STATE OF ALASKA
Department of Natural Resources

COOK INLET BASIN ANALYSIS PROGRAM
2014 FUNDING PROPOSAL

by

DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
Energy Resources Section
3554 College Road
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COOK INLET BASIN ANALYSIS PROGRAM

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EXECUTIVE SUMMARY

The Alaska Division of Geological & Geophysical Surveys (DGGS), a division in the Alaska Department of Natural Resources (DNR), proposes an integrated program of research in Cook Inlet basin. The focus of this research is on the potential for stratigraphic traps in Tertiary strata in upper Cook Inlet, the conventional and unconventional reservoir potential of Mesozoic rocks in lower Cook Inlet, and the source rock characteristics of Middle Jurassic strata in the basin. Our approach integrates structural, thermochronologic, and sedimentological/stratigraphic analyses to better understand the petroleum potential of the basin. Our 2014 program will concentrate on the west side of the basin in lower Cook Inlet, but will also include work on bluff exposures of Miocene and Pliocene strata on the Kenai lowland and description of several cores from wells in upper Cook Inlet.

This proposal outlines 10 topical projects, most of which are multi-year initiatives:

1. *What is the kinematic history of the Bruin Bay fault system, under what tectonic setting(s) did it develop, and how did it influence Jurassic–Tertiary sedimentation into the Cook Inlet forearc basin?*
2. *What is the fracture porosity and permeability of potential reservoir and source rocks in the Cook Inlet forearc basin? What was the timing and tectonic setting of fracturing and how are the fractures related to regional structures such as the Bruin Bay fault system?*
3. *What are the burial/uplift history and thermal structure of Cook Inlet basin and what are their implications for thermal maturation and gas generation?*
4. *What is the subcrop pattern of Mesozoic strata along the basal Tertiary unconformity?*
5. *Do depositional systems in Tertiary strata in upper Cook Inlet vary in a predictable way relative to the basin margins?*
6. *What depositional systems are recorded in Mesozoic strata in lower Cook Inlet and how do these systems control sand body geometries and influence conventional and unconventional reservoir quality and petroleum source-rock characteristics?*
7. *Can stratal geometries be recognized on industry seismic data that provide clues to specific depositional systems recorded in Tertiary strata?*
8. *How does the composition of sandstones vary with time and location in the forearc basin, and how do these variations affect diagenetic history and, ultimately, reservoir quality?*
9. *How does depositional environment affect reservoir quality in Mesozoic and Cenozoic strata in Cook Inlet basin?*
10. *Are fluid inclusions present in laumontite and does the formation of laumontite in the Mesozoic section precede hydrocarbon generation and migration?*

The geologic context for these projects, along with brief descriptions of each, are presented in the pages that follow. The cost of this program for FY15 is $384,355. We hope that your organization will support our program at the requested level of $40,000. If your support cannot be at the $40,000 level, we will accept participation at a reduced level or in-kind support in the form of subsurface data.

If sufficient funding is received we will run a day-long tour following our field work at the end of July 2014, highlighting stratigraphic and structural relations along the west side of the basin in the vicinity of the Iniskin Peninsula. If funding is insufficient for the full program as proposed, we will scale back our plans and concentrate on fewer objectives. The decision of whether or not to offer the proposed tour will be made by early June 2014 to allow sufficient time for logistical and travel arrangements.

For more information regarding this proposal and the DGGS Cook Inlet Basin Analysis Program please contact Robert Gillis at 907-451-5024 (robert.gillis@alaska.gov) or David LePain at 907-451-5085 (david.lepain@alaska.gov).

INTRODUCTION

Commercial quantities of oil and gas have been produced from Tertiary nonmarine reservoirs in Cook Inlet since the early 1960s. Exploration throughout this time has focused largely on structural traps involving Tertiary nonmarine rocks in upper Cook Inlet. A location map of the oil and gas wells in the basin shows a clearly recognizable pattern (fig. 1). Most wells cluster along the crests of north–northeast-trending faulted anticlines. Although most structural traps in the basin have stratigraphic components, very little exploration has been devoted explicitly to the search for stratigraphic traps. Lateral discontinuity of channel sand bodies, channel belts, and crevasse-splay sand bodies, and their encasement in fine-grained overbank lithologies capable of serving as reservoir seals, are well documented in the literature from basins around the world. Lateral discontinuity and lithologic heterogeneity are inherent in most alluvial depositional systems—the rule rather than the exception. Why have stratigraphic traps not been pursued and documented in Cook Inlet? Part of the reason is that structural traps were relatively easy to find—they represented the "low-hanging fruit" that was picked early in the basin's exploration history. Stratigraphic traps are far more subtle and difficult to recognize on exploration seismic data. The search for stratigraphic traps requires detailed knowledge of the depositional systems present in the basin in space and through time. Several important questions need to be addressed regarding stratigraphic traps, including: *Are stratigraphic traps in Cook Inlet skewed toward low-volume reservoirs as a function of depositional architecture? What depositional systems present in the Cook Inlet Tertiary succession are most likely to include stratigraphic traps, and in which facies associations? Can we recognize these depositional systems on two-dimensional seismic data and, if we can, how?*

Mesozoic sedimentary rocks underlie Tertiary nonmarine strata throughout the basin and are discontinuously exposed along the folded and faulted basin margins, particularly along the west side in lower Cook Inlet. All oil produced from Tertiary strata in upper Cook Inlet is derived from

Mesozoic marine source rocks, and most likely from Middle Jurassic source rocks of the Tuxedni Group. Most of this oil was produced from Tertiary sandstone reservoirs but a minor amount was produced from fractured Mesozoic rocks. The Mesozoic succession is also endowed with many thick marine and marginal-marine sand bodies that, at the time of deposition, possessed textures characteristic of good reservoirs. Yet the limited well penetrations have nearly all encountered rocks with low porosity and permeability—the result of pervasive diagenetic modifications. These findings raise several questions, including: *Why are Mesozoic sandstones with good conventional reservoir potential so scarce? Are there areas, or stratigraphic intervals, in the basin where Mesozoic sandstones have escaped extensive diagenetic modification and porosity destruction, or where diagenetic processes have resulted in creation of significant effective secondary porosity? Considering the migration pathways from Mesozoic source beds to Tertiary reservoirs, why have no traps been found in Mesozoic strata? What is the potential for unconventional reservoirs in Mesozoic rocks in the basin? What are the characteristics of Middle Jurassic rocks thought to be the source of oil in upper Cook Inlet fields?*

These questions, and many others, are addressed in the DGGS Cook Inlet basin analysis program.

Over the decades much detailed work has been done in this basin by industry geoscientists on both Tertiary and Mesozoic strata, but this work is proprietary and unlikely to be documented in public domain literature. The DGGS Cook Inlet Basin Analysis program is designed to provide relevant geologic data in the public domain to catalyze hydrocarbon exploration in the basin.

