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RESERVOIR CHARACTERIZATION STUDIES IN ALASKA

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INTRODUCTION

Reservoirs are key components in petroleum systems—they provide the storage for hydrocarbons into which companies drill to extract oil and gas. Petroleum reservoir characterization is the complex process of identifying and quantifying properties that influence the distribution and migration of oil or gas within a reservoir. Studying the geologic details of known and potential reservoirs allows for simulation and analysis of different economic models essential to guide reservoir development and production management. Reservoir characterization studies can be done from well core, down-hole geophysical information, surface geophysical information, or surface bedrock exposures. The ultimate goal of the studies is to develop reasonable physical descriptions of potential reservoirs to minimize exploration, development, and production costs and financial risks while maximizing hydrocarbon recovery.

Reservoir characterization studies by the Division of Geological & Geophysical Surveys (DGGS) are currently underway in two basins—the North Slope basin and the Yukon Flats basin (fig. 1). Potential North Slope reservoirs are being characterized and quantified using petrophysics (porosity and permeability determinations) and detailed petrography (study of paper-thin sections of rock using a microscope). Petrographic study includes determining the percent abundance of various types of sandstone grains, measuring grain size, determining what kind of cement binds the sandstone, and when, during the geologic history of the sandstone, that cement formed. Additionally, the details and distribution of the sandstone reservoir rock types are considered using detailed geologic mapping and systematic description of well-exposed sandstone bedrock. Finally, our approach combines subsurface and surface geology from the North Slope Foothills Program to develop a regional basin analysis interpretation. The basin analysis attempts to picture what the basin looked like during deposition of the sands that now form potential subsurface reservoirs. Integration of this study with ongoing DGGS North Slope Foothills bedrock mapping of the last decade results in a more accurate evaluation of the principal target reservoirs. Also, reservoir characterization is an element of the federally funded Yukon Flats basin project, a collaborative effort by the U.S. Geological Survey (USGS) and DGGS to evaluate the petroleum potential of the basin.

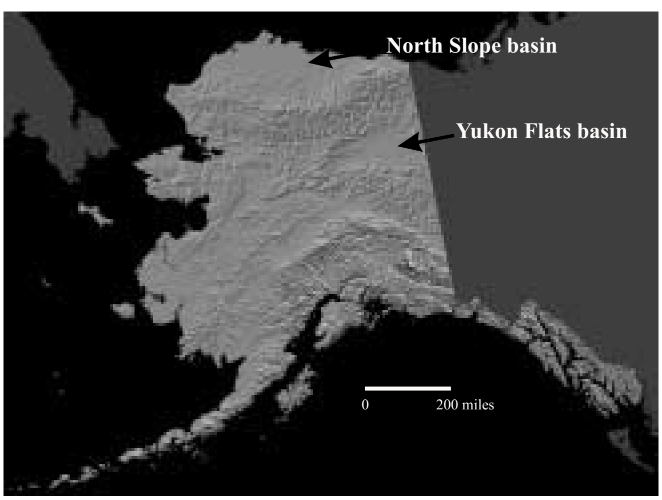

Figure 1. *Shaded relief image of Alaska with location of the North Slope basin and the Yukon Flats basin.*

POROSITY AND PERMEABILITY

Porosity and permeability (P&P) data obtained from core and surface outcrops can serve as a useful screening tool in the search for potential petroleum reservoirs. P&P data are useful in evaluating reservoir potential when they are integrated with information on rock body geometry and depositional setting in which the sand originally accumulated. Porosity is the percent volume of pore space of the rock that is available to store oil or gas. Permeability (reported as millidarcies, or md) is a measure of how well connected these pore spaces are. If permeability is reasonably high, hydrocarbons in the pore space of a reservoir can flow through the rock and reach the wellhead for successful economic oil and gas recovery. However, it is possible to have oil trapped in a reservoir with little or no permeability, making extraction difficult. Low porosity and permeability of reservoirs are significant technical problems that limit production in petroleum basins worldwide. Although P&P data have been obtained from producing reservoirs and potential reservoirs for decades by petroleum companies operating in Alaska, very little of this information is publicly available. Likewise, although state, federal, and university geologists have collected potential reservoir data for many years, no single source exists for this information.

