STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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April 2009

Prospective Industry Sponsors for North Slope Geologic Work:

The Alaska Division of Geological & Geophysical Surveys (DGGS) is pleased to submit the enclosed 2009 industry funding proposal for its North Slope program. We are confident you will find our proposed research program beneficial to your company's exploration for petroleum resources in the region. A .pdf version of this proposal is also be available online at: http://wwwdggs.dnr.state.ak.us/index.php?menu_link=energy&link=energy_proposals

Since 1994, DGGS has pursued a leadership role in advancing the geologic understanding of North Slope geology and petroleum systems, primarily through stratigraphic studies and geologic mapping in the foothills of the northern Brooks Range (see attached publication list). This program was developed in response to the need for high quality, publicly available geologic data to stimulate exploration for hydrocarbons in northern Alaska. Funding for this program is from a balance of state monies and sponsorship by major and independent oil and gas companies. While directed by DGGS, this research effort is a multi-agency collaboration that includes the Alaska Division of Oil & Gas and the United States Geological Survey, among others. We also have a long standing relationship with faculty and students at the University of Alaska Fairbanks and regularly cooperate in planning our respective studies. Professor Wallace will be circulating a proposal this year to seek additional funding for graduate students; this effort complements the existing DGGS graduate student internships and I encourage you to support these efforts to train and mentor the next generation of petroleum geologists.

The following DGGS proposal is organized in three sections. Section I briefly reviews project results from prior field seasons, particularly recent and upcoming publications. Section II includes a description of the proposed projects for the upcoming 2009 field season, focusing on topics relevant to exploration on Alaska's North Slope. Section III includes a discussion of field logistics, project staff, and proposed budget. Additional details are also provided regarding the **annual field sponsors' tour on July 8th and 9th**, as well as a spring 2010 technical review meeting.

The costs associated with operating a remote field program have increased about 20% in the last several years, primarily due to rising helicopter expenses. The proposed 2009 field and analytical budget totals approximately $350,000 (not including salaries and benefits covered by the State of Alaska). This request is being submitted to oil and gas companies and Native corporations to solicit participation. We hope your organization will support our program at the **requested level of $45,000**, although we will accept participation at a reduced level. If funding is insufficient for the full program as proposed, we will scale back our plans and concentrate on fewer objectives. DGGS values the financial support received from industry and looks forward to providing up-to-date information on economically significant stratigraphic units on the North Slope. We hope to continue expanding DGGS's petroleum-related work, particularly the integration of surface and subsurface geologic data. Although we are continually seeking increased state and federal funding, support from industry remains critically important to DGGS's work. Industry support also helps provide both direction and scope for our North Slope studies, which are in the best interest of Alaska and its industry.

We look forward to and welcome your input for the planning of our field program. Please feel free to contact Marwan Wartes at DGGS or Paul Decker at the Alaska Division of Oil & Gas with questions or comments. Marwan may be reached in Fairbanks at 907-451-5056, or via e-mail at marwan.wartes@alaska.gov; Paul may be reached at 907-269-8791, or paul.decker@alaska.gov.

Sincerely,

Robert Swenson
Director and State Geologist

SUMMARY PROPOSAL FOR THE
ALASKA DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
NORTH SLOPE PROGRAM:

PETROLEUM-RELATED GEOLOGICAL STUDIES NORTH SLOPE, ALASKA

2009 Field Program

Research to be conducted by:

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April 2009

INTRODUCTION—The Alaska Division of Geological & Geophysical Surveys (DGGS) proposes a diverse 2009 field program of petroleum-related studies on the east-central North Slope (Figs. 1 and 2). Structural, stratigraphic, and reservoir quality studies will be conducted on prospective lower and upper Cretaceous units, addressing key components of the petroleum system in the Colville Basin. As in previous years, the 2009 field season will involve close collaboration with geologists from the Alaska Division of Oil and Gas (DOG), the University of Alaska Fairbanks (UAF), and the United States Geological Survey (USGS). All proposed research will focus on economically significant strata and topics relevant to oil and gas exploration in the Brooks Range foothills and North Slope of Alaska. These include the following:

1. *Sequence Stratigraphy of Campanian–Paleocene Strata*
2. *Sedimentology and Stratigraphy of Distal Torok and Seabee Formation Strata*
3. *Application of Chemostratigraphic Methods for Correlating Brookian Units*
4. *Characterization of Source Rocks and Hydrocarbon Occurrences*
5. *Controls on Reservoir Quality in the Nanushuk Formation*
6. *Detailed 1:63,360-scale Geologic Mapping in the East-central North Slope (Ivishak River Area)*

This proposal is organized in three sections. Section I briefly reviews noteworthy results from recent investigations. Section II includes a description of the proposed projects for the upcoming 2009 field season. Section III includes a discussion of field logistics, project staff, details regarding a field sponsors' tour, and proposed budget. As in the past, we welcome your comments and suggestions on any aspect of DGGS's North Slope Energy Program and this proposal.

SECTION I—RESULTS OF RECENT WORK

During the 2008 field season, we made detailed outcrop observations at several hundred separate field stations in the course of mapping approximately 1200 square miles of the east-central North Slope in the Sagavanirktok River area (Figs 1 and 2). This work differed from previous DGGS and DOG field mapping in that subsurface interpretations were projected to inform geologic mapping in areas of substantial Quaternary cover (Gillis *et al.*, in press; Fig. 3). In an effort to better characterize and understand the North Slope petroleum system in this region, we also conducted focused stratigraphic and structural studies and collected a comprehensive suite of samples for laboratory analyses. A brief overview of the mapping studies is now available in poster format online:
http://www.dggs.dnr.state.ak.us/index.php?menu_link=energy&link=posters_energy&sub2_link=posters

We strive to communicate our results in a timely manner through presentations at industry and geological conferences; our work was summarized this spring in six posters at the annual Alaska Geological Society Technical Conference (Decker *et al.*, 2009; Loveland *et al.*, 2009; van der Kolk *et al.*, 2009; Wallace *et al.*, 2009; Speeter *et al.*, 2009; Wright *et al.*, 2009). Additional preliminary results are also conveyed through our periodic DNR technical review meetings held in Anchorage. Although some of our posters and oral presentations are posted online in a preliminary format (see URL above), our ultimate goal is always to summarize our data and interpretations in refereed technical publications (see below). Similar to last years edited publication (Wartes and Decker, 2008a) we are again compiling a volume that includes nine papers detailing various topics addressed by recent stratigraphic, structural, and geochemical studies. These papers are in the final stages of publication as DGGS Preliminary Interpretive Report 2009-1 (Wartes and Decker, in review) and will be available either as individual chapters or in its entirety prior to the 2009 field season.