The focus of the 2014 program will be Mesozoic strata along the west side of Cook Inlet basin, in the vicinity of Iniskin Peninsula and Tuxedni Bay, and late Miocene and Pliocene strata of the Beluga and Sterling Formations between Anchor Point and Ninilchik, on the Kenai lowland. In addition, we will describe several cores of Tertiary sandstones from wells in upper Cook Inlet.

REGIONAL GEOLOGY

Mesozoic and Tertiary rocks of Cook Inlet basin comprise the fill of a long-lived northeast-trending collisional forearc basin that extends approximately from the Shelikof Strait to the Wrangell Mountains (Trop and Ridgway, 2007). The basin is bounded by high-angle faults on the west (Bruin Bay fault system), northwest (Capps Glacier fault), north (Castle Mountain fault), and east (Border Ranges fault zone) sides (fig. 1). Its fill spans nearly 200 million years and represents a rich archive of events that shaped the basin, adjacent arc, and accretionary complex (fig. 2). The arc and accretionary complex are represented by the Aleutian–Alaska Range and Chugach Mountains, respectively. Complex plate motions and collisions throughout Jurassic and Cretaceous time led to the assembly of the Wrangellia composite terrane and its juxtaposition with the ancestral Alaska continental margin. Throughout this time Cook Inlet basin was dominantly a marine forearc basin with marginal-marine facies confined to the flanks of the arc massif and shallow marine through basinal facies dominating the stratigraphy. Arc magmatism was initiated in latest Triassic and reached an initial zenith in the Jurassic with extrusion of extensive volcanogenic rocks recorded in the Talkeetna Formation (Early Jurassic) and emplacement of an extensive suite of plutons (Early through Late Jurassic). Arc exhumation supplied enormous quantities of first cycle volcanic and plutonic sediment to the basin which, along with related arc topography and bathymetry, exerted strong controls on sediment composition and depositional systems. Complex facies changes over short distances reflect deposition in a marine basin characterized by steep topographic–bathymetric gradients that led to close juxtaposition of marginal-marine and basinal facies (LePain and others, 2011b, 2013; Wartes and others, 2011, 2013a, 2013b). It was in this complex marine setting that the organic-rich mudstones and first-cycle volcanogenic sandstones of the Middle Jurassic Tuxedni Group were deposited, followed by first-cycle sediments of mixed volcanogenic and plutonic provenance represented by the Upper Jurassic Chinitna through Naknek Formations. Organic-rich mudstones of the Tuxedni Group (Red Glacier Formation) are thought to be the source for oil in upper Cook Inlet fields (Magoon and Anders, 1992). This complex facies motif continued throughout the Cretaceous, but sediment supply evolved to a mix of first-cycle volcanogenic and plutonic material and recycled material from underlying older Mesozoic strata and possibly contributions from more distant source terranes.

The forearc region experienced a profound episode of uplift and deformation in latest Cretaceous–early Paleocene time associated with subduction of a spreading center, resulting in formation of a regional subaerial erosion surface that extends throughout the forearc basin (Bradley and others, 2003). Following this event depositional patterns basin-wide were fundamentally different and dominated by nonmarine depositional systems. It is unknown whether portions of the axial region of the basin were still characterized by marine deposition as large areas remain undrilled. The dominant depositional pattern during the Tertiary included relatively-high-gradient alluvial fans along the eastern and western basin margins (present-day coordinates) that fed sediment to an axial fluvial system that included large channel tracts separated by vast, poorly drained flood basins (Swenson, 2003; LePain and others, 2013). The relative extents of these contrasting depositional tracts varied through time, with large portions of the basin dominated by relatively-high-gradient, coarse-grained fluvial systems with corresponding smaller flood basins during the Oligocene and Pliocene when the Hemlock Conglomerate and Sterling Formation were deposited, in contrast to large portions dominated by low-gradient, perennially wet flood basins with areally restricted channel tracts during the middle and late Miocene when the upper part of the Tyonek and Beluga Formations were deposited. During this time thick peats accumulated in raised and topogeneous mires that were gradually transformed to bituminous and lignitic coals upon burial.

Collision of the Yakutat microplate in eastern south-central Alaska starting in Oligocene time transformed the forearc basin to a collisional basin, with collapse and inversion of the basin progressing from northeast to southwest, resulting in inverted stratigraphy in the northeastern segment (Matanuska Valley) and north–northeast-trending folds arranged in an en-echelon pattern in the Cook Inlet segment (Haeussler, 2008; Trop and Ridgway, 2007). These folds involve both Mesozoic and Cenozoic stratigraphy, and most are cored by high-angle reverse faults and have their axes offset by complex high-angle cross-faults (Swenson, 2003). Faulting associated with these structures provided conduits for migration of liquid hydrocarbons from Middle Jurassic source rocks that ultimately charged Tertiary sandstone reservoirs. Fold development and associated uplift was critical to desorption of microbial gas from coal seams and migration to nearby sand bodies (Claypool and others, 1980).

DGGS' Cook Inlet basin analysis program aims to improve understanding of the complex geology of Cook Inlet basin and its petroleum potential. The work done to date under this program and the work proposed in this document adds relevant information on basin subsidence and uplift history, source rock characteristics, reservoir architecture, conventional and unconventional reservoir potential, and reservoir quality.

SUMMARY OF PRIOR FIELD SEASONS

DGGS' 2006 through 2011 field seasons focused on the Tertiary stratigraphy in upper Cook Inlet and was done in close collaboration with the Alaska Division of Oil and Gas (DOG). Reconnaissance level work on Mesozoic strata during the 2009 and 2010 seasons represents our initial efforts in lower Cook Inlet; our focus subsequently shifted to this area and these rocks in 2012. Our work in upper Cook Inlet has demonstrated the influence of coeval motion on the Capps Glacier fault and explosive volcanism on deposition of the West Foreland Formation in basin proximal locations (Gillis and others, 2009, in preparation; LePain and others, 2011a, 2013). Work on Oligocene through early Pliocene strata has documented sand body geometries and reservoir quality (LePain and others, 2009, 2013; Helmold and others, 2013). Our work on the Miocene Beluga and Pliocene Sterling Formations has documented the role fluvial style exerts on sand body architecture and the potential role of soft-sediment deformation in compartmentalizing these sands (Mongrain, 2012; LePain and others, 2013). Our work also documents the significant role coeval volcanism played in influencing sand composition and deposition in the Sterling Formation (Helmold and others, 2013; LePain and others, 2013). Our work on the Mesozoic section in lower Cook Inlet has begun to document the facies complexity of marine sandstones and source rock characteristics of the Middle Jurassic Tuxedni Group (LePain and others, 2011b, 2013; Wartes and others, 2011, 2013a, 2013b). Work under this program has also begun to unravel the structural and thermal history of the western basin margin (Gillis and others, 2009; Gillis 2013; Betka and Gillis, in preparation; and Gillis and others, in preparation).