METHODOLOGY

As part of new North Slope geologic mapping, about 175 samples were collected and analyzed for porosity and perme-

(continued on page 2)

ability. From the Yukon Flats basin, 26 drill hole core samples were selected for P&P analyses; 12 of these samples were selected for additional detailed petrographic study of the rocks. By cutting paper-thin sections (0.03 mm thick) of each rock and analyzing the specimens using a microscope, fundamental reservoir properties are determined. For analysis, a 1-inch-diameter core plug is drilled from the primary core sample (fig. 2); nitrogen gas is forced through the plug to test its flow capacity and the plug is analyzed for grain volume, bulk volume, and sample weight. These values allow calculation of porosity, permeability, and grain density. Details of individual sandstone grain boundaries, sandstone cement type, geologic timing of cementation, and porosity are determined using a petrographic microscope and the rock thin sections (fig. 3).

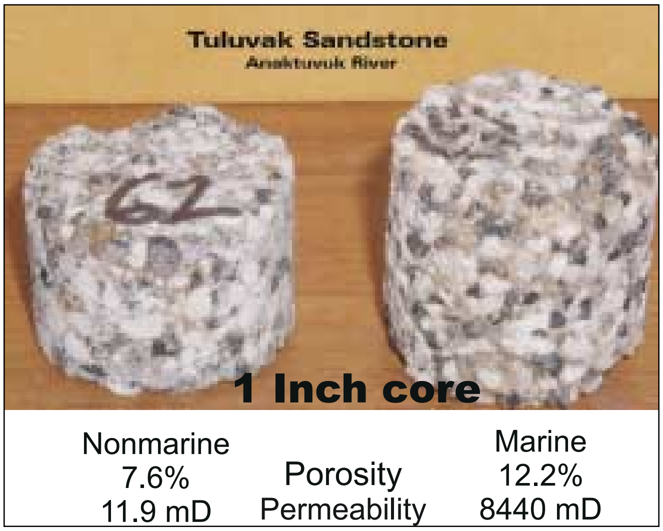

Figure 2. *Core plugs (1-inch diameter) for porosity and permeability analyses, Tuluvak Formation, North Slope, Alaska. For this study such core plugs are cut from outcrop samples or drill core samples. The plug is then measured for its capacity for flow to nitrogen gas as well as grain volume, bulk volume, and weight. Porosity, permeability, and grain density are derived from these data and are critical information related to oil and gas reservoirs.*

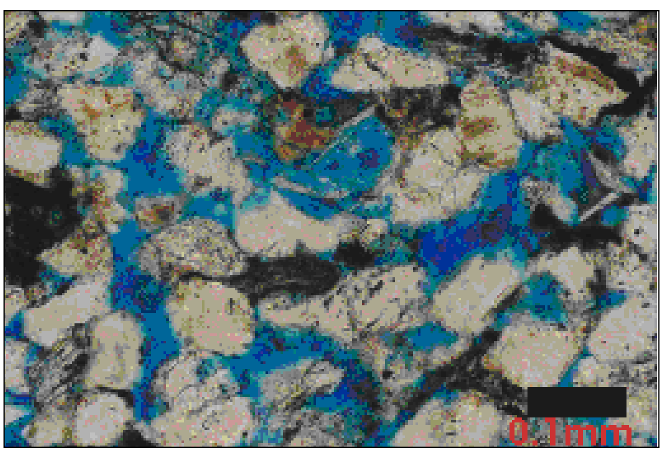

Figure 3. *Photo of Tuluvak Formation sandstone from the North Slope Foothills outcrop belt, taken through a microscope. Blue interconnected area is porosity (measured at 19.2 percent), or void space in the rock, which has been filled with epoxy during sample preparation. Porosity has been reduced during the rock's geologic history by deformation of the relatively soft metamorphic grains and dissolution of silica from some quartz-rich grains of this sandstone (sample 01RR24-400; Shale Wall Bluff measured section, Umiat Quadrangle).*