- Overview of 2008 Field Investigations, North Slope and Brooks Range Foothills, Alaska
  Wartes, M.A., Decker, P.L., Gillis, R., and Loveland, A.
- Preliminary results of new 1:63,360-scale geologic mapping of the southwest and southcentral Sagavanirktok Quadrangle, North Slope foothills
  Gillis, R.J., Decker, P.D., Wartes, M.A., and Loveland, A.M.
- Sedimentology, Stratigraphy, and Subsurface Expression of Upper Cretaceous Strata in the Sagavanirktok River Area, east-central North Slope, Alaska
  Decker, P.L., LePain, D.L., Wartes, M.A., Gillis, R.J., Mongrain, J.R., Kirkham, R.A., and Shellenbaum, D.P.
- Depositional environment of the Prince Creek Formation along the east side of the Toolik River: Sagavanirktok Quadrangle, North Slope, Alaska
  Flaig, P.P., and van der Kolk, D.A.
- Preliminary geologic map of the Gilead syncline area, northeast Brooks Range, Alaska
  Speeter, G., Wallace, W.K., and Decker, P.L.
- Source Rock Potential of the Lower Cretaceous Pebble Shale Unit, Northeastern Alaska
  van der Kolk, D.V., Whalen, M.T., and Wartes, M.A.
- Measured Sections of the Permian Echooka and Triassic Ivishak Formations, Shaviovik River, Eastern Sagavanirktok Quadrangle
  LePain, D.L, and Wartes, M.A.
- Reconnaissance investigation of the Lisburne Group in the Cobblestone Creek area, Chandler Lake Quadrangle, Alaska
  Dumoulin, J.A., and Whalen, M.T.
- Geochemical, reservoir quality, and age data from measured sections of the Nanushuk Formation along the Colville River between the confluences with the Awuna and Killik Rivers
  Wartes, M.A., LePain, D.L., and Decker, P.L.

In addition, two legacy manuscripts and three geologic maps are in press and should be released this summer:

- Sedimentology, stacking patterns, and depositional systems in the middle Albian-Cenomanian Nanushuk Formation in outcrop, central North Slope, Alaska
  LePain, D.L., McCarthy, P.J., and Kirkham, R.
- Kemik Sandstone – petrology, physical properties, and facies of 40 outcrop and subsurface samples, Canning River to Sagavanirktok River, northeast North Slope, Alaska
  Reifenstuhl, R.R.
- Geology of the Cobblestone Creek–May Creek area, Northeastern Brooks Range foothills
  Mull, C.G., Harris, E.E., Peapples, P.R., and Swenson R.F.
- Geologic map of the Kanayut River area, Chandler Lake Quadrangle, Alaska
  Harris, E.E., Peapples, P.P., Mull, C.G., LePain, D.L., and Burns, P.A.
- Surficial geologic map of the Kavik River area, west central Mount Michelson Quadrangle, northeastern Brooks Range Alaska
  Carson, E.C.

Finally, another noteworthy effort during the spring of 2009 has involved preparations for a core workshop on Lower Cretaceous clinoforms on the North Slope to be held at this year's annual AAPG meeting. This short course will be a collaboration between the USGS (D. Houseknecht and C. Schenk) and DNR (D. LePain and P. Decker). Several publications will likely grow out of this effort—for example the following report is in preparation:

- Continuously-cored topsets of the Albian-Cenomanian(?) Nanushuk Formation, Wainwright No. 1 well, northwestern Alaska: Deposition in a marine-influenced lower delta plain setting *LePain, D.L. and Decker, P.L.*

SECTION II—PROPOSED STUDIES FOR THE 2009 FIELD SEASON

We propose to conduct approximately 3 weeks of stratigraphic and structural studies during the 2009 field season. This research program is subdivided into six sub-projects, a few of which represent a continuation of previous work. Although this proposal is focused around field-related activities, it should be noted that many of the topics listed below will benefit from allied subsurface investigations, led principally by DOG staff. This work plan reflects expressions of interest from industry sponsors and the resource evaluation needs of the State of Alaska. Each project is listed separately for clarity, but it should be emphasized that all work is interrelated and shares the common goal of increasing the availability of high quality geologic data pertinent to understanding the North Slope petroleum system.

1. Sequence Stratigraphy of Campanian–Paleocene Strata

The majority of detailed field studies of Campanian-Paleocene strata have focused on the greater Colville River area (*e.g.* Houseknecht and Schenk, 2005; Flores *et al.,* 2007). Much less attention has been placed on the more basinward (eastern) equivalents of these units, despite the dramatic changes in depositional style that occur as a result of inherited shelf-slope morphologies from prior sequences (Decker, 2007). Our recent mapping (Gillis *et al.*, in press; Fig. 3) and stratigraphic studies in the Sagavanirktok River area have documented a number of important exposures that provide insight into the time-transgressive northeastward progradation of genetically related shelf, slope, and deep water facies (LePain *et al.,* 2008). In particular, the integration of measured section data with regional seismic interpretations and well character have yielded a much improved understanding of the facies and stratigraphic organization of these units (Decker *et al*, in press). One outgrowth of this evolving data set is a revised chronostratigraphic chart, depicted in figure 4, that builds on nomenclature revisions suggested by Mull *et al.* (2003), and concisely summarizes many of our key stratigraphic observations over the last two field seasons.

In 2009, we propose to extend these studies and measure a number of detailed sections aimed at understanding the vertical and lateral sequence stratigraphic architecture of these units (selected locations of interest are highlighted in figure 2). Local and regional correlations will be facilitated by new biostratigraphic data, geochronology of abundant tuffaceous horizons, and chemostratigraphic data (see below). We will focus on slope facies of the lower part of the Canning Formation (basinward equivalent of the lower Schrader Bluff), and shelf facies of the middle and upper Schrader Bluff Formation (Fig. 4). Our prior mapping and detailed sedimentologic work have established many of the key features of these units and will allow us to focus on more targeted sequence stratigraphic questions. For example, we have noted several intriguing outcrops of the Canning Formation (Fig. 4) between the Sagavanirktok and Ivishak Rivers that contain coarse-grained sandstone and conglomerate. Elsewhere, the Canning Formation is typified by thin-bedded and fine-grained slope facies, indicating that these unique exposures likely mark events with sequence stratigraphic significance (lowstand?) that promote the export of coarse grained material into a deep water setting. Ideally, we hope to correlate these more prospective facies into nearby wells (e.g. Decker *et al.*, in press), ultimately improving our understanding of this depositional system. With respect to the Schrader Bluff Formation topsets, we aim to build on preliminary sequence stratigraphic interpretations that have grown out of recent measured section data collected by D. LePain along the Ivishak River. In particular, we've noted clear transgressive-regressive parasequence stacking patterns that we hope to document further and correlate with T-R parasequence sets recognized in nearby wells. Finally, during the 2008 field season, we made progress on understanding the evolution of the Paleocene nonmarine depositional system recorded

by the Prince Creek and lower Sagavanirktok Formations. Although additional exposures of this interval will not be present in the 2009 study area, we intend to integrate our recent surface studies with available subsurface data, paying particular attention to the regionally significant intra-Paleocene unconformity that separates these two formations. Specifically we aim to better resolve the unconformity's age and the stratigraphic expression of the correlative sequence boundary in slope and deepwater facies of the Canning Formation.

