology careers at UAF's Career Day.
- Served on UAF graduate student thesis committees.

MINERAL RESOURCES

- Published Alaska's Mineral Industry (Special Reports 64 and 65), an authoritative annual report of statewide mining activity, in collaboration with the Alaska Department of Commerce, Community & Economic Development.

- Initiated the Rare-Earth Elements and Strategic Minerals Assessment project to assess Alaska's Rare-Earth-Element (REE) potential. Conducted rock and stream-sediment geochemical sampling in the William Henry Bay area, southeastern Alaska, and the Moran area, Interior Alaska, and began compiling statewide REE data.
- Published an Information Circular on Rare-Earth Elements (IC 61), summarizing their uses, worldwide resources, and known occurrences in Alaska.
- Helped organize and participated in the Governor's Strategic and Critical Minerals Summit in Fairbanks. This public forum provided global and national perspectives on strategic and critical mineral resources and issues, highlighted Alaska's mineral wealth and research capabilities, and encouraged industry exploration, development, production, and processing of strategic and critical minerals in Alaska.
- Conducted bedrock geologic mapping, associated geologic studies, and a mineral-resource assessment of 301 square miles in the Moran area in central Interior Alaska. This mapping coincides with the eastern half of the DGGS Moran airborne-geophysical survey tract, and covers a historic mining district with numerous placer gold and tin deposits and several lode gold occurrences.
- Published a structural-geology data report for the Council area, Seward Peninsula, Alaska.
- Published a geochronological report for the Eastern Bonnifield area, Interior Alaska.
- Published a geochemical report for the Livengood South area, Interior Alaska.
- Published a geochemical report for the Moran area, Interior Alaska.
- Completed a draft bedrock geologic map of 276 square miles of the Livengood South area, Interior Alaska.
- Released airborne geophysical survey data for 742 square miles of the Ladue area, western Interior Alaska.
- Released airborne geophysical survey data for 852 square miles of the Iditarod area, southwest Alaska.
- Supported the Division of Mining, Land and Water and the U.S. Bureau of Land Management by providing extensive mineral-resource reviews for area plans and state land disposals.
- Provided mineral-resource-potential evaluations of state land throughout Alaska, to identify and prioritize appropriate land to relinquish from Alaska's overselected Statehood land entitlement.
- Gave a presentation entitled "Alaska Airborne Geophysical/Geological Inventory Program: Integrating Airborne-Geophysical Surveys, Geologic Mapping, and Mineral-Resource Assessments" at the Geological Society of America national meeting in Minneapolis and the Yukon Geoscience Forum in Whitehorse, Yukon.
- Responded to more than 850 public, industry, and agency requests for mineral resources information.

ENGINEERING GEOLOGY AND HAZARDS

- Conducted geologic fieldwork along the Alaska and Parks highways in support of proposed export and in-state natural gas pipeline projects.
- Completed geologic fieldwork in Whittier, Seward, Sitka, Shaktoolik, and Unalakleet to provide scientific information for community-based hazards evaluation projects.
- Mounted a highly successful quick-response coastal hazards assessment field campaign to Unalakleet, Shaktoolik, Nome, and Golovin in the aftermath of the historic November 2011 Bering Sea storm.
- Published four surficial-/engineering-geologic maps with accompanying GIS data in support of geologic and hazards studies throughout Alaska.
- Published five paleoseismic–neotectonic reports documenting observations related to potential active faulting in Alaska.
- Presented talks and posters at numerous state, national, and international conferences, to inform the geologic community and government representatives about new DGGS Engineering Geology Section geologic studies, with the primary goals of disseminating geologic information and encouraging informed planning and development in Alaska.
- Major participant in the 2011 annual meeting of the Association of Environmental & Engineering Geologists, including chairing a symposium on coastal processes, presenting multiple papers and posters on DGGS's geologic hazards- and engineering-related studies in Alaska, and leading a field trip on effects of the 1964 earthquake and hazards from future earthquakes and tsunamis.
- Expanded a program to collect high-resolution lidar (Light Detection and Ranging) data along multiple proposed natural gas pipeline corridors in Alaska.
- Continued collaborative efforts with the U.S. Geological Survey to compile a Quaternary Fault and Fold Database for Alaska, an online digital resource for active geologic structures in the state. The database will be completed and merged with the national database in 2012.
- Supported the Alaska Energy Authority by reviewing alternative energy project proposals for potential geologic hazards that would need to be addressed in project implementation.
- Participated in meetings and discussions as part of the Statewide Digital Mapping Initiative (SDMI), which has the primary goals of acquiring new and better digital map data for Alaska, including orthoimagery and digital elevation models, and making existing map products more readily accessible.
- Completed agency reviews regarding potential geologic hazards and engineering-geologic considerations for multiple DNR land disposal and subdivision projects, large project exploration and development plans for the federal Bureau of Ocean Energy Management, and Environmental Impact Statements of the U.S. Department of the Interior's Bureau of Land Management.

- Led teacher and student activities and workshops in Fairbanks, Huslia, Hughes, Manley Hot Springs, and Old Minto as part of DGGS's ongoing involvement in MapTEACH (Mapping Technology Experiences with Alaska's Community Heritage), a geoscience education-outreach project developed by DGGS in collaboration with the University of Alaska Fairbanks and University of Wisconsin–Madison. MapTEACH is now being run by the University of Alaska Integrated Geography program.
- Supported the former Alaska Coastal Management Program (ACMP) by reviewing Coastal Project Questionnaires, advising project review coordinators on natural hazards issues, and reviewing and contributing to the ACMP Strategy and Assessment Plan.
- Secured additional funding from the federal Coastal Impact Assistance Program (CIAP) to continue a major new DGGS program of coastal community geohazards evaluation and geologic mapping in support of coastal district and community planning.
- Provided administrative support for the Alaska Seismic Hazards Safety Commission. The Commission produces a separate annual report.

VOLCANOLOGY

- Conducted the seventh consecutive year of water-quality monitoring at Mother Goose Lake and the King Salmon River by collecting water samples and measuring the pH of natural acid water draining from Chiginagak volcano's crater lake, and published a DGGS Report of Investigations describing the water chemistry and crater-lake observations between 2004 and 2011.
- Published, as a DGGS Report of Investigation, a comprehensive overview publication of the 2009 Redoubt eruption, summarizing unrest, eruption, impacts, monitoring, and the Alaska Volcano Observatory's (AVO) operational responsibilities.
- Updated the map, "Historically Active Volcanoes of Alaska," adding the 2011 eruption of Cleveland volcano.
- Created new basemaps of Okmok volcano using data from a digital elevation model (DEM) that was acquired after the 2008 eruption. The post-eruption DEM and basemaps are being used to map and quantify volumes of the new volcanic features formed during the eruption.
- Wrote or co-wrote several chapters in U.S. Geological Survey Professional Paper 1769 covering the 2006 eruption of Augustine Volcano. The report was published online in December 2010 (http://pubs.usgs.gov/pp/1769/).
- Prepared multiple manuscripts as part of a special issue on the 2009 eruption of Redoubt Volcano to be published by the *Journal of Volcanology and Geothermal Research,* including the introductory overview paper for the issue and papers on tephra, the 2009 dome, and outreach.
- Conducted fieldwork to describe the geologic history of Redoubt Volcano.
- Conducted additional fieldwork at Kasatochi volcano in preparation for drafting a geologic map. Also collected and interpreted chemical data on >70 samples to be used to refine map units and their descriptions.
- Procured and provided logistical coordination and support for interagency AVO flight activities throughout Alaska.
- Scanned ~6,500 photographic slides of volcanoes taken over the past several decades, and uploaded more than 1,000 to the AVO image database, with image metadata. These are important legacy images for tracking morphologic change due to eruptions.
- Responded to more than 340 emails to the Alaska Volcano Observatory.
- Continued development of GeoDIVA, the database that feeds the AVO website, by completing modal analyses of samples from Kasatochi Island; compiling additional sample metadata, increasing the total recorded samples to ~9,300 (from ~7,200); verifying and loading additional geochemical data (number of samples with analyses is now ~3,650); and updating the bibliography through 2010 (now ~4,650 references).
- Recalculated the entire 20-year catalog of inductively coupled plasma–mass spectrometry (ICP–MS) analyses of volcanic samples so that they all conform to the latest calibration. This is now the largest unexplored, self-consistent compilation of trace-element data for any volcanic arc worldwide.
- Created and began to populate a queryable database to store AVO's published and internal GIS data—with a web-accessible upload interface for basic metadata.
- Refined the citizen ash observer ash fall reporting database and user interface. Initially built in haste during the Redoubt eruption, it is now a more useful tool for future eruptions.
- Created and installed the Volcano Notification Service, a service for signing up and receiving information updates from the U.S. volcano observatories (http://volcanoes.usgs.gov/vns/).
- Completed a major rewrite of the internal AVO logs system; exported software to the Ecuadorian national seismological and volcanological observatory.
- Updated the interface for public searches of AVO's informational products (http://www.avo.alaska.edu/activity/search_reports.php).
- Added AVO-and Alaska Earthquake Information Center (AEIC) located earthquakes to the internal map system.
- Transferred all AVO web traffic to the new servers that were configured and installed last year.
- Authored or co-authored a total of 18 reports (either released or in press).

GEOLOGIC INFORMATION MANAGEMENT AND DELIVERY

- Distributed nearly 5,000 hard-copy geological and geophysical reports and maps and recorded more than 117 million web page views on the DGGS and Alaska Volcano Observatory websites. In addition, users downloaded 1,115 digital data packages (summarized below) from the DGGS website—primarily GIS files and data tables that users can import directly into their computer systems for analysis. Information Circular 59, an educational deck of playing cards with photos and other descriptive information about each of Alaska's 52 historically active volcanoes, continues to be a hot seller at $6 per deck.
- Published 27 new geological/geophysical reports and maps, 25 GMC reports, and many maps and publications for the Ladue, Moran, and Iditarod geophysical survey areas; loaded 273 organic geochemistry sample analyses into the DGGS database; and added 375 U.S. Bureau of Mines maps and reports to the DGGS website, significantly increasing the number of Alaska-related geologic minerals research documents available to users of all types.
- Completed redesigning DGGS's website to meet the revised State-mandated look and feel. Used Java to integrate more dynamic content into the site.
- Contracted the Geographic Information Network of Alaska (GINA) at UAF to develop a DGGS web-based mapping application. Substantial work has been completed on the project, and the new application is on schedule for release in 2012.
- Released Alaska geologic hazard map outlines through an open standard web service for use in GIS software applications.
- Maintained and continued development on the DGGS production database, web applications, and services including Publications, Geospatial Data Application (D3), WebGeochem, and DGGS Web Feature Service (WFS).
- Updated the USGS National Geologic Map Database (NGMDB) with bibliographic and location information for 36 new DGGS publications.
- Provided site-specific inventory records to the U.S. Geological Survey National Digital Catalog as part of the National Geologic and Geophysical Data Preservation Program (NGGDPP), including 290 published organic geochemistry samples, and 1,594 detailed inventory records of valuable Amchitka hard-rock mineral core and coalbed methane core samples stored at the Alaska Geologic Materials Center.
- Received funding from the USGS Minerals Data Information Rescue in Alaska (MDIRA) program to complete three data preservation projects including the Alaska Geologic Map Index, Alaska Minerals Industry Data Inventory (AKMIDI) database, and Alaska Paleontology Database. Work on these three projects is progressing rapidly and will be available online by December 2012 in searchable, spatially enabled web mapping interfaces that will provide users easy access to geologic, geologic hazard, and mineral resource information.
- With the help of the American Geological Institute, DGGS surveyed more than 1,250 organizations (university geology departments, state and national geological surveys, and the private sector) regarding their interest in and current use of technology in geologic field mapping. Results are compiled and will be published through the USGS. After the USGS sets up the new wiki/multi-user blog for all of the digital mapping themes, DGGS will likely be the national and international content manager and moderator for the digital field mapping section.
- Prepared displays of DGGS products and represented the division at two major conferences in Anchorage—the Association of Environmental and Engineering Geologists (AEG) 54th Annual Meeting and the Alaska Miners Association (AMA) annual conference. Both functions were well attended; the AMA saw its greatest attendance levels ever, at around 1,000 participants.
- Established a Linux-based ArcGIS server to be used both in-house and externally for serving out GIS data.
- Took over web hosting for http://akgeology.info and http://akmining.info from DNR's Information Resource Management section.
- Reproduced several volumes of *Short Notes on Alaska Geology* that had been scanned by a contractor several years ago for posting to the website, but were found to be of very poor quality. The publications were rescanned at higher resolution (using improved scanning technology as well), and original text was salvaged from an outdated document layout program. Combined the two to make much sharper, more readable .pdf files. These publications appear in the DGGS Professional Reports series.
- Created digital files for numerous printed manuscripts, reports, and theses from scans, for either archiving or addition to the website. Repaired online scanned publications when problems were reported, such as missing pages, illegible copy, or wrong publication. The quality and accuracy of our online collection continues to be improved by these fixes.

GEOLOGIC MATERIALS CENTER

- Hosted 511 visits to the GMC in Eagle River by industry, government, and academic personnel to examine rock samples and processed materials. Collaboration from these visits helped acquire 2,108 processed slides, oil and gas material representing 123,526 feet from 40 wells, including three geothermal exploration boreholes, and publish 12 new laboratory data reports derived from third-party sampling.
- Completed approximately 45 percent of a major sample-inventory mapping project, a focused effort to provide an updated, detailed, and barcoded inventory of the facility's entire 77,060 ft^3 collection. The inventory map will identify available, empty shelves and provide the location and counts of specific material types, more accurate core recovery data and volume estimates, and unique IDs (barcodes) for every box in the collection.

- Completed 60 percent of a project to incorporate the entire oil and gas collection into a working barcode/database system. This massive effort will make the future transition to a new repository much more manageable, improve the quality of the collection data, and pave the way for a future web-interface to query the available materials at the GMC.
- Completed a detailed GMC inventory summary as a product of the inventory-mapping project. The GMC now has a much better understanding of the facility's inventory growth rate and the number of boxes, amount of core, sample types, and volume of samples that make up the entire inventory.
- A GMC online inventory was released to the public in April 2010. Since the release, the inventory files have been downloaded 5,431 times (4,352 times in FY11 alone). This dataset, available in Google Earth and PDF formats, includes oil and gas well locations, mineral prospect locations, sample types, and box-level details for more than 80 percent of the materials inventory available at the GMC. The online inventory allows users to quickly and easily view details of the GMC's materials repository before visiting the facility.
- Created and distributed a thorough, anonymous evaluation questionnaire to 85 individuals, representing 40 agencies, companies, and universities to obtain feedback regarding GMC user satisfaction. The GMC user survey summary is now available online.
- Completed two major curation projects involving valuable core sample collections at risk of severe material and data loss with funding in part from the National Geologic and Geophysical Data Preservation Program. As a result, much of the data associated with the Amchitka Island hard-rock core has been greatly improved and 94 percent of the 818 boxes of coal-bed methane core from five wells has been cleaned, re-boxed, and saved.
- Analyzed visitor statistics dating back to 1999 and generated an informative GMC visitor statistics summary, highlighting trends in the total number of yearly visitors, the types of groups visiting the facility, and the agencies, companies, and universities who most frequently visit the facility.
- Confirmed, detailed, and barcoded the core samples, box by box, for the USGS, NPR-A collection to improve the quality of the GMC inventory.
- Organized, documented, and detailed approximately 95 percent of the hard-rock material stored in 20+ shipping containers. These efforts will improve the in-house materials database inventory, allowing staff to help users of the facility find information more quickly, and pave the way for a future web-interface to query the available materials at the GMC.
- Improved the usability of the GMC core viewing area. Proper tables, capable of supporting up to 2,500 pounds, and portable "daylight" lamps have been added to better accommodate users who wish to view and photograph a large number of samples.
- Drafted an Inventory Transfer Plan summarizing logistical plans and costs associated with the possible future transfer of the entire inventory, an estimated 77,060 ft^3 storage volume, from its current location in Eagle River to a larger facility potentially located in Anchorage.

KEY ISSUES FOR FY2012–2013

UPDATING AND IMPROVING THE ALASKA GEOLOGIC MATERIALS CENTER

- Our ability to develop the State's natural resources and maintain a robust economic engine is at a critical juncture. Significant investment in infrastructure will be required in the coming years to advance exploration and development efforts statewide. The Geologic Materials Center (GMC) is a key part of that resource infrastructure and is the "first stop" for oil and gas and mineral exploration companies that are attempting to prospect in the complex geology of Alaska.
- The GMC facility archives samples and rock core representing more than 13 million feet of drilled core and samples from 1,600 oil and gas exploration and development wells; 300,000 feet of mineral diamond core wells, and irreplaceable samples from geologic research performed and mapping completed for every corner of the state.
- Although the GMC is being maintained in its current condition, the facility is filled to more than 170 percent *above* its maximum sample-storage capacity, and is very poorly designed to handle the frequent requests for reasonable access to the material.
- The GMC currently utilizes 60 portable shipping containers as storage facilities for newer sample acquisitions. These containers are unlighted, unheated, and house thousands of feet of core, some of which will disintegrate with repeated freeze-thaw cycles. It is important to note that this collection represents hundreds of millions of dollars of acquisition and preservation costs and is in significant risk of damage or loss.
- Providing efficient and comprehensive access to these data is critically important for viable exploration programs, for both seasoned Alaska exploration companies and new companies that are trying to identify potential exploration areas.
- The core and sample observation area is essentially unusable for confidential work and examination of more than a few feet of core length. An exploration company's ability to keep their activities confidential is critical to exploration success in a fiercely competitive environment. Often the core must be taken off site for substantial projects, creating a significant security threat to the unique core, and an expensive alternative for the exploration company. All of these factors results in reluctance by some companies to

make use of the facility because they must go through the onerous effort of transporting and unnecessarily handling the material at risk.

- A facility concept study, funded through a special federal appropriation, was completed in July 2006. The study identified the most feasible options for design and provided cost estimates for various configurations. It is the basis for our FY09 CIP-funded project to support the next phase—an architectural and engineering design of the facility.
- A significant challenge for DGGS in the near term will be to convince the public, lawmakers, and government officials of the importance of upgrading this facility and providing the funding necessary to keep this critical data source safe and accessible. One piece of core from this archive has the capability to identify a resource prospect that will bring billions of dollars to the state. It is imperative that we inform Alaskans of this fact so they understand that investment in the GMC upgrade is an investment in future revenue generation.

RENEWED FOCUS ON NATURAL RESOURCE DEVELOPMENT

- Increased activity in the natural resource exploration and development industries is good for the state on many fronts. With an increase in activity comes an expectation that the state will provide the necessary data to facilitate that development. DGGS welcomes this challenge and will be doing everything possible to meet the needs of this renewed focus.
- Our effort to provide critical geologic data to these resource exploration and development industries will be tested as more and more end-users of our products demand quicker and more comprehensive response. The main challenge will arise from a static division personnel count and our inability to meet the rapidly changing needs of the resource development community with the current number of personnel. An additional key challenge will be to continue gathering required new field information in the face of rising operating costs.
- Spikes in the exploration cycle also create a situation where high-paying, private-sector jobs become abundant, and opportunities for experienced geoscientists become commonplace. The state must remain diligent in order to keep our best and brightest employees.
- DGGS must continue developing and optimizing its data acquisition programs and work to discover new and more efficient ways to disseminate the information to the groups that need it.

INFRASTRUCTURE PROJECTS AND PUBLIC SAFETY

- Development of Alaska's vast resource base requires access to world markets. Providing geologic data for infrastructure maintenance and development will remain a key challenge for DGGS.
- The Alaska Gasline Inducement Act (AGIA) pipeline will require comprehensive information about construction materials and geologic hazards data to allow timely and safe design and development. DGGS is currently acquiring those data, but will need to accelerate the current pace to supply the needed maps and information.
- Large projects to develop Alaska's huge natural-resource base and sustain the State's economy require baseline data and hazards analysis to enable permitting to be completed in a reasonable timeframe and the environment can be properly protected. Unfortunately, most areas have only minimal data, and little of the detailed geologic mapping that will be necessary to undertake these activities.
- Continued arctic warming will undoubtedly increase maintenance requirements on many of Alaska's current roads and transportation corridors. Identifying geologic hazards and areas prone to failure will be necessary to mitigate this change. Increased materials requirements will likewise strain Department of Transportation and Public Facilities' (DOT/PF) ability to address this issue. DGGS will work with other state agencies to provide modern analytical techniques for this work.
- Population continues to expand in some areas of the state, and those regions (such as Wasilla) have essentially no baseline data on which to base zoning efforts and restrictions. Likewise, many areas where resource development is expanding lack the most rudimentary baseline data on things such as groundwater, geologic hazards, and resource abundance.
- DGGS will be challenged to provide geologic information for infrastructure, human, and economic development, as well as for the transitioning our hydrocarbon-based economy. All construction in the state requires a complete analysis of the inherent geologic risks that are commonplace but poorly understood in most areas of Alaska.

CHANGES IN LOCAL ENERGY SUPPLY AND CONSUMPTION

- A complete, or even partial, retooling of the state's domestic energy supply is not a trivial exercise. Providing the investment necessary to make changes is a first important step; however, there must also be oversight and monitoring of projects to avoid the substantial mistakes of the past. The Alaska Energy Authority has completed the first four rounds of the renewable energy grant program, which is working to develop alternate forms of energy in all corners of the state. DGGS will continue to be closely involved in reviewing the proposals for resource and hazards potential, methodology, and data review. DNR will be tasked with the substantial job of regulating and permitting the hundreds of projects that have the real potential to significantly impact the state's natural resources.
- Sustained high energy prices and the current push to curtail carbon-based fuel use could have a significant impact on the economies of rural Alaska and threaten the viability of rural infrastructure.

- Many remote areas of the state lack sufficient geologic information about potential alternate forms of energy such as shallow natural gas, coal, geothermal, and conventional gas. The cost associated with developing these alternates is often prohibitive on a small scale, but in some cases will be necessary to replace even higher cost diesel fuel. Helping local governments grapple with increasing energy costs will remain a key challenge.
- Misinformation about viable alternate energy sources is rampant and many expensive mistakes can be avoided by getting accurate information in the hands of the local governments and decision makers.
- DGGS will be challenged to provide pertinent and timely data on numerous fronts, and address the occurrence of locally available energy sources. DGGS will continue to strive to make data available to those that need it, movintg Alaska toward a more secure energy future.

RESPONSE TO DATA NEEDS FOR ADAPTATION TO A CHANGING ARCTIC CLIMATE

- Over the coming years, Alaska will be a national focal point for indications and impacts of climate change. DGGS's ability to provide reliable, unbiased data for the development and evaluation of emerging policy and statute changes will be very important for achieving reasonable, long-range planning and mitigation. We will continue to collect geologic and hazards data needed to help mitigate risks and adapt to the changing environment, and make that data available to the public.
- Geologic information will be needed in a number of key climate-related mitigation efforts. Most importantly, these data will be required in areas of coastal development and critical infrastructure where ground settlement from thawing permafrost, erosion and landslide hazards, and changes in hydrologic systems (both surface and subsurface aquifers) will be prevalent.
- Historically, the state has relied on site-specific hazards analyses related to ongoing development or permit approval. The recognition of significant change across the arctic will require that up-to-date regional baseline data be gathered and made available. Continued population growth and development in Alaska will continue to encroach on areas with heightened geohazard risk.
- Because of the nearly ubiquitous need for modern geologic mapping in impacted areas of the state, DGGS will be tasked with acquiring geologic data, producing maps, and identifying risks (information that can be used in both short-term and long-term planning). In some cases it will be critical to have this data available in crisis situations.
- DGGS will work with numerous agencies (with a wide range of mandates) in a coordinated effort so that the most important needs are addressed, and redundancy is minimized.
- The key challenge will be in the prioritization of the areas because there is much more need for data than there are personnel and funding to acquire it.

DGGS FY2012 PROGRAM

PROGRAM FOCUS

DGGS develops its strategic programs and project schedule through consultation with the many users of geologic information—state and federal agencies, the Alaska State Legislature, the federal Congressional delegation, professionals in the private sector, academia, and individual Alaskans. Their input to DGGS programs comes through the Alaska Geologic Mapping Advisory Board, liaison activities of the Director, and personal contact between DGGS staff and the above groups.

The FY2012 DGGS program focuses on projects designed to foster the creation of future Alaska natural-resource jobs and revenue and to mitigate adverse effects of geologic hazards. For the foreseeable future, much of the state's economy will continue to depend on developing the natural resources. Within that future, energy and mineral resources constitute a major portion of the state's wealth. Mitigating the effects of geologic hazards helps preserve public safety and private investments by fostering sound land-use, design, and construction practices. Both resource development and hazard risk mitigation depend heavily on the availability of reliable geologic information.

The role of DGGS in state revenue generation and the maintenance of Alaska's economy is strategic. DGGS provides objective geologic data and information used by in-state, national, and international mineral and energy companies, construction companies, air carriers, other DNR agencies, Department of Commerce, Community & Economic Development, Department of Transportation & Public Facilities, Division of Homeland Security & Emergency Management, and the Federal Emergency Management Agency. DGGS geologists provide geological and geophysical information to assist mineral prospectors, oil and gas explorationists, and others to explore for, discover, and develop Alaska's subsurface resources. DGGS is a central repository of information on Alaska geologic resources and a primary source of information for mitigating geologic hazard risks. To focus attention on Alaska's subsurface resource potential and geologic hazards, DGGS makes the state's geologic information available on statewide, national, and international levels. Through its Geologic Materials Center in Eagle River, DGGS also provides access to physical geologic samples collected by private companies and government agencies.

Minerals Data and Information Rescue in Alaska (MDIRA) Program

Downsizing of federal and state agencies in Alaska during the late '80s and early '90s placed at risk an extensive body of geological, geochemical, mineral, and mineral-development data that had been collected by federal, state, and private organizations over the past century. These data are archived in various locations offering various levels of storage capacity, quality, and accessibility. The budget shortfalls for federal and state archival functions created a need to develop aggressive plans for assembling, maintaining, and most importantly, creating value from this data legacy. For the purpose of this effort, “at risk data” is defined as any geologic data or voucher samples existing in substandard storage sites or in a mode in which data may be subject to irretrievable loss or degradation, or may be unavailable to meet the needs of its intended users. Beginning in 1998, a liaison committee comprising representatives from the Alaska Miners Association, Alaska Native corporations, University of Alaska, Alaska Department of Natural Resources, and independent mining industry consultants guided the implementation of the Alaska minerals data rescue efforts through a federally funded program entitled Minerals Data and Information Rescue in Alaska (MDIRA). DGGS projects supported in whole or in part by this program have been undertaken by the Mineral Resources and Geologic Communications sections. Although primary MDIRA funding for DGGS ended in early FY2010, in FY11 DGGS received a final allocation of remaining funds, which is being used to complete four ongoing MDIRA-related projects. In the FY2012 Program Summaries that follow, these projects are indicated by an asterisk (*). Information compiled through MDIRA-supported projects is available at http://www.akgeology.info/.

FY2012 DIVISION EXPENSE BUDGET
(estimated expenses in thousands of dollars)

Program	General Fund	CIP	Federal	Interagency & Program Receipts	Total
Energy Resources	815.0	577.4	131.4	157.0	1,680.8
Mineral Resources	1,549.7	498.8	291.8	6.0	2,346.3
Engineering Geology	445.0	349.0	513.8	814.6	2,122.4
Volcanology	0.0	0.0	1,438.7	0.0	1,438.7
Geologic Communications	941.6	0.0	0.0	10.0	951.6
Geologic Materials Center	309.0	145.0	21.7	50.0	525.7
Administrative Services	398.0	0.0	0.0	0.0	398.0
Seismic Hazards Safety Commission	10.0	0.0	0.0	0.0	10.0
Total by funding source	**4,468.3**	**1,570.2**	**2,397.4**	**1,037.6**	**9,473.5**

PROGRAM SUMMARIES

STATE GEOLOGIST/DIRECTOR

The Director’s Office provides leadership and coordination for the activities of the Division through the State Geologist/Director, Division Operations Manager, and administrative staff.

OBJECTIVES

1. Provide executive leadership for the Geological Development component of DNR’s program budget and act as liaison between the Division and the DNR Commissioner’s Office, other state agencies, Legislature, Governor’s Office, and local, federal, and private entities.
2. Stimulate exploration, discovery, and development of the geologic resources of the state through implementation of detailed geological and geophysical surveys as prescribed by AS §41.08.
3. Provide geologic information to mitigate the adverse effects of natural geologic hazards.
4. Provide secure archival storage and efficient public access to the state’s growing legacy of geologic information, and energy- and minerals-related reference cores and samples.

TASKS

- Prepare annual Division funding plan including Alaska General Fund base budget, Capital Improvement Project budget, interagency programs, and federal initiatives.
- Inform Alaska state legislators, Governor’s Office, Alaska Congressional delegation, and the public about the DGGS geologic program and its significance.
- Focus the Division’s geologic expertise on addressing Alaska’s highest priority needs for geologic information.

ENERGY RESOURCES

The Statewide Energy Resource Assessment program produces new geologic information about the state's oil, natural gas, coal, and geothermal resources. As both State and national oil and gas reserves continue to decline, and associated price volatility becomes the norm, it will become exceedingly important that new energy resources are identified in the state to help offset declining conventional reserves and state income. An additional short-term need that must be addressed is that of identifying affordable energy resources that can be economically developed for smaller local markets. As a consequence, there is a continual need for acquisition and dissemination of fundamental geologic data using modern technology that will enable industry and local governments to better focus exploration efforts on prospective areas beyond the currently producing fields. Recent DGGS stratigraphic studies and geologic mapping in the central and eastern North Slope are stimulating exploration interest in the Brooks Range foothills. This underexplored frontier province appears to be dominantly gas-prone and has the potential to yield additional reserves for the proposed natural gas pipeline. In summer 2011, DGGS resumed stratigraphic studies in the Umiat region south and southeast of the Colville River in the Umiat Quadrangle of the central Brooks Range foothills. This area encompasses approximately 700 square miles straddling the proposed road corridor between Umiat and the Dalton Highway, and includes stratigraphic and structural elements important to understanding the oil and gas potential of Alaska's North Slope.

Predicted deliverability shortfalls in the southcentral Alaska gas market have resulted in a significant increase in exploration interest in Cook Inlet Basin. In addition, over the last few years several companies new to Alaska have expressed significant interest in the basin's oil potential. This new interest is focusing attention on undiscovered conventional oil and gas reservoirs and the possibility of unconventional reservoirs (such as tight gas sands, fractured reservoirs, and source-reservoired oil and gas). To stimulate sustained exploration interest, DGGS initiated a multi-year study of this basin in 2007, providing relevant high-quality data to help evaluate resource potential of the basin. This project focuses on building a robust model of the basin's stratigraphy to help predict the distribution of potential sandstone reservoirs and to provide a better understanding of parameters controlling reservoir quality and producibility. In summer 2011 DGGS resumed stratigraphic and structural studies along the northwestern margin of the basin, in the Tyonek Quadrangle. This area includes some of the same rock formations that produce oil and gas in nearby fields such as Beluga, North Cook Inlet, and Granite Point. Features studied in outcrop are important for developing new techniques that will allow the productive life of these fields to be extended and help in the recognition of stratigraphic traps and reservoirs in tight formations.

There are many sedimentary basins in Alaska whose geological characteristics are conducive to natural gas, including unconventional gas. However, most of these basins are so poorly known that we do not have a realistic understanding of their gas potential. For example, the geology of the Susitna and Nenana basins suggests they could host natural gas in quantities that could be exploited for in-state use. In 2011 DGGS initiated a multi-year study of the natural gas potential of the Susitna basin, and is currently compiling available data and planning fieldwork in the Nenana basin for the 2012 field season. Information obtained from this work will add to the database of publicly available information on the petroleum geology of these basins, which will help stimulate private-sector exploration activity.

The Statewide Energy Resource Assessment program also is collecting new coal quality and stratigraphic data and working to implement a comprehensive statewide coal resource data file as part of an integrated DGGS geologic data management system.

DGGS has finished reviewing available information on potential geology-based energy resources for use by rural communities. This work summarizes available relevant information and identifies areas of the state where additional information is needed to better understand the true resource potential, and will be published in 2012. This information will ultimately be incorporated into the web-based interactive map currently hosted by the Alaska Energy Authority.

The numerous elements of the Statewide Energy Resource Assessment program are financed from a mixture of sources: General Fund, Industry Receipts, Federal Receipts, and Capital Improvement Project funding.

OBJECTIVES

1. Encourage active private-sector oil and gas exploration on the North Slope outside the Prudhoe Bay–Kuparuk field areas.
2. Collect and publish new geologic data to stimulate renewed, successful exploration for hydrocarbons in the Cook Inlet Basin.

3. Collect and publish new geologic data to stimulate exploration for natural gas in the Susitna and Nenana basins.
4. Provide DNR, other state agencies, and the public with authoritative information relating to the energy resources of the state so that rational policy and investment decisions can be made.

FY2012 ENERGY RESOURCES PROJECTS

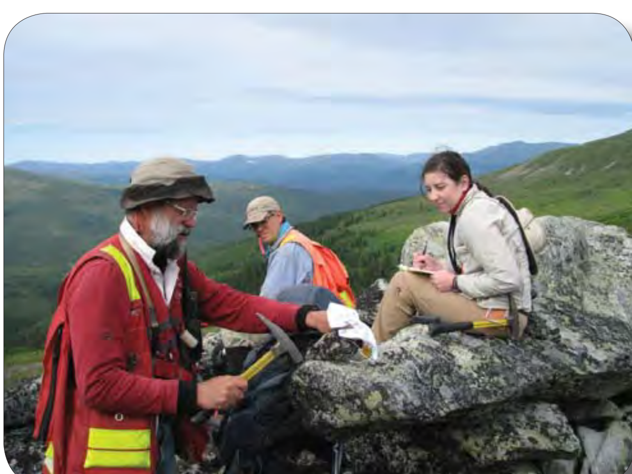
Detailed project summaries for the following energy resources projects appear in the section *Project Summaries—FY2012*:

In addition to the above projects, the Energy Resources section performs the following tasks:

- Provide written evaluations of mineable coal potential for lease areas in response to requests from Division of Mining, Land and Water.
- Respond to verbal requests from other state agencies, federal agencies, industry, local government, and the public for information on energy-related geologic framework and oil, gas, and coal resource data.

MINERAL RESOURCES

The minerals industry has been a significant and steadfast partner in the economic well-being of Alaska since the late 1800s. In more recent times, global demand for precious, base-metal, and strategic minerals is at an all-time high and Alaska's mineral reserves will play a significant role in helping to meet that rising demand. The minerals industry, however, has historically been reluctant to commit significant company resources to exploration anywhere without sufficient understanding of the geologic framework of their areas of interest. To attract exploration interest and to support responsible stewardship of Alaska's mineral endowment, DGGS conducts geological and geophysical surveys of the most prospective Alaska lands that are open to mineral and other geologic resource development. Alaska has an accessible state land endowment of more than 100 million acres, much of it selected under the Statehood Act because of perceived potential to host mineral wealth. Currently the overwhelming majority of these lands are not geologically or geophysically surveyed at a sufficiently detailed level, nor with the focus needed, to optimize mineral discovery and development. Since the early 1990s, a DNR/DGGS program of integrated geological and geophysical mapping has been effective in attracting new private-sector mineral investment capital to Alaska. Projects conducted by the Mineral Resources section are designed to produce, on a prioritized schedule, the critical new geophysical surveys, geologic maps, and reports needed to sustain Alaska's mineral industry investments and provide management agencies with information needed to formulate rational management policy.



The Mineral Resources section also shares responsibilities with the Geologic Communications Section in the Division-wide task of continuing the implementation of a publicly accessible, comprehensive, on-line, computerized Alaska geologic information database developed through the Minerals Data and Information Rescue in Alaska (MDIRA) program.

The numerous elements of the Mineral Resources section are financed from a mixture of sources: General Fund base budget, Capital Improvement Project funding, and Federal Receipts.

OBJECTIVES

1. Catalyze increased mineral resource exploration in Alaska.
2. Provide DNR, other state agencies, and the public with unbiased, authoritative information on the geologic framework and mineral resources of the state, to support rational land-policy and investment decisions.
3. Provide, in cooperation with the Department of Commerce, Community & Economic Development, an accurate annual statistical and descriptive summary of the status of Alaska's mineral industry.

FY2012 MINERAL RESOURCES PROJECTS

Detailed project summaries for the following Mineral Resources projects appear in the section *Project Summaries—FY2012*:

**MDIRA-supported project (see p. 15)*

In addition to the above projects, the Mineral Resources section performs the following tasks:

- DGGS Mineral Resource geologists provide timely responses to verbal and written requests for mineral information from other state and federal agencies, local government, industry, and the general public.
- Provide authoritative briefings about the status of Alaska's mineral industry, state support for mineral-resource ventures, and recently acquired geophysical and geological data at professional mineral industry conventions and trade shows, and in professional journals.

ENGINEERING GEOLOGY

The Engineering Geology program addresses major engineering-geology and geologic-hazards issues that affect public safety and economic well-being in developing areas of Alaska. DGGS conducts engineering-geologic mapping to determine the distribution and character of surficial deposits, their suitability for foundations, susceptibility to erosion, earthquakes and landslides, and other geologic hazards. Geologic evaluations of areas subject to major hazards like floods, earthquakes, volcanic eruptions, tsunamis, and landslides help to forecast the likelihood of future major events and the severity of hazards associated with them. In addition to General Funds, some elements of the Engineering Geology program are partially or largely financed through Federal and interagency receipts or state Capital Improvement funds.