A list of publications stemming from our work in the basin is presented at the end of this proposal. Many of these documents are available as digital documents from DGGS's website, http://www.dggs.alaska.gov/pubs/.

PROPOSED 2014 RESEARCH AND PRODUCTS

We propose an integrated program of field and subsurface studies to be conducted in collaboration with DOG that bear on reservoir architecture and quality of Tertiary sandstones in upper Cook Inlet, the reservoir potential (conventional and unconventional) of Mesozoic strata in lower Cook Inlet, and the source rock characteristics of Middle Jurassic rocks also in lower Cook Inlet, and the structural and thermal evolution of the basin. The following topical projects address these broadly defined areas:

1. ***What is the kinematic history of the Bruin Bay fault system, under what tectonic setting(s) did it develop, and how did it influence Jurassic–Tertiary sedimentation in the Cook Inlet forearc basin?*** This study is directed at understanding the kinematic evolution, relative timing, and tectonic significance of brittle deformation that occurred on the Iniskin Peninsula in lower Cook Inlet. The study is important because the Iniskin Peninsula is transected by the Bruin Bay fault system, a major northeast-striking structural boundary in southeast Alaska that is continuous for >450 km from the upper Alaska Peninsula to the northwest terminus of Cook Inlet basin (fig. 1). In lower Cook Inlet the Bruin Bay fault system defines the tectonic boundary between Mesozoic and Cenozoic sediments of the forearc basin and the crystalline batholith and volcanic edifice of the Jurassic arc. Despite its large geographic extent and significance as a major tectonic boundary in southeast Alaska, relatively little is known about the kinematic history of the Bruin Bay fault system. This three-year study (2013–2015) focuses on collecting field data and conducting kinematic analyses from more than 125 fault surfaces that are exposed in both the hanging wall and footwall of the Bruin Bay fault system. The data are evaluated with the goal of describing fault kinematics, discerning kinematically compatible fault populations, and testing for potential genetic relationships between unique fault sets. Preliminary results from the first field season (2013) indicate that most of the faults (n=108, 86%) can be divided into two fault populations with statistically distinct kinematic histories. Faults from one set include northeast-striking thrust and left-lateral strike-slip faults and northwest-striking right-lateral faults that altogether record southeast-trending shortening (n=56). The other population of faults includes northeast- and northwest- striking right- and left-lateral strike-slip faults, respectively, that record east-trending shortening (n=52). Analysis of fault slip data and spatial distribution of the two populations indicates that each fault set probably reflects separate deformations and suggests that fault reactivation likely occurred along all of the major structures that comprise the Bruin Bay fault system near the Iniskin Peninsula. Ongoing work during 2014–2015 will include field visits to important, newly discovered exposures of the fault system and expanding the map area to include data from an additional ~300 $miles^2$ adjacent to the system. Results will provide an important characterization of brittle deformation along the Bruin Bay fault system and help to constrain the tectonic evolution of the Cook Inlet forearc basin. Staff include Paul Betka (DGGS) and Bob Gillis (DGGS). *A preliminary interpretive report summarizing results from the 2014 field season will be released during Winter/Spring 2015.*

2. ***What is the fracture porosity and permeability of potential reservoir and source rocks in the Cook Inlet forearc basin? What was the timing and tectonic setting of fracturing and how are the fractures related to the regional structures such as the Bruin Bay fault system?*** DGGS will be co-sponsoring a graduate student with the Department of Geology & Geophysics at the University of Alaska Fairbanks (UAF) as a Graduate Research Intern. The intern will be 50 percent supported by DGGS and participate in DGGS-sponsored field-work that will support his Master's thesis. He will be part of an ongoing DGGS effort aimed at improving understanding of the petroleum potential of Cook Inlet basin. The field area for this project is the Iniskin Peninsula and the area between Chinitna and Tuxedni bays. The internship project

will involve structural analysis of a previously undocumented system of fractures that occur in potential source and reservoir rocks, with the goal of understanding fracture-induced reservoir porosity/permeability. The intern will also be encouraged to understand the structural relationship/timing of the fractures relative to the development of regional fault systems and in the tectonic context of the forearc basin. Other possible research directions include determining the thermal conditions of fracturing and/or relative timing of fracturing and hydrocarbon migration. Staff include Paul Betka (DGGS), Bob Gillis (DGGS), and incoming University of Alaska Fairbanks graduate student Jacob Rosenthal. *The intern will produce a DGGS preliminary interpretive report during Winter/Spring 2015 and produce a Master's thesis that satisfies the requirements of the Department of Geology & Geophysics at UAF; results will be published in the form of reports through the DGGS publication series to satisfy the requirements of the DGGS internship.*

3. ***What is the burial/uplift history and thermal structure of Cook Inlet basin and what are their implications for thermal maturation and gas generation?*** How does the timing of subsidence, maximum burial, and episodes of uplift compare with the record of uplift and denudation of the basin margins? We plan to initiate a pilot thermochronologic project that integrates proposed new apatite fission-track analyses of selected upper Cook Inlet wells with published and new vitrinite reflectance analyses to develop thermal and uplift histories in key locations in the basin. Estimates of burial and uplift from these data will be compared to results from a sonic-porosity log study by Peterson (2010) from the same Cook Inlet wells as an independent check on the magnitudes of subsidence, uplift, and unconformities. The results from more than 50 detrital apatite fission-track and 30 detrital zircon samples recently analyzed by DGGS from outcrops along the western and eastern basin margins of the upper Cook Inlet segment of the forearc basin will also be compared with apatite fission-track and new detrital zircon results from the wells to refine tectonic and provenance models of the basin. Paired apatite fission-track thermochronology and vitrinite reflectance analysis from wells are the only means of extracting basin thermal histories and have been instrumental in understanding basin subsidence, thermal maturity, and uplift in basins worldwide (such as North Sea, Irish Sea, northwestern shelf of Australia, Canadian cordillera, U.S. Rocky Mountain and Mid-Continent regions, the North Slope of Alaska). However, these data do not exist in the public domain for Cook Inlet basin except for one well in lower Cook Inlet (COST #1). Staff include Gillis (DGGS), Peterson (DOG), Wartes (DGGS), and Helmold (DOG). *We anticipate releasing a preliminary interpretive report summarizing initial results of this project during Fall–Winter 2015–2016.*

4. ***What is the subcrop pattern of Mesozoic strata along the basal Tertiary unconformity?*** We continue to work on mapping the distribution of Mesozoic formations at the basal Tertiary unconformity surface using publicly available wireline log, core, and seismic data. A structure contour map of the basal Tertiary unconformity surface (Shellenbaum and others, 2010) forms the base for the subcrop map. Staff include Gregersen (DOG) and Shellenbaum (DOG) with contributions from other DOG and DGGS staff. *We anticipate release of the Mesozoic subcrop map for upper Cook Inlet during Summer–Fall 2014.*