2. Sedimentology and Stratigraphy of distal Torok and Seabee Formation Strata

The Tertiary uplift of the northeastern Brooks Range exhumed the entire Brookian section and allows a unique opportunity to examine the deeper parts of the Colville basin. Most notably, more than 850 meters of Albian to Turonian rocks are locally well exposed along the upper Ivishak River, and Gilead Creek, and in the Gilead syncline. The Albian-Cenomanian rocks are equivalent to the Nanushuk-Torok depositional system (Huffman *et al.*, 1985), but are here referred to as the Gilead sandstone (Reifenstuhl, 1991) in recognition of its unique stratigraphic expression. Unlike the mudstone-dominated type Torok Formation in the inner Brooks Range foothills, the Gilead sandstone includes discrete sandstone-dominated intervals that are tens of meters thick. The grain size (locally medium to coarse-grained) and the thickness of amalgamated sandstone bodies suggest subsurface equivalents of the Gilead sandstone may represent viable exploration targets. Based on the overall sedimentology, stacking pattern, and position within the basin, we interpret the unit as base of slope or basin floor deposits where migrating sandstone lobes or channels are interspersed with off-axis finer grained facies (Decker *et al.*, 2008). Previous workers have noted the abundance of sediment gravity flows and also inferred a deepwater setting, such as a lowstand fan (Schenk and Bird, 1993). However, other studies have raised the possibility of shelfal deposition based on interpretations of sedimentary structures within the upper part of the unit (Reifenstuhl, 1991; LePain *et al.,* 2002). Resolving these diverse interpretations will be a focus of our sedimentologic and stratigraphic investigations.

Regional seismic data indicate a clear east-northeast progradation of Torok clinoforms (e.g. Houseknecht *et al.*, 2009). As such, the upper part of the Torok-equivalent Gilead sandstone represents the youngest exposures of this unit and the only place on the North Slope where Cenomanian age Torok Formation can be studied at the surface. The Nanushuk-Torok system terminated with the major Cenomanian-Turonian transgression which can be well seen in the central North Slope in both outcrop and subsurface data (e.g. Houseknecht and Schenk, 2005; Decker, 2007). In our study area, this transition is less clear—Turonian rocks equivalent to the Seabee Formation overlie the Gilead sandstone, but the sedimentary facies and sandstone composition are remarkably similar to one another, and the original stratigraphic relationship is obscured by structural complications. In 2009, we intend to continue our efforts to distinguish these units and characterize the stratigraphic expression of the Cenomanian-Turonian flooding zone in this deepwater setting. Resolution of these stratigraphic details will be important precursors to applying our data as reservoir analogues in Torok and Seabee Formation exploration fairways throughout the foothills.

3. Application of Chemostratigraphic Methods for Correlating Brookian Units

Detailed studies of Brookian stratigraphy have long suffered from limited or poorly resolved biostratigraphic control. This has proven especially problematic in our field-based investigations that often seek to reconstruct stratigraphic relationships from widely spaced, discontinuous exposures of otherwise lithologically similar units. To address this limitation, we initiated a study in 2008 to asses whether or not stratigraphic units possess unique inorganic geochemical signatures

(defined by major- and trace-element ratios). This technique, termed "chemostratigraphy", has proven successful in a number of basins that are biostratigraphically barren or otherwise difficult to correlate (*e.g.* Pearce and Jarvis, 1995).

We reported our preliminary chemostratigraphic results at the 2009 Alaska Geological Society Technical Conference (Wright *et al.*, 2009). Analysis was carried out on a total of 145 cuttings samples from four widely spaced exploration wells (Echooka Unit 1, Susie Unit 1, Lupine Unit 1 and Aufeis Unit 1), and a suite of 147 outcrop samples. Rock chips from each cutting sample were carefully selected for analysis, using gamma ray data in order to determine the most representative lithology from each cutting interval. Whole-rock inorganic geochemical data were acquired for 50 elements by combining inductively coupled plasma - optical emission spectrometry (ICP-OES) and inductively coupled plasma - mass spectrometry (ICP-MS) analyses. Preliminary results from this study show that the Fortress Mountain and Nanushuk Formations possess unique geochemical signatures, an observation that agrees with other recent independent data sources (Wartes, 2008). The new data also suggest it is locally possible to differentiate sandstones of the Torok and Seabee Formations—units which are otherwise difficult to distinguish in this part of the basin (see above). Furthermore, the Schrader Bluff and Canning Formations are recognizably different than the Prince Creek and Sagavanirktok Formations. Locally, certain formations show internal chemical trends or variations that may make it possible to place isolated exposures in their approximate stratigraphic position. The elements used to characterize these formations are likely controlled by a number of factors, including changes in sediment provenance, air-fall volcanic material, clay mineral species, and paleo-redox conditions through time.

In light of the success of our pilot study, we propose to extend this technique in 2009 by regularly collecting chemostratigraphic samples in the field and to begin integrating this elemental data with companion mineralogical data from petrographic and X-ray diffraction analyses. In addition, we hope to assess these data in terms of our growing sequence stratigraphic understanding. For example, are there demonstrable provenance changes across the unconformity separating the Prince Creek and Sagavanirktok Formations, and if so, what can we infer about the tectonic and physical processes responsible for this basinward shift in facies?

4. Characterization of Source Rocks and Hydrocarbon Occurrences

Indications of migrated hydrocarbons are common in the foothills belt, typically manifest as either solid bitumen or a recognizable gas odor on freshly broken surfaces. In addition, numerous gas shows in exploratory wells in the foothills belt indicate that both oil- and gas-generating source rocks are present in this part of the Colville basin. Similar to previous years, DGGS will continue to collect samples to assess source rock quality and distribution via organic geochemical analyses, including:

- Source rock richness (Total organic carbon)
- Kerogen typing (S2 and HI)
- Thermal maturity (Vitrinite reflectance)

In addition, where sufficient migrated hydrocarbons are present, organic extract and biomarker data will be analyzed to link occurrences to effective source rocks. This information is vital for assessing viable migration routes and, when tied to burial history models, can constrain the timing of hydrocarbon generation. Furthermore, robust prediction of hydrocarbon characteristics (phase, gas-oil ratio, oil gravity, biogenic vs. thermogenic gas, etc.) is a critical part of modern exploration models.

5. Controls on Reservoir Quality in the Nanushuk Formation

The typically poor reservoir quality of most Lower Cretaceous sandstones remains a fundamental risk in exploring for Brookian targets. To reduce this uncertainty, we propose to conduct a robust study of the controls on reservoir quality within the Nanushuk Formation (Fig. 4), led by K. Helmold (DOG). During the course of previous detailed stratigraphic studies of this prospective unit (LePain *et al.*, in press), we have systematically collected samples for thin section analysis, occasionally accompanied by porosity and permeability data (*e.g.* Reifenstuhl and Loveland, 2004). The proposed work will leverage this large existing collection of sandstone thin sections, many of which are tied to detailed measured sections, allowing us to relate this data in the context of depositional environment where possible (*e.g.* Kirkham, 2005). We also intend to augment this dataset with selected core samples to isolate the effects of surface weathering and to better characterize the variability of reservoir quality within the greater Nanushuk depositional system. Detailed compositional and grain size data will be acquired by Michael Wilson (consultant), a widely respected expert in reservoir quality of North Slope sandstones. By combining new petrographic data with our growing database of porosity and permeability and thermal maturity information, we hope to begin quantitatively isolating the most important variables affecting reservoir quality (*e.g.* burial history, diagenesis, provenance, grain size, etc.; Bloch and Helmold, 1995). For example, elsewhere on the North Slope, maximum burial depth has proven to be a reliable predictor of porosity and permeability (Nelson and Bird, 2005).