Petrographic compositional point counting involves selecting representative fine-grained sandstones from rock units of interest and using a microscope to systematically identify and tabulate the mineral composition of 400 grains. Results are plotted on triangular diagrams that yield a sandstone classification and an inferred geologic environment for the sandstone. These are useful for comparing sandstones within the basin and comparing sandstone reservoirs globally. Understanding the composition of potential reservoir sandstones is fundamental to understanding their viability as reservoirs.

NORTH SLOPE

In 2001 DGGS and Alaska Division of Oil and Gas initiated a pilot project within the NPRA Foothills Program (a joint DGGS–USGS–industry-supported effort) to collect new reservoir characterization data, including P&P, and to begin to assemble a reservoir quality database for the North Slope of Alaska. The project also incorporates new surface bedrock geologic mapping (Harris and others, 2002). We developed models of the ancient distribution of depositional environments and potential reservoirs on the basis of surface rock exposures and subsurface well cores. The basic parameters of potential reservoirs are currently poorly known, but are economically critical for explorationists and current state and federal oil and gas leaseholders. The results of this project improve understanding of the reservoir characteristics of sandstone and limestone formations relevant to oil and gas exploration for Prudhoe Bay satellite fields and new oil and gas exploration areas in the central North Slope.

Petroleum geology framework

North Slope Foothills outcrop samples are selected from the entire rock section, and lie north of the main Brooks Range. Our rock samples come from the 1,000-km-long, 50- to 350-km-wide Colville Basin. This basin includes reservoir and source rocks in the subsurface of the North Slope. Defining potential North Slope Foothills reservoirs is important because the entire southern flank of the North Slope Foothills has the potential for a variety of oil and gas migration through the subsurface rocks. These subsurface pathways were formed during the mountain building events of 150 to 100 million years ago. During that time period, 250- to 150-million-year-old, organic-rich, oil- and gas-prone source rocks were eroded and redeposited in an ancient mountain building process.

Porosity and permeability

A summary of the porosity and permeability data from the North Slope includes:

- Tuluvak Formation (porosity of 5 to 20 percent and permeability of 0.5 to 8,660 md; 38 samples);
- Nanushuk Formation (3 to 14 percent and 0.005 to 1,404 md; 42 samples);
- Gilead sandstone (5 to 6 percent and 0.001 md; 5 samples);
- Fortress Mountain Formation (3 to 8 percent and 0.1 to 12 md; 8 samples);
- Cobblestone Sandstone Member of the Fortress Mountain Formation (2 percent and 0.08 md; 8 samples); and
- Lisburne Limestone (1.4 to 2.8 percent and 0.1 to 0.4 md; 16 samples) (fig. 4).

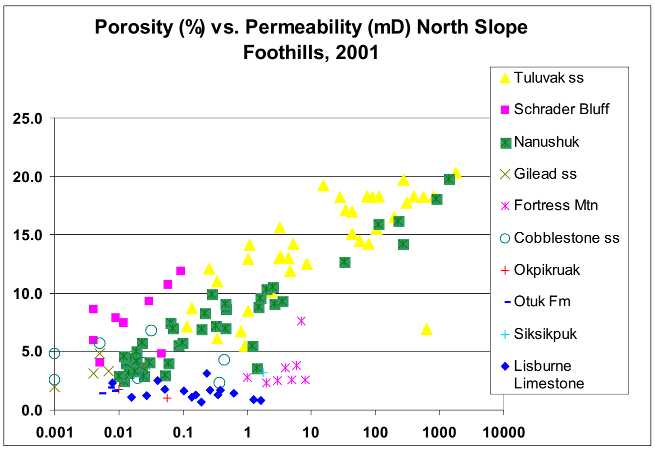

Figure 4. *Porosity (in percent) on vertical axis versus permeability (in millidarcies [md]) on horizontal axis for North Slope Foothills outcrop samples.*

Petrography

Petrography is the detailed study of the grains that compose a rock, the geologic history and implications of the sandstone grains, the cements that bind the rock, and other details. Petrographic data for the rock units of the North Slope are discussed below from youngest to oldest unit. Data are based on thin-section analysis.