5. ***Do depositional systems in Tertiary strata in upper Cook Inlet vary in a predictable way relative to the basin margins?*** We hypothesize that depositional systems characterized by steep alluvial gradients and relatively coarse and immature textures are present near the basin margins, and that alluvial gradients and corresponding textural maturity decrease and increase, respectively, toward the basin axis. This seems intuitively obvious, but the details, on both spatial and temporal scales, are very poorly known. These details are important to the explorationist trying to understand the distribution of reservoir-quality sand bodies and their geometries. Since 2006 DGGS and DOG have measured more than 60 detailed stratigraphic sections in Tertiary formations in upper Cook Inlet, including the West Foreland, Hemlock, Tyonek, Beluga, and Sterling, and conducted detailed facies analyses using this data set. Many of these sections are tied to high-resolution photographic panoramas that allow mapping architectural elements in two, and locally, in three dimensions. All measured sections include a detailed suite of samples tied to facies for analysis of reservoir quality (see projects 8 and 9 below). In addition, we are extending our detailed facies analysis into the subsurface via core, wireline log, and 2D seismic data (see project 7, below). We will continue this work in 2014, measuring several sections in the Sterling Formation between Anchor Point and Ninilchik and by describing several cores from the Hemlock and Tyonek. Staff include LePain (DGGS), Stanley (USGS), Helmold (DOG), Peterson (DOG), Herriott (DGGS), and Wartes (DGGS). *A DGGS preliminary interpretive report with all measured stratigraphic sections from 2006–2007 field seasons was released in 2009 (LePain and others, 2009). We anticipate releasing our measured sections and preliminary facies analysis of the Tyonek Formation in outcrop during 2014. Additional reports will be released as facies analyses are completed.*

6. ***What depositional systems are recorded in Mesozoic strata in lower Cook Inlet and how do these systems control sand body geometries and influence conventional and unconventional reservoir quality and source rock characteristics?*** DGGS initiated study of Middle Jurassic through Maastrichtian strata exposed along the west side of lower Cook Inlet in 2009. We plan to continue this work in 2014. As with our work on the Tertiary succession in upper Cook Inlet, this effort will involve an integrated analysis of depositional systems, potential reservoir architecture (sand body geometries), and reservoir quality (see projects 8 and 9 below). In 2014 the focus will be on the Tuxedni Group and Naknek Formation in the vicinity of the Iniskin Peninsula and Tuxedni Bay. Work on the Tuxedni will include detailed analysis of depositional thickness changes, associated facies patterns, and mudrock composition and source-rock characteristics in the Red Glacier Formation. Work on the Gaikema Sandstone through Bowser Formation (Tuxedni Group) will focus on facies relations, sandstone compositions, and potential unconventional reservoir geometries. Work on the Naknek will continue to focus on detailed facies analysis and partitioning of sand in marginal-marine to deep-marine settings and implications for reservoir architecture. Facies information resulting from this work will inform the fracture study described in project 2 above. Staff include LePain (DGGS), Wartes (DGGS), Herriott (DGGS), Helmold (DOG), Peterson (DOG), and

Stanley (USGS). *We anticipate releasing several reports summarizing our work on the Mesozoic succession in 2015.*

7. ***Can stratal geometries be recognized on industry seismic data that provide clues to specific depositional systems recorded in Tertiary strata?*** We hypothesize that depositional systems, and possibly architectural elements in these systems, can be recognized on high-quality industry seismic data. To test this hypothesis we plan to build a 2D geophysical model of either the Sterling Formation or Beluga Formation in bluff exposures along the east side of Cook Inlet and west side of Kachemak Bay, respectively. Using detailed measured sections, rock physics measurements on hand samples, nearby well control, and a digital map of architectural elements present in the exposures, a petro-acoustic model will be developed and used as input to seismic modeling software to create a synthetic, 2D seismic section. The ability to image/resolve stratigraphic detail at different frequencies will be explored using the resulting model. Some data necessary to complete this project have already been collected, and samples for the rest of the required data will be collected during Fall 2014 and Spring 2015. Staff include LePain (DGGS), Shellenbaum (DOG), Gregersen (DOG), and Helmold (DOG). *Preliminary results from this pilot project will be summarized in a brief report released by Fall 2015.*

8. ***How does the composition of sandstones vary with time and location in the forearc basin, and how do these variations affect diagenetic history and, ultimately, reservoir quality?*** We hypothesize there are temporal and spatial variations in sandstone composition in the basin and these variations influence the diagenetic history of the sandstones. Previous work by industry geologists suggests: (1) Tertiary sands derived from the accretionary prism contain elevated percentages of sedimentary rock fragments (for example, Hayes and others, 1976); (2) sediment derived from the volcanic arc are enriched in plutonic rock fragments and associated grains; and (3) sands toward the basin axis have mixed provenance due to contributions from both sides of the basin. It is well established that the framework composition of sandstones can dictate the style and extent of diagenetic modification. For example, quartz arenites are commonly cemented by quartz overgrowths on detrital grains, plagioclase-rich arkoses are susceptible to laumontite replacement and cementation, and volcanogenic sandstones are readily cemented by chlorite, chlorite/smectite mixed-layer clays, and heulandite. We will continue to obtain point-count data on sandstones near the basin margins and from cores near the basin axis to test this hypothesis. These new thin sections will be used to expand our understanding of the distribution of sandstone petrofacies and to refine our paragenetic sequence of diagenetic events. Work on this project is primarily done by Helmold (DOG), with contributions from various DGGS staff. *A DGGS preliminary interpretive report was published in 2013 summarizing data gathered from 2006 through 2011 (Helmold and others, 2013). This report will be updated as new data become available.*

9. ***How does depositional environment affect reservoir quality in Mesozoic and Cenozoic strata in the Cook Inlet basin?*** Extensive literature on depositional systems in basins worldwide has

established that depositional texture (grain size, sorting, roundness, stratification, etc.) strongly influences the ultimate reservoir quality of sandstones, even after extensive burial diagenesis. Point-count data obtained from work on projects 4, 5, and 7 above and porosity and permeability (P&P) data from samples tied to measured stratigraphic sections and core logs will be integrated with lithofacies data to examine reservoir quality parameters and the influence of depositional processes on reservoir parameters. Staff includes Helmold (DOG), LePain (DGGS), Wartes (DGGS), Herriott (DGGS), Peterson (DOG), and Stanley (USGS). *A DGGS preliminary interpretive report was published in 2013 summarizing data gathered from 2006 through 2011. This report will be updated as new data become available.*