In many areas, the state lacks the fundamental geologic data needed to guide the proper development and implementation of building codes, land-use zoning, right-of-way siting, and contingency planning for adverse natural hazards events. Loss of life and damage to infrastructure and buildings can be reduced through informed construction practices, land-use planning, building-code application, and emergency preparedness. However, economics and practicality dictate that mitigation measures be implemented first where risk is highest. Because hazards are not uniformly distributed, engineering-geologic and hazards maps become the first source of information about where damage is likely to be greatest and, therefore, where mitigation efforts should be concentrated. These maps are critical for emergency planning and the allocation of emergency-response resources prior to an adverse event.

The type of surficial-geologic mapping conducted for purposes of identifying geologic hazards and locating sources of construction materials is also of benefit for locating placer-mineral deposits. For this reason, engineering-geology personnel often participate in teams with DGGS's mineral-resources geologists to map areas of interest for minerals exploration.

A major continuing program headed by the Engineering Geology section, but also involving members of the Mineral Resources section, is the geologic mapping and hazards evaluation of the proposed natural gas pipeline corridor from Delta Junction to the Canada border. The purpose of this multi-year project is to provide detailed geologic information for a 12-mile-wide corridor on which to base alignment decisions, engineering design, permitting, and planning for future development along the Alaska Highway. Following acquisition of high-resolution airborne geophysical data in 2006, DGGS began collecting field data from Delta Junction eastward. More recently, DGGS acquired high-resolution airborne lidar (Light Detection and Ranging) data along this corridor, which has enabled significant refinement of the geologic mapping and more thorough evaluation of potentially active faults and other hazards. Fieldwork was largely complete by 2010, with a minor amount of additional field assessment in 2011 and 2012 and final reports and maps to be published in 2012.

Major new projects have been developed in response to the overwhelming need for baseline geologic mapping and natural hazards evaluations in and near communities and important infrastructure that are being affected by severe problems. Funded by the federal Coastal Impact Assistance Program, the DGGS Coastal Hazards program is undertaking an ambitious 5-year mission to evaluate surficial geology and geologic hazards in up to 19 Alaska coastal communities that are at risk for serious erosion and flooding hazards. Thawing permafrost

and possible sea level changes are also a growing concern for many Alaskan communities. DGGS recognizes the importance of reliable scientific information to help the state and its communities prepare for potential emergency situations resulting from geologic hazards, including those that are affected or amplified by climate change. The Climate Change Hazards program performs geologic studies to identify high-risk areas where proactive mitigation efforts will be needed and useful, as well as evaluating proposed relocation sites for communities faced with the immediate need to move to a safer location. Additionally, new DGGS expertise in the field of neotectonics (active faulting) is dedicated to identifying and understanding active faults and earthquake hazards in developing areas of the state.

OBJECTIVES

1. Help mitigate risks to public safety and health by providing information on geologic hazards as they affect human activity.
2. Provide geologic information to help lower the costs of construction design and improve planning to mitigate consequences arising from hazardous natural geologic events and conditions.
3. Provide reliable engineering-geologic data for informed land-use decisions by the government and private sector.
4. Identify sources of sand, gravel, rip-rap, stone, and other geologic construction materials required to create the infrastructure, roads, and other land-based transportation corridor improvements necessary to support expanded development of natural resources and other local economic activities in Alaska.
5. Identify potential sources of placer minerals in conjunction with minerals resources mapping projects.

FY2012 ENGINEERING GEOLOGY PROJECTS

Detailed project summaries for the following Engineering Geology projects appear in the section *Project Summaries—FY2012*:

In addition to the above projects, the Engineering Geology section performs the following tasks:

- Produce written evaluations of potential hazards in areas of oil exploration leases, land disposals, permit applications, and other proposed development projects, and respond to verbal requests for information from other state agencies, local government, and the general public.
- When appropriate, conduct post-event hazard evaluations in response to unexpected major geologic events (for example, earthquakes and severe coastal flooding and erosion), providing timely information dispersal to the public via electronic as well as traditional methods, and providing event and continuing hazard information to appropriate emergency management agencies.

VOLCANOLOGY

The Volcanology program of DGGS works as part of the Alaska Volcano Observatory (AVO), an interagency consortium, to mitigate hazards from Alaska volcanoes. AVO was formed by Memorandum of Understanding in 1988. Its partners are DGGS, the U.S. Geological Survey (USGS), and the University of Alaska Fairbanks Geophysical Institute (UAF/GI). The Director of DGGS established Volcanology as a separate section in early 2007.

AVO studies volcanoes to increase understanding of hazards at particular volcanoes and how volcanoes work in general; monitors volcanoes using seismology, geodesy, satellite remote sensing, field studies, and local observers; and provides timely and accurate warning of increasing unrest and eruptions to emergency management agencies, other government entities, the private sector, and the public. The majority of Alaska's 52 historically active volcanoes are remote from human settlements, but all underlie the heavily traveled north Pacific passenger and cargo air routes between North America and Asia; thus the aviation sector is an important recipient of AVO monitoring reports. The vulnerability of local infrastructure to active volcanoes was illustrated by the near flooding of the Drift River Oil Terminal by lahars (volcanic mudflows) generated on three separate occasions during the spring 2009 eruption of Redoubt Volcano. In addition, important transportation hubs at Cold Bay, Unalaska/Dutch Harbor, and Adak are all downwind from nearby active volcanoes, and construction began in the spring of 2010 on a ~4,500-foot airstrip 15 miles downwind from Akutan Volcano.

The three component agencies of AVO each bring particular strengths to the observatory, while sharing general expertise in volcanology. Among these agencies, DGGS is a leader in outreach, geologic studies, and petrologic and geochemical studies. DGGS builds and maintains the AVO website, serving a large database of descriptive material about volcanoes, providing a cutting-edge system for intra-observatory communication and data sharing, and providing notices of eruptions and unrest to users in public, private, and government sectors. The database and information dissemination tools built around the database have emerged as the most powerful such tool among volcano observatories worldwide, and portions of the software designed and written at DGGS are in use at other volcano observatories, both nationally and internationally. Particular strengths of the USGS are the federal hazards mandate and direct ties with federal agencies. UAF/GI brings a research focus and access to technological resources (such as satellite data downlink centers) beyond the financial capability of other AVO partners. All agencies have fundamental expertise in the many scientific and technical disciplines that comprise volcanology.

Funds for DGGS participation in AVO come from cooperative agreements with the USGS through the USGS Volcano Hazards Program. In the past, the remainder of the funding has come through congressionally authorized programs in other departments, including Transportation (DOT) and Defense (DOD). Most recently, AVO has had support through the American Reinvestment and Recovery Act (ARRA). However, DOT, DOD, and ARRA funds have expired.

OBJECTIVES

1. Help mitigate risks to public safety and health by providing information on volcanic hazards as they affect human activity.
2. Represent the State of Alaska's interests in the multiagency Alaska Volcano Observatory.
3. Develop and maintain the Alaska Volcano Observatory website as a primary communications vehicle to deliver information about Alaska's volcanoes to the public and provide internal communications and data exchange among AVO personnel.
4. Provide comprehensive information on Alaska volcanoes, including past history and current activity, to the general public, agencies, and volcanologists worldwide.

FY2012 VOLCANOLOGY PROJECTS

Detailed project summaries for the following Volcanology projects appear in the section *Project Summaries—2012:*

In addition to the above projects, the Volcanology section performs the following tasks:

- Assist AVO in volcano monitoring. AVO monitors volcanoes using short-period seismometers, broadband seismometers, continuous telemetered GPS, satellite imagery, gas measurements, web cameras, and local observer reports. AVO maintains seismic networks on about 30 active volcanoes (up from four in the mid-1990s), and monitors more than 100 volcanoes twice daily by satellite. While not a primary DGGS activity, DGGS assists in volcano monitoring when needed during eruption crises.
- Provide advanced GIS expertise to all component agencies in AVO. This includes producing base maps in areas where 1:63,360-scale topographic maps do not exist, retrieving and georegistering maps from discontinued map series, and producing a variety of other georegistered data products. DGGS also provides expertise in finalizing and troubleshooting GIS-based map publications using standard GIS techniques for numerous projects in all AVO component agencies. DGGS is currently leading the effort in AVO to make a web-accessible catalogue of GIS resources.
- Provide helicopter and fixed-wing airplane logistics. DGGS manages helicopter charter procurement for all major AVO projects, and fixed-wing charter for volcanic gas measurement flights. Having all the contracting done by a single agency results in significant budgetary and logistic efficiencies.
- Perform geochemical data procurement and archiving, coordinating geochemical analyses, and maintaining the archive of those data. The data share rigid inter-project quality controls, making the combined dataset a major resource for researchers, and adding substantially to the value of the data from individual geologic mapping projects.
- Represent DGGS to CUSVO/NVEWS. DGGS is one of the charter members of the Consortium of U.S. Volcano Observatories (CUSVO), which provides coordination among the five volcano observatories in the United States. The National Volcano Early Warning System (NVEWS) is a major emerging initiative of CUSVO; the DGGS project leader serves on the NVEWS steering committee.
- Provide information on geothermal resources to state and federal agencies, the private sector, and the public.

GEOLOGIC COMMUNICATIONS

The Geologic Communications Section provides information technology, publication, and outreach services to make Alaska geologic and earth science information accessible to the public, private industry, government, and academia. 'GeoComm' team members work together to complete final design and production of reports and maps, maintain and upgrade the division's Digital Geologic Database, update and improve the DGGS website, and ensure the entire division has the infrastructure (GIS tools, network, computer equipment, etc.) and skills necessary to efficiently perform their responsibilities.

The section's publications specialists edit, complete the layout, publish, and distribute technical and summary reports and maps generated by the Division's technical projects describing Alaska's geologic resources and hazards. The maps and reports released with the help of this group are the state's primary means for widely disseminating detailed information and data relating to Alaska's subsurface mineral and energy wealth, geologic construction materials, and geologic hazards. These printed or digital-format documents and datasets focus on Alaska's most geologically prospective and developable lands and are the authoritative geologic basis for many of the state's resource-related land-policy decisions. They also encourage geologic exploration investment leading to resource discoveries and subsequent major capital investments and job opportunities. Timely availability of geologic information from DGGS encourages investment in Alaska's economy, helps foster wise land-use management, and helps mitigate the adverse effects of geologic hazards.

The section's geologic information center ensures that information produced by the division is delivered to the public on a wide range of topics including mineral and energy resources, construction materials, earthquakes, volcanoes, permafrost, and other hazards. It assists customers in understanding geological and geophysical maps, and manages sales and inventories of geologic reports, maps, and digital data. Additionally, the information center prepares displays and represents the division at geologic conferences and events.

The Geologic Communications Section produces this annual report, which presents a summary of division activities and accomplishments; publishes newsletters to communicate division progress and announce recent publications; designs, edits, and produces technical and educational geologic maps and reports in printed and digital formats; manages the DGGS library/repository of printed literature so that reports (by DGGS and other agencies) are available as resources for geologic staff use; and participates in outreach activities such as classroom presentations, science fair judging, and providing resources for teachers to help with preparing earth science learning units.

DGGS's digital geologic database (Geologic & Earth Resources Information Library of Alaska [GERILA]) has three primary objectives: (1) Maintain this spatially referenced geologic database system in a centralized data and information architecture with networked data access for new DGGS geologic data; (2) create a functional, map-based, on-line system that allows the public to find and identify the type and geographic locations of geologic data available from DGGS and then retrieve and view or download the selected data along with national-standard metadata (http://www.dggs.alaska.gov/pubs/); and (3) integrate DGGS data with data from other, related geoscience agencies through a multi-agency web portal (http://www.akgeology.info/).

The Geologic Communications Section sets up and maintains microcomputer and server hardware and software and network, provides Geographic Information System (GIS) service and support to DGGS staff, and streamlines information delivery to the public. The section developed the division's website and began extensive use of the Internet in FY98 to increase the availability of the Division's information and to provide worldwide access to the information about the geology of Alaska. These efforts developed into a major project to establish, maintain, and enhance a state–federal, multi-agency, Internet-accessible Alaska geologic database management system. Federal funding provided several years of support for an extensive effort to scan, convert to digital format, and post the entire hardcopy DGGS collection of publications on our website. The U.S. Geological Survey (USGS) provided additional funds to do the same for all pre-digital Alaska-related USGS publications and make them available via the DGGS website. Recent additions to the DGGS website include the Alaska minerals-related publications of the former U.S. Bureau of Mines, additional USGS publications, and publications produced by the University of Alaska Fairbanks Mineral Industry Research Laboratory (MIRL).

The Geologic Communications Section is supported by the state General Fund, Program Receipts from publication sales, and Federal Receipts.

OBJECTIVES

1. Disseminate new, accurate, unbiased, Division-generated data describing Alaska's geology, as well as selected pertinent data from other sources, to DNR and other State policy and regulatory groups, to the public at large, and to all other interested parties, within one year of its acquisition.
2. Preserve and manage the data and knowledge generated by the Division's special and ongoing projects in an organized, readily retrievable, and reproducible form consistent with pertinent professional standards and documented with national-standard metadata.
3. Enhance public awareness of Alaska's prospective mineral and energy resources and geologic hazards.

FY2012 GEOLOGIC COMMUNICATIONS PROJECTS

Detailed project summaries for the following Geologic Communications projects appear in the section *Project Summaries—FY2012*:

**MDIRA-supported project (see p. 15)*

GEOLOGIC MATERIALS CENTER

The Alaska Geologic Materials Center (GMC) in Eagle River archives and provides public access to non-proprietary oil, gas, and coal drill cores and drill-cutting samples, rock cores from mineral properties, and processed ore, oil, gas, coal, and source-rock samples. These samples are analyzed by government and private-sector geoscientists with the goal of improving the odds of finding new oil, gas, and mineral deposits that will maintain the flow of state revenues and provide in-state employment. The Geologic Materials Center Project is supported by the General Fund budget and in-kind contributions from industry. Additional financial support is received annually from the Alaska Oil & Gas Conservation Commission. The private sector contributes the cost of delivering all new samples, sample preparation and analyses, sample logs, and data logs, and occasionally donates storage containers and/or shelving.

The GMC holdings are a continually growing asset that is compounding in value over time at little cost to the state. Three

Division geologists, a contract geologist, two student interns, and several volunteers staff the facility. The GMC has formal cooperative agreements with the U.S. Geological Survey, the U.S. Bureau of Ocean Energy Management, and U.S. Bureau of Land Management to house and control their geologic materials from Alaska. A voluntary 14-member board advises the curator and DGGS on matters pertaining to the GMC.

With federal funding and through a Reimbursable Services Agreement with the Department of Transportation & Public Facilities (DOTPF), DGGS recently completed a concept study for construction of a new materials center to replace the existing GMC. The sample collection long ago exceeded available warehouse space, with the overflow now occupying 60 unheated tractor–trailer type portable storage containers. Limited space and unsuitable site conditions preclude significant expansion at the existing site in Eagle River. DGGS is exploring various options for replacing the facility. The 2006 concept study report is available on the GMC web page (http://dggs.alaska.gov/gmc/). DGGS has begun design work for a new facility through DOTPF with support of state Capital Improvement Project (CIP) funds and has drafted an inventory transfer plan. A private engineering firm contracted by DOTPF is conducting the design work.

OBJECTIVES

1. Encourage responsible resource development and in-state employment opportunities by increasing accessibility to representative geologic samples and information pertaining to oil, gas, and mineral exploration.
2. Advance the knowledge of the geology and resources in Alaska's structural basins favorable for oil or gas discovery.
3. Advance the knowledge of Alaska's mineral potential by making available representative samples of ores and drill cores from mineral deposits throughout the state.

A detailed project description for the Geologic Materials Center appears in the section *Project Summaries–FY2012* (p. 79).

ADMINISTRATIVE SERVICES

The Administrative Services group provides financial control and administrative support for all other projects in the Geological Development component including: securing lowest costs for goods and services; coordinating maintenance for state equipment fleet vehicles, and when necessary, procuring vehicles for fieldwork; coordinating travel arrangements and appropriate paperwork to minimize travel expenses and field party subsistence costs; administering and monitoring grants and contracts; tracking and reporting project expenditures to ensure cost containment within budget for all projects; providing mail/courier services; providing assistance in personnel matters; and any other support necessary to increase efficiency or savings in acquiring and disseminating knowledge of the geology of Alaska.

OBJECTIVE

1. Facilitate the efficient administration of DGGS programs and projects.

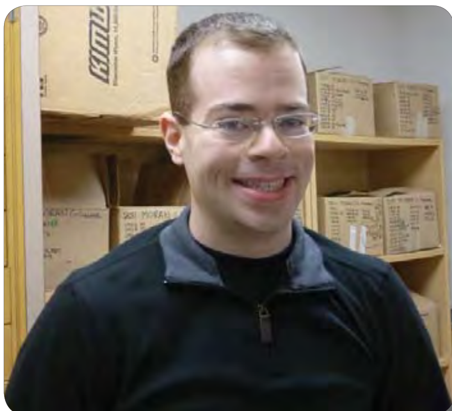
TASKS

- Monitor grants and contracts (Federal, Interagency, CIP, and Program Receipts) to ensure deliverables are produced on schedule and within budget; ensure expenses are timely and properly billed against grants and contracts and receipts are collected promptly; ensure progress reports and financial paperwork are submitted accurately and on time.
- Provide accurate, timely reporting of project expenditures and current balances to project managers; encourage prudent money management.
- Provide accurate, timely processing of employee timesheets, vendor invoices, procurement records, and other documentation required by the State; ensure strict adherence to State archiving requirements.

- Minimize the cost of transportation to and from the field by coordinating personnel travel and supply shipments.
- Coordinate Division vehicle use to minimize requests for reimbursement for personal vehicle mileage.
- Make travel arrangements and complete travel authorizations to ensure use of the most cost-effective travel options.
- Assist staff with personnel matters; inform staff of changes in personnel rules or benefits and ensure that all personnel paperwork complies with applicable rules and regulations. Estimate future personnel salaries and benefits to assist management in making human resource decisions necessary to efficiently accomplish the division's mission.

EMPLOYEE HIGHLIGHTS

WELCOME



Geologist **Michael Blessington** joined DGGS's Mineral Resources Section in September 2011 to assist with an ongoing project to explore, quantify, and assess Alaska's potential for rare-earth-element mineral production. Project duties involve compiling geochemical and spatial data from previous mineral exploration projects as well as sample preparation and future field-related duties.

Michael was born and raised in Eagle River, Alaska, and has been interested in the geosciences since a very young age. He earned a B.S. in Geological Sciences from Arizona State University in fall 2008, and subsequently participated as a volunteer in a project at the university's Planetary Science Laboratory. The experiment involved eolian processes on the surface of Mars and included wind-tunnel modeling and field studies of terrestrial analogues. He then returned to Alaska to begin a professional career in Geology.

Meagan DeRaps joined DGGS in March 2011 as a Geologist in the Engineering Geology Section's new Coastal Hazards Program.

She was born and raised in Tampa, Florida, but soon after graduating from high school headed out West, where she earned her B.S. in Earth Science from Montana State University. While at Montana State she got her first taste of Alaska geology with fieldwork and an undergraduate thesis in basalt geochemistry of the Pribilof Islands.

She went on to earn her Master's degree in Environmental Geoscience from Utah State University. Her research there focused on the volcanic evolution of the western Snake River Plain, Idaho, and included geologic mapping and stratigraphic interpretation of phreatomagmatic deposits. Her time at Utah State also included an internship with the Bureau of Land Management's Shoshone Field Office and fieldwork for a USU tight gas reservoir fracture characterization study. In 2009 she moved with her husband to Fairbanks, where she worked as a geologist with an engineering firm engaged in environmental remediation.

In her free time, Meagan enjoys the company of her husband and two dogs while sailing the magnificent coastline of Prince William Sound, riding the rolling hills of the Interior (by bike, ski, or sled), and exploring the vast wilderness that is their backyard.

Trevelyn Lough began her work at DGGS in June 2011 as a geologist with the Mineral Resources section. She spent her first two months in the field near Tanana managing the database for the Moran STATEMAP project. She performs various tasks in support of the Moran project, including database management, sample preparation, XRF analysis, GIS data generation, and publishing the project's geochemical data.

Although born in Texas, Trevelyn was raised in Minnesota. She earned a B.A. from Hamilton College in 2008 with a major in geoscience and minor in mathematics. Her senior thesis focused on using magnetic susceptibility to characterize the deformational history of a domical feature in the Payne Lake body of the Adirondack lowlands in upstate New York.

Trevelyn moved to Alaska in January 2011 as she was finishing her M.S. in geology from the State University of New York–Buffalo (SUNY Buffalo). For her thesis, she generated three geologic maps of a volcanologically complex region of the Moon using three mapping techniques to more clearly understand the geologic uses and limitations of different data types, especially when field studies are not possible.

When not at work, Trevelyn enjoys reading, hiking, yoga, capoeira (a Afro-Brazilian martial art), and brewing beer and cider.

James (Jim) Weakland started working with DGGS in February 2011 as a geographic information system (GIS) analyst in the Geologic Communications Section. He is updating legacy geologic mapping techniques to take advantage of GIS software advances and current geologic mapping standards. He is also focused on instituting division standards for GIS data creation, storage, and archiving; converting legacy analog and digital geologic information to current digital data formats; and creating web mapping applications for customers without access to GIS software.

Originally from Virginia, Jim earned his B.S. in Liberal Studies with a focus in Geography from Excelsior College in 2006. Jim is studying at The Pennsylvania State University (Penn State) for his Post Baccalaureate Certificate in Geographic Information Systems. Prior to working for DGGS, Jim had extensive experience mapping southern California, Japan, Australia, Thailand, Indonesia, the Philippines, the Korean Peninsula, and the Middle East. He also has experience in geodetic and topographic surveying for southern California, Hawaii, and Japan.

Outside of the office, Jim enjoys learning new GIS technology, reading, gardening, and cooking.

MORE THAN 25 YEARS

In 2011 Governor Parnell recognized geologist **Christopher (Chris) Nye** for 25 of service to the State of Alaska. Chris grew up in Vermont and went to grade school across the street and high school across the river (class of 1970). He first came to Fairbanks in early January of 1973, and other than a five-winter stint at UC Santa Cruz, has remained in Fairbanks. At UAF, he earned a B.S. in Geology in 1976 and an M.S. in Geology in 1978. The M.S. thesis involved mapping ~60-million-year-old volcanic rocks in what was then Mt. McKinley National Park under the direction of Wyatt Gilbert, a DGGS stalwart of the 1970s. His Ph.D. thesis (UC Santa Cruz, 1983) revolved around detailed geochemistry and magma-genesis at two volcanoes, Wrangell and Okmok. Both volcanoes turned out to be archetypal in at least one major aspect of volcanism, and continue to serve as robust bookends for his growing shelf of diverse volcanological understanding.

Chris started his career with DGGS in the geothermal resource evaluation program, charged with folding the geologic perspective of volcano-hosted geothermal systems into the picture sketched by hot springs and their chemistry. The first major project included mapping and petrologic studies to accompany the geothermal drilling program at Makushin Volcano in 1982 and 1983. A second major project, at Mt. Spurr, was well underway when interrupted by 'The Great Alaska Budget Catastrophe of 1986.' A 50 percent drop in oil prices resulted in an 85 percent downsizing of DGGS—mostly through restructuring, and, incidentally, in Chris's layoff. He got married, and moved himself and the mostly-completed Spurr project to the UAF Geophysical Institute. While at the GI he was co-Principal Investigator on the last large DOE-funded geothermal program in Alaska, which was at Geyser Bight, 90 miles west of Unalaska. The same drop in oil prices that had been catastrophic for the Alaska budget resulted in a national hiatus in alternative energy development—and the termination of funding for the federal programs that had supported the geothermal work.

Chris returned to DGGS to lead an EPA-funded study of indoor radon. The radon hazard had exploded onto the national scene when a worker at a nuclear plant started setting off radiation alarms on his way *in* to work in the morning, and there was a scramble nationwide to see how widespread and severe this newfound hazard was. This project used techniques new to Chris—a statistically representative statewide survey implemented using 10 telephone operators and thousands of pieces of mail.

As the radon project was winding down in 1989, serendipity struck again—Redoubt Volcano erupted. All available hands claiming any basic knowledge of volcanoes or data management were pressed into frenetic work. Drift River Oil Terminal was threatened; ash-fall shorted out transformers, taking out power throughout the Kenai; holiday air traffic in and out of Anchorage was chaotic; and a Boeing 747 full of passengers lost power in all engines and came within a few short minutes of crashing. Chris's twins were born in May of 1990—the second major 'eruption' of the year—a life change with a lasting, engrossing, and rewarding impact.

After the ash had settled, the 1989–1990 Redoubt eruption emerged as the second-most-costly eruption in U.S. history. Chris became the State of Alaska's representative to the newly created Alaska Volcano Observatory (AVO), which had been formed as a cooperative interagency program (USGS, UAFGI, DGGS) in 1988. With the Redoubt impact, AVO's annual budget leapt from hundreds of thousands to millions of dollars, and the modern AVO was born. AVO has been busy ever since, monitoring more active volcanoes and more eruptions than any other volcano observatory on earth. The geologic, petrologic, and geographic diversity of eruptions led to the use of multiple data streams—from space to geophysics to geology to local observers. Chris found the interdisciplinary science required to understand how volcanoes work—and how unrest might or might not lead to one of several types of eruption—exhilarating, and came to consider himself a volcanologist more than geologist. He was bemused to also find himself strongly attracted to the particular demands required in making an interagency program function smoothly, such as building and fostering an understanding and respect of divergent agency cultures and how those differences manifest interpersonally. Chris has had the honor and satisfaction of leading DGGS activities within AVO for the past 20+ years, and of representing the state's interests among the federal and university interests that form the other legs of the three-legged stool that is AVO.

Chris has found myriad satisfactions in his job: Intellectual stimulation; societal relevance; an intriguing labyrinth of an organizational structure; time to study one of the few aspects of geology where the mantle-deep evolution of the planet acts on a human timescale; and the fantastic fun of exploding mountains. Within DGGS he has found organizational flexibility and the autonomy that comes with sustained external support.

PROJECT SUMMARIES—FY2012

Alaska faces the challenge of growing a healthy economy from its natural resources while protecting an environmental legacy that is the envy of many. The Department of Natural Resources' Division of Geological & Geophysical Surveys is an integral partner in the team of state agencies that strive to meet this challenge. The output from our projects provides the fundamental earth-science information required to guide critical policy decisions, encourage exploration investment, mitigate the effects of geologic hazards, and improve the quality of life for all Alaskans.

The overviews of the following 50 projects that DGGS is pursuing in FY2012 span the scope of our legislative mission statement.

Each of these projects is making a positive difference for Alaska. Many are implemented through various cooperative agreements with other state and federal agencies, universities, in-house project teams, and contracts. We leverage state General Funds through these arrangements so that the Division's work provides the greatest possible benefit from the public's investment.

ENERGY RESOURCES

MINERAL RESOURCES

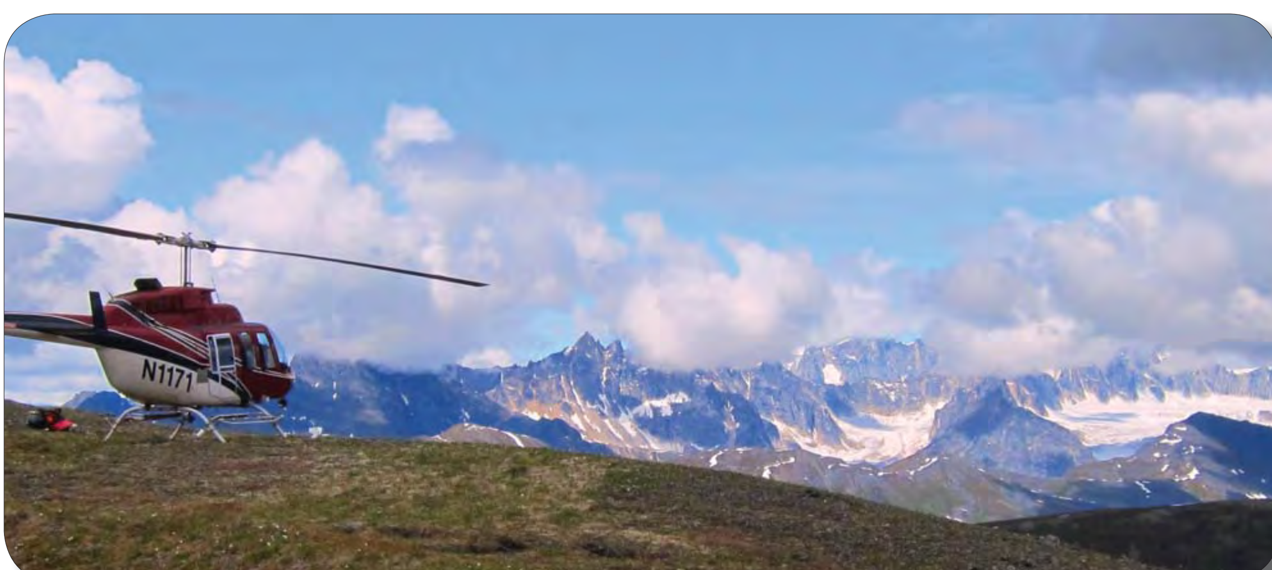
ENGINEERING GEOLOGY

*MDIRA-supported project (see p. 15)

Volcanology

Geologic Communications

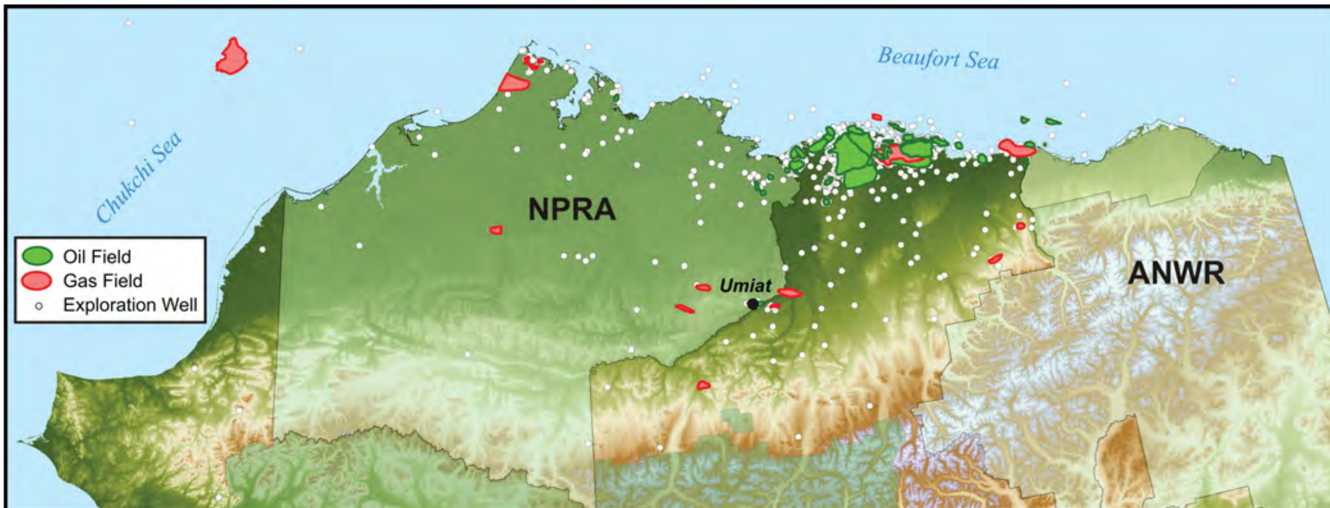
Geologic Materials Center



MDIRA-supported project (see p. 15)

BROOKS RANGE FOOTHILLS & NORTH SLOPE PROGRAM

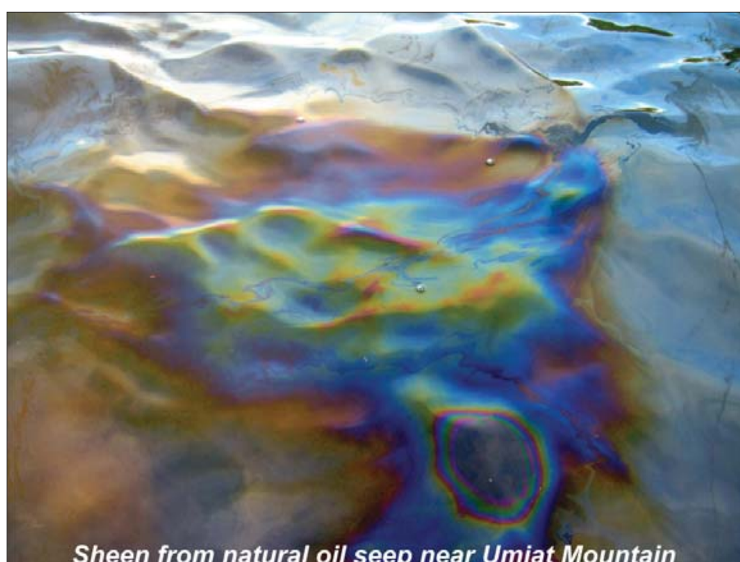
Northern Alaska is a world-class petroleum province that includes some of the most prospective onshore regions remaining in North America. Despite this potential, the North Slope remains underexplored relative to other sedimentary basins around the world. New exploration ventures are hampered by the limited amount of published geologic data, much of it reconnaissance in nature. This problem is particularly acute for smaller companies with limited access to proprietary industry data. In an effort to stimulate exploration for hydrocarbons in northern Alaska, DGGS developed a program to acquire and publish high-quality geologic data to improve our understanding of regional petroleum systems, entice new exploration investment, and support responsible resource and land-use management. The cost of this program is shared by industry, the State of Alaska, and federal government. While directed by DGGS, this research effort is a multi-agency collaboration that includes the Alaska Division of Oil & Gas (ADOG), the United States Geological Survey (USGS), the University of Alaska, and others.



The limited exploration and development on the central North Slope partly reflects the region's remoteness and lack of infrastructure. To help stimulate industry activity, the State is pursuing the construction of a road to the undeveloped oil and gas fields in the Umiat area (see map). During the 2011 field season, our program conducted detailed geologic mapping and associated studies in the area of the proposed transportation corridor (see p. 31). Our work includes examination of the sedimentology and stratigraphy of key Cretaceous-age reservoir and source-rock intervals, providing new constraints on the depositional history and correlation of units. This type of detailed analysis of outcrop geology leads to improved models for subsurface hydrocarbon accumulation.

Over the past several years we have also collaborated closely with the State Division of Oil and Gas to interpret available seismic and well data on the North Slope. The integration of our surface structural and stratigraphic observations with subsurface data has allowed for an improved understanding of basin evolution and regional exploration potential.

During 2011, DGGS delivered a number of technical presentations at regional and international petroleum geology conferences, summarizing the results of our recent work relevant to oil and gas exploration in northern Alaska. We also published more than 600 square miles of detailed geologic mapping of prospective State lands on the eastern North Slope, adjacent to ANWR. Additional geologic maps will be published through DGGS in 2012 (see p. 31) as well as a collection of papers summarizing topical structural and stratigraphic studies.



Sheen from natural oil seep near Umiat Mountain

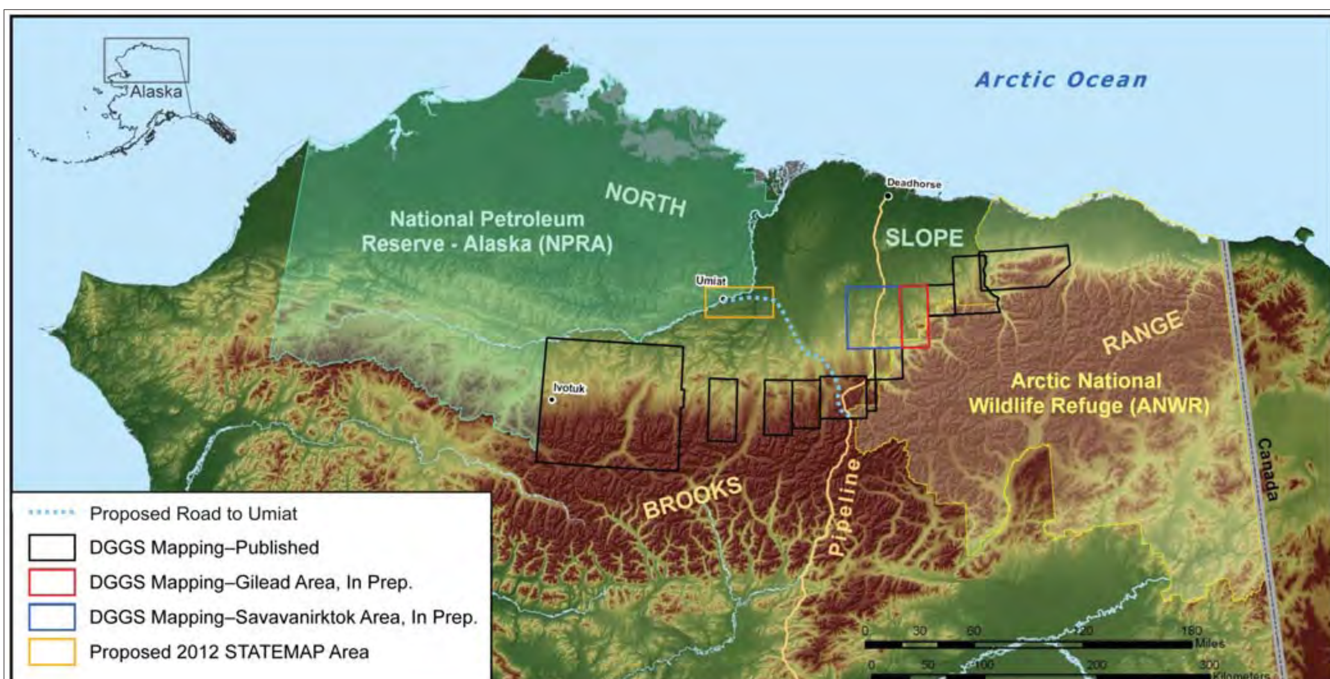
Contact: Marwan A. Wartes, 907-451-5056, marwan.wartes@alaska.gov

GEOLOGIC MAPPING ON THE NORTH SLOPE

Many regions of the North Slope that are prospective for oil and gas exploration are covered by tundra, thus limiting the collection of geologic data to very costly subsurface methods such as seismic reflection and drilling efforts. However, geologic investigation of related rocks exposed at the surface in the northern foothills of the Brooks Range offers a unique opportunity to study structural and stratigraphic relationships, often resulting in predictive insights into the subsurface petroleum geology elsewhere on the North Slope. The Energy Resources Section of DGGS conducts bedrock geologic mapping as an integral component of the Brooks Range Foothills and North Slope Program (see p. 30). Our long-range objective is to produce a series of contiguous, detailed geologic maps along the entire foothills belt. These maps will establish the regional geologic framework necessary to understand the evolution of the petroleum system needed to support resource management and industry exploration on State lands. In addition, our ongoing work provides critical baseline geologic information that helps constrain the resource potential and long-term supply for the Trans-Alaska Pipeline System and the proposed natural gas pipeline.

