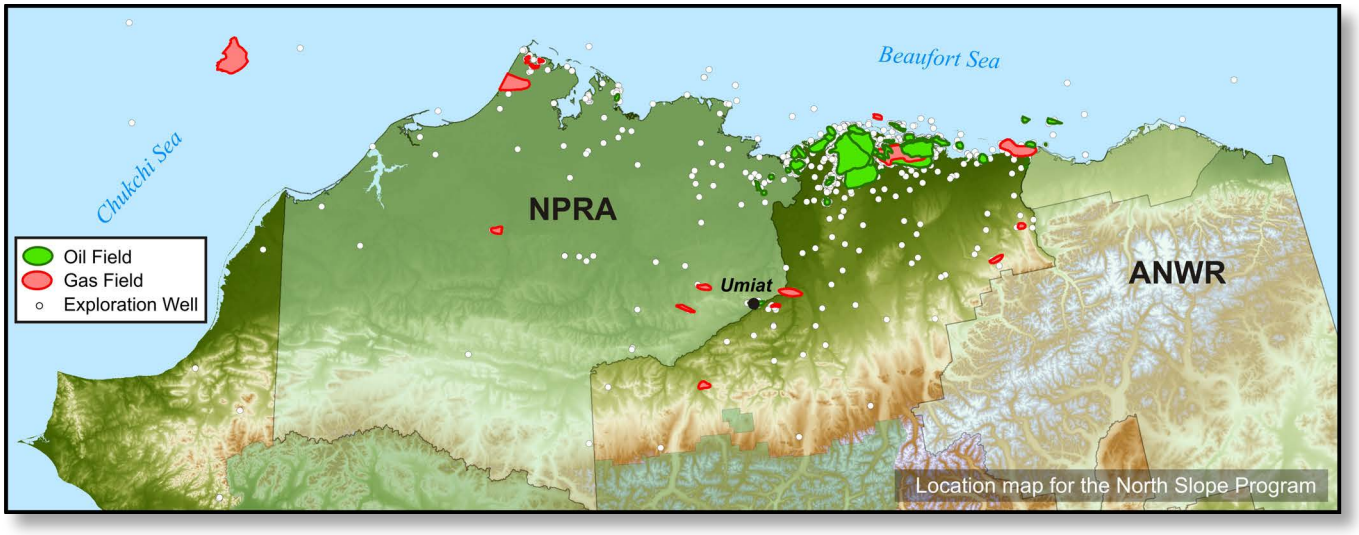
BROOKS RANGE FOOTHILLS & NORTH SLOPE PROGRAM

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 partially 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, the Division of Geological & Geophysical Surveys (DGGS) developed a program to acquire and publish high quality geologic data to improve our understanding of regional petroleum systems and entice new exploration investment. 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 Fairbanks, and others. Additionally, the oil & gas industry supports this program through contributions of funds and data.



During recent field seasons, our program conducted detailed geologic mapping and associated studies in the area of the proposed Umiat transportation corridor (see also page 29). 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 strata. This type of detailed analysis of outcrop geology leads to improved models for where hydrocarbons will be most likely to accumulate in the subsurface.

Over the last several years we have collaborated closely with the Division of Oil & 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 2012, DGGS also initiated a collaborative study with UAF and the USGS to evaluate the geology of prospective shale oil units. Exploration for this unconventional resource has only recently begun in northern Alaska. Although unproven, the world class source rocks in the region indicate this play has the potential to eventually add significant new petroleum production from the North Slope.

Two new 1:63,360-scale geologic maps will be published through DGGS early in 2013 (see page 29), as well as a collection of papers summarizing recent topical structural and stratigraphic studies. The limited exploration and development on the central North Slope partly reflects the region's remoteness and lack of infrastructure. This body of work directly impacts exploration in the area and compliments efforts of the State's Roads to Resources program.

DGGS geologist and "field assistant" conducting detailed stratigraphic studies at Umiat Mountain along the Colville River.