10. ***Are fluid inclusions present in laumontite and does the formation of laumontite in the Mesozoic section precede hydrocarbon generation and migration?*** Addressing this question represents a novel approach toward addressing the petroleum potential of Mesozoic strata in Cook Inlet. Work in several circum-Pacific basins shows that laumontite ($CaAl_2Si_4O_{12}{\cdot}4H_20$) is present as a direct replacement of plagioclase and is a pervasive cement that typically occludes all residual porosity. Previous examinations by industry geologists of outcrop and subsurface samples from OCS wells in lower Cook Inlet show laumontite is regionally extensive in the Mesozoic section, particularly the Pomeroy Arkose Member of the Naknek Formation. The timing of laumontite genesis relative to hydrocarbon migration is critical to evaluating the petroleum potential of the basin. If regional cementation postdates hydrocarbon migration, then significant potential exists for conventional reservoirs in Mesozoic strata. It may be possible to estimate the temperature of laumontite formation through fluid inclusion analysis. The temperature of formation can then be related to the thermal history of the basin to estimate the time of cementation. Thermal history can also be used to estimate the timing of hydrocarbon migration. This work depends on the presence of fluid inclusions in laumontite, the assumption of no fluid leakage from them, and the ability to differentiate primary and secondary inclusions. No literature exists on fluid inclusions in zeolite minerals. This scoping study will involve examination of an existing suite of sandstone thin sections from Cook Inlet basin, the Yukon–Koyukuk flysch belt, the San Joaquin basin, and Santa Ynez basin to answer two fundamental questions: ‘Are fluid inclusions present and, if present, can primary and secondary inclusions be differentiated?’. This project is run by Helmold (DOG). *A DGGS preliminary interpretive report summarizing our findings on this question will be published after the scoping study has been completed.*

FIELD LOGISTICS, STAFF, AND BUDGET

DNR will have a field party based at Bear Mountain Lodge on the north shore of Chinitna Bay for approximately three weeks in July (fig. 1). The party will work daily from this base on outcrops between Iniskin and Tuxedni bays. Access to exposures on the Iniskin Peninsula is contingent on permission from Cook Inlet Region, Inc., and various Native village corporations; access to exposures north of Chinitna Bay is contingent on permission from Lake Clark National Park and Preserve staff. Field crews will be deployed each day using a helicopter (Bell Long Ranger) based at Bear Mountain Lodge. Field work on the Kenai lowland will take place in September from a base of operations in Homer.

Project Budget—The detailed budget for the proposed work is included in table 1. The project, as proposed, will cost $384,355.

Project Staff—This program is managed by DGGS with research carried out by geoscientists at DGGS, DOG, and the University of Alaska Fairbanks. Each geoscientist listed below is expected to contribute to, or lead, some aspect of the research covered in this proposal.

- Paul Betka (DGGS)—Structural geology and geologic mapping
- Robert Gillis (DGGS)—Structural geology, geologic mapping, and thermochronology
- Laura Gregersen (DOG)—Wireline log analysis, subsurface correlations, and petroleum geology
- Ken Helmold (DOG)—Reservoir quality and basin modeling
- Trystan Herriott (DGGS) —Clastic sedimentology and geologic mapping
- David LePain (DGGS)—Clastic sedimentology, sequence stratigraphy, reservoir architecture, and basin analysis
- Diane Shellenbaum (DOG)—Seismic data acquisition and licensing, seismic interpretation, time-depth conversion, and forward seismic modeling
- Shaun Peterson (DOG)—Wireline log analysis, subsurface correlations, and GIS applications
- Marwan Wartes (DGGS)—Clastic sedimentology and basin analysis

In addition, we anticipate informal collaboration with Dr. Richard Stanley (USGS, Menlo Park, CA)

REFERENCES CITED

Bradley, D.C., Kusky, T.M., Haeussler, P.J., Goldfarb, R.J., Miller, M.L., Dumoulin, J.A., Nelson, S.W., and Karl, S.M., 2003, Geologic signature of early Tertiary ridge subduction in Alaska, *in* Sisson, V.B., Roeske, S.M., and Pavlis, T.L., eds., Geology of a transpressional orogen developed during ridge–trench interaction along the North Pacific margin: Geological Society of America Special Paper 371, p. 19–49.

Claypool, G.E., Threlkeld, C.N., and Magoon, L.B., 1980, Biogenic and thermogenic origins of natural gas in Cook Inlet basin, Alaska: AAPG Bulletin, v. 64, p. 1131-1139.

Gillis, R.J., Herriott, T.M., Shellenbaum, D.P., Mauel, D.J., Wartes, M.A., Decker, P.L., and Gregersen, L.S., in prep., Interpretive bedrock geologic map of the south-central Tyonek Quadrangle, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation, 1 sheet, 1:63,360-scale.

Gillis, R.J., LePain, D.L., Ridgway, K.D., and Finzel, E.S., 2009, A reconnaissance view of an unnamed fault near Capps Glacier, northwestern Cook Inlet basin, and its potential as a regional-scale, basin-controlling structure: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2009-3, 9 p., http://www.dggs.alaska.gov/pubs/id/19503.

Haeussler, P.J., 2008, An overview of the neotectonics of interior Alaska—Far-field deformation from the Yakutat microplate collision, *in* Freymueller, J.T., Haeussler, P.J., Wesson, R.L., and Ekstrom, G., eds., Active tectonics and seismic potential of Alaska: American Geophysical Union Geophysical Monograph 179, p. 83–108.

Hayes, J.B., Harms, J.C., and Wilson, T., 1976, Contrasts between braided and meandering stream deposits, Beluga and Sterling Formations (Tertiary), Cook Inlet, Alaska, *in* Miller, T.P., ed., Recent and ancient sedimentary environments in Alaska: Proceeding of the Alaska Geological Society Symposium, April 204, 1975, Anchorage, Alaska, p. J1-J27.

Helmold, K.P., LePain, D.L., Wilson, M.D., and Peterson, C.S., 2013, Petrology and reservoir potential of Tertiary and Mesozoic sandstones, Cook Inlet, Alaska—A preliminary analysis of outcrop samples collected during 2007–2010 field seasons: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2013-5, 34 p., http://www.dggs.alaska.gov/pubs/id/25035.

LePain, D.L., Stanley, R.G., Helmold, K.P., and Shellenbaum, D.P., 2013, Geologic framework and petroleum systems of Cook Inlet basin, south-central Alaska, *in* Stone, D.M. and Hite, D.M., eds., Oil and Gas Fields of the Cook Inlet Basin, Alaska: AAPG Memoir 104, p. 37–116.

LePain, D.L., Stanley, R.G., Helmold, K.P., Peterson, C.S., Gillis, R.J., Wartes, M.A., and Herriott, T.M., 2011a, Deposition of the Paleocene(?)–Eocene West Foreland Formation, northwest basin margin, Cook Inlet basin—Record of coeval faulting and explosive volcanism [abstr.]: AAPG Pacific Section Meeting, Anchorage, AK, May 6–14, 2014, p. 70.