During recent summer field campaigns we completed detailed 1:63,360-scale geologic mapping of approximately 1,800 square miles of the eastern North Slope (red and blue box above). We have also conducted preliminary mapping in the Umiat area (yellow box) and propose to conduct additional work in this prospective region during 2012. In collaboration with the Alaska Division of Oil and Gas, we have integrated our surface observations with available subsurface data (seismic and wells) to arrive at a more robust interpretation of the petroleum geology. The new mapping has improved our understanding of fold geometry, which is a key component in evaluating hydrocarbon trapping mechanisms. Detailed stratigraphic observations also enhance our knowledge of how Upper Cretaceous rocks correlate with one another, allowing for improved models explaining the distribution of potential source and reservoir rocks in the subsurface.

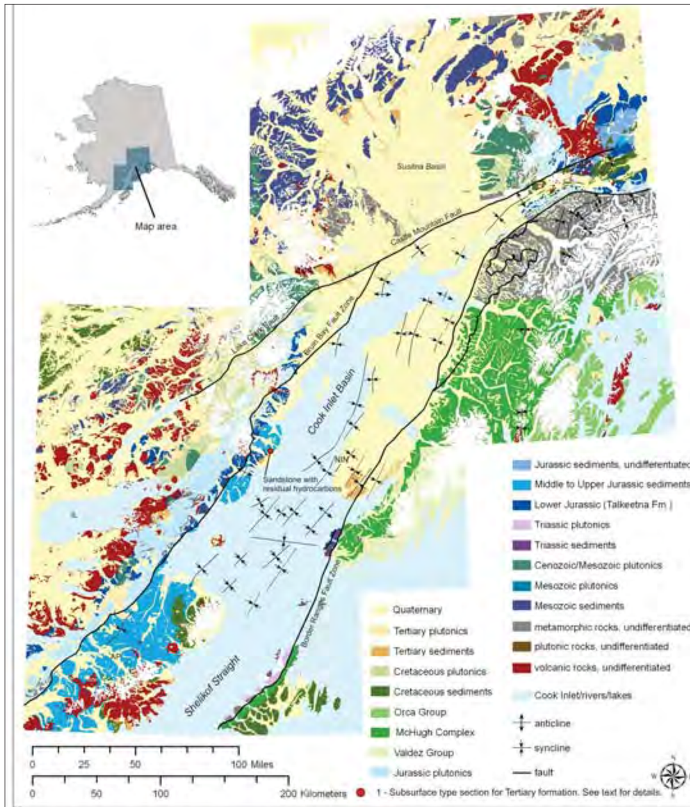
This work is supported in part by the federally funded STATEMAP program administered by the U.S. Geological Survey (USGS). The Sagavanirktok River and Gilead Creek map products will be published by mid 2012 as DGGS Reports of Investigation.



Contact, Sag River map area: Robert J. Gillis, 907-451-5024, robert.gillis@alaska.gov
Contact, Gilead map area: Trystan M. Herriott, 907-451-5011, trystan.herriott@alaska.gov
Contact, Umiat-Gubik map area: Marwan A. Wartes, 907-451-5056, marwan.wartes@alaska.gov

COOK INLET GEOLOGY AND HYDROCARBON POTENTIAL

Increasing demand and predicted deliverability shortfalls for Cook Inlet gas to south-central Alaska customers, combined with significant oil production declines, pose serious threats to the region's economy. The Alaska Division of Geological & Geophysical Surveys (DGGS) is responding to these challenges by leading a multi-year, multi-agency program of applied geologic research to promote new exploration investment and support responsible resource and land-use management. This collaborative effort involves DGGS, the Alaska Division of Oil & Gas (DOG), the University of Alaska Fairbanks, and the U.S. Geological Survey.



Generalized geologic map of Cook Inlet basin. Modified from Wilson and others, U.S. Geological Survey Open-File Report 2009-1108

Generalized geologic map of Cook Inlet basin. Modified from Wilson and others, U.S. Geological Survey Open-File Report 2009-1108.

Historically, Cook Inlet exploration has focused on locating large fold structures with four-way closure (analogous to an inverted bowl). Most large structures have been found and tested, and the exploration focus is gradually shifting to subtle stratigraphic traps, reservoirs in formations with low porosity and permeability, and source reservoirs (shale oil and shale gas). Successful exploration for these more elusive reservoirs requires detailed knowledge of potential reservoir geometries, geologic factors controlling them, and geologic controls on reservoir producibility. The initial goal of this program is to improve understanding of reservoir geometries, reservoir quality, their geologic controls, and the structural history of Cook Inlet basin.

During 2011, DGGS and DOG continued documenting the geometry of potential reservoir sand bodies in Tertiary- and Mesozoic-age sandstones in the Capps Glacier–Beluga River region west of Anchorage and along the west side of lower Cook Inlet, due west of Anchor Point (see map, right). Work in the former area focused on documenting alluvial fan and gravelly and sandy river deposits along the western basin margin, and basin-bounding structures that deform them. Detailed stratigraphic and structural studies by our group have demonstrated these rocks were deposited during a period of active faulting and volcanic activity, both of which dramatically affected sand body geometries and reservoir quality, and were subsequently subjected to complex folding and faulting. Work in the latter area focused on documenting sand body geometries, reservoir quality, and petroleum-source-rock potential of Middle Jurassic- through Lower Cretaceous-age rocks in coastal exposures. An exposure of sandstone with residual oil, located east of Iliamna Volcano, was sampled for geochemical analysis (see outcrop photograph). Oil extracted from this sample has provided valuable information on petroleum source rocks known to underlie much of the basin. Important additional components of this program include (1) integrated analysis of reservoir potential and quality of Mesozoic sandstones in lower Cook Inlet and Cenozoic sandstones in upper Cook Inlet; (2) a subsurface mapping effort aimed at delineating the distribution of petroleum source rocks relative to thick accumulations of potential reservoir sandstones; (3) structural analysis of basin-bounding faults; (4) analysis of the subsidence and uplift history of upper Cook Inlet basin using publicly available well data; and (5) a detailed bedrock mapping project along the northwestern basin margin (see p. 33).

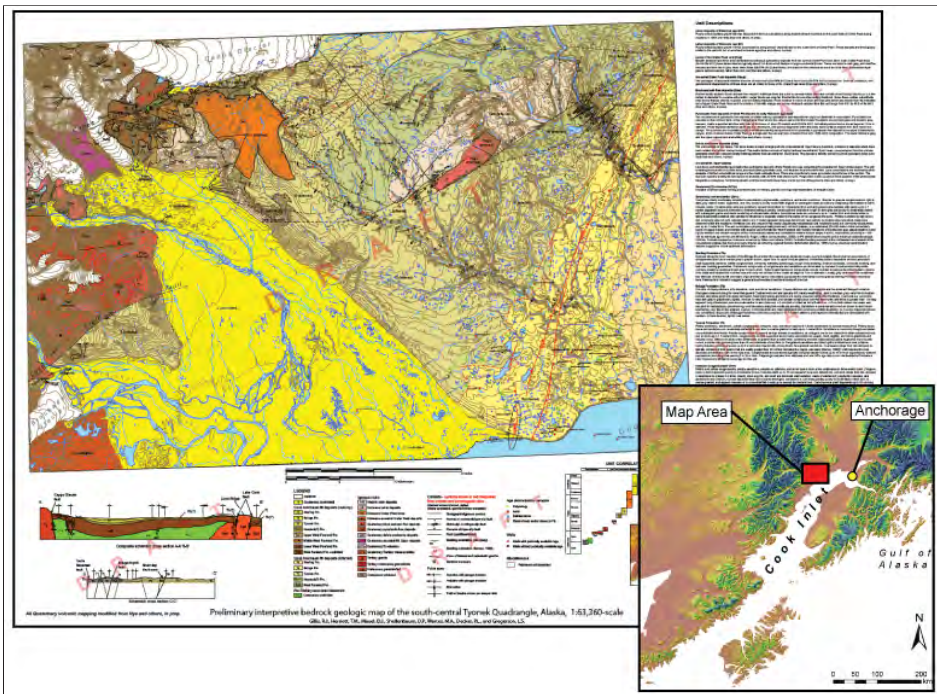
This project is funded by the State of Alaska and the U.S. Geological Survey, with contributions by Apache Corporation. Results of this work have been documented in a series of publications available from the DGGS website (http://www.dggs.alaska.gov). Additional publications will be released as they become available, including a brief report describing the sandstone with residual hydrocarbons (available early 2012).

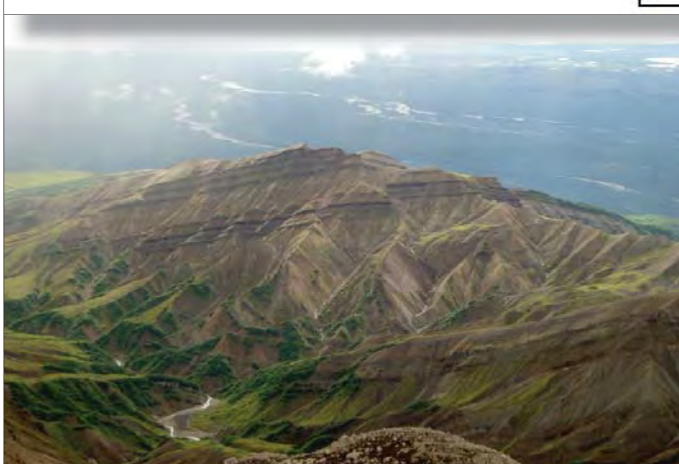
Contact: David L. LePain, 907-451-5085, david.lepain@alaska.gov

GEOLOGIC MAPPING OF THE TYONEK–CAPPS AREA

Rising residential and commercial heating and power demands, predicted deliverability shortfalls, and volatility in commodity prices underscore the need for discovery of additional gas reserves in Cook Inlet. However, until just recently, new exploration continued to be weak despite the growing need and significant gas potential remaining in the basin. The Division of Geological & Geophysical Surveys (DGGS) is attempting to promote exploration interest by focusing on understanding the potential for stratigraphic traps and gas reservoirs in low porosity and permeability (tight) formations (see p. 32). This program includes detailed geologic mapping of areas where outcrop relations are complex, poorly understood, yet important for understanding the potential for gas reservoirs in stratigraphic traps and tight formations.

During the summers of 2009–2011, DGGS completed 1:63,360-scale geologic mapping of nearly 875 square miles in the Tyonek Quadrangle along the northwestern margin of Cook Inlet basin (see inset geologic map). A more thorough geologic understanding of this area is important because it includes some of the best exposures of Tertiary strata in the basin (see inset photo), some of which serve as reservoirs in the nearby Beluga River, North Cook Inlet, and Granite Point fields. Additionally, the area is transected by several major faults that influenced sedimentation in the greater Cook Inlet basin, including a family of faults that are also responsible for forming some of its structural hydrocarbon traps. Yet available geologic mapping in the area predates modern stratigraphic nomenclature used in the basin and lacks the structural detail necessary to adequately understand the geologic development of the basin margin. Further hindering such understanding is a thin cover of Quaternary deposits that obscure underlying bedrock relationships throughout some of the most prospective onshore regions of the basin. With the aid of publicly and privately held subsurface and airborne geophysical data, our field mapping and stratigraphic work has unraveled complex stratigraphic and structural relationships and represents a major step forward in understanding the geologic evolution of the northwestern margin of the basin. Direct results of our work include (1) the recognition of at least two episodes of deformation along the northwestern basin margin involving different structural styles, (2) the first recognized occurrence of the Hemlock Conglomerate, one of the principal oil reservoirs in the basin, to the northwest of what has long been recognized as the Bruin Bay fault, and (3) that the Bruin Bay fault is not mappable as a through-going fault at the surface in upper Cook Inlet. The Bruin Bay fault thus should be redefined as a mostly pre-Tertiary structure. These insights are novel, well documented concepts that will provide important new information to companies and agencies interested in the hydrocarbon potential of Cook Inlet basin.





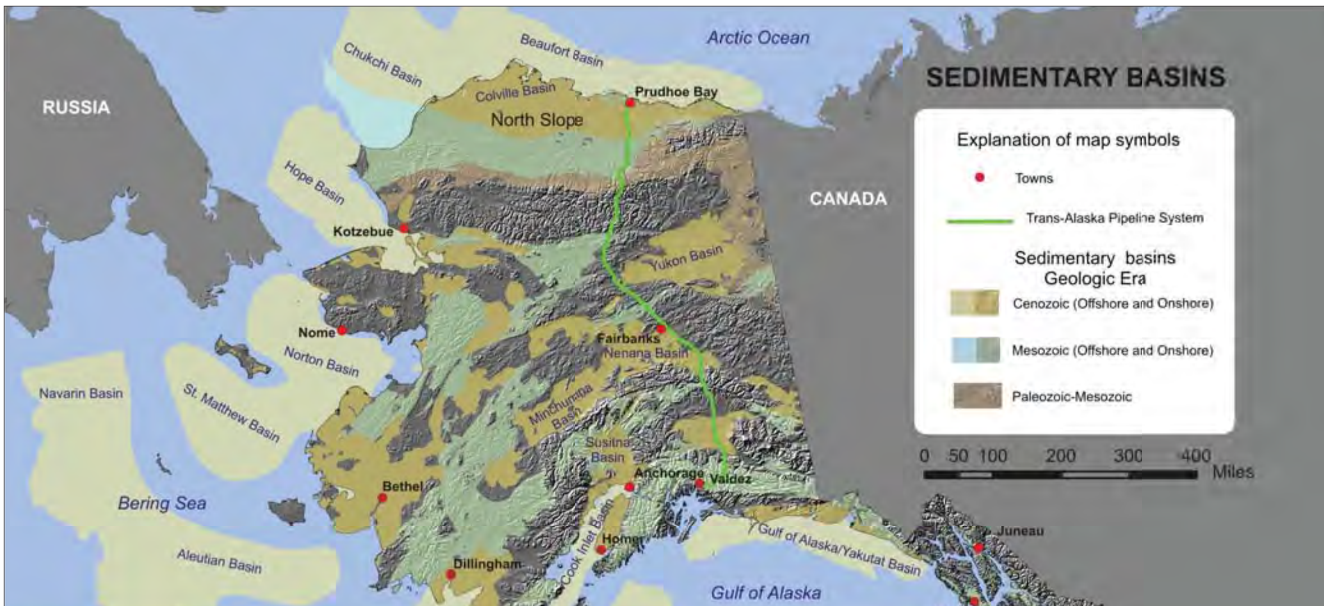
Preliminary 2009 and 2010 mapping was completed with partial funding from the U.S. Geological Survey's STATEMAP program and a preliminary map of the project area was submitted to the USGS in spring 2011. A final digital map product and results from related stratigraphic and structural studies will be published as DGGS reports in summer 2012.

Contact: Robert J. Gillis, 907-451-5024, robert.gillis@alaska.gov

NATURAL GAS POTENTIAL OF THE SUSITNA AND NENANA BASINS

Alaska faces significant domestic energy challenges that threaten the economic well-being of the population and the state's economic future. Simply stated, the state has not identified adequate energy sources to serve domestic needs at reasonable cost over the next few decades. The only way to mitigate these challenges is to look for local sources of energy that have the potential to supply more affordable energy for local consumption.

The Alaska Division of Geological & Geophysical Surveys (DGGS), in collaboration with the Alaska Division of Oil & Gas (DOG), has responded to these challenges by reviewing publicly available data on sedimentary basins throughout Alaska to identify basins whose geology suggests significant natural gas potential. The Susitna and Nenana basins have been identified, on geological grounds, as having significant gas potential to help meet in-state needs. Basin analysis projects are underway in each basin aimed at better understanding the possible presence of functioning petroleum systems. This project is being conducted in three phases, with phase I focusing on the Susitna basin, phase II on the Nenana basin, and phase III on finalizing work in both basins and generation of final reports.



In June 2011, DGGS completed ten days of fieldwork in the Susitna basin. Work centered on documenting characteristics of nonmarine floodplain mudstones, coals, and river channel deposits of sandstone, as well as documenting the structural evolution of the basin. Floodplain mudstones and coal seams represent potential reservoir seal and gas source rocks, respectively, and sandstones are potential gas reservoirs. These lithologies must be present in the subsurface of the basin in favorable locations relative to one another to allow the accumulation and entrapment of gas. Structural data gathered from the basin margin and intra-basinal uplifts will help define the timing of uplift events. These data will be integrated in a basin model for use in evaluating the possibility of microbial gas in the Susitna basin analogous to producing fields in neighboring Cook Inlet basin to the south.

Planning is underway for 10 days of fieldwork in the Nenana basin in May 2012. Publicly available data are being compiled in ArcGIS for use in designing the field program. The field focus will be to document potential gas source and reservoir rocks and to better understand the basin history as it relates to gas generation, migration, and entrapment in reservoir sand bodies.

This project is funded by the State of Alaska. Results will be documented in a series of publications available from the DGGS website (http://www.dggs.alaska.gov/pubs/) over the next 2–3 years.

Contact: David L. LePain, 907-451-5085, david.lepain@alaska.gov

STATE OF ALASKA CONTRIBUTIONS TO THE NATIONAL GEOTHERMAL DATA SYSTEM

The National Geothermal Data System (NGDS) is a U.S. Department of Energy-funded distributed national network of databases and data sites that collectively form a system for the acquisition, management, and maintenance of geothermal and related data. The NGDS website is: http://www.geothermaldata.org/. This national project, involving all 50 states, is organized by the Association of American State Geologists and administered by the Arizona Geological Survey (AZGS). The goal of the NGDS is to make large quantities of geothermal-relevant geoscience data available to the public by creating a national, sustainable, distributed, and interoperable network of data providers. The state geological surveys will develop, collect, serve, and maintain geothermal-relevant data as an integral component of NGDS. The project is digitizing at-risk, legacy geothermal-relevant data and publishing existing digital data by making databases and directories available to the network.

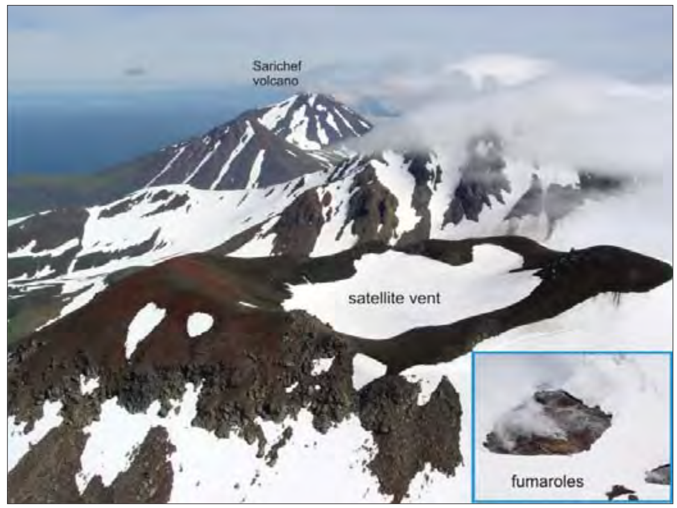
Much of the risk of geothermal energy development is associated with exploring for, confirming and characterizing the available geothermal resources. The overriding purpose of the NGDS is to help mitigate this risk by serving as a central repository for geothermal and relevant related data as well as a link to distributed data sources. By helping with the process of assessing and categorizing the nation's geothermal resources, providing strategies and tools for financial risk assessment, and consolidating all geothermal data through a publicly accessible data system the NGDS will support research, stimulate public interest, promote market acceptance and investment, and in turn support the growth of the geothermal industry.

Key components of the NGDS network include:

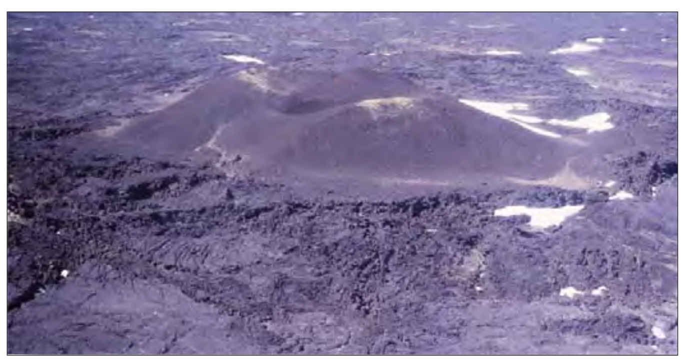
- Catalog systems for data discovery;
- Service specifications that define interfaces for searching catalogs and accessing resources;
- Shared interchange formats to encode information for transmission (i.e., various XML markup languages);
- Data providers that publish information using standardized services defined by the network; and
- Client applications enabled to utilize information resources provided by the network.

The Alaska Division of Geological & Geophysical Surveys (DGGS) is contributing Alaska geothermal data to the NGDS as part of a three-year national effort called the *State Geological Survey Contributions to NGDS Data Development, Collection and Maintenance*. The Arizona Geological Survey has developed a series of geothermal feature templates that includes: Volcanic vents (including vents, fissures, fumaroles, cones, domes, and maars; see photos); thermal hot springs and water chemistry; geothermal well data; active faults and fault features; earthquake hypocenters; developed geothermal systems; and borehole temperature observations. As part of this three-year project that began in 2010, DGGS will compile the available Alaska data for the appropriate AZGS feature templates for input into the NGDS.

Examples of volcanic vents



Young satellite vent on the northeast shoulder of Kliuchef volcano, Atka Island, Aleutians. Sarichef volcano in the distance. Inset, cluster of small fumaroles located on the southern flanks of Kliuchef. Both photos by Game McGimsey, Alaska Volcano Observatory—U.S. Geological Survey.



Lost Jim Cinder Cone, Imuruk Basin, Seward Peninsula. This cinder cone erupted from a Holocene-age volcanic vent. Photo by James Clough, DGGS.

Upon completion of this three-year project in 2013, the compiled Alaska geothermal data along with associated metadata will be placed into the NGDS and available for public and governmental use. A new digital ArcGIS format Geothermal Map of Alaska will be created and made available online.

Contact: Jim Clough, 907-451-5030, jim.clough@alaska.gov

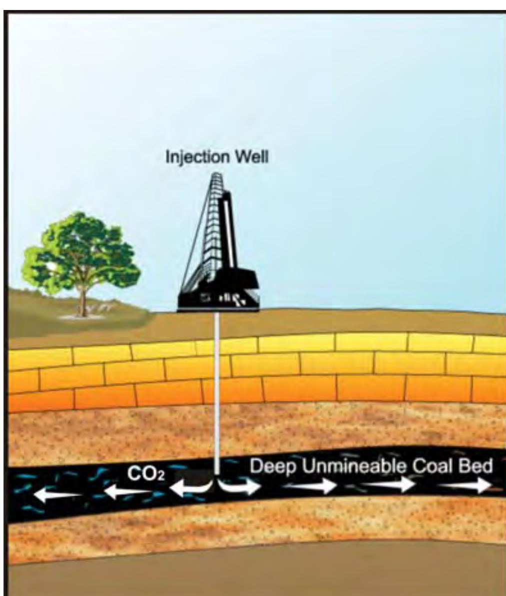
ALASKA COAL DATABASE—NATIONAL COAL RESOURCE DATABASE SYSTEM

The long-term goal of the Alaska Division of Geological & Geophysical Surveys' (DGGS) participation in the U.S. Geological Survey's (USGS) National Coal Resource Database System (NCRDS) cooperative program is to record all known coal occurrences in Alaska and archive the information in a single, readily accessible database available at the USGS website, http://energy.er.usgs.gov/products/databases/USCoal/. The NCRDS program is funded by USGS through a multi-year proposal process with final reporting at the end of each funding period.

Alaska's coal resources make up about half of the United States' coal-resource base and approximately one-sixth of the total world-resource base. Total identified Alaska coal resources (all ranks) amount to only about 160 billion short tons, yet hypothetical and speculative resources are as high as 5.5 trillion short tons. During the course of gathering information to expand the NCRDS database for Alaska, we recognized the need to collect new coal samples and current stratigraphic data for previously described occurrences. Sometimes a coal occurrence described in older literature is poorly located and the description is either inaccurate or inadequate for a proper resource assessment. The most frequent problems we have encountered are unverified coal seams and coal sample locations, suspect coal quality analyses, and insufficient stratigraphic control.

Cook Inlet–Capps coal bed, Capps Creek (Tyonek Formation). Similar thick and continuous coal seams that are conventionally unmineable are present in the subsurface. Photo by Bob Gillis, DGGS.

The Cook Inlet basin contains extensive Tertiary-age coal resources, estimated to be up to 1,570 billion short tons, which are mostly within the Tertiary-age Tyonek Formation of the Kenai Group (fig. 1). A large portion of this coal resource is in unmineable coal seams that are either too deep or too thin to be mined economically with conventional surface or underground means, although several areas of the Cook Inlet basin are currently being assessed for *in situ* coal gasification. Many of the subsurface coal seams contain methane adsorbed onto the coal pores and within coal fractures. Because coal has an affinity to preferentially absorb carbon dioxide (CO_2) over methane (CH_4), at CO_2:CH_4 ratios up to 7:1, it may be possible to inject CO_2 into deep, unmineable coal seams and potentially increase production of methane while sequestering carbon dioxide (fig. 2). Extensive infrastructure of roads and pipelines, combined with nearby CO_2 emission sources, makes the Cook Inlet basin prospective for future CO_2 injection into coal seams. Estimates for Cook Inlet CO_2 coal seam storage capacity range from 21 to 43 gigatons, on the basis of comparison to coal basins elsewhere as general analogues. However, actual coal seam CO_2 storage capacity is dependent on a number of factors that include coal rank, porosity, cleating (fractures), and coal quality. No direct measurement of CO_2 adsorption capacity of Alaska coal has been determined in the laboratory. Therefore, estimates of coal seam CO_2 storage capacity are based on comparison to coal basins elsewhere as analogues.



This project will collect coal samples from recent coring of deep unmineable coal seams in the Cook Inlet basin and conduct high-pressure CO_2 gas adsorption testing. These data, combined with coal quality analyses of the same samples, will provide empirical data that can be directly applied to estimating the CO_2 storage potential in the Cook Inlet basin. The final technical report on high-pressure CO_2 gas adsorption and coal quality of core samples will be submitted to the USGS in the fall of 2012.

Contact: Jim Clough, 907-451-5030, jim.clough@alaska.gov

AIRBORNE GEOPHYSICAL SURVEY OF THE LADUE AREA, FORTYMILE MINING DISTRICT, EASTERN ALASKA

The Airborne Geophysical/Geological Mineral Inventory (AGGMI) program, supported by State General Funds, is a multi-year investment to expand the knowledge base of Alaska's mineral resources and catalyze private-sector mineral development. The program seeks to delineate mineral zones on Alaska state lands that: (1) have major economic value; (2) can be developed in the short term to provide high-quality jobs for Alaska; and (3) will provide economic diversification to help offset the loss of Prudhoe Bay oil revenue. Candidate lands for the AGGMI program are identified considering existing geologic knowledge, land ownership, and responses to solicitations for nominations from Alaska's geologic community. As a result of this investment, the mineral industry has spent millions of dollars of venture capital in the local economies of the surveyed mining districts and adjacent areas in direct response to the new geologic knowledge provided by the surveys.

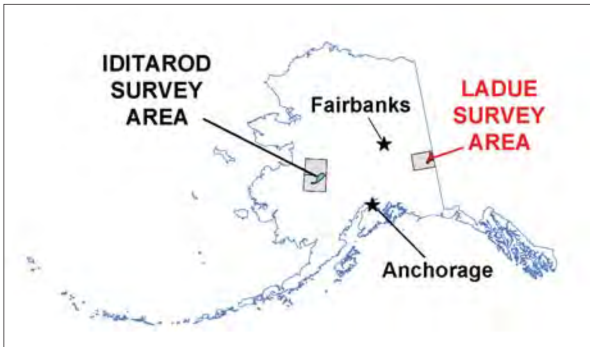


Figure 1. Locations of recent airborne geophysical surveys. The Ladue survey is in the Tanacross Quadrangle; the Iditarod survey is in the Iditarod and Ophir quadrangles.

Through the AGGMI program, DGGS acquired and released airborne-geophysical data for the Ladue and Iditarod areas (fig. 1; see p. 38) in FY11 and FY12. The 742-square-mile Ladue survey tract, about 25 miles east of Tok, is all State land and is part of the Fortymile mining district, the oldest placer gold camp in Alaska. More than 500,000 ounces of placer gold have been produced from the district. Like much of the Yukon–Tanana Uplands, the Ladue survey area is underlain by Paleozoic and older(?) deformed and regionally metamorphosed rocks, including quartzite, schist, gneiss, marble, greenstone, amphibolite, and orthogneiss. Cretaceous- to Tertiary-age igneous rocks of mafic, intermediate, and granitic composition intruded the metamorphosed rocks. The survey area contains large, low-grade copper–molybdenum±gold(?) porphyry deposits, plutonic-related lode gold prospects, and prospects with anomalous lead and zinc concentrations. The survey area also has the potential for hosting emerald deposits similar to the Tsa Da Glisza property in Yukon, Canada, and metamorphic/orogenic lode gold deposits similar to those of the historic Klondike Gold District in Yukon, Canada, and the Napoleon deposit northeast of Chicken, Alaska.

Airborne-geophysical surveys enable users to delineate regional geologic structures and identify metamorphic–stratigraphic lithologies and plutonic rock types based on their geophysical characteristics. The magnetic map (fig. 2) reveals numerous lineations trending northeast, northwest, and west. Observable geophysical offsets on the lineations suggest many are probably high-angle faults. These potential faults are not necessarily currently active. Follow-up geologic mapping tests geophysical anomalies and interpretations, and provides detailed documentation of the types, locations, and spatial distribution of metamorphic and plutonic rocks and structural features. By completing an integrated geophysical–geological mineral inventory study, new zones of mineralization may be identified, and extrapolation of some of the information into surrounding areas may be possible.

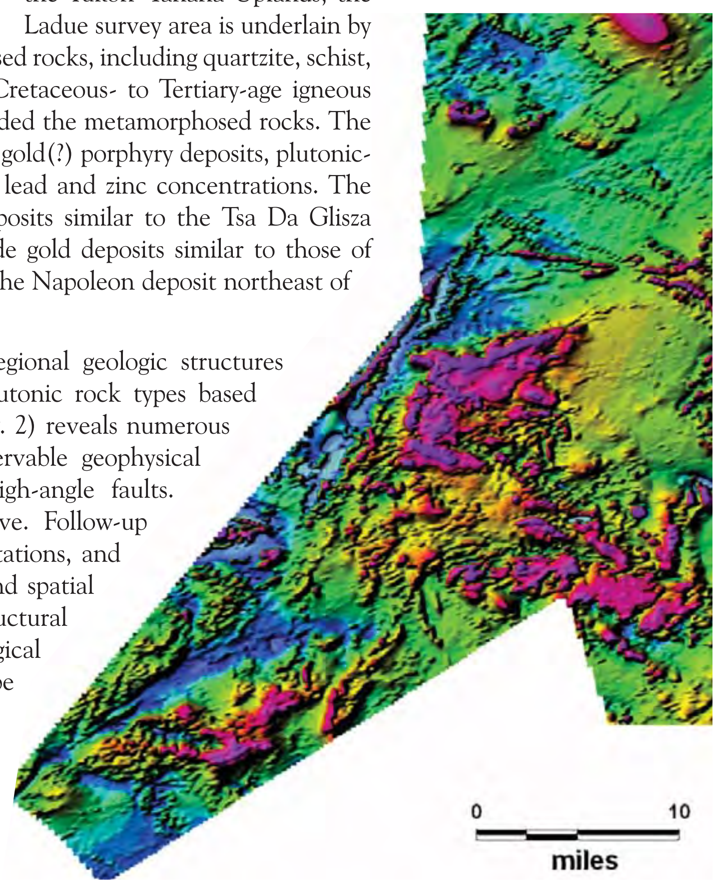


Figure 2. Ladue aeromagnetic data shown as a color shadow map. The rainbow of colors represents high magnetic values as magenta and low values as blues.

The Ladue area aeromagnetic and electromagnetic maps and data were released in June 2011. A second publication, containing a project report, interpretation, and electromagnetic anomalies, will be released in spring 2012. DGGS believes these data will lead to a better understanding of the geologic framework of the area and will stimulate increased mineral exploration investment within the survey boundary and the surrounding area.

Contact: Laurel Burns, 907-451-5021, laurel.burns@alaska.gov

AIRBORNE GEOPHYSICAL SURVEY OF THE IDITAROD AREA, IDITAROD, INNOKO, AND McGRATH MINING DISTRICTS, WESTERN ALASKA

The Airborne Geophysical/Geological Mineral Inventory (AGGMI) program, supported by State General Funds, is a multi-year investment to expand the knowledge base of Alaska's mineral resources and catalyze private-sector mineral development. The program seeks to delineate mineral zones on Alaska state lands that: (1) have major economic value; (2) can be developed in the short term to provide high-quality jobs for Alaska; and (3) will provide economic diversification to help offset the loss of Prudhoe Bay oil revenue. Candidate lands for the AGGMI program are identified considering existing geologic knowledge, land ownership, and responses to solicitations for nominations from Alaska's geologic community. As a result of this investment, the mineral industry has spent millions of dollars of venture capital in the local economies of the surveyed mining districts and adjacent areas in direct response to the new geologic knowledge provided by the surveys.

Figure 1. Locations of recent airborne geophysical surveys. The Iditarod survey is in the Iditarod and Ophir quadrangles.

Through the AGGMI program, DGGS acquired and released airborne-geophysical data for the Iditarod and Ladue areas (fig. 1; see p. 37) in FY11 and FY12. The 852-square-mile Iditarod survey tract is about 20 miles west of McGrath and 240 miles northwest of Anchorage. The survey area is primarily State land, with a small amount of Federal and Native land. Most of the area is part of the Iditarod and Innoko mining districts, which have produced more than 2.3 million ounces of gold; only 3,000 ounces of this production has been from lode sources. The survey tract contains several known mineralized lode and placer areas, such as Ganes Creek, north Flat, Beaver Mountains (plutonic part of BMC discussed below), and Camelback Mountain (fig. 2). Besides plutonic-related gold deposits, other lode potential in the survey area includes mesothermal and epithermal deposits that contain mercury, tungsten, silver, antimony, and tin. The discovery of more than 30 million ounces of gold associated with a Late Cretaceous dike swarm at the Donlin Gold deposit, about 30 miles southwest of the survey area, has kept exploration activity high in the region.

Bedrock in the survey tract is very similar to that of the Donlin Gold area. It is composed of the Upper Cretaceous Kuskokwim Group, a flysch sequence of interbedded sandstone and shale; the Upper Cretaceous—Early Tertiary Beaver Mountain volcano–plutonic complex (BMC); the northern part of the Upper Cretaceous–Early Tertiary Flat volcano–plutonic complex (FC); and numerous dikes throughout the survey area. Mineralization is thought to be contemporaneous with plutonism at several localities. The most strongly magnetized rocks in the survey are the volcanic rocks of the BMC (figs. 2, 3A), which are reversely magnetized such that their magnetic field points about 180 degrees from the current magnetic pole. The southwestern and northeastern parts of the tract also show signatures of reversely magnetized igneous rocks. Magnetic data also suggest the presence of a previously unknown, low to moderately magnetic intrusion(s) at depth in the Ganes Creek area. Small, normally magnetized dikes of low to moderate amplitude are present throughout the northern area. The apparent resistivity map (fig. 2B) shows volcanic and plutonic rocks of the BMC as most strongly conductive and strongly resistive, respectively. Geophysical data indicate that both volcano complexes are more extensive than mapped (fig. 3).

The Iditarod area aeromagnetic and electromagnetic maps and data were released November 3, 2011. A second publication containing a project report, interpretation, and electromagnetic anomalies will be released in spring 2012. DGGS believes these data will lead to a better understanding of the region's geologic framework and will stimulate increased mineral exploration investment in the survey area and the surrounding region.