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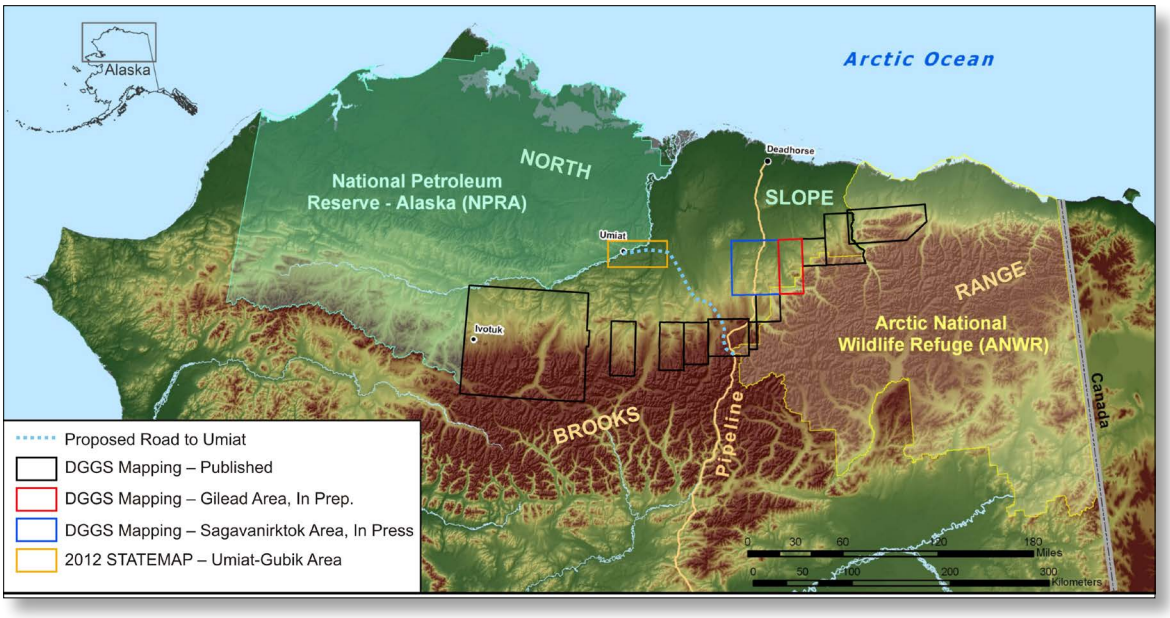
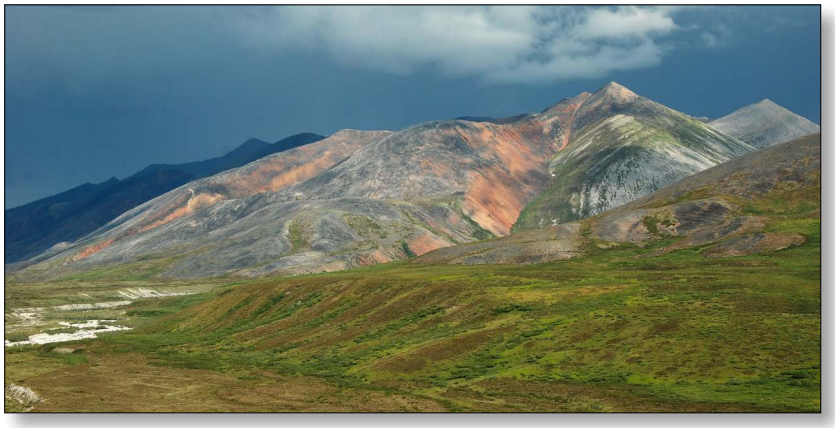
GEOLOGIC MAPPING ON THE NORTH SLOPE

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 providing predictive insights into the subsurface petroleum geology elsewhere on the North Slope. The Energy Resources Section of the Division of Geological & Geophysical Surveys (DGGS) conducts bedrock geologic mapping as an integral component of the Brooks Range Foothills and North Slope Program (see also page 28). Our long range objective is to produce a series of contiguous detailed geologic maps along the entire foothills belt, thereby establishing the regional geologic framework necessary to understand the evolution of the petroleum system in support of resource management and industry exploration on State lands. The data generated from this work will directly impact efforts in conventional oil & gas exploration, as well as potential development of wide-spread unconventional resources like shale oil and gas, gas hydrates, and coal-related resources.