6. Detailed 1:63,360-scale Geologic Mapping in the East-central North Slope (Ivishak River Area)

Previous reconnaissance work and stratigraphic studies by DGGS have documented a number of important exposures of Cretaceous strata between the Ivishak and Echooka rivers (Wartes and Decker, 2008b; Decker et al., 2008; Fig. 2). Mapping the complex structure of this area is essential to enable correct interpretation of the stratigraphy based on information from isolated exposures and wells. The proposed map area is near active industry leases and includes a number of potential reservoir units that are locally oil-stained. The area also occupies an important structural transition between basement-involved deformation in the northeastern Brooks Range (e.g. Echooka anticlinorium) and thin-skinned folding and thrusting confined to the Brookian section. This change is best illustrated by comparison of the broad open folding style of mid-Cretaceous units at Gilead syncline versus the tighter folding and overturned forelimbs documented just to the west along the Ivishak River (Decker et al., 2008; Fig. 2). The map area also occupies a unique position within the Cretaceous Colville basin where the thick mid-Cretaceous clastic wedge rapidly thins northeastward into basin floor condensed facies. The nature of this stratigraphic transition and its probable effect on mechanical stratigraphy are not well understood but can be clarified through careful detailed mapping. This map area represents an eastward continuation of our 2008 mapping along the Sagavanirktok River (Gillis et al., in press; Fig. 3). Completion of this area would result in continuous 1:63,360-scale mapping along the mountain front between the Dalton Highway and the Canning River. Unlike many of our previous mapping efforts, this work will benefit from a published preliminary map of part of our selected area by Pessel *et al.* (1990) and earlier USGS reconnaissance 1:125,000-scale mapping along the mountain front (Keller *et al.*, 1961). Our new work will also benefit from recent detailed mapping of the Gilead syncline area by UAF Masters student Garrett Speeter (Speeter *et al.*, in press).

SECTION III—LOGISTICS / REVIEW MEETINGS / BUDGET / STAFF

BASE CAMP—Pending final logistical arrangements, DGGS will deploy a field party from approximately June 18th to July 10th. Most of our team will work daily out of the base camp, although depending on the flight logistics, some of the stratigraphic sections will warrant a remote spike camp, staged to conserve expensive helicopter round-trips. Similar to previous years, our group will be subdivided into teams focused on geologic mapping and higher priority stratigraphic studies of Cretaceous units between the Ivishak and Echooka rivers.

SPONSORS TOUR—The annual DGGS two-day sponsors' tour will be run on **July 8th and 9th**. We annually attempt to schedule this event mid-week to avoid attendees traveling or otherwise working over the weekend. The location will depend upon forthcoming logistical arrangements for our basecamp. Representatives of sponsoring organizations are invited to join us for this overview and to participate in field discussions on regional geology and to consider new results from the summer fieldwork. A brief, informal presentation summarizing the field program and preliminary results will be given on the evening of July 7th. During this presentation, an overview of the scheduled tour stops and tour itinerary will be provided. The tour will be arranged to highlight our new observations and provide a broad view of the stratigraphy, structural geology and petroleum system of the Brooks Range foothills and North Slope.

Due to the increasing number of participants, attendees must secure their own helicopter. In previous years several companies have been able to defray helicopter costs by sharing with other companies also participating in the tour. Helicopters remain in high demand during this time of the year, so it is recommended that efforts to secure field transportation be made well in advance. As always, the logistics of the tour will depend on weather. To assist participants, further details regarding room and board arrangements and suggested charter flights to the field will be provided.

This annual gathering of geologists interested in North Slope exploration is becoming an increasingly visible event within the oil and gas community. In recent years we have enjoyed participation from the directors of the USGS, DOG, and DGGS. We again expect participation from several key state officials including Commissioner of the Department of Natural Resources Tom Irwin. Similar to previous years, we hope this meeting will provide a unique forum for discussion of Alaska oil and gas issues.

ANNUAL REVIEW MEETING—DGGS is always seeking to improve the timely release of our data and interpretations. In previous years, we have given a series of presentations at the January Alaska Geological Society meeting (*e.g.* Wartes *et al.,* 2006). However, the format and time constraints proved insufficient to cover the breadth of our studies. Furthermore, it was difficult for companies outside of Alaska to justify sending staff for such a short meeting. Based on feedback from sponsoring companies we've instituted occasional one day technical review meetings. These meetings were held in Anchorage in the spring of 2007 and 2008 and proved a successful venue to formalize the communication of our recent results and create a forum to discuss ongoing work and future directions for the program. Although we were unable to host a similar meeting in 2009, we intend to again organize a 2010 meeting. Please feel free to offer suggestions on dates and locations, as well as how DGGS can best frame this type of meeting to convey new results and successfully stimulate discussion on the petroleum geology of northern Alaska.

BUDGET AND REQUESTED CONTRIBUTIONS—The costs associated with operating a remote field program have increased about 20% in the last several years. This substantial increase is largely due to rising expenses associated with helicopter services, which are already the single largest component of the project budget. The field and analytical budget we propose for the 2009 field season will require funding for field operations and analytical services of $350,000 (not including salaries and benefits covered by the State of Alaska). This request is being submitted to oil and gas companies and Native corporations to solicit participation. We hope that your organization will support our program at the requested level of $45,000, and welcome your input into the planning of the program. If your support cannot be at the $45,000 level, we will accept participation at a reduced level. If funding is insufficient for the full program as proposed, we will scale back our plans and concentrate on fewer objectives. In recent years, DGGS has successfully sought supplementary monies to support North Slope field studies through Capital Improvement Project grants from the State of Alaska and federal grants through the USGS. However, the financial support of sponsoring companies remains vital to the success of our geological work on the North Slope. A detailed summary of the proposed project budget is included in Table 1.

PROJECT STAFF—Although this program is led by principal investigators at DGGS and DOG, it remains a multi-agency collaborative effort. As was true in previous years, this program has assembled a team with an excellent cross-section of expertise to address the topics outlined in this proposal. The geologists listed below are expected to participate in various aspects of field and/or analytical work described in this proposal.

Marwan Wartes (DGGS)—Clastic sedimentology, basin analysis, and tectonics
Paul Decker (DOG)—Stratigraphy, structural geology, subsurface, and petroleum geology
David LePain (DGGS)—Clastic sedimentology and sequence stratigraphy
Robert Gillis (DGGS)—Structural geology, geologic mapping, and thermochronology
Trystan Herriott (DGGS)—(New hire) Geologic mapping
Andrea Loveland (DGGS)—GIS, structural geology, and geologic mapping
James Clough (DGGS)—Carbonate sedimentology and stratigraphy
Robert Swenson (DGGS)—Structural geology and petroleum geology
Ken Helmhold (DOG)—Reservoir quality and basin modeling
Diane Shellenbaum (DOG)—Seismic stratigraphy and data processing
Wes Wallace (UAF)—Structural geology, tectonics, and geologic mapping

In addition, we also anticipate informal collaboration with other USGS geologists who have been involved in previous years' work in northern Alaska:

David Houseknecht (USGS)—Sequence stratigraphy, subsurface, and reservoir quality
Tom Moore (USGS)—Structural geology and regional stratigraphy
Chris Schenk (USGS)—Stratigraphy and petroleum geology
Chris Potter (USGS)—Structural geology

REFERENCES CITED

Bloch, S., and Helmold, K.P., 1995, Approaches for predicting reservoir quality in sandstones, AAPG Bulletin, v. 79, no. 1, p. 97-115.