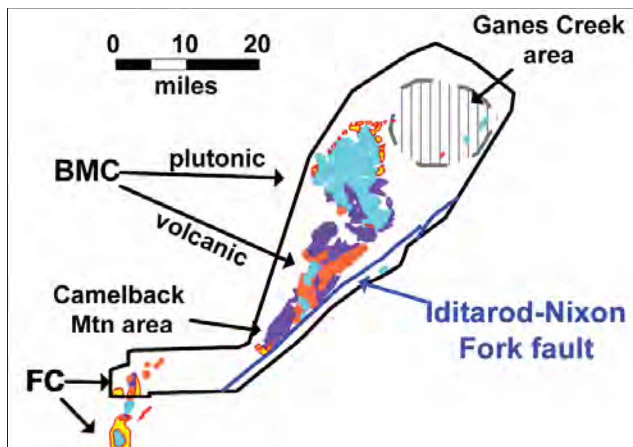


Figure 2. Generalized geologic map showing some mineralized areas and the volcano–plutonic complexes.

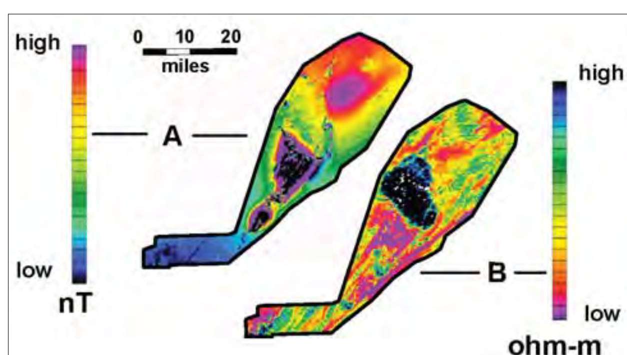


Figure 3. A. Aeromagnetic map. B. 900 Hz apparent resistivity map. Conductive values are low, resistive values are high.

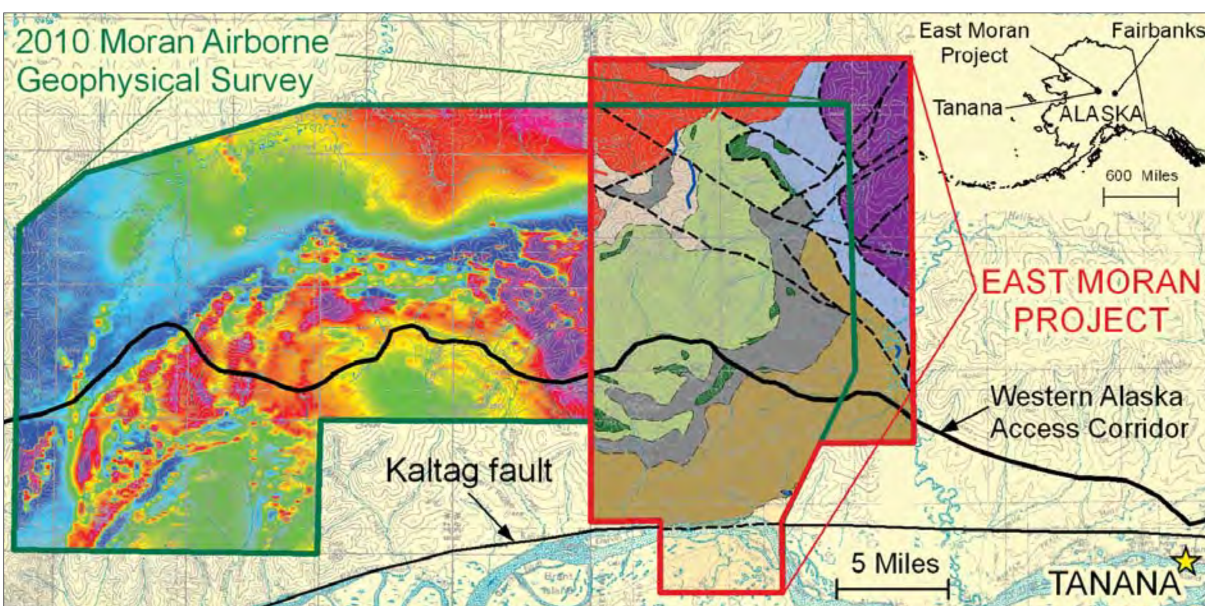
Contact: Laurel Burns, 907-451-5021, laurel.burns@alaska.gov

GEOLOGIC MAPPING IN THE EASTERN MORAN AREA, TANANA AND MELOZITNA QUADRANGLES, ALASKA

Historic and active placer mines in the Melozitna mining district, which encompasses the Moran Dome area, have produced more than 12,000 ounces of gold and an undetermined amount of tin, yet little is understood about sources for the placer metals, or the area's gold and polymetallic lode occurrences. To encourage renewed industry exploration for mineral deposits in this region, in 2010 DGGS released the 653-square-mile Moran airborne-geophysical survey (see figure) as part of the State-funded Airborne Geophysical/Geological Mineral Inventory program. The Moran survey area is 150 miles west of Fairbanks, on the north side of the Yukon River between the villages of Ruby and Tanana. During the summer of 2011, the DGGS geologically mapped 301 square miles in the eastern part, and conducted reconnaissance mapping in the western part of the Moran geophysical survey. Products will include a 1:63,360-scale geologic map and supporting data, which will foster a better understanding of the area's geology and mineral potential. The map and interim data releases will be published in 2012. This mapping project is funded primarily by State General Funds, with supplemental funding from the Federal STATEMAP program through the U.S. Geological Survey.

Prior to 2011, only reconnaissance-level, 1:250,000-scale geologic maps were available for the Moran area; DGGS's 2010 geophysical data indicate the geology is much more complex than shown on these maps. During 2011 fieldwork, DGGS geologists field-checked airborne geophysical interpretations, identified the location, type, and character of bedrock and surficial-geologic units, examined and geochemically sampled known and newly discovered lode and placer occurrences, and determined the location and kinematics of structural features. This detailed geologic framework, supported with ongoing geochemical, geochronologic, and petrographic studies, will allow us to develop deposit models for the area's gold and polymetallic lode prospects and explain the distribution and metal content of local placer deposits. Concurrent surficial-geologic mapping will illuminate potential engineering-geologic challenges of future infrastructure development, including the preferred Western Alaska Access Corridor, which transects the Moran map area. Regional geologic hazards are also of concern, and potentially include the Kaltag fault, which crosses the southern edge of the map area. Part of the 2011 study includes evaluation of possible Holocene and Quaternary displacement history of the Kaltag fault and its associated seismic hazards between Tanana and Ruby. As DGGS's investigations progress, preliminary results will be presented in public venues, allowing timely access to the new information on the Moran area's geology, mineral resources, and geologic hazards.

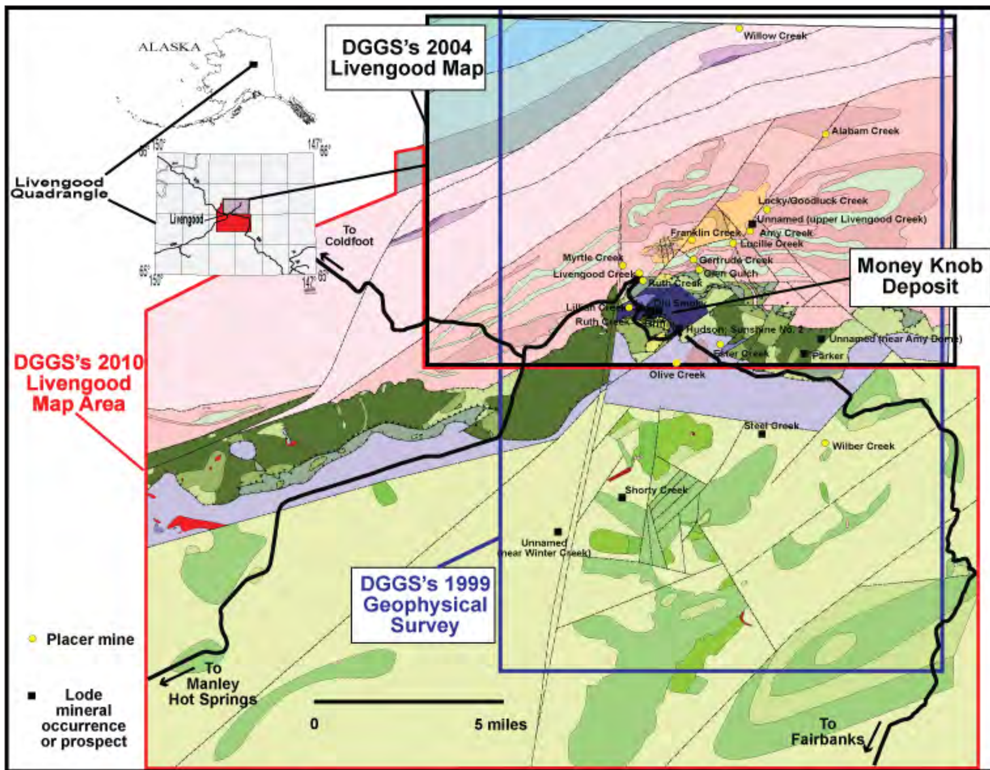
The primary objective of the eastern Moran project is to map the geology in sufficient detail to inform State and local land-use decisions and to guide mineral industry exploration efforts. The timing of this project coincides with renewed mineral-industry interest in underexplored gold districts and in critical and strategic metals. Because economic or infrastructure development could potentially conflict with other land uses, the availability of DGGS's detailed geologic, mineral-resource, and hazard assessments is important for long-range planning by State and local agencies that need to balance resource and infrastructure development with other land-management strategies.



Contact: Larry Freeman, 907-451-5027, larry.freeman@alaska.gov

BEDROCK GEOLOGIC MAPPING IN THE TOLOVANA MINING DISTRICT, LIVENGOOD QUADRANGLE, ALASKA

Historic and active placer mines have produced more than 500,000 ounces of placer gold in the Livengood area. To encourage renewed industry exploration for mineral deposits in this region, and to provide geologic data for State and local land-use management, the DGGS has conducted a series of geophysical and geological investigations in the area. This work is part of the Airborne Geophysical/Geological Mineral Inventory (AGGMI) program, supported by State General Funds. DGGS released a 230-square-mile airborne-geophysical survey of the Livengood area in 1999. In 2004, DGGS published a geologic map and associated geologic report for an area that includes the northern portion of the 1999 geophysical survey (see figure). Subsequent mineral industry exploration within this map area resulted in the discovery of a large gold deposit at Money Knob, with a defined resource of 20.6 million ounces. In 2010, DGGS conducted geologic mapping and sampling of the southern portion of the 1999 geophysical survey and surrounding area (see figure). A geochemical report for the south Livengood area was published in 2010, and a 1:50,000-scale bedrock-geologic map and accompanying interpretive report will be published in 2012.



The purpose of DGGS's mapping is to provide geologic context for known lode and placer deposits and occurrences, and to evaluate the area's mineral-resource potential. The only known significant lode mineralization within the 2010 map area is located 5.5 miles south of Money Knob at Shorty Creek, a high Ag–Bi–Sn and locally anomalous Au prospect. Felsic igneous rocks spatially associated with the Shorty Creek prospect are compositionally different and temporally about 25 million years younger than the Money Knob gold-related plutonic rocks; hence they represent two different types of mineralizing systems. Rocks of the Cascaden Ridge pluton, 13 km southwest of Money Knob, are compositionally equivalent to Money Knob dikes and, similarly, intrude Devonian volcanic rocks that act as the host rock in the Money Knob system.

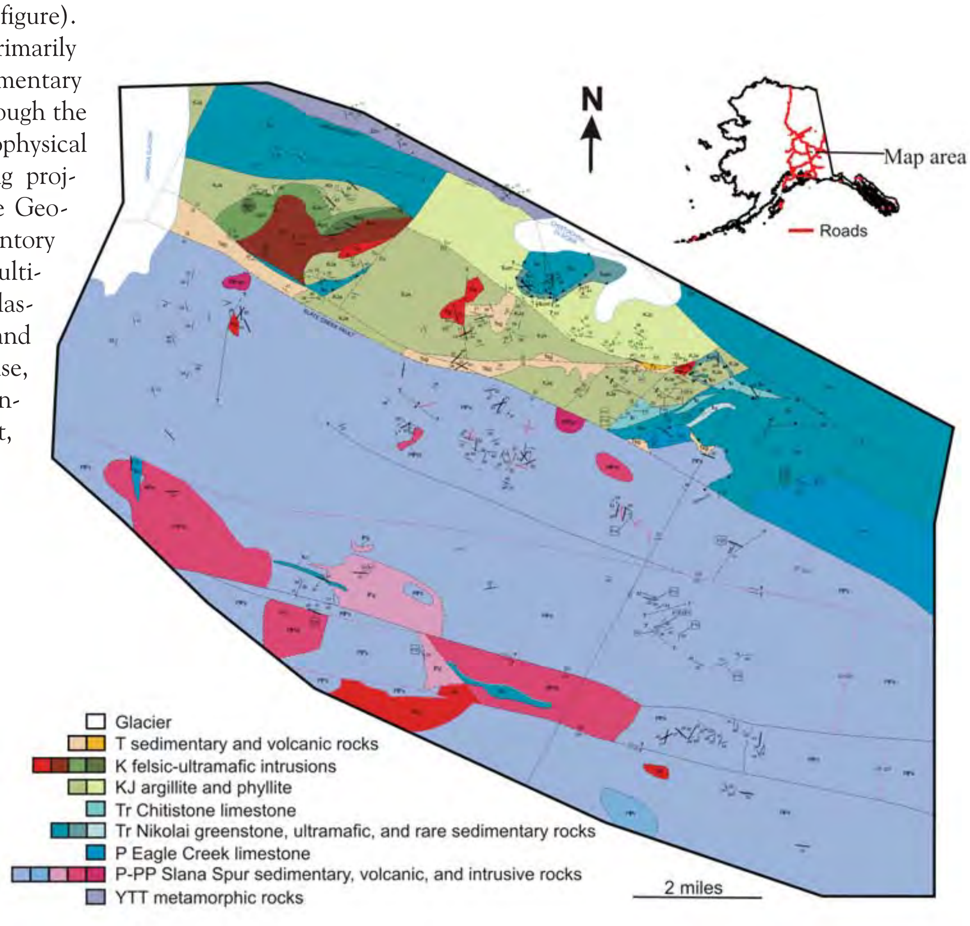
Wilber Creek is the only creek in the 2010 map area with known placer gold production. Its gold compositions are similar to placer gold of the Livengood area, and the area's present stream morphology suggests the gold is derived from the 2010 map area. Magnetic anomalies in the 1999 geophysical survey indicate a potential igneous source for the Wilber Creek placer deposit. A group of felsic dikes, of similar composition to the gold-related Money Knob rocks, occur within the area and may represent the placer source.

In 2012, DGGS will release an interpretive report and bedrock-geologic map of the entire Livengood study area. These publications will summarize the collective findings of the DGGS 2004 and 2010 investigations, as well as incorporating industry data around the Money Knob deposit. AngloGold (2003–2006) and International Tower Hill Mines Inc. (2006–present) have conducted detailed geologic mapping of Money Knob and the surrounding area, and contributed to geologically subdividing the Paleozoic Amy Creek assemblage, the Cambrian ophiolite package, and the Devonian Cascaden Ridge unit. DGGS also used the 2010/2011 lidar survey of the Trans-Alaska Pipeline corridor to identify faults in the map area. The lidar project is described separately (p. 54).

Contact: Gerry Griesel, 907-451-5086, gerry.griesel@alaska.gov

BEDROCK GEOLOGIC MAPPING OF THE SLATE CREEK AREA, MT. HAYES QUADRANGLE, SOUTH-CENTRAL ALASKA

The Division of Geological & Geophysical Surveys (DGGS) released a 442-square-mile airborne geophysical survey, including magnetic and electromagnetic data, for the Slate Creek–Slana River area in the northern Chistochina mining district in early 2009. DGGS conducted geologic mapping of about 113 square miles in the western Slate Creek portion of the geophysical survey tract during July 2009 (see figure). This mapping project is funded primarily by State CIP funds, with supplementary Federal STATEMAP funding through the U.S. Geological Survey. The geophysical survey and Slate Creek mapping project are part of DGGS's Airborne Geophysical/Geological Mineral Inventory (AGGMI) program, a special multi-year investment by the State of Alaska to expand Alaska's geologic and mineral resources knowledge base, catalyze future private-sector mineral exploration and development, and guide state planning.



The Slate Creek study area is in the southern foothills of the Alaska Range, about 140 miles southeast of Fairbanks and 20 miles east of Paxson. Approximately 183,000 ounces of placer gold have been mined from the region since 1898, with most production from the historic Slate Creek subdistrict. One active placer gold mine, 64 inactive placer gold occurrences and mines (with minor platinum-group metals [PGM]), and 29 metallic lode occurrences are present in the map area. There are no significant known lode gold occurrences to explain the extensive placers. Gold chemical data suggest the placers are derived from transported and reworked auriferous Tertiary gravels instead of from the local gold-bearing bedrock. The Mentasta–Slana area also hosts many plutonic-related skarn, replacement, and vein–gossan occurrences as well as potential porphyry(?) copper–gold lode prospects and 'Alaska-type' PGM lode occurrences associated with Cretaceous mafic–ultramafic rocks.

A portion of the main strand of the Denali fault system (DFS), which ruptured in 2002 (with an associated magnitude 7.9 earthquake), bounds the northern edge of the study area. DGGS is identifying, determining orientations, and characterizing the kinematics of active and inactive faults along the DFS and subsidiary faults to provide a better understanding of the regional stress regime and earthquake potential. The results of a paleoseismic trench study across the 2002 rupture trace of the Denali fault were published by DGGS in 2011. These data are necessary for subsequent assessment of earthquake hazards to critical infrastructure and population centers.

New geologic mapping and neotectonic studies, incorporating interpretations of DGGS's airborne geophysical data, will lead to a better understanding of the region's geologic framework, provide data on recent fault movement essential to geologic hazard assessments, provide geologic-resource data critical to land-use decisions, and help to stimulate increased mineral exploration investment in this belt of rocks. Products will be a series of geologic maps at 1:50,000 scale, and reports containing geological, geochemical, and geophysical data. Geologic maps of the Slate Creek–Slana River area will be completed in 2012.

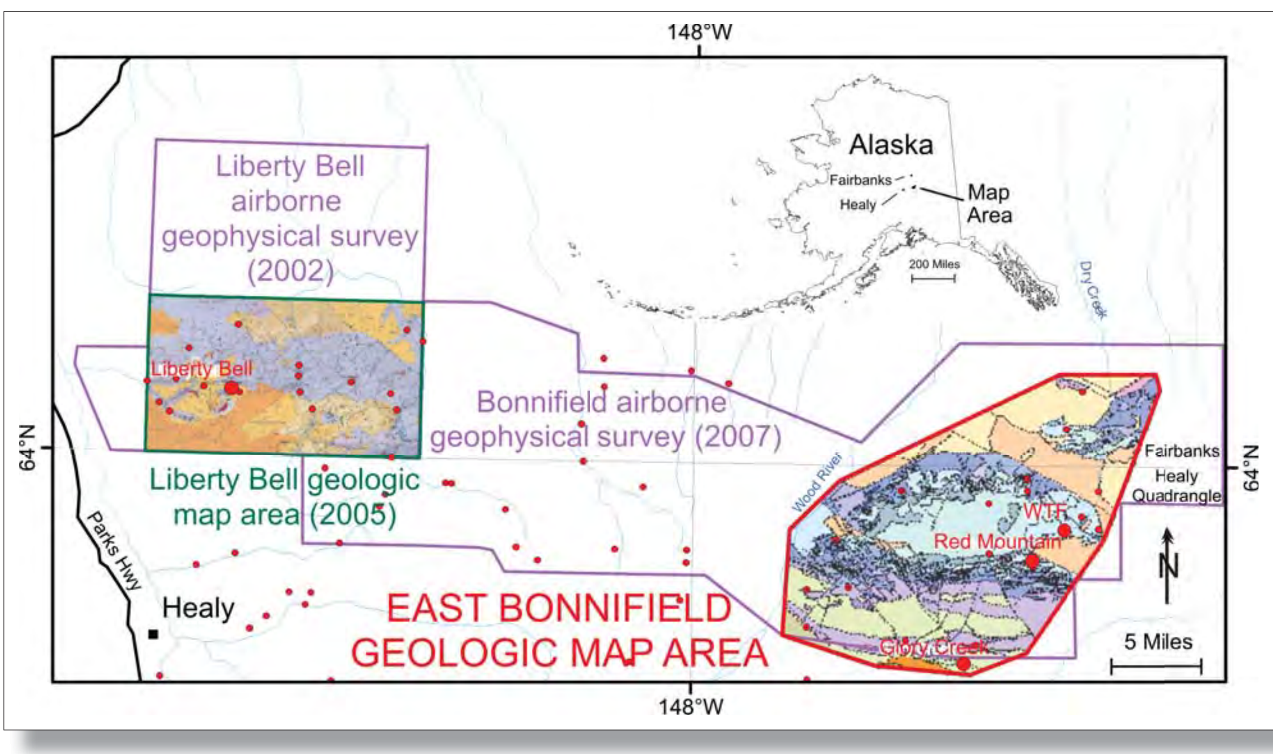
Contact: Jennifer E. Athey, 907-451-5028, jennifer.athey@alaska.gov

GEOLOGIC MAPPING IN THE EASTERN BONNIFIELD MINING DISTRICT, HEALY AND FAIRBANKS QUADRANGLES, ALASKA

Historic and active placer mines in the Bonnifield mining district have produced more than 86,000 ounces of gold; the region also contains numerous significant polymetallic volcanogenic massive-sulfide (VMS) and gold–polymetallic pluton-related lode occurrences. To encourage renewed industry exploration for mineral deposits in this region, and to provide geologic data for State and local land-use management, in 2007 DGGS released a 613-square-mile airborne-geophysical survey for the eastern two-thirds of the area outlined in purple (see figure) as part of the State-funded Airborne Geophysical/Geological Mineral Inventory program. In summer 2008, DGGS conducted fieldwork to geologically map an approximately 27,300-square-mile area in the eastern Bonnifield mining district (outlined in red; see figure). A geochemical data report was published in 2009, and 1:50,000-scale bedrock- and comprehensive-geologic maps will be published in 2012. This project is funded primarily by State Capital Improvement Project (CIP) funds, with supplemental funding from the Federal STATEMAP program through the U.S. Geological Survey.

The eastern Bonnifield map area is 60 miles south of Fairbanks in the northern foothills of the Alaska Range. The area contains significant mineral occurrences, most notably the WTF and Dry Creek VMS prospects, which contain drill-inferred resources of copper, lead, zinc, silver, and gold. Lithologic and structural relationships and interpretations from 50-year-old published geologic maps of the area are not supported by our summer 2008 investigations. DGGS's new geologic map incorporates interpretations of our Bonnifield airborne geophysical survey data, aerial photographs, donated industry data, and our 2008 field observations and new scientific analytical data. Our work documents many sets of newly discovered inactive faults and one potentially active fault, and presents a revised stratigraphic section based on actual lithologic units instead of grouped rock packages.

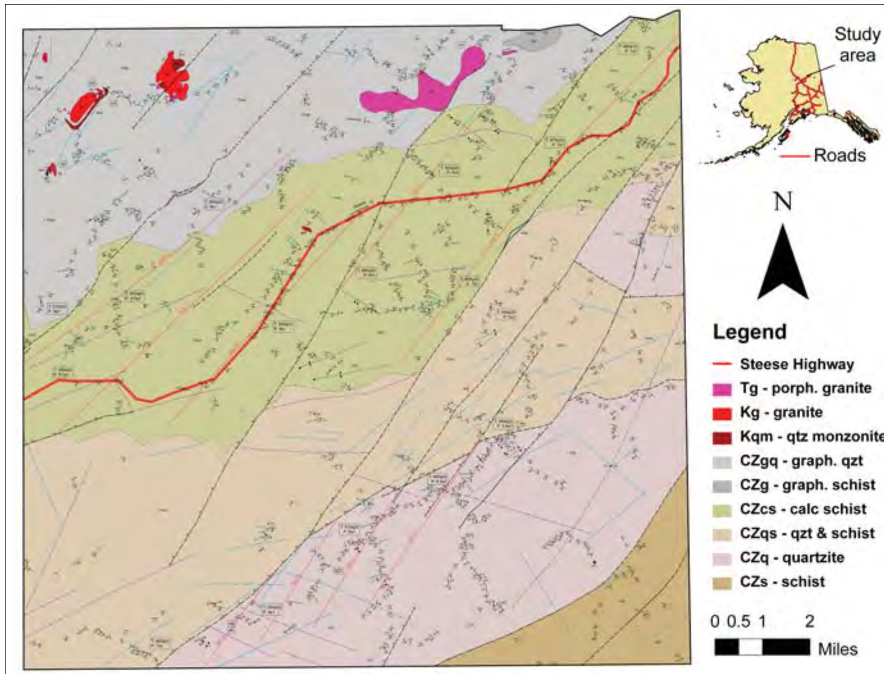
The eastern Bonnifield project's primary objective is to map the geology in sufficient detail to facilitate wise State and local land-use decisions and to guide mineral industry exploration efforts. The timing of this project coincides with renewed mineral-industry interest in exploration for volcanogenic massive-sulfide deposits including those in the eastern Bonnifield mining district; exploration activity in Alaska in general is near an all-time high. Economic development could potentially conflict with other land uses, thus DGGS's detailed geologic, resource, and reconnaissance hazard assessments are important for long-range planning. A basic geologic framework and an inventory of potentially mineralized areas will help State and local planners balance the need for resource development versus other land-management strategies. Geologic maps and data produced by this project will also serve as a framework for further scientific studies and for increased regional understanding of this tectonically active area 21 miles north of the Denali fault.



Contact: Larry Freeman, 907-451-5027, larry.freeman@alaska.gov

BEDROCK GEOLOGIC MAPPING, NORTHERN FAIRBANKS MINING DISTRICT, CIRCLE QUADRANGLE, ALASKA

In summer 2007, DGGS conducted fieldwork for geologic mapping of 189 square miles northeast of Fairbanks, covering the central portion of DGGS's 404-square-mile Northeast Fairbanks airborne magnetic and electromagnetic geophysical surveys released in January 2006. The mapping project is part of DGGS's Airborne Geophysical/Geological Mineral Inventory program, an annual investment by the State of Alaska to expand Alaska's geologic- and mineral-resource knowledge base, catalyze future private-sector mineral exploration and development, and guide state planning. This project received a portion of its support from the federal STATEMAP program through the U.S. Geological Survey.



Draft bedrock geologic map.

The Steese Highway bisects the study area from highway mileposts 66 through 85. Good access from the highway, placer mining roads, and a few trails, in addition to nearby power from the high-voltage power lines of the Fort Knox gold mine 25 miles to the southwest, would facilitate possible mineral development. The map area lies in a northeast-oriented trend of plutonic-related gold mineralization between the central and southwestern Fairbanks and Circle mining districts. The Fairbanks mining district boasts the most historic gold production in Alaska, with nearly 12.9 million troy ounces of gold produced as of 2007. Three placer mines (two active) and one lode gold prospect are present in the Northeast Fairbanks map area. Placer gold is spatially associated with monzogranite and quartz monzonite plugs, dikes, and sills. The distribution of paystreaks within the placers and the paucity of mineralization within the intrusions suggest some of the gold may be structurally controlled. In 2007, DGGS identified arsenopyrite–pyrite–quartz veins and boxworks and semi-massive stibnite–quartz veins proximal to the intrusive suite.

View, looking north, of the Faith Creek gold placer.

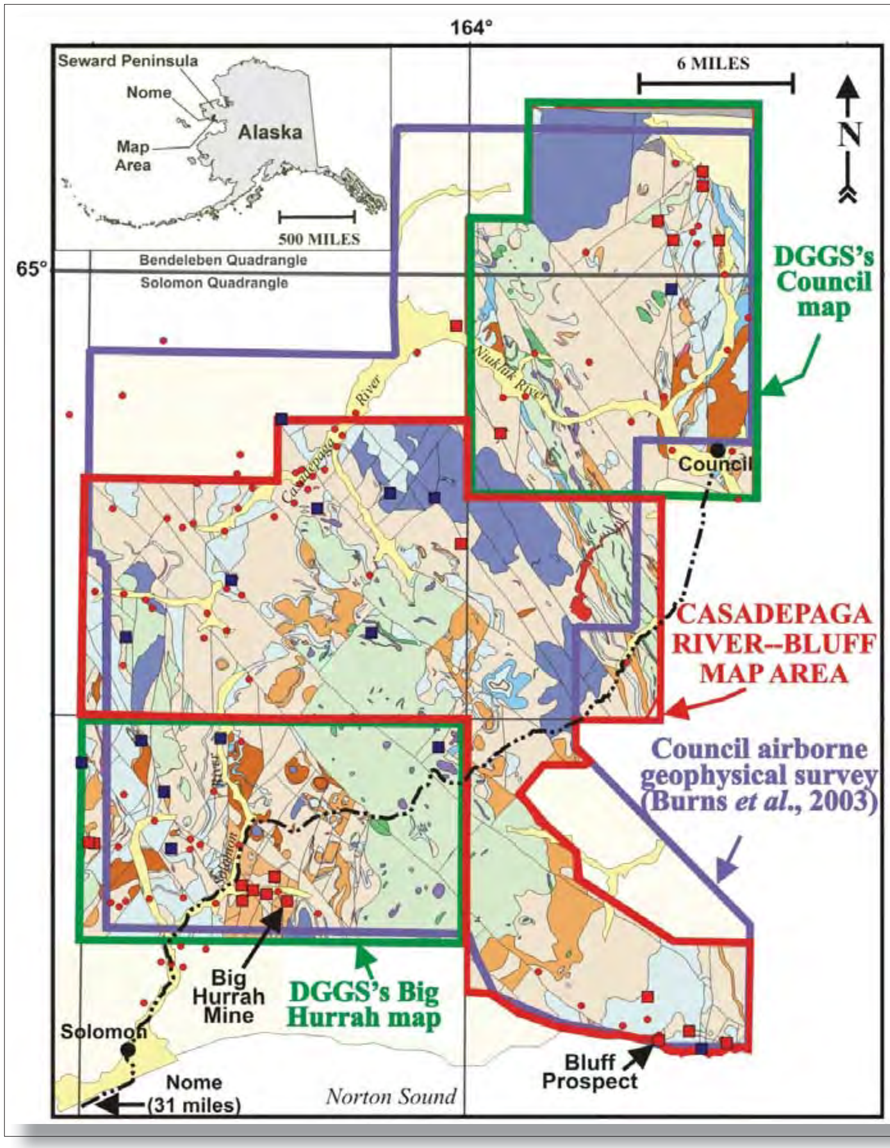
In addition to geologic mapping, DGGS conducted a rock and stream-sediment geochemical study instrumental in the Alaska Division of Mining, Land & Water's decision to relocate a portion of the proposed Mount Ryan Remote Recreational Cabin Sites Staking Area to an area with lower perceived mineral potential. Land open to settlement is usually closed to mineral exploration and development, thus, knowledge of an area's mineral potential is crucial to decisions on whether to retain that land for subsurface uses. These geochemical data were published in January 2008.

DGGS's geologic mapping incorporates interpretations of our airborne geophysical data, and provides: (1) a better understanding of the lithologic, metamorphic, and tectonic framework of Interior Alaska; (2) baseline geologic-materials and hazards data for future infrastructure and residential construction, and current maintenance of the Steese Highway; (3) geologic-resource data critical to land-use decisions; and (4) geologic knowledge that will help encourage mineral exploration investment in the northern section of the Fairbanks mining district. A series of 1:50,000-scale geologic maps and associated scientific studies for this project will be completed in 2013. Surficial-geologic mapping performed in conjunction with this project was published in 2011 as DGGS Report of Investigations 2011-4.

Contacts: Jennifer Athey, 907-451-5028, jennifer.athey@alaska.gov

BEDROCK GEOLOGIC MAPPING OF THE COUNCIL–BIG HURRAH–BLUFF AREA, SEWARD PENINSULA, ALASKA

More than 1 million ounces of placer gold have been extracted from the Solomon–Council area of Alaska's Seward Peninsula during the past century, but gold production has declined in recent decades. To encourage renewed industry exploration for lode gold and base-metal deposits in this region, and to provide geologic data for land-use management, in 2003 DGGS released airborne-geophysical surveys for the area outlined in purple (see figure). In 2004, DGGS conducted 1:50,000-scale geologic mapping and geochemical sampling in the Big Hurrah and Council areas (green outline in figure). In 2006, DGGS extended this mapping into the Casadepaga River–Bluff area (red outline in figure), and will produce a combined bedrock map and a geologic report of the entire project area in 2012. A geochemical report for the 2006 map area was released in 2007. This project is part of the ongoing Airborne Geophysical/Geological Mineral Inventory (AGGMI) program, supported mainly by State Capital Improvement Project (CIP) funds, with 2007 contributions from the U.S. Geological Survey's STATEMAP program.



DGGS's mapping provides geologic context for known lode gold and base-metal deposits and occurrences, and helps to evaluate the area's mineral-resource potential. The Casadepaga River–Bluff map area contains the Bluff lode gold prospect, and covers the headwaters of the Casadepaga River, known for its rich placer gold deposits. The lode sources of this placer gold have not yet been identified.

The Casadepaga River–Bluff area is underlain by Proterozoic to Lower Paleozoic metasedimentary and metaigneous rocks of the Nome Group, including the Solomon Schist, Mixed Unit, Casadepaga Schist, and undifferentiated marble. DGGS's recent detailed geologic mapping defines the internal metamorphic stratigraphy of these rock units, and is revealing new relationships between units as well. Stratigraphic relationships and depositional-age data are essential for evaluating the economic potential of the Nome Group for hosting base-metal sulfide deposits.

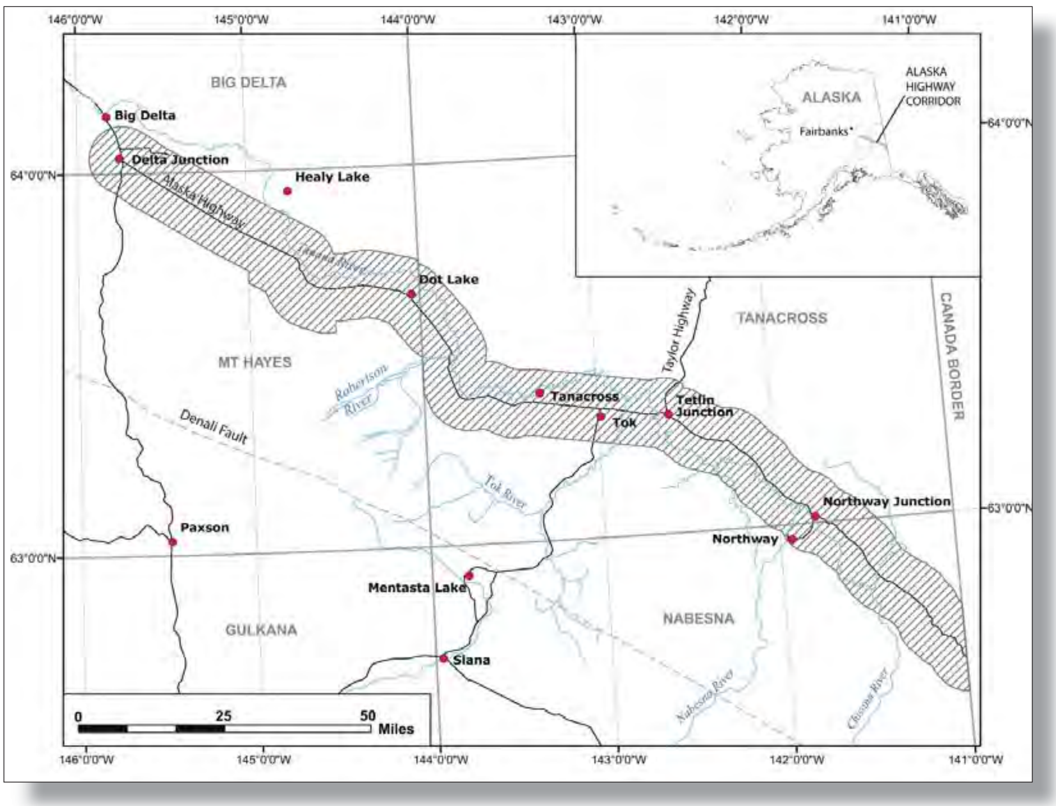
In the Casadepaga River–Bluff area, DGGS's geologic mapping and associated studies have documented the location, geochemistry, age, distribution, orientation, and regional structural controls on the area's gold-bearing quartz vein systems. To help predict where additional veins may be located, it is important to determine the timing of gold-vein formation relative to structural features, metamorphic events, and igneous intrusions. Our preliminary work indicates that Nome Group rocks underwent high-pressure blueschist-facies metamorphism ~200 million years ago, and were later partially overprinted by a greenschist-facies mineral assemblage. Rare, extension-related alkalic intrusions of Cretaceous to Quaternary age are scattered throughout the map areas, but are not spatially associated with gold-bearing quartz veins. These veins yield $^{40}Ar/^{39}Ar$ adularia and white mica ages of ~105 to 115 Ma. Hydrothermal kaolinite, cinnabar, and adularia indicate epithermal-style mineralization on the southern Seward Peninsula, as well as the more widely distributed gold-bearing veins of possible orogenic or extensional origin.