During recent summer field campaigns we completed detailed 1:63,360-scale geologic mapping of approximately 1800 square miles of the eastern North Slope (red and blue box on map). We have also conducted mapping in the Umiat-Gubik area (yellow box), a region whose recognized potential has led to a State proposal for construction of a major transportation corridor (blue dashed line on map). In collaboration with the Alaska Division of Oil & 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 enhanced our knowledge of how Upper Cretaceous rocks correlate with one another, allowing for improved models concerning the distribution of potential source and reservoir rocks in the subsurface.

This work was 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 spring 2013—both as DGGS Reports of Investigation.



View of north-dipping stratigraphy at the Brooks Range mountain front in the Gilead area.

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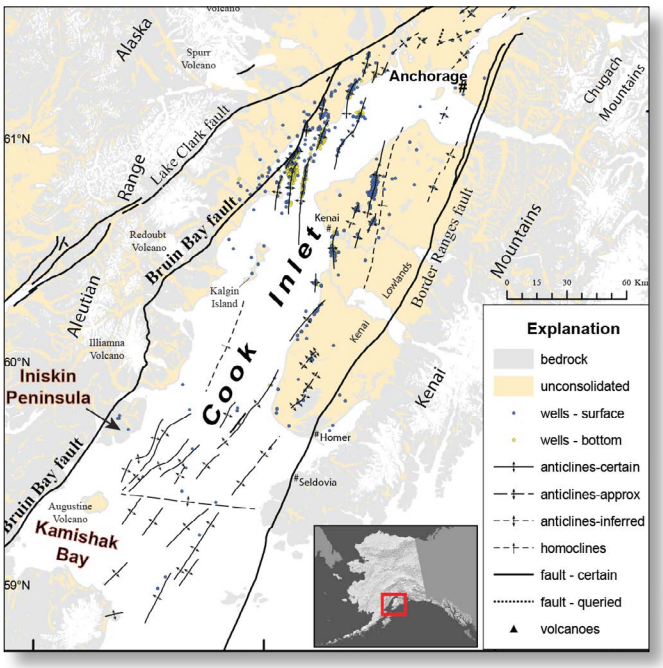
ALASKA DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
FY13 Project Description

COOK INLET GEOLOGY AND HYDROCARBON POTENTIAL

Increasing demand and predicted deliverability shortfalls for Cook Inlet gas supply to south-central Alaska customers, combined with significant oil production declines, pose potential 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.

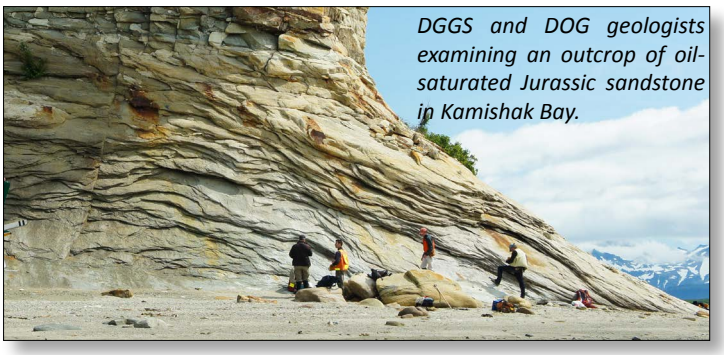
Historically, Cook Inlet exploration has focused on locating large fold structure reservoirs with four-way closure (analogous to an inverted bowl) in younger, shallower Cenozoic rocks. Most of these large, relatively shallow structures have been found and tested, but the older, deeper rocks that underlie the basin, and contain the source rocks for the Cook Inlet petroleum system, remain virtually unexplored. To incentivize exploration of pre-Cenozoic (Mesozoic) strata, the State Legislature in 2010 offered tax credits of up to 100 percent for the first three wells drilled by unaffiliated parties using a jack-up rig to test viable Mesozoic petroleum targets. DGGS and DOG during that period also began reconnaissance field studies of Mesozoic rocks in the lower Cook Inlet to improve understanding of reservoir types, reservoir quality, their geologic controls, and the structural history of the older parts of the basin.