LePain, D.L., Stanley, R.G., Gillis, R.J., Helmold, K.P., Peterson, C.S., and Wartes, M.A., 2011b, Deposition of Middle Jurassic Tuxedni Group, lower Cook Inlet, Alaska—Initial exhumation of an Early Jurassic island arc and incipient motion on the Bruin Bay fault zone [abstr.]: American Association of Petroleum Geologists, Pacific Section Annual Meeting, p. 71.

LePain, D.L., Wartes, M.A., McCarthy, P.J., Stanley, R.G., Silliphant, L.J., Peterson, Shaun, Shellenbaum, D.P., Helmold, K.P., Decker, P.L., Mongrain, Jacob, and Gillis, R.J., 2009, Facies associations, sand body geometry, and depositional systems in Late Oligocene–Pliocene Strata, southern Kenai Peninsula, Cook Inlet, Alaska—Report on progress during the 2006–07 field season, *in* LePain, D.L., ed., Preliminary results of recent geologic investigations in the Homer–Kachemak Bay area, Cook Inlet basin—Progress during the 2006–2007 field season: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2009-8A, p. 1–97, http://www.dggs.alaska.gov/pubs/id/20162.

Magoon, L.B., and Anders, D.E., 1992, Oil-to-source-rock correlation using carbon-isotopic data and biological marker compounds, Cook Inlet–Alaska Peninsula, Alaska, *in* Moldowan, J.M., Albrecht, P., and Philp, R.P., eds., Biological Markers in Sediments and Petroleum: Englewood Cliffs, NJ, Prentice-Hall, Inc., p. 241–273.

Mongrain, Jacob, 2012, Depositional systems, paleoclimate, and provenance of the late Miocene to Pliocene Beluga and Sterling Formations, Cook Inlet forearc basin, Alaska: Fairbanks, Alaska, University of Alaska, unpublished Ph.D. dissertation, 201 p.

Peterson, Shaun, 2010, Using geophysical logs to estimate relative uplift in Cook Inlet Basin [presentation], U.S. Geological Survey Cook Inlet Geology Review Meeting, Anchorage Alaska, September 21–22, 2010: Alaska Division of Geological & Geophysical Surveys, 29 p. PDF of PowerPoint presentation is available from the DGGS website at: http://www.dggs.alaska.gov/pubs/keyword/energy-resources-posters-and-presentations

Shellenbaum, D.P., Gregersen, L.S., and Delaney, P.R., 2010, Top Mesozoic unconformity depth map of the Cook Inlet basin, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2010-2, 1 sheet, scale 1:500,000.

Swenson, R.F., 2003, Introduction to Tertiary tectonics and sedimentation in the Cook Inlet basin, *in* Dallegge, T.A., compiler, 2001 Guide to the petroleum geology and shallow gas potential of the Kenai Peninsula, Alaska: Alaska Division of Geological & Geophysical Surveys Miscellaneous Publication 128, p. 10–19.

Trop, J.M., and Ridgway, K.D., 2007, Mesozoic and Cenozoic tectonic growth of southern Alaska—A sedimentary basin perspective, *in* Ridgway, K.D., Trop, J.M., Glen, J.M.G., and O'Neill, J.M., eds., Tectonic growth of a collisional continental margin—Crustal evolution of southern Alaska: Geological Society of America Special Paper 431, p. 55–94.

Wartes, M.A., Decker, P.L., Stanley, R.G., Herriott, T.M., Helmold, K.P., and Gillis, R.J., 2013a, Preliminary stratigraphy and facies analysis of the Upper Cretaceous Kaguyak Formation, including a brief summary of newly discovered oil stain, upper Alaska Peninsula, *in* Gillis, R.J., ed., Overview of 2012 field studies—Upper Alaska Peninsula and west side of lower Cook Inlet, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2013-1F, p. 25–32, http://www.dggs.alaska.gov/pubs/id/24849.

Wartes, M.A., Herriott, T.M., Helmold, K.P., and Gillis, R.J., 2013b, Preliminary stratigraphic interpretation of the Naknek Formation—Evidence for Late Jurassic activity on the Bruin Bay fault, Iniskin Peninsula, lower Cook Inlet, *in* Gillis, R.J., ed., Overview of 2012 field studies—Upper Alaska Peninsula and west side of lower Cook Inlet, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2013-1H, p. 39–46, http://www.dggs.alaska.gov/pubs/id/24851.

Wartes, M.A., Herriott, T.M., Helmold, K.P., Gillis, R.J., LePain, D.L., and Stanley, R.G., 2011, Stratigraphic evidence for Late Jurassic activity on the Bruin Bay fault, Iniskin Peninsula, lower Cook Inlet, Alaska: American Association of Petroleum Geologists, Pacific Section Annual Meeting, p. 96.

COOK INLET BASIN ANALYSIS PROGRAM PUBLICATIONS

Finzel, E.S., Gillis, R.J., Ridgway, K.D., and LePain, D.L., 2009, Preliminary evaluation of basin margin exhumation and provenance of Cenozoic strata, Chuitna and Beluga rivers area, Cook Inlet forearc basin, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2009-4, 16 p., http://www.dggs.alaska.gov/pubs/id/19641.

Finzel, E.S., Ridgway, K.D., and LePain, D.L., 2009, Sedimentology of an Oligocene–Miocene incised paleovalley, Tyonek Formation, Cook Inlet basin, Alaska, *in* LePain, D.L., ed., Preliminary results of recent geologic investigations in the Homer–Kachemak Bay area, Cook Inlet basin—Progress during the 2006–2007 field season: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2009-8B, p. 99–107, http://www.dggs.alaska.gov/pubs/id/20163.

Gillis, R.J., Herriott, T.M., Shellenbaum, D.P., Mauel, D.J., Wartes, M.A., Decker, P.L., and Gregersen, L.S., in preparation, Interpretive bedrock geologic map of the south-central Tyonek Quadrangle, Alaska, 1:63,360-scale.

Gillis, R.J., ed., 2013, Overview of 2012 field studies—Upper Alaska Peninsula and west side of lower Cook Inlet, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2013-1, 48 p., http://www.dggs.alaska.gov/pubs/id/24824.

Gillis, R.J., 2013, Overview of 2012 field studies—Upper Alaska Peninsula and west side of lower Cook Inlet, Alaska, *in* Gillis, R.J., ed., Overview of 2012 field studies—Upper Alaska Peninsula and west side of lower Cook Inlet, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2013-1A, p. 1–4, http://www.dggs.alaska.gov/pubs/id/24844.