Schrader Bluff Formation (Upper Cretaceous) sandstone is typically a litharenite sandstone (a sandstone composed of quartz and other rock fragments), with abundant volcanic rock grains.

Tuluvak Formation (Upper Cretaceous) sandstone is quartz-rich with very few rock fragments. The typical Tuluvak sandstone contains more than 75 percent quartz grains and up to 20 percent porosity.

Nanushuk Formation sandstones (Lower Cretaceous) were selected from the nonmarine upper part of the unit. The two petrographic samples of nonmarine sandstone are quartz-rich. It should be noted that the marine sandstone of the Nanushuk Formation is compositionally different from the nonmarine sandstones studied here (Reifenstuhl and others, 2001). Nonetheless, the relative quartz-rich composition of the petrographic samples of the upper Nanushuk Formation nonmarine sandstones demonstrates that the nonmarine sands in the North Slope Foothills belt have potential as oil and gas reservoirs.

Fortress Mountain Formation (Lower Cretaceous) sandstone typically contains quartz, abundant rock grains, and chert (a fine-grained sediment composed of silica). The Fortress Mountain Formation contains more fine-grained rock fragments and feldspar rock fragments (a common igneous mineral) than any other rock unit in this study.

The Cobblestone Member of the Fortress Mountain Formation (Mull and others, in press) (Lower Cretaceous; lower Albian) sandstone typically contains abundant quartz, rock fragments, and chert.

Lisburne Group limestone was deposited in a shallow marine environment, and is Carboniferous age. The Lisburne Group occurs widely in outcrop and subsurface throughout northern Alaska, and is as thick as 1 km. Seven samples were examined by J. Dumoulin of the U.S. Geological Survey. Reservoir quality of all samples is low (fig. 4). Primary porosity in the Lisburne has been largely destroyed by early calcite cement filling pore spaces in the rock. Worldwide, porosity and permeability values for outcrop samples of carbonate rocks are known to be generally lower than their subsurface counterparts because of the tendency for surface weathering to reduce porosity and permeability in carbonate rocks more readily than in sandstone.

Sandstone petrography implications

Based on analyses of the North Slope sandstones and the grains that make up those sandstones, their original geologic source environment included abundant quartz, sedimentary rock fragments, and metamorphosed sedimentary rock fragments. These types of rock fragments are recognized worldwide as a record of erosion from uplifted mountain ranges composed of continental margin rocks, that is, generally sedimentary rocks which form along the edge of a continent in the adjacent ocean. The rocks studied here are the erosional and depositional products of the continental margin rocks that, in modern times, form the bulk of the Brooks Range. The North Slope Foothills rock units are discussed by Reifenstuhl (2002) and below from youngest to oldest.

Schrader Bluff Formation sand grain or clast composition data indicate a volcanic component in addition to the more typical continental margin-derived clasts. The presence of volcanic clasts results in an overall low porosity and permeability, as a result of a variety of chemical changes in the grains as subsurface waters move through the sandstone.

Tuluvak Formation compositional data vary considerably, but sandstone is typically quartz rich, reflecting a dominantly quartz-rich source. The dominantly quartz-rich character of the Tuluvak samples, their fairly uniform grain size, and preservation of porosity due to a favorable post-burial history yield good reservoir potential.