Generalized geologic map of Cook Inlet basin. Modified from Haeussler and Saltus, 2011, U.S. Geological Survey Professional Paper 1776-D.

One of the challenges facing new exploration of the Mesozoic petroleum system in Cook Inlet is the identification of reservoir rocks capable of hosting oil and gas, because much of the pre-Cenozoic stratigraphy is commonly viewed as lacking sufficient porosity. During 2012, DGGS and DOG focused on developing a better understanding of the conventional and unconventional reservoir potential of Mesozoic rocks, and structural controls on Mesozoic depositional systems in the Kamishak Bay and Iniskin Peninsula areas in lower Cook Inlet (see map). Work in the Kamishak Bay area (see photo) focused on Jurassic and Cretaceous-age rocks, both of which contained intervals that are oil saturated, indicating that they had sufficient conventional permeability and porosity to pass and retain liquid hydrocarbons in the past. Samples collected at both locations will help to identify the hydrocarbon source rocks and determine whether the sandstone composition or other factors were responsible for their enhanced reservoir quality. Continued stratigraphic and structural studies in the Iniskin Peninsula area focused on how major geologic structures, such as the Bruin Bay fault (see map), influenced the stratigraphic architecture, which has implications for predicting the distribution of reservoirs and reservoir seal lithologies. We conducted fracture studies of Mesozoic rocks in the Kamishak Bay and Iniskin Peninsula areas to characterize the fractures with regard to rock type and proximity to faults and folds and to gather baseline data about non-conventional fracture porosity and hydrocarbon migration pathways.

Important additional components of this program include (1) a subsurface mapping effort aimed at delineating the distribution of petroleum source rocks relative to thick accumulations of potential reservoir sandstones; (2) structural analysis of basin bounding faults; (3) analysis of the subsidence and uplift history of upper Cook Inlet basin using publicly available well data; and (4) a detailed bedrock mapping project on the Iniskin Peninsula and nearby area (summer 2013 and 2014).



DGGS and DOG geologists examining an outcrop of oil-saturated Jurassic sandstone in Kamishak Bay.

This project is funded by the State of Alaska and the U.S. Geological Survey, with contributions from industry. 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, beginning in early 2013.

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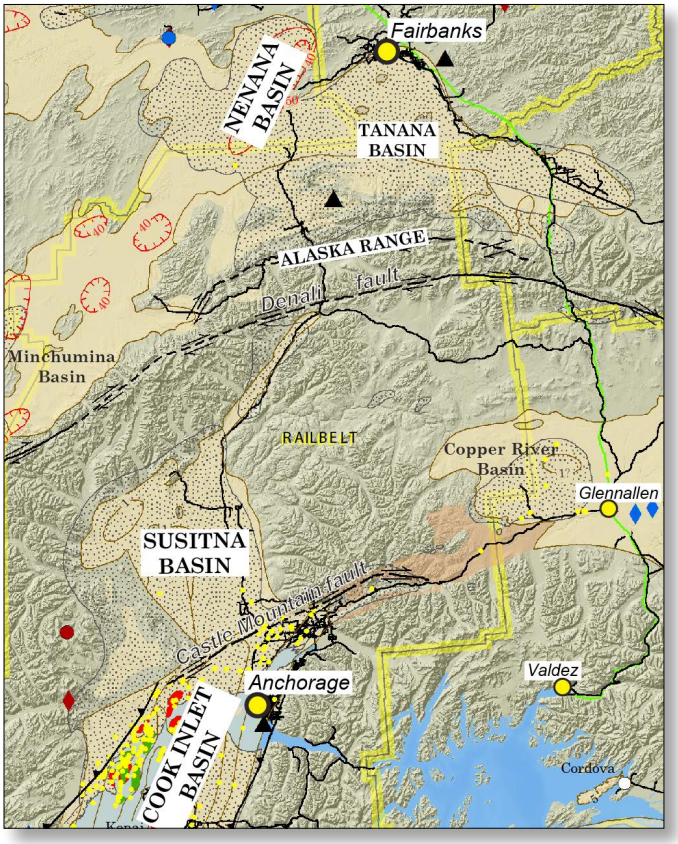
NATURAL GAS POTENTIAL OF THE SUSITNA AND NENANA BASINS