Decker, P.L., LePain, D.L., Wartes, M.A., Gillis, R.J., Mongrain, J.R., Kirkham, R.A., and Shellenbaum, D.P. (in press) Sedimentology, Stratigraphy, and Subsurface Expression of Upper Cretaceous Strata in the Sagavanirktok River Area, east-central North Slope, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2009-X

Decker, P.L., LePain, D.L., Wartes, M.A., Gillis, R.J., Mongrain, J.R., Kirkham, R.A., and Shellenbaum, D.P. 2009, Sedimentology, Stratigraphy, and Subsurface Expression of Upper Cretaceous Strata in the Sagavanirktok River Area, east-central North Slope, Alaska: Alaska Geological Society Technical Conference Abstracts, p. 19.

Decker, P.L., Wartes, M.A., Wallace, W.K., Houseknecht, D.W., Schenk, C.J., Gillis, R.J., and Mongrain, J., 2008, Stratigraphic and structural investigations in the Ivishak River and Gilead Creek areas: Progress During 2007: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2008-1F

Decker, P.L., 2007, Brookian Sequence Stratigraphic Correlations, Umiat Field to Milne Point Field, West-central North Slope, Alaska: DGGS Preliminary Report of Investigations.

Flores, R.M., Myers, M.D., Houseknecht, D.W., Stricker, G.D., Brizzolara, D.W., Ryherd, T.J., and Takahashi, K.I., 2007, Stratigraphy and facies of Cretaceous Schrader Bluff and Prince Creek Formations in Colville River Bluffs, North Slope, Alaska: U.S. Geological Survey Professional Paper 1748, 52 p.

Garrity, C.P., Houseknecht, D.W., Bird, K.J., Potter, C.J., Moore, T.E., Nelson, P.H., and Schenk, C.J., 2005, U.S. Geological Survey 2005 oil and gas resource assessment of the central North Slope, Alaska: play maps and results: U.S. Geological Survey Open-File Report 2005-1182, 25 p.

Gillis, R.J., Decker, P.D., Wartes, M.A., and Loveland, A.M. (in press) Preliminary results of new 1:63,360-scale geologic mapping of the southwest and southcentral Sagavanirktok Quadrangle, North Slope foothills: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2009-X

Houseknecht, D.W, and Schenk, C.J., 2005, Sedimentology and sequence stratigraphy of the Cretaceous Nanushuk, Seabee, and Tuluvak Formations exposed on Umiat Mountain, north-central Alaska, in Haeussler, P., and Galloway, J.P., eds., Studies by the USGS in Alaska, 2004, USGS Professional Paper 1709B, 18p., 1 plate.

Houseknecht, D.H., Bird, K.J., and Schenk, C.J., 2009, Seismic analysis of clinoform depositional sequences and shelf-margin trajectories in Lower Cretaceous (Albian) strata, Alaska North Slope: Basin Research (online version available Jan., 2009).

Huffman, A.C., ed., 1985, Geology of the Nanushuk Group and related rocks, North Slope, Alaska: U.S. Geological Survey Bulletin 1614, 129 p.

Keller, A.S., Morris, R.H., and Detterman, R.L, 1961, Geology of the Shaviovik and Sagavanirktok Rivers Region, Alaska: U.S. Geological Survey Professional Paper 303-D, p. 169–222, 5 plates.

Kirkham, R., 2005, Petrology, Depositional setting, and reservoir quality of the Torok-Nanushuk transition, central North Slope, Alaska: University of Alaska Fairbanks MS Thesis.

LePain, D.L., Kirkham, R., and McCarthy, P.J., 2002, Shoreline to basin transition (?) in Albian-Cenomanian strata east of the Sagavanirktok River, Brooks Range foothills, Alaska [abs.]: AAPG Pacific Section/SPE Regional Conference, Program and Abstracts, p. 87.

LePain, D.L., Kirkham, R., Gillis, R.J., and Mongrain, J., M.A., 2008, Turonian-Campanian Strata East of the Trans-Alaska Pipeline Corridor, North Slope Foothills, Alaska: Progress During the 2001-02 and 2007 Field Seasons: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2008-1G

LePain, D.L., McCarthy, P.J., and Kirkham, R., in press, Sedimentology and sequence stratigraphy of the Nanushuk Formation in the central Brooks Range foothills, northern Alaska: DGGS Report of Investigation

Loveland, A.M., Gillis, B.G., Decker, P.L., Wartes, M.A., and Hubbard, T.D., 2009, Geologic Map of the south-central Sagavanirktok Quadrangle, North Slope, Alaska: Alaska Geological Society Technical Conference Abstracts, p. 31.

Mull, C.G., Houseknecht, D.W., and Bird, K.J., 2003, Revised Cretaceous and Tertiary stratigraphic nomenclature in the Colville basin, Northern Alaska: U.S. Geological Survey Professional Paper 1673, 51 p.

Nelson, P.H., and Bird, K.J., 2005, Porosity-depth trends and regional uplift calculated from sonic logs, National Petroleum Reserve in Alaska, USGS Scientific Investigations Report 2005-5051, 28pp.

Pearce, T.J. and Jarvis, 1995, High-resolution chemostratigraphy of Quaternary distal turbidites: a case study of new methods for the correlation of barren strata: in Dating and Correlating biostratigraphically barren strata, Dunay, R.E., and Hailwood (eds.), Geological Society of London Special Publication 89, p. 107-143.

Pessel, G.H., Robinson, M.S., Clough, J.G., Imm, T.A., Reifenstuhl, R.R., Ryherd, T.J., Myers, M.D., and Mull, C.G., 1990, Preliminary geologic map of the Gilead Creek area, Sagavanirktok A-2 Quadrangle, Arctic Foothills, Alaska, ADGGS PDF 90-18, 7 p., 1 sheet.

Reifenstuhl, R.R., and Loveland, A.L., 2004, Reservoir characterization study: porosity and permeability of 148 Tertiary to Mississippian age outcrop samples, east-central Brooks Range Foothills and North Slope, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Investigative Report 2004-5, 21 pp.

Reifenstuhl, R.R., 1991, Gilead sandstone, northeastern Brooks Range, Alaska: An Albian to Cenomanian marine clastic succession, in Reger, R.D., ed., Short Notes on Alaskan Geology 1991: Alaska Division of Geological & Geophysical Surveys Professional Report 111, p. 69-76.

Schenk, C.J., and Bird, K.J., 1993, Depositional sequences in Lower Cretaceous rocks, Atigun syncline and Slope Mountain areas, Alaskan North Slope, *in* Dusel-Bacon, C., and Till, A.B., eds., Geologic studies in Alaska by the U.S. Geological Survey, 1992: U.S. Geological Survey Bulletin 2068, p. 48–58.

Speeter, G., Wallace, W.K., and Decker, P.L., (in review) Preliminary geologic map of the Gilead syncline area, northeast Brooks Range, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2009-X

Speeter, G., Wallace, W.K., and Decker, P.L., 2009, Preliminary geologic map of the Gilead syncline area, northeast Brooks Range, Alaska: Alaska Geological Society Technical Conference Abstracts, p. 41.