Nanushuk Formation nonmarine sandstone grains indicate that the source area that eroded to produce the nonmarine Nanushuk sands was, again, dominated by quartz-rich continental margin rocks plus a source that yielded abundant rock fragments such as shale, slate, chert, and various kinds of metamorphic rock grains. This mix of compositions, combined with a low clay matrix, yields sandstone with promising reservoir potential (fig. 4).

The marine sandstones of the Nanushuk Formation are less favorable for oil and gas reservoirs than the nonmarine units, however, locally, the nonmarine units do have a moderate potential. Locally, some marine Nanushuk sandstone has reasonable reservoir potential.

Fortress Mountain Formation sandstone compositional data show affinity to a quartz-rich continental margin source area, with locally abundant volcanic components. This requires that during erosion of the highlands during Fortress Mountain Formation time, volcanic rocks were also being eroded and deposited as sand size grains. Grain boundary, grain type, and rock type suggest that the Fortress Mountain Formation was deposited in a marine setting, relatively close to its erosional source in what could be thought of as a transition between an alluvial fan and a river delta.

Compositional data from the Cobblestone Member of the Fortress Mountain Formation show the rocks to be generally quartz rich with a minor component of volcanic rock grains. The volcanic component of the Cobblestone Member is consistent with its being part of the Fortress Mountain Formation's record of local erosion of a volcanic-bearing highland.

YUKON FLATS

The Yukon Flats basin is in east-central Interior Alaska (fig. 1). Twenty-six drill core samples from the basin margins were analyzed for porosity and permeability; 12 of these were analyzed petrographically in June 2002. Surface samples were collected during July and September 2002 fieldwork, and were incorporated with concurrent reservoir studies. This project is a collaborative effort with the U.S. Geological Survey (USGS).

Petroleum geology framework

The Yukon Flats basin is located in east-central Alaska, between the Trans-Alaska Pipeline and the Canadian border, and contains known coal-bearing rocks on the western, southwestern, and southeastern margins. The basin is considered to be a latest Cretaceous and Cenozoic sedimentary basin that formed due to extensional forces in the earth's upper crust. These pull-apart forces are associated with movement along the well known and well documented Tintina and Kaltag fault systems (Kirschner, 1994), which have the same sense of movement as the well-known San Andreas fault in southern California.

Gravity and seismic geophysical information suggest that this basin is locally filled with at least 15,000 feet of nonmarine sediments consisting of three thick rock packages, each including different proportions of lake and river sediments (Kirschner, 1994). The lake sediments in the Yukon Flats basin may include oil-prone or gas-prone organic material. Oil and gas prospects (plays) include reservoir sandstones that might trap hydrocarbons in either a fault-related structure, termed a structural trap, or in a stratigraphic trap, a feature that is formed by an impermeable layer (topseal) overlying a porous and permeable sandstone layer (reservoir). Lake sediments can act as both topseals and as source rock. Petroleum generation is estimated to be possible below a depth of 7,000 to 10,000 feet, based on a typical increase of temperature with depth gradient that is reasonable for an interior basin (Kirschner, 1994; R.G. Stanley, USGS, personal commun., 2002). Potential energy resources include coalbed gas, shalebed methane, conventional gas, and oil.

Porosity, permeability, and petrography

A summary of the porosity and permeability data from the 24 Yukon Flats basin margin drill cores includes porosity of 1.1 to 11.7 percent (average about 4 percent) and permeability of 0.001 to 171.3 md (average about 0.4 md). A summary of the porosity and permeability data from the 11 Yukon Flats basin outcrop samples include porosity of 2.7 to 38.7 percent (average about 13 percent) and permeability of 0.006 to 203 md (average about 20 md).