Contact: Melanie Werdon, 907-451-5082, melanie.werdon@alaska.gov

BEDROCK GEOLOGY & MINERAL-RESOURCE ASSESSMENT ALONG THE PROPOSED GAS PIPELINE CORRIDOR FROM DELTA JUNCTION TO THE CANADA BORDER

The Alaska Highway is the primary land transportation route to Interior Alaska from the contiguous United States, and is likely to become the locus of increasing development, especially if the proposed natural gas pipeline or Alaska Railroad extension are constructed along this route. Despite the corridor's strategic location, relatively little geological and geotechnical work has been published relating to this corridor. This multi-year program, primarily supported by State Capital Improvement Project (CIP) funds, is providing a framework of geologic data upon which engineering, design, and resource decisions may be evaluated for future development between Delta Junction and the Canada border. In 2006, as the first phase of this project, DGGS collected, interpreted, and published airborne-geophysical data for a 16-mile-wide corridor centered on the Alaska Highway. In the second phase of the project, DGGS is charged with mapping the bedrock and surficial geology of the area and evaluating the geologic hazards and resources. The surficial-geology and geologic-hazards segments of the project are described separately (p. 53).

DGGS staff have completed the field data collection phase needed to assess the mineral resources of the area and create a 1:63,360-scale bedrock-geologic map. In 2006 and 2007, DGGS conducted geologic fieldwork between Delta Junction and Dot Lake, in 2008 between Dot Lake and Tetlin Junction, in 2009 between Tetlin Junction and the Canada border, and in 2010 from Delta Junction to the Canada border.



The bedrock maps incorporate interpretations of DGGS's airborne magnetic and resistivity data, field data, and various scientific analytical data. The geophysical data is particularly valuable for interpreting the geology in areas covered by surficial deposits or vegetation. Preliminary results from 2009 fieldwork showed a continuation of geologic relationships determined from 2006–2008 fieldwork, along with new features and interpretations. Numerous plutonic rock suites were defined; these plutons intruded complexly deformed, amphibolite-facies metasedimentary and metaigneous rocks similar to those elsewhere in the Yukon–Tanana Upland, as well as a suite of greenschist-facies metasedimentary rocks and metamorphosed mafic intrusions, which likely correlate with similar units directly across the border in Canada. DGGS also determined the location and kinematics of many smaller-scale faults in the corridor that are related to the Denali fault system; this data will provide a better understanding of the history and potential impacts of these faults.

DGGS also evaluated the mineral potential of bedrock units by sampling and analyzing altered rocks to provide baseline geochemical data for use by State land-use planners and mineral exploration companies. Geochemical analyses, U-Pb and $^{40}Ar/^{39}Ar$ age dates for samples collected during 2008–2010 fieldwork will be published in 2012. The bedrock-geologic maps for the 2006–2009 corridor segments will also be published in 2012.

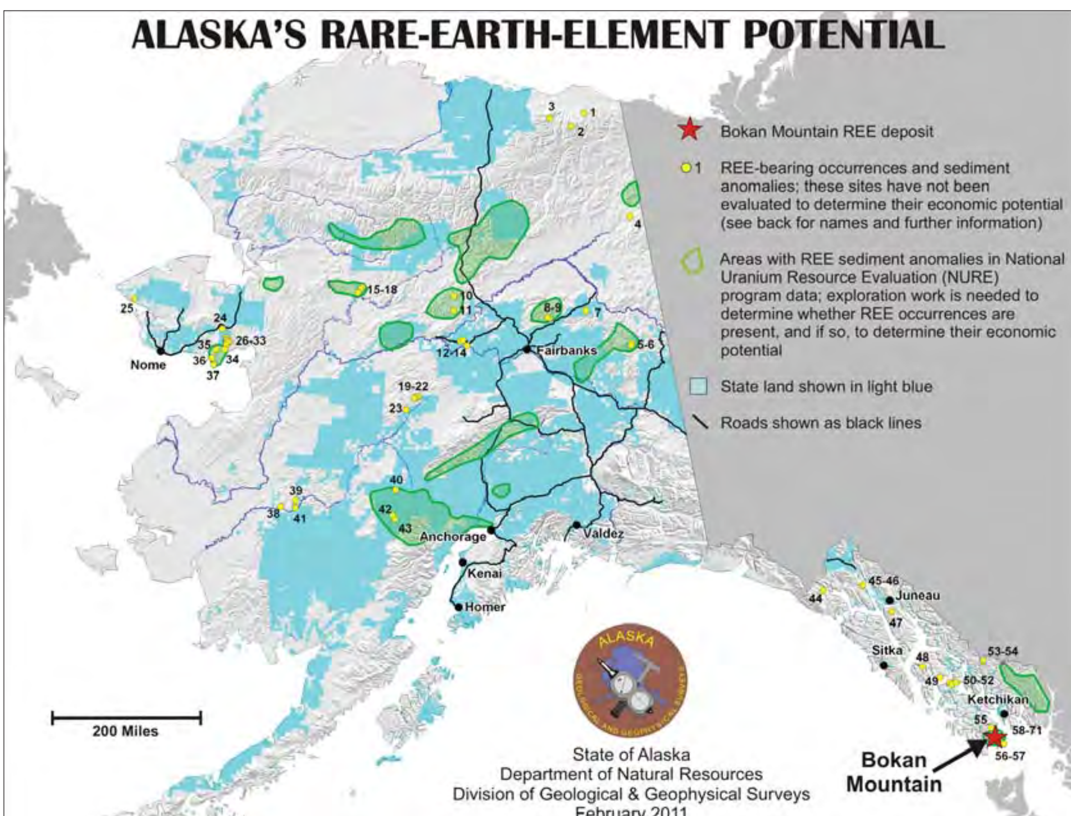
Contact: Brent Elliott, 907-451-5040, brent.elliott@alaska.gov

RARE-EARTH ELEMENTS AND STRATEGIC MINERALS ASSESSMENT

Rare-Earth Elements (REE) are indispensable for military and high-technology applications, as well as clean/renewable-energy technologies (such as wind turbines, solar panels, batteries for electric vehicles). For instance, liquid-crystal displays for computer monitors and televisions use the REE europium, which produces the color red; there is no known substitute. REEs are used to convert heavy crude oil into gasoline and other products, and REEs are also used to make "permanent magnets," which enable miniaturization of electronic components (e.g. cell phones). U.S. defense systems depend heavily upon REEs for current technology and system designs, and there is a lack of effective non-REE substitutes. The lack of a domestic REE supply chain in the U.S., and near 100 percent dependence on imports for these elements, presents national security concerns for the U.S. and diminishes its ability to be a world technology leader.

At least 70 mineral localities in Alaska contain REEs, and additional areas, identified during the 1970s National Uranium Resource Evaluation (NURE) program, have sediments with anomalous REE values (see figure). Although many areas of Alaska are geologically permissible for hosting REEs, the lack of basic geologic data hinders evaluation of the state's true REE potential. To advance the state's knowledge of its geologic resources, promote informed state management decisions, and encourage mineral industry exploration for REEs and other strategic minerals in Alaska, in 2011 the state's Division of Geological & Geophysical Surveys (DGGS) initiated the *Rare-Earth Elements and Strategic Minerals Assessment* project. The goals of this 3-year project are (1) to compile historic and industry-donated data in digital format; (2) to obtain new field and analytical data critical for assessing Alaska's REE potential; (3) to evaluate the historic and new data to identify areas of Alaska with the highest REE potential, as well as those needing additional geologic evaluation; (4) to communicate the results of our work to the public; and (5) to publish the data and results of our studies on the DGGS website (free access). Work conducted as part of this project is supported by State Capital Improvement Project funds.

In 2011, DGGS collected rock, soil, stream-sediment and/or pan-concentrate samples in the Moran area of central Interior Alaska, and near William Henry Bay in Southeast Alaska. The Moran area (see p. 39 for project description) spatially coincides with NURE sediment anomalies with elevated uranium and REE values. The William Henry Bay area contains uranium-, thorium-, and REE-bearing lode mineral occurrences, and genetically associated intrusions. Geochemical data from these two areas will be released in the first half of 2012. Currently, DGGS is actively compiling historic geochemical data for areas with REE mineral potential throughout Alaska, and in early 2012, will start obtaining modern geochemical analyses for archived samples stored at the DGGS Geologic Materials Center. In the summer of 2012, DGGS will conduct geologic fieldwork in one or two areas identified as having high REE potential.

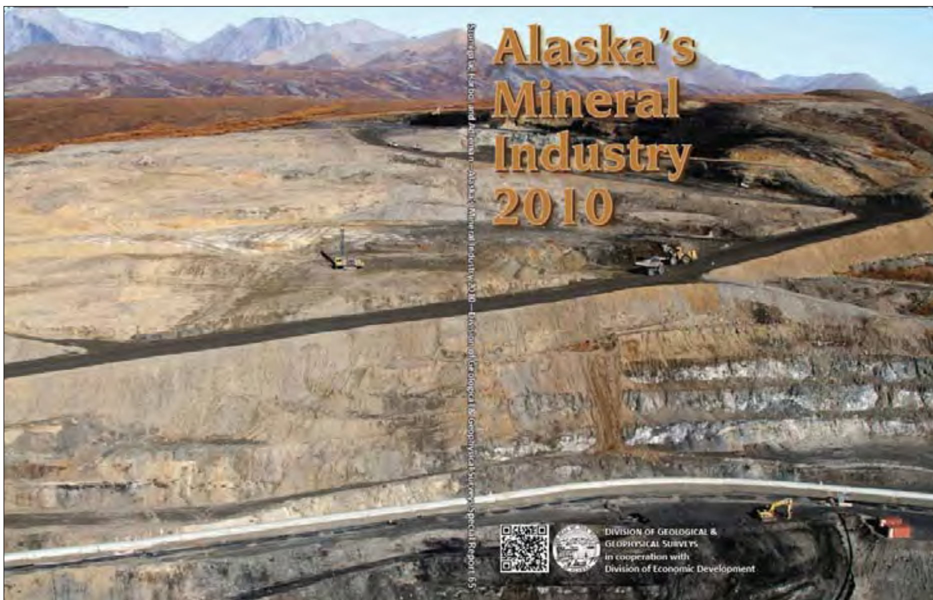


Contact: *Melanie Werdon, 907-451-5082,* melanie.werdon@alaska.gov

ANNUAL ALASKA MINERAL INDUSTRY REPORT

Alaska Statute 41.08 charges the Division of Geological & Geophysical Surveys (DGGS) *"…to determine the potential of Alaska land for production of metals, minerals, fuels, and geothermal resources…"; "…conduct such other surveys and investigations as will advance knowledge of the geology of Alaska…"; and "…print and publish an annual report and such other special and topical reports and maps as may be desirable for the benefit of the state."* To meet part of this goal, we gather, verify, collate, and distribute statistics and summary observations about Alaska's mineral industry and release this information in a timely manner to the public in the form of an annual mineral industry report, an interim summary, and public presentations. This project supplies information to the mineral industry, provides the State and the public with valuable data pertaining to the health of Alaska's mineral industry, and fosters a better understanding of the significance of the mineral industry to Alaska's private sector and government.

The annual Alaska mineral industry report is a key source of information about exploration, development, and production of Alaska's mineral resources. Statewide and international circulation of the report and its findings at professional mineral industry conventions and trade shows, at chambers of commerce and other organizations' meetings, and in professional journals informs the general public, local and international mineral industry, and local, state, federal, and international government agencies about current activities in Alaska's mineral industry. The report serves as a barometer for the mineral industry's status in any given year and provides unbiased, authoritative information compiled in a consistent format. Government personnel rely on the report as an essential tool for formulating public policy affecting resource and land management.



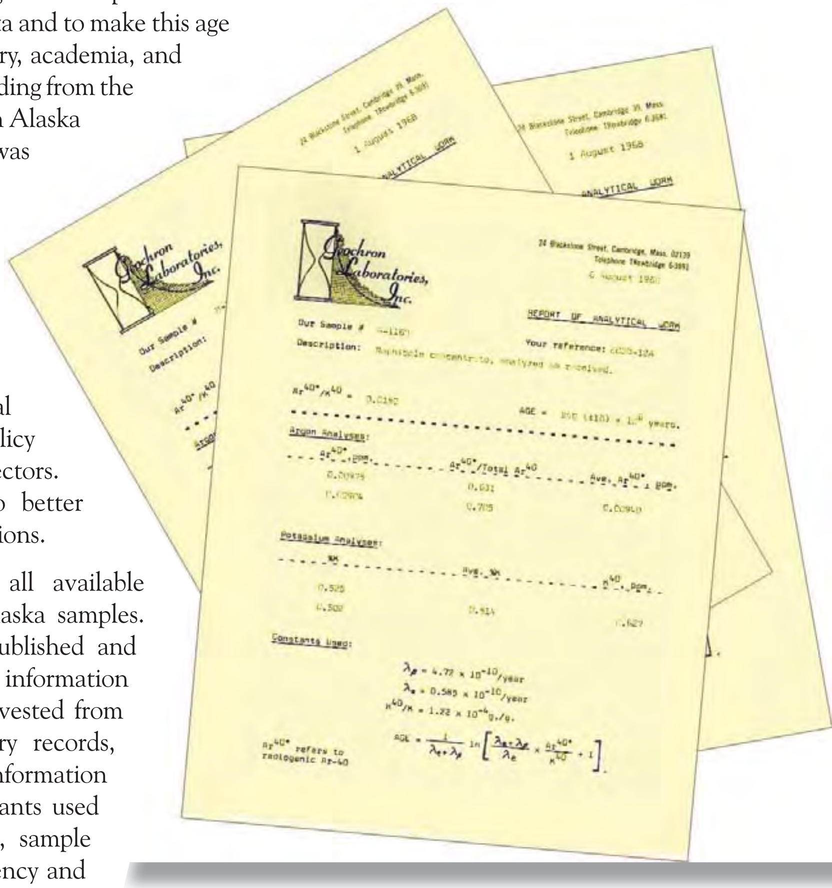
The 2010 Alaska mineral industry report, released in November 2011, summarizes information provided through replies to questionnaires mailed by DGGS, phone interviews, press releases, and other information sources. The 2010 cumulative value of Alaska's mineral industry, the sum of exploration, development, and production values, was $3.685 billion, $718.1 million higher than 2009's value of $2.966 billion. Exploration expenditures for 2010 were $264.4 million, approximately one-third of the United States total, and a 47 percent increase from the $180.0 million expended on exploration in 2009. Development expenditures amounted to $293.3 million, down 11 percent from the $330.8 million spent in 2009, and the estimated first market value of mineral production was $3,126.8 million, an increase of more than 27 percent from the 2009 value of $2,455.6 million. The estimated value of mineral production has exceeded $1 billion for nine consecutive years. Alaska's mineral industry value will increase in 2011 to more than $4 billion in total value due to strong metal prices and new mines starting production in 2010 and 2011.

The annual mineral report has been published for 30 consecutive years as a cooperative venture between the Department of Natural Resources' Division of Geological & Geophysical Surveys, and the Division of Economic Development in the Department of Commerce, Community & Economic Development. A summary of the 2011 Alaska mineral industry activities will be released by February 2012. The 2011 Alaska mineral industry report will be released by early November 2012.

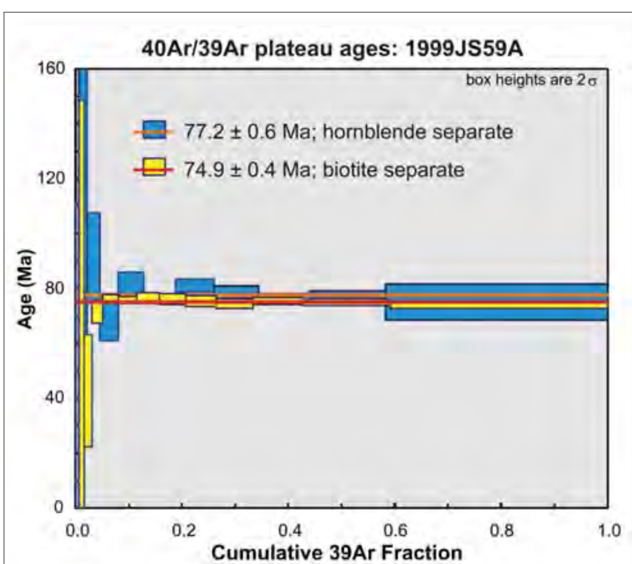
Contact: David J. Szumigala, 907-451-5025, david.szumigala@alaska.gov

GEOCHRONOLOGIC DATABASE FOR ALASKA

In 2005, DGGS initiated development of a comprehensive geochronologic database for Alaska. The geochronologic database contains summary interpretive and detailed analytical data and associated information for all available radiometric ages of rocks and minerals in Alaska. The project is designed to expand the most-current existing compilations of radiometric data and to make this age information widely accessible to private industry, academia, and government. This project was initiated with funding from the Federal Minerals Data & Information Rescue in Alaska (MDIRA) program, whose primary objective was to ensure that all available Alaska minerals data are securely archived in perpetuity, in a format easily accessible by all potential users. Since 2008, the Geochronologic Database for Alaska has been supported by State General Funds, with help from the National Geological & Geophysical Data Preservation Program (NGGDPP). Information about mineral resources is important for management policy decisions in both the public and private sectors. Increased use of high-quality data leads to better economic, legislative, and environmental decisions.



The compilation includes information for all available U-Pb, K-Ar, $^{40}Ar/^{39}Ar$, and Rb-Sr ages of Alaska samples. Radiometric ages are compiled from both published and unpublished sources. Essential basic supporting information that is currently not easily accessible was harvested from original publications, student theses, industry records, and laboratory archives. This detailed information includes raw analytical data, standards, constants used in calculations, analytical laboratory, analyst, sample preparation and processing steps, sampling agency and geologist, and sample context and descriptions. To date, more than 4,925 age records have been compiled.



Age spectra plot generated from detailed $^{40}Ar/^{39}Ar$ age data stored in the geochronologic database.

In 2009, DGGS loaded the compiled geochronologic data into its enterprise Oracle database. In 2010, DGGS created a beta-version Web Feature Service (WFS) containing age sample locations, basic metadata, and references to the appropriate original publications that were harvested by the NGGDPP's National Digital Catalog. WFS data are served online to the public in real time directly from DGGS's Digital Geologic Database (described on p. 70) and are importable into Geographic Information Systems (GIS) software. In 2012, DGGS anticipates upgrading the WFS with summary age data, developing a WFS-type data release with instructions for GIS users, and publishing a report of all summary geochronologic data in the central database. The final stage of the geochronology project will be to make these data fully accessible via an interactive, map- and text-based search application on DGGS's website and through a link on the MDIRA resource page (http://akgeology.info). DGGS's enterprise database will serve as a repository for future Alaska radiometric data and provide an authoritative, up-to-date, digital source of this important geologic information.

Contacts: Jennifer Athey, 907-451-5028, jennifer.athey@alaska.gov

ALASKA STAND-ALONE GAS PIPELINE GEOHAZARDS STUDY

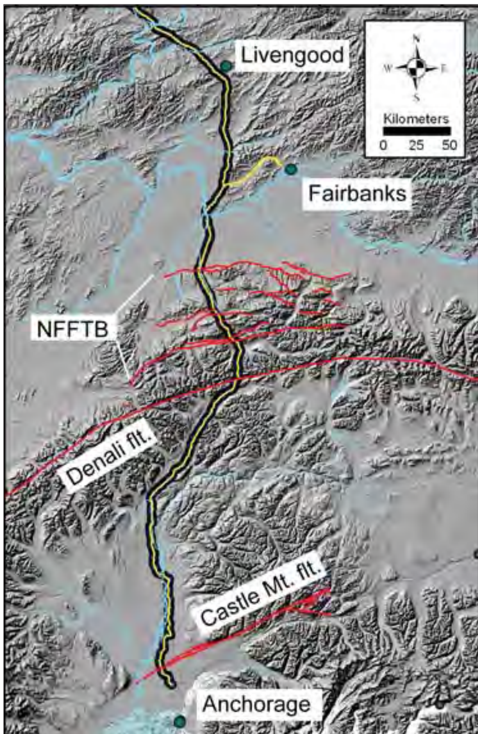


Figure 1. Hillshade map showing southern portion of proposed Alaska Stand-Alone Gas Pipeline (ASAP) route alignment and major faults. Primary gas line shown in black and yellow, smaller spur line to Fairbanks in yellow. NFFTB denotes Northern Foothills Fold and Thrust Belt.

In 2011, the Alaska Division of Geological & Geophysical Surveys (DGGS) initiated a multi-year geohazards investigation along the proposed Alaska Stand-Alone Gas Pipeline (ASAP) from Livengood to Anchorage (fig. 1). The ASAP project is being considered as an in-state pipeline designed to provide long-term supplies of natural gas from the North Slope to local markets. The purpose of the DGGS investigation is to characterize a variety of geologic hazards including earthquakes, mass movements, and cryogenic processes that could potentially affect pipeline route feasibility, design, and construction. DGGS's approach is to systematically evaluate geohazards along the proposed route based on a series of sequential studies that progress from more general to specific as detailed information develops.

During the 2011 summer field season, DGGS geologists compiled existing maps and data, contracted and acquired new high-resolution airborne lidar data (described separately, p. 54), and performed helicopter and field reconnaissance aimed at characterizing geologic hazards (fig. 2). Relevant geospatial data sources were integrated into a common Geographic Information System (GIS) where all the available data could be cataloged, georeferenced, and analyzed at the same scale. The project geodatabase will be used to archive specific data related to the assessment of geologic hazards and the pipeline alignment, including soil characteristics, Quaternary geology, active fault traces, landslide scarps, floodplains, and permafrost issues. The project GIS data were also used to plan logistics for daily field programs, which were conducted out of four base camps near Willow, Talkeetna, Cantwell, and Healy.

DGGS geologists have begun to produce a preliminary geohazards report and map showing areas susceptible to geologic hazards along the pipeline route. Hazard maps originally compiled on topographic maps will be reevaluated and upgraded based on our interpretation of the recently acquired lidar data. Final maps will show the location, distribution, and relative importance of specific geologic hazards, which will be useful to assess route alignment and sites for more detailed, site-specific analyses. Critical geologic hazards identified during the 2011 field season will be further investigated in 2012. In particular, site-specific fault studies along the Castle Mountain and Denali faults (fig. 1) will help define fault displacement parameters necessary for adequate pipeline design considerations. Funding for this project was provided by the Alaska Gasline Development Corporation.

Figure 2. DGGS geologist measuring a stream offset along the Denali fault east of Cantwell. Photo by Rich Koehler, June 12, 2011.

Contact: Richard Koehler, 907-451-5006, richard.koehler@alaska.gov

ASSESSMENTS OF GEOLOGIC HAZARDS ASSOCIATED WITH CLIMATE CHANGE

Evidence indicates that most high-latitude northern regions have undergone rapid and substantial warming over the last few decades. Alaska is particularly sensitive to the effects of climate warming, as much of its social and economic activity is affected by the conditions of snow, ice, and permafrost. Changes in climate can modify natural processes and could increase the magnitude and frequency of certain types of geologic hazards (such as flooding, erosion, slope instability, and thawing permafrost) (fig. 1) and, if not properly addressed, can have a direct effect on Alaska communities and infrastructure, as well as on the livelihoods and lifestyles of Alaskans. The State can help preserve the integrity of its infrastructure and the health and safety of Alaska's people by being prepared for potential emergency situations resulting from geologic hazards that are caused or amplified by climate change. A critical first step is to perform the necessary sound science to identify high-risk areas where proactive mitigation efforts will be needed and useful, and areas where design structure and proper, informed planning can alleviate the need for future mitigation.

The Division of Geological & Geophysical Surveys (DGGS) has developed a Climate Change Hazards Program to rigorously assess geologic hazards associated with climate change and publish information to be used for planning, hazard mitigation, and emergency response in high-risk communities and developing areas. DGGS is accomplishing this by collecting the necessary field data to assess geologic hazards and publish peer-reviewed geologic-hazards maps and reports of high-risk communities and infrastructure in Alaska. We are completing these assessments at local and/or regional scales as needed to address specific local problems and to understand and evaluate the larger geologic context. This effort is a collaboration with relevant outside organizations including the Immediate Action Work Group of the Governor's Subcabinet on Climate Change, University of Alaska, Federal Emergency Management Agency, Alaska Division of Homeland Security & Emergency Management, Alaska Department of Commerce, Community and Economic Development, U.S. Geological Survey, and U.S. Army Corps of Engineers, and will provide valuable information to allow planners and design engineers to minimize the economic impacts and public safety risks associated with geologic hazards.

DGGS scientists conducted field-based geologic hazards assessments and mapping in and around the communities of Seward and Whittier during summer 2011, and expect to complete draft products for these communities in FY2012. The geologic-hazards maps will delineate areas where potential natural hazards such as avalanches, flooding, erosion, slope instability, and thawing permafrost should be considered at a more detailed level to fully evaluate risk for any given use and will be published in digital GIS format in conformance with national standards. Reports describing the geology and hazards will accompany the maps.

The Climate Change Hazards Program is funded by the State of Alaska as a Capital Improvement Project (CIP).

Figure 1. Multiple transverse cracks indicate an unstable south-facing slope above Spruce Creek and Lowell Point near Seward, Alaska. Increases in temperature and the number of high-magnitude precipitation events can lead to an increase in landslide activity that can threaten property and infrastructure.

Contact: Gabriel Wolken, 907-451-5018, gabriel.wolken@alaska.gov

GEOHAZARD EVALUATION AND GEOLOGIC MAPPING FOR COASTAL COMMUNITIES

According to the 2010 United States census, more than 60 percent of Alaskans reside in coastal communities. Many of these communities are exposed to a wide range of geologic hazards including erosion, landslides, wave attack, storm surge/flooding, tsunami and ivu (ice push). Since 2004, reports and recommendations from the U.S. General Accounting Office, the U.S. Army Corps of Engineers, and the Immediate Action Work Group of the Governor's Subcabinet on Climate Change have highlighted the imperiled or at-risk status of many Alaskan villages that are subject to severe flooding and erosion. In response to both existing risks and to shifts in the frequency and/or magnitude of geohazard-triggering events, including those that may be influenced by changing climate, communities throughout the state are becoming increasingly involved with mitigation or adaptation efforts in response to these natural hazards. Baseline data pertaining to local geology, coastal and oceanic processes, and historic natural hazard events are necessary to facilitate these efforts (fig. 1).

Figure 1. Meagan DeRaps uses precision GPS equipment to measure elevations (a) perpendicular to a Unalakeet beach and (b) on a bluff ~10 miles east of Nome that was overtopped in the 2011 Bering Sea storm.

In 2009, DGGS received federal funding from the Minerals Management Service (now Bureau of Ocean Energy Management) through the Coastal Impact Assistance Program (CIAP) to establish a coastal community geohazards evaluation and geologic mapping program in support of local and regional planning. Following an extensive review of existing data and consultation with numerous agencies and affected coastal districts, a priority mapping list was developed (fig. 2). The program was launched in 2010 with a pilot project in Kivalina (see p. 52), which leveraged State CIP funds and federal STATEMAP funds from the U.S. Geological Survey for an expanded scope. Subsequent fieldwork in the summer of 2011 was conducted in the communities of Shaktoolik and Unalakleet. Maps and reports for Kivalina will be published in 2012, and those for Shaktoolik and Unalakleet will be published in 2013.

The DGGS CIAP program will document the geologic context and dominant coastal processes near at least nine Alaskan communities by FY2014. A coastal geohazard map series tailored to the specialized needs of Alaska will identify local natural hazards that must be considered in the siting, design, construction, and operations of development projects to ensure protection of human life, property, and the coastal environment. Where necessary, surficial geologic mapping (1:63,360 scale) will also be completed. These maps will be published in GIS format with standard metadata. For communities that are seeking to relocate or to establish evacuation shelters/routes, these products will be a useful planning tool for informed decision making because they delineate areas where geologic hazards should be considered at a more detailed level to fully evaluate construction risk, identify potential sources of construction materials, and ensure that planned and proposed development will not exacerbate existing hazards.

Ongoing consultation and coordination with the Immediate Action Work Group, Alaska Division of Community & Regional Affairs, U.S. Army Corps of Engineers, Alaska Department of Transportation & Public Facilities, U.S. Geological Survey, National Oceanic and Atmospheric Administration, affected coastal communities, and private-sector geotechnical consultants will continue to shape this program and avoid duplication of efforts.

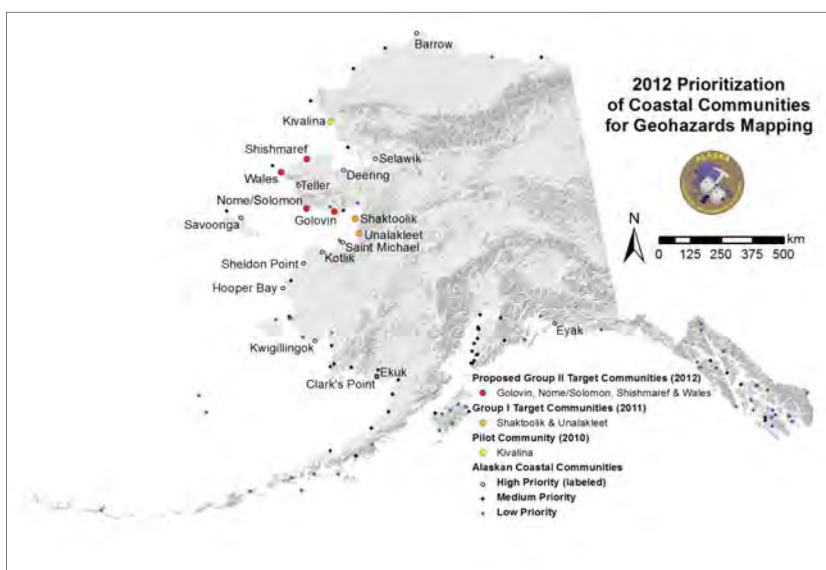


Figure 2. Communities currently selected for inclusion in the DGGS CIAP mapping program. Prioritization is subject to revision based on direct dialogue with community leadership and the recommendations and activities of other state, federal, and local agencies.

Contact: Nicole Kinsman, 907-451-5026, nicole.kinsman@alaska.gov

GEOLOGIC MAPPING AND HAZARDS EVALUATION IN AND NEAR KIVALINA, NORTHWEST ALASKA

Approximately 10,600 kilometers of Alaska's coastline and many low-lying areas along the state's rivers are subject to severe flooding and erosion. The United States General Accounting Office (GAO; now the U.S. Government Accountability Office) reported in 2004 that flooding and erosion affects 184 out of 213 (86 percent) of Alaska Native villages. These findings were reinforced by subsequent studies, conducted by the U.S Army Corps of Engineers and the Immediate Action Workgroup of the Alaska Governor's Subcabinet on Climate Change, which identified a number of communities as being in greatest peril due to anticipated climate change phenomena and therefore in most need of immediate actions to prevent loss of life and property.

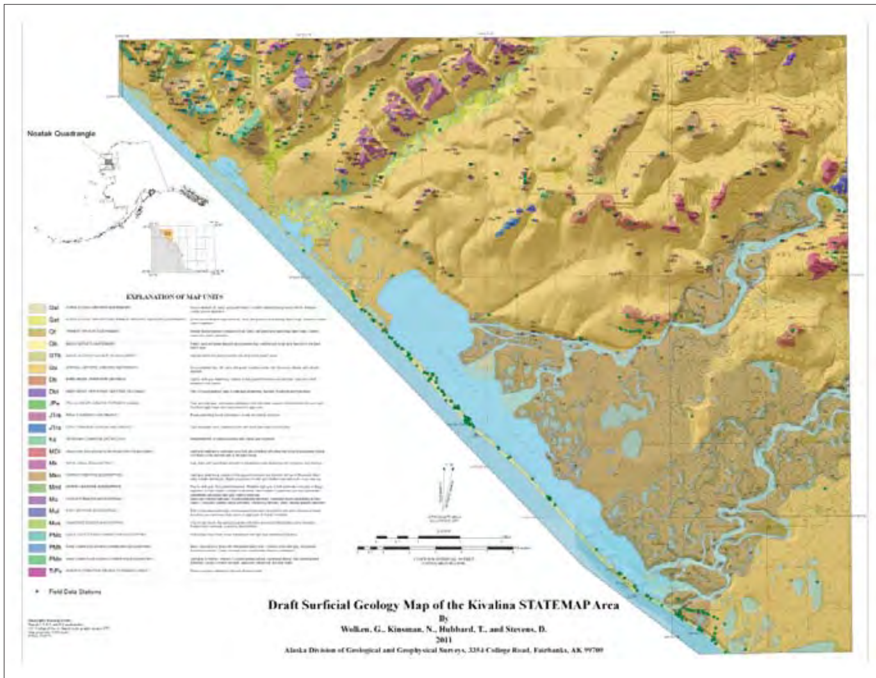


Figure 1. Draft surficial-geologic map of Kivalina study area.

The Alaska Division of Geological & Geophysical Surveys (DGGS) has statutory responsibility to perform the necessary science to identify high-risk areas where proactive mitigation efforts will be needed and useful. For FFY10, Alaska's Geologic Mapping Advisory Board (GMAB) endorsed DGGS's choice of the high-risk community of Kivalina (fig. 1) as a U.S. Geological Survey (USGS) STATEMAP-funded project in order to map surficial geology and assess geologic materials and natural hazards in support of informed community planning to deal with the severe flooding and erosion.

The objectives of the Kivalina STATEMAP project are: (1) Map the surficial geology in sufficient detail to develop comprehensive lithologic unit descriptions and a geomorphic framework that can be used to understand the active earth processes affecting the village of Kivalina and the surrounding area, and map the bedrock geology at a reconnaissance level sufficient to evaluate the lithologies for general engineering charac-teristics; (2) Develop information matrices and derive maps that describe the general engineering properties of bedrock and unconsolidated geologic units in the map area; and (3) Identify and map potential geologic hazards, including the coastal zone and areas of flooding, erosion, thawing permafrost, and slope instability (fig. 2).

Figure 2. Thermokarst and drainage system development near Kivalina, Alaska.

DGGS personnel have compiled field and remote-sensing data and have generated draft maps for the Kivalina STATEMAP project. Additionally, data from this project were presented at the fall 2010 American Geophysical Union and the 2011 American Society of Civil Engineers (ASCE) Solutions to Coastal Disasters Conference. These new data and products will be critical to community planners as they develop and administer their plans in the context of these major undertakings. We anticipate publishing the final maps and report in fall 2012.

This project is funded by the State of Alaska through DGGS's Climate Change Hazards program and by the federal STATEMAP program through USGS. Additional federal funding for this project was provided by the Coastal Impact Assistance Program (CIAP) through the Bureau of Ocean Energy Management as part of the DGGS Coastal Hazards program.

Contact: Gabriel Wolken, 907-451-5018, gabriel.wolken@alaska.gov

GEOLOGY, GEOHAZARDS, AND RESOURCES ALONG THE PROPOSED NATURAL GAS PIPELINE CORRIDOR, ALASKA HIGHWAY, FROM DELTA JUNCTION TO THE CANADA BORDER

In preparation for the proposed Alaska natural gas pipeline, the Alaska Division of Geological & Geophysical Surveys (DGGS) has continued work on a multi-year project to evaluate the geology, geohazards, and material resources between Delta Junction and the Canada border along a 12-mile-wide corridor centered along the Alaska Highway. This work is now being enhanced with recently acquired high-resolution lidar (light detection and ranging) data along an approximately 1-mile-wide corridor centered along the Alaska Highway (fig. 1).

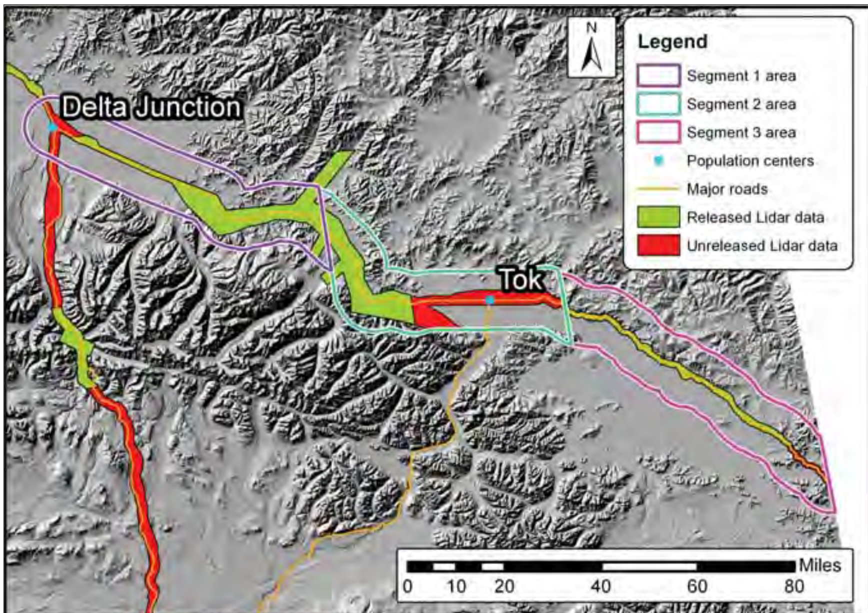


Figure 1. Map showing the three segments of the Alaska Highway Corridor study and areas where lidar was collected. All lidar data will be available to the public.