Van der Kolk, D.A., Whalen, M.T., Wartes, M.A., Newberry, R.J., and McCarthy, P.J., 2009, A surface to subsurface correlation of the Lower Cretaceous Pebble Shale Unit, northeastern Alaska: Alaska Geological Society Technical Conference Abstracts, p. 42.

Wallace, W.K., Polkowski, S.J., Swenson, R.F., Wartes, M.A., 2009, Relations at the leading edge of the Endicott Mountains Allochthon, east-central Brooks Range: Alaska Geological Society Technical Conference Abstracts, p. 43.

Wartes, M.A., and Decker, P.L., eds. (in review) Preliminary Results of Recent Geologic Field Investigations in the Brooks Range Foothills and North Slope, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2009-X (nine chapters, 5 sheets)

Wartes, M.A., Decker, P.L., Gillis, R., and Loveland, A. (in review) Overview of 2008 Field Investigations, North Slope and Brooks Range Foothills, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2009-X

Wartes, M.A., and Decker, P.L., eds., 2008a, Preliminary results of recent geologic field investigations in the Brooks Range foothills and North Slope, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2008-1, 206p.
http://www.dggs.dnr.state.ak.us/pubs/pubs?reqtype=citation&ID=16083

Wartes, M.A., and Decker, P.L., 2008b, Overview of recent geologic field investigations, North Slope and Brooks Range foothills, Alaska: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2008-1A

Wartes, M.A., 2008, Evaluation of stratigraphic continuity between the Fortress Mountain and Nanushuk Formations in the central Brooks Range foothills—Are they partly correlative?: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2008-1C

Wartes, M.A., Decker, P.L., Reifenstuhl, R.R., Peapples, P, Finzel, E., Swenson, R., Mull, C.G., 2006, Brooks Range foothills and North Slope program: Alaska Geology, January Newsletter of the Alaska Geological Society.

Wright, A.M., Ratcliffe, K.T., Decker, P.L., and Wartes, M.A., 2009, Chemostratigraphic characterization of Lower Cretaceous to Paleocene Formations of the Brookian sequence, Alaskan North Slope Foothills: Alaska Geological Society Technical Conference Abstracts, p. 46.

Table 1: Proposed budget for DGGS 2009 field studies in northern Alaska. The State of Alaska will cover salaries, benefits and overhead. Recent multi-year state grants will also defray a small portion of the operational costs listed below.

Budget Category	Unit Cost	Unit	No. Units	Outside Receipts
100 Salaries				
Student intern	18,600	year	1.5	27,900
Subtotal				$27,900
200 Field Expenses				
Charter flights (staff and equipment)	3,500	one-way	8	28,000
lodging & meals	350	person/day	125	43,750
Bell 206B3 Helicopter (daily + 5 hrs/day)	4,050	day	21	85,050
Helicopter ferry (206B3 between Bethel and North Slope)	5,250	one-way	2	10,500
Helicopter fuel (30 gal/hr x 5 hr/day x 21 days)	8	gallon	3150	25,200
Subtotal				$192,500
300 Analytical Expenses & Contracts (preliminary)				
Thin sections	20	sample	200	4,000
Total organic carbon (TOC)	25	sample	40	1,000
Rock-eval 6	30	sample	40	1,200
Vitrinite reflectance/kerogen typing	158	sample	40	6,320
Isotopic analysis-oil	730	sample	10	7,300
Isotopic analysis-gas	240	sample	2	480
Porosity and permeability	100	sample	50	5,000
Major and trace element geochemistry (chemostratigraphy)	150	sample	100	15,000
Micropaleo	250	sample	75	18,750
Megafossil ID	125	sample	30	3,750
U/Pb zircon geochronology	1,000	sample	15	15,000
Grain size and point count analysis	350	sample	75	26,250
Subtotal				$104,050
400 Miscellaneous Supplies, Software, & Travel				
Air photos & Topo maps	1,000	one-time	1	1,000
Handheld GPS	550	one-time	2	1,100
Mountain tent	500	one-time	1	500
Miscellaneous field equipment and gear*	2,500	one-time	1	2,500
Software licenses (Geographix, Lithotect, Arc-GIS)	10,000	renewal	1	10,000
Travel to annual sponsor technical review meeting	500	trip	4	2,000
Travel to Denver Core Facility	1,500	person	2	3,000
AAPG annual meeting	2,000	person	2	4,000
Subtotal				$24,100
Project Total				**$348,550**

*batteries, tent stakes, field notebooks, sample bags, safetey equipment, propane, etc.