Geologic setting and source area of sandstone units

The 12 drill hole sandstone samples from the Yukon Flats basin that were studied by microscope are predominantly erosional products of an upland area that was a mixture of quartz-rich rocks and rocks that were quartz poor, such as shale, igneous rocks, and metamorphic rocks. One sample indicates a strictly quartz-rich source. This one sample is the Triassic- to

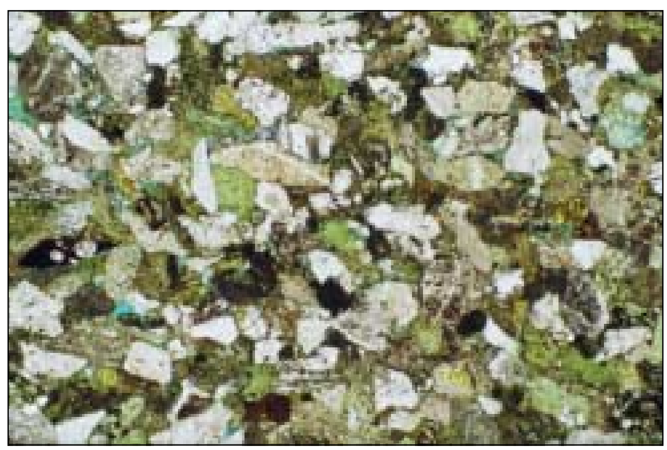

Figure 5. *Photograph taken through a microscope (magnification 40X, with polarized light) of Yukon Flats basin sample. Photo shows Paleogene-age sample is medium-grained, well-sorted, clay- and chert-rich sandstone with abundant rock grains or clasts. Cementation and porosity reduction is by deformation of soft grains, infilling of the matrix with clay, and squashing of the quartz-rich grains against similar grains. The most abundant framework components are 20 percent chert, 14 percent dark volcanic rock, and 12 percent indeterminate soft deformed grains. The porosity of this representative sandstone from Maypole Hill drill hole core is close to zero. However, nine of the 11 Yukon Flats basin outcrop samples have 7 percent porosity; the average for all outcrop samples is about 13 percent (see text).*

Jurassic-age sandstone from the Step Mountain area in the eastern Yukon Flats basin. Two sandstone samples, of probable Paleogene age (fig. 5), were deposited at the same time as known continental faulting and volcanic eruptions of rocks with a wide range of chemical composition were occurring. Consequently, this Paleogene-age sandstone has abundant rock fragments and is particularly rich in volcanic rock fragments.

FUTURE WORK

DGGS is pursuing funding through state, federal, and industry sources to support evaluation of a suite of about 1,000 representative sandstone samples from the North Slope Foothills, Yukon Flats basin, and other interior basins. For the proposed work, outcrop samples will make up about 90 percent of the suite, and well samples the remainder. The DGGS Geologic Materials Center (GMC) in Eagle River will be the source for the bulk of the North Slope subsurface samples, and will archive all sample material upon completion of our work. Archiving of sample material at GMC allows access to our collections by all future users. The goal is to create a publicly available reservoir quality database for Alaska. Final data will be published in peer-reviewed DGGS reports, accessible from the DGGS database, and on the DGGS Web site.

REFERENCES

Harris, E.E., Mull, C.G., Reifenstuhl, R.R., and Montayne, Simone, 2002, Geologic map of the Dalton Highway (Atigun Gorge to Slope Mountain) area, southern Arctic Foothills, Alaska, Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2002-2, 1 sheet, scale 1:63,360.

Kirschner, C.E., 1994, Interior basins of Alaska, *in* Plafker, George, and Berg, H.C., eds., The Geology of Alaska: Boulder, Colorado, Geological Society of America, The Geology of North America, v. G-1, p. 469–493.

Mull, C.G., Houseknecht, D.W., and Bird, K.J., in press, Revised Cretaceous and Tertiary stratigraphic nomenclature in east-central Colville basin, northern Alaska, U.S. Geological Survey Open-File Report.

Reifenstuhl, R.R, 2001, Tectonic setting and provenance, petrography and reservoir characteristics of nine siliciclastic sandstone formations, Mississippian to Tertiary age, Sagavanirktok Quadrangle, eastcentral Brooks Range foothills and Arctic Slope, Alaska, *in* Abstracts with programs, American Association of Petroleum Geologists Annual Meeting, v. 10, p. A165.