Alaska faces serious domestic energy challenges that place a significant percentage of the state's population, particularly in rural areas and interior regions, under heavy financial strain. This is because adequate energy sources at reasonable cost have not been identified to serve domestic needs over the next few decades. These challenges can be mitigated by looking for local sources of energy that have the potential to supply more affordable energy for local consumption.

The Alaska Division of Geological & Geophysical Surveys, in collaboration with the Alaska Division of Oil & Gas (DOG) and the U.S. Geological Survey, 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 (see http://www.dggs.alaska.gov/webpubs/dggs/sr/text/sr066.PDF). We have identified the Susitna and Nenana basins, on geological grounds, as having significant gas potential to help meet in-state needs. However, neither of these basins has been adequately explored, and little geologic data exists to help attract exploration interest. 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 in summer 2011, phase II on the Nenana basin in spring 2012, and phase III on finalizing work in both basins and generating the final reports for each basin.



Map showing distribution of some interior sedimentary basins and their proximity to Anchorage and Fairbanks.

The Susitna basin (approximately 5,000 square miles) is thought to host some of the same gas-producing rocks as the neighboring Cook Inlet. During the 2011 field season, DGGS and DOG studied and described stratigraphic exposures at several locations within the basin and collected over 250 samples for various analyses related to evaluating petroleum system potential and geologic development of the region. The Nenana basin lacks exposures of potentially hydrocarbon-producing rocks at the surface for study, but the rocks in the subsurface are thought to be correlative to stratigraphy of similar age exposed in the foothills of the Alaska Range directly to the south. Similar to the Susitna basin, DGGS and DOG studied, described, and sampled selected stratigraphic intervals of these rocks at several locations during the spring of 2012. In addition, approximately 50 samples were collected from around the periphery of the Nenana and Tanana basins to develop a better understanding of how and when the basins began to form. DGGS and DOG will visit new locations of rocks related to the Susitna and Nenana basins to wrap-up our field studies of the basins in summer 2013 or 2014. Final reports will be released in 2015.

DGGS and DOG geologists examining coal-bearing strata of the Usibelli Group in Suntrana Creek near Healy.

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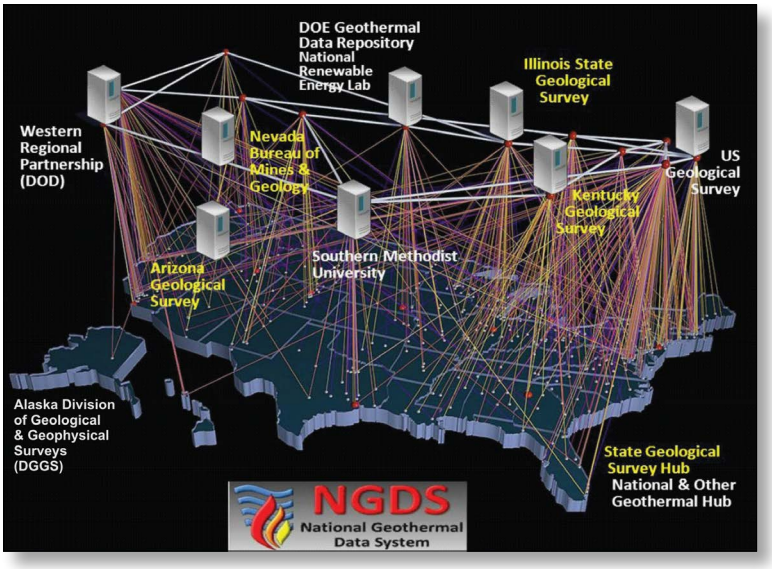
ALASKA DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
FY13 Project Description