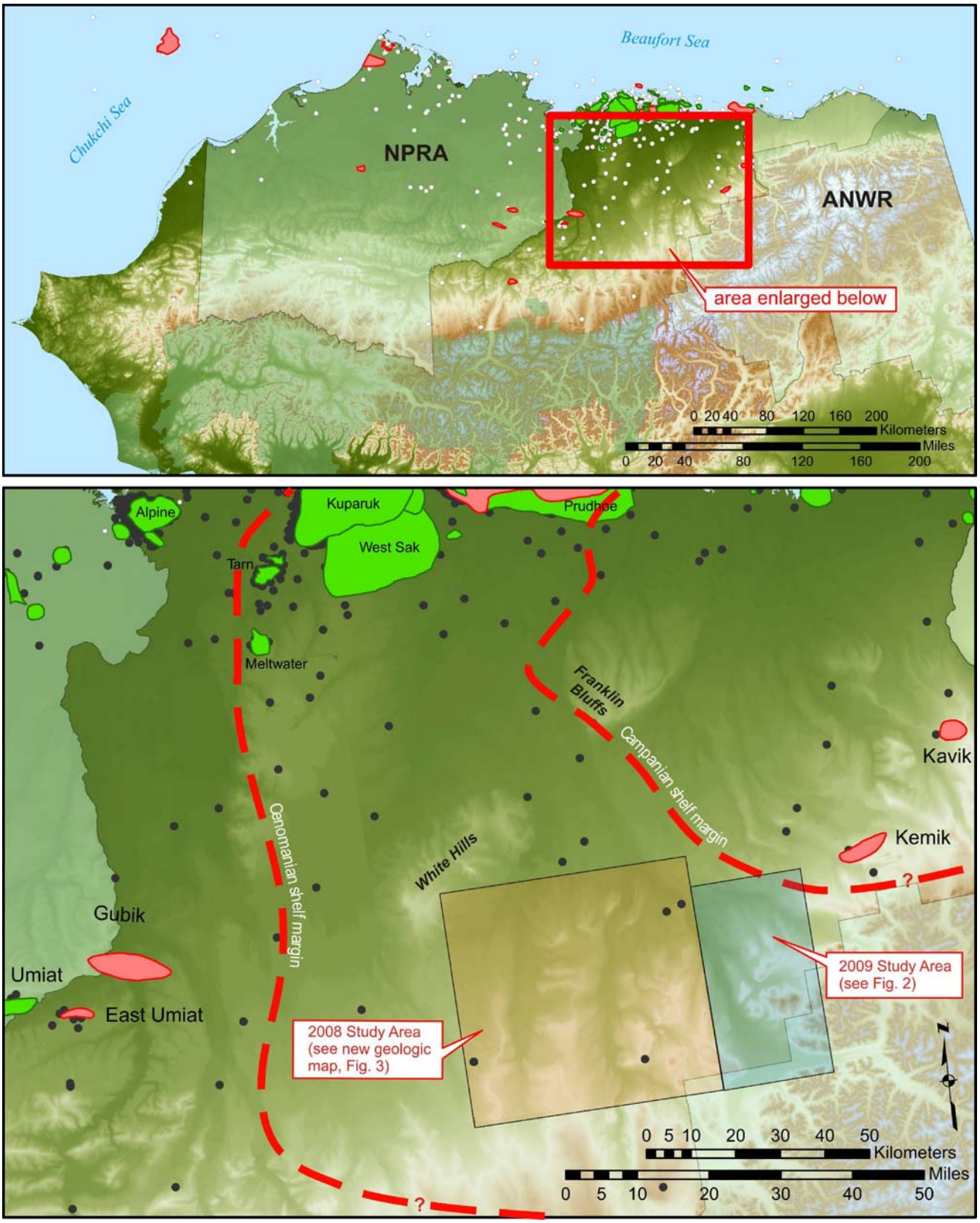

Figure 1. Regional map of northern Alaska (top) illustrating main land status, wells (dots), and oil and gas fields. Expanded view of east central North Slope State lands (bottom) highlighting 2008 and 2009 study areas and approximate position of Cenomanian and Campanian shelf margins.

1 “Echooka Point” upper Kingak Sh. & Kemik Ss

2 Echooka River; distal condensed Albian-Turonian + Hue Shale + Canning

3 Ivishak River; upper Schrader Bluff Fm

4 Ivishak River; Canning Fm

5 Ivishak River; Albian-Campanian (Gilead/Torok, Seabee, and Canning Fms)

6 Gilead Creek; Seabee + Canning Fms

7 Gilead syncline; Albian-Cenomanian Torok Fm (Gilead Ss; Decker et al., 2008)

8 Saviukviayak River; Albian Torok Fm

9 SW plunging Echooka Anticlinorium (Ellesmerian rocks)

10 “Sagashak Creek”; Turonian-Campanian reference section (LePain et al., 2009; Decker et al., in press)

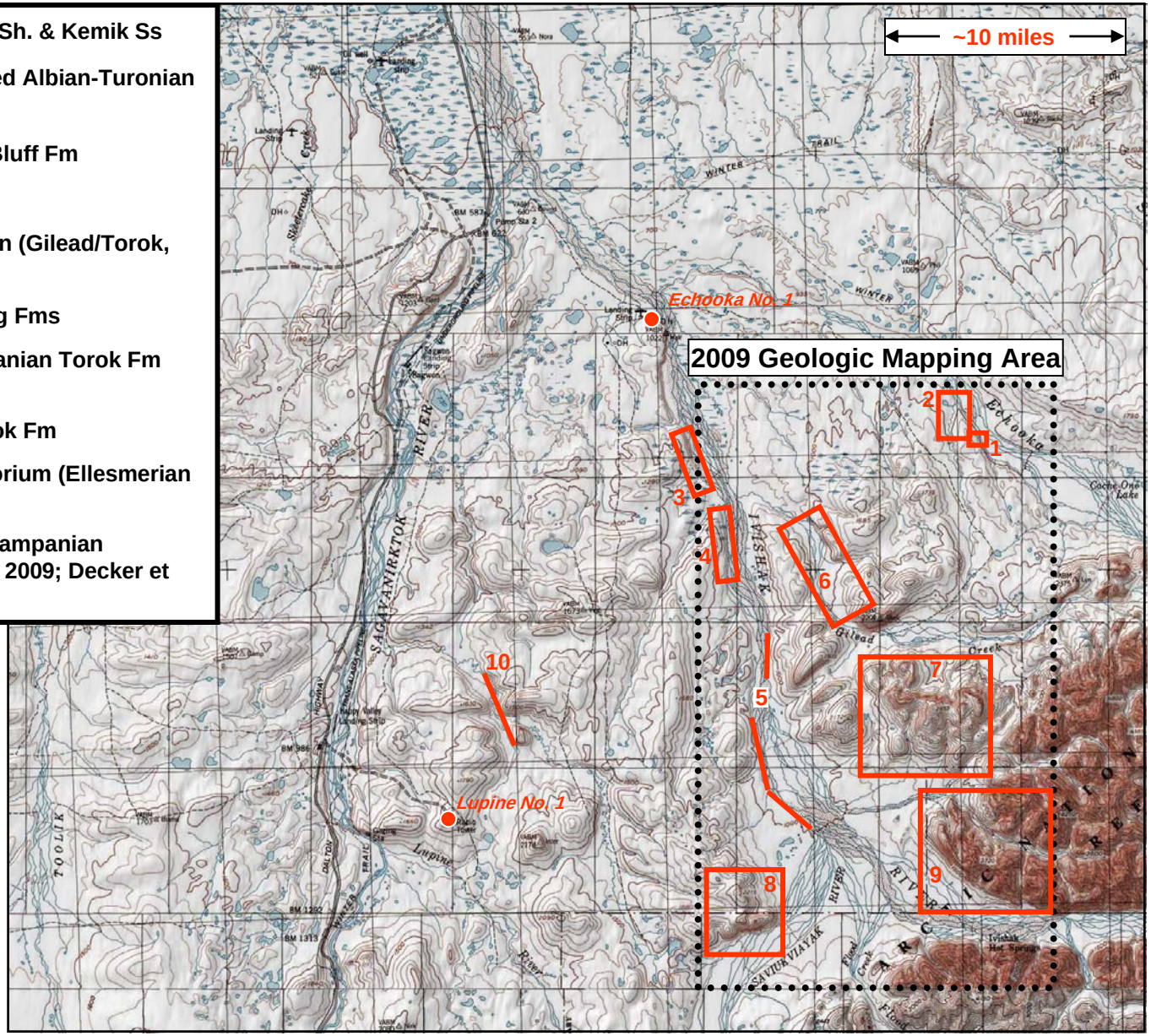

Figure 2. Location map of proposed 2009 study area showing geographic references noted in the text and highlighting selected regions of interest in the southern Sagavanirktok Quadrangle (see figure 1 for regional location).