Gillis, R.J., Maley, M.R., Frohman, R.A., and Peterson, C.S., 2013, Fracture studies in Upper Cretaceous and Upper Jurassic strata on the upper Alaska Peninsula and lower Cook Inlet, *in* Gillis, R.J., ed., Overview of 2012 field studies—Upper Alaska Peninsula and west side of lower Cook Inlet, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2013-1D, p. 13–17, http://www.dggs.alaska.gov/pubs/id/24847.

Gillis, R.J., Swenson, R.F., Wartes, M.A., and Frohman, R.A., 2013, Reconnaissance investigations of the Bruin Bay fault system along the western margin of lower Cook Inlet and upper Alaska Peninsula, *in* Gillis, R.J., ed., Overview of 2012 field studies—Upper Alaska Peninsula and west side of lower Cook Inlet, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2013-1G, p. 33–37, http://www.dggs.alaska.gov/pubs/id/24850.

Gillis, R.J., Wartes, M.A., and O'Sullivan, P.B., 2011, Preliminary findings from reconnaissance structural studies along the Bruin Bay fault system and adjacent areas, south-central Alaska; AAPG Pacific Section Meeting, Anchorage, AK, May 10, 2011: Alaska Division of Geological & Geophysical Surveys, 1 sheet, http://www.dggs.alaska.gov/pubs/id/23403.

Gillis, R.J., LePain, D.L., Reifenstuhl, R.R., and Helmold, K.P., 2009, Regional Paleocene–Eocene exhumation of the North American forearc basin margin, south-central Alaska, recorded by apatite fission-track thermochronology [poster]; Geological Society of America Abstracts with Programs, v. 41, no. 7: Alaska Division of Geological & Geophysical Surveys, 1 sheet., http://www.dggs.alaska.gov/pubs/id/21163.

Gillis, R.J., LePain, D.L., Ridgway, K.D., and Finzel, E.S., 2009, A reconnaissance view of an unnamed fault near Capps Glacier, northwestern Cook Inlet basin, and its potential as a regional-scale, basin-controlling structure: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2009-3, 9 p., http://www.dggs.alaska.gov/pubs/id/19503.

Gillis, R.J., LePain, D.L., Ridgeway, K.A., and Finzel, E.F., 2008, Preliminary observations of the Capps Glacier fault and its potential for being a regional-scale Tertiary-age structure along the western and northern margin of the Cook Inlet basin: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2009-3, 9 p., http://www.dggs.alaska.gov/pubs/id/19503.

Gregersen, Laura, and Shellenbaum, D.P., 2010, Progress on developing a Cook Inlet Mesozoic subcrop map [presentation]; U.S. Geological Survey Cook Inlet Geology Review Meeting, Anchorage Alaska, September 21–22, 2010: Alaska Division of Geological & Geophysical Surveys, 51 p., http://www.dggs.alaska.gov/pubs/id/21801.

Helmold, K.P., LePain, D.L., Wilson, M.D., and Peterson, C.S., 2013, Petrology and reservoir potential of Tertiary and Mesozoic sandstones, Cook Inlet, Alaska—A preliminary analysis of outcrop samples collected during 2007–2010 field seasons: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2013-5, 34 p., http://www.dggs.alaska.gov/pubs/id/25035.

Helmold, K.P., LePain, D.L., Wartes, M.A., Stanley, R.G., Gillis, R.J., Peterson, Shaun, and Herriott, T.M., 2011, Reservoir potential of Tertiary and Mesozoic sandstones, Cook Inlet, Alaska [presentation]; AAPG Pacific Section Meeting, Anchorage, AK, May 10, 2011: Alaska Division of Geological & Geophysical Surveys, 28 p., http://www.dggs.alaska.gov/pubs/id/22502.

Helmold, K.P., 2010, Petrology & reservoir quality of Cook Inlet sandstones—Regional perspective [presentation], U.S. Geological Survey Cook Inlet Geology Review Meeting, Anchorage Alaska, September 21–22, 2010: Alaska Division of Geological & Geophysical Surveys, 42 p., http://www.dggs.alaska.gov/pubs/id/21804.

Herriott, T.M., and Wartes, M.A., in review, Overview of geologic-mapping-based observations of the Middle Jurassic Chinitna Formation and Upper Jurassic Naknek Formation in the Tilted Hills, Iniskin Peninsula, Cook Inlet, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report.

Herriott, T.M., Nye, C.J., Reger, R.D., Wartes, M.A., LePain, D.L., and Gillis, R.J., in press, Geologic context, age constraints, and sedimentology of a Pleistocene volcaniclastic succession near Mount Spurr Volcano, south-central Alaska: Alaska Division of Geological & Geophysical Surveys, Report of Investigations.

Herriott, T.M., Wartes, M.A., Stanley, R.G., Lillis, P.G., Helmold, K.P., Decker, P.L., and Gillis, R.J., 2013, Oil-stained sandstones of the Upper Jurassic Naknek Formation and Upper Cretaceous Kaguyak Formation, Kamishak Bay area, lower Cook Inlet, Alaska [poster]; AAPG Pacific Section Meeting, Monterey, CA, April 23, 2013: Alaska Division of Geological & Geophysical Surveys, 1 sheet, http://www.dggs.alaska.gov/pubs/id/25139.

Herriott, T.M., Nye, C.J., Reger, R.D., Wartes, M.A., LePain, D.L., and Gillis, R.J., 2011, Sedimentology, age, and geologic context of a Pleistocene volcaniclastic succession near Spurr volcano, Alaska [presentation]; AAPG Pacific Section Meeting, Anchorage, AK, May 10, 2011: Alaska Division of Geological & Geophysical Surveys, 29 p., http://www.dggs.alaska.gov/pubs/id/22503.

LePain, D.L., Stanley, R.G., Helmold, K.P., and Shellenbaum, D.P., 2013, Geologic framework and petroleum systems of Cook Inlet basin, south-central Alaska, *in* Hite, D., and Stone, D., eds., Oil and Gas Fields of Cook Inlet Basin, Alaska: AAPG Memoir 104, p. 37–116.

LePain, D.L., Lillis, P.G., Helmold, K.P., and Stanley, R.G., 2012, Migrated hydrocarbons in exposure of Maastrichtian nonmarine strata near Saddle Mountain, lower Cook Inlet, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2012-1, 13 p., http://www.dggs.alaska.gov/pubs/id/23943.

LePain, D.L., Stanley, R.G., Helmold, K.P., Peterson, C.S., Gillis, R.J., Wartes, M.A., and Herriott, T.M., 2011, Deposition of the Paleocene(?)–Eocene West Foreland Formation, northwest basin margin, Cook Inlet basin—Record of coeval faulting and explosive volcanism [abstr.]: AAPG Pacific Section Meeting, Anchorage, AK, May 6–14, 2014, p. 70.