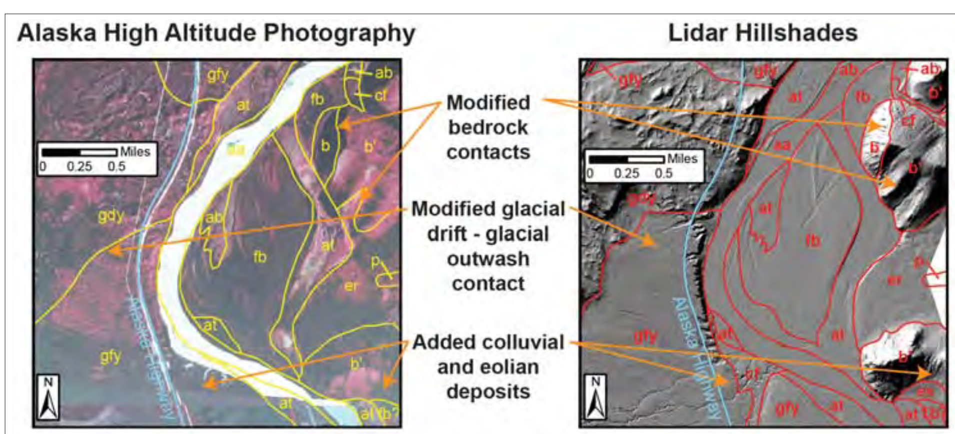
Published materials from each of three segments along this route include reports describing surficial geology, permafrost, bedrock geology, and potentially active faults. Each report, with the exception of one describing potentially active faults, will be accompanied by 1:63,360-scale reconnaissance maps and digital GIS data. An engineering-geologic map and associated descriptive table will also be published as a derivative product from each surficial-geologic map.

During 2011, DGGS published the surficial geology report and accompanying maps for the second segment between Dot Lake and Tetlin Junction. With the exception of bedrock geology, this completes publication of maps and reports for the first two segments. Maps and reports for the third segment of the corridor between Tetlin Junction and the Canada Border are in the advanced stages of editing and we anticipate publication in 2012.

Fieldwork was conducted during the summer of 2011 to refine geologic mapping and use lidar to evaluate potential geologic hazards (fig. 2). DGGS plans to complete fieldwork and lidar evaluation in 2012, and anticipates completing for review a draft comprehensive report describing the geology and geologic hazards for the entire corridor route, including results from lidar evaluations, in fall 2012. DGGS will publish a set of final comprehensive geologic maps in 2013, accompanied by seamless GIS layers of all geologic mapping.

The Gas Pipeline Corridor project is funded by the State of Alaska as a Capital Improvement Project (CIP).

Figure 2. Examples from the Tanacross B-6 Quadrangle illustrating how lidar is being used to refine geologic contacts originally mapped using airphoto interpretations. Original mapping on left, revised mapping on right.



Contact: *Trent Hubbard, 907-451-5009,* trent.hubbard@alaska.gov

AIRBORNE LIDAR ACQUISITION FOR GEOLOGIC HAZARD EVALUATION OF PROPOSED NATURAL GAS PIPELINE CORRIDORS

In advance of design, permitting, and construction of potential pipelines to deliver North Slope natural gas to out-of-state and Alaska customers, the Division of Geological & Geophysical Surveys (DGGS) has acquired and is making publicly available high-resolution airborne lidar (light detection and ranging) data for an area of approximately 3,000 square miles along proposed pipeline routes (fig. 1). Financial support for the project comes from the Alaska Gas Pipeline Project Office, the Office of the Federal Coordinator, and the Alaska Gasline Development Corporation (AGDC). These data serve multiple purposes, but were primarily collected to (1) evaluate geologic hazards, including active faulting, slope instability, thaw settlement, erosion, and other engineering considerations along the proposed pipeline routes, and (2) provide a base layer for the State–Federal GIS database that will be used to evaluate permit applications and construction plans.

Lidar data for this project include: (1) Continuous, 1-mile-wide coverage over existing infrastructure along the lengths of the various proposed natural gas pipeline corridors from Prudhoe Bay to Valdez following the route of the Trans-Alaska Pipeline System (TAPS), the Alaska Highway from Delta Junction to the Canada border, and Livengood to the Anchorage area along the George Parks Highway; (2) approximately 1-mile-wide corridors over routes the State believes gas pipeline applicants are considering, where departing from existing infrastructure; (3) half-mile-wide coverage of existing primary pipeline-support roads where outside the main corridor; and (4) expanded areas of coverage along these corridors where data are needed for evaluation of known or suspected active faults, slope instability, and other hazards.

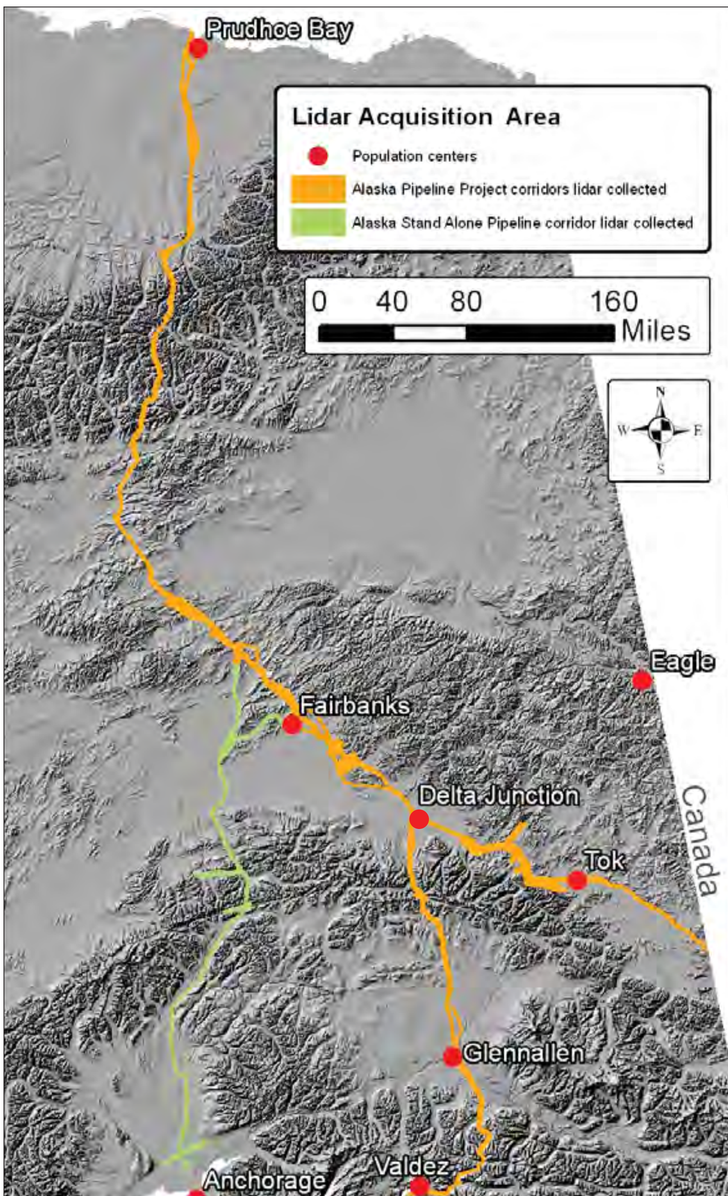


Figure 1. Lidar acquisition areas.

The quality-controlled lidar data and products, grouped by USGS quadrangle, are being made available to the public on the DGGS website (http://dggs.alaska.gov/pubs/id/22722) soon after delivery from the contractor. The initial DGGS lidar data release includes bare-earth digital elevation models (DEMs), lidar intensity images, bare-earth hillshade images, and water-body polygons. Other lidar products, including point cloud data, vegetation metrics, and digital surface models will be made available at a later time. In addition to making the data publicly available, DGGS is using lidar data for ongoing projects to evaluate active faults and geologic hazards. For example, the lidar products have enabled the Proposed Natural Gas Pipeline Corridor Geohazards Project (described separately, p. 53) to refine geologic contacts from earlier work and to identify areas of previously unrecognized slope instability. All lidar data and products from this project will be available to the public online by spring 2012.

Contact: Trent Hubbard, 907-451-5009, trent.hubbard@alaska.gov

SURFICIAL-GEOLOGIC MAP OF THE LIVENGOOD AREA, TOLOVANA MINING DISTRICT, ALASKA

During the summer of 2003 DGGS geologists mapped the northern 124 square miles of the 229-square-mile Livengood airborne geophysical survey tract (fig. 1). These geophysical and geological projects are part of the Alaska Airborne Geophysical/Geological Mineral Inventory Program, a multi-year investment by the State of Alaska to expand Alaska's geologic and mineral resources knowledge base, catalyze future private-sector mineral exploration and development, and guide State planning. The Livengood area, located about 75 miles northwest of Fairbanks in the northern part of the Tintina gold belt, contains the most productive portion of the Tolovana mining district. Approximately 500,000 ounces of placer gold have been mined from the Livengood subdistrict. The Elliott Highway, numerous mine roads, and the Trans-Alaska Pipeline System (TAPS) corridor provide excellent accessibility to the mineralized zones.

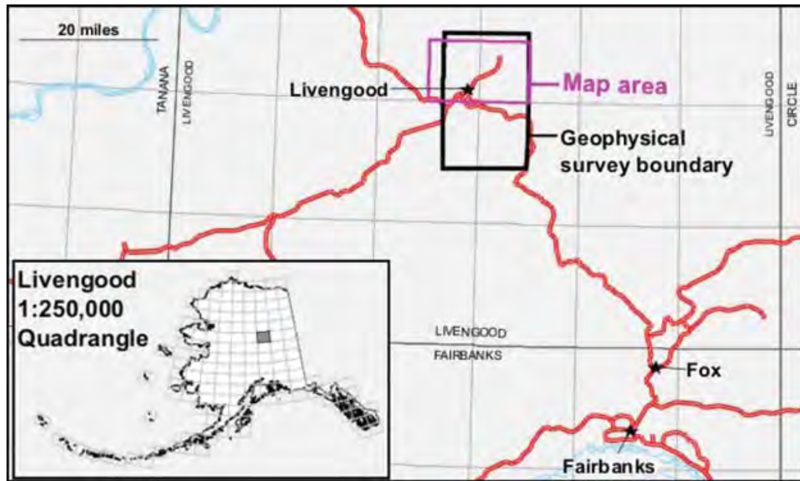


Figure 1. Livengood study area.

DGGS published a 1:50,000-scale bedrock geologic map and supporting geochemical and geochronologic data in 2004, but the surficial-geologic map was not completed at that time. In response to current high commodity prices and renewed interest in Livengood-area geology and mineral resources, DGGS is working to revise and update the draft map and publish it in hard copy and GIS formats (fig. 2). In support of this effort, DGGS contractors engaged in field work in summer 2011 to acquire the data necessary to complete the mapping project. We anticipate publication of the 1:50,000-scale surficial-geologic map in fall 2012.

New surficial-geologic interpretations in the map area will lead to better understanding of the geologic framework for placer deposits in the Livengood area, stimulate increased mineral exploration investment, and provide construction-materials resource information useful for planning and construction of future infrastructure in this developing region. The Livengood geologic mapping project was funded by the State of Alaska, with additional support by the U.S. Geological Survey STATEMAP program.

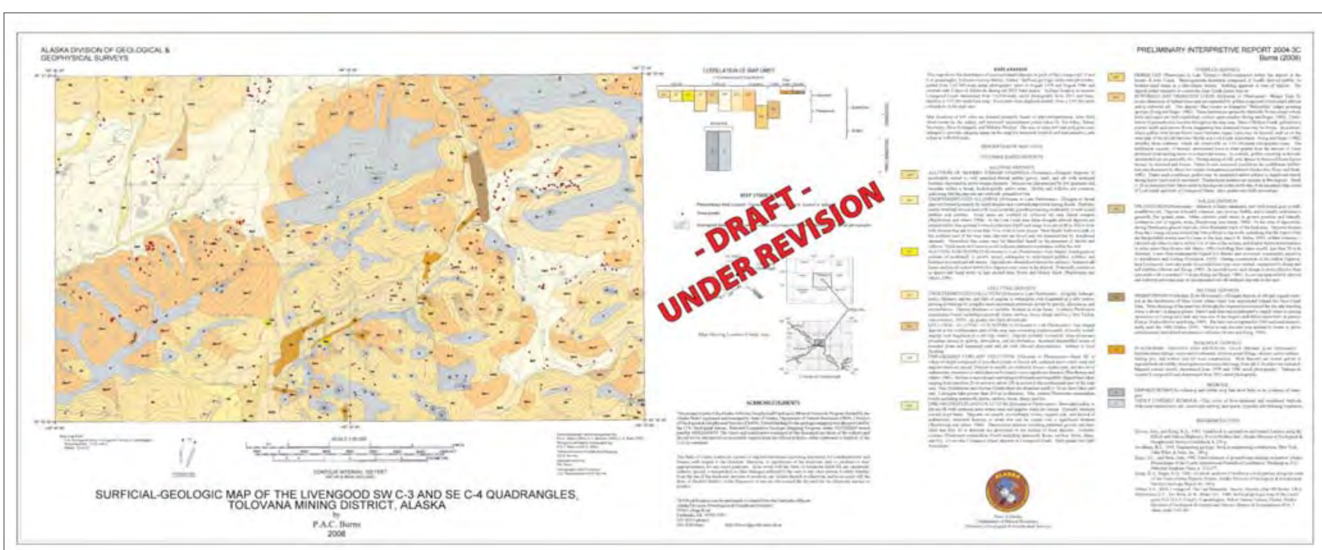


Figure 2. Draft surficial-geologic map of the Livengood area based on 2003 fieldwork and air photo interpretation. The map is undergoing extensive revision in response to additional field data collected in 2011.

Contact: De Anne Stevens, 907-451-5014, deanne.stevens@alaska.gov

MapTEACH

Alaska's Division of Geological & Geophysical Surveys (DGGS) continues to participate in MapTEACH (Mapping Technology Experiences with Alaska's Community Heritage), an education–outreach program that targets geospatial technology skills for rural Alaska students (fig. 1). This program is a continuation of what was originally a multi-year NSF-funded collaborative project led by DGGS and is now an important part of the University of Alaska Integrated Geography Program. MapTEACH emphasizes hands-on experience with spatial technology (GPS, GIS, Google Earth, and remote-sensing imagery in a local landscape–landform context) in conjunction with traditional activities. Working directly with geologists and local landscape experts, participants are presented with a chance to authentically emulate scientific data collection and mapping activities at a novice level, using real data in a real-world setting.

Figure 1. The MapTEACH website (http://www.mapteach.org) offers curriculum resources and other helpful information about the program to teachers wishing to explore place-based education in Alaska.

MapTEACH is founded on the integration of three focus areas: Geoscience, geospatial technology, and local landscape knowledge. Program materials are built on a menu-based model in which users (teachers) can select those portions of the curriculum that are most useful for their classroom objectives. When implementing the full range of MapTEACH curriculum, students and teachers interact in field settings with Native Elders, traditions-based community leaders, and professional geologists from DGGS and the University of Alaska. Introducing students to geoscience and geospatial technology in culturally responsive and stimulating classroom and field settings will enhance community understanding of landscape processes and natural hazards in rural Alaska. It will also foster appreciation of state-of-the-art technology tools and datasets that can be applied to informed community planning and decision making.

Figure 2. The 2011 MapTEACH Capstone Field Experience provided an intensive field-based integration of the program's focus areas of geoscience, geospatial technology, and local knowledge. Students and teachers collaborated with Elders, local knowledge experts, and scientists to understand, document, and map the history and landscape of the Tanana River between Manley Hot Springs and Old Minto using GPS units and GIS.

The MapTEACH training model includes multiple workshops and on-site training and classroom visits with participating teachers. In 2011, MapTEACH conducted a 6-day field camp for students, teachers, Elders, and scientists in Manley Hot Springs and Old Minto (fig. 2). MapTEACH is currently working primarily with the Yukon–Koyukuk and Yukon Flats school districts to train science and geography teachers in the use of the MapTEACH curriculum, but the program has attracted the attention of other school districts and resulted in additional teacher-participants in Sleetmute, Hoonah, and Metlakatla.

MapTEACH is funded by the Alaska Department of Education and Early Development (EED) through an Alaska Native Education Program (ANEP) grant to the University of Alaska Fairbanks. Additional EED support is provided through Alaska Title II-A SEP Competitive grants to the Yukon–Koyukuk and Yukon Flats school districts.

Contact: De Anne Stevens, 907-451-5014, deanne.stevens@alaska.gov

QUATERNARY FAULT AND FOLD DATABASE

The Alaska Division of Geological & Geophysical Surveys (DGGS) has designed a Quaternary fault and fold database for Alaska in conformance with standards defined by the U.S. Geological Survey (USGS) for the National Quaternary fault and fold database (fig. 1). Alaska is the most seismically active region of the United States; however, little information exists on the location, style of deformation, and slip rates of Quaternary faults. Thus, to provide an accurate, user-friendly, reference-based fault inventory to the public, we have produced a digital GIS shapefile of Quaternary fault traces. This database will be of great utility to the earthquake engineering community, the insurance industry, scientific researchers, policy planners, and the general public, and will contribute to the established database of active faults for the nation. The release of the database is timely for the assessment of seismic hazards associated with several proposed natural gas pipelines presently under consideration within the State.

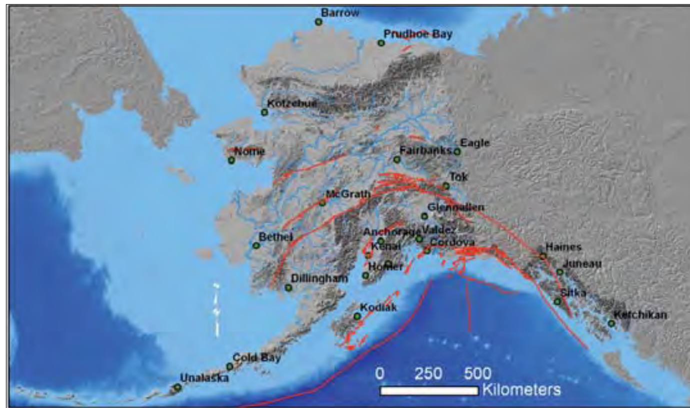


Figure 1. Hillshade image of the State of Alaska and surrounding areas showing fault traces from the Alaska Quaternary fault and fold database.

Fault parameters in our GIS fault attribute tables are in accordance with national guidelines and include fault name, age, slip rate, slip sense, dip direction, location confidence (i.e., well constrained, moderately constrained, or inferred), and mapped scale. Our initial effort will serve as a platform to append additional information as new faults are discovered and future detailed studies are implemented.

To host the database, we are developing an interactive web-map application that will present the database through a variable scale range, with each fault displayed at the resolution of the original map. Application functionality includes search by name or location, identification of fault by manual selection, and choice of base map. Base map options include topographic, satellite imagery, and digital elevation maps available from ArcGIS on-line (fig. 2). We anticipate that the database will be publicly accessible from a portal embedded on the DGGS website by early 2012 and will provide a comprehensive resource for seismic hazard assessment and regional policy planning.

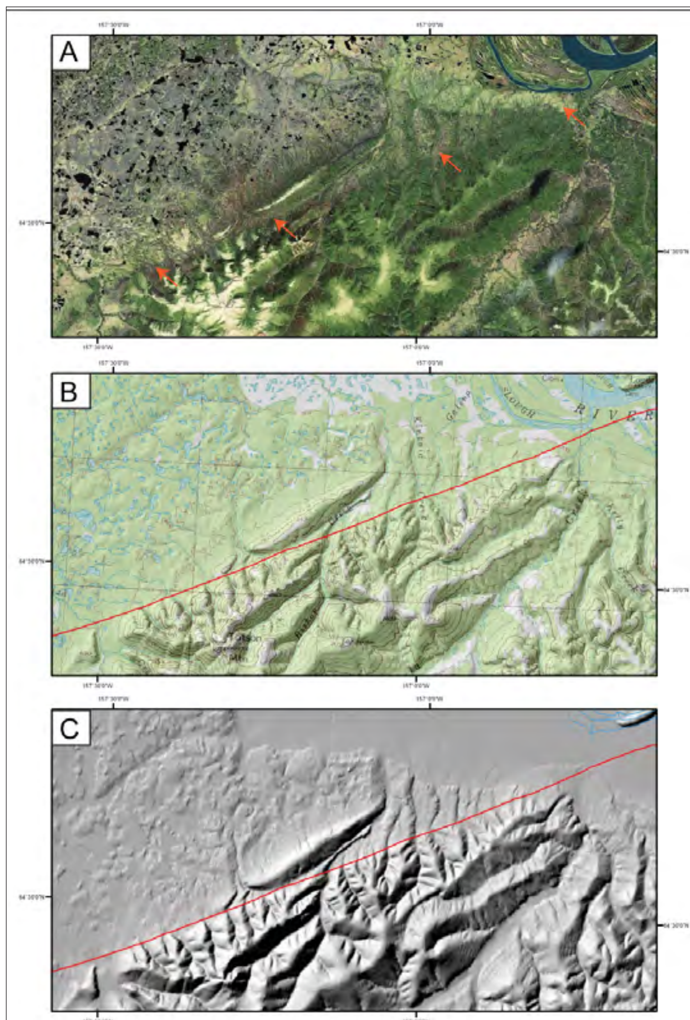


Figure 2. Examples of the digital base maps available for viewing Quaternary faults and folds in the web-map application. (A) Satellite image, (B) 1:250,000-scale topographic map, and (C) hillshade image. Shown is the Kaltag fault in central Alaska.

Initial funding was provided by the USGS; funding to support the GIS digitizing efforts was provided by the Federal Emergency Management Agency (FEMA) through the Alaska Division of Homeland Security & Emergency Management. Pending additional funding, DGGS plans to develop text-based descriptions about individual structures. Pertinent data summarized in these descriptions will include geographic information, geomorphic expression, length, average strike, sense of movement, age of faulted surficial deposits, existing paleoseismological studies, and a list of references.

Contact: Richard Koehler, 907-451-5006, richard.koehler@alaska.gov

SURFICIAL-GEOLOGIC MAP OF THE SAGAVANIRKTOK AREA, NORTH SLOPE ALASKA

The Alaska Division of Geological & Geophysical Surveys (DGGS) continues work begun in 2008 to publish a new 1:63,360-scale surficial-geologic map covering approximately 1,200 square miles of the northern Brooks Range foothills in the Sagavanirktok B-3, B-4, B-5, A-3, A-4, and A-5 quadrangles (fig. 1). The Trans-Alaska Pipeline System (TAPS) and Dalton Highway run through the central portion of the study area; detailed geologic mapping will provide important information about construction materials resources and potential geologic hazards such as thawing permafrost, slope failure, and flooding, which are important for highway and pipeline maintenance, as well as for planning for future infrastructure development.

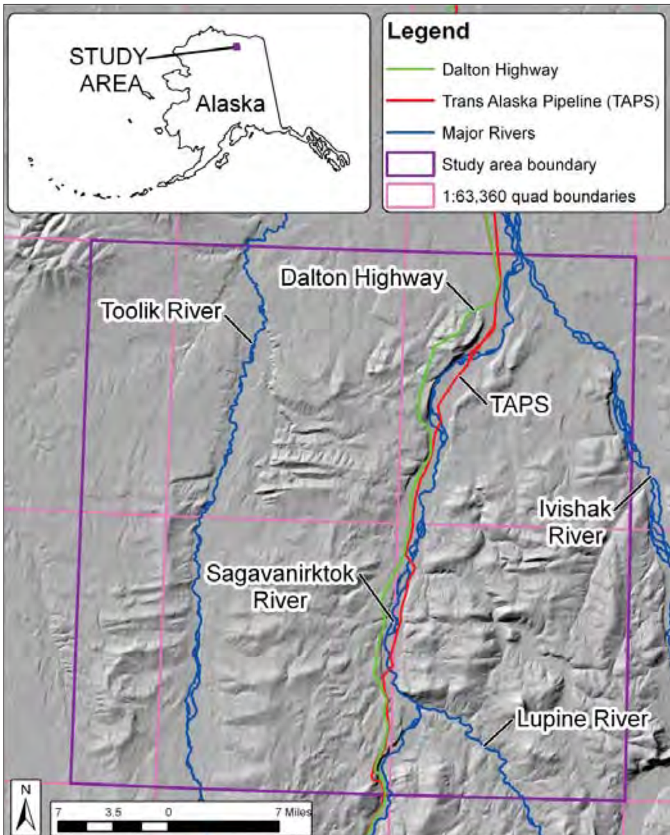


Figure 1. Sagavanirktok study area.

The surficial geology of the study area is dominated by glacial deposits, often highly modified by slope processes (fig. 2) and containing extensive ice-rich permafrost. Middle to upper Pleistocene glacial deposits in the southern and eastern parts of the map typically retain primary glacial morphology, whereas Tertiary to lower Pleistocene glacial deposits farther to the north and west are characterized by more gentle gradients and extensive solifluction. Polygonal ground and thermokarst are common in silt-rich, low-lying areas and in unglaciated terrain in the northern- and westernmost portions of the map area.

Surficial-geologic mapping in this area will provide baseline data necessary for future development such as resource exploration and construction of a proposed natural gas pipeline. This kind of detailed baseline geologic information is generally very limited in arctic regions of Alaska. The mapping will additionally provide information useful for assessing the nature and rate of landscape change over time.

We anticipate that the map will be submitted for publication in 2012, with final release expected by 2013. This project has been conducted in conjunction with the DGGS Energy Resources section as part of its continuing work assessing and mapping the geology of the northern foothills of the Brooks Range. The Sagavanirktok mapping project is funded by the State of Alaska, with additional funding provided by the federal STATEMAP program through the U.S. Geological Survey.

Figure 2. Anaktuvuk River drift of early Pleistocene age is characterized by broad, gently sloping surfaces extensively modified by colluvial and periglacial processes.

Contact: Trent Hubbard, 907-451-5009, trent.hubbard@alaska.gov

SURFICIAL-GEOLOGIC MAP OF THE TYONEK AREA, WEST COOK INLET, ALASKA

In conjunction with the 2010 Tyonek STATEMAP project (see p. 33), the Division of Geological & Geophysical Surveys (DGGS) is undertaking surficial-geologic mapping on the west side of Cook Inlet (fig. 1). The 875-square-mile map area in the northwestern Cook Inlet trough is rich in petroleum, coal, geothermal, aggregate, and timber resources, but the detailed geologic mapping necessary for planning future resource development exists only in part of the area. The purpose of our surficial-geologic mapping is to provide important detailed information for the entire STATEMAP area to supplement cooperative bedrock investigations there by DGGS, the U.S. Geological Survey (USGS), and University of Alaska geologists.

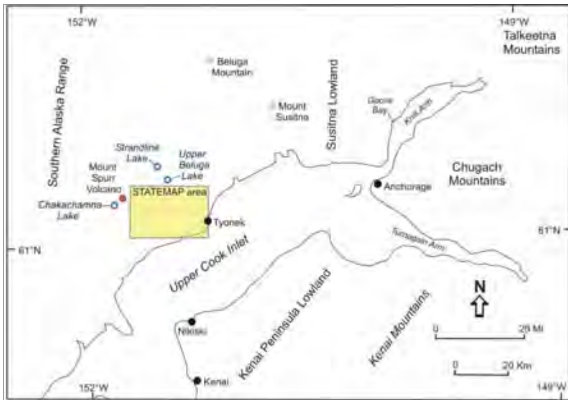


Figure 1. Location map of Tyonek area.

Glacial, volcanic, and mass-movement deposits dominate the Tyonek landscape (fig. 2). During the last major glaciation, the map area was invaded by the massive Cordilleran Ice Sheet, which spread eastward into the Cook Inlet trough from sources in the southern Alaska Range to the west and north. Following the maximum ice extent about 23,000 years ago, the glacier complex thinned and ice from individual lobes fluctuated as it deposited glacial and glacioestuarine sediment that is now preserved in the coastal lowland area of northwestern Cook Inlet. Volcanism centered on the Mt. Spurr complex temporarily dammed the valley of Chakachatna River, producing extensive flooding in the southwestern part of the map area. Massive landslides have displaced bedrock and Quaternary sediments in the uplands and valley walls of incised streams, and the volcanic plateau in the northwestern map area is being actively dismantled by complex landslides along the eastern and western margins.

New geologic mapping will lead to a better understanding of the region's geologic framework and provide geologic-resource and -hazards data critical to sound land management decisions. Final products of the Tyonek surficial mapping project will be a report and 1:63,360-scale surficial-geologic map, which are anticipated to be published in summer 2012. Bedrock geologic mapping performed in conjunction with this project is described separately. This project is funded by the State of Alaska and by the federal STATEMAP program through the USGS.

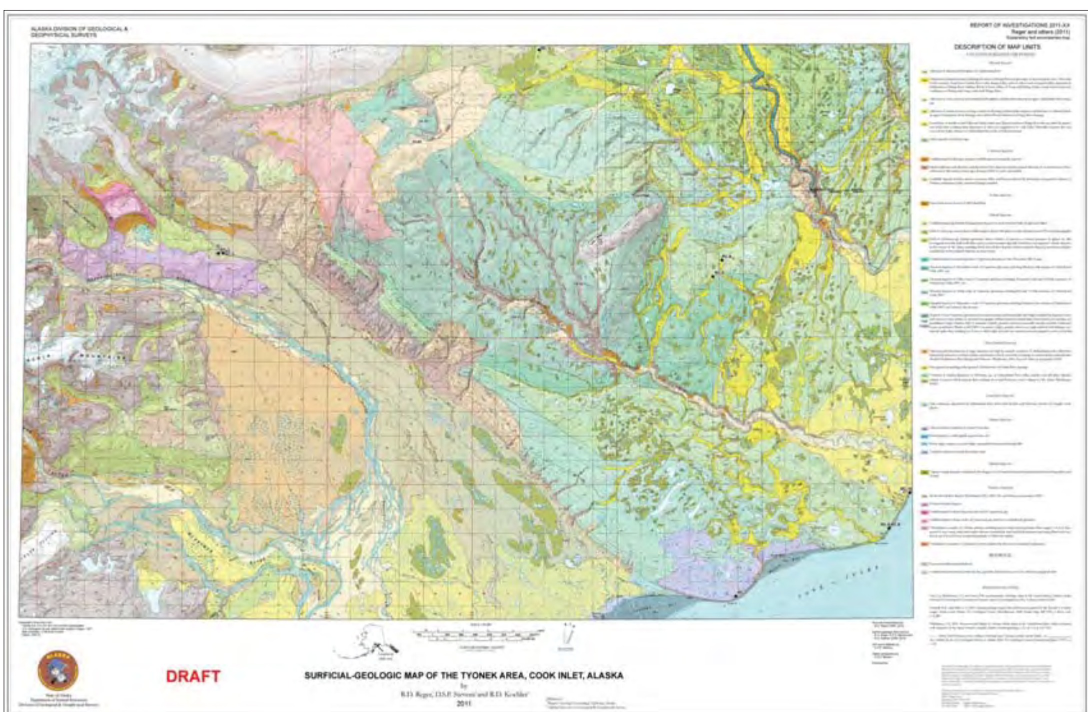


Figure 2. Draft surficial-geologic map of the Tyonek area. Green=glacial deposits, yellow=alluvial deposits, blue=glacioestuarine deposits, salmon=landslides, orange=flood deposits, and pink–purple=volcanic deposits.

Contact: De Anne Stevens, 907-451-5014, deanne.stevens@alaska.gov

GEOLOGIC CONTRIBUTIONS TO THE PROPOSED SUSITNA–WATANA HYDROELECTRIC PROJECT, ALASKA

The Alaska Energy Authority (AEA) has been authorized by the State of Alaska to develop the Susitna–Watana Hydroelectric Project on the Susitna River, Alaska (fig. 1). The purpose of the project is to help meet the future electrical needs of Alaska's Railbelt Region by providing clean, renewable energy at the lowest possible long-term cost. Located approximately halfway between Anchorage and Fairbanks on the upper Susitna River, the 700-foot-high Susitna–Watana dam is expected to have a reservoir 39 miles long and up to 2 miles wide, with an average annual power generation of 2,600 GWhrs (AEA). The powerhouse, dam, and related facilities would be linked by a transmission line to the Railbelt Intertie, as well as to road or railroad access from the Parks or Denali highways.

Figure 1. The Susitna–Watana Hydroelectric Project will provide power to meet the electrical needs of Alaska's Railbelt Region. Map by the Alaska Energy Authority, http://www.susitna-watanahydro.org.

An accurate assessment of the site geology and potential for seismic and other geologic hazards is essential for dam location, design, and construction. The Alaska Division of Geological & Geophysical Surveys (DGGS) has therefore initiated a project at the request of AEA to evaluate seismic-hazard issues and produce GIS-based geologic and derivative construction-materials resources maps in support of the hydroelectric project. Planned work includes map and data compilation and assessment of existing geologic and seismic hazards data. Information developed in the course of this project will be disseminated through publicly available maps and reports published by DGGS.

DGGS's overall project plan reflects a phased approach to evaluating selected geologic aspects of the proposed Susitna–Watana Hydroelectric Project. Phase 1 is currently underway and consists of (1) a review of existing and new AEA-contractor-developed seismic hazards reports, (2) a review of existing contractor-developed geologic maps of the Susitna–Watana Hydroelectric Project area, and (3) conversion of the existing hardcopy geologic maps into digital GIS format. Phase 1 preliminary maps and geologic assessments are anticipated to be completed in 2012. Future work is dependent on additional funding but may include Phase 2 field-based verification to improve and expand the body of geologic data needed to fully meet the requirements of this major hydroelectric project, and a Phase 3 wrap-up of the geologic evaluation with final field checks, additional data analysis, and report writing.

This project is funded by the Alaska Energy Authority.

Contact: De Anne Stevens, 907-451-5014, deanne.stevens@alaska.gov

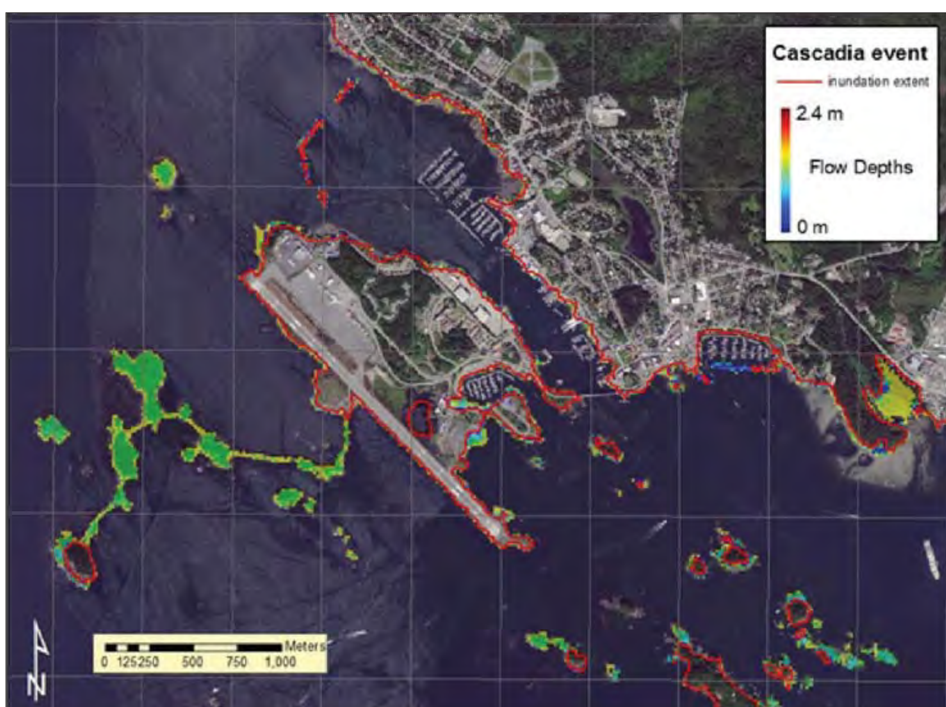
TSUNAMI INUNDATION MAPPING FOR ALASKA COASTAL COMMUNITIES

With funding from Congress, the National Oceanic & Atmospheric Administration (NOAA) initiated the National Tsunami Hazard Mitigation Program in 1997 to assist Pacific states in reducing losses and casualties from tsunamis. The program included funding for five states (Alaska, Hawaii, Washington, Oregon, and California) to address four primary issues of concern: (1) Quickly confirm potentially destructive tsunamis and reduce false alarms, (2) address local tsunami mitigation and the needs of coastal residents, (3) improve coordination and exchange of information to better utilize existing resources, and (4) sustain support at state and local level for long-term tsunami hazard mitigation. In 2005, following the catastrophic Sumatra earthquake and tsunami, the U.S. program was expanded to include Atlantic and Gulf of Mexico states and territories.

As part of this program, the Division of Geological & Geophysical surveys (DGGS) participates in a cooperative project with the Alaska Division of Homeland Security & Emergency Management (DHSEM) and the University of Alaska Geophysical Institute (UAGI) to prepare tsunami inundation maps of selected coastal communities. Communities are chosen and prioritized on the basis of tsunami risk, infrastructure, availability of bathymetric and topographic data, and willingness of a community to use results for emergency preparedness. For each community, DGGS and UAGI develop multiple hypothetical tsunami scenarios that are based on the parameters of potential underwater earthquakes and landslides. We have completed and published tsunami inundation maps for the Kodiak area, Homer, Seldovia, Seward, and Whittier. Source scenarios are being developed and wave modeling performed for Sitka and Valdez, for which draft maps and reports will be submitted in 2012.

To develop inundation maps, we use complex numerical modeling of tsunami waves as they move across the ocean and interact with the seafloor and shoreline configuration in shallower nearshore water. UAGI conducts the wave modeling using facilities at the Arctic Region Supercomputing Center. DGGS, UAGI, and DHSEM meet with community leaders to communicate progress and results of the project, discuss format of resulting maps, and obtain community input regarding past tsunami effects and extent. DGGS publishes the final maps along with explanatory text, which are available in both hardcopy and digital formats. DGGS also makes the GIS files of inundation limit lines available to the local communities for use in preparing their own tsunami evacuation maps.