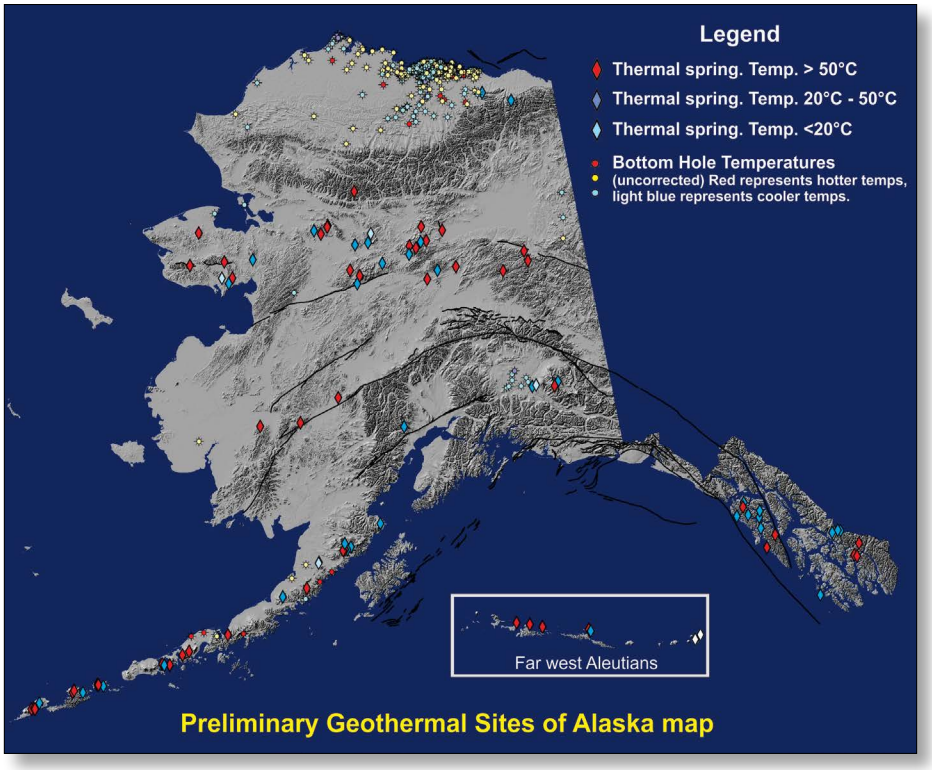
STATE OF ALASKA CONTRIBUTIONS TO THE NATIONAL GEOTHERMAL DATA SYSTEM

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.stategeothermaldata.org/. This national project, involving all 50 states, is organized by the Association of American State Geologists and administered by the Arizona Geological Survey. The goal of the NGDS is to make large quantities of geothermal-relevant geoscience data available to the public and industry 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 state databases and directories available to the network.



50-state network of geothermal data providers to the NGDS and the regional hubs (in yellow).

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.



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 developed a series of geothermal feature templates for data to be included in the NGDS. During 2011 and 2012, DGGS submitted these feature templates to the NGDS: Alaska thermal springs, aqueous chemistry, volcanic vents, geothermal well-core descriptions (for Makushin and Akutan volcanoes), bottom hole temperature observations (for oil and gas wells), and Quaternary-active faults. In 2013, DGGS will complete this project by submitting feature templates on geothermal direct use and earthquake hypocenters around geothermal areas, and will complete a new comprehensive bibliography of Alaska geothermal information. The project will culminate in the completion of a new digital, ArcGIS-based "Geothermal Sites of Alaska Map" that will incorporate all of the related geothermal data sets submitted to the NGDS (see preliminary map above). This map will be available online for the public by spring of 2013.