LePain, D.L., Stanley, R.G., Gillis, R.J., Helmold, K.P., Peterson, C.S., and Wartes, M.A., 2011, Deposition of Middle Jurassic Tuxedni Group, lower Cook Inlet, Alaska—Initial exhumation of an Early Jurassic island arc and incipient motion on the Bruin Bay fault zone [abstr.]: AAPG Pacific Section Meeting, Anchorage, AK, May 6–14, 2014, p. 71.

LePain, D.L., ed., 2009, Preliminary results of recent geologic investigations in the Homer–Kachemak Bay area, Cook Inlet basin—Progress during the 2006–2007 field season: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2009-8, 187 p., http://www.dggs.alaska.gov/pubs/id/20161.

LePain, D.L., Wartes, M.A., McCarthy, P.J., Stanley, R.G., Silliphant, L.J., Peterson, Shaun, Shellenbaum, D.P., Helmold, K.P., Decker, P.L., Mongrain, Jacob, and Gillis, R.J., 2009, Facies associations, sand body geometry, and depositional systems in Late Oligocene–Pliocene strata, southern Kenai Peninsula, Cook Inlet, Alaska—Report on progress during the 2006–07 field season, *in* LePain, D.L., ed., Preliminary results of recent geologic investigations in the Homer–Kachemak Bay area, Cook Inlet Basin—Progress during the 2006–2007 field season: Alaska Division of Geological & Geophysical

Surveys Preliminary Interpretive Report 2009-8A, p. 1–97, http://www.dggs.alaska.gov/pubs/id/20162.

LePain, D.L., Wartes, M.A., McCarthy, P.J., Stanley, R.G., Silliphant, L.J., Helmold, K.P., Shellenbaum, D.P., Gillis, R.J., Peterson, Shaun, Mongrain, Jacob, and Decker, P.L., 2008, Tertiary depositional systems in upper Cook Inlet, Alaska—Influence of fluvial style on reservoir geometries and stratigraphic trap potential [poster]; AAPG 2008 Annual Convention and Exhibition, Abstract Volume 17, p. 119: Alaska Division of Geological & Geophysical Surveys, 1 sheet, http://www.dggs.alaska.gov/pubs/id/21829.

Loveland, A.M., 2014, Results of mercury-injection capillary pressure tests on outcrop samples in the Tyonek area of Cook Inlet: Alaska Division of Geological & Geophysical Surveys Raw Data File 2010-1 v. 1.1, 102 p., http://www.dggs.alaska.gov/pubs/id/20481.

Loveland, A.M., and PetroTech Associates, 2014, Mercury injection capillary pressure results from outcrop samples in the Kaguyak, Naknek, and West Foreland Formations, Iniskin Peninsula region, Alaska: Alaska Division of Geological & Geophysical Surveys Raw Data File 2014-1, 5 p., http://www.dggs.alaska.gov/pubs/id/27021.

Loveland, A.M., and PetroTech Associates, 2013, Mercury injection capillary pressure (MICP) results from outcrop samples in the Naknek Formation, Iniskin Peninsula, Alaska: Alaska Division of Geological & Geophysical Surveys Raw Data File 2013-6, 10 p., http://www.dggs.alaska.gov/pubs/id/25494.

Loveland, Andrea, 2009, Mercury injection capillary pressure results from outcrop samples in the Homer area of Cook Inlet, *in* LePain, D.L., ed., Preliminary results of recent geologic investigations in the Homer–Kachemak Bay area, Cook Inlet Basin—Progress during the 2006–2007 field season: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2009-8D, p. 117–187, http://www.dggs.alaska.gov/pubs/id/20165.

Mongrain, Jacob, 2012, Depositional systems, paleoclimate, and provenance of the late Miocene to Pliocene Beluga and Sterling Formations, Cook Inlet forearc basin, Alaska: Fairbanks, University of Alaska, unpublished Ph.D. dissertation, 201 p.

Peterson, Shaun, 2010, Using geophysical logs to estimate relative uplift in Cook Inlet Basin [presentation]; U.S. Geological Survey Cook Inlet Geology Review Meeting, Anchorage Alaska, September 21–22, 2010: Alaska Division of Geological & Geophysical Surveys, 29 p., http://www.dggs.alaska.gov/pubs/id/21803.

Shellenbaum, D.P., Gregersen, L.S., and Delaney, P.R., 2010, Top Mesozoic unconformity depth map of the Cook Inlet Basin, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2010-2, 1 sheet, scale 1:500,000, http://www.dggs.alaska.gov/pubs/id/21961.

Stanley, R.G., Herriott, T.M., LePain, D.L., Helmold, K.P., and Peterson, C.S., 2013, Reconnaissance studies of potential petroleum source rocks in the Middle Jurassic Tuxedni Group near Red Glacier, eastern slope of Iliamna Volcano, *in* Gillis, R.J., ed., Overview of 2012 field studies—Upper Alaska Peninsula and west side of lower Cook Inlet, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2013-1B, p. 5–9, http://www.dggs.alaska.gov/pubs/id/24845.

Stanley, R.G., Herriott, T.M., Helmold, K.P., Gillis, R.J., and Lillis, P.G., 2013, Hydrocarbon-bearing sandstone in the Upper Jurassic Naknek Formation on the south shore of Kamishak Bay, *in* Gillis, R.J., ed., Overview of 2012 field studies—Upper Alaska Peninsula and west side of lower Cook Inlet, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2013-1E, p. 19–23, http://www.dggs.alaska.gov/pubs/id/24848.

Wartes, M.A., Decker, P.L., Stanley, R.G., Herriott, T.M., Helmold, K.P., and Gillis, R.J., 2013, Preliminary stratigraphy and facies analysis of the Upper Cretaceous Kaguyak Formation, including a brief summary of newly discovered oil stain, upper Alaska Peninsula, *in* Gillis, R.J., ed., Overview of 2012 field studies—Upper Alaska Peninsula and west side of lower Cook Inlet, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2013-1F, p. 25–32, http://www.dggs.alaska.gov/pubs/id/24849.

Wartes, M.A., Herriott, T.M., Helmold, K.P., and Gillis, R.J., 2013, Preliminary stratigraphic interpretation of the Naknek Formation—Evidence for Late Jurassic activity on the Bruin Bay fault, Iniskin Peninsula, lower Cook Inlet, *in* Gillis, R.J., ed., Overview of 2012 field studies—Upper Alaska Peninsula and west side of lower Cook Inlet, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2013-1H, p. 39–46, http://www.dggs.alaska.gov/pubs/id/24851.

Zippi, P.A., and Loveland, A.M., 2012, Palynological analysis of 228 outcrop samples from the Kenai, Seldovia, and Tyonek quadrangles, Cook Inlet region, Alaska: Alaska Division of Geological & Geophysical Surveys Raw Data File 2012-1, 10 p., http://www.dggs.alaska.gov/pubs/id/23723.