Team members have presented results of this program at international tsunami symposia in Seattle; Honolulu; Istanbul; Vienna; Melbourne; Hania, Greece; and Perugia, Italy; and at American Geophysical Union annual meetings in San Francisco. Locally, we have given presentations in the affected communities, in Dutch Harbor, and at the Association of Environmental & Engineering Geologists 2011 national meeting in Anchorage. In addition, this project has been the subject of articles in *Geotimes* and *TsuInfo Alert Newsletter.*



Draft tsunami inundation map of Sitka, Alaska, showing modeled inundation from a hypothetical magnitude 9 subduction-zone earthquake in Cascadia, off the coast of Oregon and Washington.

Contact: Rod Combellick, 907-451-5007, rod.combellick@alaska.gov

REDOUBT VOLCANO: GEOLOGIC INVESTIGATIONS

In 2008 the Alaska Volcano Observatory (AVO), led by the Division of Geological & Geophysical Surveys (DGGS), initiated efforts to produce an updated geologic map and hazard assessment of Redoubt Volcano. Those efforts were interrupted by the onset of Redoubt's eruption on March 15, 2009, following 19 years of repose. The eruption ceased by July 1, 2009. Fieldwork since that time has concentrated in decreasing measure on mapping and sampling of 2009 deposits and increasingly back to completion of the geologic map and hazard assessment report.

Activities and Results: The primary goal of the 2011 field season on Redoubt Volcano was to increase our sample density of lava flows on the edifice and finalize placement of geologic contacts. The purpose of the sampling was to complement the dataset of surprisingly variable Holocene lava ages already analyzed by U.S. Geological Survey (USGS) collaborators, and help define units. A secondary goal for the 2011 season was to increase the sample density over the surface of the 2009 lava dome. Vesicularity studies and geochemical analyses completed earlier in the year indicate that a lava, which was more (and highly) vesicular and slightly different chemically than the initially extruded lava, began to effuse from the top of the final 2009 lava dome one month into its growth. Unfortunately, field efforts by AVO–DGGS geologists this season were hampered by persistently poor weather. Almost two weeks of planned mapping and sampling were reduced to fewer than four days. The sampling goal was nonetheless adequately accomplished over three days of intense sampling, but little to no time was left for detailed mapping; the dome was inaccessible.

Products: AVO–DGGS geologist Kate Bull is lead author on two manuscripts in review as part of a 2012 special issue on the 2009 eruption of Redoubt Volcano to be published in the *Journal of Volcanology and Geothermal Research.* One paper provides an overview of the eruption and summarizes the contributions of the papers in the special issue, the second describes the morphologic and vesicularity changes that occurred during growth of the final 2009 lava dome. Co-authors include collaborators from the USGS Volcano Hazards Program at AVO, the Cascades Volcano Observatory, and Menlo Park, and researchers from the University of Alaska Fairbanks and the University of Northern Colorado. Completion of the geologic map of Redoubt Volcano is expected in 2012.

Figure 1. AVO–USGS geologist Heather Bleick sampling lava flows on Redoubt Volcano's edifice (Photo by Kate Bull, DGGS–AVO).

Contact: Katharine Bull, 907-451-5055, katharine.bull@alaska.gov

CHIGINAGAK VOLCANO: GEOLOGIC MAPPING AND HAZARD ASSESSMENT

Mount Chiginagak is a hydrothermally active volcano on the Alaska Peninsula, approximately 170 kilometers (100 miles) south–southwest of King Salmon. This small stratovolcano, approximately 8 km in diameter, has erupted through Tertiary to Permian sedimentary and igneous rocks. The DGGS-led geologic mapping and hazard assessment work that began in 2004 was curtailed by the 2005 acid crater lake drainage (see p. 64). However, intermittent geologic fieldwork since 2005 has consisted of lava sample collection for age dating and geochemical analysis, mapping of Holocene lava flows, lahars, and debris avalanches, and the collection and stratigraphic description of tephra deposits.

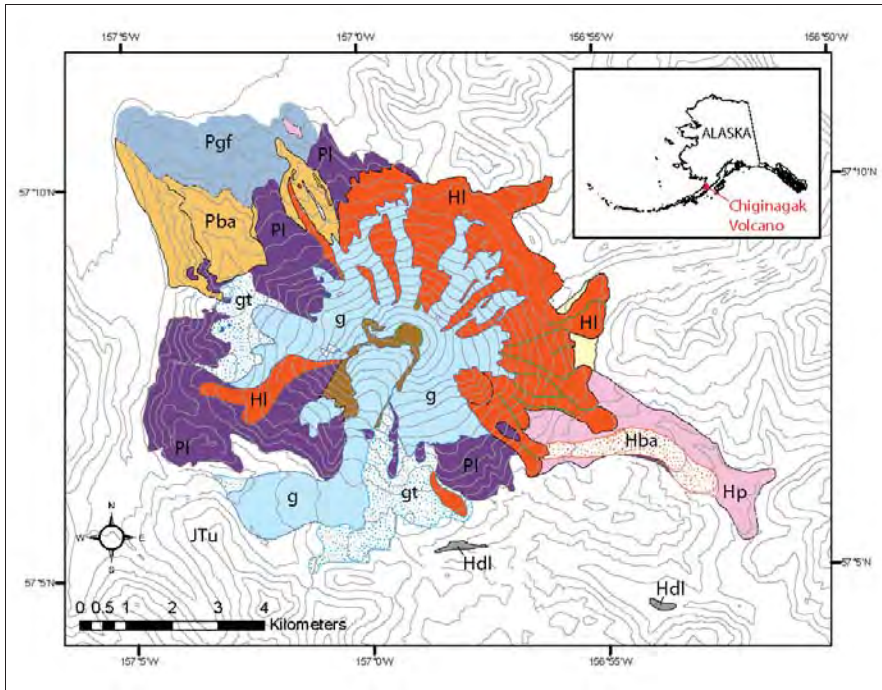


Figure 1. Generalized geologic map of Chiginagak volcano showing major undifferentiated deposits of Pleistocene lavas (Pl), Pleistocene block-and-ash flow deposits interlayered with andesite lavas (Pba), undifferentiated glaciofluvial and glaciolacustrine deposits (Pgf), Holocene lavas (Hl), Holocene block-and-ash flow deposits (Hba), Holocene pyroclastic flow deposits (Hp), Holocene debris avalanche and lahar deposits (Hdl), glaciers and perennial snow fields (g), and glacial till (gt). Pending $^{40}Ar/^{39}Ar$ age determinations and geochemical analyses will help differentiate these major depositional units. Unit JTu refers to undifferentiated bedrock (Tertiary to Permian rocks mapped by Detterman and others, 1987).

Pleistocene pyroclastic flows and block-and-ash flows, interlayered with andesitic lava flows, dominate the edifice rocks on the northern and western flanks (fig. 1, Unit Pba). The oldest rocks dated (~250 thousand years old) are lava bombs found in a cliff-forming pyroclastic flow deposit on the northwestern flank. Pleistocene porphyritic lava flows range in composition from 54.2 to 62.7 weight percent silica (SiO_2) and contain variable proportions of plagioclase, hypersthene, and augite.

Figure 2. Janet Schaefer (DGGS) collecting a sample of a prismatically jointed andesite lava block atop a block-and-ash flow deposit on the southeastern flank of Chiginagak volcano. Photo by Willie Scott (USGS), August 21, 2004.

Our mapping indicates that Holocene activity consists primarily of debris avalanches, lahars, and lava flows. Terrace deposits of lahars and debris avalanches appear along a creek draining the southeastern flank toward the Pacific Ocean (fig. 1, Unit Hdl) and in upper Indecision Creek below the toe of the south flank glacier. Holocene lava flows (Unit Hl, fig. 1) cover Pleistocene lavas on the northeastern flank and range in composition between 55.9 and 57.5 weight percent SiO_2. Holocene block-and-ash flow and pyroclastic flow deposits extend almost 8 km from the summit, down a valley on the southeastern flank (fig. 1, Units Hba and Hp; and fig. 2). Proximal tephra collected during recent fieldwork suggests there may have been limited Holocene explosive activity that resulted in localized ash fall.

A geologic map is scheduled to be published in 2012, followed by a hazard assessment in 2013.

Contact: Janet Schaefer, 907-451-5005, janet.schaefer@alaska.gov

CHIGINAGAK VOLCANO: MONITORING THE PERSISTENT ENVIRONMENTAL DAMAGE FROM THE 2005 ACID CRATER LAKE DRAINAGE

Mount Chiginagak is a hydrothermally active volcano on the Alaska Peninsula, approximately 170 kilometers (100 miles) south–southwest of King Salmon. Sometime between November 2004 and May 2005, a 400-meter-wide (~1,300-foot-wide), 100-meter-deep (~330-foot-deep) lake developed in the formerly snow-and-ice-filled crater of the volcano. In early May 2005, an estimated 3 million cubic meters (106 million cubic feet) of sulfurous, clay-rich debris and acidic water exited the crater through tunnels in the base of a glacier that breaches the south crater rim. More than 27 kilometers (17 miles) downstream, the acidic waters of the flood reached approximately 1.3 meters (4 feet) above normal stream levels and inundated an important salmon spawning drainage, acidifying Mother Goose Lake from its surface to its maximum depth of 45 meters (~148 feet; resulting pH ~2.9) and preventing the annual salmon run in the King Salmon River. A simultaneous release of gas and acidic aerosols from the crater caused widespread vegetation damage along the flow path.

Since 2005, a DGGS-led interdisciplinary science team has been monitoring the crater lake water that continues to flow into Mother Goose Lake by collecting surface water samples for major cation and anion analysis, measuring surface-water pH of affected drainages, and photo-documenting the condition of the summit crater lake. Results of this work have been published as DGGS Report of Investigations 2011-6. The report describes water sampling locations, provides a table of chemistry and pH measurements, and documents the condition of the summit crater between 2004 and 2011.

Beginning in 2009, 4 years after the flood event, an ice layer began to form again in the crater lake, indicating a cessation in the crater's fumarolic heat source. By 2011, the water level in the crater had decreased significantly (fig. 1). Although the crater lake surface is freezing, some water likely remains under the ice, draining beneath the south flank glacier into Indecision Creek, continuing to supply acidic water to Mother Goose Lake. Despite this acid input, acidity in Mother Goose Lake is decreasing, fish are returning, and time-series trends show decreasing concentrations of pollutants such as copper (Cu) and cadmium (Cd). We expect these trends to continue as input of acidic water from the crater lake declines.

This work was made possible with funding from the U.S. Geological Survey's Volcano Hazard Program as well as the U.S. Department of Interior, Fish & Wildlife Service (USFWS). The DGGS-led geologic mapping and hazard assessment fieldwork that began in 2004 is described separately (p. 63).

Figure 1. Crater lake images showing the change from 2004 through 2011. (A) A pre-flood, ice-filled crater in August 2004 (Mother Goose Lake in background), to (B) a partially drained crater lake in August 2005, 3½ months after the flood, and (C) a mostly drained crater lake and the accumulation of snow and ice in August 2011. Photos by J. Schaefer.

Contact: Janet Schaefer, 907-451-5005, janet.schaefer@alaska.gov

OKMOK VOLCANO: GEOMORPHOLOGY AND HYDROGEOLOGY OF THE 2008 PHREATOMAGMATIC ERUPTION

On July 12, 2008, with less than 5 hours of precursory seismic activity, the central Aleutian volcano Okmok erupted explosively, marking the beginning of a 5-week-long eruption that dramatically changed the morphology and groundwater system within the 8-km-wide caldera. The initial explosion sent an ash- and gas-rich column to 15 km above sea level. Early in the eruption, heavy rain mixed with new tephra on the flanks of the volcano, generating lahars (volcanic mudflows) that traveled across the upper slopes of the volcano and down all major drainages, creating large new deltas along the shoreline. For the next 5 weeks, eruption intensity waxed and waned with explosions occurring from multiple vents on the caldera floor as rising magma interacted with shallow groundwater. One crater formed next to, and eventually captured and drained, the largest pre-existing caldera lake (total volume drained was 13.6 million cubic meters). As the eruption subsided, coalescing maar and collapse craters eventually filled with water, forming a new lake to the west of cone D and dramatically changing the morphology and volume of the old lake. The longest-lived vent formed a 250–300-m-high, ~1.5-km-wide tuff cone on the western flank of pre-existing cone D. This new tuff cone, the new lakes and collapse pits, and the accumulation of many tens of meters of fine-grained tephra have significantly altered the Okmok landscape. This eruption was substantially larger than any Okmok eruption since that of 1817 (which destroyed the then-unoccupied village of Egorkovskoe on the north coast of Umnak) and far larger than the eruptions of 1945, 1958, or 1997.

Division of Geological & Geophysical Surveys (DGGS) geologist Janet Schaefer, along with Alaska Volcano Observatory (AVO) colleagues Jessica Larsen (University of Alaska Fairbanks Geophysical Institute) and Tina Neal (U.S. Geological Survey), are writing a DGGS Report of Investigations documenting this fascinating eruption. Fieldwork focused on the stratigraphy and sedimentology of the tephra deposits from the 2008 eruption, documentation and description of vent evolution, a revision of the hazard assessment, creation of a post-eruptive geologic map, and acquisition of surveyed GPS points for digital elevation model (DEM) creation. The new post-eruption DEM of the caldera will aid significantly in quantifying the geomorphic changes in the caldera (fig. 1). Anticipated release of the Report of Investigations is fall 2012.

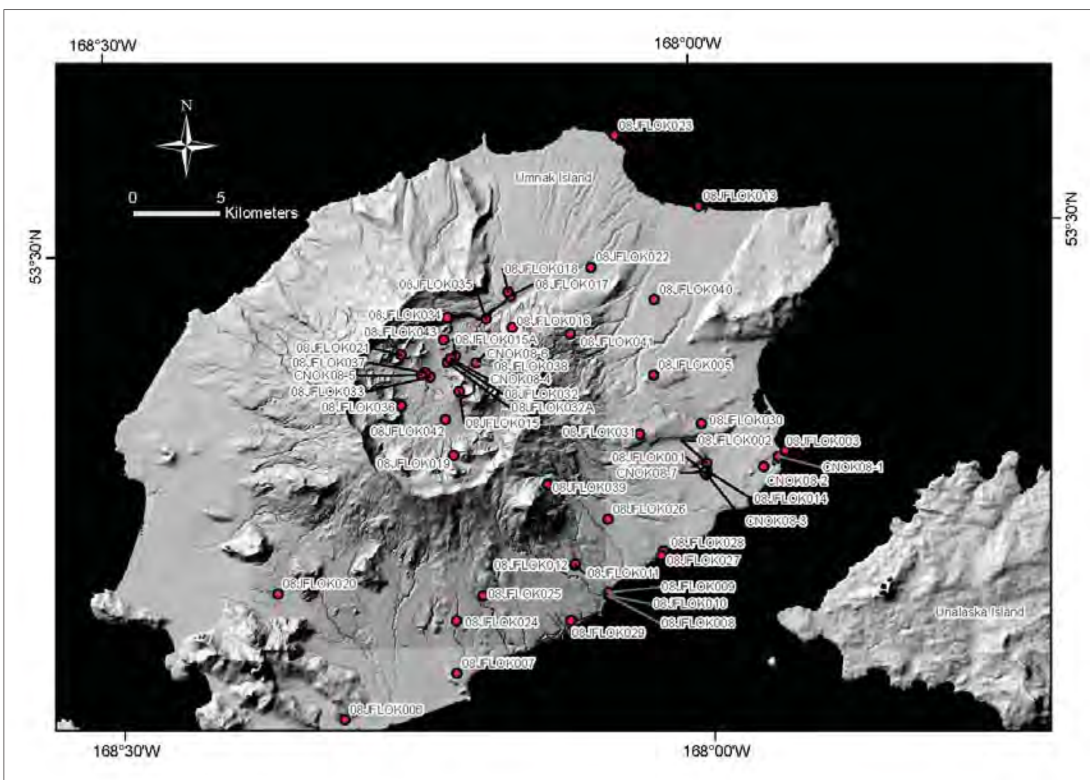


Figure 1. Field stations around Okmok volcano from August and September 2008. The shaded-relief basemap combines DEM data from 2000 with an overlay of a more detailed shaded relief image in the caldera derived from a DEM created from January 21, 2010, Worldview imagery.

Contact: Janet Schaefer, 907-451-5005, janet.schaefer@alaska.gov

ALASKA VOLCANO OBSERVATORY WEBSITE AND DATABASE

The Alaska Volcano Observatory (AVO) public website (http://www.avo.alaska.edu) serves about 6 million pages and approximately 300 gigabytes of data to well over 100,000 unique visitors per month, and is among the top ten U.S. Geological Survey (USGS) and USGS-affiliated websites in the country. It continues to be the most complete single resource on Quaternary volcanism in Alaska. DGGS was the original creator of the AVO website in 1994, and continues to be the site designer, builder, and manager.

AVO's website content is dynamically queried from a combination of MySQL and PostgreSQL databases named GeoDIVA (Geologic Database of Information on Volcanoes in Alaska). GeoDIVA maintains complete, flexible, timely, and accurate geologic and geographic information on Pleistocene and younger Alaska volcanoes to assist scientific investigations, crisis response, and public information. GeoDIVA is currently the most comprehensive and up-to-date authoritative source for information on Alaska volcanoes. It is still under construction, in a modular format. As modules are completed, they undergo continual maintenance so that they remain timely and useful. Current modules in maintenance mode include: bibliography (4,650+ references); basic volcano information (~140 major and ~200 minor volcanic features, 52 "historically active" volcanoes); eruption history information (information, text, and references for more than 430 historical eruptions); images (19,300+); sample information (~9,300); hand-sample storage (15,000+); and vent count (~1,200 vents). Modules in continuing development and initial data-load stages include geochemistry (~3,650 analyses); petrology (~130 1,000-point point-count analyses); GIS data; geochronology; and tephra chronology/tephra impacts.

The website employs several map interfaces to display spatial information to the public. As the Department of the Interior moves toward a restrictive contract with Google for use of Google's map interface, AVO is starting to move toward a more open interface to display maps on the website. In addition to being less restrictive, the other map interfaces AVO is investigating will allow AVO to display much more spatial data on the website than before.

AVO is on the leading edge of web and database development for volcano observatories, and is actively sharing its expertise with other observatories in the U.S. DGGS is following new and emerging technologies that will allow staff to further enhance AVO's web presence and data dissemination abilities. DGGS refines and enhances the applications that AVO and other observatories use on a regular basis. We will focus on continual incremental improvements to the site, and serving new database modules as they become available.

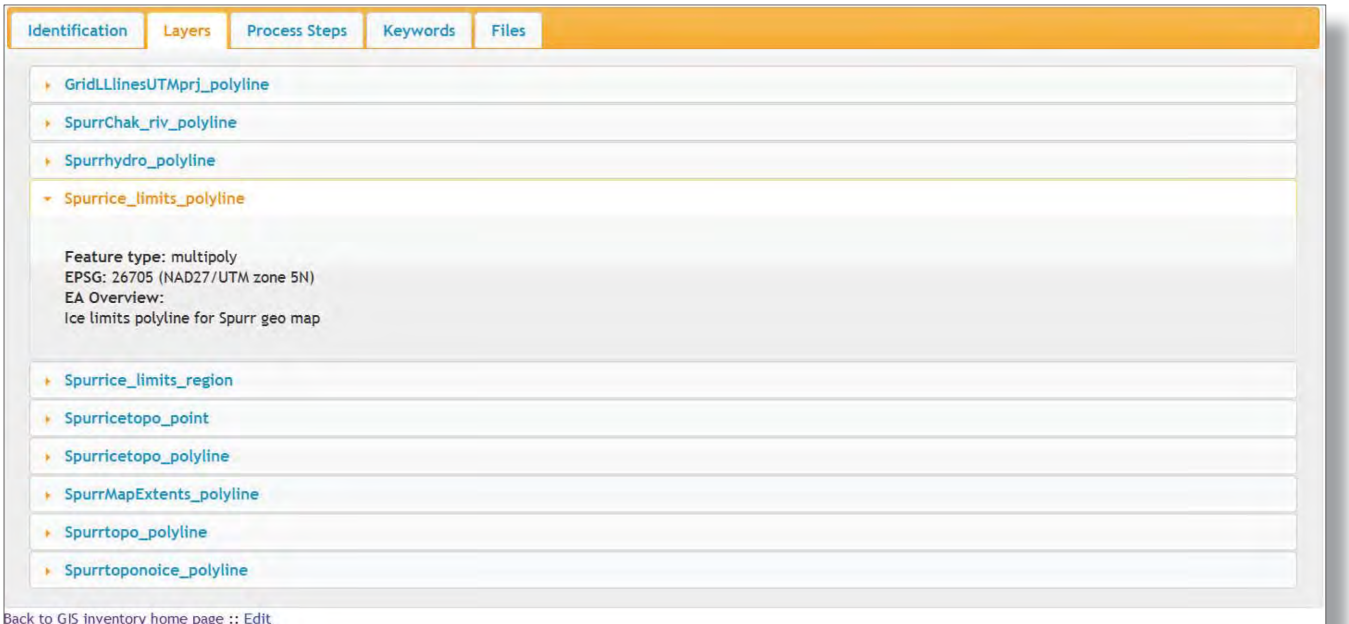
The map display of recent earthquakes (among other items) uses Google maps as its mapping interface. AVO is moving toward using alternate interfaces such as ESRI's API or the OpenLayers API.

Contacts: Seth Snedigar, 907-451-5033, seth.snedigar@alaska.gov
Cheryl Cameron, 907-451-5012, cheryl.cameron@alaska.gov

ALASKA VOLCANO OBSERVATORY GIS INVENTORY DATABASE

Nearly every Alaska Volcano Observatory (AVO) geoscientist now uses geographic information system (GIS) software for some of their tasks. AVO also collects georeferenced imagery for use in volcano monitoring and mapping. These data traditionally have been stored on individual users' desktop computers, leading to data inconsistencies, inaccessible data, and lack of standard metadata. As an initial goal toward implementing an enterprise GIS system for AVO, DGGS has created a utility to inventory, organize, and store AVO's existing GIS files. Staff are currently uploading data to the catalog, and making improvements to the user interface and export options.

Users of this database can upload their spatial data to a server, along with associated metadata. Other users (currently internal to AVO) can search within the metadata, and download the spatial files for their own use.



A list of layers associated with the Spurr geology map as stored in the AVO GIS inventory database.

The data and metadata upload routine is a multipart procedure during which the user can save their progress at any point and return to finish the process at a later time. Because not all collected data will be immediately published, only a subsection of the Federal Geographic Data Committee (FGDC) metadata standard is required at the time of data upload. For data that will be published in the future, metadata stored in the database can be exported to a standard xml file, where it can then be imported into the metadata editor of choice.

This GIS catalog (all of our most critical GIS data on one server, with appropriate metadata and use restrictions) is a stepping stone toward implementation of a more robust web GIS application of viewing/selecting the data files within a web browser, via a larger geospatial database.

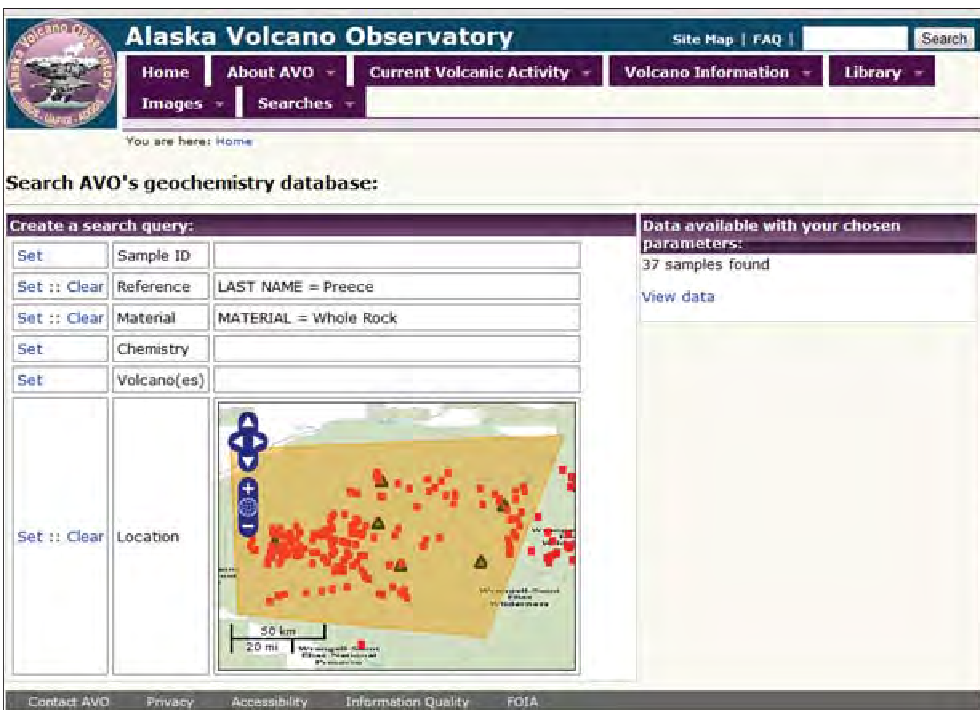
Contacts: Seth Snedigar, 907-451-5033, seth.snedigar@alaska.gov
Cheryl Cameron, 907-451-5012, cheryl.cameron@alaska.gov

ALASKA VOLCANO OBSERVATORY GEOCHEMICAL DATABASE

As part of DGGS's ongoing efforts with the Geological Database of Information on Volcanoes in Alaska (GeoDIVA), DGGS/AVO staff have created a database structure to hold geochemical data on Quaternary volcanic rocks in Alaska. Published data will be available to the public through AVO's website, and searchable by map, volcano, sample metadata information, or specific geochemical values or analysis types. Unpublished data will also be available internally to AVO users, if the data owner has granted explicit permission.

Currently, only whole-rock major and trace element values and metadata are being uploaded to the database, although the system is designed to accommodate other types of geochemical data, and is intended to be compatible with other major geochemical database efforts such as EarthChem. We are making every effort to provide the best data possible for each sample and analysis, which often entails additional actions such as tracking down obscure references and untangling sample nomenclatures through the decades. In addition, we have adjusted the results for some samples analyzed by inductively coupled plasma mass spectrometry (ICP-MS) at Washington State University prior to 2007 to correct calibration errors in the original report; we retain the best known value for each analysis, and do not keep the erroneous values.

This database will be a valuable research tool for geoscientists, with interests ranging from volcano-specific processes to whole-arc data synthesis. Because the database is an intrinsic part of GeoDIVA, it will also help consolidate all of Alaska's volcano information in one place. The database currently holds about 9,300 samples, and nearly half of those (4,674) have geochemical data entered. We estimate that fewer than 1,000 published analyses remain to be entered. We estimate the geochemical database will be ready for release and on-line public query in the fall of 2012 and will continue to grow as new geochemistry is published and added to the system.



View of prototype geochemical web-based search: in this example 37 sample analyses published by Shari Preece are located in the user-created polygon.

Contacts: Seth Snedigar, 907-451-5033, seth.snedigar@alaska.gov
Cheryl Cameron, 907-451-5012, cheryl.cameron@alaska.gov
Christopher Nye, 907-474-7430, chris.nye@alaska.gov

ALASKA VOLCANO OBSERVATORY — VOLCANO NOTIFICATION SERVICE (VNS)

AVO/DGGS developed the Volcano Notification Service (VNS), allowing the public to customize the information products they receive from all U.S. volcano observatories about any U.S.-monitored volcano. Previously, information releases were sent on an all-or-nothing basis per observatory—if an email address was on a list, that address was sent all information about all volcanoes by that observatory.

Anyone can subscribe to the VNS with an email address, and can create their own username and password for the VNS. Users can add as many email addresses as they need: a confirmation code is sent to each address to ensure the address was entered correctly and the user owns the address in question. The service can be accessed at http://volcanoes.usgs.gov/vns/.

Once a user is registered, he/she can select any or all volcanoes from each region—Alaska, Cascades, Hawaii, Long Valley, Yellowstone, and the Northern Marianas Islands. Volcanoes can be selected through a map view (fig. 1), or via a text-based list, sorted by region. Once selected, users can choose volcano-specific alert levels and color codes for their notifications. For example, an airline user may only be interested in Cook Inlet volcanoes when they are at elevated color codes, so the user might select Redoubt, Spurr, and Augustine, and elect to receive updates about those volcanoes when they are at color code Yellow or higher.

After a user selects volcanoes and alert levels/color codes, he/ she can then choose which information products to receive. Information products are observatory-specific and range from general information statements that include background commentary about volcanoes, to daily status reports on volcanic activity, to urgent notifications of significant activity.

The notification service checks for new volcano updates every five minutes, so users can expect to receive their emails between five and ten minutes after a new notification has been posted. Traditional notifications such as faxes and phone calls to emergency managers and airline coordinators will also continue.

Figure 1. The volcano selection interface uses a Google map to display monitored US monitored volcanoes. Users can zoom to specific regions by clicking the regional links to the left of the map.

Contacts: Seth Snedigar, 907-451-5033, seth.snedigar@alaska.gov

DIGITAL GEOLOGIC DATABASE PROJECT

In 2000, the Alaska Division of Geological & Geophysical Surveys (DGGS) saw an urgent need to develop a geologic database system to provide the architecture for consistent data input and organization. That database system now includes data identification and retrieval functions that guide and encourage users to access geologic data online. This project was initiated as part of the federally funded Minerals Data and Information Rescue in Alaska (MDIRA) program; ongoing data input, use, and maintenance of the database system are now an integral part of DGGS's operations supported by State General Funds.

DGGS's digital geologic database (Geologic & Earth Resources Information Library of Alaska [GERILA]) has three primary objectives: (1) Maintain this spatially referenced geologic database system in a centralized data and information architecture with access to new DGGS geologic data; (2) create a functional, map-based, on-line system that allows the public to find and identify the type and geographic locations of geologic data available from DGGS and then retrieve and view or download the selected data along with national-standard metadata (http://www.dggs.alaska.gov/pubs/); and (3) integrate DGGS data with data from other, related geoscience agencies through the multi-agency web portal, http://akgeology.info.

During the first 11 years, the project work group established a secure and stable enterprise database structure, started loading data into the database, and created multiple Web-based user interfaces. As a result, the public can access Alaska-related reports and maps published by DGGS, the U.S. Geological Survey, the U.S. Bureau of Mines, and the University of Alaska Fairbanks Mineral Industry Research Laboratory through a search interface that replaces the MDIRA Interagency Bibliography. Also easily accessible are DGGS project digital GIS data through a search page on the DGGS website (http://www.dggs.alaska.gov/pubs/), and DGGS geochemical data though a specialized search engine (http://www.dggs.alaska.gov/webgeochem/). Over the past few years, DGGS has become the leading Alaska geology-related database agency and a trusted online repository geologic publications and data.

During 2011, the project team continued progress on various projects requiring database and application support: National Geological & Geophysical Data Preservation Program (NGGDPP, http://datapreservation.usgs.gov) (p. 74), Geologic Map Index of Alaska (p. 76), Alaska Paleontology Database (p. 78), Alaska Geologic Data Index (formerly AKMIDI) (p. 77), ongoing additions of Alaska-related U.S. Bureau of Mines and U.S. Geological Survey publications, and maintenance of existing applications. These applications will also be available through the multi-agency web portal http://akgeology.info, which is now maintained by DGGS. Over the coming years, DGGS will continue to expand its repository of geologic data and strive to meet public demand for technologically advanced, easy-to-use, online data delivery systems.

Contacts: Susan Seitz, 907-451-5052, susan.seitz@alaska.gov
Jennifer Athey, 907-451-5028, jennifer.athey@alaska.gov

FIELD MAPPING TECHNOLOGY PROJECT

The Alaska Division of Geological & Geophysical Surveys (DGGS) collects, analyzes, and publishes geological and geophysical information toward its mandate to inventory and manage Alaska's natural resources and evaluate geologic hazards. DGGS creates a large amount of new data each year and synthesizes the data into multiple reports and maps for publication. On average, DGGS conducts seven field projects per year, each with teams of five geologists in the field for three weeks, or 735 person-days in the field. Each geologist records detailed observations at an average of 25 locations per day in a notebook or on a paper map, which amounts to more than 18,000 multi-part parcels of data per year that must be hand recorded and then translated and parsed into digital media for analysis and eventual publication.

DGGS is committed to the timely release of data to the public and prompt fulfillment of obligations to funding sources. In 2005, DGGS began investigating the potential of using digital field mapping to streamline data collection and processing. Digital mapping is defined as using a computer or personal digital assistant (PDA) to display and record information that has traditionally been recorded on paper, whether on note cards, in a notebook, or on a map. Computer technology and software are now becoming portable and powerful enough to take on some of the burden of the more mundane tasks a geologist must perform in the field, such as obtaining precise locations, plotting structural data, and color coding different physical characteristics of a rock. Additionally, computers can now perform some tasks that were formerly difficult to accomplish in the field, for example, recording text or voice digitally and annotating photographs on the spot. DGGS believes that the greatest benefit of digital mapping will be a decrease in the amount of time necessary for data entry, thereby potentially increasing the amount and quality of information that can be recorded during a field day.

In 2011, DGGS field tested Windows tablet computers and third-party field mapping software with mixed results. Staff successfully located interesting geologic features on the ground by viewing imagery on a tablet, while riding in a helicopter. Other applications on the same device, such as taking field notes in bright sunlight, were unsuccessful. Most DGGS geologists need lightweight, fully ruggedized, field-ready tablet computers with screens readable in bright light—however, no such equipment is available. DGGS continues to actively monitor technological advances in this area for likely prospects.

To facilitate discussion in the geologic community regarding digital field mapping technology, DGGS implemented a three-prong plan. In 2009, DGGS created a digital geologic mapping Wikipedia page (http://en.wikipedia.org/wiki/Digital_geologic_mapping). The web page was accepted into WikiProject Geology—an attempt to create a standardized, informative, comprehensive, and easy-to-use geology resource. In 2010, DGGS created a mailing list (http://list.state.ak.us/soalists/geomapping_technology/jl.htm) that currently has more than 60 members in the U.S. and abroad. DGGS also surveyed the geologic community regarding their interest in digital geologic mapping and the current technology being used. With the help of the American Geological Institute, the e-mail survey went out to more than 1,250 organizations (university geology departments, state and national geological surveys, and the private sector) with a ~13 percent response rate. Final results of the survey are posted (http://ngmdb.usgs.gov/Info/dmt/docs/DMT11_Athey.pdf) and DGGS has submitted a paper to U.S. Geological Survey for publication.

Contacts: Jennifer Athey, 907-451-5028, jennifer.athey@alaska.gov

WEBSITE DEVELOPMENT/ONLINE DIGITAL DATA DISTRIBUTION

The Division of Geological & Geophysical Surveys (DGGS) posted its first website in the late 1990s—a humble "starter site" comprising a few static HTML pages. Since that time, the site has been transformed into an informative, useful, well used, database-driven site that is now the division's primary means to announce and distribute the geological and geophysical publications and information it produces.

The cumulative result of a series of multi-year projects, the current website (http://www.dggs.alaska.gov) provides access to users to search and view or download online DGGS publications; additionally, the site posts publications produced by other geoscience agencies, including the U.S. Geological Survey, UAF Mineral Industry Research Lab, and U.S. Bureau of Mines.

DGGS's site also provides easy access to its geophysical data, geochemical data, information about its Geologic Materials Center, an online Guide to Geologic Hazards in Alaska, descriptions of the division's projects and special studies, accomplishments from previous years, and other topics of interest.

Users can view (and download at no charge) approximately 7,000 text reports, 9,000 oversized sheets, and more than 200 digital geospatial datasets.

In 2010 the Governor's Office updated the statewide "look and feel" for State of Alaska public web pages. In adopting the new State standards, DNR has implemented additional "look and feel" and navigation specifications that facilitate access to the information and services provided by the DNR divisions. The new standards have provided DGGS with an exciting opportunity to add fresh content to our site, to optimize site performance, and to better integrate the website with data stored in our geologic database.

Contacts: Simone Montayne, 907-451-5036, simone.montayne@alaska.gov

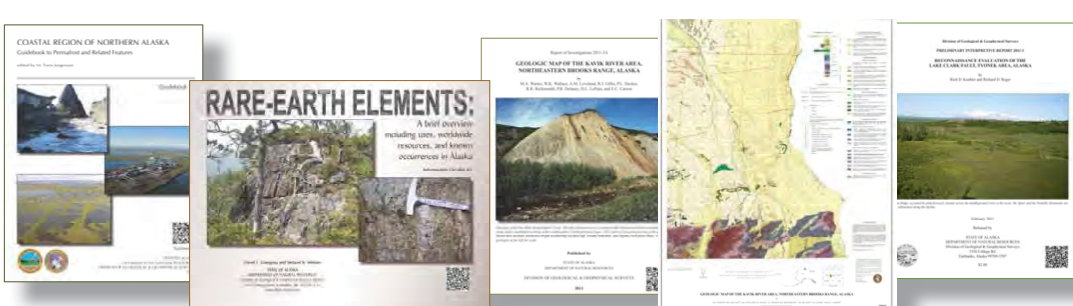
PUBLICATIONS AND OUTREACH PROJECT

The Publications and Outreach Project publishes and distributes geologic data that has been collected, analyzed, and assembled by geologists in DGGS's Minerals, Energy, Engineering Geology, and Volcanology sections and Geologic Materials Center (GMC). Some of the functions carried out under this project are:

- Design, digitally assemble, edit, and oversee final production of technical and educational geologic maps, reports, and informational publications in printed and digital formats.
- Prepare an annual report, with articles written by division staff, describing DGGS projects and activities, announcing new products, and relating plans for future projects.
- Publish newsletters to summarize DGGS's progress and announce new publications.
- Prepare displays and represent the division at geologic conferences and meetings by providing staff and assembling and transporting the display booth (seen at right).
- Staff full-time geologic information center in Fairbanks, providing data about Alaska's geologic resources and hazards through DGGS's publications, geoscience specialists, and other resources. Sell and distribute printed and online geologic reports, maps, and digital data.
- Assist staff in writing, then review and ensure completeness and accuracy of metadata for each digital project and file in its appropriate online repository.
- Manage DGGS's reference library so that reports, maps, and other data are available and publications are on hand that geologists need to prepare geologic products.
- Maintain as complete a collection as possible of Alaska-related geoscience publications produced by the U.S. Geological Survey, the former U.S. Bureau of Mines, and the U.S. Bureau of Land Management; collect and maintain other Alaska-related publications as needed.