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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 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 stratigraphic field data for previously described occurrences. Sometimes a coal occurrence described in 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.

We continue to submit coal samples collected from field crews conducting studies in both the Cook Inlet and North Slope coal provinces, for proximate and ultimate analyses. We focus only on thicker, potentially-mineable coal seams that have not been sampled previously. We are still in the process of acquiring Cook Inlet samples for CO_2 high pressure gas adsorption, with requests to industry to obtain samples from the North Slope and the Nenana basin also underway. The project continues to make progress rectifying for accuracy the legacy Alaska NCRDS data sent to DGGS by the USGS team.

The database for both the Alaska coal quality and stratigraphic information continues to grow and we are incorporating this data and the appropriate GIS files into the new coal resources of Alaska GIS map. This new ArcGIS-based coal resources map of Alaska (fig. 1) meshes well with the NCRDS work by incorporating the coal data into a meaningful and useful format. The map contains compiled geology layers, where available, and coal isopachs where calculated and available. We are also incorporating the Alaska abandoned coal-mine inventory data into this map, which has never been available in a digital format. The complete coal dataset incorporated into this new GIS map will allow for calculations of coal resources in areas with sufficient coal-thickness point-source data. This map will be completed at the end of the current 5-year NCRDS project in the fall of 2015. The final GIS map product will be placed on the DGGS website.

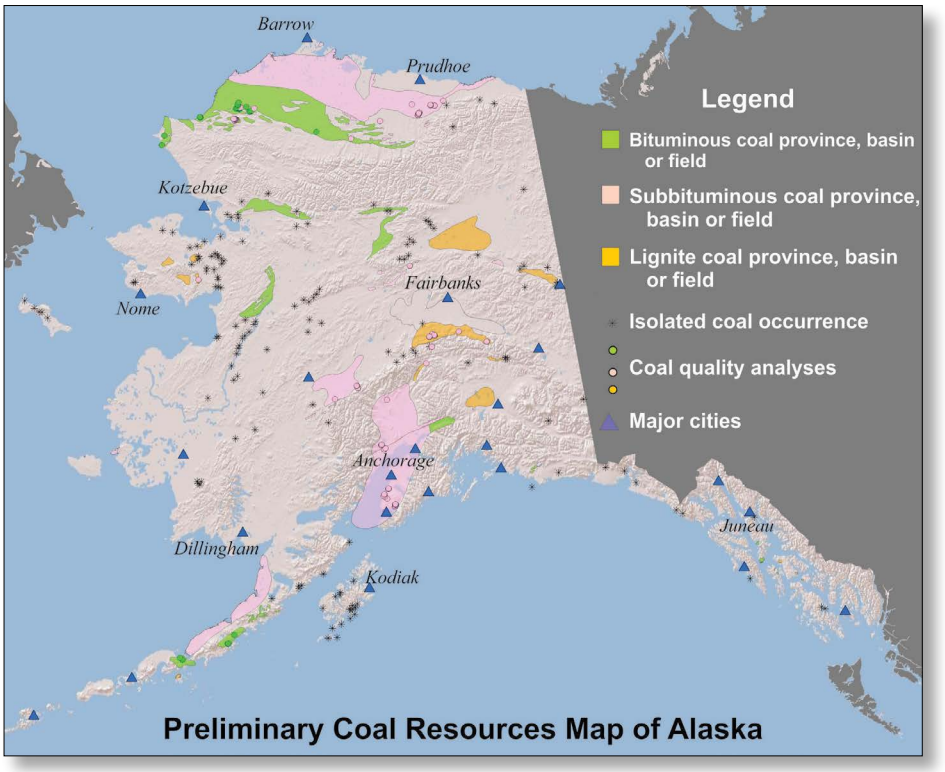

Figure 1. Preliminary draft version of GIS-based coal resources of Alaska map that displays coal provinces, basins, coal fields, and isolated coal occurrences and incorporates NCRDS coal quality point source data.

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