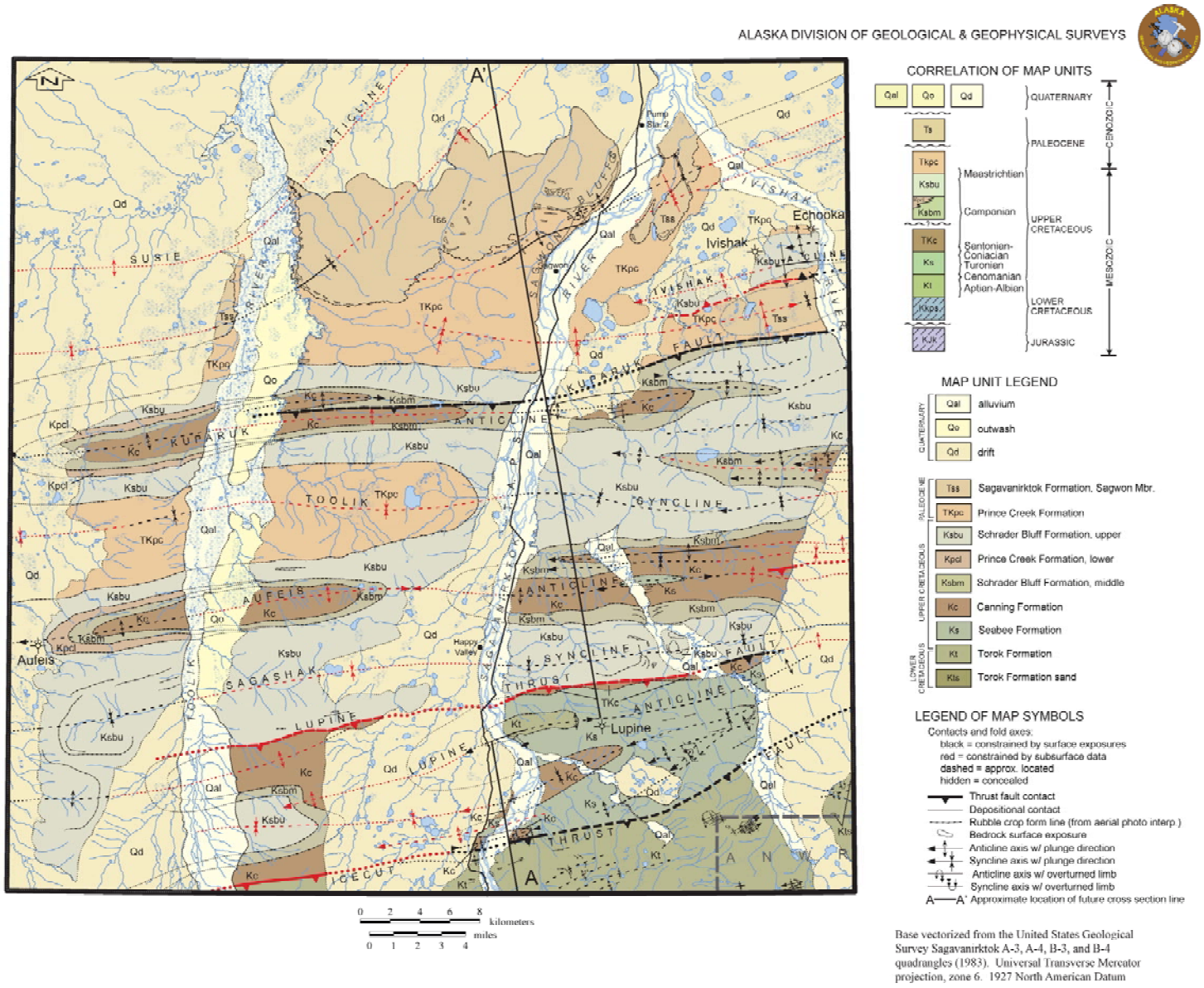

Figure 3. Preliminary geologic map of the Sagavanirktok River area, redrawn from 1:63,360-scale mapping for illustrative purposes (Gillis *et al.*, in press). See figures 1 and 2 for regional location and figure 4 for additional stratigraphic context.

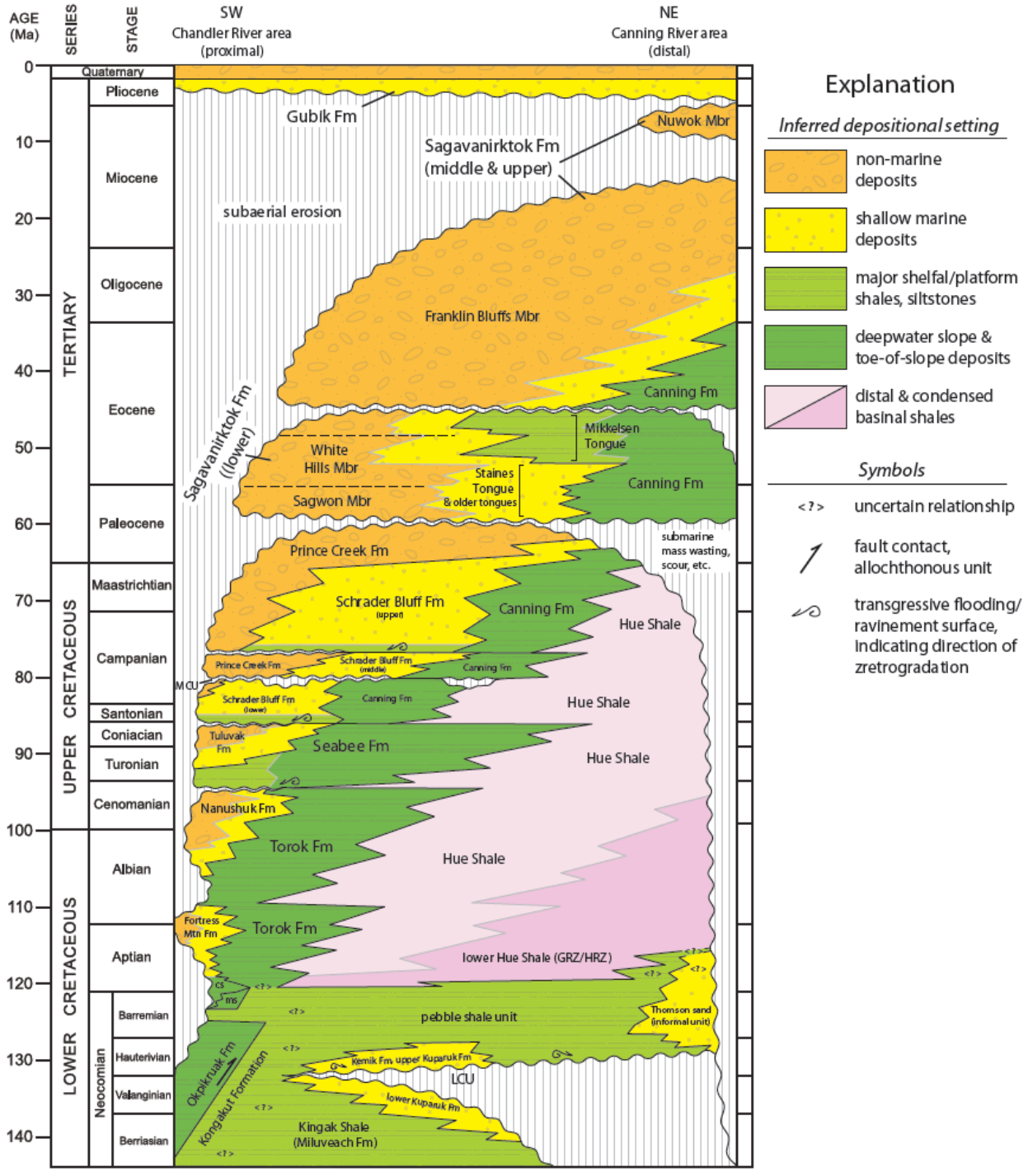

Figure 4. Chronostratigraphic column for the Colville basin, northern Alaska (Decker *et al.*, in press, revised from Mull *et al.*, 2003 and Garrity *et al.*, 2005). Abbreviations as follows: Fm, Formation; Mbr, Member; Mtn, Mountain; LCU, Lower Cretaceous unconformity; MCU, mid-Campanian unconformity; cs, Cobblestone sandstone of Fortress Mountain Formation (informal); ms, manganiferous shale unit (informal).