Reifenstuhl, R.R., 2002, Reservoir characterization pilot study: Porosity permeability, petrography, and facies analysis of 75 Upper Cretaceous to Mississippian age outcrop samples, east-central Brooks Range foothills and North Slope, Alaska, *in* Abstracts with programs, American Association of Petroleum Geologists Annual Meeting, v. 11, p. A146.

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NEW PUBLICATIONS

MP 124. Preliminary engineering-geologic database of the proposed Alaska Natural Gas Transportation System (ANGTS) corridor from Prudhoe Bay to Livengood, Alaska, by C.E. Cameron, E.E. Thoms, and C.A. Galló, 2002, 4 CD-ROMS. $40.

MP 125. Engineering-geologic database of the proposed Alaska Natural Gas Transportation System (ANGTS) corridor from Prudhoe Bay to Delta Junction, Alaska, by C.E. Cameron, E.E. Thoms, and C.A. Galló, 2002, 6 CD-ROMS. $60.

MP 126. 400 MHz ground-penetrating radar, Itkillik River, North Slope, Alaska, by P.R. Peapples, A.J. Delaney, D.L. LePain, 2002, 1 sheet. $13.00

PIR 2002-2. Geologic map of the Dalton Highway (Atigun Gorge to Slope Mountain) area, southern Arctic Foothills, Alaska, by E.E. Harris, C.G. Mull, R.R. Reifenstuhl, and Simone Montayne, 2002, 1 sheet, scale 1:63,360. $13.

RDF 2002-1. Major oxide, minor oxide, trace element, rare-earth element, trace geochemical, and coal quality data from rocks collected in Eagle and Tanacross quadrangles, Alaska in 1999, 2000, and 2001, by D.J. Szumigala, M.B. Werdon, R.J. Newberry, J.E. Athey, K.H. Clautice, R.L. Flynn, J.C. Grady, W.C. Munly, and M.R. Johnson, 2002, 35 p., 1 sheet, scale 1:63,360. $17.

RDF 2002-3. Major oxide, minor oxide, trace element, and geochemical data from rocks collected in the Big Delta Quadrangle, Alaska, in 2001, by J.E. Athey, M.B. Werdon, D.J. Szumigala, R.J. Newberry, and M.R. Johnson, 20 p., 2 sheets, scale 1:150,000. $15.

RI 2002-3. Paleontological inventory of the Amphitheater Mountains, Mt. Hayes A-4 and A-5 quadrangles, southcentral Alaska, by R.B. Blodgett, 2002, 11 p. $2.

SR 56. Alaska's Mineral Industry, 2001, by R.C. Swainbank, D.J. Szumigala, M.W. Henning, and F.M. Pillifant, 2002, 65 p.

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Dear Readers:

One of the main missions of DGGS is to define the geologic framework of Alaska's mineral and energy resources. Achieving this objective requires work across a wide spectrum of observation that ranges from regional-scale geologic maps to the scale of single rock-thin sections examined by microscope. The detailed rock thin-section examinations and data discussed in this issue of *GeoSurvey News* provide the relevancy for determining the surface and subsurface distribution of key rock units such as the North Slope Tuluvak Sandstone and the non-marine sandstones of the Nanushuk Formation.

Data from detailed microscope study of rock units also yield valuable information about the ancient geography and continental-scale geologic mountain building and erosion events that occurred millions of years ago. Understanding that geography and the relative sequence of occurrence of those events allows geologists to make better forecasts of where accumulations of oil and gas are likely to occur today. Generating these data requires a sound knowledge of the geologic history of Alaska and a commitment to accurate observation and attention to detail. Deriving the benefit of the observations requires the ability to draw the data together into a clear and rational interpretation. The author and editors for this issue of *GeoSurvey News* have attempted to do that in order to share with you some of the work that DGGS is pursuing to help maintain oil production in Alaska.

Sincerely,

Milton A. Wiltse

Milton A. Wiltse
Director and State Geologist

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