Publications produced and distributed by this group record and preserve geologic data such as definitive statistics for Alaska's mineral industry; detailed (1:63,360-scale) bedrock, surficial, and engineering-geologic maps for specific areas in the state; sources of Alaska's geologic information; annual information about DGGS's programs and accomplishments; airborne geophysical data for areas with promising mineralization; and educational brochures and pamphlets explaining Alaska's geology or natural-science features. Some of the most recent DGGS publications include: ♦ LiDAR data for Alaska infrastructure corridors; ♦ geophysical surveys for the Ladue and Iditarod areas; ♦ guidebook of the coastal region of northern Alaska; ♦ geologic hazards assessment along proposed in-state gas pipeline route; ♦ a paleoseismic study along the central Denali fault, Chistochina Glacier area; ♦ a top Mesozoic unconformity depth map of Cook Inlet basin; ♦ geologic map of the Kavik River area, northeastern Brooks Range; ♦ a new information circular about rare-earth elements; ♦ a reconnaissance evaluation of the Lake Clark fault in the Tyonek area; ♦ a surficial geologic map of the Eagle A-1 Quadrangle; ♦ a report on Alaska's Mineral Industry 2010; and ♦ 22 new Geologic Materials Center reports describing analyses of materials housed at the GMC.

Publications are available in paper format (plotted as needed and sold for the cost of printing) and as digital PDF documents and scanned, compressed maps on the DGGS website (available for download at no charge). An increasing number of GIS digital datasets are available on the DGGS website, along with the maps and other images that DGGS has produced with those datasets. Having the geospatial data available allows our users to download the data and use it as they need. The geological and geophysical data and reports published by DGGS encourage wise management and exploration of Alaska's natural resources and mitigation of risks from the state's geologic hazards.



Contact: Paula Davis, 907-451-5053, paula.davis@alaska.gov

NATIONAL GEOLOGICAL & GEOPHYSICAL DATA PRESERVATION PROGRAM

The Alaska Division of Geological & Geophysical Surveys (DGGS) is charged by statute (AS 41.08) with collecting, archiving, managing, and disseminating geological and geophysical data that describes and inventories the subsurface energy resources, mineral resources, and geologic hazards of the state. During the past 10 years, through the federally funded Minerals Data and Information Rescue in Alaska (MDIRA) program, DGGS cataloged and greatly improved the condition of its archive of geological and geophysical data, upgraded its system for data management system, and began disseminating this data through the internet.

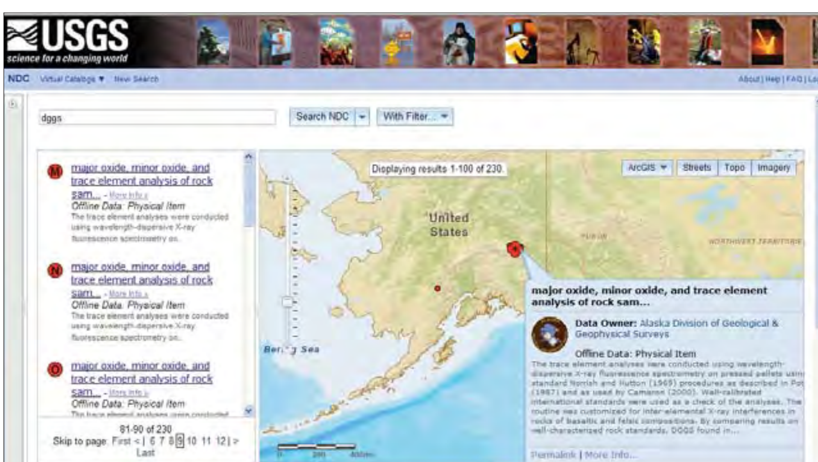
DGGS is advancing its data preservation goals by participating in the federally funded National Geological & Geophysical Data Preservation Program (NGGDPP; http://datapreservation.usgs.gov). This U.S. Geological Survey program is committed to assisting state geological surveys with four data preservation priorities: (1) inventory geological and geophysical data collections to assess their data preservation needs, (2) create site-specific metadata for individual items in those data collections, (3) create new digital infrastructure or improve the state's existing digital infrastructure for archiving and preserving these data, and (4) rescue geologic data at risk of loss through "special needs" awards. DGGS received funding for the FY2010 phase of NGGDPP to directly address the site-specific metadata priority and the "special needs" data preservation priority.

Figure 1. Core box from coalbed methane well Kashwitna Lake #1, 848–858 feet. Box on left shows white mold and cardboard deterioration. Box on right shows same core, cleaned and re-boxed.

First, DGGS completed a Collection Inventory of published Alaska organic geochemical data and is preparing NGGDPP-compliant metadata for this high-priority dataset. Eight publications were identified, with a total of 273 organic geochemical sample analyses among them. The organic geochemistry dataset is critical for an assessment of technically recoverable petroleum resources in major source-rock systems of the Alaska North Slope, led by the USGS and scheduled for late 2011 and 2012. The data are commonly requested by researchers and private industry.

Second, Geologic Materials Center (GMC) staff attempted to salvage approximately 10,300 feet of drill core that was on the verge of total loss due to deteriorating written labels on severely damaged boxes and damage to the samples from multiple freeze/thaw cycles and moisture. Cores from Amchitka Island, Alaska, which were collected after underground nuclear tests between 1965 and 1971, were re-boxed (75 percent of the 717 boxes), barcoded, and indexed. GMC staff also successfully moved, cleaned, re-boxed, barcoded, and transferred 769 out of 818 boxes of coalbed methane core. The project only lost 49 boxes of coalbed methane core (6 percent) in cases of completely disintegrated core and core box.

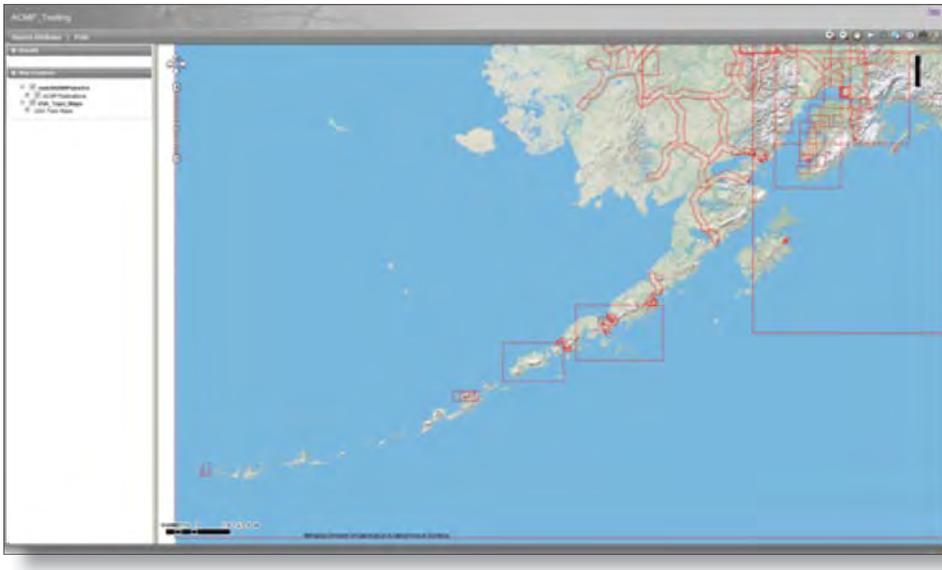
The metadata records for these collections will be served out to the National Digital Catalog through DGGS's Web Feature Service (WFS) interface and an NGGDPP sitemap. The DGGS WFS is currently a beta version for its staff to import data into Geographic Information Systems (GIS) software. However, both the WFS and sitemap allow the site-specific metadata records to be harvested and synchronized automatically by the National Catalog system, thus freeing DGGS staff members of the manual task of uploading data to an additional database on a regular basis. These relevant energy-related datasets will be available for harvest by the National Digital Catalog by the end of 2011. Access to these collections through the National Digital Catalog will improve their accessibility to both in-state and national users.



Contacts: Jennifer Athey, 907-451-5028, jennifer.athey@alaska.gov

GEOGRAPHIC INFORMATION SYSTEM (GIS) PROJECTS

The GIS projects underway at the Division of Geological & Geophysical Surveys (DGGS) are designed to take advantage of recent advancements in geospatial tools, and to present DGGS's geospatial data in multiple ways, making it more accessible and easier for users to view, acquire, and use.

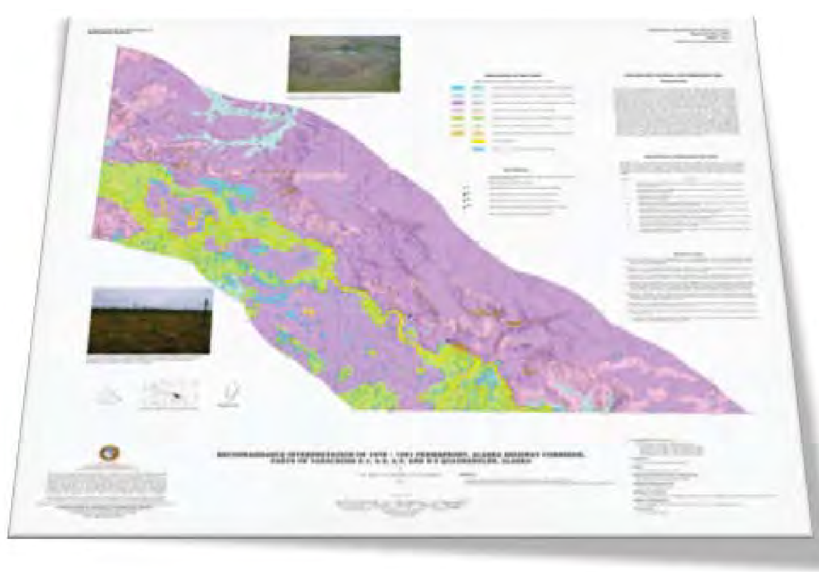


Web Map Applications
DGGS is beginning to design Web map applications for internal and public use. A Web map is an Internet-based, interactive map application that allows the user to display and query the layers on the map. A Web map contains one or more *ArcGIS for Server*® map services. DGGS is currently designing the geodatabases required to populate the services that will be used to create the Web map.

USGS National Cooperative Geologic Mapping Program (NCGMP) Geodatabase
The division is in the testing phase of instituting a division-wide, standardized geodatabase model based on the U.S. Geological Survey (USGS) NCGMP (http://ncgmp.usgs.gov/) format. The NCGMP is a proposed standard for digital publication of geologic maps that are funded by the USGS under the program. Instituting a division-wide geodatabase has several benefits, including standardizing the data's content, attributes, naming conventions, and other pertinent information required for archiving and dissemination. A standardized geodatabase will be instrumental in creating future Web map applications.

DGGS Geologic Mapping Template
DGGS is finalizing a geologic mapping template for use by the division's geologic staff. The benefit of instituting a division-wide template is to standardize the design layouts while streamlining the process used to create geologic maps.

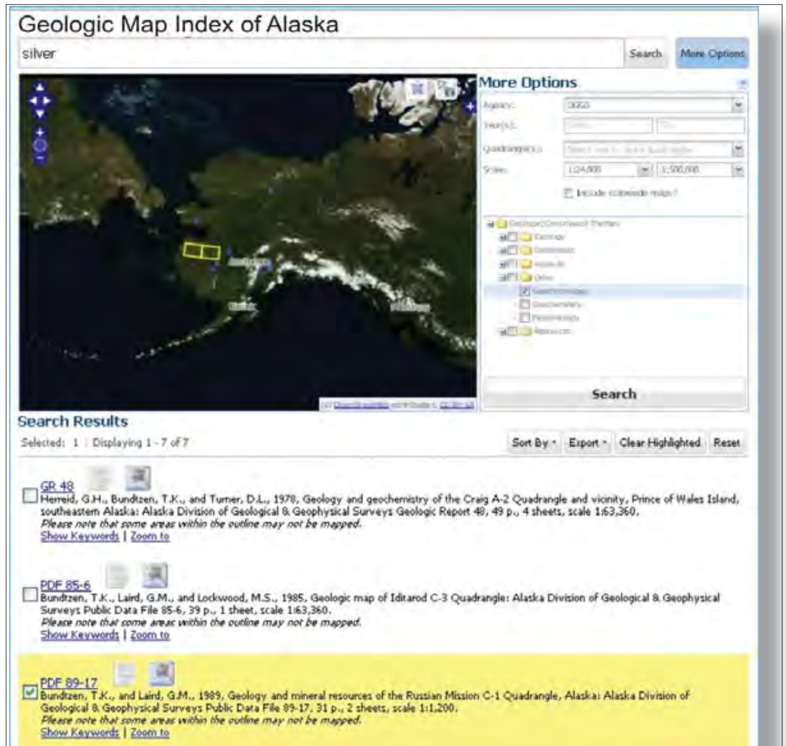
Historical U.S. Geological Survey Topographic Map Inventory and Archive
DGGS is inventorying and archiving its collection of historical USGS topographic maps. A database is being created based on the publication dates of the maps. Map sheets will be scanned and georeferenced for use in a GIS; the georeferenced maps will be used to create a seamless mosaic dataset for internal and public use. A retired DGGS employee currently volunteers time as the project manager for creating and populating the inventory database.



Contacts: James Weakland, 907-451-5029 james.weakland@alaska.gov

ALASKA GEOLOGICAL AND GEOPHYSICAL MAP INDEX

In 2003, in cooperation with DNR's Land Records Information Section (now Information Resource Management), DGGS released the first version of the "Geologic Map Index of Alaska" web application that will, when complete, provide the locations, outlines, and current status of Alaska geological and geophysical maps from all government agencies in a single, interactive, Internet-accessible location. No geographic index of Alaska geologic maps exists at this time. This upgraded resource will make it easier for the public and government agencies to find the maps they need to make informed resource- and land-management decisions.



DGGS is working with Geographic Information Network of Alaska (GINA) at the University of Alaska Fairbanks to upgrade the Map Index interface to a fully integrated map- and text-based search application based on real-time data served from DGGS's central Oracle database. Users will be able to: (1) retrieve subsets of map outlines by map categories (bedrock geology, surficial geology, resources–metals–lode, hazards–permafrost, etc.) or metadata (scale, publishing organization, publication date, etc.); (2) view the results in an interactive map interface and listing; and (3) highlight results by individual record or map selection. The interface will also provide links to downloadable digital reports and maps for each citation, where available. DGGS anticipates that the web application will be completed in spring 2012 with an abbreviated dataset.

The database behind the application currently contains about 300 citations and outlines for DGGS-authored geologic maps. About 900 additional U.S. Geological Survey (USGS) and DGGS geologic map outlines and associated bibliographic references have been compiled but require quality control for categorization and spatial information. The categorized database provides an effective means of searching for maps of particular interest. The USGS's National Geologic Map Database (http://ngmdb.usgs.gov/) is sharing its data with DGGS to streamline the process of updating the Map Index database and keep the USGS publication information current. DGGS intends to add outlines and data to the application for remaining geologic maps by DGGS, USGS, U.S. Bureau of Mines (BOM), and U.S. Bureau of Land Management (BLM), and geophysical maps by DGGS and other agencies as time and funding allow.

The project was initiated with funding from the Federal Minerals Data and Information Rescue in Alaska (MDIRA) program, administered by USGS; development of the web mapping and search application continues under that funding source. Compilation and maintenance of the underlying database is now supported by State of Alaska General Funds. The primary objective of the MDIRA program is to ensure that all available Alaska minerals-related data are preserved in a safe and readily accessible format for all potential users.

Contact: Jennifer Athey, 907-451-5028, jennifer.athey@alaska.gov

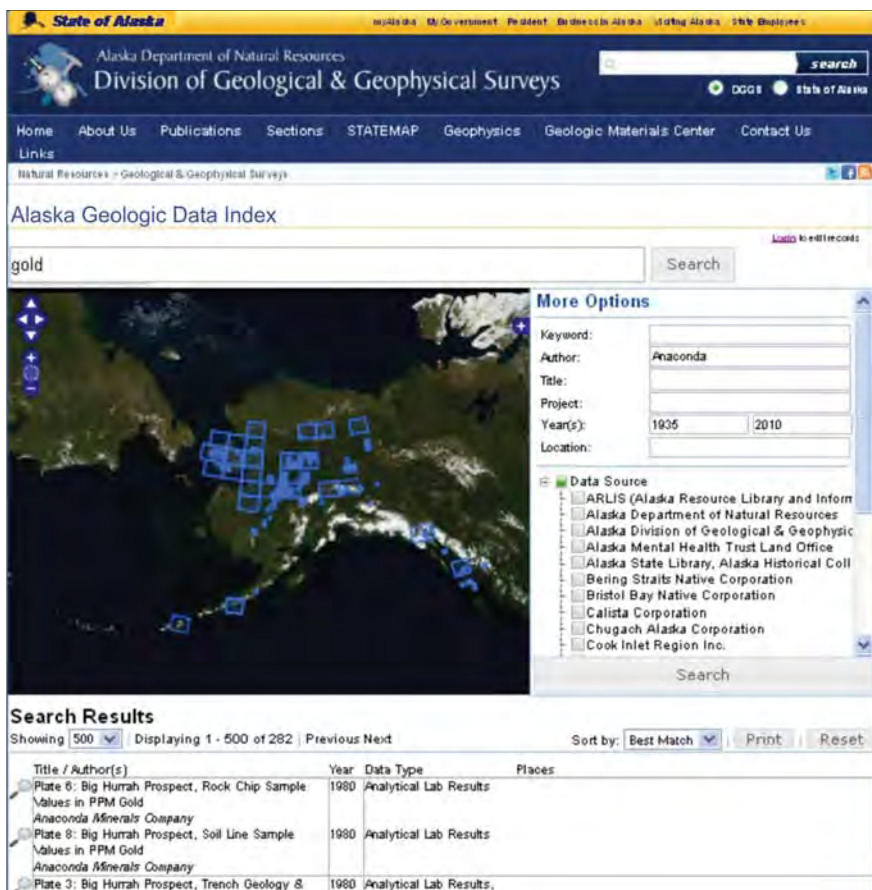
ALASKA MINERAL INDUSTRY DATA INDEX (AKMIDI)—ALASKA GEOLOGIC DATA INDEX (AGDI)

The Alaska Mineral Industry Data Index (AKMIDI) database comprises nearly 16,000 records for mineral information owned by 18 diverse groups around the state, including Native corporations, private companies, state libraries, and land managers. The index includes information needed to find industry reports and maps, field notes, drill logs, and other data from the private sector. Much of the data is still held and controlled by private entities. Approximately 1,800 files and 4,300 maps from the Anaconda Collection of minerals exploration data are available through Alaska Resources Library and Information System (ARLIS). Support for the AKMIDI web search engine ended in 2009 and the database went offline. In the interim, the original Microsoft Access database is available for download (http://www.dggs.alaska.gov/pubs/akmidi.jsp).

This newer project integrates the existing AKMIDI database into DGGS's enterprise Oracle database and converts the search and data-management tools into Java server pages (JSP). Because the new application indexes not only mineral industry information, but unpublished geologic data of any type, it will be released under a new name, Alaska Geologic Data Index (AGDI). The database captures the physical location of archived physical files, contact information and rules for accessing the data, and three levels of proprietary access. At the most secure level, data owners may make their records invisible to the public and other data owners.

The application contains a map-based search tool that allows web-based public queries of the data, a data-entry interface so the AKMIDI database holdings can be expanded in the future, and administrative capabilities for routine, secure data maintenance. Digital images of maps, reports, and other data (such as the images of the Anaconda Collection) can be gathered and linked to the relational database so that the public can obtain some insight about the content of a potentially useful map, figure, or photograph without having to retrieve the physical materials from the archive. The index will be available in spring 2012 on DGGS's website (http://www.dggs.alaska.gov) and through a link on the MDIRA webpage (http://www.akgeology.info).

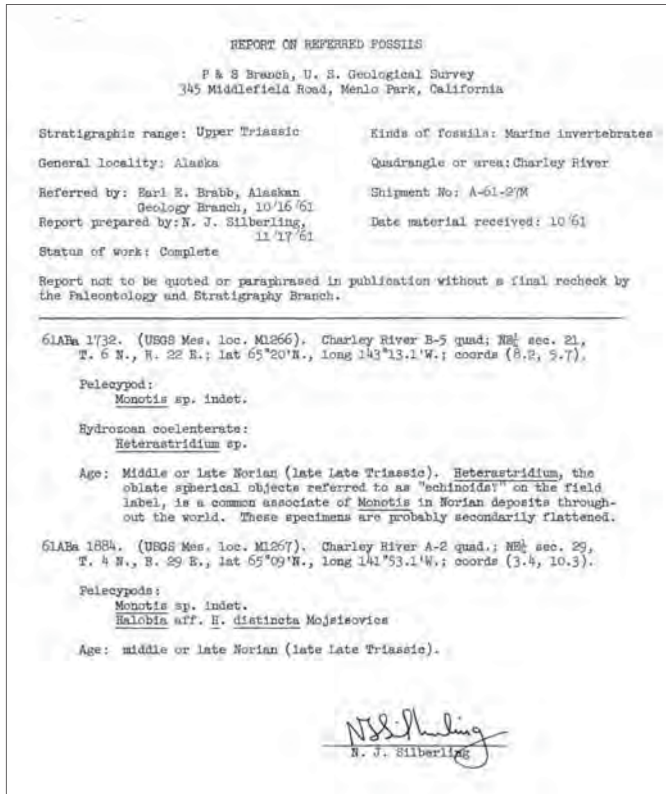
This project is supported through a re-appropriation of some remaining funds in the federal Minerals Data and Information Rescue in Alaska (MDIRA) program, administered by the U.S. Geological Survey. The primary objective of the program is to ensure that all available Alaska minerals data are securely archived in perpetuity and in a format readily accessible by all potential users. Information on mineral resources is important for management policy decisions in both the public and private sectors. Increased use of high-quality data should lead to better economic, legislative, and environmental decisions.



ALASKA PALEONTOLOGY DATABASE MIGRATION

The Alaska Paleontology Database contains detailed information on fossils and fossil localities in Alaska. The database was created by Alaska paleontologist Robert Blodgett and paleontologist/computer programmer Ning Zhang with funding from the U.S. Geological Survey's (USGS) Minerals Data and Information Rescue in Alaska (MDIRA) program. The MDIRA program was established to ensure that all available Alaska minerals data are securely archived in perpetuity and in a format readily accessible by all potential users. Information about mineral resources is important for management policy decisions in public and private sectors. Increased use of high-quality data should lead to better economic, legislative, and environmental decisions.

Information stored in the fossil database is drawn from informal, unpublished USGS 'Examine and Report' (E&R) fossil reports (fig. 1) and published literature (fig. 2), as well as released industry data. Data entry for this project is about 60 percent complete. The database's website (http://alaskafossil.org) receives daily traffic, primarily from Alaskans, including those from bush communities, and from worldwide locations. The database benefits the minerals community in areas with sedimentary-rock-hosted stratiform or stratabound mineral occurrences. Currently the database is hosted on a privately owned server, which is occasionally offline.


REPORT ON REFERRED FOSSILS

P & S Branch, U. S. Geological Survey
345 Middlefield Road, Menlo Park, California

Stratigraphic range: Upper Triassic
Kinds of fossils: Marine invertebrates
General locality: Alaska
Quadrangle or area: Charley River
Referred by: Earl E. Brabb, Alaskan Geology Branch, 10/16/61
Shipment No: A-61-27M
Report prepared by: N. J. Silberling, 11/17/61
Date material received: 10/61
Status of work: Complete

Report not to be quoted or paraphrased in publication without a final recheck by the Paleontology and Stratigraphy Branch.

61ABa 1732. (USGS Mes. loc. M1266). Charley River B-5 quad; NE¼ sec. 21, T. 6 N., R. 22 E.; lat 65°20'N., long 143°13.1'W.; coords (8.2, 5.7).

Pelecypod:
Monotis sp. indet.

Hydrozoan coelenterate:
Heterastridium sp.

Age: Middle or late Norian (late Late Triassic). Heterastridium, the oblate spherical objects referred to as "echinoids?" on the field label, is a common associate of Monotis in Norian deposits throughout the world. These specimens are probably secondarily flattened.

61ABa 1884. (USGS Mes. loc. M1267). Charley River A-2 quad.; NE¼ sec. 29, T. 4 N., R. 29 E., lat 65°09'N., long 141°53.1'W.; coords (3.4, 10.3).

Pelecypods:
Monotis sp. indet.
Halobia aff. H. distincta Mojsisovics

Age: middle or late Norian (late Late Triassic).

N. J. Silberling

Figure 1. Sample E & R report.

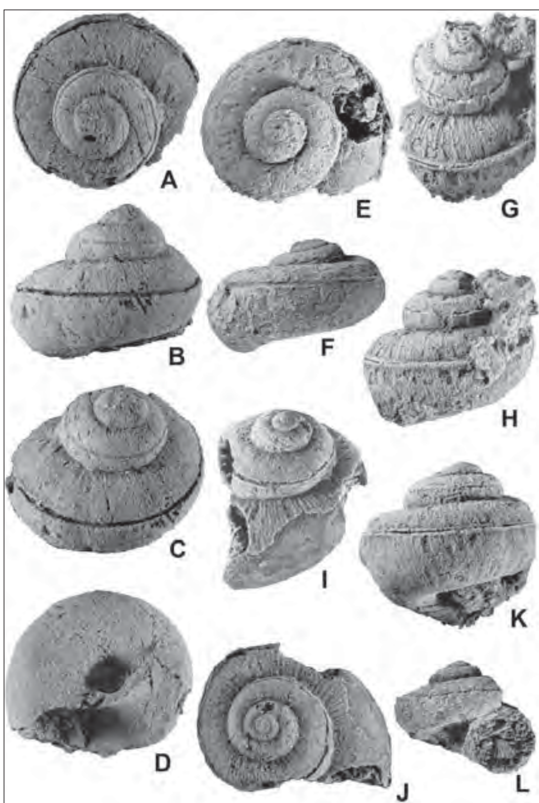


Figure 2. Photographs of fossils described in the database.

This MDIRA-funded project will migrate the fossil database to DGGS's Digital Geologic Database so the database is ensured regular maintenance, back-up, continued data expansion, and consistent public internet access. The existing Microsoft SQL Server database system and Active Server Pages (ASP)-based user interface are incompatible with DGGS's web environment. The database structure is being optimized and the data transferred to DGGS's existing enterprise Oracle database. In consultation with Robert Blodgett, existing ASP-based user interfaces (a data-entry form and a public-access, text-based search application) will be rebuilt into Java Server Pages (JSP)-based web pages. The final application will have a limited-access data-entry form, an interactive text- and map-search application, and database administrative utilities. The paleontology database for Alaska will be available on DGGS's website and through a link on the MDIRA page (http://akgeology.info) in summer 2012.

Contact: Jennifer Athey, 907-451-5028, jennifer.athey@alaska.gov

THE ALASKA GEOLOGIC MATERIALS CENTER

The Alaska Geologic Materials Center (GMC) in Eagle River holds nonproprietary rock core and cuttings that represent nearly 13 million feet of exploration and production drilling (76,000 linear feet of core) on Federal, State, and private lands in Alaska, including the Alaska outer continental shelf. Additionally, the collection holds more than 252,000 linear feet of diamond-drilled hard-rock mineral core, representing more than 1,800 exploratory boreholes; rock samples from more than 1,650 oil and gas exploratory or production wells; samples for geotechnical boreholes; and numerous surface rock and sediment samples. The GMC also maintains extensive geochemical data, reports derived from third-party sampling, and has an archive of more than 187,000 processed slides, including petrographic thin sections and paleontological glass slides derived from this rock.

The GMC is operated by the Alaska Department of Natural Resources, Division of Geological & Geophysical Surveys, with support from cooperating government agencies that include the U.S. Bureau of Land Management (BLM), U.S. Geological Survey (USGS), U.S. Bureau of Ocean Energy Management (BOEM), and Alaska Oil and Gas Conservation Commission (AOGCC). The mission of the GMC is to permanently archive, index, protect, and make available for public inspection, accessible geologic materials and related data to help advance exploration and knowledge of Alaska's natural resources. Chief users of the GMC are the oil and gas industry, although use by the minerals industry, government, engineering firms, and academic institutions is increasing.

The current staff consists of a Curator, two full-time geologists, a contract curator, two volunteers, and two student interns. The Curator's focus is to preserve and ensure the safety of the samples stored at the facility and make the samples and their derived data more accessible to the public. Despite the ongoing struggle to maintain the 26-year-old collection in a much older and deteriorating facility, many improvements have occurred at the GMC. Its staff completed two major curation projects involving valuable core sample collections at risk of severe material and data loss, with funding in part from the National Geologic and Geophysical Data Preservation Program of USGS and the Minerals Data Information Rescue of Alaska program. As a result, for example, much of the data associated with the Amchitka Island hard-rock core has been greatly improved and, after countless hours of rigorous work by contract curator Don Hartman, 94 percent of the 818 deteriorating boxes of moldy coal-bed methane core from five wells has been cleaned, re-boxed, and moved to an environmentally controlled storage area. This effort has made the core accessible once again, allowing geoscientists an opportunity to study and log the young, unique coal sections found throughout the core.

During FY2011, the GMC hosted 511 visits to its facility in Eagle River by industry, government, and academic personnel to examine rock samples and processed materials, breaking the 2008 record of 497 visitors. An analysis of visitor statistics dating back to 1999 has resulted in a very informative GMC visitor statistics summary, highlighting trends in the total number of yearly visitors, the types of groups visiting the facility (fig. 1), and the agencies, companies, and universities who most frequently visit the facility. The results indicate an average increase of 12 visits per year between 1999 to present with 43 percent of the visits coming from the oil and gas industry and 19, 13, 11, 10, and 4 percent coming from academia, the general public, the mining industry, state agencies, and the federal government, respectively.

GMC staff has completed 45 percent of its inventory-mapping project, a focused effort to provide an updated, detailed inventory of the entire collection. The inventory map will identify empty shelves and provide the location and counts of specific sample types, more accurate core recovery data and footage estimates, and unique IDs (barcodes) for every box. GMC staff has already incorporated 60 percent of the entire oil and gas collection into a working barcode/database system. This massive effort will make our hoped-for future transition to a new repository much more manageable, improve the quality of the collection data, and pave the way for a web interface to query the available materials at the GMC.

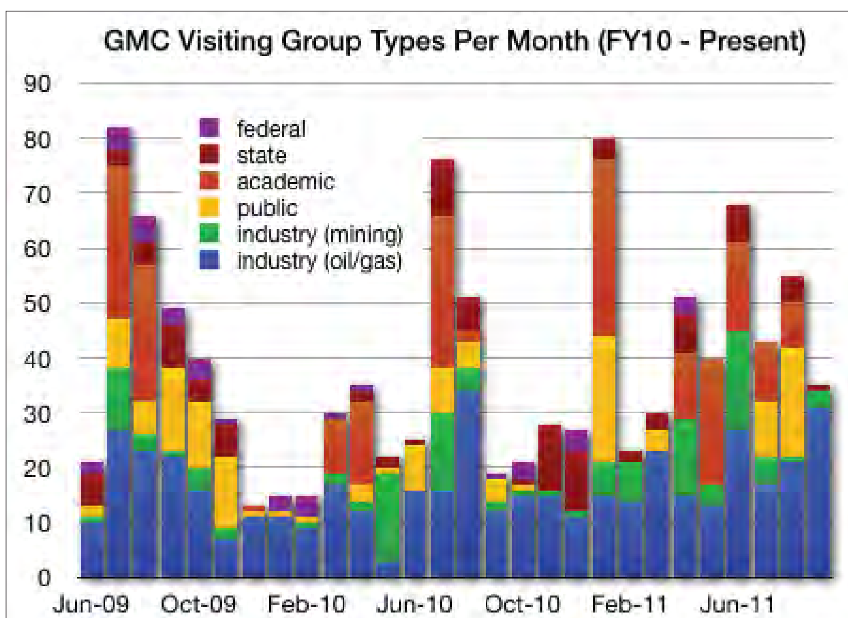


Figure 1. Number of monthly visits, FY10 to present, by group types.

Contact: Kenneth Papp, GMC Curator, 907-696-0079, kenneth.papp@alaska.gov

As a result of this project, GMC staff has released a detailed GMC inventory summary. The staff now has a much better understanding of the facility's inventory growth rate, the number of boxes, amount of core, sample types, and the sample volume distribution (fig. 2) that make up the entire 77,060 ft^3 collection. For example, the GMC's 28-year average growth rate is 2,752 cubic feet of samples per year. After the limited space in the main warehouse was filled, the GMC in 1992 purchased its first of 60 shipping containers. Since that time, additional sample donations have filled roughly three shipping containers per year.

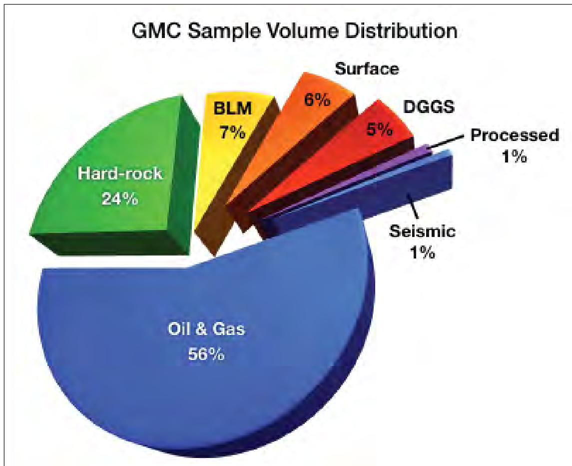


Figure 2. Pie chart showing percentages of sample collection groups by volume.

Although workable, the current facility lacks sufficient space and equipment for proper sample storage, processing, and viewing. Available heated warehouse space has long been exceeded and more than half of the inventory is stored in unheated, unlighted portable shipping containers, endangering the samples by exposing them to large changes in temperature and humidity. We estimate that within 3 years, we may have to turn away newly donated material due to a lack of storage space. Although user satisfaction was determined to be 100 percent in the past, many GMC users continue to express concerns over the poor geologic materials storage and lighting conditions, inadequate work space, and substandard sampling equipment. As a result, a more thorough, anonymous evaluation was distributed to 85 individuals, representing 40 agencies, companies, and universities to obtain feedback regarding GMC user satisfaction. We received 25 responses, 11 of which specifically commented on their satisfaction of GMC visits. The results indicate that, of the 11 respondents who commented on their satisfaction, only 36 percent were satisfied with the usability, convenience, and storage conditions of material. More encouraging, however, was that 83 percent of respondents report making a positive economic, exploration, or research decision as a direct result of utilizing the current facility. A summary of the GMC user survey is now available online. Special thanks to all of those who took the time provide such valuable feedback.

DGGS managers, working with the Alaska Department of Transportation & Public Facilities and GMC staff, are developing plans for a new facility to help ensure the future accessibility and protection of the material currently stored at the GMC. Site selection and preliminary design work plans are described in a concept study report and a brochure, *A Vision for Responsible Stewardship*, both downloadable from the GMC website (http://dggs.alaska.gov/gmc/). The Curator has drafted an Inventory Transfer Plan summarizing the logistics and costs associated with the transfer of the entire inventory from the Eagle River facility to a larger repository potentially located in Anchorage. We estimate that moving the entire GMC collection will involve three months of work requiring 2,250 pallets to be loaded into 113 forty-foot tractor-trailer truckloads.

"We resampled core from a chromium prospect to assess platinum-group elements, which led to a discovery of over 20 grams/ton of platinum and palladium on Alaska state land. The area is now staked and under exploration."

Curt Freeman, President
Avalon Development Corp.

Despite the challenges associated with safely maintaining and providing access to this valuable geologic library, GMC staff are working hard to provide more useful geologic information to the users and accommodate their current needs. We encourage users who haven't visited the GMC in the past several years to do so and, as always, user feedback is most welcome.

Contact: Kenneth Papp, GMC Curator, 907-696-0079, kenneth.papp@alaska.gov

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PDF 98-37C	Tanana A-1 and A-2 surficial geologic map	7
PDF 98-37D	Tanana A-1 and A-2 engineering geology	2
PIR 1999-1	Central and east Anchorage geologic map	7
PIR 2001-3A	Fortymile mining district, Eagle A-2 geology	6
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PIR 2002-1B	Fortymile mining district, Eagle A-1 bedrock geology	3
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PIR 2005-1	Bristol Bay AK Peninsula 2004 sample analyses	3
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